4TH Edition

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AC & DC PRODUCT GUIDE

Programmable Power Supplies &
Electronic Loads Catalog

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About: AMETEK® PROGRAMMABLE POWER

Headquartered in San Diego, California, AMETEK Programmable Power is the global leader in the design and manufacture of precision, programmable power supplies and electronic loads for R&D, ATE, process control, power bus simulation and power conditioning applications covering diverse industrial segments. AMETEK Programmable Power is part of the Power Systems & Instruments Division of AMETEK, Inc. AMETEK is a leading global manufacturer of electronic instruments and electromechanical devices with annual sales over $3 billion.

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AC & DC Programmable Power Supplies Catalog

Product Guide

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DC Bench Top Power Supplies

	Model	Power	Voltage	Current	Rackmount	Benchtop	Analog	GPIB	RS232	USB	LXI-Ethernet	Ethernet	Page
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AC Rack Mount Power Supplies

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	Compact iX	750-2250 VA	150-300 V	10-40 A	●		○	○	●	●	○		135
	ContinuousWave (CW)	800-2500 VA	135-310 V	2.6-18.6 A	●		●	○	○				139
	iX / i Series II	3000-15000 VA	150-300 V	0-120 A	●			●	●	●	○		145
	Ls	3000-18000 VA	135-400 V	0-132 A	●			○	●	●	○		155
	Lx	3000-18000 VA	135-400 V	0-132 A	●			●	●	●	○		161
	CSW	1750-22200 VA	156-312 V	6.5-192 A	●		●	●	●	●	○		167
	BPS	30–180 kVA	150-400 V	0-500 A / Phase				●	●	●	○		175
	MX	15-135 kVA	150-400 V	0-375 A / Phase				●	●	●	○		181
	RS	90–540 kVA	150–400 V	0-1500 A / Phase				●	●	●	○		189
	Global UPS (GUPS)	2400 VA	115/230 V	20.8 A	●				●				197
AC Current Sources													
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	CS	3-18 kVA	208-400 V	44.44-177.77 A	●			●	●	●	○		207
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	CTS	1250–15000 VA	150–300 V	0–37 A	●			●	●	●	○		217
	MX CTS	30–90 kVA	150–300 V	0-75 A / Phase			●	●	●	●	○		219

● Standard ○ Option

AC/DC Electronic Loads

	Model	Power Range: Power	Power Range: Voltage	Power Range: Current	Rackmount	Benchtop	Interface: Analog	Interface: GPIB	Interface: RS232	Interface: USB	Interface: LXI-Ethernet	Interface: Ethernet	Page
	PLA	0.8 - 7.5 kW	10 - 1200 V	10 - 1500 A	●			●	●	●		○	225
	PLW	6 - 250 kW	60 - 1200 V	10 - 5000 A	●			●	●	●		○	233
	SL	75-14.4 kW	60-500 V	1-720 A	○	●	●	○	●				241
	3091LD	3000-12000 VA	50-350 VRMS	120 ARMS	●			●	●				249

AC/DC Modular Power Supplies

	Model	Power	Voltage	Current	Rackmount	Benchtop	Analog	GPIB	RS232	USB	LXI-Ethernet	Ethernet	Page
	ReFlex Power DC Modules	330 W / 1000 W	16-450 V	2.3-30 A	●						●	●	259
	ReFlex Power AC Modules	875 VA	140-280 VAC	3.5-7 Arms	●						●	●	263
	ReFlex Power Load Modules	375-750 W	500 V	15-30 A	●						●	●	265

Engineered Solutions

	Model	Power	Voltage	Current	Rackmount	Benchtop	Analog	GPIB	RS232	USB	LXI-Ethernet	Ethernet	Page
	Solar Array Simulator (SAS)	900 - 1000 W			●			○				●	277
	Batter Simulation System (BSS)	60 W - 30 kW	120 VA - 480 kVA		●			○				●	281
	TerraSAS	1kW - 1MW	80 V -1000 V		●						○	●	285
	ETS	1kW - 1MW	60 V		●						○	●	291
	DC Power / Energy Absorber Test System	60 kW	400 V	150 A	●			●					297
	High Current Research Test System	45–75 kW	0-5 V	9000-15000 A	●								301
	Isolation / Polarity Chassis	60 VA	600 V	250 A	●								303
	MFP	300 - 1200 W	22 - 35 V	12.5 - 50 A		●							305

● Standard ○ Option

DC
Rack Mount Power Supplies

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Considerations When Specifying a DC Power Supply

Article

By Bill Martin, Sales/Applications Engineer

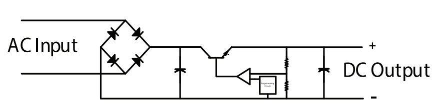
Every automated test system that tests electronic circuit boards, modules or equipment needs one or more DC power supplies. DC supplies provide power to the device under test as well as test stimulus.

In some cases, the supply used to provide power to the DUT also provides a test stimulus by simulating the operating environment. For example, while most automotive electronics run at a nominal 12 VDC, the maximum input voltage may be as high as 27 VDC. Because this is so, some automotive standards require margin testing up to 27 VDC on a 12 VDC device. Necessities such as these determine power supply requirements.

Let's take a look at other common power supply specifications that you need to consider when selecting a power supply for an automated test system.

Linear or Switching Supply?

The first choice you must make when purchasing a DC power supply is whether to select a linear supply or switching supply. Linear power supplies offer low ripple and noise specifications and have fast transient behavior. They are, however, inefficient and generate a lot of heat. They are also quite heavy. As a result, most engineers find them desirable only at lower output power levels (typically less than 500 watts). Most linear DC power supplies are benchtop supplies.



Basic Linear Power Supply

One application for which a linear benchtop supply may be the best choice is when testing communication devices such as a radio or mobile phone or the demodulator module of a radar system. These devices have very sensitive discriminator or demodulator circuitry that work best with a low noise figure. To test the true performance of these units, we need to ensure that the DC power supply does not add any parasitic noise to the test setup, and because linear supplies have lower output ripple and noise than switching supplies, they are a better choice for this application.

Linear supplies are also a good choice when power requirements are low. The main benefits of a switching supply are only relevant at higher output power levels. It is, therefore, less expensive to use linear DC power supplies in applications that do not require more than 100 W to 200 W per DC output channel.

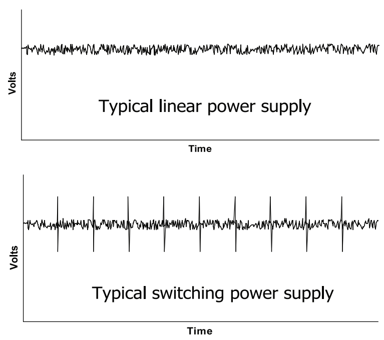
At this point, it is also important to consider the total power output of all the DC channels in your system. If your system has four channels or less, and the power requirements are relatively low, a good solution would be to use four linear supplies in a 19-in. rack-mount kit.

If your system requires more output channels, or higher output power, then using switching supplies is a better option. They provide higher power density than linear supplies. By using switching supplies, you can have 12 DC outputs, providing up to 4,000 W of power in the same rack mount. Switching supplies are easier to control than linear supplies and cost about the same per channel.

AMETEK Programmable Power provides a range of DC power supplies that offer some of the highest power densities available. The Sorensen ASD series, for example, provides up to 30 kW of power in a 3U package. The water-cooled packaging allows it to be used in environments that normally exclude air-cooled power supplies.

Even in applications where low ripple and noise output are required, switching supplies are often more than sufficient. Recent developments in power electronics, such as zero-switching, have dramatically improved the ripple and noise specifications of switching power supplies. When you also consider that switching power supplies are more flexible than linear supplies and provide higher power density, it becomes apparent they are the favored choice for all but a handful of applications.

Noise Profile on Linear vs. Switching



- RMS ripple, measured up to 300 kHz with an RMS voltmeter.
- Peak-to-Peak noise, measured from 20 Hz to 20 MHz, generally with an oscilloscope

Transient Response

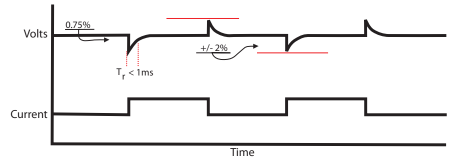
Transient response is a measure of how well a supply copes with changes in current demand or how well the supply follows changes in the load impedance. This is an important specification for many applications.

When the output current demand decreases or increases significantly over a short period of time, the output voltage may also decrease or increase significantly. The power supply's internal voltage control-loop will try to keep the output at the set voltage, but the response is not instantaneous.

Article

Considerations When Specifying a DC Power Supply

To get a faster transient response, you sometimes have to settle for more ripple and noise. Within the programmable power supply, the tradeoff is between the internal voltage control-loop and the output filter. A large output filter will limit the ripple and noise, but will make the supply slower to react to fast changing loads. A very fast internal voltage control loop will shorten transient response times, but may cause overshoot or undershoot, which may damage the Device Under Test (DUT).



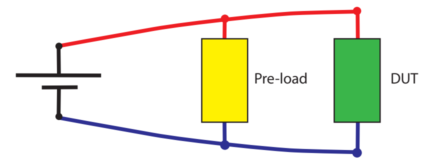
Typical transient response specification for a switch-mode programmable DC power supply:
At a current change of 50% of maximum output current range, the DC output voltage will over- or undershoot not more then 2% of its set voltage. And recover within 0.75% of the set voltage, within less then 1ms.

A typical application example where transient response is important is mobile phone testing. In this application, the DC power supply simulates the mobile phone's internal battery. When it begins to transmit, the current rise is very quick.

This is not a problem for the internal phone battery, but for a programmable switching supply, it is a more difficult task. For this application, a linear supply would be a better choice than a switching supply because the power requirements are low, and the transient response of a linear supply is, in general, better than a switching supply.

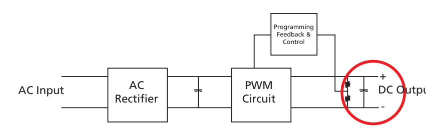
Testing automotive relays and fuses is, however, another matter. For this application, the programmable DC power supplies must provide high currents at voltages up to 30 VDC, and typically, the power required is 5 kW to 10 kW. In this test, a large DC output voltage overshoot could damage the relay or fuse. To prevent this from happening, you want a supply that will control the DC output current instantaneously from zero to maximum output or from maximum to zero output.

A practical technique to limit overshoot and undershoot is to use a pre-load. Putting a pre-load in parallel with the DUT and the DC output of the programmable power supply will now limit the percent current change, causing the DC voltage over- and undershoots to be significantly less. Imagine that 50% of the current travels through this additional pre-load and 50% through the DUT. When the DUT creates a 100% current demand step, the power supply only sees a 50% current demand change. For the power supply to manage 50% in current demand changes, instead of 100%, it is much easier and almost eliminates the effect of high voltage overshoots and therefore eliminates any damage to the DUT. A simple inexpensive resistive load can be used in this case to function as a pre-load. Any ratio is fine. In other words, to obtain the transient response and overshoot specifications improvements it does not really matter if this load absorbs 40%, 50% or 60% of the current demand.



The pre-load should draw a current at least up to 75% of the DUT, to significantly improve the output voltage over- & undershoots

A disadvantage of using a pre-load is that twice as much DC output current is required. Fortunately, if you use AMETEK switching power supplies, additional power is relatively inexpensive. This makes using pre-load a much cheaper and more practical approach than specialized power supply sub-systems for this specific application.



Switching Supply Architecture

Slew Rate

The next specification to consider is the DC output voltage slew rate (rise and fall time). To improve ripple and noise specifications, DC programmable power supplies have output filters that use large capacitors that store a lot of energy. It's mainly the charge and discharge time of this filter, combined with the current demand of the DUT, that determine a supply's voltage slew rate. The voltage slew rate is mostly independent of the connected DUT.

The DC output rise time for most AMETEK supplies is sufficiently fast for most applications. It is the DC output fall time that you must consider. The fall time depends not only on the internal LCR filter network at the DC output of the programmable power supply, but also of the connected DUT. If the current draw through the DUT is relatively low compared with the power supply current capacity, it can take many seconds before the energy stored in the output capacitors "leaks" away through the DUT. If the DUT requires a minimum current demand of at least 60% of the power supply capability, the stored energy will leak away instantaneously and the output voltage fall-time will be the shortest. Nevertheless, in most cases the DC output fall-time will be two to three times slower than the DC output rise time.

One way to improve the DC output rise time is to choose a programmable power supply with a higher DC output range. For example, if the DUT is an automotive-related device and a 30VDC power supply would cover all test applications, choose instead a 60 VDC programmable supply, but only use up to 30VDC. The reason for this is that the output capacitor for the 60 VDC supply will be much smaller than the output capacitor for the 30 VDC programmable supply. This is to allow the voltage to rise from 0 V to full scale in the same amount of time for both supplies. In other words, when looking at the rise time in V/ms, the rise time for the 60 VDC power supply will be twice as fast..

Considerations When Specifying a DC Power Supply

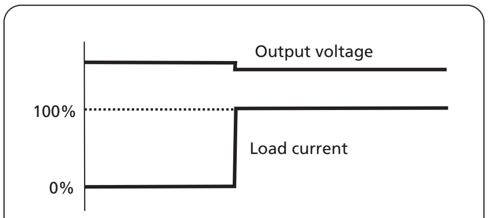
To improve the DC output fall-time, use a pre-load in parallel with the DUT or DC output of the power supply. Ensure that the total current demand of the pre-load and the DUT combined is at least 65% of the programmable power supply's current capability. This approach requires more power from the supply as more DC output voltage range is required with the same output current demand.

A typical output current slew-rate is 45A/ms. AMETEK Programmable Power also makes some DC power supplies to support solid-state laser applications. These are current sources with an output current slew-rate up to 400A/ms.

Faster current slew-rates are possible by putting an electronic load in series with the power supply and using the electronic load as a current modulator. This combination allows for a current slew-rate up to 6000A/ms..

Load Regulation

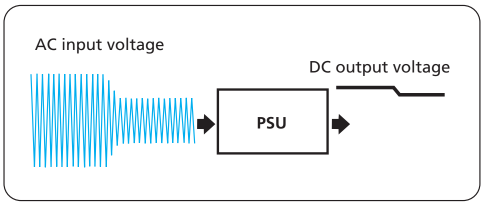
Another important specification of programmable power supplies is load regulation. This means some percent output voltage change from its set-point due to a change in the current demand of the DUT. Normally this effect should be very small (less then 0.01% of set output voltage).



Percent change of the output voltage as a function of load change

Line Regulation

Line regulation specifies the percent change of the DC output voltage or current as a function of AC input line voltage. This specification is important when the input line voltage is not stable.



Stability

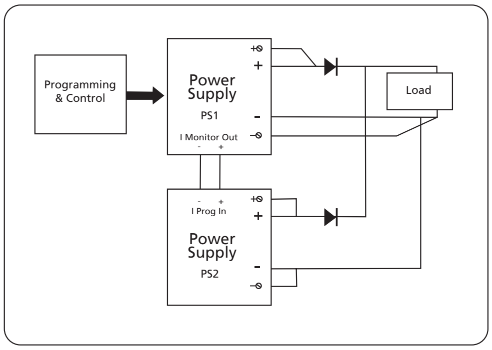
stability is a measure of a supply's long-term output voltage or current drift.

A typical application is a magnet drive test, in which the programmable supply works as a current source in constant current mode. For this test, the user needs to be sure that the magnetic flux value is the same throughout the test. The supply must, therefore, set the DC output current to a specific value and maintain the value for the duration of the test. Stability is primarily specified in parts per million or ppm.

Parallel Operation

If you need more output current than a single supply can provide, paralleling power supply outputs is generally the solution. AMETEK Programmable Power uses a dedicated control bus to connect its power supplies in parallel. The benefit of this dedicated bus is that the total performance of the units in parallel still meets the original specifications for just one single power supply. The system configures itself automatically, identifying which unit is the master and which units are the slaves. With fast transient DUT's it is sometimes recommended to use protection blocking diodes in the positive output line of each power supply.

When paralleling supplies in this way, you can use supplies that have different current ranges, but all of the supplies should have the same output voltage range. All manual or remote control is done through the master unit. Any sense lines are connected only to the master unit. Realize that the total current is the sum of the current values displayed on each individual power supply. Some advanced models, such as the Sorensen SGI Series can compute and display the total system current.



Series Operation

To supply a higher output voltage than is possible with a single supply, DC power supplies can be connected in series. All you have to do is to connect the positive terminal of one supply to the negative of another.

This is true, but there are some limitations. Every programmable power supply has voltage isolation specifications, one for the negative to chassis isolation and one for the positive to chassis isolation. Ensure these voltages are not exceeded.

A second limitation is that when operated in series, there are no master or slave units. What this means is that the power supplies need to be programmed individually. When using remote control for this, all interfaces need to be galvanically isolated through opto-couplers. Most DC power supplies offer a number of isolated interfaces, including analog, RS-232, RS-485 and Ethernet.

Analog Programming

DC programmable power supplies typically provide a standard and isolated analog interface. Through the analog interface a supply's DC output voltage, current and over-voltage-protection (OVP) can be set. These values are controlled by supplying a voltage signal, a current signal, or by connecting a resistor to the analog input.

Considerations When Specifying a DC Power Supply

For example, you can use the analog output of a PLC to control the output voltage of a power supply. Or, you might use a thermistor to control the output of a supply. Also provided are voltage and current monitoring signal lines and control lines to enable or disable the power supply with millisecond reaction time.

Local and Remote Sensing

Many DC supplies can be configured for either local or remote sensing. For a more accurate output voltage setting, remote sensing should be used. In this mode, you sense the voltage where the power supply connects to the load. This method compensates for the voltage drop across the leads.

If sense lines are long, it is recommended to use shielded cables to avoid any interference being superimposed on the main DC output. Remote sensing can often compensate for a voltage drop much larger than specified One issue that can arise when using remote sensing is that transient response may be slower when the voltage drop across the power leads is high, but this is usually not a problem.

Constant-Current Mode

Although most supplies are used in constant-voltage mode, many applications call for using a DC power supply in constant current mode. When operated in constant-current mode, some features or specifications are not applicable. For example, in constant current mode, remote sensing is not a consideration. Neither is the output voltage set-point accuracy and resolution. What is important is accurate current control. Output voltage ripple and noise are not as important as output current ripple and noise.

In constant current mode, the analog control can drive current changes at least 100 times faster than output voltage changes. The crossover from voltage to current mode is automatic. As soon as the current demand is larger than the set current limit, the DC power supply regulates its voltage down to match the set current limit and keeps the output current constant.

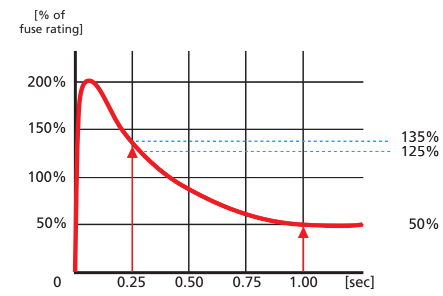
Inrush Current

For some applications, inrush current is a major consideration. Inrush current is the instantaneous input current drawn by an electrical device when first turned on. Some loads, such as electric motors and power converters draw high inrush currents. A power supply may need to be sized for the inrush current.

Digital Control and Measurement

In general, the output voltage and current of a programmable supply is set most accurately, with the highest resolution, through its digital interface. As mentioned earlier, DC supplies typically offer many different interfaces, including RS-232, RS-485, USB, GPIB, Modbus-TCP, Modbus-RTU, and Ethernet. In addition to the hardware, most DC power supply companies also supply the software you need to easily integrate your DC

supply into your system. For example, AMETEK supplies IVI drivers with each supply, and the supplies are programmed using standard SCPI commands. This makes system programming and system integration much simpler.



Fast output current profile created through sequence programming supporting fuse rating test

Accessories and Support

The availability of accessories could also be an important consideration in your choice of power supply. For example, if you plan to rack mount the power supply, verify that one is available for your supply. Purchasing an off-theshelf rack-mount kit is always less expensive than making one yourself.

In Conclusion

When selecting a DC programmable power supply, there are many parameters to consider. Electrical specifications are perhaps the most important, but you also need to consider the form factor, control needs, and even what accessories are available. By taking all of these into account, you'll make the best choice for your application.

For More Information

To learn more about the company's programmable power supplies and programmable loads, contact AMETEK Programmable Power Sales toll free at 800-733-5427, or 858-458-0223, or by email at sales.ppd@ametek.com.

Users can also contact an authorized AMETEK Programmable Power sales representative by visiting

http://www.programmablepower.com/contact/

About AMETEK Programmable Power

AMETEK Programmable Power offers the engineer's most reliable and trusted power brands: AMREL, California Instruments, Elgar, EM Test and Sorensen. AMETEK's strong brands, broad product portfolio of AC and DC power supplies/loads, and deep application expertise across a wide array of industries make it the industry's trusted "power partner."

AMETEK Programmable Power is a unit of AMETEK Electronic Instruments Group, a leader in advanced instruments for the process, aerospace, power and industrial markets and a division of AMETEK, Inc., a leading global manufacturer of electronic instruments and electromechanical devices with annual sales of more than $3.0 billion.

Bill Martin is a Sales/Applications Engineer for AMETEK Programmable Power. He joined the company in October 1992 and holds a bachelor's degree in electronic engineering from Arizona State University.

High Ripple Current Loads

Application Note

Considerations when using switchmode power supplies to drive high ripple current loads such as motors and switch mode converters.

For applications where there is a large ripple component in the load current (such as DC-AC inverter/DC-DC converter/DC motor loads), there are several unexpected (and undesirable) problems that can occur with source power supplies of the switchmode type.

The reason for this is that, unlike linear supplies, the power is delivered to the output storage capacitors in 'packets' at a regular rate (switching frequency). For a steady load, the converter supplies a predictable 'packet' that keeps the capacitor 'topped up' and a steady output is produced. This output capacitance must not be too large, however, for when it is desired to reduce the output voltage, this capacitance must discharge into the load, and under light load the slew rate can be quite long. Under pulse load conditions, however, this output capacitance will significantly discharge upon application of the pulse load current and it will take a short time for the control loop to increase the output of the converter to the new load requirement. Since the voltage on the output capacitor will have dropped, the converter would have to supply almost infinite current into the capacitance to bring it back to the set voltage. Since the converter output is current limited, recharge of the capacitance can take several cycles.

If the ripple element is more than about 5% of the DC current, the power supply can start to have over-current operating phenomena either in the output over-current detection and control system or in the primary over-current sense and control system.

If the pulse rate of the load is harmonically related to the power supply switching frequencies, instability can occur in the control loops.

High ripple currents can seriously over stress the output capacitors of the power supply and precipitate early failure.

The most practical solution to most of these problems is to provide sufficient low ESR external capacitance so that the power supply sees a steady DC load. To this end, one needs to provide capacitance that limits the ripple voltage to significantly less than 5% of the operating output voltage.

As a general rule of thumb, one can compute the needed capacitance from the peak output current and allowing, say, 2.5% of the operating output voltage as ripple; the duty cycle; and frequency of the load.

C=(t/2.5%Vout) x I pk = (40 x t / Vout) x I pk

Where: C = farads

t = seconds

V = Volts

I = amperes

Generally, the capacitance will run between 1000uF and 10,000uF per amp of peak load current, with the higher needed at low output voltages and the lesser at higher output voltages.

It is very important that the capacitor be of a so called 'computer grade' which has a low ESR and can tolerate very high ripple currents. Typically it will be a screw terminal type, and it is essential that it be installed between the power supply and the load. Leads are run from the power supply output terminals to the capacitor terminals and a second set of leads run from the capacitor to the load, to force the current to flow through the capacitor terminals.

Article

Advanced Electronic Power Simulation

Advanced electronic power simulation with unique specifications through basic power test building blocks, creating more efficiency, effectiveness and flexibility for a lower investment.

Exciting times:
The world market for cars is growing at a steady but modest CAGR of approximately 7%. More interesting is to look at the growth of all electronic components within a car. Industry annalists expect that the electronic cost content in a car will grow from 22% in 2005 to 40% in 2010. This means that the market for electronic car components show a CAGR of approximately 15%. This is twice a much as the total growth of the car industry and doubles the market in five years.

Another growth factor is the continuous need for more power within the car. What started with 6VDC batteries at a few hundred Watts has become kilo Watts at 12VDC or 24VDC. All this need for more power is causing the DC current through the DC bus to increase dramatically. Hence the discussions to increase the cal DC voltage bus to 42VDC.

The need for testing also dramatically increases. Where in the past there was just a few electronic components, there is now many hundreds of electronic devices. A car today can have up to a hundred circuits with some kind of micro-processor installed.

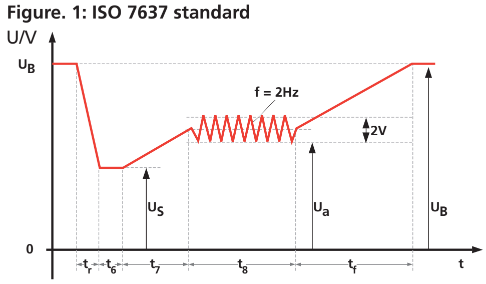
Two types if testing needs to be done. Each electronic device needs to be tested individually. And later, integration testing needs to be performed to ensure that all these devices do not interfere with each other and cause the total car to fail.

Both types of testing happen during R&D and during production. During the R&D phase, mainly margin testing and integration testing has the highest priority. During production the focus is mainly burn-in & test.

With more power comes cheaper and better specifications.
This article focuses on power simulation of the car. For this purpose, several specialized power sub-systems exist on the market today. Their attributes are low ripple & noise, fast voltage slew-rate and low transient response time. Lets first review why these attributes are so important. For this we need to start with the ISO 7637 standard (see figure 1). Required is a 5ms fall-time over 9 Volts or a 2Hz sine wave superposed on a 5 Volts DC offset level. This kind of power simulation signal requires a fast DC output slew-rate. To do this with a switch-mode DC power supply brings the advantage of high DC output current for a reasonable price in a compact, high-power density form-factor. But at the same time the DC output topology has a high stored energy, which does not allow for fast output voltage changes. Required therefore is a down-programmer as part of the DC output topology. But still in many cases this is not always fast enough. In that case, we suggest to select a DC power supply with a higher rated DC output voltage capability than required for the application. For instance, the specific application requires a 20VDC rated power supply. The selected switch-mode supply needs 40ms to go from 90% to 10% of the rated DC output -- in this case from 18 VDC to 2 VDC. This means a DC output voltage slew-rate of 0.5 V/ms. Instead I would select a 60VDC rated switch-mode power supply. With a similar specification of 90% to 10% of the rated DC output voltage will take 40 ms, the output voltage fall-time is now 1.5V/ms. To drop 9 Volts will take 6 ms. Very close to the requirement of the ISO 7637 standard.

The disadvantage of this method is that with three times the rated output voltage at the same current requirements, three times the power is needed. At AMETEK, additional power in the same product family comes with just 50 cents per Watt. A much cheaper and more practical approach than specialized power supply sub-systems uniquely dedicated for specific automotive applications. And this last comment highlights another large benefit. A standard switch-mode DC power supply with some extra power offers a higher degree of flexibility to support other future applications, and thus a more protected investment.

Figure. 1: ISO 7637 standard



Voltage transient at engine start-up
UB=12V, US=3V, Ua=4V
tr<5ms, t6=15ms, t7=50ms, t8=1s, tf=100ms

Voltage rise- & fall-time specifications in V/ms.

Notice that the higher the rated DC output voltage, the faster the output voltage the unit is. This can be attributed to the fact that the space for the switch-mode power supply output filter circuitry remains the same, but the rated output voltage increases and the stored energy decreases, which makes DC output voltage changes faster.

	SGA / SGI	
VDC	Rise V / ms	Fall V / ms
40	2.2	0.85
60	3.25	1.55
80	2.67	0.95
100	4.75	1.85
160	3.66	1.42
200	4.36	1.69
250	5.10	1.98
330	5.12	2.00
400	6.70	2.60
600	15.50	5.97

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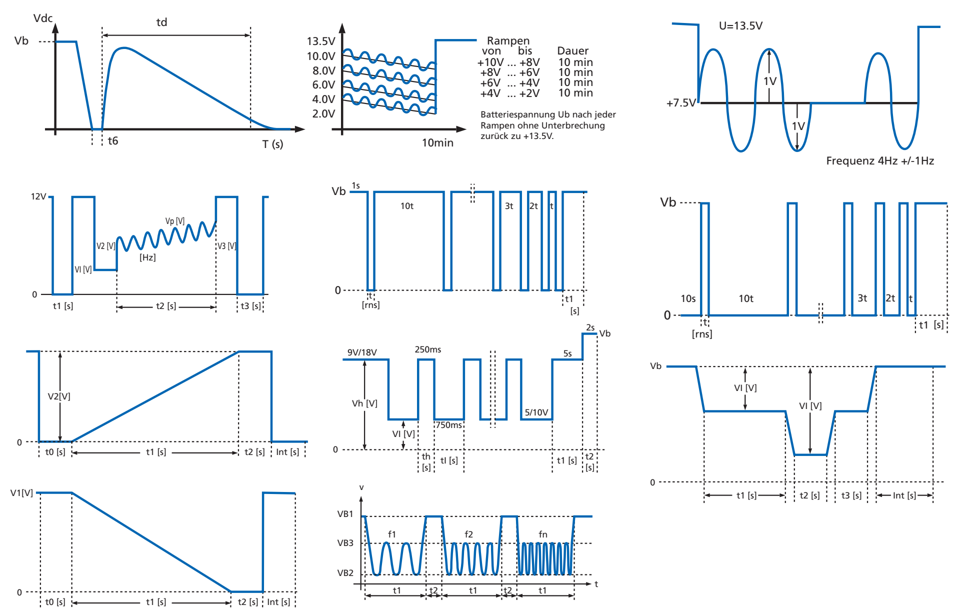
Figure 2. Examples of power simulation test scenarios



The need for fast analog control
Over the years many test scenarios have been created. For every electrical failure a new simulation had to be developed. Figure 2 shows some of the many examples of test scenarios used by the different car manufactures.

A very practical method to reproduce these typical power simulation waveforms is through an arbitrary waveform generator connected to the analog input for the DC output voltage control. Most switch-mode power supply provides an analog control input. This is normally a 25-pin connector allowing for many control functions, like: set output voltage, set current limit, voltage read-back monitoring and current read-back monitoring. Typically a zero (0) to five (5) or ten (10) volts signal will drive the DC output voltage from zero (0) to maximum rated voltage. The benefits for the use of a general arbitrary waveform generator is its extreme flexibility, combined with its memory depth and sequencing capability it can potentially simulate any power transient behavior for now or the future. Again I classify this as a very practical solution, because both the arbitrary waveform generator and switch-mode power supply are very common and relatively inexpensive pieces of equipment. Only two attributes are really important to watch for: The analog control input of the switch-mode DC power supply should have a bandwidth of at least 1kHz and the arbitrary waveform generator should be able to output at least 10Vpp in an open circuit.

Some switch-mode power supplies have an arbitrary waveform generator built in. Of course this solution is more compactly integrated. But mostly these built-in arbitrary waveform sequence generators lack the flexibility an external dedicated arbitrary waveform generator can offer. In most cases the capability of the built-in arbitrary waveform sequence generators are adequate for production purposes, but for R&D more flexibility is needed. In case of such a built-in arbitrary sequence generator, a minimum requirement will be a voltage, current or power ramp of 1ms or less and a sequence programming resolution of 1ms or less.

The next power supply attribute to discuss is transient response. Very high current demands are activated on and off in a car. Figure 3 shows the same ISO 7637 standard, but now with the typical corresponding current demands.

These large current demand changes cause transients in the DC output voltage.
Figure 4 shows the transient effects on the DC output voltage of a switch-mode power supply due to large current changes. Important specifications are the size of the overshoot and the time it takes to recover back to the set output voltage. The internal voltage control-loop regulates this. The faster the voltage control-loop the higher the overshoot. The slower the voltage control-loop the longer it takes for the power supply to recover to the set voltage.

A large portion of automotive electronics testing relates to breakers, fuses, relays, etc. To perform these tests properly without damaging the devise under test due to the test method alone, the voltage overshoot needs to be kept to a minimum. To achieve this the current demand step for the power supply needs to be reduced. A smaller current demand step will cause smaller overshoots. A simple way to avoid these overshoots, is to put a pre-load in parallel with the devise under test (see figure 5). Imagine that 50% of the current travels through

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this additional pre-load and 50% through the device under test. When the device under test creates a 100% current demand step, the power supply only sees a 50% current demand change. Always a base current demand remains present. For the power supply to manage 50% in current demand changes, instead of 100%, is much easier and almost eliminates the effect of high voltage overshoots and therefore eliminates any damage on the device under test. A simple inexpensive resistive load can be used in this case to function as a pre-load. Any ratio is fine. In other words, to obtain the transient response and overshoot specifications improvements it does not really matter if this load absorbs 40%, 50% or 60% of the current demand. Again the same disadvantage arises; twice as much current is required, therefore more power is required. And also in this case, more power comes at 50 cents per Watt. In other words, increasing power is a relative simple and inexpensive method to obtain significantly better specifications.

In conclusion:
More power capability from a general-purpose switch-mode power supply can substitute the need for specialized linear-type unique power supplies. The benefits are much lower capital investment and much smaller form-factor. This philosophy will not completely eliminate the need for these high-end specialized power simulation subsystems, but it will provide a choice to allocate capital budget more effectively in a practical way to support automotive electronics power simulation test needs. At least in 90% of all cases this philosophy provides a more flexible alternative.

About AMETEK
Headquartered in San Diego, California, AMETEK Programmable Power is the new global leader in the design and manufacture of precision, programmable power supplies for R&D, test and measurement, process control, power bus simulation and power conditioning applications across diverse industrial segments. From benchtop supplies to rack-mounted industrial power subsystems, AMETEK Programmable Power produces Sorensen, Argantix and PowerTen brand DC supplies ranging from 30W to 150kW; Elgar and California Instruments brand programmable AC sources from 800VA to 480kVA, and Sorensen brand AC/DC loads in both modular and high-power models. AMETEK Programmable Power is a division of AMETEK, Inc, a leading global manufacturer of electronic instruments and electromechanical devices with annual sales of more than $2.5 billion. For more information, contact AMETEK Programmable Power, 9250 Brown Deer Road, San Diego, CA 92121. Web site: www.programmablepower.com.

Typical pin-layout of the analog-programming interface

I/O	Function	Standard Description	Isolated Description	Pin No.	Electrical Chars.
In	ISO On/Off	Enables / Disables output with an externally supplied AC/DC voltage. Voltage may be 12 to 240 VAC or 6 to 120 VDC. A positive voltage will turn on the output of the supply. isolated up to 500v.	Enables/Disables output with an externally supplied AC/DC voltage. Voltage may be 12 to 240 VAC or 6 to 120 VDC. A positive voltage will turn on the output of the supply. I solated up to 500V.	1	Zin - 1.2 kohm
In	Ipgm	0-5V for 0-FS current programming	0-5V for 0-FS current programming	10	Zin - 10 kohm
Out	Iset	0-5V for 0-FS indicates FP potentiometer setting	N/A	11	Zout - 100 ohm
In	Vsns -	Negative remote sense input	Negative remote sense input	12	- 100 ohm to negative output term.
In	Vsns +	Positive sense input (<60V)	Positive sense input (<60V)	13	- 100 ohm to positive output term.
In	ISO TTL/CMOS ON/OFF	TTL/CMOS logic level enables supply	TTL/CMOS logic level enables supply	14	Zin - 2.2 kohm
In	Vpgm	0-10V for 0-FS for voltage programming	0-10V for 0-FS for voltage programming	15	Zin - 20 kohm
In	Ipgm	0-10V for 0-FS for current programming	0-10V for 0-FS for current programming	16	Zin - 20 kohm
Out	FAULT	High for module fault -14Vdc	N/A	17	Zout - 100 ohm
In/Out	S/D FAULT	High +12V for shutdownfault; also if driven high will shutdown the supply	N/A	18	Zout - 100 ohm
Out	Vmon	0-10V for 0-FS sample of output voltage	0-10V for 0-FS sample of output voltage	19	Zout - 100 ohm
In	ISO RTN	Return for pins 1 and 14	Return for pins 1 and 14	2	
Out	Vpgm Current Source	1mA CS	N/A	21	- 10.8V compliance

I/O	Function	Standard Description	Isolated Description	Pin No.	Electrical Chars.
Out	Ipgm Current Source	1mA CS	N/A	22	- 10.8V compliance
–	Ipgm Return	Return for Ipgm; <2.5V to COM to enable Ipgm	Return for Ipgm; <2.5V to COM to enable Ipgm	23, 25	Zin - 10 kohm
In	REM OV SET	0-5V for 0-FS for OVP trip point, >10V resets OVP	0-5V for 0-FS for OVP trip point, >10V resets OVP	3	Zin - 20 kohm
–	Vpgm Return	Return for Vpgm; <2.5V to COM to enable Vpgm	Return for Vpgm; <2.5V to COM to enable Vpgm	4, 20	Zin - 10 kohm
In	ON/OFF	Tied to pin 6 to enable supply	Tied to pin 6 to enable supply	5	Must sink - 1 mA to turn unit on.
–	COM	Return for control signals; same potential as - output terminal	Return for control signals	6, 24	
Out	Imon	0-10V wrt pin 6 for 0-FS sample of output setting	0-10V wrt pin 6 for 0-FS sample of output current	7	Zout - 100 ohm
Out	Vset	0-5V for 0-FS indicates FP potentiometer setting	N/A	8	Zout - 100 ohm
In	Vpgm	0-5V for 0-FS voltage programming	0-5V for 0-FS voltage programming	9	Zin - 10 kohm

Solving Unique Challenges Inherent in HEV/BEV Power Bus Testing

Introduction

The advent of high voltage DC power busses in hybrid and full electric vehicles (HEV/BEV), as well as the continued electrification of previously crank driven accessories such as vehicle HVAC, steering, brakes, and active suspension systems, brings some unique testing challenges. In particular, specifying and acquiring compact, high voltage (200 Vdc to 600 Vdc), high current sources capable of providing fast slew rate transient test signals is a potential product development bottleneck.

Typically, to simulate a fast transient DC pulse from a DC source requires a full linear or linear post regulator equipped switch mode power architecture (hybrid) supply. However, at high voltage and high currents these can be extremely large and inefficient. Switch mode power supplies (SMPS) for these power levels offer compact size and efficiency. However, because of the large output capacitance and filtering typically employed to reduce the ripple and noise from the high frequency switching conversion, slew times are fairly slow…in the several 10s or more of milliseconds.

In this application note we explore using an electronic load (eLOAD1) as a series modulation element to provide fast transient 200 A current pulses from a 400 V dc SMPS source. In essence, the eLOAD becomes an external linear post regulator that can be sized and optimized for the type of device to be tested. The eLOAD also conveniently provides a built-in transient modulator, greatly facilitating appropriate test signal generation.

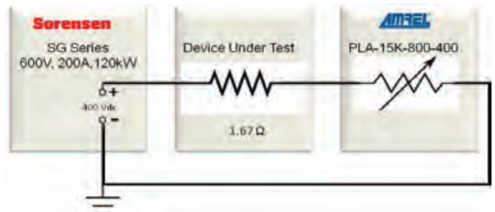
The test setup and results are presented here along with observations and considerations when specifying equipment for conducting similar testing.

Application Requirement

The application statement is simply to generate a 200 Adc pulse string or repetitive square wave signal using a 400 Vdc source. The rise and fall time is to be less than 150 microseconds.

Application Solution

The block diagram for the solution to be tested is straightforward and shown above, right:



The test setup consists of a high power Sorensen 0 to 600 Vdc, 120kW DC programmable supply set at 400 Vdc and operating in constant voltage mode. The device under test (DUT) was simulated by combining power resistors in series / parallel combination to achieve a resistance of 1.67 Ohms. The electronic load is an AMREL brand air cooled model set to operate in a constant current mode. As noted before, the eLOAD has an internal transient generator. In transient operation the eLOAD offers 7 modes: continuous, toggle, step, step auto, step once and trigger. For this test the continuous mode was used. That is, the eLOAD switched between the main level and transient level based on frequency, duty cycle and slew time as defined by the user. In this case, the current was switched between 2A and 200A at a 20 Hz rate with 50% duty cycle.

Results

In summary, the test setup achieved current pulses of the defined amplitude with rise and fall times of approximately 110 microseconds as can be seen in the scope captures in figure 1. Note that the waveforms are very clean with minimal to no overshoot.

The eLOAD transient generator was set to its fastest slew rate setting of 50 µsec. To see what impact the DUT reactive impedance was having on the rise time, the test was repeated without the DUT in the loop. Refer to Figure 2. Note that the achievable rise and fall times were cut in half. As noted previously, the DUT simulated load was made up of multiple power resistors in a series / parallel combination. In fact, there were 60, 1 Ohm resistors used. The resistors used were helical coil types so the DUT was not a pure resistive load but had an inductive reactance as well. Also contributing to the inductive component in the load circuit was the heavy cabling used to handle the high currents.

Solving Unique Challenges Inherent in HEV/BEV Power Bus Testing

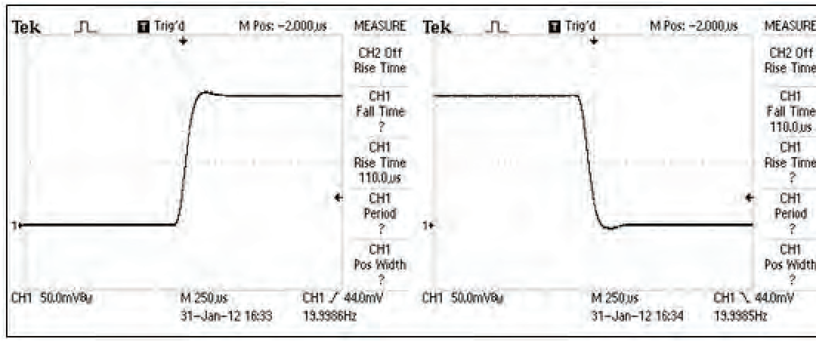


Figure 1

Current Pulse Rise and Fall Time

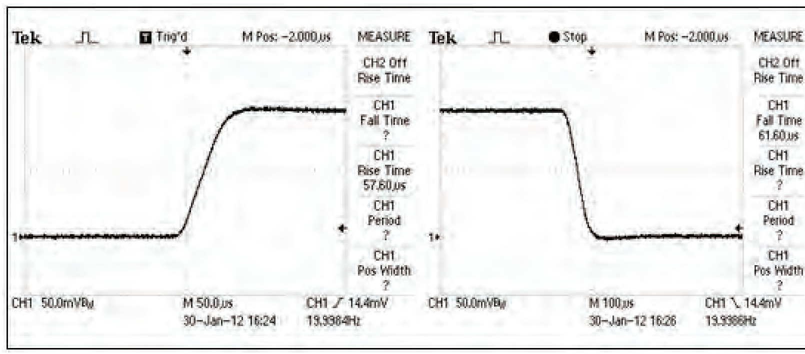


Figure 2

Current Pulse Rise and Fall Times w/o DUT in Circuit

Note: Charts use different time base settings. Refer to scope calculated rise and fall times

Conclusions

It has been demonstrated that It is quite feasible to generate high voltage, high current, fast transient test pulses using an eLOAD combined with a compact, high power programmable switch mode power supply thereby taking advantage of the compact size, efficiency and lower cost of this type of equipment when compared to high power linear sources.

Additional observations:

1. While conceptually simple, the practical high power engineering details can be fairly complex and should be discussed with a power engineer who understands the application and system requirements.

2. The use of off- the-shelf power products affords flexibility for configuring the equipment for specific test requirements. For instance:
   a. The series eLOAD, when controlled in constant resistance mode, could be used to simulate a battery series resistance turning the "stiff" power supply into a battery simulator
   b. When combined with appropriate switches, the system could provide charge and discharge (multi- quadrant) operation

3. Careful consideration must be given to sizing the equipment appropriately for the DUT and type of test to be conducted.

4. A detailed understanding of the DUT electrical characteristics is important in determining the limitations or test envelope that can be achieved.

About AMETEK Programmable Power Division (PPD)

For more than forty years AMETEK has supplied precision programmable power products and systems to diverse industries for test and measurement needs, ATE systems, R&D, process control, power bus simulation and power conditioning. Its products and services are recognized around the world for robust performance, high quality, reliability and economic value.

Contact your AMETEK PPD sales rep for application assistance to optimize a solution for your test needs. Visit the website at www.programmablepower.com, click on Contact Us and then Find Your Rep.

Simulating HBLEDs for Driver Testing

Article

Introduction

The rapid adoption of High Brightness LEDs (HBLEDs) for general lighting applications is challenging the designers of the lighting fixtures or luminaires with the need to develop low cost, efficient, low voltage, constant current drivers. Depending on the application, number of LEDs and their configuration in series and parallel strings, the number of designs required is exploding. Being able to rapidly test these power supplies with a flexible, programmable load that simulates the particular LED configuration is of increasing importance. This is especially the case if the driver design precedes the availability of the actual LED assembly in design. Being able to simulate anomalous operation such as a shorted or open diode in a series string, parallel string or matrix connection can save time and money in the qualification of the power supply.

In this application note, we explore using an electronic load (eLOAD1) as an HBLED load simulator. This note details how to use a simple standard feature of the AMREL load functionality, "V(on)" or otherwise referred to as "under voltage lockout protection" (UVL), to simulate the forward voltage turn on of the HBLED string. The constant resistance control mode is then used to set the nominal operating point. In addition, the note briefly explores the use of multiple loads to simulate more complex parallel string and matrix configurations.

The test setup and results are presented along with a brief discussion of some of the considerations when specifying equipment for testing.

Application Requirement

The application statement is simply to simulate a simple series string connection of HBLEDs with a forward voltage threshold of 40 volts DC and specified operating voltage and current of 42.2 V and 3 A DC, respectively. For application simplicity, a standard lab power supply will be used to simulate the HBLED driver (DUT).

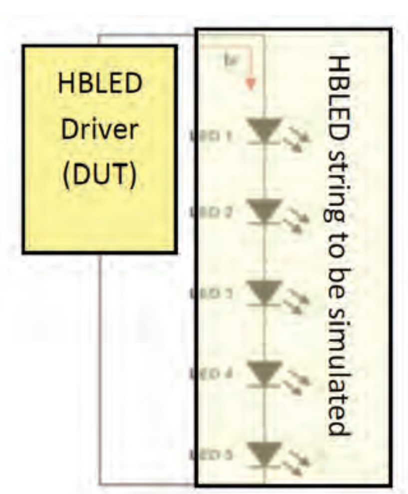


Fig. 1 HBLED String

Application Solution

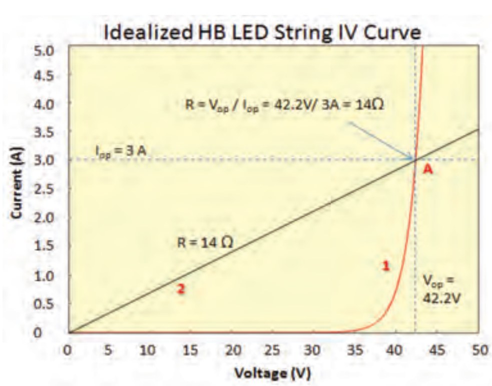
The standard programmable function being used to set the simulated V(fwd) of the string is called V(on) or undervoltage lockout " UVL". This function allows the user to set a trigger point between zero and the load's full-scale voltage. The input will remain off until the input voltage is greater than the pre-programmed value (V(on) = Voltage threshold). For the V(on) (UVL) feature, there are two modes that can be set. In "continuous" mode, the UVL detection will remain active, and each time the voltage drops below the set threshold voltage, the function will shut off the input. When in "input on" mode, the function will only trigger once to shut down the input and will reset each time the input is cycled.

Refer to the VI chart below. The two curves illustrate an idealized diode string curve (1) and a constant resistance profile (2). To establish the operating point, the constant resistance control mode will be used with the resistance value set to be that where the DUT specified operating voltage and current intersect (A). That is, R = V(op)/I(op)

The simulation test setup consists of a Sorensen XG 60-14, a 0 to 60 Vdc, 0-14A, 850 W DC programmable supply set at 45 Vdc. to simulate the driver DUT. The supply will be set to operate in constant current mode at 3A. The load being used here to simulate the HB LED string is the AMREL bench load series model BPL400-400-30.

The eLOAD is set to operate in constant resistance mode with a R = V(op) / I(op) = 42.2V/3.0A = 14Ω. The V(on) function is set to trigger at 40V.

Fig. 2 Typical IV Chart



Simulating HBLEDs for Driver Testing

Results

In summary, as can be seen from the scope capture below (figure 3), the load turns on at the set V(on) point (trace 2) and the current (trace 1) rises to the designed operating point. This illustrates how the standard functionality of the eLOAD can be used to simulate diode characteristic loads including, but not limited to, HBLEDs.

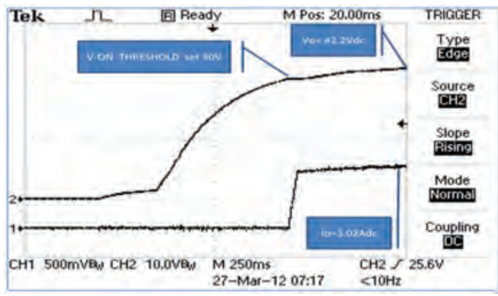


Fig. 3 eLOAD Scope Trace

For more complex connection schemes including parallel strings and matrix configurations (figures Y and Z), multiple eLOADs can be used. To simulate shorted or open circuit diodes or strings, the individual eLOADs can be set to toggle between various resistance values to provide the desired anomalous conditions to observe the operation of the driver under test.

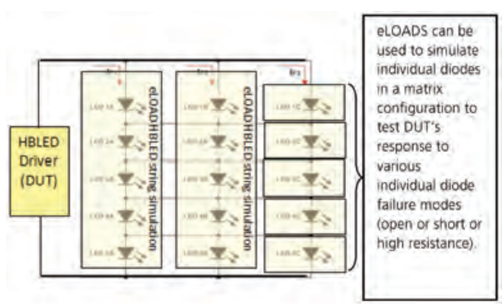


Fig. 4 Simplified Matrix Configuration

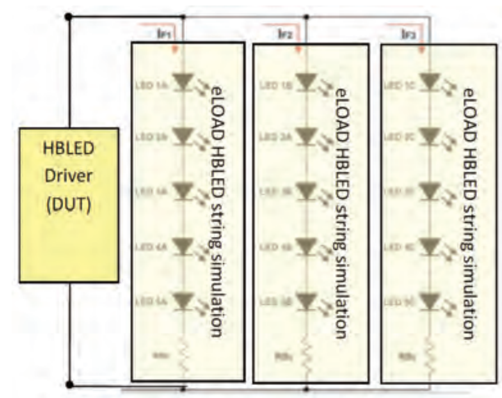


Fig. 5 Parallel String Configuration

Conclusions

It has been demonstrated that load simulation of HBLEDs in various configurations, for testing of HBLED driver supplies can be achieved quite simply using the standard functionality of the AMREL eLOADs

In addition, the use of off-the-shelf power products affords flexibility for configuring the equipment for specific test requirements. Careful consideration should be given to sizing the equipment appropriately for the DUT and type of test to be conducted. For example the eLOAD for simulating individual diodes may require an understanding of the forward threshold voltage to be modeled and require a "zero" volt type of eLOAD:

About AMETEK Programmable Power

AMETEK PPD is a division of AMETEK Inc, a multi-billion dollar manufacturer of differentiated technology solutions, and designs and manufactures advanced programmable DC, AC and eLOAD products under the well known and respected Sorensen, California Instruments, Elgar and AMREL brands.

For more than forty years AMETEK has supplied precision programmable power products and systems to diverse industries for test and measurement needs, ATE systems, R&D, process control, power bus simulation and power conditioning. Its products and services are recognized around the world for robust performance, high quality, reliability and economic value.

Contact your AMETEK PPD sales rep for application assistance to optimize a solution for your test needs.

Remote Sensing

Application Note

Purpose
Implement remote sensing to compensate for voltage drop in load lines.

Background
As energy is transferred from the power supply to the load by means of load leads, a voltage drop across the load leads occurs and may significantly interfere with load regulation. Remote sensing is a method of compensating for this load lead effect on the output of the power supply.

When to use Remote Sensing
You should use remote sensing in applications where the load is located some distance, typically >10 feet (3 meters), from the power supply output terminals.

You should also use remote sensing if the measured voltage at the load input power terminals is significantly lower than the voltage measured at the power supply output terminals. The difference in voltage is based on the amount of current and the load lead size and length.

CAUTION!

Consult the power supply operation manual for maximum voltage drop compensation the sense lines can correct for.

Calculating Voltage Drop

To calculate voltage drop of the load lines, first calculate the resistance of the load leads. Resistance = (Load line length in feet \ 100 ft) * resistivity coefficient in Ohms (Column 3 in the following table). Then apply Ohms law: Volts = Amps * Ohms.

Column 1	Column 2	Column 3	Column 4
Size (AWG)	Amperes (Maximum)	Ohms/100ft (one-way)	IR Drop/100ft (Col. 2x Col. 3)
14	15	0.257	3.85
12	20	0.162	3.24
10	30	0.102	3.06
8	40	0.064	2.56
6	55	0.043	2.36
4	70	0.025	1.75
2	95	0.015	1.42
1/0	125	0.010	1.25
3/0	165	0.006	1.04

Example
Load is 25 feet from the power supply, so total cable length is 50 feet. Load draws 15 Amps through a #12 American Wire Gauge (AWG) line; calculate voltage drop:

Resistance = 50 / 100 * 0.162 » 0.081W
Voltage Drop = 15 * 0.081 » 1.215 volts

Selecting Sense Cables
Sense lines carry very little current due to higher input impedance (typically 1kΩ; refer to operation manual for input impedance of specific supply) than the load lines. Sense line wire gauge should be selected so that there is no greater than a 100 mV drop across the sense lines. Typically #24 - #18 (AWG) is recommended.

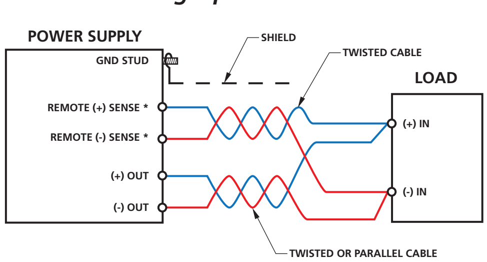
Noise and Impedance Effects
To minimize noise pickup or radiation from load circuits, load wires and remote sense wires should be twisted–pair with minimum lead length. Shielding of the sense leads may be necessary in high noise environments. Even if noise is not a concern, the load and remote sense wires should be twisted–pairs to reduce coupling between them, which could impact the stability of the power supply. If connectors are utilized for the power and sense leads, be careful not to introduce coupling between the leads. Ensure that the connector terminals for the sense leads are in adjacent locations, and minimize the physical loop area of the untwisted portions. Ideally, the sense leads should be separated from the power leads and should have their own connector.

Twisting the load wires provides an additional benefit in reducing the parasitic inductance of the cable. This improves the dynamic response characteristics at the load by maintaining low source impedance at high frequencies. Also, with long load wires, the resultant inductance and resistance could produce high frequency voltage spikes at the load because of current variations in the load itself. The impedance introduced between the output of the power supply and the load could make the ripple/noise at the load worse than the specifications of the power supply (which are valid when measured at the rear panel bus bars). Additional filtering with bypass capacitors at the load terminals may be required to bypass the high frequency load currents.

In addition, when operating with external sense, the recommendation is that it be done with twisted shielded pair, with one end of the shielding connected to ground close to the sense connector. The other end does not need to be connected.

Setup
To use remote voltage sensing, connect the power supply output to the load input terminals. Next, connect the sense lines to the load input as illustrated below.

Remote Sensing Operation at the Load



Remote Sensing

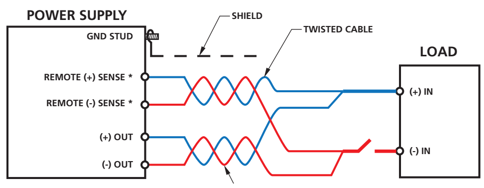
Using a Load Setup

CAUTION!

Internal power supply damage may occur if the power supply is operated with load power lines disconnected and sensing line connected, which causes the output current to flow through sensing terminals.

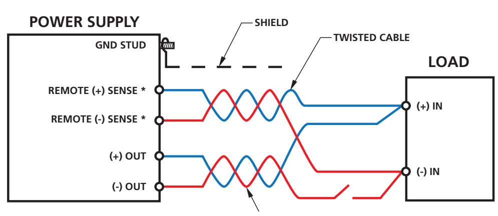
Example of a Good Setup

In the figure below, when the switch opens the power supply output current will drops to zero and the voltage at the output of the supply will decrease by the difference of the line loss of the cables when the load was present.



Example of a Bad Setup

In the figure below, when the switch opens the sense lines are no longer connected to the output of the supply. Sensing no output voltage, the sense attempts to boost the output voltage of the supply. The output voltage being boosted feeds higher current flowing through the sense lines to the load and may eventually cause damage to the supply. The eventual output of the supply may be slightly higher than the maximum rating of the supply (Max output voltage rating + Max sense compensation).



Recommendations

CAUTION!

Do not perform series operation when using remote sensing, as damage to the power supply may occur

Sorensen DLM 600 Series

375–600 W

Half Rack Programmable DC Power Supply

5–300 V

2–75 A

∿	110	220

GPIB LXI RS232

- High Power Density: 600 watts in 1U (1.75 inches) high, half rack (8.5 inches) wide; no top or bottom clearance spacing required.
- Near Linear Ripple & Noise Ripple as low as 2.5mV rms, noise as low as 15mV p-p.
- Remote Control
- LXI Compliant Ethernet LAN / RS-232C (16 bit)
- IEEE-488.2 / RS-232C (12 bit)
- Standard analog programming 0-5V, 0-10V, or 0-5kΩ.

The Sorensen DLM 600 series of programmable power supplies is designed to provide continuously variable output voltage and current for a broad range of applications in a compact 1U (1.75 inches) high, half-rack (8.5 inch) wide chassis.

With the use of Zero Voltage Switching (ZVS) technology, these supplies are able to achieve exceptionally low ripple and noise rivaling larger and more expensive linear power supplies.
In addition, the high efficiency and fast load transient response assure that the DLM 600 is ideal for even the most demanding applications.

The DLM 600 models are ideal for high density multiple output rackmount requirements or low profile benchtop applications. Output voltages from 0-5VDC to 0-300VDC and currents from 0-2A to 0-75A are available.

The cooling air intake is at the front and sides with exhaust at the rear and sides. Variable speed fans are controlled as a function of ambient air temperature and load, thus reducing acoustic noise and increasing fan life. This allows supplies to be stacked one directly on top of another without space in between, yielding maximum rackmount packing density and a wide operating temperature of 0-50° C. An optional rackmount kit is available to easily mount one or two units side-by-side.

The front panel layout makes the DLM 600 series easy to use. Voltage and current can be set from individual 10-turn potentiometer knobs. Control push buttons include power on, output on, local/remote, voltage/current preview and overvoltage protection preview. Set-point or actual voltage/ current values can be viewed on two 3 ½digit LED displays.

Supplies can be connected in series or parallel. All models automatically accept any standard single phase input without manual set up.

DLM 600 Series : Product Specifications

Common	
Remote Sense	The maximum load line drop is up to the full voltage rating of the supply. The drop in the load leads subtracts from the maximum voltage available for the load except as follows: maximum rated voltage is available at the load and voltage regulation specifications apply for line drops of<1V on DLM5-75 and DLM8-75, <2V for all other DLM600 models
Remote Programming	Voltage, current (0-100%) and OVP (5-110%) of full scale can be programmed by selectable 0-5VDC, 0-10VDC, or 0-5kΩ
Remote Monitoring	Voltage or current can be monitored with user selectable ranges, scaled to 0-5 VDC or 0-10 VDC
Operational Features	Master/slave parallel operation, up to 4 units of the same model can be connected in parallel, with active current sharing control. Series operation, multiple units of the same model can be connected in series, limited by 300Vpk between either output terminal and chassis.
Software	IVI-COM, LabVIEW® or LabWindow®/CVI driver for Ethernet and IEEE-488.2
Regulatory Compliance	CE Compliant: • Low Voltage Directive (73/23/EEC) using EN 61010-1, and • EMC Directive (89/336/EEC) using EN 61326 Certified to UL 61010-1, CSA C22.2 No. 61010.1 and IEC/EN 61010-1
Input	
Voltage and Frequency	90-132 VAC or 180-264 VAC max, auto ranging, 47-63 Hz, single phase, 2-wire plus ground
Current	11A maximum at 115VAC, 6A maximum at 230 VAC
Connector	IEC 320 with detachable line cord
Power Factor	0.6, typical at full load; dependent on the impedance of the AC input.
Output	
Line Regulation	Voltage: 0.005% of V max + 2 mV Current: 0.01% of I max + 2 mA See table for input voltage variation over the AC input voltage range, with constant rated load.
Load Regulation	Voltage: 0.005% of V max + 2 mV Current: 0.02% of I max + 5 mA See table For 0-100% load variation, with constant nominal line voltage
Transient Response	500 µs to steady-state output voltage (within 0.1% of Vmax) for 50-100% or 100-50% load change
Stability	±0.05% of maximum voltage or current over 8 hours after 30 minute warm-up time at fixed line, load and temperature
Efficiency	84% typical at maximum output power; 82% typical for DLM 5-75 and DLM 8-75
Temperature Coefficient	0.02%/°C of maximum output voltage, 0.03%/°C of maximum output current. Change in output per °C change in ambient temperature, with constant line and load.
Environmental	
Operating Temperature	0°C to 50°C (no derating)
Storage Temperature	-40°C to 65°C
Cooling	Internal variable speed fans with over temperature protection. Air intake is from the front and sides with exhaust at rear and sides for maximum rackmount packing density.
Physical	
Dimensions	Width: 8.5” (216 mm) Height: 1U or 1.75” (44 mm) Depth: 17” (432 mm) Option M6 depth 20” (508 mm)
Weight	9.7 lbs. (4.4 kg)
Shipping Weight	12.7 lbs. (5.8 kg)

DLM 600 Series : Product Specifications 375–600 W

Model	Output Ratings			Line Regulation		Load Regulation	
	Voltage (VDC)	Current (ADC)	Power (Watts)	Voltage (0.005% of Vmax + 2 mV)	Current (0.01% of Imax + 2 mA)	Voltage (0.005% of Vmax + 2 mV)	Current (0.02% of Imax + 5 mA)
DLM 5-75	0-5	0-75	375	2.25 mV	9.5 mA	2.25 mV	20 mA
DLM 8-75	0-8	0-75	600	2.4 mV	9.5 mA	2.4 mV	20 mA
DLM 10-60	0-10	0-60	600	2.5 mV	8 mA	2.5 mV	17 mA
DLM 20-30	0-20	0-30	600	3 mV	5 mA	3 mV	11 mA
DLM 40-15	0-40	0-15	600	4 mV	3.5 mA	4 mV	8 mA
DLM 60-10	0-60	0-10	600	5 mV	3 mA	5 mV	7 mA
DLM 80-7.5	0-80	0-7.5	600	6 mV	2.75 mA	6 mV	6.5 mA
DLM 150-4	0-150	0-4	600	9.5 mV	2.4 mA	9.5 mV	5.8 mA
DLM 300-2	0-300	0-2	600	17 mV	2.2 mA	17 mV	5.4 mA

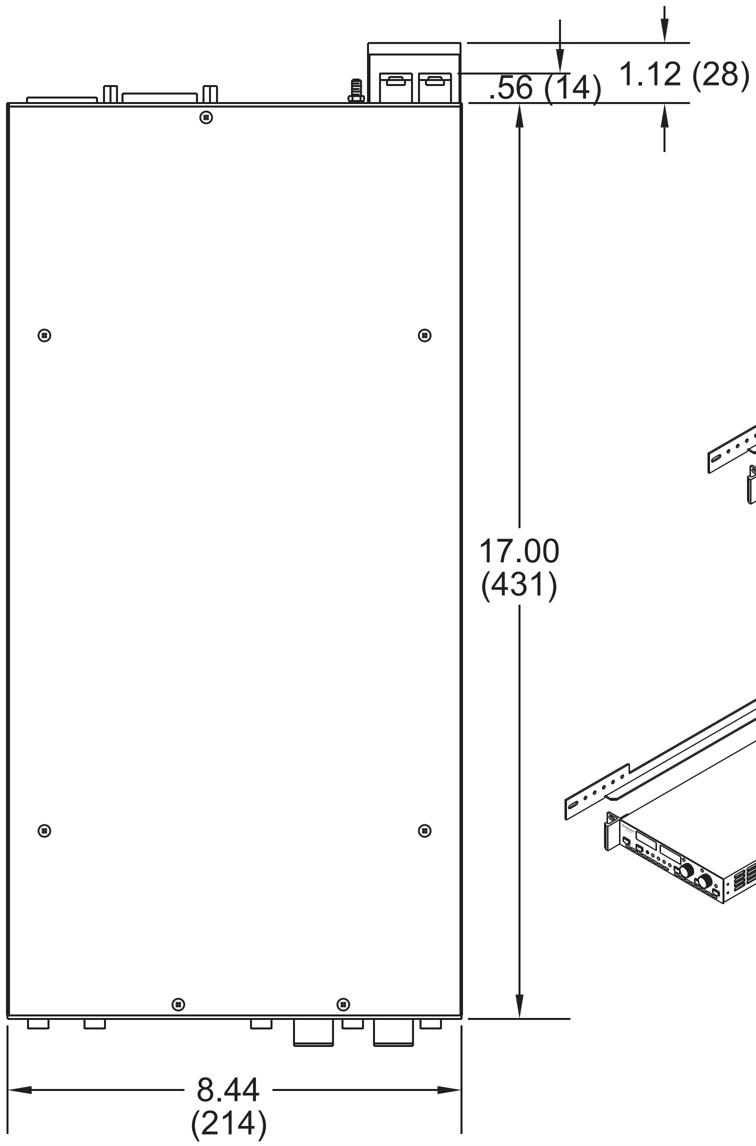
Model	Programming Accuracy‡						Load Regulation	
	Ethernet (M130/M131)			GPIB (M9G/M85)				
	Voltage (0.1% of VMax)	Current (0.25% of IMax)	Power (0.5% of 1.1 x Vmax)	Voltage (0.2% of VMax)	Current (0.5% of IMax)	OVP (1.0% of 1.1 x Vmax)	Voltage (0.5% of Vmax + 1 count)	Current (1.0% of Imax + 1 count)
DLM 5-75	5 mV	188 mA	44 mV	16 mV	375 mA	55 mV	35 mV	850 mA
DLM 8-75	8 mV	188 mA	44 mV	16 mV	375 mA	88 mV	50 mV	850 mA
DLM 10-60	10 mV	150 mA	55 mV	20 mV	300 mA	110 mV	60 mV	700 mA
DLM 20-30	20 mV	75 mA	110 mV	40 mV	150 mA	220 mV	200 mV	400 mA
DLM 40-15	40 mV	38 mA	220 mV	80 mV	75 mA	440 mV	300 mV	260 mA
DLM 60-10	60 mV	25 mA	330 mV	120 mV	50 mA	660 mV	400 mV	210 mA
DLM 80-7.5	80 mV	19 mA	440 mV	160 mV	38 mA	880 mV	500 mV	85 mA
DLM 150-4	150 mV	10 mA	825 mV	300 mV	20 mA	1.65 V	850 mV	50 mA
DLM 300-2	300 mV	5 mA	1.65 V	600 mV	10 mA	3.3 V	2.5 V	30 mA

‡ Readback accuracy is the same as programming accuracy for all parameters except GPIB Voltage readback which is 0.25% of VMax

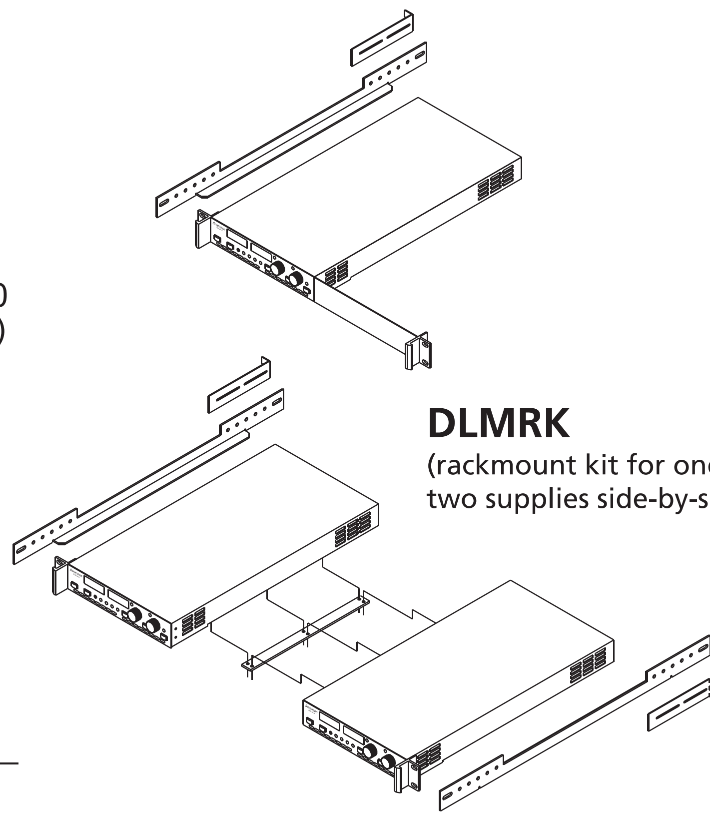
Model	Ripple and Noise, Voltage Mode		OVP Adjustment Range (5% - 110% of Vmax)	Stability		Temperature Coefficient		Maximum Total Remote Sense Drop
	Ripple (rms)*	Noise (p-p)*		Voltage (0.05% of Vmax)	Current (0.05% of Imax)	Voltage (0.02%/°C of Vmax)	Current (0.03%/°C of Imax)	
DLM 5-75	5 mV	30 mV	0.25-5.5 V	2.5 mV	37.5 mA	1 mV/°C	22.5 mA/°C	1 V
DLM 8-75	5 mV	30 mV	0.4-8.8 V	4 mV	37.5 mA	1.6 mV/°C	22.5 mA/°C	1 V
DLM 10-60	5 mV	30 mV	0.5-11 V	5 mV	30 mA	2 mV/°C	18 mA/°C	2 V
DLM 20-30	2.5 mV	15 mV	1-22 V	10 mV	15 mA	4 mV/°C	9 mA/°C	2 V
DLM 40-15	2.5 mV	15 mV	2-44 V	20 mV	7.5 mA	8 mV/°C	4.5 mA/°C	2 V
DLM 60-10	2.5 mV	20 mV	3-66 V	30 mV	5 mA	12 mV/°C	3 mA/°C	2 V
DLM 80-7.5	4 mV	20 mV	4-88 V	40 mV	3.8 mA	16 mV/°C	2.25 mA/°C	2 V
DLM 150-4	7 mV	40 mV	7.5-165 V	75 mV	2 mA	30 mV/°C	1.2 mA/°C	2 V
DLM 300-2	10 mV	60 mV	15-330 V	150 mV	1 mA	60 mV/°C	0.6 mA/°C	2 V

* rms noise typical from 20 Hz to 20 MHz
Specifications subject to change

DLM 600 Series : Product Diagram

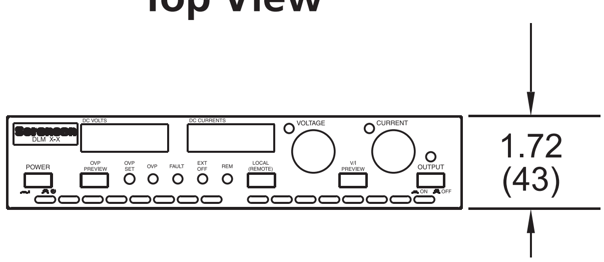


Top View

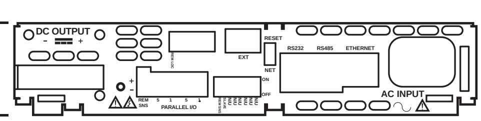


DLMRK

(rackmount kit for one or two supplies side-by-side)



Front View



Rear View

Dimensions in inches (millimeters)

*80V, 150V and 300V models have two position terminal blocks for the output

**M6 Options 20” (508 MM).

DLM 600 Series 375–600 W

Model Number Description

DLM 40 - 15 (MXX)

Series — Voltage — Current — Options

Voltage and Current Ranges

Model	Voltage	Current
DLM 5-75	0-5 V	0-75 A
DLM 8-75	0-8 V	0-75 A
DLM 10-60	0-10 V	0-60 A
DLM 20-30	0-20 V	0-30 A
DLM 40-15	0-40 V	0-15 A
DLM 60-10	0-60 V	0-10 A
DLM 80-7.5	0-80 V	0-7.5 A
DLM 150-4	0-150 V	0-4 A
DLM 300-2	0-300 V	0-2 A

Options and Accessories

M130	Ethernet/LAN Option (16 bit) • LXI Class C Compliant • 10/100 base-T • TCP/IP Protocol • ICMP (Ping Server) • Web Server: Direct control of power supply via standard web browser. RS-232C Interface
M6	Disconnect & Polarity reversal relays (10V to 300V models only. This option requires one of the following options: M9G, M85, M130 or M131) Output disconnect and polarity reversal relays controlled via SCPI commands. An SPST relay is in line with each output lead.
M9G	IEEE-488.2 and RS-232C Interfaces
M13	Locking shafts (front panel potentiometers)
M51A	Optically Isolated Analog Programming and Monitoring. This isolation allows users to control power supplies not connected to a common ground. In addition, in systems with high ambient noise or with large ground loop currents the control ground can be isolated from the power ground eliminating problems.
M85	Multichannel Slave Interface
M131	Multichannel Slave Interface (16 bit) (M130 Master ONLY)
DLMP1	Paralleling Cable; one cable per slave unit
DLMRK	Rackmount Kit for single DLM with filler panel and for two units mounted side-by-side

DLM 600 Series

J1 Connector			
1	ANALOG-CONTROL Input	14	EXTERNAL-OFF Input (+)
2	EXTERNAL-OFF Return	15	Auxiliary 5 VDC Output (+)
3	OVP Programming Input	16	OVP Resistance Programming Output
4	REMOTE-CONTROL Status Output	17	OVP Resistance Programming Return
5	VOLTAGE-MODE Status Output	18	FAULT Status Output
6	Auxiliary 5 VDC Return	19	Voltage Monitor Output
7	Current Monitor Output	20	Voltage Resistance Programming Return
8	Voltage/Current Monitor Return	21	Voltage Resistance Programming Output
9	Voltage Programming Input	22	Current Resistance Programming Output
10	Current Programming Input	23	Current Resistance Programming Return
11	Not Used	24	LOCAL-LOCKOUT Input
12	V/I/OVP Programming Return	25	OVP Status Output
13	Not Used		

Sorensen XG 850 Series

670–850 W

850 W, 1U Half Rack Programmable DC Power Supplies

6–600 V

1.4–110 A

∿		110	220

ETHERNET USB GPIB RS232

- Highest Power Density
- Comprehensive Digital and Analog Interface Options
- Scalable, Multi-Unit Design
- Multi-Channel Support
- Straightforward Front Panel Controls
- High Reliability

The Sorensen XG Series is an 850 Watt, 1U half-rack DC power supply. The XG Series is the new standard for powerful, programmable DC power systems. Designed for test, production, laboratory, OEM and quality assurance applications, the XG Series provides a wealth of features to ensure accuracy and greater efficiency. It puts clean, reliable power at your disposal and delivers stable, variable output voltage and current for a broad range of development, test and system requirements.

Highest Power Density
High frequency, soft switching technology in the XG Series provides up to 850 Watts in a 1U half-rack package. This represents the highest power density available from any manufacturer. With 12 models, there is a configuration available to meet every application.

Comprehensive Digital and Analog Interface Options
The XG Series comes standard with USB 2.0, RS-232, RS-485, isolated and non-isolated analog interfaces to provide a comprehensive set of options to connect to a PC or other network device. This design provides the convenience of being able to accommodate a wide range of installation configurations. Ethernet and GPIB interfaces are available as options.

Scalable, Multi-Unit Design
XG Series power supplies can be connected in parallel or series to produce greater current or voltage output for your applications. This scalability allows you to build rack-mounted systems with the XG Series that exactly meet your existing requirements, while allowing for future expansion.

Multi-Channel Support
Up to 30 XGs Series can be connected easily via an RS-485 bus to provide the ultimate flexibility in remote programming. This eliminates the cost and complexity of requiring GPIB cards in each unit. Once connected, multiple power supplies can be controlled via a single LAN, USB 2.0, GPIB, RS-232 or RS-485 interface. This provides an efficient option to centrally manage each XG Series needed for your applications.

Straightforward Front Panel Controls
The XG Series is equipped with a unique push-button encoder and function selector dial to provide a simple, uncluttered front panel. Both voltage and current can be set quickly and easily using these two controls. Front panel access can be locked out to ensure secure remote operation. This streamlined front panel layout results in fast, intuitive set-up and operation of the XG Series.

High Reliability
To guarantee long-term trouble-free performance, the XG Series was designed with reliability in mind. Soft-switching technology ensures higher mean time between failure (MTBF) by eliminating high voltage transients found in conventional hard-switching power supplies which can cause premature failure of power components. AMETEK engineers also rigorously tested the XG Series during the design phase using Highly Accelerated Life Testing (HALT). This rigorous test procedure combines powerful thermal and vibration technologies to stress a product beyond its rated specifications. HALT testing allows our engineers to uncover and correct design issues early in the development cycle. This care in design and comprehensive testing ensures the XG Series exceeds the reliability and quality standards of both AMETEK and our customers.

XG 850 Series : Product Specifications

Output : Voltage and Current			
Models	Output Voltage [1]	Output Current [2]	Output Power [3]
XG 6-110	6 V	110 A	670 W
XG 8-100	8 V	100 A	810 W
XG 12-70	12 V	70 A	850 W
XG 20-42	20 V	42 A	850 W
XG 33-25	33 V	25 A	835 W
XG 40-21	40 V	21 A	850 W
XG 60-14	60 V	14 A	850 W
XG 80-10.5	80 V	10.5 A	850 W
XG 100-8.5	100 V	8.5 A	860 W
XG 150-5.6	150 V	5.6 A	850 W
XG 300-2.8	300 V	2.8 A	850 W
XG 600-1.4	600 V	1.4 A	850 W

	Line Regulation Voltage	Line Regulation Current	Load Regulation Voltage	Load Regulation Current
Models	(0.005% of rated output voltage +2 mV) [4]	(0.01% of rated output current +2 mA) [5]	(0.005% of rated output voltage + 2 mV) [6]	(0.02% of rated output current +5 mA) [7]
XG 6-110	2.3 mV	13 mA	2.3 mV	27 mA
XG 8-100	2.4 mV	12 mA	2.4 mV	25 mA
XG 12-70	2.6 mV	9 mA	2.6 mV	19 mA
XG 20-42	3.0 mV	6.2 mA	3.0 mV	13.4 mA
XG 33-25	3.7 mV	4.5 mA	3.7 mV	10 mA
XG 40-21	4 mV	4.1 mA	4 mV	9.2 mA
XG 60-14	5 mV	3.4 mA	5 mV	7.8 mA
XG 80-10.5	6 mV	3.1 mA	6 mV	7.1 mA
XG 100-8.5	7 mV	2.9 mA	7 mV	6.7 mA
XG 150-5.6	9.5 mV	2.6 mA	9.5 mV	6.1 mA
XG 300-2.8	17 mV	2.3 mA	17 mV	5.6 mA
XG 600-1.4	32 mV	2.1 mA	32 mV	5.3 mA

	Output Noise (rms, 300 kHz)		Output Ripple (p-p, 20 MHz)
Models	Voltage	Current [8]	Voltage
XG 6-110	8 mV	200 mA	50 mV
XG 8-100	8 mV	180 mA	50 mV
XG 12-70	8 mV	120 mA	50 mV
XG 20-42	8 mV	75 mA	50 mV
XG 33-25	8 mV	60 mA	50 mV
XG 40-21	8 mV	45 mA	50 mV
XG 60-14	8 mV	35 mA	50 mV
XG 80-10.5	8 mV	25 mA	80 mV
XG 100-8.5	8 mV	20 mA	80 mV
XG 150-5.6	10 mV	16 mA	100 mV
XG 300-2.8	25 mV	10 mA	150 mV
XG 600-1.4	50 mV	6 mA	250 mV

1. Maximum output voltage is guaranteed to be ≤ 0.2% of the rated voltage at zero output setting, using the front panel or digital remote programming modes.
2. Maximum output current is guaranteed to be ≤ 0.4% of the rated current at zero output setting, using the front panel or digital remote programming modes, and when measured with rated load resistance.
3. Total output power is also based on AUX1 Output Voltage (5 V) and AUX1 Output Current (0.5 A) and AUX2 Output Voltage (15 V) and AUX2 Output Current (0.5 A).
4. From 85–132 Vac or 170–265 Vac, constant load.
5. From 85–132 Vac or 170–265 Vac, constant load.
6. From no load to full load, constant input voltage.
7. For load voltage change, equal to the unit voltage rating, constant input voltage.
8. For 6 V models the current ripple is measured at 2–6 V output voltage and full output current. For all other models, the current ripple is measured at 10–100% output voltage and full output current.

Note: All specifications are subject to change.

XG 850 Series : Product Specifications 670–850 W

Model	Maximum Recommended Remote Sense Line Drop Compensation per Line [9]	Up-prog. Response Time, 0~Vmax [10]	Efficiency [11] (100/200 VAC input)
XG 6-110	1 V	60 ms	75/77%
XG 8-100	1 V	60 ms	77/80%
XG 12-70	1 V	60 ms	79.5/82.5%
XG 20-42	1.5 V	60 ms	82/85%
XG 33-25	2 V	60 ms	83/86%
XG 40-21	2 V	60 ms	83/87%
XG 60-14	3 V	60 ms	83/87%
XG 80-10.5	5 V	100 ms	83/87%
XG 100-8.5	5 V	100 ms	83/87%
XG 150-5.6	5 V	100 ms	83/87%
XG 300-2.8	5 V	150 ms	83/87%
XG 600-1.4	5 V	250 ms	83/87%
Model	**Down-prog. Response Time: Full Load**	**Down-prog. Response Time: No Load**	**Over-Voltage Trip Point**
XG 6-110	50 ms	300 ms	0.5–7.5 V
XG 8-100	50 ms	400 ms	0.5–10 V
XG 12-70	50 ms	500 ms	1–15 V
XG 20-42	50 ms	600 ms	1–24 V
XG 33-25	50 ms	700 ms	2–39 V
XG 40-21	50 ms	800 ms	2–44 V
XG 60-14	50 ms	900 ms	3–66 V
XG 80-10.5	80 ms	1000 ms	3–95 V
XG 100-8.5	100 ms	1200 ms	3–125 V
XG 150-5.6	150 ms	1800 ms	3–180 V
XG 300-2.8	150 ms	2200 ms	5–330 V
XG 600-1.4	250 ms	3500 ms	5–660 V

Environmental Specifications (Indoor use)	
Operating Temperature Range	32°F to 122°F, 100% load (0°C to 50°C)
Storage Temperature Range	-4°F to 158°F (–20° C to 70°C)
Operating Humidity Range	30–90% RH (no condensation)
Storage Humidity Range	10–95% RH (no condensation)
Operating Altitude	Up to 6,500 feet (2,000 m)
Installation Category	II (IEC 1010-1)
Pollution Degree	2 (IEC 1010-1)
Regulatory Approvals	
Safety	CSA 22.2 No. 61010-1, 60950-1-07 and UL61010-1, UL60950-1-(2nd Ed) [12]. Marked with cCSAus, CE for EMC & low voltage directive
EMC	Complies with EN61326-1 Complies with EN55022, Class B, FCC Part 15B for conducted emissions Complies with EN55022, Class A, FCC Part 15A for radiated emissions Complies with EN61000-4 series of standards for immunity

9. When using remote sense, the total of the load voltage and the load line drops must not exceed the rated output of the power supply. For example, for an XG 6-110 in an application with 1 V of load line loss (0.5 V/Line), the maximum available load voltage would be 6–1= 5 V. Note: The unit may operate at higher output voltages than this, but there is no guarantee that the power supply will meet performance specifications. Ultimately, the upper limit of the output voltage will be determined by internal circuitry of the power supply (non-adjustable.)
10. With rated, resistive load.
11. At maximum output power.
12. Double insulation on primary to secondary isolation barriers. Basic insulation primary to protective earth ground.

Applies to all footnotes: Programming and Readback: RS-232, RS-485, USB built in. GPIB, Ethernet optional. Specifications are guaranteed from 1% to 100% of the rated output voltage, current, and power.

Note: All specifications are subject to change.

XG 850 Series : Product Specifications

Programming Mode	APG	ISOL	Digital
Voltage & Current Output Voltage Programming	0-100% Voltage control range is 0.0 to 2.0 - 10.0V in 0.1V increments		
Voltage & Current Output Resistive Programming	0-100% Resistive control range is 0.0 to 2.0 - 10.0V in 0.1V increments		
Output Voltage and Current Monitor	0-100% Output Voltage Monitor range is 0.0 to 2.0 - 10.0V in 0.1V increments		
Voltage Programming Accuracy [1]	± 0.5% of rated output voltage, max (0 to 4.0V / 4K Ohm range) ± 0.5% of rated output voltage, typical in other ranges		± 0.1% of rated output voltage
Current Programming Accuracy [1]	± 0.5% of rated output current, max (0 to 4.0V / 4K Ohm range) ± 0.5% of rated output current, typical in other ranges		± 0.2% of rated output current
Voltage Feedback Accuracy	± 1% of rated output voltage		± 0.1% of rated output voltage
Current Feedback Accuracy	± 1% of rated output current		± 0.2% of rated output current
Isolation (Prog and Readback Lines)	With respect to chassis potential: 500 V	With respect to: chassis potential: 600 V negative or positive main output 1500 V negative or positive auxiliary output 300 V	
Parallel Operation	Up to 4 units in master slave mode	Up to 4 units in master slave mode	Up to 4 units in master slave mode
Series Operation		Up to 2 units (with external diodes)	Up to 2 units (with external diodes)
Constant Voltage (CV) Constant Current (CC) Indicator	CV: TTL High (4-5 V) CC TTL Low (0-0.6 V)		
Shutdown Control [2]		Logic low 0.0 - 1.4 V Logic high 2.0 - 15 V Dry contact compatible	
AUX On/Off Control		TTL level or dry contact compatible	
Power Supply Status Signal		TTL high: OK (4-5 V) TTL low: fail (0-0.6 V)	
Interlock Enable/Disable		Dry contact. Open/Short: On or Off programmable	

1. Typical APG or isolated APG accuracy can be improved to max accuracy by user calibration at the specific range selected
2. The shutdown input has user selectable negative logic operation via front panel or remote digital input/output

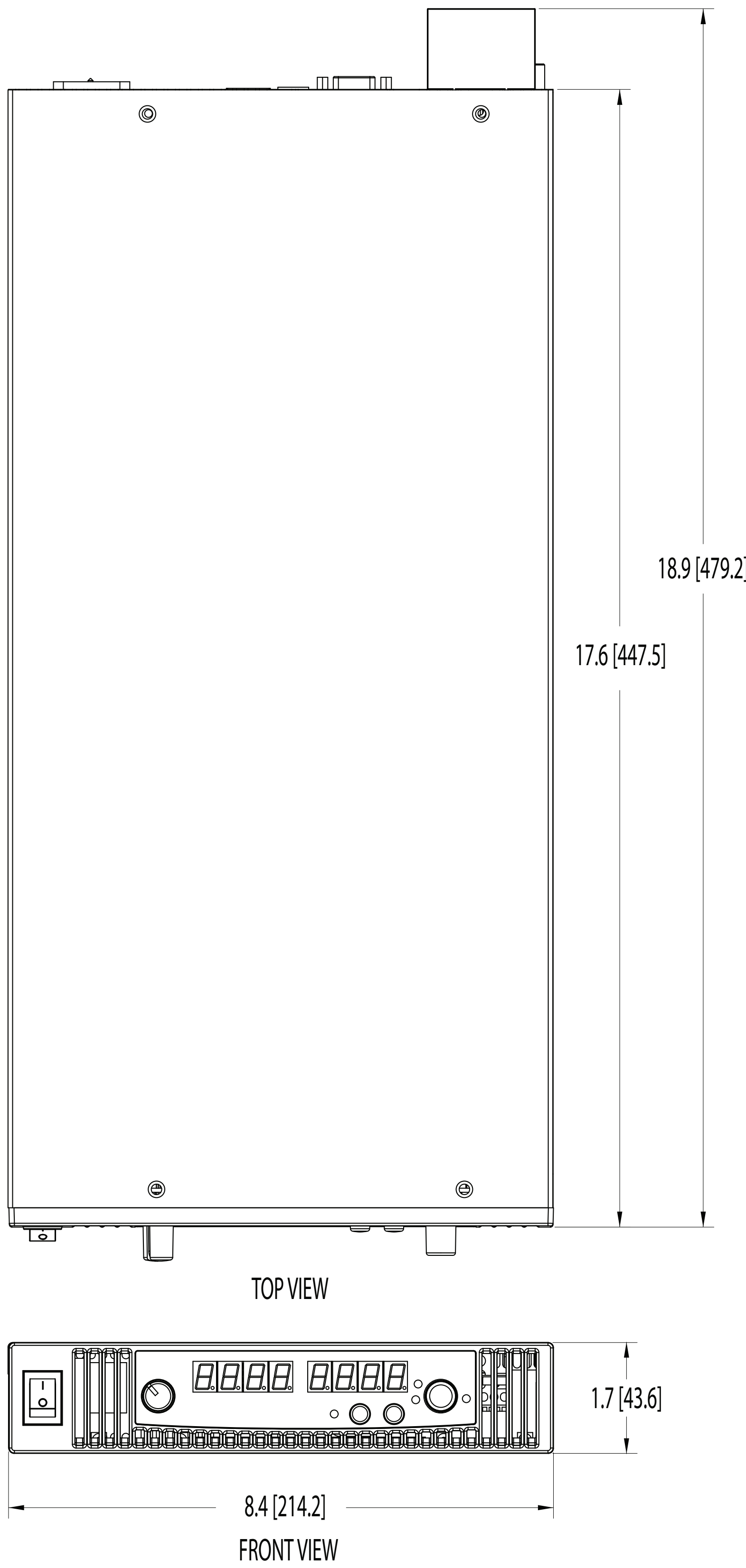
AC Line Input Specifications	
Rated AC Input Voltage/Frequency	100–240 Vac, 47–63 Hz
Operational AC Input Voltage/Frequency	85–265 Vac continuous, 47–63 Hz, single phase
Input Current (at 100/200 Vac)	11.5/6 A (850 W)
Inrush Current (100/200 Vac)	Less than: 25 A (850 W)
Power Factor Correction	0.99@100/200 Vac, rated output power
Output Performance Specifications	
Temperature Coefficient	100 PPM/° C from rated output voltage, after a 30-minute warm-up
Drift (8 hours)	0.05% of rated output voltage & current over an 8 hour interval with constant line, load & temperature, after a 30-minute warm-up
Hold-up Time	Typical 20 ms at any rated input line.
Transient Response Time [2]	Less than 1 ms for 6 V to 60 V models. Less than 2 ms for 80 V to 600 V models
Meter Accuracy	0.5% of actual output voltage or current ± 1 count
Aux output [1]	+5 V: +0.4 V, – 0.5 V at 0.4 A +15 V: +1.2 V, – 1.4 V at 0.4 A
Isolation [4]	1500Vac or 2121Vdc between mains terminals and accessible conductive parts / chassis ground. Output to chassis 500Vac.
AC Line Input Specifications	
XG 850 Watt (W×H×D)	8.4 × 1.7 × 19.0 inch (214 × 43.6 × 483 mm)
Weight	11 lb (5kg)
Cooling	Forced air cooling by internal fans

1. Current: 0.51 A minimum guaranteed, 0.72 A typically available. Overcurrent protection (each output) is automatic, non-latching. When OCP is tripped the aux voltage folds back and will recover to nominal condition when the over current condition is removed (typ. <0.2A). To protect external circuits attached to the aux outputs it is recommended that customers use an appropriately rated fuse in series with the aux outputs set point 10-100%
2. Time for the output voltage to recover within 0.5% at its rated output for a load change 10-90% of rated output current. Output set point 10-100%
3. For floating chassis ground applications, please contact application engineering for system design assistance.
4. Double insulation on primary to secondary isolation barriers. Basic insulation primary to protective earth ground.

Note: All specifications are subject to change.

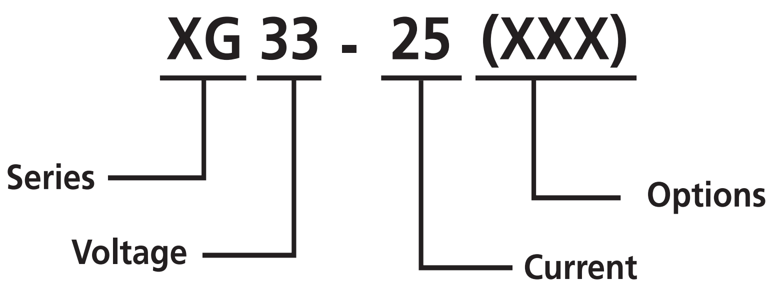
XG 850 Series : Product Diagram

670–850 W



XG 850 Series

Model Number Description



XG 850 Options	
MGA	GPIB, IEEE 488.2
MEB	LXI Class C ETHERNET

XG Options and Accessories	
RM - XG1	Rackmount Angle Brackets
RM - D - XG1	Rackmount Kit for 2 Units
RM - S - XG1	Rackmount Kit for 1 Unit
Constant Power Mode available	Please consult factory
XG 850 available in Full Rack	Please consult factory

Note: All specifications are subject to change.

Sorensen XG 1500 Series

1500 W

1500 Watt, 1U Programmable DC Power Supplies

6–600 V

2.6–187.5 A

∿		110	220

ETHERNET USB GPIB RS232

- Industry Leading Power Density
  – Up to 1500 Watts in 1U
- Standard Digital Interfaces – USB&RS232/485
- LXI Ethernet and Isolated analog interfaces
- Power Factor Correction-PFC and universal AC input
- “Green” Sleep Mode – Automatically “sleeps” after period of non-use
- Built in sequencing - Unload your system controller
- Programmable fold-back protection delay

The XG 1500 is an industry leading programmable DC power supply designed for test, production, laboratory, OEM and quality assurance applications. The XG 1500 is a 1500 Watt, 1U programmable power supply with constant voltage and constant current modes, automatic cross-over and numerous features enabling cost effective, easy integration.

Key Features

Easy Integration
XG 1500 has many control and indication signals such as shutdown, constant voltage (CV) vs. constant current (CC) mode indication, OVP, OCP, OTP, and so on. In addition, the logical-high or -low is free selectable. Thus enabling the XG 1500 to replace existing power supplies with little or no system engineering required.

Free selectable analog control range
Most DC power supplies provide a 0 to 5 or 0 to 10 V analog control range to control the DC output from zero to full DC output range. With the XG 1500, the analog control range is free selectable starting at 0V to an upper range between 2V and 10V. In other words, the analog programming interface range is freely adjustable.

Auxiliary DC output channels with control
In many ATE systems one or more low power, fixed voltage supplies are needed to provide electrical power for any periphery within the ATE cabinet. For this purpose, the XG 1500 provides two standard auxiliary DC output channels. Both auxiliary power channels are controllable directly from the front-panel or through SCPI commands. With these channels, it is possible to drive output-disconnect or polarity-reversal relays, without needing a complicated computer controlled relay board.

DC-waveforms through internal sequencing
To allow for extremely fast programming, sequences can be programmed into and stored in memory using standard SCPI commands through USB, RS-232/485, LXI or GPIB.

Variable Fan Speed Control
The XG 1500’s innovative approach to fan speed is determined by internal heat sink temperature. This allows the fans to adjust to a constant optimal speed when the output of the supply is being pulsed. This also reduces noise and increases fan life.

Power Saving Standby Mode
When the XG 1500 has been in an idle state, the supply can go into “sleep mode”, much like a computer monitor. This will allow the user to save energy and minimize lab noise. Since an XG 1500 left in sleep mode is still “on” the user will have quicker access to an enabled output.

Key Modes

Output Auto Start Mode (Auto Restart)
The Auto Start mode establishes the state of the output of the power supply after recovery from a complete power cycle (all front panel LEDs are not illuminated), or after recovery from a PC failure or reboot. If Auto Start mode is set to On, the power supply output will return to its previous value. Also, after the loss of any remote digital control, the XG unit will remain active in its last programmed setting and will not disrupt any test process.

Auxiliary Auto Start Mode
The Auxiliary Auto Start mode determines the state of the auxiliary output after a complete power cycle (all front panel LEDS are not illuminated). With Auxiliary Auto Start mode turned to On, the auxiliary output will be activated after the power supply is powered up again.

Foldback Mode
Foldback mode is used to disable the output when a transition is made between the operating modes. The power supply will turn off/disable the output and lock in foldback mode after a specified delay if the power supply transitions into CV mode or into CC mode, depending on the foldback mode settings. This feature is particularly useful for protecting current or voltage sensitive loads. Foldback can be set to trigger a switch when transitioning from CV to CC mode or from CC to CV mode.

XG 1500 Series : Product Specifications 1500 W

Output

Models	Output Voltage [1]	Output Current [2]	Output Power [3]
XG 6-220	6 V	220 A	1320 W
XG 8-187.5	8 V	187.5 A	1500 W
XG 12.5-120	12.5 V	120 A	1500 W
XG 20-76	20 V	76 A	1520 W
XG 30-50	30 V	50 A	1500 W
XG 40-38	40 V	38 A	1520 W
XG 60-25	60 V	25 A	1500 W
XG 80-19	80 V	19 A	1520 W
XG 100-15	100 V	15 A	1500 W
XG 150-10	150 V	10 A	1500 W
XG 300-5	300 V	5 A	1500 W
XG 600-2.6	600 V	2.6 A	1560 W

	Line Regulation Voltage	Line Regulation Current	Load Regulation Voltage	Load Regulation Current
Models	(0.005% of rated output voltage +2 mV) [4]	(0.01% of rated output current +2 mA) [5]	(0.005% of rated output voltage + 2 mV) [6]	(0.02% of rated output current +5 mA) [7]
XG 6-220	2.3 mV	24 mA	2.3 mV	49 mA
XG 8-187.5	2.4 mV	20.7 mA	2.4 mV	42.5 mA
XG 12.5-120	2.62 mV	14 mA	2.62 mV	29 mA
XG 20-76	3.0 mV	9.6 mA	3.0 mV	20.2 mA
XG 30-50	3.5 mV	7 mA	3.5 mV	15 mA
XG 40-38	4 mV	5.8 mA	4 mV	12.6 mA
XG 60-25	5 mV	4.5 mA	5 mV	10 mA
XG 80-19	6 mV	3.9 mA	6 mV	8.8 mA
XG 100-15	7 mV	3.5 mA	7 mV	8 mA
XG 150-10	9.5 mV	3 mA	9.5 mV	7 mA
XG 300-5	17 mV	2.5 mA	17 mV	6 mA
XG 600-2.6	32 mV	2.26 mA	32 mV	5.5 mA

	Output Noise (rms, 300 kHz)		Output Ripple (p-p, 20 MHz)
Models	Voltage	Current [8]	Voltage
XG 6-220	8 mV	400 mA	50 mV
XG 8-187.5	8 mV	319 mA	50 mV
XG 12.5-120	8 mV	206 mA	50 mV
XG 20-76	8 mV	136 mA	50 mV
XG 30-50	8 mV	120 mA	50 mV
XG 40-38	8 mV	81 mA	50 mV
XG 60-25	8 mV	63 mA	50 mV
XG 80-19	8 mV	45 mA	80 mV
XG 100-15	8 mV	35 mA	80 mV
XG 150-10	10 mV	29 mA	100 mV
XG 300-5	25 mV	18 mA	150 mV
XG 600-2.6	50 mV	11 mA	250 mV

1. Minimum output voltage is guaranteed to be ≤ 0.2% of the rated voltage at zero output setting.
2. Minimum output current is guaranteed to be ≤ 0.4% of the rated current at zero output setting when measured with rated load resistance.
3. Total output power is also based on AUX1 Output Voltage (5V) and AUX1 Output Current (0.5 A) and AUX2 Output Voltage (15 V) and AUX2 Output Current (0.5 A).
4. From 85-132 Vac or 170-265 Vac, constant load.
5. From 85-132 Vac or 170-265 Vac, constant load.
6. From no load to full load, constant input voltage.
7. For load voltage change, equal to the unit voltage rating, constant input voltage.
8. For 6 V models the ripple is measured at 2-6 V output voltage and full output current. For other models, the ripple is measured at 10-100% output voltage and full output current.

Note: All specifications are subject to change.

XG 1500 Series : Product Specifications

Model	Maximum Recommended Remote Sense Line Drop Compensation per Line [9]	Up-prog. Response Time, 0~Vmax [10]	Efficiency [11] (100/200 VAC input)
XG 6-220	1 V	60 ms	75/77%
XG 8-187.5	1 V	60 ms	77/80%
XG 12.5-120	1 V	60 ms	80/83%
XG 20-76	1.5 V	60 ms	82/85%
XG 30-50	2 V	60 ms	83/86%
XG 40-38	2 V	60 ms	83/87%
XG 60-25	3 V	60 ms	83/87%
XG 80-19	5 V	100 ms	83/87%
XG 100-15	5 V	100 ms	83/87%
XG 150-10	5 V	100 ms	83/87%
XG 300-5	5 V	150 ms	83/87%
XG 600-2.6	5 V	250 ms	83/87%
Model	**Down-prog. Response Time: Full Load***	**Down-prog. Response Time: No Load***	**Over-Voltage Trip Point**
XG 6-220	50 ms	300 ms	0.5-7.5 V
XG 8-187.5	50 ms	400 ms	0.5–10 V
XG 12.5-120	50 ms	500 ms	1–15 V
XG 20-76	50 ms	600 ms	1–24 V
XG 30-50	50 ms	700 ms	2–39 V
XG 40-38	50 ms	800 ms	2–44 V
XG 60-25	50 ms	900 ms	3–66 V
XG 80-19	80 ms	1000 ms	3–95 V
XG 100-15	100 ms	1200 ms	3–125 V
XG 150-10	150 ms	1800 ms	3–180 V
XG 300-5	150 ms	2200 ms	5–330 V
XG 600-2.6	250 ms	3500 ms	5–660 V

9. When using remote sense, the total of the load voltage and the load line drops must not exceed the rated output of the power supply. For example, for an XG 6-220 in an application with 1 V of load line loss (0.5 V/Line), the maximum available load voltage would be 6-1=5 V. Note: The unit may operate at higher output voltages than this, but there is no guarantee That the power supply will meet performance specifications. Ultimately, the upper limit of the output voltage will be determined by internal circuitry of the power supply (non-adjustable)
10. With rated, resistive load.
11. At 100/200 Vac input voltage and maximum output power.
Applies to all footnotes: Programming and Readback: RS-232, RS-485, USB built in. GP1B, Ethernet optional. Specifications are guaranteed from 1% to 100% of the rated output voltage, current, and power.
* Typical

Note: All specifications are subject to change.

XG 1500 Series : Product Specifications 1500 W

AC Line Input Specifications	
Rated AC Input Voltage/Frequency	100–240 Vac, 47–63 Hz
Operational AC Input Voltage/Frequency	85–265 Vac continuous, 47–63 Hz, single phase
Input Current (at 100/200 Vac)	23/12 A
Inrush Current (100/200 Vac)	Less than: 50 A
Power Factor Correction	0.99@100/200 Vac, rated output power

Programming Mode	APG	ISOL	Digital
Voltage & Current Output Voltage Programming	0-100% 2~up to 10 V, programmable		
Voltage & Current Output Resistive Programming	0-100% 2~up to 10 kΩ, programmable		
Voltage Output Resistor Programming	0-100% 2~up to 10 kΩ, programmable		
Output Voltage and Current Monitor	0-100% 2~up to 10 V, programmable		
Voltage Programming Accuracy (mV)[1]	± 0.5% of rated output voltage, max (0-4V/4K range)		± 0.1% of rated output voltage
Current Programming Accuracy (mV)[1]	± 1% of rated output current, max (0-4V/4K range)		± 0.2% of rated output current
Voltage Readback Accuracy (mV)	± 1% of rated output voltage		± 0.1% of rated output voltage
Current Readback Accuracy (mV)	± 1% of rated output current		± 0.2% of rated output current
Isolation (Prog and Readback Lines)	With respect to chassis potential: 500 V	With respect to: chassis potential: 600 V negative or positive main output 1500 V negative or positive auxiliary output 300 V	
Voltage and Current Programming Resolution			0.012% of full scale
Voltage and Current Readback Resolution			
Parallel Operation	Up to 4 units in master / slave	Up to 4 units in master / slave	Up to 4 units in master / slave
Series Operation		Up to 2 units (with external diodes)	Up to 2 units (with external diodes)
Constant Voltage (CV) Constant Current (CC) Indicator	CV: TTL High (4-5 V) CC TTL Low (0-0.6 V)		
Shutdown Control [2]		Logic low 0.0 - 1.4 V Logic high 2.0 - 15 V Dry contact compatible	
AUX On/Off Control		TTL level or dry contact compatible	
Power Supply Status Signal		TTL high: OK (4-5 V) TTL low: fail (0-0.6 V)	
Interlock Enable/Disable		Dry contact. Open/Short: On or Off programmable	

1. Typical APG or isolated APG accuracy can be improved to max accuracy by user calibration at the specific range selected
2. The shutdown input has user selectable negative logic operation via front panel or remote digital input/output

Note: All specifications are subject to change.

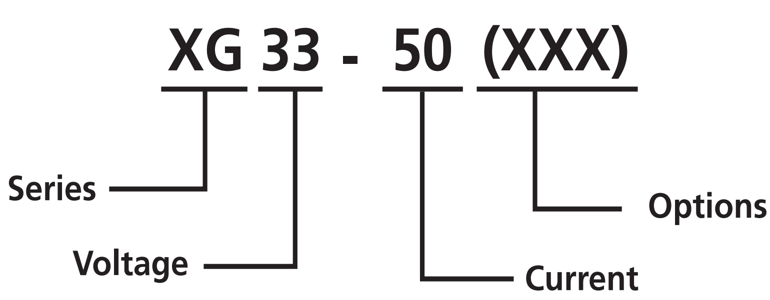
XG 1500 Series : Product Specifications

Output Performance Specifications	
Temperature Coefficient	100 PPM/° C from rated output voltage, after a 30-minute warm-up*
Drift (8 hours)	0.05% of rated output voltage & current over an 8 hour interval with constant line, load & temperature, after a 30-minute warm-up
Hold-up Time	Typical 20 ms at any rated input line.
Transient Response Time [1]	Less than 1 ms for 6 V to 60 V models. Less than 2 ms for 80 V to 600 V models*
Meter Accuracy	0.5% ± 1 count
Aux output [3]	+5 V: +0.4 V, – 0.5 V at 0.4 A +15 V: +1.2 V, – 1.4 V at 0.4 A
Isolation [2]	1500Vac or 2121Vdc between mains terminals and accessible conductive parts / chassis ground. Output to chassis 500Vac.
Environmental Specifications (Indoor use)	
Operating Temperature Range	32°F to 122°F, 100% load (0°C to 50°C)
Storage Temperature Range	-4°F to 158°F (–20° C to 70°C)
Operating Humidity Range	30–90% RH (no condensation)
Storage Humidity Range	10–95% RH (no condensation)
Operating Altitude	Up to 6,500 feet (2,000 m)
Installation Category	II (IEC 1010-1)
Pollution Degree	2 (IEC 1010-1)
Regulatory Approvals	
Safety	CSA 22.2 No. 61010-1, 60950-1-07 and UL61010-1, UL60950-1-(2nd Ed) [2]. Marked with cCSAus, CE for EMC & low voltage directive
EMC	Complies with EN61326-1 Complies with EN55022, Class A, FCC Part 15A for conducted emissions Complies with EN55022, Class A, FCC Part 15A for radiated emissions Complies with EN61000-4 series of standards for immunity
Mechanical Specifications	
XG 1500 Watt (W×H×D)	16.8 x 1.7 x 19.0 inch (429 x 43.6 x 483 mm without rack mount ears)
Weight	22 lb (10 kg)
Cooling	Forced air cooling by internal fans

* Typical
1. Time for the output voltage to recover within 0.05% at its rated output for a load change 10-90% of rated ouput current. Output set point 10-100%
2. Double insulation on primary to secondary isolation barriers. Basic insulation primary to protective earth ground.
3. Current: 0.51 A minimum guaranteed, 0.72 A typically available. Overcurrent protection (each output) is automatic, non-latching. When OCP is tripped the aux voltage folds back and will recover to nominal condition when the over current condition is removed (typ. <0.2A). To protect external circuits attached to the aux outputs it is recommended that customers use an appropriately rated fuse in series with the aux outputs set point 10-100%

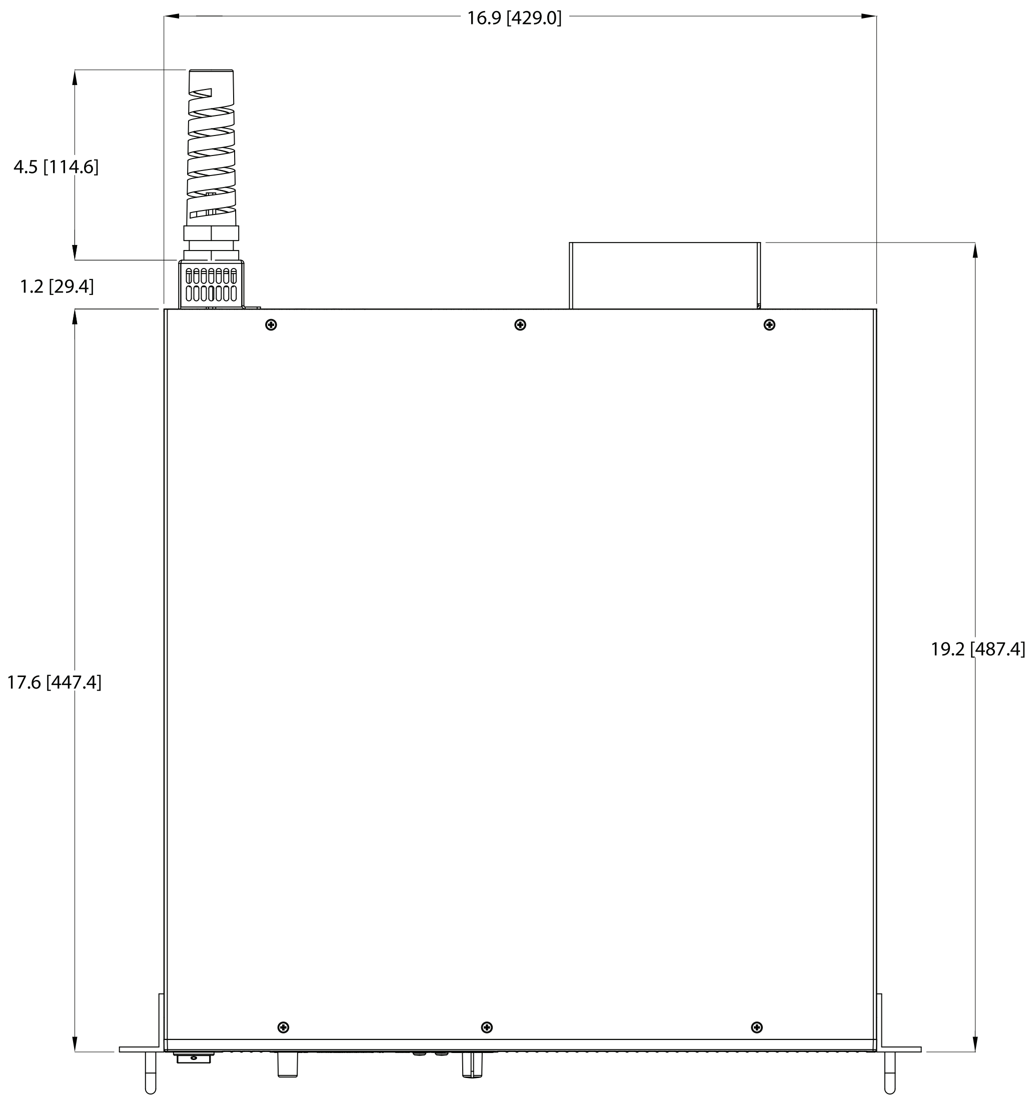
Note: All specifications are subject to change.

Model Number Description

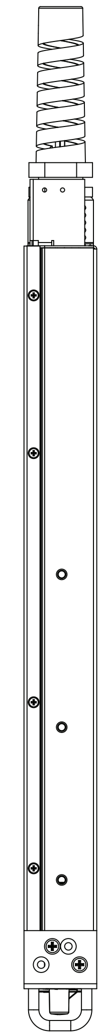


XG Options	
MEB	LXI Class C ETHERNET
MGA	GPIB, IEEE 488.2
MIA	Isolated Analog Interface
XG Options and Accessories	
RM - XG1	Rackmount Angle Brackets

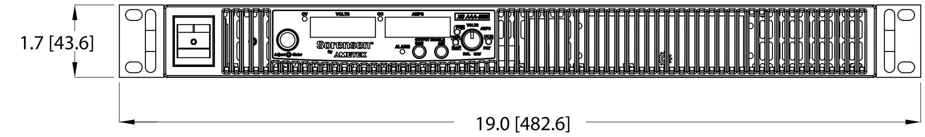
XG 1500 Series : Product Diagram 1500 W



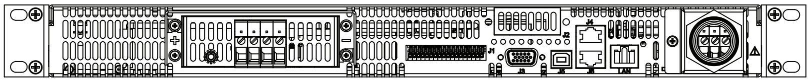
TOP VIEW



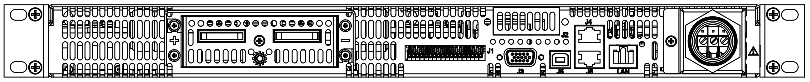
SIDE VIEW



FRONT VIEW



BACK VIEW (60-600V)



BACK VIEW (6-40V)

Sorensen XG 1700 Series

1700 W

1700 Watt, 1U Programmable DC Power Supplies

6–600 V

2.8–220 A

~		110	220

ETHERNET USB GPIB RS232

- Industry Leading Power Density
  – Up to 1700 Watts in 1U
- Standard Digital Interfaces – USB&RS232/485
- LXI Ethernet and Isolated analog interfaces
- Power Factor Correction-PFC and universal AC input
- "Green" Sleep Mode – Automatically "sleeps" after period of non-use
- Built in sequencing - Unload your system controller
- Programmable fold-back protection delay

The XG 1700 is an industry leading programmable DC power supply designed for test, production, laboratory, OEM and quality assurance applications. The XG 1700 is a 1700 Watt, 1U programmable power supply with constant voltage and constant current modes, automatic cross-over and numerous features enabling cost effective, easy integration.

Key Features

Easy Integration
XG 1700 has many control and indication signals such as shutdown, constant voltage (CV) vs. constant current (CC) mode indication, OVP, OCP, OTP, and so on. In addition, the logical-high or -low is free selectable. Thus enabling the XG 1700 to replace existing power supplies with little or no system engineering required.

Free selectable analog control range
Most DC power supplies provide a 0 to 5 or 0 to 10 V analog control range to control the DC output from zero to full DC output range. With the XG 1700, the analog control range is free selectable starting at 0V to an upper range between 2V and 10V. In other words, the analog programming interface range is freely adjustable.

Auxiliary DC output channels with control
In many ATE systems one or more low power, fixed voltage supplies are needed to provide electrical power for any periphery within the ATE cabinet. For this purpose, the XG 1700 provides two standard auxiliary DC output channels. Both auxiliary power channels are controllable directly from the front-panel or through SCPI commands. With these channels, it is possible to drive output-disconnect or polarity-reversal relays, without needing a complicated computer controlled relay board.

DC-waveforms through internal sequencing
To allow for extremely fast programming, sequences can be programmed into and stored in memory using standard SCPI commands through USB, RS-232/485, LXI or GPIB.

Variable Fan Speed Control
The XG 1700's innovative approach to fan speed is determined by internal heat sink temperature. This allows the fans to adjust to a constant optimal speed when the output of the supply is being pulsed. This also reduces noise and increases fan life.

Power Saving Standby Mode
When the XG 1700 has been in an idle state, the supply can go into "sleep mode", much like a computer monitor. This will allow the user to save energy and minimize lab noise. Since an XG 1700 left in sleep mode is still "on" the user will have quicker access to an enabled output.

Key Modes

Output Auto Start Mode (Auto Restart)
The Auto Start mode establishes the state of the output of the power supply after recovery from a complete power cycle (all front panel LEDs are not illuminated), or after recovery from a PC failure or reboot. If Auto Start mode is set to On, the power supply output will return to its previous value. Also, after the loss of any remote digital control, the XG unit will remain active in its last programmed setting and will not disrupt any test process.

Auxiliary Auto Start Mode
The Auxiliary Auto Start mode determines the state of the auxiliary output after a complete power cycle (all front panel LEDS are not illuminated). With Auxiliary Auto Start mode turned to On, the auxiliary output will be activated after the power supply is powered up again.

Foldback Mode
Foldback mode is used to disable the output when a transition is made between the operating modes. The power supply will turn off/disable the output and lock in foldback mode after a specified delay if the power supply transitions into CV mode or into CC mode, depending on the foldback mode settings. This feature is particularly useful for protecting current or voltage sensitive loads. Foldback can be set to trigger a switch when transitioning from CV to CC mode or from CC to CV mode.

XG 1700 Series : Product Specifications

Output			
Models	Output Voltage [1]	Output Current [2]	Output Power [3]
XG 6-220	6 V	220 A	1330 W
XG 8-200	8 V	200 A	1610 W
XG 12-140	12 V	140 A	1690 W
XG 20-84	20 V	84 A	1690 W
XG 33-50	33 V	50 A	1660 W
XG 40-42	40 V	42 A	1690 W
XG 60-28	60 V	28 A	1690 W
XG 80-21	80 V	21 A	1690 W
XG 100-17	100 V	17 A	1710 W
XG 150-11.2	150 V	11.2 A	1690 W
XG 300-5.6	300 V	5.6 A	1690 W
XG 600-2.8	600 V	2.8 A	1690 W

	Line Regulation Voltage	Line Regulation Current	Load Regulation Voltage	Load Regulation Current
Models	(0.005% of rated output voltage +2 mV) [4]	(0.01% of rated output current +2 mA) [5]	(0.005% of rated output voltage + 2 mV) [6]	(0.02% of rated output current +5 mA) [7]
XG 6-220	2.3 mV	24 mA	2.3 mV	49 mA
XG 8-200	2.4 mV	22 mA	2.4 mV	45 mA
XG 12-140	2.6 mV	16 mA	2.6 mV	33 mA
XG 20-84	3.0 mV	10.4 mA	3.0 mV	22 mA
XG 33-50	3.7 mV	7 mA	3.7 mV	15 mA
XG 40-42	4 mV	6.2 mA	4 mV	13 mA
XG 60-28	5 mV	4.8 mA	5 mV	10.6 mA
XG 80-21	6 mV	4.1 mA	6 mV	9.21 mA
XG 100-17	7 mV	3.7 mA	7 mV	8.4 mA
XG 150-11.2	9.5 mV	3.12 mA	9.5 mV	7.2 mA
XG 300-5.6	17 mV	2.56 mA	17 mV	6.1 mA
XG 600-2.8	32 mV	2.28 mA	32 mV	5.6 mA

	Output Noise (rms, 300 kHz)		Output Ripple (p-p, 20 MHz)
Models	Voltage	Current [8]	Voltage
XG 6-220	8 mV	400 mA	50 mV
XG 8-200	8 mV	340 mA	50 mV
XG 12-140	8 mV	240 mA	50 mV
XG 20-84	8 mV	150 mA	50 mV
XG 33-50	8 mV	120 mA	50 mV
XG 40-42	8 mV	90 mA	50 mV
XG 60-28	8 mV	70 mA	50 mV
XG 80-21	8 mV	50 mA	80 mV
XG 100-17	8 mV	40 mA	80 mV
XG 150-11.2	10 mV	32 mA	100 mV
XG 300-5.6	25 mV	20 mA	150 mV
XG 600-2.8	50 mV	12 mA	250 mV

1. Minimum output voltage is guaranteed to be ≤ 0.2% of the rated voltage at zero output setting.
2. Minimum output current is guaranteed to be ≤ 0.4% of the rated current at zero output setting when measured with rated load resistance.
3. Total output power is also based on AUX1 Output Voltage (5V) and AUX1 Output Current (0.5 A) and AUX2 Output Voltage (15 V) and AUX2 Output Current (0.5 A).
4. From 85-132 Vac or 170-265 Vac, constant load.
5. From 85-132 Vac or 170-265 Vac, constant load.
6. From no load to full load, constant input voltage.
7. For load voltage change, equal to the unit voltage rating, constant input voltage.
8. For 6 V models the ripple is measured at 2-6 V output voltage and full output current. For other models, the ripple is measured at 10-100% output voltage and full output current.

Note: All specifications are subject to change.

XG 1700 Series : Product Specifications

1700 W

Model	Maximum Recommended Remote Sense Line Drop Compensation per Line [9]	Up-prog. Response Time, 0~Vmax [10]	Efficiency [11] (100/200 VAC input)
XG 6-220	1 V	60 ms	75/77%
XG 8-200	1 V	60 ms	77/80%
XG 12-140	1 V	60 ms	80/83%
XG 20-84	1.5 V	60 ms	82/85%
XG 33-50	2 V	60 ms	83/86%
XG 40-42	2 V	60 ms	83/87%
XG 60-28	3 V	60 ms	83/87%
XG 80-21	5 V	100 ms	83/87%
XG 100-17	5 V	100 ms	83/87%
XG 150-11.2	5 V	100 ms	83/87%
XG 300-5.6	5 V	150 ms	83/87%
XG 600-2.8	5 V	250 ms	83/87%
Model	**Down-prog. Response Time: Full Load***	**Down-prog. Response Time: No Load***	**Over-Voltage Trip Point**
XG 6-220	50 ms	300 ms	0.5–7.5 V
XG 8-200	50 ms	400 ms	0.5–10 V
XG 12-140	50 ms	500 ms	1–15 V
XG 20-84	50 ms	600 ms	1–24 V
XG 33-50	50 ms	700 ms	2–39 V
XG 40-42	50 ms	800 ms	2–44 V
XG 60-28	50 ms	900 ms	3–66 V
XG 80-21	80 ms	1000 ms	3–95 V
XG 100-17	100 ms	1200 ms	3–125 V
XG 150-11.2	150 ms	1800 ms	3–180 V
XG 300-5.6	150 ms	2200 ms	5–330 V
XG 600-2.8	250 ms	3500 ms	5–660 V

9. When using remote sense, the total of the load voltage and the load line drops must not exceed the rated output of the power supply. For example, for an XG 6-220 in an application with 1 V of load line loss (0.5 V/Line), the maximum available load voltage would be 6-1=5 V. Note: The unit may operate at higher output voltages than this, but there is no guarantee That the power supply will meet performance specifications. Ultimately, the upper limit of the output voltage will be determined by internal circuitry of the power supply (non-adjustable)
10. With rated, resistive load.
11. At 100/200 Vac input voltage and maximum output power.
Applies to all footnotes: Programming and Readback: RS-232, RS-485, USB built in. GP1B, Ethernet optional. Specifications are guaranteed from 1% to 100% of the rated output voltage, current, and power.
* Typical

Note: All specifications are subject to change.

XG 1700 Series : Product Specifications

AC Line Input Specifications			
Rated AC Input Voltage/Frequency	100–240 Vac, 47–63 Hz		
Operational AC Input Voltage/Frequency	85–265 Vac continuous, 47–63 Hz, single phase		
Input Current (at 100/200 Vac)	23/12 A		
Inrush Current (100/200 Vac)	Less than: 50 A		
Power Factor Correction	0.99@100/200 Vac, rated output power		
Programming Mode	**APG**	**ISOL**	**Digital**
Voltage & Current Output Voltage Programming	0-100% 2~up to 10 V, programmable		
Voltage & Current Output Resistive Programming	0-100% 2~up to 10 kΩ, programmable		
Voltage Output Resistor Programming	0-100% 2~up to 10 kΩ, programmable		
Output Voltage and Current Monitor	0-100% 2~up to 10 V, programmable		
Voltage Programming Accuracy (mV)[1]	± 0.5% of rated output voltage, max (0-4V/4K range)		± 0.1% of rated output voltage
Current Programming Accuracy (mV)[1]	± 1% of rated output current, max (0-4V/4K range)		± 0.2% of rated output current
Voltage Readback Accuracy (mV)	± 1% of rated output voltage		± 0.1% of rated output voltage
Current Readback Accuracy (mV)	± 1% of rated output current		± 0.2% of rated output current
Isolation (Prog and Readback Lines)	With respect to chassis potential: 500 V	With respect to: chassis potential: 600 V negative or positive main output 1500 V negative or positive auxiliary output 300 V	
Voltage and Current Programming Resolution			0.012% of full scale
Voltage and Current Readback Resolution			
Parallel Operation	Up to 4 units in master / slave	Up to 4 units in master / slave	Up to 4 units in master / slave
Series Operation		Up to 2 units (with external diodes)	Up to 2 units (with external diodes)
Constant Voltage (CV) Constant Current (CC) Indicator	CV: TTL High (4-5 V) CC TTL Low (0-0.6 V)		
Shutdown Control [2]		Logic low 0.0 - 1.4 V Logic high 2.0 - 15 V Dry contact compatible	
AUX On/Off Control		TTL level or dry contact compatible	
Power Supply Status Signal		TTL high: OK (4-5 V) TTL low: fail (0-0.6 V)	
Interlock Enable/Disable		Dry contact. Open/Short: On or Off programmable	

1. Typical APG or isolated APG accuracy can be improved to max accuracy by user calibration at the specific range selected
2. The shutdown input has user selectable negative logic operation via front panel or remote digital input/output

Note: All specifications are subject to change.

XG 1700 Series : Product Specifications

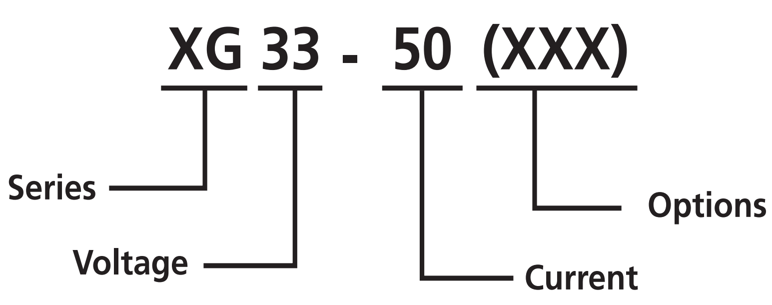
1700 W

Output Performance Specifications	
Temperature Coefficient	100 PPM/° C from rated output voltage, after a 30-minute warm-up*
Drift (8 hours)	0.05% of rated output voltage & current over an 8 hour interval with constant line, load & temperature, after a 30-minute warm-up
Hold-up Time	Typical 20 ms at any rated input line.
Transient Response Time [1]	Less than 1 ms for 6 V to 60 V models. Less than 2 ms for 80 V to 600 V models*
Meter Accuracy	0.5% ± 1 count
Aux output [3]	+5 V: +0.4 V, – 0.5 V at 0.4 A +15 V: +1.2 V, – 1.4 V at 0.4 A
Isolation [2]	1500Vac or 2121Vdc between mains terminals and accessible conductive parts / chassis ground. Output to chassis 500Vac.
Environmental Specifications (Indoor use)	
Operating Temperature Range	32°F to 122°F, 100% load (0°C to 50°C)
Storage Temperature Range	-4°F to 158°F (–20° C to 70°C)
Operating Humidity Range	30–90% RH (no condensation)
Storage Humidity Range	10–95% RH (no condensation)
Operating Altitude	Up to 6,500 feet (2,000 m)
Installation Category	II (IEC 1010-1)
Pollution Degree	2 (IEC 1010-1)
Regulatory Approvals	
Safety	CSA 22.2 No. 61010-1, 60950-1-07 and UL61010-1, UL60950-1-(2nd Ed) [2]. Marked with cCSAus, CE for EMC & low voltage directive
EMC	Complies with EN61326-1 Complies with EN55022, Class A, FCC Part 15A for conducted emissions Complies with EN55022, Class A, FCC Part 15A for radiated emissions Complies with EN61000-4 series of standards for immunity
Mechanical Specifications	
XG 1700 Watt (W×H×D)	16.8 x 1.7 x 19.0 inch (429 x 43.6 x 483 mm without rack mount ears)
Weight	22 lb (10 kg)
Cooling	Forced air cooling by internal fans

* Typical
1. Time for the output voltage to recover within 0.05% at its rated output for a load change 10-90% of rated ouput current. Output set point 10-100%
2. Double insulation on primary to secondary isolation barriers. Basic insulation primary to protective earth ground.
3. Current: 0.51 A minimum guaranteed, 0.72 A typically available. Overcurrent protection (each output) is automatic, non-latching. When OCP is tripped the aux voltage folds back and will recover to nominal condition when the over current condition is removed (typ. <0.2A). To protect external circuits attached to the aux outputs it is recommended that customers use an appropriately rated fuse in series with the aux outputs set point 10-100%

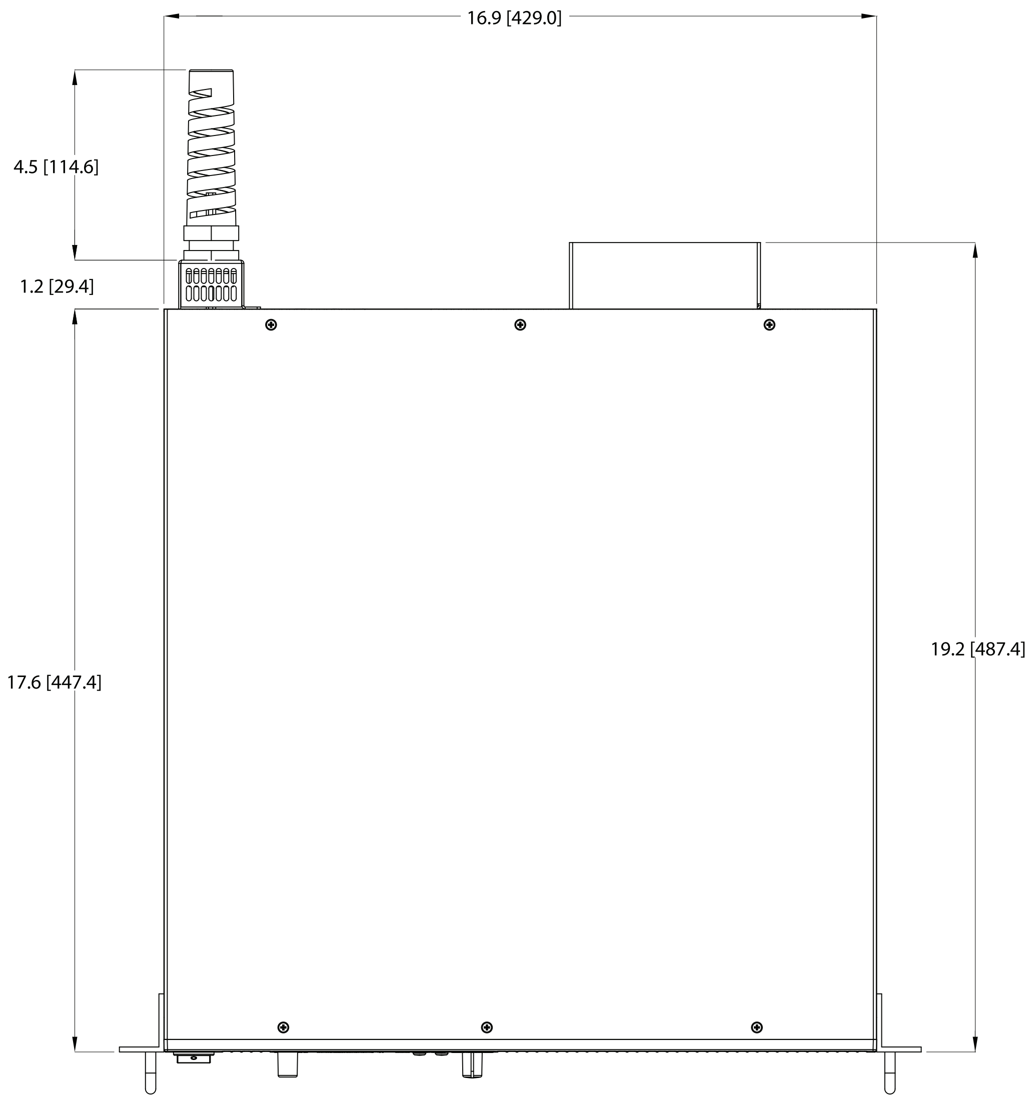
Note: All specifications are subject to change.

Model Number Description

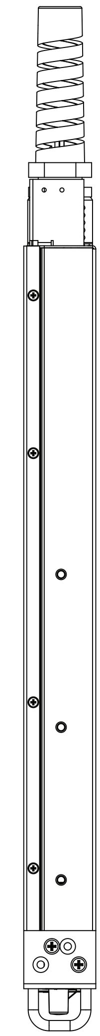


XG Options	
MEB	LXI Class C ETHERNET
MGA	GPIB, IEEE 488.2
MIA	Isolated Analog Interface
XG Options and Accessories	
RM - XG1	Rackmount Angle Brackets

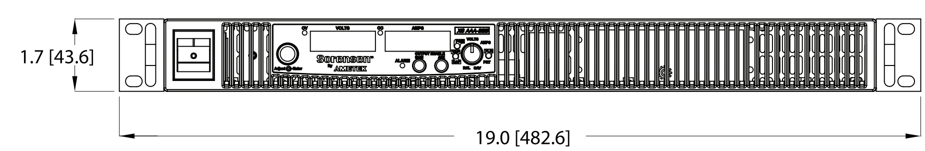
XG 1700 Series : Product Diagram



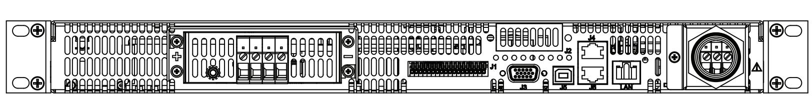
TOP VIEW



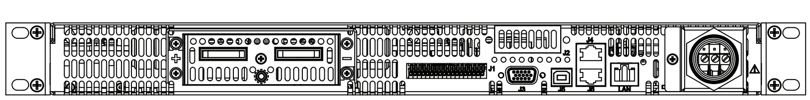
SIDE VIEW



FRONT VIEW



BACK VIEW (60-600V)



BACK VIEW (6-40V)

Sorensen XFR Series

2.8 kW

DC Power Supply with Zero Voltage "Soft Switching"

7.5–600 V

4–300 A

∿		208	230
≋		208	230

GPIB RS232

- Analog programming
- Zero voltage "soft switching"
- Constant voltage or constant current operation with automatic crossover and mode indication
- Standby/Remote/Local modes
- Front panel button preview of voltage, current, OVP
- Remote sense, 5 V line loss compensation
- LabVIEW® and LabWindows® drivers

The Sorensen XFR Series provides 2.8 kilowatts of power for research, product development, and production test applications such as magnet control, ATE, process control, electroplating and burn-in. The XFR Series is ideal for applications where high power and a wide adjustment of output voltage or current is required.

The XFR Series is designed for excellent thermal management so each unit can be conveniently stacked in rack mounts without leaving ventilation space between each unit.

The XFR Series features zero voltage "soft switching" which virtually eliminates switching transients, resulting in lower noise performance that is closer to linear levels. Soft switching also increases efficiency, decreases heat generation, and reduces stress on the switching transistors – resulting in higher reliability.

XFR Series : Product Specifications

Common	
Switching Frequency	XFR 2.8 kW: Nominal 31 kHz (62 kHz output ripple) 60 V to 600 V models: nominal 62.5 kHz (125 kHz output ripple).
Time Delay	7 sec maximum from power on until output stable
Voltage Mode Transient Response Time	< 3 ms for output voltage to recover within 0.5% of its rated voltage after a step change in load current of up to 10% to 90% of rated output
Maximum Voltage Differential	±600 Vdc from output to safety ground
Remote Start/Stop and Interlock	2.5-15 V signal or TTL-compatible input, selectable logic
Remote Analog Programming	Voltage and current programming inputs (source must be isolated): 0-5 k, 0-10 k resistances; 0-5 V, 0-10 V (default) voltage sources
Remote Analog Monitoring	Voltage and current monitor outputs 0-5 V, 0-10 V (default) ranges for 0-100% of output
Remote Programming & Monitoring Accuracy	1% zero to full scale output for the default range
Maximum Remote Sense Line Drop Compensation	5 V / line (Line drop is subtracted from total voltage available at supply output.)
Front Panel Voltage and Current Control	10-turn voltage and current potentiometers
Front Panel Voltage Control Resolution	0.02% of maximum voltage
Main Output Connector	XFR 2.8 kW: 7.5 - 100 V models: nickel-plated copper bus bars with bus bar cover and strain relief; 150V to 600 V models: 4-terminal, wire clamp connector with cover and strain relief
Approvals	NRTL approved and CE-marked to UL Std. No. 61010-1, CAN/CSA-C22.2 No. 61010-1-04, EN 610101-1 (Equipment Class I, Pollution Degree 2, Installation Category II) Meets USA EMC standard: FCC, part 15B, Class A; Meets Canadian EMC standard: ICES-001, Class A.

Input	
Input Voltage Ranges	XFR 2.8 kW: 190-264 Vac, 1ϕ (24.3 A @ 208 Vac; 20.5 A @ 230 Vac typical), 47-63 Hz; Option: M2 3ϕ 208 Vac input
AC Input Connector	Type 3-terminal, 34 A, 250 V, wire clamp connector with strain relief cover

Protection Features	
Over-voltage protection	
Over-temperature protection	
Environmental	
Operating Temperature	XFR 2.8 kW: 0 to 50°C
Storage Temperature	-20°C to 70°C
Humidity (Non-condensing)	Up to 90% RH, non-condensing
Physical	**XFR 2.8 kW**
Dimensions	Width: 19" (429.4 mm) Height: 3.5" (88.9 mm) Depth: 21" (533.5 mm)
Weight	33 lb (15 kg)

Model	Output Voltage	Output Current	Output Power	Line Regulation[2]	
				Voltage	Current
XFR 7.5-300	0-7.5 V	0-300 A	2250 W	2.75 mV	32 mA
XFR 12-220	0-12 V	0-220 A	2640 W	3.2 mV	24 mA
XFR 20-130	0-20 V	0-130 A	2600 W	4 mV	15 mA
XFR 33-85	0-33 V	0-85 A	2805 W	5.3 mV	10.5 mA
XFR 40-70	0-40 V	0-70 A	2800 W	6 mV	9 mA
XFR 60-46	0-60 V	0-46 A	2760 W	8 mV	6.6 mA
XFR 100-28	0-100 V	0-28 A	2800 W	12 mV	4.8 mA
XFR 150-18	0-150 V	0-18 A	2700 W	17 mV	3.8 mA
XFR 300-9	0-300 V	0-9 A	2700 W	32 mV	2.9 mA
XFR 600-4	0-600 V	0-4 A	2400 W	62 mV	2.4 mA

XFR Series : Product Specifications

2.8 kW

Model	Load Regulation[3]		Meter Accuracy	
	Voltage	Current	Voltage (1% of Vmax + 1 count)	Current (1% of Imax + 1 count)
XFR 7.5-300	6.5 mV	65 mA	0.09 V	4 A
XFR 12-220	7.4 mV	49 mA	0.13 V	2.3 A
XFR 20-130	9 mV	31 mA	0.3 V	1.4 A
XFR 33-85	11.6 mV	22 mA	0.43 V	0.95 A
XFR 40-70	13 mV	19 mA	0.5 V	0.8 A
XFR 60-46	17 mV	14.2 mA	0.7 V	0.56 A
XFR 100-28	27 mV	10.6 mA	1.1 V	0.38 A
XFR 150-18	35 mV	8.6 mA	1.6 V	0.19 A
XFR 300-9	65 mV	6.8 mA	4 V	0.1 A
XFR 600-4	125 mV	5.8 mA	7 V	0.05 A

Model	Output Noise (0-20MHz)	Output Ripple (rms)	
	Voltage (p-p)	Voltage	Current
XFR 7.5-300	100 mV	10 mV	1600 mA
XFR 12-220	100 mV	10 mV	1200 mA
XFR 20-130	100 mV	10 mV	400 mA
XFR 33-85	100 mV	15 mV	300 mA
XFR 40-70	150 mV	15 mV	200 mA
XFR 60-46	150 mV	15 mV	100 mA
XFR 100-28	175 mV	25 mV	80 mA
XFR 150-18	200 mV	25 mV	40 mA
XFR 300-9	400 mV	40 mV	20 mA
XFR 600-4	500 mV	100 mV	10 mA

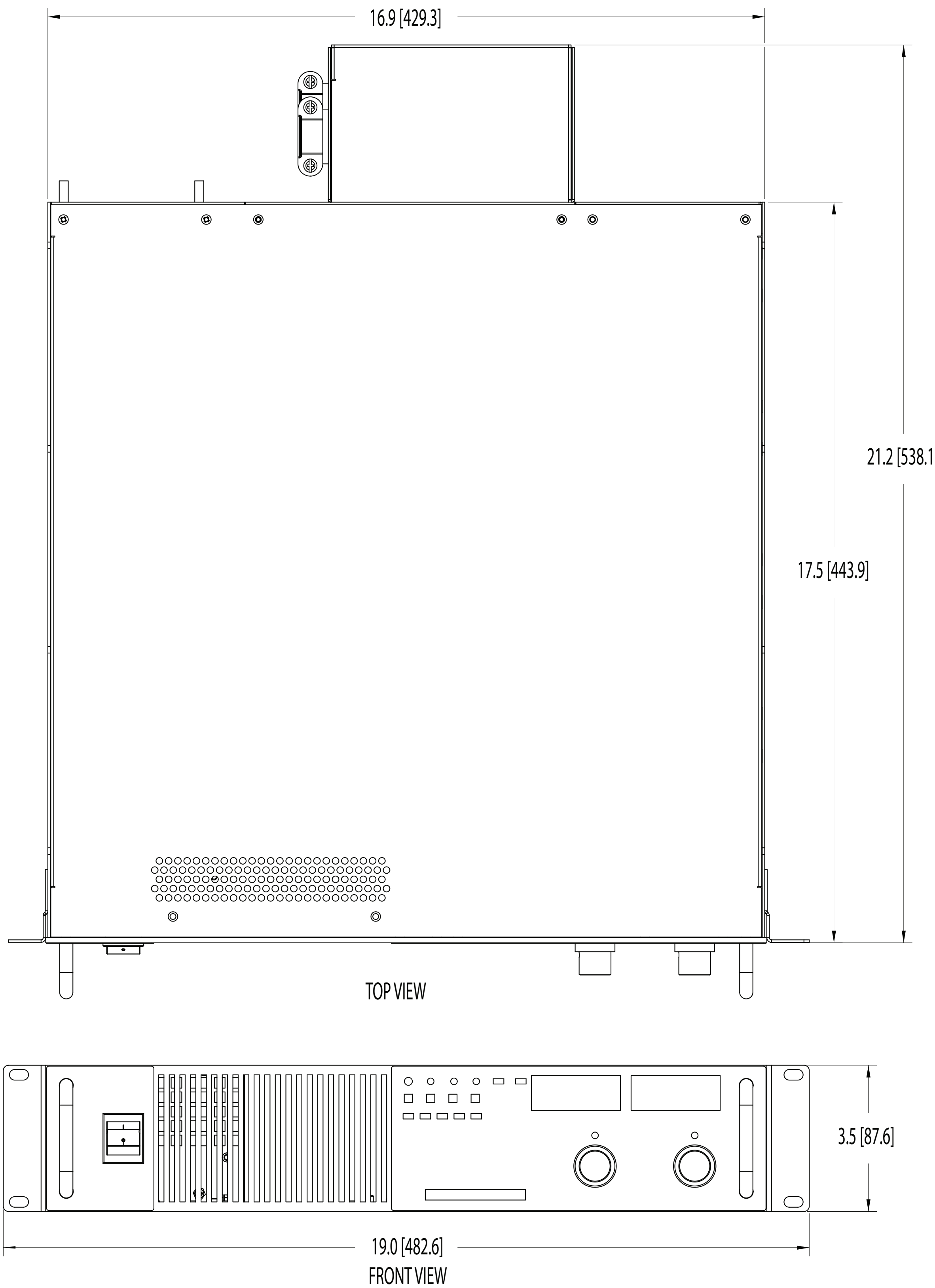
Model	Drift (8 hours)[4]		Temp Coeffcient[5]	
	Voltage (0.05% of Vmax)	Current (0.05% of Imax)	Voltage (0.02% of Vmax °C)	Current (0.03% of Vmax °C)
XFR 7.5-300	3.75 mV	150 mA	1.5 mV	90 mA
XFR 12-220	6 mV	110 mA	2.4 mV	66 mA
XFR 20-130	10 mV	65 mA	4 mV	39 mA
XFR 33-85	16.5 mA	42.5 mA	6.6 mV	25.5 mA
XFR 40-70	20 mV	35 mA	8 mV	21 mA
XFR 60-46	30 mV	23 mA	12 mV	13.8 mA
XFR 100-28	50 mV	14 mA	20 mV	8.4 mA
XFR 150-18	75 mV	9 mA	30 mV	5.4 mA
XFR 300-9	150 mV	4.5 mA	60 mV	2.7 mA
XFR 600-4	300 mV	2 mA	120 mV	1.2 mA

Model	Program Slew Rate[6]		OVP Adjustment Range (5% to 110% of Vmax)	Efficiency[7]
	Rise time	Fall time		
XFR 7.5-300	100 ms	100 ms	0.375-8.25 V	80%
XFR 12-220	100 ms	100 ms	0.6-13.2 V	82%
XFR 20-130	100 ms	100 ms	1-22 V	85%
XFR 33-85	100 ms	100 ms	1.65 - 36.6 V	85%
XFR 40-70	100 ms	100 ms	2-44 V	87%
XFR 60-46	100 ms	100 ms	3-66 V	90%
XFR 100-28	170 ms	170 ms	5-110 V	90%
XFR 150-18	170 ms	170 ms	7.5-165 V	90%
XFR 300-9	170 ms	170 ms	15-330 V	91%
XFR 600-4	170 ms	100 ms	30-660 V	91%

Interface Specifications with RS-232 or GPIB Interface Installed*

Model	Program Accuracy			Readback Accuracy	
	Voltage (mV)	Current (mA)	OVP (mV)	Voltage (mV)	Current (mA)
XFR 7.5-300	10 +0.12%	900 +0.15%	40	30 +0.12%	900 +0.1%
XFR 12-220	75 +0.12%	750 +0.15%	75	75 +0.12%	750 +0.1%
XFR 20-130	75 +0.12%	500 +0.15%	100	75 +0.2%	500 +0.1%
XFR 33-85	75 +0.3%	425 +0.1%	175	75 +0.3%	425 +0.1%
XFR 40-70	75 +0.3%	350 +0.15%	200	75 +0.3%	350 +0.1%
XFR 60-46	150 +0.3%	250 +0.1%	300	150 +0.35%	250 +0.1%
XFR 100-28	150 +0.35%	140 +0.15%	500	150 +0.35%	140 0.1%
XFR 150-18	225 +0.35%	120 +0.1%	750	225 +0.35%	120 +0.1%
XFR 300-9	225 +0.35%	80 +0.1%	1500	225 +0.35%	80 +0.1%
XFR 600-4	300 +0.35%	80 +0.1%	3000	250 +0.35%	80 +0.1%

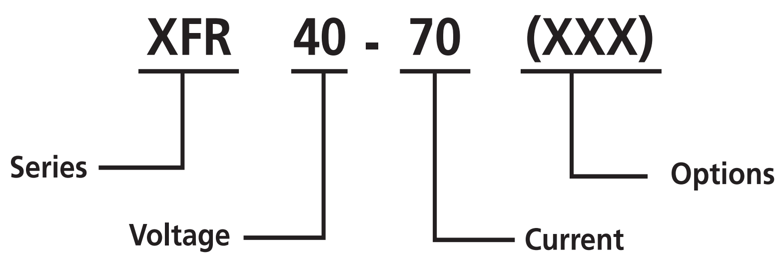
XFR Series : Diagram



XFR 2.8

XFR Series 2.8 kW

Model Number Description



XFR 2.8 Options and Accessories	
MGA / MGB*	GPIB / IEEE 488.1
MGP	Multi-channel GPIB / IEEE 488.2
MCA	CANbus interface for hardware linking multiple units (used with GPIB-M)
MRA / MRB*	RS-232 interface
MIA	ISOL interface card provides isolated analog control and readback
M2	3-phase 208 Vac input

Specifications subject to change without notice.

1. Specifications indicate typical performance at 25°C ±5°C, nominal line input of 208 Vac.
2. For input voltage variation over the AC input voltage range, with constant rated load.
3. For 0-100% load variation, with constant nominal line voltage.
4. Maximum drift over 8 hours with constant line, load and temperature, after 30 minute warm-up.
5. Change in output per °C change in ambient temperature, with constant line and load.
6. Measured with stepped 0-10 V analog programming source and a resistive load.
7. Typical efficiency at nominal input voltage and rated output power.
8. Apply accuracy specifications according to the following voltage program accuracy example:
   Set a model 20-130 power supply to 10 V. The expected result will be within the range of 10 V ± 75 mV ± 0.12% of the set voltage of 10 V.

* MGB/MRB 600V output only. MGA/MRA for output less than 600V GB 600V output only. MGA for output less than 600V

Notes

Sorensen DCS Series

1–3 kW

General Purpose Systems Power Supply

8–600 V

1.7–350 A

∿	115	230
≋	208	230

GPIB LXI RS232

- High power density / low ripple and noise
- High programming resolution with Ethernet interface
- Constant voltage and current mode
- Remote sensing
- Isolated analog control and monitoring (optional)

DCS Applications

The Sorensen DCS Series (hereafter DCS Series) is ideally suited for a wide range of applications requiring DC power in a small form factor. Applications range from manufacturing test and burn-in of automotive components, avionics electronics, telecommunications and consumer products to beam steering, process control and laboratory R&D use.

The DCS Series is comprised of 1kW, 1.2kW and 3kW programmable power supplies utilizing switchmode technology to achieve high power density in a low profile chassis. The design platform provides a highly reliable power supply for years of constant use. The unique design is available in a variety of maximum voltages from 8V to 600V and maximum currents from 1.7A to 350A with low ripple and noise.

This user-friendly platform can be controlled from the front panel with 10-turn potentiometers to adjust voltage, current and OVP settings. LEDs indicate over temperature, remote programming, shutdown and overvoltage protection

Remote control options allow full computer control through IEEE-488 (option M9C), LXI Standard Compliant* Ethernet LAN (option M130) or RS-232 (options M9C, M130)

Automotive Component Test

The 16-bit resolution of the Ethernet programming and hardware triggering allows for detailed sequencing associated with battery fluctuation simulation. The tight load regulation capability of the DCS series makes it a superior source for validation and acceptance testing and burn-in of automotive components. The 20V models, in particular, provide a full range of testing to simulate battery conditions. Margin testing of 12V and 14V nominal components, such as electronic control units (ECU) and electromechanical components, is easily achieved.

Rackmount ATE Systems

The high power density of the DCS series makes it ideal for ATE System integration. The wide variety of voltage and current combinations in 1U and 2U heights allows multiple voltage outputs in a small amount of space. The wide variety of control methods possible, allows easy integration into legacy systems as well as high speed systems.

Battery Charging

Battery charging requires high accuracy voltage and stable current output for fast bulk and absorption phase charging and high accuracy and stable voltage for float charging to avoid “gassing” the battery. The DCS series provides a high accuracy voltage output to optimize battery charging. With the remote interface options, the charging process can easily be automated for volume production.)

DCS Series : Product Specifications

Common	
Meter Accuracy	1% of full scale + 1 count
Max. Voltage Differential from Output to Safety Ground	150 VDC
Remote Start/Stop and Interlock	TTL compatible input or 12-250 VAC (12-130 VDC) or a contact closure
Cooling	Internal fan, over temperature shutdown if internal heat sink exceeds set temperature
Remote Sense	The maximum allowed sense line drop is 4V per line (2V on the DCS 8/10V 1 kW/1.2 kW models and 1V/line for all 3 kW models). Line drop subtracts from the maximum available output voltage at full rated power.
Remote Programming	Enabled via external jumper on rear panel connector J3
Overvoltage Protection	Crowbar type adjustable from 5-110% of rated output using front panel control (local or remote program selectable via J3 jumper)
Remote Analog Programming Linearity	±1%
Accuracy	±5%
Regulatory	Certified to UL/CSA 61010 and IEC/EN 61010-1 CE. Compliant (LVD and EMC directive)

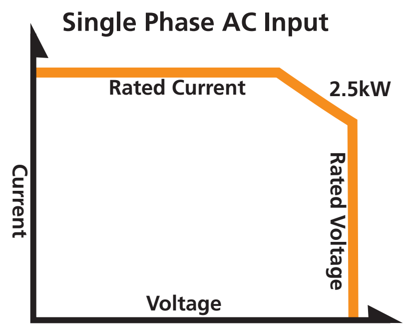
Input	1 kW	1.2 kW	3 kW
Voltage Ranges	200-250 VAC / 100-132 VAC	200-250 VAC / 100-132 VAC	190-250 VAC / 200-250 VAC
Phases	Single Phase	Single Phase	Three Phase / Single Phase * (See Below)
Current	8A typical, 47-63 Hz 15A typical, 47-63 Hz	9A typical, 47-63 Hz 18A typical, 47-63 Hz	190-250 VAC, three phase, 14A, 47-63Hz. * (See Below) User configurable for: 200-250VAC, single-phase operation, 20A, 47- 63Hz. * See the modified operation curve below.

Output	
Stability	±0.05% of maximum voltage or current over 8 hours after 30 minute warm-up time at fixed line, load and temperature
Line Regulation	For input voltage variation over the AC input voltage range, with constant rated load.
Load Regulation	For 0-100% load variation, with constant nominal line voltage.
Voltage Resolution	0.02%
Transient Response	Typically recovers in 500 µs (1 & 1.2 kW) or 1ms (3k W) to 1% of steady-state output voltage (within 1% of Vmax) for 70-100% or 100-70% load change.

Output : Voltage and Current

1 kW Model	Voltage	Current	1.2 kW Model	Voltage	Current	3 kW Model	Voltage	Current
DCS 8-125E	0-8	0-125	DCS 8-140E	0-8	0-140	DCS 8-350E	0-8	0-350
DCS 10-100E	0-10	0-100	DCS 10-120E	0-10	0-120	DCS 12-250E	0-12	0-250
DCS 20-50E	0-20	0-50	DCS 20-60E	0-20	0-60	DCS 20-150E	0-20	0-150
DCS 33-33E	0-33	0-33	DCS 33-36E	0-33	0-36	DCS 40-75E	0-40	0-75
DCS 40-25E	0-40	0-25	DCS 40-30E	0-40	0-30	DCS 55-55E	0-55	0-55
DCS 50-20E	0-50	0-20	DCS 50-24E	0-50	0-24	DCS 60-50E	0-60	0-50
DCS 60-18E	0-60	0-18	DCS 60-20E	0-60	0-20	DCS 80-37E	0-80	0-37
DCS 80-13E	0-80	0-13	DCS 80-15E	0-80	0-15	DCS 150-20E	0-150	0-20
DCS 100-10E	0-100	0-10	DCS 100-12E	0-100	0-12			
DCS 150-7E	0-150	0-7	DCS 150-8E	0-150	0-8			
DCS 300-3.5E	0-300	0-3.5	DCS 300-4E	0-300	0-4			
DCS 600-1.7E	0-600	0-1.7						

Modified Operation Curve for DCS Series 3 kW



DCS Series : Product Specifications 1–3 kW

Environmental			
Operating Temperature	0°C to 50°C (no derating)		
Storage Temperature	-55°C to 85°C		
Humidity (Non-condensing)	0 to 85% RH		
Physical	**1kW**	**1.2kW**	**3kW**
Dimensions	Width: 19″ (483 mm) Height: 1.72″ (43 mm) - 1U Depth: 17.52″ (445 mm)	Width: 19″ (483 mm) Height: 1.72″ (43 mm) - 1U Depth: 17.52″ (445 mm)	Width: 19″ (483 mm) Height: 3.46″ (87 mm) - 2U Depth: 17.52″ (445 mm)
Weight	19 lbs. (8.6 kg)	19 lbs. (8.6 kg)	33 lbs. (15 kg)
Shipping Weight	24 lbs. (10.9 kg)	24 lbs. (10.9 kg)	42 lbs. (19 kg)

Model	Programming Accuracy M130 / M131 / M9C / M85 Options			Readback Accuracy	
	Voltage 0.1%+	Current 0.1%+	OVP 0.5%+	Voltage 0.1%+	Current 0.1%+
DCS Series 1 kW					
DCS 8-125E	8mV	500mA	44mV	12mV	500mA
DCS 10-100E	10mV	400mA	55mV	15mV	400mA
DCS 20-50E	20mV	200mA	110mV	30mV	200mA
DCS 33-33E	33mV	132mA	182mV	50mV	132mA
DCS 40-25E	40mV	100mA	220mV	60mV	100mA
DCS 50-20E	50mV	80mA	275mV	75mV	80mA
DCS 60-18E	60mV	72mA	330mV	90mV	72mA
DCS 80-13E	80mV	52mA	440mV	120mV	52mA
DCS 100-10E	100mV	40mA	550mV	150mV	40mA
DCS 150-7E	150mV	28mA	825mV	225mV	28mA
DCS 300-3.5E	300mV	14mA	1650mV	450mV	14mA
DCS 600-1.7E	600mV	6.8mA	3300mV	900mV	7mA
DCS Series 1.2 kW					
DCS 8-140E	8mV	560mA	44mV	12mV	560mA
DCS 10-120E	10mV	480mA	55mV	15mV	480mA
DCS 20-60E	20mV	240mA	110mV	30mV	240mA
DCS 33-36E	33mV	144mA	182mV	50mV	144mA
DCS 40-30E	40mV	120mA	220mV	60mV	120mA
DCS 50-24E	50mV	96mA	275mV	75mV	96mA
DCS 60-20E	60mV	80mA	330mV	90mV	80mA
DCS 80-15E	80mV	60mA	440mV	120mV	60mA
DCS 100-12E	100mV	48mA	550mV	150mV	48mA
DCS 150-8E	150mV	32mA	825mV	225mV	32mA
DCS 300-4E	300mV	16mA	1650mV	450mV	16mA
DCS Series 3 kW					
DCS 8-350E	8mV	1400mA	44mV	12mV	1400mA
DCS 12-250E	12mV	1000mA	66mV	18mV	1000mA
DCS 20-150E	20mV	600mA	110mV	30mV	600mA
DCS 40-75E	40mV	300mA	220mV	60mV	300mA
DCS 55-55E	55mV	220mA	303mV	83mV	220mA
DCS 60-50E	60mV	200mA	330mV	90mV	200mA
DCS 80-37E	80mV	148mA	440mV	120mV	148mA
DCS 150-20E	150mV	80mA	825mV	225mV	80mA

DCS Series : Product Specifications

Model	Output Power		Combined Regulation Line and Load %	Constant Voltage Mode*			Temp. Coeff. Voltage% /°C (Typ)	Voltage Drift %Vmax (Typ)	Programming Constants Voltage Mode	
	Voltage VDC	Current ADC@ 50 °C		Ripple** (rms) mV	Noise** (p-p) mV	Transient Response Time µs (Typ)			Ohms / V	V / V
DCS Series 1 kW										
DCS 8-125E	0-8	0-125	0.2	4	60	500	0.02	0.05	625	0-10V = 0-100% V_o or 0-5V = 0-100% V_o
DCS 10-100E	0-10	0-100	0.2	4	60	500	0.02	0.05	500	
DCS 20-50E	0-20	0-50	0.2	4	60	500	0.02	0.05	250	
DCS 33-33E	0-33	0-33	0.2	4	60	500	0.02	0.05	151.5	
DCS 40-25E	0-40	0-25	0.2	4	60	500	0.02	0.05	125	
DCS 50-20E	0-50	0-20	0.2	4	60	500	0.02	0.05	100	
DCS 60-18E	0-60	0-18	0.2	4	60	500	0.02	0.05	83	
DCS 80-13E	0-80	0-13	0.2	4	60	500	0.02	0.05	62.5	
DCS 100-10E	0-100	0-10	0.2	6	60	500	0.02	0.05	50	
DCS 150-7E	0-150	0-7	0.2	12	160	500	0.02	0.05	33.3	
DCS 300-3.5E	0-300	0-3.5	0.2	20	200	500	0.02	0.05	16.67	
DCS 600-1.7E	0-600	0-1.7	0.2	50	300	500	0.02	0.05	8.33	
DCS Series 1.2 kW										
DCS 8-140E	0-8	0-140	0.2	5	60	500	0.02	0.05	625	0-10V = 0-100% V_o or 0-5V = 0-100% V_o
DCS 10-120E	0-10	0-120	0.2	5	60	500	0.02	0.05	500	
DCS 20-60E	0-20	0-60	0.2	5	60	500	0.02	0.05	250	
DCS 33-36E	0-33	0-36	0.2	5	60	500	0.02	0.05	151.5	
DCS 40-30E	0-40	0-30	0.2	5	60	500	0.02	0.05	125	
DCS 50-24E	0-50	0-24	0.2	5	60	500	0.02	0.05	100	
DCS 60-20E	0-60	0-20	0.2	5	60	500	0.02	0.05	83	
DCS 80-15E	0-80	0-15	0.2	5	60	500	0.02	0.05	62.5	
DCS 100-12E	0-100	0-12	0.2	10	60	500	0.02	0.05	50	
DCS 150-8E	0-150	0-8	0.2	15	160	500	0.02	0.05	33.3	
DCS 300-4E	0-300	0-4	0.2	25	200	500	0.02	0.05	16.67	
DCS Series 3 kW										
DCS 8-350E	0-8	0-350	0.2	15	100	1000	0.02	0.05	625	0-10V = 0-100% V_o or 0-5V = 0-100% V_o
DCS 12-250E	0-12	0-250	0.2	10	100	1000	0.02	0.05	416.7	
DCS 20-150E	0-20	0-150	0.2	10	100	1000	0.02	0.05	250	
DCS 40-75E	0-40	0-75	0.2	20	100	1000	0.02	0.05	125	
DCS 55-55E	0-55	0-55	0.2	20	100	1000	0.02	0.05	90.9	
DCS 60-50E	0-60	0-50	0.2	20	100	1000	0.02	0.05	83	
DCS 80-37E	0-80	0-37	0.2	20	100	1000	0.02	0.05	62.5	
DCS 150-20E	0-150	0-20	0.2	30	200	1000	0.02	0.05	33.3	

* Typical resolution is 0.02% ** Typical P-P noise and ripple (20Hz to 300kHz)

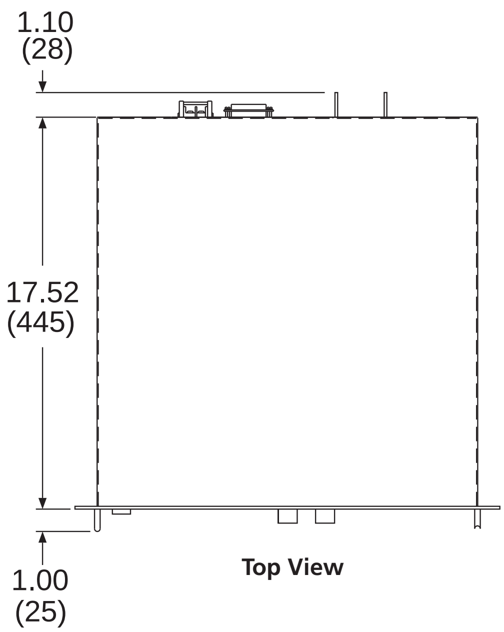
DCS Series : Product Specifications 1–3 kW

Model	Constant Current Mode*		Temperature Coefficient %/°C (Typ.)	Current Drift %I out Max. (Typ.)	Programming Constants, Current Mode		Efficiency % (Typ.)
	Regulation Line and Load% Combined	Ripple (rms)** mA			Ohms/A	V/A	
DCS Series 1 kW							
DCS 8-125E	0.2	160	0.03	0.05	40	0-10V = 0-100% I_o or 0-5V = 0-100% I_o	82
DCS 10-100E	0.2	128	0.03	0.05	50		82
DCS 20-50E	0.2	25	0.03	0.05	100		82
DCS 33-33E	0.2	10	0.03	0.05	151.5		84
DCS 40-25E	0.2	7	0.03	0.05	200		84
DCS 50-20E	0.2	7	0.03	0.05	250		84
DCS 60-18E	0.2	6	0.03	0.05	277.8		86
DCS 80-13E	0.2	4	0.03	0.05	384.6		86
DCS 100-10E	0.2	3	0.03	0.05	500		86
DCS 150-7E	0.2	2	0.03	0.05	714.3		86
DCS 300-3.5E	0.2	1	0.03	0.05	1428.6		86
DCS 600-1.7E	0.2	1	0.03	0.05	2941.2		86
DCS Series 1.2 kW							
DCS 8-140E	0.2	180	0.03	0.05	35.7	0-10V = 0-100% I_o or 0-5V = 0-100% I_o	82
DCS 10-120E	0.2	153	0.03	0.05	41.7		82
DCS 20-60E	0.2	30	0.03	0.05	83.3		82
DCS 33-36E	0.2	11	0.03	0.05	138.9		84
DCS 40-30E	0.2	9	0.03	0.05	166.7		84
DCS 50-24E	0.2	8.5	0.03	0.05	208.3		84
DCS 60-20E	0.2	6.6	0.03	0.05	250.0		85
DCS 80-15E	0.2	6	0.03	0.05	333.3		85
DCS 100-12E	0.2	3.6	0.03	0.05	416.7		85
DCS 150-8E	0.2	2.3	0.03	0.05	625.0		85
DCS 300-4E	0.2	1.2	0.03	0.05	1250.0		85
DCS Series 3 kW							
DCS 8-350E	0.2		0.03	0.05		0-10V = 0-100% I_o or 0-5V = 0-100% I_o	82
DCS 12-250E	0.2		0.03	0.05			82
DCS 20-150E	0.2		0.03	0.05			82
DCS 40-75E	0.2		0.03	0.05			86
DCS 55-55E	0.2		0.03	0.05			82
DCS 60-50E	0.2		0.03	0.05			86
DCS 80-37E	0.2		0.03	0.05			86
DCS 150-20E	0.2		0.03	0.05			86

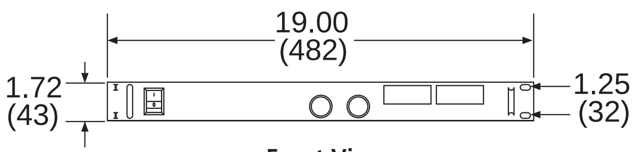
* Typical resolution is 0.02% ** rms ripple typical from 20 Hz to 300 kHz

DCS Series : Diagram

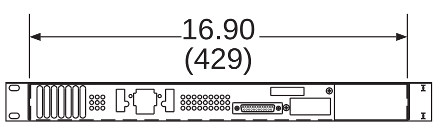
1 kW and 1.2 kW



Top View

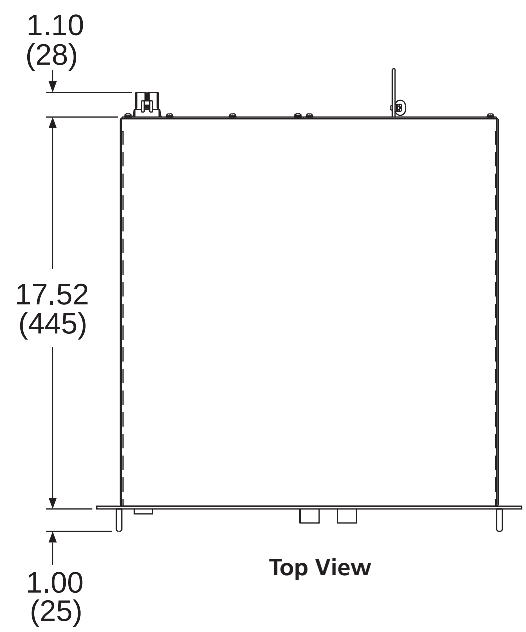


Front View

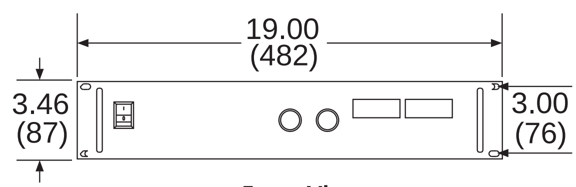


Rear View

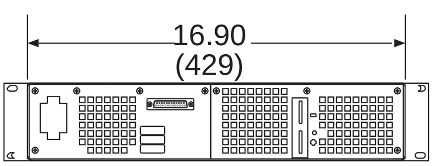
3 kW



Top View



Front View



Rear View

Dimensions in inches (millimeters)

J3 Connector			
1	90-250 VAC Remote Shutdown	14	TTL Shutdown
2	Shutdown Return	15	+12 VDC
3	OVP Program	16	1 mA Current Source (OVP)
4	Remote/Local Status Indicator	17	OVP Indicator
5	Mode Status Indicator	18	Thermal S/DN Status
6	Ground	19	0-5V Voltage Monitor
7	0-5V Current Monitor	20	Remote Voltage Select
8	Voltage Control	21	1 mA Current Source (V)
9	Voltage Program Input	22	1 mA Current Source (I)
10	Current Program Unit	23	Remote Current Select
11	Current Control	24	Return
12	Return Sense	25	POS Output (8-100V Models Only)
13	POS Sense (8-100V Models Only)		

Model Number Description

DCS 20 - 50E (MXX)

Series

Voltage

Current

Options

Options and Accessories

M1	Factory configured for 115 VAC input (1 kW and 1.2 kW units only)
M9C	Internal IEEE-488/RS-232 Interface (can only support 12-bit slaves)
M13	Locking shafts (front panel potentiometers)
M32	Master/slave paralleling cable configured for two units
M33	Replace input connector with terminal block (3 kW only)
M51A	Isolated analog programming control of V/I/OVP and isolated V/I monitor outputs up to 500V relative to the supply's return line. This isolation allows users to control power supplies not connected to a common ground. In addition, in systems with high ambient noise or with large ground loop currents the control ground can be isolated from the power ground eliminating problems.
M85	12-bit slave interface option for use with M9 or M130 master (3 ft. control cable included)
M102	Front panel binding posts for 1 kW or 1.2 kW, Models ≤30A, ≤100V. Not compatible with M9C, M85, M130, M131, M133, M135, M136
M130	LXI™compliant 10/100 Base T Ethernet remote control master interface; includes web server for direct control of power supply via web browser (MS Internet Explorer 6.0 or later)
M131	16-bit slave interface option for use with a M130 master (3 ft. control cable included)
M133	Output disconnect and polarity reversal relays controlled via SCPI commands. Limited to 1kW or 1.2 kW, ≤100V, ≤60A
M135	M130 & M133 combination. Limited to 1kW or 1.2 kW, ≤100V, ≤60A
M136	M131 & M133 combination. Limited to 1kW or 1.2 kW, ≤100V, ≤60A
105-300-26	Rack slide kit (3 kW only)

Software

IVI-Com and Labview drivers available for free download at http://www.elgar.com/products/DCS/DCS_Downloads.htm

Notes

Sorensen DLM 3 & 4 kW Series

3–4 kW

DC Power Supply

5–600 V

5–450 A

~		208	230
≋	208	400	480

GPIB RS232

- High Power Density : 3 kW and 4 kW models, 2U (3½" high), (19" wide); no top or bottom clearance spacing required
- Preview Push-button : Overvoltage protection (OVP), voltage and current preview buttons
- Remote Voltage Sense : Sense leads are easily connected to a solderless connector
- Parallel or Series Operation Field configurable
- Power Factor Correction ≥0.98 1 Φ 3kW

The Sorensen DLM 3kW and 4kW Series programmable DC power supplies are designed to provide highly stable, continuously variable output voltage and current for a broad range of applications in a compact 2U (3½" high) chassis.

Both the 3 kW and 4 kW models have output voltages from 0-5 VDC to 0-600 VDC and a current range from 0-5A to 0-450A. The output rms noise is as low as 10 mV. The output will recover to 1% of its steady-state voltage within 1 ms for a step load change of 100% to 70% or 70% to 100%. The front panel layout makes the series extremely easy to use. Control switches include: power on, enable/ standby and local/ remote.

Displays and indicators show programmed set points and operational control status. The programmed voltage, current and overvoltage set points are displayed with two large 3½ digit LED displays. Operational Status LEDs indicate power on, shutdown, over temperature, overvoltage, constant current and voltage mode status. Control Status LEDs indicate front panel lockout, remote control and standby status. IEEE- 488.2 control LEDs indicate error, service request and remote address status.

The 3 kW Models will accept 200*/230 VAC single phase and 200*/208 VAC three phase input power.

The 4 kW Models will accept 200*/208 VAC, three phase or optional 400 or 480 VAC three phase input power.

*Operating temperature below 40°C

DLM 3 & 4 kW Series : Product Specifications

Common		
Front Panel Controls	Knobs with 3½ digit digital displays to control output voltage and current settings. Power on/off switch, output enable/standby switch and local/remote switch. Voltage, current and overvoltage preview push buttons allow you to preview the programmed settings at any time; overvoltage limit is adjusted with a set screw accessible through the front panel.	
Displays and Indicators	Voltage and overvoltage setting 3½ digit LED display, current setting 3½ digit LED display. LED indicators for power on, shutdown, remote, overvoltage protection, over temperature and front panel lockout, constant voltage and constant current modes. IEEE-488.2 indicators include error, SRQ and address (M9E option).	
Overvoltage Protection	Output overvoltage (resets by cycling the enable/standby switch)	
Cooling	Internal fans with over temperature protection	
Remote Sense	The maximum load line drop is up to the full voltage rating of the supply. The drop in the load leads subtracts from the maximum voltage available for the load except as follows: maximum rated voltage is available at the load and voltage regulation specifications apply for line drops of <2V for models rated 5V to 16V, and <5V for all other models.	
Remote Sense Protection	Unit will not be damaged due to misconnection of the remote sense leads.	
Remote Programming	Voltage, current (0-100%) and OVP (5-110%) of full scale can be programmed by selectable 0-5 VDC, 0-10 VDC, or 0-5 kΩ.	
Remote Monitoring	Voltage or current can be monitored with user-selectable ranges, 0-5 VDC or 0-10 VDC	
Operational Features	Master/slave parallel operation, up to 2 units can be connected in parallel with active current sharing control to within 10% of each supply. Series operation, up to 3 units of the same model type can be connected in series (consult manual). Negative terminal rated at 150 Vmax above ground	
Software	LabVIEW® driver M9E/M85 programs can be downloaded at no cost at www.elgar.com	
Regulatory	CE Mark, 16-185 & 22-180 certified NRTL to EN 61010-1. Marked cCSAus	
Environmental		
Operating Temperature	0°C to 50°C, no derating (<200 VAC range limited to 40°C maximum)	
Storage Temperature	-40°C to 65°C	
Physical		
Dimensions	Width: 19" (483 mm) Height: 3.5" (88 mm) Depth: 18" (508 mm)	
Weight	40 lbs. (18.2 kg)	
Shipping Weight	49 lbs. (22.3 kg)	
Input	**3 kW**	**4 kW**
Voltage Ranges	180-264 VAC, 47-63 Hz, (<200 VAC range limited to 40°C maximum)	180-264 VAC, 345-455 VAC, 432-528 VAC, 47-63 Hz (<200 VAC range limited to 40°C maximum)
Phases	single or three phase	three phase
Power Factor	0.95 typical with three phase input, 0.98 typical with single phase input	0.95 typical with three phase input
Current	single phase, 21A rms; three phase, 12A rms	180-264 VAC, 15A rms; 345-455 VAC, 8.5A rms; 432-528 VAC, 6.5A rms;
Output		
Stability	±0.05% of maximum voltage or current over 8 hours after 15 minute warm-up time at fixed line, load and temperature. Current accuracy for 5V, 8V, and 16V models is 1% typical.	
Line Regulation	For input voltage variation over the AC input voltage range, with constant rated load. Voltage: 0.05% of maximum rated output +2mV Current: 0.1% of maximum rated output	
Load Regulation	For 0-100% load variation, with constant nominal line voltage. Voltage: 0.05% of maximum rated output +2mV Current: 0.1% of maximum rated output	
Voltage Regulation	0.05% of maximum rated output +2mV	
Transient Response	Typically recovers in 1.5 ms to within 1% of steady-state output voltage (greater than 50% of Vmax) for 70-100% or 100-70% load change.	
Temperature Coefficient	0.02%/°C of rated output voltage; 0.03%/°C of rated output current. Change in output per °C change in ambient temperature, with constant line and load.	
Efficiency	5-8V Models: 82% typical 16-80V Models: 87% typical 150-600V Models: 85% typical (at maximum output power)	

DLM 3 & 4 kW Series : Product Specifications

Output : Voltage and Current

3 kW Model	Voltage	Current	4 kW Model	Voltage	Current
DLM 5-350E	0-5	0-350	DLM 5-450E	0-5	0-450
DLM 8-350E	0-8	0-350	DLM 8-450E	0-8	0-450
DLM 16-185E	0-16	0-185	DLM 16-250E	0-16	0-250
			DLM 22-180E *	0-22	0-180
DLM 32-95E	0-32	0-95	DLM 32-125E	0-32	0-125
DLM 40-75E	0-40	0-75	DLM 40-100E	0-40	0-100
DLM 60-50E	0-60	0-50	DLM 60-66E	0-60	0-66
DLM 80-37E	0-80	0-37	DLM 80-50E	0-80	0-50
DLM 150-20E	0-150	0-20	DLM 150-26E	0-150	0-26
DLM 300-10E	0-300	0-10	DLM 300-13E	0-300	0-13
DLM 600-5E	0-600	0-5	DLM 600-6.6E	0-600	0-6.6

Model	Output Ratings		Regulation Line and Load		Meter Accuracy	
	Voltage (VDC)	Current (ADC)	Voltage (0.05% of Vmax + 2 mV)	Current (0.1% of Imax)	Voltage (0.5% of Vmax + 1 count)	Current (0.75% of Imax + 1 count)
DLM 5-350E	0-5	0-350	5 mV	350 mA	0.04V	4A
DLM 5-450E	0-5	0-450	5 mV	450 mA	0.04V	5A
DLM 8-350E	0-8	0-350	6 mV	350 mA	0.05V	4A
DLM 8-450E	0-8	0-450	6 mV	450 mA	0.05V	5A
DLM 16-185E	0-16	0-185	10 mV	185 mA	0.09V	3A
DLM 16-250E	0-16	0-250	10 mV	250 mA	0.09V	3A
DLM 22-180E *	0-22	0-180	13 mV	180 mA	0.2V	3A
DLM 32-95E	0-32	0-95	18 mV	95 mA	0.3V	0.8A
DLM 32-125E	0-32	0-125	18 mV	125 mA	0.3V	1A
DLM 40-75E	0-40	0-75	22 mV	75 mA	0.3V	0.7A
DLM 40-100E	0-40	0-100	22 mV	100 mA	0.3V	0.9A
DLM 60-50E	0-60	0-50	32 mV	50 mA	0.4V	0.5A
DLM 60-66E	0-60	0-66	32 mV	66 mA	0.4V	0.6A
DLM 80-37E	0-80	0-37	42 mV	37 mA	0.5V	0.4A
DLM 80-50E	0-80	0-50	42 mV	50 mA	0.5V	0.5A
DLM 150-20E	0-150	0-20	77 mV	20 mA	0.9V	0.3A
DLM 150-26E	0-150	0-26	77 mV	26 mA	0.9V	0.3A
DLM 300-10E	0-300	0-10	152 mV	10 mA	3V	0.09A
DLM 300-13E	0-300	0-13	152 mV	13 mA	3V	0.11A
DLM 600-5E	0-600	0-5	302 mV	5 mA	4V	0.05A
DLM 600-6.6E	0-600	0-6.6	302 mV	7 mA	4V	0.06A

* 22V Model available as 4kW

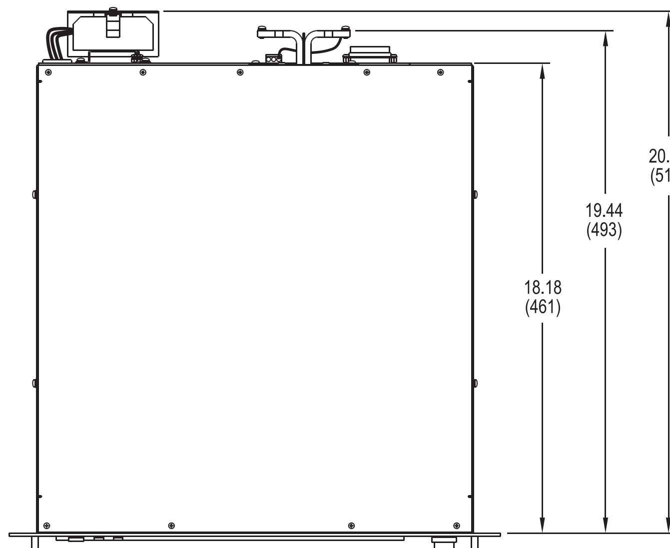
DLM 3 & 4 kW Series : Product Specifications

Model	Preview Accuracy		OVP Adjustment Range (6% to 110% Vmax)	Ripple & Noise		Stability		Temp Coefficient		Maximum Total Remote Sense Drop
	Voltage (05% of Vmax +1 count)	Current (1.0% of Imax +1 count)		Ripple (rms)*	Noise (p-p)	Voltage (0.05% of Vmax)	Current (0.05% of Imax)	Voltage (0.02% C of Vmax)	Current (0.03% C of Imax)	
DLM 5-350E	0.04V	5A	0.3-5.5V	12 mV	100 mV	3 mV	175 mA	1 mV	105 mA	2V
DLM 5-450E	0.04V	6A	0.3-5.5V	12 mV	100 mV	3 mV	225 mA	1 mV	135 mA	2V
DLM 8-350E	0.05V	5A	0.4-8.8V	12 mV	100 mV	4 mV	175 mA	1.6 mV	105 mA	2V
DLM 8-450E	0.05V	6A	0.4-8.8V	12 mV	100 mV	4 mV	225 mA	1.6 mV	135 mA	2V
DLM 16-185E	0.09V	3A	0.8-17.6V	10 mV	100 mV	8 mV	93 mA	3.2 mV	55 mA	2V
DLM 16-250E	0.09V	4A	0.8-17.6V	10 mV	100 mV	8 mV	125 mA	3.2 mV	75 mA	2V
DLM 22-180E *	0.2V	3A	1.1-24.2V	10 mV	100 mV	11 mV	90 mA	4.4 mA	54 mA	2V
DLM 32-95E	0.3V	1.1A	1.6-35V	10 mV	100 mV	16 mV	48 mA	6 mV	30 mA	5V
DLM 32-125E	0.3V	1.4A	1.6-35V	10 mV	100 mV	16 mV	63 mA	6 mV	38 mA	5V
DLM 40-75E	0.3V	0.9A	2-44V	10 mV	100 mV	20 mV	38 mA	8 mV	23 mA	5V
DLM 40-100E	0.3V	1.1A	2-44V	10 mV	100 mV	20 mV	50 mA	8 mV	30 mA	5V
DLM 60-50E	0.4V	0.6A	3-66V	15 mV	100 mV	30 mV	25 mA	12 mV	15 mA	5V
DLM 60-66E	0.4V	0.8A	3-66V	15 mV	100 mV	30 mV	33 mA	12 mV	19.8 mA	5V
DLM 80-37E	0.5V	0.5A	4-88V	15 mV	120 mV	40 mV	19 mA	16 mV	12 mA	5V
DLM 80-50E	0.5V	0.6A	4-88V	15 mV	120 mV	40 mV	25 mA	16 mV	15 mA	5V
DLM 150-20E	0.9V	0.3A	7.5-165V	30 mV	200 mV	75 mV	10 mA	30 mV	6 mA	5V
DLM 150-26E	0.9V	0.4A	7.5-165V	30 mV	200 mV	75 mV	13 mA	30 mV	7.8 mA	5V
DLM 300-10E	1.6V	0.11A	15-330V	60 mV	300 mV	150 mV	5 mA	60 mV	3 mA	5V
DLM 300-13E	1.6V	0.14A	15-330V	60 mV	300 mV	150 mV	6.5 mA	60 mV	3.9 mA	5V
DLM 600-5E	3.1V	0.06A	30-660V	100 mV	500 mV	300 mV	2.5 mA	120 mV	1.5 mA	5V
DLM 600-6.6E	3.1V	0.08A	30-660V	100 mV	500 mV	300 mV	3.3 mA	120 mV	2.0 mA	5V

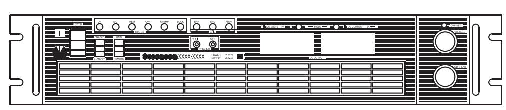
J3 Connector			
1	Remote Output Enable	14	Remote Shutdown Input (+). Positive or negative true logic selection with S1
2	Remote Shutdown Return (-)	15	+5 VDC Auxiliary Output
3	Remote OVP Programming Input	16	1 mA Current Source for OVP Programming
4	Remote Programming Indicator	17	OVP Status Indicator
5	Operating Mode Indicator	18	Over temperature Shutdown Indicator
6	Status Indicator Return (-)	19	DC Voltage Monitor Output
7	Current Monitor Output	20	Remote /Local Voltage Control Select
8	Not Used	21	1 mA Current Source for Voltage Programming
9	Voltage Programming Input	22	1 mA Current Source for Current Programming
10	Current Programming Input	23	Remote/Local Current Control Select
11	Not Used	24	Not Used
12	Programming/Monitor Return (-)	25	Not Used
13	Not Used		

* 22V Model available as 4kW

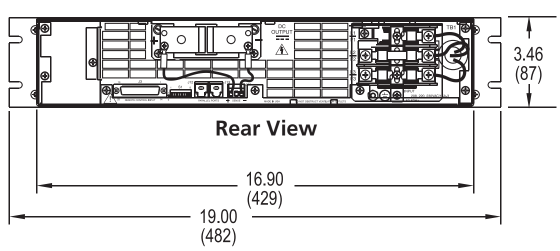
DLM 3 & 4 kW Series : Diagram



Top View



Front View



Rear View

Input Connections
Compression lug terminals
#6 AWG max wire size

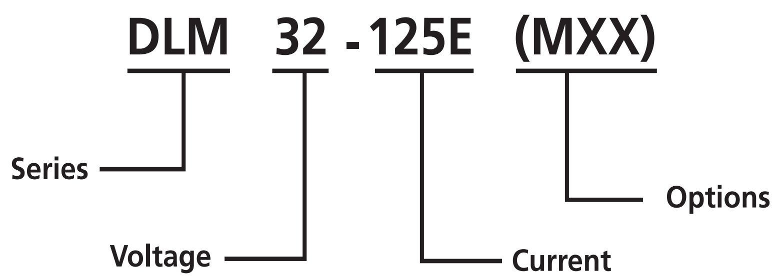
Chassis Ground Connection
#10-32 threaded stud

Output Connections
5V to 80V
Copper bus bars, nickel plated
Holes in bus bar 0.312 (7.92)
150V to 600V
Terminal block with #8-32 screws

Dimensions in inches (millimeters)

DLM 3 & 4 kW Series

Model Number Description



Options and Accessories	
M1	345-455 VAC, 47-63 Hz, three phase, 3 wire plus ground, Delta or WYE may be used (4 kW only)
M2	432-528 VAC, 47-63 Hz, three phase, 3 wire plus ground, Delta or WYE may be used (4 kW only)
M9E	SCPI compatible IEEE-488.2 and RS-232 interfaces (May not be combined with M51A or M85)
M13	Locking shafts (front panel potentiometers)
M51A	Isolated analog programming (May not be combined with M9C or M85). This isolation allows users to control power supplies not connected to a common ground. In addition, in systems with high ambient noise or with large ground loop currents the control ground can be isolated from the power ground eliminating problems.
M85	12-bit slave interface (May not be combined with M9E or M51A)
5361969-01	Paralleling Cable; one cable per slave unit
105-300-26	Rack slide kit

Sorensen SG Series

4–150 kW

Programmable Precision High Power DC Power Supply

10–1000 V

5–6000 A

≈	208	400	480

ETHERNET GPIB LXI RS232

- High Power Density: up to 15 kW in 3U, 30 kW in a 6U chassis
- Wide Voltage Range: 0-10V up to 0-1000V, from 4 to 30 kW
- Fast Load Transient Response: Protection from undesired voltage excursions
- Low Ripple and Noise
- Hardware Trigger (Ethernet Option)
- Parallelable up to 150 kW
- Sequencing: Free system controller & speed up test
- Low audible noise: Temperature controlled variable speed fans

The Sorensen SG Series (hereafter SG Series) represents the next generation of high power programmable DC power supplies. The SG Series is designed for exceptional load transient response, low noise and the highest power density in the industry. With a full 15 kW available down to 20VDC output in a 3U package the SG leads the industry in power density. The power density is enhanced by a stylish front air intake allowing supplies to be stacked without any required clearance between units.

At the heart of the SG series is a 5 kW power module. Depending on the output voltage, one to six modules can be configured in a single chassis to deliver 5 kW to 30 kW of power. Combinations of these chassis can then be easily paralleled to achieve power levels up to 150 kW. Paralleled units operate like one single supply providing total system current. Available in two control versions, the SGA has basic analog controls, while the SGI provides intelligent control features.

SGI: Advanced Intelligent Control
(Sorensen General purpose Intelligent) The SGI combines onboard intelligent controls with the outstanding power electronics common to all SG family supplies. These controls enable sophisticated sequencing, constant power mode and save/recall of instrument settings. Looping of sequences makes the SGI ideal for repetitive testing. An impressive vacuum fluorescent graphical display in eight languages, context sensitive "soft" keys and front panel keyboard simplify programming of the SGI.

SGA: Outstanding Value - Analog Control
(Sorensen General purpose Analog) The SGA, with its industry leading performance, is available for customers requiring simple front panel analog controls or external control. With the same high performance power electronics as the SGI, the SGA provides essential features like 10- turn potentiometers for setting voltage and current, 3 ½ digit LED readout plus front panel over-voltage protection (OVP) preview/adjustment and reset.

SG Series : Product Specifications

Common	
Remote Sense	Terminals are provided to sense output voltage at point of load. Maximum line drop 5% of rated voltage per line for 40-100V models, line drop 1V of rated voltage per line for 10-20V models, 1.5V for 30V models, 2% of rated voltage per line for models 160V and greater. (Greater line drop is allowed, but output regulation specifications no longer apply).
Parallel Operation	Up to 5 units may be paralleled for additional current within the power supply single-unit specifications, with exception of the DC output current set accuracy. Additional paralleled SG units will add 0.3% inaccuracy per unit. To parallel more than 5 units, contact factory.
Series Operation	Up to 2 units (see Output Float Voltage)
Input	
Nominal Voltage 3 phase, 3 wire + ground	208/230 VAC (operating range 187 - 253 VAC) 380/400 VAC (operating range 342 - 440 VAC) 440/480 VAC (operating range 396 - 528 VAC)
Frequency	47 – 63Hz , 400Hz (400Hz @ 208VAC, for 6U units is optional modification and does not carry CE, UL or CSA markings)
Power Factor	>0.9 typical for 10V - 30V, 50V, 1000V and other models with optional "PF" modification. >0.75 typical for 208/220 VAC input (40V, 60V - 800V models, 0.9 available with modification "PF") >0.72 typical for 380/480 VAC input (40V, 60V - 800V models, 0.9 available with modification "PF") >0.69 typical for 440/480 VAC input (40V, 60V - 800V models, 0.9 available with modification "PF")
Protection (typical)	½ cycle ride-though , typical, on all three phases, 3 cycle ride through on single phase; missing phase shutdown (800V model 6.4 msec on all 3 phases)

Programming & Read-back Specifications (with sense wires used)					
	Programming		Read-Back / Monitoring		
	Accuracy	Resolution	Accuracy	Resolution	
Front panel Display	SGA: +/- (0.5%fs + 1 digit) SGI (40-1000V) +/- 0.1% of voltage at full scale SGI (40-1000V) +/- 0.4% of current at full scale SGI (10-30V) 0.1% of set point +0.1% of voltage rating SGI (10-30V) 0.1% of set point +0.4% of current rating	SGA: 3.5 digits SGI: 4.0 digits	SGA: +/- (0.5%fs + 1 digit) SGI, Voltage: +/- 0.1% of full scale SGI, Current: +/- 0.4% of full scale SGI (10-30V) 0.1% of actual +0.15% voltage rating	SGA: 3.5 digits SGI: 4.0 digits	Knob control & Display read-back
Remote Analog Interface	Voltage +/-0.25% of full scale Current (40-1000V) 0.8% of full scale , (10-30V) 1.0% of full scale	NA	(40-1000V) +/-1.0% of full scale (10-30V) +/-0.5% of full scale	NA	25-pin D-sub connector (0~5 V or 0~10 V)
Remote Digital Interface	Voltage: +/- 0.1% of full scale, Current: +/- 0.4% of full scale	+/-0.002% of full scale	Voltage: +/- 0.1% of full scale Current: +/- 0.4% of full scale	+/-0.002% of full scale	RS-232C (Standard on SGI), Optional IEEE-488.2 and Optional LXI Compliant 10/100 base-T Ethernet (see Options)
OVP	+/- 1% of full scale	+/-0.002% of full scale			Programming range: 5-110% Configured from front panel, remote analog or via optional digital inputs
User I/O	Disconnect & Polarity-reversal relay control (Only available with Ethernet Option)				Digital 10-pin Molex type connector See www.programmablepower.com
Software	IVI & CVI drivers available under SUPPORT at: www.ProgrammablePower.com				

Physical	**3U Models (10V-30V)**	**3U Models (40V-1000V)**	**6U Models (60V-600V)**
Width	19.00 in (48.3 cm)	19.00 in (48.3 cm)	19.00 in (48.3 cm)
Depth	28.09 in (71.35 cm)	26.4 in (67.1 cm)	27.18 in (69.04 cm)
Height	5.25 in (13.3 cm)	5.25 in (13.3 cm)	10.5 in (26.7 cm)
Weight	(4kW, 10V 15V) ≈<65 lbs (29 kg) (5kW, 20V 30V) ≈<65 lbs (29 kg) (8kW, 10V 15V) ≈<85 lbs (39 kg) (10kW, 20V 30V) ≈<85 lbs (39 kg) (12kW, 10V 15V) ≈<110 lbs (50 kg) (15kW, 20V 30V) ≈<110 lbs (50 kg)	(5kW) ≈ 40 lbs (18 kg) (10kW) ≈ 60 lbs (27 kg) (15kW) ≈ 80 lbs (36 kg)	(20kW) ≈ 120 lbs (54 kg) (25kW) ≈ 140 lbs (64 kg) (30kW) ≈ 160 lbs (73 kg)
Shipping Weight	Contact factory for more product & shipping weights		

SG Series : Product Specifications

4-150 kW

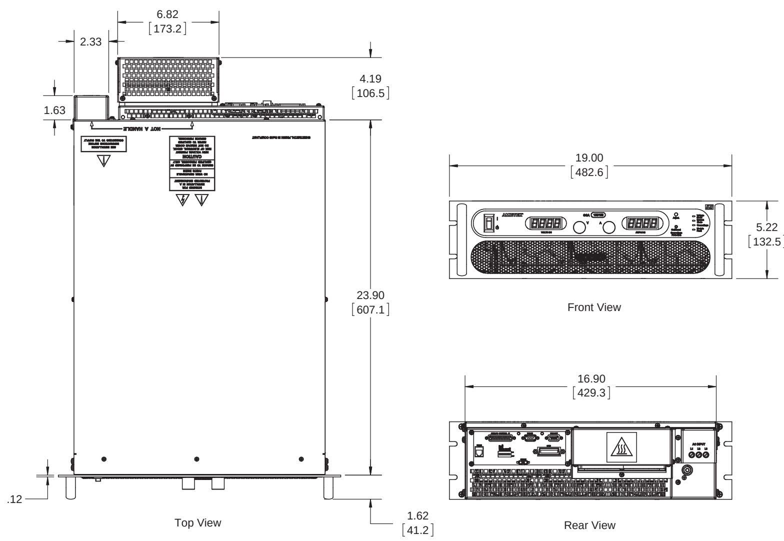
Output	
Ripple & Noise (Voltage Mode, Typical)	See Output: Voltage & Current Ranges Chart below. Ripple and noise specified at full load, nominal AC input. Noise measured with 6 ft. cable, 1µf at load
Ripple (Current Mode)	<+/- 0.04% of full scale rms current
Output Voltage Rise Time (40-1000V)	≈< 100 ms 10-90% of full scale typical - full resistive load (Contact factory for model specific slew rates)
Output Voltage Rise Time (10-30V)	Rise Time, ms, max: 10 Condition: Measured from 10% to 90% of the output voltage change - resistive load, typical
Output Voltage Fall Time (10-30V)	Fall Time, ms max: No Load 1: 50; 100% CC Load: 10; 100% CR Load: 10 Condition: Measured from 90% to 10% of the output voltage change. - resistive load, typical
Output Current Rise Time (10-30V)	Rise Time, ms max: 20 Condition: Measured from 10% to 90% of the output current change - resistive load, typical
Output Current Fall Time (10-30V)	Fall Time, ms max: 10 Condition: Measured from 90% to 10% of the output current change - resistive load, typical
DC Current Slew Rate	45A / ms typical - resistive load
Line Regulation (with sense wires used)	(±10% of nominal AC input, constant load) Voltage Mode: +/- 0.01% of full scale (40-800V) Current Mode: +/- 0.05% of full scale (40-800V) Voltage Mode and Current Mode: +/- 0.05% of full scale (10-30V)
Load Regulation (with sense wires used)	(no load to full load, nominal AC input) Voltage Mode: +/- 0.02% of full scale (40-800V) Current Mode: +/- 0.1% of full scale Voltage Mode: +/- 0.05% of full scale (10-30V)
Load Transient Response	Recovers within 1ms to +/-0.75% of full-scale of steadystate output for a 50% to 100% or 100% to 50% load change
Efficiency	87% typical at nominal line and max load
Stability	±0.05% of set point after 30 minute warm-up and over 8 hours at fixed line, load and temperature, typical
Temperature Coefficient	0.02%/ C of maximum output voltage rating for voltage set point, typical 0.03%/ C of maximum output current rating for current set point, typical
Output Float Voltage	Negative terminal within +/- 300 V of chassis potential. (We recommend the use of optional isolated analog Interface (IAI).) Supplies in "series" have a system current limit of the lowest current supply in the system.

Output: Voltage and Current Ranges

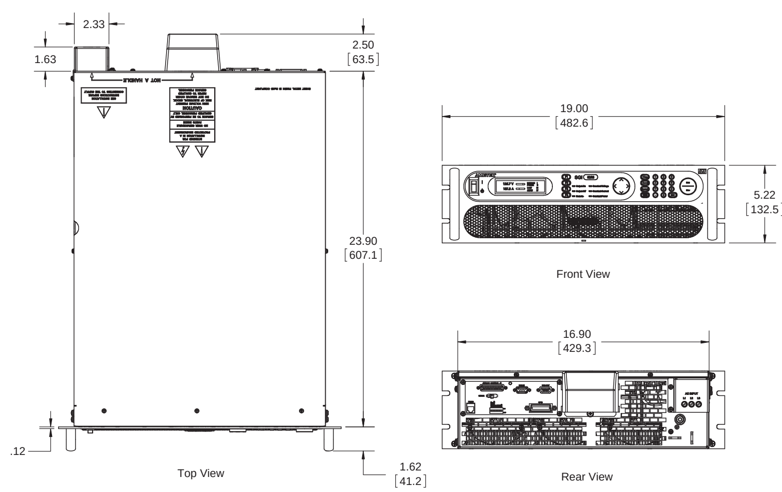
	3U			6U			Ripple & Noise	
Power	4/5 kW	8/10 kW	12/15 kW	16/20 kW	20/25 kW	24/30 kW	rms (20 Hz-300 kHz)	p-p (20 Hz-20 MHz)
Voltage	Current							
10	400	800	1200	1600*	2000*	2400*	20 mV	50 mV
15	267	534	801	1068*	1335*	1602*	20 mV	50 mV
20	250	500	750	1000*	1250*	1500*	20 mV	60 mV
30	167	334	501	668*	835*	1002*	20 mV	60 mV
40	125	250	375	500*	625*	750*	20 mV	75 mV
50	100	200	300	400*	500*	600*	20 mV	75 mV
60	83	167	250	333	417	500	20 mV	75 mV
80	63	125	188	250	313	375	20 mV	100 mV
100	50	100	150	200	250	300	20 mV	100 mV
160	31	63	94	125	156	188	25 mV	150 mV
200	25	50	75	100	125	150	25 mV	175 mV
250	20	40	60	80	100	120	30 mV	200 mV
330	15	30	45	61	76	91	30 mV	200 mV
400	12	25	38	50	63	75	30 mV	300 mV
500	10	20	30	40	50	60	50mV	350mV
600	8	17	25	33	42	50	60 mV	350 mV
800	6.2	12.5	18.7	25*	31.2*	37.5*	80 mV	500 mV
1000	5	10	15	20*	25*	30*	100 mV	650 mV

* By way of paralleling 3U supplies

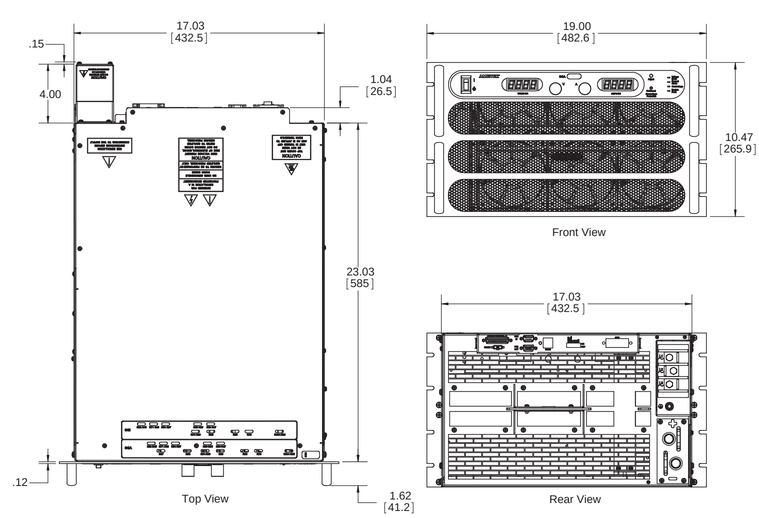
SG Series : Product Diagram



3U Case (10-30V)



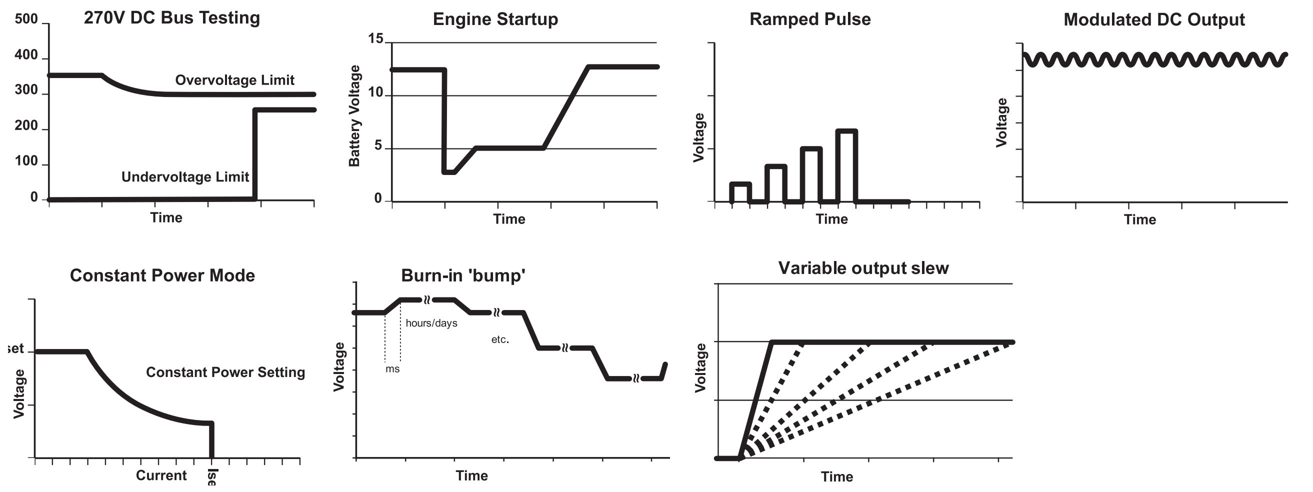
3U Case (40-1000V)



6U Case (60-600V)

SG Series 4–150 kW

Advanced Power Simulation



SGI model provides constant power mode allowing independent setting of the max voltage, current and power

SGI / SGA Comparison Chart

Feature	SGA	SGI
Modular Design	•	•
Fast Load Transient	•	•
Parallelable	•	•
Analog & Digital Summing	Optional	•
Direct Front Panel V/I Control	•	•
3½ Digit LED Readout	•	
Graphics Display		•
Sequencing		•
Save/Recall Setups		•
System Power Readouts		•
Constant Power Mode		•
IEEE-488.2/RS-232C	Optional	RS-232C Std, IEEE-488.2 Optional
LXI Class C Ethernet/ RS-232	Optional	RS-232C Std, Ethernet Optional
Front Panel Dust Filter	Optional (3U unit only)	Optional (3U unit only)

Environmental

Operating Temperature	0 to 50° C
Storage Temperature	-25° C to 65° C
Humidity Range	Relative humidity up to 95% non-condensing, 0° C – 50° C
Altitude	Operating full power available up to 5,000 ft. (~1,500 m), derate 10% of full power for every 1,000 feet higher; non-operating to 40,000 ft. (~12,000 m)
Cooling	Front and side air inlet, rear exhaust. Temperature controlled, variable speed fans. Units may be stacked without spacing.
Regulatory	Certified to UL/CSA 61010 and IEC/EN 61010-1 by a NRTL, CE Compliant, Semi-F47 Compliant. LVD Categories: Installation Category II: Pollution Degree 2; Class II Equipment: for Indoor Use Only, back panel not user accessible (see user manual for installation instructions) EMC Directive, EN 61326:1998
Front Panel Dust Filter	30 PPI (Pores Per Inch) - must ensure adequate airflow and / or derate max. temperature. 3U unit only.

SG Series

SG A 100 X 100 C - 1A AA AA

Control Designation — A = Analog; I = Intelligent

Voltage

4 - 15kW = “ X ”
20 - 30kW = “ / ”

Current

Input Voltage Options

Remote Control Options

Process Options

Modifications

(For units with greater than 3 digits, Voltage/Current is represented in numeric format, e.g., above “100” represents 100A.
For units at 1000 and above, the voltage is represented by the format “XKX”, e.g. 1K2 = 1200V and 1K0 = 1000V)

Options and Accessories	
Control Options	A: Analog I: Intelligent
Input Options	C: Input Voltage 187 / 242VAC, 3 Phase D: Input Voltage 342 / 440VAC, 3 Phase E: Input Voltage 396 / 528VAC, 3 Phase
Remote Control Options	0A: No Option 1A: IEEE-488.2 + RS-232C (Note: SGI comes standard with RS-232C) 1C: Ethernet + RS-232C 1D: Isolated Analog Control 1E: Shaft Locks (SGA series only) 2A: Combined Options 1A+1D 2C: Combined Options 1A+1E (SGA Only) 2G: Combined Options 1C+1D 2H: Combined Options 1C+1E (SGA Only) 2J: Combined Options 1D+1E (SGA Only) 3C: Combined Options 1A+1D+1E (SGA Only) 3G: Combined Options 1C+1D+1E (SGA Only)
Process Options	AA: No option AB: Certificate of Calibration to ANSI / NCSL Z540-1 (includes Test Data)
Modifications	AJ: Front panel dust filter - factory installed - 3U unit only CV: 400Hz AC input @ 208 VAC (does not carry CE, CSA or UL marks) (6U only) STD on 3U PF: Passive power factor correction to 0.9 (Only applicable to 40V, 60V to 800V. Included in 10V-30V, 50V and 1000V.)
Accessories	890-453-03: Paralleling Cable (for up to 5 units, requires one cable per unit placed in parallel) K550212-01: 3U Rack Slides (for 5kW, 10kW and 15kW models) K550213-01: 6U Rack Slides (for 20kW, 25kW and 30kW models) 5550568-01: Front panel dust filter - field installation kit - 3U unit only 5551082-01: Optional AC input cover kit - 3U unit only
Contact factory for other combinations	

Sorensen SFA Series

5–150 kW

High Slew Rate Current Source

60–160 V

31–2500 A

≈	208	400	480

ETHERNET GPIB LXI RS232

The SFA family builds on the industry leading Sorensen SGA series to provide a high power current source for laser diode applications. State of the art high power laser diodes require well-regulated current control to avoid catastrophic damage. Under anomalous operating conditions, excessive stored energy in the output circuit of the power supply can result in peak stresses that can permanently damage the device. Providing a constant current regulation mode only, the SFA's low stored energy output minimizes damage potential for sensitive devices as well as enabling a current slew rate of up to 400 A/msec.

Power	3U			6U		
	5 kW	10 kW	15 kW	20 kW	25 kW	30 kW
Voltage	Maximum Current *(parallel for higher current.)*					
60	83	167	250	333	417	500
100	50	100	150	200	250	300
160	31	63	94	125	156	188

Specifications (at nominal AC line and 25°C)	
Output Slew Rate (10-90% resistive load)	250A/ms (400A/ms typical) rise, 200A/ms typical fall; 160V model 87A/ms/5kW (145A/ms/5kW typical), 60A/ms, typical, fall
Control Mode	Current Control Only
Front Panel Meter Accuracy	Voltage ±0.5% of full-scale + 1 digit, Current ±0.5% of full-scale + 1 digit
Load Regulation	(no load to full load, nominal AC input) Current 0.1% of rated output current
Line Regulation	(±10% of nominal AC input) Current 0.05% of rated output current
Current Ripple	1% p-p of full-scale current
Transient Response	Output current recovers to within 1% of current setpoint within 1ms for a 10 to 100% or 100% to 10% step load change
Current Overshoot	Maximum 8% of full-scale for 0 to 100% change into a resistive load
Output Capacitance	60V Models <10 µF / 5 kW, 100/160V Models 3 µF / 5 kW
Stability	±0.05% of setpoint after 8–hr. warm-up at fixed line, load, and temperature using remote sense
Power Factor	>0.9 typical for 208/220VAC input, >0.78 typical for 380/400VAC input, >0.7 typical for 440/480VAC input
Remote Analog Control	Current Setpoint Accuracy, ±0.8% of full-scale output; Overcurrent Protection, ±1% of full-scale output; Resistive Control, 0–5kΩ = 0-100% Current; Voltage Control, 0–5 or 0–10 VDC = 0-100% Current; Overcurrent Protection, 0–5.5 VDC = 0-110%
Efficiency	87% typical at full load, nominal line
Remote Control/Monitor	On/Off control via contact closure, 6-120 VDC or 12-240VAC, and TTL or CMOS switch, current monitor, OCP limit set, summary fault status
Overvoltage Protection	Fixed at approximately 110% of the rating compliance voltage. Reset requires cycling the front panel standby power switch off/on
Ethernet Control (optional)	LXI compliant 10/100 Base T Ethernet remote control with web server for direct control of power supply via web browser.
Isolated Analog Control (optional)	Input to Output Isolation: 500 V Compliant with max. terminal float voltage. Recommended operation under SELV normal conditions.
Regulatory	Certified to UL/CSA 61010 and IEC/EN 61010-1, CE Compliant (LVD and EMC Directives), Input power options
Input Power Configuration	3–phase, 3–wire plus ground. Not phase, rotation sensitive. Neutral not used.
Input Power Voltage Selection	208/220 VAC±10%, 47 to 63 Hz, 380/400 VAC±10%, 47 to 63 Hz, 440/480 VAC±10%, 47 to 63 Hz
Environmental	
Ambient Operating Temperature	0 to 50°C
Storage Temperature	-25 to 65°C
Temperature Coefficient	Current Setpoint 0.03%/°C of rated current
Cooling	Internal Fans. Zero clearance stacking
Humidity	0 to 90% at 40°C; 0 to 50% at 25°C, non-condensing
Altitude	Full power at 5,000 feet, 10% derating of full power for every 1,000 feet above 5,000 feet
Physical	
5 to 15 kW in 3U	19.00in W x 25.12in D x 5.25inH; 80 lbs., (48.3cm W x 63.8cm D x 13.3cm H; 36 kg)
20 - 30 kW in 6U	19.00in W x 25.12in Dx 10.5in x H; 160 lbs., (48.3cm W x 63.8cm D x 36.7cm H; 73 kg)
Accessories	
Modifications	AJ: Front panel dust filter - factory installed - 3U unit only
K550212-01 / 5550568-01	3U Rack Slides (for 5kW, 10kW and 15kW models) / Front panel dust filter - field installation kit - 3U unit only
K550213-01 / 9550589-01	6U Rack Slides (for 20kW, 25kW and 30kW models) / AC input cover - 3U unit only

Notes

Sorensen ASD Series

10–320 kW

Programmable Precision High Power DC Power Supply

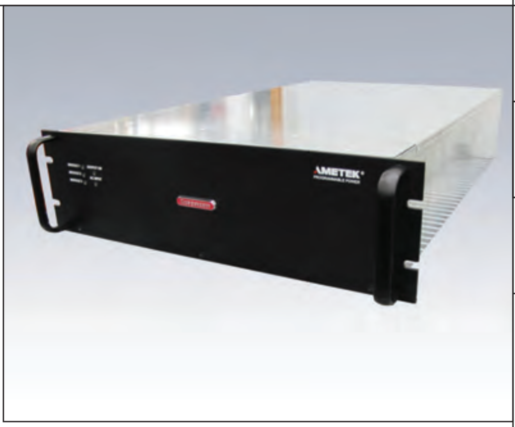
40–60 Vdc

167–8000 Adc

≈	380	400	480

ETHERNET (Modbus-TCP) RS485 (Modbus-RTU)

- Highest Power Density: 30kW in 3U
- Water-Cooled
- Full Digital Control Loops
  - Stable operation over wide range of complex load impedances
- Advanced Digital Features
  - "Flight data" recorder-like function
  - Oscilloscope function
  - Output impedance measurement
  - Advanced fault detection
  - PLC feature: close loop on external variable such as temperature



The ASD with DaVinci Power™ technology represents the next generation of precision programmable AC-DC power conversion.

The ASD with its 3U, 30kW water-cooled packaging provides the highest power density available. The ASD is designed for industry leading load transient response with outstanding output ripple and noise. The water-cooling packaging allows for use in environments that normally exclude air-cooled power supplies.

The ASD advanced digital architecture, with real-time digital control and Graphical User Interface (GUI), enables many features to better control and monitor your process or application. The optional advanced features package includes a built-in oscilloscope function for measurement and display of: power, voltage, current, output impedance, output cable impedance and output cable voltage drop. The ASD allows you to program different "fault levels", enabling detection of output cabling, connections or load problems before they cause critical system problems. The ASD can replace your PLC device by closing the loop on an external parameter such as temperature. The ASD's Advanced Diagnostics And Maintenance (ADAM^{sm}) feature includes a flight data recorder feature that lets you access multiple recorded parameters, such as: voltage, current, power, load impedance, faults and input voltage. This allows you to easily determine "why" you had an unexpected outcome.

The advanced digital monitoring and control features combined with industry leading power density and reliability makes the Sorensen ASD the supply of choice for stringent and high value processes and applications.

Advanced features include:

- Precise programming of voltage and current slew rate for sensitive loads.
- Modules within one chassis can be connected to different loads and controlled independently.
- Industrial field bus interface (Modbus-TCP, Modbus-RTU, Ethernet/IP (Industrial Protocol)) enable real-time digital control.
- Built-in energy meter calculates the delivered energy throughout a process or period of time.
- Optional real time clock enables accurate timestamping of events.
- Built in power quality monitoring detects and saves input voltage anomalies which can be saved for later diagnostic analysis.
- Programmable analog interface scaling facilitates incorporating the ASD to existing systems with minimal effort.
- Load impedance measurement, including rate-of-change calculations, enable load "state of health" monitoring and implementation of system preventive maintenance algorithms
- Programmable filter bandwidth of the output voltage, current and power monitors let the user accommodate their response speed to particular needs.
- Full featured GUI (Graphical User Interface) helps to test and debug the system by communicating with the power supply in real time

ASD Series : Product Specifications

Input	Type: 3-phase, 3-wire plus ground, neutral not required. Not phase rotation sensitive		
Voltage Ranges	342VAC to 440VAC (model D). Nominal rating is 380/400VAC. 432VAC to 528VAC (model E). Nominal rating is 480VAC		
Frequency	Rated 47 through 63 Hz		
Efficiency	>91% (typical), nominal line, full load.		
Max Current, per phase, low line		400/380Vac	480Vac
	10kW unit (1 module)	21Arms	17Arms
	20kW unit (2 modules)	42Arms	33Arms
	30kW unit (3 modules)	63Arms	50Arms
Current Inrush	200A Typical		
Power Factor	>0.9 @ Full Load and at nominal line		
Brownout Provisions	Designed to meet SEMI F47-0706, S3, S8, S14 at nominal input voltages		

Output					
Voltage Output	10kW	20kW	30kW	Noise (pk-pk)***	Noise (RMS)***
40Vdc	250A	500A	750A	150mV	40mV
60Vdc	167A	334A	501A	150mV	40mV

(*) Measured at the load terminals, with 1uF in parallel and 6ft of low-inductance load cable with supply operating at full load and nominal input line voltage.
(**) RMS noise is measured directly across the output terminal with supply operating at full load and nominal input line voltage.
(***) Value is for 30kW, single voltage models. Other variations may increase value by 2x.

Sense	To compensate load cables voltage drop, units can generate 2% additional voltage at full scale of output voltage.

Output	
Load Regulation (Specified at No load to Full load change, nominal AC input)	
Voltage	0.1% of maximum output voltage/ current
Current	0.1% of maximum output voltage/ current
Line Regulation (Specified at ±10% of nominal AC input, constant load)	
Voltage	0.05% of maximum output voltage/ current
Current	0.05% of maximum output voltage/ current
Transient Response	A 50% step load will recover to within 0.75% of original value within 1mSec
Stability	±0.05% of set point after 8 hrs. at fixed line, load and temperature. After 30min warm-up.
Analog Remote Programming	
Voltage Accuracy	0.5% of full scale
Current Accuracy	1% of full scale
Power Accuracy	1.5% of full scale
Voltage Monitoring	0.5% of full scale
Current Monitoring	1% of full scale
Power Monitoring	1.5% of full scale
Programming range	0-10Vdc, 4-20mA

Output	
Output Float	Units maybe put in series with the float limit of output terminals must be within ±150V of chassis potential
Parallel	Multiple units can be paralleled to form higher power systems. Chassis control loops are tied together so that resulting higher power systems have the same transient response as a 30kW system. Control commands are only required to be sent to "master" supply. Parallel supplies require a shielded CAT 5 cable (STP) and appropriate output wiring connections by the user.
Calibration	End user calibration is supported. All standard and digital calibration can be performed without removing covers.
Digital Control (Optional)	Ethernet (Modbus-TCP or Ethernet/IP), RS-485 (MODBUS-RTU)
Analog Control	All control signals are isolated from the outputs

ASD Series : Product Specifications 10–320 kW

Advanced Digital Features (Requires Optional Digital Control):	
Graphical User Interface	Graphical User Interface (Windows based) enables remote control and display of the supply operation including the a dvanced features listed below:
Oscilloscope Function (125 Hz)	Up to two parameters; Voltage, current, output impedance, output cable impedance, output cable voltage drop, power delivered…
Data logging	Programmable update rate of 1 sec to 1000 sec (default 10 sec) with last 1000 points stored. Stored parameters include, output voltage/current, programmed set points, input voltage, output impedance, cable impedance, total power deliver, power meter, internal faults
System fault reporting	Outside of set point, output impedance (detection of cabling, connection or load problems)

Physical	30 kW	20 kW	10 kW
Width	19.00in (48.3cm)	19.00in (48.3cm)	19.00in (48.3cm)
Depth	30.00” (76.2 cm)	30.00” (76.2 cm)	30.00” (76.2 cm)
Height	3U - 5.22” rack mount (13.25 cm)	3U - 5.22” rack mount (13.25 cm)	3U - 5.22” rack mount (13.25 cm)
Weight	≤125 lbs (56.69 kg)		
Shipping Weight	Contact factory for more product & shipping weights		
Mounting provisions	EIA rack-mount with slide provisions. Recommended rack slide: Jonathan slide, P/N 370EZ-28		
AC Input Connector	Phoenix Contact terminal block		
Protective Ground	1/4-20 stud		
Output Connectors	bus bars with 3/8-16 inserted PEM nuts		
Water Connections	3/8-18 NPTF hex bulkhead		
Ambient Temperature	0 to 50ºC		
Humidity	Relative humidity up to 95%, non-condensing		

Water cooling specifications	
Flow	1.5 gpm nominal, 1.25gpm minimum, 1.75gpm maximum. Internal condensation must be prevented by ensuring that the temperature of the coolant is sufficiently high compared with the ambient air dew point
Temperature	25ºC nominal, 20ºC minimum, 30ºC maximum
Maximum pressure	80 PSI
Pressure drop	typical 12 PSI @ 1.5gpm per chassis

Regulatory

Certified to UL/CSA 61010 and IEC/EN 61010-1 by a NRTL, CE Compliant, LVD Categories: Installation Category II: Pollution Degree 2; Class II Equipment: for Indoor Use Only. Rack mount equipment requires proper enclosure provided in end use. EMC Directive, EN 61326:1998

Model Number Description

ASD V1 - V2 - V3 ACin Option Option

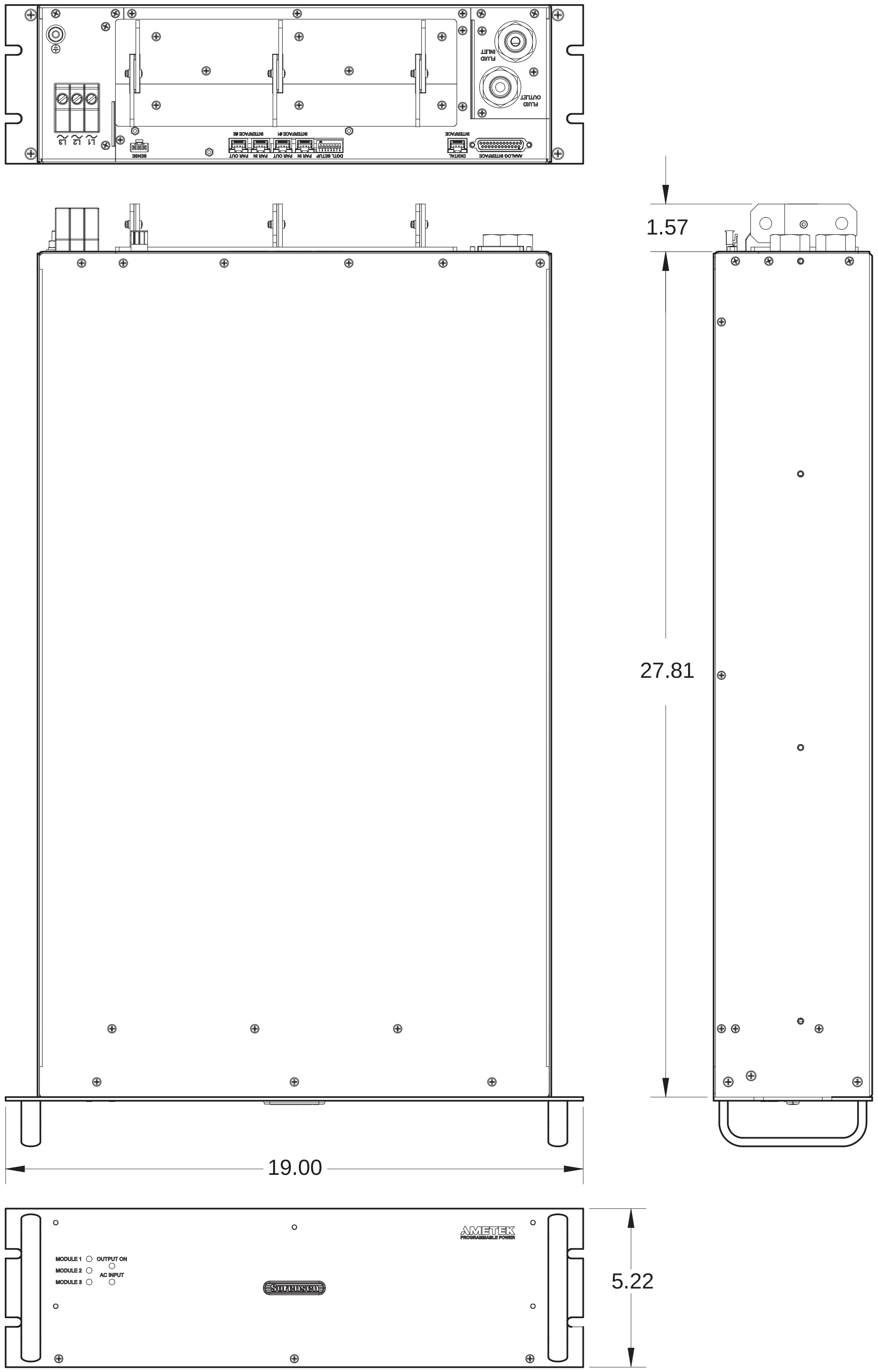
Where V1, V2, V3 (2 characters) indicate the individual module voltage levels:
- 40, for a 40V, 250A module.
- 60, for a 60V, 167A module.
- 00, for no module (empty slot).

ACin (1 character) indicates the AC input voltage:
- D, for 380/400Vrms line to line, nominal voltage.
- E, for 480Vrms line to line, nominal voltage.

Option (2 characters) indicates the optional interface type:
- 2A, Advanced digital feature package including full isolated analog interface and Ethernet (Modbus-TCP) or RS485 interface.
- 2G, Advanced digital feature package including full isolated analog interface (SG-compatible) and Modbus-RTU (serial) inteface
- 1D, for SG-compatible isolated analog interface. No access to advanced digital features or GUI. Serial port is available with maintenance functions only.

Option (2 characters) indicates other optional features:
- AA, standard unit AC Real-time clock (must include advanced digital feature package).

ASD Series : Product Diagram



DC
Bench Top
Power Supplies

Notes

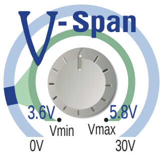
Power Protection of Electrical Devices During Test with Digital Controls on a Programmable Power Supply

Technical Note

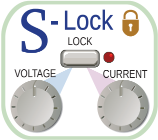
Engineers and technicians in electrical laboratories use programmable power supplies as a basic instrument for either base power or variable power in margin testing. These supplies are typically low cost instruments with very basic controls of an on/off switch and two knobs, one for voltage control and one for current limiting. Knob control continues to be the preferred interface as it allows for each varying of the voltage or current level while viewing other measurement instruments or the device under test for performance.

With the majority of power supplies in this low cost application, there are no limits on the power supply to protect the device under test. Further, most bench top power supplies are required to be used in many different applications at different voltage levels, but are typically needed only over a very narrow range (±10% or ±20%) for an individual application. With the basic controls and wide ranging requirements, it is left to the user to ensure that the voltage is not increased or decreased outside range of safe operation for the device. This makes it easy to damage devices.

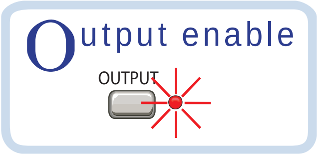
The Sorensen XEL series solves the safety dilemma while maintaining the ease-of-use that knob controls provide.



V-span allows the user to set the minimum and maximum voltage for the knob. The limits can be set at any level up to the rating of the supply. Setup is as easy as 1-2-3. 1a. Use the knob to set the minimum voltage desired, 1b. press and hold the Vmin button until “Set” appears on the display, 2a. Use the knob to set the maximum voltage desired, 2b. press and hold the Vmax button until “Set” appears on the display, 3. Press the ”ENABLE” button to activate the limits. The voltage knobs now will go down to Vmin when turned fully counterclockwise and up to Vmax when turned fully clockwise. For example, if working with a device designed for 5V power, the Vmin might be set at 4 volts and Vmax at 6 volts (±20%). The user can now feel safe in turning the voltage control knob without fear of accidently under- or over- voltage of the device as the knob is turned while watching an output signal. If a broader test is quickly needed without the “safe” limits, the V-span can quickly be turned off with a press of the ”ENABLE” button.



Further device protection is provided for fixed output applications. In these uses, the programmable power supply is used as a voltage rail, e.g. 3.3V, 5V or 12V or 24V. The S-lock provides an easy fixed voltage output from the supply. This effectively provides a front panel lockout of the knob control so that the voltage and current levels are not accidentally changed.



Most low cost power supplies turn on their output as soon as the on/off switch is turned on. This prevents the user from verifying the set voltage and current limit. The XEL Output Enable feature allows preview of the voltage and current settings before turning on the output. While a simple feature, it allows the user to verify the settings before applying them and further avoid damage to the device being tested.

Notes

Sorensen XT Series

42–60 W

60 Watt Linear Performance DC Power Supply

7–250 V

0.25–6 A

~ 115 230

GPIB RS232

- Low noise and ripple
- Excellent line/load regulation
- Fast transient response
- Constant voltage or constant current operation with automatic crossover and mode indication
- Current limit
- Front and rear outputs
- Remote sense 0.5 V per line
- LabVIEW® and LabWindows® drivers

The Sorensen XT Series provides 60 watts of programmable linear DC power in a quarter-rack package suited for both benchtop and system applications. XT Series power supplies are ideal for OEM applications where a wide adjustment of output voltage or current is required in a compact package. For systems applications, multiple single units can be rack mounted in configurations of up to four independent 60-watt outputs.

XT Series : Product Specifications[1]

Output : Voltage and Current

Models	Output Voltage	Output Current	Output Power
XT 7-6	0-7 V	0-6 A	42 W
XT 15-4	0-15 V	0-4 A	60 W
XT 20-3	0-20 V	0-3 A	60 W
XT 30-2	0-30 V	0-2 A	60 W
XT 60-1	0-60 V	0-1 A	60 W
XT 120-0.5	0-120 V	0-0.5 A	60 W
XT 250-0.25	0-250 V	0-0.25 A	60 W

Models	Line Regulation[2] Voltage	Line Regulation[2] Current	Load Regulation[3] Voltage	Load Regulation[3] Current
XT 7-6	2.7 mV	6.25 mA	2.7 mV	6.25 mA
XT 15-4	3.5 mV	4.25 mA	3.5 mV	4.25 mA
XT 20-3	4 mV	3.25 mA	4 mV	3.25 mA
XT 30-2	5 mV	2.25 mA	5 mV	2.25 mA
XT 60-1	8 mV	1.25 mA	8 mV	1.25 mA
XT 120-0.5	14 mV	0.75 mA	14 mV	0.75 mA
XT 250-0.25	27 mV	0.50 mA	27 mV	0.50 mA

Models	Output Noise & Ripple (20 Hz – 20 MHz) Voltage	Output Noise & Ripple (20 Hz – 20 MHz) Current	Meter Accuracy Voltage (1% of Vmax + 1 count)	Meter Accuracy Current (1% of Vmax + 1 count)
XT 7-6	< 1 mVrms	< 2 mArms	0.08 V	0.07 A
XT 15-4	< 1 mVrms	< 2 mArms	0.25 V	0.05 A
XT 20-3	< 1 mVrms	< 2 mArms	0.3 V	0.04 A
XT 30-2	< 1 mVrms	< 2 mArms	0.4 V	0.03 A
XT 60-1	< 1 mVrms	< 2 mArms	0.7 V	0.02 A
XT 120-0.5	< 1 mVrms	< 2 mArms	2.2 V	0.006 A
XT 250-0.25	< 5 mVrms	< 1 mArms	3.5 V	0.003 A

Models	Drift (8 hours)[4] Voltage (0.02% of Vmax)	Drift (8 hours)[4] Current (0.03% of Imax)	Temperature Coefficient[5] Voltage (0.015% of Vmax/°C)	Temperature Coefficient[5] Current (0.02% of Imax/°C)
XT 7-6	1.4 mV	1.8 mA	1.05 mV	1.2 mA
XT 15-4	3 mV	1.2 mA	2.25 mV	0.8 mA
XT 20-3	4 mV	0.9 mA	3 mV	0.6 mA
XT 30-2	6 mV	0.6 mA	4.5 mV	0.4 mA
XT 60-1	12 mV	0.3 mA	9 mV	0.2 mA
XT 120-0.5	24 mV	0.15 mA	18 mV	0.1 mA
XT 250-0.25	50 mV	0.075 mA	37.5 mV	0.05 mA

Specifications subject to change without notice.
1. Specifications indicate typical performance at 25° C ± 5°C, nominal line input of 115 Vac.
2. For input voltage variation over the AC input voltage range, with constant rated load.
3. For 0-100% load variation, with constant nominal line voltage.
4. Maximum drift over 8 hours with constant line, load, and temperature, after 30-minute warm-up.
5. Change in output per °C change in ambient temperature, with constant line and load.
6. Apply accuracy specifications according to the following voltage program accuracy example: Set a model 15-4 power supply to 10 V. The expected result will be within the range of 10 V ± 20 mV ± 0.1% of the set voltage of 10 V.

XT Series : Product Specifications[1]

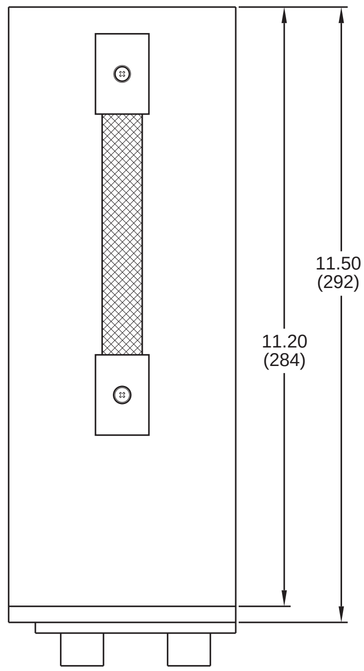
42–60 W

XT 60 W Internal Interface Specifications with RS232 or GPIB Interface Installed[1,6]			
Models	Program Accuracy Voltage (mV)	Program Accuracy Current (mA)	Program Accuracy OVP (mV)
XT 7-6	10 + 0.1%	110 + 0.15%	70
XT 15-4	20 + 0.1%	70 + 0.15%	150
XT 20-3	20 + 0.15%	50 + 0.15%	200
XT 30-2	30 + 0.15%	40 + 0.15%	300
XT 60-1	200 + 0.15%	26 + 0.2%	200
XT 120-0.5	400 + 0.15%	13 + 0.2%	1200
XT 250-0.25	800 + 0.15%	7 + 0.2%	2400

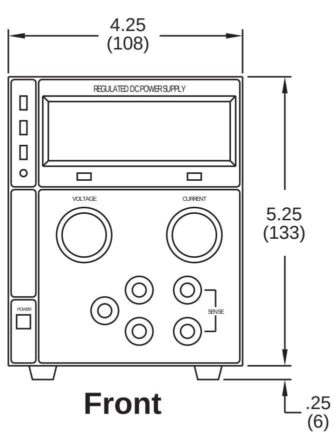
Models	Readback Accuracy Voltage (mV)	Readback Accuracy Current (mA)
XT 7-6	10 + 0.15%	110 + 0.15%
XT 15-4	10 + 0.1%	70 + 0.15%
XT 20-3	10 + 0.1%	50 + 0.15%
XT 30-2	15 + 0.1%	40 + 0.15%
XT 60-1	35 + 0.15%	26 + 0.2%
XT 120-0.5	70 + 0.15%	13 + 0.2%
XT 250-0.25	140 + 0.15%	7 + 0.2%

Input	
Operational AC Input Voltage	Standard: 115 Vac ±10%. 57-63 Hz; Optional: 110/220/230/240 Vac ±10%, 47-63 Hz
AC Input Current	Single Unit: 1.2 A
General	
Voltage Mode Transient Response Time	< 100 µs recovery to 0.05% band, ±50% load change in the range of 25% to 100% of the rated load
Front Panel Voltage and Current Control	10-turn voltage and 1-turn current potentiometers (10-turn current optional)
Front Panel Voltage Control Resolution	0.02% of maximum voltage
AC Input Connector Type	IEC 320 connector
Approvals	CSA certified to CSA C22.2 No. 107.1. Meets USA EMC standard FCC Part 15B Class A; meets Canadian EMC standard: ICES-001, Class A (Models up to and including 120 V)
Analog Programming (with optional APG interface installed)	
Remote On/Off and Interlock	2 to 25 Vdc high. < 0.8 Vdc low. User-selectable.
Remote Analog Programming Option	0-10 Vdc for 0-100% or rated voltage or current ±0.1%, 0-10 kΩ for 0-100% of rated voltage or current ±0.1%
Remote Monitoring	0-10 Vdc for 0-100% of rated voltage or current ±0.1%
Over Voltage Protection Trip Range	3 V to full output +10%
Tracking Accuracy	±1% for series operation
Environmental	
Operating Temperature	0 to 30°C for full rated output. Above 30°C, derate output linearly to zero at 70°C
Storage Temperature	- 55 to 85°C
Humidity Range	Up to 80% RH, non-condensing
Physical	
Dimensions	Width: 4.2” (109.2 mm) Height: 5.2” (134.7 mm) Depth: 11.7” (297 mm)
Weight	Approximately 7.7 lb (3.5 kg)

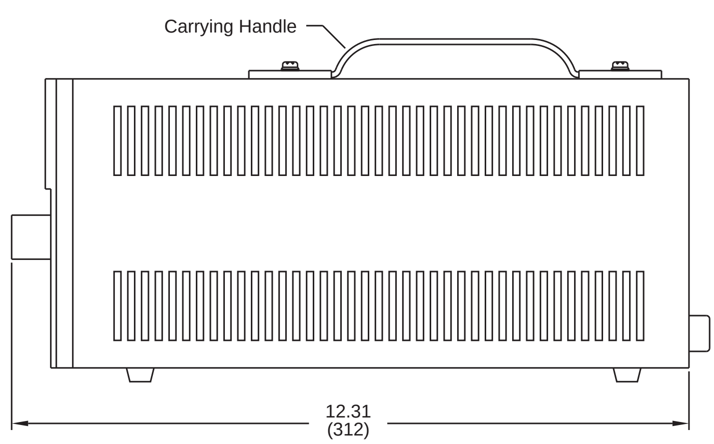
XT Series : Technical Diagram



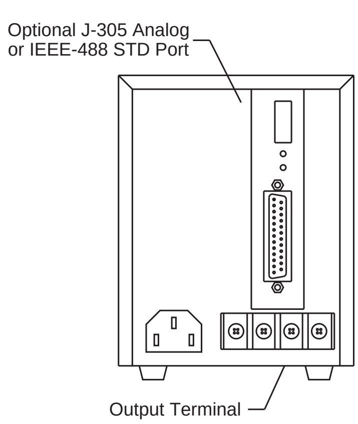
Top



Front

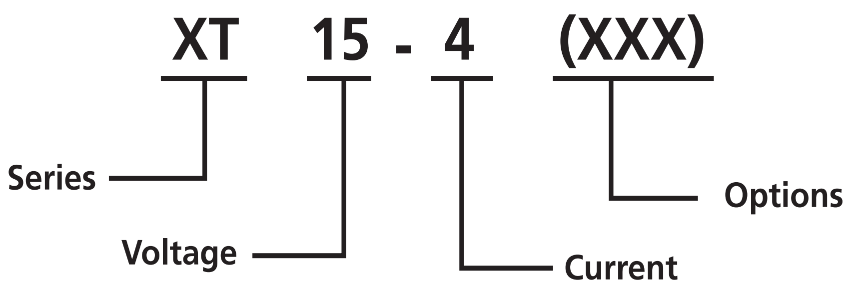


Right Side



Back

Model Number Description



Options and Accessories	
MGA	GPIB Interface card *
MRA	RS-232 Interface card *
MAA	Analog programming interface card *
RM-XPDG-3	19-inch Rack Mount Kit
M11	10-turn current potentiometer
M13A	Locking knobs for front panel controls
M43	Switch Selectable Input 110 Vac or 220 Vac
AC Input Options	
M1	110 Vac Input (50/60Hz)
M2	220 Vac Input (50/60 Hz)
M3	230 Vac Input (50/60Hz)
M4	240 Vac Input (50/60Hz)

* Options cannot be combined.

Notes

Sorensen XPL Series

Compact, low power/low cost benchtop DC power supplies

30–125 W

18–56 V

1–3.3 A

∿	115	230

- Low Noise
- Excellent line/load regulation
- Remote sense
- Coarse and fine voltage controls
- Constant voltage or constant current operation with automatic crossover and mode indication
- Individual On/Off switch per output (not including fixed output)
- Variable (1.5V to 5V) Auxiliary Output
- Shrouded socket-compatible with bare wire and shrouded safety plug connections up to 4 mm.

The Sorensen XPL Series provides 30 to 125 watts of programmable linear DC power. The XPL is a compact, high performance, low cost power supply suited for benchtop applications. The XPL Series uses linear regulation for high performance. The XPL Series features excellent line and load regulation with low noise and good transient response. When the switchable remote sense is used, regulaltion specifications apply at the load. The XPL Series is available in a single, dual and triple-output for benchtop use.

The XPL dual-output model has two independent and isolated outputs each with a 0 to 30 volt, 0 to 2 amps capability and its own On/Off switch. The outputs can be wired in either series or parallel to provide voltages up to 60 volts or currents up to 4 amps. All outputs are intrinsically short-circuit proof, and are protected against external voltages and reverse currents. The XPL triple-output model has the same features as the dualoutput model with an additional variable (1.5V to 5V) auxiliary logic output. Set voltage of the auxilary output can be viewed by a simple touch of a button.

Model Number Description

XPL 18 - 3 _ (XXX)

- **Series** – XPL
- **Voltage** – 18
- **Current** – 3
- **Blank - Single Output**
- **D - Dual Output**
- **T - Triple Output**
- **Options** – (XXX)

XPL Series : Product Specifications[1]

Output : Voltage and Current						
Models	18-3	30-1	30-2	30-2D	30-2T	56-1
Output Voltage	0-18 V	0-30 V	0-30 V	0-30 V	0-30 V	0-56 V
Output Current	0-3.3 A	0-1 A	0-2 A	0-2 A	0-2 A	0-1.1 A
Outputs	1	1	1	2	2 + Aux	1
Output Power	60 W	30 W	60 W	120 W	125 W	60 W
Operating Mode	Constant voltage or constant current with automatic cross-over and indication					
Voltage Setting	By coarse and fine controls					
Current Setting	By single logarithmic control					
Line Regulation	< 0.01% of max. output for a 10% line voltage change					
Load Regulation	< 0.01% of max. output for a 90% load change					
Output Impedance	Typically < 5 mΩ in constant voltge mode. Typically > 50 kΩ in constant current mode					
Ripple & Noise	(20 MHz) Typically < 1 mVrms (CV mode)					
Transient Response	< 20 μs to within 50 mV of set level for 90% load change					
Temperature Coefficient	Typically < 100 ppm/°C					
Output Protection	Outputs will withstand forward voltages of up to 20 V above the rated output voltage. Reverse protection by diode clamp for current up to 3 A.					
Status Indication	Ouptut ON lamps. Constant current mode lamps					
Output Switch	Electronic. Preset voltage and current displayed when output is off					
Output Terminals	4 mm terminals on 19 mm (0.75”) pitch					
Remote Sense	Voltage, local or remote by front panel switch					
Meter	Dual 4 digit meters with 14mm LEDs. Read rate 4Hz.					
Meter Resolutions	10 mV, 1 mA					
Meter Accuracy Voltage	0.3% ± 3 digits					
Meter Accuracy Current	0.6% ± 3 digits					
Auxiliary Logic Output (XPL30-2T only)	Voltage: Variable <1.5V to >5V by front panel control. Meter Voltage Accuracy: 0.3% ± 1 digit Current Limit: 2A minimum Output Protection: Output will withstand up to 7V forward voltage. Diode clamp reverse protection for currents up to 3A Ripple & Noise (20MHz Bandwidth): Typically <5mVrms, <15mVpk-pk (CV mode) Load Regulation: <3% for 90% load change Line Regulation: <0.2% for a 10% line voltage change. Status Indication: UNREG lamp.					
AC Input	115 V or 230 Vac ±10% (adjustable internally, option HV for factory set 230 Vac input) Installation Category II					
Power Consumption	85 VA (XPL 30-1) 160 VA (XPL 30-2, XPL 18-3, XPL 56-1) 320 VA (XPL 30-2D, XPL 30-2T)					
Operating Range	5 to 40°C , 20% to 80% RH					
Storage Range	- 40 to 70°C					
Environmental	Indoor use at altitudes to 2000 m, Pollution Degree 2					
Cooling	Silent fan-less convection cooling					
Safety	Complies with EN61010-1					
EMC	Complies with EN61326					
Dimensions (H x W x D)	6.3 x 5.5 x 11.6” (160 x 140 x 295 mm) (XPL 30-1, XPL30-2, XPL 18-3, XPL 56-1) 6.3 x 10.2 x 11.6” (160 x 260 x 295 mm) (XPL 30-2D, XPL 30-2T)					
Weight	7.5 lb (3.4 kg) (XPL 30-1) 9.7 lb (4.4 kg) (XPL30-2, XPL 18-3 XPL 56-1) 16.5 lb (7.5 kg) (XPL 30-2D, XPL 30-2T)					
Approvals	CE-marked units meet: EN61010-1 and EN61326					
Options						
230 Vac input factory set (Option HV)						

Sorensen XEL Series

90W Linear Benchtop Supply with V-Span

75–180 W

15–250 V

360 mA–6 A

	∿	115	230

LXI USB GPIB RS232

- Ideal for engineering lab use
- Digital features with analog controls
- Remote control for bench & system application
- S-Lock: Set and lock the voltage
- V-Span: user-defined voltage limits
- Small benchtop footprint

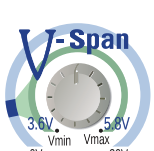
The Sorensen XEL benchtop power supply is as easy to use as simple analog power supplies but offers the flexibility of advanced digital features. The user interface allows easy control with single-turn knobs including a fine control knob for voltage.

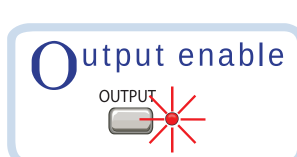
This easy-to-use interface is complemented by V-Span, S-lock and Output Enable functions. V-Span allows the user to set a maximum and minimum value over which the knob control operates. This provides more precise control over the voltage as the knob operates over a narrow range as well as protecting devices under test by limiting the maximum voltage. S-Lock provides an easy method to output a regulated fixed voltage. Output Enable lets the user setup the desired voltage and current levels prior to actually turning on the output. All of these features in a laboratory bench supply are only found in the XEL series.

At 4.2x11.3 inches (108mm x 287mm), the XEL series occupies the least bench top space of any programmable power supply. The dual output model offers 90W per channel, also in a compact 8.4x11.3 inches (216mm x 287mm)

The dual output XEL30-3D is two 30V/3A power supplies in one unit. All of the features of the single output version are also in the dual output. The outputs are fully independent and isolated. Plus, the outputs can be operated in 4 modes: isolated, tracking, ratio tracking and true parallel. In addition, the outputs can be enable (on/off) independently or synchronously.

The programming “P” option includes LXI Class C Ethernet, USB, RS-232 and analog remote control. The option “GP” inlcudes GPIB programming plus all of the interface methods included in the “P” option described above.





XEL Series : Product Specifications

Output Ratings						
Model	XEL 15-5	XEL 30-3	XEL 60-1.5	XEL 30-3D	XEL 120-0.75	XEL 250-0.37
Voltage (VDC)	0-15	0-30	0-60	0-30	0-120	0-250
Current (ADC)	0.1 mA - 5 A	0.1 mA - 3 A	0.1 mA - 1.5 A	0.1 mA - 3 / 6 A	0.01 mA - 750 mA	0.01 mA - 375 mA
Power (W)	75	90	90	90/180	90	90
Output Performance[1]						
Voltage Meter	4-digit meter					
Accuracy, Resolution	0.1% + 10mV, 10mV				0.1% + 100mV, 100mV	
Current Meter	4-digit meter					
Accuracy	± (0.3% + 0.005A) to 3A, ± (0.5% + 0.005A) to 6A, ± (0.3% + 0.5mA) on 500mA range				± (0.3% + 0.1mA), ± (0.3% + 0.01mA) on 75mA range	
Resolution	1mA (0.1mA on 500mA range)				0.1mA (0.01mA on 75mA range)	
Low Current	< 500mA				< 75mA	
Accuracy, Resolution	0.3% + 0.3mA, 0.1mA				0.3% + 0.03mA, 0.01mA	
Voltage Ripple (20MHz bandwidth)	0.4 mVRMS				2mV	
Voltage Noise (20MHz bandwidth)	2 mVpp				10mVpp	
Current Ripple	< 0.2 µARMS (< 40 µARMS on 500mA range)				< 10 µARMS (< 1 µARMS on 75mA range)	
Digital Programming Performance Option						
Voltage Accuracy, Resolution	± (0.05% + 10mV), 1mV				± (0.05% + 50mV), 10mV	
Current Accuracy	± (0.3% + 0.005A) to 3A, ± (0.5% + 0.005A) to 6A, ± (0.3% + 0.5mA) on 500mA range				± (0.3% + 0.1mA), ± (0.3% + 0.01mA) on 75mA range	
Current Resolution	0.1mA (0.01mA on 500mA range)				0.1mA (0.01mA on 75mA range)	
Load Regulation						
Voltage	0.01% + 4.5mV with remote sense up to 0.5V line drop					
Current	0.01% + 500µA Specification applies for line resistance <0.5ohms when remote sense is used					
Line Regulation (10% line change)						
Voltage	0.01% + 2.0mV				0.01% + 10mV	
Current	0.01% + 250µA				0.01% + 50µA	
Transient Response	< 250µs to within 50mV of setting (90% load change)					

[1] 120V & 250V models have a slightly modified performance specification. See data sheet or manual on web site for complete specifications

Common	
AC Input	115 VAC ± 10%, 50/60Hz (230VAC available as option MHV) (100VAC available as option MJV)
Power	280VA maximum
Operating Temperature	5-40 °C, 20-80% RH
Storage Temperature	-40 to +70 °C
Weight	9.9 lbs. / 4.5 kgs, XEL30-3D: 18.8 lbs. / 9 kgs
Size (WxHxD)	4.2x5.2x11.3 inches / 107x131x288 mm, XEL30-3D: 8.4x5.2x11.3 inches / 214x131x288 mm

Options	
MHV	Configured for 230VAC input
MJV	Configured for 100VAC input
Programming “P”	LXI Class C Ethernet, USB, RS-232 and remote analog **
Programming “PG”	GPIB 488.2, LXI Class C Ethernet, USB, RS-232 and remote analog **
RM - XPDG-3	Rackmount Kit

Model Numbers	
XEL15-5	15 V, 5 A
XEL30-3	30 V, 3 A
XEL60-1.5	60 V, 1.5 A
XEL30-3D	30 V, 3 A Dual Output. The outputs are fully independent and isolated.
XEL120-0.75	120V, 0.75A
XEL250-0.37	250V, 0.37A

* Current accuracy in parallel mode = 0.5% + 3mA ** Remote Analog not available on dual “D” ouput option

Sorensen XDL Series II

105–215 W

Digitally Controlled DC Linear Power Supplies

35–56 V

0.5–5 A

	∿	115	230

USB GPIB RS232 LXI

- Very high precision, very low noise, excellent dynamics
- Advanced user interface with direct numericentry and incremental rotary control
- Fifty store/recall setup locations
- Fully isolated outputs for maximum flexibility
- Constant voltage or constant current operation with automatic crossover and mode indication
- GPIB, RS-232, USB and LXI Compliant LAN Ethernet are provided interfaces

Exceptional precision
The XDL Series II offers an unparalleled level of precision. Voltage and current are controlled using instrumentation quality 16 bit DACs enabling voltages to be set to 1mV resolution even at full output voltage. Indeed, the accuracy is sufficient for the XDL to be used as a calibration source for some hand-held DMMs.

Multiple ranges for greater flexibility
The XDL Series II provides multiple ranges for increased current capability at lower voltages. The XDL564, for example, is a 112W PSU with three ranges. The main range offers 0 to 56 volts at up to 2 amps. The higher current range provides up to 4 amps for voltages up to 25V. A further low current range provides an enhanced current setting and measurement resolution of 0.1mA.

Unrivalled performance
The XDL Series II uses pure linear technology and offers unrivalled performance in terms of regulation, output noise and dynamics. Line and load regulation are close to the limit of measurement. Recovery time from transient current pulses is better than 50µs. Differential output noise is less than 350µV rms in CV mode and down to 20µA rms in CI mode. Of equal importance for critical applications in areas such as telecoms is common mode noise current (the noise current flowing between the output terminals and ground). This is less than 4µA rms on the XDL Series II - dramatically better than most other PSUs.

Direct numeric entry
Settings can be made by direct numeric entry using the 0 to 9 keypad. Each new setting is previewed on the display and must be confirmed with the OK key. Settings recalled from memory are similarly previewed and confirmed. Numeric setting is very fast requiring only three key presses to set to 5 volts, for example, (V, 5, OK). To set a more precise level such as 12.725 volts requires more key presses, but can still be done in seconds.

Incremental rotary control
For those preferring quasi-analogue control, or for applications where the voltage or current must be gradually changed, the Jog wheel is available. The wheel has a positive stepped action but can be spun rapidly when required. Output voltage can be incremented or decremented in steps of 0.1V, 10mV or 1mV. Current steps can be selected from 0.1A down to 0.1mA.

The Jog function can be left permanently engaged or can be disabled at the touch of a button.

Setting memories for added convenience
The XDL Series II II provided storage of up to 50 power supply sets-up in non-volatile memory (160 set-ups for a triple). Voltage, current, OVP and OCP are all saved. An further power-down memory is also incorporated. Upon mains switch-off, the set-up of the PSU is saved and is automatically restored at switch-on. On the triple output models, independent memories are provided for each output, plus an additional set for 'linked' mode where the user may wish to recall settings for both outputs simultaneously.

Remote or local sense
The XDL Series II provides full remote sense capability via dedicated sense terminals. Remote sense is essential to maintain regulation at the load (two 0.01 Ohm connection leads will drop 100mV at 5 amps).When remote sense is not required, internal local sensing can be selected at the touch of a button.

XDL Series II : Product Specifications[1]

Output : Voltage and Current						
Models	35-5	35-5T	35-5P	35-5TP	56-4	56-4P
Output Range	1 0-35 V, 0-3 A	0-35 V, 0-3 A	0-35 V, 0-3 A	0-35 V, 0-3 A	0-56 V, 0-2 A	0-56 V, 0-2 A
Output Range 2	0-15 V, 0-5 A	0-15 V, 0-5 A	0-15 V, 0-5 A	0-15 V, 0-5 A	0-25 V, 0-4 A	0-25 V, 0-4 A
Output Range 3	0-35 V, 0-500.0 mA	0-35 V, 0-500.0 mA	0-35 V, 0-500.0 mA	0-35 V, 0-500.0 mA	0-56 V, 0-500.0 mA	0-56 V, 0-500.0 mA
Outputs	1	2 + 1 Aux	1	2 + 1 Aux	1	1
Output Power	105 W	215 W	105 W	215 W	112 W	112 W
Interface (GPIB/RS-232/USB/LXI LAN)	No	No	Yes	Yes	No	Yes
Voltage Setting	By floating point numeric entry or rotary jog wheel; resolution 1mV					
Current Setting	By floating point numeric entry or rotary jog wheel; resolution 1mA or 0.1mA depending on range					
Voltage Setting	Resolution 1mV Accuracy ± (0·03% + 5mV)					
Current Setting	Resolution 1mA; 0·1mA on 500mA range Accuracy ± (0·2% + 5mA); ± (0·2% + 0·5mA) on 500mA range.					
Output Mode	Operation in constant voltage or constant current modes with automatic cross-over and mode indication by LEDs.					
DC Output Switch	Illuminated when output is on. Preset voltage and current limit displayed when output is off.					
Output Terminals	4 mm terminals on 19 mm (0.75") spacing. Duplicate rear panel sense terminals on remote control models (XDL35-TP)					
Load Regulation	Voltage: < 0.01% + 2 mV Current: < 0.01% + 250 µA; < 0.01% + 50 µA on 500 mA range (measured at output terminals using remote sense)					
Line Regulation	Voltage: < 0.01% + 2 mV for 10% line change Current: < 0.01% + 250 µA; < 0.01% + 50 µA on 500 mA range					
Ripple and Noise	Typically < 0.35% 1mVrms 2 mVp-p CV mode, and < 0.2 mArms, < 20 µArms (500 mA range) CI mode					
Transient Response	50 µs to within 15 mV of set level for a change in load current from full load to half load or vice versa					
Temperature Coefficient	<± (50 ppm + 0.5 mV) / °C, < (100ppm + 1 mA) °C, < (100ppm + 0.1 mA) 500 mA range typical					
Remote Sense	Eliminates up to 0.5 V drop per lead. Remote sense operation selected from front panel and indicated by LED					
Sense Terminals	Recessed sprung sockets for direct insertion of wires. Duplicated on rear terminal block (P versions only)					
Auxiliary Logic Output	Voltage: 2-7V or 5V, selectable by front panel switch Voltage Accuracy: ± 5% Current Limit: 1A minimum Output Protection: Output will withstand up to 16V forward voltage. Diode clamp reverse protection for currents up to 3A. Ripple & Noise (20MHz Bandwidth): Typically <1m Vrms Load Regulation: <1-0% for 90% load change Line Regulation: <0-1% for a 10% line voltage change Status Indication: Current limit lamp.					
Digital Bus Interfaces (P suffix models only)	All interfaces are at ground potential and opto-isolated from the output terminals. RS-232: Standard 9-pin D connector. Baud rate variable 600 to 19,200. USB: USB 2.0 connection operates as a virtual COM port. GPIB (IEEE-488): The interface conforms with IEEE-488.1 and IEEE-488.2. Ethernet (LAN): Standard 10/100 base-T hardware connection. ICMP and TCP/IP Protocol for connection to Local Area Network or direct connection to a single PC. LAN interface is compliant with LXI class C.					

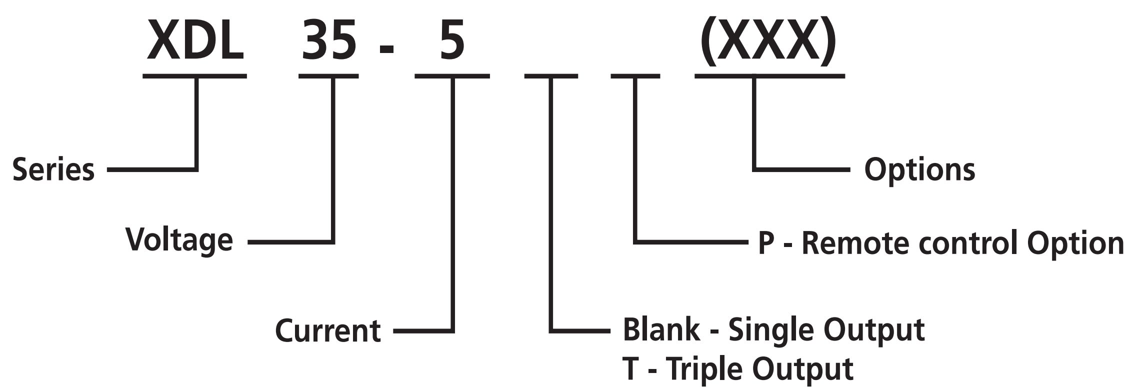
General Specifications	
Operational AC Input Voltage	115 V or 230 V ± 10% (adjustable internally, option HV for factory set 230 Vac input), 50/60 Hz. Installation Category II
Operating Temperature Range	5 to 40°C, 20% to 80% RH
Storage Temperature Range	- 40 to 70°C
Dimensions (H x W x D)	6.3 x 5.5 x 11.4" (160 x 140 x 290 mm) (XDL 35-5, XDL 35-5P, XDL 56-4, XDL 56-4P), 6.3 x 11.0 x 11.4" (160 x 280 x 290 mm) (XDL 35-5T, XDL 35-5TP)
Weight	11.9 lb (5.4 kg) (XDL 35-5, XDL 56-4) 12.1 lb (5.5 kg) (XDL 35-5P, XDL 56-4P) 23.1 lb (10.5 kg) (XDL 35-5T) 23.3 lb (10.6 kg) (XDL 35-5TP)
Benchtop Operation	Folding legs are incorporated that can be used to angle the front panel upwards when required
Rack Mount Operation	19-inch 4U mount for up to three single output units or one triple, plus one single Blanking plates available for unused sections
Approvals	CE-marked units meet: EN61010-1 and EN61326

Specifications subject to change without notice.

XDL Series II

105–215 W

Model Number Description



Notes

Sorensen XBT 32-3FTP

222 W

True Triple Output Digital Benchtop Power Supply

15–32 V

3–5 A

~	115	230

ETHERNET USB GPIB RS232

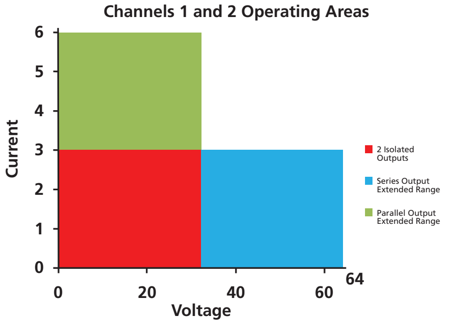
- Fully programmable 3rd output 15V/5A/30W
- High resolution, 16-bit programming and readback
- Isolated, tracking, parallel or series operation
- 100 hour timer
- USB and RS-232 Standard
- IEEE488.2 and Ethernet control Optional

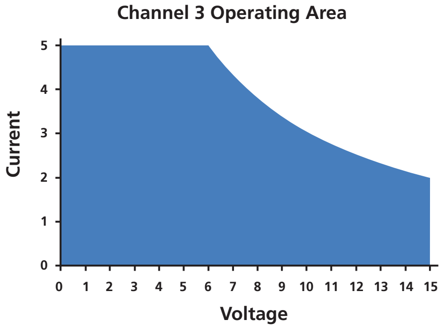
The XBT32-3FTP adds to the capability of the Sorensen benchtop product line with a 16-bit triple output supply. Channels 1 and 2 can be programmed 0-32V and 0-3A each. The third output is fully programmable 0-15V, 0-5A up to a maximum of 30W. Channels 1 and 2 can be configured for tracking, parallel or series operation to, in effect, provide the equivalent of 6 different power supplies. In isolated mode, each of the 3 outputs functions independently; in tracking mode, channels 1 and 2 provide the same, but isolated output; in parallel mode, there is one 0-32V/0-6A output and one 0-15V/0-5A/30W output; in series mode, there is one 0-64V/0-3A output and one 0-15V/0-5A/30W output.

Safety of devices under test is paramount. The XBT series of power supplies provides superior device protection. Each output is fully isolated with voltage/current preview before turning on the output. Built-in switches, in addition to enabling the preview mode, can configure the outputs for parallel or series connection while graphics on the front panel show the user where to make connections.

Advanced engineering features include storage of 100 different setups (voltage and current) as well as a 100 hour timer. Power- on state and synchronous or individual control of each channel output can also be set. Over-voltage and over-current protection is programmed for each channel.

Computer control is easily accomplished through industry-standard SCPI commands via the USB or RS-232C interfaces which come standard on every unit. The GPIB / Ethernet interface option allows 3 low power channels in a half-rack for ATE applications. This option also includes an 8-bit digital I/O which can be set as input or output signals for programming.





XBT 32-3FTP : Product Specifications

Output Ratings		
	Channel 1 and 2	**Channel 3**
Voltage (VDC)	0-32	0-15
Current (ADC)	0-3	0-5
Power (W)	96	30
Output Performance		
Voltage Setting and Readback		
Accuracy	0.01% + 5mV	
Amplitude Resolution	1mV	1mV
Current Setting and Readback		
Accuracy	0.1% + 3mA	0.1% + 3mA
Resolution	100 µA	100 µA
Voltage Ripple	0.5 mVRMS	1mVRMS
Voltage Noise	5 mVpp	20mVpp
Current Ripple	1mA	5mARMS
Load Regulation		
Voltage	0.01% + 2mV	5mV
Current	0.01% + 300 µA	
Line Regulation		
Voltage	0.01% + 2mV	
Current	0.01% + 300 µA	
Stability (8 hours, constant load and temperature)		
Voltage	0.02% + 2mV	
Current	0.01% + 1mA	
Temperature Coefficient (per C)		
Voltage	0.01% + 3mV	
Current	0.02% + 2mA	
Transient Response	50µS	
Voltage Programming Time (typical)		
Rise Time (Full Load)	1ms	3ms
Rise Time (No Load)	1ms	3ms
Fall Time (Full Load)	3ms	8ms
Fall Time (No Load)	250ms	250ms

Common	
Memory Storage	100 setups
Timer	1 second to 100 hours
Regulatory Compliance	cETLus (ANSI/UL61010-1-04, CAN/CSA C22.2 No. 61010-1-04) Compliant to CE Mark LVD EN61010-1, EMC EN61326
AC Input	115 / 230 VAC 10%, 47-63Hz
Operating Temperature	0 to 40 C
Storage Temperature	-10 to +70 C
Weight	14.3 lbs. / 6.5 kgs
Size (WxHxD	8.5x5.3x17 in / 216x135x432 mm
Options and Accessories	
M139	IEEE488.2 and Ethernet control interfaces
MHV	Setup for 230V 10% AC Input
RM-XBT	Rack mount kit for XBT Series power supplies

Sorensen XPF Series

350–840 W

Single or Dual Output DC Power Supply with Powerflex™

35–60 V

10–20 A

∿	115	230

GPIB RS232 LXI

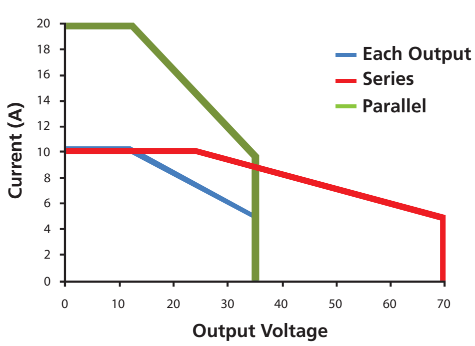
- PowerFlex design with parallel or series configuration gives variable voltage/current combinations **equivalent to 6 power supplies in one unit**
- Individual on/off switch per output
- Dual isolated outputs
- Coarse and fine voltage controls
- Simultaneous display of output voltage and current for each output

The Sorensen XPF is a new type of bench power supply designed to meet the need for flexibility in the choice of voltage and current. Typically, the maximum voltage and maximum current are not required simultaneously. The PowerFlex™ design enables higher currents to be generated at lower voltages within an overall power limit envelope. This is achieved by using the latest switch-mode technology.

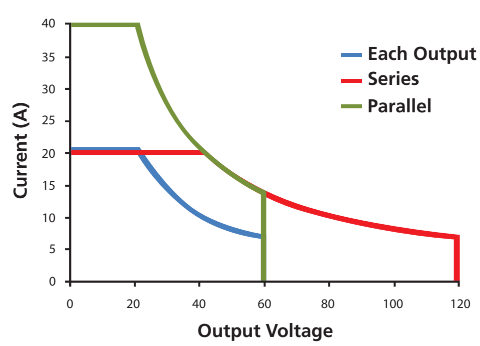
The XPF Series are dual output DC power supplies with two completely independent and isolated outputs. If required, the outputs can be wired in series or parallel to achieve up to double the maximum voltage or double the maximum current.

PowerFlex Operating Configurations

XPF35-10 Series Operating Area



XPF60-20 Series Operating Area



XPF Series : Product Specifications

Output : Voltage and Current		
Models	35-10 Series	60-20 Series
Output Ratings (Each Output)		
Output Voltage	0 - 35 V	0 - 60 V
Output Current	0 - 10 A	0 - 20 A
Outputs	2	Single: 1 Dual: 2
Output Power	up to 175 W (See PowerFlex envelope graph)	up to 420 W (See XPF 35-10 and XPF 60-20 PowerFlex power envelope graph)
Output		
Models	35-10 Series	60-20 Series
OVP Range	10% - 110% of maximum output voltage	1V to 66V
Voltage Setting	By coarse and fine controls	
Current Setting	By single logarithmic control	
Output Impedance	Typically <5mΩ in constant voltage mode. Typically >5kΩ in constant current mode (voltage limit at max.)	
Line Regulation	<0.01% for a 10% line voltage change.	
Load Regulation	<0.05% for a 90% load change.	<0.01% for a 90% load change.
Ripple and Noise	typically 2 mV rms, <20 mV pk-pk, (20 MHz bandwidth) both outputs fully loaded (5A @ 35 V), in CV mode.	typically 1 mV rms, <10 mV pk-pk, (20 MHz bandwidth) both outputs loaded (10A @ 42 V), in CV mode.
Transient Response	<2ms to within 100mV of set level for 90% load change.	<250µs to within 50mV of setting for a 5% to 95% load change
Temperature Coefficient	Typically <100ppm/°C	
Output Protection	Forward protection by OVP trip; maximum voltage that should be applied to the terminals is 50 V for XPF35-10 and 70V for XPF60-20. Reverse protection by diode clap forreverse currents up to 3A.	
Status Indication	LED indication of Output On, CV, CI and Power Limit. Message on display for over-voltage trip	
Output Switch	Push-push switch operating electronic power control. Preset voltage and curent are displayed when the output is off	
Output Terminals	4mm terminals on 19mm (0.75”) pitch. 15 A max. rating (XPF 35-10) and 30 A max. rating (XPF 60-20)	
Sensing	Remote sensing via a front panel terminal block or local sensing (at output terminals). Selection by slide switch	
Meter Type	Dual 4 digit meters with 12.5mm LEDs. Read rate 4Hz.	
Meter Resolution	10 mV, 10 mA	
Meter Accuracy		
Voltage	0.2% ± 1 digit	0.1% +/- 2 digit
Current	0.5% ±1 digit	0.3% +/- 2 digit
Input		
AC Input	110 V - 120 V AC or 220 V - 240 V AC +/- 10% (adjustable internally, option HV for factory set 220-240 VAC input) 50/60 Hz. Installation Category ll	110 to 240 volts ±10% 50/60Hz. Installation Category II
Environmental		
Operating Temperature	Indoor use at altitudes up to 2000m, Pollution Degree 2	
Storage Temperature	-40 °C to + 70 °C	
Physical		
Dimensions	130x210x350mm (½ rack 3U height)	Single - 107 x 130 (¼ rack 3U) x 398mm Dual - 210 x 130 mm (½ rack 3U) x 377mm (size excludes feet, knobs and terminals)
Weight	5kg (11lb)	Single - 4.25kg (9.35lb) Dual - 6.3kg (13.9lb)
General		
Cooling	Convection (XPF 35-10), Fan (XPF 42-20)	
Power Consumption	625 VA max. (XPF 35-10)	1250 VA max. (XPF 60-20)
Safety	Complies with EN61010-1	
EMC	Complies with EN61326	
Regulatory	CE-marked units meet: EN61010-1 and EN61326	
Protection Features		
Over voltage protection per output		
Switchable remote or local sense		

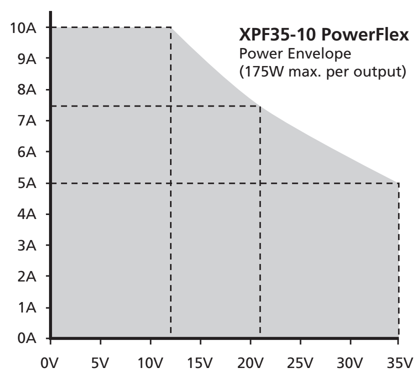
XPF Series

350–840 W

Power Envelope (each output)

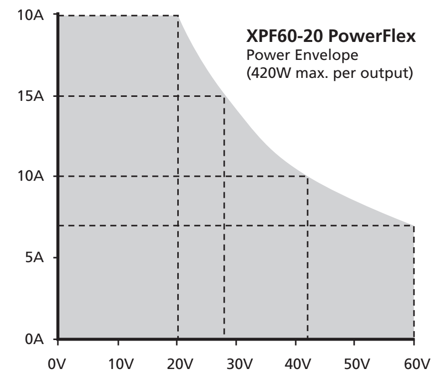
The maximum current at any voltage setting is limited by the power envelope which is set to give 5A at 35V rising to 10A at 12V and lower.

Double the current or double the voltage can be achieved by parallel or series connection of the two outputs.

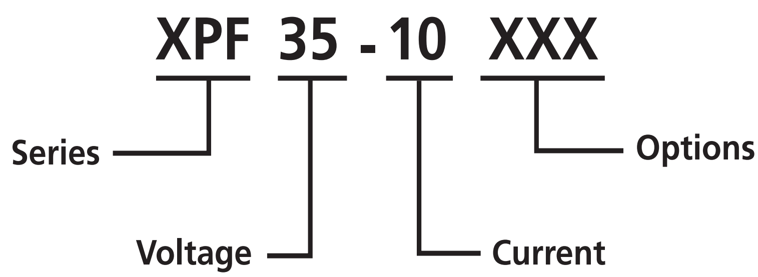


The maximum current at any voltage setting is limited by the power envelope which is set to give 7A at 60V rising to 20A at 20V and lower.

Double the current or double the voltage can be achieved by parallel or series connection of the two outputs.



Model Number Description



Options and Accessories

MHV (Input Voltage Option)	230 VAC input factory set

Model Table

		Interfaces				
Model	Outputs	Analogue	RS-232	USB	LAN (LXI)	GPIB
XPF35-10	2					
XPF60-20S	1	•				
XPF60-20SA	1		•	•	•	•
XPF60-20SP	1					
XPF60-20D	2		•	•	•	•
XPF60-20DP	2					

Notes

Sorensen HPD Series

300 W

300 Watt DC Power Supply with Near-Linear Performance

15–60 V

5–20 A

∿ 115 230

GPIB RS232

- Low noise and ripple
- Excellent line/load regulation
- Constant voltage or constant current operation with automatic crossover and mode indication
- Current limit
- Front and rear outputs
- Remote sense
- LabVIEW® and LabWindows® drivers

The Sorensen High Power Density (HPD) Series provides 300 watts of reliable DC power in a quarter-rack wide unit. The HPD Series power supplies are ideal for benchtop, ATE and OEM applications where a wide adjustment of output voltage or current is required in a compact unit.

The HPD series uses switch-mode technology combined with linear post regulation to provide performance comparable to an all-linear design. The HPD series features excellent line and load regulation with low noise and good transient response. The series is available in a single unit for benchtop use. For systems applications, multiple units can be rack-mounted in configurations of up to four independent 300-watt outputs.

HPD Series : Product Specifications[1]

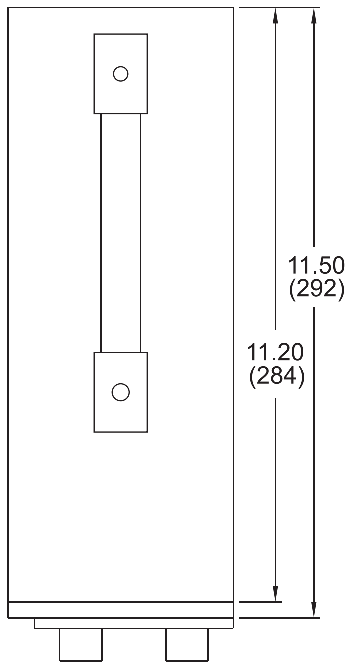
Output : Voltage and Current			
Models	15-20	30-10	60-5
Output Ratings			
Output Voltage	0-15 V	0-30 V	0-60 V
Output Current	0-20 A	0-10 A	0-5 A
Output Power	300 W	300 W	300 W
Line Regulation [2]			
Voltage (0.01% of Vmax + 2 mV)	3.5 mV	5 mV	8 mV
Current (0.05% of Imax + 2 mA)	12 mA	7 mA	4.5 mA
Load Regulation [3]			
Voltage (0.01% of Vmax + 2 mV)	3.5 mV	5 mV	8 mV
Current (0.05% of Imax + 2 mA)	12 mA	7 mA	4.5 mA
Meter Accuracy			
Voltage (1% of Vmax + 1 count)	250 mV	400 mV	700 mV
Current (1% of Imax + 1 count)	300 mA	200 mA	60 mA
Output Noise (90-20 MHz)			
Voltage (p-p) (0-20 MHz) rear panel	75 mV	75 mV	100 mV
Voltage (p-p) (0-20 MHz) front panel	100 mV	100 mV	180 mV
Output Ripple			
Voltage rms, rear panel	5 mV	5 mV	5 mV
Voltage rms, front panel	10 mV	10 mV	10 mV
Drift (8 hours) [4]			
Voltage (0.02% of Vmax)	3 mV	6 mV	12 mV
Current (0.08% of Imax)	16 mA	8 mA	4 mA
Temperature Coefficient [5]			
Voltage (0.015% of Vmax/°C)	2.25 mV	4.5 mV	9 mV
Current (0.02% of Imax/°C)	4 mA	2 mA	1 mA
HPD 300 W Internal Interface Specifications with RS-232 or GPIB Interface Installed [1,6]			
Models	15-20	30-10	60-5
Program Accuracy			
Voltage (mV)	60 + 0.1%	70 + 0.1%	90 + 0.12%
Current (mA)	75 + 0.12%	50 + 0.12%	25 + 0.1%
OVP (mV)	1500	3000	6000
Readback Accuracy			
Voltage (mV)	45 + 0.3%	90 + 0.3%	175 + 0.3%
Current (mA)	75 + 0.12%	40 + 0.12%	25 + 0.1%

Specifications subject to change without notice.
1. Specifications indicate typical performance at 25°C ± 5°C, nominal line input of 120 Vac.
2. For input voltage variation over the AC input voltage range, with constant rated load.
3. For 0-100% load variation, with constant nominal line voltage.
4. Maximum drift over 8 hours with constant line, load, and temperature, after 60-minute warm-up.
5. Change in output per °C change in ambient temperature, with constant line and load.
6. Apply accuracy specifications according to the following voltage program accuracy example: Set a model 15-20 power supply to 10 V. The expected result will be within the range of 10 V ± 60 mV ± 0.1% of the set voltage of 10 V.

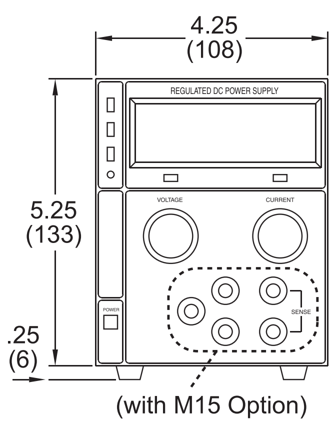
HPD Series : Product Specifications[1] 300 W

Input	
Operational AC Input Voltage	Single unit: 104-127 Vac at 6 Arms; 47-63 Hz
General	
Switching Frequency	100 kHz (nominal)
Voltage Mode Transient Response Time	< 500 µs recovery to 50 mV band for ±50% load change in the range of 25% to 100% of the rated load
Front Panel Voltage and Current Control	10-turn voltage and 1-turn current potentiometers (10-turn current optional)
Front Panel Voltage Control Resolution	0.02% of maximum voltage
AC Input Connector Type	EC 320 connector
Approvals	CE-marked units meet: EN61010-1, EN61000-6-2 and EN61000-6-4; CSA C/US certified to UL61010-1B and CSA C22.2 No 1010.1; Meets USA EMC standard: FCC, part 15B, Class A; Meets Canadian EMC standard: ICES-001, Class A.
Analog Programming (with optional APG interface installed)	
Remote On/Off and Interlock	2 to 25 Vdc high. <0.8 Vdc low. User-selectable.
Remote Analog Programming Option	0-10 Vdc for 0-100% of rated voltage or current ±1.0%, 0-10kΩ for 0-100% of rated voltage or current ±1.0%
Remote Monitoring	0-10 Vdc for 0-100% or rated voltage or current ±1.0%
Over Voltage Protection Trip Range	3 V to full output ±10%
Tracking Accuracy	±1% for series operation
Environmental	
Operating Temperature	0 to 30°C for full rated output. Above 30°C, derate output linearly to zero at 70°C.
Storage Temperature	- 55 to 85°C
Humidity Range	0 to 80% RH, non-condensing
Physical	
Dimensions	Width: 4.2” (109.2 mm) Height: 5.2” (134.7 mm) Depth: 11.7” (297 mm)
Weight	Approximately 7.7 lb (3.5 kg)

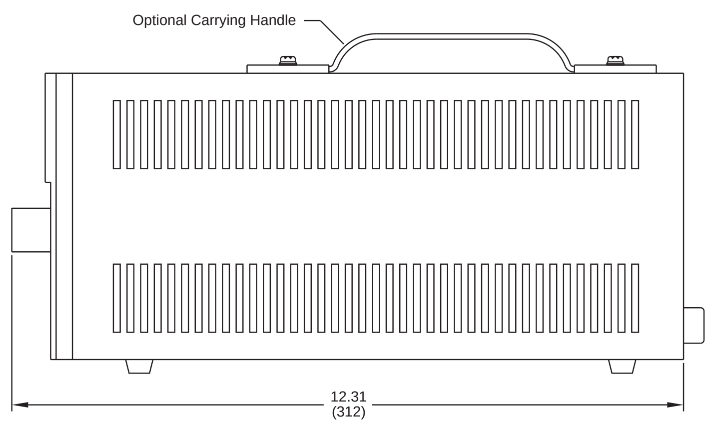
HPD Series : Technical Diagram



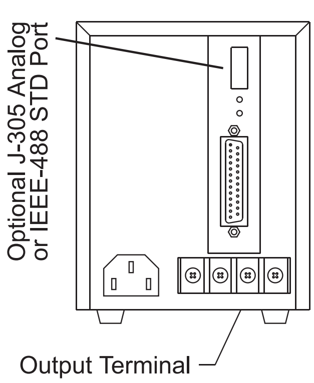
Top



Front



Right Side

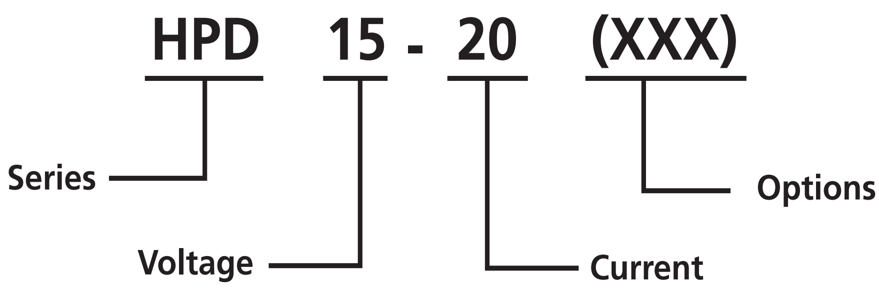


Back

HPD Series

300 W

Model Number Description



Options and Accessories

MGA *	GPIB Interface card
MRA *	RS-232 Interface card
MAA *	Analog programming interface card
M2S	Switch selectable input 110 Vac or 220 Vac
M11	10-turn current potentiometer
M13A	Locking knobs for front panel controls
RM-XPDG-3	19-inch Rack Mount Kit
M2	AC Input Option - 200-250 Vac Input (50/60 Hz)

* Options cannot be combined.

Notes

Sorensen XPH Series

175–420 W

Compact High Power Bench DC Power Supplies

18–75 V

2–20 A

~	115	230

- Low noise
- Excellent line/load regulation
- Coarse and fine voltage controls
- Constant voltage or constant current operation with automatic crossover and mode indication
- Individual On/Off switch per output (not including fixed output)
- Variable 1.5 -5V output on triple output model
- Switchable remote sense

The Sorensen XPH Series provides 175 to 420 watts of programmable DC power. The XPL is a compact, high performance, low cost power supply suited for benchtop applications.

The XPH Series uses combined switchmode pre-regulation with linear post-regulation to provide performance comparable with an all-linear design. The XPH features excellent line and load regulation with low noise and good transient response. The XPH Series is available in a single, dual and triple output for benchtop use.

The XPH dual output models have two independent and isolated outputs with its own On/Off switch. The outputs can be wired in either series or parallel to provide higher voltage or higher current output. All outputs are intrinsically short circuit proof, and are protected against external voltages and reverse currents. The XPH triple-output model has the same features as the dual-output model with an additional variable auxilary output of 1.5 volts to 5 volts with a minimum of 5A current capabilities.

Output voltages up to 150 volts
The XPH75-2D is a dual-output 300-watt power supply with multi-mode capability. This enables it to operate as a dual power supply with two independent and isolated outputs, or as a single power supply of double the power. As a dual, each output provides 0 to 75 volts at 0 to 2 amps (mode A). As a single the output can be selected as either 0 to 75 volts at 0 to 4 amps (mode B) or 0 to 150 volts at 0 to 2 amps (mode C). In single modes, the unused half of the unit becomes completely inoperative and its displays are blanked.

Higher currents and remote sense
The XPH-R series are single-output power supplies similar in size and weight to the standard XPH series but offering higher output currents. To match their higher current capability, XPH-R models include switchable remote sensing and XPH extended voltmeter resolution.

Suitable for 42-volt automotive
The XPH 42-20 provides 420 watts of power within a highly compact and lightweight unit. It can provide current of up to 10 amps at voltages up to 42 volts in both constant voltage and constant current modes. The choice of 42 volts enables it to be used as a test source for the new generation of automotive electrical parts which will use 42 volts (18-cell batteries) instead of 14 volts (six-cell batteries), thus reducing currents and hence wiring losses. Switchable remote sense is provided to remove the effects of connection lead resistance at high current.

XPH Series : Product Specifications

Output : Voltage and Current				
Models	Output Voltage	Output Current	Output Power	Outputs
XPH 18-10	0-18 V	0-10 A	180 W	1
XPH 20-20	0-20 V	0-20 A	400 W	1
XPH 35-5	0-35 V	0-5 A	175 W	1
XPH 35-4D	0-35 V	0-4 A	280 W	2
XPH 35-4T	0-35 V	0-4 A	305 W	2 + Aux
XPH 42-10	0-42 V	0-10 A	420 W	1
XPH 75-2D	0-75 V	0-2 A	300 W	2

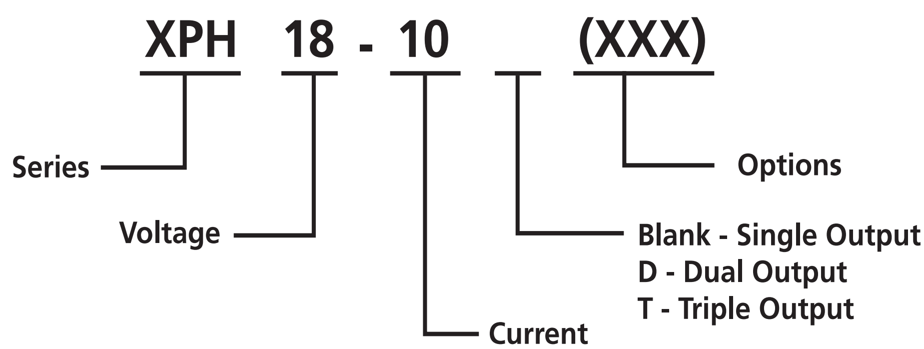
Output Terminals	
Standard	4mm “touch proof” binding posts/terminals on 0.75”/19mm pitch. Suitable for bare wire, hook terminals or plugs.
Remote Sense	Switch selectable as Local or Remote (main outputs only)
Input	
AC Input	110-240 V ± 10%, 50/60 Hz (XPH 35-5, XPH 35-4D, XPH 35-4T, XPH 75-2D) Factory set: 110-120 Vac ± 10% or 220-240 Vac ±10%, 50/60 Hz (XPH 18-10, XPH 20-20, XPH 42-10),... Installation Category II
Consumption	400 VA (XPH 35-5, XPH 18-10) 500 VA (XPH 35-4D, XPH 35-4T, XPH 75-2D) 800 VA (XPH 20-20), (XPH 42-10)
General Specifications	
Operating Mode	Constant voltage or constant current with automatic cross-over and indication
Voltage Setting	By coarse and fine controls (auxiliary third output on XPH35-4T course only)
Current Setting	By single logarithmic control
Output Impedance	Typically < 5 mΩ in constant voltage mode. Typically > 50 kΩ (XPH35-4, XPH75-2D), > 20 kΩ (XPH35-5, XPH42-10), > 10 kΩ (XPH18-10) in constant current mode.
Line regulation	< 0.01% of max. output for a 10% line voltage change
Load regulation	< 0.01% of max. output for a 90% load change, < 0.1% (XPH75-2D in Mode C)
Ripple & Noise Typically	< 2 mVrms, < 10 mVpk-pk, < 15 mV (XPH75- 2D), <20mVpk-pk for XPH 20-20 & XPH 42-10 CV mode (20 MHz bandwidth)
Transient Response	< 200 μs to within 50 mV of set level for 90% load change (mode A only XPH75-2D)
Temperature Coefficient	Typically < 100 ppm /°C
Output Protection	Outputs will withstand forward voltages up to 40 V (XPH 35-5. XPH 35-4D, XPH 35-4T) or 85V/170V (XPH 75-2D) or 22V (XPH 18-10) or 48V (XPH 42-10)
Status Indication	Output ON lamps. Constant current mode lamps
Output Switch	Electronic. Preset voltage/current displayed with output off.
Regulatory	CE-marked to: EN61010-1 and EN61326
Auxiliary Logic Output (XPL30-2T only)	Voltage: Variable <1.5V to >5V by front panel control. Meter Voltage Accuracy: 0.3% ± 4 digits Current Limit: 5A minimum Output Protection: Output will withstand up to 7V forward voltage. Diode clamp reverse protection for currents up to 3A Ripple & Noise (20MHz Bandwidth): Typically <2mVrms, <10mVpk-pk (20MHz bandwidth) Load Regulation: <0.5% for 90% load change Line Regulation: <0.1% for 10% line voltage change. Status Indication: UNREG lamp.
Meters (main outputs)	
Meter Types	Separate four-digit meters for voltage and three-digit meter current with 14 mm (0.56”) LED displays. Reading rate 4/sec
Meter Resolutions	10 mV, 1 mA (25V output), 10mA (18V, 20V, 42V, 75V Outputs
Meter Accuracy	
Voltage	0.3% ± 3 digits
Current	0.6% ± 3 digits

XPH Series : Product Specifications[1]

175–420 W

Environmental	
Operating Temperature	5 to 40°C
Storage Temperature	- 40 to 70°C
Humidity Range	20% to 80% RH
Cooling	Convection (Fan assisted for XPH 42-10 and XPH 20-20)
Environmental	Indoor use at altitudes to 2000 m, Pollution Degree 2
Physical	
Dimensions (H x W x D)	6.3 x 5.5 x 12.6” (160 x 140 x 320 mm) (XPH 35-5, XPH 18-10, XPH 20-20, XPH 42-10) 6.3 x 10.2 x 12.6” (160 x 260 x 320 mm) (XPH 35-4D, XPH 35-4T, XPH 75-2D)
Weight	6.2 lb (2.8 kg) (XPH 35-5, XPH 18-10) 7.9 lb (3.6 kg) (XPH 20-20, XPH 42-10) 9.5 lb (4.3 kg) (XPH 35-4D, XPH 35-4T) 9.7 lb (4.4 kg) (XPH 75-2D)

Model Number Description



Options and Accessories	
MHV	220-240 Vac input factory set

Notes

Sorensen XPD Series

500–540 W

Compact 500 Watt Quarter-Rack DC Power Supply

7.5–120 V

4.5–67 A

∿	115	230

GPIB RS232

- Analog programming
- Universal input
- Zero voltage "soft switching"
- Power factor correction (PFC)
- Front and rear connectors
- Ten-turn front panel knobs
- Remote sense with 5V line loss compensation
- LabVIEW® and LabWindows® drivers

The Sorensen XPD Series features the smallest 500-watt programmable power supply available. The XPD Series is ideal for benchtop, ATE and OEM applications where a wide range of output voltage or current is needed in a compact unit.

The XPD can be combined in a mix-and-match configuration with the quarter-rack 300-watt HPD series and 60-watt XT series. Each unit features zero voltage "soft switching" to virtually eliminate switching transients. This switching technology contributes to high efficiency, low noise, and high reliability. The XPD series also features power factor correction (PFC) technology to enable low current draw and to greatly reduce generation of input current harmonics.

XPD Series : Product Specifications[1]

Output : Voltage and Current					
Models	7.5-67	18-30	33-16	60-9	120-4.5
Output Ratings					
Output Voltage [2]	0-7.5 V	0-18 V	0-33 V	0-60 V	0-120 V
Output Current [3]	0-67 A	0-30 A	0-16 A	0-9 A	0-4.5 A
Output Power	502.5 W	540 W	528 W	540 W	540 W
Line Regulation [4]					
Voltage	2.8 mV	3.8 mV	5.3 mV	8 mV	14 mV
Current	7.7 mA	4 mA	2.6 mA	2 mA	2 mA
Load Regulation [5]					
Voltage	2.8 mV	3.8 mV	5.3 mV	8 mV	14 mV
Current	11.7 mA	8 mA	6.6 mA	5.9 mA	5.5 mA
Meter Accuracy					
Voltage (1% of Vmax + 1 count)	0.2 V	0.3 V	0.5 V	0.7 V	2.2 V
Current (1% of Imax + 1 count)	0.8 A	0.4 A	0.3 A	0.2 A	0.2 A
Output Noise (90-20 MHz)					
Voltage (p-p)	50 mV	50 mV	75 mV	125 mV	180 mV
Output Ripple					
Voltage	5 mV	5 mV	7.5 mV	10 mV	20 mV
Current [6]	250 mA	250 mA	150 mA	150 mA	75 mA
Drift (60 minutes) [7]					
Voltage (0.15% of Vmax)	11.3 mV	27 mV	49.5 mV	90 mV	180 mV
Current (0.3% of Imax)	201 mA	90 mA	48 mA	27 mA	13.5 mA
Drift (8 hours) [8]					
Voltage (0.03% of Vmax)	2.3 mV	5.4 mV	9.9 mV	18 mV	36 mV
Current (0.05% of Imax)	34 mA	15 mA	8 mA	4.5 mA	2.3 mA
Temperature Coefficient [9]					
Voltage (0.015% of Vmax/°C)	1.2 mV	2.7 mV	5 mV	9 mV	18 mV
Current (0.02% of Imax/°C)	13.4 mA	6 mA	3.2 mA	1.8 mA	0.9 mA
OVP Adjustment Range					
(5% to 110% of Vmax)	0.4-8.3 V	0.9-19.8 V	1.7-36.3 V	3-66 V	6-132 V
Efficiency [10]	81%	83%	85%	85%	84%

Specifications subject to change without notice.

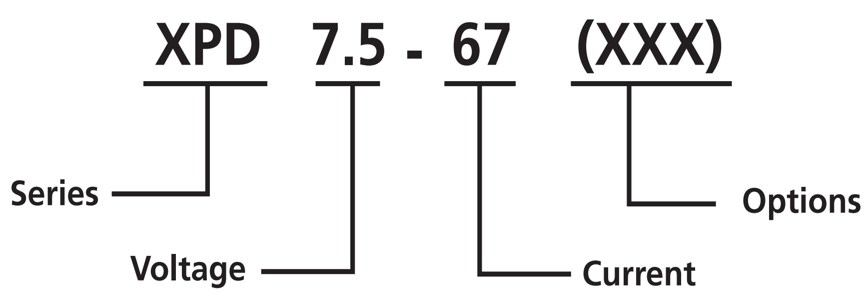
1. All electrical specifications are represented at the full operating temperature range for all models, unless otherwise stated.
2. Minimum output voltage is < 0.15% of rated voltage at zero output setting.
3. Minimum output current is < 0.2% of rated current at zero setting when measured with rated load resistance. Front output current limited to 30 A maximum.
4. For input voltage variation over the AC input voltage range, with constant rated load.
5. For 0-100% load variation, with constant nominal line voltage.
6. Current mode noise is measured from 10% to 100% of rated output voltage, full current.
7. Maximum drift over 60 minutes with constant line, load, and temperature, after power up.
8. Maximum drift over 8 hours with constant line, load, and temperature, after 60 minute warm-up.
9. Change in output per °C change in ambient temperature, with constant line and load.
10. Typical efficiency at 120 V and full output power.
11. Interface specifications at 25°C ± 5°C, nominal line input of 120 Vac. Apply accuracy specifications according to the following voltage program accuracy example: Set a model 18-30 power supply to 10 V. The expected result will be within the range of 10 V ± 75 mV ± 0.12% of the set voltage of 10 V.

XPD Series : Product Specifications[1] 500–540 W

XPD 500 W Internal Interface Specifications with RS-232 or GPIB Interface Installed[11]					
Models	7.5-67	18-30	33-16	60-9	120-4.5
Program Accuracy					
Voltage (mV)	10 +0.12%	75 +0.12%	75 +0.12%	150 +0.3%	180 +0.25%
Current (mA)	250 +0.1%	140 +0.1%	115 +0.15%	80 +0.15%	80 +0.1%
OVP (mV)	80	200	330	600	1200
Readback Accuracy					
Voltage (mV)	30 (±0.12%)	75 (±0.12%)	75 (±0.2%)	150 (±0.3%)	180 (±0.25%)
Current (mA)	250 (±0.1%)	140 (±0.1%)	115 (±0.15%)	80 (±0.15%)	80 (±0.1%)
Input					
Operational AC Input Voltage	85-264 Vac, 47-63 Hz; power factor corrected. Derate maximum output power to 450 W for AC input less than 95 V.				
Maximum Input Current	7 A maximum at 100 Vac, 6 A maximum at 120 Vac, 3 A maximum at 220 Vac				
General					
Power Factor	0.98 minimum for full load at nominal voltage				
Input Harmonic Distortion	Current harmonics meet IEC 1000-3-2				
Switching Frequency	125 kHz (250 kHz output ripple)				
Time Delay	3 sec maximum, from power on to output stable				
Voltage Mode Transient Response Time	1 ms for output voltage to recover within 0.5% of its previous level after a step change in load current of up to 50% of rated output				
Maximum Voltage Differential	±300 Vdc from output to safety ground				
Remote On/Off and Interlock	5-15 V signal or TTL-compatible input, selectable logic. TTL input impedance: 2 k (in series with one diode drop)				
Remote Analog Programming (Full Scale Input)	Voltage and current programming inputs (source must be floating): 0-10 V voltage sources. Input impedance (V and I): 20 k				
Remote Programming & Monitoring Accuracy	1% of full scale output for the default range				
Front Panel Voltage and Current Control	10-turn voltage and current potentiometers				
Front Panel Voltage Control Resolution	0.02% of maximum voltage				
AC Input Connector Type	IEC 320 connector, appropriate power cord provided for destination country				
Main Output Connector	Front panel: five-way binding posts. Maximum current limit 30 A; Rear Panel: 7.5-18 V models: Bus bars; 33-120 V models: wire clamp connectors.				
Approvals	CE-marked units meet: EN61010-1, EN61000-6-2 and EN61000-6-4; CSA C/US certified to UL3111-1 and CSA C22.2 No 1010.1; Meets USA EMC standard: FCC, part 15B, Class A; Meets Canadian EMC standard: ICES-001, Class A.				
Environmental					
Operating Temperature	0 to 50°C				
Storage Temperature	-40°C to 85°C				
Humidity Range	Up to 95% RH, non-condensing				
Physical					
Dimensions	Width: 4.2” (109.2 mm) Height: 5.2” (134.7 mm) Depth: 13” (330 mm)				
Weight	9.0 lb (4.1 kg)				
Protection Features					
Over voltage protection per output					
Switchable remote or local sense					

XPD Series

Model Number Description



Options and Accessories

MGA *	GPIB / IEEE 488.1
MRA *	RS-232 interface card
RM-XPDG-3	19-inch Rack Mount Kit
M13	Locking bushings
M13A	Locking knobs

* Options cannot be combined

Sorensen XHR Series

1 kW

DC Power Supply

7.5–600 V

1.7–130 A

∿	115	230

GPIB RS232

- Universal input 85-250 Vac
- Power Factor Correction (PFC)
- Zero voltage "soft switching"
- Simultaneous front panel display voltage and current
- Constant voltage or constant current operation
- Front and rear connectors
- Remote sense with 5 V line loss compensation
- LabVIEW® and LabWindows® drivers

The Sorensen XHR Series provides 1000 watts of DC power in a compact half-rack package. The supplies are designed for benchtop and system use, and as an ideal companion for other half-rack instruments in a test console. Its unique size also eliminates the need for a blank panel to preserve vertical rack space for OEM applications.

The XHR is power factor corrected for low current draw - only 11 amps at 120 volts AC for 1000 watts - and reduced generation of input current harmonics. Zero voltage or "soft switching" virtually eliminates switching transients for high efficiency, low noise and high reliability. It is also stackable, with a small footprint, front panel binding post connectors, and a low current requirement with universal input, making the XHR ideal for benchtop applications.

XHR Series : Product Specifications

Common	
Switching Frequency	7.5 V to 300 V models: nominal 125 kHz (250 kHz output ripple); 600 V model: nominal 62.5 kHz (125 kHz output ripple)
Time Delay	4 sec maximum from power on until output stable
Voltage Mode Transient Response Time	1 ms for output voltage to recover within 0.5% of its previous level after a step change in load current of up to 50% of rated output
Maximum Voltage Differential	±600 Vdc from output to safety ground
Remote Start/Stop and Interlock	2.5-15 V signal or TTL-compatible input, selectable logic
Remote Analog Programming	Voltage and current programming inputs (source must be isolated): 0-5 k, 0-10 k resistances; 0-5 V (default), 0-10 V voltage sources
Remote Analog Monitoring	Voltage and current monitor outputs 0-5 V (default), 0-10 V ranges for 0-100% of output
Remote Programming & Monitoring Accuracy	1% zero to full scale output for the default range
Front Panel Voltage and Current Control	10-turn voltage and current potentiometers
Front Panel Voltage Control Resolution	0.02% of maximum voltage
Main Output Connector	7.5 to 40 V models: nickel-plated copper bus bars; 60 to 600 V models: 4-terminal wire clamp connector for DC output and local sense
Protection Features	Over-voltage protection and Over-temperature protection
Approvals	CE-marked units meet: EN61010-1, EN61000-6-2 and EN61000-6-4; CSA C/US certified to UL61010-1B and CSA C22.2 No 1010.1; Meets USA EMC standard: FCC, part 15B, Class A; Meets Canadian EMC standard: ICES-001, Class A.
Environmental	
Operating Temperature	0°C to 40°C
Storage Temperature	-40°C to 85°C
Humidity Range	Up to 80% RH, non-condensing
Physical	
Dimensions	Width: 8.5” (216 mm) Height: 3.4” (86.4 mm) Depth: 18.6” (472.2 mm)
Weight	Approximately 14 lbs. (6.4 kg)
Input	
Voltage Ranges	85-250 VAC, 47-63 Hz, power factor corrected. Derate maximum output power to 900 W for AC input less than 95 V
Phases	
Power Factor	0.99 minimum for full load and 120 Vac input
Current	13 A maximum at 100 Vac; 11 A maximum at 120 Vac; 6 A maximum at 220 Vac
AC Input Connector Type	IEC 320 connector

XHR Series : Product Specifications

1 kW

Output			
Model	**Voltage**	**Current**	**Power**
XHR 7.5-130	0-7.5	0-130	975 W
XHR 20-50	0-20	0-50	1000 W
XHR 33-33	0-33	0-33	1089 W
XHR 40-25	0-40	0-25	1000 W
XHR 60-18	0-60	0-18	1080 W
XHR 100-10	0-100	0-10	1000 W
XHR 150-7	0-150	0-7	1050 W
XHR 300-3.5	0-300	0-3.5	1050 W
XHR 600-1.7	0-600	0-1.7	1020 W

Output : At the front panel binding posts

Model	Output Ratings		Line Regulation [2]		Load Regulation [3]	
	Voltage (VDC)	Current (ADC)	Voltage	Current	Voltage	Current
XHR 7.5-130	0-7.5	0-130	3 mV	14 mA	3 mV	66 mA
XHR 20-50	0-20	0-50	4 mV	6 mA	4 mV	26 mA
XHR 33-33	0-33	0-33	5 mV	4.3 mA	5 mV	18 mA
XHR 40-25	0-40	0-25	8 mV	3.5 mA	6 mV	14 mA
XHR 60-18	0-60	0-18	8 mV	2.8 mA	8 mV	10 mA
XHR 100-10	0-100	0-10	12 mV	2 mA	12 mV	6 mA
XHR 150-7	0-150	0-7	17 mV	1.7 mA	17 mV	4.5 mA
XHR 300-3.5	0-300	0-3.5	32 mV	1.3 mA	32 mV	3 mA
XHR 600-1.7	0-600	0-1.7	62 mV	1.2 mA	62 mV	2 mA

Model	Meter Accuracy		Output Noise (0-20 MHz) Voltage (p-p)	Output Ripple (rms) Voltage	Drift (8 hours) [4]	
	Voltage (0.5% to 1% of Vmax + 1 count)	Current (0.5% of Imax + 1 count)			Voltage (0.05% of Vmax)	Current (0.1% of Imax)
XHR 7.5-130	0.09 V	1.4 A	70 mV	10 mV	3.75 mV	130 mA
XHR 20-50	0.3 V	0.6 A	70 mV	10 mV	10 mV	50 mA
XHR 33-33	0.43 V	0.43 A	75 mV	7.5 mV	16.5 mV	33 mA
XHR 40-25	0.5 V	0.35 A	75 mV	7.5 mV	20 mV	25 mA
XHR 60-18	0.7 V	0.19 A	75 mV	10 mV	30 mV	18 mA
XHR 100-10	1.1 V	0.11 A	100 mV	10 mV	50 mV	10 mA
XHR 150-7	1.6 V	0.08 A	150 mV	20 mV	75 mV	7 mA
XHR 300-3.5	4 V	0.05 A	250 mV	30 mV	150 mV	3.5 mA
XHR 600-1.7	7 V	0.03 A	500 mV	120 mV	300 mV	1.7 mA

3. For 0-100% load variation, with constant nominal line voltage. Measured at the rear panel output connector unless stated otherwise.
4. Maximum drift over 8 hours with constant line, load, and temperature, after 30-minute warm-up.

XHR Series : Product Specifications

Model	Temperature Coefficient [5]		Maximum Remote Sense Line Drop Compensation [6]	OVP Adjustment Range (5%to 110% of Vmax)	Efficiency [7]
	Voltage (0.02% of Vmax/°C)	Current (0.03% of Imax/°C)			
XHR 7.5-130	1.5 mV	39 mA	3 V / line	0.375-8.25 V	81%
XHR 20-50	4 mV	15 mA	5 V / line	1-22 V	83%
XHR 33-33	6.6 mV	9.9 mA	5 V / line	1.65-36.3 V	83%
XHR 40-25	8 mV	7.5 mA	5 V / line	2-44 V	83%
XHR 60-18	12 mV	5.4 mA	5 V / line	3-66 V	84%
XHR 100-10	20 mV	3 mA	5 V / line	5-110 V	84%
XHR 150-7	30 mV	2.1 mA	5 V / line	7.5-165 V	85%
XHR 300-3.5	60 mV	1.1 mA	5 V / line	15-330 V	85%
XHR 600-1.7	120 mV	0.48 mA	5 V / line	30-660 V	85%

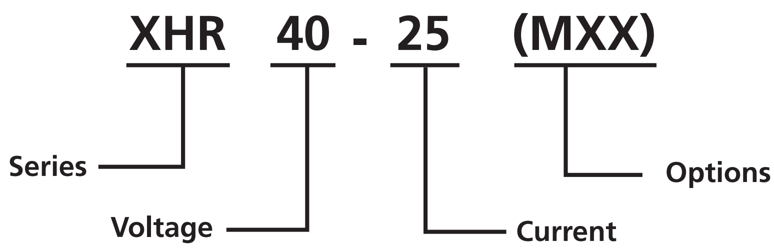
XHR 1 kW Internal Interface Specifications with RS-232 or GPIB Interface Installed [1, 8]

Model	Program Accuracy			Readback Accuracy	
	Voltage (mV)	Current (mA)	OVP (mV)	Voltage	Current
XHR 7.5-130	10 +0.12%	900 +0.1%	80	30 +0.12%	900 +0.1%
XHR 20-50	50 +0.12%	750 +0.1%	200	60 +0.12%	750 +0.1%
XHR 33-33	75 +0.12%	500 +0.1%	330	75 +0.12%	500 +0.1%
XHR 40-25	75 +0.3%	350 +0.15%	400	75 +0.3%	350 +0.1%
XHR 60-18	150 +0.25%	250 +0.1%	600	150 +0.25%	250 +0.1%
XHR 100-10	150 +0.35%	140 +0.15%	800	150 +0.35%	140 +0.15%
XHR 150-7	225 +0.35%	120 +0.1%	1500	225 +0.35%	120 +0.1%
XHR 300-3.5	225 +0.35%	80 +0.1%	3000	225 +0.35%	80 +0.1%
XHR 600-1.7	250 +0.35%	80 +0.1%	6000	300 +0.35%	80 +0.1%

Specifications subject to change without notice.
1. Specifications indicate typical performance at 25°C ± 5°C, nominal line input of 120 Vac.
5. Change in output per °C change in ambient temperature, with constant line and load.
6. Line drop is subtracted from total voltage available at supply output.
7. Typical efficiency at 115 Vac input and rated output power.
8. Apply accuracy specifications according to the following voltage program accuracy example:
   Set a model 20-50 power supply to 10 V. The expected result will be within the range of
   10 V ± 75 mV ± 0.12% of the set voltage of 10 V.

XHR Series

Model Number Description



Options and Accessories

MGA *	GPIB / IEEE 488.1 (up to 300V models)
MRA *	RS-232 interface card (up to 300V models)
MIA *	ISOL interface card provides isolated analog control and readback
RM-XHR	19-inch Rack Mount Kit for up to two XHR power supplies
M13A	Locking knobs for front panel controls
M22A	No front binding post
MGB *	GPIB/IEEE 488.1 (600V models)
MRB *	RS-232 Interface (600V models)

* Options cannot be combined

Notes

AC
Power Sources

Notes

How to Select an AC Power Source

Article

By Grady Keeton

Today's electronic products must work under all types of conditions, not just ideal ones. That being the case, AC sources used in test applications must not only supply a stable source of AC, they must also simulate power-line disturbances and other non-ideal situations.

Fortunately, today's switching AC power sources are up to the task. They offer great specifications and powerful waveformgeneration capabilities that allow users to more easily generate complex harmonic waveforms, transient waveforms, and arbitrary waveforms than ever before. Some can even provide both AC and DC outputs simultaneously and make measurements as well as provide power. This level of flexibility is making it easier to ensure that electronic products will work under adverse conditions.

When choosing an AC source, make sure to consider the following criteria:

- Current requirements for your device under test
- Worst-case input current (including transient demands, such as inrush)
- Crest factor of your load's current
- Power factor
- Regulation and distortion
- Response time and slew rate
- User and test-system interfaces
- Facility requirements

Current Requirements

When selecting an AC source for your test application, you must consider both much current your unit under test (UUT) will draw. Be sure to include inrush current and transient currents that may occur during intentional input voltage swings and during different modes of operation your device may use.

Worst-Case Input Current

Rectifier-type power supplies and motors are notorious for drawing high inrush currents. These devices have inrush currents anywhere from two to ten times the nominal run current, and they will draw this current anywhere from a few cycles to several seconds.

The response of the AC power source to inrush current is dependent on the method that the source uses for currentlimiting. AC power sources are designed to protect themselves from excessive loads current by either folding back the voltage (current limiting) or shutting down the output (current-limiting shutdown) and in many cases, this is user selectable.

In some instances, it may not be practical to have an AC source that can supply the full inrush current demanded by the load. If the test does not require the stress test from this current, it may be possible to use the current-limiting foldback technique for these tests. AC motors can draw up to seven times the normal operating current when first started. How long the motor will draw this current depends on the mechanical load and the motor design.

For loads such as motors and rectifier-type power supplies, an AC source that is folding back its output voltage to limit current will result in a longer start up time for the device under test. A source that is not capable of supplying the proper level of voltage and current may remain in the current-foldback state too long, causing the device under test to not start correctly or shut off altogether.

If you must measure the inrush current or your test call for supplying the full inrush as part of the test, you will need an AC source that can supply the full peak inrush current, so that the source never reaches the foldback state.

Crest Factor

Crest factor is the ratio of the peak current amplitude to the rms amplitude of an alternating current or pulsating direct current waveform. For UUTs that draw an input current with a high crest factor, it is important to select an AC source with low impedance and high peak instantaneous current capability. Low source impedance facilitates the quick transfer of current to the load. High peak current is provided from these sources for pulse widths ranging from 60° to 30°. The narrower the pulse width, the higher the crest factor capability of the high peak current source.

Switch-mode, or rectifier-type power supplies that are not power factor corrected, are an example of a UUT that has a high crest factor. They draw current from a power source in narrow pulses at the peaks of the voltage waveform. These pulses can be from 3 to 4 times the value of the rms current.

Many AC sources can only support a crest factor of 1.414 (the peak of a sinusoidal current waveform). If your source is not capable of supplying a load that exhibits a high crest factor, it may reduce its output voltage to unacceptable levels, have a distorted output, or shut down completely. In either case, the UUT will not be tested properly. With a crest factor rating of up to 3.25:1; the AMETEK CSW Series AC source, for example, can drive difficult nonlinear loads with ease. This translates into driving a rectifier for instance, has a 52A peak current at 13Arms at a 120/208 three phase output.

How to Select an AC Power Source

Power Factor

If your load has a low power factor, this will cause a derating of the output capacity of most linear AC sources. This is due to both the added reactive power being dissipated by the source and the current being drawn much closer to zero crossing of the voltage waveform. The graph shows a typical curve that you would use for derating a linear source's output capacity.

Switching AC power sources, on the other hand, need not be derated for power factor since they operate much differently with reactive loads. The power devices dissipate much less power and therefore operate much cooler as a result.

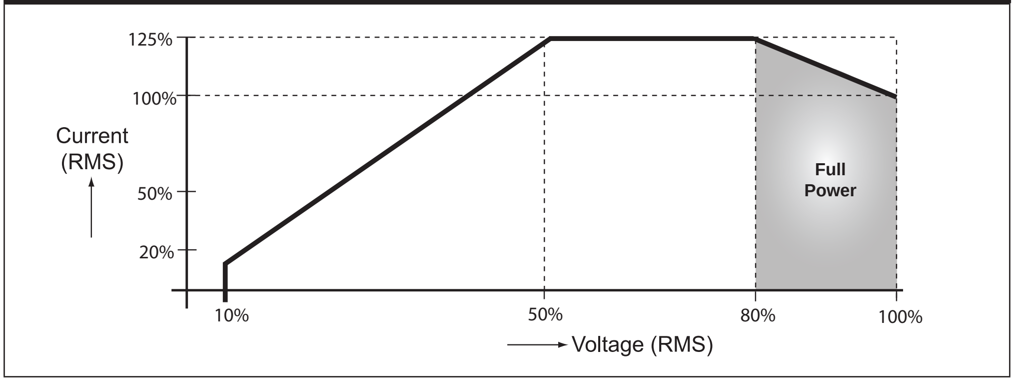
In many cases, typical power sources derate the VA rating of both switching and linear sources when performing tests at low voltage settings. Make sure to take this into account when testing a device at its worst-case, low voltage input. For an example, on the CSW series, each phase amplifier is rated for 1,850 VA maximum. The amplifier has a maximum current rating of 16A FROM 0-115 V AND a maximum voltage rating of 156 V. The current derates in a linearmanner above 115 V to maintain the maximum limitof 1,850 VA. (i.e. 1850 VA/146 V = 12.67 A). Severalof our AC sources like the Compact iX, Ls/Lx andMx/RS feature Constant Power Mode, meaning thesource offers the benefit of providing additional current when operating at reduced voltages, hence maintaining VA output rating of the source.

Regulation and Distortion

Load and line regulation should be tight, and distortion low. Poor regulation and distortion can lead to faulty test data that may not be discovered until units are in the field, or lead to false failure in testing. Typically, quality AC sources will have a voltage accuracy of +/- 0.1% and a maximum total harmonic distortion (THD) of no more than 0.25%.

AC power sources with poor regulation are sometimes called "soft sources." A soft source has a high output impedance and low peak current capability and cannot provide the peak currents that may be required for stress testing components properly. This leads to a higher failure rate. For example, if you used a soft source to perform the tests specified by IES LM-41-1985, "IES approved method for photometric testing of indoor fluorescent luminaires" to test a fluorescent lamp and ballast, the source would produce a distorted waveform and invalidate the test results.

Constant Power AC Mode - Available Max. AC Current



How to Select an AC Power Source

Response Time

Another consideration is the load response time, or the time it takes an AC source to respond to a change in the load. AC sources with fast load response times generally have low source impedance and tight regulation. AC sources with these characteristics are sometimes called "stiff sources" because their outputs remain constant, even when switching from no load to full load.

Typically, stiff sources have used analog technology to provide tight regulation and low source impedance, but sources that use switching technologies now perform just as well as linear sources. An example of this type of AC source is California Instruments' CSW Series. It has a voltage accuracy specification of +/- 0.1%, a THD specification of 0.25%, and very fast load response times.

Slew Rate

For many tests that require that you simulate real-world conditions, such as fluctuations in voltage, sags, surges, dropouts, or spikes, you need a source with a fast slew rate. An AC source's slew rate is the time it takes the source to respond to a change in the programmed voltage or frequency. High performance AC sources typically have slew rates of less than 50 µs.

User and Test-System Interfaces

AMETEK offers many different interfaces, including RS-232, USB, GPIB, and Ethernet, for integrating an AC source with your test system. In addition to the hardware, AMETEK also supplies IVI drivers with each AC source for use with National Instruments LabVIEW and LabWindows/CVI. Other user-developed systems are readily supported due to the use of SCPI programming syntax. This eases the tasks of ATE system programming and integration.

In addition, a Graphical User Interface application is supplied to provide a means of remote operation. Figure 1 shows how you use this application to easily create a test waveform with harmonic content.

Facitlity Requirements:

If the AC source must supply a lot of power, you may have to plan for a new power distribution and disconnects at your facility. Physical and environmental requirements must also be taken into account. Large AC sources can require significant floor space, and will require a high volume of airflow within a specified temperature range.

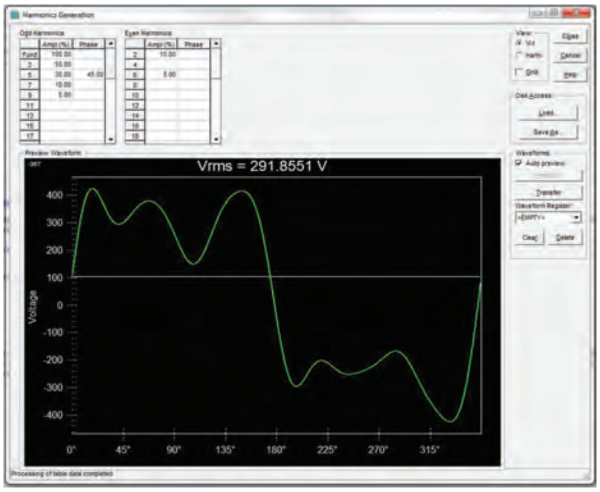
Cleanliness is also a consideration. Airborne contaminates from some manufacturing processes can result in conductive particulates drawn into the cooling air flow, and cause the source to fail. In order to avoid these failures, you need to locate your AC sources in clean areas with temperatures and humidity held within the ratings required for the prospective source.

Switching Sources Offer Many Advantages

For your next test system, you really should consider selecting a switching AC source. The digital technology used in modern switching AC sources not only improves the performance of the sources, but also offer users a number of other features that make testing with complex waveforms easier. The California Instruments' CSW Series can, for example, be used as an AC source, DC source, or provide a combination of AC and DC sources.

Using the latest digital signal processing (DSP) technology, modern switching AC sources can easily be programmed to provide whatever kind of waveform you need to test your products. These include waveforms with harmonic content to test for harmonic susceptibility and AC and DC transients. And because these waveforms are digitally generated, the user has complete control over when these events happen.

In addition to these powerful waveform-generation capabilities, the CSW Series also offers advanced measurement capability. Its measurement system digitizes voltage and current waveforms in real time and provides detailed information on both voltage and current waveforms. This includes detailed harmonic information on acquired waveforms.



Notes

Crest Factor Definition and Example

Purpose
To serve as a guideline in power source selection.

Crest Factor Defined
The crest factor and the peak currents of a load are important considerations in power source selection. Crest factor is defined as the ratio of peak value to rms value of a current waveform:

The crest factor for a sinusoidal current waveform, such as that which a pure resistive load would draw, is 1.414 since the peak of a true sinusoid is 1.414 times the rms value. However, the crest factor for a non-sinusoidal current waveform can differ dramatically for loads that are not power factor corrected, such as a switching power supply or lamp ballast, which give a current waveform that is short in duration but high in amplitude.

Crest Factor Example
The following graph shows two current waveforms, one sinusoidal and one non-sinusoidal:

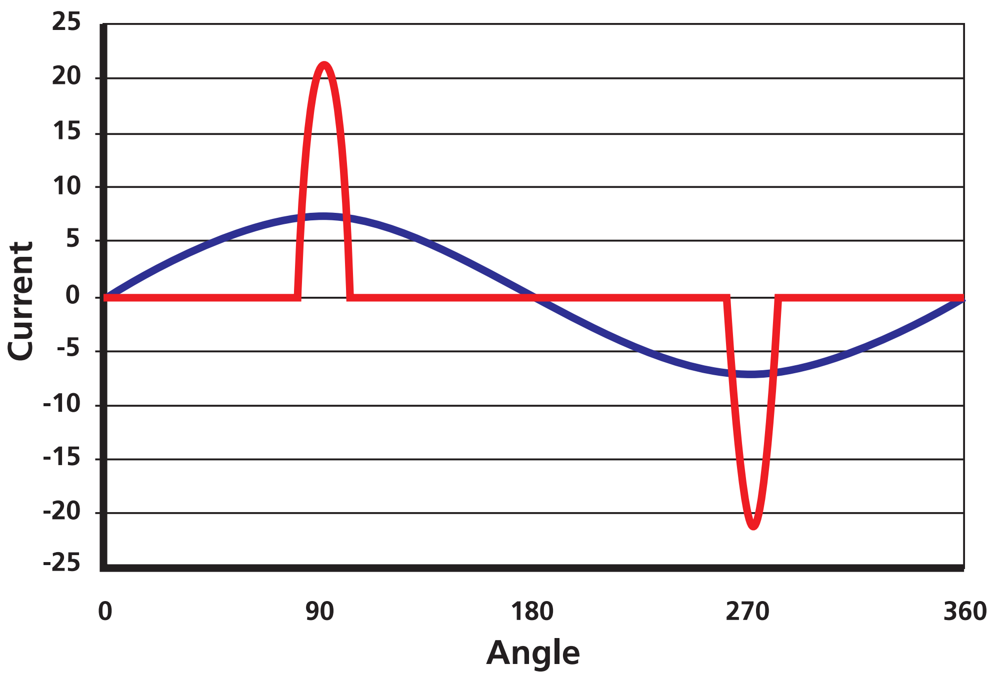
Discussion of Example
The blue trace is a 5A rms sinusoid with a peak current of 7.07A:

The red trace is a non-sinusoidal waveform that is also 5A rms, but has a peak at 21.21A. The crest factor for this example is 4.24:1. A 5A rms current would have a peak of 7.07A for a true sine, therefore:

Since the same rms current level is drawn in both examples, the true power provided would be the same for both (if the voltage were held at a constant level for both examples). This means that a power source selected to feed the loads at 120VAC would need to provide the 600VA that both loads require. However, the power source rated for 600VA may not be able to provide the required peak currents that the load demands.

Power Source Selection
The power source feeding the high crest factor load would need to be able to support the crest factor or have an output current that would provide this peak level. In order to determine the ability to provide the high crest factor peak currents you need to look for "peak repetitive current" or "crest factor" in the data sheet or spec sheet of a power source.

As a final note, peak currents are also important in calculating the voltage drop across conductors to minimize voltage drops.



Note: Non-sinusoid current waveforms can be a much different shape than that which is depicted here.

Notes

Testing Electric Motor Driven Equipment

Application Note

Introduction
Precision power sources, by AMETEK Programmable Power, can be used to test electric motor/drive systems. These systems may include either AC or DC motor types, sometimes combined with electronic controls. Motors are typically used to drive pumps, blowers, fans, conveyors, elevators, printing presses, robotics equipment, NC machinery, and a variety of appliances such as vacuum cleaners, mixers, refrigerators etc. This application note describes the features and capabilities of various power sources, and how they may be used to test products that rely on electric motors.

Motor types and applications
Electric motors can be divided into categories by application, design type, or even by horsepower. DC motors are commonly found in applications where speed control is required, or where only battery power is available. High power DC motors are used in many public transportation systems such as subways. Brushless DC motors, either permanent magnet or Switched Reluctance (SR) types are found in appliances such as vacuum cleaners. Many home appliances are driven by single phase AC motors.

Three phase induction motors are the industrial "workhorses" available in two basic types, the wound rotor and the squirrel cage motor.

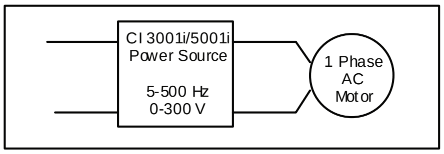


Figure 1 : Single Phase AC Motor

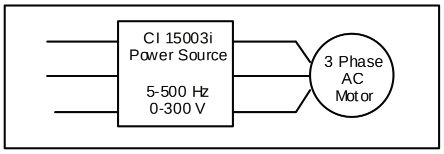


Figure 2 : Three Phase AC Motor

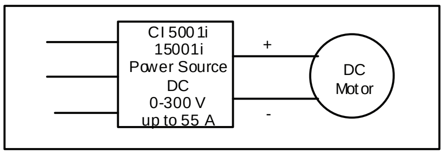


Figure 3 : DC Motor

Whereas variable speed applications used to be the exclusive domain of DC motors, high power solid state electronics have made variable frequency AC drives (VFD) a popular choice. These modern pulsewidth modulated (PWM) variable speed drives offer energy savings in many cases where standard induction motors are used today. Those PWM-AC drives are therefore quickly finding their way into many drive systems, even those with constant speed-variable torque applications.

Irrespective of type, be it AC or DC, more than 85 % of all motors require less than 50 kVA in power, hence we are primarily concerned with products in the power range up to this level. Generally, efficiency and operating reliability are the most important characteristics of any motor driven equipment, although regulatory requirements play a critical role as well. Therefore, in addition to efficiency and reliability aspects, a number of other characteristics need to meet minimum standards.

Motor Operating Characteristics
First and foremost, the motor/driven equipment has to perform properly in its primary function, to reliably convert electrical into mechanical energy, preferably in an efficient manner, without affecting other (electrical) equipment.

It is unacceptable if the motor or its electronic drive cause problems for other equipment which may be connected to the same line voltage. Tests therefore must include reliability and efficiency, as well as other operating aspects. Modern power sources provide the required voltages and drive frequency flexibility needed to perform testing in a consistent manner.

- Overall efficiency and efficiency vs. load. The user can read the electricity consumption directly from the power source, and thus determine input power for various conditions. For motors with AC drives, the power source can take the place of the drive, allowing the impact of different fundamental frequency and V/Hz settings on motor performance to be established quickly.

- Power consumption and line distortion. Distortion may be caused by the motor or the controller. Current harmonics, overall Power Factor, and the influence of line voltage variations may need to be determined.

- Inrush and operating current levels. The motor/driven equipment must perform as required under various load and line voltage conditions. It may be necessary to establish current/torque at full load, locked-rotor current, and the current at breakdown torque. For AC drives, it may be necessary to evaluate the start-up behavior with different current limit settings.

Testing Electric Motor Driven Equipment

· **Determining system losses**. When evaluating overall efficiency it is necessary to establish where losses come from. This may include motor related losses such as Stator I2R losses, Core loss, Friction, and Stray losses, using the methods described in IEEE-Std-112 *. Test method C of this standard (Duplicate Machines) can be implemented using AMETEK's power sources and two identical motors.

· **Emulating variable speed drives**. The power source may be operated as the "ideal" variable speed drive, as frequency and voltage can be varied, and even be swept across ranges as needed (see Figure 4). This allows the system integrator to test the driven equipment under any condition. Also, the user can establish (motor) operating temperatures for low speeds, check required skip ranges, determine the required peak current levels, and even test braking and reversed rotation capabilities.

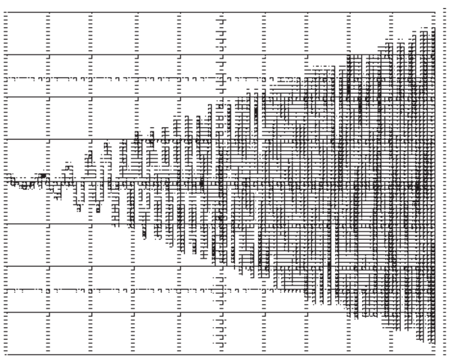


Figure 4 : Voltage-Frequency Sweep @ 4 V / Hz

Power Source Capabilities

Reviewing the capabilities of modern power sources will help to better understand their test capabilities. Figure 5 shows the basic architecture of a typical modern, programmable power source.

For many fractional horsepower motors, a 3000VA output capability of an AC source will suffice. This source operates from a single phase line voltage, from 188 - 264 Vrms, and a frequency of 45 - 66 Hz. As follows from Figure 5, the line voltage is first converted to DC, and then inverted to the desired voltage (and frequency), using state-of-the-art power electronics.

Variable frequency and voltage

The power sources can produce either AC or DC output voltages, in two ranges of 0 - 135 and 0 - 270 Volt. The AC voltage can be set to frequencies from 5 to 500 Hz. Current limits can be set as required, although the sources can drive high inrush currents. In fact, AMETEK AC power sources can support peak currents up to 110 Amp. This is important when measuring locked rotor or motor inrush current. The user can program the output voltage starting angle, simulating arbitrary turn-on points in the power cycle.

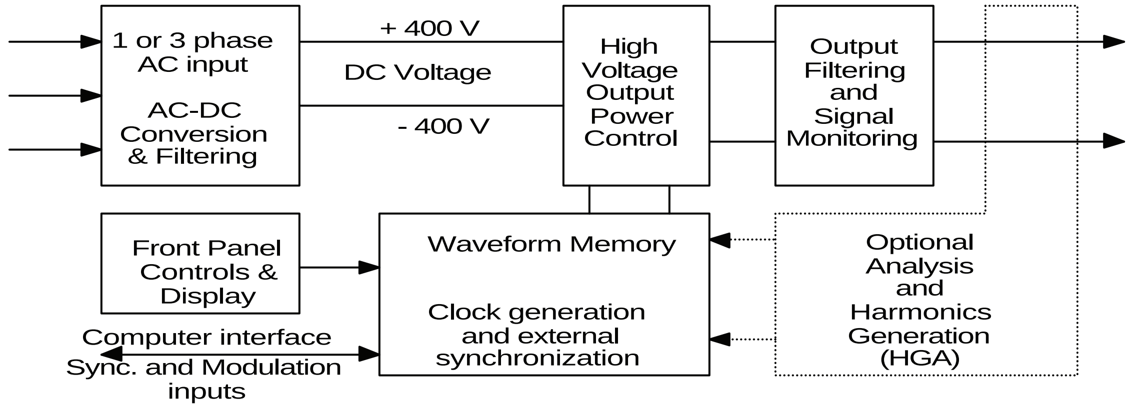


Figure 5 : Power Source Block Diagram

Testing Electric Motor Driven Equipment

Built-in measurement & analysis

With the built-in measurement capability, the user can monitor RMS as well as peak current levels, along with a number of other parameters such as power, Power Factor, voltage, and frequency. The power source can be controlled by a PC through the Graphical User Interface (GUI) software and provide detailed voltage and current analysis (Figure 7).

Line distortion simulation

As many as 32 test sequences to emulate line transients, drop-outs, power sags, etc. can be selected by the user. The power source can be programmed to perform powerful motor tests with user defined voltage harmonics. Harmonics may cause motor temperatures to increase. Also, mechanical problems, not detected with nice clean supply lines, may show up when operating with distorted supply voltages.

Line induced vibration/torsion transients

The 5th and 11th harmonic currents produce negative phase sequences, which in turn may excite torsional resonances. This is of particular importance for complete drive systems, with speed reduction/step-up gears, pumps, blowers, conveyors, fans etc.

Line drop-outs or voltage surges can also cause mechanical problems. New standards are going into effect, which require the manufacturer to test electrical equipment under these adverse supply line conditions. The new IEC1000-4-11, Edition 2.0 standard calls for a specific set of voltage dips, interruptions and variations, which electronic and electrical equipment must withstand without causing danger or adverse consequences for the user. The specified voltage fluctuations are based on elaborate survey data, obtained in industrialized countries.

Table 1 (next page) shows the typical number of line disturbances per year, classified by severity, that have been measured in European countries. As the table shows, voltage dips up to 30 % with a duration of 0.01 - 0.1 second occur 61 times per year. Similarly, voltage dips up to 60 %, with durations ranging from 0.1 - 3 seconds, total 49 times per year (8 + 36 + 4 + 1) hence about once per week. Even more severe dips (drop-outs) occur relatively frequently.

Often the motor and motor drive equipment, when tested separately at each manufacturer's facility, perform just fine during line disturbances. Once coupled together, the combined system could still be susceptible to line disturbances. For systems controlled by an electronic drive, transient problems may be compounded for the longer duration voltage dips. Typically, the drive has the ability to "ride through" voltage dips lasting only a few cycles. Depending on load condition, longer dips may cause the drive to completely reset, and turn off the output or activate a new start-up cycle. Therefore, the complete drive system needs to be verified under various operating and supply line conditions. These supply line conditions can be simulated at will with the modern solid state power source.

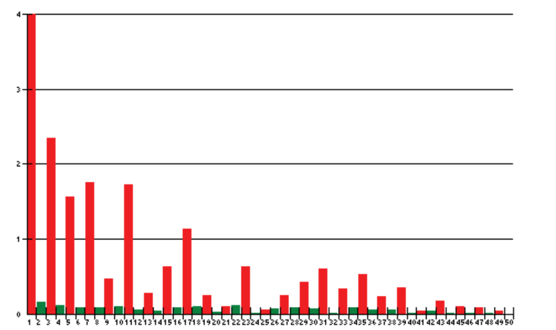


Figure 7 : Harmonic Analysis

Conclusions

Electrical motor driven pumps, fans, blowers etc. need to be tested for supply line conditions they will encounter. These tests include not only different line frequencies, but also have to simulate voltage fluctuations, harmonics, and brown-out conditions. Programmable power sources facilitate these tests with relative ease.

Electronic motor controls are used in increasing numbers, either because they offer significant energy savings, or because variable speed operation is required or offers competitive advantages. Actual energy savings can only be determined through accurate power measurement under different operating conditions. Power sources, possibly with harmonics generation and analysis options, permit simulation and analysis of almost every electronic drive and line voltage condition.

* IEEE-Std-112-1991 may be ordered from:

IEEE Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

Table 1 : Voltage Dips/Year in Europe

	Duration of voltage dips (sec)			
Dip in %	0.01- 0.1	0.1 - 0.5	0.5 - 1.0	1 - 3
10 - 30 %	61	66	12	6
30 - 60 %	8	36	4	1
60 - 99 %	2	17	3	2
100 %	0	12	24	5

Notes

California Instruments Compact i/iX Series

750–2250 VA

Precision Programmable AC Source

150–300 V

10–40 A

~	115	208	230

ETHERNET USB GPIB RS232 LXI

- 750 VA to 2250 VA of AC Output Power
- Combines AC/DC source and power analyzer
- Harmonic analysis of Voltage and Current
- AC, DC and AC+DC Output Modes
- Multiple Chassis Configurations
- Powerful output transient generation
- High Crest Factor Capability
- Arbitrary & harmonic waveform generation
- Single and Three Phase models available

The Compact iX Series represents a new generation of AC/DC power sources that address the increasing demands on test equipment to perform additional functions at a lower cost. By combining a flexible AC/DC power source with a high performance power analyzer, the Compact iX Series is capable of handling complex applications that have traditionally required multiple systems.

The sleek integrated approach of the Compact iX Series avoids cable clutter that is commonly found in test systems. All connections are made internally and the need for digital multimeters, power harmonics analyzers, and current shunts or clamps is eliminated.

Since many components in the Compact iX Series are shared between the AC/DC source and the power analyzer, the total cost of the integrated system is less than the typical cost of a multiple unit system.

For less demanding applications, the Compact i Series provides similar output and transient capabilities as the Compact iX Series, as well as basic power measurements.

Easy To Use Local Controls

Both the Compact i and iX Series are microprocessor controlled and can be operated from an easy to use front panel keypad. Functions are grouped logically and are directly accessible from the keypad. This eliminates the need to search through various levels of menus and/or soft keys. A large analog control knob can be used to quickly slew output parameters. This knob is controlled by a dynamic rate change algorithm that combines the benefits of precise control over small parameter changes with quick sweeps through the entire range.

Applications

With precise output regulation and accuracy, the compact i/iX series AC and DC sources address many application areas for AC and DC power testing. The i/iX also provides a high load current capability, multi or single phase output modes, and built-in power analyzer measurements. Additional features including line distortion simulation (LDS) and arbitrary waveform generation address requirements for product quality and regulatory compliance testing.

Product Evaluation and Test

Increasingly, manufacturers of electronic equipment and appliances are required to fully evaluate and test their products over a wide range of input line conditions. The built-in output transient generation and readback measurement capability offers the convenience of an easy to use and integrated test system.

Avionics

With an output frequency range to 1000 Hz, at up to 150 VRMS, the Compact i/iX Series is well suited for aerospace applications. Precise frequency control and accurate load regulation are key requirements in these applications. The standard USB (or optional GPIB / LAN) control interface and SCPI command language provide for easy integration into existing ATE systems. Since the Compact i/iX Series can eliminate the need for several additional pieces of test equipment and only occupies 3.5 inches of rack space (2U), saving both cost and space. Instrument drivers for popular programming environments such as National Instruments LabView, DO-160, ABD-0100, MIL-STD-704A-F, A350, AIRB, AMD and Boeing B787 are available to speed up system integration.

Compact i/iX Series : Product Specifications

Input			
Model	751i/iX (1 Phase Output)	1501i/iX (1 Phase Output)	2253i/iX (1 or 3 Phase Output)
Voltage	115Vrms +/- 10% or 230Vrms +/- 10%	115Vrms +/- 10% or 230Vrms +/- 10%	115V, 1ø input = 1500VA out 230V, 1ø input = 2250VA out
Current	<8.5 Arms @ 115 V <4.4 Arms @ 230 V	<17 Arms @ 115 V <8.8 Arms @ 230 V	<20 Arms @ 115 V <15 Arms @ 230 V
Frequency	47 to 63 Hz	47 to 63 Hz	47 to 63 Hz
Power Factor	0.97 (typical @ full load)	0.97 (typical @ full load)	0.98 (typical @ full load)
Efficiency	80%	80%	77%
AC Output			
Voltage	Hi : 0 - 300Vrms Low : 0 - 150Vrms	Hi : 0 - 300Vrms Low : 0 - 150Vrms	Hi : 0 - 300Vrms Low : 0 - 150Vrms
Max. Current	Hi : 3.25Arms Low : 6.5Arms	Hi : 6.5Arms Low : 13Arms	Hi : 3.25Arms (per phase) Low : 6.5Arms (per phase)
Peak Current	Hi : 10 A Peak Low : 20 A Peak	Hi : 20 A Peak Low : 40 A Peak	Hi : 10 A Peak (per phase) Low : 20 A Peak (per phase)
AC Power	750VA	1500VA	750VA (per phase)
Phase Output	1	1	3/1[1,2]
Distortion	< 1% THD	< 1% THD	< 1% THD

[1] With -MODE Option [2] Single Phase with "Mode" Option

DC Output			
Voltage	Hi : 0 - 400Vdc Low : 0 - 200Vdc	Hi :0 - 400Vdc Low : 0 - 200Vdc	Hi : 0 - 400Vdc Low : 0 - 200Vdc
Max. Current	Hi : 1.63Adc max Low : 3.25Adc max	Hi : 3.25Adc max Low : 6.50Adc max	Hi : 1.63Adc (per phase) Low : 3.25Adc (per phase)
DC Power	500W	1000W	500W (per output)
Voltage Accuracy/Programming Resolution (AC/DC)			
Accuracy (ALC mode ON)	0.1% FS (from 5V to FS)	0.1% FS (from 5V to FS)	0.1% FS (from 5V to FS)
Programming Resolution	0.1V	0.1V	0.1V
Frequency			
Range	16 – 1000Hz	16 – 1000Hz	16 – 1000Hz
Resolution	0.01 Hz (16 – 81.91 Hz), 0.1 Hz (82.0 – 819.1 Hz) 1 Hz (820– 1000 Hz)	0.01 Hz (16 – 81.91 Hz), 0.1 Hz (82.0 – 819.1 Hz) 1 Hz (820– 1000 Hz)	0.01 Hz (16 – 81.91 Hz), 0.1 Hz (82.0 – 819.1 Hz) 1 Hz (820– 1000 Hz)
Accuracy	0.025%	0.025%	0.025%
Measurements			
Voltage Accuracy	V: 0.1% FS	V: 0.1% FS	V: 0.1% FS
Current Accuracy	C: 0.5% FS	C: 0.5% FS	C: 0.5% FS
Mechanical Specifications			
Dimensions	H: 3.5" (89mm) W: 19" (483mm) D: 23" (584mm)	H: 3.5" (89mm) W: 19" (483mm) D: 23" (584mm)	H: 5.25" (133mm) W: 19" (483mm) D: 23" (584mm)
Weight	30 lbs (25kg)	37 lbs (30kg)	58 lbs (26kg)
Operating Temperature	0-40°C	0-40°C	0-40°C
Interfaces			
USB	Standard	Standard	Standard
GPIB	Option (i) Std (iX)	Option (i) Std (iX)	Option (i) Std (iX)
LAN	Option (iX)	Option (iX)	Option (iX)
RS232	N/A	N/A	Standard

Compact i/iX Series

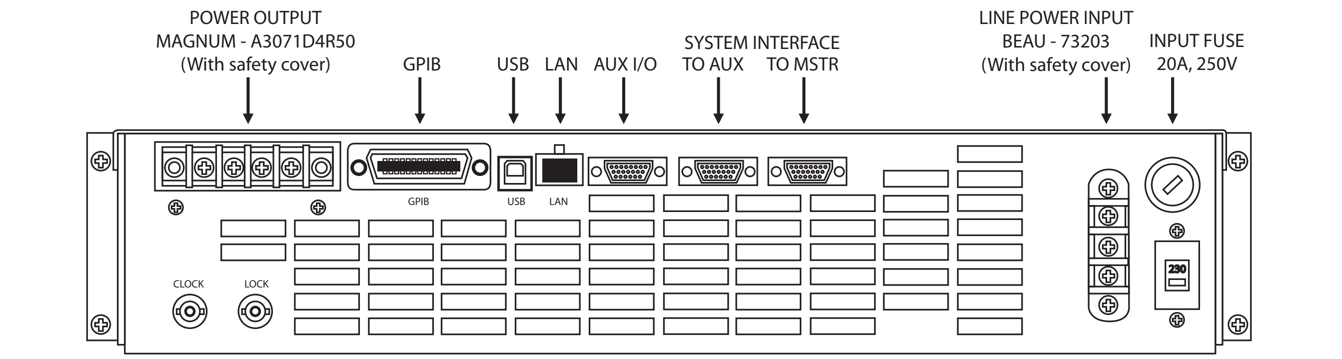
750–2250 VA

Options	
-LF	Limits maximum frequency to 500Hz -- 2253 i/iX only
-LKM	Clock/Lock Master
-LKS	Clock/Lock Auxiliary
-MODE	Allows all three amplifier outputs to be combined on phase A output terminal. No external switching or reconnection to the load is required (2253 i/iX only).
-RMS	Rackmount Slides
-RPF	Remote programming frequency (0-10 V DC).
-RPV	Remote programming voltage (0-10 V DC).
-WHM	Watt-hour measurement.
Controller Options	
-ABL	ABLE Command (Emulates Elgar SL - PIP 9012 Functions)
-EXS	External Sync Input. (Excludes LKS & RPF)
-LAN	LXI Ethernet LAN Inter face (RJ45 Connector) (iX Only)
Avionics Test Routine Options	
-ABD	Airbus Directive 0100.1.8 tests.
-AMD	Airbus AMD-24C Test
-A350	Airbus Test Software
-AIRB	Airbus ABD0100.1.8, AMD 24 and A350 combination test software suite
-B787	Boeing 787B3-0147 tests.
-704	Mil Std 704D/E test firmware
-704F	Mil Std 704 Revision A-F test firmware/software.
-160	RTCA/DO-160D/E and EUROCAE test firmware. Refer to -160 option data sheet for details.
* Note Reference the Avionics Test User Manual P/N 4994-971 for a complete listing of performance capabilities.	

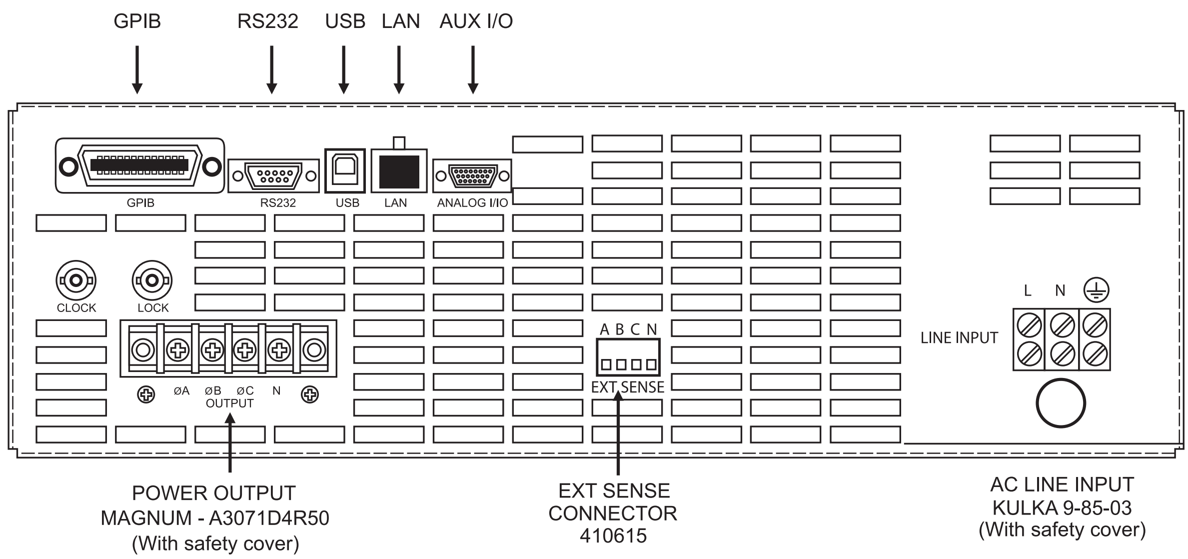
Feature Comparison		
Model	i	iX
AC Mode	x	x
DC Mode	x	x
AC+DC Mode		x
Transient Programming	x	x
Arbitrary Waveforms		x
Measurements	x	x
Harmonic Measurements		x
Waveform Acquisition		x

Compact i/iX Series : Product Diagram

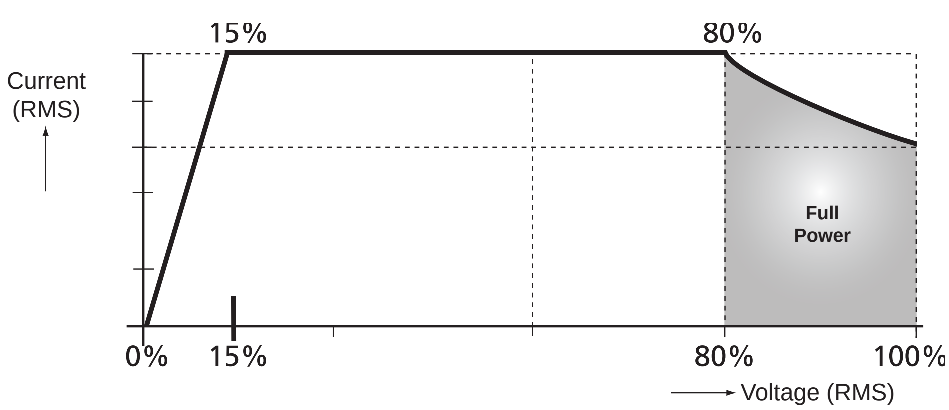
Compact 750/1501 i/iX Rear Panel



Compact 2253 i/iX Rear Panel



Constant Power Chart



Note: Constant power mode provides increased current at reduced voltage. Maximum available current shown.

Elgar ContinuousWave Series

800–2500 VA

Pure Sinewave, Low Power AC Source

135–310 V

2.6–18.6 A

∿	115	208	230

GPIB RS232

- Low THD and AC noise
- Advanced Measurement Available
- Wide range PFC Input
- Field Parallel Configurable
- Multiple Units Configurable for Multi-Phase Operation

The Elgar ContinuousWave (CW) Series of AC power sources provides clean single phase power at an impressive price/performance ratio. These compact switch mode sources come in two series, manual (CW-M) or programmable (CW-P) with standard IEEE-488.2 and RS-232 control. Both series have three power levels, 800 VA, 1250 VA and 2500 VA. The 800 and 1250 VA models are 2U (3.5”) high and allow the unit under test to be connected to the front or rear panel. The 2500 VA model is 3U (5.25”) high with rear panel output connections. All models can be operated in a benchtop or rackmount configuration.

The front panels have two bright four digit, seven segment displays. Power Factor Corrected (PFC) universal input voltage allows maximum power to be delivered from an AC outlet without the user selecting the range. Fully rated current is delivered for either output voltage range of 135 VAC or 270 VAC over a standard frequency range of 45 to 500 Hz. Both series can be paralleled to provide extra power.

A separate output-on switch controls power to the load. Remote voltage sense is standard. Transformer coupled output is protected against overvoltage and overcurrent. The unit is also protected against over temperature conditions. A two-speed fan results in quieter operation at lower power levels. All models are CE marked.

Applications for the CW Series include:

- Testing for real world sine wave power conditions
- 400 Hz testing for avionics equipment
- 50/60 Hz margin testing
- Ballast testing
- Components testing
- Power supply testing for AC to DC converters

Manual CW Features And Benefits

The manual series front panel knobs (10 turn potentiometers) allow quick adjustment of voltage, current and frequency settings. Frequency and voltage can be programmed remotely using a 0 to 5V analog signal. LED’s indicate: output-on, voltage or current mode operation, fault and slave modes. Models can also be paralleled in the field or configured for three phase operation using a factory supplied cable. Current shutdown or foldback modes can be selected from a rear panel switch.

Programmable CW Features And Benefits

Front panel encoder knobs allow programming of voltage, current and frequency settings. Programmed or measured values can be viewed on the two LED displays through push button selection. Menu push buttons enable setting system configuration including parallel or three phase operation. This menu also allows setting current shutdown or foldback modes. Remote IEEE-488.2 and RS-232 control interfaces are standard. LEDs indicate: high or low range output voltage, measure or program mode, voltage or current mode operation and output-on. LED’s indicate menu/status, remote control, lockout and fault conditions. Digital Signal Processing (DSP) based measurements include voltage, current (amperes, peak amperes, crest factor), power (watts, VA and power factor) and frequency.

CW Series : Product Specifications

Input						
Model	CW 801M	CW 1251M	CW 2501M	CW 801P	CW 1251 P	CW 2501 P
Power	800 VA	1250 VA	2500 VA	800 VA	1250 VA	2500 VA
Voltage	90 - 264 VAC	103 - 264 VAC	180 - 264 VAC	90 - 264 VAC	103 - 264 VAC	180 - 264 VAC
Current	13 ARMS max	18.5 ARMS max	19.5 ARMS max	13 ARMS max	18.5 ARMS max	19.5 ARMS max
Frequency	47 to 63 Hz					
Phases	single-phase					
Power Factor	>0.99 typical at full load nominal line					
Efficiency	>73% typical at full load					

Output						
Model	CW 801M	CW 1251M	CW 2501M	CW 801P	CW 1251 P	CW 2501 P
Power	800 VA	1250 VA	2500 VA	800 VA	1250 VA	2500 VA
Voltage						
Voltage ranges	0 to 135 Vrms, 0 to 270 Vrms, user selectable					
Accuracy (>5VAC)	± 1% of range			±0.1% of range <100 Hz, ± 0.2% of range >100 Hz		
Resolution	0.1 Vrms					
Total harmonic distortion	0.25% typical <100Hz add 0.5%/100 Hz above 100 Hz					
AC noise level (typical)	<50 mVRMS	<50 mVRMS	<100 mVRMS	<50 mVRMS	<50 mVRMS	<100 mVRMS
Amplitude stability[1]	±0.1% of full scale			±0.05% of full scale		
Load regulation	±0.1% of full scale voltage for a full resistive load to no load (<10 mVRMS typical, measured at point of sense)					
Line regulation	±0.1% of full scale voltage for a ±10% line change from nominal line voltage (<5 mVRMS typical, measured at point of sense)					
Remote voltage sense	5 Vrms total lead voltage drop					
Current						
135VAC Range	6.0 ARMS	9.4 ARMS	18.6 ARMS	6.0 ARMS	9.4 ARMS	18.6 ARMS
270VAC Range	3.0 ARMS	4.7 ARMS	9.3 ARMS	3.0 ARMS	4.7 ARMS	9.3 ARMS
Accuracy	± 0.5% typical			± 0.5% max		
Resolution	0.1 ARMS			0.01 ARMS		
Frequency range						
Range	45 to 500 Hz			45 to 500 Hz, 45 to 1000 Hz (option)		
Accuracy	±0.5% typical			±0.02% max		
Resolution	0.1 Hz			0.1 Hz, 0.01 Hz for remote programming		
Phase	All models single phase output. Multi-phase system configuration with Digital Expansion Cable					
Power factor of load	0 lag to 0 lead					

Physical						
Model	CW 801M	CW 1251M	CW 2501M	CW 801P	CW 1251 P	CW 2501 P
Height	3.5 in.	3.5 in.	5.25 in.	3.5 in.	3.5 in.	5.25 in.
Width	19 in.	19 in.	19 in.	19 in.	19 in.	19 in.
Depth	20.07 in.	20.07 in.	20.07 in.	20.07 in.	20.07 in.	20.07 in.
Weight	48 lbs (22 kg)	53 lbs (24 kg)	86 lbs (39 kg)	48 lbs (22 kg)	53 lbs (24 kg)	86 lbs (39 kg)
Shipping Weight	56 lbs (25 kg)	61 lbs (28 kg)	94 lbs (43 kg)	56 lbs (25 kg)	61 lbs (28 kg)	94 lbs (43 kg)

Environmental	
Operating Temperature	0 to 40°C
Storage Temperature	-40 to +70°C
Humidity Range	0 to 85% at 25°C derate to 50% at 40°C (non condensing)
Altitude	Operating full power available up to 6,000 feet, non operating to 40,000 feet
Cooling	Dual fan speed with side air intake, exhaust to rear

General	
Regulatory compliance	CE Mark

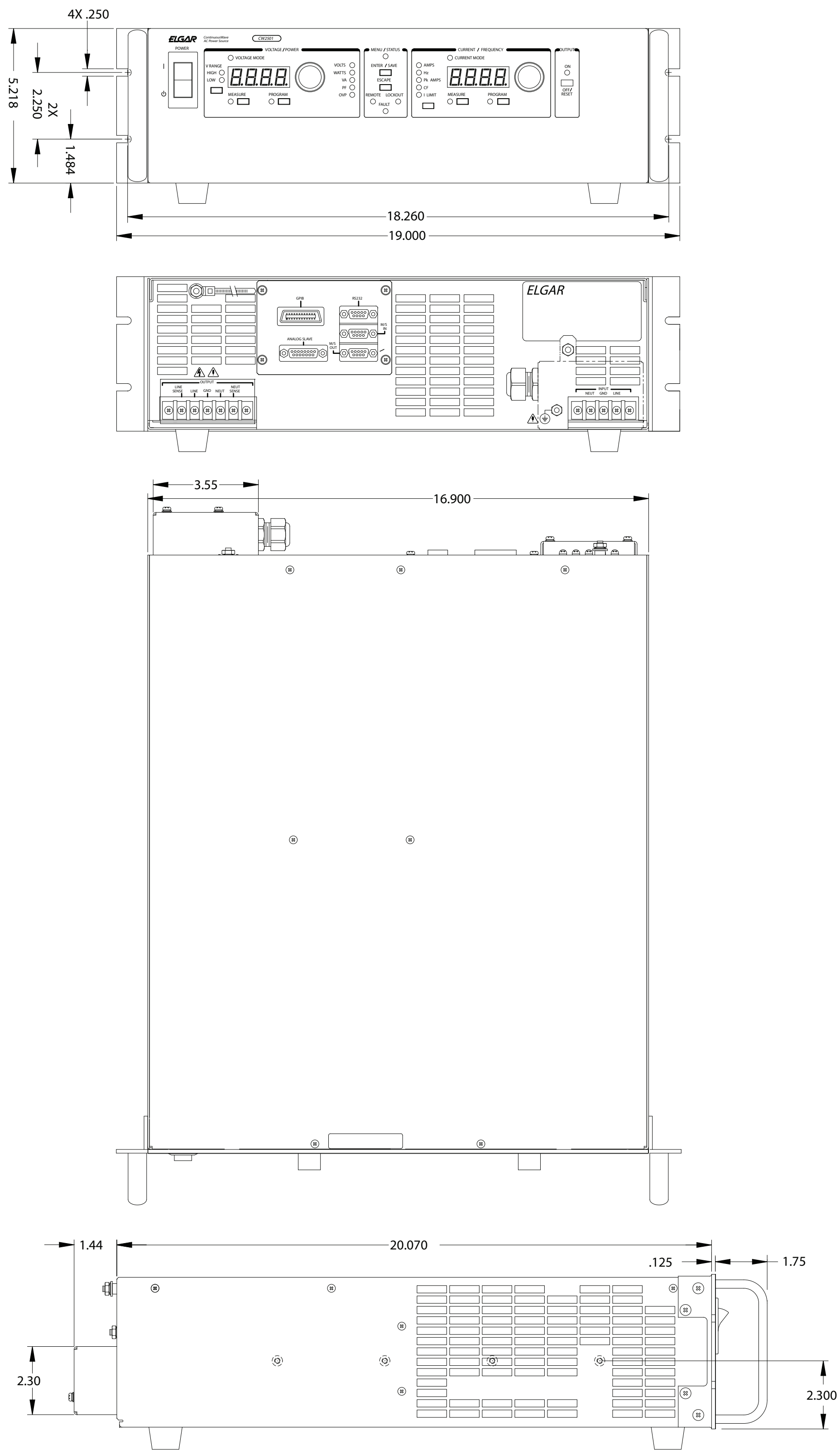
CW Series : Product Specifications 800–2500 VA

Measurements						
Model	CW 801M	CW 1251M	CW 2501M	CW 801P	CW 1251 P	CW 2501 P
Power	800 VA	1250 VA	2500 VA	800 VA	1250 VA	2500 VA
Voltage						
Range	0 to 270 Vrms			0 to 270 Vrms, 0 to 310VRMS (option)		
Accuracy[2] (VAC >5V)	± 1% of full range			±0.1% of range <100 Hz, ± 0.2% of range>100 Hz, ± 0.3% of range>500 Hz (option)		
Resolution	0.1 Vrms			0.1 Vrms		
Current[3]						
Range	0 - 6.0 ARMS	0 - 9.4 ARMS	0 - 18.6 ARMS	0 - 6.0 ARMS	0 - 9.4 ARMS	0 - 18.6 ARMS
Accuracy	±2% of range for linear loads with current >0.2A, > 0.4A for 2500 VA			±0.5% of range for linear loads		
Resolution	0.1 ARMS			0.01 ARMS		
Peak Current[3]						
Range	-	-	-	0 to 25 A	0 to 35 A	0 to 70 A
Accuracy	-	-	-	±1% of range		
Resolution	-	-	-	0.1 A		
Frequency						
Range	45 to 500 Hz			45 to 500 Hz, 45 to 1000 Hz (option)		
Accuracy	±0.5% typical			±0.02% max		
Resolution of display	0.1 Hz			0.1 Hz		

Measurements			
Model	CW 801 P	CW 1251 P	CW 2501 P
Power	800 VA	1250 VA	2500 VA
Power[3]			
Range	0 - 800 W	0 - 1250 W	0 - 2500 W
Accuracy	±2% of range for linear loads		
Resolution	1 W		
Apparent Power[3]			
Range	0 to 800 VA	0 to 1250 VA	0 to 2500 VA
Accuracy	±2% of range for linear loads		
Resolution	1 VA		
Power Factor[3]			
Range	0 to 1		
Accuracy	±4% of range for linear loads		
Resolution	0.01		
Crest Factor			
Range	0 to 3.5		
Accuracy	±5% of range		
Resolution	0.01		
Phase			
Range	-359 to +359 degrees. Positive indicates time lag from reference		
Accuracy	Within 100 microseconds of equivalent angle		
Resolution	1 degree		

[1] Over 8 hours at constant line, load and temperature after 15-minute warm-up typical
[2] Typical values measured at point of sense
[3] In a parallel system (for programmable units only), the current/power displayed on the master unit is the sum of all units in the system

CW Series : Product Diagram



CW 2501

Dimensions are in inches

CW Series

800–2500 VA

Model Number Description

CW 1251 - M XXX

Series

Maximum Power Single Phase
801
1251
2501

M = Manual
P = Programmable

Options

Options and Accessories
H: Expanded frequency range 45 to 1000 Hz (CWP only)
L: Locking knobs (front panel potentiometers) (CW-M only)
S: Sync In/Out (clock/lock) (standard on CW-P)
V: 0-155V/0-310V Output (CW-P only)
-108: 200V/400V Output for (CW 801P Only)
Certificate of Calibration (CW-P only)
Rack Slide Kit: Elgar Part No. K161570-01
Multi-Unit Cable: Elgar Part No. 890-497-40
Digital Expansion Cable: Elgar Part No. 890-499-00 (CW-P only) Required to parallel or configure a 3ø system

CW Series

Notes

California Instruments i/iX Series II

3000–15000 VA

General purpose AC power sources

150–300 V

0–120 A

≈	208	230	400
∼	208	230	

ETHERNET USB GPIB RS232

- Combination AC and DC Power Source and Power Analyzer
- 3000 VA - 15000 VA of Output Power
- Arbitrary Waveform Generation
- Built-in Digital Power Analyzer
- Scope Capture Capability
- EN61000-3-2 and EN61000-3-3
- Powerful Programing Software
- Constant Power Mode

Intergrated System
The iX Series II represents a new generation of AC and DC power source that addresses increasing demands on test equipment to perform more functions at a lower cost. By combining a flexible AC/DC power source with a high performance power analyzer, the iX Series II systems are capable of handling complex applications that have traditionally required multiple instruments.

The sleek integrated approach of the iX Series II avoids the cable clutter that is commonly found in AC test systems. The i/iX Series II is rackmountable with a 4U chassis design. All connections are made internally and the need for external digital multimeters, power harmonics analyzer and current shunts or clamps is completely eliminated.

Using a state of the art digital signal processor in conjunction with precision high resolution A/D converters, the iX Series II provides more accuracy and resolution than can be found in some dedicated harmonic power analyzers. Since many components in the iX Series II are shared between the AC/DC source and the power analyzer, the total cost of the integrated system is less than the typical cost of a multiple unit system.

For less demanding applications, the i Series II provides similar output and transient capabilities as the iX Series II, as well as basic measurements.

Easy To Use Controls
Both the iX Series II and i Series II are microprocessor controlled and can be operated from an easy to use front panel keypad. Functions are grouped logically and are directly accessible from the keypad. This eliminates the need to search through various levels of menus and/or soft keys. A large analog control knob can be used to quickly slew output parameters. This knob is controlled by a dynamic rate change algorithm that combines the benefits of precise control over small parameter changes with quick sweeps through the entire range.

Applications
With precise output regulation and accuracy, the iX Series II AC and DC sources address many application areas for AC and DC power testing. The iX also provides a high load current capability, multi or single phase output modes, and built-in power analyzer measurements. Additional features including line distortion simulation (LDS), arbitrary waveform generation, and programmable output impedance address requirements for product quality and regulatory compliance testing.

Product Evaluation and Test
Increasingly, manufacturers of electronic equipment and appliances are required to fully evaluate and test their products over a wide range of input line conditions. The built-in output transient generation and readback measurement capability offers the convenience of an easy to use and integrated test system.

Avionics
With an output frequency range to 1000 Hz, up to 150 VRMS, the iX Series II is well suited for aerospace applications. Precise frequency control and accurate load regulation are key requirements in these applications. The standard IEEE-488 control interface and SCPI command language provide for easy integration into existing ATE systems. Since the iX Series II can eliminate the need for additional pieces of test equipment and only occupies 7 inches of rack space (4U), it significantly saves cost and space. Options are available for popular avionics test routines such as: DO-160, ABD- 0100, MIL-STD-704A-F, Boeing 7E73B-0147, and Airbus test routines.

i/iX Series II

Regulatory Testing

As governments are moving to enforce product quality standards, regulatory compliance testing is becoming a requirement for a growing number of manufacturers. The iX Series II is designed to meet AC source requirements for use in Euronorm EN 61000 compliance testing. For flicker testing, the programmable output impedance capability of the 3001iX, 5001iX and 15003iX can be used to create the required IEC 725 reference impedance. Run IEC61000-4-11, IEC61000-4-14 and IEC61000-4-28 test programs.

Multi-Box Configurations

For high power applications, two or three 5001i/iX chassis can be combined to provide 10 to 15 kVA of single or three phase power. A 9003iX, 15003iX or 15003i three phase configuration can be ordered with the MODE-iX option. This option allows automatic switching between single or three phase output mode. In single phase mode, all current is available on phase A.

High Crest Factor

With a crest factor of up to 5:1, the i/iX Series II AC source can drive difficult nonlinear loads with ease. Since many modern products use switching power supplies, they have a tendency to pull high repetitive peak currents. The 5001iX can deliver up to 110 Amps of repetitive peak current to handle such loads.

Remote Control

Standard IEEE-488 and RS232C remote control interfaces allow programming of all instrument functions from an external computer. The popular SCPI command protocol is used for programming. Drivers for several popular instrumentation programming environments are available to facilitate systems integration of the i/iX Series II. Instrument drivers for popular programming environments such as National Instruments LabView™ are available to speed up system intergration.`

Application Software

Windows® application software is included with the iX and i Series II[1] . This software provides easy access to the power source’s capabilities without the need to develop any custom code. The following functions are available through this GUI program:

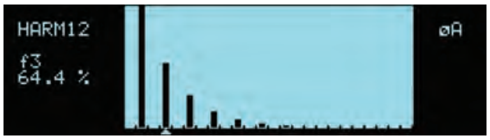
- Steady state output control (all parameters)
- Create, run, save, reload and print transient programs
- Generate and save harmonic waveforms [iX only]
- Generate and save arbitrary waveforms [iX only]
- Download data from a digital storage oscilloscope [iX only]
- Measure and log standard measurements
- Capture and display output voltage and current waveforms [iX only]
- Measure, display, print and log harmonic voltage and current measurements [iX only]
- Display IEEE-488 or RS232C bus traffic to and from the AC Source to help you develop your own test programs..

1. Requires PC running WindowsXP™ or Windows 2000™

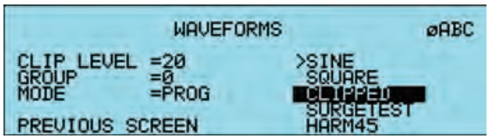
Harmonic Waveform Generation

Using the latest DSP technology, the iX Series II controller is capable of generating harmonic waveforms to test for harmonics susceptibility of a unit under test. Included is a Graphical User Interface program that can be used to define harmonic waveforms by specifying amplitude and phase for up to 50 harmonics. The waveform data points are generated and downloaded by the GUI to the AC source through either the USB, IEEE-488, RS232C bus or LAN and remain in nonvolatile memory. Up to 200 waveforms can be stored and given a user defined name for easy recall.

The three phase configuration iX Series II offers independent waveform generation on each phase allowing three phase anomalies to be programmed. It also allows simulation of unbalanced harmonic line conditions.



Harmonic waveform, Fund., 3rd, 5th, 7th, 9th,11th and 13th.

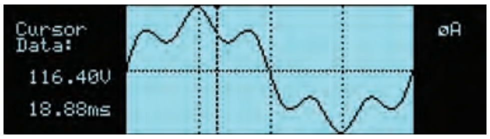


Two hundred user defined waveforms.

Arbitrary Waveform Generation [iX Series II only]

Using the provided GUI program or custom software, the user also has the ability to define arbitrary AC waveforms. The arbitrary waveform method of data entry provides an alternative method of specifying AC anomalies by providing specific waveform data points. The GUI program includes a catalog of custom waveforms. It also allows real-world waveforms captured on a digital oscilloscope to be downloaded to one of the many AC source's waveform memories.

Arbitrary waveform capability is a flexible way of simulating the effect of real-world AC power line conditions in both engineering and production environments.



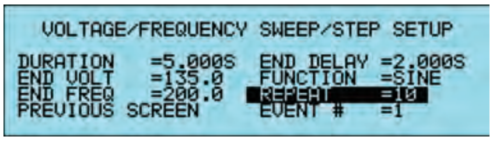
Two hundred user defined waveforms.

iX and i Series II - AC and DC Transient Generation

The iX and i Series II controllers have a powerful AC and DC transient generation system that allows complex sequences of voltage, frequency and waveshapes to be generated. This further enhances the i/iX's capability to simulate AC line conditions or DC disturbances. When combined with the multi phase arbitrary waveform capabilities, the AC and DC output possibilities are truly exceptional. In three phase i/iX system configurations, transient generation is controlled independently yet time synchronized on all three phases. Accurate phase angle control and synchronized transient list execution provide unparalleled accuracy in positioning AC output events.

Transient programming is easily accomplished from the front panel where clearly laid out menu's guide the user through the transient definition process. The front panel provides a convenient listing of the programmed transient sequence and allows for transient execution, Start, Stop, Abort and Resume operations.

User defined transient sequences can be saved to nonvolatile memory for instant recall and execution at a later time. The included Graphical User Interface program supports transient definitions using a spreadsheet-like data entry grid. A library of frequently used transient programs can be created on disk using this GUI program.



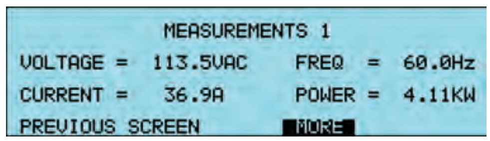
Transient List Data Entry from the front panel

Transient List Data Entry in GUI program.

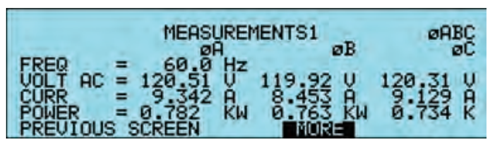
i/iX Series II

Measurement and Analysis

The i/iX Series II is much more than a programmable AC and DC power source. It also incorporates an advanced digital signal processor based data acquisition system that continuously monitors all AC source and load parameters. This data acquisition system forms the basis for all measurement and analysis functions. These functions are accessible from the front panel and the remote control interface.



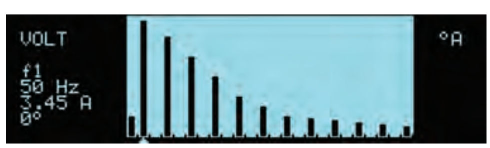
Measurement data for single phase (iX Display).



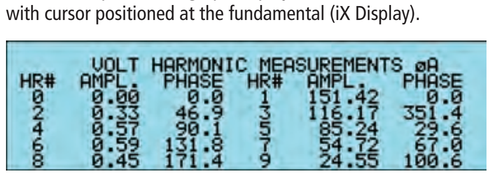
Measurement data for all three phases (iX Display).

Harmonic Analysis [iX Series II only]

The iX Series II provides detailed amplitude and phase information on up to 50 harmonics of the fundamental voltage and current for either one or three phases. Harmonic content can be displayed in both tabular and graphical formats on the front panel LCD for immediate feedback to the operator. Alternatively, the included GUI program can be used to display, print and save harmonic measurement data. Total harmonic distortion of both voltage and current is calculated from the harmonic data.



Absolute amplitude bar graph display of current harmonics with cursor positioned at the fundamental (iX Display).

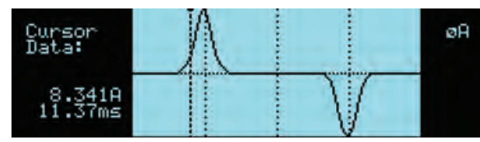


Voltage harmonic measurement table display in absolute values (iX Display).

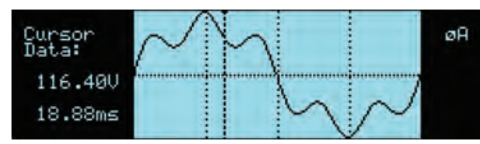
Waveform Acquisition [iX Series II only]

The measurement system is based on real-time digitization of the voltage and current waveforms using a 4K deep sample buffer. This time domain information provides detailed information on both voltage and current waveshapes. Waveform acquisitions can be triggered at a specific phase angle or from a transient program to allow precise positioning of the captured waveform with respect to the AC source output.

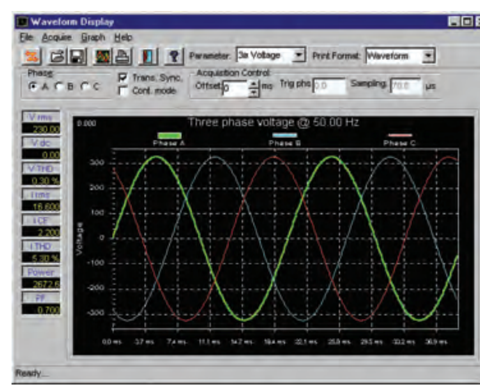
The front panel LCD displays captured waveforms with cursor readouts. The included GUI program also allows acquired waveform data to be displayed, printed and saved to disk.



Acquired Current waveform (iX Display).



Acquired Voltage waveform (iX Display).



Acquired three phase voltage waveforms display on PC.

i/iX Series II : Product Specifications

3000–15000 VA

Operating Modes	
iX Series II	AC, DC or AC+DC
i Series II	AC or DC

AC Mode Output	
Frequency	Range: 16.00-1000 Hz (Note: Voltage on 300 V range derates from 300 Vrms max at 500 Hz to 150 Vrms max at 1000 Hz; See V-F rating chart. below)
Total Power	**3001i/iX**: 3000 VA, **5001i/iX**: 5000 VA, **9003i/iX**: 3000 VA per phase, with mode iX: 9000 VA 1ø, **10001i/iX**: 10000 VA, **15001i/iX**: 15000 VA, **15003i/iX**: 5000 VA/ø 3ø, with mode iX: 15000 VA 1ø
Load Power Factor	0 to unity at full output VA

AC Mode Voltage

Voltage Ranges

Range	V Low	V High
AC	0-150 V	0-300 V
AC+DC	0-150 V	0-300 V

Load Regulation (with ALC on):	< 0.2%
Load Regulation (with ALC off):	< 0.5% DC to 100 Hz, < 0.6% 100 Hz to 500 Hz in high voltage range, < 2.2% 100 Hz to 500 Hz in low voltage range, < 3% 500 Hz to 1000 Hz
Line Regulation:	< 0.1% for 10% line change

Output Noise (20 kHz to 1 MHz)	< 250 mVrms typ., < 500 mVrms max
Harmonic Distortion (Linear)	< 1% from 16 - 66 Hz, < 2% at 400 Hz, < 3% at 800 Hz (Full resistive load)
DC Offset	< 20 mV
External Amplitude Modulation	Depth: 0 - 10 %, Frequency: DC - 2 KHz
Isolation Voltage	300 Vrms output to chassis
Voltage slew rate	200 µs for 10% to 90% of full scale change into resistive load, 0.5V / µSec

AC Mode Current

Steady State AC Current

Model	3001i/iX	5001i/iX	9003i/iX 3ø	10001i/iX	15001i/iX	15003i/iX 3ø
300 V range	11.1	18.5	11.1 /ø	37.0	55.5	18.5 /ø
150 V range	22.2	37.0	22.2 /ø	74.0	111.0	37.0 /ø

Note: Constant power mode provides increased current at reduced voltage (See chart below)

Peak Repetitive AC Current

Model	3001i/iX	5001i/iX	9003i/iX 3ø	10001i/iX	15001i/iX	15003i/iX 3ø
High range	96.0	96.0	96.0 /ø	192.0	288.0	96.0 /ø
Low range	110.0	110.0	110.0 /ø	220.0	330.0	110.0 /ø

Programming Accuracy	Voltage (rms): ± 0.2 of range, 16 to 1000 Hz, Frequency: ± 0.01 % of programmed value, Current Limit: ± 0.5 % of programmed value, Phase: < 1.5° with balanced load at 50/60 Hz
Programming Resolution	Voltage (rms): 100 mV, Frequency: 0.01 Hz from 16 - 81.91 Hz, 0.1 Hz from 82.0 - 819.1 Hz, 1 Hz from 820-1000 Hz, Current Limit: 0.1 A, Phase, 0.1°
Output Relay	Push-button controlled or bus controlled output relay
Output Impedance (iX Only)	Programmable Z on 3001iX, 5001iX, 9003iX and 15003iX (3ø mode only) for 50 Hz fundamental
Resistive	Range: 17 - 1000 mOhm,resolution: 4 mOhm accuracy, 2 % FS
Inductive	Range: 230 - 1000 µH, resolution: 4 µH, accuracy: 2 % FS

DC Mode Output	
Power (Max at full scale of DC Voltage Range):	3001i/iX: 2100 W, 5001i/iX: 3500 W, 9003i/iX: 2100 W/ø 3ø, 6300 W 1ø, 10001i/iX: 7000 W, 15001i/iX: 10500 W, 15003i/iX: 3500 W/ø 3ø
Voltage Ranges	Range: Low: 200 Vdc, High: 400 Vdc
Line Regulation	< 0.1% FS or 10% line change
Output Noise	< 250 mV rms typ., < 500 mV rms max., (20 kHz to 1 MHz)

Max DC Current (Maximum current at 65% of V Range)

Model	3001i/iX	5001i/iX	9003i/iX 3ø	10001i/iX	15001i/iX	15003i/iX 3ø
400V range	7.8	13	7.8	26	39	13
200V range	15.6	26	15.6	52	78	26

Note: Constant power mode provides increased current at reduced voltage (See chart below)

Current Limit	Programmable from 0 A to maximum current for selected range

AC+DC Mode Output	
Output Power (iX only)	Full AC Power if DC component is less than 20% of full scale voltage, Full DC power if DC component is above 20%

i/iX Series : Product Specifications

Measurements

Output Parameter	i Series	iX Series
Current Limit Range	Programmable 0 to 100% of range for all ranges	Programmable 0 to 100% of range for all ranges
Current Limit Resolution	0.1 Arms	0.1 Arms
Current Limit Accuracy	± 0.5 A	± 0.5 A
Frequency Range	16.00 - 81.91 Hz (0.01 Hz resolution) 81.0 – 819.1 Hz (0.1 Hz resolution) 820 – 1000 Hz (1 Hz resolution)[1]	16.00 - 81.91 Hz (0.01 Hz resolution) 81.0 – 819.1 Hz (0.1 Hz resolution) 820 – 1000 Hz (1 Hz resolution)[1]
Frequency Accuracy	± 0.01% of programmed value	± 0.01% of programmed value
DC Offset Voltage	Less than 20 mV with linear load.	Less than 20 mV with linear load.
Output Impedance Range	n/a	Rmin to 1000 mΩ Lmin to 1000 μH
Output Impedance Resolution	n/a	4 mΩ 4 μH
Output Impedance Accuracy	n/a	± 2% F.S. at 796 μH and 400 mΩ
Output Noise (20 kHz to 1 MHz)	<250 mV rms (typ), <500 mV rms (max)	<250 mV rms (typ), <500 mV rms (max)

1 Note: AC voltage in 300V range derates from 300 Vrms max. at 500 Hz to 150 Vrms max. at 1000 Hz.

Measurements : Peak AC Current

Output Parameter	i Series	iX Series
3001i/iX 5001i/iX	110 A for 150 V range, 92 A for 300 V range	110 A for 150V range, 92 A for 300 V range,
10001i/iX	220 A for 150 V range, 184 A for 300 V range	220 A for 150 V range, 184 A for 300 V range
15001i/iX	330 A for 150 V range, 276 A for 300 V range	330 A for 150 V range, 276 A for 300 V range
Crest Factor	Up to 5:1	Up to 5:1

AC Measurements

Parameter	Range	Accuracy (±)	Resolution
Frequency	16.00 - 1000 Hz	2 counts	0.01: 16 to 81.91 Hz 0.1: 82.0 to 819.0 Hz 1: 820 to 1000 Hz
RMS Voltage	0 - 300 Volts	0.25V + 0.1%, <100 Hz 0.25V + 0.2%, 100-1000 Hz	0.01 Volt
RMS Current	0 - 40 Amps	0.25A + 0.1%, <100 Hz 0.25A + 0.2%, 100-1000 Hz	0.001 Amp
Peak Current	0 - 119 Amps	0.5A + 0.2%, <100 Hz 0.5A + 0.5%, 100-1000 Hz	0.01 Amp
VA Power	0 – 6000 VA	10 VA + 0.1%, <100 Hz 20 VA + 0.2%, 100-1000 Hz	1 VA
Real Power	0 – 6000 W	10 W + 0.1%, <100 Hz 20 W + 0.2%, 100-1000 Hz	1 W
Power Factor (>0.2kVA)	0 - 1.00		0.01

Accuracy specifications apply above 100 counts. Current and Power Accuracy specifications are times two for 10001iX and times three for 15001iX. For 10001iX and 15001iX, resolution decreases by factor of 10, ranges for current and power increases by factor of three. Measurement bandwidth is limited to 16 Khz.

DC Measurements

Parameter	Range	Accuracy (±)	Resolution
Voltage	0 – 400 Volts	0.4 Volts	0.01 Volt
Current	0 – 40 Amps	0.1 Amps	0.001 Amp
Power	0 – 6000 W	20 W	1 W

Accuracy specifications apply above 100 counts. Current and Power Accuracy specifications are times two for 10001iX and times three for 15001iX. For 10001iX and 15001iX, resolution decreases by factor of 10, ranges for current and power increases by factor of three.

i/iX Series : Product Specifications 3000–15000 VA

Harmonic Measurements (iX series)

Parameter	Range	Accuracy (±)	Resolution
Frequency fundamental	16.00 - 1000 Hz	2 counts	0.01 Hz to 1 Hz
Frequency harmonics	32.00 Hz - 16 kHz	2° typ.	0.5°
Voltage	Fundamental	0.25V	0.01V
	Harmonic 2 - 50	0.25V + 0.1% + 0.1%/kHz	0.01V
Current	Fundamental	0.05A	0.01A
	Harmonic 2 - 50	0.05A + 0.1% + 0.1%/kHz	0.01A

Accuracy specifications are times three for three phase mode. Harmonics frequency range in three-phase mode is 32 Hz - 16 kHz. Resolution decreases by factor of 10 for 10001iX and 15001iX.

Remote Control

IEEE-488 Interface optional / USB standard	IEEE-488 (GPIB) talker listener. Subset: AH1, C0, DC1, DT1, L3, PP0, RL2, SH1, SR1, T6, IEEE-488.2 SCPI Syntax (GPIB standard on iX)
RS232C Interface (LAN Optional)	9 pin D-shell connector, Handshake: CTS, RTS, Data bits: 7,8, Stop bits: 1, 2, Baud rate: 9600, 19200, 38400, 57600, 115200, IEEE-488.2 SCPI Syntax (Supplied with RS232C cable). (RS232C Standard on iX - LAN Optional)

AC Input

Voltage	3001 and 9003: 208-240 ± 10% Vac, (L-N, 1ø), All other models: Standard: 208-240 ± 10% Vac, (L-L, 3ø), Option -400: 400-480 ± 10% Vac, (L-L, 3ø) (Input range must be specified when ordering).
Input Line Current (per phase):	

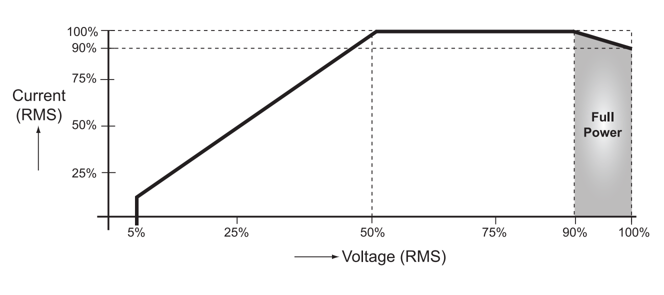
Model	3001i/iX	5001i/iX	9003i/iX	10001i/iX	15001i/iX	15003i/iX
187-264V	25 A	23 A	75 A	46 A	69 A	69 A
360-528V	N/A	12 A	N/A	24 A	36 A	36 A

Inrush Current per chassis	< 100 Apk for 100 µs at 208-240 V, < 50 Apk for 100 µs at 400-480 V
Line Frequency	50-60 Hz ± 10 %
Efficiency	75% typical
Power Factor	0.6 typical
Regulatory	IEC61010, EN50081-2, EN50082-2, CE EMC and Safety Mark requirements
RFI Suppression	CISPR 11, Group1 , Class A
Rear Panel Connectors	AC Input & Output terminal block with cover, IEEE-488 (GPIB) connector (rear panel), 9 pin D-Shell RS232C connector*, Remote voltage sense terminal block, System Interface Connector, *RS232 DB9 to DB9 cable supplied

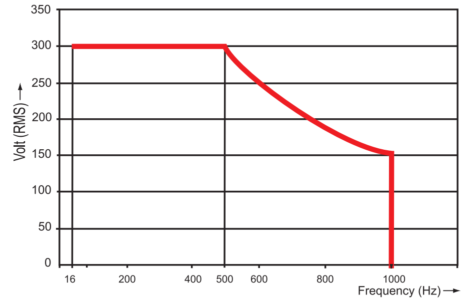
Mechanical

Dimensions	Height: 7” (178 mm), Width: 19” (483 mm), Depth: 24” (610 mm) (depth includes rear panel connectors)
Weight	per Chassis: Net: 61 lbs / 28 Kg, Shipping: 115 lbs / 52 Kg
Vibration and Shock	Designed to meet NSTA project 1A transportation levels
Air Intake/Exhaust	Forced air cooling, side air intake, rear exhaust.
Operating Humidity	0 to 95 % RAH, non condensing.
Temperature	Operating: 0 to 40° C, Storage: -20 to +85° C

Constant Power AC Mode - Available Max. AC Current



V-F Rating Chart - 300V Range



Note: Specifications are subject to change without notice. Specifications are warranted over an ambient temperature range of 25°± 5° C. Unless otherwise noted, specifications are per phase for a sinewave with a resistive load and apply after a 30 minute warm-up period. For three phase configurations, all specifications are for L-N. Phase angle specifications are valid under balanced load conditions only.

i/iX Series : Product Specifications

Standard controller versions							
Model	Output Power AC	Phase Output	Max. current per phase				Input Voltage[2]
			Low V range		High V range		
			AC	DC	AC	DC	
3001i/iX	3 kVA	1	22	15.6	11	7.8	208-240V
5001i/iX	5 kVA	1	37	26	18.5	13	208-240V
5001i/iX-400	5 kVA	1	37	26	18.5	13	400-480V
9003iX1	9 kVA	3	22	15.6	11	7.8	208-240V
10001i/iX[1]	10 kVA	1	74	52	37	26	208-240V
10001i/iX-400[1]	10 kVA	1	74	52	37	26	400-480V
10002i/iX[3]	10 kVA	2	37	26	18.5	13	208-240V
10002i/iX-400[3]	10 kVA	2	37	26	18.5	13	400-480V
15001i/iX[1]	15 kVA	1	111	78	55.5	39	208-240V
15001i/iX-400[1]	15 kVA	1	111	78	55.5	39	400-480V
15003i/iX[1]	15 kVA	3	37	26	18.5	13	208-240V
15003i/iX-400[1]	15 kVA	3	37	26	18.5	13	400-480V

Note (1): Supplied with System Interface cable(s). Controller in master unit only.
Note (2): All input voltage specifications are for Line to Line three phase except 3001iX and 9003iX which require single phase input only.
Note (3): For 10002iX split phase system specifications, refer to 5001iX for each phase.

Controller		
Controller	i	iX
AC mode	X	X
DC mode	X	X
AC+DC mode		X
Transient programming	X	X
Arbitrary waveforms		X
Measurements (standard)	X	X
Harmonic measurements		X
Waveform acquisition		X
Programmable Impedance		X
IEEE / RS232 / USB	X	X

Storage	
Non Volatile Mem. storage	16 instrument setups, 200 user defined waveforms

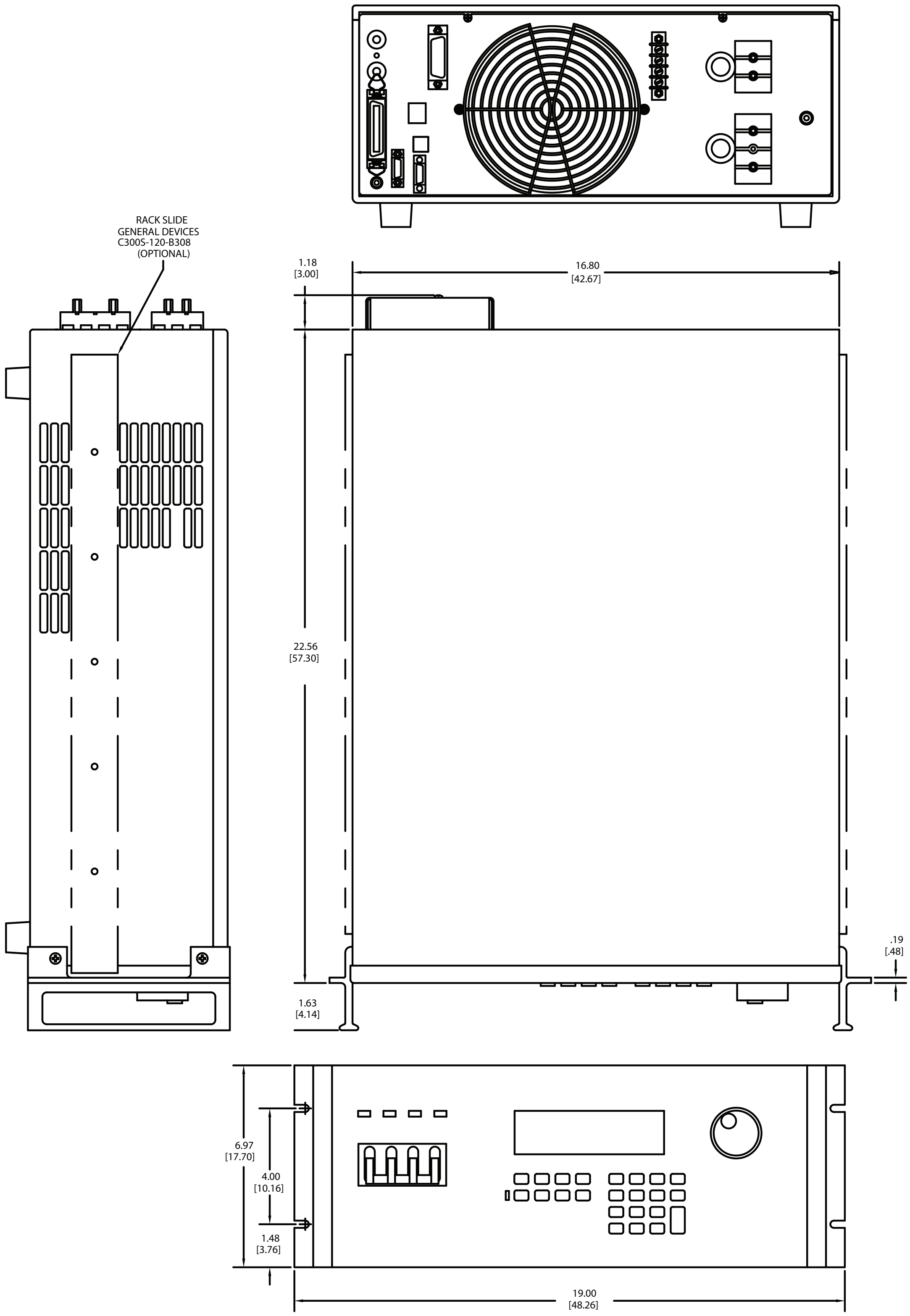
Waveforms	
Waveform Types	i Series II: Sine, iX Series II: Sine, Square, Clipped sine, User defined
User defined waveform storage	Four groups of 50 user defined arbitrary waveforms of 1024 points for a total of 200 (One group can be active at a time)

System Interface	
Inputs	Remote shutdown, External Sync, Clock/Lock (option)
Outputs	Function Strobe, Clock/Lock (option)

Protection	
Over Load	Constant Current or Constant Voltage mode
Over Temperature	Automatic shutdown

i/iX Series Diagram

3000–15000 VA



i/iX Series

Supplied with

User Manual, Programming Manual, Software (all on CD ROM) and RS232C serial cable.

Options

Option Code	Description
-LKM	Clock/Lock Master
-LKS	Clock/Lock Auxiliary
-LNS	Internal AC Line Sync.
-FC	Modifies output frequency control to ± 0.15%
-XLS	External AC Line Sync adaptor. (-LNS and XLS are mutually exclusive)
-MODE-iX	Switches between 1 and 3 phase output modes, for 9003iX or 15003i/iX only. (Separate box)
OMNI-1-18i	Impedance matching network for single phase 3001i/iX or 5001i/iX to support IEC-1000-3-3 flicker tests.
OMNI-3-18i	Impedance matching network for three phase 9003iX or 15003i/iX systems to support IEC-1000-3-3 flicker tests.
OMNI-3-37i	Impedance matching network for three phase 30003i/iX systems to support IEC-1000-3-3 flicker tests.
-RMS	Rackmount Slides.
-WHM	Watt-Hour Measurement option.
-400	400-480 Volt Line to Line AC input.
-FC	Modifies output frequency control to ± 0.15%
-411	IEC61000-4-11 test firmware. See also EOS1/3.
-413	IEC61000-4-13 Harmonics and Interharmonics test firmware and hardware.
-EOS-1	IEC61000-4-11 Electronic Output Switch (1 phase) Includes -411 option. Refer to EOS data sheet for details.
-EOS-3	IEC61000-4-11 Electronic Output Switch (3 phase) Includes -411 option. Refer to EOS data sheet for details.
-LAN	LXI Ethernet LAN Interface (Rj45 Connector) (iX Only)
Cabinets	Multi box iX Series II systems can be factory installed and wired in 19 inch cabinets. Cabinet configurations can be ordered by preceeding the model number with a "C1-C4" prefix. Contact factory for pricing and details.
Avionics Test Routine Options	
-ABD	Airbus Directive 0100.1.8 tests.
-AMD	Airbus AMD24 tests.
-A350	Airbus A350 tests.
-AIRB	Airbus test package (A380, A350, AMD24)
-B787	Boeing 787B3-0147 tests.
-160	RTCA/DO-160D and EUROCAE test firmware. Refer to -160 option data sheet for details.

* Note Reference the Avionics Test User Manual P/N 4994-971 for a complete listing of performance capabilities.

California Instruments Ls Series

3000–18000 VA

3-18 kVA Programmable AC Power Source / Analyzer

135–400 V

0–132 A

≋	208	230	400
∼		230	

ETHERNET USB GPIB RS232

- Backward Compatible with L Series
  Function and bus compatible with the California Instruments L Series
- Three phase and Single phase modes
  Ideally suited for avionics and defense applications
- 3 kVA to 18 kVA Power Levels
  Match power source and cost to application requirements
- Transient Programming
  Test products for susceptibility to AC line disturbances
- Built-in Measurements
  Performs voltage, current, and power measurements
- Advanced Features
  Arbitrary waveform generation, harmonic analysis, GPIB interface are some of the available options
- Interface
  Standard USB & RS232C interface.
  Optional GPIB & LAN available
- CE Marked (400V Input model ONLY)
  Safe, reliable, and consistent operation

Integrated System
The Ls Series is an improved version of the classic California Instruments L Series AC power sources. The Ls Series provides many basic AC source capabilities at an economical cost. Additional capabilities such as arbitrary waveform generation and harmonic analysis can be added as options.

The Ls Series can be ordered in either single phase (-1) or three phase (-3) configurations. Power levels range from 3 kVA to 6 kVA in a single chassis. Multiple chassis can be combined for power levels up to 18 kVA.

Easy-To-Use Controls
The Ls Series is completely microprocessor controlled and can be operated from simple front panel controls. A pair of analog controls located next to the backlit alphanumeric LCD display allows output voltage and frequency to be slewed up or down dynamically. For more advanced operations, a series of menus is provided using a dual line high contrast LCD display. An optional full keypad is available.

Applications
With precise output regulation and accuracy, high load drive current, multi or single phase mode and built-in measurement capabilities, Ls Series AC sources address many application areas of AC power testing. Additional features such as DO 160, MIL 704, Boeing, or Airbus test standards are available options that establishes the Ls Series as a solid choice for avionics or defense applications. All Ls Series AC sources are standard equipped with USB and RS232C remote control interfaces. GPIB and Ethernet (LAN) interfaces are optional.

Compatibility
Although the standard command language is SCPI, the Ls Series also offers functional and bus compatibility with the CI L Series AC power sources. Using the APE (Abbreviated Plain English) command syntax, the Ls Series can be used in existing test systems without having to modify program code. The APE language is part of the -GPIB option which includes a GPIB/ IEEE-488 interface.

Ls Series

Transient Programming
To simulate common line disturbance occurrences, the Ls Series offers a list of transient steps. These steps can be programmed from the front panel or downloaded over the interface using the Interface Instrument Control Software (GUI) program supplied. The GUI allows libraries of commonly used line disturbances to be created on disk for quick recall. Once downloaded, the transient program can be executed from the PC or from the front panel. AC transient generation allows the effect of rapid changes in voltage, frequency, phase angle and waveform shape on the unit under test to be analyzed. The Ls Series is available in either three or one phase output configurations and offers standard voltage ranges of 135 Vrms and 270 Vrms. A wide range of options can be added to customize the Ls Series to meet your specific application requirements.

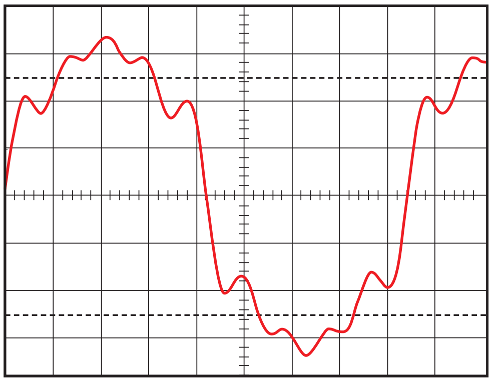
Voltage Range Options
Output voltage range options are available to provide higher voltage outputs. In addition to the standard 135/270 V range pair, 156/312 Vrms (-HV option) or 200/400 Vrms (-EHV option) can be specified at the time of order. All voltage ranges are Line to Neutral. On three phase Ls Series models, maximum Line to Line voltages are 467 V (standard), 540 V (-HV option) and 692 V (-EHV option).

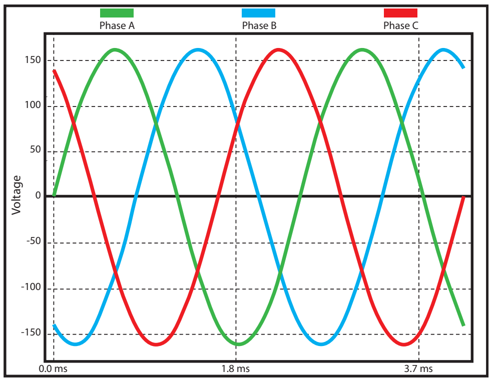
Phase Mode
The -MODE option provides automatic switching between three phase and single phase output modes. In single phase mode, all output current is routed to the Phase A output terminal.
The -MODE option is available for 3 phase Ls configurations.

Waveform Generation
The standard Ls Series provides sine wave output capability. For more demanding test applications, the advanced option package (-ADV) adds the following waveform capabilities:

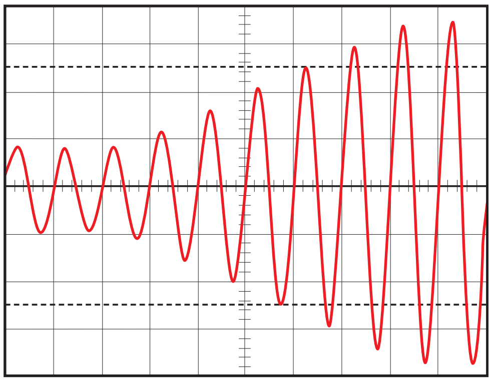
- Squarewave.
- Clipped Sinewave - Simulates THD levels to test for harmonic distortion susceptibility.
- Harmonic and Arbitrary (User defined) waveforms.

Using the provided Windows GUI, defining harmonic waveforms is as easy as specifying the relative amplitude and phase angle for each of up to the 50th harmonic. The waveform data points are generated and downloaded by the ICS to the AC source through the standard RS232C, USB or optional LAN or GPIB bus and are retained in non-volatile memory. Up to 50 waveforms can be stored and named for easy recall.


Harmonic waveform, Fund., 3rd, 5th, 7th and 9th.



Three phase output mode.


Voltage sweep transient causes output voltage to change at a programmed rate.

Ls Series - Measurement and Analysis
The Ls Series measurement system is based on real-time digitization of the voltage and current waveforms using a 4K sample buffer. The digitized waveform data is processed by a Digital Signal Processor to extract conventional load values such as rms voltage, rms current, real and apparent power. With the addition of the advanced features option. (-ADV option), the same data can also be used to perform Fast Fourrier Transformation (FFT) to extract the harmonic amplitude and phase angle of 50 harmonics, or display acquired voltage and current waveforms.

Ls Series 3000–18000 VA

Standard Measurements

The following standard measurements are available from the front panel or via the bus:

- Frequency and Phase
- Voltage (rms)
- Current(rms) and Peak Current
- Crest Factor
- Real Power and Apparent Power
- Power Factor

Advanced Measurement Functions (-ADV option)

Power analysis of EUT load characteristics is available by adding the -ADV option. Harmonics up to the 50th harmonic (for fundamental frequencies up to 250 Hz) and total harmonic distortion of both voltage and current is provided as well.

Harmonic analysis data can be displayed on the front panel display or on the PC using the GUI program. The GUI can also be used to save and print harmonics data in tabular, bar graph or time domain formats.

The acquired voltage and current time-domain waveforms for each output phase can be displayed using the GUI program. Waveform displays on the PC. Available display modes include voltage and current combined, three phase voltage, three phase current and true power. The time-domain data is also available for transfer to a PC through the bus when using custom software.

Diagnostics Capability

The AC Source can perform a self test and report any errors. The self test will run until the first error is encountered and terminate. The response to the self test query command will either be the first error encountered or 0 if no error was found. (Self test passed).

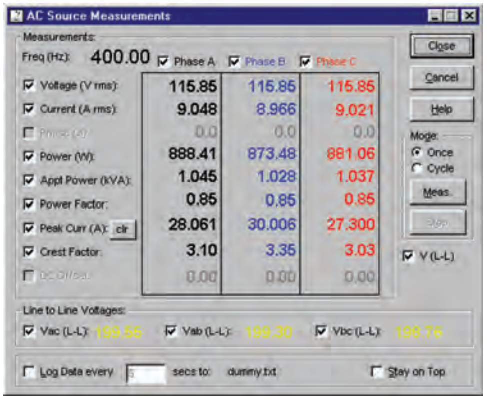
Windows Graphical User Interface

A Windows compatible Instrument Control Software (GUI) offers a soft front panel interface for operation from a PC. The following functions are available through this GUI program:

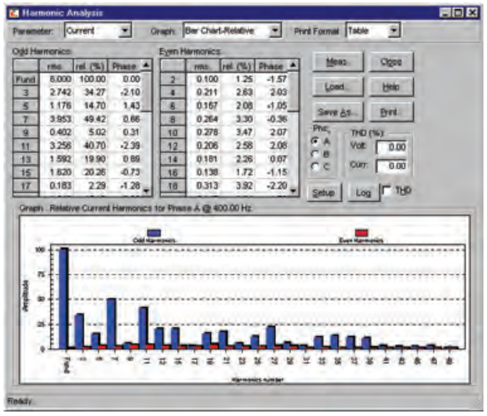
- Steady state output control (all parameters).
- Create, run, save and print transient programs.
- Measure and log standard measurements.

With -ADV option:

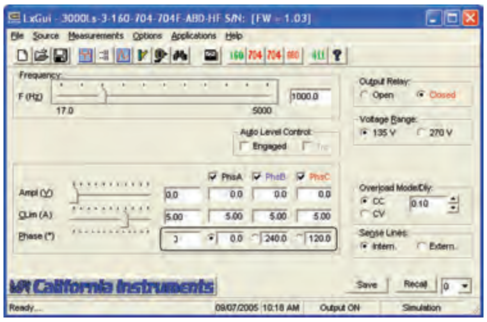
- Generate and save harmonic waveforms.
- Generate and save arbitrary waveforms.
- Capture and display Voltage and Current waveforms.
- Measure, display, print and log harmonic voltage and current measurements.



Standard measurements for all phases.

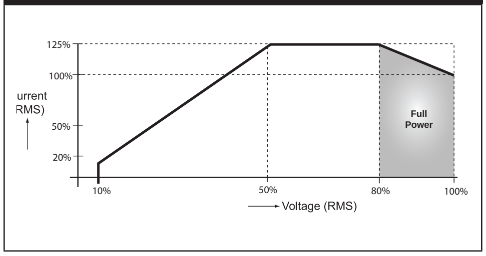


Standard measurements for all phases.



Standard measurements for all phases.

Constant Power AC Mode - Max. AC Current



Ls Series : Specifications

Output

Maximum Power per phase	3000Ls: 1 phase: 3000 VA, 3 phase: 1000 VA; 4500Ls: 1 phase 4500 VA, 3 phase 1500 VA; 6000Ls: 1 phase 6000 VA, 3 phase: 2000 VA
Power factor	0 to unity at full output VA

Voltage Ranges

Range	V Low	V High
AC	0-135V	0-270V

VA Programming Resolution	100 mV
Load Regulation	< 0.1 % FS
Line Regulation	< 0.02 % for 10 % line change

See -HV and EHV options for alternative voltage range pairs.

Programming Accuracy (25°C ±5°C	Voltage (rms): ± (0.05% + 0.25) V from 5.0 V to FS; Frequency: ± 0.025 45 Hz - 819.1 Hz, ± 0.7 % > 819.1 Hz; Phase: ± 1° 45-100 Hz, ± (1° + 1°/kHz) 100 Hz-1kHz
Frequency Range	45 Hz - 1000 Hz (see -HF option for higher output frequencies) 17 - 45 Hz operation available at reduced voltages
Frequency Resolution	0.01 Hz at < 81.9 Hz, 0.1 Hz at 82.0 to 819.1 Hz, 1 Hz2 at > 819 Hz

Max RMS Current

V Range	V high	V low
-3 3 ø	7.4 A	14.8 A
-1 1 ø	22.2 A	44.4 A

< At Full Power	Model	3000Ls-3 Ø	3000Ls-1 Ø	4500Ls-3 Ø	4500Ls-1 Ø	6000Ls-3 Ø	6000Ls-1 Ø
At FS Voltage >	V Low	7.4 A	22.2 A	11.1 A	33.3 A	14.8 A	44.4 A
	V High	3.7 A	11.1 A	5.5 A	16.7 A	7.4 A	22.2 A

Note: Constant power mode on 3000Ls and 4500Ls provides increased current at reduced voltage; 6000Ls provides maximum voltage.

Current Limit	Programmable from 0 Amps to maximum current for selected range
Peak Current	3000Ls: 6 X (Irms @ full scale voltage); 4500Ls: 4 X (Irms @ full scale voltage); 6000Ls: 3 X (Irms @ full scale voltage)
Output Noise	100mV rms typ. (20 kHz to 1 MHz) Harmonic Distortion < 1% (at full scale voltage, full resistive load)
Isolation Voltage	300 V rms output to chassis Output Relay Push button controlled and bus controlled output relay

Input

Voltage	Models 3000Ls, 4500Ls, 9000Ls, 13500Ls: Standard: 208-230 ± 10% VAC, (L-L, 3 Phase); Option -400: 400 ± 10% VAC (L-L, 3 Phase); Models 6000Ls, 12000Ls, 18000Ls: Standard 208-230 + 10% VAC (L-L, 3 Phase) 450V L-L: Consult factory Notes: 1. Input must be specified when ordering. 2. -400 option not availble on 6000Ls, 12000Ls, 18000Ls. 3. 3000Ls can be operated from 1 phase AC.

Line Current (rms per phase)

Model	3000Ls	3000Ls (1Phase)	4500Ls	6000Ls (@ 208V)
187 VLL	19 A	32 A	31 A	38 A
360 VLL	10 A	n/a	16 A	n/a

Inrush Current (Per phase):	@ 180-254 V: 50 A peak @ 360-440 V: 83 A peak
Line Frequency:	47-440 Hz

Efficiency	75% typical
Power Factor	0.6 typical
Hold-up Time	At least 10 ms

System

Storage	Setup: 16 complete instrument setups / Transient List: 100 transient steps per list (SCPI mode) or 16 transient registers (APE mode)
Trigger Input/Output	Input: Triggers measurements or transient steps - SMA connector: 10K pull-up / Output: SMA Connector: HCTTL output

Protection

Overload/Temp/Voltage	Overload: Constant current or constant voltage mode; Over temperature: Automatic Shutdown; Over voltage: Automatic shutdown
Regulatory/RFI Suppresion	IEC1010, EN50081-2, EN50082-2, CE (for 400V input only), EMC, and safety mark requirements / RIF Suppression: CISPR 11, Group1, Class A

Measurement

Measurements - Standard (AC Measurements)

Parameter	Frequency	Phase	Voltage (AC)	Current (AC rms)	Real Power	Apparent Power	Power Factor
Range	45-81.91 Hz 82.0-819.1 Hz > 819 Hz	45-100 Hz 100-1000 Hz	0-400 V	0-50 A	0-6 kW	0-6 kVA	0.00-1.00
Accuracy* (±) 1 ø mode (-1)	0.1% + 1 digit	0.5°	0.5% + 250 mV	0.1% + 150 mA	0.15% + 9 W	0.15% + 9 VA	0.03
3 ø mode (-3)		2°		0.1% + 50 mA	0.15% + 3 W	0.15% + 3 VA	0.01
Resolution*	.01 Hz / 0.1 Hz / 1 Hz	0.1° / 1°	10 mV	1 mA	1 W	1 VA	0.01

* Accurac specifications are in % of reading and apply above 100 counts. For multi-chassis configurations, current, power range and accuracy specifications are times three. Power factor accuracy applies for PF > 0.5 and VA > 50% of max. Frequency measurement specification valid for output > 30 Vrms.

Note: Specifications are subject to change without notice. Specifications are warranted over an ambient temperature range of 25°± 5° C. Unless otherwise noted, specifications are per phase for a sinewave with a resistive load and apply after a 30 minute warm-up period. For three phase configurations, all specifications are for L-N. Phase angle specifications are valid under balanced load conditions only.

Ls Series : Specifications 3000–18000 VA

Remote Control

IEEE-488 Interface (option)	IEEE-488 (GPIB) talker listener. Subset: AH1, C0, DC1, DT1, L3, PP0, RL2, SH1, SR1, T6, IEEE-488.2 SCPI Syntax
USB Interface & Ethernet	Version: USB 1.1; Speed: 460 Kb/s maximum / Ethernet Interface (Optional): specify -LAN option. 10BaseT, 100BaseT, RJ45
RS232C Interface	Bi-directional serial interface; 9-pin D-shell connector. Handshake: CTS, RTS. Databits: 7 w/ parity, 8 w/o parity. Stopbits: 2. Baud rate: 9600 to 115200. Supplied with RS232C cable / Code and Format: SCPI; APE (option -GPIB)

Physical Dimensions

Dimensions (per chassis)	Height: 10.5" (267 mm), Width: 19" (483 mm), Depth: 23.7" (602 mm) (depth includes rear panel connectors)
Weight	Chassis: Net: 193 lbs / 87.7 Kg, Shipping: 280 lbs / 127.3 Kg (for /2 or /3 model configuarations multiply number of chassis)
Vibration and Shock	Designed to meet NSTA project 1A transportation levels
Air Intake/Exhaust	Forced air cooling, side air intake, rear exhaust
Temperature & Diagnostics	Temperature: Operating: 0 to 35° C, full power / Storage: -40 to +85° C; Diagnostics: Built-in self test available over bus (*TST)
Rear Panel Connectors	* Three phase AC input and output terminal block with safety cover. * IEEE-488 (GPIB) connector (Option -GPIB). * 9-pin D-Shell RS232C connector (RS232 DB9 to DB9 cable supplied). * Remote Inhibit (INH) and Discrete Fault Indicator (DFI). * Remote voltage sense terminal block. * Trigger In1 and Trigger Out1. * System interface connectors. * Auxilary Output (Option -AX)

Option -AX Specifications

Option -AX	Provides seperate isolated 26 VAC regulated and 5 Vac unregulated outputs. The 26 V is normally used for servo-synchro excitation, and the 5 V for lamp power. 26 Volt-Accuracy: ± 2%. Current capacity: 3 ARMS. Frequency: 360/440 Hz. Regulation ± 0.05%. 5 Volt-Accuracy: ± 5%. Current capacity: 5 ARMS

Option -ADV Specifications

Measurements - Harmonics

Parameter	Frequency Fundamental Harmonics	Voltage	Current
Range	45-250 Hz / 0.09 - 12.5 kHz	Fundamental Harmonics 2 - 50	Fundamental Harmonics 2 - 50
Accuracy* (±)	0.01% + 1 digit / 0.5% + 1 digit	750 mV 0.3% + 750 mV+0.3% /1 kHz	0.5 A / 0.3% + 150 mA +0.3% /1 kHz
Resolution	0.01 Hz / 0.1 Hz	10 mV / 10 mV	10 mA / 10 mA

* Accuracy specifications are in a percent of reading for single unit in 3-phase mode.

Waveforms	Pre defined: Sine, Square, Clipped User defined, 1024 addressable data points; Storage: 50 user waveforms, non-volatile memory
Data Acquisition	Parameters: Voltage, Current time domain, per phase; Resolution: 4096 data points, 10.4 usec (1ø) or 31.25 usec (3ø) sampling interval

Option -HV Specifications

Voltage/Frequency Ranges	Low: 0-156 Volt; High: 0-312 Volt / Frequency: With -HF option: 3000Ls, 4500Ls, 6000Ls: 45 Hz - 5000 Hz; 9000Ls, 12000Ls, 13500Ls, 18000Ls: 45 Hz - 5000 Hz
Max RMS Current at Full Power	3 Phase: High: 6.4 A, Low 12.8 A; 1 Phase: High: 19.2 A, Low: 38.4 A; Note: Constant power modes on 3000Ls and 4500Ls. Current available at reduced voltage for 3000Ls, 4500Ls, and max voltage for 6000Ls
Max RMS Current at FSVoltage	3000Ls: 3 Phase: High: 3.2 A, Low: 6.4 A; 1 Phase: High 9.6 A, Low: 19.2 A; 4500Ls: 3 Phase: High: 4.8, Low 9.6; 1 Phase: High: 14.4 A, Low: 28.8 A; 6000Ls: 3 Phase: High: 6.4 A, Low 12.8 A; 1 Phase: High: 19.2 A, Low: 38.4 A

Option -EHV Specifications

Voltage/Frequency Ranges	Voltage: Low: 0-200 Volt; High: 0-400 Volt / Frequency: With -HF option: 45 Hz - 5000 Hz
Max RMS Current at Full Power	3 Phase: High: 5.0 A, Low 10.0 A; 1 Phase: High: 15.0 A, Low: 30.0 A; Note: Constant power modes on 3000Ls and 4500Ls. Current available at reduced voltage for 3000Ls, 4500Ls, and max voltage for 6000Ls
Max RMS Current at FS Voltage	3000Ls: 3 Phase: High: 2.5 A, Low: 5.0 A; 1 Phase: High 7.5 A, Low: 15.0 A; 4500Ls: 3 Phase: High: 3.8, Low 7.5; 1 Phase: High: 11.3 A, Low: 22.5 A; 6000Ls: 3 Phase: High: 5.0 A, Low 10.0 A; 1 Phase: High: 15.0 A, Low: 30.0 A

Option -HF Specifications

Measurements:

F < 2000 Hz: See standard Ls Specifications;

F > 2000 Hz: See table >

Parameter	Frequency	Phase	Voltage (AC)	Current (AC rms)	Real Power	Apparent Power	Power Factor
Range	45 - 5000 Hz	< 2000 Hz > 2000 Hz	0-300 V < 1000 Hz / > 1000 Hz	0-50 A	0-5 kW	0-5 kVA	0.00-1.00
Accuracy* (±) 1 ø mode (-1)	0.1% + 1 digit	0.5°	0.05% + 250 mV	0.5% + 150 mA	0.5% + 9 W	0.5% + 9 VA	0.03
3 ø mode (-3)		5°	0.1% + 0.1%/kHz +300MV	0.5% + 50 mA	0.5% + 3 W	0.5% + 3 VA	0.01
Resolution*	0.01 Hz / 0.1 Hz / 1 Hz	0.1° / 1°	10 mV	1 mA	1 W	1 VA	0.01

* Accurac specifications are in % of reading and apply above 100 counts. For multi-chassis configurations, current, power range and accuracy specifications are times three. Power factor accuracy applies for PF > 0.5 and VA > 50% of max. Frequency measurement specification valid for output > 30 Vrms.

250 mVrms typical (20 kHz to 1 MHz)	3000Ls 4500Ls, 6000Ls: Standard: -HV 45 Hz- 5000 Hz; - EHV: 45 Hz - 5000 Hz
Output Noise	250 mVrms typical (20 kHz to 1 MHz)

Ls Series

Model¹	Output Power	No of Output Phases		Nom. Input Voltage²
		-1	-3	
3000Ls	3 kVA	1	3	208-230 V
3000Ls-400	3 kVA	1	3	400 V
4500Ls	4.5 kVA	1	3	208-230 V
4500Ls-400	4.5 kVA	1	3	400 V
6000Ls	6 kVA	1	3	208-230 V
9000Ls/2	9 kVA	1	3	208-230 V
9000Ls/2-400	9 kVA	1	3	400 V
12000Ls/2	12 kVA	1	3	208-230 V
13500Ls/3	13.5 kVA	1	3	208-230 V
13500Ls/3-400	13.5 kVA	1	3	400 V
18000Ls/3	18 kVA	1	3	208-230 V

Note 1: The /2 or /3 designation indicates number of chassis.
Note 2: All input voltage specifications are for Line to Line three phase, delta or wye. Model 3000Ls (208 V input) can be operated on 230 V L-N single phase if needed.

HF Table Model	Max. Freq.
3000Ls	5000 Hz
4500Ls	5000 Hz
6000Ls	5000 Hz
9000Ls/2	2000 Hz
12000Ls/2	2000 Hz
13500Ls/3	2000 Hz
18000Ls/3	2000 Hz

Ordering Information

Model
Refer to table shown for model numbers and configurations. Specify number of output phases (-1 or -3) as part of model number, eg 4500Ls-1 or 4500Ls-3.

Supplied with
User / Programming Manual on CD-ROM, Software and RS232C serial cable.

Options

Input Options

-400 400 ±10% Volt Line to Line AC input Includes CE Mark. [Not available on 6000Ls, 12000Ls and 18000Ls Models]

-480 480 ±10% (3 phase output only)

Output Options

-AX Auxiliary outputs, 26 VAC, 5 VAC. Limits upper frequency to 800 Hz.

-HV 156/312 V output range.

-EHV 200/400 V output range.

-HF Extends upper frequency limit. See HF table.

-LF Limits output frequency to 500 Hz.

-FC Modifies output frequency control to ± 0.15%

Keypad Options

-KP Upgraded keypad control panel.

Cabinet Options

-RMS Rackmount Slides. Recommended for rack mount applications.

C prefix Cabinet System. Installed and pre-wired in 19” cabinet.

Controller Options

-ABL Emulates Elgar SL Series

-ADV Advanced feature set. Adds arbitrary waveform generation and harmonic analysis of voltage and current.

-GPIB GPIB interface and APE programming language.

-LAN Ethernet Interface.

-MB Multi-box. Adds controller to auxiliary chassis of multi-chassis systems.

-MODE Add phase mode selection for 3 models

-L22 Locking Knobs.

-LKM Clock and Lock Master

-LKS Clock and Lock Auxiliary

-LNS Line Sync.

-EXS External Sync.

Avionics Test Routine Options

-ABD Airbus Directive 0100.1.8 tests. [AC only]. Requires -ADV and use of Windows PC and included LxGui software.

-AMD Airbus AMD24 Test

-A350 Airbus Test Software

-AIRB Airbus A380, A350 & AMD24 package

-704 Mil-Std 704 rev D and E test firmware. [AC only]

-704F Mil-Std 704 rev A - F

-160 RTCA/DO-160, Change 2, EuroCAE-14D [Section 16, AC only]

* Note Reference the Avionics Test User Manual P/N 4994-971 for a complete listing of performance capabilities.

Option Matrix

	HF	LF	HV	EHV	LKM	LKS	EXS	AX
HF	-	X	O	O	X	X	O	X
LF	X	-	O	O	O	O	O	O
HV	O	O	-	X	O	O	O	O
EHV	O	O	X	-	O	O	O	O
LKM	X	O	O	O	-	X	O	O
LKS	X	O	O	O	X	-	X	O
EXS	O	O	O	O	O	X	-	O
AX	X	O	O	O	O	O	O	-

Note 1: See option matrix
Note2 : -LKS, -LNS and -EXS are mutually exclusive and with Ext Trig function.

California Instruments Lx Series

3000–18000 VA

3-18 kVA Programmable AC Power Source / Analyzer

156–400 V

0–132 A

≋	208	230	400
∼		230	

ETHERNET USB GPIB RS232

- **Backward Compatible**
  Compatible with HP6834B & iL Series AC Sources
  Function & bus compatible with the Agilent HP6834B & California Instruments iL Series
- **Three phase and Single phase modes**
  Ideally suited for avionics and defense applications
- **3 kVA to 18 kVA Power Levels**
  Match power source and cost to application requirements
- **Arbitrary Waveform Generator**
  Test products for harmonics susceptibility
- **Built-in Power Analyzer**
  Performs voltage and load current harmonic analysis and waveform acquisition
- **Standard IEEE-488, USB & RS232**
  Remote control interface for ATE system integration included

Integrated System
The Lx Series represents a modern AC power source that addresses increasing demands on test equipment to perform more functions at a lower cost. By combining a flexible AC power source with a harmonic power analyzer, the Lx Series systems are capable of handling applications that would traditionally have required multiple instruments.

The sleek integrated approach of the Lx Series avoids the cable clutter that is commonly found in AC test setups. All connections are made internally and the need for external digital multimeters, power harmonics analyzer and current shunts is completely eliminated.

Using a state of the art Digital Signal Processor in conjunction with precision A/D converters, the Lx Series provides more accuracy and resolution than can be found in most dedicated harmonic power analyzers. Since many components in the Lx Series are shared between the AC source and the power analyzer, the total cost of the integrated system is less than the typical cost of a multiple unit system.

Easy To Use Controls
The Lx Series is completely microprocessor controlled and can be operated from a simple front panel keypad. An analog control located next to the backlit alphanumeric LCD display allows output voltage and frequency to be slewed up or down dynamically. The control employs a dynamic rate change algorithm that combines the benefits of precise control over small parameter changes with quick sweeps through the entire range. A keypad makes precise entries simple.

Applications
With precise output regulation and accuracy, high load drive current, multi or single phase mode and built-in power analyzer measurement capabilities, Lx Series AC source/analyzers address many application areas for AC power testing. Additional features, like line arbitrary waveform generation and available DO 160, MIL 704, or Airbus test standards, make the Lx Series a good choice for avionics or defense applications. All Lx Series AC sources are equipped with IEEE-488 (GPIB), USB and RS232C remote control interfaces and support SCPI command language programming. An ethernet interface option is available.

HP6834B Compatibility
The Lx Series offers functional and bus compatibility with the Agilent HP6834B AC power sources as well as the CI iL Series AC power sources and may be used in existing test systems without the need to modify program code.

Standard Waveforms

The Lx Series provides three standard waveforms that are always available for output. The standard waveforms are:
• Sinewave for normal AC applications.
• Squarewave for special applications.
• Clipped Sinewave - Simulates THD leveLx to test for harmonic distortion susceptibility.

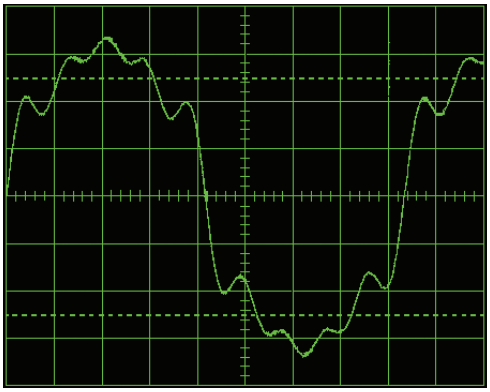
In addition to these standard waveforms, user defined waveform can be downloaded over the bus.

Lx Series

Lx Series - AC Transient Generation

Harmonic Waveform Generation

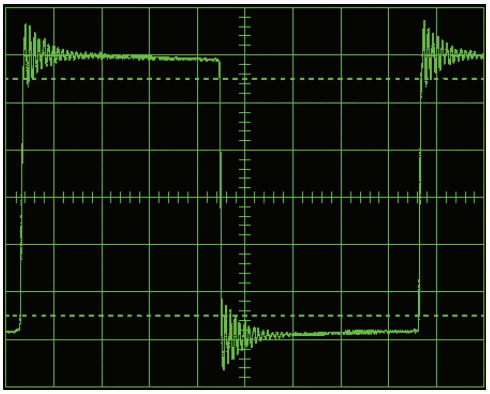
Using the latest DSP (Digital Signal Processing) technology, the Lx Series controller is capable of generating harmonic waveforms to test for harmonics susceptibility of a unit under test. With the help of the supplied Windows Graphical User Interface program, defining harmonic waveforms is as easy as specifying the relative amplitude and phase angle for each of up to 50 harmonics. The waveform data points are generated and downloaded by the GUI to the AC source through either IEEE-488 or RS232C bus and remain in non-volatile memory. Up to twelve waveforms can be stored and given a user defined name for easy recall.



Harmonic waveform, Fund., 3rd, 5th, 7th and 9th.

Arbitrary Waveform Generation

Using the provided GUI program or custom software, the user also has the ability to define arbitrary waveform data. Complex AC voltage anomalies can be simulated this way. The GUI program provides a catalog of custom waveforms and also allows real-world waveforms captured on a digital oscilloscope to be downloaded to one of the AC source's waveform memories. Downloaded waveforms are retained in non-volatile memory for recall over the bus or from the front panel. User defined waveform names make it easy to recall the desired waveform when needed.

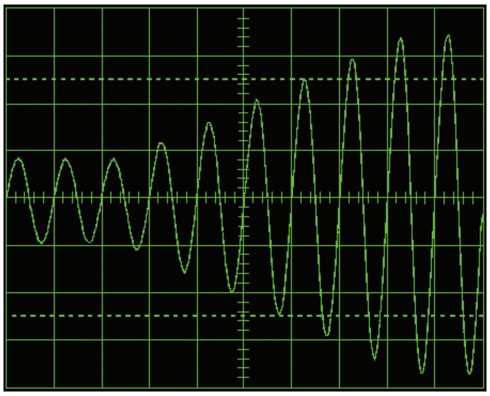


Simulation of severe ringing on the output of a UPS.

Lx Series - Configuration Options

Transient Programming

To simulate common line disturbance occurrences, the Lx Series offers a list of transient steps. These steps can be programmed from the front panel or downloaded over the interface using the GUI program supplied. The GUI allows libraries of commonly used line disturbances to be created on disk for quick recall. Once downloaded, the transient program can be executed from the PC or from the front panel. AC transient generation allows the effect of rapid changes in voltage, frequency, phase angle and waveform shape on the unit under test to be analyzed. The combination of transients and user defined arbitrary waveforms creates a powerful test platform for AC powered products.



Voltage sweep transient causes output voltage to change at a programmed rate.

Lx Series - Measurement and Analysis

The Lx Series measurement system is based on real-time digitization of the voltage and current waveforms using a 4K sample buffer. The digitized waveform data is processed by a Digital Signal Processor to extract conventional load values such as rms voltage, rms current, real and apparent power. The same data is also used to perform Fast Fourrier Transformation (FFT) to extract the harmonic amplitude and phase angle of up to 50 harmonics.

Standard Measurements

The following standard measurements are available from the front panel or via the bus:

- Frequency and Phase
- Voltage (rms)
- Current(rms) and Peak Current
- Crest Factor
- Neutral Current (rms)
- Real Power and Apparent Power
- Power Factor

Lx Series

3000–18000 VA

Advanced Measurement Functions

In addition to standard load parameters, the Lx Series is capable of measuring voltage and current amplitude and phase harmonics up to the 50th harmonic (for fundamental frequencies up to 250 Hz). Total harmonic distortion of both voltage and current is also available. Harmonic analysis data can be displayed on the front panel display or on the PC using the GUI program. The GUI can also be used to save and print harmonics data in tabular, bar graph or time domain formats. The acquired voltage and current time-domain waveforms for each output phase can be displayed using the GUI program. Waveform displays on the PC include voltage and current combined, three phase voltage, three phase current and true power. The time-domain data is aLxo available for transferr to a PC through IEEE-488, USB, RS232C, or Ethernet (option) when using custom software.

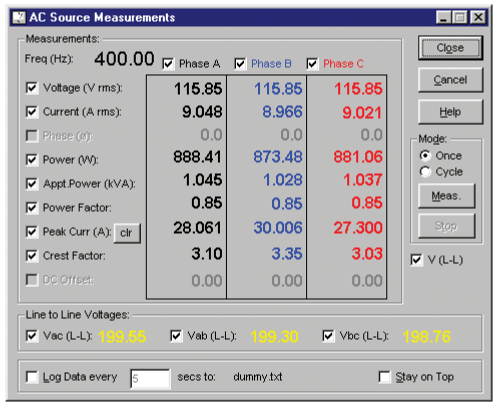
Diagnostics Capability

The AC Source can perform a self test and report any errors. The self test will run until the first error is encountered and terminate. The response to the self test query command will either be the first error encountered or 0 if no error was found. (Self test passed).

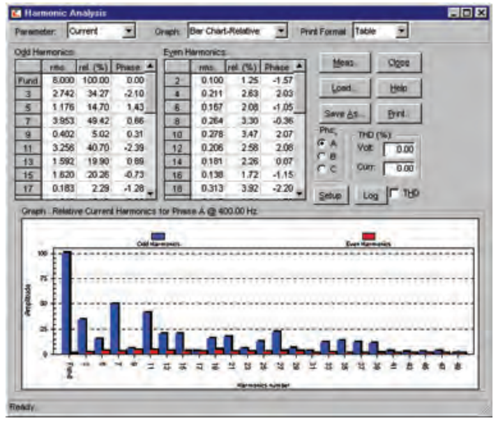
Windows Instrument Control Software

A Windows Vista/2000/XP™ compatible Instrument Control Software (GUI) offers a soft front panel interface for operation from a PC. The following functions are available:

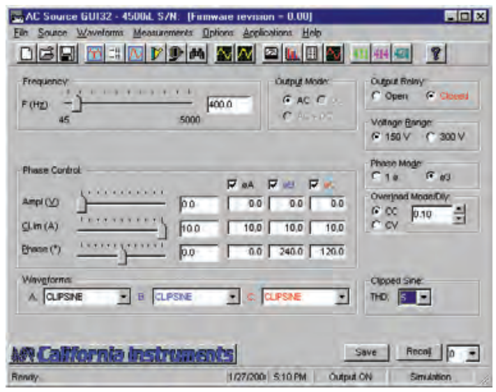
- Steady state output control (all parameters).
- Create, run, save and print transient programs.
- Generate and save harmonic waveforms.
- Generate and save arbitrary waveforms.
- Download data from a digital storage oscilloscope.
- Measure and log standard measurements.
- Capture and display Voltage and Current waveforms.
- Measure, display, print and log harmonic voltage and current measurements.



Standard measurements for all phases.

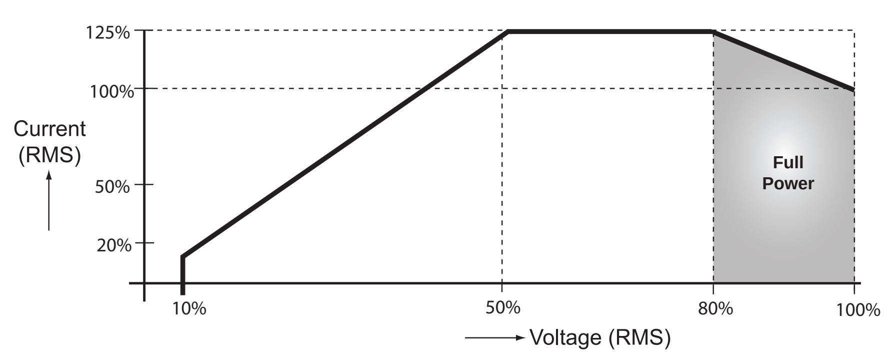


Relative Current Harmonics shown in table and chart.



Soft front panel control through Windows GUI.

Constant Power AC Mode - Available Max. AC Current



Lx Series

Output

Maximum Power per phase	3000Lx: 1 phase: 3000 VA, 3 phase: 1000 VA; 4500Lx: 1 phase 4500 VA, 3 phase 1500 VA; 6000Lx: 1 phase 5770 VA, 3 phase: 1923 VA
Power factor	0 to unity at full output VA

Voltage Ranges

Range	V Low	V High
AC	0-150V	0-300V

VA Programming Resolution	100 mV
Load Regulation	< 0.1 % FS
Line Regulation	< 0.02 % for 10 % line change

See EHV options for alternative voltage range pairs.

Programming Accuracy (25°C ±5°C	Voltage (rms): ± (0.05% + 0.25) V from 5.0 V to FS; Frequency: ± 0.025 45 Hz - 819.1 Hz, ± 0.7 % > 819.1 Hz; Phase: ± 1° 45-100 Hz, ± (1° + 1°/kHz) 100 Hz-1kHz
Frequency Range	17 Hz - 1000 Hz (see -HF option for higher output frequencies)
Frequency Resolution	0.01 Hz at < 81.9 Hz, 0.1 Hz at 82.0 to 819.1 Hz, 1 Hz at > 819 Hz

Max RMS Current

V Range	V high	V low	< At Full Power	Model	3000Lx-3 Ø	3000Lx-1 Ø	4500Lx-3 Ø	4500Lx-1 Ø	6000Lx-3 Ø	6000Lx-1 Ø
-3 3 ø	6..4 A	12.8 A	At FS Voltage >	V Low	6.6 A	20.0 A	10.0 A	30.0 A	12.8 A	38.4 A
-1 1 ø	19.2 A	38.4 A		V High	3.3 A	10.0 A	5.0 A	15.0 A	6.4 A	19.2 A

Note: Constant power mode on 3000Lx and 4500Lx provides increased current at reduced voltage; 6000Ls provides maximum voltage.

Current Limit	Programmable from 0 Amps to maximum current for selected range
Peak Current	3000Lx: 5.7 X (lrms @ full scale voltage); 4500Lx: 3.8 X (lrms @ full scale voltage); 6000Lx: 3 X (lrms @ full scale voltage)
Output Noise	100mV rms typ. (20 kHz to 1 MHz)
Harmonic Distortion	< 1% (at full scale voltage, full resistive load)
Isolation Voltage	300 V rms output to chassis
Output Relay	Push button controlled and bus controlled output relay

Input

Voltage	ModeLx 3000Lx, 4500Lx, 9000Lx, 13500Lx: Standard: 208-230 ± 10% VAC, (L-L, 3 Phase); Option -400: 400 ± 10% VAC (L-L, 3 Phase); ModeLx 6000Lx, 12000Lx, 18000Lx: Standard 208-230 + 10% VAC (L-L, 3 Phase) Notes: 1. Input must be specified when ordering. 2. -400 option not availble on 6000Lx, 12000Lx, 18000Lx. 3. 3000Lx can be operated from 1 phase AC.

Line Current (rms per phase)

Model	3000Lx	3000Lx (1Phase)	4500Lx	6000Lx (@ 208V)
187 VLL	19 A	32 A	31 A	38 A
360 VLL	10 A	n/a	16 A	n/a

Inrush Current (Per phase):	@ 180-254 V: 50 A peak @ 360-440 V: 83 A peak
Line Frequency:	47-440 Hz

Efficiency	75% typical
Power Factor	0.6 typical
Hold-up Time	At least 10 ms

System

Storage	Setup: 16 complete instrument setups / Transient List: 100 transient steps per list (SCPI mode) or 16 transient registers (APE mode)
Trigger Input/Output	Input: Triggers measurements or transient steps - SMA connector: 10K pull-up / Output: SMA Connector: HCTTL output

Protection

Overload/Temp/Voltage	Overload: Constant current or constant voltage mode; Over temperature: Automatic Shutdown; Over voltage: Automatic shutdown
Regulatory/RFI Suppresion	IEC1010, EN50081-2, EN50082-2, CE (for 400V input only), EMC, and safety mark requirements / RIF Suppression: CISPR 11, Group1, Class A

Measurement

Measurements - Standard (AC Measurements)

Parameter	Frequency	Phase	Voltage (AC)	Current (AC rms)	Real Power	Apparent Power	Power Factor
Range	45-81.91 Hz 82.0-819.1 Hz > 819 Hz	45-100 Hz 100-1000 Hz	0-300 V	0-50 A	0-6 kW	0-6 kVA	0.00-1.00
Accuracy* (±) 1 ø mode (-1) 3 ø mode (-3)	0.1% + 1 digit	0.5° 2°	0.5% + 250 mV	0.1% + 150 mA 0.1% + 50 mA	0.15% + 9 W 0.15% + 3 W	0.15% + 9 VA 0.15% + 3 VA	0.03 0.01
Resolution*	.01 Hz / 0.1 Hz / 1 Hz	0.1° / 1°	10 mV	1 mA	1 W	1 VA	0.01

* Accuracy specifications are in % of reading and apply above 100 counts. For multi-chassis configurations, current, power range and accuracy specifications are times three. Power factor accuracy applies for PF > 0.5 and VA > 50% of max. Frequency measurement specification valid for output > 30 Vrms.

Note: Specifications are subject to change without notice. Specifications are warranted over an ambient temperature range of 25°± 5° C. Unless otherwise noted, specifications are per phase for a sinewave with a resistive load and apply after a 30 minute warm-up period. For three phase configurations, all specifications are for L-N. Phase angle specifications are valid under balanced load conditions only.

Lx Series 3000–18000 VA

Remote Control

IEEE-488 Interface (option)	IEEE-488 (GPIB) talker listener. Subset: AH1, C0, DC1, DT1, L3, PP0, RL2, SH1, SR1, T6, IEEE-488.2 SCPI Syntax
USB Interface & Ethernet	Version: USB 1.1; Speed: 460 Kb/s maximum / Ethernet Interface (Optional): specify -LAN option. 10BaseT, 100BaseT, RJ45
RS232C Interface	Bi-directional serial interface; 9-pin D-shell connector. Handshake: CTS, RTS. Databits: 7 w/ parity, 8 w/o parity. Stopbits: 2. Baud rate: 9600 to 115200. Supplied with RS232C cable / Code and Format: SCPI; APE (option -GPIB)

Physical Dimensions

Dimensions (per chassis)	Height: 10.5” (267 mm), Width: 19” (483 mm), Depth: 23.7” (602 mm) (depth includes rear panel connectors)
Weight	Chassis: Net: 193 lbs / 87.7 Kg, Shipping: 280 lbs / 127.3 Kg (for /2 or /3 model configuarations multiply number of chassis).
Vibration and Shock	Designed to meet NSTA project 1A transportation leveLx
Air Intake/Exhaust	Forced air cooling, side air intake, rear exhaust
Temperature & Diagnostics	Temperature: Operating: 0 to 35° C, full power / Storage: -40 to +85° C; Diagnostics: Built-in self test available over bus (*TST)
Rear Panel Connectors	*Three phase AC input and output terminal block with safety cover. *IEEE-488 (GPIB) connector, USB connector, RJ45 connector (with -LAN Option). *9-pin D-Shell RS232C connector (RS232 DB9 to DB9 cable supplied). *Remote Inhibit (INH) and Discrete Fault Indicator (DFI). *Remote voltage sense terminal block. *Trigger In1 and Trigger Out1. *System interface connectors. *Auxilary Output (Option -AX)

Option -AX Specifications

Option -AX	Provides seperate isolated 26 VAC regulated and 5 Vac unregulated outputs. The 26 V is normally used for servo-synchro excitation, and the 5 V for lamp power. 26 Volt-Accuracy: ± 2%. Current capacity: 3 ARMS. Frequency: 360/440 Hz. Regulation ± 0.05%. 5 Volt-Accuracy: ± 5%. Current capacity: 5 ARMS

Option -ADV Specifications

Measurements - Harmonics

Parameter	Frequency Fundamental Harmonics	Voltage	Current
Range	45-250 Hz / 0.09 - 12.5 kHz	Fundamental Harmonics 2 - 50	Fundamental Harmonics 2 - 50
Accuracy* (±)	0.01% + 1 digit / 0.5% + 1 digit	750 mV 0.3% + 750 mV+0.3% /1 kHz	0.5 A / 0.3% + 150 mA +0.3% /1 kHz
Resolution	0.01 Hz / 0.1 Hz	10 mV / 10 mV	10 mA / 10 mA

* Accuracy specifications are in a percent of reading for single unit in 3-phase mode.

Waveforms	Pre defined: Sine, Square, Clipped User defined, 1024 addressable data points; Storage: 50 user waveforms, non-volatile memory
Data Acquisition	Parameters: Voltage, Current time domain, per phase; Resolution: 4096 data points, 10.4 usec (1ø) or 31.25 usec (3ø) sampling interval

Option -HV Specifications

Voltage/Frequency Ranges	Low: 0-135 Volt; High: 0-270 Volt / Frequency: With -HF option: 3000Lx, 4500Lx, 6000Lx: 45 Hz - 5000 Hz; 9000Lx, 12000Lx, 13500Lx, 18000Lx: 45 Hz - 5000 Hz
Max RMS Current at Full Power	3 Phase: High: 7.4 A, Low 14.8 A; 1 Phase: High: 22.2 A, Low: 44.4 A; Note: Constant power modes on 3000Lx and 4500Lx. Current available at reduced voltage for 3000Lx, 4500Lx, and max voltage for 6000Lx
Max RMS Current at FSVoltage	3000Lx: 3 Phase: High: 3.7 A, Low: 7.4 A; 1 Phase: High 11.1 A, Low: 22.2 A; 4500Lx: 3 Phase: High: 5.6, Low 11.1; 1 Phase: High: 16.7 A, Low: 33.3 A; 6000Lx: 3 Phase: High: 7.4 A, Low 14.8 A; 1 Phase: High: 22.2 A, Low: 44.4 A

Option -EHV Specifications

Voltage/Frequency Ranges	Voltage: Low: 0-200 Volt; High: 0-400 Volt / Frequency: With -HF option: 45 Hz - 5000 Hz
Max RMS Current at Full Power	3 Phase: High: 5.0 A, Low 10.0 A; 1 Phase: High: 15.0 A, Low: 30.0 A; Note: Constant power modes on 3000Lx and 4500Lx. Current available at reduced voltage for 3000Lx, 4500Lx, and max voltage for 6000Lx
Max RMS Current at FS Voltage	3000Lx: 3 Phase: High: 2.5 A, Low: 5.0 A; 1 Phase: High 7.5 A, Low: 15.0 A; 4500Lx: 3 Phase: High: 3.8, Low 7.5; 1 Phase: High: 11.3 A, Low: 22.5 A; 6000Lx: 3 Phase: High: 5.0 A, Low 10.0 A; 1 Phase: High: 15.0 A, Low: 30.0 A

Option -HF Specifications

Measurements:

F < 2000 Hz: See standard Lx Specifications;

F > 2000 Hz: See table >

Parameter	Frequency	Phase	Voltage (AC)	Current (AC rms)	Real Power	Apparent Power	Power Factor
Range	45 - 5000 Hz	< 2000 Hz > 2000 Hz	0-300 V < 1000 Hz / > 1000 Hz	0-50 A	0-5 kW	0-5 kVA	0.00-1.00
Accuracy* (±) 1 ø mode (-1)	0.1% + 1 digit	0.5°	0.05% + 250 mV	0.5% + 150 mA	0.5% + 9 W	0.5% + 9 VA	0.03
3 ø mode (-3)		5°	0.1% + 0.1%/kHz +300MV	0.5% + 50 mA	0.5% + 3 W	0.5% + 3 VA	0.01
Resolution*	0.01 Hz / 0.1 Hz / 1 Hz	0.1° / 1°	10 mV	1 mA	1 W	1 VA	0.01

* Accurac specifications are in % of reading and apply above 100 counts. For multi-chassis configurations, current, power range and accuracy specifications are times three. Power factor accuracy applies for PF > 0.5 and VA > 50% of max. Frequency measurement specification valid for output > 30 Vrms.

250 mVrms typical (20 kHz to 1 MHz)	3000Lx 4500Lx, 6000Lx: Standard: -HV 45 Hz- 5000 Hz; - EHV: 45 Hz - 5000 Hz
Output Noise	250 mVrms typical (20 kHz to 1 MHz)

Lx Series

Model[1]	Output Power	No of Output Phases		Nom. Input Voltage[2]
		-1	-3	
3000Lx	3 kVA	1	3	208-230 V
3000Lx-400	3 kVA	1	3	400 V
4500Lx	4.5 kVA	1	3	208-230 V
4500Lx-400	4.5 kVA	1	3	400 V
6000Lx	6 kVA	1	3	208-230 V
9000Lx/2	9 kVA	1	3	208-230 V
9000Lx/2-400	9 kVA	1	3	400 V
12000Lx/2	12 kVA	1	3	208-230 V
13500Lx/3	13.5 kVA	1	3	208-230 V
13500Lx/3-400	13.5 kVA	1	3	400 V
18000Lx/3	18 kVA	1	3	208-230 V

Note 1: The /2 or /3 designation indicates number of chassis.

Note 2: All input voltage specifications are for Line to Line three phase, delta or wye. Model 3000Ls (208 V input) can be operated on 230 V L-N single phase if needed.

HF Table Model	Max. Freq.
3000Lx	5000 Hz
4500Lx	5000 Hz
6000Lx	5000 Hz
9000Lx/2	2000 Hz
12000Lx/2	2000 Hz
13500Lx/3	2000 Hz
18000Lx/3	2000 Hz

Ordering Information

Model

Refer to table shown for model numbers and configurations. Specify number of output phases (-1 or -3) as part of model number, eg 4500Lx-1 or 4500Lx-3.

Supplied with

User / Programming Manual on CD-ROM, Software and RS232C serial cable.

Options

Input Options

-400 400 ±10% Volt Line to Line AC input Includes CE Mark. [Not available on 6000Ls, 12000Ls and 18000Ls Models]

-480 480 ±10% (3 phase output only)

Output Options

-AX Auxiliary outputs, 26 VAC, 5 VAC. Limits upper frequency to 800 Hz.

-EHV 200/400 V output range.

-HF Extends upper frequency limit. See HF table.

-LF Limits output frequency to 500 Hz.

-FC Modifies output frequency control to ± 0.15%

Keypad Options

-RP LS style rotary knobs

Cabinet Options

-RMS Rackmount Slides. Recommended for rack mount applications.

C prefix Cabinet System. Installed and pre-wired in 19” cabinet.

Controller Options

-ABL Emulates Elgar SL Series

-ADV Advanced feature set. Adds arbitrary waveform generation and harmonic analysis of voltage and current.

-GPIB GPIB interface and APE programming language.

-LAN Ethernet Interface.

-MB Multi-box. Adds controller to auxiliary chassis of multi-chassis systems.

-MODE Add phase mode selection for 3 models

-L22 Locking Knobs.

-LKM Clock and Lock Master

-LKS Clock and Lock Auxiliary

-LNS Line Sync.

-EXS External Sync.

Avionics Test Routine Options

-ABD Airbus Directive 0100.1.8 tests. [AC only]. Requires -ADV and use of Windows PC and included LxGui software.

-AMD Airbus AMD24 Test

-A350 Airbus Test Software

-AIRB Airbus A380, A350 & AMD24 package

-B787 Boeing 787 Test Software

-704 Mil-Std 704 rev D and E test firmware. [AC only]

-704F Mil-Std 704 rev A - F

-160 RTCA/DO-160, Change 2, EuroCAE-14D [Section 16, AC only]

* Note Reference the Avionics Test User Manual P/N 4994-971 for a complete listing of performance capabilities.

Option Matrix

	HF	LF	HV	EHV	LKM	LKS	EXS	AX
HF	-	X	O	O	X	X	O	X
LF	X	-	O	O	O	O	O	O
HV	O	O	-	X	O	O	O	O
EHV	O	O	X	-	O	O	O	O
LKM	X	O	O	O	-	X	O	O
LKS	X	O	O	O	X	-	X	O
EXS	O	O	O	O	O	X	-	O
AX	X	O	O	O	O	O	O	-

Note 1: See option matrix

Note2 : -LKS, -LNS and -EXS are mutually exclusive and with Ext Trig function.

California Instruments CSW Series

5550–33300 VA

High Performance Programmable AC and DC Power Source

156–312 V

8–288 A

≈	208	230	400

ETHERNET USB GPIB RS232

- Combination AC and DC Power Source
- 40-5,000Hz Output Frequencies
- Arbitrary and Harmonic Waveform Generation
- Built-In Digital Power Analyzer
- Scope Capture Capability
- Power Programming Software
- Constant Power Mode
- Multi-Box Option

Introduction

The CSW Series represents a new generation of AC/DC power sources that address the increasing demands on test equipment to perform additional functions at a lower cost. By combining a flexible AC/DC power source with a high performance power analyzer, the Compact CSW Series is capable of handling complex applications that have traditionally required multiple systems. The sleek integrated approach of the CSW avoids cable clutter that is commonly found in test systems. All connections are made internally and the need for digital multimeters, power harmonics analyzers, and current shunts or clamps is eliminated.

Since many components in the CSW are shared between the AC/DC source and the power analyzer, the total cost of the integrated system is less than the typical cost of a multiple unit system.

Easy to use controls

The CSW Series is DSP controlled and can be operated from an easy to use front panel keypad. Functions are grouped logically and are directly accessible from the keypad. This eliminates the need to search through various levels of menus and/or soft keys. A large analog control knob can be used to quickly slew output parameters. This knob is controlled by a dynamic rate change algorithm that combines the benefits of precise control over small parameter changes with quick sweeps through the entire range.

Applications

The CSW is designed for testing today's complex electronics, including avionics, telecommunications and commercial electronics requiring low profile, light weight power supplies

Other applications include:

- Testing for real world power conditions using different waveforms on all 3 phases (including DC)
- Load susceptibility testing with sequence or event programming and multiple voltage harmonics
- Power line disturbance simulation testing
- MIL-STD-704, DO-160, B787 and ABD100 avionics testing
- Power supply testing for AC-DC, DC-DC converters and UPS's
- Transients on 12 & 24 VDC for automotive applications

AC, DC or AC+DC Output

A direct coupled, transformerless design allows AC and DC on separate phases or on the same phase. The CSW can be used as a true DC power supply. High DC content waveforms (up to 312 volts) can be created with no derating of output power, even with 100% reactive loads, eliminating the need for a separate DC supply. Waveform programming is easily accomplished using the Graphical Users Interface software. Waveforms can be uploaded and modified from a digital scope. The waveforms can then be downloaded to the CSW and output to precisely simulate real-world conditions.

CSW Series

Flexability in Power Ranges

The CSW Series is based on a 5,550VA power source. The CSW features selectable Single or Three Phase output via front panel menu selection or via remote control interface. Utilizing Master / Auxilary arrangement the CSW offers the flexibility to paralled up to power levels of 33,300VA

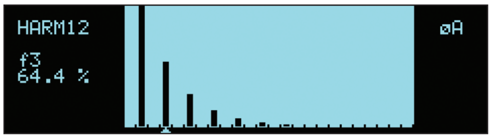
High Crest Factor

With a crest factor of up to 3.25:1; the CSW Series AC source can drive difficult nonlinear loads with ease. Since many modern products use switching power supplies, they have a tendency to pull high repetitive peak currents. The CSW5550 can deliver up to 38.5 Amps of repetitive peak current (156 V range) per phase

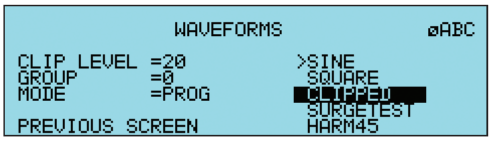
Harmonic Waveform Generation

Using the latest DSP technology, the CSW Series programmable controller is capable of generating harmonic waveforms to test for harmonics susceptibility. The Windows Graphical User Interface program can be used to define harmonic waveforms by specifying amplitude and phase for up to 50 harmonics. The waveform data points are generated and downloaded by the GUI to the AC source through the remote interface. Up to 200 waveforms can be stored in nonvolatile memory and given a user defined name for easy recall.

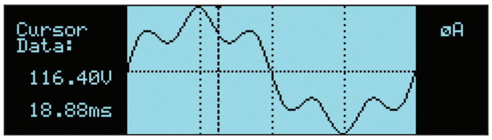
Arbitrary Waveform Generation



Harmonic waveform, Fund., 3rd, 5th, 7th, 9th,11th and 13th.



Two hundred user defined waveforms.



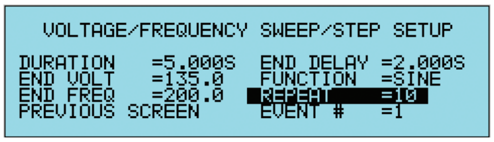
Harmonically distorted waveform.

Using the provided GUI program or custom software, the user also has the ability to define arbitrary AC waveforms. The arbitrary waveform method of data entry provides an alternative method of specifying AC anomalies by providing specific waveform data points. The GUI program provides a catalog of custom waveforms and also allows real-world waveforms captured on a digital oscilloscope to be downloaded to one of the many AC source's waveform memories. Arbitrary waveform capability is a flexible way of simulating the effect of real-world AC power line conditions on a unit under test in both engineering and production environments.

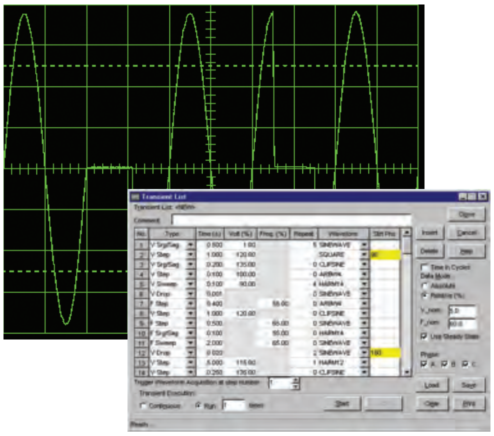
CSW Series - AC and DC Transient Generation

The CSW Series controller has a powerful AC and DC transient generation system that allows complex sequences of voltage, frequency and waveshapes to be generated. This further enhances the CSW's capability to simulate AC line conditions or DC disturbances. When combined with the multiphase arbitrary waveform capabilities, the AC and DC output possibilities are truly exceptional. Transient generation is controlled independently yet time synchronized on all three phases. Accurate phase angle control and synchronized transient list execution provide unparalleled accuracy in positioning AC output events.

Transient programming is easily accomplished



Transient List Data Entry from the front panel.

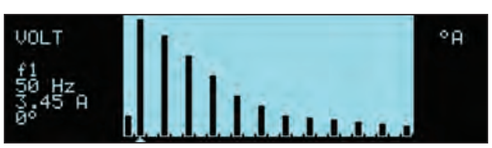


Transient List Data Entry in GUI program.

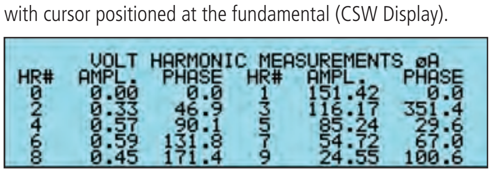
from the front panel where clearly laid out menu's guide the user through the transient definition process.

The front panel provides a convenient listing of the programmed transient sequence and allows for transient execution Start, Stop, Abort and Resume operations. User defined transient sequences can be saved to non-volatile memory for instant recall and execution at a later time. The included Graphical User Interface program supports transient definitions using a spreadsheet-like data entry grid. A library of frequently used transient programs can be created on disk using this GUI program.

Harmonic Analysis
The CSW Series provides detailed amplitude and phase information on up to 50 harmonics of the fundamental voltage and current (up to 16 kHz). Harmonic content can be displayed in both tabular and graphical formats on the front panel LCD for immediate feedback to the operator. Alternatively, the included GUI program can be used to display, print and save harmonic measurement data. Total harmonic distortion of both voltage and current is calculated from the harmonic data.



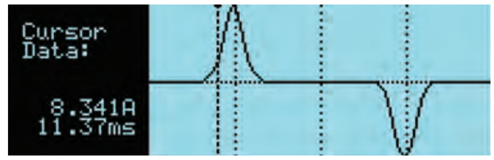
Absolute amplitude bar graph display of current harmonics with cursor positioned at the fundamental (CSW Display).



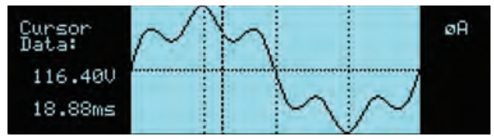
Voltage harmonic measurement table display in absolute values (CSW Display)

Waveform Acquisition
The measurement system is based on real-time digitization of the voltage and current waveforms using a 4K deep sample buffer. This time domain information provides detailed information on both voltage and current waveshapes. Waveform acquisitions can be triggered at a specific phase angle or from a transient program to allow precise positioning of the captured waveform with respect to the AC source output.

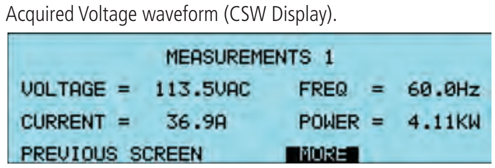
The front panel LCD displays captured waveforms with cursor readouts. The included GUI program also allows acquired waveform data to be displayed, printed, and saved to disk.



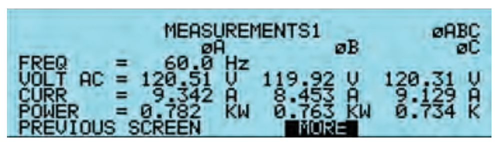
Acquired Current waveform (CSW Display).



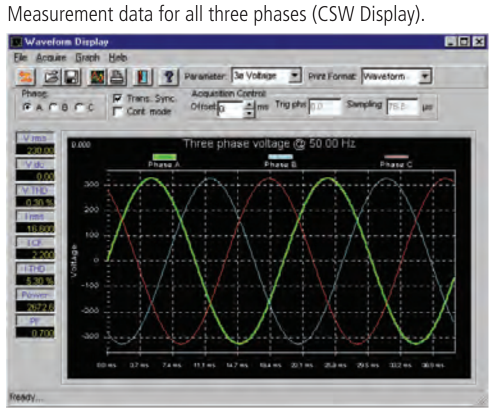
Acquired Voltage waveform (CSW Display).



Measurement data for single phase (CSW Display).



Measurement data for all three phases (CSW Display).



Acquired three phase voltage waveforms display on PC.

Multi-Box Option
In many applications high power is required for a small portion of the testing while a majority of the tests are performed at reduced power levels. The controller architecture of the CSW provides the end-user with a wide array of configuration options that often eliminate the need to purchase different AC or DC power systems to meet a variety of applications. The Multi-Box option is available which allows multiple channel systems to be separated into individually controlled stand alone power sources. By simply connecting the interface cable between multiple sources the hardware automatically sets itself to the system configuration offering Plug and Play performance. There is no need to modify configuration settings from the front panel or hardware jumpers located internally to the source. The multi-box feature is ideal for end-users planning to increase power levels or separate a system into multiple smaller sources.

CSW Series : Product Specifications

Input	
Voltage Ranges	Factory configured 187 to 264 Vrms, 3ø L-L (3 wire), or 342 to 457 Vrms, 3ø L-L (4 wire). A chassis ground is also required.
Power Factor	PFC Input, 0.99PF
Frequency Range	47 to 440 Hz
Efficiency	70% min, at full load
Ride Through	10 ms minimum
Output	
Power	5550 VA: 1ø or 3ø (systems up to 33,000 VA)
AC or DC Output Voltage	0 to156 Vrms L-N, low range; 0 to 312 Vrms L-N, high range
Current Per Phase	16A to 115V in 156V range; 8A to 230V in 312V range per, 1850 VA module.
Power Factor of Load	0 lagging to 0 leading (0-unity)
Crest Factor	3.25:1 (peak output current to rms output current))
Frequency Range	Specifications apply DC, 40Hz to 5kHz. For output frequencies greater than 1 kHz, the max slew rate allowed is 1 kHz per second.
Max Total Harmonic Distortion	(Full Linear Load or No Load): 0.25% max, 40 to 100 Hz; 0.5% max to 500 Hz; and 1% max to 1 kHz plus 1%/kHz to 5 kHz
AC Noise Level	>60 dB rms below full output voltage
Amplitude Stability With Remote Sense	±0.1% of full scale over 24 hours at constant line, load and temperature
Line Regulation	(DC, or 40 Hz to 5 kHz): ±0.015% of full scale for a ±10% input line change
Load Regulation	±0.025% of full scale voltage for a full resistive load to no load; above 1 kHz, add ±0%/kHz
Voltage Accuracy	±0.1% of range. Above 1 kHz, add 0.2%/kHz. Add ±0.1% of full scale for "AC PLUS DC" mode. Valid for 5 to 156 Vrms and 10 to 312 Vrms at 25°C
Voltage Resolution	1mV (0.1V) Full Scale
Frequency Accuracy	±0.01% at 25°C ±0.001%/°C
Frequency Resolution	40 Hz to 81.91 Hz (0.01 Hz) 81.90 Hz to 819 Hz (0.01 Hz) 820 Hz to 5000 Hz (1 Hz)
Phase Accuracy, Phase-to-Phase Balanced Linear Resistive Load	±1% of Programmed value
Phase Angle Resolution	0.1°
Remote Output Voltage Sense	5 Vrms total lead drop, max
Common Intput and Outputs	
Remote Inhibit	A logic Low or High contact closure input to inhibit the outputs
External Amplitude Modulation	0 to 5 VRMS provides 0 to 20% output amplitude modulation (±2% of full scale output).
External Drive Input	Acts as Amplifier, 0 to 5 VRMS (DC to 5 kHz) or ±5 VDC input for zero to full scale programmed voltage output (±2% of full scale output). Individual inputs for an external signal for each of the three phases.
Remote Programming Voltage	0 to ±7.07 VDC provides zero to full scale programmed voltage output (±2% of full scale output).
External Input Impedance	40K (ohm symbol) for each of the three inputs.
Externaly Sync	External Sync allows the output frequency of the AC source to be synchronized to an external TTL level clock signal.
LKM	Clock and Lock Master. Enables synchronizing outputs of two or more California Instruments sources, one acts as master.
LKS	Clock and Lock Auxiliary
Front Panel Trigger, BNC Connector	Output available at the front panel BNC connector that provides a negative going pulse for any programmed voltage or frequency change. The trigger can be reassigned as an output when running list transients.
Front Panel Phase A, B and C, BNC connectors	These three outputs are representive of the programmed output waveform, magnitude and frequency. 0 to 4.86 Vrms represents 0 to a full-scale output voltage.

CSW Series : Product Specifications

5550–33300 VA

Environmental

Operating Temperature	0°C to 45°C (32°F to 113°F)
Storage Temperature	-40°C to 70°C (-40°F to 158°F)
Cooling	Air is drawn in from the top, bottom, and sides and exhausted through the rear
Humidity (Non-condensing)	0 to 85% at 25°C (77°F); derate to 50% at 40°C (104°F)
Altitude	Operating 10,000 ft, non operating 40,000 ft

Physical

Dimensions	Width: 19" (483 mm) Height: 8.75" (222 mm) Depth: 23.5" (597 mm)
Weight	CSW 5550 - 127 lbs (57.5 kg)
Shipping Weight - US	CSW - 160 lbs (72 kg)
Note	Multi Chassis systems, dimension and weight are approximately x2, x3, x4, x5 and x6 CSW Specifications

Measurements

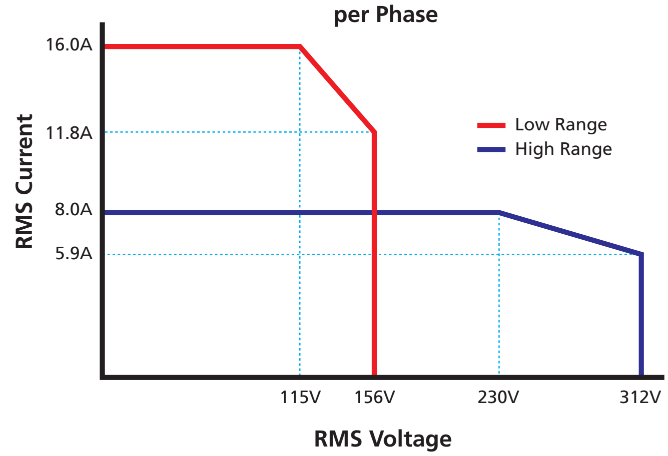
Measurements - Standard (AC Measurements)

Parameter	Frequency	Phase	Voltage (AC)	Current (AC rms)	Real Power	Apparent Power	Power Factor
Range	40-81.91 Hz 82.0-819.1 Hz > 819 Hz	40-100 Hz 100-1000 Hz	0-300 V	0-50 A	0-6 kW	0-6 kVA	0.00-1.00
Accuracy* (±)							
1 ø mode (-1)	0.1% + 1 digit	0.5°	0.5% + 250 mV	0.1% + 150 mA	0.15% + 9 W	0.15% + 9 VA	0.03
3 ø mode (-3)		2°		0.1% + 50 mA	0.15% + 3 W	0.15% + 3 VA	0.01
Resolution*	.01 Hz / 0.1 Hz / 1 Hz	0.1° / 1°	10 mV	1 mA	1 W	1 VA	0.01

* Accuracy specifications are in % of reading and apply above 100 counts. For multi-chassis configurations, current, power range and accuracy specifications are times three. Power factor accuracy applies for PF > 0.5 and VA > 50% of max. Frequency measurement specification valid for output > 30 Vrms.

Constant Power AC Mode

5550 CSW Operating Area per Phase



Harmonic Measurements

Parameter	Range	Accuracy (±)	Resolution
Frequency fundamental	16.00 - 1000 Hz	2 counts	0.01 Hz to 1 Hz
Frequency harmonics	32.00 Hz - 16 kHz	2° typ.	0.5°
Voltage	Fundamental	0.25V	0.01V
	Harmonic 2 - 50	0.25V + 0.1% + 0.1%/kHz	0.01V
Current	Fundamental	0.05A	0.01A
	Harmonic 2 - 50	0.05A + 0.1% + 0.1%/kHz	0.01A

Harmonics frequency range in three-phase mode is 32 Hz - 16 kHz. Accuracy specifications are multiplied by the number of power sources in multi-source systems with the 3-phase (3Ø) or the number of sources times 3 in the 1-phase (1Ø) mode . Measurement bandwidth is limited to 16 Khz.

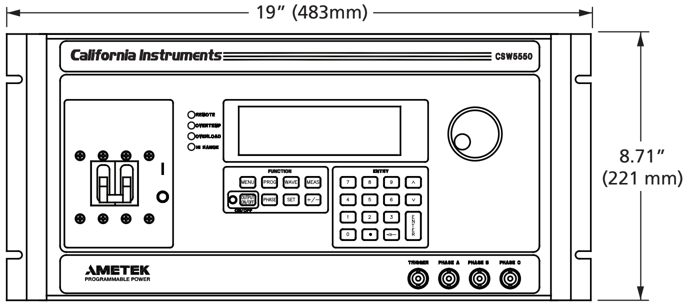
Model	CSW5550	CSW11100	CSW16650	CSW22200	CSW17750	CSW33300
Multiplier 3Ø/1 Ø	1/3	2/6	3/9	4/12	5/15	6/18

CSW Series : Product Specifications

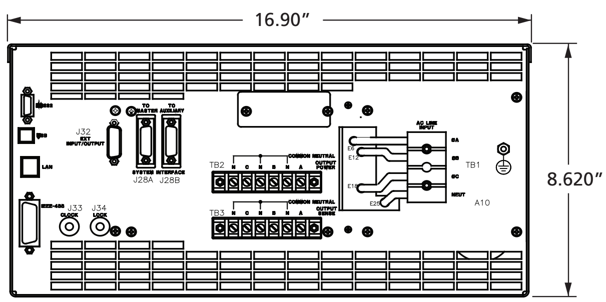
Protection And Safety	
Overvoltage Shutdown	Programmable for 15V to 255V peak, 156V range; 30V to 510V peak, 312V range
Programmable Current Limit Shutdown	Settable to 0.01 ARMS Resolution
Programmable Current Limit with Timed Shutdown	Settable to 1% of range: the timeout is settable from 100 ms to 10s.
Over temperature Shutdown	Automatic, not programmable
Regulatory Compliance	• EN 61010 • EN 55011 • UL 3111 • EN 50082-2 • EN 61000-4-3, EN 61000-4-4 • FCC Part 15, Class A • CE Mark Designed to meet: • EN 61010 • EN 55011 • UL 3111 • EN 50082-2 • EN 61000-4-3, EN 61000-4-4 • FCC Part 15, Class A

CSW Series : Product Diagram

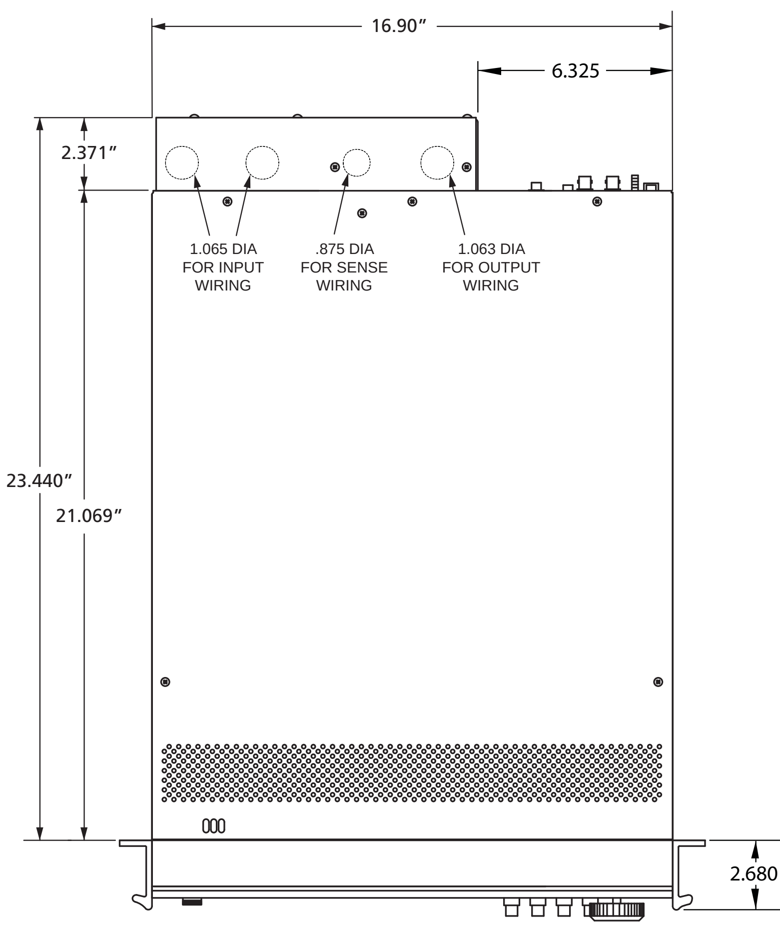
5550–33300 VA



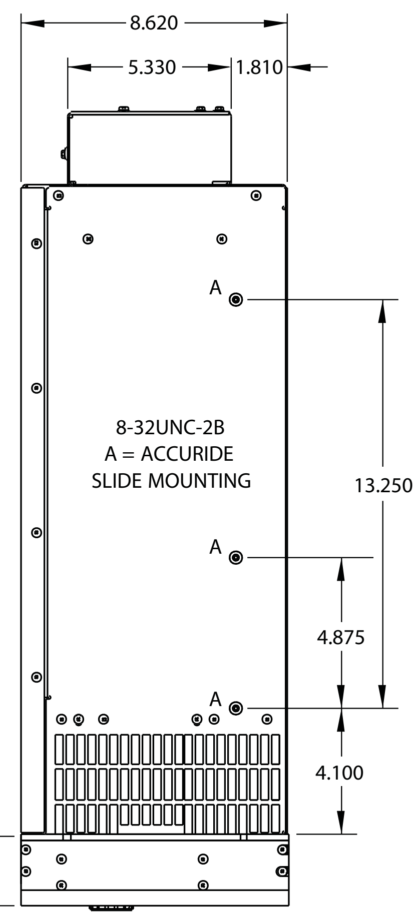
Front View



Rear View



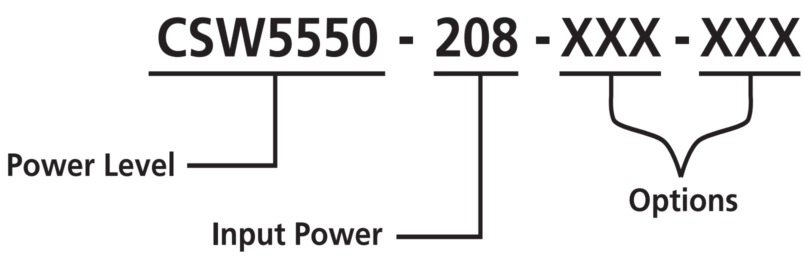
Top View



Side View

CSW Series

Model Number Description



Options

Options Code	Description
-LAN	LXI Ethernet LAN Interface (Rj45 Connector)
-LKM	Clock/Lock Master
-LKS	Clock/Lock Auxiliary
-413	IEC61000-4-13 Harmonics and Interharmonics test firmware and hardware.
-411	IEC61000-4-11 test firmware. See also EOS1/3.
-WHM	Watt-Hour Measurement option.
-MB	Multi-Box. Adds controller to auxiliary chassis of multi-chassis systems
-SW	SCPI Command Firmware (Simulates the Elgar SW Series) Not all commands are supported. Please contact factory for details.
Input Options	
-400	342-457 Volt Line to Line AC input.
Output Options	
-LF	Limits output frequency to 500 Hz.
-FC	Modifies output frequency control to ± 0.15%
Cabinet Options	
-RMS	Rackmount Slides. Recommended for rack mount applications.
C prefix	Cabinet System. Installed and pre-wired in 19” cabinet.
Avionics Test Routine Options	
-ABD	Airbus Directive 0100.1.8 tests.
-AMD	Airbus AMD24 tests.
-A350	Airbus A350 tests.
-AIRB	Airbus ABD0100.1.8, AMD 24 and A350 combination test software suite
-B787	Boeing 787B3-0147 tests.
-704F	Mil. Std. 704A-F tests
-160	RTCA/DO-160D, Change 2, EuroCAE-14D and Airbus test firmware.

* Note Reference the Avionics Test User Manual P/N 4994-971 for a complete listing of performance capabilities.

California Instruments BPS Series

30–180 kVA

Overview

150–400 V

0–400 A / Phase

≈	208	230	400
	480		

ETHERNET USB GPIB RS232

- **High Power AC Source**
  Programmable AC power for frequency conversion and product test applications
- **Expandable Power Levels**
  Available output power of 30, 45, 75 and 90 kVA per unit and multi-unit configurations for power requirements up to 180 kVA and above
- **Remote Control**
  Standard RS232, USB and IEEE-488 (GPIB) and optional LAN interfaces are available for automated test applications.

Introduction
The BPS Series consists of multiple high power AC power systems that provide controlled AC output for ATE and product test applications.

This high power AC test system covers a wide spectrum of AC power applications at an affordable cost. Using state-of-the-art PWM switching techniques, the BPS Series combines compactness, robustness and functionality in a compact floor-standing chassis, no larger than a typical office copying machine. This higher power density has been accomplished without the need to resort to elaborate cooling schemes or additional installation wiring. Simply roll the unit to its designated location (using included casters), plug it in, and the BPS Series is ready to work for you.

Simple Operation
The BPS Series can be operated completely from its menu driven front panel controller. A backlit LCD display shows menus, setup data, and read-back measurements. IEEE-488, RS232C, USB and LAN remote control interfaces and instrument drivers for popular ATE programming environments are available. This allows the BPS Series to be easily integrated into an automated test system.

Configurations
The BPS is capable of delivering 30, 45, 75, 90, 150 or 180kVA of AC power. The 30 and 45kVA models come as dedicated single or three phase output while the 75, 90, 150 and 180kVA models are dedicated three phase.

For higher power requirements, simply parallel the BPS in multi-cabinet configuration. Multi cabinet systems always operate in three phase output mode commonly found in power systems.

Product Evaluation and Test
Increasingly, manufacturers of high power equipment and appliances are required to fully evaluate and test their products over a wide range of input line conditions. The built-in output transient generation and read-back measurement capability of the BPS Series offers the convenience of a powerful, and easy to use, integrated test system.

Avionics
With an output frequency range to 819 Hz, the BPS Series is well suited for aerospace applications. Precise frequency control and accurate load regulation are key requirements in these applications. The available remote control interfaces and SCPI command language provide for easy integration into existing ATE systems. The BPS Series eliminates the need for several additional pieces of test equipment, saving cost and space. Instrument drivers for popular programming environments such as National Instruments LabView™ are available to speed up system integration.

Choice of voltage ranges
Standard voltage ranges are 150V L-N (259V L-L) and 300V (519V L-L) and are direct coupled output.

For applications requiring more than 300V L-N (or 519V L-L), the optional -HV output transformer provides a third additional 400V L-N and 693 V L-L output range which is internal to the AC chassis. No external magnetics modules are required.

Multi-Box Configurations
For high power applications, two BPS75 or BS90 chassis can be combined to provide 150kVA or 180kVA of output power. For higher power requirement please contact sales for custom configurations.

BPS Series

Simple transition from R&D to Manufacturing.
The California Instruments Mx and RS Series are high performance, feature rich Research and Development solutions. That level of advanced performance is not always required in production and lab environments. Since the BPS shares common code structure and performance characteristics as the Mx and RS the BPS is ideally suited to easily transition into cost effective production solutions.

High Crest Factor
With a crest factor of up to 4.5, the BPS Series AC source can drive difficult nonlinear loads with ease. Since many modern products use switching power supplies, they have a tendency to pull high repetitive peak currents.

Remote Control
Standard RS232, USB and IEEE 488 (GPIB) along with optional LAN remote control interfaces allow programming of all instrument functions from an external computer. The popular SCPI command protocol is used for programming.

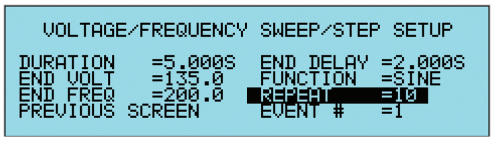
Application Software
Windows® application software is included. This software provides easy access to the power source's capabilities without the need to develop any custom code. The following functions are available through this GUI program:

- Steady state output control (all parameters)
- Create, run, save, reload and print transient programs
- Measure and log standard measurements
- Capture and display output voltage and current waveforms.
- Measure standard power measurements..
- Display IEEE-488, RS232C, USB and LAN bus traffic to and from the AC Source to help you develop your own test programs.

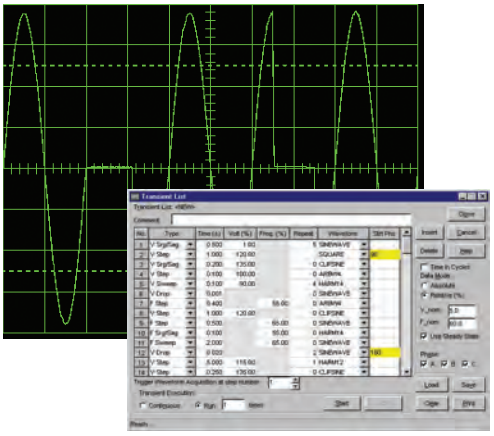
BPS Series - AC Transient Generation
The BPS Series controller has a powerful AC transient generation system that allows complex sequences of voltage and frequency to be generated. This further enhances the BPS's capability to simulate AC line conditions and disturbances. Transient generation is controlled independently yet time synchronized on all three phases. Accurate phase angle control and synchronized transient list execution provide unparalleled accuracy in positioning AC output events.

Transient programming is easily accomplished from the front panel where clearly laid out menu's guide the user through the transient definition process.

The front panel provides a convenient listing of the programmed transient sequence and allows for transient execution Start, Stop, Abort and Resume operations. User defined transient sequences can be saved to non-volatile memory for instant recall and execution at a later time. The included Graphical User Interface program supports transient definitions using a spreadsheet-like data entry grid. A library of frequently used transient programs can be created and saved using this GUI program.



Transient List Data Entry from the front panel.



Transient List Data Entry in GUI program.

BPS Series

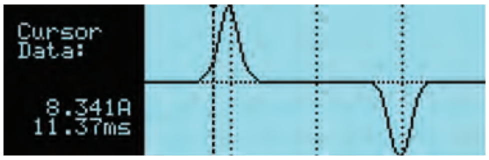
30–180 kVA

BPS Series - Measurement and Analysis
The BPS Series is much more than a programmable AC power source. It also incorporates an advanced digital signal processor based data acquisition system that continuously monitors all AC source and load parameters. This data acquisition system forms the basis for all measurement and analysis functions. These functions are accessible from the front panel and the remote control interface for the BPS Series.

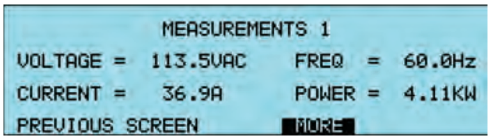
Conventional Measurements
Common AC measurement parameters are automatically provided by the data acquisition system. These values are displayed in numeric form on the front panel LCD display. The following measurements are available: Frequency, Vrms, Irms, Ipk, Crest Factor, Real Power (Watts), Apparent Power (VA) and Power Factor.

Waveform Acquisition
The measurement system is based on real-time digitization of the voltage and current waveforms using a 4K deep sample buffer. This time domain information provides detailed information on both voltage and current waveshapes. Waveform acquisitions can be triggered at a specific phase angle or from a transient program to allow precise positioning of the captured waveform with respect to the AC source output.

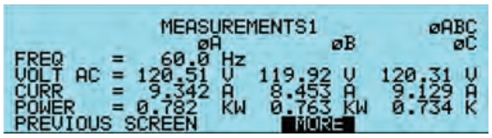
The front panel LCD displays captured waveforms with cursor readouts. The included GUI program also allows acquired waveform data to be displayed, printed, and saved to disk.



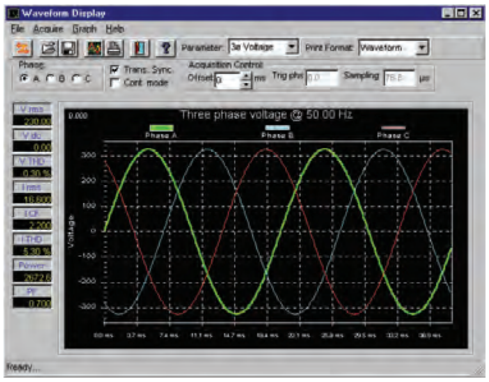
Acquired Current waveform (BPS Display).



Measurement data for single phase (BPS Display).



Measurement data for all three phases (BPS Display).



Acquired three phase voltage waveforms display on PC.

BPS Series : Specifications

Operating Modes

BPS Series	AC

AC Mode Output

Frequency	Range: 16.00-819.0 Hz, -LF Option: 16.00-500.0 Hz, Resolution: 0.01 Hz: 16.00 - 81.91 Hz, 0.1 Hz: 82.0 Hz - 819.1 Hz
Phase Outputs	1 or 3 Neutral: Floating, Coupling: DC (except for -HV option) Please specify Single (-1) or Three Phase (-3) for BPS30 and BPS45 at time of order.
Total Power	BPS30-1/3; 30kVA, BPS45-1/3: 45kVA, BPS75-3: 75kVA, BPS90-3: 90kVA, BPS150-3:150kVA, BPS180-3, 180kVA
Load Power Factor	0 to unity at full output current

AC Mode Voltage

Voltage Ranges

Range	V Low	V High
AC	0-150 V	0-300 V

Load Regulation	< 0.25 % FS to 100 Hz, < 0.5 % FS 100 Hz to 819 Hz
Line Regulation	< 0.1% FS for 10 % line change

External Sense	Voltage drop compensation (5% Full Scale)
Harmonic Distortion (Linear)	Less than 0.5% from 16 - 66 Hz, Less than 1% from 66 - 500 Hz, Less than 1.25% above 500 Hz
DC Offset	< 20 mV
Load Regulation	0.25% FS @ - 100 Hz, 0.5% FS > 100 Hz
External Amplitude Modulation	Depth: 0 - 10 %, Frequency: DC - 2 KHz
Voltage slew rate	200 μs for 10% to 90% of full scale change into resistive load, 0.5V / μSec

AC Mode Current

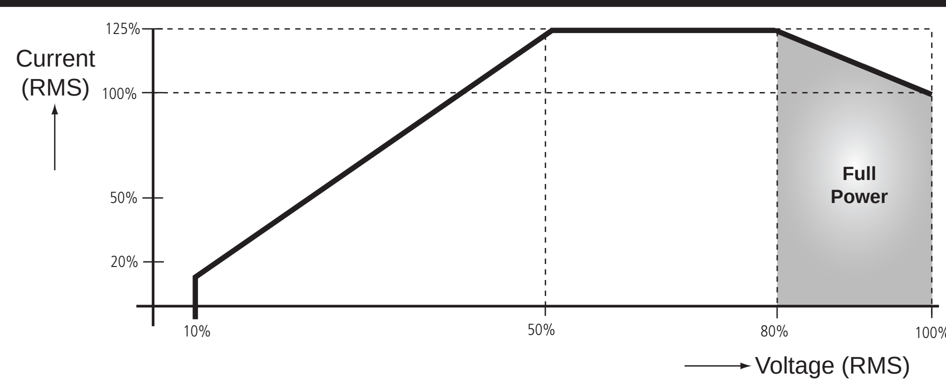
Output

Model	BPS30-1/3	BPS45-1/3	BPS75	BPS90	BPS150	BPS180
	30 KVA	45 KVA	75 KVA	90 KVA	150 KVA	180 kVA
	BPS30-1 V Lo:200 A V Hi: 100A Single phase BPS30-3 V Lo: 66.7A V Hi: 33.3A per phase 3 phase	BPS45-1 V Lo:300 A V Hi: 150A Single phase BPS45-3 V Lo: 100 V Hi: 50A per phase 3 phase	BPS75 V Lo: 166A V Hi: 83A per phase	BPS90 V Lo:200A V Hi: 100A per phase	BPS150 V Lo:332A V Hi: 166A per phase	BPS180 V Lo:400A V Hi: 200A per phase

Note: Constant power mode provides increased current at reduced voltage. See chart below

Peak Repetitive AC Current	4.5 x RMS current for BPS30, 3.0 x RMS current for BPS45, 3.6 x RMS current for BPS75 and 3.0 x RMS current for BPS90. BPS150 is 2x BPS75 and BPS180 is 2x BPS90
Programming Accuracy	Voltage (rms): ± 0.3 Vrms, Frequency: ± 0.01 % of programmed value, Current Limit: - 0 % to + 5 % of programmed value + 1A, Phase: < 0.5° + 0.2°/ 100 Hz with balanced load
Programming Resolution	Voltage (rms): 100 mV, Frequency: 0.01 Hz from 16 - 81.91 Hz, 0.1 Hz from 82.0 - 819 Hz, Current Limit: 0.1 A, 3 phase mode, 1.0 A, 1 phase mode, Phase: 0.1°

Constant Power AC Mode - Available Max. AC Current



Note: Specifications are subject to change without notice. Specifications are warranted over an ambient temperature range of 25°± 5° C. Unless otherwise noted, specifications are per phase for a sinewave with a resistive load and apply after a 30 minute warm-up period. For three phase configurations, all specifications are for L-N. Phase angle specifications are valid under balanced load conditions only.

BPS Series : Specifications 30–180 kVA

Measurement

Measurements - Standard (AC Measurements)

Parameter	Frequency	RMS Voltage	RMS Current	Peak Current	Crest Factor	Real Power	Apparent Power	Power Factor	Phase
Range	16-100 Hz 100-820 Hz	0-400 V	0-300 A	0-800 A	0.00-6.00	90 kW	90 kW	0.00-1.00	0.0-360.0
Accuracy* (±)	0.01% + 0.01 Hz	0.05V + 0.02% 0.1V + 0.02%	0.15A + .02% 0.3A + .02%	0.15A + 0.02% 0.3A + .02%	0.05 0.05	30 W + 0.1% 60 W + 0.1%	30 VA + 0.1% 60 VA + 0.1%	0.01 0.02	2.0° 3.0°
Resolution*	0.01 Hz / 0.1 Hz	10 mV	10 mA	10 mA	0.01	10 W	10 VA	0.01	0.1°

* Measurement system bandwidth = DC to 6.7 kHz. Accuracy specifications are valid above 100 counts. Current and Power Accuracy and Range specifications are times three for BPS 150 and BPS180 in single phase mode. PF accuracy applies for PF > 0.5 and VA > 50 % of range

Protection

Over Load	Constant Current or Constant Voltage mode
Over Temperature	Automatic shutdown

Storage

Non Volatile Mem. storage	16 instrument setups, 200 user defined waveforms [Pi only]

Waveforms

Waveform Types	Std: Sine Wave

System Interface

Inputs	Remote shutdown
Outputs	Function Strobe / Trigger out

Remote Control

IEEE-488 Interface	IEEE-488 (GPIB) talker listener. Subset: AH1, C0, DC1, DT1, L3, PP0, RL2, SH1, SR1, T6, IEEE-488.2 SCPI Syntax
RS232C Interface	9 pin D-shell connector (Supplied with RS232C cable)
LAN (option)	Ethernet Interface: 10BaseT, 100BaseT, RJ45
USB	Version: USB 1.1; Speed: 460 Kb/s maximum
Output Relay	Push button controlled or bus controlled output relay

AC Input

Voltage	Must be specified at time of order. All inputs are L-L, 3ø, 3 wire + Gnd. 208 ± 10% VAC, 230 ± 10% VAC, 400 ± 10% VAC, 480 ± 10% VAC

Input Line Current (per phase)

BPS30-1/3	BPS45-1/3	BPS75	BPS90	BPS150	BPS180
116 ARMS @ 187 VLL 105 ARMS @ 207 VLL 60 ARMS @ 360 VLL 50 ARMS @ 432 VLL	175 ARMS @ 187 VLL 157 ARMS @ 207 VLL 90 ARMS @ 360 VLL 75 ARMS @ 432 VLL	285 ARMS @187 VLL 256 ARMS @ 207 VLL 147 ARMS @ 360 VLL 122 ARMS @ 432 VLL	350 ARMS @ 187 VLL 314 ARMS @ 207 VLL 180 ARMS @ 360 VLL 150 ARMS @ 432 VLL	Each BPS75 chassis requires its own AC service. Total Line currents are 2 x BPS75	Each BPS90 chassis requires its own AC service. Total Line currents are 2 x BPS90

Line Frequency	47 - 63 Hz
Efficiency	85 % typical
Power Factor	0.95 typical

AC Service

Inputs/Outputs	Rear panel connection
Regulatory	IEC61010, EN50081-2, EN50082-2, CE EMC and Safety Mark requirements
EMI	CISPR 11, Group1 , Class A
Connectors	All remote interface connections available from the rear panel.

Physical Dimensions

BPS30/45 Dimensions	Height: 50” 1270 mm, Width: 28.75” 731mm, Depth: 34.5” 876mm
BPS30/45 Weight	Per Chassis: Net: 1150 lbs / 522 Kg approximately, Shipping: 1231 lbs / 560 Kg approximately
BPS75/90 Dimensions	Height: 76” 1930 mm, Width: 32.0” 812mm, Depth: 40.0” 1016mm
BPS75/90 Weight	Per Chassis: Net: 1650 lbs / 748 Kg approximately, Shipping: 1731 lbs / 785 Kg approximately
Chassis	Casters and forklift openings.
Vibration and Shock	Designed to meet NSTA project 1A transportation levels. Units are shipped in wooden crate with forklift slots
Air Intake/Exhaust	Forced air cooling, front air intake, rear exhaust
Operating Humidity	0 to 95 % RAH, non condensing
Temperature	Operating: 0 to 40° C (30° C max in CP mode), Storage: -20 to +85° C

BPS Series

Supplied with
Standard: User/Programming Manual and Software on CD ROM. RS232C serial cable.

Input Voltage Settings
Specify input voltage (L-L) setting for each BPS system at time of order:
208 Configured for 208 V ±10 % L-L, 4 wire input.
230 Configured for 230 V ±10 % L-L, 4 wire input.
380 Configured for 380V +/- 10% L-L, 4 Wire Input
400 Configured for 400 V ±10 % L-L, 4 wire input.
480 Configured for 480 V ±10 % L-L, 4 wire input

Standard Model Options

- LF Limits maximum frequency to 500 Hz.

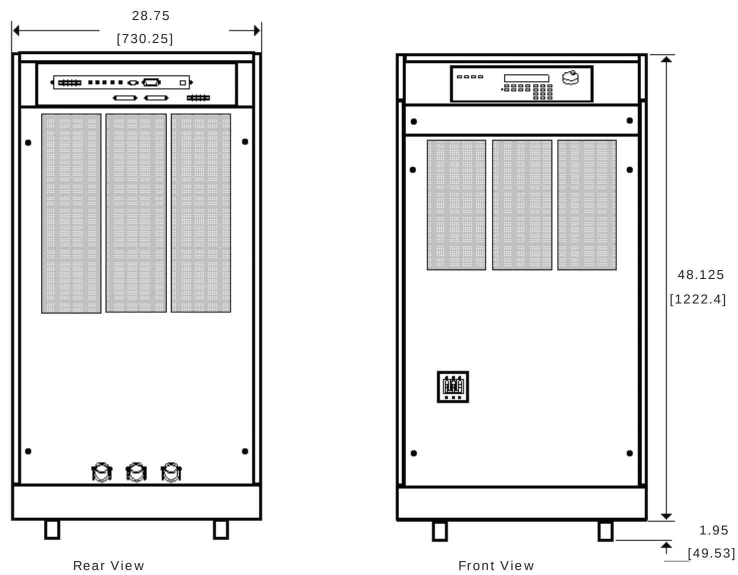
-LAN Ethernet Interface.

-HV Adds 400 V L-N AC-only output range.

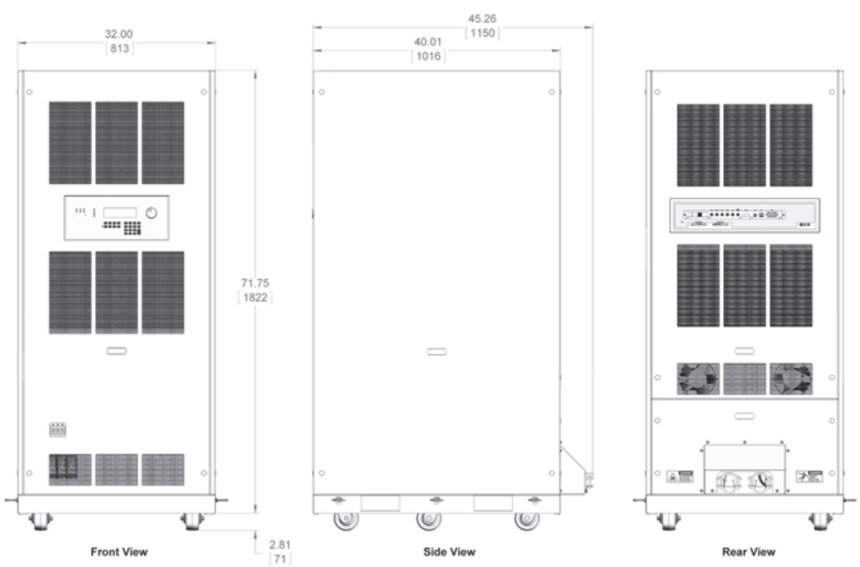
Packaging and Shipment

All BPS systems are packaged in re-usable protective wooden crates for shipment.

BPS30/45 Dimensions - single chassis



BPS75/90 Dimensions - single chassis



California Instruments MX Series II

15–135 kVA

Overview

150–400 V

0–375 A / Phase

≈	208	230	400
	480		

ETHERNET USB GPIB RS232

- **High Power AC and DC Power Source**
  Programmable AC and DC power for frequency conversion and product test applications
- **Expandable Power Levels**
  Available output power of 15, 30, and 45 kVA per unit and multi-unit configurations for power requirements up to 135 kVA and above
- **Single and Three Phase Mode**
  Phase mode programming on MX30-3Pi and MX45-3Pi allows switching between single and three phase output modes
- **Arbitrary & Harmonic Waveform Generation**
  User defined voltage waveform and distortion programming
- **Regenerative, bidirectional "Green" Power Solution**
  Automatic crossover between Source and Sink power mode offers regenerative capabilities in AC mode. Regenerate up to 100% of the rated output power back to the utility grid during sink mode operation. (-SNK option)
- **Remote Control**
  Standard RS232C & USB along with optional IEEE-488 & LAN Interfaces are available for automated test applications

Introduction
The MX Series consists of multiple high power AC and DC power systems that provide controlled AC and DC output for ATE and product test applications.

This high power AC and DC test system covers a wide spectrum of AC and DC power applications at an affordable cost. Using state-of-the-art PWM switching techniques, the MX series combines compactness, robustness and functionality in a compact floor-standing chassis, no larger than a typical office copying machine. This higher power density has been accomplished without the need to resort to elaborate cooling schemes or additional installation wiring. Simply roll the MX15, MX30, or MX45 unit to its designated location (using included casters), plug it in, and the MX series is ready to work for you.

Simple Operation
The MX Series can be operated completely from its menu driven front panel controller. A backlit LCD display shows menus, setup data, and read-back measurements. IEEE-488, RS232C, USB and LAN remote control interfaces and instrument drivers for popular ATE programming environments are available. This allows the MX Series to be easily integrated into an automated test system.

For advanced test applications, the programmable controller version offers full arbitrary waveform generation, time and frequency domain measurements, and voltage and current waveform capture.

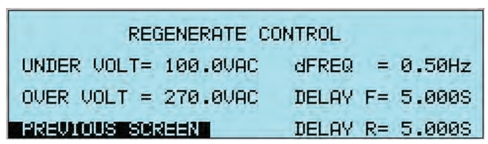
Configurations
The MX15 delivers up to 15 kVA of single phase output. The MX30 delivers up to 30 kVA, and the MX45 up to 45 kVA. Both operate using single or three phase output in AC mode. In DC mode, 50% of the AC power level is available. On MX-P models, AC+DC mode is also supported.

For higher power requirements, the MX90 and MX135 models are available. Multi cabinet MX45 systems always operate in three phase output mode. Available reconfigurable MX90 and MX135 models (-MB designation) provide multiple controllers which allow separation of the high power system into two or three individual MX45 units for use in separate applications. This ability to reconfigure the system provides an even greater level of flexibility not commonly found in power systems.

Product Evaluation and Test
Increasingly, manufacturers of high power equipment and appliances are required to fully evaluate and test their products over a wide range of input line conditions. The built-in output transient generation and read-back measurement capability of the MX Series offers the convenience of a powerful, and easy to use, integrated test system.

MX Series II

Regenerative, bidirectional “Green” Power Solution
The MX Series features the ability to both source and sink current, i.e. bi-directional current flow. The MX amplifier is designed to reverse the phase relationship between the AC input voltage and current in order to feed power back onto the utility grid. This mode of operation is particularly useful when testing grid-tied products that feed energy back onto the grid. Static Power Converters such as grid-tied and off-grid photovoltaic inverters are tested for frequency variations, voltage transients, remove.



Programming sink (-SNK) mode operation

Avionics
With an output frequency range to 819 Hz (or 1000 Hz with -HF option), the MX Series is well suited for aerospace applications. Precise frequency control and accurate load regulation are key requirements in these applications. The available IEEE-488 remote control interface and SCPI command language provide for easy integration into existing ATE systems. The MX Series eliminates the need for several additional pieces of test equipment, saving cost and space. Instrument drivers for popular programming environments such as National Instruments LabView™ are available to speed up system integration.

Regulatory Testing
As governments are moving to enforce product quality standards, regulatory compliance testing is becoming a requirement for a growing number of manufacturers. The MX Series is designed to meet AC source requirements for use in compliance testing such as IEC 61000, 3-2, 3-3, 3-11, 3-12, to name a few.

Choice of voltage ranges
The MX30 and MX45 can be ordered with either a 150 V RMS Line to Neutral output voltage range or a 300 V RMS Line to Neutral range. This provides 3 phase output capability of 260 Vac or 520 Vac line to line respectively. If dual output ranges are required, the programmable range change option (-R) provides the ability to switch between both output ranges. Pi version models offer standard dual voltage ranges.

For applications requiring more than 300 V L-N (or 520 V L-L), the optional -HV output transformer provides an additional 400 V L-N and 693 V L-L output range for use in AC mode only.

Multi-Box Configurations
For high power applications, two or three MX45 chassis can be combined to provide 90 to 135 kVA of three phase power. MX90 and MX135 systems are always configured for three phase operation. Contact sales for custom configurations.

High Crest Factor
With a crest factor of up to 3.6, the MX Series AC source can drive difficult nonlinear loads with ease. Since many modern products use switching power supplies, they have a tendency to pull high repetitive peak currents. The MX30-3Pi can deliverup to 240 Amps of repetitive peak current (150 V AC range) per phase to handle three phase loads.

Remote Control
Standard RS232C & USB IEEE-488 along with optional LAN remote control interfaces allow programming of all instrument functions from an external computer. The popular SCPI command protocol is used for programming.

Application Software
Windows® application software is included. This software provides easy access to the power source’s capabilities without the need to develop any custom code. The following functions are available through this GUI program:

- Steady state output control (all parameters)
- Create, run, save, reload and print transient programs
- Generate and save harmonic waveforms.
- Generate and save arbitrary waveforms.
- Measure and log standard measurements
- Capture and display output voltage and current waveforms.
- Measure, display, print and log harmonic voltage and current measurements.
- Display IEEE-488, RS232C, USB and LAN bus traffic to and from the AC Source to help you develop your own test programs.

MX Series II

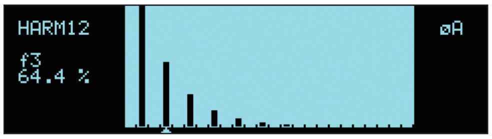
15–135 kVA

1. Requires PC running WindowsXP™ or Windows 2000™.

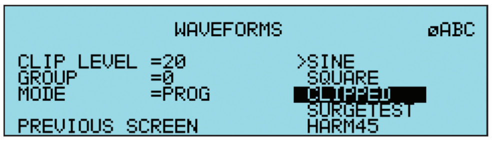
Harmonic Waveform Generation
Using the latest DSP technology, the MX Series programmable controller is capable of generating harmonic waveforms to test for harmonics susceptibility. The Windows Graphical User Interface program can be used to define harmonic waveforms by specifying amplitude and phase for up to 50 harmonics. The waveform data points are generated and downloaded by the GUI to the AC source through the IEEE-488 or RS232C bus. Up to 200 waveforms can be stored in nonvolatile memory and given a user defined name for easy recall.

All MX-Pi Series configurations offer three phase waveform generation, allowing independent phase anomalies to be programmed. It also allows simulation of unbalanced harmonic line conditions.

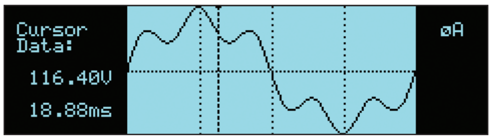
Arbitrary Waveform Generation
Using the provided GUI program or custom software, the user also has the ability to define arbitrary AC waveforms. The arbitrary waveform method of data entry provides an alternative method of specifying AC anomalies by providing specific waveform data points. The GUI program provides a catalog of custom waveforms and also allows real-world waveforms captured on a digital oscilloscope to be downloaded to one of the many AC source's waveform memories. Arbitrary waveform capability is a flexible way of simulating the effect of real-world AC power line conditions on a unit under test in both engineering and



Harmonic waveform, Fund., 3rd, 5th, 7th, 9th,11th and 13th.



Two hundred user defined waveforms.



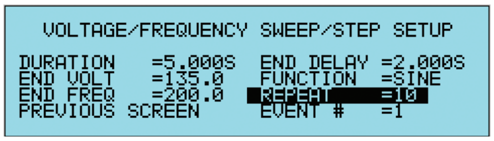
Harmonically distorted waveform.

production environments.

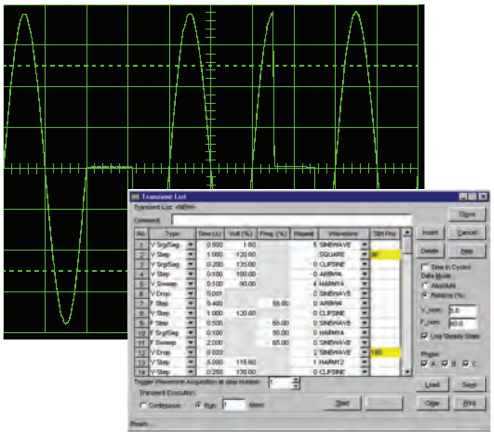
MX Series - AC and DC Transient Generation
The MX Series controller has a powerful AC and DC transient generation system that allows complex sequences of voltage, frequency and waveshapes to be generated. This further enhances the MX's capability to simulate AC line conditions or DC disturbances. When combined with the multiphase arbitrary waveform capabilities, the AC and DC output possibilities are truly exceptional. Transient generation is controlled independently yet time synchronized on all three phases. Accurate phase angle control and synchronized transient list execution provide unparalleled accuracy in positioning AC output events.

Transient programming is easily accomplished from the front panel where clearly laid out menu's guide the user through the transient definition process.

The front panel provides a convenient listing of the programmed transient sequence and allows for transient execution Start, Stop, Abort and Resume operations. User defined transient sequences can be saved to non-volatile memory for instant recall and execution at a later time. The included Graphical User Interface program supports transient definitions using a spreadsheet-like data entry grid. A library



Transient List Data Entry from the front panel.



Transient List Data Entry in GUI program.

MX Series II

of frequently used transient programs can be created on disk using this GUI program.

MX Series - Measurement and Analysis

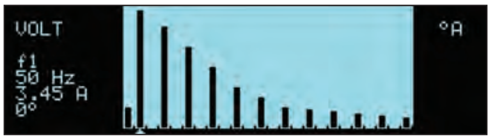
The MX Series is much more than a programmable AC, DC or AC+DC power source. It also incorporates an advanced digital signal processor based data acquisition system that continuously monitors all AC source and load parameters. This data acquisition system forms the basis for all measurement and analysis functions. These functions are accessible from the front panel and the remote control interface for the MX Series (MX15 excluded; uses 2-line display shown below).

Conventional Measurements [All controllers]

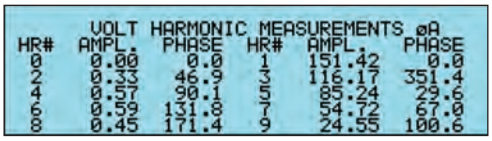
Common AC and DC measurement parameters are automatically provided by the data acquisition system. These values are displayed in numeric form on the front panel LCD display. The following measurements are available: Frequency, Vrms, Irms, Ipk, Crest Factor, Real Power (Watts), Apparent Power (VA) and Power Factor.

Harmonic Analysis

The MX Series provides detailed amplitude and phase information on up to 50 harmonics of the fundamental voltage and current (up to 16 kHz in three phase mode) for either one or three phases. Harmonic content can be displayed in both tabular and graphical formats on the front panel LCD for immediate feedback to the operator (excluding MX15). Alternatively, the included GUI program can be used to display, print and save harmonic measurement data. Total harmonic distortion of both voltage and current is calculated from the harmonic data.



Absolute amplitude bar graph display of current harmonics with cursor positioned at the fundamental (MX30/45 Display).


VOLT HARMONIC MEASUREMENTS øA

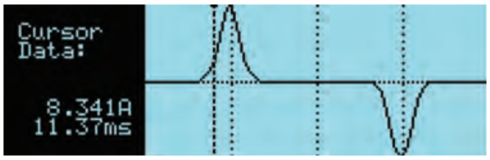
HR#	AMPL.	PHASE	HR#	AMPL.	PHASE
0	0.00	0.0	1	151.42	0.0
2	0.33	46.9	3	116.17	351.4
4	0.57	90.1	5	85.24	29.6
6	0.59	131.8	7	54.72	67.0
8	0.45	171.4	9	24.55	100.6

Voltage harmonic measurement table display in absolute values (MX30/45 Display)

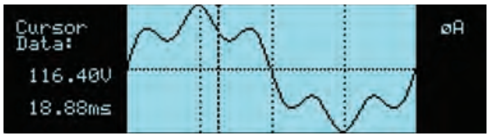
Waveform Acquisition

The measurement system is based on real-time digitization of the voltage and current waveforms using a 4K deep sample buffer. This time domain information provides detailed information on both voltage and current waveshapes. Waveform acquisitions can be triggered at a specific phase angle or from a transient program to allow precise positioning of the captured waveform with respect to the AC source output.

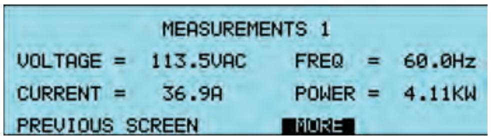
The front panel LCD displays captured waveforms with cursor readouts (excluding MX15). The included GUI program also allows acquired waveform data to be displayed, printed, and saved to disk.



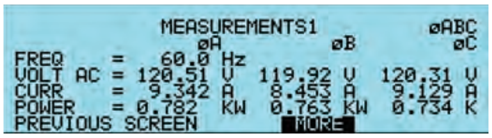
Acquired Current waveform (MX30/45 Display).



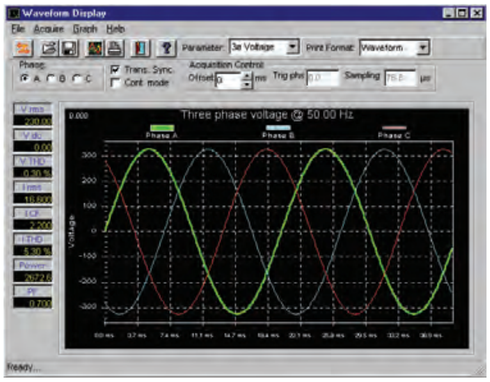
Acquired Voltage waveform (MX30/45 Display).



Measurement data for single phase (MX30/45 Display).



Measurement data for all three phases (MX30/45 Display).



Acquired three phase voltage waveforms display on PC.

MX Series II : Specifications

15–135 kVA

Operating Modes

Pi Version	AC, DC and AC+DC

AC Mode Output

Frequency	Range: 16.00-819.0 Hz, -LF Option: 16.00-500.0 Hz, -HF Option: 16.00-1000 Hz (supplemental specifications apply above 819 Hz). Resolution: 0.01 Hz: 16.00 - 81.91 Hz, 0.1 Hz: 82.0 Hz - 819.1 Hz
Phase Outputs	MX15-1/15-1Pi: 1, MX30/45-3Pi: 1 or 3 switchable, Neutral: Floating, Coupling: DC (except for -HV option)
Total Power	MX15-1/1Pi: 15 kVA, MX30-1/3: 30 kVA, MX45-1/3: 45 kVA, MX90: 90 kVA, MX135: 135 kVA
Load Power Factor	0 to unity at full output current

AC Mode Voltage

Voltage Ranges

Range	V Low	V High
AC	0-150 V	0-300 V
AC+DC	0-150 V	0-300 V

Load Regulation	< 0.25 % FS DC to 100 Hz, < 0.5 % FS 100 Hz to 819 Hz
Line Regulation	< 0.1% FS for 10 % line change

External Sense	Voltage drop compensation (5% Full Scale)
Harmonic Distortion (Linear)	Less than 0.5% from 16 - 66 Hz, Less than 1% from 66 - 500 Hz, Less than 1.25% above 500 Hz
DC Offset	< 20 mV
Load Regulation	0.25% FS @ DC - 100 Hz, 0.5% FS > 100 Hz
External Amplitude Modulation	Depth: 0 - 10 %, Frequency: DC - 2 KHz
Voltage slew rate	200 µs for 10% to 90% of full scale change into resistive load, 0.5V / µSec

AC Mode Current

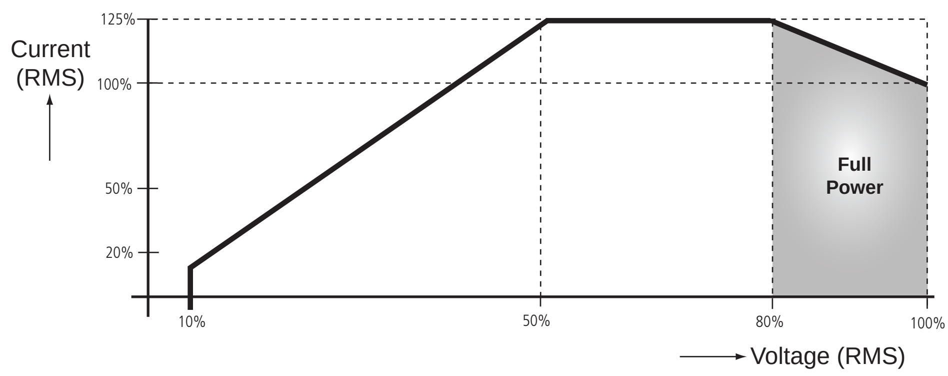
Steady State AC Current @ FS V

Model	MX15-1Pi	MX30-3Pi / 1Pi	MX45-3Pi / 1Pi	MX90-3/Pi	MX135-3/Pi
V Low	100	66.6/ø / 200	100/ø / 300	200/ø	300/ø
V High	50	33.3/ø / 100	50/ø / 150	100/ø	150/ø

Note: Constant power mode provides increased current at reduced voltage. See chart below

Peak Repetitive AC Current	Up to 3.6 x rms current at full scale voltage
Programming Accuracy	Voltage (rms): ± 0.3 Vrms, Frequency: ± 0.01 % of programmed value, Current Limit: - 0 % to + 5 % of programmed value + 1A, Phase: < 0.5° + 0.2°/ 100 Hz with balanced load
Programming Resolution	Voltage (rms): 100 mV, Frequency: 0.01 Hz from 16 - 81.91 Hz, 0.1 Hz from 82.0 - 819 Hz, Current Limit: 0.1 A, 3 phase mode, 1.0 A, 1 phase mode, Phase: 0.1°

Constant Power AC Mode - Available Max. AC Current



Note: Specifications are subject to change without notice. Specifications are warranted over an ambient temperature range of 25°± 5° C. Unless otherwise noted, specifications are per phase for a sinewave with a resistive load and apply after a 30 minute warm-up period. For three phase configurations, all specifications are for L-N. Phase angle specifications are valid under balanced load conditions only.

MX Series II : Specifications

Measurement

Measurements - Standard (AC Measurements)

Parameter	Frequency	RMS Voltage	RMS Current	Peak Current	Crest Factor	Real Power	Apparent Power	Power Factor	Phase	DC Voltage	DC Current	Power
Range	16-100 Hz 100-820 Hz	0-400 V	0-160 A	0-400 A	0.00-6.00	0-15 kW	0-15 kVA	0.00-1.00	0.0-360.0	0-400 V	0-160 A	Power
Accuracy* (±)	0.01% + 0.01 Hz	0.05 V + 0.02% 0.1 V + 0.02%	0.15 A + .02% 0.3 A + 0.02%	0.15 A + 0.02% 0.3 A + 0.02%	0.05 0.05	30 W + 0.1% 60 W + 0.1%	30 VA + 0.1% 60 VA + 0.1%	0.01 0.02	2.0° 3.0°	0.5 V	0.5 A	0.15 kW
Resolution*	0.01 Hz / 0.1 Hz	10 mV	10 mA	10 mA	0.01	10 W	10 VA	0.01	0.1°	10 mV	10 mA	10 W

* Measurement system bandwidth = DC to 6.7 kHz. Accuracy specifications are valid above 100 counts. Current and Power Accuracy and Range specifications are times three for MX90, MX135 or MX30/45-3Pi in single phase mode. PF accuracy applies for PF > 0.5 and VA > 50 % of range

Measurements - Harmonics (Pi controller only)

Parameter	Frequency Fundamental Harmonics	Phase	Voltage	Current
Range	16.00-1000.0 Hz / 32.00 Hz - 16 kHz	0.0 - 360.0°	Fundamental Harmonics 2-50	Fundamental Harmonics 2-50
Accuracy* (±)	0.03% + 0.03 Hz / 0.01 Hz	2° typ.	750 mV 0.3% + 750 mV+0.3% /1 kHz	0.5 A / 0.3% + 150 mA +0.3% /1 kHz
Resolution	0.01 Hz	0.5°	10 mV / 10 mV	100 mA / 100 mA

* Accuracy specifications are valid above 100 counts. Accuracy specifications are for three phase mode. Harmonics frequency range for MX30/45-3Pi in single phase mode is 32 Hz - 48 kHz

DC Mode Output

Power	Maximum DC power at full scale of DC voltage range. **MX15-1Pi**: (10 kW), **MX30-3Pi**: (6.5 kW per output, 3 outputs. 20 kW in 1 channel mode), **MX45-3Pi**: (10 kW per output, 3 outputs. 30 kW in 1 channel mode)
Voltage Ranges	Range: Low (0 - 200 V), High (0 - 400 V)
Output Accuracy	± 1 Vdc
Load Regulation	< 0.25 % FS
Line Regulation	< 0.1% FS or 10 % line change
Ripple	< 2 Vrms Lo Range, < 3 Vrms Hi Range

Max DC Current @ FSV per output

Model	MX15-1Pi	MX30-3Pi / 1Phs	MX45-3Pi / 1Phs	MX90-3/Pi	MX135-3/Pi
V Low	50	33.3 / 100	50 / 150	100	150
V High	25	16.6 / 50	25 / 75	50	75

Note: Constant power mode provides increased current at reduced voltage. See chart on previous page

Current Limit	Programmable from 0 A to max. current for selected range

AC+DC Mode Output

Output (Pi) Power	Maximum current and power in AC+DC mode is same as DC mode

Protection

Over Load	Constant Current or Constant Voltage mode
Over Temperature	Automatic shutdown

Storage

Non Volatile Mem. storage	16 instrument setups, 200 user defined waveforms [Pi only]

Waveforms

Waveform Types	Std: Sine, Pi: Sine, Square, Clipped sine, User defined
User defined waveform storage	Four groups of 50 user defined arbitrary waveforms of 1024 points for a total of 200. One group can be active at a time

System Interface

Inputs	Remote shutdown, External Sync, Clock/Lock
Outputs	Function Strobe / Trigger out, Clock/Lock

Remote Control (Pi standard with -P option)

IEEE-488 Interface	IEEE-488 (GPIB) talker listener. Subset: AH1, C0, DC1, DT1, L3, PP0, RL2, SH1, SR1, T6, IEEE-488.2 SCPI Syntax
RS232C Interface	9 pin D-shell connector (Supplied with RS232C cable)
LAN (option)	Ethernet Interface: 10BaseT, 100BaseT, RJ45
USB	Version: USB 1.1; Speed: 460 Kb/s maximum
Output Relay	Push button controlled or bus controlled output relay
Output impedance (not available with -SNK Option)	Programmable Z available on **MX30-3Pi** and **MX45-3Pi** in 3 phase mode only. Specifications apply at 50 Hz fundamental. Resistive: 1 - 200 mOhm, Inductive: 15 - 200 uH

MX Series

Model
Refer to table shown for model numbers and configurations.

Supplied with
Standard: User Manual on CD ROM.
Pi version: User/Programming Manual and Software on CD ROM. RS232C serial cable.

Input Voltage Settings
Specify input voltage (L-L) setting for each MX system at time of order:
208 Configured for 208 V ±10 % L-L, 4 wire input.
230 Configured for 230 V ±10 % L-L, 4 wire input.
380 Configured for 380V +/- 10% L-L, 4 Wire Input
400 Configured for 400 V ±10 % L-L, 4 wire input.
480 Configured for 480 V ±10 % L-L, 4 wire input

Standard Model Options
Specify output range on standard models. All range values shown are Line to Neutral.

- 150 Configured for 150 V AC and 200 V DC output ranges.
- 300 Configured for 300 V AC and 400 V DC output ranges.
- R Range change. Provides 150/200 & 300/400 AC/DC output ranges. (Std. MX15)
- P IEEE-488 & RS232C Interface Adds programming, Windows & RS232 Cable.

Pi Model Options
-411 *IEC 1000-4-11 test firmware.
- LF Limits maximum frequency to 500 Hz.
-FC Modifies output frequency control to ± 0.15%
-LAN Ethernet Interface.
- HF Increases max frequency to 1000 Hz.
-413 *IEC 1000-4-13 Harmonics & Interharmonics test firmware.
-HV Adds 400 V L-N AC-only output range.
-HF Increases max. frequency to 905 Hz.
-XV Adds other AC-only output range. Consult factory.
-LKM Clock/Lock Master
-LKS Clock/Lock Auxiliary
-WHM Watt-Hour Measurement option.
-SNK Bidirectional auto source and sink mode. Offers up to 100% power sink capability in AC mode of operation..

Avionics Test Routine Options
-ABD ABD0100.1.8 Test Option.
-AMD Airbus AMD24 Test
-A350 Airbus Test Software
-B787 Boeing 787 Test Software
-160 RTCA/DO-160D, DO-160E, and EUROCAE test firmware.
-704 Mil Std 704 A - F test - firmware/ software.

* Note: Reference the Avionics Test User Manual P/N 4994-971 for a complete listing of performance capabilities.

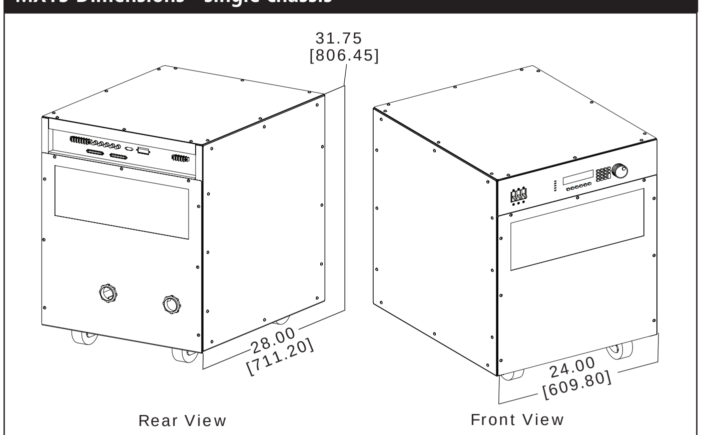
Packaging and Shipment

All MX systems are packaged in re-usable protective wooden crates for shipment.

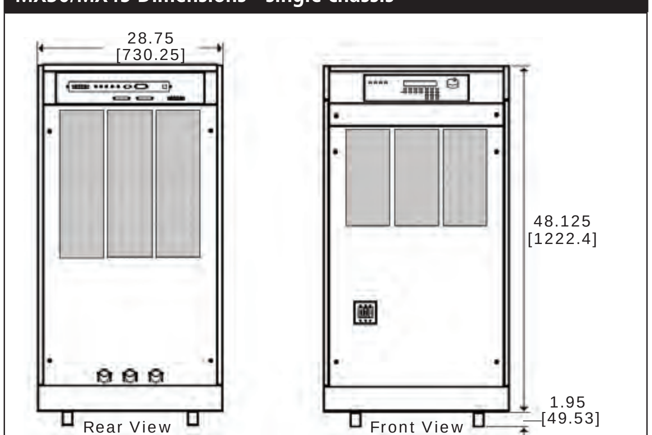
Feature Comparison

Model	Pi
AC mode	X
DC mode	X
AC+DC mode	X
Dual V Range	X
Transient programming	X
Arbitrary waveforms	X
Measurements	X
Harmonic measurements	X
Waveform acquisition	X
1 or 3 Phase mode	MX30/45-3Pi
IEEE / RS232	X

MX15 Dimensions - single chassis



MX30/MX45 Dimensions - single chassis



MX Series II : Specifications 15–135 kVA

AC Input

Voltage	Must be specified at time of order. All inputs are L-L, 3ø, 3 wire + Gnd. 208 ± 10% VAC, 230 ± 10% VAC, 400 ± 10% VAC, 480 ± 10% VAC
Input Line Current (per phase)	see below
Line Frequency	47 - 63 Hz
Efficiency	85 % typical
Power Factor	0.95 typical

Input Line Current (per phase):

Current (MX15):

V L-L	208	230	400	480
St State	58.3 ARMS	52.3 ARMS	30 ARMS	25 ARMS

Current (MX30/45):

V L-L	208	230	400	480
St State	116/175 ARMS	105/157 ARMS	60/90 ARMS	50/75 ARMS

Distortion: < 8 % at full power < 20 % below 35 % of power

AC Service

Inputs/Outputs	**MX30/MX45**: Front access, cables routed through rear panel, exit in back. **MX15**: Rear Access
Regulatory	IEC61010, EN50081-2, EN50082-2, CE EMC and Safety Mark requirements
EMI	CISPR 11, Group1 , Class A
Connectors	AC Input & Output terminal block behind front cover, IEEE-488 (GPIB) connector (rear panel), 9 pin D-Shell RS232C connector*, (rear panel), Remote voltage sense terminal block (rear panel), System Interface Connector, DB-37 (rear panel). *RS232 DB9 to DB9 cable supplied

Physical Dimensions

MX30/MX45 Dimensions	Height: 50.0” (1270 mm), Width: 28.75” (731 mm), Depth: 34.5” (876 mm)
MX30/MX45 Weight	Chassis: Net: 1150 lbs / 522 Kg, Shipping: 1231 lbs / 560 Kg, Amp Module: Net: 63 lbs / 29 Kg
MX15 Dimensions	Height: 31.75” (806 mm), Width: 24.0” (610 mm), Depth: 28.0” (711 mm)
MX15 Weight	Chassis: Net: 600 lbs / 272 Kg, Shipping: 681 lbs / 309 Kg, Amp Module: Net: 63 lbs / 29 Kg
Chassis	MX30/MX45: Casters and forklift openings. MX15: Casters
Vibration and Shock	Designed to meet NSTA project 1A transportation levels. Units are shipped in wooden crate with forklift slots
Air Intake/Exhaust	Forced air cooling, front air intake, rear exhaust
Operating Humidity	0 to 95 % RAH, non condensing
Temperature	Operating: 0 to 40° C (30° C max in CP mode), Storage: -20 to +85° C

Programmable controller versions with dual voltage ranges

Model	AC Output Power	Phase Outputs	AC/DC Voltage Range	Controller
MX15-1Pi	15kVA	1	150/200 & 300/400	Programmable
MX30-3Pi	30 kVA	1 & 3	150/200 & 300/400	Programmable
MX45-3Pi	45 kVA	1 & 3	150/200 & 300/400	Programmable
MX90-3Pi	90 kVA	3	150/200 & 300/400	Programmable
MX135-3Pi	135 kVA	3	150/200 & 300/400	Programmable

Pi models include IEEE-488, RS232C & USB interfaces, Advanced measurements, arbitrary waveform generation. Phase mode switching on MX-30/45-3Pi.

-MB Option

Model	AC Output Power	Phase Outputs	AC/DC Voltage Range	Controller
MX90-3Pi-MB	90 kVA	3	150/200 & 300/400	Dual MX45-3Pi
MX135-3Pi-MB	135 kVA	3	150/200 & 300/400	Triple MX-45-3Pi

Reconfigurable systems can be separated into stand-alone MX45-3Pi models or combined for higher power levels.

Steady State AC RMS Current in Regeneration Mode (-SNK Option)

Model	MX15-1Pi	MX30-3Pi	MX45-3Pi	MX60-3Pi	MX90-3Pi	MX135-3Pi
V Low	100A	66.6/Ø / 200	100A/Ø/300	133.3/Ø	200/Ø	300/Ø
V High	50A	33.3/Ø / 100	50A/Ø/150	66.6/Ø	100/Ø	150/Ø

California Instruments RS Series

90–540 kVA

Overview

150–400 V

0–1500 / Phase

≈	208	230	400
	480		

ETHERNET USB GPIB RS232

- **High Power AC and DC Power Source**
  Programmable AC and DC power for frequency conversion and product test applications
- **Expandable Power Levels**
  Available output power of 90 kVA per unit and multi-unit configurations for power requirements up to 540 kVA and above
- **Arbitrary & Harmonic Waveform Generation**
  User defined voltage waveform and distortion programming
- **Regenerative, bidirectional "Green" Power Solution**
  Automatic crossover between Source and Sink power mode offers regenerative capabilities in AC, AC+DC and DC modes. Regenerate up to 100% of the rated output power back to the utility grid during sink mode operation. (-SNK option)
- **Remote Control**
  Standard RS232C USB & IEEE-488 along with optional LAN Interfaces are available for automated test applications

Introduction
The RS Series consists of multiple high power AC and DC power systems that provide controlled AC and DC output for ATE and product test applications.

This high power AC and DC test system covers a wide spectrum of AC and DC power applications at an affordable cost. Using state-of-the-art PWM switching techniques, the RS series combines compactness, robustness and functionality in a compact floor-standing chassis, no larger than a typical office copying machine. This higher power density has been accomplished without the need to resort to elaborate cooling schemes or additional installation wiring. Simply roll the RS unit to its designated location (using included casters), plug it in, and the RS series is ready to work for you.

Simple Operation
The RS Series can be operated completely from its menu driven front panel controller. A backlit LCD display shows menus, setup data, and read-back measurements. IEEE-488, RS232C, USB and LAN remote control interfaces and instrument drivers for popular ATE programming environments are available. This allows the RS Series to be easily integrated into an automated test system.

For advanced test applications, the programmable controller version offers full arbitrary waveform generation, time and frequency domain measurements, and voltage and current waveform capture.

Configurations
The RS90 delivers up to 90 kVA of AC or AC + DC power. In DC mode, 50% of the AC power level is available.

For higher power requirements, the RS180, RS270, RS360, RS450 and RS540 models are available. Available reconfigurable RS models (-MB designation) provide multiple controllers which allow separation of the high power system into individual RS90 units for use in separate applications. This ability to reconfigure the system provides an even greater level of flexibility not commonly found in power systems.

Product Evaluation and Test
Increasingly, manufacturers of high power equipment and appliances are required to fully evaluate and test their products over a wide range of input line conditions. The built-in output transient generation and read-back measurement capability of the RS Series offers the convenience of a powerful, and easy to use, integrated test system.

RS Series

Regenerative, bidirectional "Green" Power Solution

The RS Series features the ability to both source and sink current, i.e. bi-directional current flow. The RS amplifier is designed to reverse the phase relationship between the AC input voltage and current in order to feed power back onto the utility grid. This mode of operation is particularly useful when testing grid-tied products that feed energy back onto the grid. Static Power Converters such as grid-tied and off-grid photovoltaic inverters are tested for frequency variations, voltage transients, DC injection and harmonic susceptibility.

Programming sink (-SNK) mode operation

Avionics

With an output frequency range to 819 Hz (or 1000 Hz with -HF option), the RS Series is well suited for aerospace applications. Precise frequency control and accurate load regulation are key requirements in these applications. The IEEE-488 remote control interface and SCPI command language provide for easy integration into existing ATE systems. The RS Series eliminates the need for several additional pieces of test equipment, saving cost and space. Instrument drivers for popular programming environments such as National Instruments LabView™ are available to speed up system integration.

Regulatory Testing

As governments are moving to enforce product quality standards, regulatory compliance testing is becoming a requirement for a growing number of manufacturers. The RS Series is designed to meet AC source requirements for use in compliance testing such as IEC 61000, 3-2, 3-3, 3-11, 3-12, to name a few.

Choice of voltage ranges

The RS Series includeds 150V and 300V line to neutral. These models provide 3 phase output capability of 260 Vac or 520 Vac line to line respectively.

For applications requiring more than 300 V L-N (or 520 V L-L), the optional -HV output transformer provides an additional 400 V L-N and 693 V L-L output range for use in AC mode only. For custom applications the XV option is availible and is user defined.

High Crest Factor

With a crest factor of up to 3.6, the RS Series AC source can drive difficult nonlinear loads with ease. Since many modern products use switching power supplies, they have a tendency to pull high repetitive peak currents. The RS90 can deliver up to 720 Amps of repetitive peak current (150 V AC range) per phase to handle high crest factor three phase loads.

Remote Control

Standard RS232C USB & IEEE-488 along with optional LAN remote control interfaces allow programming of all instrument functions from an external computer. The popular SCPI command protocol is used for programming.

Application Software

Windows® application software is included. This software provides easy access to the power source's capabilities without the need to develop any custom code. The following functions are available through this GUI program:

- Steady state output control (all parameters)
- Create, run, save, reload and print transient programs
- Generate and save harmonic waveforms.
- Generate and save arbitrary waveforms.
- Measure and log standard measurements
- Capture and display output voltage and current waveforms.
- Measure, display, print and log harmonic voltage and current measurements.
- Display IEEE-488, RS232C, USB and LAN bus traffic to and from the AC Source to help you develop your own test programs.

1. Requires PC running WindowsXP™ or Windows 2000™ / 2007.

RS Series

90–540 kVA

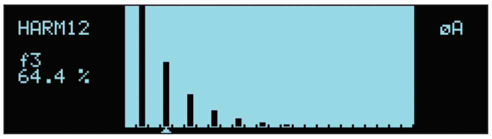
Harmonic Waveform Generation

Using the latest DSP technology, the RS Series programmable controller is capable of generating harmonic waveforms to test for harmonics susceptibility. The Windows Graphical User Interface program can be used to define harmonic waveforms by specifying amplitude and phase for up to 50 harmonics. The waveform data points are generated and downloaded by the GUI to the AC source through the remote interface. Up to 200 waveforms can be stored in nonvolatile memory and given a user defined name for easy recall.

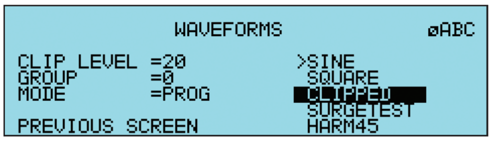
All RS Series configurations offer three phase waveform generation, allowing independent phase anomalies to be programmed. It also allows simulation of unbalanced harmonic line conditions.

Arbitrary Waveform Generation

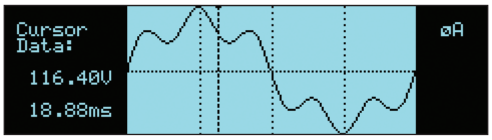
Using the provided GUI program or custom software, the user also has the ability to define arbitrary AC waveforms. The arbitrary waveform method of data entry provides an alternative method of specifying AC anomalies by providing specific waveform data points. The GUI program provides a catalog of custom waveforms and also allows real-world waveforms captured on a digital oscilloscope to be downloaded to one of the many AC source's waveform memories. Arbitrary waveform capability is a flexible way of simulating the effect of real-world AC power line conditions on a unit under test in both engineering and production environments.



Harmonic waveform, Fund., 3rd, 5th, 7th, 9th,11th and 13th.



Two hundred user defined waveforms.



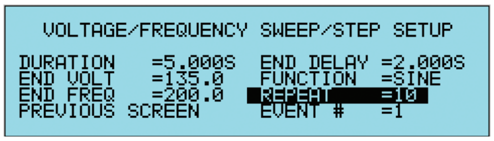
Harmonically distorted waveform.

RS Series - AC and DC Transient Generation

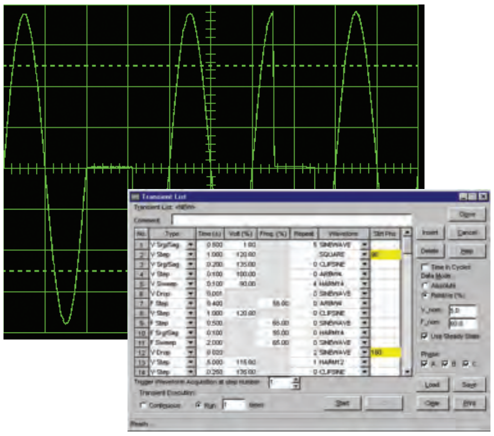
The RS Series controller has a powerful AC and DC transient generation system that allows complex sequences of voltage, frequency and waveshapes to be generated. This further enhances the RS's capability to simulate AC line conditions or DC disturbances. When combined with the multiphase arbitrary waveform capabilities, the AC and DC output possibilities are truly exceptional. Transient generation is controlled independently yet time synchronized on all three phases. Accurate phase angle control and synchronized transient list execution provide unparalleled accuracy in positioning AC output events.

Transient programming is easily accomplished from the front panel where clearly laid out menu's guide the user through the transient definition process.

The front panel provides a convenient listing of the programmed transient sequence and allows for transient execution Start, Stop, Abort and Resume operations. User defined transient sequences can be saved to non-volatile memory for instant recall and execution at a later time. The included Graphical User Interface program supports transient definitions using a spreadsheet-like data entry grid. A library of frequently used transient programs can be created on disk using this GUI program.



Transient List Data Entry from the front panel.



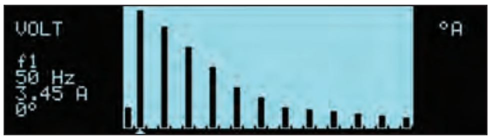
Transient List Data Entry in GUI program.

RS Series

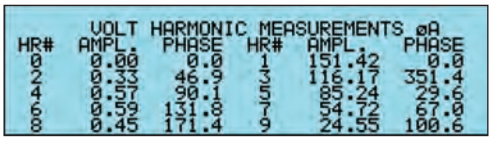
RS Series - Measurement and Analysis
The RS Series is much more than a programmable AC, DC or AC+DC power source. It also incorporates an advanced digital signal processor based data acquisition system that continuously monitors all AC source and load parameters. This data acquisition system forms the basis for all measurement and analysis functions. These functions are accessible from the front panel and the remote control interface for the RS Series

Conventional Measurements [All controllers]
Common AC and DC measurement parameters are automatically provided by the data acquisition system. These values are displayed in numeric form on the front panel LCD display. The following measurements are available: Frequency, Vrms, Irms, Ipk, Crest Factor, Real Power (Watts), Apparent Power (VA) and Power Factor.

Harmonic Analysis
The RS Series provides detailed amplitude and phase information on up to 50 harmonics of the fundamental voltage and current (up to 16 kHz). Harmonic content can be displayed in both tabular and graphical formats on the front panel LCD for immediate feedback to the operator. Alternatively, the included GUI program can be used to display, print and save harmonic measurement data. Total harmonic distortion of both voltage and current is calculated from the harmonic data.



Absolute amplitude bar graph display of current harmonics with cursor positioned at the fundamental (RS90 Display).

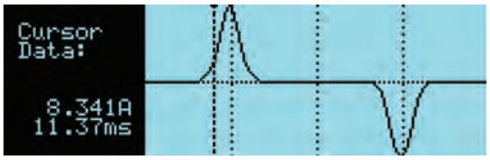

VOLT HARMONIC MEASUREMENTS øA

HR#	AMPL.	PHASE	HR#	AMPL.	PHASE
0	0.00	0.0	1	151.42	0.0
2	0.33	46.9	3	116.17	351.4
4	0.57	90.1	5	85.24	29.6
6	0.59	131.8	7	54.72	67.0
8	0.45	171.4	9	24.55	100.6

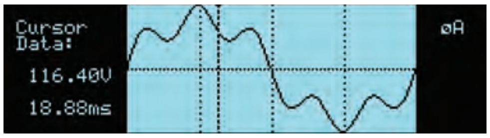
Voltage harmonic measurement table display in absolute values (RS90 Display)

Waveform Acquisition
The measurement system is based on real-time digitization of the voltage and current waveforms using a 4K deep sample buffer. This time domain information provides detailed information on both voltage and current waveshapes. Waveform acquisitions can be triggered at a specific phase angle or from a transient program to allow precise positioning of the captured waveform with respect to the AC source output.

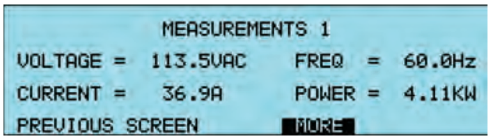
The front panel LCD displays captured waveforms with cursor readouts. The included GUI program also allows acquired waveform data to be displayed, printed, and saved to disk.



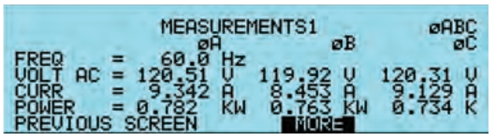
Acquired Current waveform (RS90 Display).



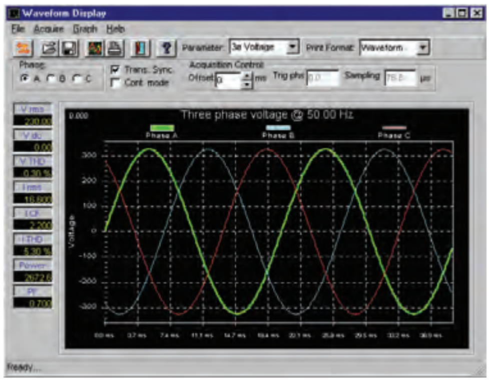
Acquired Voltage waveform (RS90 Display).



Measurement data for single phase (RS90 Display).



Measurement data for all three phases (RS90 Display).



Acquired three phase voltage waveforms display on PC.

RS Series : Specifications

90–540 kVA

Operating Modes	
RS90 Version	AC, DC and AC+DC
AC Mode Output	
Frequency	Range: 16.00-819.0 Hz, -LF Option: 16.00-500.0 Hz, -HF Option: 16.00-905 Hz (supplemental specifications apply above 819 Hz). Resolution: 0.01 Hz: 16.00 - 81.91 Hz, 0.1 Hz: 82.0 Hz - 819.1 Hz, 1 Hz: 820-905 Hz, SNK 16-500Hz
Phase Outputs	3 Phase, Neutral Floating, Coupling DC (except -HV and -XV Opition)
Total Power	RS90: 90kVA, RS180: 180kVA, RS270: 270kVA, RS360: 360kVA, RS450: 450kVA, RS540: 540kVA. Please consult factor for power levels above 540kVA
Load Power Factor	0 to unity at full output current
AC Mode Voltage	
Voltage Ranges	(see tables below)
External Sense	Voltage drop compensation (5% Full Scale)
Harmonic Distortion (Linear)	Less than 0.5% from 16 - 66 Hz, Less than 1% from 66 - 500 Hz, Less than 1.25% above 500 Hz
DC Offset	< 20 mV
Load Regulation	0.25% FS @ DC - 100 Hz, 0.5% FS > 100 Hz
External Amplitude Modulation	Depth: 0 - 10 %, Frequency: DC - 2 KHz
Voltage slew rate	200 μs for 10% to 90% of full scale change into resistive load, 0.5V / μSec

Voltage Ranges:

Range	V Low	V High
AC	0-150 V	0-300 V
AC+DC	0-150 V	0-300 V

Load Regulation	< 0.25 % FS DC to 100 Hz, < 0.5 % FS 100 Hz to 819 Hz
Line Regulation	< 0.1% FS for 10 % line change

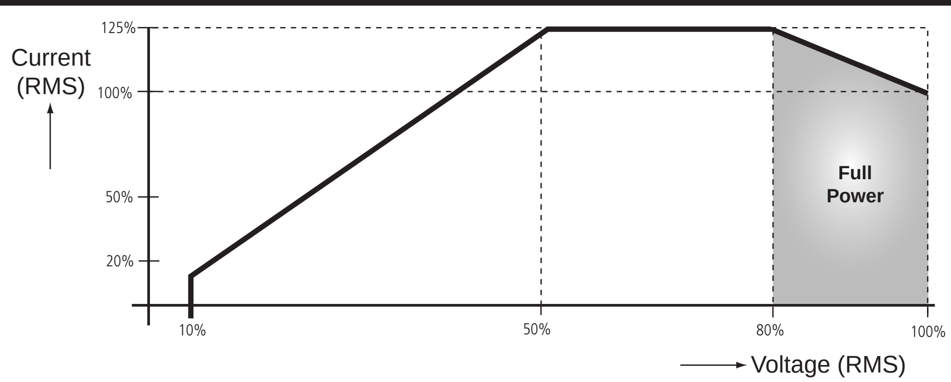
AC Mode Current	
Steady State AC Current @ FS V	(see table below)
Peak Repetitive AC Current	Up to 3.6 x rms current at full scale voltage
Programming Accuracy	Voltage (rms): ± 0.3 Vrms, Frequency: ± 0.01 % of programmed value, Current Limit: - 0 % to + 5 % of programmed value + 1A, Phase: < 0.5° + 0.2°/ 100 Hz with balanced load
Programming Resolution	Voltage (rms): 100 mV, Frequency: 0.01 Hz from 16 - 81.91 Hz, 0.1 Hz from 82.0 - 819 Hz, Current Limit: 0.1 A, 3 phase mode, 1.0 A, 1 phase mode, Phase: 0.1°

Steady State AC Current @ FS V:

Model	RS90	RS180	RS270	RS360	RS450	RS540
V Low	200A	400A	600A	800A	1000A	1200A
V High	100A	200A	300A	400A	500A	600A
	per phase	per phase	per phase	per phase	per phase	per phase

Note: Constant power mode provides increased current at reduced voltage. See chart below

Constant Power AC Mode - Available Max. AC Current



Note: Specifications are subject to change without notice. Specifications are warranted over an ambient temperature range of 25°± 5° C. Unless otherwise noted, specifications are per phase for a sinewave with a resistive load and apply after a 30 minute warm-up period. For three phase configurations, all specifications are for L-N. Phase angle specifications are valid under balanced load conditions only.

RS Series : Specifications

Measurement

Measurements - Standard (AC Measurements)

Parameter	Frequency	RMS Voltage	RMS Current	Peak Current	VA Power	Real Power	Power Factor (>0.2kVA)
Range	16.00 - 820.0Hz	0-400V	0 - 300A	0 - 800 Amps	0–90KVA	0–90KW	0.00-1.00
Accuracy* (±)	0.01% +0.01Hz	0.05V+0.02%,<100Hz 0.1V+.02%,100-820Hz	0.5A+0.2%,<100Hz 0.5A+0.5%, 100-500Hz 0.5A+1.0%,>500Hz	0.5A+0.2%,<100Hz 0.5A+0.5%, 100-500Hz 0.5A+1.0%, > 500Hz	90VA+0.2%, <100Hz 90VA+0.5%, 100-500Hz 90VA+1.0%, >500Hz	90W+0.2%, <100Hz 90W+0.5%, 100-500Hz 90W+1.0%, >500Hz	0.01, <100Hz 0.02, 100-820Hz
Resolution*	0.01 to 81.91Hz 0.1 to 500Hz 1Hz above 500Hz	0.01V	0.01A	0.01A	10VA	10W	0.01

* Note: Accuracy specifications are valid above 100 counts. For current and power measurements, specifications apply from 2% to 100% of measurement range. Current and Power range and accuracy specifications are two times for RS180.

Measurements - Harmonics (Pi controller only)

Parameter	Range	Accuracy* (±)	Resolution
Frequency Fundamental	16.00 - 820 Hz	0.03% + 0.03 Hz	0.01 Hz
Frequency harmonics			
RS90 RS180 RS270 RS360 RS450 RS540			
	32.00 Hz – 16 KHz	0.03% + 0.03 Hz	0.01 Hz
RS90-3Pi			
	32.00 Hz – 48 KHz	0.03% + 0.03 Hz	0.01 Hz
Phase	0.0 - 360.0°	2° typ.	0.5°
Voltage	Fundamental	0.75V	0.01V
Harmonic 2 - 50		0.75V + 0.3% + 0.3%/kHz	0.01V
Current	Fundamental	0.5A	0.1A
Harmonic 2 - 50		0.15A + 0.3% + 0.3%/kHz	0.1A

Note: For current measurements, specifications apply from 2% to 100% of measurement range.

DC Mode Output

Power	Maximum DC Power at full scale of DC voltage range. RS90: 45kW, RS180: 90kW, RS270: 135kW, RS360: 180kW, RS450: 225kW, RS540: 270kW
Voltage Ranges	Range: Low (0 - 200 V), High (0 - 400 V)
Output Accuracy	± 1 Vdc
Load Regulation	< 0.25 % FS
Line Regulation	< 0.1% FS or 10 % line change
Ripple	< 2 Vrms Lo Range, < 3 Vrms Hi Range

DC Mode AC+DC Mode

Model	RS90	RS180	RS270	RS360	RS450	RS540
V Low	100A	200A	300A	400A	500A	600A
V High	50A	100A	150A	200A	250A	300A
	per phase	per phase	per phase	per phase	per phase	per phase

Note: Constant power mode provides increased current at reduced voltage. See chart on previous page

Current Limit	Programmable from 0 A to max. current for selected range

AC+DC Mode Output

Output (Pi) Power	Maximum current and power in AC+DC mode is same as DC mode

Protection

Over Load	Constant Current or Constant Voltage mode
Over Temperature	Automatic shutdown

System Interface

Inputs	Remote shutdown, External Sync, Clock/Lock
Outputs	Function Strobe / Trigger out, Clock/Lock

Remote Control (Pi standard with -P option)

IEEE-488 Interface	IEEE-488 (GPIB) talker listener. Subset: AH1, C0, DC1, DT1, L3, PP0, RL2, SH1, SR1, T6, IEEE-488.2 SCPI Syntax
RS232C Interface	9 pin D-shell connector (Supplied with RS232C cable)
LAN (option)	Ethernet Interface: 10BaseT, 100BaseT, RJ45
USB	Version: USB 1.1; Speed: 460 Kb/s maximum
Output Relay	Push button controlled or bus controlled output relay

Waveforms

Waveform Types	Std: Sine, Pi: Sine, Square, Clipped sine, User defined
User defined waveform storage	Four groups of 50 user defined arbitrary waveforms of 1024 points for a total of 200. One group can be active at a time

RS Series : Specifications 90–540 kVA

AC Input

Voltage	Must be specified at time of order. All inputs are L-L, 3ø, 3 wire + Gnd. 208 ± 10% VAC, 230 ± 10% VAC, 400 ± 10% VAC, 480 ± 10% VAC
Line Voltage (3 phase, 3 wire + ground (PE))	208 VLL ±10%, 230 VLL ±10%, 400 VLL ±10%, 480 VLL ±10%
Line VA	(see table below)

Line VA

RS90	RS180	RS270	RS360	RS450	RS540
112 KVA	225 KVA	300 KVA	412KVA	525 KVA	637 KVA
350 ARMS @ 187 VLL	Each RS90 chassis requires its own AC service.				
314 ARMS @ 207 VLL	Total Line currents are 2 x RS90	Total Line currents are 3 x RS90	Total Line currents are 4 x RS90	Total Line currents are 5 x RS90	Total Line currents are 6 x RS90
180 ARMS @ 360 VLL					
150 ARMS @ 432 VLL					

Line Frequency	47 - 63 Hz
Efficiency	85 % (typical) depending on line and load
Power Factor	0.95 (typical) / 0.99 at full power.
Inrush Current	(see table below)

Inrush Current

RS90	RS180	RS270	RS360	RS450	RS540
460 Apk @ 208 VLL	Each RS90 chassis requires its own AC service.	Each RS90 chassis requires its own AC service.	Each RS90 chassis requires its own AC service.	Each RS90 chassis requires its own AC service.	Each RS90 chassis requires its own AC service.
440 Apk @ 230 VLL					
264 Apk @ 400 VLL	Total Line currents are 2 x RS90	Total Line currents are 3 x RS90	Total Line currents are 4 x RS90	Total Line currents are 5 x RS90	Total Line currents are 6 x RS90
220 Apk @ 480 VLL					

Hold-Up Time	>10ms
Isolation Voltage	2200 VAC input to output, 1350 VAC input to chassis

AC Service

Inputs/Outputs	Rear Panel Access
Regulatory	IEC61010, EN50081-2, EN50082-2, CE EMC and Safety Mark requirements
EMI	CISPR 11, Group1 , Class A
Connectors	AC Input and Output terminal blocks behind rear panel access cover. IEEE-488 (GPIB) connector behind rear panel access cover. 9 pin D-Shell RS232C connector*, behind rear panel access cover. Remote voltage sense terminal block behind rear panel access cover. System Interface Connector, DB-37 behind rear panel access cover. *RS232 DB9 to DB9 cable supplied

Physical Dimensions

RS90 Dimensions	Height: 76” (1930 mm) , Width: 32.0” (812mm), Depth: 40.0” (1016mm),
RS90 Weight	Net: 2250 lbs / 748 Kg approximately, Shipping: 2500 lbs / 785 Kg approximately
Chassis	RS90: Casters and forklift openings
Vibration and Shock	Designed to meet NSTA project 1A transportation levels. Units are shipped in wooden crate with forklift slots
Air Intake/Exhaust	Forced air cooling, front air intake, rear exhaust
Operating Humidity	0 to 95 % RAH, non condensing
Temperature	Operating: 0-35* (30*C max is CP mode), Storage -20 tp +85*C

-MB Option

Model	AC Output Power	Phase Outputs	AC/DC Voltage Range	Controller
RS180-3Pi-MB	180kVA	3	150/200 & 300/400	2 x RS90
RS270-3Pi-MB	270kVA	3	150/200 & 300/400	3 x RS90
RS360-3Pi-MB	360kVA	3	150/200 & 300/400	4 x RS90
RS450-3Pi-MB	450kVA	3	150/200 & 300/400	5 x RS90
RS540-3Pi-MB	540kVA	3	150/200 & 300/400	6 x RS90

Reconfigurable systems can be separated into stand-alone MX45-3Pi models or combined for higher power levels.

Steady State AC RMS Current in Regeneration Mode (-SNK Option)

Model		RS90	RS180	RS270	RS360	RS450	RS540
AC Mode	V Lo	200A	400A	600A	500A	1000A	1200A
	V Hi	100A	200A	300A	400A	500A	600A
		per phase	per phase	per phase	per phase	per phase	per phase
V High	V Lo	100A	200A	300A	400A	500A	600A
	V Hi	50A	100A	150A	200A	250A	300A
		per phase	per phase	per phase	per phase	per phase	per phase

Storage

Non Volatile Mem. storage	16 instrument setups, 200 user defined waveforms

RS Series

Unit Protection	
Input Over current	In-line fast acting fuses. Circuit breaker for LV supply.
Input Over voltage	Automatic shutdown.
Input Over voltage Transients	Surge protection to withstand EN50082-1 (IEC 801-4, 5) levels.
Output Over current	Adjustable level constant current mode with programmable set point.
Output Short Circuit	Peak and RMS current limit.
Over temperature	Automatic shutdown
System Specification	
External Modulation	0 to 10%
Synchronization Input	Isolated TTL input for external frequency control.
Trigger Input	External trigger source input.
Trigger Output	400 µs pulse for voltage or frequency change Isolated TTL output Output reverts to Function strobe frequency change. Isolated TTL output. Output reverts to Function strobe when not uses as Trig Out. This function is mutually exclusive with the Function Strobe output.
Function Strobe	Active for any voltage or frequency program change. 400 µs pulse for voltage or frequency change.
Output Status	Monitors status of output relay. SELV Isolated TTL output.

Model
Refer to table shown for model numbers and configurations.

Supplied with
User/Programming Manual and Software on CD ROM. RS232C serial cable.

Input Voltage Settings
Specify input voltage (L-L) setting for each RS system at time of order:

208 Configured for 208 V ±10 % L-L, 4 wire input.
230 Configured for 230 V ±10 % L-L, 4 wire input.
380 Configured for 380V +/- 10% L-L, 4 Wire Input
400 Configured for 400 V ±10 % L-L, 4 wire input.
480 Configured for 480 V ±10 % L-L, 4 wire input

Standard Model Options
Specify output range on standard models. All range values shown are Line to Neutral.

- 150 Configured for 150 V AC and 200 V DC output ranges.
- 300 Configured for 300 V AC and 400 V DC output ranges.

-411 *IEC 1000-4-11 test firmware.

- LF Limits maximum frequency to 500 Hz.

-FC Modifies output frequency control to ± 0.15%

-LAN Ethernet Interface.

-413 *IEC 1000-4-13 Harmonics & Interharmonics test firmware.

-HV Adds 400 V L-N (AC-only output range.)

-HF Increases max. frequency to 905 Hz.

-XV Adds other AC-only output range. Consult factory.

-LKM Clock/Lock Master

-LKS Clock/Lock Auxiliary

-WHM Watt-Hour Measurement option.

-SNK Bidirectional auto source and sink mode. Offers up to 100% power sink capability.

Avionics Test Routine Options

-ABD ABD0100.1.8 Test Option. -Rev. D-E

-AMD Airbus AMD24 Test -Rev. A-C

-A350 Airbus Test Software -Rev A-C

-B787 Boeing 787 Test Software -Rev A-C additional

-704 Mil Std 704 A - F test - firmware/ software.

-160 RTCA/DO-160D, DO-160E, and EUROCAE test firmware.

* Note: Reference the Avionics Test User Manual P/N 4994-971 for a complete listing of performance capabilities.

Packaging and Shipment

All RS systems are packaged in re-usable protective wooden crates for shipment.

Feature Comparison	
AC mode	X
DC mode	X
AC+DC mode	X
Dual V Range	X
Transient programming	X
Arbitrary waveforms	X
Measurements	X
Harmonic measurements	X
Waveform acquisition	X
Bi-Directional Regenerative	X
IEEE / RS232	X

Elgar GUPS Series

2400 VA

Ruggedized Uninterruptible Power Supply

115/230 VAC

20.8 ARMS

~		115	230

RS232

- Ruggedized
- Wide (Global) Input
- On-Line Battery Back-Up
- Transient (Spike) Suppression
- Surge Suppression
- Input Distortion Elimination

Product Overview
GUPS are ruggedized on-line “UPS’s” that accept a broad range of worldwide utility and military AC input power. Without operator intervention, they automatically select the appropriate input power ranges to accommodate global operation. The GUPS Series has been specifically designed to withstand the rigors of mobile applications. They meet the vibration and shock requirements as specified in MIL-STD-810E, Methods 514.4 and 516.4. Their rackmounted aluminum chassis with stainless steel hardware withstands harsh environments and provides a strong, light weight enclosure.

Features And Benefits
Universal Input The GUPS 2400A AC input model provides 2400VA/1920W of 115 VAC, 60 Hz of output power. It automatically selects between two input ranges of 85 to 140 VAC and 170 to 280 VAC, while accepting any frequency from 45 to 450 Hz, and provides 115 VAC, 60 Hz output power.

The GUPS 2400U universal output model provides 115 VAC, 60 Hz standard U.S. power or 230 VAC, 50 Hz international power (user selectable). Without operator intervention, it automatically selects between two input ranges of 85 to140 VAC and 170 to 280 VAC, while accepting any frequency from 45 to 450 Hz.

The Elgar GUPS is tolerant of variable power associated with “soft” sources such as engine/motor generators. Stable output power is provided, without oscillating between generator and battery input, regardless of how the input power varies within the allowed ranges. This prevents battery discharge and ensures that battery power is available in the event of generator failure. Soft-start of the UPS input rectifier, limits the inrush current during start-up, precluding fluctuations in the AC source voltage that could affect other loads.

Precise And Stable Output
The output is precisely regulated, providing a low distortion sine waveform. Protection of the critical load is maximized because it is continually supplied by the online inverter; the output is never dependent on the condition of the AC input, and there are no switching transients. Low output impedance allows driving non-linear loads that draw currents with high crest factors, such as computer power supplies. The 200% overload rating of the inverter, with a greater than 3:1 crest factor, provides an enhanced capability to supply the start-up inrush current of such loads. High frequency power conversion technology is utilized for fast dynamic response to changing load conditions. Continuous overload and short circuit protection ensure reliable operation.

Global UPS Series
A shielded transformer is used to galvanically isolate the output from the AC input, and battery. The output is further protected with suppression networks that absorb high energy transients and surges that occur on the AC input. EMI filtering and the shielded isolation transformer provide transverse-mode and common-mode attenuation of electrical noise. UPS integrity is determined through a self test that is performed automatically during start-up. Proper operation is ensured prior to energizing the critical load. After start-up, this function can also be manually selected by the user from the front panel.

Communications Interface
An RS-232 communications interface provides information to the host system about operating status and UPS parameters such as voltages and currents. Isolated relay contacts are available for remote annunciation of loss of AC input power and impending shutdown during operation from the battery.

Batteries
The GUPS 2400A and GUPS 2400U include a drawer-mounted internal battery module that is removable from the front panel without the use of tools; this allows servicing of the battery without removing the UPS from its rack. Battery life is maximized with automatic microprocessor controlled equalization and temperature compensation during charging. An optional external rackmounted battery pack increases the backup time to 18 minutes at full rated load; multiple packs further extend the backup.

Applications
GUPS are especially useful for demanding field computer applications powered by engine generators where a need for ruggedization, as well as voltage and frequency variations, have traditionally been a problem for regular UPS operation.

The ability to accept a broad range of AC input voltages and frequencies, as well as ruggedized construction, make the GUPS an ideal choice for the following military and

commercial applications:

- Remote computer based systems
- Engine generator output conditioning
- Communications
- Remote SATCOM
- Airborne telemetry backup
- Geological exploration
- Oil field instrumentation/logging
- Data acquisition
- Military C4I

Output

Model	GUPS 2400A	GUPS 2400U
Maximum Output Rating	2.4 kVA/1920W	2.4 kVA/1920W
Output Voltage	115 VAC ±2%	115 or 230 VAC ±2%
Output Voltage	60 Hz ±0.1%	60 Hz or 50 Hz ±0.1%
Input Frequency	45 to 450 Hz	45 to 450 Hz
Input Voltage	85 to 140 VAC or 170 to 280 VAC Auto Range	85 to 140 VAC or 170 to 280 VAC Auto Range
Battery	Removable internal battery module	Removable internal battery module
Battery Backup Time	5 min. backup w/2400 VA load; 1920W 0.8 PF@ 25°C	5 min. backup w/2400 VA load; 0.8 PF@ 25°C
Optional External Battery Packs Available	Yes. For total of 18 min. at full rated load	Yes. For total of 18 min. at full rated load
Weight	78 lbs without battery module; Removable internal battery module is 48 lbs; total 126 lbs	83 lbs without battery module; Removable internal battery module is 48 lbs; total 131 lbs
Dimensions	7” H x 19” W x21” L	7” H x 19” W x21” L

GUPS Series : Product Specifications

2400 VA

Input		
Input Voltage, AC	85 to 140 VAC or 170 to 280 VAC	
Input Current, AC	33A at 120 VAC, 17A at 240 VAC	
Input Frequency, AC	45 to 450 Hz	
Output		
Model	GUPS 2400A	GUPS 2400U
Output Voltage	115 VAC ±2% over full range of line and load variations	115 VAC ±2% over full range of line and load variations
Output Frequency	60 Hz ±0.1%	50 Hz or 60 Hz ± 0.1%
Crest Factor	3:1 FS rms current	
Efficiency	70% from AC input	
Output Current:	21 ARMS, 63A peak	
Output Distortion:	2% maximum THD with linear loads	
Output Power	2400 VA into ±0.8 PF load Output	
Overload	150% for 30s; 150% to 200% for 3s.	
Power Loss During Crossover	None	
Internal Battery Module	192 VDC, 2.5 AH. Optional external battery packs available	
Battery Hold-Up Time	5 minutes for internal module with 2400 VA load, 0.8 PF@25°C. Adding one external battery pack increases time to a minimum of 18 minutes at full rated load. Reduced loads increase backup time.	
Environmental		
Operating Temperature	0° to 40°C; non-operating -40° to 65°C	
Humidity Range	5 to 95% non-condensing	
Altitude	Operating 0 to 10,000 ft; non-operating 0 to 40,000 ft	
Physical		
Weight GUPS 2400A	78 lbs, maximum without battery module. Removable internal battery module is 48 lbs (126 lbs max combined weight).	
Weight GUPS 2400U	83 lbs, maximum without battery module. Removable internal battery module is 48 lbs (131 lbs max combined weight).	
Dimensions	7”H x 1 9”W x 21 “L	
Battery Modules		
Battery Description	192 VDC, 2.5 AH sealed lead acid	
Configuration	96 cells at 2.0 V, 2.5 AH in a single pullout, removable module	
Recharge Time	4 hours, 90% full charge with integral battery charger	
TypicalMinimum Hold-Up Time 2400 VA at 25°C:	5 minutes	
Temperature	Operating 0° to 40°C; non-operating -40° to 65°C	
Microprocessor Controlled Equalization	Batteries maintained on a temperature compensated, constant voltage float charge with automatic equalization as required	

Notes

AC
Current Sources

Notes

California Instruments FX Series

4500 VA–13.5 kW

Precision Voltage and Current Source

0–270 V

20.1–200 A
2.01–20 A
0.02–2 A

GPIB RS232

- **Computer Control for**
  Automated Systems Remote programming and collection of measurement data
- **Separate Single Phase**
  Outputs of up to 200 A & 270V (L-N) Simulation of power levels up to 54kW
- **Multiple Chassis**
  Configurations for Two & Three-Phase Systems Power level simulation up to 162 kW for Three-Phase Operation
- **Independent Full Capability**
  Measurement System Monitors load parameters without additional instrumentation

The FX Series
With the combined voltage and current source in a single compact chassis, the FX Series is the ideal choice for the simulation of high power levels. Either single or multi-phase, this versatile source can simulate power levels from just a few milliwatts to 54kW single phase or 162 kW three-phase and provides a universal system for both manual and programmable control applications.

Single Phase Systems
A single chassis includes a 1500 VA voltage source with 270V output (optional 312V L-N) and a 200A Current Source, which is derived from exactly the same master oscillator as the voltage source. This means that the voltage and current outputs are at precisely the same frequency, although the phase relationship between the two may be varied to simulate different load power factors.

Multi-Phase Systems
For either two or three phase systems, additional chassis are added. The individual oscillators are clocked from a single master, with a phase lock to ensure phase angle integrity. In multi-phase systems, the phase angle of the voltage may be varied independently as well as the phase angle between the voltage and current source for each phase. The system can simulate two or three-phase outputs with a different P.F. on each phase. This is extremely important when evaluating measurement or control scenarios for multi-phase systems with unbalanced loads.

Wide Range Current Source
Whether the application is power simulation or just AC current, the FX Series provides a very wide range of controllable constant current output from 20 mA to 200 A. The current source section features three ranges to ensure good resolution at low current settings. In fact, the 2 A range is usable down to 20 mA. The 20 A to 200 A output is available via bus bar outputs, whereas outputs below 20 A are available at the rear panel barrier strip.

Fully Independent Measurement Capability
It is often difficult to provide accurate measurement capability at high power levels. In addition to the basic accuracy of the source, the FX Series provides a fully independent measurement system that may be used to verify the output settings or determine the load characteristics. This independent measurement system is included in each controller, which means that independent and simultaneous monitoring of each phase is possible. The parameter that is displayed on the front panel of the source may be selected manually or by computer control. All measurement parameters may be interrogated by a computer controller.

Full Programmability
The entire system, either single or multi-phase, is programmed from a computer controller. The most popular control architecture is the IEEE-488 bus. However, other systems such as RS232C and VXI can be accommodated using a simple protocol translator. All set up parameters, such as Voltage, Current, Frequency and Phase Angle may be controlled. Additionally, in multi-phase systems the relative angle between phases can also be changed between 0° and 359°.

Measurement parameters may be selected and the result displayed on the front panel, output to the computer, or a combination of both. Computer control is particularly useful for the collection and tabulation of test results over a series of different conditions such as temperature, load or frequency. Graphical user interface programs are ideal for changing test requirements.

FX Series : Specifications

High Efficiency Design
The FX Series uses a pulse width modulated conversion technique which is extremely efficient and allows the single phase system to be packaged in just 10.5 inches of rack space at a weight of only 165 lb (75.2 kg). Additional benefits are: a) that the unit uses less power than traditional linear systems, and b) unit generates less heat.

Covers-on Calibration
Although periodic calibration is necessary for any precision system, down time and interference with the production or engineering evaluation operation can be disruptive. The FX Series however, allows routine calibration to be performed either from the front panel or via the IEEE-488 bus with the system in situ. Disruption is minimized and full calibration can be achieved in minutes.

All FX Series Models Conform to These Specifications

Measurements:

Volt Output:
- Range: 0.0 to 270 Volts
- Resolution: 0.1 Volt
- Accuracy: ±10 Digits of Resolution
- Temperature Coefficient: ±0.05 Volts per Degree C.

Phase Angle:
- Range: 0 to 360 degrees
- Resolution: 0.1 degree/
- Accuracy: ±1 degree

Frequency:
- Range: 47 Hz to 66 Hz
- Resolution: 0.01 Hz
- Accuracy: ±0.02 Hz

Current Output:
- Range: 20.1-200A, 2.01-20A, 0.02-2A
- Resolution: 0.1A, 0.01A or 0.001A
- Accuracy: ±10 Digits of Resolution
- Temperature Coefficient: ±0.016% of full scale current per Degree C.

Power:
- Range: 0.0 to 5.4kW or 54kW
- Resolution: 0.001kW or 0.01kW
- Accuracy: ±10 Digits of Resolution
- Temperature Coefficient: ±0.06% of full scale per Degree C.

General:

Line Input:
- 47 Hz to 440 Hz
- 187 V - 252 V, L-L, 3ø
- 342 V - 456 V, L-L, 3ø with -UP option

Protection:
- Overcurrent
- Overpower
- Short circuit
- Over voltage
- Sense Line Fault
- Digital Controller
- Shuts down system
- Over-temperature
- All units have adjustable Current Limit on Voltage Output

Control:
- Front Panel Controls
  - Circuit Breaker
- Keypad
  - L Type
- Bus
  - IEEE-488.1
- Subsets
  - SH1, AH1, T6, L3, SR1, R12, DC1, DT1
- Data Transfer Rate
  - 200 K Bytes/sec.
- Language
  - Abbreviated Plain English (APE)
- Front Panel Indicators:
  - Power
  - Over temperature
  - Overload
  - High Range
  - Analog Volt Meter
  - Input Circuit Breaker

Connectors:
- Input provided on rear terminal block (TB-1)
- Output provided on rear terminal block (TB-2) (voltage & low output current)
- Bus Bars (high output current)

Note: Remote Sense Mating Connectors are provided

Mechanical:
- Height: 10.5 In. (26.7 cm)
- Width: 19 In. (48.3 cm)
- Depth: 23 In. (58.4 cm)
- Weight: 165 Lbs (75 kg)

FX Series : Specifications

4500 VA–13.5 kW

Specification	Voltage Output	High Current Output	Low Current Output
Ranges	Standard 0-270 V. All voltages are L-N. For other voltage ranges, please contact Factory.	Standard: 20.1 - 200 Amps. All current levels are rms.	Standard: 0.020 - 20 Amps. All current levels are rms.
Accuracy*	TRMS Sense: ±0.135V from 5 V to 135V. ±0.54V from 135V to 270V. All at 25°C±1°C (Based on TRMS reading)	Calibrates to ±0.02 Amps at five cardinal points within range.	a) Calibrates to ±0.002 Amps on 2-20 Amp range (5pts) b) Calibrates to ±0.0002 Amps on 0.02-2 Amps range (6 pts)
Load Resolution	TRMS Sense: ±0.05% FS, no load to full load.	±0.05% FS	±0.05% FS
Line Regulation	±0.02% FS for ±10% line change	±0.05% FS	±0.05% FS
Stability (Amplitude)	±0.04 Volts per 24 hours.	±0.015% FS per 1000 hours at constant line and load; 25°C.	±0.05% of range per 24 hours.
Default Values	5.0 volts (field selectable)	5.0 volts (field selectable)	0.2 A Output Shorted
Frequency Range	47 Hz to 66 Hz	45 Hz to 66 Hz	45 Hz to 66 Hz
Frequency Resolution	0.01 Hz	0.01 Hz	0.01 Hz
Frequency Accuracy (25°C ±1°C):	±0.001% of programmed value	±0.001% of programmed value	±0.001% of programmed value
Default Frequency (initial Value)	Customer selectable (within range)	Customer selectable (within range)	Customer selectable (within range)
Compliance Voltage	N/A	0-7.5 V Operating 20.1-200 Amps	0-25V Operating 2-20 Amps 0-200V Operating 0.02-20 Amps
Total Power (RMS) Output**	1500 VA	1500 VA	400 VA at 2 Amps 500 VA at 20 Amps
Phase Accuracy	±1°	±1°	±1°
Phase Angle Programming	0 to ±999.9 degrees in 0.35 degree increments	High/Low current output relative to Voltage output: 0 to ±999.9 degrees in 0.35 degree increments	High/Low current output relative to Voltage output: 0 to ±999.9 degrees in 0.35 degree increments
Current Limit	Adjustable Trip Setting	N/A	N/A
Harmonic Distortion (to 30 kHz)	< 1% (with Linear Load) 0.5% Typical	1.5% Max. (with Linear Load) 0.8% Typical	1.5% Max. (with Linear Load) 0.8% Typical

* Accuracy is specified from 10% of Full Scale to Full Scale Output.
** Total Output power refers to power out of each individual channel.

Order Example:

MODEL 4500FX-1P/200
Complete 200 Amps Single Phase System consisting of:

(1) 1500VA Voltage Source 0-270V, L-N
(1) 1500VA Current Source 20-200A
(1) 400VA Current Source 0.020-20A

MODEL 13500FX-3P/200
Complete 200 Amps Three Phase System consisting of:

(3) 4500FX-1P/200 Units, Phase Locked together

NOTE:
When ordering, please specify:
- · Initialization values of:
  - Voltage Output
  - Frequency

Input	Description
-UP	Input Voltage for 4500FX (342-456V, L-L)
-1P/20 -3P/20	20 Amp Output Maximum (remove 20-200A Current Source)
-HV	High Voltage Output on Voltage Channel (0-312V, L-N)

Notes

California Instruments CS Series

3–18 kVA

Programmable high power AC current source

0–270 V

14.8–2000 A

≋	208	230	400
∼		230	

ETHERNET USB GPIB RS232

- **Precision Current Source**
  Ideally suited for current protection device testing
- **Single and Three Phase Modes**
  Built-in phase mode switch makes output configuration easy
- **3kVA to 18kVA Power Levels**
  Match power source & cost to application requirements
- **Arbitrary Waveform Generator**
  Test products using real world current profiles including harmonic currents
- **Built-In Power Analyzer**
  Performs voltage & current harmonic analysis & waveform acquisition
- **Standard IEEE-448, USB and RS232C**
  Remote control interface for ATE system integration
- **GUI Software Suite**
  Allows users to access the powerful features & functions of the instrument on a Windows™ system
- **Programmable Transients**
  Amplitude & time control with up to 1ms resolution

Introduction

The CS Series is an advanced AC current source that addresses increasing demands on manufacturers to test products using real-world current profiles. By combining true current trans-conductance amplifiers with an advanced digital controller and harmonic power analyzer, the CS Series current sources are capable of performing tests that traditionally have been difficult to accomplish.

The CS Series is completely microprocessor-controlled and can be operated from a simple front panel keypad. An analog knob located next to the backlit alphanumeric LCD display allows output current or frequency to be slewed up or down dynamically.

With precise current programming and regulation, high output current, multi-phase mode and built-in power analyzer measurement capabilities, the CS Series AC current sources address many AC current test applications. Additional features, like arbitrary waveform generation and transient generation make the CS Series the ideal source for demanding production test requirements.

All CS Series AC Sources are equipped with IEEE-488 (GPIB), USB and RS232C remote control interfaces and support SCPI command language programming. An Ethernet interface is optional (-LAN Option).

Applications

AC Current Sources are useful in a variety of applications where precision is required; including precise evaluation of circuit breakers, overload relays, bi-metal temperature sensors and heating elements. Another common application is non-destructive testing of fuses. The arbitrary waveform capability of the CS makes it possible to test these devices under real-world circumstances with harmonically rich current waveforms. Protection devices that are specified to withstand specific current levels for certain durations can be tested easily with the CS current source by programming specific current levels, frequencies, and durations using the transient programming system. Available transient modes are fixed, step, pulse, and list.
Other typical applications include:

- Life testing and continuity checking of harnesses and connectors.
- Electro-plating at frequencies other than 50 or 60 Hz.
- Calibration of current clamps, watt-hour meters, current probes
- Transformer and inductor testing

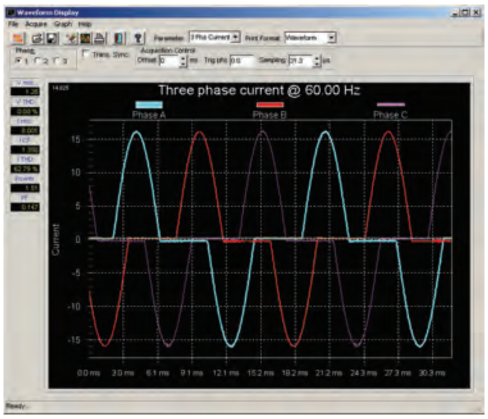
Current Control

The CS Series uses true current feedback control. This is considerably different from many commonly available AC power sources that use a voltage feedback scheme in combination with a constant current mode of operation. Such power sources adjust the output voltage to try and maintain the requested current level (Voltage controlled current). These voltage controlled

CS Series

current sources have a finite response time to sudden impedance changes, which typically results in dynamic current over or undershoot as the load impedance changes. A current controlled current source does not suffer from the response lag and will always maintain the current at the specified level, regardless of transient load conditions. The maximum compliance voltage supported by the CS Series is 270 Vrms. A lower compliance voltage trip level can be programmed as needed.

Waveform Generation
The CS Series provides sine, clipped sine and square waveforms in addition to user defined arbitrary waveforms. Harmonic waveforms can be used to test for harmonic current susceptibility of a unit under test. With the help of the supplied Windows Instrument Control Software (GUI), defining harmonic waveforms is as easy as specifying the relative amplitude and phase angle for each of up to 50 harmonics. The user also has the ability to define arbitrary waveform data. Complex AC current anomalies can be simulated this way. The waveform data points generated are downloaded by the ICS to the AC source through IEEE-488, USB or RS232C bus. Up to 50 user-defined waveforms can be stored and given a descriptive name for easy recall. Downloaded waveforms are retained in non-volatile memory for recall over the bus or from the front panel.



Waveform Display, Three Phase

Transient Generation
To simulate complex current events, the CS Series offers a list of transient steps. These steps can be programmed from the front panel or downloaded over the interface using the software supplied. The ICS allows libraries of commonly used sequences to be created on disk for quick recall. Once downloaded, the transient program can be executed from the PC or from the front panel.

AC current transient generation allows the effect of rapid changes in current, frequency and current waveform shape on the unit under test to be analyzed. The combination of transients and user defined arbitrary waveforms creates a powerful test platform for AC powered products.

Measurements
The CS Series measurement system is based on real-time digitization of the voltage and current waveforms using a 4K-sample buffer. The digitized waveform data is processed by a Digital Signal Processor to extract conventional load values such as rms voltage, rms current, real and apparent power. The same data is also used to perform Fast Fourier Transformation (FFT) to extract the harmonic amplitude and phase angle of 50 harmonics.

Standard Measurements
The following standard measurements are available from the front panel or via the bus: Frequency, Phase, Voltage (rms), Current (rms), Peak Voltage, Voltage Crest Factor, Real Power, Apparent Power, Power Factor

Advanced Measurement Functions
In addition to standard load parameters, the CS Series is capable of measuring voltage and current amplitude and phase harmonics. Total harmonic distortion of both voltage and current is also available. Advanced measurement results like harmonic content of voltage and current for all three phases are available over the bus. The GUI can be used to save and print harmonics data in tabular, bar graph or time domain formats. The acquired voltage and current time-domain waveforms for each output phase can also be displayed using the software. Waveform displays on the PC include voltage and current combined, three-phase voltage, three-phase current and true power. The time-domain data is also available for transfer to a PC.

Windows Graphical User Interface
The GUI offers a soft front panel interface for operation from a PC running Windows Vista™, Windows XP™, or Windows 2000™. The following functions are available through this software:

- Steady state output control (all parameters).
- Create, run, save and print transient programs.
- Generate and save harmonic waveforms.
- Generate and save arbitrary waveforms.
- Measure and log standard measurements.
- Capture and display Voltage and Current waveforms.
- Measure, display, print and log harmonic voltage and current measurements.

CS Series : Specifications 3–18 kVA

Output Power	
Maximum Power Per Phase	3000CS: Single Phase = 3000 VA, Three Phase = 1000 VA. 4500CS: Single Phase = 4500 VA, Three Phase = 1500 VA
Multi-Chassis Maximum Power Per Phase	9000CS/2: Single Phase = 9000 VA, Three Phase = 3000 VA. 13500CS/3: Single Phase = 13500 VA, Three Phase = 4500 VA. 18000CS/4: Single Phase = 18000 VA, Three Phase = 6000 VA.
Current	
Maximum Available Current	3000CS: Single Phase = 44.44 A, Three Phase = 14.81 A. 4500CS: Single Phase = 44.44 A, Three Phase = 14.81 A
Multi-Chassis Maximum Available Current	9000CS/2: Single Phase = 88.88 A, Three Phase = 29.62 A. 13500CS/3: Single Phase = 133.33 A, Three Phase = 44.44 A. 18000CS/4: Single Phase = 177.7 A, Three Phase = 59.24 A
Programming Resolution	0.01 A
Programming Accuracy	Three Phase Mode: ± (0.1% + 0.05 A) from .5A to full scale. Single Phase Mode: ± (0.1% + 0.15 A) from .5A to full scale.
Distortion THD (full scale current, resistive load conditions)	< 1.2% [60-500 Hz], < 2% [500-1000 Hz], < 2.5% [1000-2000 Hz]
Load Regulation	0.1% full scale
Line Regulation	0.02% for 10% input line change
Output Noise	(20 kHz to 1 MHz, full current output): Three Phase Mode: < 13 mARMS, Single Phase Mode: < 40 mARMS
Temperature Coefficient	± 0.01% of range / °C
Stability	± 0.01 A over 24 hours
DC Offset Current	0.0 A
Output Coupling	Transformer coupled
Output Impedance	>100KOhm
Voltage Limit Programming	Range: 3000CS: 0 to 270 Vrms @ 7.41 A, 0 to 67.5 Vrms @ 14.81 A. 4500CS: 0 to 270 Vrms @ 11.11 A, 0 to 101.3 Vrms @ 14.81 A Programming Resolution: 0.1 Vrms
Frequency	Range: 45 Hz - 2000 Hz. Resolution: 0.01 Hz [<81.91 Hz], 0.1 Hz [> 82.0 to 819.1 Hz], 1 Hz [> 819 Hz]. Accuracy: ± 0.025%. Temperature Coefficient: ± 5 ppm of value / °C. Stability: ± 15ppm of value/year
Phase	Range: Phase B/C relative to phase A 0.0 to 360.0°. Resolution: (0.1° < 819.1 Hz), (0.5° > 819.1 Hz). Accuracy: < 1° [45 Hz-1000 Hz], <1° + 1°/kHz [>1000 Hz]
Protection	
Input Current	Input circuit breaker. Breaker protects the equipment only and is not a branch protection device. AC input connection should be made using a suitable branch protection device per local electrical code
Input Voltage Transients	Surge protection to withstand EN50082-1 (IEC 801-4, 5) levels
Output Over Voltage	Adjustable level constant voltage mode with programmable set point
Open Circuit & Over Temperature	Automatic Shutdown
Input	
Line Voltage	(Three Phase, 3-wire + ground - PE) 3000CS, 4500CS, 9000CS/2, 13500CS/3, 18000CS/4: Standard: 208-230 VL-L ± 10%, -400: 400 VLL ± 10%. Note: Each CS chassis requires its own AC service. 3000CS may be operated from 208-230 V L-N single phase AC input between B & C on TB3 for 3000CS
Line VA	3000CS: 5900 VA / 4100 W. 4500CS: 8900 VA / 5900 W (x2 for 9000CS/2, x3 for 13500CS/3, X4 for 18000CS/4)
Line Current (per phase)	3000CS: Standard: 19 Arms @ 187 VL-L, 3 phase AC input or 32 Arms @ 187 VLN single phase AC input. 4500CS: Standard 31 Arms @ 187 VL-L, - 400: 16 Arms @ 360 VL-L. Currents shown are for single chassis models. Currents are per chassis for multi-chassis configurations
Line Frequency & Efficiency	Line Frequency: 47-440 Hz; Efficiency: 75% (typical) depending on line and load
Power Factor	0.65 (typical)
System	
Storage	Setup Storage: 16 complete instrument setups; User Waveform Storage: 50 User-defined arbitrary waveforms of 1024 points each; Transient Lists Storage: Up to 100 transient steps per list.
Remote Control Interfaces	IEEE-488 (GPIB), USB, RS232C, Ethernet (Optional-LAN)

Note: Specifications are subject to change without notice. Specifications are warranted over an ambient temperature range of 25°± 5° C. Unless otherwise noted, specifications are per phase for a sinewave with a resistive load and apply after a 30 minute warm-up period. For three phase configurations, all specifications are for L-N. Phase angle specifications are valid under balanced load conditions only.

CS Series

Measurement

Measurements - Standard (AC Measurements)

Parameter	Frequency	Phase	Voltage (AC)	Current (AC rms)	Real Power	Apparent Power	Power Factor
Range	5.00-81.91 Hz 82.0-819.1 Hz > 819 kHz	0-360°	0 - 400	0 - 50 A	0.5 kW	0.5 kVA	0.00 - 1.00
Accuracy* (±)	0.1% + 1 digit	0.5° < 500 Hz 2° > 500 Hz	0.05% + 0.25 V	0.1% + 0.15 A 0.1% + 0.05 A	1ø Mode: 0.15% + 9W 3ø Mode: 0.15% + 3W	1ø Mode: 0.15% + 9 VA 3ø Mode: 0.15% + 3 VA	1ø Mode: 0.03 3ø Mode: 0.01
Resolution	0.01 Hz 0.1 Hz 1 Hz	0.1° 1°	10 mV	1 mA	1 W	1 VA	0.01

* Accuracy specifications are valid above 100 counts. For multi-chassis configurations, Current and Power range and accuracy specifications are per chassis. Frequency measurement accuracy applies to output voltages of 1 Arms or higher

Measurements - Harmonics

Parameter	Frequency Fundamental	Voltage	Current
Range	45-81.91 Hz / 82.0-819.1 Hz / >819 Hz	Fundamental Harmonics 2 - 50	Fundamental Harmonics 2 - 50
Accuracy* (±)	0.1% + 1 digit	0.05% + 0.25 V / 0.1% + 0.1%/kHz + 0.25 V	0.5 A / 0.1% + 0.05 A + 0.1% /1 kHz
Resolution	0.01 Hz / 0.1 Hz / 1 Hz	10 mV / 10 mV	10 mA / 10 mA

* Accuracy specifications are in percent of reading for single unit and three phase mode

Physical Dimensions

Dimensions	Height: 10.5” (267 mm), Width: 19.0” (483 mm), Depth: 23.0” (584 mm) All dimensions are per chassis. For /2, /3, or /4 model configurations, multiply height by 2, 3, or 4 for total height. Width includes integrated front panel rackmount ears
Weight	Chassis: Net: 193 lbs / 87.7 Kg, Shipping: 280 lbs / 127.3 Kg
Vibration and Shock	Designed to meet NSTA project 1A transportation levels. Units are shipped in wooden crate with forklift slots
Air Intake/Exhaust	Forced air cooling, side air intake, rear exhaust
Temperature	Operating Temperature: 0 to 35° C, full power; Storage Temperature: -40 to 85° C

Model: Refer to table shown for model numbers and configurations.

Input Options

-400 400 ±10% Volt Line to Line AC input

Output Options

-AX[1] Auxiliary outputs, 26 VAC, 5 VAC. Limits upper frequency to 800 Hz.
-LF[1] Limits output frequency to 500 Hz

Note 1: See option matrix

Controller Options

-HF High Frequency - up to 5 kHz (except with multi-box configurations 2 kHz)
-MB Multi-box. Adds controller to auxiliary chassis of multi-chassis systems
-L22 Locking Knob.
-LAN Ethernet Interface
-LKM[1] Clock and Lock Master
-LKS[1,2] Clock and Lock Auxiliary
-LNS[2] Line Sync.
-EXS[2] External Sync

Note 1: See option matrix
Note 2 : -LKS, -LNS and -EXS are mutually exclusive and with Ext Trig function

Cabinet Options

-RMS Rackmount Slides. Recommended for rack mount applications
C1-C5 prefix: Cabinet System. Number indicates cabinet height. Installed and pre-wired in 19” cabinet. Consult factory for available cabinet sizes

Standard controller versions with single voltage range

Model	Output Power	Phase Output	Input Voltage[1]
3000CS	3 kVA	1/3	208-230V
4500CS	4.5 kVA	1/3	208-230V
4500CS-400	4.5 kVA	1/3	400V
9000CS/2	9 kVA	1/3	208-230V
9000CS/2-400	9 kVA	1/3	400V
13500CS/3	13.5 kVA	1/3	208-230V
13500CS/3-400	13.5 kVA	1/3	400V
18000CS/4	18 kVA	1/3	208-230V
18000CS/4-400	18 kVA	1/3	400V

Note (1): All input voltage specifications are for Line-to Line three phase, delta or wye. Model 3000CS (208 V input) can be operated on 230 V L-N single-phase.

	LF	LKM	LKS	EXS	AX
LF	–	O	O	O	O
LKM	O	–	X	O	O
LKS	O	X	–	X	O
EXS	O	O	X	–	O
AX	O	O	O	O	–

Option Matrix: Note that some options are mutually exclusive as indicated in the table below. An ‘o’ means the options can be combined. An ‘x’ means they cannot.

COMPLIANCE TEST SYSTEMS

Notes

Techniques to Verify Immunity from Voltage

Voltage Dips, Interruptions & Variations

The Standard

The IEC1000-4-11, Edition 2.0 standard concerns testing and measurement techniques that verify the immunity of electrical (and electronic) products from "voltage dips, short interruptions, and voltage variations." Although the standard is European, it is being used as a basis for internal company design verification testing throughout the world.

The need for a "standard" for this type of testing is clear. There are many ways to test a product to verify immunity from line variations, and some form of standardization, for comparison purposes, is desirable. However, IEC 1000-4-11, Ed. 2.0 leaves many options available, and does not absolutely specify which tests should apply to a particular type of product.

The standard also seeks to specify the parametric requirements of an AC source suitable for performing the specified tests. Generally, these requirements go beyond what is necessary to perform the specified tests on a particular product. For example, it is neither necessary nor cost effective to have an in-rush current capability significantly greater than that needed by the product to be tested.

In this application note we will explain the tests specified in the standard and draw conclusions concerning the capabilities of suitable AC power sources to perform those tests.

Generally, throughout this document, comments in italics are commentary on the spec. Normal type is either a direct quote from the spec or a precise explanation

Test Levels

Voltages specified are the rated voltage of the equipment (Ut). If the equipment to be tested has a specified input voltage range, then testing should be performed at the lower and upper limits of the voltage ranges specified. However, in practice it is only necessary to perform the tests at the lowest specified input voltage, since all the tests concern a reduction or interruption of supply voltage.

As a further guide to the test parameters to be applied to the equipment under test, this standard advises the typical number of occurrences per annum (in Europe) for various durations of line voltage reduction or interruption (see Fig. 1).

Depth	Duration			
(Voltage Reduction)	10 to 100 ms	100 to 500 ms	500 ms to 1 s	1 s to 3 s
10 to < 30 %	61	66	12	6
30 to < 60 %	8	36	4	1
60 to < 100 %	2	17	3	2
100 %	0	12	24	5

Fig. 1 : Number of typical Line Disturbances annually, in Europe.

Tests for Voltage Dips and Short Interruptions

All changes in the test voltage must be abrupt, and not slewed. The test can start and stop at any phase angle of the line voltage, and should not be contrived to occur at the best case condition. Tests are specified at 0%, 40% 70% and 80% of the rated input voltage (Ut) of the product under test. This is a reduction in test voltage (Ut) of 100%, 60%, 30% and 20%.

The duration of the test (reduction in voltage) is specified in periods of the supply voltage. These range from 0.5 to 50 cycles, or any duration up to 3000 cycles, although the standard states that dips and interruptions of greater than 50 cycles are not common.

The following table of Preferred Test Levels and Durations appears in the standard.

Fig. 2: Preferred Test Levels and Durations

Test Level % of Ut	Voltage Dip / Interruption % of Ut	Duration (Periods)
0	100	0.5* 1
40	60	5 10
70	30	25 50
80	20	X

(*) For 0.5 Period, the test shall be made in positive and negative polarity, i.e. starting at 0º and 180º respectively.

Techniques to Verify Immunity from Voltage

Fig. 4: Timing of short term supply voltage variations.

Voltage test level	Time for decreasing V	Time at reduced V	Time for increasing V
40% of Ut	2s ± 20%	1s ± 20%	2s ± 20%
0% of Ut	2s ± 20%	1s ± 20%	2s ± 20%
	X	X	X

Notes:
1) One or more of the test levels and durations in Fig. 2 may be chosen. Particular test levels and durations are not specified.

2) If the EUT (Equipment Under Test) is tested for voltage dips of 100%, it is generally unnecessary to test for other levels for the same durations. However, for some cases (safeguard systems or electromechanical devices) this is not true. The product specification or product committee shall give an indication of the applicability of this note. Again, 100% dips (or interruptions) are not actually specified. This is defined in the Product Specification or specified by the "Product Committee". (See "The Product Committee" & Product Specifications following this section)

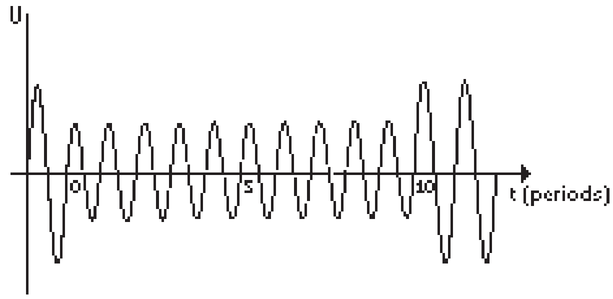


Fig. 3: Typical Voltage dips test.

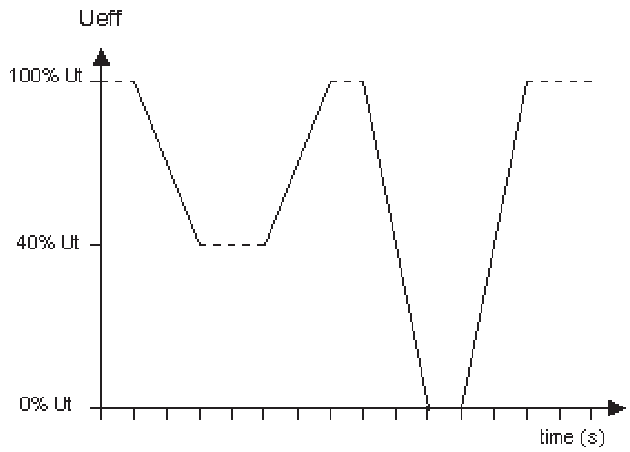


Fig. 5: Typical Voltage variations test sequence.

3) "X" is an open duration which can be given in a product specification. Utilities in Europe have measured dips and short interruptions between 0.5 and 3,000 periods, but durations of less than 50 periods are most common.

4) Any duration may apply to any test level. Note again that the combination of items 1) and 4) leaves a great deal of speculation to the company or authority making the test.

To answer the question of whether a particular power source can be used for IEC 1000-4-11, Edition 2.0 applications demands that the user first specify which of the 1000-4-11, Ed. 2.0 tests they wish to apply to their product.

The Product Committee

Often a group of manufacturers of the same or similar products will get together to decide which tests should be run on a particular group of products; i.e., appliances such as Stereo Systems. That industry group will decide what tests are necessary, taking into consideration the environment in which the products will be used, and the level of product sophistication. For a manufacturer of Stereo Systems to claim that their Systems meet IEC 1000-4-11, Ed. 2.0, a series of tests, as defined by the industry group, must be run and the results must be acceptable (again as defined by the industry group or "Product Committee").

Product Specifications

If a Product committee does not dictate which tests should be performed, then it is up to the manufacturer to define the tests in a product specification. To ensure integrity, tests should be defined according to market and user requirement, not according to which of the many combinations of tests the unit actually passed.

Note: The voltage decreases to 70% for 10 periods. Steps are at zero crossing.

Voltage Variations (optional)

These tests consider defined transitions between the rated voltage (Ut) and a changed voltage. As noted, they are optional and not required (unless defined by the Product Committee). This section of the standard defines simulated voltage changes that take place over a relatively short period, and may occur due to change of load, or stored energy in the local power network.

The preferred voltages, slew rates, and durations are given in Fig. 4. The rate of change of voltage should be constant; however, the voltage may be stepped. The steps should occur at the zero crossings, and shall not be greater than 10% of Ut. Steps under 1% of Ut are considered as a constant change of voltage.

Note: Figure 5 shows a typical voltage variations sequence.

Note: In Fig. 4, X represents an open set of durations that can be given in the product specifications. Again, not only is this test optional, but it leaves a great deal of leeway to the company or authority performing the test.

Techniques to Verify Immunity from Voltage

Test Conditions for Performing IEC 1000-4-11 Tests, Edition 2.0
The following section describes the recommended test plan and test report.

1. Prepare a test plan specifying the following:
   a) The type designation of the EUT.
   b) Pertinent information concerning the connections, (plugs terminals etc.) and corresponding cables and peripherals.
   c) Input power port of the equipment used.
   d) Operational modes of the EUT.
   e) Performance criteria.
   f) Operational modes of the equipment.
   g) Description of the test set-up.

Record any degradation of performance for each test. The monitoring equipment should be capable of displaying the status of the operational mode of the EUT during and after the tests. After each group of tests, a full functional check shall be performed.

2. The climatic conditions should be within the following ranges:

   Temperature: 15 - 35° C
   Relative humidity: 25 - 75 %
   Barometric pressure: 86 - 106 kPa

3. Electromagnetic conditions:

The electromagnetic conditions shall be such to guarantee the correct operation of the EUT in order not to influence the test results.

4. Execution

During the tests the supply voltage for testing is monitored to an accuracy of 2%. The zero crossing control of the test generator must have an accuracy of ±10°.

   a) Voltage dips and short interruptions The EUT shall be tested for each selected combination of test interval and duration with a sequence of 3 dips /interruptions with 10 seconds minimum interval between each test event. Each representative mode of operation shall be tested. Abrupt changes in supply voltage should occur at zero crossings, and at additional angles considered critical by product committees or individual product specifications. For 3-phase systems, phase by phase test is preferred. In certain cases (3-phase meters and 3-phase supply equipment) all three phases must be simultaneously tested. When dips and interruptions are applied simultaneously to all three phases, the zero crossing condition will be fulfilled on only one phase.

   b) Voltage variations (optional) The EUT should be tested to each of the specified voltage variations, three times at 10 second intervals for the most representative modes of operation.

5. Test results and test report

Basically the test results should be noted, and classified as follows:

   a) Normal performance within specification limits.
   b) Temporary degradation or loss of function or performance which is self-recoverable.
   c) Temporary degradation or loss of function or performance which requires operator intervention or system reset.
   d) Degradation or loss of function which is not recoverable due to damage of equipment (components) or software, or loss of data.

   The EUT shall not become dangerous or unsafe as the result of the application of the tests defined in the standard.

The standard does not define PASS or FAIL criteria. However, category a) is a clear PASS, b) is usually also interpreted as a PASS. Even c) can be defined as a PASS , if that is the way the performance of the product to these non-standard line input conditions is defined. However, it would be difficult to think of any condition where category d) could be considered as a PASS.

Test Generator (AC Supply Source) considerations:

Specifications

Output Voltage:
As required, ±5% Change with load (load regulation requirement at various output levels):

100% output, 0 to 16 A rms. < 5 %
80% output, 0 to 20 A rms. < 6 %
70% output, 0 to 23 A rms. < 7 %
40% output, 0 to 40 A rms. < 10 %

Output Current Capability:
16 A rms. at 100% of Ut (per phase)
20 A rms. at 80% of Ut
23 A rms. at 70% of Ut
40 A rms. at 40% of Ut

(These are the requirements from the Standard. It is not necessary to provide this current capability if it is not required by the EUT)

Peak Inrush Current Drive Capability:
(not required for voltage variation tests) Must not be limited by the generator. However, need not exceed 500A for 220-240V, and 250A for 100-120V.

The inrush current of the EUT should be less than 70% of that available from the AC source. Inrush current can be measured with a current transformer and storage oscilloscope or suitable power analyzer. Worst case conditions are usually at 90° and 270°.

Techniques to Verify Immunity from Voltage

Specifications Continued

Overshoot/Undershoot:
Loaded with 100 ohms < 5 %
Voltage Rise/Fall Time, Abrupt Change:
Loaded with 100 ohms 1 to 5 micro seconds

(The specification here is 1 to 5 micro seconds; however, the voltage variation spec.'s are over 1 or 2 seconds, and the dips and short interruption tests should occur at zero crossings, making the rise/fall time relatively unimportant if other spec requirements are met.)

Phase Shifting: 0 to 360 Degrees
Phase Relationship of Voltage Dips & Interruptions with Power Frequency: ±10°
(Since 10° is 560 ms at 50 Hz, this also presents the question of why the rise time specification needs to be < 5 micro seconds)

Output Impedance:
Predominately resistive Must remain low even during transitions

Note: Certain of the generator characteristics are not absolutely required for any of the tests, e.g. peak inrush drive capability (if not required by the EUT) and rise/fall time.

California Instruments AC sources, by AMETEK Programmable Power, generally meet or exceed the requirements for IEC 1000-4-11, Edition 2.0 testing applications. However, the source must be sized so that the EUT can draw sufficient current at reduced voltage. Also, some sources require the -ODS option to perform 0.5 cycle (and odd multiples of 0.5 cycles) dropout tests.

To determine the correct AC source for performing IEC 1000-4-11 tests, Edition 2.0 requires the following essential information:

A) Steady state rms. current at the EUT at nominal input voltage.
B) Peak in-rush current at nominal input voltage, and duration of the in-rush current.
C) A definition of which of the many IEC 1000-4-11, Ed. 2.0 tests will be performed.
D) A definition of which of the many IEC 1000-4-11, Ed.. 2.0 tests will be performed and other information such as load current at 70% and/or 40% of nominal input voltage (it is wise to check the equipment rather than extrapolate. Many devices will shut off around 70% of nominal input voltage; therefore, the load current at 40% is probably zero).

With this essential information, an AMETEK Programmable Power Applications Engineer can determine the best AC power source for the application.

California Instruments CTS Series 3.2

1250–15000 VA

IEC Compliance Test Systems
1250-15000VA Programmable AC & DC Immunity Compliance Testing

150–300 V

0–37 A

- **Complete Test Solutions**
  Complete test solutions for emissions and immunity compliance testing of AC and DC powered products
- **Single & Three Phase Operation**
  Offers flexibility
- **Direct PC Bus Access**
  Provides high sampling rate and resolution for accurate measurements and high speed data transfers
- **PC based harmonic & flicker testing**
  provides real-time full color data display updates and continuous PASS/FAIL monitoring.
- **Supports Global Standards**
  Supports European and Japanese standards
- **Easy To Use Interface**
  Provides IEC test setup, data analysis, display, MS Word test reports, and data files are generated in MS Excel format
- **High resolution**
  Data storage to disk in for post-acquisition analysis and reporting
- **Single Step**
  Single Step and Fast Forward replay of recorded test data

Integrated System

The CTS Series is a complete, turn-key compliance test system for EN IEC 1000-3-2 (Harmonics), EN IEC 1000-3-3 (Flicker) and various EN IEC 1000-4 AC immunity tests. Consisting of an AC power source, a power analysis conditioning system unit (PACS) and a PC based data acquisition system, the CTS provides a complete turn-key solution for IEC testing. The Windows™ based CTS software performs all required IEC tests and generates detailed test reports. Comprehensive data files are stored on disk to allow post test analysis.

The CTS system implements various IEC standards including the new Amendment 14 and provides a software only upgrade path for future standard changes.

A European style AC outlet is provided on the front panel or rear panel for easy connection of single phase loads. Three phase loads are connected using rear terminal blocks.

Covered EN IEC Standards

The following tests can be performed using an iX Series based CTS system:

EN 61000-3-2	Harmonics
EN 61000-3-3	Flicker
EN 61000-4-11	Voltage Dips and Interruptions (EOS Option)
EN 61000-4-13	Harmonics and Inter-harmonics (requires option -413)
EN 6100-4-17	DC Ripple
EN 61000-4-14	Voltage Fluctuations
EN 61000-4-28	Frequency Variations
EN 61000-4-29	DC Dips and Interruptions (Pre-compliance)

EN 61000-3-2 Harmonics

Full compliance testing for current harmonics emissions of class A, B, C and D products is supported. Support for both the 1998 and 2001 version (Amendment 14) of the Harmonics standard is built-in for full compliance with both harmonics standards.

EN 61000-3-3 Flicker

Flicker PST & PLT results are displayed in real-time during the entire test. No need to wait until the entire test is completed to know if the EUT passed or failed. Both programmable and lumped reference impedance methods are available for flicker testing.

EN 61000-4-11 Voltage Dips

Pre-compliance Voltage Dips and Interruptions are available on most CTS systems. For full compliance solutions, the Electronic Output Switch (option -EOS1 or -EOS3) may be added to iX based CTS systems.

CTS Series

EN 61000-4-13 Interharmonics

Testing to the EN 61000-4-13 Interharmonics standard is supported on all iX Series based CTS systems by adding the -413 option.

Other EN 61000-4 Immunity Tests

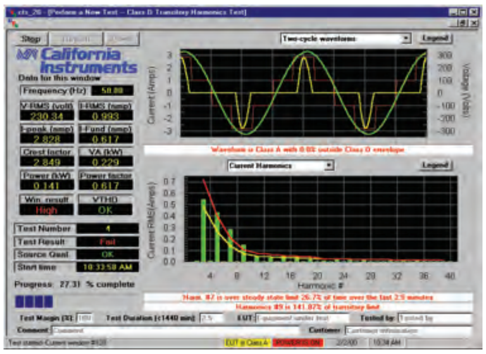
Additional immunity test standards are supported on all iX based CTS Systems.

Configurations

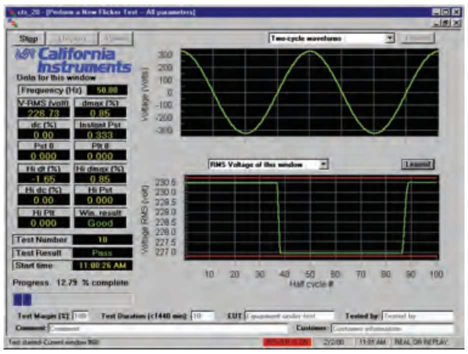
The CTS system is available in both single phase and three phase configurations. Single phase configurations range in power from 1250 VA to 5000 VA.

Three phase configurations offer 15 k VA or 18.5 A per phase at 230 V. Single phase 5001iX-CTS systems can be upgraded to three phase systems if needed.

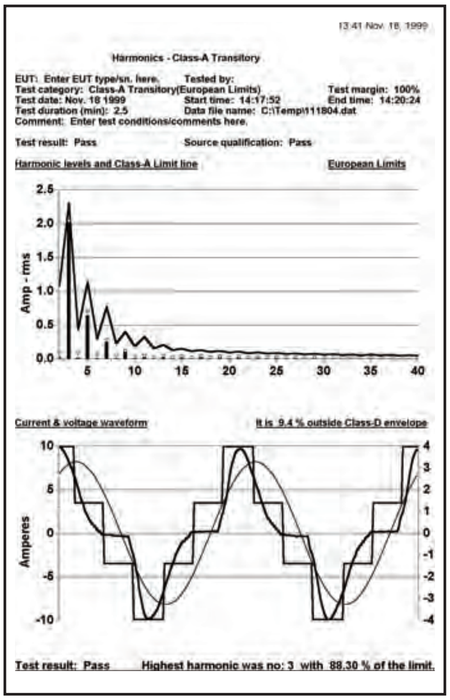
Measurement only CTS system versions (100-CTS and 300-CTS) can be added to an existing California Instruments power source.



Current Harmonics test display



Real-time Flicker test display



Detailed Test Reports and Data

CENELEC - Amendment 14

The CTS, with its flexible architecture, allows the user to select measurements to be made per the recently harmonized amendment.

Model 15003iX-CTS 15 kVA three phase test system shown in optional Cabinet

Model	Output Power	Source Model	No of Phases	EN61000-3 Test	EN61000-4 Test
100-CTS		n/a	1	√	
300-CTS		n/a	3	√	
1251RP-CTS	1250 VA	1251RP	1	√	
3001iX-CTS	3000 VA	3001iX	1	√	√
5001iX-CTS	5000 VA	5001iX	1	√	√
15003iX-CTS	15000 VA	15003iX	3	√	√

California Instruments
MX Compliance Test Systems

30–90 kVA

Harmonics and Flicker testing of high power AC products

150–300 V

0–62.5 A/Phase

Introduction
The MX45/30-CTS Series is a complete, turn-key compliance test system for EN IEC 61000-3-12 (Harmonics), EN IEC 61000-3-11 (Flicker) and various EN IEC 1000-4 AC immunity tests. Consisting of an AC power source, a power analyzer & conditioning system (PACS-3-75) and a PC based data acquisition system, the MX45/30-CTS provides a complete turn-key solution for IEC testing. The Windows™ based MXCTS software performs all required IEC tests and generates detailed test reports. Comprehensive data files are stored on disk to allow post test analysis.

The MXCTS system implements various IEC standards including the new Amendment 14 and provides a software only upgrade path for future standard changes.

Three phase loads are connected using rear terminal blocks.

Covered EN61000 Standards
The following tests can be performed using an MX45/30 based CTS system:

EN 61000-3-12	Harmonics
EN 61000-3-11	Flicker CTSH
EN 61000-3-2	Harmonics (option)
EN 61000-3-3	Flicker (option)
EN 61000-4-11	Pre-Compliant
EN 61000-4-13	Harmonics and Inter-harmonics (requires option -413)
EN 6100-4-17	DC Ripple
EN 61000-4-14	Voltage Fluctuations
EN 61000-4-28	Frequency Variations
EN 61000-4-29	DC Dips and Interruptions (Pre-compliance)
EN 61000-3-12	Harmonics

Full compliance testing for current harmonics emissions products is supported. Support for the 2001 version (Amendment 14) of the Harmonics standard is built-in for full compliance with both harmonics standards.

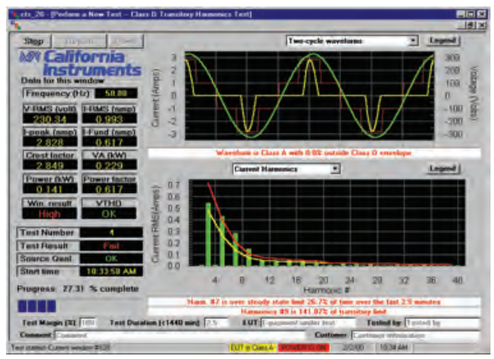
EN 61000-3-11 Flicker
Flicker PST & PLT results are displayed in real-time during the entire test. No need to wait until the entire test is completed to know if the EUT passed or failed. A Ztest reference impedance (OMNI-3-75) is provided for IEC 61000-3-11 flicker testing (-CTSH) and a Zref (OMNI-3-37MX) for IEC 61000-3-3 flicker testing (-CTSL).

Configurations
The MX45/30-CTS system is available with flicker reference impedance for either IEC61000-3-11 (-CTSH) or IEC 61000-3-3 (-CTSL). A system with both impedances and both high and low power software is available as well (-CTSHL). It is strongly recommended that California Instruments supply the required PC with the test system due to A/D card compatibility. (Option CIC-PC)

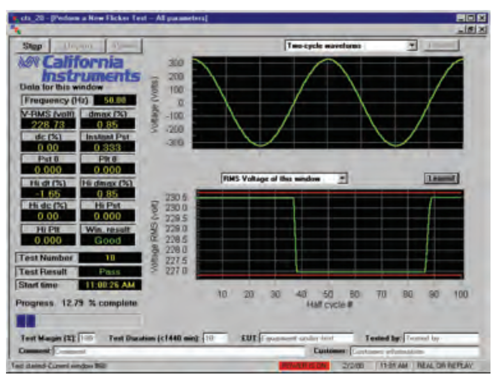
CENELEC - Amendment 14
The MX45-CTS, with its flexible architecture, allows the user to select measurements to be made per the recently harmonized amendment, or older standards.

MX Compliance Test Systems

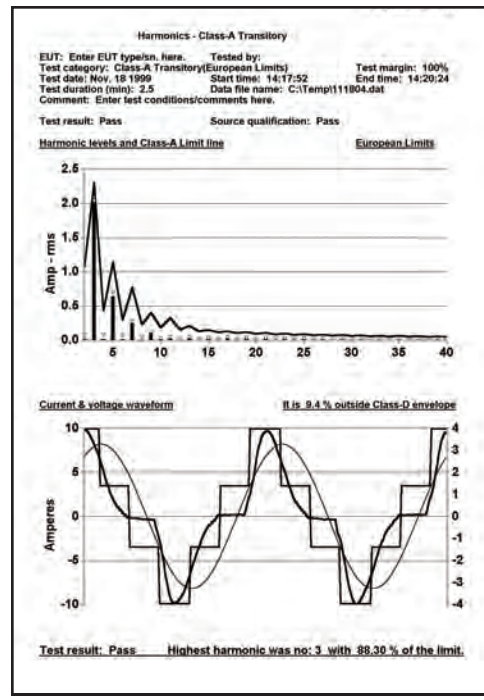
MX45-CTS Series Model Numbers			
Model	Description	Flicker Impedance	Software
MX45-CTSH	IEC 61000-3-11/12 harmonics and flicker test system	OMNI-3-75	CTSMXH
MX45-CTSL	IEC 61000-3-2/3 harmonics and flicker test system	OMNI-3-37MX	CTSMXL
MX45-CTSHL	Combination harmonics and flicker test system	OMNI-3-37MX OMNI-3-75	CTSMXL CTSMXH



Current Harmonics test display



Real-time Flicker test display



Detailed Test Reports and Data

AC/DC Electronic Loads

Notes

DC Electronic Load Selection

Introduction

Electronic loads have found a variety of applications ranging power converter testing to current modulation. A large range of power sources can be tested using an electronic load from converters, inverters and UPSs TO electrochemical sources such as batteries and fuel cells. They are easy-to-use and provide much higher throughput than resistors when varying loads are needed. For battery test, they provide a constant loading which can greatly reduce the time for test when compared to resistor load banks. Electronic loads can also simulate various power states of a device such as a handheld which may have sleep, power conservation and full power modes. They also present a complex electronic load which more closely simulates the real environment of the power source. Modulation uses improve the performance of programmable power supplies by providing faster transient response than a standard supply. This application is covered in more detail in The article “Considerations when Specifying a DC Power Supply” on page 9.

Converter/Inverter Test: Electronic loads provide a very fast method to test converters of all types DC-DC, AC-DC and DC-AC. Load regulation, overcurrent protection, noise testing (with appropriate filtering), and overpower protection can all be very quickly tested in a laboratory or production environment. The flexibility in operating range of the electronic load also allows a quick verification of power supply ratings.

UPS Test: Fully testing a UPS requires an AC source, DC source, DC load and AC load. The DC load is used to test the battery backup and charger within the UPS, while an AC load is utilized to test the base output of the UPS. In this latter application, both pure sine wave current waveforms as well as high crest factor waveforms are required. High crest factor waveforms simulate the powering of switchmode power supplies as are common in computers and servers.

Battery Test: Electronic loads can be used to directly test the capacity of a battery. This can be done in constant power mode (CP) to provide a consistent drain that does not change as the battery voltage drops. Electronic loads are also used in battery forming operations as part of the charge/discharge cycling.

With the constant drive to find high power density batteries for both handheld applications and hybrid vehicles, battery controller development and test are a common application for electronic loads. As discharge profiles are specific to a particular battery design and/or charge state, the ability of a load to produce quick changes in load are essential for this application.

Electronic Load Sizing

The Basics

Electronic loads are sized according to voltage/current and power rating. In contrast to power supplies which typically just require knowledge of maximum voltage and current, all electronic loads also have a power limit. Thus, the user must know the simultaneous voltage and current to ensure the application does not overpower the load. Each load model has its power curve (Fig. 1) in which all operating points must be within the curve.

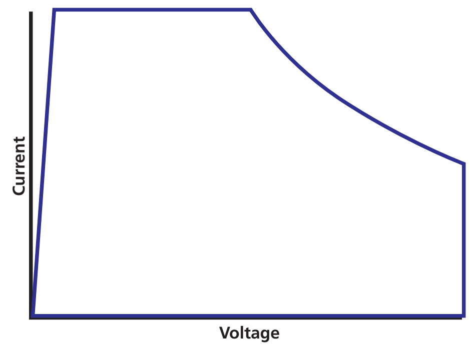


Fig. 1. Electronic load operating power curve

For example, when testing a 12V/30A power supply, it is important to know the actual operating conditions. In many cases, the supply never operates at 12V and 30A, but may run at 12V/5A and then 3V/30A. Thus, rather than a 360W or great electronic load, a 90W or larger load would be sufficient.

Load as a Modulator. A special case for load sizing occurs when it is used as a fast current modulator to improve the performance of a power supply. In this case, only a fraction of the power supply power rating is required. When current is modulated to its highest level, the voltage across the load will be minimal (~1-2V). When the current is “modulated” off, there is no power (but the voltage will be at maximum). In general, if the modulation is from zero current to some maximum, the load power can be sized at one-quarter of the operating voltage times the operating current, although the maximum voltage and current ratings must be respected . The maximum power occurs during the transition from low to high and at approximately half of the operating current and voltage.

Dynamic Testing

All electronic loads have the capability to quickly pulse the current between two states. This can simulate a sleep mode and a full power mode of a device. Typically, the user can define the two current states, the time in each state and the slew rate between the two states. A typical load, the SL series for example, can pulse at times down to 50 microseconds (20kHz).

DC Electronic Load Selection

Low Voltage Testing

Low voltage testing is common in fuel cell characterization and voltage regulators for computers. All electronic loads require a minimum voltage to fully turn on. This is shown on the power curve where the voltage does not go to zero at maximum current. The minimum voltage for maximum current is typically <1V. The majority of loads on the market will operate below this voltage but not necessarily at the full rated current. The SL series has very good low voltage capability with full current down to 0.6-0.8V. If operating voltages lower than this are required (due to a low voltage from the source or due to the source voltage minus the voltage drop due to cabling resistance), there are two solutions: use a power supply in series with the load to boost the voltage seen by the load or use a load with a higher current rating.

The first solution works well for fixed load setting and has been integrated by some load manufacturers. However, this is a relatively high cost solution that also has technical issues under transient conditions. The power supply must be sized for the full current rating, but only requires 1 to 3 volts, just enough to boost the voltage fully into the load's power curve. Whether integrated or an independent unit, the power supply is typically much slower than the requirement for the load. In pulsing or other load varying tests, the power supply cannot keep up with the transients required.

The second solution is to select a load with a higher current rating than required. For example, the SLH-60-120-600 load will sink 120A @ 0.8V. In a particular application, the power source operates at 1V. With cabling losses of 0.3V, the actual voltage at the load input is 0.7V. At this voltage the load would sink 0.7 divided by 0.8 times 120A = 105A. However, if the SLH-60-240-1200 load is selected, with the same 0.8V full turn-on, a load of 210A could be pulled. This method retains the full programmability and bandwidth of the load.

Operating Modes

In the most common uses (modulator applications excepted), the load is used as either a resistor replacement (CR Mode) or a constant current (CC Mode) load. CR mode is used as a straightforward replacement in existing test systems. CC Mode is the most common usage of electronic loads. It allows the load to simulate a complex electronic system which has different power states and draws a constant current based on the mode (sleep, partial function, full function or different radio power states wireless devices). Constant voltage mode (CV Mode) is used to test current sources, fuel cells and battery chargers. For battery chargers, it provides a replacement for an actual battery that takes a few seconds to test what could take hours with a real battery. The voltage setpoints of the load are sequenced to simulate different states of charge of the battery and hence different voltages. Constant Power mode (CP) is a somewhat newer operating mode. It is most commonly used for battery and fuel cell testing to determine the "storage" capacity.

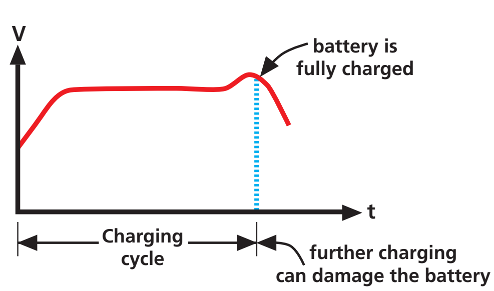


Fig. 2. Battery charging profile. An electronic load can test points along the curve to quickly verify proper operation of a battery charger.

Other Considerations

Although the majority of loads used are DC, there are many applications which require either fast, random slew rates or an AC signal on top of the DC level. These are typical in development phases for rechargeable battery controllers, fuel cells and magnet control. These applications require both a high bandwidth electronic load and the ability to generate an arbitrary waveform. The SL Loads have a 20khz bandwidth full scale across all DC models and up to 40-50kHz for small signal AC on a DC setpoint. These frequencies can be driven through analog control by either an arbitrary waveform generator or a signal generator depending upon the waveform desired. In battery controllers, the electronic load is in parallel with a power supply to simulate battery charge/discharge cycles as may be seen in real applications for the controller in a hardware in the loop (HIL) system. In fuel cell testing, a high frequency, low amplitude current can be drawn to perform electrochemical impedance spectroscopy (EIS) for characterization of cell impedances.

Other features may also be important depending upon the user's method of control and monitoring requirements. Current monitoring outputs can provide a valuable feature to simplify and reduce the cost of viewing waveforms. These outputs typically provide a 0-10V output reference which can be directly input to an oscilloscope thereby eliminating the need for a separate current shunt. Programmed sequencing provides a method to simulate multiple test conditions without computer intervention with more precise step times not possible with computer control. Computer control through RS-232 or GPIB is common for larger programs and common workstations with Ethernet on the horizon.

Summary

Electronic loads have a variety of applications across a broad range of the power industry. In proper selection of a load, it is first important to consider the application requirements. Load selection can then become straightforward by ensuring that all test conditions fall within the power curve. Other considerations include load bandwidth, operating modes, analog inputs and outputs, sequencing and computer control. With the proper selection, an electronic load will provide an easy replacement for resistor banks with much more flexibility and better real-world correlation to electronic devices

AMREL eLoad PLA Series

800 W–7.5 kW

Air-cooled programmable DC electronic load

10–1200 Vdc

10–1500 Adc

∿	95	240 VAC

GPIB RS232 ETHERNET USB

- Broadest Model Selection: 800W to 7.5kW (higher power available up to 250kW Contact Factory)
- Exclusive Voltage Models: 10V to 1200V
- Multiple loads in one: Multiple ranges for voltage, current resistance and power
- Intuitive Front Panel Control: Run sequences, triggers, constant current to constant power cross over

Traditional dc Electronic Load Solutions are bulky and large in size. Most are offered with standard voltage, current and power ratings. In the ATE world, rack space is a highly coveted asset and application demands are constantly diversifying with new technology development.

AMREL's PLA Series of "Air-cooled" dc Electronic eLoads offers the industry's smallest footprint, the highest power density and current rating, along with the broadest selection of high voltage models on the market. PLA models are capable of being custom-tailored to meet your application requirements.

Key Features

Closed-case Calibration
With the eLoad line, there's no longer a need to send your electronic load back to the factory for calibration or remove dozens of screws to reach a potentiometer. Simply follow the AMREL calibration routine from the front panel and you should be back up and running in a very short period of time (some electronic test equipment needed). This will virtually eliminate downtime and eradicate the annual cost associated with shipping your eLoad back to the factory for calibration.

Individual FET Protection
To ensure the reliability of the PLA Series, AMREL's design includes individual FET protection. A programmable electronic load may contain many FETs in parallel, which can create a cascading failure if one of them was to short out. AMREL's eLoad programmable electronic load design isolates failures so other components will not be affected or stressed, increasing the system's level of protection against catastrophic failure. With individual FET protection, the MTTR is reduced and the electronic load quickly returns to full operation.

Ultra-low Voltage Operation
The PLA design allows the programmable electronic load to operate at voltage levels approaching .1V. They will typically dissipate full rated current below 1% of their maximum rated voltage. For example, a 60V unit designed to dissipate1500A will allow the user to operate at .6V and still dissipate the full amount.

PLA Series : Product Selector

PLA Selector Guide

Model	VOLT \ AMP	5A	12A	15A	20A	30A	50A	60A	75A	100A	120A	150A	200A	240A	300A	360A	400A	500A	600A	800A	1000A	1200A	1500A
PLA800	60V			●	●	●	●	●	●	●	●	●	●	●	●								
	120V		●	●	●	●	●	●	●	●	●	●											
	400V	●	●	●	●	●	●																
	600V	●	●	●	●	●																	
	800V	●	●	●																			
	1000V	●																					
PLA1.5K	60V					●	●	●	●	●	●	●	●	●	●	●	●	●	●				
	120V			●	●	●	●	●	●	●	●	●	●	●	●								
	400V	●	●	●	●	●	●	●	●	●													
	600V	●	●	●	●	●	●	●															
	800V	●	●	●	●	●																	
	1000V	●	●																				
PLA2K	60V						●	●	●	●	●	●	●	●	●	●	●	●	●				
	120V	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●						
	400V	●	●	●	●	●	●	●	●	●	●	●											
	600V	●	●	●	●	●	●	●	●	●													
	800V	●	●	●	●	●																	
	1000V	●	●	●																			
PLA2.5K	60V						●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		
	120V					●	●	●	●	●	●	●	●	●	●	●	●	●	●				
	400V		●	●	●	●	●	●	●	●	●	●	●										
	600V	●	●	●	●	●	●	●	●	●	●												
	800V	●	●	●	●	●	●																
	1000V	●	●	●	●																		
PLA3K	60V						●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		
	120V					●	●	●	●	●	●	●	●	●	●	●	●	●	●	●			
	400V		●	●	●	●	●	●	●	●	●	●	●	●	●								
	600V	●	●	●	●	●	●	●	●	●	●	●											
	800V	●	●	●	●	●	●																
	1000V	●	●	●	●	●																	
PLA4K	60V									●	●	●	●	●	●	●	●	●	●	●	●	●	
	120V						●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		
	400V		●	●	●	●	●	●	●	●	●	●	●	●	●	●							
	600V		●	●	●	●	●	●	●	●	●	●	●										
	800V	●	●	●	●	●	●	●	●														
	1000V	●	●	●	●	●																	
PLA5K	60V									●	●	●	●	●	●	●	●	●	●	●	●	●	
	120V						●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
	400V			●	●	●	●	●	●	●	●	●	●	●	●	●	●						
	600V		●	●	●	●	●	●	●	●	●	●	●	●									
	800V		●	●	●	●	●	●	●	●													
	1000V	●	●	●	●	●	●																
PLA6K	60V										●	●	●	●	●	●	●	●	●	●	●	●	●
	120V						●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	400V			●	●	●	●	●	●	●	●	●	●	●	●	●	●	●					
	600V		●	●	●	●	●	●	●	●	●	●	●	●	●								
	800V		●	●	●	●	●	●	●	●	●												
	1000V		●	●	●	●	●	●															
PLA7.5K	60V											●	●	●	●	●	●	●	●	●	●	●	●
	120V								●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	400V				●	●	●	●	●	●	●	●	●	●	●	●	●	●	●				
	600V			●	●	●	●	●	●	●	●	●	●	●	●	●	●						
	800V		●	●	●	●	●	●	●	●	●	●											
	1000V		●	●	●	●	●	●	●														

PLA Series : Product Specifications

800 W–7.5 kW

General							
Models	Power Input (MAX)	Voltage (V) (MAX)	Current (A) (MAX)	CR Low (min) Ω	CR High (max) Ω	Vmin at Imax	LxWxH & Weight
PLA800-60-300	800W	60	300	0.0125	200	0.75	2U, 21"D
PLA800-120-150	800W	120	150	0.0150	800	1.8	2U, 21"D
PLA800-400-50	800W	400	50	0.0068	8000	2.7	2U, 21"D
PLA800-600-30	800W	600	30	0.0130	20000	7.8	2U, 21"D
PLA800-800-15	800W	800	15	0.0049	53333.3	3.9	2U, 21"D
PLA800-1000-5	800W	1000	5	0.0050	200000	5	2U, 21"D
PLA1.5K-60-600	1.5KW	60	600	0.0125	100	0.75	2U, 21"D
PLA1.5K-120-300	1.5KW	120	300	0.0150	400	1.8	2U, 21"D
PLA1.5K-400-100	1.5KW	400	100	0.0068	4000	2.7	2U, 21"D
PLA1.5K-600-60	1.5KW	600	60	0.0130	10000	7.8	2U, 21"D
PLA1.5K-800-30	1.5KW	800	30	0.0049	26666.7	3.9	2U, 21"D
PLA1.5K-1000-12	1.5KW	1000	12	0.0060	83333.3	6	2U, 21"D
PLA2K-60-600	2KW	60	600	0.0100	100	0.6	3U, 25.5"D
PLA2K-120-400	2KW	120	400	0.0150	300	1.8	3U, 25.5"D
PLA2K-400-150	2KW	400	150	0.0068	2666.7	2.7	3U, 25.5"D
PLA2K-600-100	2KW	600	100	0.0140	6000	8.4	3U, 25.5"D
PLA2.5K-60-1000	2.5KW	60	1000	0.0100	60	0.6	3U, 25.5"D
PLA2.5K-120-600	2.5KW	120	600	0.0150	200	1.8	3U, 25.5"D
PLA2.5K-400-200	2.5KW	400	200	0.0068	2000	2.7	3U, 25.5"D
PLA2.5K-600-120	2.5KW	600	120	0.0130	5000	7.8	3U, 25.5"D
PLA3K-60-1000	3KW	60	1000	0.0100	60	0.6	3U, 25.5"D
PLA3K-120-800	3KW	120	800	0.0133	150	1.6	3U, 25.5"D
PLA3K-400-300	3KW	400	300	0.0068	1333.3	2.7	3U, 25.5"D
PLA3K-600-150	3KW	600	150	0.0120	4000	7.2	3U, 25.5"D
PLA3K-800-50	3KW	800	50	0.0031	16000	2.5	3U, 25.5"D
PLA3K-1000-30	3KW	1000	30	0.0060	33333.3	6	3U, 25.5"D
PLA4K-60-1200	4KW	60	1200	0.0100	50	0.6	4U, 25.5"D
PLA4K-120-1000	4KW	120	1000	0.0150	120	1.8	4U, 25.5"D
PLA4K-400-360	4KW	400	360	0.0068	1111.1	2.7	4U, 25.5"D
PLA4K-600-200	4KW	600	200	0.0130	3000	7.8	4U, 25.5"D
PLA5K-60-1200	5KW	60	1200	0.0100	50	0.6	4U, 25.5"D
PLA5K-120-1200	5KW	120	1200	0.0150	100	1.8	4U, 25.5"D
PLA5K-400-400	5KW	400	400	0.0070	1000	2.8	4U, 25.5"D
PLA5K-600-240	5KW	600	240	0.0130	2500	7.8	4U, 25.5"D
PLA5K-800-100	5KW	800	100	0.0045	8000	3.6	4U, 25.5"D
PLA5K-1000-50	5KW	1000	50	0.0060	20000	6	4U, 25.5"D
PLA6K-60-1500	6KW	60	1500	0.0100	40	0.6	6U, 25.5"D
PLA6K-120-1500	6KW	120	1500	0.0150	80	1.8	6U, 25.5"D
PLA6K-400-500	6KW	400	500	0.0075	800	3	6U, 25.5"D
PLA6K-600-300	6KW	600	300	0.0140	2000	8.4	6U, 25.5"D
PLA7.5K-60-1500	7.5KW	60	1500	0.0100	40	0.6	6U, 25.5"D
PLA7.5K-120-1500	7.5KW	120	1500	0.0150	80	1.8	6U, 25.5"D
PLA7.5K-400-600	7.5KW	400	600	0.0068	666.7	2.7	6U, 25.5"D
PLA7.5K-600-400	7.5KW	600	400	0.0140	1500	8.4	6U, 25.5"D
PLA7.5K-800-150	7.5KW	800	150	0.0045	5333.3	3.6	6U, 25.5"D
PLA7.5K-1000-75	7.5KW	1000	75	0.0060	13333.3	6	6U, 25.5"D

Note: Higher powers available. Contact your sales rep for PLA options or see PLW for water cooled solutions.

Option

I = Isolated Analog Programming
E = Ethernet (10/100 Lan) & USB 2.0 Interface
-XX = Ultra Low Range (xx = UL current rating)

PLA Series : Product Specifications 800 W–7.5 kW

Constant Resistance Mode						
Models	CRH Range Ω		CRM Range Ω		CRL Range Ω	
	Rmin	Rmax	Rmin	Rmax	Rmin	Rmax
PLA800-60-300	2.0	200	0.2	50	0.0025	0.20
PLA800-120-150	8.0	800	0.8	200	0.0120	0.80
PLA800-400-50	80.0	8000	8.0	2000	0.0540	8.00
PLA800-600-30	200.0	20000	20.0	5000	0.2600	20.00
PLA800-800-15	533.3	53333.3	53.3	13333.3	0.2600	53.33
PLA800-1000-5	2000.0	200000	200.0	50000	1.0000	200.00
PLA1.5K-60-600	1.0	100	0.1	25	0.0013	0.10
PLA1.5K-120-300	4.0	400	0.4	100	0.0060	0.40
PLA1.5K-400-100	40.0	4000	4.0	1000	0.0270	4.00
PLA1.5K-600-60	100.0	10000	10.0	2500	0.1300	10.00
PLA1.5K-800-30	266.7	26666.6	26.6	6666.6	0.1300	26.67
PLA1.5K-1000-12	833.3	83333.3	83.3	20833.3	0.5000	83.33
PLA2K-60-600	1.0	100	0.1	25	0.0010	0.10
PLA2K-120-400	3.0	300	0.3	75	0.0045	0.30
PLA2K-400-150	26.7	2666.6	2.6	666.6	0.0180	2.67
PLA2K-600-100	60.0	6000	6.0	1500	0.0840	6.00
PLA2.5K-60-1000	0.6	60	0.06	15	0.0006	0.06
PLA2.5K-120-600	2.0	200	0.2	50	0.0030	0.20
PLA2.5K-400-200	20.0	2000	2.0	500	0.0135	2.00
PLA2.5K-600-120	50.0	5000	5.0	1250	0.0650	5.00
PLA3K-60-1000	0.6	60	0.06	15	0.0006	0.06
PLA3K-120-800	1.5	150	0.15	37.5	0.0020	0.15
PLA3K-400-300	13.3	1333.3	1.3	333.3	0.0090	1.33
PLA3K-600-150	40.0	4000	4.0	1000	0.0480	4.00
PLA3K-800-50	160.0	16000	16.0	4000	0.0500	16.00
PLA3K-1000-30	333.3	33333.3	33.3	8333.3	0.2000	33.33
PLA4K-60-1200	0.5	50	0.05	12.5	0.0005	0.05
PLA4K-120-1000	1.2	120	0.12	30	0.0018	0.12
PLA4K-400-360	11.1	1111.1	1.1	277.7	0.0075	1.11
PLA4K-600-200	30.0	3000	3.0	750	0.0390	3.00
PLA5K-60-1200	0.5	50	0.05	12.5	0.0005	0.05
PLA5K-120-1200	1.0	100	0.1	25	0.0015	0.10
PLA5K-400-400	10.0	1000	1.0	250	0.0070	1.00
PLA5K-600-240	25.0	2500	2.5	625	0.0325	2.50
PLA5K-800-100	80.0	8000	8.0	2000	0.0360	8.00
PLA5K-1000-50	200.0	20000	20.0	5000	0.1200	20.00
PLA6K-60-1500	0.4	40	0.04	10	0.0004	0.04
PLA6K-120-1500	0.8	80	0.08	20	0.0012	0.08
PLA6K-400-500	8.0	800	0.80	200	0.0060	0.80
PLA6K-600-300	20.0	2000	2.00	500	0.0280	2.00
PLA7.5K-60-1500	0.4	40	0.04	10	0.0004	0.04
PLA7.5K-120-1500	0.8	80	0.08	20	0.0012	0.08
PLA7.5K-400-600	6.7	666.6	0.67	166.6	0.0045	0.67
PLA7.5K-600-400	15.0	1500	1.50	375	0.0210	1.50
PLA7.5K-800-150	53.3	5333.3	5.33	1333.3	0.0240	5.33
PLA7.5K-1000-75	133.3	13333.3	13.33	3333.3	0.0800	13.33

Constant Resistance Mode			
Transient Time Range : CRM / CRH	Same As CC Mode	Temperature Coefficient : CRM / H	300 ppm / °C of Minimum Resistance
Transient Time Range : CRL	Same As CV Mode	Temperature Coefficient : CRL	300 ppm / °C of Maximum Resistance

Constant Resistance Mode - Program : CR Resolution*2 - 1/16000 Of Rated Value

*1 All Mode Specification measure by 25°C room temperature unless otherwise specified *2 Transient Mode Specification must be x2

PLA Series : Product Specifications

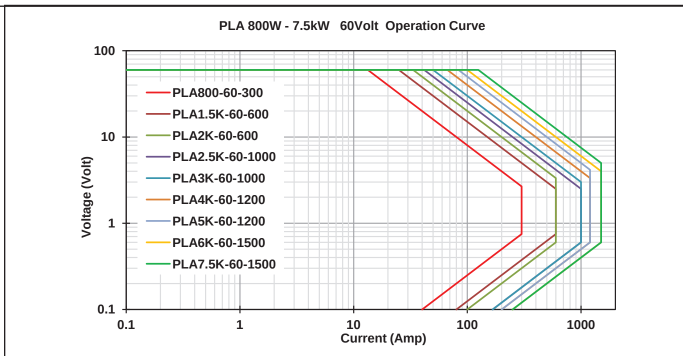
Constant Voltage Mode	
CVHigh Range	(0-V) V
CVMedium Range	0 - (V / 2) V
CVLow Range	0 - (/ 10) V
Temp Coefficient	100 ppm / °C of Rated Voltage
Transient Time Range	
Fast Band(default, Osc1)	0.500 ~ 51.19 ms
Slow Band(Osc2, Osc3)	0.500 ~ 511.9 ms
CV Resolutions*2	1/16000 of rated voltage
CV Accuracy*2 (CVH, CVM, CVL)	0.05% +/- (0.1% x Vmax) V
Display Specifications	
CV Resolution	1/16000 of Rated Voltage
CV Accuracy (CVH, CVM, CCL)	0.05% +/- (0.1% x V) V
Constant Power Mode	
CPHigh Range	(0-P) W
CPMedium Range	0 - (P/2) W @ DC input current ≤ (I/2) A
CPLow Range	0 - (P/10) W @ DC input current ≤ (I/10) A
Transient Time Range	Same as CC Mode
Temperature Coefficient	300 ppm / °C of Rated Power
Constant Power Mode : Program	
CPHigh Accuracy*2	1.00% +/- (Px0.5%) W @ input current > (I/20) A, input voltage > (V/10) V
CPMedium Range	1.00% +/- (Px0.5%) W @ input current > (I/100) A, input voltage > (V/10) V
CPLow Range	1.00% +/- (Px0.5%) W @ input current > (I/1000) A, input voltage > (V/5) V
Program	CP Resolution*2 1/16000 of Rated Power
Constant Current Mode	
CCHigh Range	0 - I A
CCMedium Range	0 - (I/2) A
CCLow Range	0 - (I/10) A
Transient Time Range	
Fast Band (default, Osc1)	0.050 ~ 51.19 ms
Slow Band (Osc2, Osc3)	0.500 ~ 511.9 ms
Temperature Coefficient	100 ppm / °C of Rated Current
Constant Current Mode : Program	
CC Resolution*2	1/16000 of rated current
CCHigh Accuracy*2 LHM	0.05% +/- (Ix0.1%) A
Constant Resistance Mode	
Transient Time Range : CRM / CRH	Same As CC Mode
Transient Time Range : CRL	Same As CV Mode
Temperature Coefficient : CRM / H	300 ppm / °C of Minimum Resistance
Temperature Coefficient : CRL	300 ppm / °C of Maximum Resistance
Constant Resistance Mode - Program	
CR Resolution*2	1/16000 of rated value

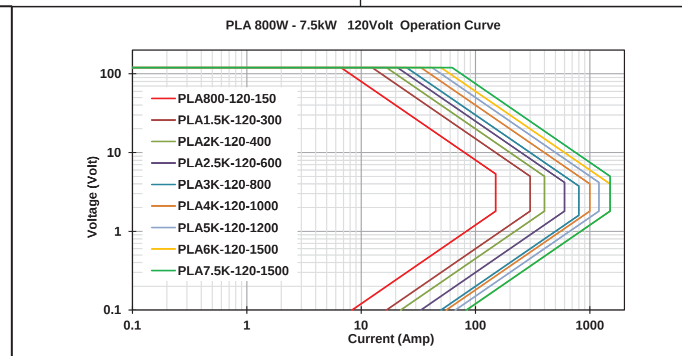
PLA Series : Product Specifications 800 W–7.5 kW

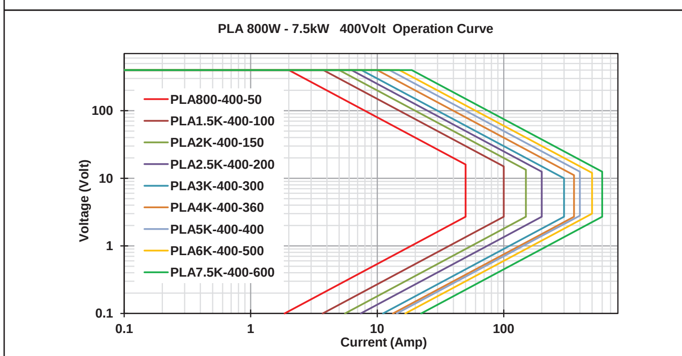
External Programming Mode	
Monitor Output Signal	0-10 Volts output for 0 to full scale value
VMON Accuracy	0.10% +/- (Vx0.1%) V
IMON Accuracy	0.10% +/- (Ix0.1%) A
Analog Program	0~10 Volts Input yields 0 -- selected full scale loading in all modes
Accuracy	Same As Internal ± 0.1% Rating
Input Impedance	200 k Ω ± 1 %
BandWidth(-3dB)	Limited By Internal Transient Time
Remote Interface	GPIB / RS-232 / ETHERNET / USB
Programmable Protection	
Power (OPP)	
Range	(Px1.05/800) ~ (Px1.05) W
Resolution	(Px1.05/8000) W
Accuracy	0.50% +/- (P x 21 / 8000) W
Voltage (OVP)	
Range	(Vx1.05/1600) ~ (Vx1.05) V
Resolution	(Vx1.05/16000) V
Accuracy	0.20% +/- (Vx1.05/800) V
Current (OCP)	
Range	(Ix1.05/1600) ~ (Ix1.05) A
Resolution	(Ix1.05/16000) A
Accuracy	0.20% +/- (Ix1.05/800) A
Under Voltage Lockout (UVL)	
Mode	Input On / Continuous
Range	((V/4000*3) ~ Vmax) V
Resolution	(V/4000) V
Accuracy	2.50% +/- (V/800) V
Anti-Oscillation	Default/ Osc1/ Osc2/ Osc3/ Disable
Protection	
Over Power (OP)	(Px1.05) +/- (Px0.02) W
Over Voltage (OV)	(Vx1.05) +/- (Vx0.02) V
Over Current (OC)	(Ix1.1) +/- (Ix1.1x0.01/1.05) A
Over Temp (OTP)	90.00 +/- 5.000 °C
Reverse Max Current (RCP)	(Ix1.1) A
Short Max Current	(Ix1.02) A
Remote Inhibit (RI)	Short
Fault Indicator	SPDT Relay (30Vdc/0.5A or 125Vac/0.25A
General	
AC Input	95~240 Vac 48~62 Hz
Derating for higher temperatures	(-)1.67% Rated Power / °C
Operating Temperature	5 °C ~ 40 °C
Transient Mode	
Frequency Range	0.100 - 10,000 Hz
Duty Range	1.000 - 100.0%
Transient Time Accuracy	10.0% +/- 50% of Min Time
Dielectric Strength	
Primary Circuit To Chassis	1500 Vac for 1 min
Primary Circuit To Load Terminal	1500 Vac for 1 min
Load Terminal To Chassis	1500 Vdc for 1 min

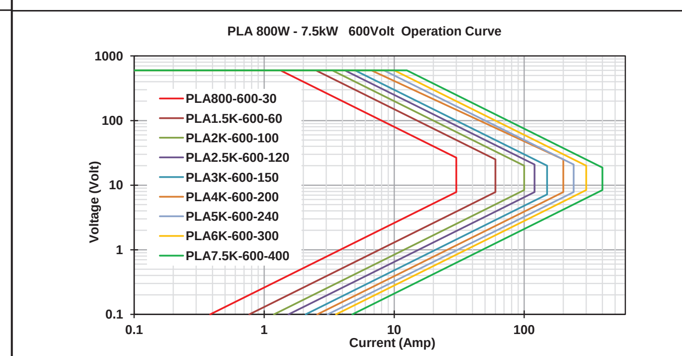
PLA Series : Operational Curves

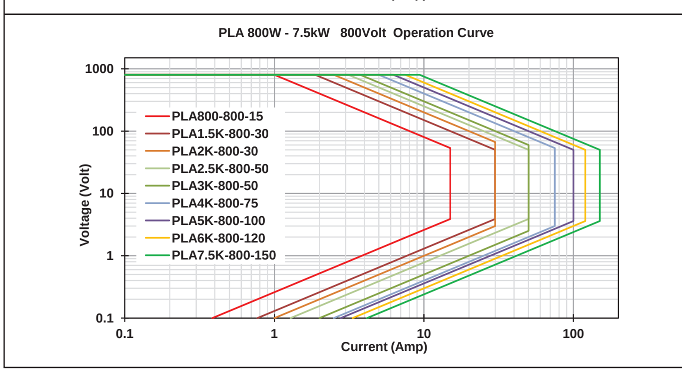
800 W–7.5 kW

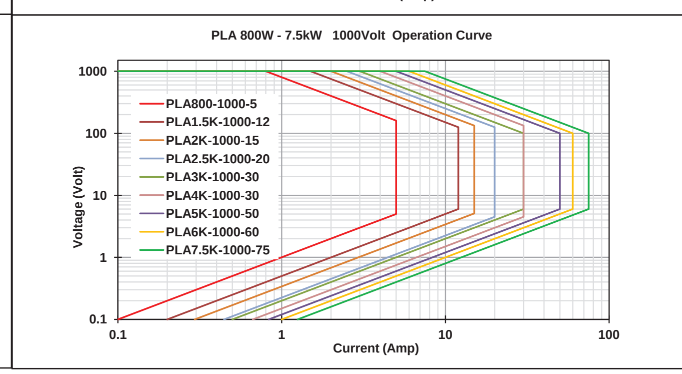












Notes

AMREL eLoad PLW Series

6–250 kW

Water-cooled programmable DC electronic load

60–1200 Vdc

10–5000 Adc

∿ 95-240 VAC

ETHERNET GPIB USB RS232

- Broadest Model Selection: 6kW, 9kW, 12kW, 18kW, 24kW, 36kW, Additional standard models above 36kW, up to 250kW, are available.
- Standard 60V, 120V, 400V, 600V, 800V and 1000V Voltage Ratings
- PLW Models Offer Ultra-compact Footprint and Boasts one of the industry's highest power densities, 18kW in 2U.
- Anti-condensation: Intelligent Fully-integrated Temperature Control Circuit and Solenoid Valve
- Standard LabWindows and LabVIEW Drivers and SCPI Command Set

Traditional dc Electronic Load Solutions are bulky and large in size. Most are offered with standard voltage, current and power ratings. In the ATE world, rack space is a highly coveted asset and application demands are constantly diversifying with new technology development.

AMREL's PLW Series of "Water-cooled" dc Electronic eLoads are capable of being custom-tailored to meet your specific application requirements. The PLW Series also offers a unique condensation protection design, the highest power density and current rating, as well as the widest selection of high-voltage models on the market..

Key Features

Closed-case Calibration
With the eLoad line, there's no longer a need to send your electronic load back to the factory for calibration or remove dozens of screws to reach a potentiometer. Simply follow the AMREL calibration routine from the front panel and you should be back up and running in a very short period of time (some electronic test equipment needed). This will virtually eliminate downtime and eradicate the annual cost associated with shipping your eLoad back to the factory for calibration.

Individual FET Protection
To ensure the reliability of the PLW Series, AMREL's design includes individual FET protection. A programmable electronic load may contain many FETs in parallel, which can create a cascading failure if one of them was to short out. AMREL's eLoad programmable electronic load design isolates failures so other components will not be affected or stressed, increasing the system's level of protection against catastrophic failure. With individual FET protection, the MTTR is reduced and the electronic load quickly returns to full operation.

Ultra-low Voltage Operation
The PLA design allows the programmable electronic load to operate at voltage levels approaching .1V. They will typically dissipate full rated current below 1% of their maximum rated voltage. For example, a 60V unit designed to dissipate1500A will allow the user to operate at .6V and still dissipate the full amount.

PLW Series : Product Selector

PLW Selector Guide

Model	VOLT \ AMP	15A	25A	30A	40A	50A	75A	100A	150A	200A	300A	400A	600A	800A	1000A	1200A	1500A
PLW6K	60V							■	■	■	■	■	■	■	■		
	120V					■	■	■	■	■	■	■	■				
	400V	■	■	■	■	■	■	■	■	■	■						
	600V	■	■	■	■	■	■	■	■	■							
	800V	■	■														
	1000V	■	■														
PLW9K	60V								■	■	■	■	■	■	■	■	■
	120V						■	■	■	■	■	■	■	■	■		
	400V		■	■	■	■	■	■	■	■	■	■					
	600V	■	■	■	■	■	■	■	■	■	■						
	800V	■	■	■	■												
	1000V	■	■	■	■												
PLW12K	60V									■	■	■	■	■	■	■	■
	120V						■	■	■	■	■	■	■	■	■	■	
	400V			■	■	■	■	■	■	■	■	■	■				
	600V		■	■	■	■	■	■	■	■	■	■					
	800V	■	■	■	■	■											
	1000V	■	■	■	■	■											
PLW18K	60V										■	■	■	■	■	■	■
	120V								■	■	■	■	■	■	■	■	■
	400V					■	■	■	■	■	■	■	■	■			
	600V		■	■	■	■	■	■	■	■	■	■	■				
	800V		■	■	■	■	■										
	1000V		■	■	■	■	■										
PLW24K	60V											■	■	■	■	■	■
	120V									■	■	■	■	■	■	■	■
	400V						■	■	■	■	■	■	■	■	■	■	
	600V				■	■	■	■	■	■	■	■	■	■			
	800V			■	■	■	■	■									
	1000V		■	■	■	■	■	■									
PLW36K	60V												■	■	■	■	■
	120V										■	■	■	■	■	■	■
	400V							■	■	■	■	■	■	■	■	■	■
	600V						■	■	■	■	■	■	■	■	■		
	800V					■	■	■	■								
	1000V				■	■	■	■	■								

PLW Series : Product Specifications

General							
Models	Power (W)	Voltage (Vdc)	Current (Adc)	CR Low (min) Ω	CR High (max) Ω	VMIN at IMAX	Size (Height, Depth)
PLW6K-60-1000	6000	60	1000	0.0150	60	0.9	2U, 27.5"D
PLW6K-120-600	6000	120	600	0.0125	200	1.5	2U, 27.5"D
PLW6K-400-300	6000	400	300	0.0090	1333.3	3.6	2U, 27.5"D
PLW6K-600-200	6000	600	200	0.0200	3000	12	2U, 27.5"D
PLW6K-800-25	6000	800	25	0.0075	32000	6	2U, 27.5"D
PLW6K-1000-25	6000	1000	25	0.0060	40000	6	2U, 27.5"D
PLW9K-60-1500	9000	60	1500	0.0150	40	0.9	2U, 27.5"D
PLW9K-120-1000	9000	120	1000	0.0125	120	1.5	2U, 27.5"D
PLW9K-400-400	9000	400	400	0.0090	1000	3.6	2U, 27.5"D
PLW9K-600-300	9000	600	300	0.0200	2000	12	2U, 27.5"D
PLW9K-800-40	9000	800	40	0.0075	20000	6	2U, 27.5"D
PLW9K-1000-40	9000	1000	40	0.0060	25000	6	2U, 27.5"D
PLW12K-60-1500	12000	60	1500	0.0125	40	0.75	2U, 27.5"D
PLW12K-120-1200	12000	120	1200	0.0130	100	1.56	2U, 27.5"D
PLW12K-400-600	12000	400	600	0.0090	666.6	3.6	2U, 27.5"D
PLW12K-600-400	12000	600	400	0.0200	1500	12	2U, 27.5"D
PLW12K-800-50	12000	800	50	0.0075	16000	6	2U, 27.5"D
PLW12K-1000-50	12000	1000	50	0.0060	20000	6	2U, 27.5"D
PLW18K-60-1500	18000	60	1500	0.0100	40	0.6	2U, 27.5"D
PLW18K-120-1500	18000	120	1500	0.0125	80	1.5	2U, 27.5"D
PLW18K-400-800	18000	400	800	0.0090	500	3.6	2U, 27.5"D
PLW18K-600-600	18000	600	600	0.0200	1000	12	2U, 27.5"D
PLW18K-800-75	18000	800	75	0.0075	10666.6	6	2U, 27.5"D
PLW18K-1000-75	18000	1000	75	0.0060	13333.3	6	2U, 27.5"D
PLW24K-60-1500	24000	60	1500	0.0075	40	0.45	4U, 27.5"D
PLW24K-120-1500	24000	120	1500	0.0100	80	1.2	4U, 27.5"D
PLW24K-400-1200	24000	400	1200	0.0090	333.3	3.6	4U, 27.5"D
PLW24K-600-800	24000	600	800	0.0200	750	12	4U, 27.5"D
PLW24K-800-100	24000	800	100	0.0075	8000	6	4U, 27.5"D
PLW24K-1000-100	24000	1000	100	0.0060	10000	6	4U, 27.5"D
PLW36K-60-1500	36000	60	1500	0.0075	40	0.45	4U, 27.5"D
PLW36K-120-1500	36000	120	1500	0.0075	80	0.9	4U, 27.5"D
PLW36K-400-1500	36000	400	1500	0.0083	266.6	3.3	4U, 27.5"D
PLW36K-600-1000	36000	600	1000	0.0167	600	10	4U, 27.5"D
PLW36K-800-150	36000	800	150	0.0075	5333.3	6	4U, 27.5"D
PLW36K-1000-150	36000	1000	150	0.0060	6666.6	6	4U, 27.5"D
Note: Higher power available. Please contact the factory.							

PLW XX - YY - ZZ - Option

P Rated Power

V Voltage

I Current

"E" = Ethernet / USB
"I" = Isolated Analog Programming

PLW Series : Product Specifications

Constant Resistance Mode						
Models	CRH Range		CRM Range		CRL Range	
	Rmin	Rmax	Rmin	Rmax	Rmin	Rmax
PLW6K-60-1000	0.6	60	0.06	15	0.0009	0.06
PLW6K-120-600	2.0	200	0.20	50	0.0025	0.20
PLW6K-400-300	13.3	1333.3	1.33	333.3	0.0120	1.33
PLW6K-600-200	30.0	3000	3.00	750	0.0600	3.00
PLW6K-800-25	320.0	32000	32.00	8000	0.2400	32.00
PLW6K-1000-25	400.0	40000	40.00	10000	0.2400	40.00
PLW9K-60-1500	0.4	40	0.04	10	0.0006	0.04
PLW9K-120-1000	1.2	120	0.12	30	0.0015	0.12
PLW9K-400-400	10.0	1000	1.00	250	0.0090	1.00
PLW9K-600-300	20.0	2000	2.00	500	0.0400	2.00
PLW9K-800-40	200.0	20000	20.00	5000	0.1500	20.00
PLW9K-1000-40	250.0	25000	25.00	6250	0.1500	25.00
PLW12K-60-1500	0.4	40	0.04	10	0.0005	0.04
PLW12K-120-1200	1.0	100	0.10	25	0.0013	0.10
PLW12K-400-600	6.7	666.6	0.67	166.6	0.0060	0.67
PLW12K-600-400	15.0	1500	1.50	375	0.0300	1.50
PLW12K-800-50	160.0	16000	16.00	4000	0.1200	16.00
PLW12K-1000-50	200.0	20000	20.00	5000	0.1200	20.00
PLW18K-60-1500	0.4	40	0.04	10	0.0004	0.04
PLW18K-120-1500	0.8	80	0.08	20	0.0010	0.08
PLW18K-400-800	5.0	500	0.50	125	0.0045	0.50
PLW18K-600-600	10.0	1000	1.00	250	0.0200	1.00
PLW18K-800-75	106.7	10666.6	10.67	2666.6	0.0800	10.67
PLW18K-1000-75	133.3	13333.3	13.33	3333.3	0.0800	13.33
PLW24K-60-1500	0.4	40	0.04	10	0.0003	0.04
PLW24K-120-1500	0.8	80	0.08	20	0.0008	0.08
PLW24K-400-1200	3.3	333.3	0.33	83.3	0.0030	0.33
PLW24K-600-800	7.5	750	0.75	187.5	0.0150	0.75
PLW24K-800-100	80.0	8000	8.00	2000	0.0600	8.00
PLW24K-1000-100	100.0	10000	10.00	2500	0.0600	10.00
PLW36K-60-1500	0.4	40	0.04	10	0.0003	0.04
PLW36K-120-1500	0.8	80	0.08	20	0.0006	0.08
PLW36K-400-1500	2.7	266.6	0.27	66.6	0.0022	0.27
PLW36K-600-1000	6.0	600	0.60	150	0.0100	0.60
PLW36K-800-150	53.3	5333.3	5.33	1333.3	0.0400	5.33
PLW36K-1000-150	66.7	6666.6	6.67	1666.6	0.0400	6.67

Constant Resistance Mode	
Transient Time Range : CRM / CRH	Same As CC Mode
Transient Time Range : CRL	Same As CV Mode
Temperature Coefficient : CRM / H	300 ppm / °C of Minimum Resistance
Temperature Coefficient : CRL	300 ppm / °C of Maximum Resistance
Constant Resistance Mode - Program : CR Resolution*2 - 1/16000 Of Rated Value	

*1 All Mode Specification measure by 25°C room temperature unless otherwise specified
*2 Transient Mode Specification must be x2

PLW Series : Product Specifications 6–250 kW

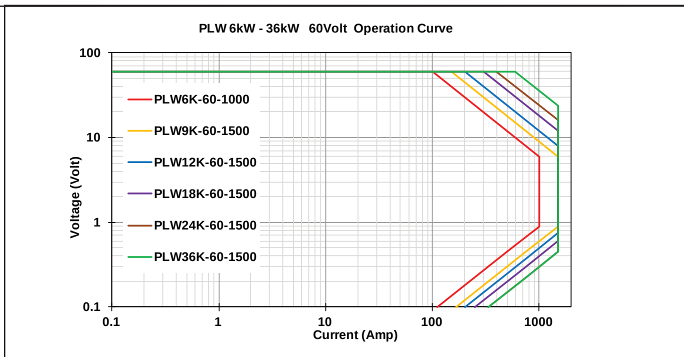
Constant Voltage Mode	
CVHigh Range	(0-V) V
CVMedium Range	0 - (V / 2) V
CVLow Range	0 - (/ 10) V
Temp Coefficient	100 ppm / °C of Rated Voltage
Transient Time Range	
Fast Band(default, Osc1)	0.500 ~ 51.19 ms
Slow Band(Osc2, Osc3)	0.500 ~ 511.9 ms
CV Resolutions*2	1/16000 of rated voltage
CV Accuracy*2 (CVH, CVM, CVL)	0.05% +/- (0.1% x Vmax) V
Display Specifications	
CV Resolution	1/16000 of Rated Voltage
CV Accuracy (CVH, CVM, CCL)	0.05% +/- (0.1% x V) V
Constant Power Mode	
CPHigh Range	(0-P) W
CPMedium Range	0 - (P/2) W @ DC input current ≤ (I/2) A
CPLow Range	0 - (P/10) W @ DC input current ≤ (I/10) A
Transient Time Range	Same as CC Mode
Temperature Coefficient	300 ppm / °C of Rated Power
Constant Power Mode : Program	
CPHigh Accuracy*2	1.00% +/- (Px0.5%) W @ input current > (I/20) A, input voltage > (V/10) V
CPMedium Range	1.00% +/- (Px0.5%) W @ input current > (I/100) A, input voltage > (V/10) V
CPLow Range	1.00% +/- (Px0.5%) W @ input current > (I/1000) A, input voltage > (V/5) V
Program	CP Resolution*2 1/16000 of Rated Power
Constant Current Mode	
CCHigh Range	0 - I A
CCMedium Range	0 - (I/2) A
CCLow Range	0 - (I/10) A
Transient Time Range	
Fast Band (default, Osc1)	0.050 ~ 51.19 ms
Slow Band (Osc2, Osc3)	0.500 ~ 511.9 ms
Temperature Coefficient	100 ppm / °C of Rated Current
Constant Current Mode : Program	
CC Resolution*2	1/16000 of rated current
CCHigh Accuracy*2 LHM	0.05% +/- (Ix0.1%) A
Constant Resistance Mode	
Transient Time Range : CRM / CRH	Same As CC Mode
Transient Time Range : CRL	Same As CV Mode
Temperature Coefficient : CRM / H	300 ppm / °C of Minimum Resistance
Temperature Coefficient : CRL	300 ppm / °C of Maximum Resistance
Constant Resistance Mode - Program	
CR Resolution*2	1/16000 of rated value

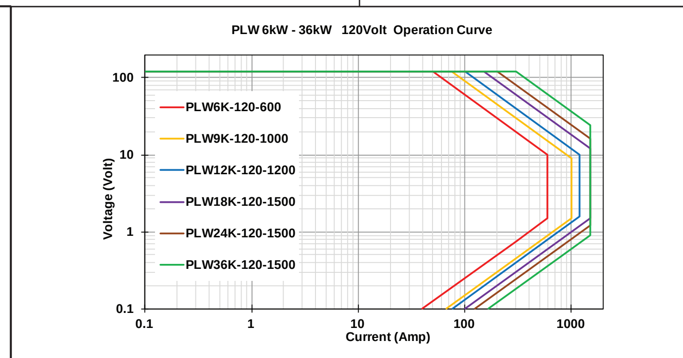
PLW Series : Product Specifications

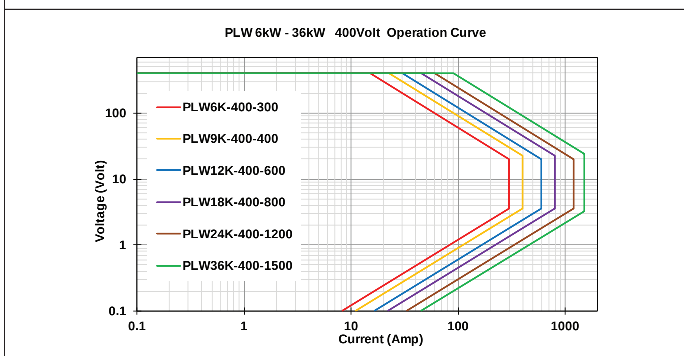
External Programming Mode	
Monitor Output Signal	0-10 Volts output for 0 to full scale value
VMON Accuracy	0.10% +/- (Vx0.1%) V
IMON Accuracy	0.10% +/- (Ix0.1%) A
Analog Program	0~10 Volts Input yields 0 -- selected full scale loading in all modes
Accuracy	Same As Internal ± 0.1% Rating
Input Impedance	200 k Ω ± 1 %
BandWidth(-3dB)	Limited By Internal Transient Time
Remote Interface	GPIB / RS-232 / ETHERNET / USB
Programmable Protection	
Power (OPP)	
Range	(Px1.05/800) ~ (Px1.05) W
Resolution	(Px1.05/8000) W
Accuracy	0.50% +/- (P x 21 / 8000) W
Voltage (OVP)	
Range	(Vx1.05/1600) ~ (Vx1.05) V
Resolution	(Vx1.05/16000) V
Accuracy	0.20% +/- (Vx1.05/800) V
Current (OCP)	
Range	(Ix1.05/1600) ~ (Ix1.05) A
Resolution	(Ix1.05/16000) A
Accuracy	0.20% +/- (Ix1.05/800) A
Under Voltage Lockout (UVL)	
Mode	Input On / Continuous
Range	((V/4000*3) ~ Vmax) V
Resolution	(V/4000) V
Accuracy	2.50% +/- (V/800) V
Anti-Oscillation	Default/ Osc1/ Osc2/ Osc3/ Disable
Protection	
Over Power (OP)	(Px1.05) +/- (Px0.02) W
Over Voltage (OV)	(Vx1.05) +/- (Vx0.02) V
Over Current (OC)	(Ix1.1) +/- (Ix1.1x0.01/1.05) A
Over Temp (OTP)	50.00 +/- 5.000 °C
Reverse Max Current (RCP)	(Ix1.1) A
Short Max Current	(Ix1.02) A
Remote Inhibit (RI)	Short
Fault Indicator	SPDT Relay (30Vdc/0.5A or 125Vac/0.25A
General	
AC Input	95~240 Vac 48~62 Hz
Derating for higher temperatures	(-)1.67% Rated Power / °C
Operating Temperature	5 °C ~ 40 °C
Fluid	
Valve	Normal closed
Flow Rate (Pmax)	>= 1.5~9.0 GPM @ 15 °C Fluid In
Derating for higher temperatures	-3% Rated Power / °C
Pressure	< 80 PSI
Pipe Size	1/2” NPT Female (<=24kW models, 3/4” for higher power)
Decondensation	Valve thermal control
Transient Mode	
Frequency Range	0.100 - 10,000 Hz
Duty Range	1.000 - 100.0%
Transient Time Accuracy	10.0% +/- 50% of Min Time
Dielectric Strength	
Primary Circuit To Chassis	1500 Vac for 1 min
Primary Circuit To Load Terminal	1500 Vac for 1 min
Load Terminal To Chassis	1500 Vdc for 1 min

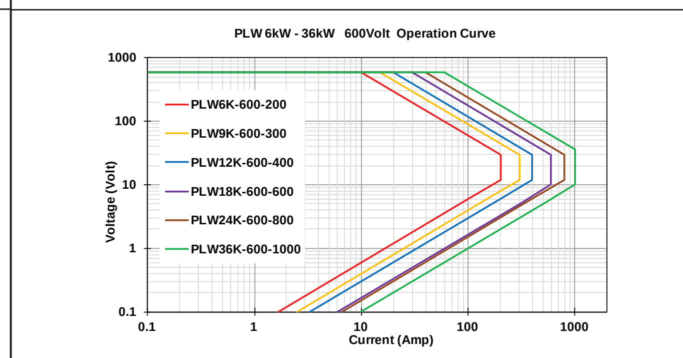
PLW Series : Operational Curves

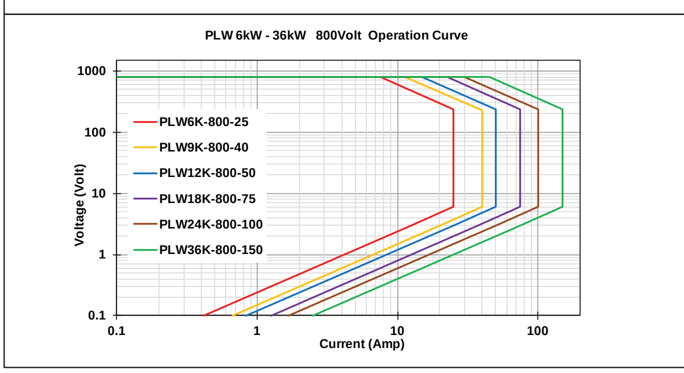
6–250 kW

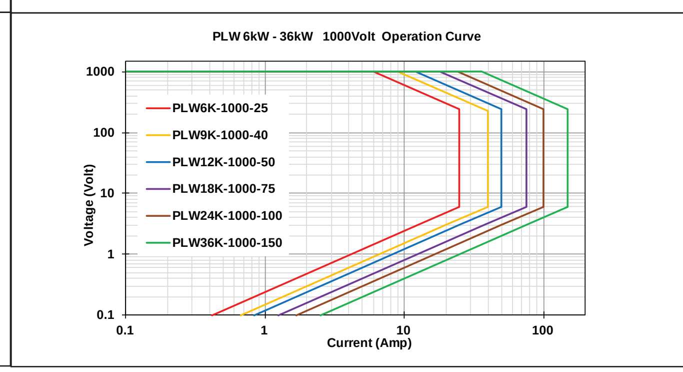












Notes

Sorensen SL Series

75 W–14.4 kW

DC and AC/DC Electronic Loads

60–500 V

1–720 A

∿	100	115	230

GPIB RS232

- Flexible Product Line
  - Low power DC modules
  - Low power AC modules
  - High power DC,
- Remote: GPIB, RS-232, Analog
- DC Modes: CC, CR, CV, CP
- AC Modes: CR, CC with crest factor control
- Dynamic mode with slew rate control
- Flexible Data Feedback
- Current monitor output (SLM DC only)

The Sorensen SL series electronic loads offer the best value with the most flexible platform. A wide range of loads are available from 75-1800W with both DC and AC input in benchtop, modular and standalone form factors.

SLM Mainframe
The SLM mainframe choices include a convenient single-bay configuration for benchtop/desktop applications or a four bay configuration for multichannel and ATE requirements. Either chassis is compatible with SLM- and SLD- loads. Each chassis contains non-volatile memory capable of storing up to 150 module setups and nine 16-step sequences for automated, standalone testing. Or for more complex test sequences, the chassis come with GPIB (optional on SLM-1) and RS-232 as standard interfaces.

SLM Family
The SLM family includes nine models of fully programmable, single input AC or DC modular electronic loads. DC models are offered to test power supplies, battery chargers, battery discharge, power supply transient response and integration into ATE systems. AC models are ideal to test low power inverters.

The DC models support operation in Constant Current (CC), Constant Voltage (CV), Constant Resistance (CR) or Constant Power (CP) mode as well as a short simulation. Engineers have ultimate control of current waveforms by using either the analog input or CC dynamic mode. An analog input (single input DC models) allows arbitrary current waveforms up to 20kHz with an external 0-10V signal. In dynamic mode, the pulse generator allows fast state switching between two programmed current levels with programmed slew rate and dwell times.

SLD Family
The SLD family offers six models of fully programmable, dual input modular electronic loads. These DC modules are specifically designed for low power, high channel count testing and provide the highest channel density available.

SLH Family
Fully programmable, high power AC or DC electronic loads. The 500V models are for PFC testing, power transformers and various other AC or DC power sources. The 300V models are used for testing of UPSs, automatic voltage regulators (AVR), and batteries.

- High current, 60V DC models for general purpose power supply testing
- High voltage,AC/DCmodels are intended for inverter test,
- Power Factor Correction (PFC) circuit testing (500V) and UPS testing (300V)

SL Series

Electronic Load Selection

Often the selection of programmable power supplies is based upon volts and amps capability. However when selecting an electronic load, it is important to account for volts, amps and power. The power limit is displayed on a constant power curve. A load must be selected so that the operating points are within the Power Curve (see Figure 1). For many applications in which different power sources are tested, there may be high voltage, low current requirements as well as low voltage, high current requirements. A single load may be able to handle both with good programming resolution. In cases where a single load may not work, the broad range of current, power and voltage available in the SL series allows optimum selection depending upon the voltage, current, power required.

Applications

Low Voltage Operation

All SL series loads operate well below 1V. However in many applications, such as fuel cell research and microprocessor voltage regulator modules (VRM), the voltage at the load inputs can be 0.1 to 0.2V. This low voltage does not allow the load transistors to fully turn-on (bottom right corner of the power contour). To utilize the full rated current of an electronic load, a boost supply can be placed in series to increase the voltage. While a fixed voltage DC-DC converter can be used as the boost supply, a programmable power supply is preferred to keep the load voltage at the minimum to draw full current as the device under test ramps up in voltage.

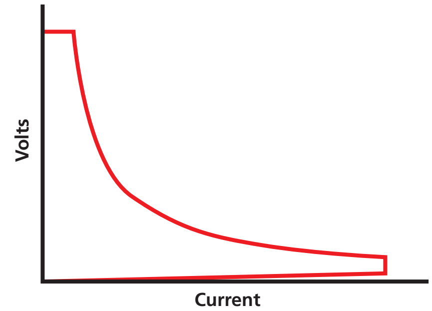
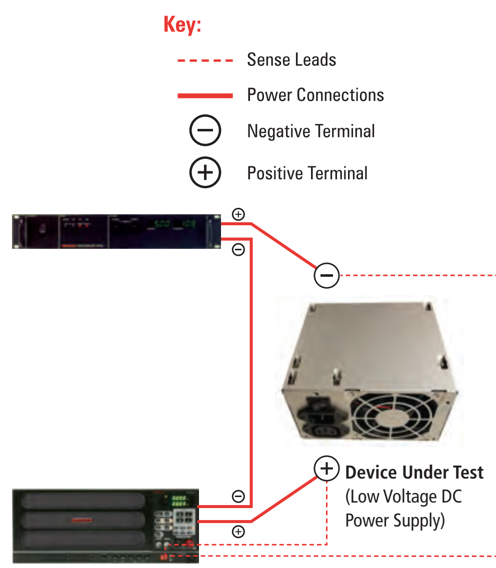


Figure 1 - Power Curve



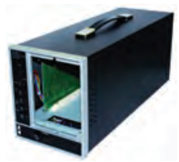
SLM-4: Chassis

SLM: DC Module

SLM: AC Module

SLD: Dual Input DC Module

SLD: Dual Input DC Module



SLM-1 Chassis

SLH: DC Electronic Load

SLH: AC Electronic Load

SL Series : Specifications

75 W–14.4 kW

SLH - Standalone AC Loads					
Model	**SLH-500-4-1200**	**SLH-500-6-1800**	**SLH-300-12-1200**	**SLH-300-12-1800**	**SLH-300-18-1800**
Input Ratings					
Power:	1200VA	1800VA	1200VA	1800VA	1800VA
Current:	4Arms	6Arms	12Arms	12Arms	18Arms
Voltage:	300Vrms / 500Vdc	300Vrms / 500Vdc	300Vrms	300Vrms	300Vrms
Frequency:	DC, 40 - 70Hz (CC Mode) ; DC - 70Hz (CR Mode)				
CC Mode					
Range:	0-2 / 2-4A	0-3 / 3-6A	0-6 / 6-12A	0-6 / 6-12A	0-9 / 9-18A
Resolution:	0.5 / 1mA	0.75 / 1.5mA	1.5 / 3mA	1.5 / 3mA	2.25 / 4.5mA
Accuracy:	±0.5% of (setting + range)				
Low Current:	0 - 0.2A	0 - 0.3A	0 - 0.6A	0 - 0.6A	0 - 0.9A
Accuracy:	±(0.5% of reading + 0.2% of range)				
Maximum Peak Current:	8A	12A	24A	24A	18A
CR Mode					
Range 1: (I>0.5% of rating)	50 - 200,000Ω	33.33 - 133,000Ω	20 - 80,000Ω	20 - 80,000Ω	13.3 - 53,333Ω
Range 2: (I>50% of rating)	12.5 - 50Ω	8.33 - 33.33Ω	5 - 20Ω	5 - 20Ω	3.33 - 13.33Ω
4 1/2 DVM					
Range:	0-500V	0-500V	300V	300V	300V
Resolution:	0.1V	0.1V	0.1V	0.1V	0.1V
Accuracy:	±(0.5% of reading + 0.2% of range)				
4 1/2 DAM					
Range:	0-4A	0-6A	0-12A	0-12A	0-18A
Resolution:	1mA	1mA	1mA	1mA	1mA
Accuracy:	±(0.5% of reading + 2% of range) ; ±0.5% of (reading + range) @ 50/60Hz				
4 1/2 Watt Meter					
Range:	0-1200W	0-1800W	0-1200W	0-1800W	0-1800W
Resolution:	0.1W				
Accuracy:	± (0.5% of reading)±3W				
VA / Power Meter:	Vrms × Arms				
Weight	18.5kgs/40.7lbs	21.5kgs/47.3lbs	18.5kgs/40.7lbs	21.5kgs/47.3lbs	21.5kgs/47.3lbs

SLM - AC Modules				
Model	**SLM-60-20-300**	**SLM-150-8-300**	**SLM-300-4-300**	**SLM-500-1-300**
Input Ratings				
Power:	300VA	300VA	300VA	300VA
Current:	20Arms	8Arms	4Arms	1Arms
Voltage:	60Vrms	150Vrms	300Vrms	300Vrms / 500Vdc
Frequency:	DC, 40 - 70Hz (CC Mode) ; DC - 70Hz (CR Mode)			
CC Mode				
Range:	0-10 / 10-20A	0-4 / 4-8A	0-2 / 2-4A	0-0.5 / 0.5-1A
Resolution:	2.5 / 5mA	1 / 2mA	0.5 / 1mA	0.125 / 0.25mA
Accuracy:	±0.5% of (setting + range)			
Low Current:	0 - 1A	0 - 0.4A	0 - 0.2A	0 - 0.05A
Accuracy:	±2% of (setting + range)			
Maxium Peak Current:	40A	16A	8A	2A
CR Mode (1)				
Range 1: (I>0.5% of rating)	1.2-4,800Ω	7.5-30,000Ω	30 - 120,000Ω	200 - 800000Ω
Range 2: (I>50% of rating)	0.3 - 1.2Ω	1.875 - 7.5Ω	7.5 - 30Ω	50 - 200Ω
4 1/2 DVM				
Range:	60V	150V	300V	500V
Resolution:	0.01V	0.01V	0.1V	0.1V
Accuracy:	±(0.5% of reading + 0.2% of range)			
4 1/2 DAM				
Range:	20A	8A	4A	1A
Resolution:	0.01A	0.001A	0.001A	0.001A
Accuracy:	±(0.5% of reading + 2% of range); ±0.5% of (reading + range) @ 50/60Hz			
4 1/2 Watt Meter				
Range:	300W			
Resolution:	0.1W			
Accuracy:	±(0.5% of reading)±3W			
VA / Power Meter:	Vrms × Arms			
Weight	3.5kgs/7.7lbs			

SL Series : Specifications

SLM - DC Modules

Model	SLM-60-30-150		SLM-60-60-300		SLM-250-10-300		SLM-500-10-300		SLM-60-15-75	
Input Ratings										
Voltage:	60V		60V		250V		500V		60V	
Current:	30A		60A		10A		10A		15A	
Power:	150W		300W		300W		300W		75W	
Minimum Voltage: (Full Current)	0.6V @ 30A		0.5V @ 60A		0.8V @ 10A		4.5V @ 10A		0.3V @ 15A	
CC Mode										
Range 1: | Range 2:	0-3A	0-30A	0-6A	0-60A	0-1A	0-10A	0-1A	0-10A	0-1.5A	0-15A
Resolution:	0.8mA	8.0mA	1.6mA	16.0mA	0.268mA	2.68mA	0.268mA	2.68mA	0.4mA	4.0mA
Accuracy:	± 0.2% of (Setting + Range)									
CR Mode										
Range 1: (I > 0.02% of RATING)	2-7.5KΩ		1-3.75KΩ		25-18.75KΩ		50-18.75KΩ		4-15KΩ	
Range 2: (I > 0.2% of RATING)	0.1067-2Ω		0.0534-1Ω		1.333-25Ω		2.67-50Ω		0.213-4Ω	
CV Mode										
Range:	0-60V		0-60V		0-250V		0-500V		0-60V	
Resolution:	0.016V		0.016V		0.067V		0.133V		0.016V	
Accuracy:	± 0.1% of (Setting + Range)									
CP Mode										
Range:	0-150W		0-300W		0-300W		0-300W		0-75W	
Resolution:	0.04W		0.08W		0.08W		0.08W		0.02W	
Accuracy:	± 0.5% of (Setting + Range)									
Short Mode:										
Resistance:	0.02Ω		8mΩ		0.08Ω		0.45Ω		0.02Ω	
Current:	30A		60A		10A		10A		15A	
Dynamic:										
T High & T Low:	50μs to 9.999s									
Rise/Fall of Range 1:	2.0-125mA/μs		4-250mA/μs		0.8-50mA/μs		0.8-50mA/μs		1.0-62.5mA/μs	
Rise/Fall of Range 2:	0.2-1.2A/μs		0.04-2.5A/μs		8.0-500mA/μs		8.0-500mA/μs		10-625mA/μs	
Accuracy:	± 10% of Setting									
4 1/2 DVM:										
Range:	15.0V	60.0V	15.0V	60.0V	30.0V	250.0V	199.99V	500.0V	15.0V	60.0V
Resolution:	0.001V	0.002V	0.001V	0.002V	0.001V	0.01V	0.01V	0.1V	0.001V	0.002V
Accuracy:	± 0.05% of (Reading + Range)									
4 1/2 DAM:										
Range:	3.0A	30.0A	6.0A	60.0A	1.0A	10.0A		10.0A	1.5A	15.0A
Resolution:	0.001A	0.01A	0.001A	0.01A	0.0001A	0.001A		0.001A	0.0001A	0.001A
Accuracy:	± 0.2% of (Reading + Range)									
Current Monitor:	3.0A/V		6.0A/V		N/A		N/A		1.5A/V	
Load ON Volt:										
Range:	0.1-25V				0.2-50V		0.4-100V		0.1-25V	
Resolution:	0.1V				0.2V		0.4V		0.1V	
Accuracy:	1% of Setting + 0.25V				1% + 0.5V		1% of Setting + 1V		1% of Setting + 0.25V	
Load OFF Volt:										
Range:	0-25V				0-50V		0-100V		0-25V	
Resolution:	0.01V									
Accuracy:	1% of Setting + 0.25V				1% + 0.5V		1% of Setting + 1V		1% of Setting + 0.25V	
Weight:	3.5kgs/7.7lbs									

SL Series : Specifications

75 W–14.4 kW

SLD - Dual Input DC Modules												
Model:	**SLD-60-505-255**		**SLD-61-505-255**		**SLD-80-20-102**		**SLD-61-5-752**		**SLD-62-5-752**		**SLD-60-105-550**	
Input Rating:												
Channel	A	B	A	B	A	B	A	B	A	B	A	B
Voltage (Volt)	+60V	+60V	+60V	-60V	+80V	+80V	+60V	-60V	-60V	-60V	+60V	+60V
Current (Ampere)	50A	5A	50A	5A	20A	20A	5A	5A	5A	5A	100A	5A
Power (VA)	250W	50W	250W	50W	100W	100W	75W	75W	75W	75W	500W	50W
Minimum Voltage (Full Current)	0.4V @ 50A	0.4V @ 5A	0.4V @ 50A	0.9V @ 5A	0.4V @ 20A	0.4V @ 20A	0.4V @ 5A	0.4V @ 5A	0.4V @ 5A	0.4V @ 5A	0.4V @ 100A	0.4V @ 5A
CC Mode:												
Range	0 - 5A / 50A	0 - 0.5A / 5A	0 - 5A / 50A	0 - 0.5A / 5A	0 - 2.0A / 20A	0 - 2.0A / 20A	0 - 0.5A / 5A	0 - 0.5A / 5A	0 - 0.5A / 5A	0 - 0.5A / 5A	0 - 10A / 100A	0 - 0.5A / 5A
Resolution	1.34 / 13.4mA	0.134 / 1.34mA	1.34 / 13.4mA	0.134 / 1.34mA	0.533 / 5.33mA	0.533 / 5.33mA	0.134 / 1.34mA	0.134 / 1.34mA	0.134 / 1.34mA	0.134 / 1.34mA	2.66 / 26.6mA	0.134 / 1.34mA
Accuracy	±0.2% of (Setting + Range)											
CR Mode:												
Range 1: (Ω) (I>0.02% of rating)	1.2 - 4500	12 - 45000	1.2 - 4500	12 - 45000	4 - 15000	4 - 15000	12 - 45000	12 - 45000	12 - 45000	12 - 45000	0.6 - 2250	12 - 45000
Range 2: (Ω) (I>0.2% of rating)	0.04-1.2	0.4-12	0.04-1.2	0.4-12	0.133-4	0.133-4	0.4-12	0.4-12	0.4-12	0.4-12	0.02-0.6	0.4-12
CV Mode												
Range	0 – 60V			0 – (-60)V	0 – 60V			0 – (-60)V			0 – 60V	
Resolution	16mV				21.3mV		16mV					
Accuracy	±0.2% of (Setting + Range)											
Short Mode												
Resistance	8mΩ	0.08Ω	8mΩ	0.18Ω	0.02Ω	0.02Ω	0.02Ω	0.06Ω	0.06Ω	0.06Ω	4mΩ	0.08Ω
Current	50A	5A	50A	5A	20A	20A	5A	5A	5A	5A	100A	5 A
Dynamic Mode												
T High / T Low	50μs to 9.999s											
Slew Rate (mA/μs)	4-200 40-2000	0.4-20 4-200	4-200 40-2000	0.4-20 4-200	1.6-80 16-800	1.6-80 16-800	0.4-20 4-200	0.4-20 4-200	0.4-20 4-200	0.4-20 4-200	8-400 80-4000	0.4-20 4-200
Resolution (mA/μs)	0.8 8	0.08 0.8	0.8 8	0.08 0.8	0.32 3.2	0.32 3.2	0.08 0.8	0.08 0.8	0.08 0.8	0.08 0.8	1.6 16	0.08 0.8
Accuracy	±(10% +10μs)											
4 1/2 DVM:												
Range	15V / 60.00V				20V / 80V		15V / 60.00V					
Resolution	0.001 V / 0.01 V											
Accuracy	±0.05% of (Reading + Range)											
4 1/2 DAM:												
Range	15A / 50A	1.5A / 5A	15A / 50A	1.5A / 5A	2.0A / 20A	2.0A / 20A	1.5A / 5A	1.5A / 5A	1.5A / 5A	1.5A / 5A	10 / 100A	1.5A / 5A
Resolution	1mA / 10mA	0.1mA / 1mA	1mA / 10mA	0.1mA / 1mA	0.1mA / 1mA	0.1mA / 1mA	0.1mA / 1mA	0.1mA / 1mA	0.1mA / 1mA	0.1mA / 1mA	1 / 10mA	0.1mA / 1mA
Accuracy	±0.2% of (Reading + Range)											
Load ON Voltage												
Range	0.1-25V											
Resolution	0.1V											
Accuracy	1% of Setting +0.25V											
Load OFF Voltage												
Range	0-25V											
Resolution	1mV											
Accuracy	1% of Setting +0.25V											

SL Series : Specifications

SLH - Standalone DC Loads							
Model	**SLH-60-120-600**	**SLH-60-120-1200**	**SLH-60-120-1800**	**SLH-60-240-1200**	**SLH-60-240-1800**	**SLH-60-360-1800**	**SLH-500-60-1800**
Input Ratings							
Voltage	60V						500 V
Current	120A			240A		360A	60 A
Power	600W	1200W	1800W	1200W	1800W	1800W	1800 W
Minimum Voltage (Full Current)	0.5V @ 120A	0.4V @ 120A	0.3V @ 120A	0.5V @ 240A	0.5V @ 240A	0.4 @ 360A	6V @ 60A
CC Mode							
Range	0-12 / 0-120A			0-24 / 0-240A		0 - 36 / 360A	0 - 6/60 A
Resolution	3.2 / 32mA			6.4 / 64mA		9.6 / 96mA	1.6/16 mA
Accuracy	±0.2% OF (SETTING + RANGE)						
CR Mode							
Range 1 (I>0.05% of rating)	0.5 - 1875Ω			0.25 - 937.50Ω		0.167 - 624.9Ω	8.33 - 18750Ω
Range 2 (I>0.5% of rating)	0.027 - 0.5Ω			0.0133 - 0.25Ω		8.3 - 167mΩ	0.444 - 8.33Ω
CV Mode							
Range	0 - 60V						0 - 500 V
Resolution	0.016V						0.133V
Accuracy	±0.1% OF (SETTING + RANGE)						
CP Mode							
Range	0 - 600W	0 - 1200W	0 - 1800W	0 - 1200W	0 - 1800W	0 - 1800W	0-1800W
Resolution	0.16W	0.32W	0.48W	0.32W	0.48W	0.48W	0.48W
Accuracy	±0.5% OF (SETTING + RANGE)						
Short Mode							
Maximum Resistance	4.2mΩ	3.3mΩ	2.5mΩ	2.1mΩ		1.1mΩ	0.1 Ω
Current	120A			240A		360A	60A
Dynamic Mode							
T High / T Low	50μs to 9.999s						
Slew Rate Low	8mA - 500mA/μs			16mA - 1A/μs		24mA - 1.5A/μs	4.8-300 mA/μs
Slew Rate High	80mA - 5A/μs			0.160A - 10A/μs		0.24A - 15A/μs	0.048-3.0 A/μs
Accuracy	±(10% OF SETTING +10μs)						
4 1/2 DVM							
Range	0 - 20.00 / 60.00V						0 - 60.00/600.0
Resolution	0.001 / 0.01V						0.01/0.1V
Accuracy	±0.05% OF (READING + RANGE)						
4 1/2 DAM							
Range	0 - 12A / 0 - 120A			0 - 24A / 0 - 240A		0 - 36A / 0 - 360A	0 - 6/60 A
Resolution	1mA / 4mA			1mA / 10mA		1.2mA / 12mA	0.001A/0.01A
Accuracy	±0.5% OF (READING + RANGE)						
Current Monitor	12A/V			24A/V		36A/V	N/A
Load ON Volt							
Range	0.1 - 25V						0.4 - 100V
Resolution	0.1V						0.4V
Accuracy	1% of SETTING +0.25V						
Load OFF Volt							
Range	0 - 25V						0 - 100V
Resolution	0.1V						
Accuracy	1% of SETTING +0.25V						
Weight	15.2kgs./33.4lbs	19.4kgs/42.7lbs	23.6kgs/51.9lbs	19.4kgs/42.7lbs	23.6kgs/51.9lbs	23.6kgs/51.9lbs	23.6 kgs. / 51.9 lbs.

SL Series : Specifications

75 W–14.4 kW

Common	
Software	LabVIEW Driver can be downloaded at no cost: www.elgar.com/products/SL/SL_Downloads.htm
Regulatory	Certified to UL/CSA 61010 and IEC/EN 61010-1, CE Compliant (LVD and EMC Directives)
Environmental	Operating Temperature: 0˚ to 40˚C Storage Temperature: -10˚ to 65˚C
Cooling	Front, Side, Top Air Inlets, Rear Exhaust, Units may be rackmounted without spacing.
SLH Memory	150 Settings for DC, 5 Settings for AC
Readback	Voltage, Current, Power: 16-bit resolution, VA: Vrms x Arms
Analog Input	SLM: DB9 connector, SLH: BNC connector. DC, Single Input (SLH or SLM), CC Mode: 0-10V = 0 – FS, Bandwidth: 20kHz, Sums Current with Programmed Value
AC (SLH or SLM)	Sync signal on zero crossing
Remote Programming	SLM-1: RS-232C, GPIB (Optional), SLM-4: RS-232C, GPIB, analog, SLH: RS-232C, GPIB, analog
Dynamic Mode (DC Models) (see Figure 4)	Mode: CC, T-high, T-low: 50 μs to 9.999 sec, Slew Rate: See Specification Tables, I high, I low: 0 to Rated Current
Options and Accessories	-1: GPIB, SLM-1 or SLM-4 only -01: 100/200V AC input, SLM-1 only -11: 100/200V AC input and GPIB M12: Front panel bus bar, SLH DC only M23: Front panel bus bar and 100/200V AC Input, SLH DC only
Input Power	
Line:	115V / 230V ± 10%, switch selectable or 100V / 200V ± 10% switch selectable (optional)
Frequency:	50 / 60Hz
Power Consumption	100W Maximum
Protection: AC input fuses	
OVP, OCP, OPP:	~5% above rated maximum
OTP:	~85°C Heat sink temperature
DC Loads:	Reverse Polarity All protection modes turn off LOAD input
Hardware Input Voltage Limit:	60V Rated DC Input: 100V, 250V Rated DC Input: 400V, 500V Rated DC and all AC Input: 900V
SLM Chassis	
Memory	150 memory settings for DC modules, 5 memory settings for AC modules, Memory settings store entire chassis condition
Sequencer (see Figure 2)	
Control	Front panel
Timing	100ms-9.9 secs per step
Maximum Steps per Sequence	16
Number of Sequences	9
Programming	
All Parameters	12-bit resolution
AC Crest Factor (see Figure 3)	Sinewave: √2, 1.5-3.5, Resolution: 0.1 Squarewave: 1.0-3.4, Resolution: 0.1
DC	√2, 2.0-3.5, Resolution: 0.5
Maximum Peak	Current = 2 x Rated Current

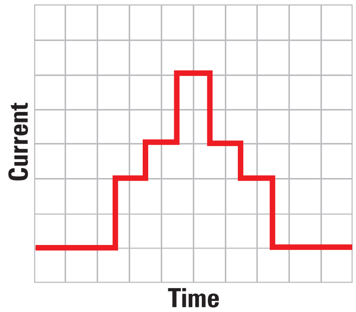


Fig.2 - Sequencer for Modules

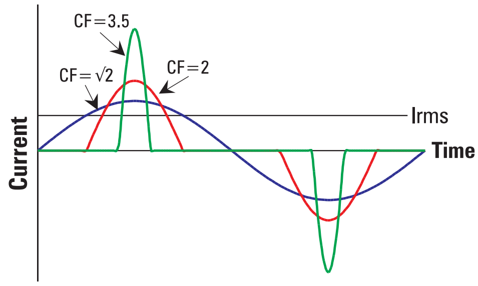


Fig.3 - Crest Factor for AC models

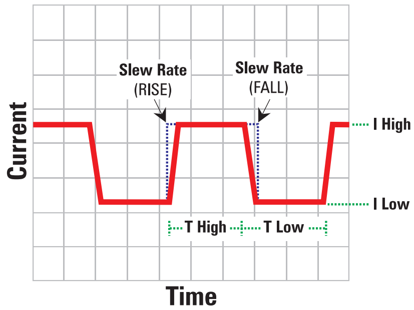


Fig.4 - Dynamic Mode for DC models

SL Series 75 W–14.4 kW

SL X - VVV - CCC - PPPP - (-11)

Type
M = modular
D = Dual Input
H = High Power

Voltage

Current

Maximum Power (watts, VA)

100/200V AC Input (SLH only)

SLH Stand Alone DC Loads	
Model Number	Description
SLH-60-120-600	60V / 120A / 600W rack mounted, programmable DC load
SLH-60-120-1200	60V / 120A / 1200W rack mounted, programmable DC load
SLH-60-120-1800	60V / 120A / 1800W rack mounted, programmable DC load
SLH-60-240-1200	60V / 240A / 1200W rack mounted, programmable DC load
SLH-60-240-1800	60V / 240A / 1800W rack mounted, programmable DC load
SLH-60-360-1800	60V / 360A / 1800W rack mounted, programmable DC load
SLH-500-60-1800	500V / 60A / 1800W rack mounted, programmable DC load
SLH-500-4-1200	500Vdc/300Vrms / 4A / 1200W rack mounted, programmable DC load
SLH-500-6-1800	500Vdc/300Vrms / 6A / 1800W rack mounted, programmable AC/DC load
SLH-300-12-1200	300Vrms / 12A / 1200W rack mounted, programmable AC/DC load
SLH-300-12-1800	300Vrms / 12A / 1800W rack mounted , programmable AC/DC load
SLH-300-18-1800	300Vrms / 18A / 1800W rack mounted , programmable AC/DC load

All SLH models include rackmount handles with ears.

SLM - 4 - aa bb cc dd - 1 (1)

Number of Mainframe Bays
1 = Single Bay Chassis
4 = Four Bay Chassis

Bay 1 Module

Bay 2 Module

Bay 3 Module

Bay 4 Module

100/200V AC Input

Programming Interface
0 = RS-232C Only
1 = GPIB / RS-232C

SLM & SLD Modular Loads		
Code	Module / Chassis	Description
C	SLM-4	Mainframe Chassis, Four (4) Bay for SLM, SLD modular loads includes GPIB/RS-232C
C	SLM-1	Mainframe Chassis, Single bay for SLM, SLD modular loads
10	SLM-60-30-150	DC Module, 60V / 30A / 150W
11	SLM-60-60-300	DC Module, 60V / 60A / 300W
12	SLM-250-10-300	DC Module, 250V / 10A / 300W
14	SLM-500-10-300	DC Module, 500V / 10A / 300W
15	SLM-60-15-75	DC Module, 60V / 15A / 75W
32	SLD-80-20-102	DC dual input module, 80V / 20A / 100W x 2
30	SLD-60-505-255	DC dual input module, 60V / 50A / 250W, 60V / 5A / 50W
31	SLD-61-505-255	DC dual input module, 60V / 50A / 250W, -60V / 5A / 50W
33	SLD-61-5-752	DC dual input module, 60V / 5A / 75W, -60V / 5A / 75W
34	SLD-62-5-752	DC dual input module, -60V / 5A / 75W x 2
35xx	SLD-60-105-550	DC dual input module, 60V / 100A / 500W, 60V / 5A / 50W
50	SLM-60-20-300	AC/DC Module, 60V / 20A / 300W
51	SLM-150-8-300	AC/DC Module, 150V / 8A / 300W
52	SLM-300-4-300	AC/DC Module, 300V / 4A / 300W
53	SLM-500-1-300	AC/DC Module, 500Vdc/300Vrms / 1A / 300W
BB	SLM-BB	Blank Panel

California Instruments 3091LD

3000–12000 VA

3000VA Programmable AC Loads

50–350 VRMS

30 ARMS

- **Multi-mode AC Electronic Load**
  Flexible solution for a wide range of AC power test applications
- **3000 Watt Power Dissipation**
  Master / Auxiliary configurations for higher power and multi phase applications
- **50 to 350 V, 45 Hz to 440 Hz**
  Commercial, Military and Avionics applications
- **Programmable Crest & Power Factor**
  Test AC power products for real-world conditions
- **Built-in Measurements**
  Eliminates the need for additional test equipment in bench or ATE applications
- **Remote Control**
  IEEE-488 and RS232C Interface for automated test applications

AC Loads
The 3091LD is designed to provide precisely controlled, non-linear loads for testing AC power generation equipment such as UPS's and AC sources. In addition, any active or passive current carrying devices such as switches, circuit breakers, fuses, connectors and power semiconductors can be tested. Traditionally, many of these products are tested using resistive load banks. This approach does not simulate real-world conditions such as switching DC/AC converters found in many AC powered products. This type of conventional testing does not fully exercise the equipment under test (EUT) under worst case operating conditions. High peak currents and low power factor loads can significantly impact the operating characteristics of a UPS or AC power product. The 3091LD AC Load can simulate high crest factor and variable power factor load conditions. This provides an effective method of testing AC products against real-world conditions and can significantly increase product reliability. Unless properly exercised, product defects may go undetected until a unit is used at a customer site, resulting in costly field returns.

Front Panel Control
The AC load can be operated from an easy to use, menu driven front panel. Product tests can be performed quickly in an R&D setting by punching up specific load conditions on the front panel and reading the measurement screen of the 3091LD. This fast interactive front panel control mode can be used during a product's early development cycle to isolate potential performance problems before the product leaves the engineering lab.

Automated Testing
The 3091LD can be deployed in ATE test stations using either IEEE-488 or RS232C remote control. The industry standard SCPI (Standard Commands for Programmable Instrumentation) protocol is used and instrument drivers are available to ease test software development. The built-in metering functions of the 3091LD AC load can be used to eliminate the need for additional test equipment such as meters, power analyzers and oscilloscopes.

This and the reduced size of the 3091LD compared to passive load banks, represents a savings in both cost and rack space.

Power Levels
Each 3091LD is capable of dissipating 3000 W of single phase AC power. For higher power or three phase applications, a 3091LD master unit can be combined with one or more auxiliary 3091 units. The master 3091LD unit provides the required consolidated measurements so the test system controller - or the operator - need only interface to the master unit, regardless of the specific configuration. Single, split or three phase configurations can be software configured from the master 3091LD when combined with 3091 slave units.

User Control
All AC load modes are easily set from the front panel using a menu-driven user interface. The large LCD screen is used to display setup information as well as measurement data. Measurements include volt RMS, volt peak, current RMS, current peak, crest factor, true power, apparent power, power factor and frequency. Both voltage and current waveforms at the load input terminals can be digitized and displayed on the front panel graphical LCD. This allows EUT output behavior to be

3091LD

analyzed quickly without the need to hook up additional test equipment. A Windows graphical user interface (GUI) is provided to expand the measurement and display capabilities of the 3091LD. The GUI can be used to save and print test results for report purposes.

Crest Factor and Power Factor control
When operating in constant current or constant power mode, the 3091LD supports crest factor control by narrowing the conduction angle of the current waveform in order to match the requested crest factor. Thus, the peak current is increased while retaining the RMS current level. While the apparent power remains constant, the true power decreases. This results in a reduced true power factor. Consequently, as crest factor is increased, the true power factor automatically decreases. The load further controls power factor by shifting the current with respect to the input voltage (displacement power factor). Both leading and lagging power factor control is available. A phase shift of the current is only possible if the crest factor is higher than 1.414. Thus, crest factor and power factor control ranges are coupled as shown in the graph to the right.

Front Panel
The large LCD screen is used to display setup information as well as measurement data.

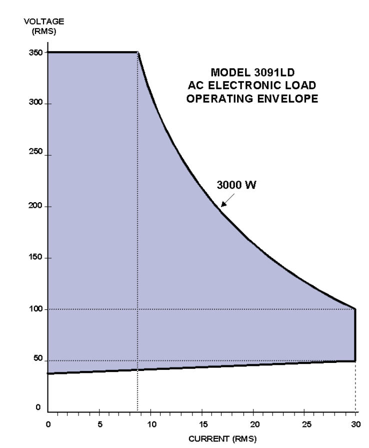
The 3091LD can be used to emulate a wide variety of AC load conditions to support real-world testing and evaluation of UPS and AC source products. Specifically, the following modes can be selected:

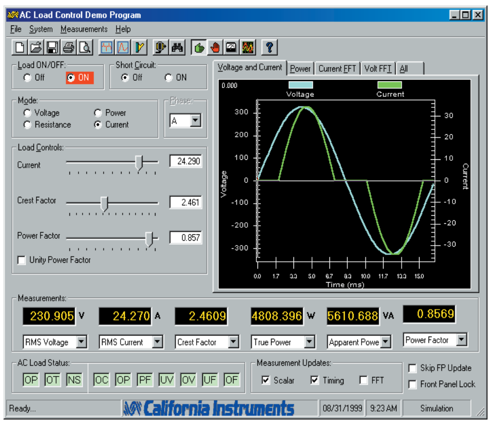
Mode		Description
Constant Power	CP	This mode effectively emulates constant power loads such as switching power supplies
Constant Resistance	CR	Emulates a conventional resistive load or power resistor. A programmable range from 2.5 Ohms to 1000 Ohms covers a wide range of applications. This mode can be used to replace conventional resistive load banks.
Constant Current	CC	Provides a constant current load. This mode may be used to simulate both linear (resistive) and non-linear (active loads for voltage regulation testing.
Constant Voltage	CV	This mode emulates a shunt regulator load and may be used to test current source products.
Short circuit	SC	Test the short circuit protection mode of the EUT by providing a short condition. The 3001LD can handle surge currents of up to 300 Amps for up to 50 msec and sustained currents of 30 Amps in this mode of operation. The low voltage cut-off of the load can be programmed from 50 Volts up.

Measurements include volt RMS, volt peak, current RMS, current peak, crest factor, true power, apparent power, power factor and frequency. Both voltage and current waveforms at the load input terminals can be digitized and displayed on the front panel graphical LCD. This allows EUT output behavior to be analyzed quickly without the need to hook up additional test equipment. A Windows graphical user interface (GUI) is provided to expand the measurement and display capabilities of the 3091LD. The ICS can be used to save and print test results for report purposes.

Power & Crest Factor Control Range

Load Power Rating curve for 3091LD





3091LD : Specifications

3000–12000 VA

Ratings	
Power	3000 W @ 0-37° C; 2400 W @ 38-50° C
Current	30 ARMS
Voltage	50 to 350 VRMS
Frequency	45 to 440 Hz
Max. Peak Power	13 kW (up to 20% duty cycle)
Max. Peak/Surge Current	90 APEAK Surge: 300 APEAK for 50 ms
Max. Peak Voltage	500 VPEAK
Operating Modes	
Constant Current	Range: 0 to 30 ARMS; Accuracy: 0.2 % of full scale; Resolution: 0.05 % of full scale; Min. Set Current: Voltage / Maximum Set Resistance
Constant Voltage	Range: 50 to 350 VRMS; Accuracy: 0.2 % of full scale; Resolution: 0.05 % of full scale
Constant Resistance	Range: 2.5 to 100 Ohms, 100 to 1000 Ohms; Accuracy: 1% FS, 5% FS; Resolution: 0.05 % FS; Max. Set Resistance: 1 / (Freq.*1.3e-5)
Constant Power	Range: 3000 W @ 0-37° C,2400 W @ 38-50° C; Accuracy: 0.5% of full scale; Resolution: 0.1% of full scale
Crest Factor	Range: 1.4142 to 4.0, limited to 90 Apeak; Accuracy: 1 % of full scale; Resolution: 0.1 % of full scale
Power Factor	Range: 0 to 1 lead or lag limited by Crest factor settings; Accuracy: 1 % of full scale; Resolution: 0.1 % of full scale
Shourt Circuit Mode	Max. Surge current: 300 APEAK, up to 50 msec; Max. Cont. current: 30 ARMS; Max. Voltage drop: 2.5 VRMS
Measurements	
Frequency	Range: 45 to 440 Hz; Accuracy: 0.1% FS; Resolution: 0.05% FS
Voltage	Range: 50 to 350 VRMS; Accuracy: 0.1% FS; Resolution: 0.05% FS
Peak Voltage	Range: 50 to 500 V; Accuracy: 0.5% FS; Resolution: 0.1% FS
Current	Range: 0 to 30 ARMS; Accuracy: 0.2% FS; Resolution: 0.1% FS
Peak Current	Range: 0 to 90A; Accuracy: 0.5% FS; Resolution: 0.1% FS
Crest Factor	Range: 1,4142 to 4.0; Accuracy: 0.5% FS; Resolution: 0.1% FS
Apparent Power	Range: 0 to 3000 VA; Accuracy: 0.5% FS; Resolution: 0.1% FS
True Power	Range:0 to 3000 W; Accuracy: 0.5% FS; Resolution: 0.1% FS
Peak Power	Range: 0 to 45,000 W; Accuracy: 1% FS; Resolution: 0.1% FS
Reactive Power	Range: 0 to 3000 VA; Accuracy: 0.5% FS; Resolution: 0.1% FS
Power Factor	Range: 0 to 1; Accuracy: 0.5% FS; Resolution: 0.1% FS
Resistance	Range: 2.5 to 100 Ohms,100 to 1000 Ohms; Accuracy: 1% FS, 5% FS; Resolution: 0.05% FS
Protection	
Over Current	Limited by input - Circuit Breaker and Set Maximum Current Limit in software.
Over Voltage	Output protected for voltage transients over 500 V in hardware.
Over Power	Power limited at maximum average and peak rated power in hardware. Limited to Set Maximum Power Limit in software.
Over Temperature	Monitors heat sink temperature.
Mechanical Specifications	
Dimensions	H: 8.75” (222 mm), W: 16.88” (429 mm), D: 25“ (635 mm)
Weight	74 lbs / 34 Kg.
Remote Sensing	Max. 2V drop between sense and load lines
Isolation	1000 V between input and chassis ground
Audible Noise (@1meter)	Audible Noise (@ 1meter): Low power: 49.0 dBA; Full power: 69.5 dBA
Control Power Input	115 Vac or 230 Vac (model -230) ± 10%, 47 to 63Hz
Operating Temperature	3000 W @ 0-37° C, 2400 W @ 39-50° C
Interfaces	
GPIB	Standard

Note: Specifications are subject to change without notice. Specifications are warranted over an ambient temperature range of 25°± 5° C. Unless otherwise noted, specifications are per phase for a sinewave with a resistive load and apply after a 30 minute warm-up period. For three phase configurations, all specifications are for L-N. Phase angle specifications are valid under balanced load conditions only.

3091LD

Ordering Examples:
1 x 3091LD-RMS
2 x 3091-RMS

Three unit, 9000 Watt system with rack slides.
3091LD-RMS-230

Remote Control

IEEE-488.2	GPIB talker, listener Subset: AH1, C0, DC1, DT1, L3, PP0, RL2, SH1, SR1, T6
Language:	SCPI
	RS232C
Baud rates:	9600, 19200, 38400
Handshake:	RTS/CTS
Format:	8,n,1
Language:	SCPI

Options:

-230	AC Line input 230 V L-N. Must be specified at the time of orignial order.
-BTM	Bench Top Model. No handles and rack mount ears. Must be specified at the time of orignial order.
-MSK	Master/Auxiliary Cable Kit Required to use 3091LD as auxiliary unit.
-RMS	Rack Mount Slides
C1-CS	Cabinet. Add prefix "C" to model number to order a rack mounted system.

Note: For rack mounting, option -RMS is recommended.

Single table top unit rated for 230 V L-N input.

Supplied with:
- Instruction / Programming Manual
- Windows™ Graphical User Interface
- Load Input Connector
- RS232C Serial Cable

AC and DC Sources
Expand your AC test systems with line input immunity testing of voltage sags, surges, swells and drop-outs using the California Instruments iX Series of programmable AC and DC power sources. The iX Series is an ideal companion product to the LD Series AC loads, providing 3000 VA to 30 kVA of AC power.

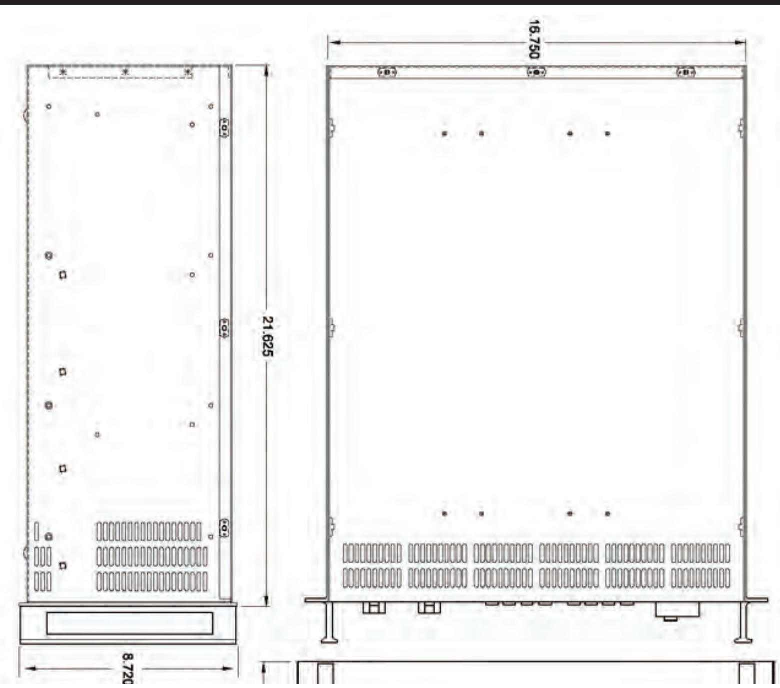
Features include arbitrary waveforms, transient generation and extensive measurements.

Configurations
Higher power AC loads or multi phase AC loads can be created by combining one 3091LD master with one or more 3091 auxiliary units in a rack system. Contact factory for system configuration information.

Standard controller versions with single voltage range

Model	Output	Input Voltage
3091LD	3000 W AC Load	115V
3091	3000 W AC Load Auxiliary	115V

3091LD Dimensions



AC/DC Modular Power Supplies

Notes

Elgar ReFlex Power™ Series

Modular Programmable AC/DC/Loads Power System

- Truly Modular Design
- Digital System and Power Converter Control
- Control up to 95 assets across 8 mainframes
- Control multiple AC and DC power supplies and loads in one or more mainframes
- Create "virtual assets"
- Highest Power Density
- World-wide AC or DC input

≋ ∿ Universal AC/DC

LXI ETHERNET

ReFlex Power™ is a high density, modular programmable power system providing DC, AC and electronic load assets all under control of a single controller. It provides a reconfigurable, flexible platform ideal for ATE and production test environments where RFP™ can provide programmable stimulus and bias power as well as programmable loads for the device(s) under test.

The EIA 4U high RFP™ Mainframe can hold up to 12 single-slot modules or combinations of single, dual and triple slot wide modules to configure (or reconfigure) the system for the particular requirements at hand. The mainframe can support up to 6 kW of output power.

Up to 8 mainframes, potentially up to 95 modules, can be controlled via a single controller. The controller communicates to the individual modules via a high speed proprietary bus protocol. The RFP™ controller communicates to the host controller via an Ethernet LAN connection designed in compliance with the LAN Extension for Instrumentation (LXI™) standard, assuring interoperability and ease of integration.

Virtual Output Channels

By using the powerful ReFlex Power software, the modules can be combined via the controller in series or parallel groups, or series / parallel arrays to form new assets, or "virtual outputs." This can be accomplished "on the fly" within a test program, with no need to shut down and reconfigure modules.

This unique capability greatly extends the operating range of a ReFlex Power System, and establishes a new power stimulus paradigm. Virtual output channels reduce the overall asset count in any particular system, while increasing the range of voltage and currents available for DUT stimulus.

Virtual channels can be set up across mainframes, and multiple virtual channels can reside in a single mainframe or system.

By implementing this functionality in test systems or as part of an overall test strategy, users can reduce both up-front capital costs, as well as long term supply chain, logistics and support costs.

Available power modules include

Single slot, 330 Watt programmable DC supplies
- 16V, 20.6A
- 65V, 5.1A

Dual slot, 1kW programmable DC supplies
- 33V, 30A
- 50V, 20A
- 50V, 25A
- 120V, 8.3A
- 450V, 2.3A

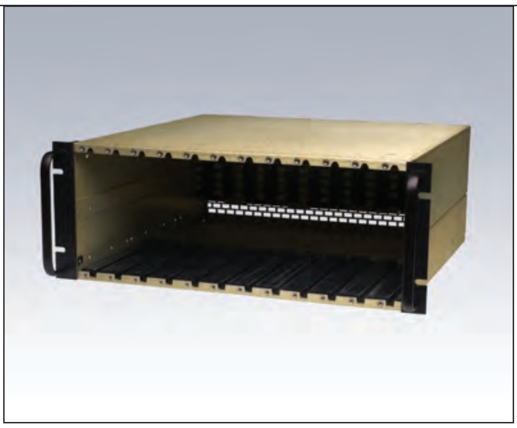
Triple slot, 875 VA, single phase, programmable AC supply
- Dual range: 280V AC, 3.5A AC
- Dual Range: 140V AC, 7A AC

Triple slot, 500V, programmable electronic DC loads
- 375 Watt, 500V, 15A
- 375 Watt, 500V, 30A

Elgar ReFlex Power™ Series

Universal 12 Slot Mainframe

- Worldwide input voltage capability
  - 270 VDC input with relay control
- Input power and connectors for system expansion
- Fully configurable
- No active components
- Power output up to 3600W / 6000W



The ReFlex Power System™ Mainframe consists of 12 fixed pitch "slots" for insertion of AC, DC or Active load modules and the Controller which are one, two, or three "slots" wide.

Very compact in size, 4RU by 17.00" deep, the mechanical design is ruggedized for harsh environments including mobile applications as well as general-purpose industrial and laboratory rack-mount ATE.

The Mainframe connectors on the rear panel facilitate the connection to the AC mains and provide for extending the system to multiple frames, (up to eight). There are no active components in the mainframe, therefore once installed, would not normally have to be uninstalled. It also accommodates the easy populating of the user system with the various power assets. The mainframe also contains the proprietary RFP backplane.

Any RFP module can be installed in any slot(s) in the mainframe. There is no Slot 0 designated in the power system for the controller. It can be installed in any location depending on the users desired configuration.

The Mainframe is available in three versions. The basic rack mount version, which installs flush with the front of a cabinet, a version which is set back by 4.0" to allow for cable space at the front of the cabinet, and a version which removes the front panel mounting ears to facilitate installation in portable systems. The setback version includes an optional removable front dress panel.

Two Slot 1000W / 1250W DC Power Modules	
Mainframe Model Number	**Description**
RFP-M0000-001-0000	12 Slot Mainframe
RFP-M0000-001-1E00	12 Slot Mainframe with 90 ° input connector
RFP-M0000-001-1J00	12 Slot Mainframe with 90 ° input connector. No rack ears
RFP-M0000-REC-0000	12 Slot RECessed Mainframe with front dress panel
RFP-M0000-REC-1E00	12 Slot RECessed Mainframe with front dress panel and 90 ° input connector.
RFP-M0000-REC-2J00	12 Slot RECessed Mainframe with front dress panel and 90 ° input connector. No rack ears.
RFP-M0000-REC-1K00	12 Slot RECessed Mainframe with front dress panel
5609184-01	12 Slot RECessed Mainframe with DC input relay connector
5380059-01	Chassis interconnect cable 36 inches **
5380059-02	Chassis interconnect cable 97 inches **
5380059-03	Chassis interconnect cable 135 inches **
Mainframe Optional Accessories	
Part Number	**Description**
5380059-01	Chassis Slot Blanking Module
	AC Power Cords
5380317-01	2 M unterminated Power Cord w/ mainframe connector mate
5380554-01	2 M unterminated Power Cord for single-phase 125V, 20A connection
5380555-01	2 M unterminated Power Cord for single-phase 250V, 20A connection
5380556-01	2 M unterminated Power Cord for three-phase 120V/208V, 30A connection
	AC Mating Connector Kit
5380318-01	AC Input mainframe connector mate

All specifications are subject to change

Elgar ReFlex Power™ Series

Common	
Module Interface Backplane	Slot Positions: 12 slots Multi-module control interface
Configuration Guidelines	Up to 8 Chassis may be interconnected. Paralleled AC, DC and Load modules must be in adjacent slots and be like modules AC modules to be configured for multi-phase operation must be in adjacent slots.
Regulatory	Certified to UL 61010-1, CSA C22.2 No. 61010.1 and IEC/EN 61010-1. Compliance with EN61326 and FCC 21 CFR, Subpart J CE Mark is to EMC and LVD
Input	
Universal Input	AC 1 phase:115/120/200/208/230V ±10% AC 3 phase: 115/200 or 120/208V ±10% delta and wye AC 3 phase: 230/400V ±10% wye – neutral AC Voltage Range: 103.5V to 253V DC Voltage Range: 210V to 300V (314V for 2 sec.) Power Factor: ≥0.95
Frequency range	47Hz to 63Hz, DC
Input Connector	Amphenol, DL3102A24-10P
Mating Connector	Amphenol, DL3106A24-10P, Input cable and mating connector kits available
Environmental (Extended range available)	
Operating Temperature	-10° C to 50° C
Storage Temperature	-40° C to 70 °C
Humidity Range	95%, non-condensating
Altitude	up to 2,000 M
Shock and vibration	Class 3 Mil-PRF-28800F
Physical : Module Sizes	
Dimensions Single Slot	1.4” (35.6mm) W - 6.75” (171.5mm) H - 15” (381 mm) D
Dimensions Dual Slot	2.8” (71.1) W - 6.75” (171.5mm) H - 15” (381 mm) D
Dimensions Triple Slot	4.2” (106.7mm) W - 6.75” (171.5mm) H - 15” (381 mm) D

Common ReFlex Power Applications

Rackmount ATE Systems
High power density, a large number of output channels and 16-bit resolution, all under the control of a single Ethernet controller, greatly simplifies ATE system integration. The wide variety of voltage and current combinations and power density, created by up to 12 separately programmable DC channels in a compact 4U system, makes RFP the most compact ATE power system on the market. Combining this with the RFP AC and load channels in the same chassis and under the same controller, RFP can elegantly satisfy your most demanding ATE system power stimulus requirements.

Product Development
Testing and burn-in of aircraft flight hardware, DC-DC converters, automotive electronics and semiconductor components are just a few applications currently being tested with RFP. From simple DC voltage set points and AC sine waves to complex waveforms and triggers, RFP keeps pace with your product development power stimulus challenges.

Aerospace Testing
ReFlex Power is ideal for testing all types of flight hardware and aircraft auxiliary systems. AC power modules can be operated in single or three phase mode, and expanded from 875 VA single phase to 2,625VA three phase, or even 5,250 VA. By combining variable frequency AC power signals from 45 to 5,000Hz with DC assets in a single 4U mainframe, most modern avionics power stimulus can be delivered.

Process Control
Whether you are driving magnets for controlling ion beams for the manufacture of semiconductors or driving a current through electrolyte for precise control of a plating process, RFP is your ideal process control choice. RFP’s small footprint with flexible configuration of DC, AC and load modules can solve the most complex process control challenges.

Research
A research environment presents some of the most demanding requirements on your test instrumentation. RFP’s flexible sequencing and triggering supports your research needs. All too often, equipment that meets the needs of your current project does not meet the needs of your next project. RFP with its modular design protects your capital assets. The RFP architecture allows you to change to different DC voltage and current combinations, add AC and load modules and parallel and phase-lock modules. This allows RFP to support all your current and future laboratory needs.

All specifications are subject to change

Elgar ReFlex Power™ System Controller

Programmable System Control Module

- LXI Ethernet interface
- SRQ functionality embedded in VISA layer
- Operates as instrument or socket connection
- Up to 16 individual sessions simultaneously
- One controller for up to 95 discrete power assets
- Modular
- IVI drivers available

The ReFlex Power™ (RFP™) System Controller (RFPC) provides a single command and status communication port for all power assets (power supplies and loads) within the RFP™ system. The RFP™ architecture is essentially a distributed processor system, and the role of the RFPC is command interpreter and redirector, plus manager of module status messages.

The unique features of the RFP™ system of configurability and extensibility are made possible through the use of the latest in controls technology. An FPGA-based implementation uses VHDL, embedded processor cores for firmware based systems control, ARCnet™ inter-module communication and LAN system communications.

The LAN network interface conforms to IEEE 802.3 standard, and is certified LXI class C compliant. Network transmission rates up to 100 Mbps conforming to 10 BASE-T and 100 BASE-TX specifications are supported. The RFP™ Controller (RFPC) module functions under remote control through a host controller. The module serves as a communications portal between the power supply modules and the remote host controller. All aspects of operation can be achieved through use of commands that comply with the requirements of the SCPI Standard 1999 command language.

Additional discrete digital control signals are available for dedicated hardware interface. All connectors for control are accessible on the front panel.

Single Slot LXI Ethernet Controller Module

Control Module Model Number	Description
RFP-C1LAN-000-0000	LXI Ethernet Interface: Ver 2 Firmware
RFP-C1LAN-000-1F00	LXI Ethernet Interface: Ver 2 Firmware + Ext'd Operating Temperature
RFP-C1LAN-000-001B	LXI Ethernet Interface: Ver 3 Firmware
RFP-C1LAN-000-1F1B	LXI Ethernet Interface: Ver 3 Firmware + Ext'd Operating Temperature

Control Module Model Optional Accessories

Part Number	Description
5380441-01	Controller 15-pin Dsub 9 foot cable
5380441-03	Controller 15-pin Dsub 9 foot cable (90 degree bend)
5380509-01	Controller interlock shorting connector (Don't order w/ cable (5380441-xx) above)
5380269-01	Connector Mating Kit

Ethernet Controller General Specifications

Function	Description
Modules Controlled	AC, DC and active Load Modules in RFP Mainframe(s)
Command Language	SCPI Standard 1997 command language via downloadable IVI Drivers
Control Interface	To host: LXI class C Ethernet
	To Module: Proprietary high speed bus protocol
Front Panel Switch	Standby switch, disables output but does notdisconnect the input power
Front Panel Connectors	Interface Connector: Subminiature D
Input	VIA RFP backplane: Hold-up-time: 10ms

Elgar Reflex Power™ System DC Power Modules

1000 W

Programmable 1000 / 1250W High Power DC Modules and Accessories

33 - 450 V

2.3 - 30 A

∿ Universal AC/DC

- Near Linear Performance
- Truly Modular
- ≥0.95 PFC
- Digital control loop technology
- High Power Density (3.5 watts/cubic inch)
- "Virtual Assets" by:
  - Series operation
  - Parallel operation
  - Combined operation with loads
- Precision Hardware & Software Triggers
- Simple integration

The High Power DC supplies of the ReFlex Power™ (RFP™) system include models rated at 1kW and 1250W. They are part of a modular family of power assets that integrate into the RFP™ Mainframe to provide a wide range of features, functionality, and extensive configurability and adaptability.

The modules can be programmed to operate as standalone assets, or in combinations of parallel, series, and series / parallel groups to extend their voltage, current, and power ratings. System shut down is not required to implement groups and multiple groups can be set up in a single system. This "on the fly" characteristic sets the ReFlex Power™System apart from competitive products.

The DB-9 connector on the front panel of each module provides variety of hardware interface lines. Included are Direct Fault Interrupt (DFI), Remote Inhibit (RI) and Trigger IN / Trigger OUT signals. Safety, ease of integration and functionality are significantly enhanced by these functions.

The DFI signal can be programmed to provide shutdown of modules in fault groups established by the user.

Used together or individually, these signals can be utilized to improve system performance, increase test through-put, reduce system idle time and assure the highest level of safety for the Device Under Test.

RFP™ system of DC power supplies brings true modularity to DC power assets, and makes possible a high degree of configurability and adaptability through a mainframe-based architecture. The mechanical design is ruggedized for harsh environments, including mobile applications, as well as general-purpose industrial and laboratory rack-mount ATE.

An advanced thermal design features integral, variable speed fans. Cooling performance scales based upon the complement of modules in the Mainframe and their output loading. This feature conserves energy, minimizes audible noise and enhances system reliability.

Two Slot 1000W / 1250W DC Power Modules

1000W / 1250W Model Number	Description	Firmware Version
RFP-D2033-030-1G00	33Vdc, 30A, w/ Output Relay	Ver 2 Firmware
RFP-D2033-030-2D00	33Vdc, 30A, w/ Output Relay + Ext'd Operating Temperature	Ver 2 Firmware
RFP-D2050-020-1G00	50Vdc, 20A, w/ Output Relay	Ver 2 Firmware
RFP-D2050-020-2D00	50Vdc, 20A, w/ Output Relay + Ext'd Operating Temperature	Ver 2 Firmware
RFP-D2050-025-1G00	50Vdc, 25A, w/ Output Relay	Ver 2 Firmware
RFP-D2050-025-2D00	50Vdc, 25A, w/ Output Relay + Ext'd Operating Temperature	Ver 2 Firmware
RFP-D2120-8A3-1G00	120Vdc, 8.3A, w/ Output Relay	Ver 2 Firmware
RFP-D2120-8A3-2D00	120Vdc, 8.3A, w/ Output Relay + Ext'd Operating Temperature	Ver 2 Firmware
RFP-D2450-2A3-1G00	450Vdc, 2.3A, w/ Output Relay	Ver 2 Firmware
RFP-D2450-2A3-2D00	450Vdc, 2.3A, w/ Output Relay + Ext'd Operating Temperature	Ver 2 Firmware
RFP-D2033-030-1G1B	33Vdc, 30A, w/ Output Relay	Ver 3 Firmware
RFP-D2033-030-2D1B	33Vdc, 30A, w/ Output Relay + Ext'd Operating Temperature	Ver 3 Firmware
RFP-D2050-020-1G1B	50Vdc, 20A, w/ Output Relay	Ver 3 Firmware
RFP-D2050-020-2D1B	50Vdc, 20A, w/ Output Relay + Ext'd Operating Temperature	Ver 3 Firmware
RFP-D2050-025-1G1B	50Vdc, 25A, w/ Output Relay	Ver 3 Firmware
RFP-D2050-025-2D1B	50Vdc, 205, w/ Output Relay + Ext'd Operating Temperature	Ver 3 Firmware
RFP-D2120-8A3-1G1B	120Vdc, 8.3A, w/ Output Relay	Ver 3 Firmware
RFP-D2120-8A3-2D1B	120Vdc, 8.3A, w/ Output Relay + Ext'd Operating Temperature	Ver 3 Firmware
RFP-D2450-2A3-1G1B	450Vdc, 2.3A, w/ Output Relay	Ver 3 Firmware
RFP-D2450-2A3-2D1B	450Vdc, 2.3A, w/ Output Relay + Ext'd Operating Temperature	Ver 3 Firmware

Elgar ReFlex Power™ Series

Optional Module Accessories and Output Cables

Ametek offers output load cables for each RFP™ module type. Cables mate directly to the modules and are 3 M land and unterminated. The cables are sized appropriately for the rated module current and include sense leads.

Also available are mating connector kits for each connector type used in the system. A module interlock shorting connector must be installed in order to enable any module. These are provided free of charge, but must be ordered on the purchase order.

DC Power Module Optional Accessories	
Part Number	Description
5380444-01	16Vdc 9 foot output cable
5380444-03	16Vdc 9 foot output cable - 90 degree bend for shorter bend radius
5380445-01	65Vdc 9 foot output cable
5380445-03	65Vdc 9 foot output cable - 90 degree bend for shorter bend radius
5380446-01	33Vdc/50Vdc 9 foot output cable
5380446-03	33Vdc/50Vdc 9 foot output cable - 90 degree bend for shorter bend radius
5380453-01	120Vdc 9 foot output cable
5380453-03	120Vdc 9 foot output cable - 90 degree bend for shorter bend radius
5380447-01	450Vdc 9 foot output cable
5380447-03	450Vdc 9 foot output cable - 90 degree bend for shorter bend radius
5380443-01	Module 9-pin D-sub 9 foot cable
5380443-03	Module 9-pin D-sub 9 foot cable (90 degree bend)
5380508-01	Module interlock shorting connector (Don't order w/ cable (5380443-xx) above)
5380270-01	16Vdc Connector Mating Kit
5380270-02	65Vdc Connector Mating Kit
5380271-01	33Vdc/50Vdc Connector Mating Kit
5380271-03	120 Vdc Connector Mating Kit
5380271-02	450Vdc Connector Mating Kit
AC Power Module Optional Accessories	
Part Number	Description
5380450-01	AC 9 foot output cable
5380450-03	AC 9 foot output cable - 90 degree bend for shorter bend radius
5380443-01	Module 9-pin D-sub 9 foot cable
5380443-03	Module 9-pin D-sub 9 foot cable (90 degree bend)
5380508-01	Module interlock shorting connector (Don't order w/ cable (5380443-xx) above)
5380272-01	AC Output Connector Mating Kit
Active Load Module Optional Accessories	
Part Number	Description
5380452-01	DC Loads 9 foot output cable
5380443-01	Module 9-pin D-sub 9 foot cable
5380443-03	Module 9-pin D-sub 9 foot cable (90 degree bend)
5380508-01	Module interlock shorting connector (Don't order w/ cable (5380443-xx) above)
5380273-01	DC Load Connector Mating Kit
5380272-01	AC Output Connector Mating Kit

Elgar Reflex Power™ System
DC Power Modules

330 W

Programmable 300W Low Power DC Modules and Accessories

16 - 65 V

5.1 - 20.6 A

Universal AC/DC

LXI ETHERNET

- Near Linear Performance
- Truly Modular
- ≥0.95 PFC
- Digital control loop technology
- High Power Density (3.5 watts/cubic inch)
- "Virtual Assets" by:
  - Series operation
  - Parallel operation
  - Combined operation with loads
- Precision Hardware & Software Triggers
- Simple integration

The Low Power DC supplies of the ReFlex Power™ (RFP™) system iare rated at 330W, They are part of a modular family of power assets that integrate into the RFP™ Mainframe to provide a wide range of features, functionality, and extensive configurability and adaptability.

The modules can be programmed to operate as standalone assets, or in combinations of parallel, series, and series / parallel groups to extend their voltage, current, and power ratings.

The DB-9 connector on the front panel of each module provides variety of hardware interface lines. Included are Direct Fault Interrupt (DFI), Remote Inhibit (RI) and Trigger IN / Trigger OUT signals. Safety, ease of integration and functionality are significantly enhanced by these functions.

The DFI signal can be programmed to provide shutdown of modules in fault groups established by the user.

Used together or individually, these signals can be utilized to improve system performance, increase test through-put, reduce system idle time and assure the highest level of safety for the Device Under Test.

RFP™ system of DC power supplies brings true modularity to DC power assets, and makes possible a high degree of configurability and adaptability through a mainframe-based architecture. The mechanical design is ruggedized for harsh environments, including mobile applications, as well as general-purpose industrial and laboratory rack-mount ATE.

An advanced thermal design features integral, variable speed fans. Cooling performance scales based upon the complement of modules in the Mainframe and their output loading. This feature conserves energy, minimizes audible noise and enhances system reliability.

Single Slot 300W DC Power Modules

300W Model Number	Description	Firmware Version
RFP-D1016-021-1G00	16Vdc, 20.6A, w/ Output Relay	Ver 2 Firmware
RFP-D1016-021-2D00	16Vdc, 20.6A, w/ Output Relay + Ext'd Operating Temperature	Ver 2 Firmware
RFP-D1065-5A1-1G00	65Vdc, 5.1A, w/ Output Relay	Ver 2 Firmware
RFP-D1065-5A1-2D00	65Vdc, 5.1A, w/ Output Relay + Ext'd Operating Temperature	Ver 2 Firmware
RFP-D1016-021-1G1B	16Vdc, 20.6A, w/ Output Relay	Ver 3 Firmware
RFP-D1016-021-2D1B	16Vdc, 20.6A, w/ Output Relay + Ext'd Operating Temperature	Ver 3 Firmware
RFP-D1016-021-1G1B	65Vdc, 5.1A, w/ Output Relay	Ver 3 Firmware
RFP-D1016-021-2D1B	65Vdc, 5.1A, w/ Output Relay + Ext'd Operating Temperature	Ver 3 Firmware

ReFlex Power™ DC Power Modules : Specifications

DC Modules General Specifications	
Regulation	
Steady State, Voltage Mode	0.01% of full-scale + 10mV (330W) and 0.03% of full-scale (1/1.2kW) for 10% line or 100% load change
Steady State, Current Mode	0.05% of full scale (330W) and 0.1% of full-scale (1/1.2 kW) for 10% line change. Less than 0.1% of full-scale for 100% load change
Load Transient	<5% of full scale maximum excursion returning to steady state value within 0.5% of full scale in 2 ms maximum, for 90% load step above and below 50% nominal load.
Remote Sense	Up to 3V total load line drop. The drop in the load leads subtracts from the maximum voltage available for the load.
Parallel Operation	Up to six like modules.
Series Operation	Up to five like modules for 16V, 65V; Up to three like models for 33V, 50V, 120V, Float not to exceed 200V (16V, 33V, 50V, 120V), 300V (65V), 450V (450V). Note: 120V and 450V cannot be placed in series.
Sag/Surge/Hold Up Time	Sag to 65% of nominal for 450ms at full output power with AC input at ≥200VAC. Surge to 135% of nominal for 450ms at full output with AC input ≤230VAC. 10ms hold up at loss of input: 8ms hold up for 50V above 20A.
Remote programming connector	9-pin D-sub miniature
Power Output Connector	Combination signal/power contact subminiature D (Output cables and Mating Connector kits available)
Trigger Latency	5 micro-seconds typical.

DC Low Power		
Output Voltage	0-16V	0-65V
Maximum Output Current	20.6A	5.1A
Maximum Power	330W	330W
Output rise/fall time	20msec	20msec
Mainframe Slots	1	1
Ripple / Noise		
RMS (20 Hz - 300 kHz)	5mV	6mV
Peak-Peak (20 Hz - 20 MHz)	25mV	18mV
Programming Accuracy		
Voltage (0.05% of setpoint + ...)	10mV	32.5mV
Current (0.1% of setpoint + ...)	21mA	5.1mA
Resolution	0.47 mV/1.28 mA	1.9 mV/0.32 mA
Temperature Coefficient		
Voltage /°C	1.6mV	6.5mV
Current /°C	5mA	1mA

DC High Power					
Output Voltage	0-33V	0-50V	0-50V	0-120V	0-450V
Maximum Output Current	30A	20A	25A*	8.3A	2.3A
Maximum Power	990W	1000W	1250W*	996W	1035W
Output rise/fall time	20msec	20msec	20msec	20msec	20msec
Mainframe Slots	2	2	2	2	2
Ripple / Noise					
RMS (20 Hz - 300 MHz)	15mV	20mV	20mV	20mV	40mV
Peak-Peak (20 Hz - 20 MHz)	60mV	75mV	75mV	75mV	200mV
Programming Accuracy					
Voltage (0.05% of setpoint + ...)	16.5mV	25mV	25mV	60mV	225mV
Current (0.2% of setpoint + ...)	30mA	20mA	25mA	10mA	2.3mA
Resolution	2 mV/1.9 mA	3 mV/1.3 mA	3 mV/1.6 mA	7 mV/0.6 mA	28 mV/0.14 mA
Temperature Coefficient					
Voltage /°C	3.3mV	5mV	5mV	12mV	45mV
Current /°C	9mA	6mA	7.5mA	2.5mA	0.7mA

* 1250 Watt module must have an AC Input voltage above 188 VAC or DC input above 210 VDC. The Module will not operate below the required input line voltage.

All specifications are subject to change

Elgar ReFlex Power™ AC Power Modules

875 VA

High Density Programmable AC Power Modules

140–280 VAC

3.5–7 Arms

Universal AC/DC

LXI ETHERNET

- Single or multi-phase output
- Parallel operation up to 5250 VA, 3 phase
- 4.8 Crest factor
- Digital control loop technology
- Brown out protection to 65% of nominal input line
- Up to 875 VA
- 45 to 1200 Hz or 5000 Hz
- Universal AC/DC input via mainframe

The ReFlex Power™ (RFP™) system includes an AC power source rated at 875VA with two output voltage ranges, 0-140VAC and 0-280VAC.

This AC source module is part of a modular family of power assets that integrate into the RFP™ Mainframe to provide a wide range of features, functionality and extensive configurability and adaptability.

The AC module can be set up to operate as a standalone asset, in combinations of parallel or in multi-phase groups to extend their voltage, current, and power rating.

The DB-9 connector on the front panel of each module provides Remote Inhibit (RI). This allows the user to turn on / off individual modules with a hardware interface. This function enhances safety and ease of integration.

The RFP AC Power module provides a very robust output, with surge rating of 140% (5A / 7A or 7A / 10A) and a crest factor rating of 4.8:1.

Two frequency options are available to satisfy most avionics, commercial and industrial test requirements; 45Hz to 1200Hz or 45 to 5000Hz. The module utilizes high-frequency power conversion for high efficiency to maximize power density and realize lightweight and small size.

Weighing only 11.4 lb., a three phase 2625 VA power system weighs only 50lbs. and can be expanded to 5250 total VA in only 8U of rack elevation.

An advanced thermal design features integral, variable speed fans. Cooling performance scales based upon the complement of modules in the Mainframe and their output loading. This feature conserves energy, minimizes audible noise and enhances system reliability.

Three Slot 875VA AC Power Modules

AC Model Number	Description	Firmware Version
RFP-A301K-875-1G00	875VA, 45-1.2 kHz w/ Output Relay	Ver 2 Firmware
RFP-A301K-875-2D00	875VA, 45-1.2 kHz w/ Output Relay + Ext'd Operating Temperature	Ver 2 Firmware
RFP-A305K-875-1G00	875VA, 45-5.0 kHz w/ Output Relay	Ver 2 Firmware
RFP-A305K-875-2D00	875VA, 45-5.0 kHz w/ Output Relay + Ext'd Operating Temperature	Ver 2 Firmware
RFP-A301K-875-1G1B	875VA, 45-1.2 kHz w/ Output Relay	Ver 3 Firmware
RFP-A301K-875-2D1B	875VA, 45-1.2 kHz w/ Output Relay + Ext'd Operating Temperature	Ver 3 Firmware
RFP-A305K-875-1G1B	875VA, 45-5.0 kHz w/ Output Relay	Ver 3 Firmware
RFP-A305K-875-2D1B	875VA, 45-5.0 kHz w/ Output Relay + Ext'd Operating Temperature	Ver 3 Firmware

ReFlex Power™ AC Power Modules : Specifications

AC Modules General Specifications	
Continuous Current	7A, maximum for 0-140VAC range, 3.5A, maximum for 0-280VAC range.
Surge Current	10A, maximum for 0-140VAC range up to 125VAC, derated linearly to 8.93A at 140VAC; 5A, maximum for 0-280VAC range up to 250VAC, derated linearly to 4.46 at 280VAC, time duration of 0.5s, maximum.
Frequency	45-1200 Hz, up to 5 kHz optional
Crest Factor	4.8 X FS rms current
Voltage Regulation, Line & Load	Voltage mode 0.1% of full scale. 100% resistive load change or 10% line change from nominal.
Programming Accuracy	Voltage +/-(0.1% + .2%/kHz) of full scale from 0.25% to 102% of range; Current +/-(0.5% + 0.75%/kHz) of full scale from 2% to 102% of range; Frequency (0.01% + 0.01%/kHz) of setpoint
Programming Resolution	Voltage 0-140VAC 20mV, 0-280 40mV Current 5mA Frequency 0.1Hz thru 1kHz; 0.5Hz thru 5KHz
Temperature Drift	Voltage .05% of full scale per °C Current .05% of full scale per °C
Voltage Distortion (Resistive Load)	<1% to 500Hz <2% to 2kHz <5% to 5kHz
Output DC Offset	0.1VDC maximum
Efficiency	(72% - 1.4%/kHz) at full output power and 115VAC input, and no load on auxiliary output, typical
Noise	55dB below full scale, typical; RMS value measured with output at 50Hz and with a bandwidth from 10kHz to 20MHz
Hold-up time	Dropout of AC input to zero for 10ms at full output power
Remote Sense	0.75Vrms per load line
Overvoltage Protection	Range: 1.4% to 110% Accuracy: 2% of setpoint
Overcurrent Protection	Range: 0.4% to 106% Accuracy: 3% of setpoint
Auxiliary AC Output	Isolated, 0Vac to 31.6Vac, 2A max, tracks main output (140 VAC range) at 22.6% of output from 350Hz - 1kHz
Cooling	required at full load & max temperature. 40CFM airflow at altitude and ambient temperature
Parallel Operation	Up to 6 Modules (must be located contiguously in mainframe.)
Multi-phase Operation	Up to 6 Delta and wye loads are supported. Modules must be configured as wye sources (neutrals connected).
Phase Programming Range	0-360 degree; with respect to A-phase; any module could be an A-Phase (the master); adjacent modules to the right of A-Phase would be B-Phase and C-Phase; counterclockwise phasor rotation is assumed, therefore the phase angle offset is lagging the master reference.
Phase Programming Accuracy	1 degree plus 1°/kHz for balanced resistive load measured with respect to A-phase
Remote programming connector	9-pin D-sub miniature
Output connector	Combination signal/power contact subminiature D (Out cables and mating connector kits available)

All specifications are subject to change

Elgar ReFlex Power™ Active Load Modules

375–750 W

High Density Programmable Active Load Modules

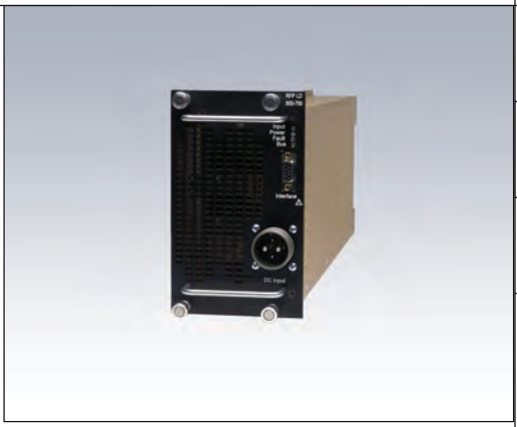
500 V

15–30 A

Universal AC/DC

LXI ETHERNET

- High Voltage (500V) Input
- Digital control loop technology
- Two models: 375 W & 750 W
- Up to 15 A or 30 A
- Parallel up to 8 automatically
- Modular
- High Power Density
- Simple integration



The High Power Active Load (HPAL) and the Low Power Active Load (LPAL) of the ReFlex Power™ (RFP™) system include models rated at 750 W and 350 W. They are part of a modular family of power assets that integrate into the RFP™ Mainframe to provide a wide range of features, functionality, and extensive configurability and adaptability.

The 500V provide an exceptlional range of operation. They can be set up to operate as standalone assets, or in combinations of parallel groups to extend their current, and power ratings up to as high as 180 A and nearly 4000W in a single mainframe.

The DB-9 connector on the front panel of each module provides Remote Inhibit (RI). This allows the user to turn on / off individual modules with a hardware interface. This function enhances safety and ease of integration. Remote analog programming is also available, allowing the user to modulate the load with a hardware line.

The modules utilize FET active current sinks in modular form to get the flexibility of the two power ranges. The 375 W module is housed in a triple-width enclosure, and weighs 8.2 lb. The 750 W module is also triple-width, and weighs 12.9 lb.

Two modes of operation are available.
Current mode up to 30A and resistive mode, programmable 0 to 5000 ohms in three ranges. In addition, each Active Load can be controlled independently with an analog signal to control or modulate the output with an external signal.

An advanced thermal design features integral, variable speed fans. Cooling performance scales based upon the complement of modules in the Mainframe and their output loading. This feature conserves energy, minimizes audible noise and enhances system reliability.

Three Slot 500V, 15A or 30A Active Load Modules

Active Load Model Number	Description	Firmware Version
RFP-D3500-375-1G00	500Vdc, 15A w/ Output Relay	Ver 2 Firmware
RFP-D3500-375-2D00	500Vdc, 15A w/ Output Relay + Ext'd Operating Temperature	Ver 2 Firmware
RFP-D3500-750-1G00	500Vdc, 30A w/ Output Relay	Ver 2 Firmware
RFP-D3500-750-2D00	500Vdc, 30A w/ Output Relay + Ext'd Operating Temperature	Ver 2 Firmware
RFP-D3500-375-1G1B	500Vdc, 15A w/ Output Relay	Ver 3 Firmware
RFP-D3500-375-2D1B	500Vdc, 15A w/ Output Relay + Ext'd Operating Temperature	Ver 3 Firmware
RFP-D3500-750-1G1B	500Vdc, 30A w/ Output Relay	Ver 3 Firmware
RFP-D3500-750-2D1B	500Vdc, 30A w/ Output Relay + Ext'd Operating Temperature	Ver 3 Firmware

ReFlex Power™ Active Load Modules : Specifications

DC Loads Modules General Specifications	
Physical	Size: 3 RFP Slots, Weight 8.2 lbs (375W); 12.9 lbs (750W)
Connectors	DC Input and Sense: MS3106F-20-24S Remote Programming: 9 pin D-Sub (Output cables and mating connector available)
Current Stability	<0.1% of full scale after 8 hrs
Current Temperature Drift	<0.05% of full scale/°C
Protection	Overvoltage: 525V ± 3%, Overcurrent: 20A ± 3% (375W), 40A ± 3% (750W) Overpower: 19-394W ± 5% (375W), 38 – 788W ± 5% (750W), Reverse Voltage: -15V ± 1V
Parallel Operation	Up to 8 modules.
Noise	30mA (pk-pk) (375W), 90mA (pk-pk)(750W), 20 Hz to 20 MHz bandwidth
Programming Response Time	55ms
Dynamic Response (10 - 90%/90 to 10%)	50µs
Remote Sense	0.75V per source line
Max Float Voltage	500VDC any input terminal to chassis
Cooling	Internal fans, require 110 CFM minimum airflow with full power and at maximum altitude and ambient temperature
All specifications	25°±5°C.

Digital Voltage Measurement	
Range	0-500V
Resolution	33mV
Accuracy	0.1% of FS

Digital Current Measurement	375W	750W
Range	0-15A	0-30A
Resolution	1.0mA	2.0mA
Accuracy	0.3% of full scale	0.3% of full scale

Current Mode	375W	750W
Range	0-15A	0-30A
Resolution	1.0mA	2.0mA
Digital Programming Accuracy	0.3% of full scale	0.3% of full scale
Regulation	0.1% of full scale for 100% load change	0.1% of full scale for 100% load change

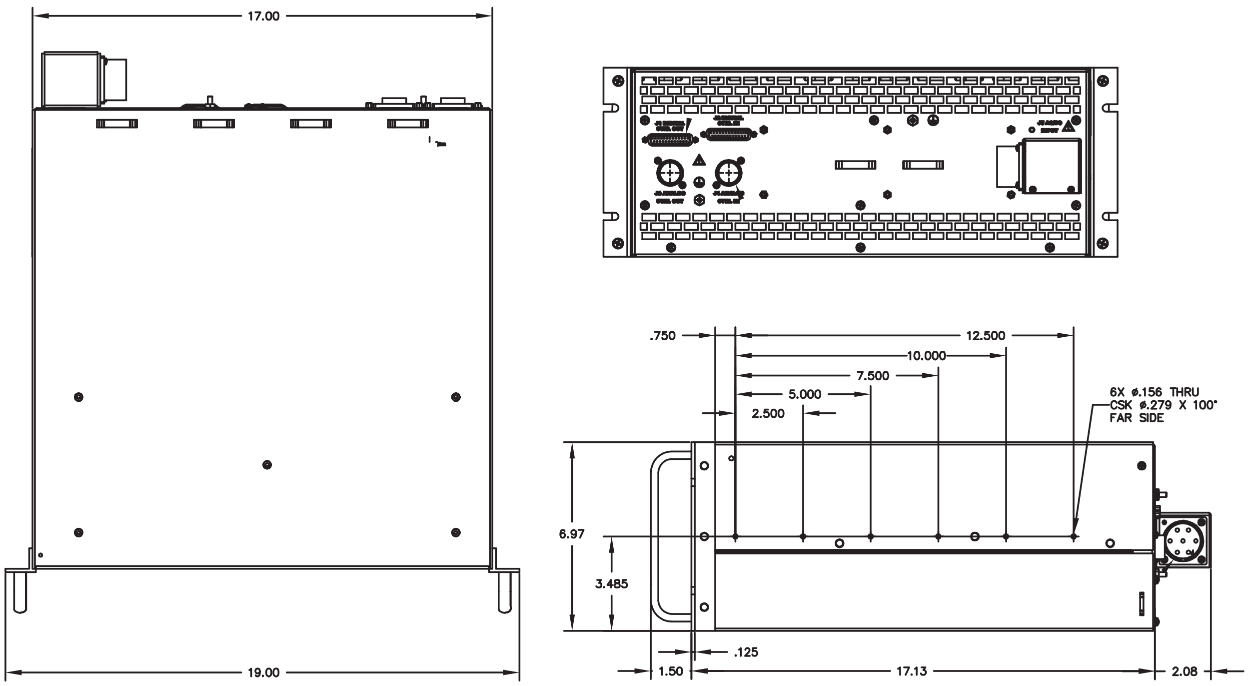
Resistance Mode	
Range 1, Resolution	1-99Ω, 1Ω resolution with Current ≥ 1% of FS
Range 2, Resolution	100-1000Ω, 100Ω full scale resolution with Current ≥ 1% of FS
Range 3, Resolution	1000-5000Ω, 1000Ω full scale resolution with Current ≥ 1% of FS
Digital Programming Accuracy	5% of setpoint. full scale with Current ≥ 10% of FS
Load Transient	60 msec to set point

Analog Control (Current Mode)	
Range	0 to 10V = zero to full scale
Accuracy	0.3% of full scale + digital accuracy
Bandwidth	8kHz @ -3dB

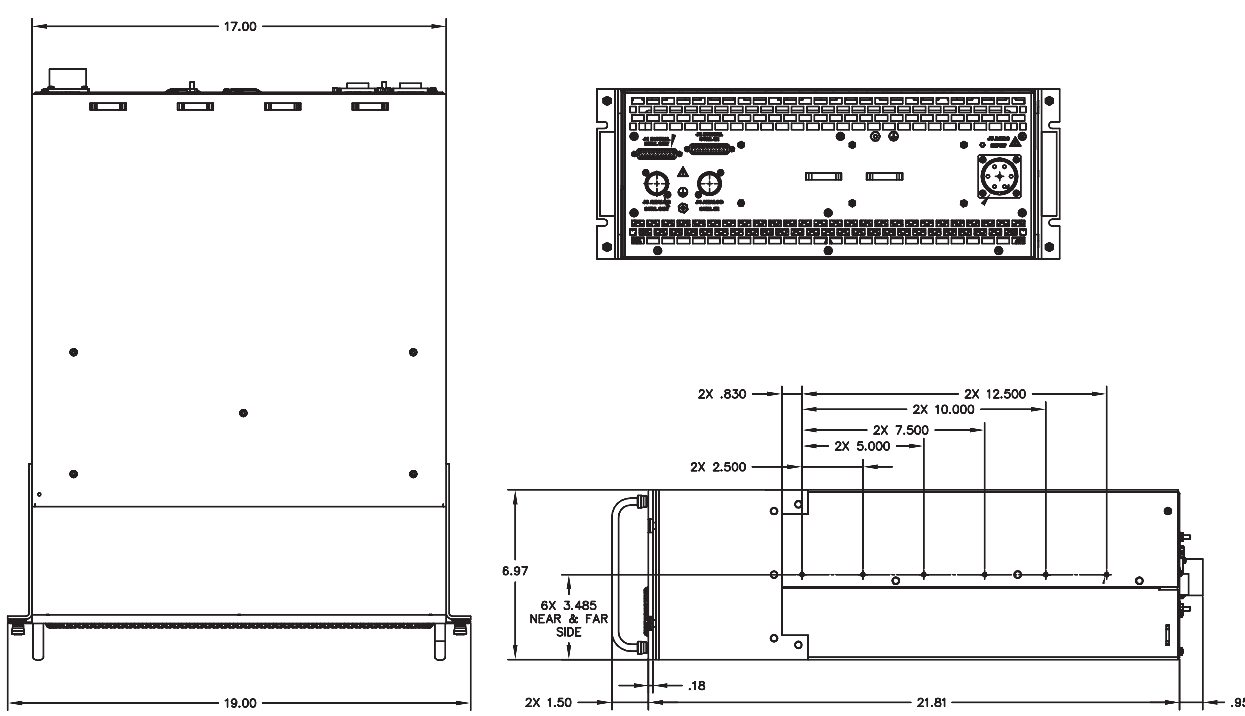
DC Input Ratings	375W	750W
Voltage	500V	500V
Current	15A	30A
Power	375W	750W
Min Voltage, Full Load	3V	3V

All specifications are subject to change

Elgar ReFlex Power™ Diagram

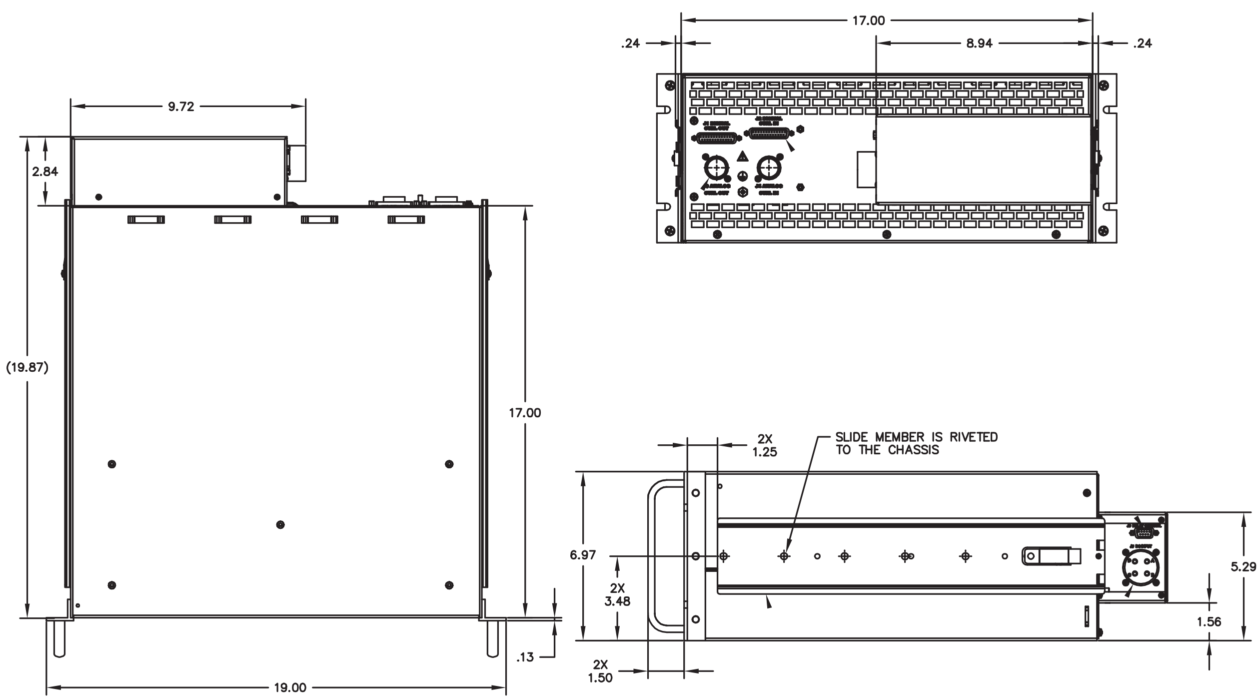


Standard Chassis with 90 degree connector shown



Recessed Chassis with straight connector shown

Elgar ReFlex Power™ Diagram



5609184-01 Chassis (DC input with contactor and 90 degree input connector)

ESG

Engineered Solutions Group

Notes

Engineered Solutions

When Requirements Go Beyond the Catalog

AMETEK Programmable Power provides engineered solutions that require "outside the box" thinking, and sometimes far outside the box development. We work directly with our customers to develop application specific solutions through modified standard products, integrated power systems using standard products, or fully customized solutions. These include:

- Power conditioning
- Custom power supplies
- OEM power subsystems
- Turnkey power systems
- And many other system solutions

We have performed hundreds of cost effective, value-added integration solutions across dozens of market segments worldwide.

Spanning:

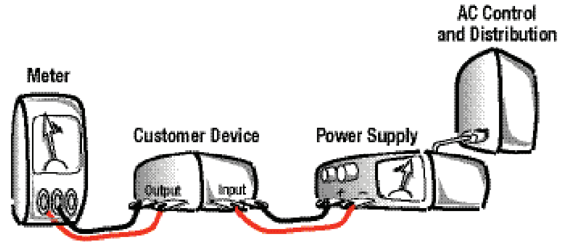
- solar array power simulation
- product burn-in systems
- custom multi-channel power supplies

You can trust us to mitigate the risk of meeting your goal.

Contact AMETEK's Solutions team at:

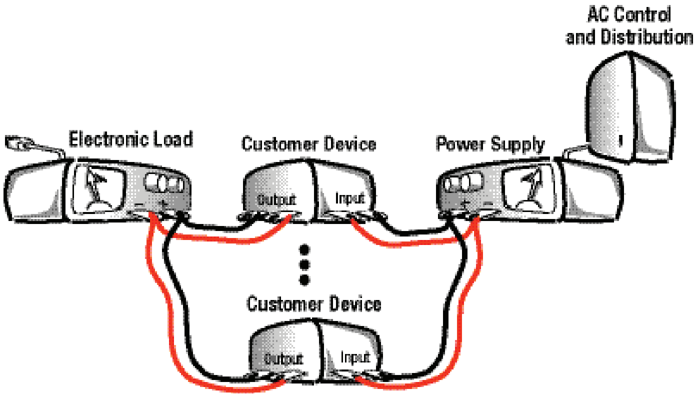
Solutions.ppd@ametek.com

Customer solutions fit into three basic categories:



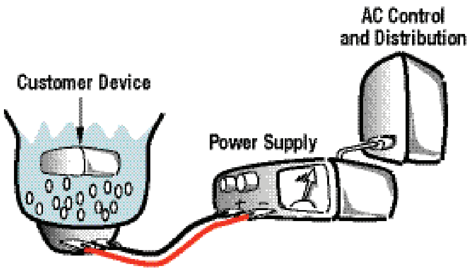
Measurement and Control

This category of power systems involves the power supply providing stimulus, either AC or DC, to a customer device so that its behavior can be measured and validated. These applications range from Research and Development Laboratories to high-rate production machines.



Reliability and Burn-in

This category essentially deals with applications where the customer device is put under a load for an extended period of time. The input power, either AC or DC, is held constant at full power or varied to promote stress in the customer device to assess product reliability or to propagate infant mortality.



Process Control

In these applications, the power subsystem is providing power to create an environment necessary to add value to a customer product. Typically, the power component of these systems has to be carefully chosen to meet the end requirements because its behavior directly affects the quality of the customer product.

Notes

Accurate PV Simulations Yield Better Test Results

Dan Donati, Vice President / Business Manager
Programmable Power Solutions

To deliver the maximum amount of power from solar panels or arrays, standalone inverters and grid-tie inverters use a sophisticated strategy to find the maximum power point, or MPP, for given conditions. They do this by varying the load on the solar panel or array until it finds the point on the panel's or array's I-V curve that will deliver the most power. The inverter then converts this DC power to AC power, which is then used locally or fed into the power grid.

Determining how well an inverter accomplishes this task is extremely important. The feasibility of a project may rely on an inverter being as efficient as the manufacturer or distributor says it is. A discrepancy of even a few percent could render a project uneconomical, and at worst, could lead to lawsuits.

To effectively test the efficiency of photovoltaic inverters, you need a solar array simulator that both accurately simulates the output of a solar panel or array and that can supply the output power required for a particular application. Using actual solar panels or arrays is just not practical because it is not feasible to control their output to the degree required to simulate all conditions.

Modern simulators are up to the challenge

To simulate a solar panel or array, inverter designers and manufacturers use modern, digitally-controlled power supplies. When coupled with sophisticated control software, these systems can simulate solar panel arrays up to 1 MW.

Accurately simulating a solar array to test inverters can be quite a challenge. As noted earlier, inverters continually change their output impedance, searching for that maximum power point. The simulator must respond to those load changes as a solar array would. Not only must the simulator maintain its power output, it must track the I-V curve of the solar panel or array it is simulating.

To complicate matters, many solar inverters generate AC ripple on their DC input, which is connected to the photovoltaic array. For single phase inverters, the frequency of this ripple is twice the line frequency (120 Hz for US models). Normally, you would want a power supply to suppress this ripple, but a solar array simulator's power supplies must not suppress it.

An increasing number of inverters (and virtually all micro-inverters) accurately measure amplitude and phase of the ripple voltage and current to quickly determine the MPP of the array. This approach allows inverters to determine the MPP at a much higher speed when compared to conventional dithering techniques (also called perturbate-and-observe). Faster tracking to the MPP results in a much higher overall efficiency in cloudy conditions, where the irradiance is constantly changing. It is likely that all solar inverters will soon use this approach since end users are very sensitive to the overall efficiency of their solar energy installations.

Another requirement for modern solar array simulators is flexibility. There are many different types of solar panels and solar arrays on the market, each having their own particular characteristics. Modern solar array simulators must be programmable to allow them to determine how inverter designs will work with all these different types of solar arrays.

Finally, solar array simulators need to measure and log inverter's AC output and correlate that data with the DC power input. This closes the test loop and allows you to determine how efficient your inverter design really is.

Staying on the curve

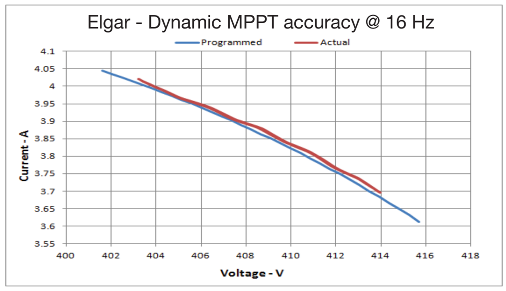
In order to perform an accurate test, the output of a solar array simulator must faithfully follow the I-V curve of a solar array or solar panel. That is to say that it must respond just as a solar array would to the changing load conditions imposed by the inverter under test. In order to evaluate how well a simulator can do this, you need to consider three parameters: output noise current, phase error between output voltage and current, and the MPP tracking accuracy.

Excessive output noise current will make it difficult, if not impossible for an inverter to find the maximum power point. Excessive output noise current will make it difficult, if not impossible for an inverter to find the maximum power point, and this will cause test problems. For instance, the Elgar TerraSAS from AMETEK Programmable Power has an output noise current of less than 70 mA.

The point of inoperability due to the level of noise of the TerraSAS is a function of the inverter itself. The noise contributed by any PV simulator is made up primarily of its internal power switching noise and its associated harmonics. Since both the inverter and the PV simulator have control loops, there could be interaction. From the inverter design perspective, the inverter design engineer is trying to design a cost effective, high performance inverter. Since an actual solar panel doesn't produce any noise, the engineer is less likely to add filtering and the associated cost. The level of noise is really key; 70ma versus 700ma is of course an order of magnitude and could be critical to some inverters and not so much to others. However, we have been seeing a trend in which the inverter designs are reducing nice-to-have circuitry in favor of lower cost. While this doesn't make the inverter any less reliable, it may make performance testing a challenge with PV simulators that are not very refined.

In the real world, there is essentially zero phase difference between the output voltage and output current of a solar panel or array, even when inverters use MPP tracking strategies that change the load very quickly. To accurately simulate a solar panel or array, therefore, it is important that the phase error of the simulator be less than 15 degrees even if the load is changing that quickly. Many simulators are unable to do this, making them unsuitable for testing those inverters that use high sweep frequencies.

Accurate PV Simulations Yield Better Test Results



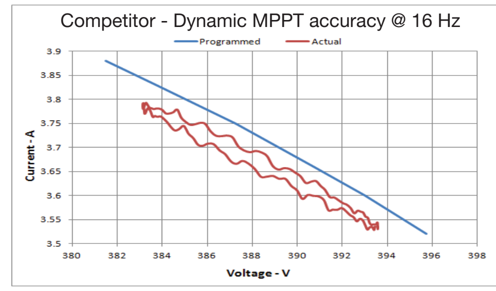


Figure 1 shows a comparison of the dynamic MPP tracking accuracy of two simulators currently on the market. A test frequency of 16 Hz was used for this test to simulate the loading effect of an inverter. The blue line shows the ideal response of the simulator, while the red lines show the actual response. As you can see, there is quite a difference between the two simulators, and the difference is even higher as the dithering frequency increases.

In an extreme case, when the phase error between the output voltage and output current approaches +/- 90 deg, the inverter under test will actually begin seeking the MPP in the wrong direction and will become unstable. With a significant phase error, even if the inverter is stable it will lock onto a curve location that is not the MPP. The amount of error is proportional to the phase error. We have observed this behavior on microinverters and residential inverters that use fast MPP tracking algorithms.

Another important specification is the maximum power point dynamic tracking accuracy. This is a measure of how much a simulator will deviate from a programmed I-V curve under dynamic conditions, where many factors can contribute to this inaccuracy.

Software Considerations

In addition to the having superb electrical specifications, it's important that a solar array simulator has software that is easy to use and capable of providing the desired test data. These features include:

- Update rate. An update rate of 20 times per second allows you to monitor inverter behavior (both operating point and sweep amplitude) in real time. Displays that are much slower do not really allow the user to view or characterize the dynamic behavior of the inverter under test. (See Figure zz, end of article)

- Ease of programming. In development environments, it's desirable to be able to change the test curves quickly or to develop a custom I-V curve. Some simulators require the user to create custom curves by modifying javascript code, then compiling and debugging it. A much simpler solution is to allow the user to simply enter parametric data, or to import data from other sources, and let the simulator software generate the curve.

- Library of available PV curves/irradiance profiles. Another feature that makes solar array software easier to use is a library of curves for common solar panels. Having a library like this means that you don't have to generate your own I-V curves and you can easily test how an inverter design will work with a wide range of different solar panels. Having a set of irradiance profiles allows users to simulate nearly any type of environmental conditions.

- Array modeling. If the inverter under test will be used with an array of solar panels, the simulator software should be able to simulate that array as well as just a single panel. In software, you should be able to build that array, and then have the simulator output reflect the output of the entire array. To make this simulation even more realistic, you should be able to simulate the effects of shadowing, aging and faulty modules.

The success and credibility of solar power depends in large part on the i performed, both at the development and production stages. To get the best results, you need the best test equipment that you can find. That means using a solar array simulator that accurately tracks the I-V curve even under the demanding conditions imposed by modern inverters. You can't really settle for anything less.

Dan Donati brings to AMETEK a unique background with over 30 years of experience in all phases of product design, manufacturing, test and corporate management. He joined AMETEK Programmable Power (formerly Elgar Electronics) in September 1991 and over the past 21 years has been responsible for a variety of initiatives serving global aerospace, military, nuclear and renewable energy applications. Donati holds a BSEE degree in Electronics Engineering.

Accurate PV Simulations Yield Better Test Results

SIDEBAR: How do photovoltaic inverters work?

Photovoltaic (PV) inverters work like any other type of inverter. That is to say they convert direct current to alternating current. PV inverters differ from standard inverters in that the DC input for a standard inverter is normally a steady DC supply, such as a battery, while the DC input for a PV inverter is a solar panel or array. The DC output of a solar panel varies widely as the temperature and amount of sunlight hitting the panel changes

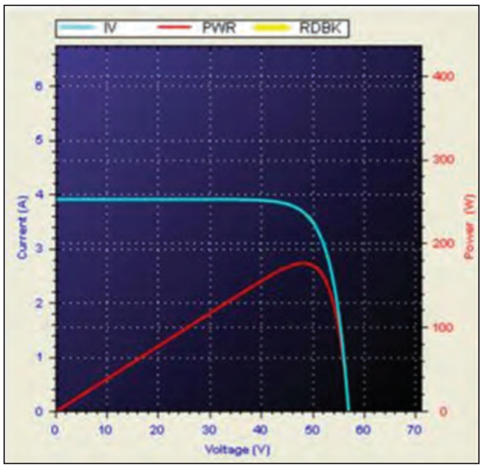


Figure 2 shows the I-V characteristics of a typical solar panel for a given illumination level. Also shown, in the red trace, is the amount of power that the solar panel will deliver to a load at points along the curve. When the output is shorted, the voltage is zero, so the output power is zero. When the output is open, the current is zero, so again the output power is zero.

At some point along the curve, the power output (which is equal to the panel's output voltage times the panel's output current) of the panel is at maximum. This point is called the maximum power point. At this combination of voltage and current, the panel will be delivering the most power it can given the operating conditions. As you can see, the maximum power point is on the knee of the curve

The PV inverter must determine what the MPP is at any point in time and change its input impedance so that the solar panel is always operating at that point. When it can do that, the PV inverter will be drawing the most power from the solar panel.

Inverters use different strategies to find the maximum power point and to continue operating at that point under varying external conditions. Perhaps the most common strategy is called "perturb and observe."

Inverters that use the "perturb and observe" strategy change their input impedance by a small amount so that the output voltage of the solar panel increases or decreases by a small amount. They then measure the output current and calculate the output power. If the power increases, the inverter makes further small adjustment in that direction until the output power no longer increases. When conditions change, the maximum power point changes, and the inverter once again goes through this process to find this point.

Because this is a very dynamic process, testing inverters is quite complicated. It's impractical to use solar panels and PV arrays for this testing because their outputs are so dependent on illumination levels. Also, characteristics vary from panel to panel, making comparisons difficult.

The only way to get reliable results is to use a simulator that will faithfully replicate the output of a solar panel or array. To do this, the simulator must not only be able to supply a significant amount of output power, but agile enough to respond quickly to changes in the load impedance. Simulators that can do this will stay on the curve and provide the best test results.

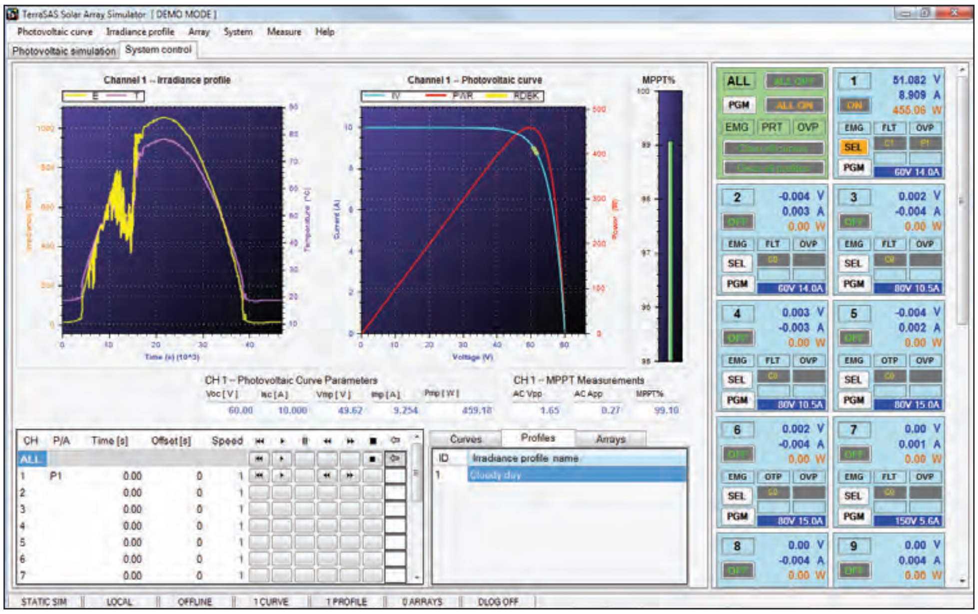


Figure 3. The TerraSAS real-time display updates 20 times per second, allowing you to see how well the simulator tracks the simulated solar panel's I-V curve.

Notes

Elgar SAS - Solar Array Simulator

900–1000 W

450 or 500 W/channel Solar Array Simulator

≈	208	400

ETHERNET GPIB

- Total control of I/V behavior
- Designed to operate at the knee
- Fast profiling current source
- Bus overvoltage protection
- Hardware shutdown system
- Multiple master SAS systems can be connected to create very large SAS systems
- Customer defined output connectors

Product Overview
A spacecraft solar array is subjected to large temperature excursions, varying insolation (the amount of sunlight falling on the array), mechanical changes and aging, which substantially effect both its short and long term performance. In order to test the spacecraft's power environment, a cost-effective solution for ground based testing is to utilize a solar array simulator.

The Elgar SAS system reproduces all possible solar array outputs, based on the wide variety of input conditions that an array faces, including orbital rotation, spin, axis alignment, eclipse events, beginning-of-life and end-of-life operation. The SAS also provides complete programmable control of all the parameters that shape the solar cell I/V output curve. By being able to accurately simulate solar panels under various space conditions with complete control, a system developer can comprehensively verify design margins and quickly test, in production, spacecraft power systems and their associated electronics.

Each Solar Array Simulator is a fully integrated, turn-key system complete with Windows graphical user interface and hardware control software. It can be remotely controlled and is addressable as a single device when integrated into a customer's test system. This control is accomplished via a standard ethernet or optional GPIB interface using standard SCPI format commands.

As a very important consideration in spacecraft testing, discrete hardware protection systems are a standard part of every SAS. These include subsystems that can remove power at the output of the SAS in under 35 microseconds. Each SAS string has an electronic circuit breaker and relay disconnect, so faults are localized and minimize disruption of the test process. SAS systems have been designed and delivered ranging from desktop, 2 channel, R&D units to systems capable of controlling 8,18 channel SAS systems simultaneously. AMETEK's Engineered Solutions Group can assist in defining special requirements and customize each system using a standard building block approach. This allows each customer to get exactly what is needed while minimizing costs.

Features And Benefits

Total Control Of I/V Behavior.
AMETEK's Fast Profiling Current Source (FPCS) provides the ability to simulate real world solar array power more accurately than other technologies by allowing programmable control of all four parameters necessary to independently control the characteristic I/V diode output curve, or profile, of each FPCS channel.

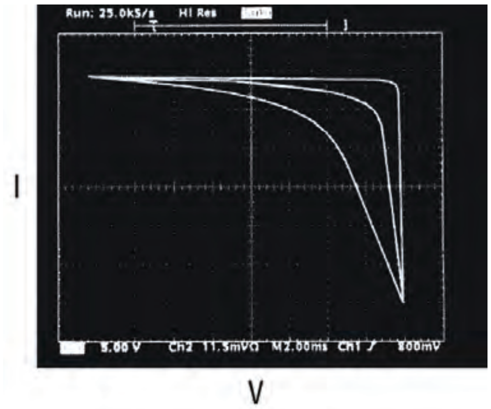
In addition, the user may choose the non-parametric mode of operation and program I/V curves unique to the application. The basic building block of an Elgar SAS is the FPCS. Each FPCS module simulates either one or two array strings, or can be connected in series or parallel with other FPCS modules to simulate larger array segments. The 900W and 1000W chassis consist of two (2) 450W or 500W power modules in parallel, housed in a single 5-1/4" chassis with one control assembly. Open circuit voltage and short circuit current are scaled to meet a customer's requirements.

SAS - Solar Array Simulator

Designed To Operate At The Knee.
The FPCS is designed to operate continuously at the peak power output, or the knee, of the solar array output. With a bandwidth of over 500 kHz, the FPCS is stable into capacitive, resistive and inductive loads up to at least 10µH (higher depending on curve parame at any point of the I/V curve. It can operate continuously at the peak power point of the output curve, into a sequential shunt unit (SSU), or into any other power system output topology.

The Proven Source.
The FPCS has been proven to supply peak power tracking, sequential shunt and series regulator power topologies. It has even been used to test Xenon Ion propulsion devices. The following is a short list of the many companies now using the Elgar Solar Array Simulators:

Ball Aerospace
Boeing Research
Boeing Space Systems
Boeing Rocketdyne
Jet Propulsion Lab
Lockheed-Martin
Northrop Grumman (TRW Space)
Northrop Grumman
Space Systems Loral
Thales Alemia Space ETCA
Thales Rome
Thales Camus
Thales Torino
Thales L'Aquita
Thales ETCA
Thales Milano
Goodrich
Astrium (Matra Marconi, DASA)
Bristol Aerospace
Clemessy
ISS Reshetnev VNIIEM
European Space Agency – ESTEC
Israeli Aircraft Industries, MBT
Korea Aerospace Research Institute
Korea Aerospace Industries
Mitsubishi Electric Corporation
Mitsubishi Heavy Industries
NEC Toshiba Space Systems, Ltd.
Patria OHB
Surrey Satellite
Siemens
Swedish Space Corporation
Terma Aerospace



I/V Diode Output Curve Control Parameters.
- Voc Maximum programmed open circuit voltage at no load
- Isc Maximum programmed short circuit current operating into short
- Rs Maximum programmed effective series resistance (voltage mode slope adjustment)
- N Curve factor (current mode steepness adjustment)

Quick Curve Recalculation
Since the FPCS is capable of a smooth transition from one calculated curve to another without any output disturbances, varying insolation patterns can easily be simulated. With a maximum curve update rate of 8 times/second, entire orbits can easily be simulated with fine time resolution.

Embedded Computer In Each Module.
An embedded Motorola microprocessor in each FPCS module provides the computational power necessary to calculate the output transfer function, to communicate via a fiber optic data link to the system computer and to continuously monitor the state of the power sections.

Fastest Switching Recovery Time.
Elgar systems feature switching recovery time of 2 microseconds or less. 450 And 900 Watt Modules and 500 and 1000 Watt Modules Systems can be as small as one 450 watt channel or they can also be paralled to achieve much higher channel counts and power levels.

Simulates Both Silicon And Gallium Arsenide Arrays
Silicon, gallium arsenide, and other types of solar array panels can be simulated realistically. The FPCS technology was specifically designed to operate into sequential shunt unit (SSU) as well as peak power tracking and linear regulation systems.

Galvanic Isolation Of Outputs.
Each FPCS chassis is controlled via a fiber optic link to eliminate nuisance ground loops associated with other hardwired control systems, such as RS-232 or GPIB

SAS - Specifications

900–1000 W

SYSTEM SPECIFICATIONS			
Specification	**Value**	**Test Conditions**	**Notes / Definitions**
Max Number of Channels	Unlimited		
Parametric IV Curve	4096 points		Voc, Isc, Rs, N
Custom IV Curve	2 to 4096 points		
System Shutdown Timing	Programmable from 25µs (default) to 99.9ms		FPCS response time is 10µs. Total minimum time is 35µs.
Operating Modes	Normal parametric IV curve simulation Switcher (12 pre-stored curves, parametric or custom). Spin (custom waveshapes, 1Hz maximum frequency). Eclipse (up to 16 curves, 32 segments)		The FPCS power sources have been tested in both series, shunt (S3R, S4R), Hybrid Series/Shunt, and MPPT modes of operation
Eclipse Mode dwell time	0.25sec – 16800sec		
Remote Control	Ethernet Standard GPIB Optional		
OVP chassis input impedance	20Megohms		Optional Chassis
OVP chassis response time	20µs		Optional Chassis
OVP Chassis filter	3dB roll off at 85KHz		Optional Chassis
Ambient Operating Temperature	0 – 38 °C		
Operating Humidity	20% to 80% non-condensing		
Operating Altitude	Up to 6,000 feet above sea level		
Non-operating Environment	Temp: -25 – 65 °C Altitude: 50000 ft Humidity: 95% non-condensing		
AC Input	208VAC L-L ±10% , 3PH 5 wire Wye, 50/60Hz or 380–400VAC L-L ±10%, 3PH 5 wire Wye, 50/60Hz		

FPCS SPECIFICATIONS			
Specification	**Value**	**Test Conditions**	**Notes / Definitions**
Output Power	450W or 500W per channel with 2 channels per chassis 900W or 1000W per channel with one channel per chassis		5-¼” 3U chassis
IV Formula	$V = \dfrac{\left(\dfrac{V_{oc}\ln\left(2-\left(\dfrac{I}{I_{sc}}\right)^{N}\right)}{\ln(2)}\right) - R_s(I - I_{sc})}{1+\left(\dfrac{R_s I_{sc}}{V_{oc}}\right)}$		Voc = Open Circuit Voltage Isc = Short Circuit Current Rs = Series Resistance N = Current Mode Behavior
Open Circuit Voltage range (Voc)	40 – 200 V		
Short Circuit Current (Isc)	Maximum 15A		
Output Voltage Accuracy	± 0.06% + 0.06% Vocmax	RL> 1MΩ, Tamb = 25 ± 5 °C	
Programmable Voc Resolution	0.025% of Vocmax	Tamb = 25 ± 5 °C	
Voltage Readback Accuracy	± 0.1% + 0.1% Vocmax	Tamb = 25 ± 5 °C	
Voltage Readback Resolution	0.025% of Vocmax	Tamb = 25 ± 5 °C	
Output Current Accuracy	± 0.1% + 0.1% Iscmax	Vout < 1V, Rs=0, N=100, Tamb=25 ± 5 °C	
Programmable Isc Resolution	0.025% of Iscmax	Tamb = 25 ± 5 °C	
Current Readback Accuracy	± 0.2% + 0.2% Iscmax	Tamb = 25 ± 5 °C	
Current Readback Resolution	0.025% of Iscmax	Tamb = 25 ± 5 °C	
Programmed Change Response Time	Voltage: 1VDC/ms		
	Current: 0.01ADC/ms	Settle to within 0.1% of programmed value	
Output Voltage Ripple	≤ 0.025% of Vocmax rms	20 Hz – 300 kHz	Apply 0.1 µF ceramic cap in parallel with meter
Output Voltage Noise (PARD)	≤ 0.25% of Vocmax	20 Hz – 20 MHz	Apply 0.1 µF ceramic cap in parallel with probe
Output Current Ripple	≤ 0.05% of Iscmax rms	20 Hz – 5 MHz, RL=3Ω, Rs=0.5, N=44, Voc=Vocmax, Isc=Iscmax	Use non inductive load resistor
Output Current Noise (PARD)	≤ 0.5% of Iscmax	20 Hz – 5 MHz, RL=3Ω, Rs=0.5, N=44, Voc=Vocmax, Isc=Iscmax	Use non inductive load resistor
Over Voltage Accuracy	± 0.5% Vocmax	Tamb = 25 ± 5 °C	
Over Voltage Resolution	± 0.03% Vocmax	Tamb = 25 ± 5 °C	
Over Voltage Range	11.5V – 110% Vocmax		
Standard Over Voltage Protection Circuitry Timing	$t = 420\mu s * \ln\left(\dfrac{V_P - V_O}{V_P - V_{LIM}}\right)$	VP-VO is the magnitude of the voltage step. VP-VLIM is the amount by which the output voltage step exceeds the limit voltage.	VLIM = voltage limit VO = initial voltage VP = final voltage

Specification	Value	Test Conditions	Notes / Definitions
Over Current Accuracy	± 100mA	Tamb = 25 ± 5 °C	
Over Current Resolution	± 0.03% Iscmax	Tamb = 25 ± 5 °C	
Over Current Range	0.57A – 105% Iscmax		
Standard Over Current Protection Circuitry Timing	$t = 420\mu s * \ln\left(\frac{I_P - I_O}{I_P - I_{LIM}}\right)$	IP-IO is the magnitude of the current step. IP-ILIM is the amount by which the output current step exceeds the limit current.	ILIM = current limit IO = initial current IP = final current
Redundant Over Voltage and Over Current modes	Time delay Integrator		
Redundant Over Voltage and Over Current trip delay Time Delay Mode	60µs to 249.9ms		
Redundant Over Voltage Accuracy (optional)	± 1.0% Vocmax	Tamb = 25 ± 5 °C	
Redundant Over Voltage Protection Circuitry Timing Integrator Mode	$t = 480\mu s * \left(\frac{V_{LIM} - V_O}{V_P - V_O}\right)$	VLIM-VO is the amount by which the output voltage step exceeds the limit voltage. VP-VO is the magnitude of the voltage step.	VLIM = voltage limit VO = initial voltage VP = final voltage
Redundant Over Current Accuracy (optional)	± 2.0% Iscmax	Tamb = 25 ± 5 °C	
Redundant Over Current Protection Circuitry Timing Integrator Mode	$t = 480\mu s * \left(\frac{I_{LIM} - I_O}{I_P - I_O}\right)$	ILIM-IO is the amount by which the output current step exceeds the limit current. IP-IO is the magnitude of the current step.	ILIM = current limit IO = initial current IP = final current
FPCS Output Fuse	125% of Iscmax typical		¼"X1¼" User accessible on rear panel of FPCS
Inductive Load Stability	0 – 10µH	0 ≤ Rs ≤ 10, 1 ≤ N ≤ 100	Equivalent to 40ft of AWG16 twisted pair cable
Inductive Load Stability	0 – 50µH	0 ≤ Rs ≤ 10, 20 ≤ N ≤ 100	Equivalent to 200ft of AWG16 twisted pair cable
Load Shunt Switching Recovery Time	≤ 2 µs 450W/500W ≤ 2.5 µs 900W/1000W	Vout= 0.5 to 32V, f=20 KHz, Voc=50V, Isc=70% of Iscmax, Rs=0.5, N=44, tr, tf=1µs	Recover to within ± 10% Isc Measured at the FPCS output connector.
Load Series Switching Recovery Time	≤ 100 µs	Vout=50 to 32V, f=1 KHz, Voc=50V, Isc=2A, Rs=0.5, N=44, tr, tf=1µs	10V or 10% voltage over shoot whichever is greater.
MPPT Voltage Tracking Error	≤ 2.0 %	f=200 Hz, Sweep amplitude 60mA p-p (3% Isc), triangular wave, Voc=50V, Isc=2A, Rs=0.5, N=44, Vout(avg)=42.5V	
MPPT Current Tracking Error	≤ 1.0 %	f=200 Hz, Sweep amplitude 60mA p-p (3% Isc), triangular wave, Voc=50V, Isc=2A, Rs=0.5, N=44, Iout(avg)=1.88A	
MPPT Voltage Tracking Error	≤ 3.5 %	f=200 Hz, Sweep amplitude 120mA p-p (6% Isc), triangular wave, Voc=50V, Isc=2A, Rs=0.5, N=44, Vout(avg)=42.5V	
MPPT Current Tracking Error	≤ 1.5%	f=200 Hz, Sweep amplitude 120mA p-p (6% Isc), triangular wave, Voc=50V, Isc=2A, Rs=0.5, N=44, Iout(avg)=1.88A	
Output Capacitance	Approximately 70nF		Modifiable by attaching capacitance to optional impedance adapter
Output Resistance	Infinite		Based on IV formula above.
Voltage Test Point Accuracy	≤ ± 1%	Tamb = 25 ± 5 °C, volt meter Zin > 10 MΩ	Located on FPCS front panel. Protected by 10Kohm resistors on + and -.
Current Test Point Accuracy	≤ ± 2.5 %	Tamb = 25 ± 5 °C, volt meter Zin > 10 MΩ	Located on FPCS front panel. Protected by 10Kohm resistors on + and -.
Minimum Voc	0.05V		
Minimum Isc	0.10A		
Output Isolation	≥ 8Megohms between channels. Outputs are completely floating and can be series or parallel connected. Either polarity may be grounded.		Series connection limited to 200V from any terminal to chassis ground. No limit for paralleled units.
Line Regulation	±0.01% of Vocmax ±0.1mA ± 0.005% Iscmax		
Recommended Calibration Interval	1 Year		
See "Telemetry Options for Solar Array and Battery Simulators" document.			

Elgar BSS - Battery Simulation System

60 W–30 kW

Battery String Simulator

- Flexible Database Operation
- Fully Programmable
- Completely Configurable
- Attention To Spacecraft Safety
- Eliminates the need for test flight batteries and their associated issues

≈	208	400

ETHERNET GPIB

Product Overview

The Elgar Battery String Simulator (BSS) provides safe, reliable battery power for spacecraft testing. The broad range of features available ensures simulation capabilities for more than just two terminal power. It's the ideal solution for complete integrated system testing, not just battery elimination.

The BSS behavior is determined by a charge table, in spreadsheet format, specific for a battery topology and various battery conditions. Many charge tables can be stored on the computer hard drive for easy retrieval.

The BSS operates in two modes, static and dynamic. In the static mode, when a state-of-charge value is entered, the BSS will instantly produce the terminal voltage corresponding to that state-of-charge. Because of this programmable flexibility, time consuming discharge cycles of flight test batteries are eliminated. In the dynamic mode, once a state-of-charge start point is entered, the BSS will monitor the charge and discharge energies being impressed on the "battery" and modify the state-of-charge and terminal voltage accordingly.

Single or dual battery pack simulator versions are available with discharge currents of up to 250A and charge power of up to 10kW per battery. In addition, optional sensor simulators (including thermistor, pressure transducer, and heater load outputs) allow closed loop input to the Spacecraft Power Regulator for true battery emulation.

As with the SAS systems, each Battery Simulator System is a fully integrated, turn-key system using a Windows Graphical User Interface and hardware control software. This control is accomplished via a standard ethernet or optional GPIB interface using standard SCPI format commands.

Features And Benefits

Flexible Database Operation

A unique database engine allows the Battery Simulator to simulate various battery chemistries. The state of charge of the "battery" and the instantaneous current flow in or out of the "battery" is used to calculate the current terminal voltage of the battery. This database engine has the capability of controlling pressure transducer simulator to allow a charging system to operate in a closed loop fashion. The database feature allows the simulator to simulate common battery ailments: shorted cells, degraded charge transfer, and aging, to name a few.

Integrated Battery Sensor Simulator Packages

Integrated thermistor and pressure transducer and cell simulators allow the user to test an entire battery conditioning system closed loop. This integration of simulators allows for faster system debug and greater test flexibility.

Fully Programmable

All aspects of the battery simulation are programmable. A file management system allows different "battery" databases to be loaded and executed transparently while the system is simulating, thus allowing the user the ability to change battery conditions quickly and efficiently. A simulation can be suspended and re-started later, allowing the user to stop the charge/discharge cycle and examine battery maintenance systems in a static environment. All system setpoints and operational points are available to the user either locally or remotely, eliminating the need for external monitoring equipment.

BSS - Battery Simulation System

Attention To Spacecraft Safety

Several safety systems are employed in the battery simulator to ensure proper system operation. Overcurrent trip or foldback points are user settable locally or remotely. Programmable overvoltage protection is also provided.

Wide Range Of Power

Charge/discharge power levels ranging from less than a kilowatt to several kilowatts, are available.

Test System Safety

The BSS is used in place of test flight batteries. There is no need to charge and discharge test batteries, and chance a shorting of the battery.

Test Process Speed

Changing from one state - of - charge to another using flight batteries and be a time consuming process. The Elgar BSS is simple, fast and accurate and can increase test throughput tremendously.

SYSTEM SPECIFICATIONS			
Specification	**Value**	**Test Conditions**	**Notes / Definitions**
Operating Modes	Static Battery Battery Simulation Power Supply		
Battery Simulation Model	Any battery can be simulated using an Excel database. Terminal voltage is a function of State of Charge (SOC) vs. Current (charge or discharge)		
Remote Control	Ethernet Standard GPIB Optional		
OVP chassis input impedance	20Megohms		Optional Chassis
OVP chassis response time	20µs		Optional Chassis
OVP Chassis filter	3dB roll off at 85KHz		Optional Chassis
Ambient Operating Temperature	0 – 38 °C		
Operating Humidity	20% to 80% non-condensing		
Operating Altitude	Up to 6,000 feet above sea level		
Non-operating Environment	Temp: -25 – 65 °C Altitude: 50000 ft Humidity: 95% non-condensing		
AC Input	208VAC L-L ±10%, 3PH 5 wire Wye, 0/60Hz or 380–400VAC L-L ±10%, 3PH 5 wire Wye, 50/60Hz		

BATTERY SPECIFICATIONS

Specification	Value	Test Conditions	Notes / Definitions
Terminal Voltage (TV) Range	Up to 200 V		
Discharge Current Limit	Up to 250 A		
Charge Current Limit	Up to 10kW		
Output Voltage Accuracy	± 0.1% of max Terminal Voltage	Tamb = 25 ± 5 °C	
Terminal Voltage Resolution	± 0.01% of max Terminal Voltage	Tamb = 25 ± 5 °C	
Voltage Readback Accuracy	± 0.2% of max Terminal Voltage	Tamb = 25 ± 5 °C	
Voltage Readback Resolution	± 0.004% of max Terminal Voltage	Tamb = 25 ± 5 °C	
Current Readback Accuracy	± 0.5% of max Discharge current	Tamb = 25 ± 5 °C	
Current Readback Resolution	± 0.004% of max Discharge Current	Tamb = 25 ± 5 °C	
Output Voltage Ripple	TV < 100V, 20.0 mV rms TV >100V, 25.0 mV rms	20 Hz – 300 kHz	
Output Voltage Noise	TV < 60V, 75.0 mV p-p 60V < TV < 100V, 100.0 mV p-p TV > 100V, 150.0 mV p-p	20 Hz – 20 MHz	
Over Voltage Accuracy	± 0.2% of max Terminal Voltage	Tamb = 25 ± 5 °C	
Over Voltage Resolution	± 0.007% of max Terminal Voltage	Tamb = 25 ± 5 °C	
Over Voltage Range	15V – 110% TVmax		
Foldback Current Accuracy	± 0.2% of max Discharge current	Tamb = 25 ± 5 °C	
Shutdown Over Current Accuracy	± 1.0% of max Discharge Current	Tamb = 25 ± 5 °C	
Over Current Resolution	± 0.007% of max Discharge Current	Tamb = 25 ± 5 °C	
Over Current Range	2A – Max Discharge I 2A – Max Charge I		
Over Voltage Protection Circuitry Timing	≤ 100 μs		
Over Current Protection Circuitry Timing	≤ 100 ms		
Transient Response	≤ 20 ms, Recovery within ±1% of TVmax or ±1V whichever is greater. Measured at the output connector.	50% load step charge and discharge current step across 8500μF capacitor.	
Transient Over/Undershoot	10% of TVmax or 10V, whichever is greater.	50% load step charge and discharge current step across 8500μF capacitor.	
Accumulator Accuracy	±2.5% SOC	Constant Current charge or discharge \ resulting in a 50% change in state of charge over 30 minutes.	
Output Capacitance	Consult Factory. Dependent on terminal voltage and maximum discharge current		
Minimum Terminal Voltage	5.0V when using 2KW electronic loads 15.0V when using 5kW electronic loads		
Output Isolation	≥ 1Megohm between channels, and from output to chassis ground.		
Recommended Calibration Interval	1 Year		

SENSOR SIMULATOR OPTIONS

See “Telemetry Options for Solar Array and Battery Simulators” document.

Notes

Elgar TerraSAS

1kW-1MW

Terrestrial Solar Array Simulator

80-1000 V

≈	208	400	480
∼	115		

ETHERNET LXI

- Full turn-key solution
- Simulate dynamic irradiance and temperature ranging from a clear day to cloud cover conditions
- Readback of voltage, current, irradiance level and temperature setting
- Tests for inverter Maximum Power Point Tracking (MPPT)
- Provides programmable I-V curves for PV Inverter testing
- Simulates different types of solar cell material
- Multi-Channel, Up to 1MW

What part of power is important?
Many solar inverters generate AC ripple on their DC input, which is connected to the photovoltaic array. For single phase inverters, the frequency of this ripple is twice the line frequency (120 Hz for US models). The simulator's power supplies must not supress this ripple as a function of their regulation loop. An increasing number of inverters (and virtually all micro-inverters) accurately measure amplitude and phase of the ripple voltage and current to quickly track the MPP of the array. This approach allows tracking the MPP at a much higher speed when compared to conventional dithering techniques (also called perturbate-and-observe). Faster tracking of the MPP results in a much higher overall efficiency in cloudy conditions, where the irradiance is constantly changing. It is likely that all solar inverters will use this approach in the near future, since end users are very sensitive to the overall efficiency of their solar energy installations.

To satisfy this requirement, the PV simulator must be capable of reproducing the voltage / current behavior of a solar array at the ripple frequency. Most standard switching power supplies employ very large output capacitors and inductors in their output circuits and are unable to deliver the required performance - regardless of the response speed of the I/V curve controller.

Elgar's line of PV simulators are based on high speed versions of our standard products, where output capacitors and other speed-limiting components have been adjusted. This results in a speed improvement of 10 times or better. Proprietary features built into the PV controller hardware and firmware, combined with our high speed power supplies, deliver the required performance. This technology was extensively tested on micro-inverters and is ready to test the next generation of inverters.

Strengths of using DSP signal processing
Our technology avoids using linear amplifiers, which are fast but bulky and inefficient. The required performance is delivered by high speed switching power supplies and advanced DSP techniques. In some conditions traditional DC power sources using IGBT technology do not meet MPPT response speed requirements, depending on the MPPT principles. Our power supplies use Power MOSFETs, which typically switch ten times faster than most recent IGBTs. Higher switching frequency translates to smaller output capacitors and inductors - which is the key to a successful high speed power supply design.

Product Overview
The Elgar TerraSAS System, provides an easily programmable means of simulating the characteristic behavior of a PV array. The system provides a turn-key approach to testing the maximum peak power tracking (MPPT) characteristics for grid-tied inverters and DC charge controllers. The ability to simulate virtually any fill factor or solar cell material allows the customer to validate the MPPT algorithm with a power source. Hardware control is accomplished by an application running on the local controller that communicates directly to the PV simulator using RS422, and operates as a dedicated IV curve generation processor. The local Graphical User Interface (GUI) is accomplished via another application that provides all of the user controls to the TerraSAS system. Imbedded in the application is the Ethernet (LAN) parser for remote communication and control. All of the functions available locally through the controller are also available remotely.

Elgar TerraSAS

Description
As shown in the image, the TerraSAS consists of programmable DC power supplies, a rack mounted controller, keyboard and LCD display with control software and GUI interface, output isolation and polarity reversing relays and a unique PV simulation engine that controls the power supplies. This combination of hardware allows the TerraSAS to simulate test protocols or combination of events that a solar installation will be subjected to. Power supplies are available in 1-15KW increments to simulate arrays up to 1MW.

The included software, as displayed below, allows modeling of a PV panel without an extensive knowledge of solar array parameters. The only parameters required for a simulation are the open circuit voltage, the short circuit current and the peak power power parameters Vmpp and Impp. Changes to these parameters will allow the shape of the VI curve to be adapted to any fill factor between 0.5 and 1. Once an IV curve has been generated, changes to the irradiation level or temperature can be modified on the fly so that the behavior of a grid tied inverter can be tested under realistic conditions for cloud shadowing and panel temperature. Long term weather simulations can be run to determine the amount of energy delivered in a given situation. Inverters can be optimized for real MPP search modes, because shadowing and temperature changes can be simulated realistically.

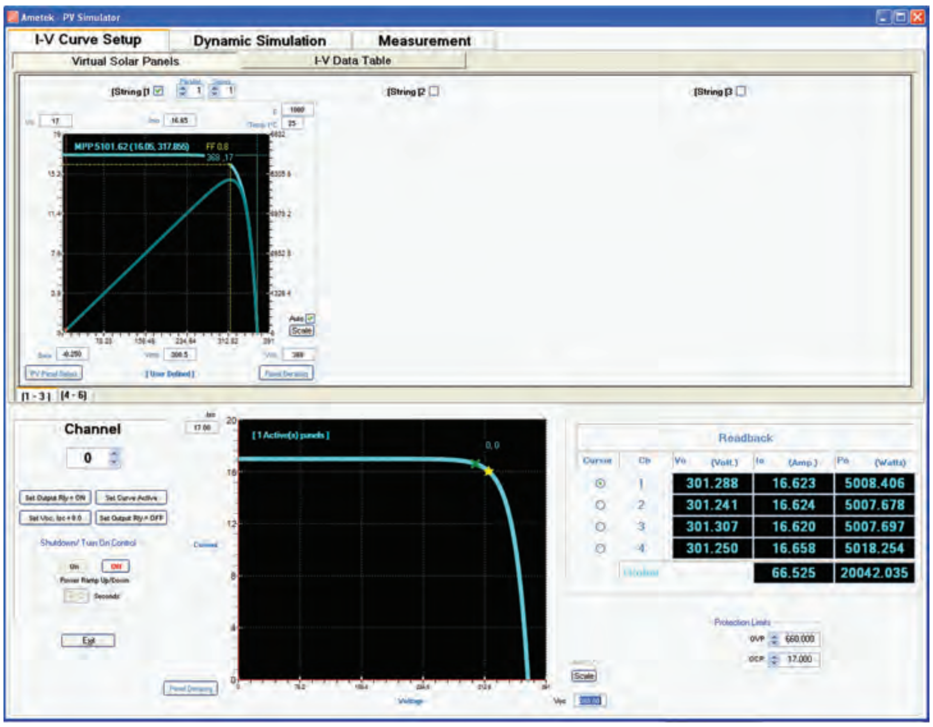
The PV simulation software allows definition of key parameters like Voc, Isc, Vmpp and Impp at 25 °C and 1000W/m^2, so that the resulting VI curve is calculated according to a standard solar cell model.

The PV simulator has the ability to simulate ideal IV curves as well as irregular characteristics that result when solar panels with different output characteristics are paralleled as shown on the two graphs below. With the simulator programmed for different values of irradiance or temperature, the characteristic "multiple hump" IV curve will result. By programming the changes in irradiance and temperature in a table, dynamic simulation of compressed time profiles of a 24 hour day can be run in a loop to simulate the day and night periods for extended periods of time.

Dynamic simulation showing changes in Irradiance and Temperature over time

TerraSAS

IV Curve Control Interface : Parameters are programmable through sliding scale or direct input of value



Control Displays

The graphic above shows the GUI interface displays. The entered set of IV curves is displayed as soon as the parameters are entered. The actual measured data is then overlaid on the screen so that the operating point can be viewed in real time. The display times can be set from minutes to days to allow for long term testing.

Programmable Parameters

- irradiance level
- temperature value
- voltage level
- current level
- temperature coefficient

Ramp of voltage, temperature or irradiance level over a programmed time interval Readback of voltage, current, irradiance level, and temperature setting.

Curve Formula

The photovotaic curves for the simulator are derived from the formula shown below.

Io as a function of Vo:
Io=Isc (1-C1 (exp (V/(C2 x Voc))-1))
C1=(1-(Imp/Isc)) (exp(-Vmp/(C2 x Voc)))
C2=((Vmp/Voc)-1)/(ln(1-Imp/Isc))

where the Reference Irradiance condition for the simulated arrays is 1000W/m^2 and the Reference Array Temperature is 25°C

The simulated PV arrays are provided in terms of array fill factor, Maximum Power Point Voltage and Maximum Power Point Power. The curves generated are based on the Sandia Labs simplified PV Array model defining the relationship between these values and other parameters as provided below:

Where:

$$P = Pref \times \frac{Irr}{Irref} \times \left(1 + \frac{\beta}{100} \times (T - Tref)\right)$$

$$V = Vref \times \frac{\ln Irr}{\ln Irref} \times \left(1 + \frac{\beta}{100} \times (T - Tref)\right)$$

$$P = V \times I$$

$$FF = \frac{Vmp \times Imp}{Voc \times Isc}$$

TerraSAS - Specifications 1kW-1MW

Where:
β Array temperature Coefficient, %/°C
T= Cell temperature, °C
V= Voltage, V
I= Current, A
FF= Fill Factor

Subscripts:
Ref= Reference (i.e., at reference or rated conditions)
MP= Maximum Power
OC= Open Circuit
SC= Short Circuit

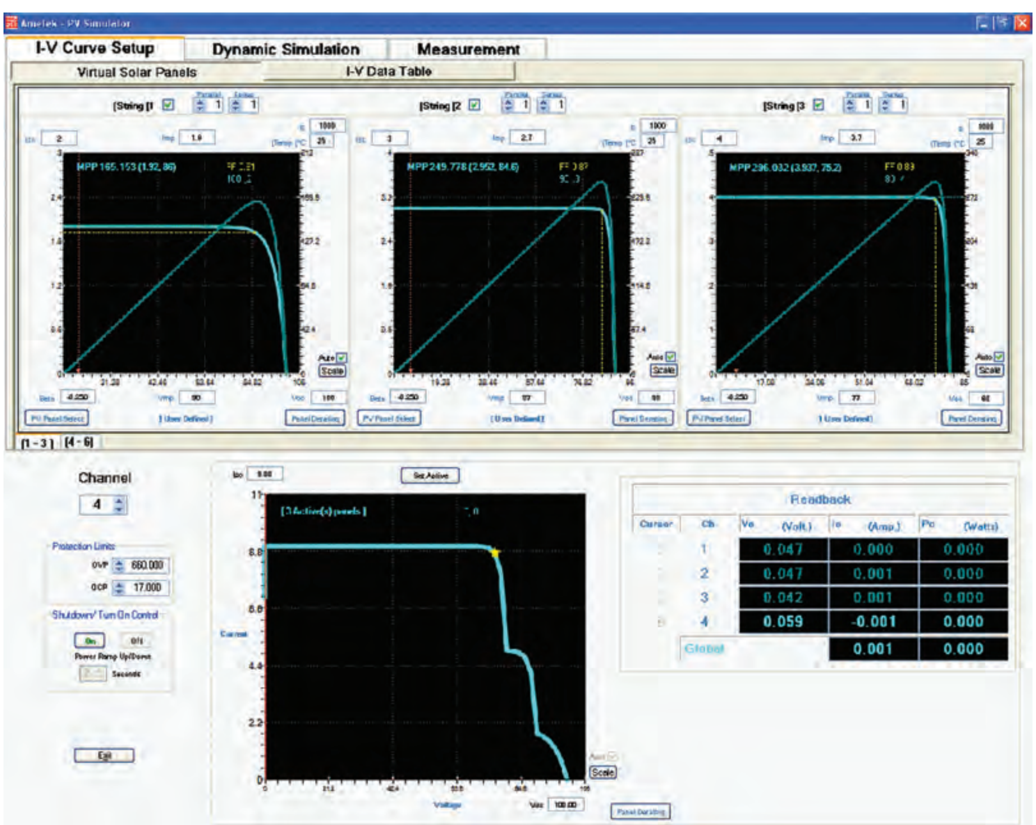
DC Output Connections
The output connections will use finger safe, pressure type connectors or terminal blocks of suitable ampacity , mounted on the rear I/O panel.

"Multiple Hump" IV Curve
Utilizing data gathered from the Solar Advisor Model (SAM) data base, the TerraSAS allows the user to model systems made up of two or more subsystems. For example, a PV system that consists of three arrays with different orientations, thus creating a "Multiple Hump" as shown below.

Safety
The system includes a shutdown function that will disable the output with an open interlock contact. In the event of an open interlock, the PV simulator chassis will program down the DC output and open the output relays, and provides complete qalvanic isolation

The benefit of simulators is that they offer the ability to test an inverter without reliance on a real array and can simulate PV behaviors that a real array cannot be easily manipulated to do.

Characteristic "multiple hump" IV curve results when three PV profiles are added



TerraSAS - Specifications

Specifications	
AC Power	AC Input Voltage: 115V (for DCS) 208VAC three phase Std, 400VAC and 480VAC three phase are optional (Input current depends on power rating)
DC Output	Open circuit voltage, Voc: 0 - 600VDC Short circuit current, Isc: 0 – 1000A Maximum output power at MPP: 1MW (Lower voltage ranges will provide proportionately higher currents) 1-6 channel output, consult factory for additional channels.
Programmable Parameters	Irradiance level: 0 to 2000 W/m² Temperature: -40 to 90°C Temperature Coefficient: 0 to -65,000 mV/°C Simulation Times: 0 to 65,000 seconds Isolation relay and polarity relay closure
Accuracy	Voltage Readback: 0.2% of rated max voltage Current Readback: 0.5% of max current
Programming Interface	Ethernet with RJ-45 connector / LAN
AC Input Connections	Finger safe, pressure type connectors three phase AC four wire plus safety ground stud AC input circuit breaker
DC Output Connections	Finger safe, pressure type connectors positive and negative
Safety	The output isolation relay operates as a disconnect relay in the event of a malfunction or an open interlock contact

Output Voltage and Current Ranges

Power	1.2 kW			RMS	P-P	DC Leakage Current
80Voc	Isc = 15A			4 mV	60 mV	
Power	5 kW	10 kW	15 kW			
600Voc	Isc = 8.0A	Isc=17A	Isc=25A			335mA
1000Vdc	Isc = 5A	Isc = 10A	N/A	10 mV	600 mV	<3.5 mA per chassis

MMPT	
Scalable (MPPT)	1000W to 1.0MW
Response to MPPT	Up to 120Hz
Current Slew Rate	3msec/A
Control Loop Sampling Rate	1usec / 10kHz

Static and Dynamic Programmable PV Array Parameters	
Irradiance Level	0-2,000W/m2
Temperature	-100 to +100*C
Voltage Level	80V, 0-600 - Consult factory for other voltages
Current level to rated output current	0-Rated Output (see MPP Chart)
Voltage Temperature Coefficient	0 to -2% / *C
Arbitrary VI Curve	Up to 4096 data points

Programmable Setpoints	
Voc	0-Rated output voltage
Fill Factor	0.5 to 0.95
Vmp	0-Voc
Imp	0-Isc
ISC	0-Rated output current
Over Voltage Protection (OVP)	0.1% to 110% of Voc Max

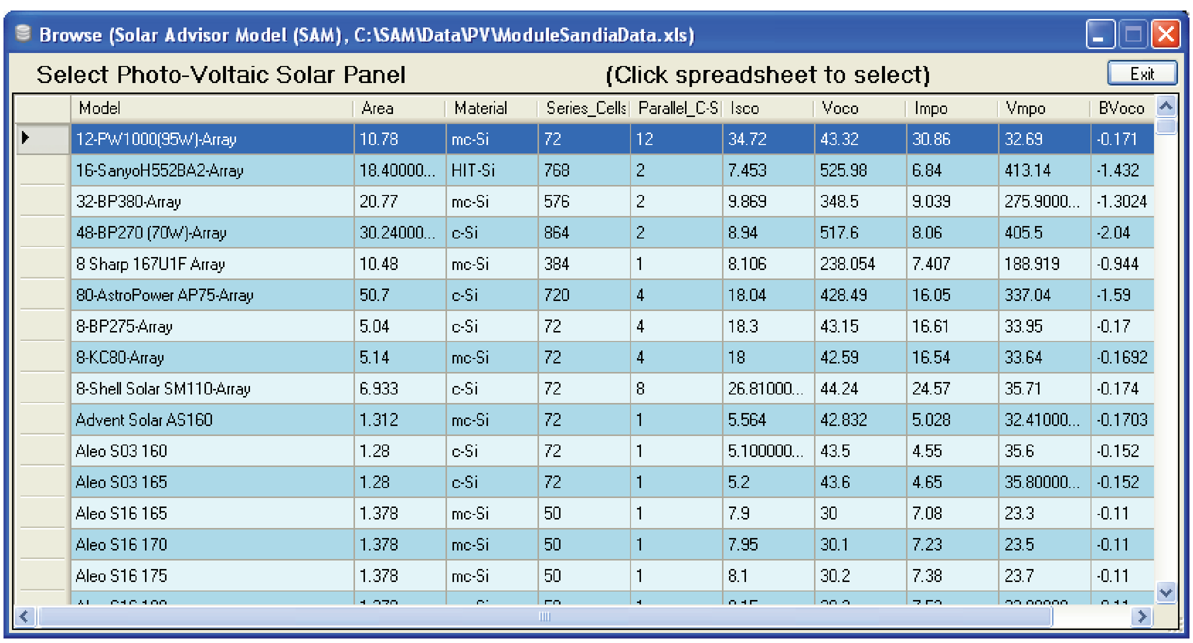
VI Curve Set Point Accuracy	
Voltage	<0.1%, FS
Current	<0.5%, FS

Programming Resolution	
Programming Resolution	<0.002% of FS
Voltage / Current	<0.002% of FS

TerraSAS 1kW-1MW

VI Curve Readback Accuracy	
Voltage	<0.1%, FS
Current	<0.5%, FS
Output Sampling Rate	100usec
IV Curve Update Rate	1sec
IV Curve Interpolation rate	7.8msec
Stability	
CC	0.05
Temperature Coefficient	
CC	0.03
Misc	
Simulation PV Array Channels	1-250
Preloaded Formula	LUFT
SAM Database	Over 100 pre-loaded PV Panels, Series & Parallel capability

Over 100 pre-loaded PV Panels, Series & Parallel capability



Model	Area	Material	Series_Cells	Parallel_C-S	Isco	Voco	Impo	Vmpo	BVoco
12-PW1000(95W)-Array	10.78	mc-Si	72	12	34.72	43.32	30.86	32.69	-0.171
16-SanyoH552BA2-Array	18.40000...	HIT-Si	768	2	7.453	525.98	6.84	413.14	-1.432
32-BP380-Array	20.77	mc-Si	576	2	9.869	348.5	9.039	275.9000...	-1.3024
48-BP270 (70W)-Array	30.24000...	c-Si	864	2	8.94	517.6	8.06	405.5	-2.04
8 Sharp 167U1F Array	10.48	mc-Si	384	1	8.106	238.054	7.407	188.919	-0.944
80-AstroPower AP75-Array	50.7	c-Si	720	4	18.04	428.49	16.05	337.04	-1.59
8-BP275-Array	5.04	c-Si	72	4	18.3	43.15	16.61	33.95	-0.17
8-KC80-Array	5.14	mc-Si	72	4	18	42.59	16.54	33.64	-0.1692
8-Shell Solar SM110-Array	6.933	c-Si	72	8	26.81000...	44.24	24.57	35.71	-0.174
Advent Solar AS160	1.312	mc-Si	72	1	5.564	42.832	5.028	32.41000...	-0.1703
Aleo S03 160	1.28	c-Si	72	1	5.100000...	43.5	4.55	35.6	-0.152
Aleo S03 165	1.28	c-Si	72	1	5.2	43.6	4.65	35.80000...	-0.152
Aleo S16 165	1.378	mc-Si	50	1	7.9	30	7.08	23.3	-0.11
Aleo S16 170	1.378	mc-Si	50	1	7.95	30.1	7.23	23.5	-0.11
Aleo S16 175	1.378	mc-Si	50	1	8.1	30.2	7.38	23.7	-0.11

Elgar ETS TerraSAS

1kW-1MW

Standalone TerraSAS Photovoltaic Simulator

60-1000 V

≋	208	400	480
~	115		

ETHERNET LXI

- Low output capacitance
- High bandwidth up to 30kHz
- High resolution I-V curve simulates static and dynamic conditions
- Designed for high speed Maximum Power Point Tracking (MPPT)
- Can be integrated into a multi-channel system for higher power testing
- Energy Harvest and Oscilloscope measurements built in. *
- Low voltage, high bandwidth version for DC Power Optimizers

For microgrids, energy storage, and inverter test applications, the TerraSAS™ series photovoltaic (PV) simulators are specifically designed to emulate the dynamic electrical behavior of a terrestrial PV solar array. They offer low output capacitance and high closed loop bandwidth to keep up with the advanced Maximum Power Point Tracking (MPPT) algorithms used in today's grid-tied inverters.

The Embedded TerraSAS (ETS) is a high performance solution in a small form factor that combines an agile power supply with an innovative I-V curve generator in a single standalone unit.

• ETS 600 / 1000: For isolated and non-isolated string inverters up to 1000Vdc Voc.

• ETS 60 / 80 / 150: For use with micro-inverters or DC optimizers up to 150Vdc Voc

Application

Many solar inverters generate AC ripple on their DC input, which is connected to the photovoltaic array. For single phase inverters, the frequency of this ripple is twice the line frequency (120 Hz for US models). The simulator's power supplies must not suppress this ripple as a function of their regulation loop. An increasing number of inverters (and virtually all micro-inverters) accurately measure amplitude and phase of the ripple voltage and current to quickly track the MPP of the array. This approach allows tracking the MPP at a much higher speed when compared to conventional dithering techniques (also called perturbate-and-observe). Faster tracking of the MPP results in a much higher overall efficiency in cloudy conditions, where the irradiance is constantly changing. It is likely that all solar inverters will use this approach in the near future, since end users are very sensitive to the overall efficiency of their solar energy installations. To satisfy this requirement, the PV simulator must be capable of reproducing the voltage / current behavior of a solar array at the ripple frequency. Most standard switching power supplies employ very large output capacitors and inductors in their output circuits and are unable to deliver the required performance - regardless of the response speed of the I-V curve controller. Elgar's TerraSAS line of PV simulators are based on high speed versions of our standard products, where output capacitors and other speed-limiting components have been adjusted. This results in a speed improvement of 10 times or better.

Proprietary features built into the PV controller hardware and firmware, combined with our high speed power supplies, deliver the required performance. This technology was extensively tested on micro-inverters and is ready to test the next generation of inverters. The required performance is delivered by high speed switching power supplies and advanced Digital Signal Processing techniques. In some conditions traditional DC power sources using IGBT technology do not meet MPPT response speed requirements, depending on the MPPT principles. Our power supplies use Power MOSFETs, which typically switch ten times as fast as the most recent IGBTs. Higher switching frequency translates to smaller output capacitors and inductors - which is the key to a successful high speed power supply design

* - Available Q4 2013

ETS TerraSAS

Product Overview

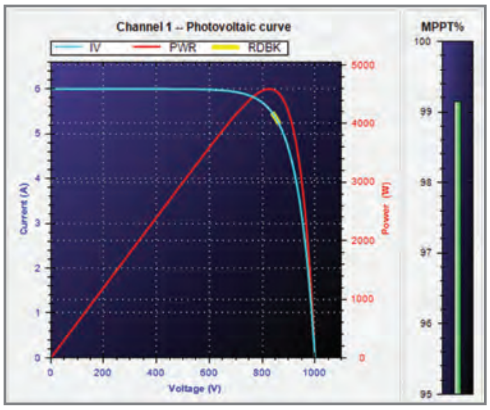
The ETS series standalone TerraSAS consists of a high performance, programmable DC power supply with control software and GUI interface, output isolation, and a unique PV simulation engine that provides the I-V curve. This combination of hardware, software, and firmware allows the TerraSAS to simulate test protocols or combinations of events that a real-world solar installation will be subjected to.

The included software allows modeling of a PV panel without an extensive knowledge of solar array parameters. The only parameters required for a simulation are the open circuit voltage (Voc), short circuit current (Isc), and the peak power parameters Vmp and Imp. Changes to these parameters allow the shape of the I-V curve to be adapted to any fill factor between 0.5 and 0.95.

Once an I-V curve has been generated, changes to the irradiation level or temperature can be modified on the fly to test the behavior of a grid tied inverter under realistic conditions for cloud shadowing and panel temperature rise. Long term weather simulations can be loaded and run to determine the amount of energy harvest delivered in a given situation. Inverter designers use these accuracy and efficiency tests to optimize real MPP search modes.

Scalability

Power supplies are available in 850W, 5kW, 10kW, and 15KW increments. The 80V units are available in two power levels: 1200W for microinverters and 850W for the latest generation microinverters and DC power optimizers. The bandwidth on the 850W version has been improved to 30kHz by adding a linear regulation output stage. 600V units are available in 5kW, 10kW, and 15kW versions depending on Isc requirements. 1000V units are rated 10kW. All versions are easily connected in parallel to scale output power up to handle microinverters, string inverters, and even utility scale inverters. Many models can also be connected in series to handle higher voltage tests. Please refer to the connection diagrams located in the User Manual and follow appropriate wiring codes before connecting ETS PV simulators in series or parallel.



Real time I-V curve display

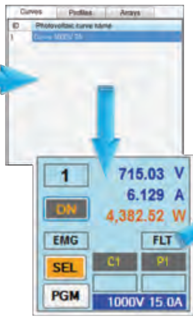
The Elgar Real time I-V curve display is updated 20 times per second to illustrate dynamic inverter behavior (operating point and sweep amplitude). Compared to other commercially available solar array simulators with an update rate of only 1Hz, this allows more accurate analysis of the inverter's actual MPP tracking ability.

ETS TerraSAS

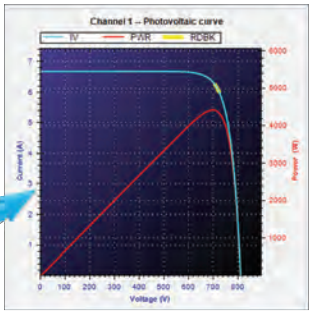
1kW-1MW

Basic I-V Curve simulation

1. Create and add a curve



2. Drag and drop this curve onto the channel tile



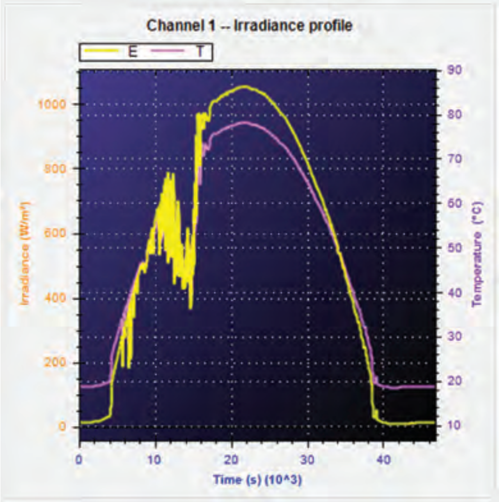
3. Click the ON/OFF button on the channel tile to execute curve

Basic I-V Curve simulation

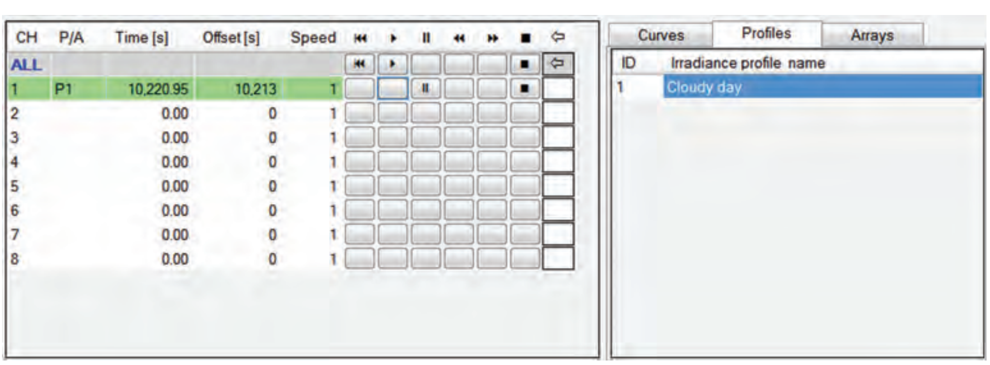
The Elgar TerraSAS user interface is intuitive, graphically colorful and simple to learn. I-V curves are created by entering simple parametric data or by importing data from the NREL SAM database. It is not necessary to use Java Script or any other Script hosting to create an IV curve and execute it.

Dynamic Irradiance profile display

The Elgar TerraSAS profile display of Irradiance and temperature is unique and innovative. It enables inverter designers to easily load and implement standards based cloudy condition scenarios, such as the weighted efficiency measurements called out in EN50530 or California Energy Commission. The ability to model dynamic performance profiles allows complex test validation in any situation in a repeatable, reliable manner. These standard profiles are impossible to simulate with a real array. It can also be controlled to a very fine degree and real profiles can be entered and run from actual speed to 100 times actual speed for accelerated lifecycle tests.



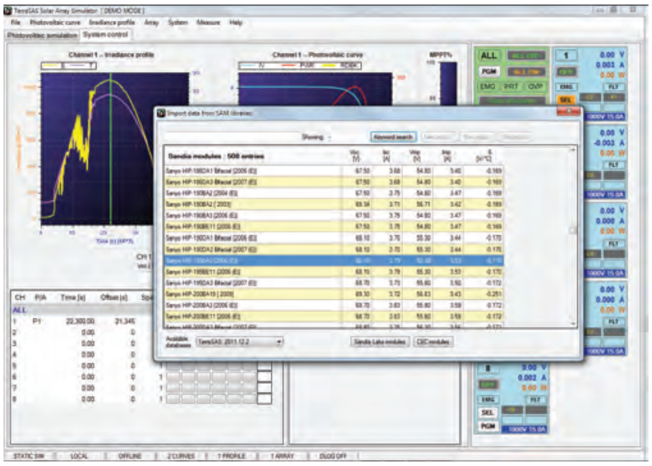
TerraSAS dynamic irradiance profile display



ETS TerraSAS - Specifications

Photovoltaic array modeling
This feature allows the user to quickly define an array of PV panels connected in series or parallel. Using this array modeling capability, the user can simulate such real world conditions as mismatched panels, which result in multiple hump I-V curves. It is important to verify that the MPPT algorithm finds and settles on the universal MPP, not a local maximum.

Photovoltaic array modeling



Import module data from embedded Sandia database and create I-V Curve

Build the array model by binding to the desired curve and specifying the array size

The effects of shadowing, aging and faulty modules can be previewed in real time. the resulting I-V curve can be dragged and dropped to any output for inverter testing.

Specifications

Model Number[1]	ETS60X14C	ETS80X10.5C	ETS150X5.6C	ETS80X15C	ETS600X _ _	ETS1000 X10
Output voltage, Voc (V)	60	80	150	80	600	1000
Output current, Isc (A)	14	10.5	5.6	15	8.3, 16.7, 25	10
Output power @ 0.85FF (W)	714	714	714	1020	4250, 8500, 12750	8500
MPP tracking speed (Hz)[2]	250	250	250	120	200	200
I-V curve resolution (# of pts)	1024	1024	1024	1024	1024	1024
Output capacitance	< 10nF	< 10nF	< 10nF	< 70uF	< 70uF	< 3uF
Output isolation (Vpk)	±1000	±1000	±1000	± 600	± 600	± 1400
Available I/O	Ethernet	Ethernet	Ethernet	Ethernet	Ethernet	Ethernet
Remote sense	2V	2V	2V	2V	10V	10V
AC Input Voltage, V (max operational range)	85-264VAC	85-264VAC	85-264VAC	100-130VAC low 170-230VAC high	C: 187-242VAC D: 342-440 VAC E: 396-528 VAC	C: 187-242VAC D: 342-440 VAC E: 396-528 VAC
Input frequency, Hz	47-63	47-63	47-63	47-63	47-63	47-63
Power factor	> 0.99 typical	> 0.99 typical	> 0.99 typical	> 0.7 typical	> 0.9 typical	> 0.9 typical
Output voltage noise Measured across a 1µF capacitor at the end of a 1.8m(6ft) line at full load, 20MHz	< 0.35 Vpp	< 0.35 Vpp	< 0.6 Vpp	< 1 Vpp	< 0.6 Vpp	< 0.6 Vpp
Output current noise Measured with hall effect sensor, BW = 650kHz	< 60 mApp	< 60 mApp	< 60 mApp	< 100 mApp	< 200 mApp	< 200 mApp
Operating temperature	0-40 degs C	0-40 degs C	0-40 degs C	0-50 degs C	0-50 degs C	0-50 degs C
Physical dimensions	22.6 x 1.7 x 19.0 in 574 x 43.6 x 483 mm 21 lbs (9.5 kg)	22.6 x 1.7 x 19.0 in 574 x 43.6 x 483 mm 21 lbs (9.5 kg)	22.6 x 1.7 x 19.0 in 574 x 43.6 x 483 mm 21 lbs (9.5 kg)	20.4 x 1.7 x 19.0 in 518 x 43.6 x 483 mm 23 lbs (10.5 kg)	25.5 x 5.3 x 19.0 in 64.7 x 13.3 x 48.3 cm 5kW 40 lbs (18 kg) 10kW 60lbs (27kg) 15kw 80lbs (36kg)	25.5 x 5.3 x 19.0 in 64.7 x 13.3 x 48.3 cm 10kW 60lbs (27kg)
Regulatory	Certified to UL/CSA 61010 and IEC/EN 61010-1					

Notes
1 See next page for full listing of model numbers and configurations
2 Maximum MPPT rate of the inverter under test. Closed loop analog output bandwidth is much greater.

ETS TerraSAS

ETS Model Numbers							
Model Number	Output islolation (V)	Output leakage capacitance (nF)	Voc (V)	Isc (A)	Power rating	Input Voltage (AC)	MPP Update Rate
ETS60X14C-PVF	±1000	45	60	14	840W	100-240VAC	250Hz (*)
ETS80X10.5C-PVF	±1000	45	80	10.5	840W	100-240VAC	250Hz (*)
ETS150X5.6C-PVF	±1000	45	150	5.6	840W	100-240VAC	250Hz (*)
ETS80X15C-PVE	±600	300	80	15	1200W	110/220VAC	120Hz
ETS600X8C-PVF	±600	200	600	8.3	5kW	208VAC	200Hz
ETS600X8D-PVF	±600	200	600	8.3	5kW	400VAC	200Hz
ETS600X8E-PVF	±600	200	600	8.3	5kW	480VAC	200Hz
ETS600X17C-PVF	±600	320	600	16.7	10kW	208VAC	200Hz
ETS600X17D-PVF	±600	320	600	16.7	10kW	400VAC	200Hz
ETS600X17E-PVF	±600	320	600	16.7	10kW	480VAC	200Hz
ETS600X25C-PVF	±600	440	600	25	15kW	208VAC	200Hz
ETS600X25D-PVF	±600	440	600	25	15kW	400VAC	200Hz
ETS600X25E-PVF	±600	440	600	25	15kW	480VAC	200Hz
ETS1000X10C-PVF	±1400	4.5	1000	10	10kW	208VAC	200Hz
ETS1000X10D-PVF	±1400	4.5	1000	10	10kW	400VAC	200Hz
ETS1000X10E-PVF	±1400	4.5	1000	10	10kW	480VAC	200Hz

(*) these models also support power optimizers

Listed part numbers refer to the end user package that contains the PV Simulator, a full set of accessories, cables and user manual in print form. Please contact the factory to order PV simulators with a customized accessory kit.

Notes

DC Power / Energy Absorber Test System

60 kW

DC Power and Regenerative Load Applications

400 V

150 A

∿	208	400	480

GPIB RS232

- 750 VA to 2250 VA of AC Output Power
- Combines AC/DC source and power analyzer
- Harmonic analysis of Voltage and Current
- AC, DC and AC+DC Output Modes
- Multiple Chassis Configurations
- Powerful output transient generation
- High Crest Factor Capability
- Arbitrary waveform generation
- Single and Three Phase models available

System Description
The Energy Absorber Test System includes power supplies and a regenerative energy absorber with a rating of 400VDC at ±150A. The system consists of DC power supplies, an AC distribution and interlock system, an energy absorber chassis and an absorber load resistor chassis. The power sources are equipped with a remote control option allowing control via GPIB or with front panel controls in local mode. The operation of the specific parts of the system is described in the sections below.

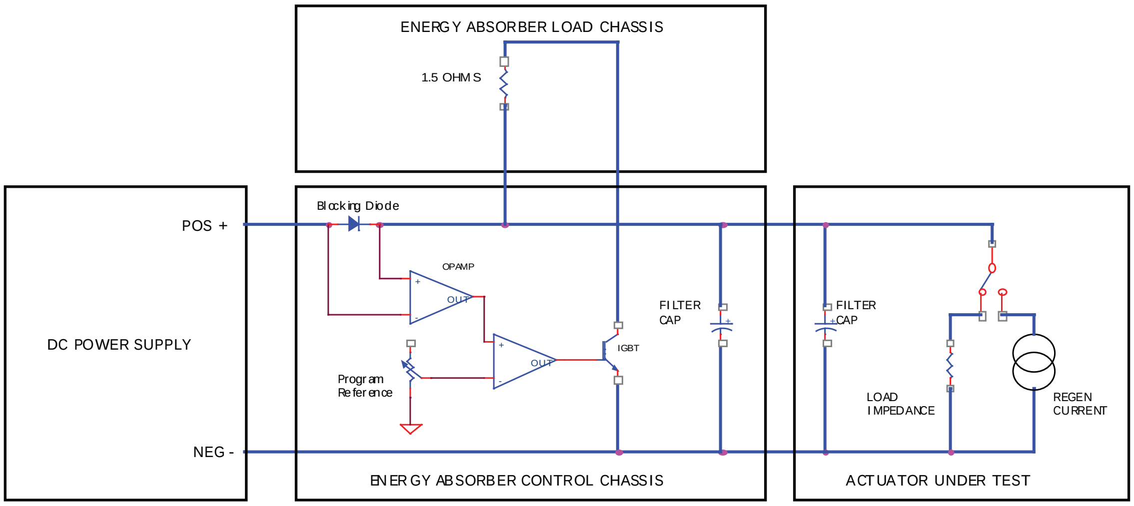
DC Power Supplies
The power supplies consist of two model types each rated for 0-400VDC at 75A. The SGI supply includes a GPIB programming interface and operates as the Master supply. The SGA supply is used as a Slave, operating as a voltage controlled current source. This Master/Slave operation is used to provide up to 400V at 150A for 60kW of output power. By operating in a Master/ Slave configuration, the supplies operate as one unit that can be controlled from the Master unit through either local control or IEEE-488 operation.

The DC power supplies contain a provision for voltage and current readback. The current readback on the front panel of the supplies is set up so that the SGI supply indicates the sum of both supplies. As used in this system, the power supply current monitoring indicates the actual power supplies output current. Regenerative current is not conducted through the power supplies due to a blocking diode in the Energy Absorber chassis so the system current readback is available separately.

Energy Absorber Load Chassis
The Energy Absorber Load chassis contains the regenerative resistive load element. The load consists of numerous high power resistors connected in series/parallel banks, creating a total resistance of approximately 1.5 Ohms at 30kW continuous and 60kW peak.

DC Power / Energy Absorber Test System

Block Diagram of Energy Absorber and Actuator



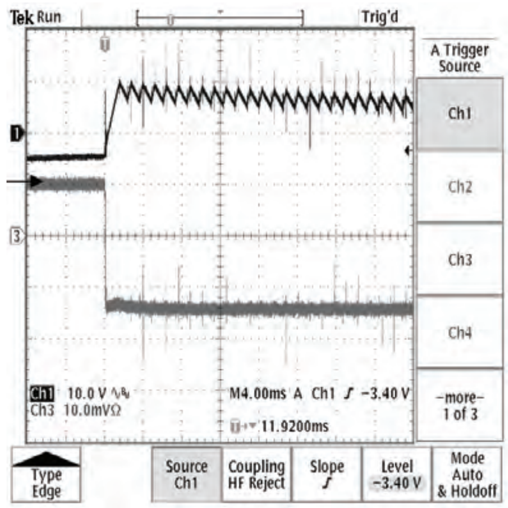
Energy Absorber Control Chassis

The Energy Absorber Control chassis contains primary and secondary voltage clamps consisting of an IGBT and an SCR. In addition, it contains a GPIB programmer and measurement circuitry and controls that provide drive signals to the power components. In the chassis, high current bus capacitors are connected between the output to limit the rate of rise of voltage (slew rate) allowing the IGBT to operate at a controlled frequency when an external Regen current pulse occurs and to store energy to provide high peak current pulses to the load. A blocking diode in series with the input power supplies is used to detect the direction and amplitude of current flow. A differential amplifier is used to monitor the voltage across the blocking diode and regulate it to a value programmed by the internal GPIB controller which is independent of the input voltage level. Since it is desirable in some tests to allow the voltage to increase above the normal voltage level during the Regen pulse event, the output occurring across the blocking diode is scaled so that the voltage that is fed to a comparator is proportional to the controllers D-A converter that is calibrated to this same voltage range. When currents from the actuator conduct back into the absorber chassis, the bus capacitor charges until the input to the comparator reaches the programmed threshold and activates a drive signal to turn on the power IGBT connecting the absorber load resistor across the output bus. The resistor discharges the output capacitor until a lower threshold voltage is reached on the comparator. In this manner, with the actuator Regen current providing the charging current and the absorber load resistor providing the discharge current, the bus capacitor bank voltage can be maintained at a constant level with approximately 5V peak to peak of ripple during the charge and discharge intervals. The Energy Absorber Control chassis also contains circuitry to activate AC input contactors, relays and power supply shutdown signals, which are enabled through a control connector. Also available are high bandwidth 0-10V analog circuitry proportional to the DC output voltage and current for monitoring with an oscilloscope or external analog system. The voltage and current monitors are also available on an internal GPIB controller in the Absorber chassis so that their values can be queried over the bus. Additional functions in the chassis include an OVP detector for a secondary protection SCR in the case of a power interruption, and front panel status LEDs to show the operating status of the OVP circuit, relays and contactors.

DC Power / Energy Absorber Test System

The oscilloscope photo example shows the action of the power supplies and regen circuitry to a specific loading condition.

The photo shows an expanded view of the output voltage where the charge and discharge intervals are more visible. The bottom trace is output current that on the Energy Absorber power rack during a pulsed regenerative event. The top trace (1) shows the output voltage programmed to 270VDC at 10V/div AC coupled. The lower trace (3) shows the load current at 100A/div being switched between a resistive load of 100A and the Regen current at 150A. The arrow at the center of the scope trace is the zero current level. The scope trace is shown at 4msec/div.



Communication
Communication to control the power supply outputs and readback of voltage and current in the power supplies is accomplished with a GPIB interface using standard SCPI commands. The power supplies can also be operated manually from the front panels. The Energy Absorber chassis includes a GPIB interface for programming the Regen clamping limit, input contactor closure, dropout relay closure and voltage and current readbacks. A GPIB connection is provided on the rear of the rack for both interfaces.

AC Control and Distribution
The power rack system includes an AC distribution system. With a DC output power rating of 60kW at 480VDC and 150A, the AC input current to the rack is 120A per phase with a 400VAC, 3 phase, 4 wire connection. AC power to the racks is through two pin and sleeve type connectors and routed through circuit breakers and the mains disconnect interlock contactors. The AC interlock operates by energizing relays which are operated by ON/OFF switch closures located on the front panel or with auxiliary switch closures which are available through a rear I/O panel connector. The ON/OFF panel contains two pushbutton switches, an ON pushbutton and a twist to lock OFF button. A door interlock and single point ground connection are also provided.

DC Output
DC output is through an MS type connector of suitable type and ampacity on the panel depicted in the image above. A mating connector is provided.

DC Power / Energy Absorber Test System : Specifications

Input	
Voltage	480VAC ±10% L-L 3 Phase, 3 Wire plus ground
Frequency	45-65 Hz
Current	60A per phase max on two AC inlets at full rated output power
Power Factor	0.65 minimum
Connections	Hubbell 460B7W AC Inlet IP67 AC Inlets two (2) each
Output	
Voltage	0-400VDC
Current	0-150A
Connections	MS3102A-36-6S
Efficiency	85% typical @ full load
Energy Absorber	
Current Rating	150A nominal, 335A peak for 50usec
Power Rating	20KW average, 50kW peak for 1 sec
Overvoltage	OVP set at 430VDC
Remote Control Interface	
Discrete Control I/O	D38999/20F35PN MS Connector
IEEE-488 Programming	GPIB Connector
AC Power Control	
Power ON pushbutton on front panel (green)	
Power OFF/Emergency locking pushbutton on front panel (red)	
AC present indicator on front panel	
Remote interlock pins on rear panel control connector	
Physical Characteristics	
Height	73 inches(including casters)
Width	24 inches
Depth	36 inches
Weight	766 lbs.max
Cabinet Color	Black, FED STD 595B,27038
Dress Panel Color	Black, FED STD 595B,27038
Other	Locking Casters; lifting eyebolts
Environment	
Temperature	0-50 C Ambient
Humidity	95% max, non condensing
Altitude	4,000 ft
Certifications	
Sorensen SGA power supplies are NRTL approved to UL102, UL61010, EN61010, IEC61010	

Elgar High Current Research Test System

45–75 kW

"Copperhead"

0–5 V

9000–15000 A

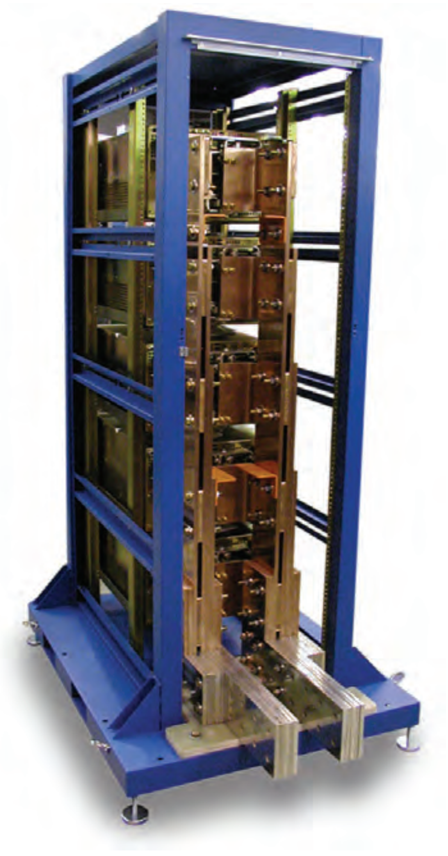
- 9000A, 12000A and 15000A configurations
- Continuous operation at max power
- Excellent transient response capabilities (similar to single power supply)
- Fast output current slew rate (rise & fall time)
- Compact, robust, transportable cabinet design (easy to move between laboratories)

The High Current Research Test System, dubbed "Copperhead," is designed to meet the demanding requirements of both Research and Development and Product Qualification Environments.

This system is capable of delivering a full 15,000 Adc with a 25msec rise time from no current to full current. It is intended to meet current-mode application requirements such as superconducting wire research, and contact current and circuit breaker qualification.

From the input AC distribution to the 810 lbs. (368 Kg.) of copper output bus bars, the Copperhead employs all of the system integration necessary to meet the application requirements. The control wiring implementation has been designed to provide the customer with a summed current readback so that current monitoring is easy.

With the understanding that the bottom trace above represents a full 15,000A of current, the system response time is well controlled and with little overshoot. The top trace depicts an ~ 40msec input control pulse and the bottom trace depicts the output response to this control pulse. Due to the power supply control loops and required stability of the output, the output pulse is delayed ~ 30msec and with a ~25msec rise time. There is also a delay once the falling edge is detected on the control pulse and is approximately the same with approximately the same fall time. Therefore, a 40msec pulse with a 3hz repetition rate is the fastest control signal possible to obtain a full 15,000A output with an output pulse ~120msec in duration and ~70msec at full current.



Unique, high-current DC output bus-bar. Design makes it easy to connect high-current UUTs.

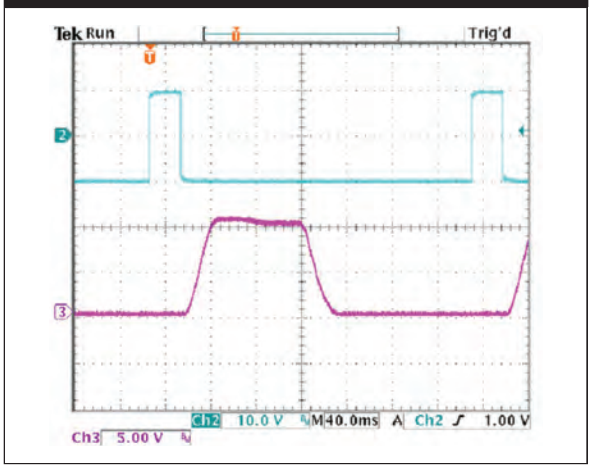
High Current Research Test System

Specifications	
Voltage	0 to 5 VDC
Current	0 to 15,000 A (Also available in 9,000A and 12,000A versions)
Regulation	Current-Mode Only – This system is not intended to run in Voltage-mode Line: For input voltage variation over the AC input voltage range, with constant rated load. Load: For 0-100% load variation, with constant nominal line voltage. Current: 0.5% of maximum rated output Voltage: 0.1% of maximum rated output
Transient response	A 30% current program step will recover to within + 2% of rated current within 10 msec.
Stability	+ 0.05% of set point over 8 hours after 30 minute warm-up with fixed line, load, and temperature.
Temperature Coefficient	Change in output per oC change in ambient temperature, with constant line and load. 0.03%/ oC of rated output current
Operating Temperature	0 - 50oC, No derating
Cooling	Each power supply has internal fans and rack system has three exhaust fans
Programming	Analog Programming; 0-10V equals 0 to full scale output
Regulatory	TUV NRTL to UL1950, TUV to IEC 950, CE Mark (Power Supplies)

Input Requirements and Physical Parameters	
AC Input Voltage	3-phase Delta or Wye C: 190-253Vac, 47-63Hz (Standard) D: 360-440Vac, 47-63Hz (Optional) E: 432-528Vac, 47-63Hz (Optional)
AC Input Current Maximum Consumption	At 380Vac (Typical at full load) 150A per phase
Power Factor	0.72 minimum
Dimensions	80” high x 36” wide x 45” deep (2040mm x 915mm x 1140mm)
Weight	2100 lbs (955 kg)

Remote Control Interface	
On/Off control	Contact Closure, TTL/CMOS or Isolated AC/DC (6-120V)
Current Control	0-10Vdc controls 0 to 100% of rated current
Current Control Accuracy	1% of full rated current
Current Monitor	0-10Vdc proportional to 0 to 100% of rated current
Current Monitor Accuracy	2% of full rated current, Output Impedance = ~200Ω
Voltage Monitor	0-10Vdc proportional to 0 to 100% of rated voltage
Voltage Monitor Accuracy	2% of full rated voltage
Connection	D-Sub 25 female connector

The figure below depicts the High Current Test System performance



Elgar Isolation / Polarity Chassis

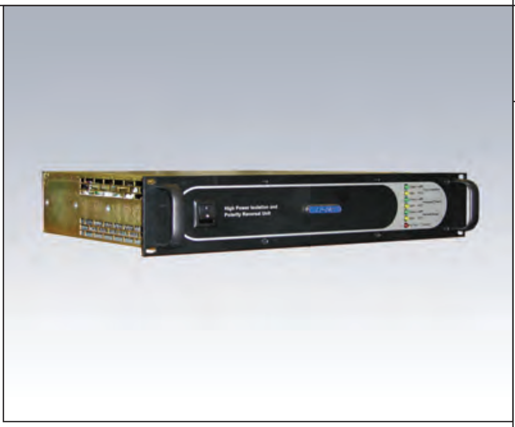
60 kW

Isolation / Polarity and Interlock Controls

600 V

250 A

- Remote Isolation control
- Remote Reverse Polarity control
- Remote Local/Remote Sense Relay control
- Output voltage isolation from load
- Relay Interlock (relays automatically open when an interlock connection is broken)
- Front panel LED's to indicate relay configuration and fault state of power supply
- Relay switch lock-out (ensures that both isolation and polarity relays are not on simultaneously)



The Elgar Isolation/Polarity Reversal Chassis, p/n 5608975-01, provides programmable normal or reverse polarity DC voltage for high voltage and high power loads. The unit is designed to connect and operate with the Ethernet user interface of a Sorensen programmable DC power supply, such as the SGA or SGI series, to provide a switched output. The unit includes controls for AC input Power, Output Isolation, Output Polarity, Output Interlock and Remote Sense relay control.

Description

The internal relays of the isolation/polarity chassis are controlled through the external user interface logic originating in the SGA/SGI series power supplies with an Ethernet Programming Interface (Option 1C). The chassis consists of a four (4) main power relays that switch the DC power supply voltage to provide full isolation when open and normal polarity or reversed output polarity when closed with the Ethernet controller.

As shown in the photo, the front panel of the Isolation / Polarity Reversal Unit includes an AC power switch that connects the AC input on the rear panel connector to an internal power supply that powers the relays. The unit includes an interlock connector that must be shorted before any relays will energize. All other controls are made through a cable connecting the SG Power Supplies External User connector on the Ethernet interface to the Isolation/Polarity chassis rear panel control connector. LEDs on the front panel of the chassis will change in response to the relay control status. The relays are interconnected so that if both isolation and polarity relays are enabled at the same time, the output contactors will be disabled to guard against shorting the output of the SG power supply. The Shutdown signal on the interlock connector also provides a way to interlock the chassis to the SG supply. This signal is connected to the S/D input of the supply and if the Interlock connection is opened, the signal will also disable the SG power supply through its Shutdown Input line. The Fault LED on the front panel indicates the status of the Fault line coming from the SG power supply. When the SG power supply is enabled, the DC voltage will be connected from the power supply to the Input connector on the rear panel. This input is connected to four power relays in a bridge matrix so that when one pair of relays are energized, the input power is connected to the output terminals with normal polarity. When the other pair of relays are energized, the input power is connected to the output terminals in a reversed polarity. The remote sense relays operate in conjunction with the isolation and polarity relay control signals so that the voltage can be sensed either remotely or at the input terminals of the chassis.

Isolation Polarity Chassis : Specifications

AC Power
AC power switch located on the front panel.

AC input voltage: 85 to 264VAC single phase at 1A maximum

AC Input connector: IEC320, C14 Inlet

(115VAC mating line cord provided)

Power Connectors
DC Input: 2 pin terminal block, M10 bolts (0.393” dia.), 600V, 250A Rated

DC Output: 2 pin terminal block, M10 bolts (0.393” dia.), 600V, 250A Rated

(M10 bolts accommodate copper wire to size 4/0.)

Control and Sense Connectors
Control Input: Molex 10 pin Micro-fit connector

Interlock: Molex 2 pin Universal Mate-N-Lock connector

Remote Sense Input: Molex 3 pin Mini-fit Jr connector

Remote Sense Output: Molex 3 pin Mini-fit Jr connector

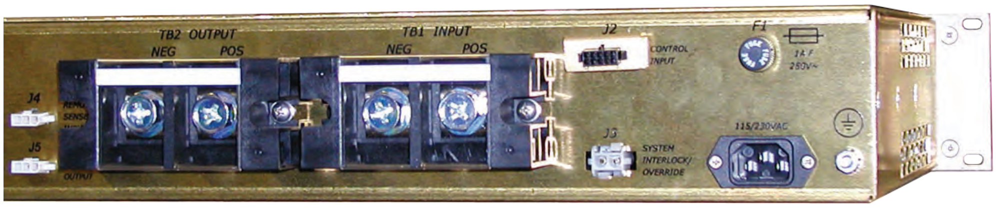
(Mating connectors provided.)

Mechanical
19” wide, 3.5” high (2U) chassis, 15” deep

Weight: 19.2 lbs

Mounting: Rack slide provisions on chassis side panels or rack support brackets.

(Mounting hardware not provided)



Isolation/Polarity Chassis Rear Panel

AMREL MFP Series

300 W - 1200 W

Millitarized Fixed Output AC-DC Power Supply

22 V - 35 V*

12.5 A - 50 A

	∼	90 VAC	250 VAC

*Consult factory for other voltage output

- Ultra Quiet - Convection Cooled.
- Rugged - MIL-STD 810F.
- Meets - MIL-STD 461
- Flexible - 85VAC - 250VAC, 45Hz - 440Hz, Active PFC
- Efficient - 85% Minimum
- Selectable Output or Fixed Output.
- Combat Proven in Iraq and Afganistan.

Designed specifically to provide accurate, reliable DC power in highly hostile environments, the AMREL MFP Series Power Supplies are proven to withstand the rigor of contemporary combat missions. Recognizing war fighter need, the MFP Series is among the most versatile and rugged COTS (Commercial-Off-The-Shelf) power supplies available.

Completely enclosed in a single extrusion, the mechanical design provides cooling and enables operation in the most severe environments. MFP Series power supplies are compliant with environmental requirements of MIL-STD 810F.

Convection cooling enables silent operation from - 40°C to + 70°C. The absence of a fan significantly reduces maintenance requirements. This allows installation in enclosed equipment, at remote sites, or even in unsheltered environments exposed to the elements.

The robust mechanical design has facilitated deployment on-board vehicles, weapons platforms, portable and stationary radar systems, shipboard, and unsheltered ground environments. For installation on aircraft the MFP operates from single phase 400 Hz power.

There are three MFP models available rated at 300 W, 400 W and 1200 W. Output voltage is either fixed or can be set from 22 VDC to 35 VDC. All models share common construction for simplified installation and packaging.

Most models include a front accessible DIP switch to accurately set output voltage to compensate for cable drop or other aspects of individual installations. Front panel LED's indicate operational status.

Active input power factor correction (PFC) allows operation from worldwide mains voltage as well as from any available generator or converter. Input ranges from 85 VAC to 250 VAC, 45 Hz to 440 Hz are automatically accommodated with no need for manual switch-over.

Current applications for the MFP include UAV Ground Control Power, Mobile Radar Equipment, Ground Radar installations, auxiliary 24VDC vehicle power, radio power, and battery charging for portable equipment.

MFP Series : Product Specifications

Voltage and Current Ranges				
Model	Voltage	Maximum Current	Output Power at 50C	Output Power at 65C
MFP 300 (SCP 2667)	24 VDC - 28 VDC	12.5 A	300 W	210 W
MFP 300-1	22 VDC - 35 VDC	12.5 A	300 W	210 W
MFP 400 with digital I/O	29 VDC	15 A	400 W	230 W
MFP 1200-1	28.75 VDC	50 A	1200 W	840 W
MFP 1200-4 (SCP 2305)	24 VDC - 28 VDC	50 A	1200 W	840 W

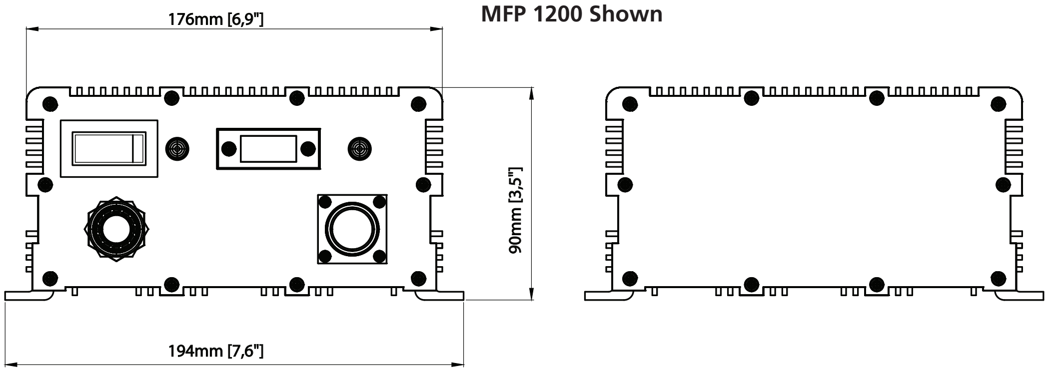
Common	
Over Current /Short Circuit	Current limit set for 150% rated output. Automatic recovery from overload.
Remote Programming	Output voltage is settable in accordance with specific model
Overvoltage Protection	Typical setting 5% - 10% above maximum output
Overtemperature Protection	Set at 100ºC with automatic recovery when temperature drops at least 5ºC.
Status Monitor	External LEDs indicate the status of the power supply.
Maintenance	None required
EMI and RFI	Meets MIL-STD-461; CE-102,CS-101, CS-114, RE-102 and RS-103.
Reliability	Minimum MTBF: 100.000 Hours in the operational environment.
Input	
Voltage and Frequency	85-250 VAC max, auto ranging, 45Hz - 440Hz, single phase, 2-wire plus ground
Current	15A maximum at 120 VAC., 1200 W output. Inrush current and voltage surge / spike protection.
Connector	IEC 320 with detachable line cord or ms connector
Power Factor	>.95 at full load
Output	
Line Regulation	+/- 0.05% from 90 VAC to 265 VAC at 100% load
Load Regulation	+/- 0.5% from No load to Full load
Transient Response	Recovers in less than 2 ms to 1% of set voltage
Stability	±0.05% of maximum voltage or current over 8 hours after 30 minute warm-up time at fixed line, load and temperature
Efficiency	>85% at full power rating.
Temperature Coefficient	Change in output 0.02% / ºC of maximum output voltage with constant line and load.
Environmental	
Operating Temperature	-40ºC to 65ºC. Derates 2%/ºC from 50ºC to 65ºC.
Storage Temperature	-40°C to 75°C
Cooling	Convection. Fully enclozed, black anodyze finish. Solar Radiation; 1130 W/meter sqared
Shock	MIL-STD-810F; Procidures IV, VI
Vibration	MIL-STD-810F; Method 514.5, Procedure II (In transit case)
Altitude	Operational: -1000 ft. to +10,000 ft. Non-operational: 40,000 ft.
Rain	MIL-STD-202: Method 104A, Test Condition A
Sand & Dust	MIL-STD-202: Method 110A
Salt Atmosphere	MIL-STD-202: Method 101E, Test Condition B
Ice, Snow and Hail	Complies with MIL-STD 810F. Meets snow load. 20lbs / ft^2 Withstands hail up to 60mm.
Fungus	MIL-STD 810F: Method 508.5
Salt Atmosphere	MIL-STD 810F: Method 509.4
Humidity	MIS-STD 810F: Method 507.4. 5% to 100% Condensing.

Physical			
Model	MFP 300	MFP 400	MFP 1200
Width	7.5” (190 mm)	7.5” (190 mm)	7.5” (190 mm)
Height	3.5” (90 mm)	3.5” (90 mm)	3.5” (90 mm)
Length	12.0” (305 mm)	12.0” (305 mm)	16.0” (406 mm)
Weight	8.9 lb. (4.04 Kg)	8.9 lb. (4.04 Kg)	15.3 lb. (6.95 Kg)
Shipping Weight	11.0 lb. (5.0 Kg)	11.0 lb. (5.0 Kg)	17.5 lb. (7.94 Kg)

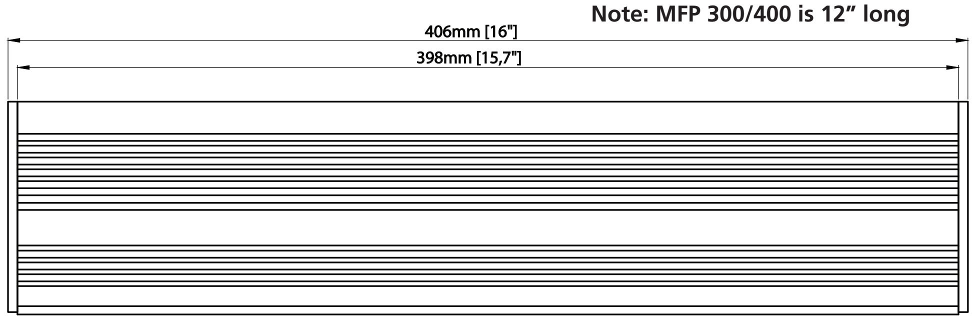
MFP Series : Product Diagram

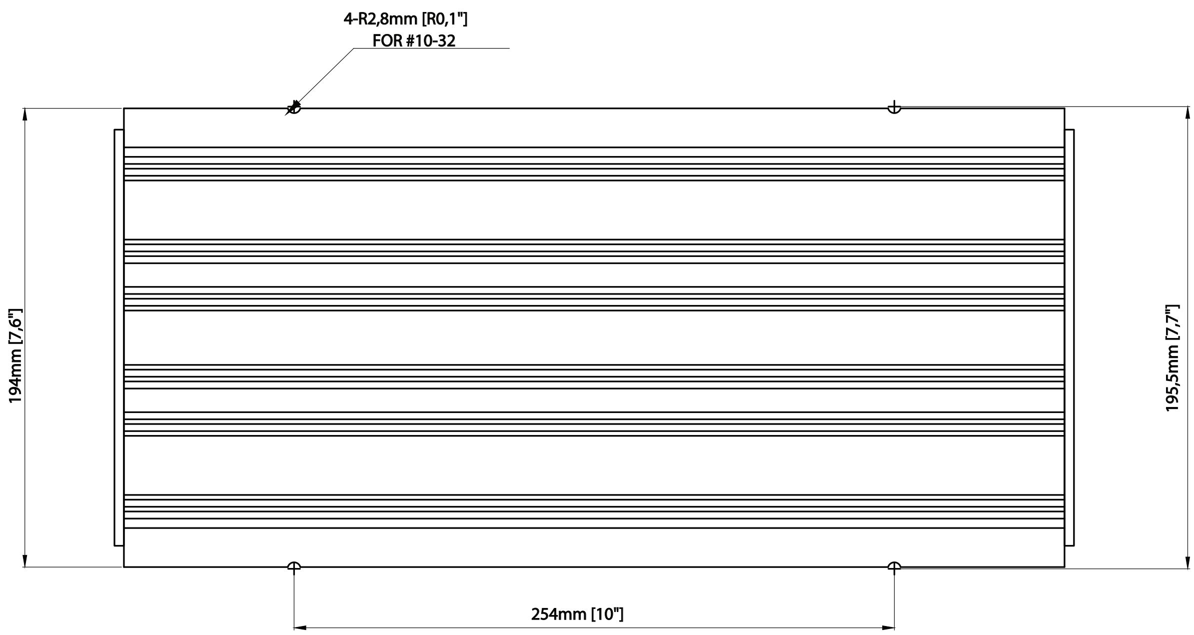
300 W - 1200 W

MFP 1200 Shown



Note: MFP 300/400 is 12" long





Connectors				
Model	MFP 300 / 300-1	MFP 400	MFP 1200-1	MFP 1200 / 1200-4
Input	MS3102E16-10P	MS3102E16-10P	AIB2-20-3PS	19616 10 B1 - power cord
Input Mate	MS3106E16-10S	MS3106E16-10S	AIB6F20-3SS	NEMA 5-15
Output	MS3112E10-6S	MS3112E10-6S	MS3470W14-4S	MS3470W14-4S
Output Mate	MS3116E10-6P	MS3116E10-6P	MS3470W14-4P	MS3470W14-4P

Notes

Warranty

Warranty

AMETEK Programmable Power warrants its products to be free from defects in material and workmanship. The warrenty period is from the date of original shipment of the product to the original purchaser (see website for warranty periods by product). Liability of AMETEK under this warranty shall exist provided that:

- the Buyer exposes the product to normal use and service and provides normal maintenance on the product;
- AMETEK is promptly notified of defects by the Buyer and that notification occurs within the warranty period;
- the Buyer receives a Return Material Authorization (RMA) number from AMETEK's Repair Department prior to the return of the product to AMETEK for repair, phone 800-733-5427 or 858-450-0085. Outside the United States, you may find an authorized service center through our website, www.programmablepower.com: in the SUPPORT page, click on SERVICE CENTERS.

NOTE: Unauthorized returns will not be accepted and will be returned at the shipper's expense;

- the Buyer returns the defective product in the original, or equivalent, shipping container;
- if, upon examination of such product by AMETEK it is disclosed that, in fact, a defect in materials and/or workmanship does exist, that the defect in the product was not caused by improper conditions, misuse, or negligence; and,
- that the product QA seal and nameplates have not been altered or removed and the equipment has not been repaired or modified by anyone other than AMETEK-authorized personnel.

This warranty is exclusive and in lieu of all other warranties, expressed or implied, including, but not limited to, implied warranties of merchantability and fitness of the product to a particular purpose. AMETEK, its agents, or representatives shall in no circumstance be liable for any direct, indirect, special, penal, or consequential loss or damage of any nature resulting from the malfunction of the product. Remedies under this warranty are expressly limited to repair or replacement of the product.

Wire Gauge and Current Limits

AWG gauge	Conductor Diameter Inches	Conductor Diameter mm	Ohms per 1000 ft	Ohms per km	Max amps for chassis wiring	Max amps for power transmission	Max freqency for 100% skin depth for solid conductor copper
OOOO	0.46	11.684	0.049	0.16072	380	302	125 Hz
OOO	0.4096	10.40384	0.0618	0.202704	328	239	160 Hz
OO	0.3648	9.26592	0.0779	0.255512	283	190	200 Hz
0	0.3249	8.25246	0.0983	0.322424	245	150	250 Hz
1	0.2893	7.34822	0.1239	0.406392	211	119	325 Hz
2	0.2576	6.54304	0.1563	0.512664	181	94	410 Hz
3	0.2294	5.82676	0.197	0.64616	158	75	500 Hz
4	0.2043	5.18922	0.2485	0.81508	135	60	650 Hz
5	0.1819	4.62026	0.3133	1.027624	118	47	810 Hz
6	0.162	4.1148	0.3951	1.295928	101	37	1100 Hz
7	0.1443	3.66522	0.4982	1.634096	89	30	1300 Hz
8	0.1285	3.2639	0.6282	2.060496	73	24	1650 Hz
9	0.1144	2.90576	0.7921	2.598088	64	19	2050 Hz
10	0.1019	2.58826	0.9989	3.276392	55	15	2600 Hz
11	0.0907	2.30378	1.26	4.1328	47	12	3200 Hz
12	0.0808	2.05232	1.588	5.20864	41	9.3	4150 Hz
13	0.072	1.8288	2.003	6.56984	35	7.4	5300 Hz
14	0.0641	1.62814	2.525	8.282	32	5.9	6700 Hz
15	0.0571	1.45034	3.184	10.44352	28	4.7	8250 Hz
16	0.0508	1.29032	4.016	13.17248	22	3.7	11 k Hz
17	0.0453	1.15062	5.064	16.60992	19	2.9	13 k Hz
18	0.0403	1.02362	6.385	20.9428	16	2.3	17 kHz
19	0.0359	0.91186	8.051	26.40728	14	1.8	21 kHz
20	0.032	0.8128	10.15	33.292	11	1.5	27 kHz
21	0.0285	0.7239	12.8	41.984	9	1.2	33 kHz
22	0.0254	0.64516	16.14	52.9392	7	0.92	42 kHz
23	0.0226	0.57404	20.36	66.7808	4.7	0.729	53 kHz
24	0.0201	0.51054	25.67	84.1976	3.5	0.577	68 kHz
25	0.0179	0.45466	32.37	106.1736	2.7	0.457	85 kHz
26	0.0159	0.40386	40.81	133.8568	2.2	0.361	107 kH
27	0.0142	0.36068	51.47	168.8216	1.7	0.288	130 kHz
28	0.0126	0.32004	64.9	212.872	1.4	0.226	170 kHz
29	0.0113	0.28702	81.83	268.4024	1.2	0.182	210 kHz
30	0.01	0.254	103.2	338.496	0.86	0.142	270 kHz
31	0.0089	0.22606	130.1	426.728	0.7	0.113	340 kHz
32	0.008	0.2032	164.1	538.248	0.53	0.091	430 kHz
Metric 2.0	0.00787	0.2	169.39	555.61	0.51	0.088	440 kHz
33	0.0071	0.18034	206.9	678.632	0.43	0.072	540 kHz
Metric 1.8	0.00709	0.18	207.5	680.55	0.43	0.072	540 kHz
34	0.0063	0.16002	260.9	855.752	0.33	0.056	690 kHz
Metric 1.6	0.0063	0.16002	260.9	855.752	0.33	0.056	690 kHz
35	0.0056	0.14224	329	1079.12	0.27	0.044	870 kHz
Metric 1.4	0.00551	0.14	339	1114	0.26	0.043	900 kHz
36	0.005	0.127	414.8	1360	0.21	0.035	1100 kHz
Metric 1.25	0.00492	0.125	428.2	1404	0.2	0.034	1150 kHz
37	0.0045	0.1143	523.1	1715	0.17	0.0289	1350 kHz
Metric 1.12	0.00441	0.112	533.8	1750	0.163	0.0277	1400 kHz
38	0.004	0.1016	659.6	2163	0.13	0.0228	1750 kHz
Metric 1	0.00394	0.1	670.2	2198	0.126	0.0225	1750 kHz
39	0.0035	0.0889	831.8	2728	0.11	0.0175	2250 kHz
40	0.0031	0.07874	1049	3440	0.09	0.0137	2900 kHz

Technical Conversions Chart

Length from metric	Multiply by	To Find
millimeters (mm)	0.04	inches (in)
centimeters (cm)	0.4	inches (in)
meters (m)	3.3	feet (ft)
meters (m)	1.1	yards (yd)
kilometers (km)	0.6	miles (m)
Length to metric	**Multiply by**	**To Find**
inches (in)	2.54	centimeters (mm)
feet (ft)	30	centimeters (cm)
yards (yd)	0.9	meters (m)
miles (m)	1.6	kilometers (km)

Weight from metric	Multiply by	To Find
grams (g)	0.035	ounces (oz)
kilograms (kg)	2.2	pounds (lb)
tonnes 1,000 kg (t)	1.1	short tons
Weight to metric	**Multiply by**	**To Find**
ounces (oz)	28	grams (g)
pounds (lb)	0.45	kilograms (kg)
short tons (2,000 lb)	0.9	tonnes (t)

Volume from metric	Multiply by	To Find
milliliters (mL)	0.03	fluid ounces (fl oz)
liters (L)	2.1	pints (pt)
liters (L)	1.06	quarts (qt)
liters (L)	0.26	gallons (gal)
cubic meters (m3)	35	cubic feet (ft3)
cubic meters (m3)	1.3	cubic yards (yd3)
Volume to metric	**Multiply by**	**To Find**
teaspoon (tsp)	5	milliliters (mL)
tablespoon (tbsp)	15	milliliters (mL)
fluid ounces (fl oz)	30	milliliters (mL)
cups (c)	0.24	liters (L)
pints (pt)	0.47	liters (L)
quarts (qt)	0.95	liters (L)
gallons (gal)	3.8	liters (L)
cubic feet (ft3)	0.03	cubic meters (m3)
cubic yards (yd3)	0.76	cubic meters (m3)

Temperature from metric	Multiply by	To Find
Celsius (°C)	(9/5)*Celsius temp. +32	Fahrenheit (°F)
Temperature to metric	**Multiply by**	**To Find**
Fahrenheit (°F)	(5/9)*(Fahrenheit temp.-32	Celsius (°C)

Electrical Formulas	Based on 60 Hz
Capacitive Reactance (XC) in Ohms	$= 1/(2\pi\ f\ C)$
Effective (RMS) AC Amperes	= Peak Amperes x 0.707
Effective (RMS) AC Volts	= Peak Volts x 0.707
Efficiency (percent)	= Output / Input x 100
Efficiency	= Output Power / Input Power
Horsepower	= Output Watts/746
Inductive Reactance (XL) in Ohms	$= 2\pi\ f\ L$
Input	= Output / Efficiency
Neutral Current (Wye)	$= \sqrt{A2 + B2 + C2 - (AB + BC + AC)}$
Output	= Input x Efficiency
Peak AC Volts	= Effective (RMS) AC Volts x $\sqrt{2}$
Peak Amperes	= Effective (RMS) Amperes x $\sqrt{2}$
Power Factor (PF)	= Watts/VA
VA (apparent power)	= Volts x Ampere or Watts/Power Factor
VA 1-Phase	= Volts x Amperes
VA 3-Phase	= Volts x Amperes x $\sqrt{3}$
Watts (real power) Single-Phase	= Volts x Amperes x Power Factor
Watts (real power) Three-Phase	= Volts x Amperes x Power Factor x $\sqrt{3}$

Power	Watts	kW	Horsepower	in-lb/s	ft-lb/s
Watts	1	100E-03	1.34E-03	8.85	0.74
kW	1000	1	1.34	8851	738
Horsepower	746	0.746	1	6600	550
in-lb/s	0.113	1.13E-04	1.52E-04	1	0.083
ft-lb/s	1.35	1.36E-03	1.82E-03	12	1

Power Conversions	Direct Current	Alternating Current	
		Single Phase	Three Phase
Amperes when horsepower (input) is known	$\frac{\text{HP X 746}}{\text{E X Eff}}$	$\frac{\text{HP X 746}}{\text{E X Eff X P.F.}}$	$\frac{\text{HP X 746}}{\text{1.73 X E X Eff X P.F}}$
Amperes when Kilowatts is known	$\frac{\text{kW X 1000}}{\text{E}}$	$\frac{\text{kW X 1000}}{\text{E X P.F.}}$	$\frac{\text{kW X 1000}}{\text{1.73 X E X P.F.}}$
Amperes when kVA is known		$\frac{\text{Kva X 1000}}{\text{E}}$	$\frac{\text{Kva X 1000}}{\text{1.73 X E}}$
Kilowatts	$\frac{\text{I X E}}{\text{1000}}$	$\frac{\text{I X E X P.F.}}{\text{1000}}$	$\frac{\text{1.73 X I X E X P.F.}}{\text{1000}}$
kVA		$\frac{\text{I X E}}{\text{1000}}$	$\frac{\text{1.73 X I X E}}{\text{1000}}$
P.F.		$\frac{\text{kW}}{\text{Kva}}$	$\frac{\text{kW}}{\text{Kva}}$
Horsepower (output)	$\frac{\text{I X E X Eff}}{\text{746}}$	$\frac{\text{I X E X Eff X P.F.}}{\text{746}}$	$\frac{\text{1.73 X I X E X Eff X P.F.}}{\text{746}}$

I = Amperes
Eff = Efficiency (decimal)
kVA = Kilovolt - amperes
E = Volts
P.F. = Power Factor
kW = Kilowatts
HP = Horsepower

C = Capacitance in Farads
F = Frequency in Hertz
L = Inductance in Henry

Glossary

Glossary

Brownout
the condition created during peak usage periods when electric utility companies intentionally reduce their line voltage by approximately 10 - 15% to counter excessive demand.

Cross-regulation
in a multiple output power supply, the voltage change at one output caused by the load change on another, expressed as a percentage of the nominal voltage.

Derating
reducing one operating parameter to compensate for changes in other parameters to maintain reliability. For example, the reduction in output power at elevated temperatures.

Efficiency
the ratio of total output power to input power, expressed as a percentage. Efficiency must be specified at a specific combination of load and input voltage.

Electromagnetic interference (EMI)
unwanted high-frequency energy that is conducted through the input or output lines or radiated into space by switching power supplies. Also known as radio-frequency interference (RFI).

Foldback current limiting
a type of power supply overload protection that decreases the output current as the overload increases, until the current reaches a minimal value at short-circuit. Foldback current limiting minimizes internal power dissipation under overload.

Forward converter
a power supply switching circuit that transfers energy to the transformer secondary when the switching transistor is on. Forward converter circuits store minimal energy in the transformer.

Ground loop
a condition that causes unwanted feedback when two or more circuits share a common electrical return or ground lines.

Holdup time
the time during which a power supply's output voltage remains within specified limits following the loss or removal of input power. Holdup time is normally measured at full load and nominal line conditions.

Input voltage range
the range of input voltage values for which a power supply or dc-ac converter operates within specified limits.

Inrush current
the peak instantaneous input current drawn by a power supply when it is initially turned on.

Inrush circuit limiting
a circuit that limits the inrush current when a power supply is turned on.

Insulation resistance
the dc resistance between two defined points at a specific voltage in a controlled environment (25°C temperature and less than 50% relative humidity).

Inverter
a device that changes dc power at its input into ac power at its output. Also called a power converter.

Isolation
the electrical separation between the input and output of a power supply due primarily to the power transformer. The isolation is a function of materials and spacings throughout the supply.

Isolation voltage
the maximum ac or dc voltage that may be continuously applied from input to output and/or chasis of a power supply.

Line regulation
the maximum change in output voltage, expressed as a percentage, that occurs as the input voltage varies over its specified limits, with load and temperature constant.

Load regulation
the change in output voltage, expressed as a percentage of nominal voltage, that occurs as the load changes from minimum to maximum, at constant line and constant temperature. Load change may be specified for other than no load to full load as, for example, 50% load to full load.

Local sensing
using the power supply output voltage terminals as the error-sensing points to provide feedback to a voltage regulator.

Mean time between failure (MTBF)
a basic measure of reliability for repairable items. It represents the average time during which all parts of an item perform within their specified limits, during a particular measurement period (typically hours) under stated conditions.

Operating temperature range
the range of ambient or case temperatures through which a power supply may operate safely and perform within specified limits.

Glossary

Output current limiting
a protective feature that keeps the output current of a power supply within predetermined limits during overload to prevent damage to the supply or the load. The supply automatically returns to normal operation following the removal of the overload.

Overload protection
a protective feature that limits the output current of a power supply under overload conditions so that it will not be damaged.

Overvoltage protection (OVP)
a protective feature that shuts down a power supply (reduces the output voltage to a minimal level) to prevent damage to the load when the output voltage exceeds a predetermined limit.

Parallel operation
the connection of the outputs of two or more power supplies of the same output voltage to obtain a higher output current than either supply can provide alone. Parallel operation requires power supplies that are specifically designed to share the load.

Ripple and Noise
the unwanted periodic (ripple) or aperiodic (noise) deviation of the power supply output voltage from its nominal value. Ripple is a function of the input line and switching components and is expressed in millivolts peak-to-peak or rms, at a specified bandwidth.

Pulse-width modulation (PWM)
a method of regulating the output voltage of a switching power supply by varying the width, but not the height, of a train of pulses that drives a power switch.

Rated output current
the maximum load current that a power supply is designed to provide at a specified ambient temperature.

Regulator
the power supply circuit that controls or stabilizes the output voltage at a preset value.

Remote sensing
a technique for regulating the output voltage of a power supply at the load by connecting the regulator error-sensing leads directly to the load. Remote sensing compensates for voltage drops in the load leads.

Resolution
for an adjustabe supply, the smallest change in output voltage can be realized by an adjustment.

Reverse voltage protection
a feature that protects a power supply from damage caused by a voltage of reverse polarity applied at the input or output terminals.)

Series regulation
a popular method of linear regulation in which the control device is connected in series with the raw dc and the load to achieve constant voltage across the load.

Short-circuit protection
a protective feature that limits the output current of a power supply to prevent damage to the supply caused by short circuits.

Switching frequency
the rate at which the dc voltage is switched in a dc-dc converter or switching power supply.

Switching regulator
a high-efficiency switching circuit that operates in a closed loop system to regulate the voltage across a load, generally by means of a pulse-width modulator.

Temperature coefficient
the average change in output voltage per change in degree of a baseplate temperature, expressed as a percentage of nomimal output voltage, over a specified temperature range.

Thermal protection
a protective feature that shuts down a power supply if its internal temperature exceeds a predetermined limit.

Transient recovery time
the time required for the output voltage of a power supply to settle within specified output accuracy limits following a step change in output load current or input voltage.

Warm-up time
the time required after a power supply is initially turned on before it operates according to specified performance limits.

DC Product Selector Guide

Voltage	Current	Model
5	3	PD 5-3 consult factory
5	10	PD 5-10 consult factory
5	12	PD 5-12 consult factory
5	20	PD 5-20 consult factory
5	24	PD 5-24 consult factory
5	30	PD 5-30 consult factory
5	40	PD 5-40 consult factory
5	75	DLM 5-75
5	350	DLM 5-350E
5	450	DLM 5-450E
6	110	XG 6-110
6	220	XG 6-220
7	6	XT 7-6
7.5	67	XPD 7.5-67
7.5	130	XHR 7.5-130
7.5	300	XFR 7.5-300
8	2	PD 8-2 consult factory
8	4	PD 8-4 consult factory
8	10	PD 8-10 consult factory
8	20	PD 8-20 consult factory
8	40	PD 8-40 consult factory
8	75	DLM 8-75
8	100	XG 8-100
8	125	DCS 8-125E
8	140	DCS 8-140E
8	187.5	XG 8-187.5
8	200	XG 8-200
8	350	DCS 8-350E
8	350	DLM 8-350E
8	450	DLM 8-450E
10	60	DLM 10-60
10	100	DCS 10-100E
10	100	XHR 10-100
10	120	DCS 10-120E

Voltage	Current	Model
10	400	SG 10-400
10	800	SG 10-800
10	1200	SG 10-1200
12	70	XG 12-70
12	140	XG 12-140
12	220	XFR 12-220
12	250	DCS 12-250E
12.5	120	XG 12.5-120
15	1.5	XEL 15-5
15	4	XT 15-4
15	5	XBT 32-3FTP
15	20	HPD 15-20
15	267	SG 15-267
15	534	SG 15-534
15	801	SG 15-801
16	20.6	RFP-D1016-021
16	185	DLM 16-185E
16	250	DLM 16-250E
18	3	XPL 18-3
18	10	XPH 18-10
18	30	XPD 18-30
20	1	PD 20-1 consult factory
20	2	PD 20-2 consult factory
20	3	PD 20-3 consult factory
20	3	XT 20-3
20	4	PD 20-4 consult factory
20	5	PD 20-5 consult factory
20	10	PD 20-10 consult factory
20	30	DLM 20-30
20	30	PD 20-30 consult factory
20	42	XG 20-42
20	50	DCS 20-50E
20	50	PD 20-50 consult factory
20	50	XHR 20-50

Voltage	Current	Model
20	60	DCS 20-60E
20	76	XG 20-76
20	84	XG 20-84
20	130	XFR 20-130
20	150	DCS 20-150E
20	250	SG 20-250
20	500	SG 20-500
20	750	SG 20-750
30	0.6	PD 30-0.6 consult factory
30	1	XPL 30-1
30	1.2	PD 30-1.2 consult factory
30	1.3	XEL 30-3
30	2	PD 30-2 consult factory
30	2	XPL 30-2
30	2	XPL 30-2D
30	2	XPL 30-2T
30	2	XT 30-2
30	2.5	PD 30-2.5 consult factory
30	3.5	PD 30-3.5 consult factory
30	5	PD 30-5 consult factory
30	6	XEL 30-3D
30	10	HPD 30-10
30	10	PD 30-10
30	50	XG 30-50
30	167	SG 30-167
30	334	SG 30-334
30	501	SG 30-501
32	95	DLM 32-95E
32	125	DLM 32-125E
33	16	XPD 33-16
33	25	XG 33-25
33	33	DCS 33-33E
33	33	XHR 33-33
33	36	DCS 33-36E

Voltage	Current	Model
33	43	RFP-D2033-030
33	50	XG 33-50
33	85	XFR 33-85
35	2	PD 35-2 consult factory
35	4	XPH 35-4D
35	4	XPH 35-4T
35	5	XDL 35-5
35	5	XDL 35-5T
35	5	XPH 35-5
35	10	XPF 35-10
40	0.5	PD 40-0.5 consult factory
40	1	PD 40-1 consult factory
40	1.5	PD 40-1.5 consult factory
40	2	PD 40-2 consult factory
40	3.5	PD 40-3.5 consult factory
40	5	PD 40-5 consult factory
40	7	PD 40-7 consult factory
40	15	DLM 40-15
40	21	XG 40-21
40	25	DCS 40-25E
40	25	PD 40-25 consult factory
40	25	XHR 40-25
40	30	DCS 40-30E
40	30	PD 40-30 consult factory
40	38	XG 40-38
40	42	XG 40-42
40	75	DLM 40-75E
40	100	DLM 40-100E
40	125	SG 40-125
40	250	ASD 40-250
40	250	SG 40-250
40	375	SG 40-375
40	500	ASD 40-500
40	750	ASD 40-750

DC Product Selector Guide

Voltage	Current	Model
50	100	SG 50-100
50	200	SG 50-200
50	300	SG 50-300
55	55	DCS 55-55E
56	1.1	XPL 56-1
56	4	XDL 56-4
56	4	XDL 56-4P
60	0.3	PD 60-0.3 consult factory
60	1	PD 60-1 consult factory
60	1	XT 60-1
60	1.5	XEL 60-1.5
60	3	PD 60-3 consult factory
60	5	HPD 60-5
60	6	PD 60-6
60	9	XPD 60-9
60	10	DLM 60-10
60	10	PD 60-10 consult factory
60	14	XG 60-14
60	18	DCS 60-18E
60	18	XHR 60-18
60	20	DCS 60-20E
60	20	PD 60-20 consult factory
60	20	XPF 60-20
60	25	XG 60-25
60	28	XG 60-28
60	46	XFR 60-46
60	50	DCS 60-50E
60	50	DLM 60-50E
60	66	DLM 60-66E
60	83	SFA 60-83
60	83	SG 60-83
60	167	ASD 60-167
60	167	SFA 60-167
60	167	SGA 60-167
60	250	SFA 60-250
60	250	SG 60-250
60	333	SFA 60-333
60	333	SG 60-333
60	334	ASD 60-334
60	417	SFA 60-417
60	417	SG 60-417
60	500	SFA 60-500
60	500	SG 60-500
60	501	ASD 60-501
65	5.1	RFP-D1065-5A1
75	2	XPH 75-2D
80	0.25	PD 80-0.25 consult factory
80	2.5	PD 80-2.5 consult factory
80	3.5	PD 80-3.5 consult factory
80	7.5	DLM 80-7.5
80	10.5	XG 80-10.5
80	13	DCS 80-13E
80	15	DCS 80-15E
80	19	XG 80-19
80	21	XG 80-21
80	37	DCS 80-37E
80	37	DLM 80-37E
80	50	DLM 80-50E
80	63	SG 80-63
80	125	SG 80-125
80	188	SG 80-188
80	250	SG 80-250
80	313	SG 80-313
80	375	SG 80-375
100	8.5	XG 100-8.5
100	10	DCS 100-10E
100	12	DCS 100-12E
100	15	XG 100-15
100	17	XG 100-17
100	28	XFR 100-28
100	50	SFA 100-50
100	50	SG 100-50
100	100	SFA 100-100
100	100	SG 100-100
100	150	SFA 100-150
100	150	SG 100-150
100	200	SFA 100-200
100	200	SG 100-200
100	250	SFA 100-250
100	250	SG 100-250
100	300	SFA 100-301
100	300	SG 100-300
120	0.3	PD 120-0.3 consult factory
120	0.5	PD 120-0.5A consult factory
120	0.5	XT 120-0.5
120	1	PD 120-1 consult factory
120	2	PD 120-2 consult factory
120	4.5	XPD 120-4.5
150	4	DLM 150-4
150	5.6	XG 150-5.6
150	7	DCS 150-7E
150	7	XHR 150-7
150	8	DCS 150-8E
150	10	XG 150-10
150	11.2	XG 150-11.2
150	18	XFR 150-18
150	20	DCS 150-20E
150	20	DLM 150-20E
150	26	DLM 150-26E
160	31	SFA 160-31
160	31	SG 160-31
160	63	SFA 160-63
160	63	SG 160-63
160	94	SFA 160-94
160	94	SG 160-94
160	125	SFA 160-125
160	125	SG 160-125
160	156	SFA 160-156
160	156	SG 160-156
160	188	SFA 160-188
160	188	SG 160-188
200	25	SG 200-25
200	50	SG 200-50
200	75	SG 200-75
200	100	SG 200-100
200	125	SG 200-125
200	150	SG 200-150
250	0.2	PD 250-0.2 consult factory
250	0.4	PD 250-0.4 consult factory
250	0.6	PD 250-0.6A consult factory
250	20	SG 250-20
250	40	SG 250-40
250	60	SG 250-60
250	80	SG 250-80
250	100	SG 250-100
250	150	SG 250-150
300	2	DLM 300-2
300	2.8	XG 300-2.8
300	3.5	DCS 300-3.5E
300	3.5	XHR 300-3.5
300	4	DCS 300-4E
300	4	PD 300-4 consult factory
300	5	XG 300-5
300	5.6	XG 300-5.6
300	9	XFR 300-9
300	10	DLM 300-10E

DC Product Selector Guide

Voltage	Current	Model
300	13	DLM 300-13E
330	15	SG 330-15
330	30	SG 330-30
330	45	SG 330-45
330	61	SG 330-61
330	76	SG 330-76
330	91	SG 330-91
350	0.15	PD 350-0.15 consult factory
350	0.6	PD 350-0.6 consult factory
350	1.2	PD 350-1.2 consult factory
400	12	SG 400-12
400	25	SG 400-25
400	38	SG 400-38
400	50	SG 400-50
400	63	SG 400-63
400	75	SG 400-75
450	2.3	RFP-D2450-2A3
500	10	SG 500-10
500	20	SG 500-20
500	30	SG 500-30
500	40	SG 500-40
500	50	SG 500-50
500	60	SG 500-60
600	1.4	XG 600-1.4
600	1.7	DCS 600-1.7E
600	1.7	XHR 600-1.7
600	2.6	XG 600-2.6
600	2.8	XG 600-2.8
600	4	XFR 600-4
600	5	DLM 600-5E
600	6.6	DLM 600-6.6E
600	8	SG 600-8
600	17	SG 600-17
600	25	SG 600-25

Voltage	Current	Model
600	33	SG 600-33
600	42	SG 600-42
600	50	SG 600-50
800	6.2	SG 800-6.2
800	12.5	SG 800-12.5
800	18.7	SG 800-18.7
1000	5	SG 1000-5
1000	10	SG 1000-10
1000	15	SG 1000-15

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