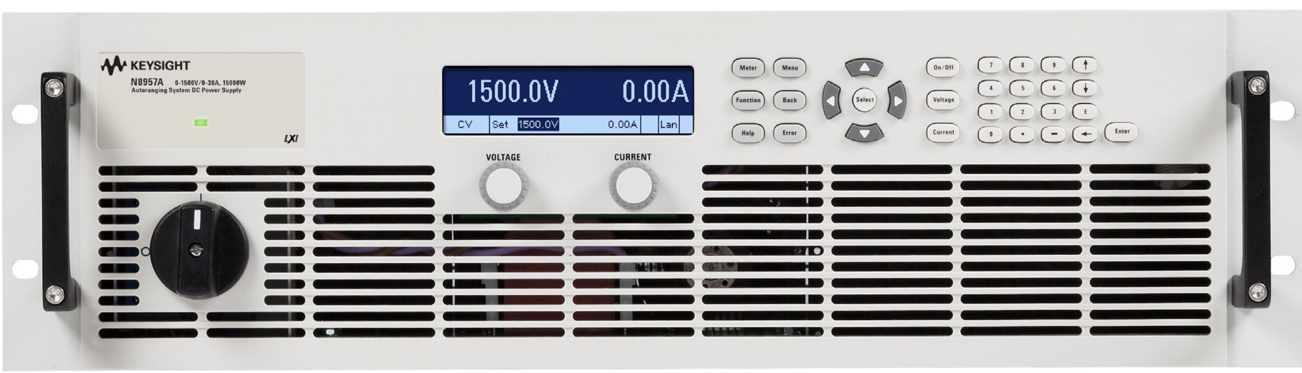
Keysight Technologies
5 Tips to Help You Master Your High-Power Test Environment

Application Note



KEYSIGHT TECHNOLOGIES

Electronic devices are increasingly power hungry. Consumers are demanding more functionality and features from everyday electronics. To meet this demand, engineers build devices that do more than ever before, and their devices consume more power to fuel the new capabilities. You can see evidence of this trend in the emerging popularity of electrics cars and the growing market for high-power DC-to-DC converters that are used in data centers, transportation, and communication systems all over the world.

As the power capabilities of devices increase, the power required in test environments must also increase. You are likely to need higher power in your DC power supplies for a wide variety of high-power test applications such as high-power DC-to-DC converters, batteries, uninterruptible power supplies, electric vehicles, and more. If you are working in a high-power environment, you face different challenges that require more expertise than you may have needed when you worked in a low-power environment.

This application note offers tips to help you be successful in a high-power test environment.

Tip 1

Use one tool for many jobs: The magic of autoranging DC power supplies

A basic rule of thumb: as the output power increases in a DC power supply, so does the price. In general, a power supply capable of high power will be more expensive than a power supply in the same performance class that is rated at a lower power level. For test engineers, this means the cost of test becomes higher in high-power test environments. A power supply that can perform multiple jobs is a valuable asset in the high-power test environment, as it is cost effective and reduces the number of instruments you need overall.

For a DC power supply, the ability to do many jobs means it needs to produce a wide range of voltages and currents with a single output. Applications that require many voltage or current combinations, such as the testing of DC-to-DC converters, would typically require many fixed-range power supplies or a very-high-power fixed-range power supply. Fixed-range power supplies have output characteristics shown in Figure 1.

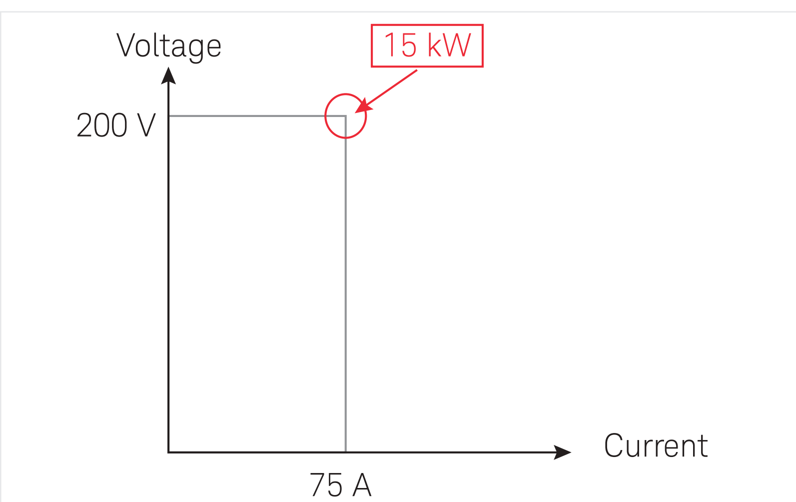


Figure 1. Output characteristics of a fixed-range power supply

Fixed-range power supplies have a maximum voltage limit and a maximum current limit, which together create an output with a rectangular characteristic. Another class of DC power supplies offers multiple ranges with output characteristics shown in Figure 2. These DC power supplies are characterized by an output characteristic that resembles multiple rectangles with slight overlap.

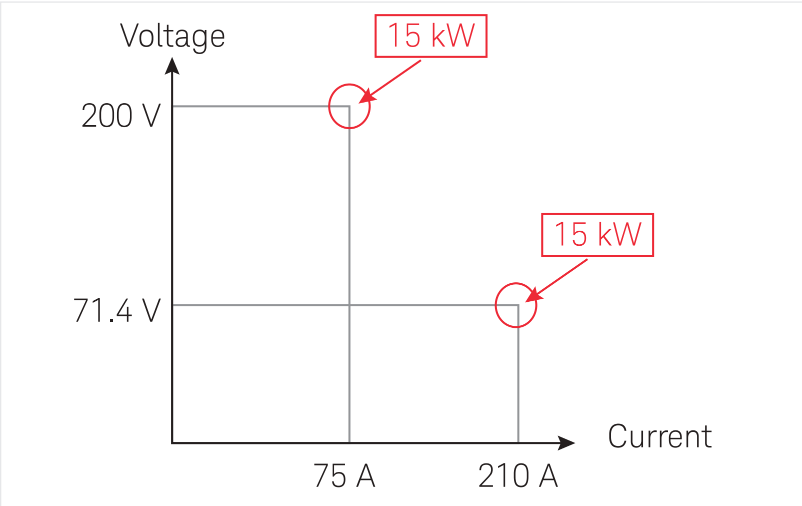


Figure 2: Output characteristics of fixed range power supply with multiple ranges

The most advanced type of DC power supply will have an autoranging characteristic. The output characteristics of an autoranging power supply are characterized by a concave curve as shown in Figure 3. The output power level is constant anywhere on the autoranging power curve. The curve is actually constructed by multiple rectangular output curves between the maximum voltage limit and the maximum current limit. Autoranging allows you to achieve a much greater set of voltage and current combinations compared to that of a fixed-range DC power supply. Hence, by using a single autoranging DC power supply, you eliminate the need to purchase and use multiple fixed-range DC power supply. This model is not only cost effective, but efficient as well. By using a single autoranging DC power supply to take the place of multiple fixed-range DC power supplies, you can accomplish many tasks with a single tool.

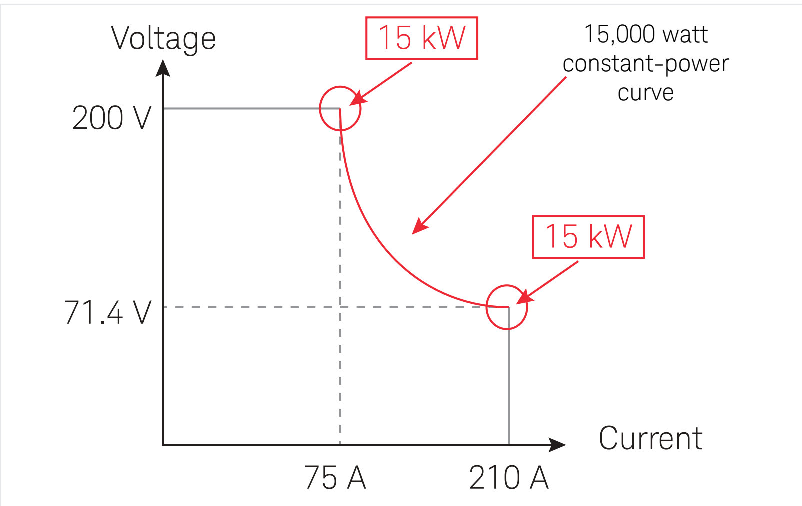


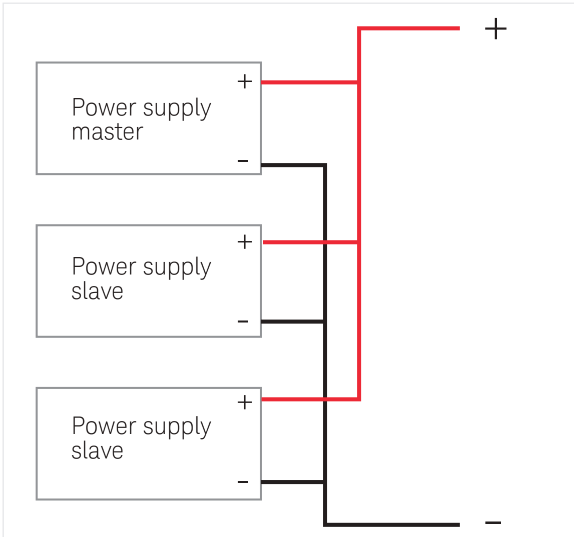
Figure 3: Output characteristics of an autoranging power supply

The Keysight N8900 Series 5-kW, 10-kW, and 15-kW autoranging DC power supplies offer this autoranging output capability, which enables unprecedented flexibility by offering a wide range of voltage and current combinations at full power. Just one N8900 does the job of multiple power supplies. It's like having many power supplies in one.

Tip 2

More is better: Getting higher power via parallel operation

No matter how much power a single-output DC power supply can deliver, there is always a demand for higher power, especially in today's high-power test environment. To achieve higher output current, you can connect two or more power supplies in parallel, as shown in Figure 4. Connecting multiple supplies is a common practice if your high-power tests require 10s and even 100s of kilowatts. With high-power test requirements, it is important to choose power supplies that provide a simple platform and control for parallel configurations.



There are a few features that make parallel configurations simple. One of those features is a group connection that allows for master/slave configuration across multiple DC power supplies of the same model. In a parallel configuration, one of the power supplies is designated as the master and all the others are slaves. A second feature that simplifies a parallel configuration is current sharing, which ensures that all power supplies connected in the same parallel configuration share the total amount of output current equally. This feature ensures no single unit is putting out the majority of the programmed current. A third feature to look for is the ability to control multiple power supplies in a parallel configuration as a single unit. This means you could simply program voltage, current, and other setting as though the entire parallel network is a single power supply, which is efficient and saves you time.

There are also physical features that make a big difference in parallel operation. The size and height of a power supply becomes extremely important once we have a system of multiple power supplies. It's important to choose power supplies that have a high power density, which means a high power rating while being physically small in size. Another physical characteristic is the stack-ability and location of air vents. Almost all DC power supplies have air vents that dissipate the heat from inside the instrument. When you are using power supplies in a system rack, it is ideal to have side vents in the power supplies , which means they can be stacked on top of each other without the air vents being blocked. This maximizes space in a system rack, which quickly becomes crowded when we add more power supplies in parallel.

The Keysight N8900 autoranging DC power supply features a built-in master/slave parallel configuration feature which makes it very easy to achieve higher power with multiple units of the same model. This feature groups all paralleled power supplies together in such a way that enables programming as if it is just one big power supply. The master unit even displays the sum of the actual current values on all the power supply units in the parallel configuration so you can see the current reading of the overall system rather than per individual unit.

Tip 3

Safety first : Safe operation in a high-power test environment

When working in a high-power environment, it is critical to take extra safety precautions to ensure the operator, device under test, and test equipment are properly protected. Operator safety is the most important issue, and there are extra precautions you can take to ensure safety. Reliable high-power DC power supplies often offer features and functionalities to maximize safety. It is essential to understand these safety features and use them during any operation. Below are examples of these various safety features and functions.

Safety covers

Most power supplies come with a set of safety covers that attach either to the AC input or the DC output. These safety covers are intended as a safety mechanism so you don't accidentally make contact with the input or output terminals. It is critical that safety covers are used at all times while operating a high-power DC power supply, whether the output is enabled or disabled or whether the power supply is powered on or off.

Front-panel lockout

In power supplies such as the Keysight N6700, N5700, N6900 and N7900 Series, there is a feature that locks the front panel of the power supply. This front-panel lockout feature, though not obvious at first, is a safety feature designed to protect the device under test. It's common for a DC power supply to have multiple operators. In certain testing operations, the output of a power supply must be maintained at a specific level, with any deviation at the output being a potential threat to the device under test. What this means is that an operator would want to prevent another operator from making changes on the front panel intentionally or unintentionally pushing buttons and causing a change at the output and damaging the device under test connected to it. The front-panel lockout feature acts as a safety feature to prevent this from happening.

Turn-on state

When a power supply is switched on, the output is typically disabled as the default turn-on state. This may be a minor point, but it is worth mentioning, as it does play a role in the overall safety. If a power supply is switched on with the output disabled, the operator has a chance to review the output settings before enabling the output. This extra step adds an extra layer of protection, especially if a device under test is connected to the output. So ensure the turn-on state is properly set when operating a power supply. You can usually do this via the front panel of the instrument.

Over-voltage and over-current protection

When you work with high power, it is important to choose a DC power supply that can protect the device under test when the voltage or current level exceeds a certain safety threshold. When the output exceeds a certain voltage or current level the power supply must be able to recognize this event and properly disable the output. Over-voltage and over-current protection are two common features that can do this. It is critical to use these two features when working with high power. Over-voltage protection protects the device under test when the power supply exceeds the preset voltage limited. You can determine this preset voltage and program it on the front panel. When the output of the power supply exceeds the preset voltage limit, the output will be disabled and an over-voltage indicator will show up. By default, over-voltage protection is typically always turned on unless you specify otherwise. On most power supplies, it's shipped in that state as default from the factory. Make sure to set and turn on your over-voltage protection limit as a safety feature in your test setup.

Power supplies also have an over-current protection feature that works in a similar manner. Instead of monitoring voltage, over-current protection monitors the current that flows out of a power supply and disables the output if the current exceeds a certain present threshold. It does this in a slightly different way than that of over-voltage protection. The preset over-current protection limit is the current limit setting itself. Once the current flowing through a power supply reaches the current limit setting, it enters into a constant current operating mode. In constant current mode, the voltage usually goes down and the current is held at the current limit setting. If over current protection is enabled, it will shut down the output to prevent too much current from flowing out. Typically over-current protection is turned off by default and it is in that state when shipped from the factory. When necessary, make use of the over-current protection feature to safeguard your setup.

Remote shutdown

Remote shutdown is a safety feature that shuts down a power supply in response to some particular operating condition. When working with multiple power supplies in a system, you can link together the remote shutdown terminal of all the power supplies. Under this setup, when a single power supply experiences a shutdown event, all the power supplies shut down as well. This is a safety feature to protect both the operator and the device under test. Almost any operating condition can trigger a remote shutdown. For example, to generate a remote shutdown when the power supply generates a voltage that is too high, enable over-voltage protection mode and program the unit to activate remote shutdown when over-voltage protection is detected. If an over-voltage event does happen, it will shut down the power supply that triggered the event as well as all the other power supplies connected on the remote shutdown line.

Tip 4

The right connection: Wiring + remote sense

A high-power environment will require the use of thicker and heavier wires to conduct the higher level of current that will go through the wires. Wires are not perfect conductors, and they always introduce a certain amount of resistance to the overall setup from the power supply to the device under test. Wire resistance limits a power supply's voltage regulation abilities. A power supply's regulation sense terminals are typically connected to the output terminals. This means if you program 5 V on the power supply, the voltage regulation circuitry will ensure that there is 5 V at the sense terminals. In this case, it is directly at the output terminals. However, the device under test is typically not directly at the output terminals. Usually there is a set of wires, called force leads, which connect the output terminals to the input of the device under test. In a high-power test environment, these long and heavy wires mean more resistance on the force leads, which as a result, create a voltage drop on the force leads. The longer the wire, the bigger the voltage drop will be. This causes the actual voltage at the input of the device under test to be drastically different from the programmed voltage setting on the power supply.

To work around this issue, it is typically beneficial to employ remote sensing when operating a power supply in a high-power environment. Remote sensing allows you to connect the sense terminals of the power supply directly to the input of the device under test. This means the power supply regulates its output at the input terminals of the device under test rather than directly at the output terminals of the power supply. In doing this, the power supply compensates for the voltage drop caused by the force leads in the setup. See Figure 5 for remote sense setup.

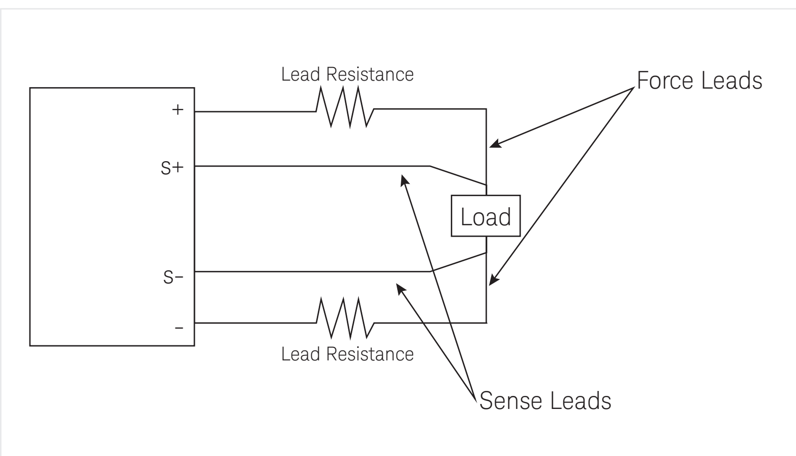


Figure 5: Remote sense setup

In addition to remote sense, choosing the right wires to act as force leads and AC input leads is critical to a safe high-power operating environment. Wires of different gauges have different current ratings. It is important to choose the right wire for job. See Figure 6.

AWG	Nearest metric size	Ampacity1	Resistance2
12	4 mm2	Up to 30A	1.59
10	6 mm2	Up to 40A	1.0
8	10 mm2	Up to 60A	0.63
6	16 mm2	Up to 80A	0.395
2	35 mm2	Up to 140A	0.156
1/0	50 mm2	Up to 195A	0.098
2/0	70 mm2	Up to 225A	0.078
3/0	95 mm2	Up to 260A	0.062
4/0	120 mm2	Up to 300A	0.049

Note 1. Ampacity is based on a single conductor in free air, 26-30 °C ambient temperature, with the conductor rated at 60 °C. Ampacity ratings decrease when wires are bundled an at higher ambient temperatures.

Note 2. Resistance is in ohms/1000 feet, at 20 °C wire temperature.

Figure 6: Current ratings for wires of different gauges

Tip 5

Don’t work hard, work smart: Use the smarts to make the job easier

When working in a high-power environment, it’s important to use the available technology onboard your test and measurement equipment to make any job easier. Power supply technology, in particular, has progressed drastically over the past many decades. The power supplies available today are no longer just a battery with a knob. Today’s power supplies have advanced measurements, protections, triggering, etc., which enable a power supply to do so much more than just sourcing power. One of those features is the ability to save and restore settings. When operating a power supply over the front panel, it’s often tedious to have to enter the settings (such as voltage, current, OVP, and so forth) over and over again when the power routinely is cycled, especially if the required setting are the same at each run. It would be much more time efficient to be able to load up a preset state and then from there make any changes necessary. Advanced power supplies like the N8900 autoranging DC power supply have a feature called save/restore that enables you to save the existing operating settings and state into nonvolatile memory. When the power is cycled on the power supply, you can simply load the saved settings and state with one step and bypass the need to manually input all relevant settings. Over many cycles, this feature is a time saver.

Another area of technological advanced in power supplies and test equipment in general is how the operators talk to it. Many decades ago, the analog knobs on the front panel were the only way to communicate with the instrument. Today, you have a choice of front panel or remote operation. The front panels of power supplies have sophisticated keypads and displays. On the remote operation front, you typically have a choice between LAN, USB or GPIB. Power supplies like the Keysight N8900 autoranging power supplies offer all three options. They are LXI compliant, which means they offer a graphical web interface to communicate with the instrument as well. Some instruments also offer digital and analog ports as communication input and outputs. These ports could be used as triggers, analog programming ports, measurement ports, and so forth. Test conditions change continuously, so having flexible and diverse communication interface and options is critical for an instrument to create to successful test environment.

Conclusion

Testing in a high-power environment introduces a set of new challenges. Identifying the necessary features and functions in your equipment is critical to the success of your application. When it comes to power supplies, choose one with the necessary capabilities and safety features to meet your testing needs.

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