Power of Choice

AMETEK®
PROGRAMMABLE POWER

Programmable Power Supplies &
Electronic Loads Catalog

TECHNICAL GUIDE

- Product Specifications
- Applications Notes
- Technical Notes
- Industry Use Articles
- How To Guides
- Technical Conversions
- Product Selector Guide

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AMETEK®

PROGRAMMABLE POWER

About

AMETEK Programmable Power

Headquartered in San Diego, California, AMETEK Programmable Power, is a 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.

Proud manufacturer of the following trusted brands:

Sorensen™ ELGAR™ POWERTEN™

From benchtop supplies to rack-mounted industrial power subsystems, AMETEK Programmable Power produces Sorensen, and PowerTen DC supplies ranging from 30W to 150kW; programmable Elgar AC sources from 800VA to 480kVA, and Sorensen AC/DC loads in both modular and high-power models.

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● Standard ○ Option

AC Rack Mount Power Supplies	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
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● Standard ○ Option

DC Rack Mount Power Supplies

Notes

Considerations When Specifying a DC Power Supply

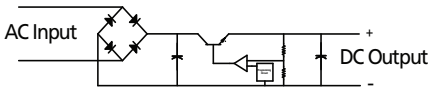
Article

By Philip Joosten

System integration made easy.
Almost every automated test system that tests electronic circuit boards, modules or equipment needs one or more power supplies.
This could be DC to simulate the DC power-bus within the equipment that powers the internal circuit boards or modules or this could be AC to simulate the AC mains of different countries or the AC power-bus used in aircrafts.

In any case the power supply simulates the environment the electronic circuitry is used in, thus it is the device under test (DUT) that determines the power supply requirements. In addition, we need to consider the requirements for margin testing. This means what internal or external standards apply to this DUT. For instance some automotive standards require margin testing up to 27VDC on a 12VDC device. This means that although the DUT runs nominal on 12VDC, the maximum test voltage is much higher.

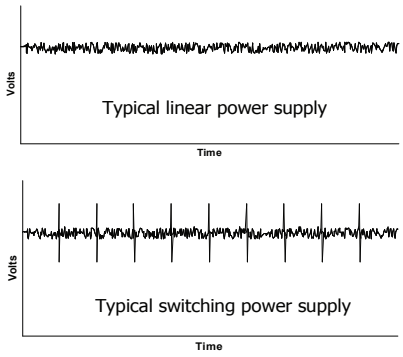
In the next paragraphs I would like to discuss most common power supply parameters to be considered when selecting a power supply to match your DUT testing requirements.



Basic Linear Power Supply

Ripple & Noise
Ripple & noise specifications are traditionally the first specifications we look at. This is important, because the first choice we must make is that between a linear or switch-mode DC power supply. Actually there are three main topologies of DC programmable power supplies to consider: linear, switch-mode and hybrid. The linear power supply has low ripple & noise and has fast transient behaviors. However, it's inefficient, producing a lot of heat in the air and becomes large and heavy and is therefore only desirable at lower output power levels (typically less then 500 Watts). Most linear DC power supplies are bench-type supplies. The following are two main reasons to consider a linear bench supply. First, when the DUT is a communication device like an RF radio or mobile phone, or the demodulator module of a radar system. What this type of equipment has in common is a very sensitive discriminator or demodulator circuitry that works the best with a low noise figure. In other words, to test its true signal-to-noise (S/N in dB) performance, we need to ensure that the DC power supply does not add any parasitical noise to the test setup. The second reason to consider a bench-type supply is when the power requirements are low. The main benefits for a switch-mode supply are only relevant at higher output power levels. It will be less expensive to use linear DC power supplies in applications with requirements not more then 100 to 200 Watts per DC output channel. Important

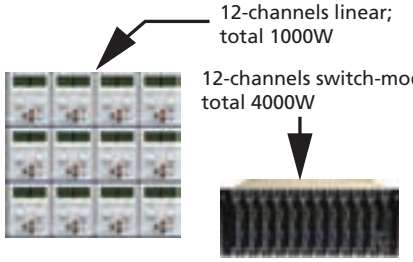
Noise Profile on Linear vs. Switching



- 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

to consider is the total power of all required DC output channels combined. Up to four channels it could be easier to just take four linear bench supplies in a 19-inch rack-mount kit. In switch-mode technology, 12 channels together providing over four thousand Watts will take the same rack-space, with less complex multi-channel control for a similar price per channel.

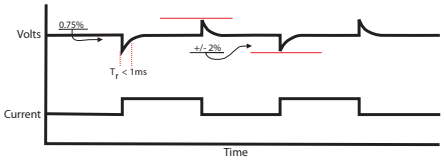
If ripple & noise is not the driving specification, realize that switch-mode programmable supplies do give you more flexibility. Switch-mode programmable supplies provide more value, or output power, for the same price in a smaller box. Better stated, they provide a larger DC output voltage and current range, covering different needs for testing your DUT.



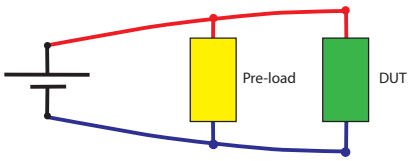
Dimension comparisons are to scale

Transient response
Over the years, innovative topology in power electronics (like zero-switching), has improved the ripple & noise specifications of switch-mode power supplies dramatically and pushed this requirement to the background. Other specifications became the gating item in supporting

Considerations When Specifying a DC Power Supply



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.

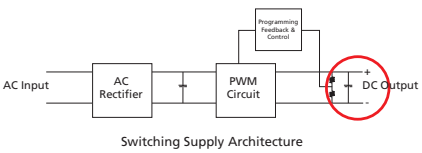


The pre-load should draw a current at least up to 75% of the DUT, to significantly improve the output voltage over- & undershoots

application need. One of these more important specifications is load transient response. In other words, how fast can the power supply follow impedance changes of the load? Or how good does the power supply cope with fast current demand changes. When the output current demand changes fast over a large range, the output voltage will decrease or increase significantly over a short period of time. Immediately the internal voltage control-loop will try to recover the output to its set voltage. Within the programmable power supply it is a compromise between the internal voltage control-loop and the output filter. A large output filter will limit the ripple & noise, but will make the supply slower to react to fast changing loads. A very fast internal voltage control-loop will recover the output to its set voltage very fast, but at the same time the overshoots and undershoots can be very high, with the potential of damaging the DUT. A typical application example is mobile phone testing. In this case the DC power supply simulates the mobile phone internal battery. Its power-bursting transmitting behavior causes very fast current transients. This is not a problem for the internal phone battery, but for a switch-mode programmable supply, this is a much more difficult task. In this case a linear (bench) type supply will be a better choice also because the output power requirements are low in Watts and the transient response specifications of a linear supply are in general better then a switch-mode supply. But for testing relays and fuses that are used in cars, for instance, the story is totally different. Now we need high currents up to 30VDC. Typically 5kW to 10kW programmable DC power supplies. In this case too large of a DC output voltage overshoot could damage the relay or fuse, by controlling the DC output current instantaneously from zero to maximum output or from maximum to zero output.

A practical trick to limit the over- and undershoots 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. Always a base current demand remains present flowing through the pre-load. 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.

Again some disadvantage arises; twice as much DC output current is now required, therefore more output power is required. At AMETEK, additional power in the same product family comes with just 50 cents per Watt more. A much cheaper and more practical approach than specialized power supply sub-systems uniquely dedicated for this specific application.



Switching Supply Architecture

Slew-rate

The next specification to consider is the DC output voltage slew-rate (rise & fall time). To improve the ripple & noise specifications, DC programmable power supplies have a large output filter that includes large capacitors with obviously a lot of stored energy. It's mainly the charge and discharge time of this filter, combined with the current demand of the DUT that determines the DC output rise & fall time.

This output voltage rise-time is mostly independent of the connected DUT. This depends mainly on the internal LCR network filter design and its LCR time constants. This rise-time is relatively fast and sufficient in most applications. It is the DC output fall-time that is causing trouble. The fall-time depends not only from 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 capability it can take many seconds before all stored energy has "leaked" 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. Never the less, in most cases the DC output fall-time will be two to three times slower then the DC output rise-time.

How to improve the DC output rise-time: 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. For the output

Considerations When Specifying a DC Power Supply

	SGA / SGI	
Range VDC	Rise V/ms	Fall V/ms
40	2.2	0.85
60	3.25	1.55
80	2.67	1.70
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

Typical DC output voltage
Slew-rate specifications

capacitor to support 60VDC maximum DC output range, the capacitance will be much smaller than the 30VDC programmable supply, thus to program from zero (0) to 30 or 60 VDC will take the same rise-time. In other words, when looking at the rise-time in V/ms, the 60 volts power supply will be twice as fast.

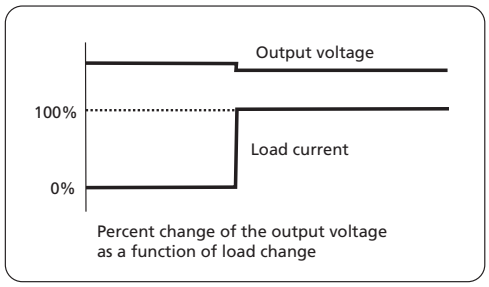
How to improve the DC output fall-time: Use a pre-load in parallel with the DUT or DC output of the power supply. Ensure that the total current demand of the pre-load and the DUT combined is at least 65% of the programmable power supply's current capability.

This approach requires more power from the supply as more DC output voltage range is required with the same output current demand. Also current slew-rate depends on the programmable power supply output stage, but is less different between different models of DC power supplies. Typically the output current slew-rate is 45A/ms. AMETEK 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 wit 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

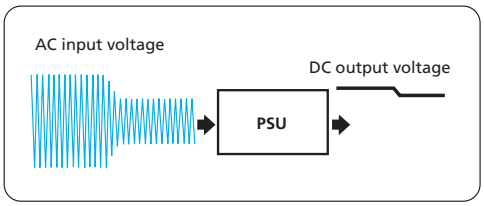
A similar specification of programmable power supplies is load regulation. This means a permanent output voltage change from its set-point due to a continuous output current demand of the DUT. Normally this effect should be very small (less then 0.01% of set output voltage). Only when the internal impedance of the programmable power supply is relatively high, the load regulation becomes an unwanted factor.



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

Line Regulation

One of the requirements for an ATE is that it can be used in different countries of the world. The test system is designed in one country, but used at an offshore production facility in another country. Often the AC mains is not that stable, or not even the same AC voltage (http://kropla.com/electric2.htm). Line regulation specifies the percent change of the DC output voltage or current as a function of AC input line voltage change.



Stability

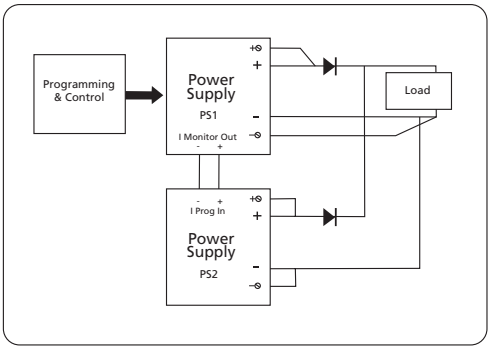
Stability specifies the long-term drift of output voltage and current. To related more specifically to an application, users want to know how repeatable is the programmable power supply in its output voltage and/or current set-point accuracy. In short, this is a repeatability specification, not an absolute specification for set-point accuracy. What most users really need to ensure when the supply is programmed to a specific value it always comes back to that same value as close as possible over a long period of time. A typical application is magnet drive, in which the programmable supply works as a current source in constant current mode. What the user really wants is to return back to the exact magnetic flux value, therefore to control the DC output current to exactly the same set-point value. Stability is primarily specified in parts-per-million or PPM.

Parallel operation

If more output current is required, paralleling power supply outputs is generally the solution. AMETEK uses a dedicated parallel control bus that daisy-chains multiple power supplies in parallel. The benefit of this dedicated paralleling 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, the different programmable supplies used can be from a different current range, but should have the same output voltage range. All manual or remote control is done through the master unit. Any sense lines are also connected only through the master unit.

Do realize that the total current is the sum of the current values displayed on each individual power supply. Some advanced models can compute and display the total system current (e.g.: SGI from Sorensen).

Considerations When Specifying a DC Power Supply



Series operation

Series operation sounds simple, "just put multiple supplies in series by connecting the positive from one supply to the negative of the other supply." 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. For example if the maximum allowable isolation from the negative to chassis is 150VDC and the maximum allowable isolation from the positive to chassis is 600VDC, one could take a 150V power supply and put in series a 600V power supply as long as the total set voltages together do not exceed more then 600VDC.

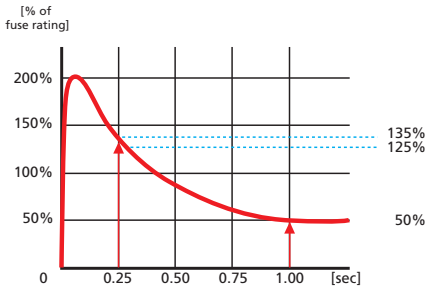
The highest serial output voltage AMETEK can provide is 1200VDC, but only when the common is connected to chassis-ground and the DUT that is connected across the 1200VDC remains floating. Typical application: solar inverter testing. With series operation there is no master/slave concept. In other words, all series power supplies need to be programmed individually. When using remote control for this, all interfaces need to be galvanically isolated through opto-couplers. In the AMETEK programmable power supplies, isolated interfaces are, analog, RS-232, RS-485 and Ethernet.

Digital programming

In general the output voltage and current is set most accurately with the highest resolution through its different digital interfaces. For this the interface set-point accuracy and resolution to set the output voltage and current is specified. AMETEK offers RS-232, RS-485, USB, GPIB and Ethernet control. The digital infrastructure of all these digital interfaces provides a 16-bit resolution with a multi-point internal reference table to calibrate for the DAC's linearity and offset errors. Important is that all interfaces are SCPI compliant to accommodate easy programming of the power supply and low switching costs.

Through digital programming with SCPI commands, many more features can be activated, such as sequencing. Controlling the power supply through SCPI commands takes 25 to 50 ms per command. The sequence capability allows you to download an auto-run program that can run through a sequence of voltage or current steps or true ramps with a 1ms fast step-time--a function that could never be done by conventional SCPI remote programming. Application examples are automotive testing according to the ISO 7637 standard or fuse rating testing according to the IEC 60269 standards.

Important is that at least IVI drivers are available. Most other drivers can be created by easy conversion of an IVI driver.



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

Analog programming

Every AMETEK programmable power supply provides a standard and isolated analog interface. Through the analog interface the DC output voltage, current and over-voltage-protection (OVP) can be set. The control is through an analog voltage signal, current signal or resistor. The example would be to use a PLC to control the power supplies, or a thermistor controlling the output of the supply. Also provided are voltage and current monitoring signal lines and control lines to enable or disable the power supply with ms reaction time. Important is that the analog control interface provides a control bandwidth, faster than the power supply output voltage and current slew-rate. AMETEK DC power supplies provide a 2kHz bandwidth, ensuring that the analog control interface is always faster than its output capabilities. Therefore the analog interface will never be the limiting factor.

Sense lines

The Sense feature "senses" (measures) and then regulates the voltage at the point it is connected to the output. When the sense leads are connected directly to the output terminal of the power supply we call it "local sense". By default AMETEK delivers new power supplies configured for local sense. Depending on the model, the sense leads may be connected to the output internally or they may be connected through external jumpers. For accurate output voltage setting, remote sense mode should be used. In this mode we regulate the power supply at 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. Sense mode can compensate a voltage drop much larger then the specified 5% to 10 %. The issue is that other specifications, like transient response, should not suffer from to large of a sense loss.

Considerations When Specifying a DC Power Supply

Article

Other considerations:
Voltage source in constant voltage mode or current source in constant current mode. These considerations drive some of the relevance for different specifications. For instance, in constant current mode, sensing is not applicable; neither is the output voltage set-point accuracy and resolution, but accurate current control is. Also, less relevant is the output voltage ripple & noise compared to the current ripple & noise.

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

Inrush current:
AMETEK programmable power supplies accommodate DUT's with large inrush currents. The function is called "Foldback Mode." It is a current limit with a time constants, settable with a milli-second resolution from zero (0) to a 10-second range. This means that the power supply will allow for a higher inrush current for a limited amount of time, before disabling the power supply output. An application example would be any electric motor.

Bench vs. linear power supply?
When the application requires low DC power combined with low ripple & noise and fast transient response time (e.g. mobile phone testing), a linear-type bench supply could be the best solution. Do realize that there are many low-cost bench supplies on the market, meeting the ripple & noise and transient response requirements thought the virtue of being from a linear topology. The issue you could face is insufficient programming and read-back accuracy and resolution. Accuracy, resolution, interfacing and other digital features set good bench supplies apart form the average performing models. In other words, "buyer beware" for cheap deals.

Verify the availability of accessories like rack-mount kits. An off-the-shelf rack-mount kit is always less expensive than constructing one yourself.

In conclusion
When selecting a DC programmable power supply, there are many parameters to consider. From fundamental specifications, to form-factor, to control, etc.

Most important is to start with the needs of the application or what makes the device under test run and what margin testing is required according to which standards.

AMETEK latest model "XTR"
850 Watts in half 19-inch form-factor (slightly bigger then a car radio); comes in 12 voltage ranges; provides unique features like, foldback-mode, sequencing, memory safe-mode, standard digital interfacing, standard isolated analog interface, wide-range PFC AC input, with great DC output specifications.

About AMETEK Programmable Power
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.

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.

Advanced Electronic Power Simulation

Article

By Philip Joosten

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.

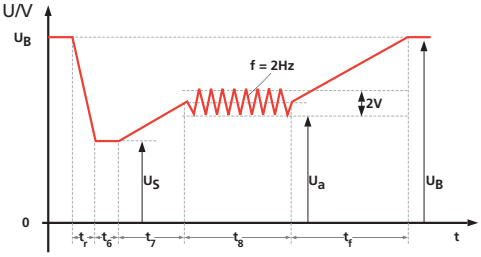
Both types of testing happen during R&D and during production. During the R&D phase, mainly margin testing and integration testing has the highest priority. During production the focus is mainly burn-in & test.

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

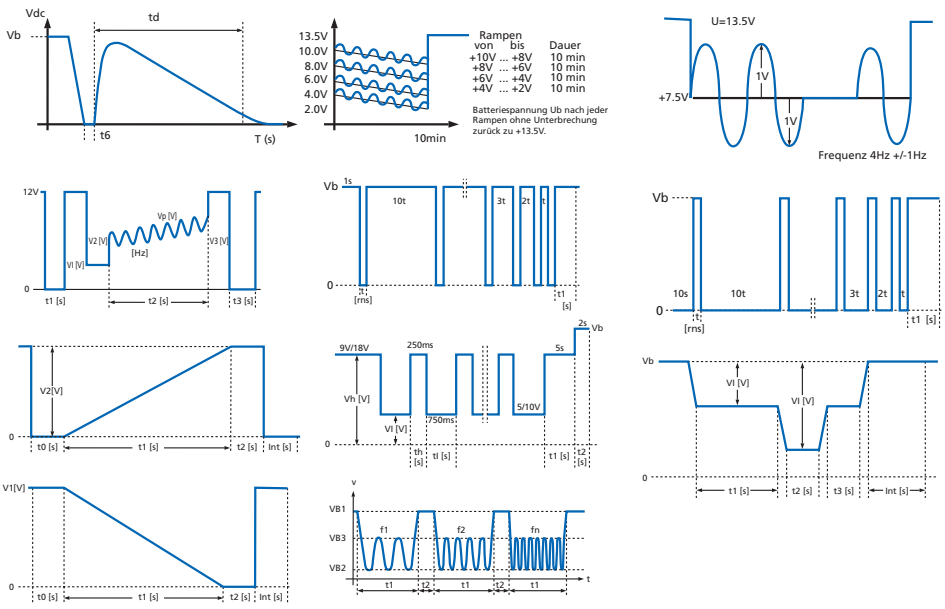
Voltage rise- & fall-time specifications in V/ms.

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

Advanced Electronic Power Simulation

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

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

Hybrid Car Power Simulation

By Philip Joosten

Back to the roots

More then 100 years ago, in the early days of car development, the technical advances between electric motor powered vehicles and combustion engine power vehicles was a neck on neck race. In fact, it was an electrical motor driven car that past for the first time a speed of over 100 km per hour. The problem was storing enough electrical energy to give an electrical powered car sufficient practical driving radius. And that is where the combustion engine was wining the race. Gasoline is so much easier to store and bring along, giving a car a large driving radius.

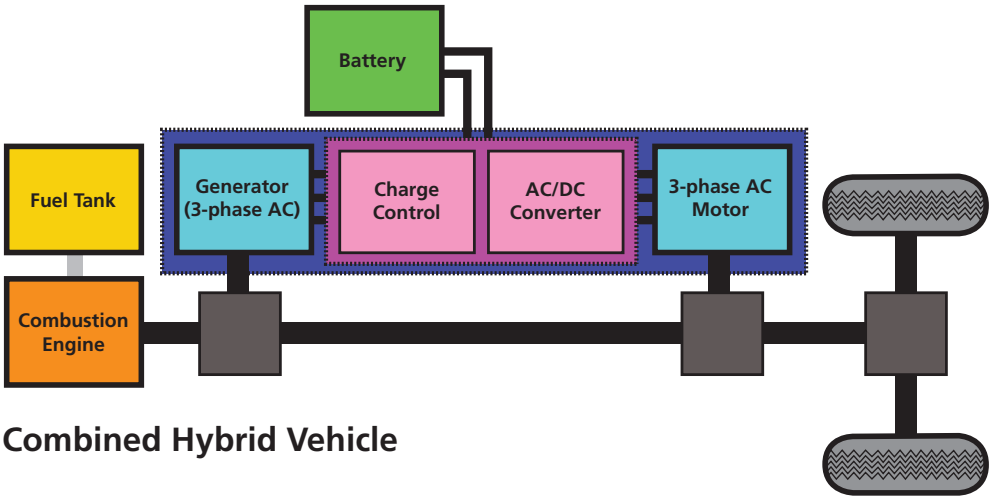
Today, over 100 years later, with a lot more new technology and not to forget, rising fuel prices, hybrid cars are a very realistic alternative to the conventional combustion engine only car. And again energy storage is one of the main challenges requiring very sophisticated modules managing and storing the required electrical energy. Interesting is that safety aspects for both the conventional gasoline tank and the new sophisticated high-voltage batteries as are important. Overheating such a specialized battery through overcharging can cause significant damage to the total vehicle. Therefore a lot of testing and power simulation is required during the development phase, long-term environmental testing and burn-in during production test.

Types of Hybrid cars

Hybrid vehicles are also not a new technology. For instance diesel electric locomotives are from the **Series Hybrid** type. **Parallel hybrid** systems, which are most commonly produced at present, have both an internal combustion engine and an electric motor connected to a mechanical transmission. Most designs combine a large electrical generator and a motor into one unit, often located between the combustion engine and the transmission, replacing both the conventional starter motor and the alternator. To store power, a hybrid uses a large battery pack with a higher voltage (up to 440VDC) than the normal automotive 12 volts. Accessories such as power steering and air conditioning are powered by electric motors instead of being attached to the combustion engine. This allows efficiency gains as the accessories can run at a constant speed, regardless of how fast the combustion engine is running. The starter motor function is now integrated between the engine and the transmission, allows for the car to start instantaneously. This means that every time the car is idling in neutral mode, the engine shots down and is restarted as soon as the car is put in its first gear.

Combined hybrid systems have features of both series and parallel hybrids. They incorporate power-split devices allowing for power paths from the engine to the wheels that can be either mechanical or electrical. The main principle behind this system is the decoupling of the power supplied by the engine (or other primary source) from the power demanded by the driver. In a conventional vehicle, a larger engine is used to provide acceleration from standstill than one needed for steady speed cruising. This is because a combustion engine's torque is minimal at lower RPMs, as the engine is its own air pump. On the other hand, an electric motor exhibits maximum torque at stall and is well suited to complement the engine's torque deficiency at low RPMs. In a combined hybrid, a smaller, less flexible, and highly efficient engine can be used.

A hybrid car has many operation modes. On the highway, when the car is running on a constant speed, a combustion engine becomes relative fuel efficient. At the same time the car is driving at relative high speed. In that case the car operates solely on its combustion engine and is charging the main battery. Next is stop & go traffic in the city. In that case the car with its combustion engine is very uneconomical. This is the ideal scenario to run



Combined Hybrid Vehicle

on the electro motors and therefore discharge the main battery. At fast acceleration, the electro motor can assist the combustion engine with the instantaneous power demands. Or vise versa, when breaking, the induction power of the electro motor can assist with breaking power and re-generate electrical energy back into the main battery. All these operation modes are managed by the charge controller, combined with the power converter applying power from the battery to the electro motor.

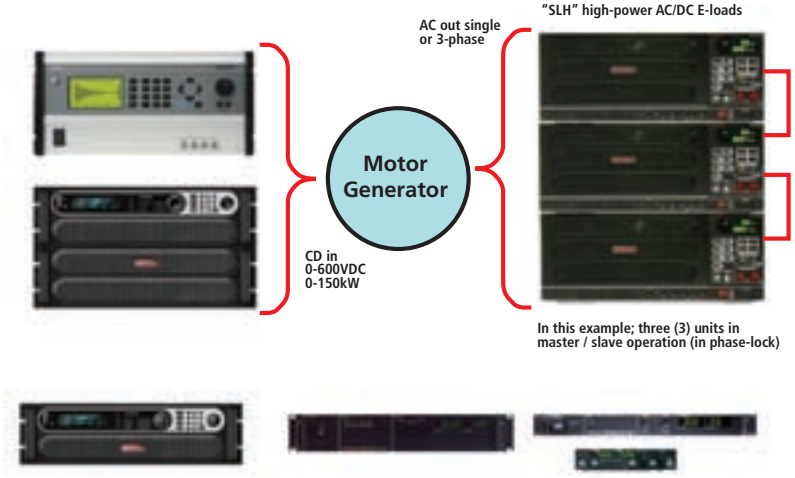
What these scenarios show is that the main battery is constantly changing from charge to discharge mode, all managed by a charge controller / power converter module. And on the other side, the electro motors, running at a moderate constant speed, either driving the car or generating electrical power to charge the battery or that same electro motor is in high acceleration mode, to start the car or slowdown the car.

To test this charge controller / power converter module we need on one side a battery simulator and on the other side an electro motor simulator. The range of these high-voltage batteries varies from 280 to 440 VDC. Therefore a high power programmable DC power supply is required up to 100 Amps at 450VDC or more. The AMETEK model SGI provides a unique sequence programming that allows different declining voltage slopes over time at a declining state of charge based on a fixed DC current demand in battery discharge mode dynamic simulation. The electronic load simulates the battery charge mode. Also in this case dynamic simulation can be performed through sequence programming of the simulated charge input current. By changing constantly from charge to discharge mode, when at the same time the charge controller module is in some kind of a HALT chamber, simulating shock & vibration and high & low ambient temperatures, will ensure a real-life environmental test as if your hybrid car was used in the north of Sweden at winter time or in the Nevada desert at summer time.

On the other side of the charge control module / power converter module is the electro motor. With most of the hybrid car manufacturers I have encountered the use of 3-phase AC electro motors up to 380VAC. To simulate the charge process, we need a 3-phase AC programmable power supply. This AC power supply must be capable of fast fluctuating output AC voltage and variable frequency. Sequence programming can simulate both the breaking energy re-generation as well as the more steady-state high-speed charge mode. During these simulation scenarios it is important to measure parameters like, peak-current, phase imbalance, etc. Therefore a build-in power analyzer makes such a test setup easy to realize.

To test the electric drive train, the same AC or DC programmable power supplies can be used. But often more power is required. For this reason I would select an AC or DC power supply that is easy to parallel on the fly to provide that extra flexibility of additional power.

I have come across hybrid car designs were the main and only battery is the high-voltage battery. To create the standard low-voltage 12VDC power-bus, High current DC/DC-converters are used. Or in addition DC/DC-converters to create a 42VDC power-bus, to drive high power components like electronic breaks. Actuators used in electronic breaks that would run at 12VDC need to much drive current, causing the electrical wiring to thick, being thicker then the hydraulics it replaces. The introduction of these DC/DC-converters requires a lot of additional testing. On the input side is a programmable DC power supply connected to perform any margin testing and at the output is a DC electronic load connected. The advance sequencing capability in such an electronic load can simulate fast and high current demand change, like activating actuators, etc. Important is that the electronic load provides enough bandwidth to support a fast dI/dT. To support these applications, the AMETEK electronic loads are capable of 20kHz bandwidth, with a current slew-rate of 4000 A/ms.



Hybrid Car Power Simulation

Lastly is battery testing. Environmental testing of batteries is crucial, because the battery performance depends greatly on its ambient temperature. This testing is very time consuming. Many daurtests at many temperature ranges. Again a combination of a DC programmable power supply and electronic load is required to simulate the charge and discharge process, but this time at relative lower DC power. The charge currents are limited to protect the battery from overheating. A nice feature AMETEK offers in this case is constant power mode, where the charge current decreases automatically when the DC voltage increases.

In all my visits to many customers I do not encounter so often that so many different power simulation and test equipment is required. Hybrid car testing is one of the few application examples where we need AC and DC power as well as AC and DC loads, in both low-voltage and high-voltage ranges. Perhaps it is good to look at a power test equipment manufacturer that can provide all needed equipment from its standard available product portfolio.

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 Size (AWG)	Column 2 Amperes (Maximum)	Column 3 Ohms/100ft (one-way)	Column 4 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.

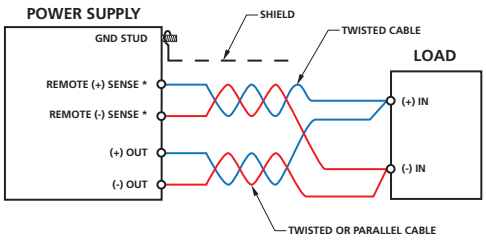
Noise and Impedance Effects
To minimize noise pickup or radiation from load circuits, load wires and remote sense wires should be twisted–pair with minimum lead length. Shielding of the sense leads may be necessary in high noise environments. Even if noise is not a concern, the load and remote sense 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

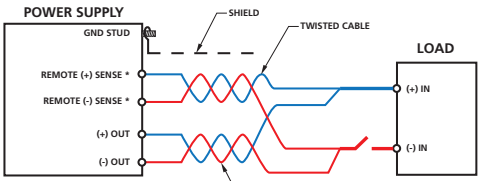
Using a Load Setup

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.

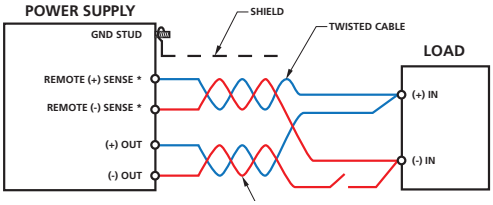
Example of a Good Setup

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

Half Rack Programmable DC Power Supply

375–600 W

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	2.4 mV	9.5 mA	2.4 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	2.8 mA	6 mV	6.5 mA
DLM 150-4	0-150	0-4	600	9.5 mV	2.2 mA	9.5 mV	5.8 mA
DLM 300-2	0-300	0-2	600	17 mV	2.1 mA	17 mV	5.4 mA

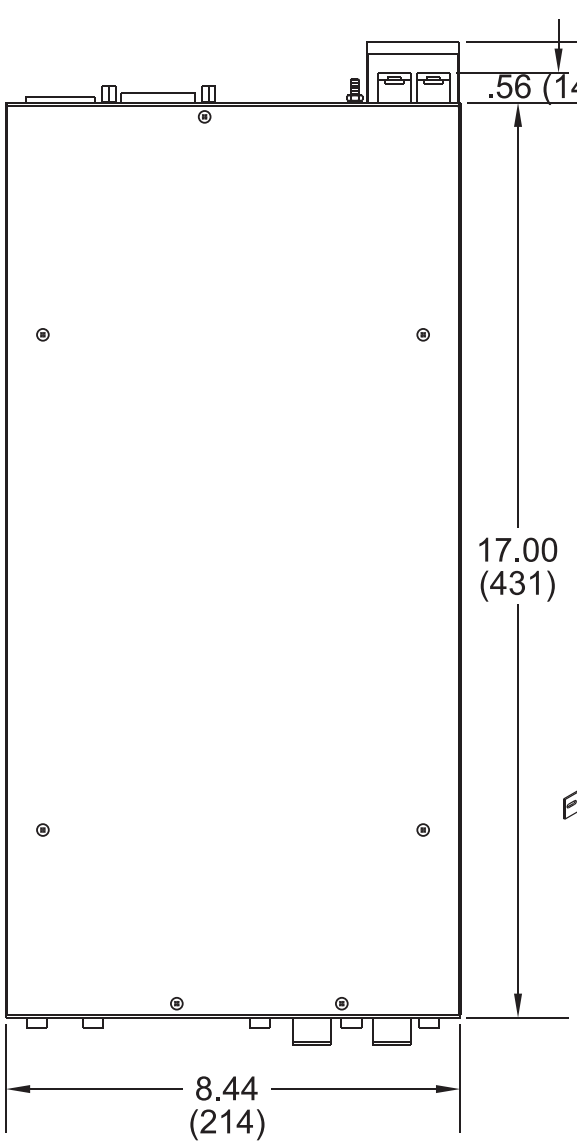
Model	Programming Accuracy‡						Load Regulation	
	Ethernet (M130/M131)			GPIB (M9G/M85)				
	Voltage (0.1% of VMax)	Current (0.25% of IMax)	Power (0.5% of 1.1 x Vmax)	Voltage (0.2% of VMax)	Current (0.5% of IMax)	OVP (1.0% of 1.1 x Vmax)	Voltage (0.5% of Vmax + 1 count)	Current (1.0% of Imax + 1 count)
DLM 5-75	8 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	160 mA
DLM 60-10	60 mV	25 mA	330 mV	120 mV	50 mA	660 mV	400 mV	110 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 mV	850 mV	50 mA
DLM 300-2	300 mV	5 mA	1.65 V	600 mV	10 mA	3.3 mV	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

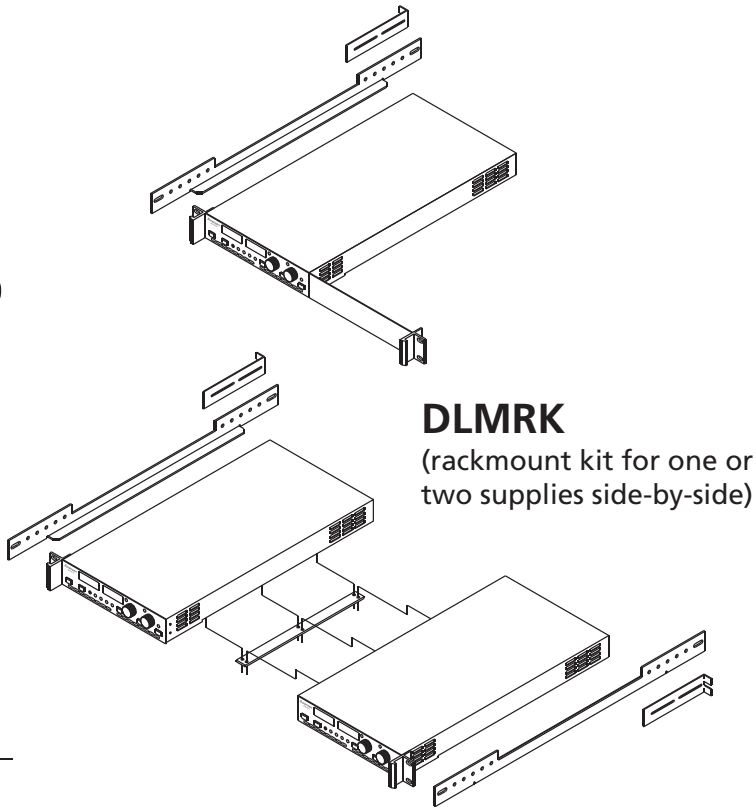
Model	Ripple and Noise, Voltage Mode		OVP Adjustment Range (5% - 110% of Vmax)	Stability		Temperature Coefficient		Maximum Total Remote Sense Drop
	Ripple (rms)*	Noise (p-p)*		Voltage (0.05% of Vmax)	Current (0.05% of Imax)	Voltage (0.02%/°C of Vmax)	Current (0.03%/°C of Imax)	
DLM 5-75	5 mV	30 mV	0.25-5.5 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

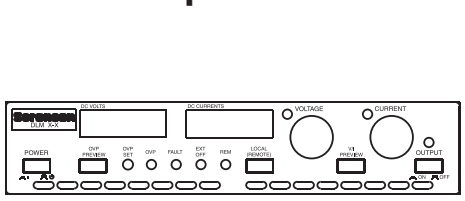
DLM 600 Series : Product Diagram



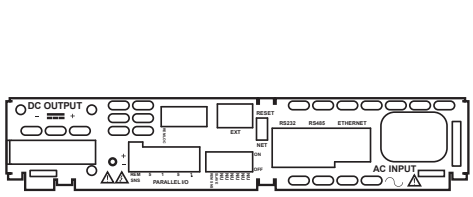
Top View



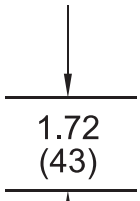
DLMRK
(rackmount kit for one or two supplies side-by-side)



Front View



Rear View

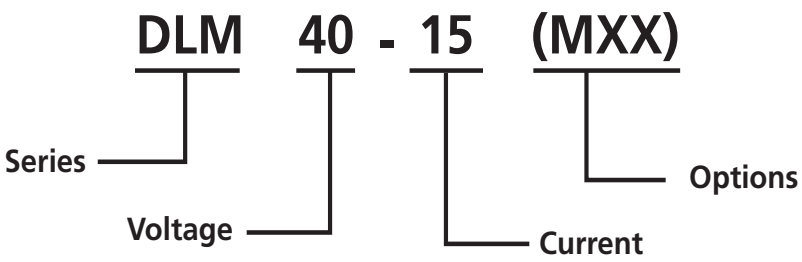


Dimensions in inches (millimeters)

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

**M6 Options 20" (508 MM).

Model Number Description



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 • LXI Compliant • 10/100 base-T • TCP/IP Protocol • ICMP (Ping Server) • Web Server: Direct control of power supply via standard web browser.
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
M130	Ethernet/LAN and RS-232C Interfaces (16 bit)
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 Series / XTR Series

850 W, 1U Half Rack Programmable DC Power Supplies

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

670–850 W

6–600 V

1.4–110 A

~		110	220

ETHERNET USB GPIB RS232

The Sorensen XG Series and the Sorensen XTR Series are the same 850 Watt, 1U half-rack DC power supply, produced in a black, Sorensen branded model primarily for the United States and produced in a White, Sorensen branded model primarily for North American distribution and International markets.

The XG / XTR Series is the new standard for powerful, programmable DC power systems. Designed for test, production, laboratory, OEM and quality assurance applications, the XG / XTR 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 / XTR 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 / XTR 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 / XTR 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 / XTR Series that exactly meet your existing requirements, while allowing for future expansion.

Multi-Channel Support
Up to 30 XGs / XTR 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 / XTR Series needed for your applications.

Straightforward Front Panel Controls
The XG / XTR 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 / XTR Series.

High Reliability
To guarantee long-term trouble-free performance, the XG / XTR 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 / XTR 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 / XTR Series exceeds the reliability and quality standards of both AMETEK and our customers.

XG / XTR Series : Product Specifications

Output : Voltage and Current			
Models	Output Voltage [1]	Output Current [2]	Output Power [3]
XG 6-110 / XTR 6-110	6 V	110 A	670 W
XG 8-100 / XTR 8-100	8 V	100 A	810 W
XG 12-70 / XTR 12-70	12 V	70 A	850 W
XG 20-42 / XTR 20-42	20 V	42 A	850 W
XG 33-25 / XTR 33-25	33 V	25 A	835 W
XG 40-21 / XTR 40-21	40 V	21 A	850 W
XG 60-14 / XTR 60-14	60 V	14 A	850 W
XG 80-10.5 / XTR 80-10.5	80 V	10.5 A	850 W
XG 100-8.5 / XTR 100-8.5	100 V	8.5 A	860 W
XG 150-5.6 / XTR 150-5.6	150 V	5.6 A	850 W
XG 300-2.8 / XTR 300-2.8	300 V	2.8 A	850 W
XG 600-1.4 / XTR 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 / XTR 6-110	2.3 mV	13 mA	2.3 mV	27 mA
XG 8-100 / XTR 8-100	2.4 mV	12 mA	2.4 mV	25 mA
XG 12-70 / XTR 12-70	2.6 mV	9 mA	2.6 mV	19 mA
XG 20-42 / XTR 20-42	3.0 mV	6.2 mA	3.0 mV	13.4 mA
XG 33-25 / XTR 33-25	3.7 mV	4.5 mA	3.7 mV	10 mA
XG 40-21 / XTR 40-21	4 mV	4.1 mA	4 mV	9.2 mA
XG 60-14 / XTR 60-14	5 mV	3.4 mA	5 mV	7.8 mA
XG 80-10.5 / XTR 80-10.5	6 mV	3.1 mA	6 mV	7.1 mA
XG 100-8.5 / XTR 100-8.5	7 mV	2.9 mA	7 mV	6.7 mA
XG 150-5.6 / XTR 150-5.6	9.5 mV	2.6 mA	9.5 mV	6.1 mA
XG 300-2.8 / XTR 300-2.8	17 mV	2.3 mA	17 mV	5.6 mA
XG 600-1.4 / XTR 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 / XTR 6-110	8 mV	200 mA	50 mV
XG 8-100 / XTR 8-100	8 mV	180 mA	50 mV
XG 12-70 / XTR 12-70	8 mV	120 mA	50 mV
XG 20-42 / XTR 20-42	8 mV	75 mA	50 mV
XG 33-25 / XTR 33-25	8 mV	60 mA	50 mV
XG 40-21 / XTR 40-21	8 mV	45 mA	50 mV
XG 60-14 / XTR 60-14	8 mV	35 mA	50 mV
XG 80-10.5 / XTR 80-10.5	8 mV	25 mA	80 mV
XG 100-8.5 / XTR 100-8.5	8 mV	20 mA	80 mV
XG 150-5.6 / XTR 150-5.6	10 mV	16 mA	100 mV
XG 300-2.8 / XTR 300-2.8	25 mV	10 mA	150 mV
XG 600-1.4 / XTR 600-1.4	50 mV	6 mA	250 mV

1. Maximum output voltage is guaranteed to be 0.1% 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 0.2% 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.

XG / XTR 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 6-110 / XTR 6-110	1 V	60 ms	75/77%
XG 8-100 / XTR 8-100	1 V	60 ms	77/80%
XG 12-70 / XTR 12-70	1 V	60 ms	81/84%
XG 20-42 / XTR 20-42	1.5 V	60 ms	82/85%
XG 33-25 / XTR 33-25	2 V	60 ms	83/86%
XG 40-21 / XTR 40-21	2 V	60 ms	83/87%
XG 60-14 / XTR 60-14	3 V	60 ms	83/87%
XG 80-10.5 / XTR 80-10.5	5 V	100 ms	83/87%
XG 100-8.5 / XTR 100-8.5	5 V	100 ms	83/87%
XG 150-5.6 / XTR 150-5.6	5 V	100 ms	83/87%
XG 300-2.8 / XTR 300-2.8	5 V	150 ms	83/87%
XG 600-1.4 / XTR 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 / XTR 6-110	60 ms	300 ms	0.5–7.5 V
XG 8-100 / XTR 8-100	60 ms	400 ms	0.5–10 V
XG 12-70 / XTR 12-70	60 ms	500 ms	1–15 V
XG 20-42 / XTR 20-42	60 ms	600 ms	1–24 V
XG 33-25 / XTR 33-25	60 ms	700 ms	2–39 V
XG 40-21 / XTR 40-21	60 ms	800 ms	2–44 V
XG 60-14 / XTR 60-14	60 ms	900 ms	3–66 V
XG 80-10.5 / XTR 80-10.5	100 ms	1000 ms	3–95 V
XG 100-8.5 / XTR 100-8.5	100 ms	1200 ms	3–125 V
XG 150-5.6 / XTR 150-5.6	100 ms	1800 ms	3–180 V
XG 300-2.8 / XTR 300-2.8	150 ms	2200 ms	5–330 V
XG 600-1.4 / XTR 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 and UL61010-1. Marked with c(UL) us, CE EN61010-1
EMC	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.

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.

XG / XTR 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: 500 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		
Series Operation	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	

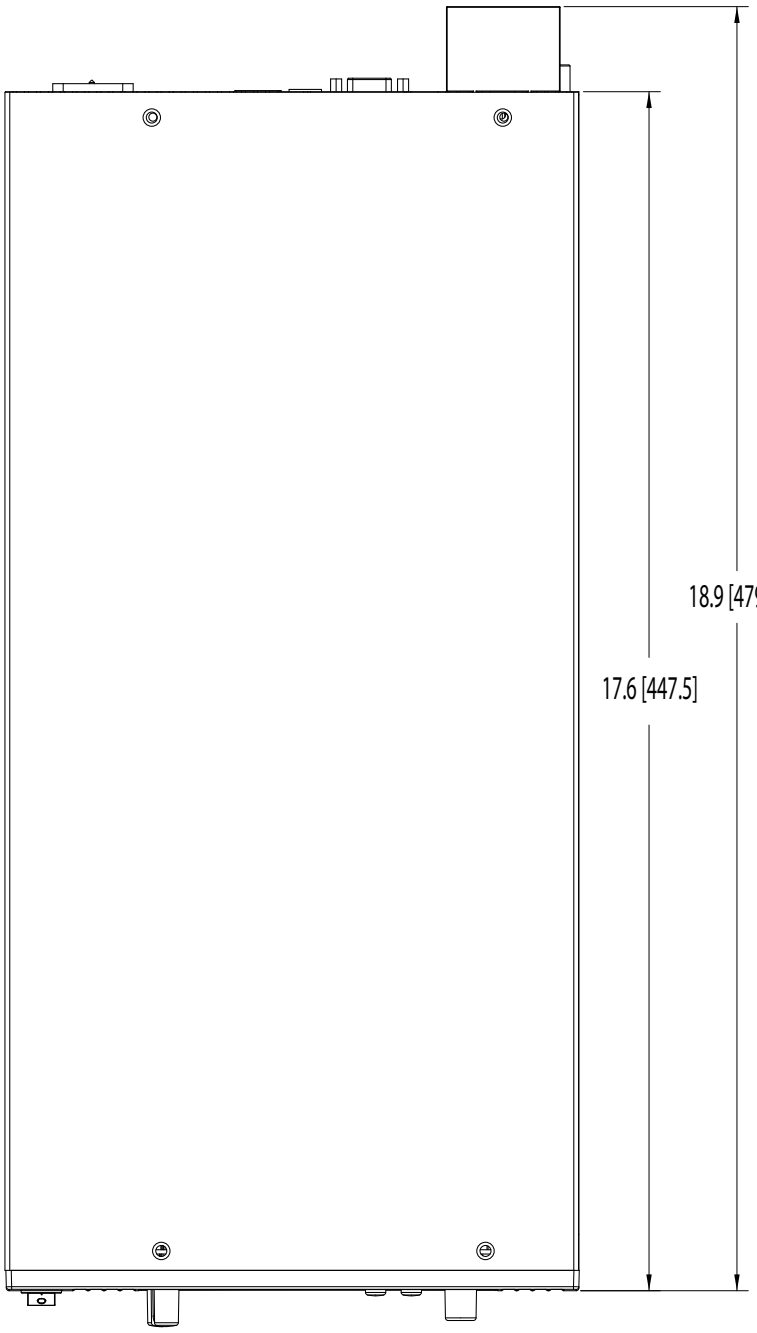
1. Typical APG or isolated APG accuracy can be improved to max accuracy by user calibration at the specific range selected
2. The shutdown input has user selectable negative logic operation via front panel or remote digital input/output

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
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
Isolation	
AC Input to Output AC Input to Chassis Output to Chassis [3]	1350 Vac 1350 Vac 500 Vac

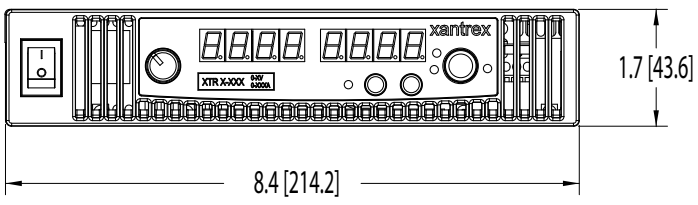
1. Current: 0.51 A minimum guaranteed, 0.72 A typically available. Overcurrent protection (each output) is automatic, non-latching. When OCP is tripped the aux voltage folds back and will recover to nominal condition when the over current condition is removed (typ. <0.2A). To protect external circuits 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.

XG / XTR Series : Product Diagram

670–850 W



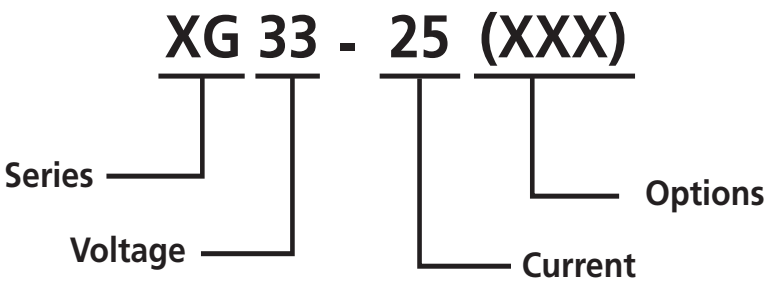
TOP VIEW



FRONT VIEW

XG / XTR Series

Model Number Description



XG / XTR Options	
MEA	ETHERNET
MGA	GPIB, IEEE 488.2
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
XTR Options and Accessories	
RM - XTR1	Rackmount Angle Brackets
RM - D - XTR1	Rackmount Kit for 2 Units
RM - S - XTR1	Rackmount Kit for 1 Unit

Sorensen DCS Series

General Purpose Systems Power Supply

1–3 kW

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.)

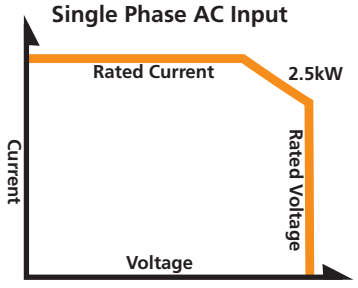
DCS Series : Product Specifications

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
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. User configurable for: 200-250VAC, single-phase operation, 20A, 47- 63Hz.
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

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% ** rms ripple typical from 20 Hz to 300 kHz

DCS Series : Product Specifications

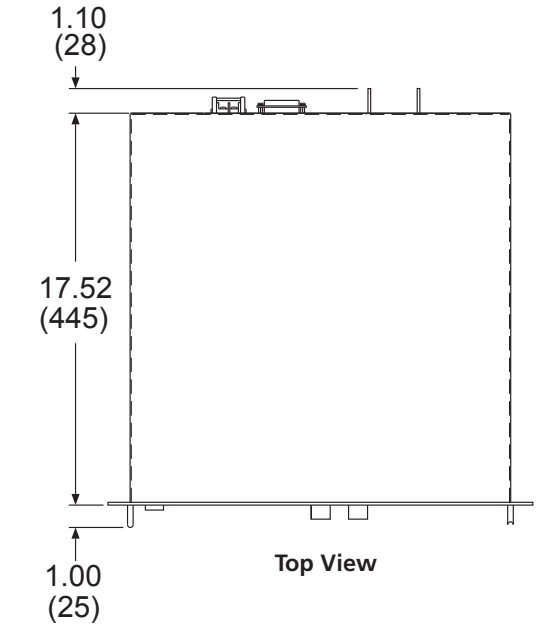
1–3 kW

Model	Constant Current Mode*		Temperature Coefficient %/°C (Typ.)	Current Drift %I out Max. (Typ.)	Programming Constants, Current Mode		Input Current, A Nominal		Efficiency % (Typ.)
	Regulation Line and Load% Combined	Ripple (rms)** mA			Ohms/A	V/A	230V Single Phase	208V Three Phase	
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	8	N/A	82
DCS 10-100E	0.2	128	0.03	0.05	50		8	N/A	82
DCS 20-50E	0.2	25	0.03	0.05	100		8	N/A	82
DCS 33-33E	0.2	10	0.03	0.05	151.5		8	N/A	84
DCS 40-25E	0.2	7	0.03	0.05	200		8	N/A	84
DCS 50-20E	0.2	7	0.03	0.05	250		8	N/A	84
DCS 60-18E	0.2	6	0.03	0.05	277.8		8	N/A	86
DCS 80-13E	0.2	4	0.03	0.05	384.6		8	N/A	86
DCS 100-10E	0.2	3	0.03	0.05	500		8	N/A	86
DCS 150-7E	0.2	2	0.03	0.05	714.3		8	N/A	86
DCS 300-3.5E	0.2	1	0.03	0.05	1428.6		8	N/A	86
DCS 600-1.7E	0.2	1	0.03	0.05	2941.2		9.5	N/A	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	9	N/A	82
DCS 10-120E	0.2	153	0.03	0.05	41.7		9	N/A	82
DCS 20-60E	0.2	30	0.03	0.05	83.3		9	N/A	82
DCS 33-36E	0.2	11	0.03	0.05	138.9		9	N/A	84
DCS 40-30E	0.2	9	0.03	0.05	166.7		9	N/A	84
DCS 50-24E	0.2	8.5	0.03	0.05	208.3		9	N/A	84
DCS 60-20E	0.2	6.6	0.03	0.05	250.0		9	N/A	85
DCS 80-15E	0.2	6	0.03	0.05	333.3		9	N/A	85
DCS 100-12E	0.2	3.6	0.03	0.05	416.7		9	N/A	85
DCS 150-8E	0.2	2.3	0.03	0.05	625.0		9	N/A	85
DCS 300-4E	0.2	1.2	0.03	0.05	1250.0		9	N/A	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	24	13	82
DCS 12-250E	0.2		0.03	0.05			26	14	82
DCS 20-150E	0.2		0.03	0.05			26	14	82
DCS 40-75E	0.2		0.03	0.05			26	14	86
DCS 55-55E	0.2		0.03	0.05			26	14	82
DCS 60-50E	0.2		0.03	0.05			26	14	86
DCS 80-37E	0.2		0.03	0.05			26	14	86
DCS 150-20E	0.2		0.03	0.05			26	14	86

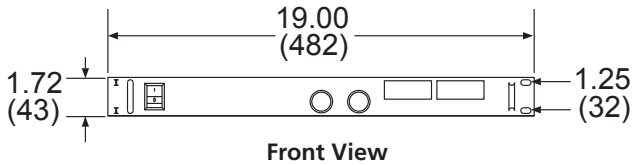
* Typical resolution is 0.02% ** rms ripple typical from 20 Hz to 300 kHz

DCS Series : Diagram

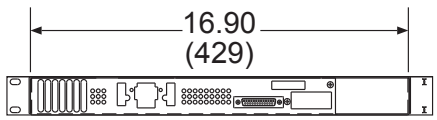
1 kW and 1.2 kW



Top View

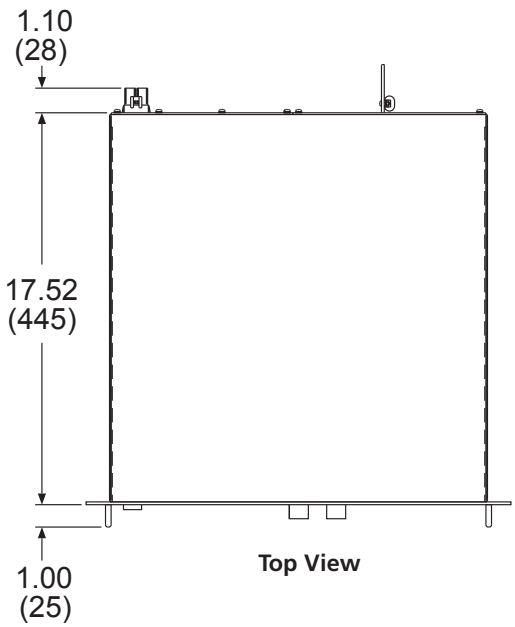


Front View

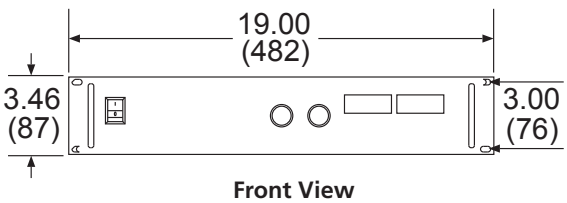


Rear View

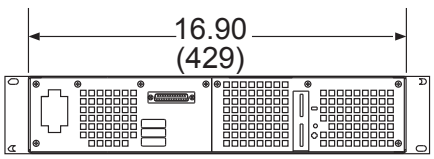
3 kW



Top View



Front View

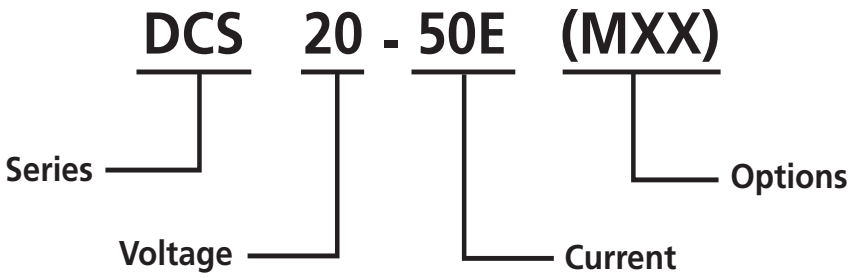


Rear View

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



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 XFR Series

1.2–2.8 kW

Low Profile DC Power Supply with Zero Voltage "Soft Switching"

6–600 V

2–300 A

- 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

~	110	208	230
≋		208	230

GPIB RS232

The Sorensen XFR Series provides 1.2 kilowatts and 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 OEM 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) XFR 1.2 kW: 6 V to 40 V models: nominal 78 kHz (156 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; XFR 1.2 kW: 6 - 40 V models: nickel-plated copper bus bars with bus bar shield; 60 - 600 V models: 4-terminal wire clamp connector with strain relief	
Approvals	CE-marked units meet: EN61010-1, EN61000-6-2 and EN61000-6-4; UL Listed to UL3111-1; CSA certified to CSA C22.2 No 1010.1 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 XFR 1.2 kW: 85-130 Vac or 190-264 Vac, 1ϕ (17 A @ 120 Vac; 8.8 A @ 230 Vac typical), 47-63 Hz. Automatic range detect.	
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, XFR 1.2 kW: 0 to 50°C; 6 V model: for rack mounted units, derate output current by 1.5 A per °C for operating temperatures between 30 - 50°C	
Storage Temperature	-20°C to 70°C	
Humidity (Non-condensing)	Up to 90% RH, non-condensing	
Physical	**XFR 2.8 kW**	**XFR 1.2 kW**
Dimensions	Width: 19" (429.4 mm) Height: 3.5" (88.9 mm) Depth: 21" (533.5 mm)	Width: 19" (429.4 mm) Height: 1.7" (43.2 mm) Depth: 20" (508.1 mm)
Weight	33 lb (15 kg)	18 lb (8.2 kg)

XFR Series : Product Specifications

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 6-200	0-6 V	0-200 A[8]	1200 W	2.6 mV	22 mA
XFR 7.5-140	0-7.5 V	0-140 A	1050 W	2.75 mV	16 mA
XFR 12-100	0-12 V	0-100 A	1200 W	3.2 mV	12 mA
XFR 20-60	0-20 V	0-60 A	1200 W	4 mV	8 mA
XFR 35-35	0-35 V	0-35 A	1225 W	5.5 mV	5.5 mA
XFR 40-30	0-40 V	0-30 A	1200 W	6 mV	5 mA
XFR 60-20	0-60 V	0-20 A	1200 W	8 mV	4 mA
XFR 100-12	0-100 V	0-12 A	1200 W	12 mV	3.2 mA
XFR 150-8	0-150 V	0-8 A	1200 W	17 mV	2.8 mA
XFR 300-4	0-300 V	0-4 A	1200 W	32 mV	2.4 mA
XFR 600-2	0-600 V	0-2 A	1200 W	62 mV	2.2 mA

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
XFR 6-200	8.2 mV	45 mA	0.07 V	2.5 A
XFR 7.5-140	6.5 mV	33 mA	0.09 V	1.5 A
XFR 12-100	7.4 mV	25 mA	0.13 V	1.1 A
XFR 20-60	9 mV	17 mA	0.3 V	0.7 A
XFR 35-35	12 mV	12 mA	0.4 V	0.45 A
XFR 40-30	13 mV	11 mA	0.5 V	0.4 A
XFR 60-20	17 mV	9 mA	0.7 V	0.3 A
XFR 100-12	27 mV	7.4 mA	1.1 V	0.13 A
XFR 150-8	35 mV	6.6 mA	1.6 V	0.09 A
XFR 300-4	65 mV	5.8 mA	4 V	0.05 A
XFR 600-2	125 mV	5.4 mA	7 V	0.03 A

XFR Series : Product Specifications 1.2–2.8 kW

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 mV
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
XFR 6-200	75 mV	9 mV	750 mA
XFR 7.5-140	75 mV	9 mV	500 mA
XFR 12-100	75 mV	9 mV	500 mA
XFR 20-60	75 mV	9 mV	500 mA
XFR 35-35	120 mV	9 mV	300 mA
XFR 40-30	150 mV	9 mV	200 mA
XFR 60-20	150 mV	9 mV	100 mA
XFR 100-12	150 mV	9 mV	100 mA
XFR 150-8	150 mV	18 mV	50 mA
XFR 300-4	200 mV	27 mV	25 mA
XFR 600-2	400 mV	72 mV	15 mA

Model	Drift (8 hours)[4]		Temp Coeffcient[5]	
	Voltage (0.5% 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
XFR 6-200	3 mV	200 mA	1.2 mV	60 mA
XFR 7.5-140	3.75 mV	70 mA	1.5 mV	42 mA
XFR 12-100	6 mV	50 mA	2.4 mV	30 mA
XFR 20-60	10 mV	30 mA	4 mV	18 mA
XFR 35-35	17.5 mV	17.5 mA	7 mV	10.5 mA
XFR 40-30	20 mV	15 mA	8 mV	9 mA
XFR 60-20	30 mV	10 mA	12 mV	6 mA
XFR 100-12	50 mV	6 mA	20 mV	3.6 mA
XFR 150-8	75 mV	4 mA	30 mV	2.4 mA
XFR 300-4	150 mV	2 mA	60 mV	1.2 mA
XFR 600-2	300 mV	1 mA	120 mV	0.6 mA

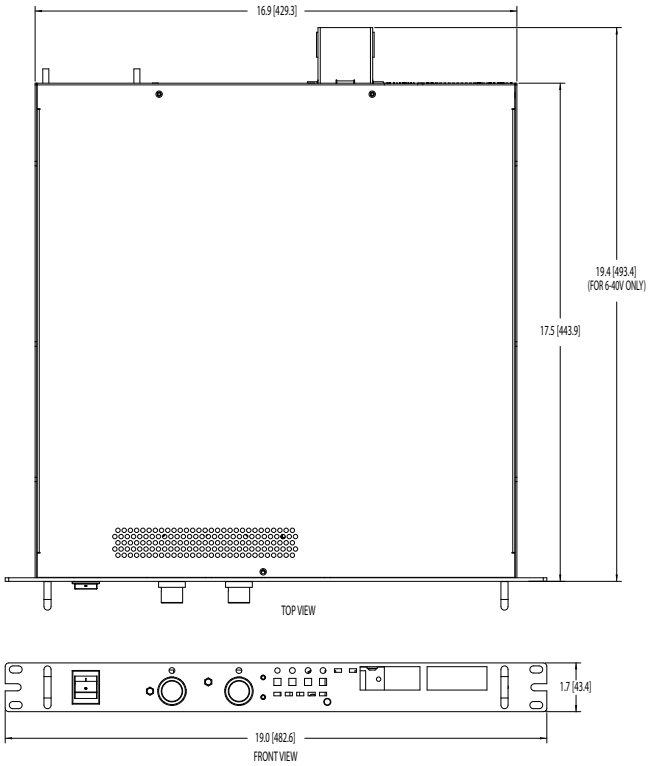
XFR Series : Product Specifications

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%
XFR 6-200	100 ms	100 ms	0.3-6.6 V	75%
XFR 7.5-140	100 ms	100 ms	0.375-8.25 V	78%
XFR 12-100	100 ms	100 ms	0.6-13.2 V	81%
XFR 20-60	100 ms	100 ms	1-22 V	81%
XFR 35-35	100 ms	100 ms	1.75-38.5 V	83%
XFR 40-30	100 ms	100 ms	2-44 V	83%
XFR 60-20	100 ms	100 ms	3-66 V	86%
XFR 100-12	170 ms	170 ms	5-110 V	84%
XFR 150-8	170 ms	170 ms	7.5-165 V	84%
XFR 300-4	170 ms	170 ms	15-330 V	85%
XFR 600-2	170 ms	170 ms	30-660 V	85%

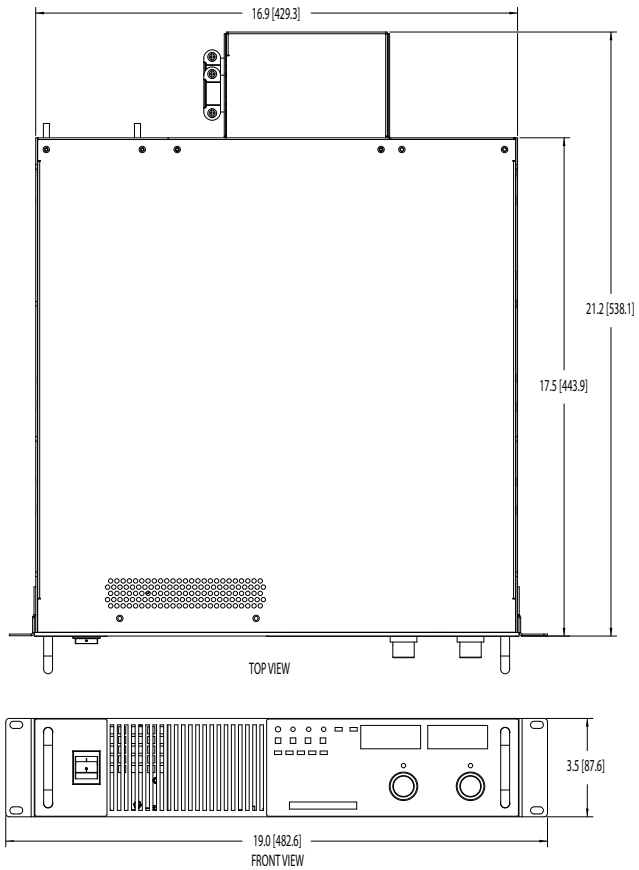
Interface Specifications with RS-232 or GPIB Interface Installed*

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	300 +0.35%	80 +0.1%
XFR 6-200	10 +0.12%	500 +0.12%	30	30 +0.12%	500 +0.1%
XFR 7.5-140	10 +0.12%	500 +0.1%	40	30 +0.12%	500 +0.1%
XFR 12-100	75 +0.12%	460 +0.1%	75	75 +0.12%	460 +0.1%
XFR 20-60	75 +0.12%	250 +0.1%	100	75 +0.12%	250 +0.1%
XFR 35-35	75 +0.3%	200 +0.1%	175	75 +0.12%	200 +0.1%
XFR 40-30	75 +0.3%	150 +0.15%	200	75 +0.12%	150 +0.1%
XFR 60-20	150 +0.25%	120 +0.1%	400	150 +0.25%	120 +0.1%
XFR 100-12	150 +0.35%	80 +0.1%	500	150 +0.35%	80 +0.1%
XFR 150-8	225 +0.35%	80 +0.1%	750	225 +0.1%	80 +0.1%
XFR 300-4	225 +0.35%	80 0.1%	1500	225 +0.1%	80 +0.1%
XFR 600-2	300 +0.35%	75 +0.1%	3000	300 +0.1%	75 +0.1%

XFR Series : Diagram

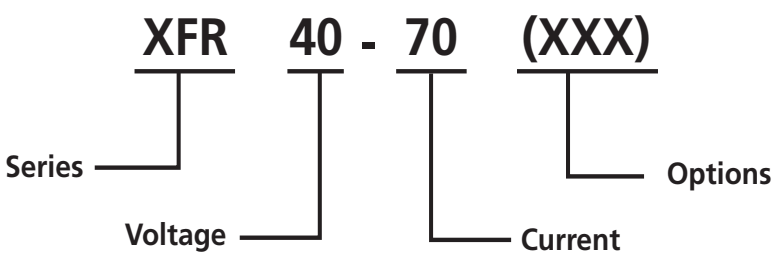


XFR 1.2



XFR 2.8

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	RS-232 interface
MIA	ISOL interface card provides isolated analog control and readback
M2	3-phase 208 Vac input

XFR 1.2 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	RS-232 interface
MIA	ISOL interface card provides isolated analog control and readback
RM-XFR	19 inch Rack Mount Kit

Specifications subject to change without notice.

1. Specifications indicate typical performance at 25°C ±5°C, nominal line input of 208 Vac for the 2.8 or 120 Vac for the 1.2.
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 600V output only. MGA for output less than 600V

Notes

Sorensen DLM 3 & 4 kW Series

DC Power Supply

3–4 kW

5–600 V

5–450 A

	~	208	230
	≈	208	230

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	
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, 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 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

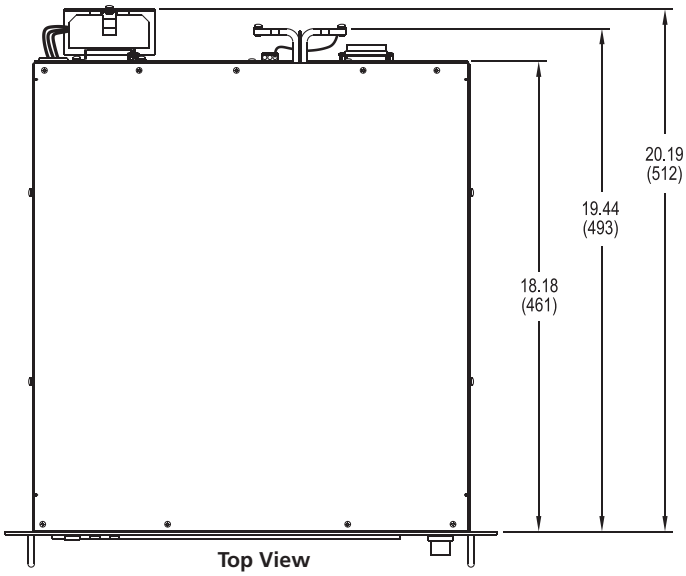
Model	Output Ratings		Regulation Line and Load		Meter Accuracy	
	Voltage (VDC)	Current (ADC)	Voltage (0.05% of Vmax + 2 mV)	Current (0.1% of Imax)	Voltage (0.5% of Vmax + 1 count)	Current (0.75% of Imax + 1 count)
DLM 5-350E	0-5	0-350	5 mV	350 mA	0.04V	4A
DLM 5-450E	0-5	0-450	5 mV	450 mA	0.04V	5A
DLM 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 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	1.6V	0.09A
DLM 300-13E	0-300	0-13	152 mV	13 mA	1.6V	0.11A
DLM 600-5E	0-600	0-5	302 mV	5 mA	3.1V	0.05A
DLM 600-6.6E	0-600	0-6.6	302 mV	7 mA	3.1V	0.06A

DLM 3 & 4 kW Series : Product Specifications

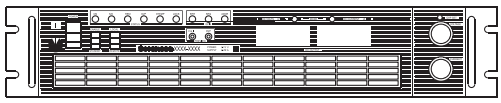
Model	Preview Accuracy		OVP Adjustment Range (6% to 110% Vmax)	Ripple & Noise		Stability		Temp Coefficient		Maximum Total Remote Sense Drop
	Voltage (05% of Vmax +1 count)	Current (1.0% of Imax +1 count)		Ripple (rms)*	Noise (p-p)	Voltage (0.05% of Vmax)	Current (0.05% of Imax)	Voltage (0.02% C of Vmax)	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 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		

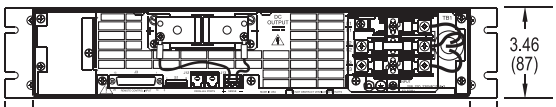
DLM 3 & 4 kW Series : Diagram



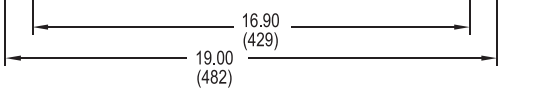
Top View



Front View



Rear View



Dimensions in inches (millimeters)

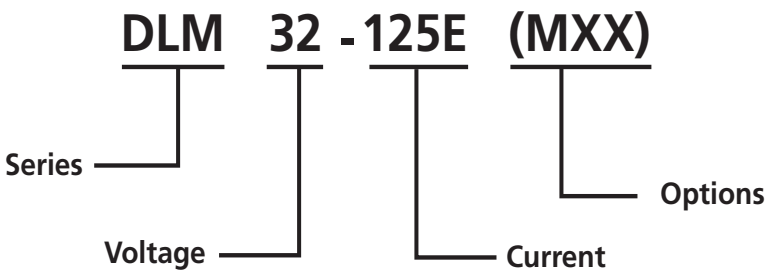
Input Connections
Compression lug terminals
#6 AWG max wire size

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

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 DHP Series

DC High Power Programmable Supplies

5–20 kW

5–50 V

133–3000 A

≋	208	400	480

GPIB RS232

- Modular Design : The series has a unique modular design that results in two rackmount profiles according to output power
- External Shutdown : An external shut down to inhibit the output
- Sequencing : Power and auto-step sequence settings
- Protection : Overvoltage, over-temperature, surge limit, soft start, brown out and short circuit protection current limit fold back.

The Sorensen DHP Series provides models ranging in output power from 5 kW to 20 kW in a single chassis. Programmable output voltages range from 5V to 50 VDC, delivering up to 3,000 amperes. This family has two operational modes, constant-voltage and constant-current.

The DHP Series uses control technology permits up to nine (9) steps per sequence with a maximum sequence duration of up to 27.75 hours.

This family has standard analog and a variety of combinations of IEEE-488.2, RS-232 and/or isolated analog input control interface options.

DHP Series : Product Specifications

Common		
Front Panel Controls	Keypad to select/adjust voltage, current and power with non-volatile memories to store commonly used parameters	
Remote Control/Monitor (Rear Panel)	On/off control via contact closure, 6-120 VDC, 12-240 VAC, TTL or CMOS switch, output voltage and current monitor, (0-10 volt) OVP limit set, summary fault status	
Remote Sense	The maximum line drop is 3% per line or 1V for 5-15V units, 3V for all others. Line drop subtracts from the maximum available output voltage at full rated power.	
Internal Programming	9 memories are on-board for auto-step programming. Each step can be 1 second to 99,999 seconds or 27.78 hours long	
Protection	Over temperature, brown out, turn on surge limit, slow start, overvoltage (OVP resettable without recycling power)	
Displays and Indicators	Back lit LCD alphanumeric display and LEDs	
Regulatory	CE mark (LVD and EMC directive), Certified to UL/cUL 61010 (Up to 10kW output), EMC is to IEC 61326-1	
Input		
Voltage Ranges	190-253 VAC, 47-63 Hz (Standard) 360-440 VAC, 47-63 Hz (Option) 432-528 VAC, 47-63 Hz (Option)	
Phases	Three phase, 3-wire plus ground, Delta or Wye input may be used (Wye does not require the neutral connection)	
Power Factor	0.72 min.	
Output		
Stability	±0.05% maximum rating per 8 hours after a 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. Voltage: 0.1% of maximum rated output. Current: 0.5% of maximum rated output.	
Load Regulation	For 0-100% load variation, with constant nominal line voltage. Voltage: 0.1% of maximum rated output. Current: 0.5% of maximum rated output.	
Transient Response	2 ms to steady state output voltage (within 2% of Vmax) for 30% step load change	
Efficiency	80% minimum at full load	
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.	
Environmental		
Operating Temperature	0°C to 50°C (no derating)	
Storage Temperature	-20°C to 70°C	
Physical	**Case 1**	**Case 2**
Dimensions	Width: 19" (482 mm) Height: 5.25" (133 mm) - 3U Depth: 22" (558 mm)	Width: 19" (482 mm) Height: 10.5" (43 mm) - 6U Depth: 22" (558 mm)
Weight	80 lbs. (55 kg)	160 lbs. (73 kg)
Shipping Weight	120 lbs. (73 kg)	200 lbs. (91 kg)
Remote Digital Control		
Programming Resolution	Voltage: 0.3% of full scale; Current: 0.3% of full scale; Overvoltage Protection: 0.5% of full scale (full scale is 110% of maximum output voltage)	
Programming Accuracy	Voltage: 0.1% + 0.3% of maximum output voltage Current: 0.3% + 0.3% of maximum output current* Overvoltage Protection: 0.5% + 0.5% of maximum output voltage	
Readback Accuracy	Voltage: 0.1% + 0.3% of full scale output voltage; Current: 0.3% + 0.3% of full scale output current*	
Soft Calibration	Calibration via front panel without removing chassis covers	
Software	LabVIEW® driver for M9D, programs can be downloaded at no cost at : www.programmablepower.com	

* After 30 minutes operation with fixed line, load and temperature

DHP Series : Product Specifications

5–20 kW

Output : Voltage and Amps

5 kW to 15 kW*	Output DC		Ripple (rms) Typical	Case	16 kW to 20 kW*	Output DC		Ripple (rms) Typical	Case
	Voltage	Amps				Voltage	Amps		
DHP 5-1000	0-5	0-1000	10 mV	I	DHP 8-2000	0-8	0-2000	25 mV	II
DHP 5-1500	0-5	0-1500	10 mV	I	DHP 8-2400	0-8	0-2400	25 mV	II
DHP 5-2000	0-5	0-2000	15 mV	II	DHP 10-1650	0-10	0-1650	25 mV	II
DHP 5-2500	0-5	0-2500	15 mV	II	DHP 10-2000	0-10	0-2000	25 mV	II
DHP 5-3000	0-5	0-3000	15 mV	II	DHP 12.5-1325	0-12.5	0-1325	25 mV	II
DHP 8-800	0-8	0-800	10 mV	I	DHP 12.5-1600	0-12.5	0-1600	25 mV	II
DHP 8-1200	0-8	0-1200	10 mV	I	DHP 15-1100	0-15	0-1100	25 mV	II
DHP 8-1600	0-8	0-1600	15 mV	II	DHP 15-1320	0-15	0-1320	25 mV	II
DHP 10-660	0-10	0-660	10 mV	I	DHP 20-830	0-20	0-830	25 mV	II
DHP 10-1000	0-10	0-1000	10 mV	I	DHP 20-1000	0-20	0-1000	25 mV	II
DHP 10-1300	0-10	0-1300	15 mV	II	DHP 25-650	0-25	0-650	25 mV	II
DHP 12.5-530	0-12.5	0-530	10 mV	I	DHP 25-800	0-25	0-800	25 mV	II
DHP 12.5-800	0-12.5	0-800	10 mV	I	DHP 30-550	0-30	0-550	25 mV	II
DHP 12.5-1060	0-12.5	0-1060	15 mV	II	DHP 30-660	0-30	0-660	25 mV	II
DHP 15-440	0-15	0-440	10 mV	I	DHP 50-330	0-50	0-330	25 mV	II
DHP 15-660	0-15	0-660	10 mV	I	DHP 50-400	0-50	0-400	25 mV	II
DHP 15-880	0-15	0-880	15 mV	II					
DHP 20-330	0-20	0-330	10 mV	I					
DHP 20-500	0-20	0-500	10 mV	I					
DHP 20-665	0-20	0-665	15 mV	II					
DHP 25-265	0-25	0-265	10 mV	I					
DHP 25-400	0-25	0-400	10 mV	I					
DHP 25-520	0-25	0-520	15 mV	II					
DHP 30-220	0-30	0-220	10 mV	I					
DHP 30-330	0-30	0-330	10 mV	I					
DHP 30-440	0-30	0-440	15 mV	II					
DHP 50-133	0-50	0-133	10 mV	I					
DHP 50-200	0-50	0-200	10 mV	I					
DHP 50-265	0-50	0-265	15 mV	II					

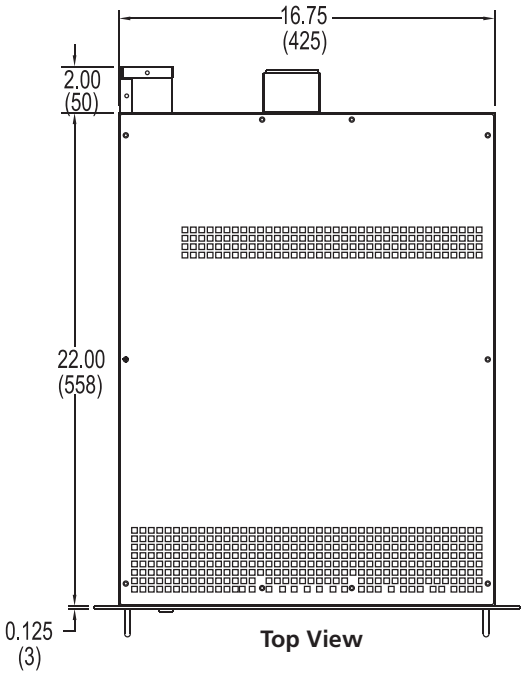
*Note: For high power 40V models and models above 50V see SG Series.
Specifications subject to change.

J3 Connector

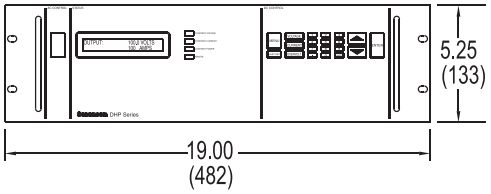
1	Remote Output Enable	14	TTL/CMOS On/Off Control
2	Remote Return for Pins 1 and 14	15	Remote Voltage Programming Input
3	Remote OVP Programming Input	16	Remote Current Programming Input
4	Voltage Return for Pins 9, 15 or 21	17	Fault State
5	Remote On/Off	18	Shutdown Fault
6	Circuit Common	19	Output Voltage Monitor
7	Current Monitor Output	20	Voltage Return for Pins 9, 15 or 21
8	Local Voltage Control Monitor	21	Voltage Control Resistance
9	Remote Voltage Programming Input	22	Current Control Resistance
10	Remote Current Programming Input	23	Current Return for Pins 10, 16 or 22
11	Local Current Control Monitor	24	Circuit Common
12	Remote Sense –	25	Current Return for Pins 10, 16 or 22
13	Remote Sense +		

DHP Series : Diagram

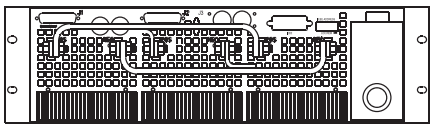
Case I



Top View

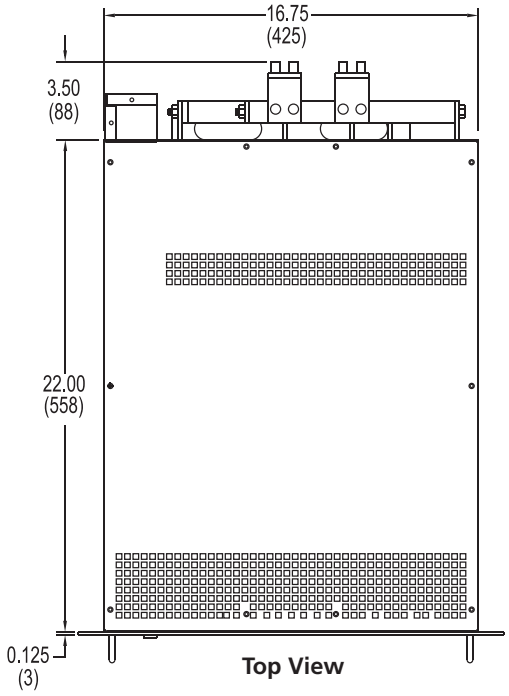


Front View

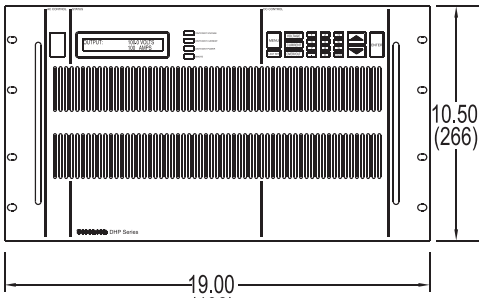


Rear View

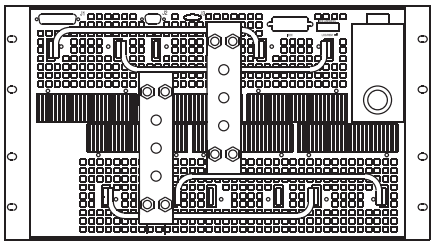
Case II



Top View



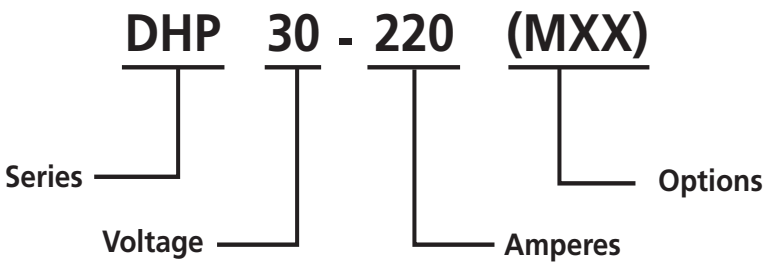
Front View



Rear View

Dimensions in inches (millimeters)

Model Number Description



Options and Accessories

M1	360-440 VAC, 47-63 Hz, three phase, 3-wire plus ground, Delta or Wye may be used
M2	432-528 VAC, 47-63 Hz, three phase, 3-wire plus ground, Delta or Wye may be used
M8	Internal RS-232 remote serial interface
M9D	Internal IEEE-488.2 interface
M10	Both IEEE-488.2 and RS-232
M11	RS-232 and isolated analog programming
M12	IEEE-488.2 and isolated analog programming
M14	IEEE-488.2, RS-232 and isolated analog programming
M51	Isolated analog programming Input Voltage Options. 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.

Software

LabVIEW® driver for M9D, programs can be downloaded at no cost at : http://www.elgar.com/products/DHP/DHP_Downloads.htm

Notes

Power Ten P Series

High Power Analog DC Supplies

2.5–20 kW

5–50 V

66–3000 A

≈	208	400	480

GPIB RS232

- Sequencing
- Digital Displays
  - Power supply rating
  - Output power, voltage and current
  - All power, voltage and current set points and limits
- Up to 3000 Amps in a single 6U package

Power Ten P Series supplies are the first choice for semiconductor burn-in systems worldwide and are providing solutions to high power DC voltage requirements in many other diverse applications. These include:

- Process Control
- Medical Systems
- Production Test
- Electromagnets
- ATE
- Battery Chargers
- Ion Implant
- Radar Systems
- High Power Lasers
- Research / Labs

Over 54 different output voltage and current combinations are available as standard products. Power Ten designs employ efficient and cost effective switching technology – including pulse width modulation (PWM) and zero crossing topology to achieve both high efficiency and high-density packaging. A 10 kW model is available in a 5–1/4" high (3U), rackmounted configuration.

Product quality starts with engineering as a design criteria and is ensured by our highly trained staff of manufacturing and test personnel. Long-term reliability is achieved by care in the derating of components combined with a conservative approach to mechanical and thermal design.

P Series : Product Specifications

P 63 Series	P 66 Series
2.5 kW, 3.3 kW, 6.6 kW and 10 kW	13 kW, 16.5 kW and 20 kW
	
3-Phase Input Power	3-Phase Input Power
Low Peak-to-Peak Ripple & Noise	Low Peak-to-Peak Ripple & Noise
Certified to UL/CSA 61010 and IEC/EN 61010-1 CE Compliant (LVD and EMC directive)	CE Compliant (LVD and EMC directive)
Optional IEEE 488.2 and RS-232 Remote Programming with SCPI Protocol	Optional IEEE 488.2 and RS-232 Remote Programming with SCPI Protocol
Input Voltage 190-253 VAC, 47-63 Hz (Standard) 360-440 VAC, 47-63 Hz (Option) 432-528 VAC, 47-63 Hz (Option)	**Input Voltage** C: 190-253 VAC, 47-63 Hz (Standard) D: 360-440 VAC, 47-63 Hz (Option) E: 432-528 VAC, 47-63 Hz (Option)
Input Current @ 208 VAC (Typical) At 3.3 kW Output: 15A At 6.6 kW Output: 28A At 10.0 kW Output: 41A Operates from Delta or Wye Source	**Input Current @ 208 VAC** (Typical) At 13 kW Output: 54A At 16.5 kW Output: 67A At 20 kW Output: 80A Operates from Delta or Wye Source
Weight: 3.3 kW: 40 Lbs. 6.6 kW: 60 Lbs. 10.0 kW: 80 Lbs.	**Weight:** 13 kW: 120 Lbs. 16.5 kW: 140 Lbs. 20 kW: 160 Lbs.
Dimensions: 19" (W) X 5.25" (H) X 22" (D)	Dimensions: 19" (W) X 10.5" (H) X 22" (D
AC Input Interface: 3 wire + GND (#10-32 threaded studs) (208 VAC)	AC Input Interface: 3 wire + GND (#1/4-20 threaded studs) (208 VAC)
DC Output Interface: Bus bars with 0.390" interface holes for output ≤50 VDC.	DC Output Interface: Bus bars with 0.410" interface holes for output ≤50 VDC..
Control/Monitor Interface: DB 25-pin female connector	Control/Monitor Interface: DB 25-pin female connector

**Note: All specifications herein @ 25°C ± 5°C and subject to change without notice*

P Series : Product Specifications

2.5–20 kW

Common Specifications		
Regulation	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.	
Voltage	0.1% of maximum rated output	
Current	0.5% of maximum rated output	
Transient Response	A 30% current step load will recover to within ±2% of set voltage within 10 msec.	
Stability	±0.05% of set point per 8 hours after 30 minutes warm-up at fixed line, load and temperature.	
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	
Operating Temperature	0 to +50°C, No derating	
Storage Temperature	-20 to +70°C	
Cooling	Internal fans	
Controls (Front Panel)	On/Off switch, DC volts adjust, DC amps adjust, OVP preset adjust (limit set)	
Meters/Indicators	LCD DC voltmeter, ammeter and OVP limit set. LED indicators for voltage mode, current mode. OVP fault and fault	
Built-In Protection	Over Voltage, Current limit Fold back, Over Temperature, Brown Out, Turn On Surge Limit, Slow Start	
Remote Control/Monitor (Rear Panel)	On/Off control via contact closure, 6-120 VDC, TTL or CMOS switch, output voltage and current monitor, OVP limit set, summary fault status on P60 Series.	
Remote Sensing	Terminals provided to sense output voltage at load. Line drop subtracts from the maximum available output voltage at full rated power.	
Operational Features	Master/Slave, Series, Parallel	
Regulatory	CE mark (LVD and EMC directive), Certified to UL/cUL 61010 (Up to 10kW output), EMC is to IEC 61326-1	
Remote Programming	**Voltage (0 to 100%)**	**Current (0 to 100%)**
Resistive	0-5K ohms	0-5K ohms
Voltage	0-5 VDC or 10 VDC	0-5 VDC or 10 VDC
Programmable Functions		
Output Voltage and Current		
Soft Limits for Voltage and Current		
Over Voltage Protection		
Output Enable/Disable		
Maskable Fault Interrupt		
Hold and Trigger		
Readback Functions		
Actual Measured Voltage and Current		
Voltage and Current Settings		
Soft Voltage and Current Limits		
Over Voltage Protection Setting		
Status and Accumulated Status Registers		
Programming Error Codes		
Fault Codes		
Manufacturer, Power Supply Model and Firmware Version Identification		

P Series : Product Specifications

Remote Computer Programming Options

IEEE 488.2 and RS-232 Interface Option enables the power supply to be operated from a computer with full remote programming control and monitoring.
The slave interface option allows multichannel control from a single bus address.

Programming Resolution	Voltage: 0.03% of full scale Current: 0.03% of full scale Over voltage Protection: 0.03% of full scale (full scale is 120% of maximum output voltage)
Programming Accuracy	Voltage: ± (0.1% + 0.1% of maximum output voltage) Current: ± (0.1% + 0.4% of maximum output voltage)*
Overvoltage Protection	± (0.5% + 0.5% of maximum output voltage)
Readback Resolution	Voltage and Current: ± 0.03% of full scale
Readback Accuracy	Voltage: ± (0.1% + 0.15% of full scale output voltage) Current: ± (0.1% + 0.4% of full scale output current)* * After 30 minutes operation with fixed line, load and temperature.

Isolated Analog Control Option (AB)

Fully Isolates Control Inputs

Eliminates System Ground-Loops

Specifications

- Input to Output Isolation: 500V
- Linearity Control to Power Output: ±1% (20-100% of Output)
- Isolation Mode Rejection: 10 KV/µS
- Isolation Mode Rejection Ratio: >100 dB

This control isolation option for all Power Ten power supply models fully isolates the remote control signals. 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.

Model	Output DC		Output p-p Ripple	Model	Output DC		Output p-p Ripple
	Volts	Amps			Volts	Amps	
P63 Series: 2.5 kW to 10 kW*				P66 Series: 10 kW to 20 kW*			
P63C-5500	0-5	500	50 mV	P66C-52000	0-5	2000	50 mV
P63C-51000	0-5	1000	50 mV	P66C-52500	0-5	2500	50 mV
P63C-51500	0-5	1500	50 mV	P66C-53000	0-5	3000	50 mV
P63C-8400	0-8	400	50 mV	P66C-81600	0-8	1600	50 mV
P63C-8800	0-8	800	50 mV	P66C-82000	0-8	2000	50 mV
P63C-81200	0-8	1200	50 mV	P66C-82400	0-8	2400	50 mV
P63C-10330	0-10	330	50 mV	P66C-101300	0-10	1300	50 mV
P63C-10660	0-10	660	50 mV	P66C-101650	0-10	1650	50 mV
P63C-101000	0-10	1000	50 mV	P66C-102000	0-10	2000	50 mV
P63C-12.5265	0-12.5	265	50 mV	P66C-12.51060	0-12.5	1060	50 mV
P63C-12.5530	0-12.5	530	50 mV	P66C-12.51325	0-12.5	1325	50 mV
P63C-12.5800	0-12.5	800	50 mV	P66C-12.51600	0-12.5	1600	50 mV
P63C-15220	0-15	220	50 mV	P66C-15880	0-15	880	50 mV
P63C-15440	0-15	440	50 mV	P66C-151100	0-15	1100	50 mV
P63C-15660	0-15	660	50 mV	P66C-151320	0-15	1320	50 mV
P63C-20166	0-20	166	75 mV	P66C-20665	0-20	665	75 mV
P63C-20330	0-20	330	75 mV	P66C-20830	0-20	830	75 mV
P63C-20500	0-20	500	75 mV	P66C-201000	0-20	1000	75 mV
P63C-25134	0-25	132	75 mV	P66C-25520	0-25	520	75 mV
P63C-25265	0-25	265	75 mV	P66C-25650	0-25	650	75 mV
P63C-25400	0-25	400	75 mV	P66C-25800	0-25	800	75 mV
P63C-30110	0-30	110	75 mV	P66C-30440	0-30	440	75 mV
P63C-30220	0-30	220	75 mV	P66C-30550	0-30	550	75 mV
P63C-30330	0-30	330	75 mV	P66C-30660	0-30	660	75 mV
P63C-5066	0-50	66	75 mV	P66C-50265	0-50	265	75 mV
P63C-50133	0-50	133	75 mV	P66C-50330	0-50	330	75 mV
P63C-50200	0-50	200	75 mV	P66C-50400	0-50	400	75 mV

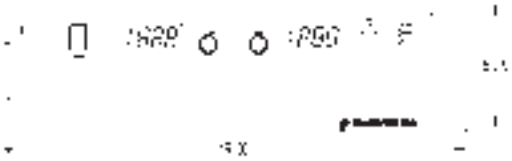
**Note: For high power 40V models and models above 50V, see SG Series.*

P Series : Diagram

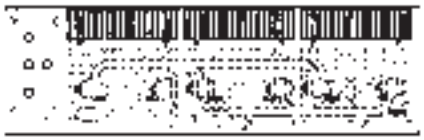
2.5–20 kW

P63

Top View

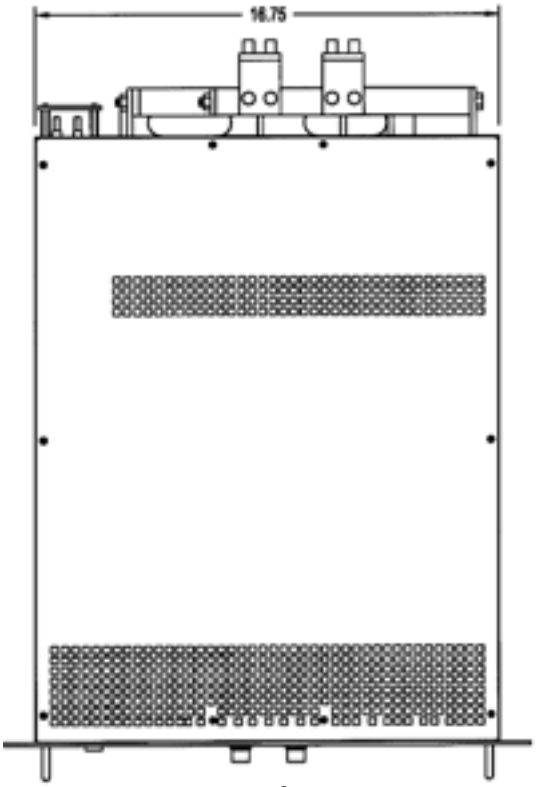


Front View

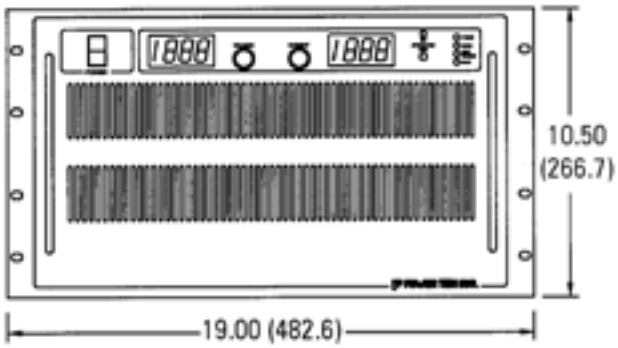


Rear View

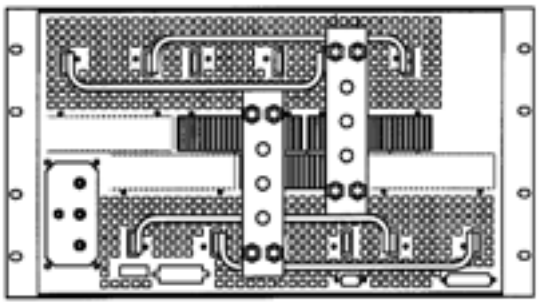
P66



Top View



Front View

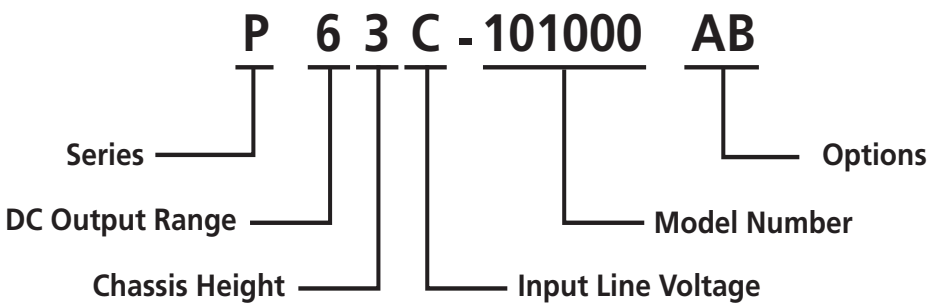


Rear View

Dimensions in inches (millimeters)

Product Name Series

Model Number Description



Options and Accessories

AB	Isolated Analog Input
R	IEEE-488.2 Interface and RS-232C Interface
J	Shaft Locks
990-323-90	L Brackets (2 Required and is for all P Series)
105-300-26	Rack Slide Kit (for all of P Series) Optional IEEE 488.2 and RS-232 Programming with SCPI protocol.

J1 Connector

1	Remote Output Enable	14	TTL/CMOS On/Off Control
2	Remote Return for Pins 1 and 14	15	Remote Voltage Programming Input
3	Remote OVP Programming Input	16	Remote Current Programming Input
4	Voltage Return for Pins 9, 15 or 21	17	Fault State
5	Remote On/Off	18	Shutdown Fault
6	Circuit Common	19	Output Voltage Monitor
7	Current Monitor Output	20	Voltage Return for Pins 9, 15 or 21
8	Local Voltage Control Monitor	21	Voltage Control Resistance
9	Remote Voltage Programming Input	22	Current Control Resistance
10	Remote Current Programming Input	23	Current Return for Pins 10, 16 or 22
11	Local Current Control Monitor	24	Circuit Common
12	Remote Sense –	25	Current Return for Pins 10, 16 or 22
13	Remote Sense +		

Sorensen SG Series

Programmable Precision High Power DC Power Supply

5–150 kW

40–600 V

8–2500 A

	208	400	480

ETHERNET GPIB LXI RS232

- High Power Density: Up to 15 kW in a 3U / 30 kW in a 6U chassis
- Wide Voltage Range: 0-40V up to 0-600V, in increments of 5 kW from 5 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: Expandable as your requirement grows
- Sequencing: Free system controller & speed up test

The Sorensen SG series (hereafter SG Series) represents the next generation of high power programmable DC power supplies. Designed for exceptional load transient response, low noise and the highest power density in the industry. The industry leading 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 idea 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 price 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	Load-line loss compensation for models <= 100 V is 10% above full scale voltage total (5% per load-line), and models > 100 V is 4% above full scale voltage total (2% per load-line).
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	208/220 VAC (operating range 187 - 242 VAC) 380/400 VAC (operating range 342 - 440 VAC) 440/480 VAC (operating range 396 - 528 VAC)
Frequency	47 – 63Hz
Power Factor	>0.9 typical at 208/220 VAC input >0.78 typical at 380/400 VAC input >0.69 typical at 440/480 VAC input
Protection	½ cycle ride-though on all three phases, 3 cycle ride through on single phase; missing phase shutdown

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. Units may be stacked without spacing.
Regulatory	Certified to UL/CSA 61010 and IEC/EN 61010-1, CE Compliant, Semi-F47 Compliant
Physical	
Dimensions	Width: 19.00" (48.3 cm), Depth 25.0" (63.5 cm) Height: 5-15 kW units: 3U – 5.25" rack mount (13.34 cm) 20-30 kW units: 6U – 10.5" rack mount (26.67 cm)
Weight	3U < 80 lbs. (36 kg) 6U <160 lbs. (73 kg)
Shipping Weight	See web site or contact factory for more product & shipping weights.

Programming & Read-back Specifications

	Programming		Read-Back / Monitoring		
	Accuracy	Resolution	Accuracy	Resolution	
Front panel Display	SGA: +/- (0.5%fs + 1 digit) SGI, Voltage: +/- 0.1% of full scale SGI, Current: +/- 0.4% of full scale	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	SGA: 3.5 digits SGI: 4.0 digits	Knob control & Display read-back
Remote Analog Interface	Voltage: +/-0.25% of full scale for 0-5 V range, +/-0.5% of full scale for 0-10 V range Current: 0.8% of full scale	NA	+/-1.0% of full scale (0 - 10V)	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: +/- 0.15% 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				

Output	
Ripple & Noise (Voltage Mode, Typical)	See Output: Voltage & Current Ranges Chart Above. 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
DC Voltage Slew Rate	100 ms 5-95% of full scale typical (Contact factory for model specific slew rates)
DC Current Slew Rate	45A / ms typical
Line Regulation	(±10% of nominal AC input, constant load) Voltage Mode: +/- 0.01% of full scale Current Mode: +/- 0.05% of full scale
Load Regulation (with sense wires used)	(no load to full load, nominal AC input) Voltage Mode: +/- 0.02% of full scale Current Mode: +/- 0.1% of full scale
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 8 hrs. warm-up at fixed line, load and temperature
Temperature Coefficient	0.02%/ C of maximum output voltage rating for voltage set point 0.03%/ C of maximum output current rating for current set point
Output Float Voltage	Negative terminal within +/- 600 V of chassis potential. (Float voltages 300V and higher require the used of the optional Isolated Analog Interface (IAI).) Supplies in "series" should be the same output voltage/current.

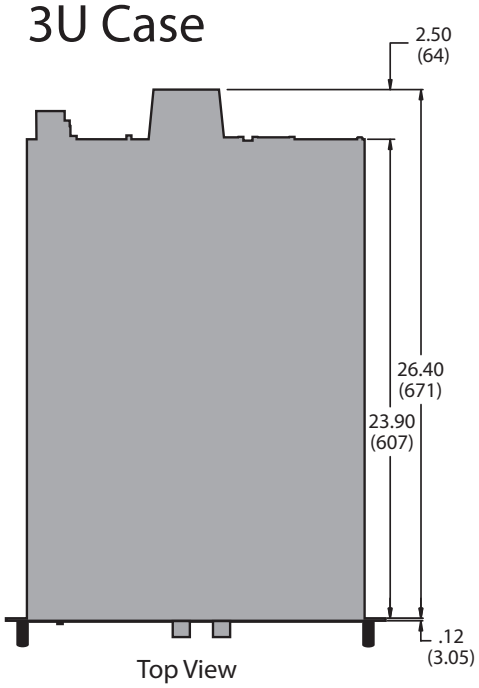
Output: Voltage and Current Ranges

	3U			6U			Ripple & Noise	
Power	5 kW	10 kW	15 kW	20 kW	25 kW	30 kW	**rms** (20 Hz-300 kHz)	**p-p** (20 Hz-20 MHz)
Voltage	Current							
40	125	250	375	500*	625*	750*	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
600	8	17	25	33	42	50	60 mV	350 mV

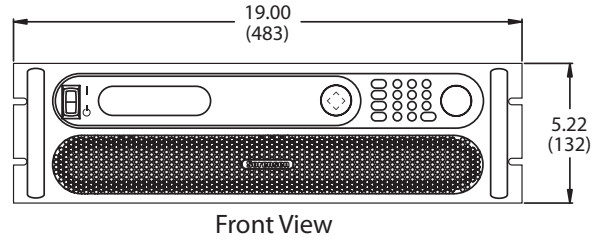
*** By way of paralleling 5 kW, 10 kW & 15 kW supplies**

SG Series : Product Diagram

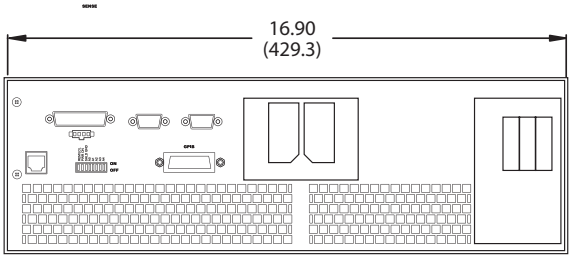
3U Case



Top View

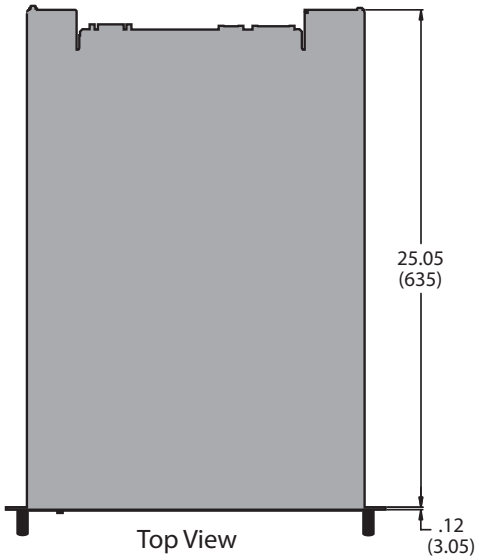


Front View

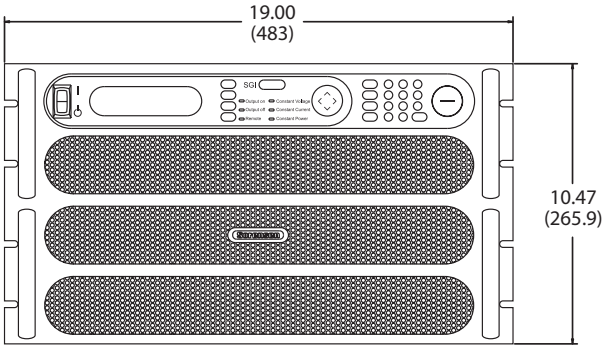


Rear View

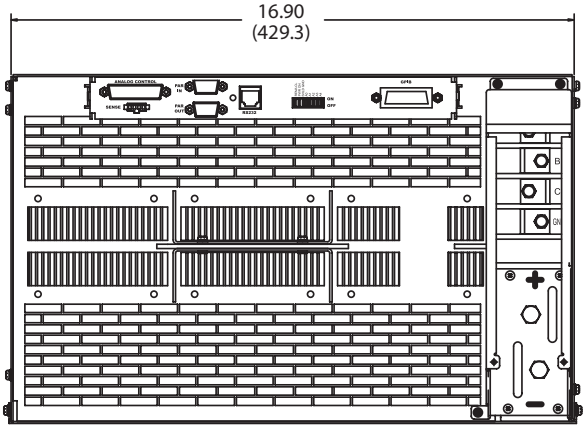
6U Case



Top View

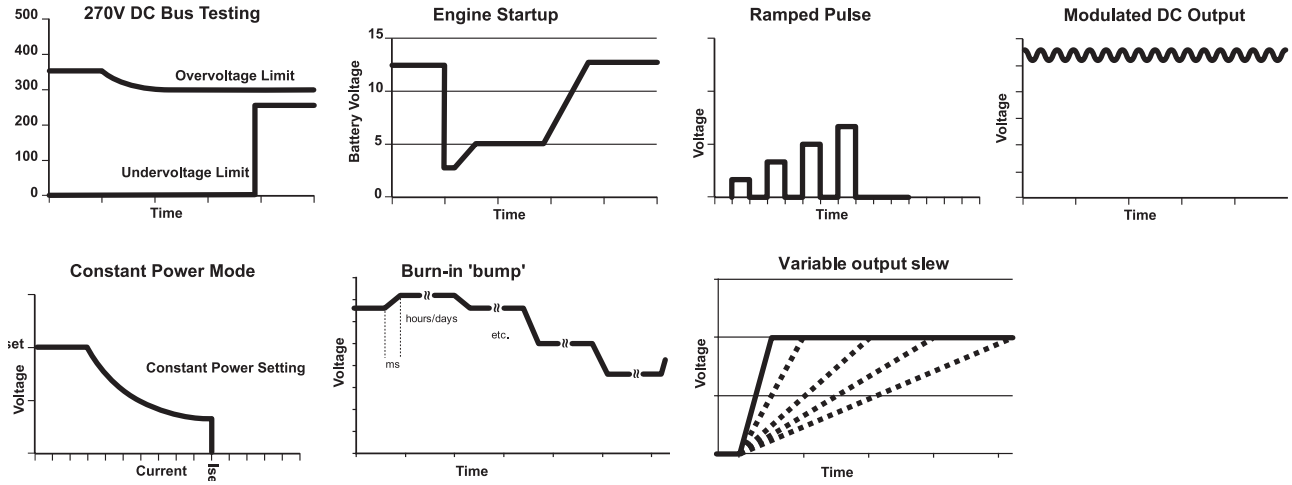


Front View



Rear View

Advanced Power Simulation

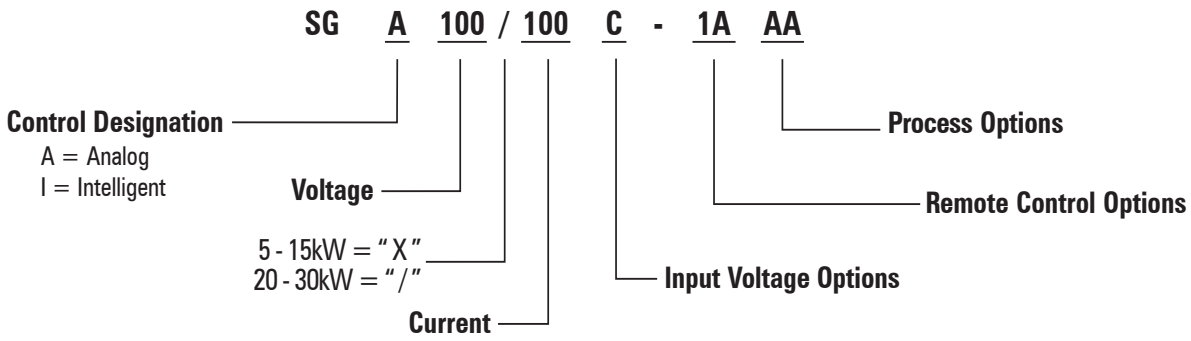


SGI model provides constant power mode allowing independent setting of the max voltage, current and power

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

SG Series



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)
Process Options	AA: No option AB: Certificate of Calibration (includes Test Data)
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)
Contact factory for other combinations	

Sorensen SFA Series

High Slew Rate Current Source

5–150 kW

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 maximum 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						
K550212-01	3U Rack Slides (for 5kW, 10kW and 15kW models)					
K550213-01	6U Rack Slides (for 20kW, 25kW and 30kW models)					

Notes

DC Bench Top Power Supplies

Notes

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

Technical Note

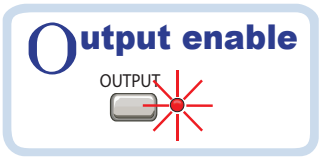
Engineers and technicians in electrical laboratories use programmable power supplies as a basic instrument for either base power or variable power in margin testing. These supplies are typically low cost instruments with very basic controls of an on/off switch and two knobs, one for voltage control and 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 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 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

60 Watt Linear Performance DC Power Supply

- 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.

42–60 W

7–250 V

0.25–6 A

	~	115	230

GPIB RS232

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	85 mA	2.7 mV	0.85 mA
XT 15-4	3.5 mV	65 mA	3.5 mV	0.65 mA
XT 20-3	4 mV	55 mA	4 mV	0.55 mA
XT 30-2	5 mV	45 mA	5 mV	0.45 mA
XT 60-1	8 mV	0.35 mA	8 mV	0.35 mA
XT 120-0.5	14 mV	0.3 mA	14 mV	0.3 mA
XT 250-0.25	27 mV	0.275 mA	27 mV	75 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.

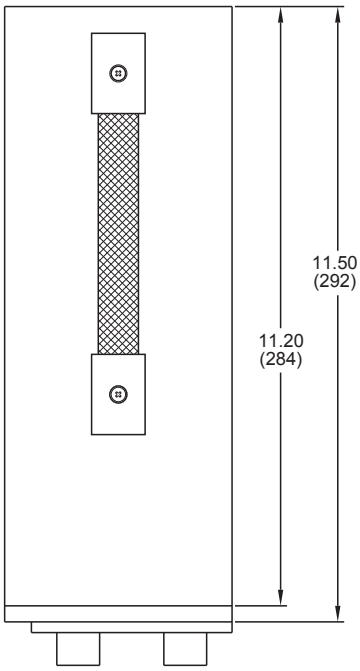
1. Specifications indicate typical performance at 25° C ± 5°C, nominal line input of 115 Vac.
2. For input voltage variation over the AC input voltage range, with constant rated load.
3. For 0-100% load variation, with constant nominal line voltage.
4. Maximum drift over 8 hours with constant line, load, 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 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

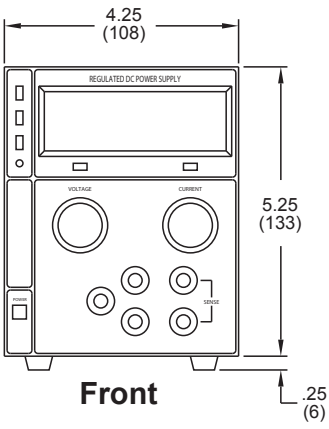
Models	Readback Accuracy Voltage (mV)	Readback Accuracy Current (mA)
XT 7-6	10 + 0.15%	110 + 0.15%
XT 15-4	10 + 0.1%	70 + 0.15%
XT 20-3	10 + 0.1%	50 + 0.15%
XT 30-2	15 + 0.1%	40 + 0.15%
XT 60-1	35 + 0.15%	26 + 0.2%
XT 120-0.5	70 + 0.15%	13 + 0.2%
XT 250-0.25	140 + 0.15%	7 + 0.2%

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)

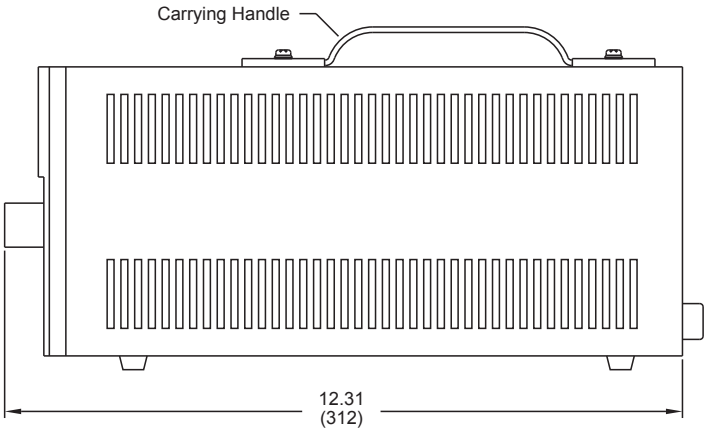
XT Series : Technical Diagram



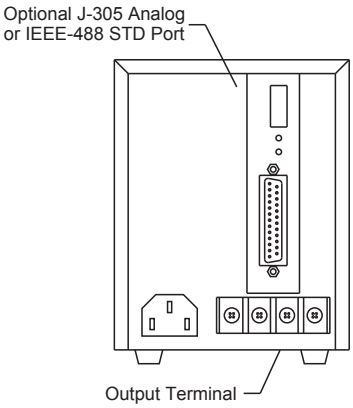
Top



Front

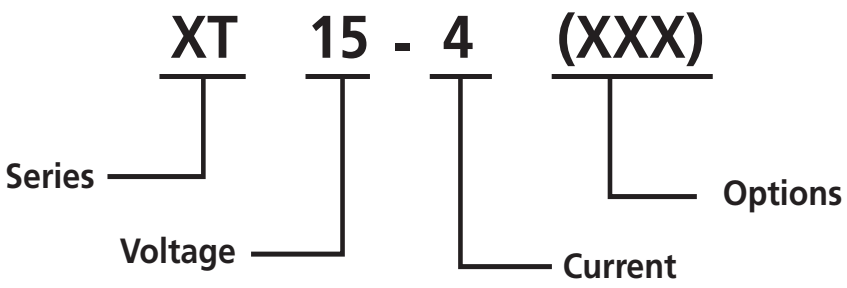


Right Side



Back

Model Number Description



Options and Accessories	
MGA	GPIB Interface card
MGP	Multichannel GPIB interface card
MCA	CANbus interface for hardware linking multiple units (used with GPIB-M)
MRA	RS-232 Interface card
MAA	Analog programming interface card
RM-XPDG-2	19-inch Rack Mount Kit for up to four XT, XPD, XEL or HPD power supplies
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)

Notes

Sorensen XEL Series

90W Linear Benchtop Supply with V-Span

- Ideal for engineering lab use
- Digital features with analog controls
- S-Lock: Set and lock the voltage
- V-Span: user-defined voltage limits
- Small benchtop footprint
- Rack mounting ¼ rack x 3U

75–180 W

15–60 V

1.5–6 A

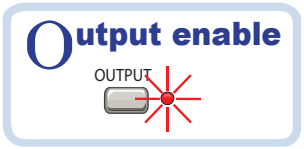
	~	115	230

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-Spa, 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. 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.



XEL Series : Product Specifications

Output Ratings				
Model	**XEL 15-5**	**XEL 30-3**	**XEL 60-1.5**	**XEL 30-3D**
Voltage (VDC)	0-15	0-30	0-60	0-30
Current (ADC)	0.1-5	0.1-3	0.1-1.5	0.1-3/6
Power (W)	75	0-90	90	90/180
Output Performance				
Voltage Meter	4-digit meter			
Accuracy	0.1% + 10mV			
Resolution	10mV			
Current Meter	4-digit meter			
Accuracy	0.5% + 3mA	0.3% + 3mA	0.3% + 3mA	0.3% + 3mA*
Resolution	1mA	1mA	1mA	1mA
Low Current	<500mA			
Accuracy	0.3% + 0.3mA			
Resolution	0.1mA			
Voltage Ripple	0.4 mVRMS			
Voltage Noise	2 mVpp			
Current Ripple	5 mARMS			
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			
Current	0.01% + 250µA			
Transient Response	<50µs to within 50mV of setting (90% load change)			

Common	
AC Input	115 VAC ± 10%, 50/60Hz (230VAC available as option MHV)
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
Accessories	
RM-XPDG2	Rack mount kit for XEL, XT and/or XPD
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

* Current accuracy in parallel mode = 0.5% + 3mA

Sorensen XBT 32-3FTP

True Triple Output Digital Benchtop Power Supply

222 W

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

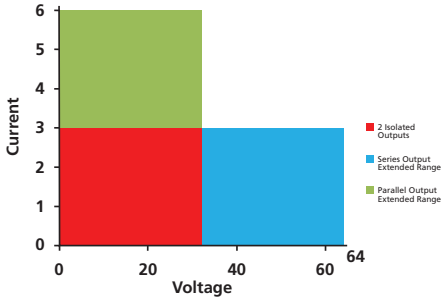
The XBT32-3FTP adds to the capability of the Sorensen benchtop product line with a 16-bit triple output supply. Channels 1 and 2 can be programmed 0-32V and 0-3A each. The third output is fully programmable 0-15V, 0-5A up to a maximum of 30W. Channels 1 and 2 can be configured for tracking, parallel 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.

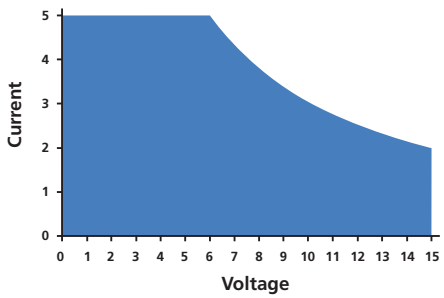
Advanced engineering features include storage of 100 different setups (voltage and current) as well as a 100 hour timer. Power- on state and synchronous or individual control of each channel output can also be set. Over-voltage and over-current protection is programmed for each channel.

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.

Channels 1 and 2 Operating Areas



Channel 3 Operating Area



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	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 XDL Series

Digitally Controlled DC Linear Power Supplies

105–215 W

35–56 V

0.5–5 A

	~	115	230

USB GPIB RS232

- Very high precision, very low noise, excellent dynamics
- Advanced user interface with direct numericentry and incremental rotary control
- Ten store/recall setup locations
- Thirty store/recall setup locations
- Fully isolated outputs for maximum flexibility
- Constant voltage or constant current operation with automatic crossover and mode indication

The Sorensen XDL Series represents the 'next generation' of high performance laboratory power supplies. Using linear technology and unrivalled performance in regulation, output noise and dynamic performance is achieved. High precision is also achieved by using instrumentation quality 16-bit DAC to control voltage and current enabling voltage set points at 1 millivolt resolution. As the XDL is highly accurate, it can be used as a calibration source for some handheld DMMs.

Direct Numeric Keypad Entry and Incremental Rotary Control Unlike other digitally controlled units, the XDL Series provides both numeric and rotary control while the illuminated keys and display legends provide instant confirmation of settings and status. Precise settings can be made by direct numeric entry using the 0 to 9 keypad. For gradual settings, a jog wheel is available for incremental or decremental changes in voltage steps of 0.1 volt, 1 millivolt or 10 millivolt and current steps of 0.1 amp down to 0.1 milliamp. The jog wheel can be engaged permanently or disabled.

Multiple Ranges For Greater Flexibility The XDL Series provides multiple ranges for voltage and current settings. Each model offers three output ranges per output.

For added convenience the XDL series provides storage of up to ten power supply set-ups in non-volatile memory (30 set-ups for a triple). Upon shutdown of the supply, the settings are saved and automatically restored at switch-on.

OVP and OCP Trips with Alarm Output The XDL Series provides fully adjustable over-voltage and over-current protection. The over-voltage and over-current protection feature provides a fail-safe mode of operation to prevent an accidental or incorrect setting, as well as protect against undesired load conditions. A trip condition switches the rear panel alarm signal, which enables other equipment to be controlled. Alarms can also be activated by over-temperature and excess voltage on the sense terminals.

USB/GPIB/RS-232 Interface
The multiple interface card enables remote control and readback via either USB, GPIB or RS-232. On triple-output models, the single interface address controls all three outputs. The USB interface is for medium speed PC connectivity and enables multiple devices to be connected. A Windows® device driver is supplied, which creates a virtual COM port, enabling USB to be used in applications that do not directly support it. The GPIB interface conforms to IEEE488.2 and IEEE488.1

Remote Sense and Local Sense
The XDL series provides full remote sense capability via dedicated sense terminals to maintain regulation at the load. When remote sense is not required, internal local sensing can be selected.

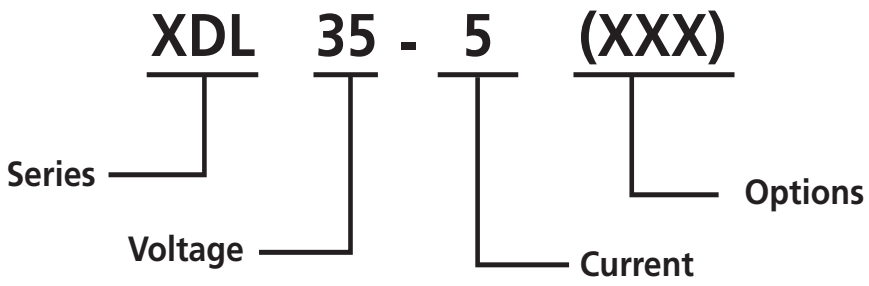
Linked and Copy Mode
The XDL triple-output models have two identical independent and isolated outputs. In situations where the user wishes to set similar voltages and current on both outputs, the "linked" mode is available. When linked, all adjustments are simultaneously applied to both outputs. The "copy" function allows all the settings of one output to be duplicated on the other prior to linking. For greater flexibility and convenience, the outputs can be linked when set to different voltages or current, allowing separate settings to be recalled into the linked mode memories for simultaneous recall.

XDL Series : 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	3	1	3	1	1
Output Power	105 W	215 W	105 W	215 W	112 W	112 W
Interface (GPIB/RS-232/USB)	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					
Setting Accuracy	Voltage 0.03% ± 5 mV. Current 0.2% ± 5 mA, 0.5 mA					
Output Mode	Operation in constant voltage or constant current modes with automatic cross-over and mode indication by LEDs.					
DC Output Switch	Sets output voltage and current levels to zero when Off.					
Output Terminals	4 mm terminals on 19 mm (0.75") spacing					
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% Vrms 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 (voltage)					
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)					
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.

Model Number Description



Notes

Sorensen XPF Series

Dual Output DC Power Supply with Powerflex™

350–840 W

35–60 V

10–20 A

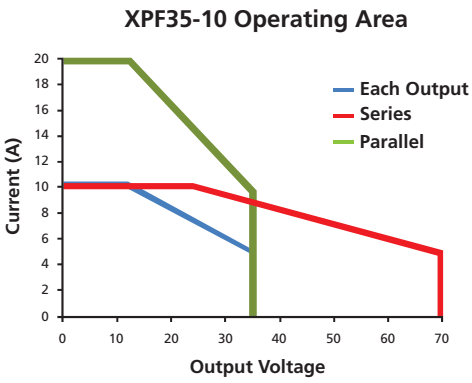
	~	115	230

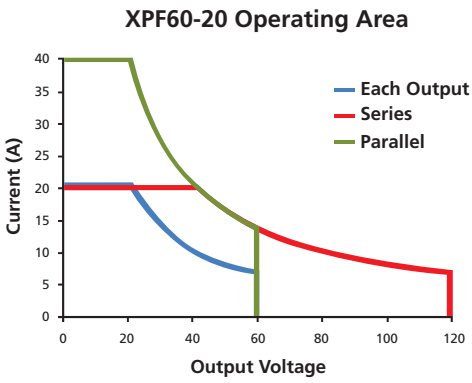
- PowerFlex design with parallel or series configuration gives variable voltage/current combinations equivalent to 6 power supplies in one unit
- Individual on/off switch per output
- Dual isolated outputs
- Coarse and fine voltage controls
- Simultaneous display of output voltage and current for each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





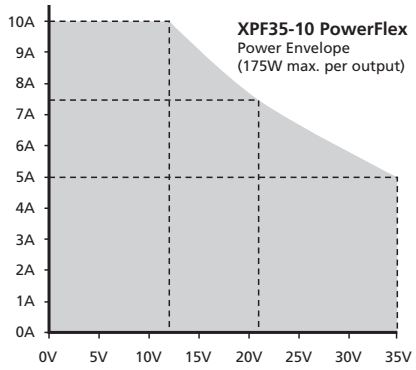
XPF Series : Product Specifications

Output : Voltage and Current		
Models	35-10	60-20
Output Ratings (Each Output)		
Output Voltage	0 - 35 V	0 - 60 V
Output Current	0 - 10 A	0 - 20 A
Outputs	2	2
Output Power	up to 175 W	up to 420 W (See XPF 35-10 and XPF 60-20 PowerFlex power envelope graph)
Output		
OVP Range	10% -110% of maximum output voltage	
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% of max. output for a 10% line voltage change	
Load Regulation	<0.05% of max. output for a 90% load change.	
Ripple and Noise	5 mV rms max, typically 2 mV rms, <20 mV pk-pk, (20 MHz bandwidth) both outputs fully loaded (7A @ 25V), CV mode (XPF 35-10) Typically <1mV rms, <10mV pk-pk, (20 MHz bandwidth) both outputs loaded (10A @ 42V) CV mode (XPF 60-20)	
Transient Response	<2ms to within 100mV of set level (XPF 35-10) and <250µs to within 50 mV of set level (XPF 60-20) for 90% 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 Resolution	10 mV, 10 mA	
Meter Accuracy		
Voltage	0.2% ± 1 digit	
Current	0.5% ±1 digit	
Input		
AC Input	XPF35-10: 110V-120V AC or 220V-240V AC ± 10% (adjustable internally, option HV for factory set 220-240 VAC input) 50/60 Hz . XPF60-20: 115V-240VAC ±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	Width: 8.3" (210 mm) Height: 5.1" (130 mm) Depth: 14.8" (375 mm)	
Weight	11 lb. (5kg)	
General		
Cooling	Convection (XPF 35-10), Fan (XPF 42-20)	
Power Consumption	600 VA max. (XPF 35-10), 1100 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		

Power Envelope (each output)

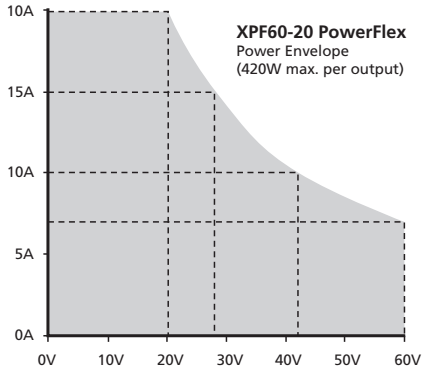
The maximum current at any voltage setting is limited by the power envelope which is set to give 5A at 35V rising to 10A at 12V and lower.

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

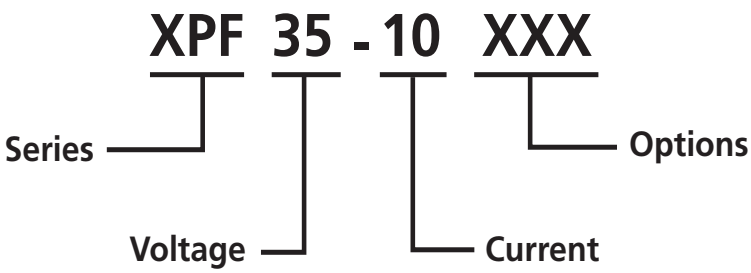


The maximum current at any voltage setting is limited by the power envelope which is set to give 7A at 60V rising to 20A at 20V and lower.

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

HV (Input Voltage Option)	230 VAC input factory set

Notes

Sorensen HPD Series

300 W

300 Watt DC Power Supply with Near-Linear Performance

15–60 V

5–20 A

	~	115	230

- 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	3.5 mV	5 mV	8 mV
Current	3 mA	2 mA	1.5 mA
Load Regulation [3]			
Voltage	3.5 mV	5 mV	8 mV
Current	3 mA	2 mA	1.5 mA
Meter Accuracy			
Voltage (1% of Vmax + 1 count)	0.25 V	0.4 V	0.7 V
Current (1% of Imax + 1 count)	0.3 A	0.2 A	0.06 A
Output Noise (90-20 MHz)			
Voltage (p-p)	100 mV	100 mV	100 mV
Output Ripple			
Voltage	5 mV	5 mV	5 mV
Drift (8 hours) [4]			
Voltage (0.15% of Vmax)	3 mV	6 mV	12 mV
Current (0.3% of Imax)	6 mA	3 mA	1.5 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%

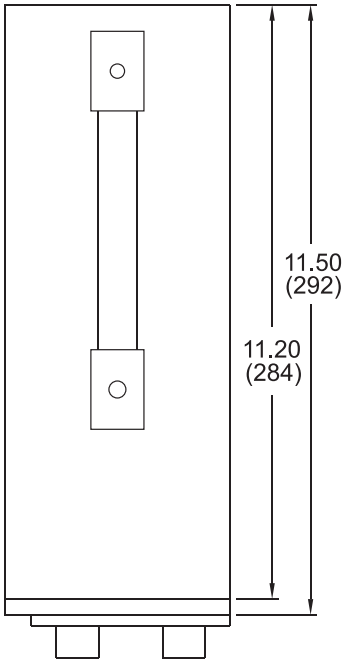
Specifications subject to change without notice.

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.

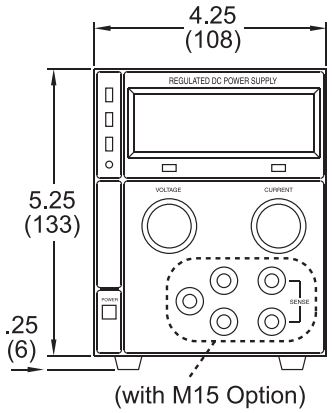
HPD Series : Product Specifications[1] 300 W

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)

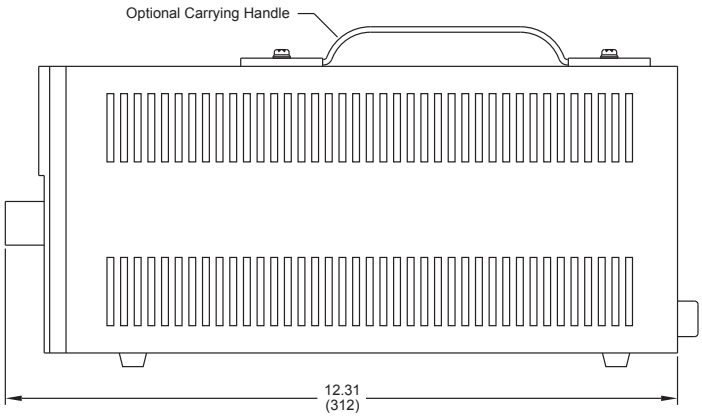
HPD Series : Technical Diagram



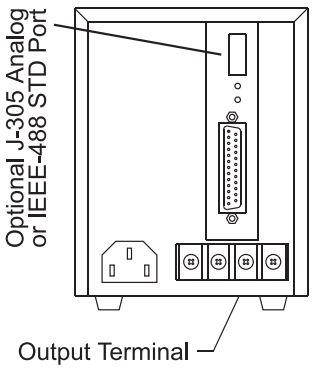
Top



Front

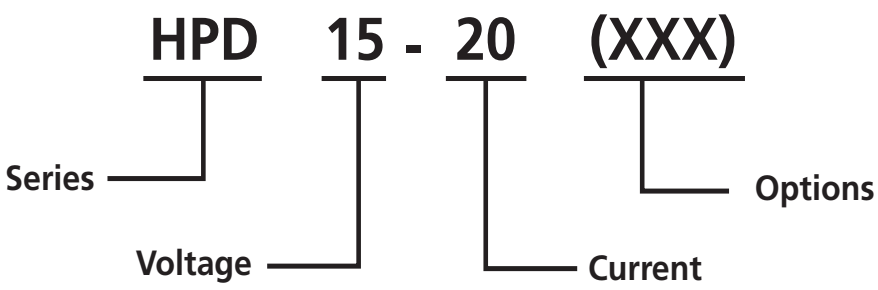


Right Side



Back

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-2	19-inch Rack Mount Kit for up to four HPD, XPD, XEL or XT power supplies
M2	AC Input Option - 200-250 Vac Input (50/60 Hz)

* Options cannot be combined.

Notes

Sorensen XPH Series

Compact High Power Bench DC Power Supplies

175–420 W

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 switchable fixed output of 3.3 volts and 5 volts.

Output voltages up to 150 volts
The XPH-M Series 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	3
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.

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 Installation Category II (XPH 18-10, XPH 20-20, XPH 42-10)
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)

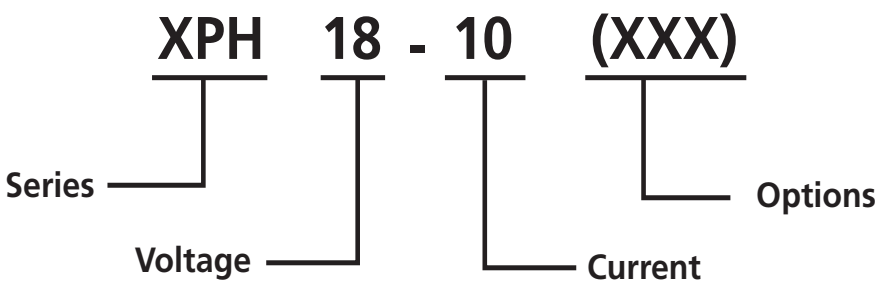
General Specifications	
Operating Mode	Constant voltage or constant current with automatic cross-over and indication
Voltage Setting	By coarse and fine controls (auxiliary third output on XPH35-4T course only)
Current Setting	By single logarithmic control
Output Impedance	Typically < 5 mΩ in constant 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), <10mVpk-pk for XPH 20-20, 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)
Status Indication	Output ON lamps. Constant current mode lamps
Output Switch	Electronic. Preset voltage/current displayed with output off.
Remote Selection	Switch selectable as Local or Remote
Regulatory	CE-marked units meet: EN61010-1 and EN61326

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	100 mV, 10 mA

Meter Accuracy	
Voltage	0.3% ± 1 digit
Current	0.6% ± 1 digit

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 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
- 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)
- Switchable 3.3 V/5 V output on triple output model
- 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. 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 switchable fixed-output of 3.3 volts and 5 volts.

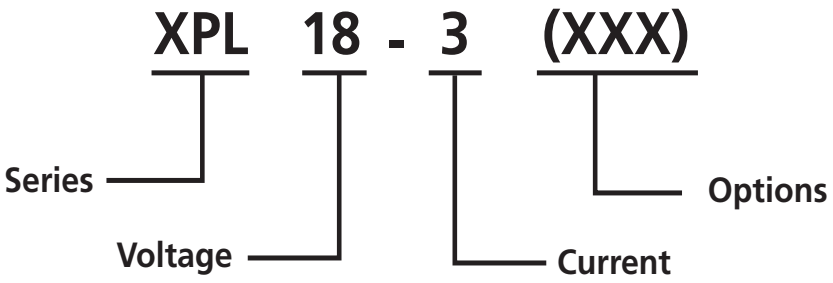
XPL Series : Product Specifications[1]

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	3	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					
Meter Resolutions	100 mV, 10 mA					
Meter Accuracy Voltage	0.3% ±1 digit					
Meter Accuracy Current	0.6% ±1 digit					
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)

Model Number Description



Sorensen XPD Series

Compact 500 Watt Quarter-Rack DC Power Supply

- 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.

500–540 W

7.5–120 V

4.5–67 A

	~	115	230

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.

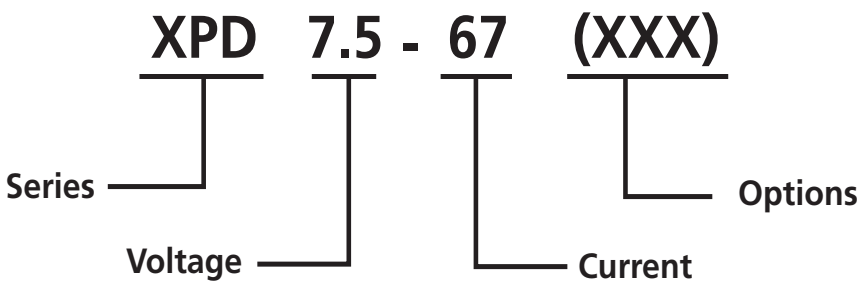
1. All electrical specifications are represented at the full operating temperature range for all models, unless otherwise stated.
2. Minimum output voltage is < 0.15% of rated voltage at zero output setting.
3. Minimum output current is < 0.2% of rated current at zero setting when measured with rated 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]

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
MGP *	Multichannel GPIB / IEEE 488.2
MCA *	Interface for linking multiple units using one GPIB address (used with GPIB-M)
MRA *	RS-232 interface card
RM-XPDG-2	19-inch Rack Mount Kit for up to four XPD, HPD, XEL or XT power supplies
M13	Locking bushings
M13A	Locking knobs

* Options cannot be combined

Sorensen XHR Series

DC Power Supply

1 kW

7.5–600 V

0–1.7 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%

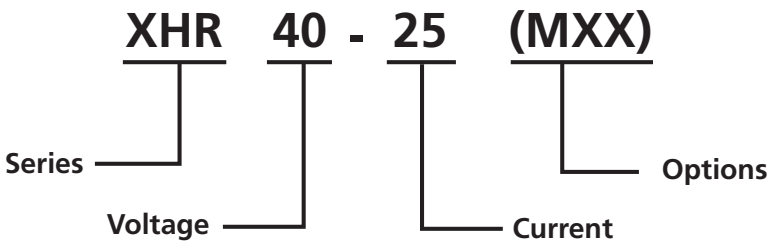
XHR 1 kW Internal Interface Specifications with RS-232 or GPIB Interface Installed [1, 8]

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
MGP *	Multi-channel GPIB / IEEE 488.2
MCA *	Interface for linking multiple units using one GPIB address (used with GPIB-M)
MRA *	RS-232 interface card
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

* Options cannot be combined

Notes

AC Rack Mount Power Sources

Notes

How to Select an AC Power Source

Article

By Martin R Sanders

Here are five practical guidelines for specifying an ac power source to test dc power supplies and other electronics in an end product

1 Regulation should be tight, and distortion and impedance low. No unknown fluctuations or distortion should be injected into the device being powered in test applications. Poor regulation and distortion can lead to faulty test data that may not be discovered until units are in the field. Poor regulation leads to the effects of a "soft source." A soft source has higher output impedance and lower peak current capability than should be. This leads to a lack of proper stressing of components and a higher rate of failures. For example, a dc power supply that has never experienced the maximum inrush current to its input rectifier stage and power components may fail at the customer site when plugged into facility power. Engineering Society-approved methods for indoor luminaries, IES LM-41-1985. A "soft source" effect would totally distort the proper testing of the lamp and ballast.

2 The ac source should handle high inrush current, The ability of the ac power source to handle inrush depends not only on low source impedance, but also on the type of current-lim- Another example of products requiring quality ac power is a lamp and ballast. In testing a lamp and ballast, tight regulation (+/-O.I%), low distortion, and low source impedance are important to ensure that the voltage to the lamp and ballast combination does not vary by more than 2%. This allows proper testing of the light intensity per the Illuminating iting scheme employed. There are two basic types of current-limiting schemes in ac sources: · Current-limiting foldback. · Current-limiting shutdown. When sizing an ac source, consider the maximum inrush current drawn by the load and how long it lasts. Two of the biggest culprits in drawing high inrush currents are motors and power supplies. Inrush currents on these devices can range from 2 to 10 times the nominal run current. Inrush current durations range from a few cycles to several seconds. AC power sources are designed to protect themselves from excessive inrush by either folding back the voltage (current limiting) or shutting down the output (current-limiting shutdown). The current-limiting foldback scheme is best for starting up high-inrush loads. The duration of the inrush determines the size of the power source. The longer the inrush duration, the larger the power source should be sized. Improper sizing would result in the power supply remaining in current-limiting foldback. A short inrush of a few cycles simply results in a flattop waveform that recovers after the inrush has diminished. Also important to consider is whether the actual inrush current of the device is to be measured. In this case, the ac source should be sized for full peak inrush capability so the voltage waveform never reaches foldback. For example, consumer products such as refrigerators and dishwashers need a power source with high-inrush capability. All these products have motors and pumps. Since most of these products must also meet UL standards, only a few of them probably need to be tested for full inrush capability. The ac source should exhibit good line and load regulation characteristics.

3. For high crest factor loads, select an ac source with low impedance and high peak instantaneous current capability. Crest factor is defined as "the ratio of the peak current amplitude to the rms amplitude of an alternating-current or pulsating direct current waveform." Most of today's electronic equipment operates from a dc bus. This dc bus is derived from the ac line through rectifiers or switching supplies. Switch-mode power supplies or capacitive input filter and rectifier loads draw current 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 only provide a crest factor of 1.414 (the peak rms value). For high crest factor loads, 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.

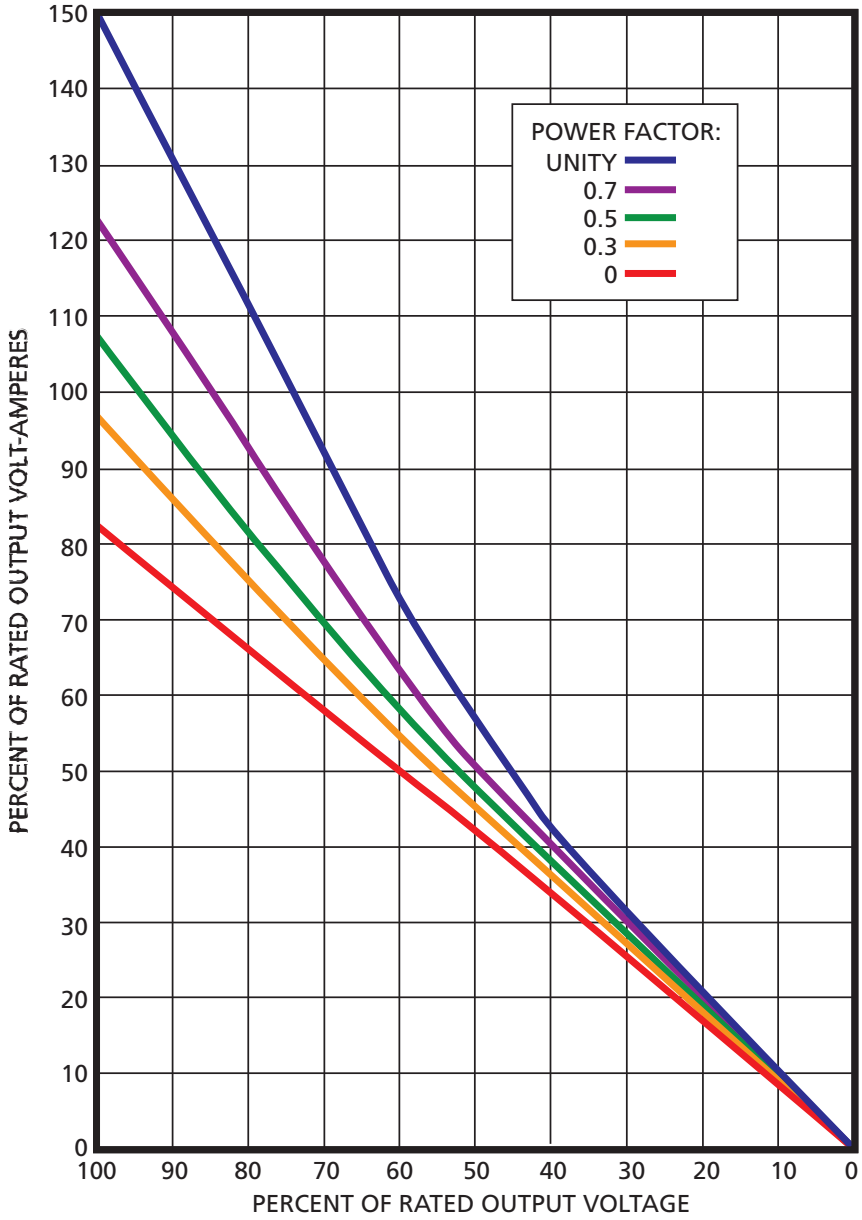
4. Consider the derating of the power source for power factor or variations in voltage in the overall size. Most linear ac sources tend to derate their power capability based on the power factor of the load. This is due both to the added reactive power being dissipated by the source and the current being drawn much closer to zero crossing of the voltage waveform. The graph shows typical derating for power factor and voltage variation in linear ac sources. Switching ac power sources on the other hand do not derate for power factor since they operate much more efficiently. The power devices operate much cooler and do

Primary applications for AC supplies

- Simple frequency conversion for 50, 60, and 400 Hz
- Real world power simulation, to produce sags, surges, and dropouts with voltage and frequency variation.
- Arbitrary waveform generation to replicate complex waveforms and distortion for application specific test.

not have to dissipate this reactive energy as in the linear source. Both switching and linear sources do, however, derate overall power with voltage adjustment. This should be taken into consideration for the worst-case low-voltage variation for a device under test.

5. Choose a source with a fast response time. Quality ac sources typically have response times of less than 50 us. This is how long it takes the source to respond to a change in voltage, frequency, or even a step load change. Fast response times are needed to simulate real world fluctuations in voltage sags, surges, dropouts, or spikes. Fast response time also helps in maintaining low impedance and tight regulation. Such a "stiff source" does not deviate from the desired value when switching from no load to full load. New switching technologies are now approaching linear performance. Typical of sources that incorporate such technologies is Elgar's Smart Wave SW5250. It incorporates arbitrary waveform generator capability and even ac and dc from the same supply, as well as low distortion, fast response time, and high efficiency. In properly sizing an ac supply, the designer should pay attention to detail as much as possible so an intelligent choice can be made the first time.



Most linear ac sources tend to derate their power capability based on the power factor of the load. A switch-mode ac source would not derate for power factor, so the source would stay on the unity for 0 to unity power factor load

Crest Factor Definition and Example

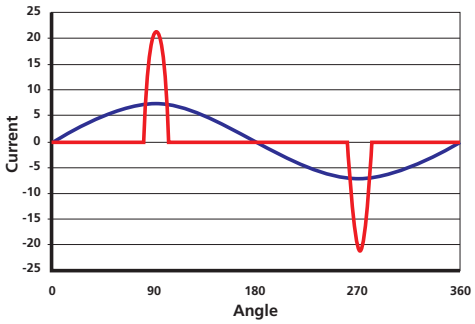
Technical Note

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:



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

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.

Notes

Single Phase Input on the SW and TW Series

Application Note

Single phase input power is possible for select models of the SW and TW Series. This article covers only single chassis SW series units and TW Series units equipped with the European PFC input. This type of input can be identified by the full model number as shown on the SW /TW series nameplate. A –4 in the first dash number indicates the unit is equipped with the European PFC input i.e. SW5250A-4-3-2 or TW5250-4. The European PFC input version of the SW/TW series allows a single phase voltage of 230VAC (nominal) to power the unit as well as the 230 L-N/400 L-L 3 phase commonly used overseas.

Don't let the name mislead you; this configuration can be used in the US as well. In many facilities, three phase 208V power may not be available. If this is the case, a 220-230 single phase or two phases from a 208 three phase system may be used to power a –4 input version. Figure 1 below shows a typical 208Vac 3 phase configuration.

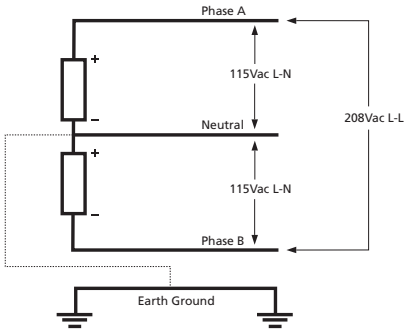


Figure 2

All of the Elgar field demo SW units are built to this configuration to allow the units to be used in the US or overseas. The SW/TW PFC option input voltage allows a wide range of 187-264VAC between the line and neutral terminations and will operate at 50,60, and 400Hz. As long as the voltage between the paralleled fuse inputs and the neutral clamp is within the 187-264VAC range, the system will operate. The common distribution for 230VAC in the US is a split phase created by a 230VAC transformer secondary with a grounded center tap. The neutral of the two lines from the secondary are grounded conductors (neutral).

CAUTION! **The Neutral lug in this case is actually 115VAC with respect to ground.**

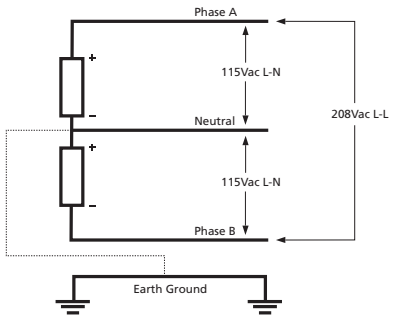


Figure 2

Figure 2 shows a typical split single phase configuration.

The warning listed in the SmartWave Operation Manual regarding the breaking of the neutral line to the unit does not apply in when wired as a single phase input.

CAUTION! **For safety reasons, you must break both poles to prevent a shock hazard at the input wiring terminations.**

Another means to get the required voltage for this configuration is to take two of the phases from a 208 3 phase system (See Figure 1) and attach one phase to the neutral and one phase to the parallel fuse bock inputs.

NOTE: The Neutral lug in this case is actually 115VAC with respect to ground.

The circuit breaker and wiring that feeds these single phase configurations will need to be rated at 40A per pole service for the units larger than 1850VA and 20A for the 1850VA and 1750VA models. See figure 3

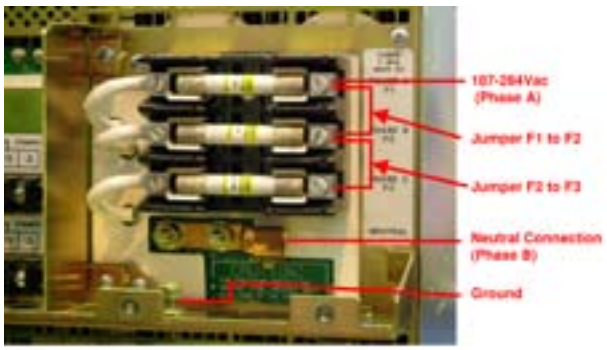


Figure 3

Notes

Elgar ContinuousWave Series

Pure Sinewave, Low Power AC Source

800–2500 VA

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 70 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	5.218 in.	5.218 in.	5.218 in.	5.218 in.	5.218 in.	5.218 in.
Width	16.9 in.	16.9 in.	16.9 in.	16.9 in.	16.9 in.	16.9 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		

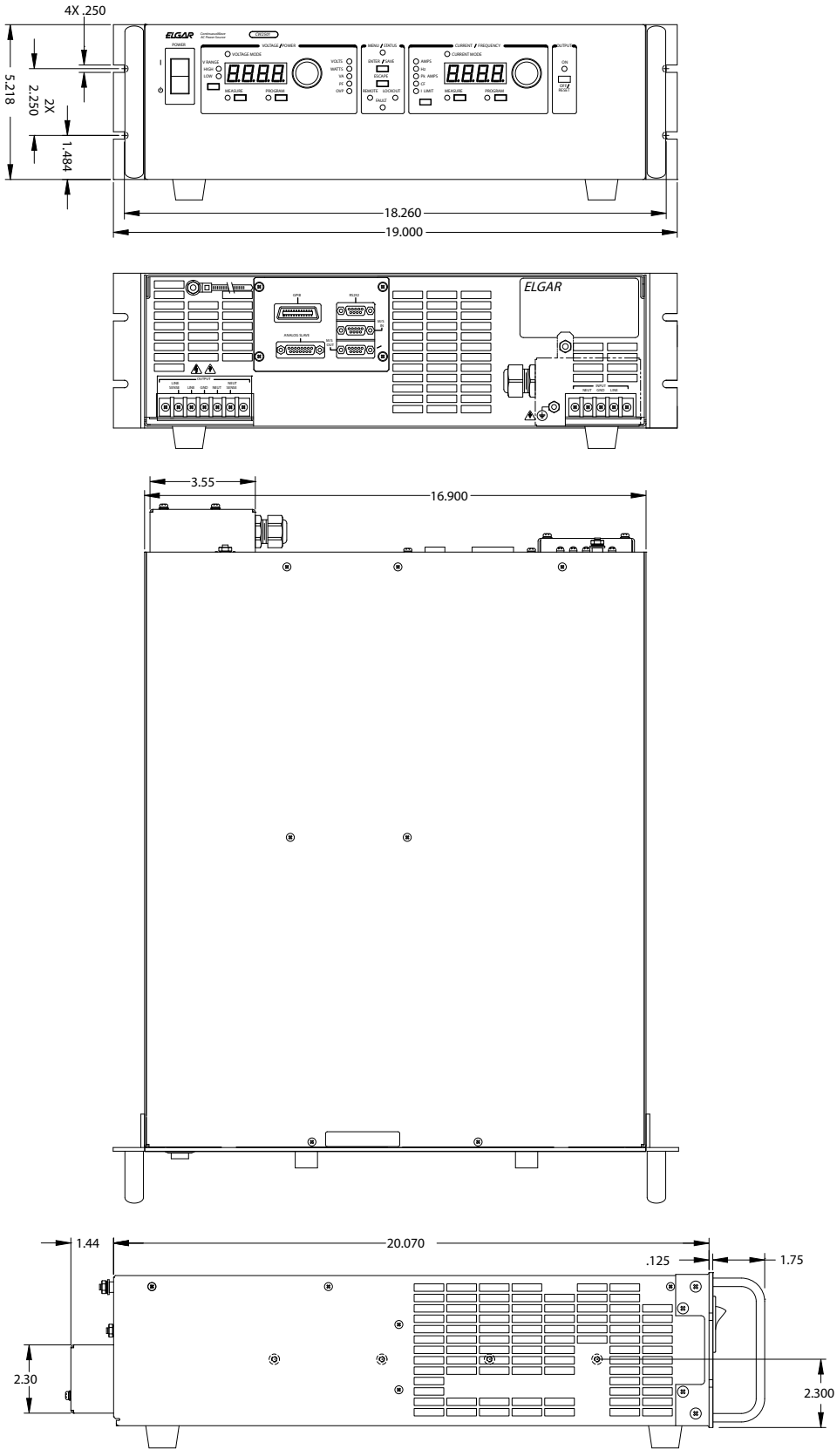
Measurements			
Model	CW 801 P	CW 1251 P	CW 2501 P
Power	800 VA	1250 VA	2500 VA
Power[3]			
Range	0 - 800 W	0 - 1250 W	0 - 2500 W
Accuracy	±2% of range for linear loads		
Resolution	1 W		
Apparent Power[3]			
Range	0 to 800 VA	0 to 1250 VA	0 to 2500 VA
Accuracy	±2% of range for linear loads		
Resolution	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*

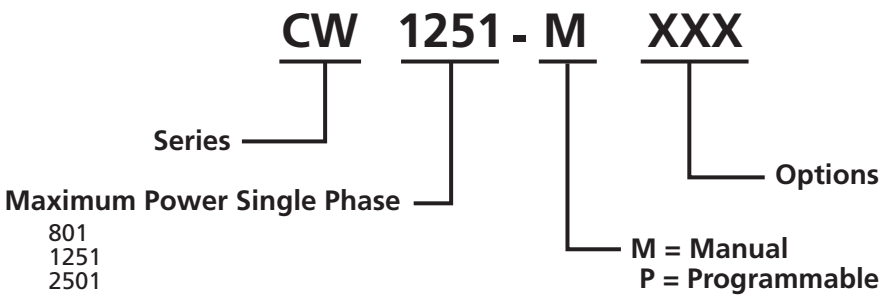
[3] *In a parallel system (for programmable units only), the current/power displayed on the master unit is the sum of all units in the system*

CW Series : Product Diagram



Dimensions are in inches

Model Number Description



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

Notes

Elgar SmartWave Series

High Performance AC/DC Power Source

1750–22200 VA

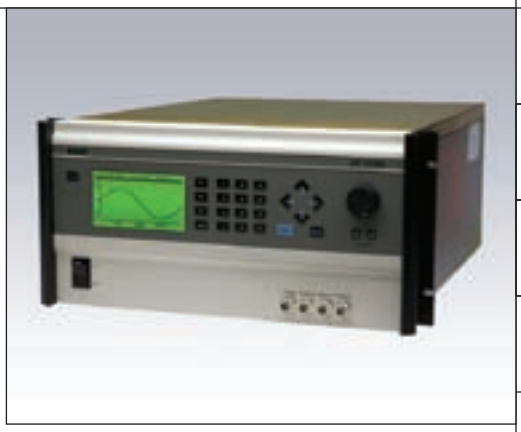
156–312 V

6.5–192 A

≋	208	230	400
∼			230

GPIB

- Arbitrary waveforms
- Compliance testing for Airbus, DO-160 and Boeing standards
- 2Hz to 6kHz standard output frequencies
- Crest factors up to 4
- Parallel up to 22.2KVA



The Elgar SmartWave™ (SW) Series of AC power sources offers powerful waveform creation for ATE and power line disturbance simulation testing. Three separate arbitrary waveform generators enable the SmartWave to create independent, complex waveforms on all three phases simultaneously. The SmartWave is designed to meet waveform requirements including DC content (up to 312V), low distortion (THD 0.25% to 100 Hz), low noise and ripple, plus full compliance testing to many EMC and avionics standards.

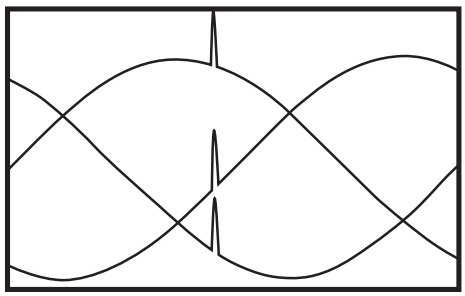
At only 8-3/4 inches high for the SW 5250A, the SmartWave delivers the most power in the smallest package. The SW Series is expandable from 1.75 kVA to 22.2 kVA. Unlike other AC power sources, the SmartWave delivers full rated power to 45ºC..

Features and Benefits

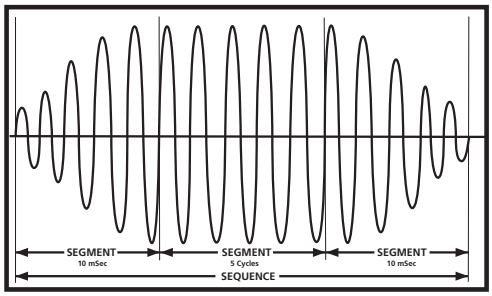
Powerful Waveshape and Waveform Creation The SmartWave can easily create fractional or multi-cycle dropouts, spikes, surges, sags and distorted waveforms from the front panel. To simulate these complex real-world power occurrences, the SmartWave comes with a library of 50 built-in waveshapes (see examples on page 74). Users can create and store an additional 50 waveshapes of their own design. Output voltages are created by adding amplitude, frequency and other parameters to the waveshapes. The user can also create over 50 custom front panel setups with all parameters included and store them for quick recall, making the SmartWave ideal for manual testing.

Sequence Programming

Complex sequence or event programming is easy with time or cycle based transient segments. The sequence library is made up of a total of 1000 segments. A sequence of up to 100 segments using up to 32 different waveshapes, arranged in any combination, can be run at any one time. The 32 waveshapes can be selected from the 50 factory supplied and 50 user created waveshapes. By setting the time or number of cycles for each segment, the user can create waveform sequences that allow automatic testing for most any standard.



True simulation of time coincident events on a 3 phase power line using 3 internal ARB Generators



Sequences can be constructed with segments defined by time or number of cycles.

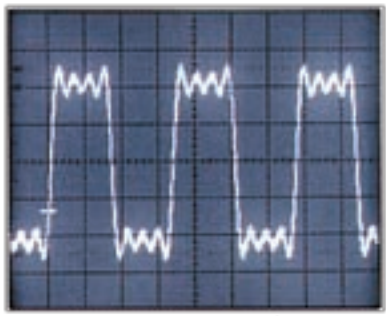
SW Series

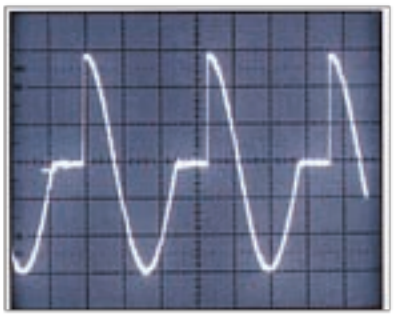
AC and/or DC
A direct coupled, transformerless design allows AC and DC on separate phases or on the same phase. The SmartWave can be used as a true DC power supply. High DC content waveforms (up to 312 volts) can be created with no derating of output power, even with 100% reactive loads, eliminating the need for a separate DC supply. Waveform Programming Software (Optional) Waveform programming is easily accomplished using the optional DSP PC software. The software allows freehand creation of waveforms, using a mouse or mathematical expressions. Waveforms can be uploaded and modified from a digital scope. The waveforms can then be downloaded to the SmartWave via GPIB and output to exactly simulate real-world conditions.

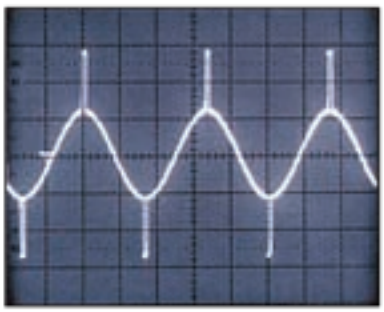
Flexibility in Power Ranges
The SmartWave series includes the SW 1750/1850 (single phase only), SW 3500/3700 (single or dual phase), and SW5550. The 5250A three phase unit can be switched to single phase or vice versa, simply by menu selection (and appropriate output wiring changes). The SW Series is factory upgradable from 1750 VA to 3500 VA or 5250 VA. Utilizing a master/slave arrangement, SW5250A can be paralleled for incrementally higher power requirements, e.g. one master/one slave= SW10500 (10.5 kVA). As many as 3 slave chassis may be paralleled with a master to form a 21 kVA system. Options include input power factor correction, measurement capability, plus 5 and 26 VAC auxiliary outputs.

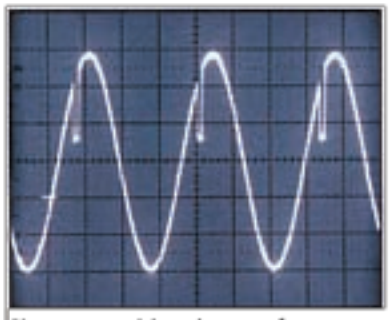
Waveshape Library
There are 50 factory-supplied waveshapes in the SmartWave. Following are examples of the types of waveshapes in the library:

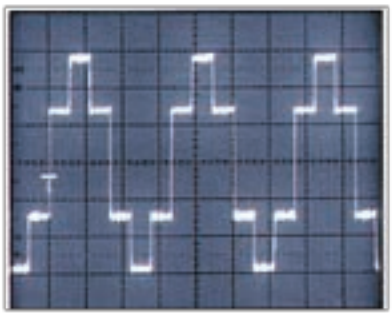
- Sine wave
- Square wave
- Triangle wave
- Clipped sine waves
- Sine waves with spikes
- Fractional dropouts
- Sine wave with dropout (0V from 0° to 90°)
- Sine waves with ±1-50% DC offset
- ±DC with 3% and 10% ripple
- Fourier square waves with harmonics
- Taylor series waves
- Sine wave with noise at zero crossing

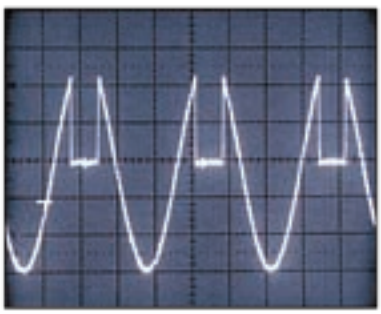

Fourier square wave with first, third, fifth and seventh harmonics.

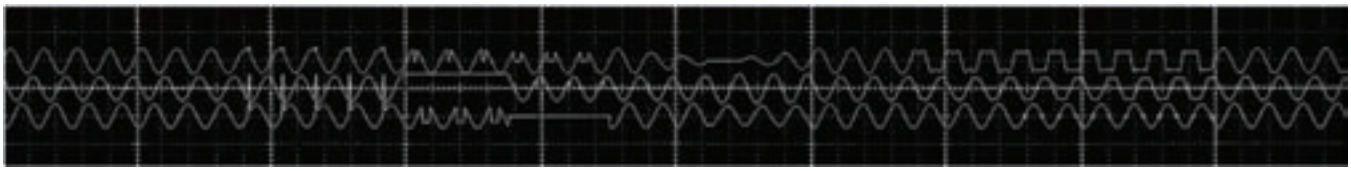

Sine wave with first quarter (0°-90°) at 0 volts (inrush).


Sine wave with spikes at 85°-95°.


Sine wave with a dropout from 45°-60°.


Six Voltage step sine wave.


Sine wave with the positive halfcycle clipped at 0V from 50°-130°.


As shown by this photo, the SmartWave can create time coincident spikes on 3 phases, fractional or multi-cycle dropouts, sags and surges, waveforms distortion, DC and noise.

APPLICATIONS

The SmartWave 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 and ABD100 avionics testing
- Power supply testing for AC-DC, DC-DC converters and UPS's
- Fluorescent lighting characteristics testing (IES LM-41-1985)
- Transients on 12 & 24 VDC for automotive applications

SMARTWAVE CONTROL SUITE (SWCS)

The SmartWave™ Control Suite is a complete Windows®-based graphical GPIB control software package for the Elgar SmartWave (SW) and SWAE product lines. It provides a simple, yet powerful, method to actively control the SW, create and edit waveforms and sequences, as well as log measurements to your PC. Comprised of six interactive windows (or tabs) SWCS provides the following SW control features:

Program Settings: Direct setting of most common parameters such as voltage, frequency, current limit, phase angle and waveform type.
Measurements: Provides a strip-chart like recording of up to four measurements. Results may be viewed and logged to a file.
Waveform: Allows creation and editing of waveforms using several powerful methods, including defining a waveform by harmonic content.
Sequence: Simplifies setup, debugging and running of waveform sequences.
Instrument: Provides setting and modifications to configuration changes such as voltage range, coupling and shutdown method.
System: Gives user access to less common features of the SW, as well as allowing direct GPIB command control.

System Requirements:

- Pentium II 500Hz or greater
- 256MB RAM
- 500GB available hard disk space
- Microsoft Windows 95/98/NT/W2K/XP
- National Instruments GPIB card or GPIB-ENET (GPIB to Ethernet converter box) or GPIB-PCMCIA

SW Series : Product Specifications

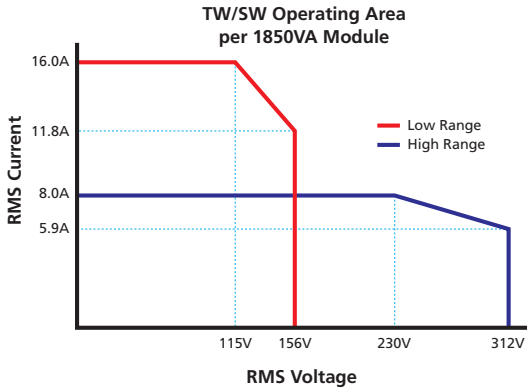
Common	
Standard Features	• 1ø to 3ø programmable • BNC outputs for scope viewing of waveforms (1 MΩLoad Drive)
Interface	IEEE-488.2 interface
Protocol	SCPI protocol
WaveForm trigger output	(1 MΩLoad Drive)
Sync OUT	User programmed for: Cycle start, all cycles. Segment start, all or selected segments. For loads ≥2 kΩ: V out ≤1V low state; V out ≥2.4V high state
Clock/lock	Clock - pulses at programmed frequency. For loads ≥2 kΩV out: ≤1V low state; V out ≥2.4V high state Lock - locks output to input 'TTL' frequency; signal needs to supply pull down current of 15 mA with voltage drop of ≤0.6V; no pull up needed
External Amplitude Modulation	0 to 5 Vrms provides 0 to ≥20% output amplitude modulation
External Drive	Normal amplifier, 0 to 5 Vrms (DC to 5 kHz) or ±5 VDC input for zero to full voltage output
External Gain Control	0 to ±7.07 VDC provides zero to full output
External Input Impedance	≥30 kΩ
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. 115 or 230 VAC single-phase is required for PDU in 10.5-21 kVA systems. (400 Hz input allowed with PFC option)
Power Factor	0.6 (.35 for Intl. Rectifier; 0.99 with PFC option) Note: With PFC option the inputs may be paralleled and wired for single phase input. Consult factory.
Frequency Range	47 to 63 Hz
Efficiency	70% min, at full load
Ride Through	3 ms min.; 10 ms min., with PFC option
Output	
Power	1750/1850 VA: 1ø, 3500/3700 VA: 1ø or 2ø, 5250/5550 VA: 1ø or 3ø (systems up to 22,200 VA)
AC or DC Output Voltage	0 to156 Vrms L-N, range 1; 0 to 312 Vrms L-N, range 2
Current Per Phase	13/16A to 135V in 156V range; 6.5/13A to 270V in 312V range per 1750/1850 VA module. Note: Higher currents may be achieved in 10.5-21 kVA systems.
Power Factor of Load	0 lagging to 0 leading
Crest Factor	4.0 (peak output current to rms output current))
Frequency Range	DC or 2Hz to 6 kHz. 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): ±0.025% 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 ±0.01%/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	0.05% of full scale
Frequency Accuracy	±0.01% at 25°C ±0.001%/°C
Frequency Resolution	40 Hz to 99.99 Hz: 0.01 Hz 100 Hz to 999.9 Hz: 0.05 Hz 1000 Hz to 5000 Hz: 0.5 Hz
Phase Accuracy, Phase-to-Phase Balanced Linear Resistive Load	±1°, 40 Hz to 1 kHz, plus ±1°/kHz above 1 kHz
Phase Angle Resolution	0.1°
Remote Output Voltage Sense	5 Vrms total lead drop, max

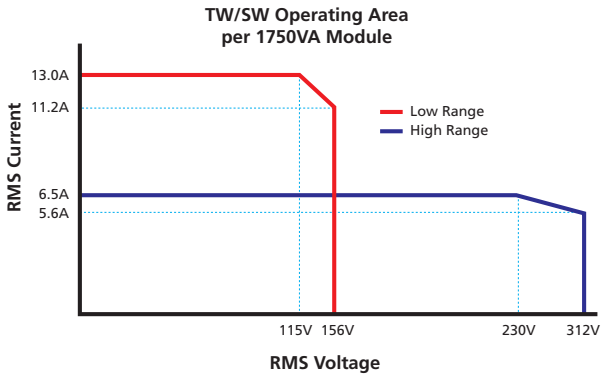
Environmental	
Operating Temperature	0°C to 45°C (32°F to 113°F)
Storage Temperature	-40°C to 70°C (-40°F to 158°F)
Cooling	Air is drawn in from the top, bottom, and sides and exhausted through the rear
Humidity (Non-condensing)	0 to 85% at 25°C (77°F); derate to 50% at 40°C (104°F)
Altitude	Operating 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	SW 1750A - 73 lbs (33.1 kg), SW 3500A - 100 lbs (45.4 kg), SW 5250A - 127 lbs (57.5 kg)
Shipping Weight - US	SW 1750A - 160 lbs (73 kg), SW 3500A - 180 lbs (82 kg), SW 5250A - 200 lbs (91 kg)
Note	Note: 10.5, 15.75 and 21 kVA systems, dimension and weight are approximately x2, x3 and x4 SW 5250A Specifications
Measurements (optional)	
Measurements	Phase to Neutral rms Output Voltages, Phase to Phase Voltages, 1ø to 3ø rms Output Currents, Peak Current, Output Frequency, 1ø to 3ø Power, 1ø to 3ø VA, Power Factor of 1ø or 3ø Loads, Output Phase Angles Relative to Phase A
Measurement Capability	4.5 Digit Analog to Digital Measurement System with .01% of full scale resolution unless otherwise noted.
Calibration Interval	12 months
Temperature Range for specified Accuracy	25°C to ±5°C unless otherwise noted
Phase to neutral rms voltage measurement	Valid for phases A, B and C (use phase A for Parallel Mode) • Range: 0V to 350V plus sign bit for DC range • Accuracy: ±0.3% of range, DC or 47 Hz to 1 kHz; ±0.5% of range, 40 to 47 Hz and for 1 kHz to 5 kHz
Phase to phase rms voltage	Calculated from Phase to Neutral voltages and phase angle • Range: 0V to 700V • Accuracy and Temperature Coefficient: The same as the Phase to Neutral voltage rms current measurement: Valid for phases A, B, and C (use phase A for Parallel Mode) • Range 1: 0A to 7.5A, plus sign bit for DC range; 3ø mode, 312V range • Range 2: 0A to 15A, plus sign bit for DC range; 3ø mode, 156V range • Range 3: 0A to 22.5A, plus sign bit for DC range; parallel mode, 312V range • Range 4: 0A to 45A plus sign bit for DC range; parallel mode, 156V range • Accuracy: ±1.0% of range, DC or 40 Hz to 500 Hz; add ±1.5%/kHz above 500 Hz of 4.0
Peak current measurement	Valid for phases A, B, and C (use phase A for Parallel Mode) • Range 1: 0A to 28A; 3ø mode, 312V range • Range 2: 0A to 56A; 3ø mode, 156V range • Range 3: 0A to 84A; parallel mode, 312V range • Range 4: 0A to 168A; parallel mode, 156V range • Accuracy: ±5% of range, 40 to 500 Hz; add ±1%/kHz, 500 Hz to 5 kHz
Power Measurement	Valid for phases A, B, and C. Up to 3ø total power and parallel mode (use phase A for Parallel Mode) • Range 1: 0 kW to 1.8 kW; 3ø mode • Range 2: 0 kW to 5.6 kW; parallel mode and total 3ø power • Accuracy: ±2.5% of range, DC or 40 to 500 Hz for crest factors <2.0. Add ±1% for crest factors up to 4.0. Add ±1%/kHz above 500 Hz
VA Measurement	Valid for phases A, B, and C. Up to 3ø total VA and parallel mode (use phase A for Parallel Mode) • Range 1: 0 kW to 1.8 kVA; 3ø mode • Range 2: 0 kW to 5.6 kVA; parallel mode and total 3ø power • Accuracy: ±2.5% of range, DC or 40 to 500 Hz for crest factors <2.0. Add ±1% for crest factors up to 4.0. Add ±1%/kHz above 500 Hz
Power Factor	Valid for phases A, B, and C (use phase A for Parallel Mode) The Power Factor is calculated from the Power and VA measurements • Range: 0 to 1.00 • Accuracy: ±5% of range at full power, DC or 40 to 500 Hz for crest factors <2.0. Add ±2% for crest factors up to 4.0. Add ±1%/kHz above 500 Hz
Frequency Measurement	Frequencies are calculated based on output zero crossing time measurements • Resolution: Frequency is displayed to 5 digits max; leading zeros are blanked. Displayed resolution is 0.01 Hz • Accuracy: ±0.5% of reading, at 10% to full output voltage, 0°C to 45°C
Phase Measurement	Valid for phases A, B, and C relative to each other • Resolution: ±1° • Accuracy: ±2°, 40 to 500 Hz; add ±2°/kHz above 500 Hz. For sine wave, balanced resistive load, 10% to 100% of voltage measurement range, 0°C to 45°C

SW Series : Product Specifications

Waveform Specifications	
Waveshape Libraries	50 factory supplied in ROM; storage available for up to 50 user created in nonvolatile RAM
Front Panel Setups	A total of 50 user created steady-state waveforms, with amplitude, frequency, phase angle and current limit parameters
Sequencing Library	1000 user created segments stored in non-volatile RAM. Segments include waveshape, amplitude, frequency, phase angle, time (from 1 ms to 1000 seconds), or number of cycles.
MIL-STD-704	Transient Library
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 1% of range (0.5A to 13A for 156V range; 0.5A to 6.5A for 312V range)
Programmable Current Limit with Timed Shutdown	Settable to 1% of range: the timeout is settable from 100 ms to 10s.
Programmable Constant Current	Settable to 1% of range (0.5A to 13A for 156V range; 0.5A to 6.5A for 312V range). For all current accuracies ±1% of fullscale, add ±1.5%/kHz above 500 Hz. For paralleled amplifiers, add ±1%
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

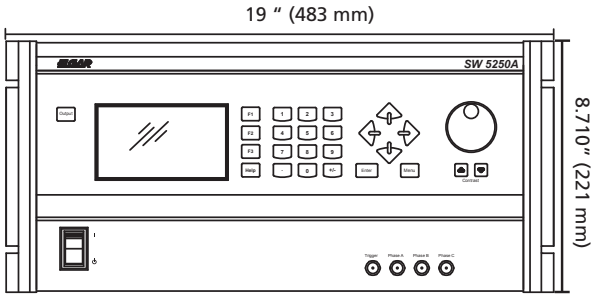
Operating Area



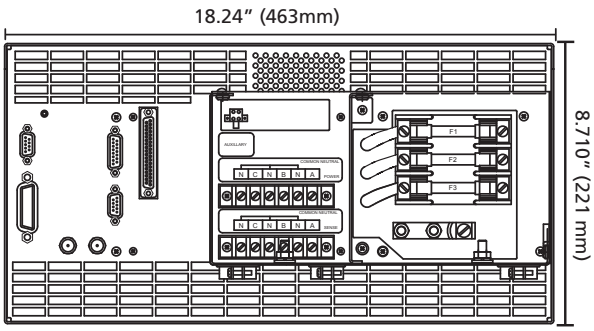


SW Series : Product Diagram

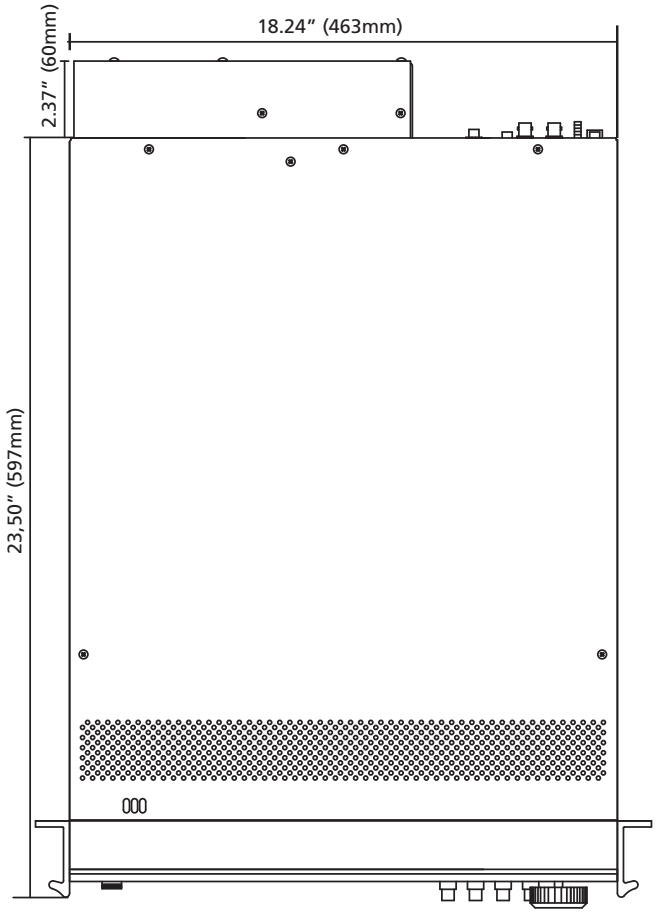
1750–22200 VA



Front View



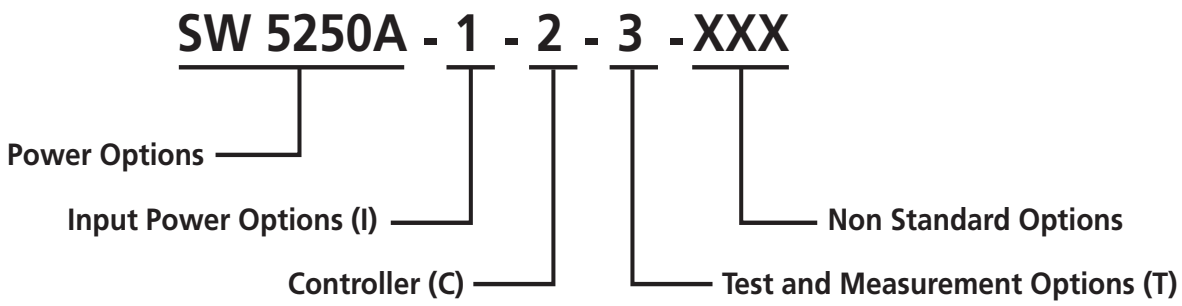
Rear View



Top View

SW Series

Model Number Description



Ordering Information

Model Number	Output Power Rating
SW 1750A	1750 VA
SW 1850A	1850 VA
SW 3500A	3500 VA
SW 3700A	3700 VA
SW 5250A	5250 VA
SW 5550A	5550 VA

Ordering Information

Model Number	Output Power Rating	5250 Master / Slave Configuration
SW 10500 / 11100	10.5 kVA / 11.1 kVA	1 master SW 5250 & 1 Slave SW 5250
SW 15750 / 16650	15.75 kVA / 16.65 kVA	1 master SW 5250 & 2 Slave SW 5250
SW 21000 / 22200	21 kVA / 22.2 kVA	1 master SW 5250 & 3 Slave SW 5250

Options

Input Power Options (I)	1: 1Rectifier 87-264VRMS (L-L), 3-wire 2: Rectifier International, 342-457 VRMS (L-L), 4-wire 3: Power factor corrected, 187-264 VRMS (L-L), 3-wire 4: Power factor corrected, 342-457 VRMS (L-L), 4-wire (option for single phase operation) 6: Power factor corrected with CE mark (SW 10500 and 15750 models only), 342-457 VRMS (L-L), 4-wire
Controller Options (C)	3: GPIB
Test and Measurement Options (T)	1: No Test and Measurement 2: Standard Test and Measurement
Non-Standard Options	102: Low Speed Fan 131: 2Hz-8kHz operation

Accessories

5161393-01	5V or 26V, or 0.25A auxiliary AC output
881-985-35	Waveform DSP II Software
A162000-01	Rackmount Kit (1 required for each 5250VA)
990-323-90	L Brackets (2 required for each 5250VA)
Certificate of Calibration	(models up to SW21000)

- Optimized for EMC directive testing
- Selectable output impedance for EN 61000-3-2 and EN 61000-3-3 testing (Single phase mode)
- Interharmonic waveform generator for EN 61000-4-13 testing
- Immunity tests include Ripple on DC input power port for portable electronic devices
- Low Impedance mode
- ARB Sequencing
- DC output

Product Overview

The European Union's EMC directive requires electronic and electrical products to be tested for immunity and emissions on AC public mains. The Elgar SmartWave AE models SW 1750AE, SW 3700AE and SW 5250AE, are an enhancement to the SmartWave Series designed to meet the strict requirements of EMC directives.

Harmonics & Flicker Testing

The SWAE is especially designed to meet the requirements for testing to EN 61000-3-2/3-3/4-13/4-14/4-17/4-28 and pre-compliance only for 4-11. This version provides selectable output impedance in addition to the many standard features of the SWseries. The SWAE also features an embedded interharmonics waveform generator.

The SWAE AC Power Source Series is designed to meet the strict requirements for equipment used in susceptibility and emissions testing. In addition to pure sine wave generation, the SW family of power sources can simulate a wide range of line conditions such as sub-cycle and multi-cycle dropouts, spikes, distorted waveforms, noise, phase shifts and voltage and frequency changes. The SW 1750AE, SW 3700AE and SW 5250AE also feature:

- Selectable output impedance for EN 61000-3-3 testing (single phase)
- Interharmonics waveform generator suitable for EN 61000-4-13 testing
- Immunity test, suites for EN 61000-4-11, 4-13, 4-14, 4-17, 4-28

Specifications

Refer to the SmartWave Series for general descriptions and specifications. The following specifications highlight the differences and enhanced modes of operation.

Low Impedance

Low Impedance Mode		
1750 VA 50 Hz 1 phase 312V range	3700 VA 50 Hz 1 phase 312V range	5250 VA 50 Hz 1 phase 312V range
<(0.07 + j0.05)Ω	<(0.05 + j0.04)Ω	<(0.03 + j0.03)Ω

Output

Voltage Accuracy: ±0.1% of range. 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, sense leads connected, no load. Temperature coefficient less than 50 ppm/°C

(Ref: EN 61000-3-3, Annex A and IEC 725

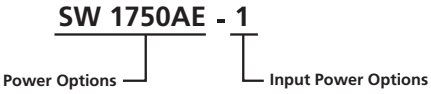
Standard Reference Impedance Mode: (0.40+j0.25)Ω±3% at 50 Hz

Output Frequency: DC or 40 to 500 Hz (SINE); 40-63 Hz (Complex WaveForms)

Interharmonic WaveForm Generator

Ref: EN 61000-4-13
Frequency Range: 15-3000 Hz
Frequency Accuracy: 0.5%
(of interharmonic signal)
Frequency Resolution:
15-60 Hz: 0.001 Hz
60-120 Hz: 0.002 Hz
120-240 Hz: 0.004 Hz
240-3000 Hz: 0.008 Hz
Voltage Range: 0-40.0 Vrms
Voltage Accuracy: ±0.23 Vrms
Voltage Resolution: 0.02 Vrms

SWAE : Model Number Description

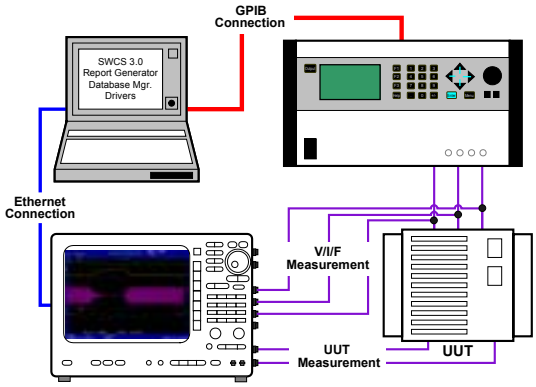


Notes

Elgar Aviation Compliance System (EACS) SW–EACS

Aviation Electrical Standards Test Solution

- Compliance testing for Airbus A380 and A400m as well as Boeing 787 standards
- Powerbus Simulation
- UUT Measurement
- Standardized Report



EACS System Diagram

The Elgar Aviation Compliance System (EACS) is a full test solution for testing of electrical and electronic components on aircraft. The system complies with requirements from Boeing and Airbus for power quality testing which generates power bus test stimulus/ anomalies, device under test (DUT) measurement (voltage, current, timing, digital I/O) and reporting in one easy-to-use package.

At the click of a few buttons, you can now fully test your avionics subsystem according to Airbus A380, Airbus A400M and Boeing 787 requirements. And, with the power of the SmartWave AC source and flexible system configuration, new tests are being added all the time. Please check our website for all available test standards.

At the heart of the system is the SmartWave AC source (SW). With three arbitrary waveform generators and 6kHz bandwidth, the SW is unparalleled in its ability to generate electrical waveforms required for compliance testing. The SW is controlled through the SmartWave Control Suite 3.0, the latest PC-based control software with add-on Test Suites designed to each standard. Measurement of voltage and current, at the input to the device under test, and other user defined parameters is accomplished with a digital oscilloscope-recorder. Report output is either in a general RTF format or Microsoft Word. The report template can be easily customized.

SWCS 3.0

SmartWave™ Control Suite (SWCS) version 3.0 puts the power of the SmartWave Series of AC power sources in your hands. Controlling a SmartWave™ has never been faster or easier!

- View actual waveforms in sequences, video playback for long sequences
- Easy sequence setup: insert, add steps, view steps
- Global sequence modifications
- Supports Applications Test suites and Elgar Avionics Compliance System

SWCS is a Windows-based software package for computer control of the SmartWave™ series of AC programmable power sources. With SWCS 3.0, you have complete control of the instrument including setup, programming, waveform and sequence creation. SWCS enhances the standard SmartWave features with an additional harmonic waveform analysis capability with data logging features for all measurements.

Version 3 has been designed from the ground up to allow more flexibility in waveform and sequence creation while reducing the program size. In addition, it supports all current and future application specific test suites and compliance systems, such as those required for testing to Airbus and Boeing specifications (see below). SWCS ships as standard with all SmartWave™ series of AC programmable power sources. The package includes basic sequences and waveforms for MIL-STD-704F and DO-160D

An upgrade is also available for existing customers.

Test Suites

Applications Test Suites provide an automatic method to generate standards-based stimulus waveforms through the SmartWave™ series of AC programmable power sources. These software packages save hundreds of hours of development time allowing users to simply select and execute either single tests or a sequence of tests compliant with the standard.

- Automated compliance test waveforms
- Save hundreds of hours in developing and verifying waveforms.
- Simulate AC or DC Buses or any combination

From SWCS 3.0, the user selects the required test specification. The Test Suite automatically lists the tests available for that specification. Once selected, the tests may be looped, single stepped, or multiple tests selected and run in a series. During execution, test status is

Elgar Aviation Compliance System (EACS)

displayed in three progress windows with total test time, individual or sequence time and progress within a test, or segment time. Test Selector also allows the user to easily build a test sequence from the library of compliance tests. Detailed descriptions of each test are provided for convenience as well as the capability of saving a test sequence for future recall. Individual tests can be easily modified and saved for margin testing.

Smartwave Control Suite sequence screen

Elgar Avionics Compliance System

EACS combines the SmartWave and SWCS with measurement and reporting to provide a full test solution. Data is collected through the use of a 16-bit, digital oscilloscope recorder. The EACS software automatically performs all setup of the oscilloscope and saves data to the local PC. The software allows full customization of the data collected and waveform captures, and pass/fail determination. For test which have hard limits according to the standard, these criteria are automatically applied for pass/fail. The data is then finalized in a report which is written according to the standard.

- Automatically generate test reports
- Save data for each test for later recall
- Approve each test result during report generation

Minimum System Requirements

- SWCS 3.0 or higher for Test Suites and Compliance Systems
- SmartWave™, ECDI rev. 5.05 or higher, DWSB rev. 2.4
- Computer with Pentium II 500MHz, 256MB, 500MB available on hard disk, CD-ROM, Windows XP/2000
- Internet Explorer 5.0 or higher
- National Instruments GPIB card and interface cable

Applications Test Suite Ordering Information

Part Number	Specification	Description
ABD100TSS-A	Airbus ABD100	Table A tests only (115VAC/400Hz)
ABD100TSS-B	Airbus ABD100	Table B tests only (26VAC/400Hz)
ABD100TSS-C	Airbus ABD100	Table C tests only (115VAC/variable freq)
ABD100TSS-DE	Airbus ABD100	Table D & E tests only (Conventional and NBPT dc)
AMD24T-SVF/SCF	Airbus AMD24	Table SVF/SCF only
AMD24T-TVF/TCF	Airbus AMD24	Table TVF/TCF only
AMD24T-LDC	Airbus AMD24	Table LDC only
AMD24T-FULL	Airbus AMD24	Tables SVF/SCF, TVF/TCF, LDC
B787PQ-1PH	Boeing 787	Single phase AC tests (115V and 235V)
B787PQ-3PH	Boeing 787	Three phase AC tests for 115V and 235V
B787PQ-28V	Boeing 787	Tests for 28V DC bus
B787PQ-270V	Boeing 787	Tests for 270V DC bus
B787PQ-FULL	Boeing 787	Single phase, 3 phase, 28VDC, 270VDC tests for Boeing 787
EN2282T-AC	BSI	AC tests for Characteristics of Aircraft Electrical Supplies
EN2282T-DC	BSI	AC tests for Characteristics of Aircraft Electrical Supplies
EN2282T-FULL	BSI	All tests for Characteristics of Aircraft Electrical Supplies

Elgar Avionics Compliance System Ordering Information

Part Number	Description
EACS-ABD100-1F EACS-ABD100-1F-EU	ABD100TSS-ABCDE, SWCS 3, 6 Channel Yokogawa ScopeCorder, Report generator/storage utility/drivers
EACS-ABD100-3F EACS-ABD100-3F-EU	ABD100TSS-ABCDE, SWCS 3, 10 Channel Yokogawa Scope-Corder, Report generator/storage utility/drivers
EACS-ABD100-S EACS-ABD100-S-EU	ABD100TSS-ABCDE, SWCS 3, Report generator/storage utility/drivers
EACS-AMD24-1F EACS-AMD24-1F-EU	AMD24-FULL, SWCS 3, 6 Channel Yokogawa ScopeCorder, Report generator/storage utility/drivers
EACS-AMD24-3F EACS-AMD24-3F-EU	AMD24-FULL, SWCS 3, 10 Channel Yokogawa ScopeCorder, Report generator/storage utility/drivers
EACS-AMD24-S EACS-AMD24-S-EU	AMD24-FULL, SWCS 3, Report generator/storage utility/drivers
EACS-B787-1F EACS-B787-1F-EU	B787PQ-FULL, SWCS 3, 6 Channel Yokogawa ScopeCorder, Report generator/storage utility/drivers
EACS-B787-3F	B787PQ-FULL, SWCS 3, 10 Channel Yokogawa ScopeCorder, Report generator/storage utility/drivers
EACS-B787-S	B787PQ-FULL, SWCS 3, Report generator/storage utility/drivers

SmartWave Control Suite 3.0 Ordering Information

Part Number	Description
SWCS3.0	SmartWave Control Suite 3.0 included with purchase of a SmartWave AC power source.
SWCS-UPG	Upgrade from a previous version of SWCS to current version.

Elgar TrueWave Series

1750–22200 VA

Avionics and Commercial Applications

156–312 V

6.5–192 A

- IEC Flicker Test Capable
- Field Parallel Configurable
- 3 phase output from a single unit
- Low Harmonic Distortion
- DC Output

≋	208	230	400
∼			230

GPIB RS232

The Elgar TrueWave (TW) is designed for testing today's complex electronics, including avionics and commercial applications requiring DC and sine wave testing. The TW is ideal for testing electronic equipment for compliance to new European Standards such as harmonics.

Measurement that can be made:

- Peak Inrush Current
- Phase to Neutral rms Output Voltages
- Phase to Phase rms Output Voltages
- rms Output Currents
- Peak Current
- Output Frequency
- 1ø to 3ø Power
- 1ø to 3ø VA
- 1ø to 3ø VA
- Output Phase Angles Relative to Phase A

Other applications include:

- Test environments that require field configurable parallel operation
- Testing for real world DC single or polyphase AC power conditions
- Automatic Test Equipment
- General AC and DC Avionics Testing
- Power Supply testing for AC-DC, DC-DC converters and UPS's
- Testing to European Standards including EN 61000-3-2
- AC Ballast testing (IES LM-41-1985)
- Field configurable parallel operation up to 8 units

TW Series : Product Specifications

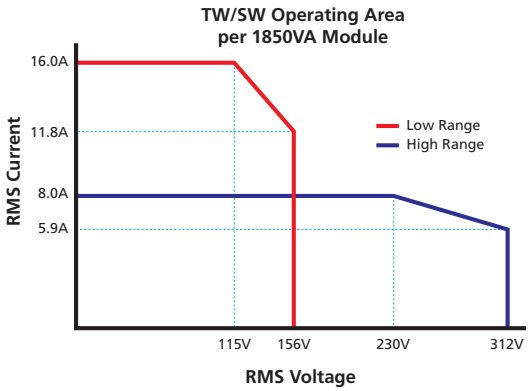
Common	
Standard Features	1ø to 3ø programmable (TW 5250 only) WaveForm trigger output (1 M Load Drive) SYNC OUT
Programmed Settings	The Sync out selections are: Even Cycle A phase (on) None (off) When change in programmed parameters occur (event) External Summing Node 0 to 5 Vrms provides 0 to 100% output
Interface	IEEE-488.2 interface and RS-232
Protocol	SCPI protocol
Certifications	CE marked and FCC compliant
Calibration Interval	1 year
Input	
Voltage Ranges	Factory configured 187 to 264 Vrms, 3ø L-L (3 wire). A chassis ground is also required.
Power Factor	0.6 (0.99 with input PFC option, 0.35 for European rectifier input)
Frequency Range	47 to 63 Hz
Efficiency	70% min, at full load
Ride Through	3 ms, min for rectifier input; 10 ms, min, with PFC option
Output	
Power	1750 VA, 3500 VA or 5250 VA
Phase	1750 VA, 1 phase; 3500 VA, 1 or 2 phase; 5250 VA, 1, 2 or 3 phase
AC Output Voltage	0 to 156 Vrms L-N low range 0 to 312 Vrms L-N high range
DC Output Voltage	0 to 207V low range 0 to 414V high range
Current Per Phase	13A to 135V in 156V range; 6.5A to 270V in 312V range (per 1750 VA module); 16A to 115V in low range; 8A to 230V in high range (per 1850Va module)
Power Factor of Load	0 lagging to 0 leading
Crest Factor	4.0 (peak output current to rms output current)
Frequency Range	45 Hz to 500 Hz
Max Total Harmonic Distortion	0.3% max (Full Linear Load or No Load)
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	0.05% of full scale for a ± 10% change in line voltages
Load Regulation	0.15% of full scale
Voltage Accuracy	± 0.1% of full scale
Voltage Resolution	0.03% of full scale
Frequency Resolution	0.1 Hz
Phase Accuracy	Phase-to-Phase Balanced Linear Resistive Load: ±1°
Phase Angle Resolution	0.1°
Remote Output Voltage Sense	5 Vrms total lead drop, max

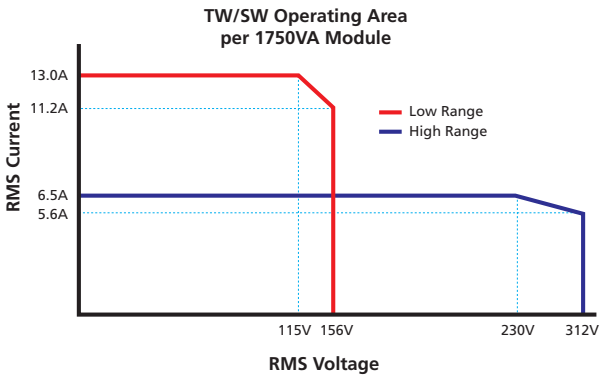
TW Series : Product Specifications

1750–22200 VA

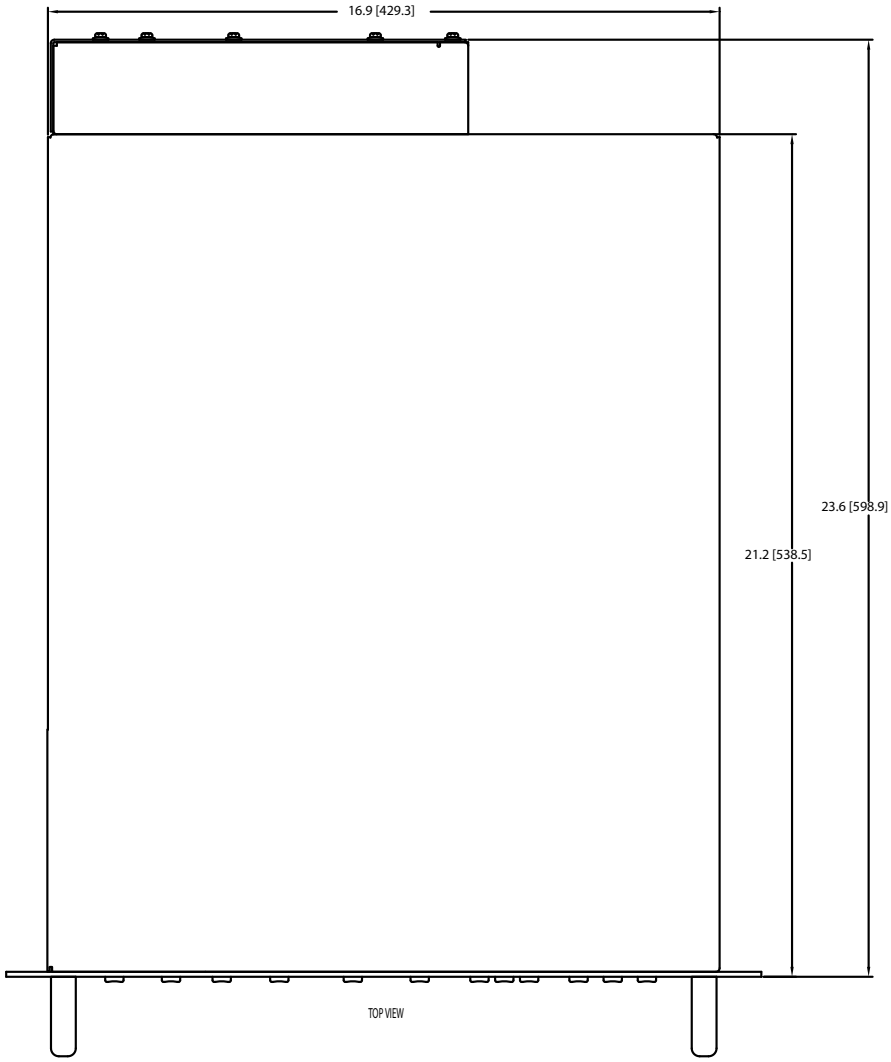
Environmental	
Operating Temperature	0°C to 45°C (32°F to 113°F)
Storage Temperature	-40°C to 70°C (-40°F to 158°F)
Cooling	Air is drawn in primarily from the front, but also from the top, bottom, and sides and exhausted through the rear.
Humidity (Non-condensing)	0 to 85%, 31°C (88°F); derate to 50% at 40°C (104°F)
Altitude	Operating 6,500 ft. Non-operating 40,000 ft
Physical	
Dimensions	Width: 19" (483 mm) Height: 8.75" (222 mm) Depth: 24.1" (613 mm)
Weight	TW 1750 - 60 lbs. (27.3 kg), TW 3500 - 83 lbs. (37.7 kg), TW 5250 - 108 lbs. (49 kg)
Shipping Weight - US	TW 1750 - 130 lbs. (59 kg), TW 3500 -153 lbs. (69.5 kg), TW 5250 - 178 lbs. (80.9 kg)
Measurement Accuracy All at 25° ± 5°C	
Power	2.5% of full scale
Voltage	0.3% of full scale + 0.2% of reading
Shipping Weight	12.7 lbs. (5.8 kg)
Current	0.3% of full scale + 0.5% of reading
Apparent Power	2.5% for output > 200 VA
Frequency	0.25%
Phase	0.5°
Protection And Safety	
Overvoltage Shutdown	Programmable for 20V to 255V peak, 156V range; 40V to 510V peak, 312V range
Programmable Current Limit Shutdown	Settable to 1% of range (0.5A to 13A for 156V range; 0.5A to 6.5A for 312V range)
Programmable Current Limit with Timed Shutdown	Settable to 1% for range; the timeout is settable from 10 ms to 10s
Programmable Constant Current	Settable to 1% of range (0.5A to 13A for 156V range; 0.5A to 6.5A for 312V range). For all current accuracies, add ± 1.5%/ kHz above 500 Hz. For paralleled amplifiers, add ± 1%.
Over temperature Shutdown	Automatic, not programmable

Operating Area

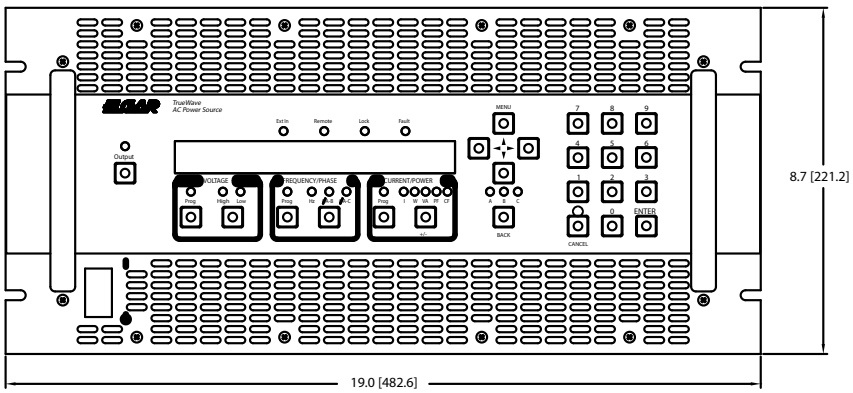




TW Series : Product Diagram

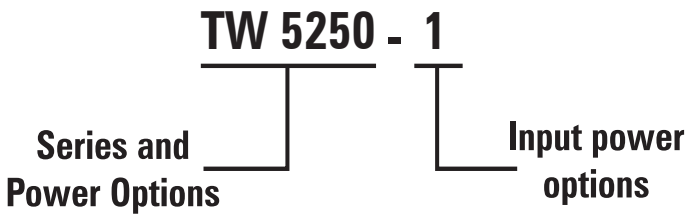


TOP VIEW



FRONT VIEW

Model Number Description



Options and Accessories

-1	187-264 Vrms (L-L), 3-wire
-2	342-457 Vrms (L-L), 4-wire
-3	PFC 187-264 Vrms (L-L), 3-wire
-4	PFC 342-457 Vrms (L-L), 4-wire
5161608-01	Paralleling Kit (1 required for each additional TW in parallel)
A162000-01	Rackmount Kit
990-323-90	L Brackets (2 Required)
Certificate of Calibration	

Ordering Information

Model Number	Output Power Rating
TW 1750	1750 VA
TW 1850	1850 VA
TW 3500	3500 VA
TW 5250	5250 VA
TW 5550	5550 VA

Notes

DMAC II

High Power AC Source / Frequency Converter

30kVA–480kVA

120–480 V

50–4000 A

- Low THD
- Flexible Modular Power Architecture
- Custom Voltage Outputs
- High Current Capability
- 150% Inrush Current Loading

The DMAC II sets a new standard of performance for power systems 12 kVA and greater. Utilizing the latest in amplification technology, the DMAC II achieves improved performance, smaller size, and modular construction, all at a lower cost per VA. Whether designing a new avionics ATE system, or replacing an older motor generator, the DMAC II offers the best choice for today's demanding requirements.

DMAC II converters use less commercial power and generate less heat, resulting in significant savings in operating costs.

Features And Benefits

30 To 480 KVA Power Rating
The DMAC II Series offers an extremely wide range of both single and three phase systems.

Modular Construction
All systems are assembled from the same basic 10 kVA plug-in modules, regardless of power level. Modular, interchangeable components provide low MTTR and facilitate upgrades and changing needs.

Effective Line Conditioning
The DMAC II Series eliminates the need for added equipment to achieve a stable, low distortion, constant voltage and frequency output. Because of the DMAC II's efficiency, quiet operation and low cost, motor generators can effectively be replaced.

Automated Or Manual Control
All models are available with manual and/or optional programmable control of all functions.

Precision Performance
DMAC IIs feature the output purity standard of a linear supply of 0.5% THD into a linear load, while providing all the benefits of switching amplification.

Soft Start
This feature protects input service from disturbances while enhancing reliability.

PFC & Low Input Current Distortion
Zig-Zag multi phase input rectification ensures under 5% THD and a reflected power factor greater than 0.98.

Wide Frequency Range
45 to 500 Hz is standard; lower or higher frequencies are optional.

Applications
Elgar's DMAC II power systems are ideal for facilities power because they feature line-drop compensation to overcome distribution losses.

DMAC II : Product Specifications

Output	
Configuration	120/208 VAC, 3 phase, 5 wire WYE. Output is fully isolated from chassis and ground; neutral may be grounded.
Voltage Range	0 to 132 VAC L-N/0 to 228 VAC L-L adjustment is via 10 turn pot and a 10% trim for phases B & C (other output configurations available, see chart).
Line Regulation	±0.1% for ±10% input voltage change
Load Regulation	±0.5% for 0-100% load changes. Regulation may be adjusted to "0.0" for known load conditions.
Output Frequency	Switch selectable, fixed frequencies of 50, 60 and 400 Hz, (variable 45-500 Hz). If operated from optional external signal source or programmable interface, full power frequency range = 10 Hz to 1 kHz
Frequency Accuracy	±0.1%
Output Power	30-480 kVA, full performance, 0.8 lead or lag. Performance degrades slightly for more extreme power factor but is unconditionally stable into any load P.F.
Overload Current	Up to 150%, (250% on 18 kVA models) of rated output current for 10 seconds, at which time the output will be gated off and require a manual restart
Repetitive Peak Current	30 kVA and above 2.9 to 1 on 12 kVA and 18 kVA models (4.8 to 1 peak to RMS ratio) available at the crest of the sine wave for driving non-linear type loads. Total kVA cannot exceed nominal rating on 12 kVA and 18 kVA models.
Output Voltage Distortion	0.75% max for linear loads, 47 to 100 Hz 1% up to 400 Hz
Response Time	Corrects for 100% load change in < 150 ms
Load Imbalance	Maintains performance with 100% load imbalance
Isolation	Output fully isolated from input. Output neutral may be grounded
Input	
Input Voltage	A muli-tapped input transformer allows a system to be quickly connected for any of the popular 3 phase forms.
Voltage tolerance	for all ranges is ± 10% 208 VAC 3 Phase Wye* 240 VAC 3 Phase Delta 460 VAC 3 Phase Delta 480 VAC 3 Phase Wye**
Frequency	47 to 63 Hz (400 Hz inputs available as option)
Power Factor Correction	Input power factor greater than 0.98 regardless of output load power factor or current waveform
Input Current Distortion	Less than 5% THD
Input Service Requirements	125% of system rating
Efficiency	90% at full load, over 92% at 75% load. Idle losses = less than 1.5 kW on a 30 KVA system
Monitors And Controls	
Output Voltmeter (true RMS)	3 1/2 digit meter with 6 position selector switch. Selects each phase to phase and phase to neutral. Accuracy = 2% of full scale
Output Current Meter (true RMS)	3 1/2 digit meter with 3 position phase select switch. Accuracy = 3% of full scale
Output Frequency Meter	Digital meter with decimal point. Accuracy = ±0.1% of full scale
Amplitude Control	Master control varies all phases; a balance adjust is provided for B & C phases, each having a 10% range.
Oscillator Mode Select	Rotary switch, selects 50 Hz, 60 Hz, 400 Hz, variable frequency and program output.
Variable Frequency Control	High resolution 10 turn pot, varies frequently from 45 to 500 Hz
Environmental	
Temperature Range	0 to 45 degrees centigrade
Humidity	0 to 95% non-condensing
Audible Noise	at 3 meters at full load, < 60 dBA at half load, < 50 dBA

*Not on 120 kVA and above

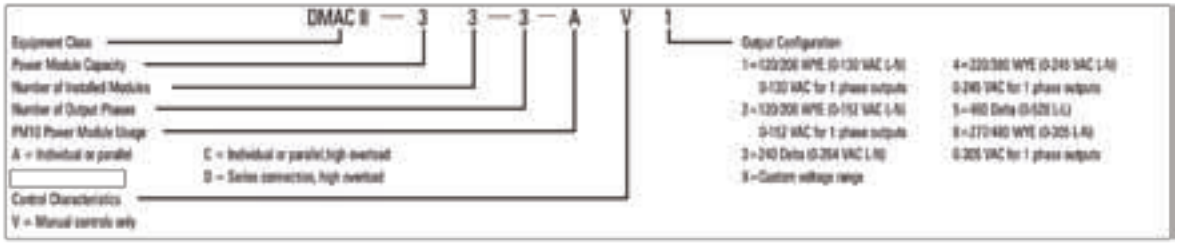
**380, 400 & 416 Wye (standard)

DMAC II : Product Specifications

30kVA–480kVA

DMAC II Standard Models

Model	Output		Size in Inches	Weight Lbs	Model	Output		Size in Inches	Weight Lbs
	kVA	Phases	H x W x D			kVA	Phases	H x W x D	
32-1-C	12	1	48 x 27 x 36	725	99-3	90	3	72 x 27 x 36	1600
33-1-C	18	1	48 x 27 x 36	750	1212-3	120	3	72 x 27 x 36	2000
33-3-C	18	3	48 x 27 x 36	750	2418-3	180	3	72 x 54 x 36	3680
33-1	30	1	48 x 27 x 36	810	2424-3	240	3	72 x 54 x 36	4800
33-3	30	3	48 x 27 x 36	810	3636-3	360	3	72 x 108 x 36	7200
66-3	60	3	72 x 27 x 36	1250	4848-3	480	3	72 x 135 x 36	9800



Notes

Elgar GUPS Series

Ruggedized Uninterruptible Power Supply

2400 VA

115/230 VAC

20.8 ARMS

~		115	230

RS232

- Ruggedized
- Wide (Global) Input
- DC 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/DC 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 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, DC 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.

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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 and DC 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 F3 rms current	
Efficiency	70% from AC input, 65% from DC input (GUPS 2400AD only)	
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. For GUPS 2400AD, when operating from DC input, overload capability is limited by 220A DC input current limit.	
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).	
Weight GUPS 2400AD	Main chassis is 95 lbs; battery chassis 116 lbs, total weight 211 lbs.	
Dimensions	7”H x 1 9”W x 21 ”L (GUPS 2400AD two chassis)	
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/DC Electronic Loads

Notes

DC Electronic Load Selection

Article

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.

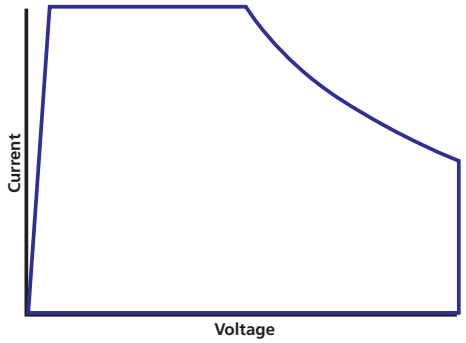

Fig. 1. Electronic load operating power curve

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.

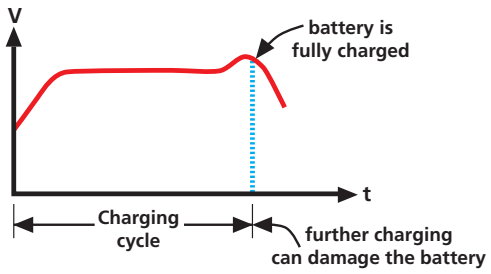

Fig. 2. Battery charging profile. An electronic load can test points along the curve to quickly verify proper operation of a battery charger.

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

Sorensen SL Series

DC and AC/DC Electronic Loads

75 W–14.4 kW

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)

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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.

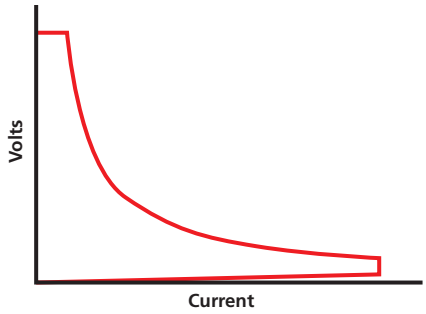
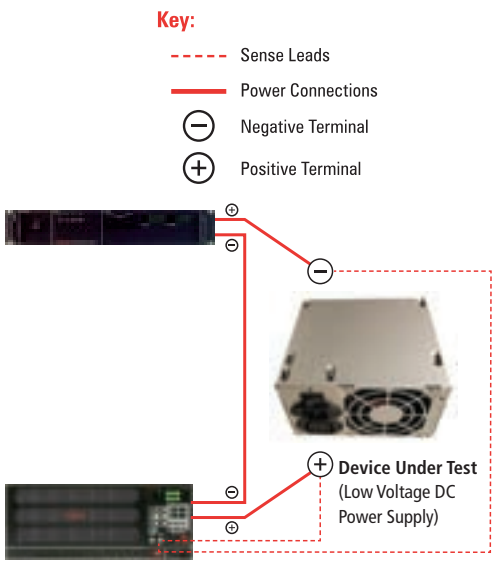


Figure 1 - Power Curve

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.



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

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

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:	32°F to 122°F, 100% load (0°C to 50°C)
Frequency:	-4°F to 158°F (–20° C to 70°C)
Power Consumption	30–90% RH (no condensation)
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

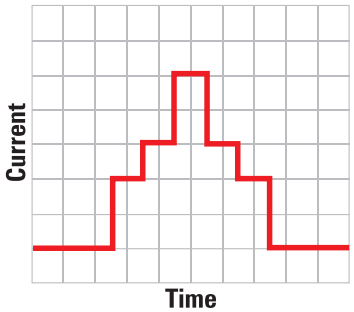


Fig.2 - Sequencer for Modules

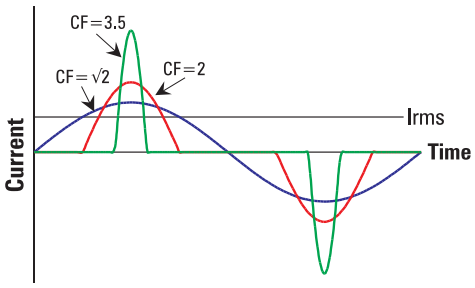


Fig.3 - Crest Factor for AC models

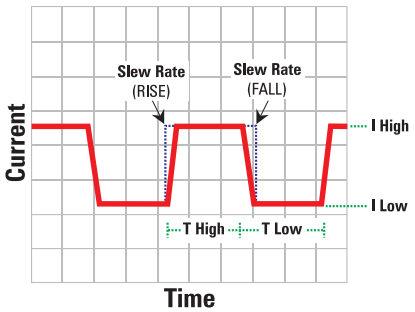
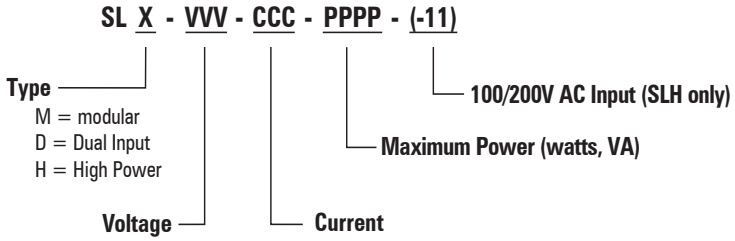
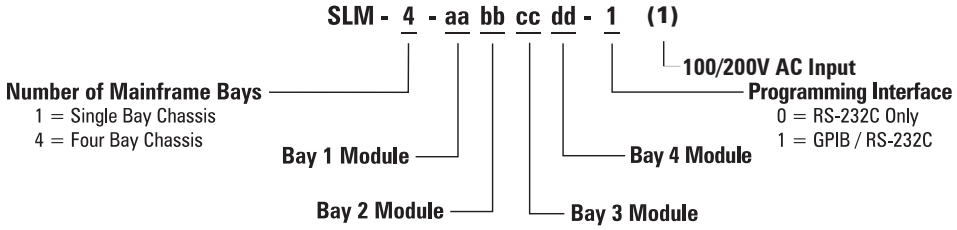


Fig.4 - Dynamic Mode for DC models



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 & 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

AC/DC Modular Power Supplies

Notes

ReFlex Power™ Series

Modular Programmable AC/DC/Loads Power System

- Truly Modular Design
- 100% Digital System
- 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, providing very high data rates and a high degree of deterministic control. 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 UUT 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
- 450V, 2.3A

Triple slot, 875 VA, single phase, programmable AC supply
- Dual range: 280Vrms, 3.5Arms
- Dual Range: 140Vrms, 7Arms

Triple slot, 500V, programmable electronic DC loads
- 15A, 375 Watt
- 30A, 750 Watt

AMETEK
Programmable Power
9250 Brown Deer Road
San Diego, CA 92121-2267
USA

AMETEK® PROGRAMMABLE POWER

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 hardware can be tested or certified.

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 or subtract AC and load modules and parallel and phase-lock modules. This allows RFP to support all your current and future laboratory needs.

Key Features

- Modular
- Control up to 95 assets
- Control multiple AC and DC power supplies and loads in one mainframe
- Create "virtual assets" on the fly
- User configurable
- Highest Power Density
- Simple integration
- PFC
- Universal AC/DC input
- Up to 6kW in one mainframe
- PFC ≥0.95
- Reduced space and supply chain hassles
- Ease of integration
  - ° Trigger bus
  - ° DFI and remote inhibit

ReFlex Power™ DC Power Modules

330 W / 1000 W

High Density Programmable DC Power Modules

16–450 V

2.3–30 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 DC power supplies of the ReFlex Power™ (RFP™) system include models rated at 330W and 1kW. 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.

Safety, ease of integration and functionality are significantly enhanced by a variety of hardware interface lines. Available at the front panel of each module via a DB-9 connector, these include Direct Fault Interrupt (DFI), Remote Inhibit (RI) and Trigger IN / Trigger OUT signals.

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.

The RFP™ system of DC power supplies brings true modularity to DC power assets, and makes possible a high degree of reconfigurability and adaptability through a mainframe-based architecture. It extends the modular configuration to include high power 1kW DC assets, without compromising performance or the controls feature set. The mechanical design is ruggedized for harsh environments, including mobile applications, as well as general-purpose industrial and laboratory rack-mount ATE.

The thermal design features integral, variable speed fans so the cooling performance scales with the complement of modules in the Mainframe and their output loading. This feature, along with a "module sleep" feature minimizes audible noise.

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 (1kW) for 10% line or 100% load change
Transient, Voltage Mode	Less than 1% of full-scale excursion returning to steady state within 500 micro-sec for 10% line change
Current Mode	0.05% of fullscale (330W) and 0.1% of full-scale (1kW) for 10% line change
Current Mode	Less than 0.1% of full-scale for 100% load change
Remote Sense	Up to 3V load line drop. The drop in the load leads subtracts from the maximum voltage available for the load.
Parallel	Up to six like modules.
Series	Up to five like modules. Float not to exceed 200V (16V, 33V), 300V (65V). 450V (450V).
Sag/Surge/Hold Up	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.
Remote programming connector	9-pin D-sub
Output connector	Combination signal/power contact subminiature D (Output cables and Mating Connector kits available)
Trigger Latency	5 micro-seconds

Output Voltage	0-16V	0-65V	0-33V	0-450V
Maximum Output Current	20.6A	5.1A	30A	2.3A
Maximum Power	330W	330W	1000W	1000W
Mainframe Slots	1	1	2	2
Ripple / Noise				
RMS (20 Hz - 300 kHz)	5mV	6mV	15mV	40mV
Peak-Peak (20 Hz - 20 kHz)	25mV	18mV	60mV	200mV
Programming Accuracy				
Voltage 0.05%+ of setpoint	8mV	32.5mV	16.5mV	225mV
Current	20mA	5.1mA	30mA	2.3mA
Resolution	0.47 mv/1.28 mA	1.9 mA/0.32 mA	2 mV/1.9 mA	28 mV/0.14 mA
Temperature Coefficient				
Voltage /°C	1.6mV	6.5mV	3.3mV	45mV
Current /°C	5mA	1mA	7.5mA	0.6mA
Output rise/fall time	20msec	20msec	20msec	20msec

All specifications are subject to change

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, and in multi-phase groups to extend their voltage, current, and power rating.

Safety, ease of integration and functionality are significantly enhanced by a variety of hardware interface lines. Available at the front panel of each module via a DB-9 connector, is Remote Inhibit (RI).

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.

The RFP AC Power module provides a very robust output, with surge rating of 140% (7A to 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.

The thermal design features integral, variable-speed fans so that the cooling performance scales with the complement of modules in the Mainframe, and their output loading. This feature, along with a "module sleep" feature, minimizes audible noise and airflow requirements.

ReFlex Power™ AC Power Modules : Specifications

AC Modules General Specifications	
Voltage / Current	140V Range 7A, not to exceed 875 VA, 10A maximum up to 125VAC, derated linearly to 8.93A at 140VAC, for 0.5 Seconds
Voltage / Current	280V Range 3.5A, not to exceed 875 VA, 5A maximum to 250VAC, derated linearly to 4.46 at 280VAC, for 0.5 Seconds
Frequency	45-1200 Hz, up to 5 kHz optional
Crest Factor	4.8 X FS rms current
RMS Regulation	100% Resistive Load effect or 10% line change from nominal Voltage Mode 0.1% of FS
Programming Accuracy	Voltage +/-(0.1% + .02%/kHz) of FS from 0.25% to 102% of range Current +/-(0.5% + 0.75%/kHz) of FS 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 FS per °C Current .05% of FS per °C
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
Power Factor	0.95 typical
Hold-up time	Dropout of AC input to zero for 10ms at full output power
Remote Sense	0.75Vrms per line Input
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
Cooling	Forced air convection, req. 40CFM airflow at altitude and ambient temperature
Parallel	Up to 6. Must be adjacent.
Multi phase	Up to 6 Delta and wye loads are supported. Modules must be configured as wye sources (neutrals connected).
Phase Programming Range	0-360 degree; B-phase and C-phase 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, at 25 degree C, +/- 5 degree.
Remote programming connector	9-pin D-sub
Output connector	Combination signal/power contact subminiature D (Out cables and mating connector kits available)

All specifications are subject to change

ReFlex Power™ Load Modules

375–750 W

High Density Programmable Load Modules

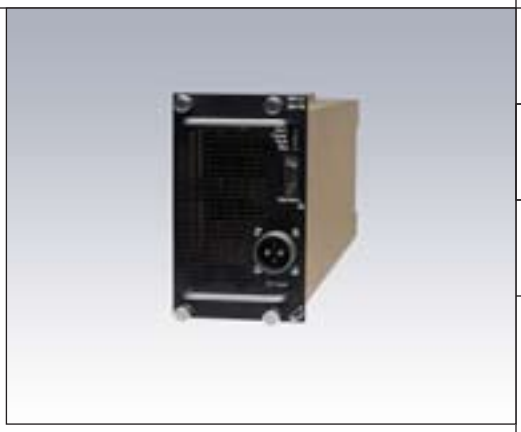
500 V

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 375 W and 750 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 modules could be set up to operate as standalone assets, or in combinations of parallel groups to extend their current, and power ratings.

Safety, ease of integration and functionality are significantly enhanced by a variety of hardware interface lines. Available at the front panel of each module via a DB-9 connector, is Remote Inhibit (RI).

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.

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 nodulate the output with an external signal.

The thermal design features integral, variable-speed fans so that the cooling performance scales with the complement of modules in the Mainframe, and their output loading, minimizing the audible noise and the airflow requirements.

ReFlex Power™ Load Modules : Specifications

DC Loads Modules General Specifications		
Physical	Size: 3 RFP Slots, Weight 7.5 lbs (375W); 10.4 lbs (750W)	
Connectors	DC Input and Sense: MS3106F-20-24S Remote Programming: 9 pin D-Sub (Output cables and mating connector available)	
Stability	<0.1% of FS after 8 hrs	
Temperature Drift	<0.05% of FS/°C	
Protection	Overvoltage: 525V ± 3%, Overcurrent: 20A ± 3% (375W), 40A ± 3% (750W) Overpower: 19-394W ± 5% (375W), 38 – 788W ± 5% (750W), Reverse Voltage: -15V ± 3%	
Parallel Operation	Up to 8 modules.	
Noise	30mA (pk-pk), 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 at altitude and ambient temperature	
All specifications	25°±5°C.	
Digital Volt Meter		
Range	0-500V	
Resolution	33mV	
Accuracy	0.1% of FS	
Digital Amp Meter	**375W**	**750W**
Range	0-15A	0-30A
Resolution	0.9mA	1.8mA
Accuracy	0.3% of FS	0.3% of FS
Current Mode	**375W**	**750W**
Range	0-15A	0-30A
Resolution	0.9mA	1.8mA
Digital Programming Accuracy	0.3% of FS	0.3% of FS
Regulation	0.1% of FS for 100% load change	0.1% of FS for 100% load change
Resistance Mode		
Range 1, Resolution	1-99Ω, 1Ω	
Range 2, Resolution	100-1000Ω, 100Ω	
Range 3, Resolution	1000-5000Ω, 1000Ω	
Digital Programming Accuracy	5% of setpoint	
Load Transient	60 msec to set point	
Analog Control (Current Mode)		
Range	0 to 5V or 0 to 10V = FS	
Accuracy	0.3% of FS	
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

ReFlex Power™ System Controller

Programmable System Controller

Universal AC/DC

LXI ETHERNET

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 reconfigurablity and extensibility are made possible through the use of the latest in controls technology. An FPGAbased 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 RFPC 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.

Ethernet Controller General Specifications	
Modules Controlled	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 not disconnect the input power
Front Panel Connectors	Interface Connector: Subminiature D - Female LAN: Ruggedized RJ45
Input	Via RFP Chassis Hold-up time: 10ms
Physical	Size: 1 RFP slot, 1.4" (35.6mm) W 6.75", (171.5mm) H 15" (381 mm) D Weight: 2.4 lbs

ReFlex Power™ System : General System Specifications

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

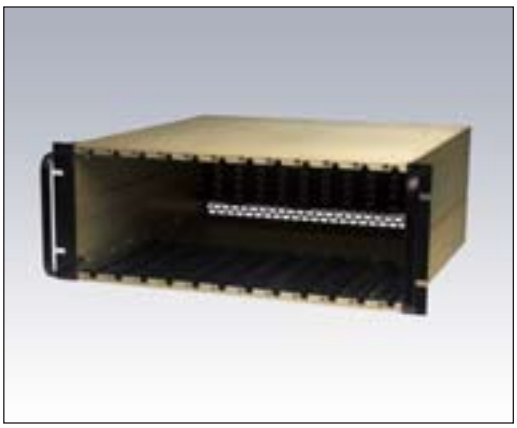
The ReFlex Power System Mainframe consists of 12 fixed pitch "slots" for insertion of AC, DC or Active load modules and the Controller which are one, two, or three "slots" wide. Very compact in size, 4RU by 17.00" deep, the mechanical design is ruggedized for harsh environments including mobile applications 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 have to be uninstalled under normal circumstances. 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. In addition, 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.

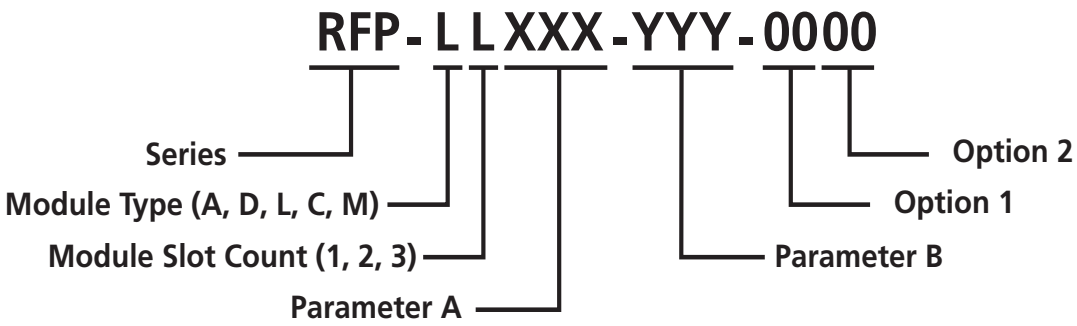
The setback version includes both a removable front dress panel and a cable chase for installation on the bottom of the mainframe.



- Worldwide input voltage capability plus 270 VDC
- System input power connections
- Connectors for system expansion
- No active components
- Rack slide mounts
- Power output up to 3600W / 6000W

All specifications are subject to change

ReFlex Power™ Series



Ordering Example Configurations	
RFP-M0000-001-0000	12 Slot Mainframe
RFP-M0000-REC-0000	12 Slot Mainframe, RECESSED
5380059-01	Chassis Slot Blank, one
5380317-01	2 meter unterminated AC line cord with mainframe connector mate
5380318-01	AC Input mainframe connector mate
5380054-01	Chassis Interconnect Cable 36 Inches ** Needed to connect multiple chassis together under one controller.
5380054-02	Chassis Interconnect Cable 97 Inches ** Needed to connect multiple chassis together under one controller.
5380054-03	Chassis Interconnect Cable 135 Inches ** Needed to connect multiple chassis together under one controller.
Controller Module & Accessories	
RFP-C1LAN-000-0000	Controller - Standard
5380509-01	Interlock loop-back - No charge
DC Modules & Accessories	
RFP-D1016-021-1G00	16V - 1 Slot, 16Vdc, 20.6A, 330W, with Disconnect Relays
RFP-D1065-5A1-1G00	65V - 1 Slot, 65Vdc, 5.1A, 330W, with Disconnect Relays
RFP-D2033-030-1G00	33V - 2 Slots, 33Vdc, 30A, 1kW, with Disconnect Relays
RFP-D2450-2A3-1G00	450V - 2 Slots, 450Vdc, 2.3A, 1kW, with Disconnect Relays
5380444-01	16V Output Cable (3m) -03 for 90-degree bend
5380445-01	65V Output Cable (3m) -03 for 90-degree bend
5380446-01	33V Output Cable (3m) -03 for 90-degree bend
5380447-01	450V Output Cable (3m) -03 for 90-degree bend
AC Modules & Accessories	
RFP-A301K-875-1G00	3 Slots, 875VA, 45-1.2kHz
RFP-A305K-875-1G00	3 Slots, 875VA, 45-5kHz
5380450-01	AC Output Cable (3m) -03 for 90-degree bend
Load Modules & Accessories	
RFP-L3500-375-1G00	3 Slots, 375W, 500Vdc, 15A
RFP-L3500-750-1G00	3 Slots, 375W, 500Vdc, 15A with Extended Operating Temp.(1F)
5380452-01	Load Output Cable (3m)
Module Options and Interlock Loop-back Accessory	
-1E00	With 90 Degree AC Input Connector (Chassis option only
-1F00	With Extended Operating Temp.(1F)
-1G00	With Disconnect Relays (1G)
-2D00	With 1F + 1G
-001A	With Calibration Certificate (1A)
-1F1A	With 1F + 1A
-1G1A	1G + 1A
-2D1A	1F + 1G and Calibration Certificate (1A)
5380508-01	Module Interlock loop-back - No charge (DC, AC and Load Modules)

Output Cable Accessories are HIGHLY RECOMMENDED for All Modules

Notes

XMP 2600 Series : Discontinued

A Customizable Multiple Output DC Power Supply System

160 W–3.2 kW

8–160 V

1.25–80 A

	~	115	230

- 22 modules with power levels icon to 2.4 kW
- Up to 99 steps auto-sequencing
- Up to 10 multi-channel store/recall settings
- Polarity and isolation relays standard
- Power envelope: 2.4 kW, 2.6 kW intermittent
- Individual module processor control
- Remote sense compensation
- Power Factor Correction (PFC)

The XMP 2600 Series has been discontinued.

The XMP 2600 is a multiple-output programmable power supply suited to ATE applications. Designed for maximum flexibility, the XMP includes a controller that allows for the inclusion of up to eight different power modules in one mainframe. The XMP can be customized with either high or low-power modules. Each module can be configured with different voltage and current ratings, ranging from 160 watts to 3.2 kilowatts.

A single XMP mainframe can be configured to hold several modules, with power being drawn from each module independently of the others, with an overall output power of 2.4 kilowatts. The XMP 2600 is designed for research, product development and production test applications such as ATE, burn-in and electronics tests.

All XMP functions can be programmed remotely through a GPIB or RS-232 interface, or manually through the convenient front panel keypad and LCD display. No other power system provides this level of configurability in a single unit.

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USA

AMETEK®
PROGRAMMABLE POWER

XMP 2600 Series : Product Specifications[1]

Output : Voltage and Current				
Models	Module Width	Output Voltage	Output Current	Output Power
A1	1/8	8 V	20 A	160 W
B1	1/8	18 V	10 A	180 W
C1	1/8	36 V	5 A	180 W
D1	1/8	80 V	2.5 A	200 W
E1	1/8	160 V	1.25 A	200 W
A2	1/8	8 V	40 A	320 W
B2	1/8	18 V	20 A	360 W
C2	1/8	36 V	10 A	360 W
D2	1/8	80 V	5 A	400 W
E2	1/8	160 V	2.5 A	400 W
A4	2/8	8 V	80 A	640 W
B3	1/8	18 V	40 A	720 W
C3	1/8	36 V	20 A	720 W
D3	1/8	80 V	9 A	720 W
E3	1/8	160 V	4.5 A	720 W
B4	2/8	18 V	80 A	1,440 W
C4	2/8	36 V	40 A	1,440 W
D4	2/8	80 V	20 A	1,600 W
E4	2/8	160 V	10 A	1,600 W
C5	3/8	36 V	80 A	2,880 W[3]
D5	3/8	80 V	40 A	3,200 W[3]
E5	3/8	160 V	20 A	3,200 W[3]
Models	Line Regulation Voltage	Line Regulation Current	Load Regulation Voltage	Load Regulation Current
A1	2 mV	8 mA	1.5 mV	8 mA
B1	2.5 mV	4 mA	1.8 mV	4 mA
C1	3 mV	2 mA	2 mV	2 mA
D1	4 mV	1 mA	3 mV	1 mA
E1	6 mV	0.5 mA	6 mV	0.5 mA
A2	2.5 mV	18 mA	1.5 mV	18 mA
B2	3 mV	10 mA	2 mV	10 mA
C2	3.5 mV	6 mA	2.5 mV	6 mA
D2	5 mV	3 mA	4 mV	3 mA
E2	7 mV	2 mA	7 mV	2 mA
A4	3 mV	49 mA	2.5 mV	49 mA
B3	3.5 mV	24 mA	2.5 mV	24 mA
C3	4 mV	13 mA	3 mV	13 mA
D3	6 mV	8 mA	5 mV	8 mA
E3	8 mV	4 mA	8 mV	4 mA
B4	4 mV	69 mA	3.5 mV	69 mA
C4	5 mV	32 mA	4 mV	32 mA
D4	7 mV	18 mA	6 mV	18 mA
E4	9 mV	10 mA	10 mV	10 mA
C5	7.5 mV	107 mA	6 mV	76 mA
D5	11 mV	59 mA	9 mV	37 mA
E5	14 mV	29 mA	14 mV	22 mA

XMP 2600 Series : Product Specifications[1]

160 W–3.2 kW

Output : Voltage and Current				
Models	Output Noise & Ripple (20 Hz – 20 MHz) RMS	Output Noise & Ripple (20 Hz – 20 MHz) Peak-Peak	Voltage Readback (0.03% of Vmax +...)	Current Readback (0.12% of Imax +...)
A1	1.8 mV	12 mV	6 mV	8 mA
B1	2 mV	14 mV	12 mV	4 mA
C1	2.5 mV	19 mV	23 mV	2 mA
D1	7 mV	42 mV	42 mV	1 mA
E1	12 mV	85 mV	85 mV	0.5 mA
A2	2 mV	13 mV	12 mV	26 mA
B2	2.5 mV	15 mV	24 mV	9 mA
C2	4 mV	25 mV	46 mV	5 mA
D2	12 mV	70 mV	90 mV	3 mA
E2	25 mV	150 mV	180 mV	2 mA
A4	4 mV	25 mV	25 mV	40 mA
B3	5 mV	30 mV	29 mV	28 mA
C3	9 mV	50 mV	55 mV	10 mA
D3	23 mV	125 mV	110 mV	4 mA
E3	50 mV	250 mV	200 mV	2 mA
B4	12 mV	68 mV	38 mV	64 mA
C4	35 mV	100 mV	66 mV	39 mA
D4	80 mV	250 mV	134 mV	15 mA
E4	180 mV	550 mV	240 mV	8 mA
C5	88 mV	210 mV	78 mV	188 mA
D5	198 mV	596 mV	146 mV	67 mA
E5	446 mV	1,330 mV	294 mV	32 mA

Programming Accuracy				
Models	Voltage (0.03% of Vmax +...)	O.V.P. (2% of Vmax +...)	Current (0.12% of Imax +...)	O.C.P. (2% of Imax +...)
A1	3 mV	90 mV	8 mA	16 mA
B1	7 mV	180 mV	4 mA	8 mA
C1	12 mV	340 mV	2 mA	4 mA
D1	26 mV	740 mV	1 mA	2 mA
E1	60 mV	980 mV	0.5 mA	1 mA
A2	5 mV	90 mV	24 mA	32 mA
B2	10 mV	181 mV	9 mA	16 mA
C2	15 mV	342 mV	5 mA	8 mA
D2	30 mV	744 mV	3 mA	4 mA
E2	65 mV	988 mV	2 mA	2 mA
A4	8 mV	98 mV	46 mA	74 mA
B3	12 mV	182 mV	28 mA	36 mA
C3	17 mV	344 mV	10 mA	18 mA
D3	34 mV	748 mV	4 mA	9 mA
E3	75 mV	996 mV	2 mA	5 mA
B4	16 mV	196 mV	58 mA	140 mA
C4	20 mV	375 mV	38 mA	40 mA
D4	38 mV	800 mV	15 mA	20 mA
E4	80 mV	1,100 mV	8 mA	10 mA
C5	25 mV	398 mV	178 mA	296 mA
D5	48 mV	874 mV	64 mA	128 mA
E5	98 mV	1,240 mV	29 mA	58 mA

XMP 2600 Series : Product Specifications[1]

Average Programming Resolution				
Models	Voltage	OVP	Current	OCP
A1	2.5 mV	2.5 mV	15 mA	15 mA
B1	12 mV	12 mV	12.5 mA	12.5 mA
C1	15 mV	15 mV	2.25 mA	2.25 mA
D1	24 mV	24 mV	1.63 mA	1.63 mA
E1	122 mV	122 mV	1.31 mA	1.31 mA
A2	2.5 mV	2.5 mV	20 mA	20 mA
B2	12 mV	12 mV	15 mA	15 mA
C2	15 mV	15 mV	12.5 mA	12.5 mA
D2	24 mV	24 mV	2.25 mA	2.25 mA
E2	122 mV	122 mV	1.63 mA	1.63 mA
A4	2.5 mV	2.5 mV	40 mA	40 mA
B3	12 mV	12 mV	20 mA	20 mA
C3	15 mV	15 mV	15 mA	15 mA
D3	24 mV	24 mV	3.25 mA	3.25 mA
E3	122 mV	122 mV	2.13 mA	2.13 mA
B4	12 mV	12 mV	40 mA	40 mA
C4	15 mV	15 mV	20 mA	20 mA
D4	24 mV	24 mV	15 mA	15 mA
E4	122 mV	122 mV	12.5 mA	12.5 mA
C5	15 mV	15 mV	40 mA	40 mA
D5	24 mV	24 mV	20 mA	20 mA
E5	122 mV	122 mV	15 mA	15 mA

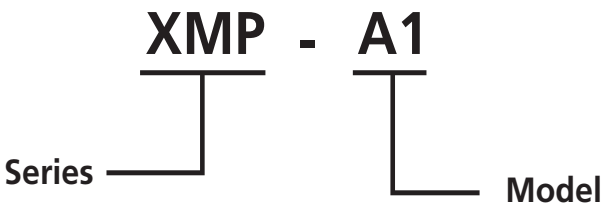
Average Readback Resolution				
Models	Voltage Readback	Current Readback	Transient Response Time (mSec)[2]	
A1	2.5 mV	15 mA	< 0.8	
B1	12 mV	12.5 mA	< 0.8	
C1	15 mV	2.25 mA	< 0.8	
D1	24 mV	1.63 mA	< 0.8	
E1	122 mV	1.31 mA	< 0.8	
A2	2.5 mV	20 mA	< 0.9	
B2	12 mV	15 mA	< 0.9	
C2	15 mV	12.5 mA	< 0.9	
D2	24 mV	2.25 mA	< 0.9	
E2	122 mV	1.63 mA	< 0.9	
A4	2.5 mV	40 mA	< 1	
B3	12 mV	20 mA	< 1	
C3	15 mV	15 mA	< 1	
D3	24 mV	3.25 mA	< 1	
E3	122 mV	2.13 mA	< 1	
B4	12 mV	40 mA	< 2	
C4	15 mV	20 mA	< 2	
D4	24 mV	15 mA	< 2	
E4	122 mV	12.5 mA	< 2	
C5	15 mV	40 mA	< 4	
D5	24 mV	20 mA	< 4	
E5	122 mV	15 mA	< 4	

XMP 2600 Series : Product Specifications[1]

160 W–3.2 kW

Operational AC Input Voltage	
170 V to 265 V, 45 to 66 Hz	Iin < 20 A nominal
Nomimal 120 V, Power output < 1 kW	Iin < 15 A nominal
Power cord length	2 m
Power Factor Correction (PFC)	Power factor correction to meet EN61000-3-2 Current Harmonics and EN61000-3-3 Voltage Fluctuations (IEC555)
Inrush current	Up to 100% of specified nominal current
Input mains protection	Circuit breaker switch on the front panel
Environmental	
Operating Temperature	0 to 55°C (LCD to 50°C)
Storage Temperature	-20 to 70°C
Derate output current/power	1% per °C from 30 to 55°C
Temperature Coefficient	
Voltage Programming	0.01% per °C
Current Programming	0.02% per °C
Voltage Readback	0.01% per °C
Current Readback	0.02% per °C
Long Term Drift	Output change after 30 min. warm-up, over an interval of 8 hours under constant load, line and temperature conditions is 0.03%.
Remote Sensing	Up to 4 V can be dropped over the two load lines together (i.e. 1.5 V + 2.5 V). At 2.5 V a warning event will be generated, alerting oversense voltage drop condition, and at 4 V the module will be shut down. The load lines drop subtracts from the voltage available for the load.
Output Programming Response	Time rise and fall time with full resistive load (10 to 90% and 90 to 10%) is 30-640 ms.
Isolation	Output terminals can be floated up to +/- 240 Vdc from chassis ground
Physical	
Dimensions without feet	Width: 19" (482.6 mm) Height: 5.2" (134.7 mm) Depth: 22.5" (570 mm)
Weight	XMP mainframe with controller 26.2 lb (11.9 kg) 1/8 width module 3.9 lb (1.75 kg) 2/8 width module 5.5 lb (2.5 kg) 3/8 width module 7.5 lb (3.4 kg)
General	
Approvals	CE-marked units meet: EN61010-1, EN61326, EN61000-3-2, and EN61000-3-3; UL Listed to UL61010-1; Meets USA EMC Standard FCC Part 15B Class A

Model Number Description



Specifications subject to change without notice.

1. Specifications refer to a chassis with only the specified module installed, with nominal resistive load (90% of rated current at the rated voltage) and the power supply sensing locally at the rear terminals, at 25 °C.
2. The time it takes for the output to recover within 75 mV of its previous level following a step change in load current of up to 10% of the rated module's current.
3. The maximum output power is limited by the mainframe controller.

Notes

ESG

Engineered Solutions Group

Notes

Engineered Solutions Group

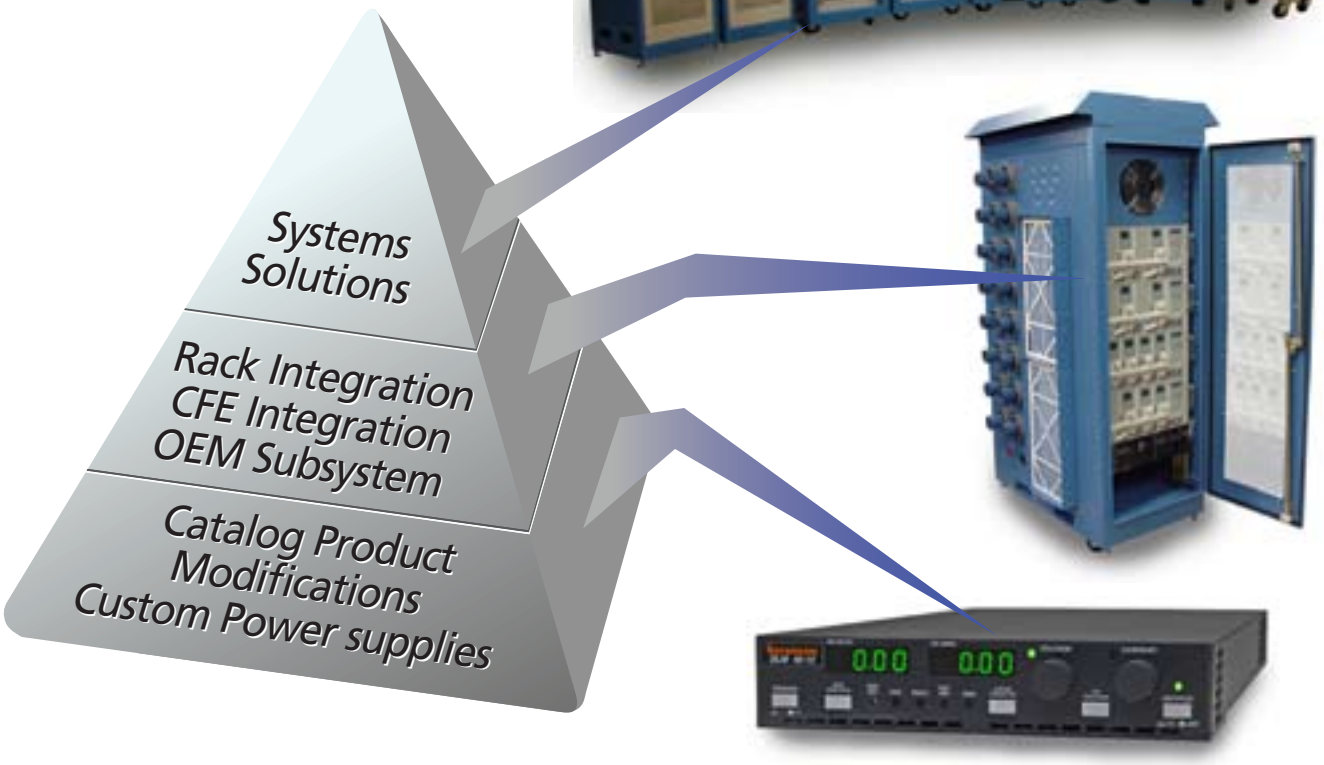
When the Requirement Goes Beyond the Catalog

Tailored Power Solutions to Fit Your Requirements

The Engineered Solutions Group (ESG) at AMETEK Programmable Power is an internal business unit dedicated to solutions that require "outside the box" thinking and … sometimes, "way" outside the box development!

ESG's mission is to work directly with our customers to develop application specific solutions through modified standard products, integrated power systems using standard products or fully customized solutions.

- **Modified standard products**
- **Power sub-systems**
- **Power conditioning**
- **Turnkey power systems**
- **... and More!**



Call or email for more information, for full requirements review or to obtain a quote.

ESG Hotline: 858-678-4411

esg@programmablepower.com

Engineered Solutions Group

The ESG Process

Custom solutions are developed to exacting standards following a well-defined process. First, an application development engineer will be assigned to your project. Our engineer will create a functional specification in collaboration with your engineering team. A written quotation will be developed describing the proposed solution, deliverables, lead-time and project costs. Following approval, AMETEK's Engineered Solutions Group will build and test the solution, providing periodic updates as needed. Upon delivery, ESG can also provide implementation training according to your needs

Modified Standard Products

The simplest custom solution is to modify one of our many standard products. This can be as simple as changing the faceplate color to match your rack application. Many of our OEM (Original Equipment Manufacturer) customers appreciate this capability to provide an integrated, corporate look to their racks. We can provide custom inputs to meet the needs of legacy ATE applications, or our engineers can modify several of the electrical characteristics of our power supplies to meet the needs of your applications.

Power Subsystems

A power subsystem is a product where power supplies and other equipment are integrated into a rack to provide a specialized component of a larger system. Typically they would include specialized customer furnished material and take their control commands from the customer's system controller. These systems are used for applications where the power source is the predominant asset in the rack or the power subsystem is a major part of the test system make-up such as in the automotive and aerospace market segments. ESG has been providing these power subsystems for many years and can add value both in time to market and simplification of the procurement process.

System Solutions

Over the years AMETEK/Elgar has created system solutions for a wide range of applications. These system solutions are standard configurations that can be easily modified to your particular application's needs. As an example AMETEK/Elgar is the industry leader in solar array simulation for the Spacecraft industry.

We have delivered systems that support ABD100 test series and other market-specific test requirements. This level of integration varies greatly with each specific customer need, and we can provide whatever level of integration is required; from a low level pre-integrated rack or we can purchase all required assets per customer specifications and perform complete pre-integration services. Power related turn-key systems are key elements to our capabilities and offer an alternative to in-house designed custom systems. Examples include:

Solar Array Simulators

This type of simulator is used in the Satellite industry for power bus simulation during ground based satellites testing.

Battery Simulators

Which are used to dynamically emulate battery behavior (charging and discharging) of various battery chemistries.

Test and Validation Systems

These systems usually supply power to a single customer device under test (DUT) while other elements of the test system take measurements gauging the performance of the DUT. Many of the systems we provide in this application category are power subsystems and function as the stimulus portion of test stations.

Process Control Systems

These are used for a variety of applications where the control of the input power controls the output process performance. Such applications are power sources for laser diodes, plating, metal forming, heater controls, etc.

Reliability and Burn-in Systems

Custom systems can be configured for product verification, engineering evaluation, and production accelerated life testing.

Elgar SAS - Solar Array Simulator

450/900 W
500/1000 W

450 or 500 W/channel Solar Array Simulator

- 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

	208	400	480

ETHERNET GPIB

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 NT graphical user interface and hardware control software. It can be remotely controlled and 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 10 microseconds. Each SAS string has an electronic circuit breaker and relay disconnect, so faults are localized and minimize disruption of the last process. SAS systems have been designed and delivered ranging from desktop, 2 channel, R&D units to systems capable of controlling two 64 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 id 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 series or paralleled with other FPCS modules to simulate larger array segments. Each FPCS channel delivers 450W or 500W of power; 2 channels are housed in a single 5-1/4" chassis. Open circuit voltage and short circuit current are scaled to meet a customer's

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AMETEK®
PROGRAMMABLE POWER

SAS - Solar Array Simulator

requirements.

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 unconditionally stable 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.

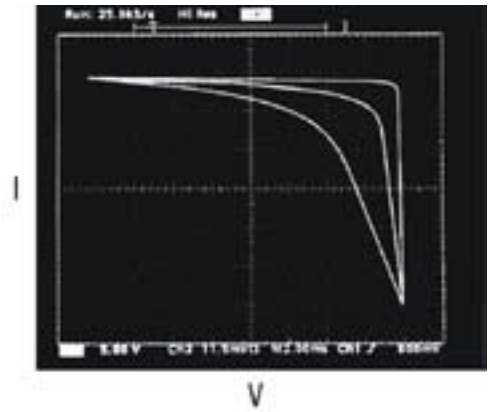
The Proven Source

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
Motorola Space and Systems Technology
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
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
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 4 times/second, entire orbits can easily be simulated with fine time resolution. An alternate mode can be programmed to allow the FPCS to operate in power supply constant current mode, where recalculation is even faster.

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 as large as 128 channels with a total output power of up to 57,600 watts. 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

Specifications	Specifications are guaranteed over a temperature range of 0-40° C, unless otherwise noted.
Power Ratings	Dual 450 watt or 500 watt outputs, or a single 900 watt or 1000 watt output in a single rackmount chassis 5-1/4" in height offer nearly twice the power density in the same package.
Output Ratings	Elgar will scale the open current voltage (Voc) to maximize the short current (Isc) within the power envelope to an individual customer's requirement at no additional charge. Outputs can be set for voltages (Voc) of up to 150 Voc and output current (Isc) of up to 15 amps per channel.
Ripple and Noise	**(In the range of 20 Hz - 20 MHz, with outputs floating or grounded)**
Constant Voltage	rms ±0.025% of maximum, p-p ±0.25% of maximum Voc
Constant Current	rms ±0.05% of maximum Isc; p-p ± 0.5% of maximum Isc Note: Test conditions maximum Voc, maximum Isc, N = 44, Rs = 0.5, load = 3Ω resistive load
Load Switching Recovery Time	2 µsec seconds. Current recovers to within 90% of programmed value in less than 2 microseconds when switched from short circuit to variable load.
Programming Accuracy	at 25°C ±5°C
Voltage	+0.06% of setting (± 0.06% of maximum Voc)
Current	+0.1% of setting (± 0.1 % maximum Isc)
Line Regulation	Change in output voltage or current for any line change
Voltage	±0.01% of maximum Voc
Current	±0.1 mA ± 0.005% of maximum Isc
Readback Accuracy	at 25°C ±5°C
Voltage	+0.1% of reading ±0.1% of maximum Voc
Current	+0.2% of reading ±0.2% of maximum Isc and tested at the factory at the system level
Output Capacitance	or 70nf accross output terminals
Constant Voltage	rms 0.025% of max Voc p+p 0.025% of max Voc
Constant Current	rms 0.05% of max Isc p+p 0.05% of max Isc

Notes

Elgar BSS - Battery Simulation System

60 W–30 kW

Battery String Simulator

120 VA–480 kVA

	208	400	480

ETHERNET GPIB

- Flexible Database Operation
- Fully Programmable
- Completely Configurable
- Attention To Spacecraft Safety
- Eliminates the need for test flight batteries and their associated issues

Product Overview

The Elgar Battery String Simulators (BSS) provide 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 terminal voltage accordingly.

Single or dual battery pack simulator versions are available with discharge currents of up to 150A and charge currents of up to 50A per battery. In addition, optional sensor simulators (including thermistor, pressure transducer, and heater loads 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 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.

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PROGRAMMABLE POWER

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.

Power Rack Integration Service

Power subsystems are a key part of electronic systems, manufacturing processes and process control equipment. The engineering and construction of these power subsystems are often unwanted diversions for the engineering staff.

AMETEK can provide you with custom designed turnkey power subsystem rack solutions to meet a variety of application requirements. Based on our vast power subsystem experience we can quickly and efficiently provide system solutions. Whether you desire to free up your current engineering talent or to add a fresh perspective in applications where power subsystems are new to your process, we can help.

AMETEK starts with the world's largest selection of programmable power sources, then designs and builds a system that will fill your every need, all with a single P.O.

Some additional benefits of a AMETEK Power Rack System are:

Strong systems experience mitigates risk of integration issues and performance problems.. Customer part number established, allowing easy reprocurement of systems for future requirements.

Building power subsystems requires more than power sources and racks; it demands attention to thousands of details.

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.

Specifications	
AC Input	208V L-L, 3 phase 60 hertz 400V L-L, 3 phase 50 hertz
Programming Accuracy	at 25˚C ± 5˚C
Voltage	0.1% of full scale voltage
Current	0.5% of full scale source current
Readback Accuracy	at 25˚C ± 5˚C
Voltage	0.2% of full scale
Current	1.0% of full scale source current
Accumulator Accuracy	Constant current charge or discharge resulting in a 50% change in state of charge over 30 minutes
State of Charge	±2.5%
RMS Ripple and Noise	20Hz to 300KHz
Voltage	0.5% of maximum output voltage
Current	0,1% of maximum output current
Transient Response	20 Milliseconds 20% to 100% discharge current step across an 8500µF capacitor recovery to within ±2.0 volts (5% of full maximum battery voltage)
Sensor Simulator Options	
Voltage Monitors	The voltage monitors are A-D converters that can monitor any voltage up to 100VDC
Thermistor	The Thermistors are programmable 12-BIT resistive ladder circuits designed to emulate the readings that a battery thermistor would provide. They are manually programmable from the Sensor Simulator GUI or remotely through the BSS system's remote control input.
Strain Gauge Outputs	The strain gauge outputs are programmable D-A outputs that emulate a battery strain gauge output. The sensor simulator software will cause the output of the strain gauge to output a signal when an excitation voltage is provided by the spacecraft.
Strain Gauge Excitation Sensing	This is an input signal is received from the spacecraft.
Cell Open and Short	
Switch Closures	
Cell Voltage Simulation	
Heater Loads	

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 CONTACT US 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.

AMETEK
Programmable Power
9250 Brown Deer Road
San Diego, CA 92121-2267
USA

AMETEK®
PROGRAMMABLE POWER

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
0000	0.46	11.684	0.049	0.16072	380	302	125 Hz
000	0.4096	10.40384	0.0618	0.202704	328	239	160 Hz
00	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

Worldwide Product Voltage Input Chart

Products	Input Voltage (Nominal)				
	Single Phase		Three Phase (L-L)		
	110-120V	220/230/240V	208-220VAC	380-415VAC	460-480VAC
XT	Std	M2 / M3 / M4	---	---	---
HPD	Std	M2	---	---	---
XPD	Std	Std	---	---	---
XHR	Std	Std	---	---	---
XDL	Std	MHV	---	---	---
XPL	Std	MHV	---	---	---
XPH	Std	Std**	---	---	---
XPF	Std	MHV	---	---	---
XTR	Std	Std	---	---	---
XFR 1.2kW	Std	Std	---	---	---
XFR 2.8kW			---	---	---
DLM 600W	Std	Std	---	---	---
XG	Std	Std	---	---	---
DCS 1kW	M1	Std	---	---	---
DCS 1.2kW	M1	Std	---	---	---
DCS 3kW	---	Std	Std	---	---
DLM 3kW	---	Std	Std	---	---
DLM 4kW	---	---	Std	M1	M2
P63/66	---	---	C	D	E
DHP	---	---	Std	M1	M2
SGA/SGI/SFA	---	---	C	D	E
CW801M/P	Std	Std	---	---	---
CW1251M/P	Std	Std	---	---	---
CW2501M/P		Std	---	---	---
TW Series	---	-4	-1 & -3	-2 & -4	---
SW Series	---	-4	-1 & -3	-2 & -4	---

Notes

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	$\frac{HP \times 746}{E \times Eff}$	$\frac{HP \times 746}{E \times Eff \times P.F.}$	$\frac{HP \times 746}{1.73 \times E \times Eff \times P.F}$
Amperes when Kilowatts is known	$\frac{kW \times 1000}{E}$	$\frac{kW \times 1000}{E \times P.F.}$	$\frac{kW \times 1000}{1.73 \times E \times P.F.}$
Amperes when Kva is known		$\frac{Kva \times 1000}{E}$	$\frac{Kva \times 1000}{1.73 \times E}$
Kilowatts	$\frac{I \times E}{1000}$	$\frac{I \times E \times P.F.}{1000}$	$\frac{1.73 \times I \times E \times P.F.}{1000}$
Kva		$\frac{I \times E}{1000}$	$\frac{1.73 \times I \times E}{1000}$
P.F.		$\frac{kW}{Kva}$	$\frac{kW}{Kva}$
Horsepower (output)	$\frac{I \times E \times Eff}{746}$	$\frac{I \times E \times Eff \times P.F.}{746}$	$\frac{1.73 \times I \times E \times Eff \times P.F.}{746}$

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

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	Pg
5	75	DLM 5-75	21
5	350	DLM 5-350E	49
5	450	DLM 5-450E	49
5	500	P63C-5500	61
5	1000	DHP 5-1000	55
5	1000	P63C-51000	61
5	1500	DHP 5-1500	55
5	1500	P63C-51500	61
5	2000	DHP 5-2000	55
5	2000	P66C-52000	61
5	2500	DHP 5-2500	55
5	2500	P66C-52500	61
5	3000	DHP 5-3000	55
5	3000	P66C-53000	61
6	110	XG 6-110	27
6	110	XTR 6-110	27
6	200	XFR 6-200	41
7	6	XT 7-6	79
7.5	67	XPD 7.5-67	109
7.5	130	XHR 7.5-130	113
7.5	140	XFR 7.5-140	41
7.5	300	XFR 7.5-300	41
8	75	DLM 8-75	21
8	100	XG 8-100	27
8	100	XTR 8-100	27
8	125	DCS 8-125E	33
8	140	DCS 8-140E	33
8	350	DCS 8-350E	33
8	350	DLM 8-350E	49
8	400	P63C-8400	61
8	450	DLM 8-450E	49
8	800	DHP 8-800	55
8	800	P63C-8800	61
8	1200	DHP 8-1200	55
8	1200	P63C-81200	61
8	1600	DHP 8-1600	55
8	1600	P66C-81600	61
8	2000	DHP 8-2000	55
8	2000	P66C-82000	61
8	2400	DHP 8-2400	55
8	2400	P66C-82400	61
10	60	DLM 10-60	21
10	100	DCS 10-100E	33
10	100	XHR 10-100	113
10	120	DCS 10-120E	33
10	330	P63C-10330	61
10	660	DHP 10-660	55
10	660	P63C-10660	61
10	1000	DHP 10-1000	55
10	1000	P63C-101000	61
10	1300	DHP 10-1300	55
10	1300	P66C-101300	61
10	1650	DHP 10-1650	55
10	1650	P66C-101650	61
10	2000	DHP 10-2000	55
10	2000	P66C-102000	61
12	70	XG 12-70	27
12	70	XTR 12-70	27
12	100	XFR 12-100	41
12	220	XFR 12-220	41
12	250	DCS 12-250E	33
12.5	265	P63C-12.5265	61
12.5	530	DHP 12.5-530	55
12.5	530	P63C-12.5530	61
12.5	800	DHP 12.5-800	55
12.5	800	P63C-12.5800	61
12.5	1060	P66C-12.51060	61
12.5	1260	DHP 12.5-1260	55
12.5	1325	DHP 12.5-1325	55
12.5	1325	P66C-12.51325	61
12.5	1600	DHP 12.5-1600	55
12.5	1600	P66C-12.51600	61
15	1.5	XEL 15-5	85
15	4	XT 15-4	79
15	5	XBT 32-3FTP	87
15	20	HPD 15-20	97
15	220	P63C-15220	61
15	440	DHP 15-440	55
15	440	P63C-15440	61
15	660	DHP 15-660	55
15	660	P63C-15660	61
15	880	DHP 15-880	55
15	880	P66C-15880	61
15	1100	DHP 15-1100	55
15	1100	P66C-151100	61
15	1320	DHP 15-1320	55
15	1320	P66C-151320	61
16	20.6	RFP-D1016-021	173
16	185	DLM 16-185E	49
16	250	DLM 16-250E	49
18	3	XPL 18-3	107
18	10	XPH 18-10	103
18	30	XPD 18-30	109
20	3	XT 20-3	79
20	30	DLM 20-30	21
20	42	XG 20-42	27
20	42	XTR 20-42	27
20	50	DCS 20-50E	33
20	50	XHR 20-50	113
20	60	DCS 20-60E	33
20	60	XFR 20-60	41
20	130	XFR 20-130	41
20	150	DCS 20-150E	33
20	166	P63C-20166	61
20	330	DHP 20-330	55
20	330	P63C-20330	61
20	500	DHP 20-500	55
20	500	P63C-20500	61
20	665	DHP 20-665	55
20	665	P66C-20665	61
20	830	DHP 20-830	55
20	830	P66C-20830	61
20	1000	DHP 20-1000	55
20	1000	P66C-201000	61
25	132	P63C-25134	61
25	265	DHP 25-265	55
25	265	P63C-25265	61
25	400	DHP 25-400	55
25	400	P63C-25400	61
25	520	DHP 25-520	55
25	520	P66C-25520	61
25	650	DHP 25-650	55
25	650	P66C-25650	61
25	800	DHP 25-800	55
25	800	P66C-25800	61
30	1	XPL 30-1	107
30	1.3	XEL 30-3	85
30	2	XPL 30-2	107
30	2	XPL 30-2D	107
30	2	XPL 30-2T	107
30	2	XT 30-2	79
30	6	XEL 30-3D	85

DC Product Selector Guide

Voltage	Current	Model	Pg
30	10	HPD 30-10	97
30	110	P63C-30110	61
30	220	DHP 30-220	55
30	220	P63C-30220	61
30	330	DHP 30-330	55
30	330	P63C-30330	61
30	440	DHP 30-440	55
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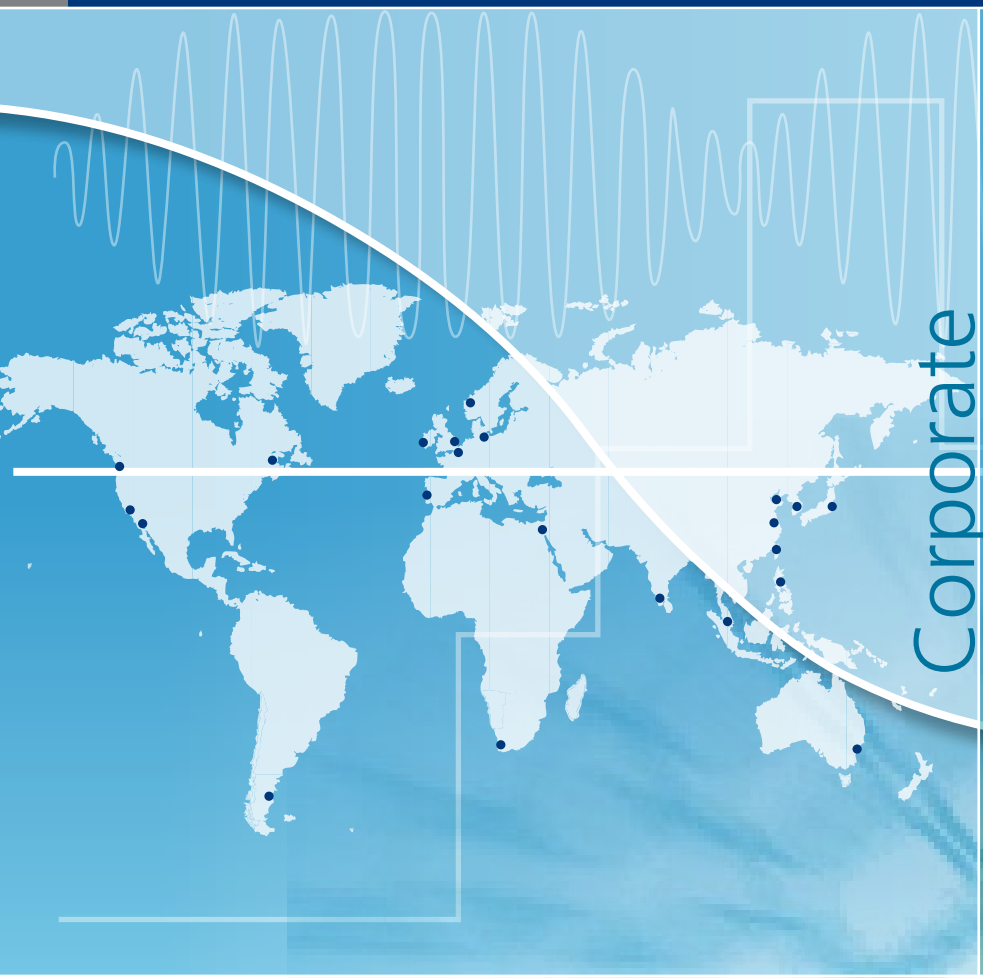

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