Electronic Design

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POWER SELECTION HANDBOOK:

Get Down to the Basics When Selecting Your DC or AC Power Supply

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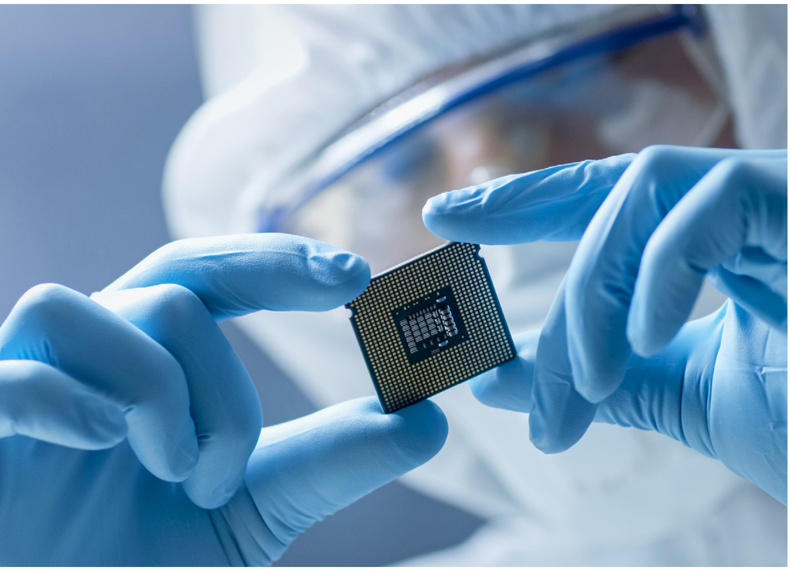
Choosing the right power supply for your test system or application is no small task. Defining the power requirements for your application comes first, but this is only the beginning. Once you know the voltages and currents that you need, you have to figure out how to power your source and how you're going to control it. So, before you issue that purchase order, ask yourself these questions:

- What do you want out of your power supply?
- What is regulation and distortion?
- What are you going to feed the power supply?
- Where are you going to put the power supply?
- How are you going to control the power supply?

What do you want out of your power supply?

The first thing that you should do when specifying a power supply is determine what outputs you need. Do you need just DC outputs, just AC outputs, or some combination of the two? Next, determine the output voltages, output currents, and output power that you'll need. Then, for the DC outputs, you'll have to consider key parameters, such as output power, line regulation, load regulation, and transient response.



The key specifications for AC power supplies are crest factor, power factor, regulation and distortion, and response time. In addition, you'll have to specify whether you simply want sine wave outputs or complex harmonic, transient, and arbitrary waveforms. AC sources can also produce simulated power-line disturbances, inrush current and other non-ideal signals.

Output voltage, current, and power

While most DC power supplies can supply a range of voltages and currents, the key specifications are maximum output voltage, maximum output current, and maximum output power, which are all inter-related.

Linear or switching?

One of the choices you can make when purchasing a DC power supply for a test system is whether to select a linear supply or switching supply. Linear power supplies offer low ripple and noise specifications and have fast transient behavior. However, they are inefficient, generate a lot of heat and are also quite heavy. As a result, most engineers find them desirable only at lower output power levels (typically less than 500 W) or when low noise output is essential, such as when testing sensitive communication devices.

Switching supplies are a better option if your system requires high output power or more than four output channels, because switching supplies provide higher power density than linear supplies. For example, using switching supplies you can have 12 DC outputs, providing up to 4,000 W of power in the same rack mount that you'd use for four linear supplies. These supplies are also easier to control than linear supplies and cost about the same per channel.

Even in applications where low ripple and noise output are required, switching supplies may fill the bill. Recent developments in power electronics, such as zero-switching, have dramatically improved the ripple and noise specifications of switching power supplies. For all but a handful of applications, switching supplies are a better choice than linear supplies because of their flexibility and higher power density.

	Advantages	Disadvantages
Linear s Supply	• Low ripple • Low noise • Fast transient behavior	• Inefficient, generates heat • Heavy
Switching supply	• Less expensive at high power levels • High power density • Easier to control in an ATE system	

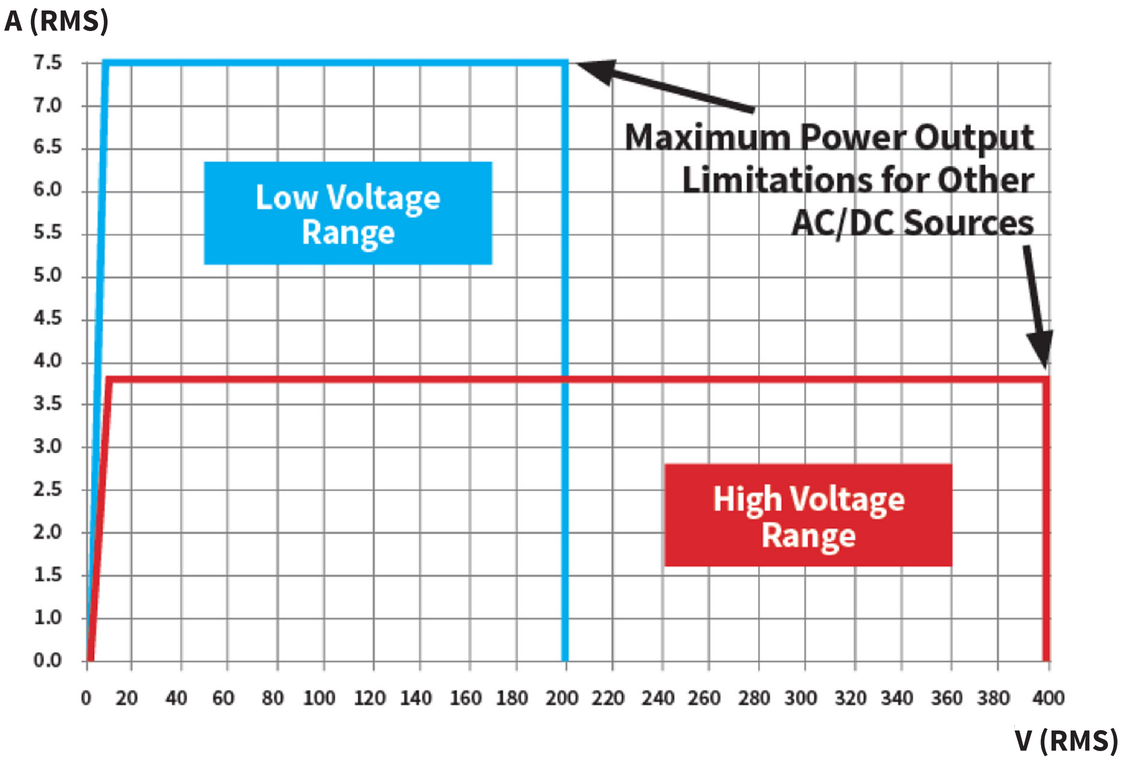


FIGURE 1: A 1,500 VA source can supply up to 3.73A at 100V.

Most conventional power sources supply full output power at one or two specific voltage and current points, as shown in **Figure 1**. This figure shows the voltage/current curves for a 1,500 W AC power supply, with two output voltage ranges: 0 - 200 VAC and 0 – 400 VAC. On the 200 VAC range, the maximum output current is 7.5 Arms, while on the 400 VAC range, the maximum output current is 3.75 Arms. This yields an output power of 1,500 W, but only at the maximum output voltage. At lower voltages, the maximum output current is 7.5 Arms and 3.75 Arms, respectively, meaning that the maximum output power is not available. Most DC supplies also have this maximum power output limitation.

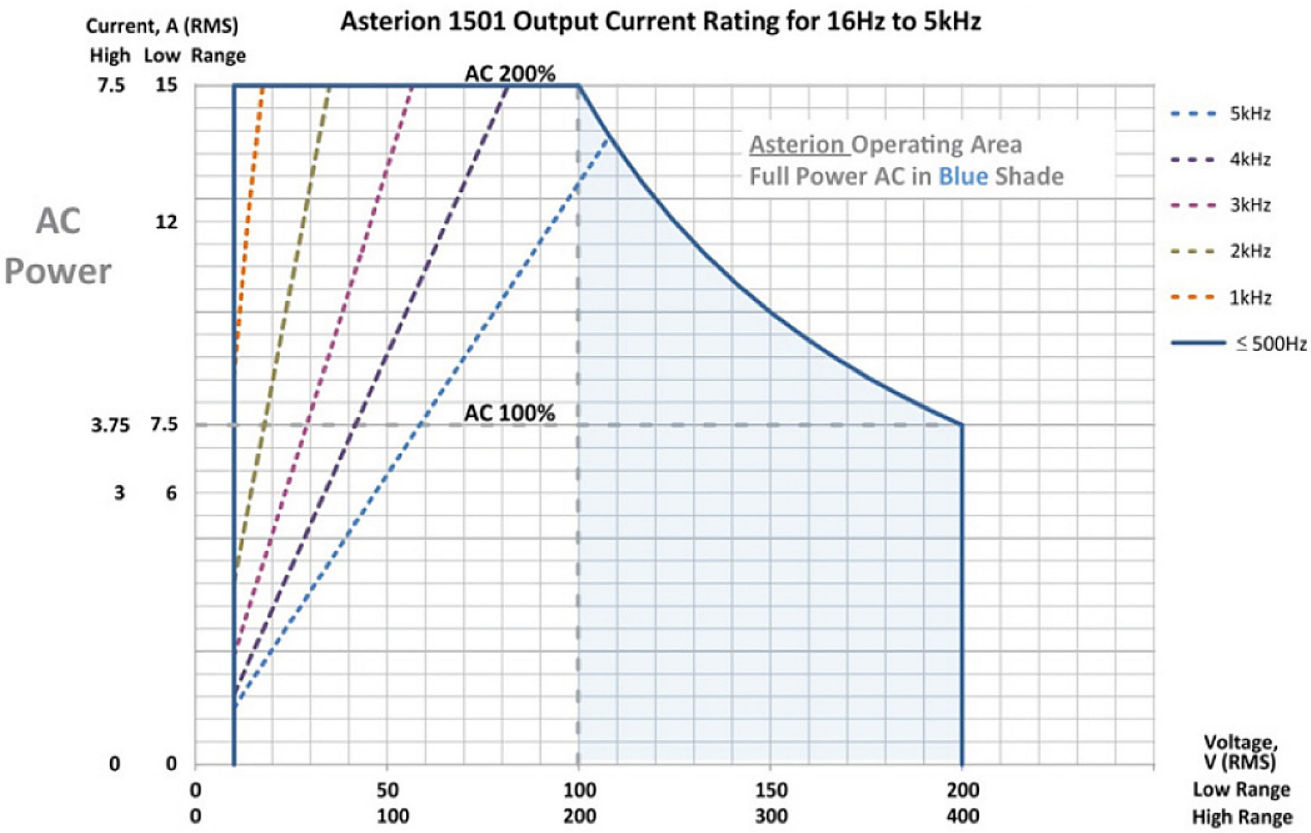


FIGURE 2: Asterion 1501 Output Current Rating for 16Hz to 5kHz.

To overcome this, AMETEK Programmable Power has incorporated its iX2™ current-doubling technology into their Asterion AC Series AC/DC power sources. iX2™ overcomes these power output limitations and allows Asterion power sources to deliver full power over a wider voltage range than conventional power supplies.

Figure 2 shows how this works. The iX2 current doubling technology enables output current to increase linearly up to two times the full voltage current as the voltage decreases from range maximum to one-half of range voltage. iX2 technology allows a power source to deliver full power over the widest voltage ranges. This eliminates the need to buy overpowered sources just to reach low line current requirements.

Line regulation

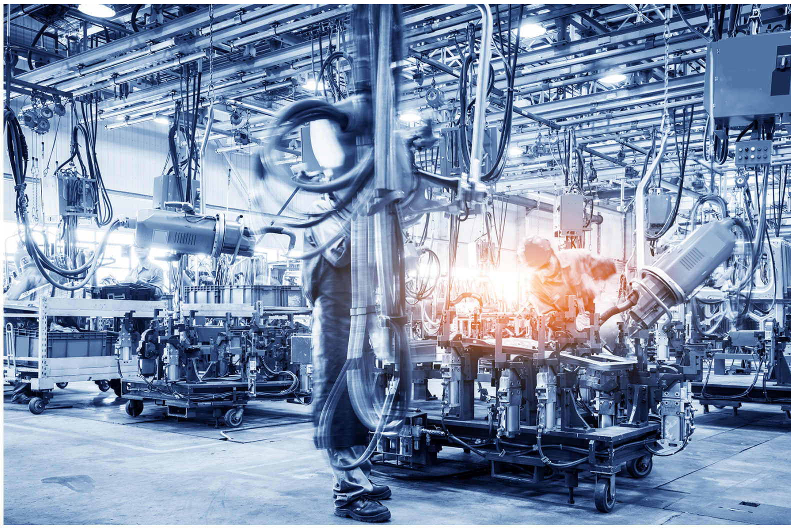
Line regulation is the ability of a power supply to maintain its specified output voltage while there are changes in the input mains voltage. High performance power supplies typically have a line regulation specification between 0.005 and 0.02% of the maximum output voltage + 2 mV.

Load regulation

Load regulation is the ability of a power supply to maintain a constant output voltage (or current) under under very light loads and under loads near the maximum current. High performance power supplies typically have a load regulation specification between 0.005 and 0.02% of the maximum output voltage + 2 mV.

Transient response

Transient response is a measure of how well a DC supply copes with changes in current demand or load impedance. Most DC power supplies easily handle slow load changes and maintain their output voltage, but when a fast transient occurs, the power supply's internal feedback loop may not be able to respond fast enough, causing the output voltage to change. If your application will have large current transients, you'll need to pay close attention to this specification.



Crest factor

The crest factor of an AC current waveform is the ratio of waveform's peak value to its rms value:

crest factor = |peak current| / rms current

The crest factor for a sinusoidal current waveform is 1.414 since the peak value of a true sinusoid is 1.414 times the rms value. Some loads, such as switching power supplies or lamp ballasts, have current waveforms that are not sinusoidal. They draw a high current for a short period of time, and their crest factors, therefore, can be quite a bit higher than 1.414.

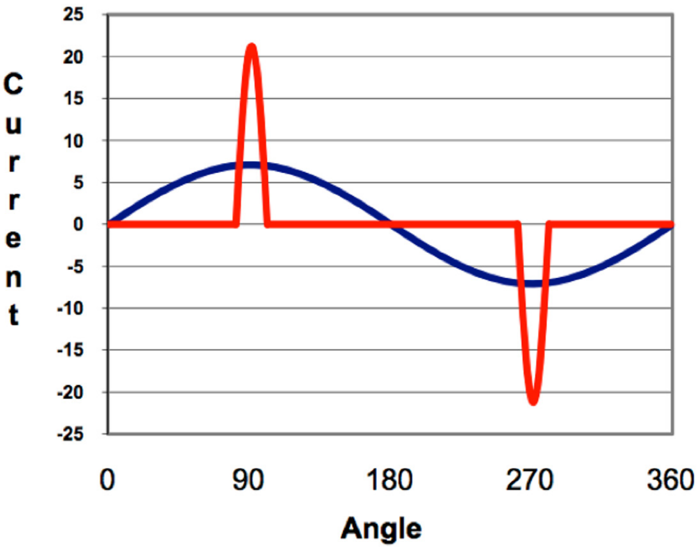


FIGURE 3: Crest Factor Example

Figure 3 shows waveforms for two different loads. Both loads are 5 Arms (assuming that the input voltage is the same for both), meaning that the true power for both loads is the same. This means that a power source selected to feed the loads at 120VAC would need to provide at least 600 VA and support a crest factor of > 3.

A power source with a power output rating of 600VA may not, however, be able to provide the required peak currents that the non-sinusoidal load demands. When selecting an AC power source to power this load, you would need to choose one capable of supply more than 21 A of peak current. In order to determine whether or not an AC source can handle high crest factor peak currents, look for the "peak repetitive current" or "crest factor" specifications in a power source's spec sheet.

Asterion AC Series is a good example of an AC power source that is designed to handle high crest factor loads. The i/iX Series II AC sources can drive difficult nonlinear loads, such as switching power supplies, with a crest factor of up to 5:1, with ease.

Power factor

Power factor is the ratio between true and apparent power. When the voltage and the current are both sinusoidal, the power factor is equal to the cosine of the phase angle between them. More often than not, however, the current contains higher order harmonics and determining the power factor is more complex. To determine the power factor, the AC source must have the ability to measure RMS voltage, RMS current, and true power in order to accurately calculate power factor.

Since the true power can never exceed the apparent power, the power factor is always less than or equal to one. While the power factor may not provide any information about the phase shift between the voltage and current, a sign is often used to indicate whether the current is leading or lagging the voltage.

Note that the power factor is a ratio between two measurements, one of which (VA) is the product of two other measurements. This has an impact on the accuracy with which power factor can be measured. If the power level of the EUT is low, percent of scale errors in the current and power measurements will impact the accuracy of the calculated power factor. Published accuracy specifications for power factor measurement may only apply above a certain current or power level.

What is the regulation and distortion?

Like DC supplies, AC power sources need good load regulation and line regulation. They also need low harmonic distortion. Low harmonic distortion means a power source will have a higher power factor, lower peak currents, and higher efficiency. Quality AC sources have a +/- 0.1% voltage accuracy and a no more than 0.25% maximum total harmonic distortion (THD).

Poorly regulated AC power sources are sometimes called "soft sources." A soft source has a high output impedance and low peak-current capability. These instruments are unable to provide the proper peak-currents for performing component stress testing, leading to a higher failure rate. For example, if you perform one of the IES LM-41-1985 tests (IES approved method for photometric testing of indoor fluorescent luminaires) using a soft power source, the source will produce a distorted waveform, thereby invalidating the test results.

Design for the worst case

During the design phase, remember to give yourself some margin for error. A power source with just enough capacity may work perfectly well under normal circumstances, but you might not have any wiggle room if the system needs more power than you anticipated or has to be expanded in the future.

Let's say you are developing a system to test a motor rated at 120 V, 10 A and purchase a power source that provides 10 A, maximum. During a low-line margin test, the motor will draw 11 or 12 A. To run a proper test, you need a power source that can deliver the necessary current under this worst-case condition.

Another factor to consider is inrush current. When an AC motor starts up, the inrush current may be five to seven times the normal operating current. The time length of this draw depends on the mechanical load and the motor design. If the power source cannot supply this start-up current, the motor may start up slowly or not at all.

The absolute maximum and minimum DC power supply voltage specifications of the UUT times a 1.5 fudge factor will provide a reasonable value for the worst-case DC supply voltage requirements. With motors, the fudge factor should be between five to seven times to account for inrush currents. With AC supplies, the best place to look for worst-case conditions is with your rectifier-type power supplies and motors. These devices draw high inrush currents that can be between two to ten times the nominal run current. The duration of these currents can last a few cycles to several seconds.

Response Time

Load response time is the time it takes for an AC source to respond to a change in the load. A "stiff-source" is an AC source that has a fast load response time. These sources generally have low source impedance and tight regulation which keep their outputs constant, even when switching from no load to full load.

In power supply design, analog technology efficiently provides low source impedance and tight regulation. But now, switching technology power sources are matching the linear-source performance. For example, California Instruments' CSW Series is an AC Power Supply that uses a switching topology. This power supply series has a voltage accuracy of +/-0.1%, a total-harmonic-distortion (THD) of 0.25%, and high-speed load response times.

The AC power source response to inrush current depends on the source's current limiting method. By design, AC power sources have an excessive load current protection. This current limiting occurs either by folding back the voltage (current limiting) or shutting down the output (current-limiting shutdown).

What are you going to feed the power supply?

Once you have determined what you want out of a power supply, the next question to ask is how are you going to feed it. By that we mean how are you going to supply the input power. For most power supplies over 1,500 W or 1,500 VA, you can't simply plug the supply into a 120 VAC wall socket. At the very least, you'll have to supply 220 VAC single-phase power, and if you have very high power requirements, then you'll have to supply some form of three-phase power.

Before you purchase a supply, consult with your facilities management people to see what's available in your lab or on the manufacturing floor. **Ask the following questions:**

- What supply voltages are available?
- Is single-phase and three-phase power available?
- What type of power outlets are currently installed and where are they installed?
- Do the power outlets that are currently available have the appropriate wire gauges?
- What are your options for cooling?

When you have the answers to these questions, you'll be able to purchase a power supply with the right input power configuration.

To learn more, read "Three-Phase AC Supplies High-Power Sources."

Where are you going to put the power supply?

Once you've determined how you're going to feed the power supply, you need to decide where you're going to put it. The information you'll need to answer this question are the environmental and mechanical specifications. The environmental specifications will provide operating temperature, storage temperature, altitude, relative humidity, vibration, shock, and transportation integrity. The mechanical specifications will contain dimension, weight, chassis material and finish, installation details, cooling requirements, and output noise details.

Keep in mind that high power sources may require significant floor space and a high volume of airflow to keep it cool. Don't order a power source before you consult with your facilities manager and make him or her aware of the floor space requirements and cooling requirements.

How are you going to control the power supply?

There are many different ways to control a power supply. Many are controlled manually. If you plan to control yours this way, ensure that the front panel interface is intuitive and easy to use. A good example of an intuitive front-panel user interface is found on AMETEK's Asterion line of power sources.

Analog control is also available on many power sources. While these days, computer control is usually the preferred method of controlling a power supply, many AMETEK Programmable Power products, such as the Sorensen SGA Series still offer analog control. Analog control is still used in many industrial applications, and it's also a good choice if you have fairly simple control needs.

For computer control, you can choose between Ethernet LXI, USB and RS232 interfaces. The interface you choose will depend on many different factors including the interfaces that you already use in your company, the data transfer rate required, and other factors.

Conclusion

Answering these questions will help you choose the power source that's right for your application:

- What do you want out of your power supply?
- What is regulation and distortion?
- What are you going to feed the power supply?
- Where are you going to put the power supply?
- How are you going to control the power supply?

For more information on how to choose the right power source for your application, contact AMETEK Programmable Power by sending an e-mail to sales.ppd@ametek.com or phoning **800-733-5427.**

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