FOUR TIPS TO

Protect Against Power-Related Damage

KEYSIGHT TECHNOLOGIES

Avoid Damaging Devices and Equipment

Extra care is necessary when working with devices that use higher power, are reactive or simple store energy. These devices are notorious for damaging themselves and the surrounding equipment. Fortunately, modern bench power supplies can protect against this damage. Learn how to protect your power supply and devices with these four power supply tips:

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Four Tips to Protect Against Power-Related Damage

TIP 1

Protect Your Device Against Overpower

OVERPOWER

TIP 1

Protect Your Device Against Overpower

Overvoltage and overcurrent protection work well for protecting a device that has a single maximum voltage and current. Some devices' max current changes with voltage. A good example is a DC-to-DC converter, as its input can accept a range of voltages, and it provides a regulated voltage output. Every DC-to-DC converter has a max power rating. An increase in voltage will cause the max current to decrease. For example, take a 12 V to 19 V / 2 A converter that can handle a 9 V to 18 V input.

A power supply can test the input 9 V to 18 V, but the max current limit needs to be set independently for each voltage step, A current acceptable with a 9 V input would be damaging at 17 V, so the current limit needs to vary with the input voltage (Table 1). The max input power is set at 50 W to handle the inefficiencies and transient currents.

Step	Voltage setting (V)	Current limit (A)	Power calculated (W)
0.	9	5.6	50
1.	10	5.0	50
2.	11	4.5	50
3.	12	4.2	50
4.	13	3.8	50
5.	14	3.6	50
6.	15	3.3	50
7.	16	3.1	50
8.	17	2.9	50

Table 1. Reducing the maximum current as voltage increases protects the converter from overpower

Power supplies, like the Keysight E36200 series autoranging power supply, support output LISTs. Output LISTs allow you to vary the output with a series of steps. Each step defines a voltage-current combination along with a dwell time and synchronizing triggers. A dwell time holds each step for the specified period before advancing to the next step.

With the power supply powering the converter in our example above, the output of the converter powers a 19 V, 2 A load.

Output 1 – Output LIST

Step	Voltage	Current	Time	BOST	EOST
0	9.000	5.556	1.000	☑	☐
1	10.000	5.000	1.000	☐	☐
2	11.000	4.545	1.000	☐	☐
3	12.000	4.167	1.000	☐	☐
4	13.000	3.846	1.000	☐	☐
5	14.000	3.571	1.000	☐	☐
6	15.000	3.333	1.000	☐	☐
7	16.000	3.125	1.000	☐	☐

Run Stopped | Add | Delete | Clear All | Properties | Back

Figure 1. An output LIST is a series of steps with an individual voltage, current, and dwell time

The power supply measures the actual voltage and current for each step and logs it. To characterize your device, multiply the actual voltage and current values and see how the power consumption changes. For this DC-to-DC converter, the input power is 44.8 W with an 8 V input, and 43.3 W with an 18 V input. We now have an accurate picture of our convertor's performance.

LIST mode is useful for setting a series of voltage-current combinations and protecting a device from overpower.

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Tip 4: Dynamically Change the Output Using List Mode

TIP 2

Keep Your Power Supply Safe When Working with Energy Storage

ENERGY STORAGE

TIP 2

Keep Your Power Supply Safe When Working with Energy Storage

A bench power supply sources current out of its positive terminal. As shown in Figure 2, a bench power supply is a quadrant-one device. You can identify power supplies that operate in additional quadrants by their titles. Common names include multiple quadrant, bipolar, or source measure unit. They may also use an active dissipator.

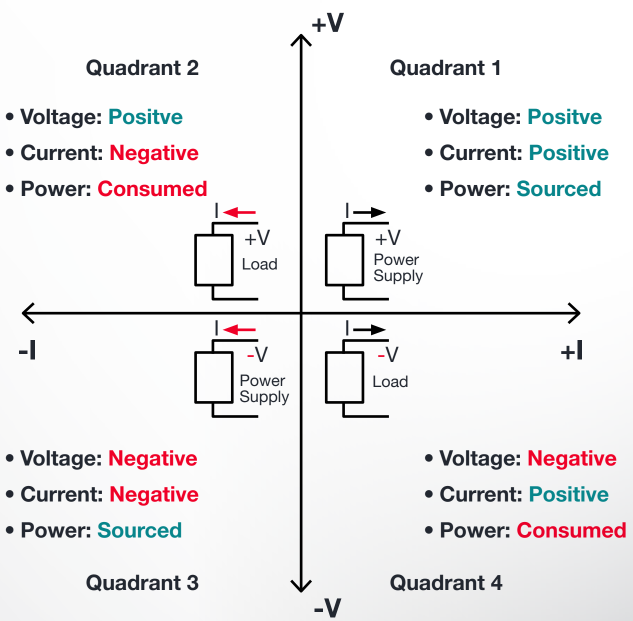

Figure 2. Quadrant map for power

Most bench power supplies use a direct connection from the internal power source to the outputs. This provides better control and eliminates the need for relays that have a limited lifetime. Since a bench power supply cannot absorb energy, it is essential to not force current into the supply from a second energy source.

Dangerous energy sources are devices like large capacitors, batteries, a second power supply, or other outputs from the same power supply. When charging a battery with a power supply, remove the charged battery from the power supply before reducing the voltage or turning off the outputs. A battery with a higher voltage than the power supply forces current into the power supply.

A simple fix is to add a diode to the power supply output when working with devices that store energy. However, make sure to account for the incremental voltage drop caused by the diode.

When using four-wire remote sense, the power supply's compensation circuit also needs protection from inbound currents. Connecting the remote sense wires behind a diode protects the power supply (Figure 3).

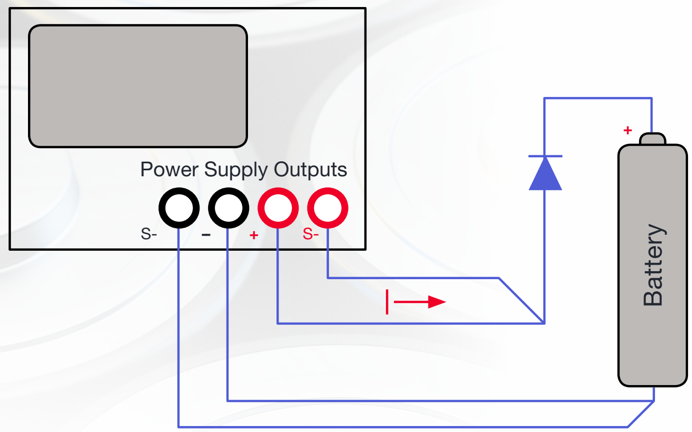

Figure 3. A diode ensures that current flows out of a power supply to a battery and not in the reverse direction.

Use extra care to keep your power supply safe when working with circuits that use multiple power supplies or have components that store energy.

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Video: Bench Power Supply low range current mode

TIP 3

Set Slew Rates to Reduce Inrush Current

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Set Slew Rates to Reduce Inrush Current

Variable slew rate controls adjust how fast a power supply can change from one voltage level to the next. Slowing the rate of voltage change reduces the rate that current flows into a capacitive device. Many devices have an input capacitor to help regulate voltage. Some devices have unintended capacitance based on their design or wiring.

For example, a sample incandescent automotive taillight has a high capacitance. As a result, it generates an inrush current that consistently burns out fuses. Figure 4 shows that the inrush current of 8 A is four times larger than the steady-state current. The 8 A inrush current occurs at 12 V. A higher voltage causes a more significant peak. It is not uncommon for an automobile to run at 14 V.

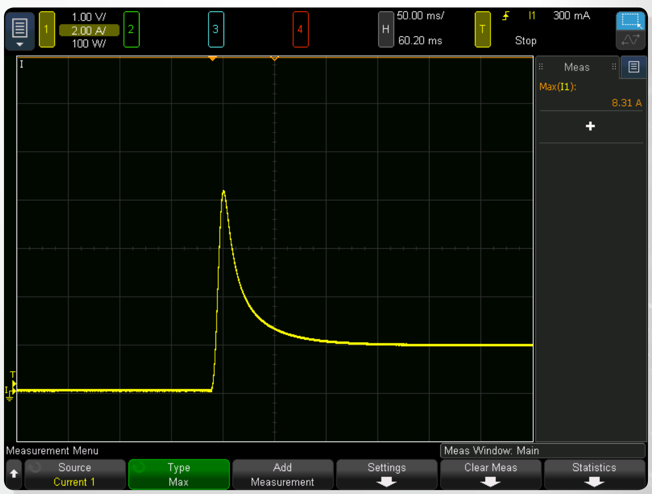

Figure 4. Shows the inrush current to an automotive taillight

Using the E36200 series slew rate control to slow the rate of change to 100 V/s cuts the peak current in half, as shown in Figure 5. At 10 V/s, a peak current is negligible, as shown in Figure 6.

Figure 6. The variable slew rate of 10 V/s eliminates the inrush current

Slew rate control slows the voltage change when the voltage is rising or falling. In our taillight example, with a slew rate of 10 V/s, you can visibly see the brightness increase as it takes more than a second to reach 12 V. Using a slew rate of 100 V/s does not cause a visual change but reduces the inrush current by 50%.

Modifying the slew rate controls allows you to both protect your device from excess inrush current and set acceptable inrush current tolerances for your devices.

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Video: Measuring Settling Time with a Power Analyzer

TIP 4

Use Delayed Overcurrent Protection to Allow Normal Operation

OVERCURRENT

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Use Delayed Overcurrent Protection to Allow Normal Operation

Once you have set up a power supply to output the correct voltage, establishing a current limit protects the device. Power supplies have multiple ways to limit current. The most common method is to set a current limit and have the power supply switch from constant voltage to constant current mode. You can review constant voltage and constant current mode in Tip 1 here: 4 Ways to Build Your Power Supply Skill Set. When operating in constant voltage mode, a power supply outputs the set voltage. If the device reaches the current limit, the power supply switches to constant current mode, outputting the max current. If the device returns to using less current, the power supply will return to constant voltage mode. In Figure 7, the device continues to pull current until the power supply switches to constant current mode. Operating a device at its max current rating typically generates excessive heat and can reduce the life of the device.

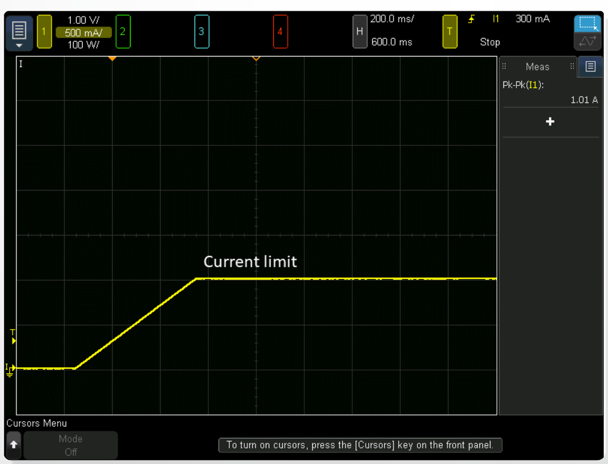

Figure 7. A device using increasingly higher current until the power supply switches to constant current mode

OVERCURRENT

A second, protection method is to use overcurrent protection (OCP), which shuts down the output when the device pulls too much current, as shown in Figure 8. Shutting down the device avoids generating excessive heat in the device.

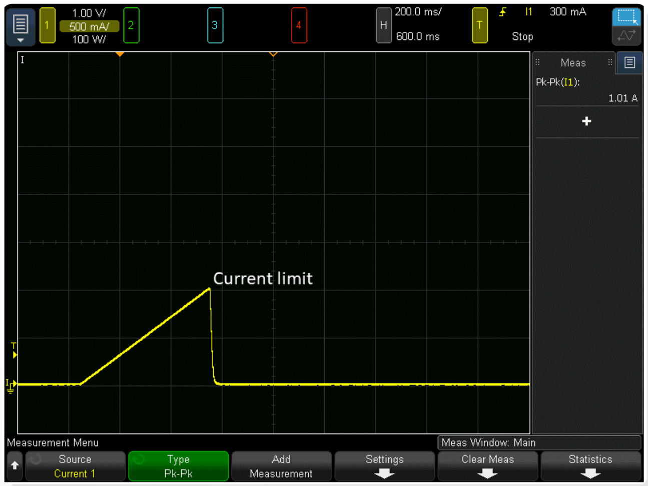

Figure 8. Overcurrent protection shuts down the output at the current limit

In a situation where a current spike is part of regular operation, delayed OCP will keep the power supply in its two normal operating modes: constant voltage and constant current. When using delayed OCP, there are two possible outcomes. The first is that the device draws less than the max current for the specified time and the power supply returns to a constant voltage mode (see Figure 9). The second possible outcome is that the device requires the max current for longer than the specified time, which disables the outputs (see Figure 10).

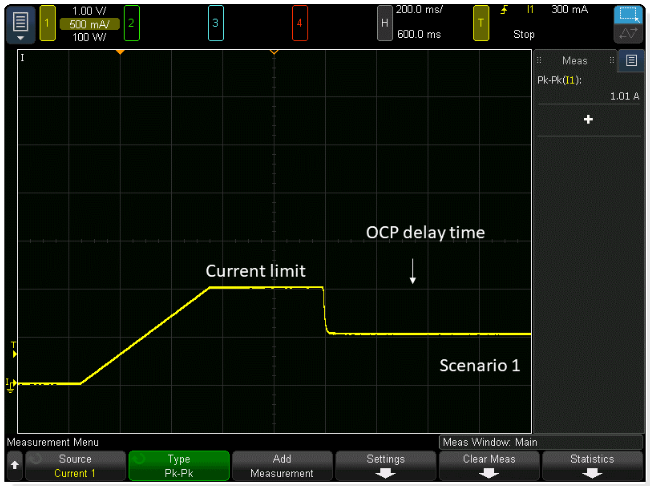

Figure 9. In scenario 1, the power supply returns to constant voltage mode before tripping the delayed OCP

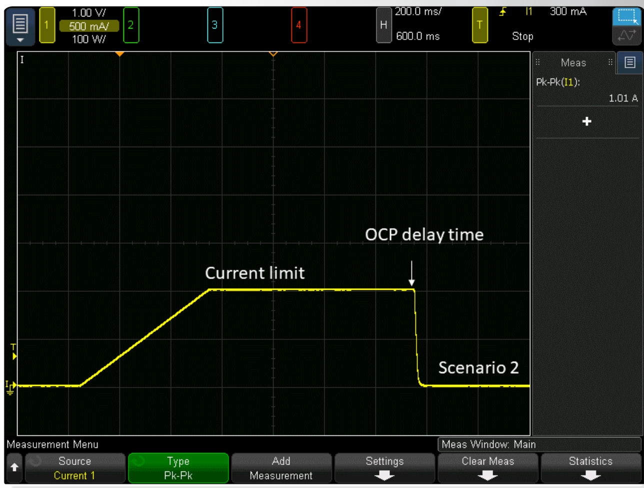

Figure 10. In scenario 2, the load continues to draw the max current, tripping the delayed OCP

Delayed OCP takes advantage of limiting the current by switching to the constant current mode and restricts the amount of time that the device can draw the max current, which limits damage from overheating.

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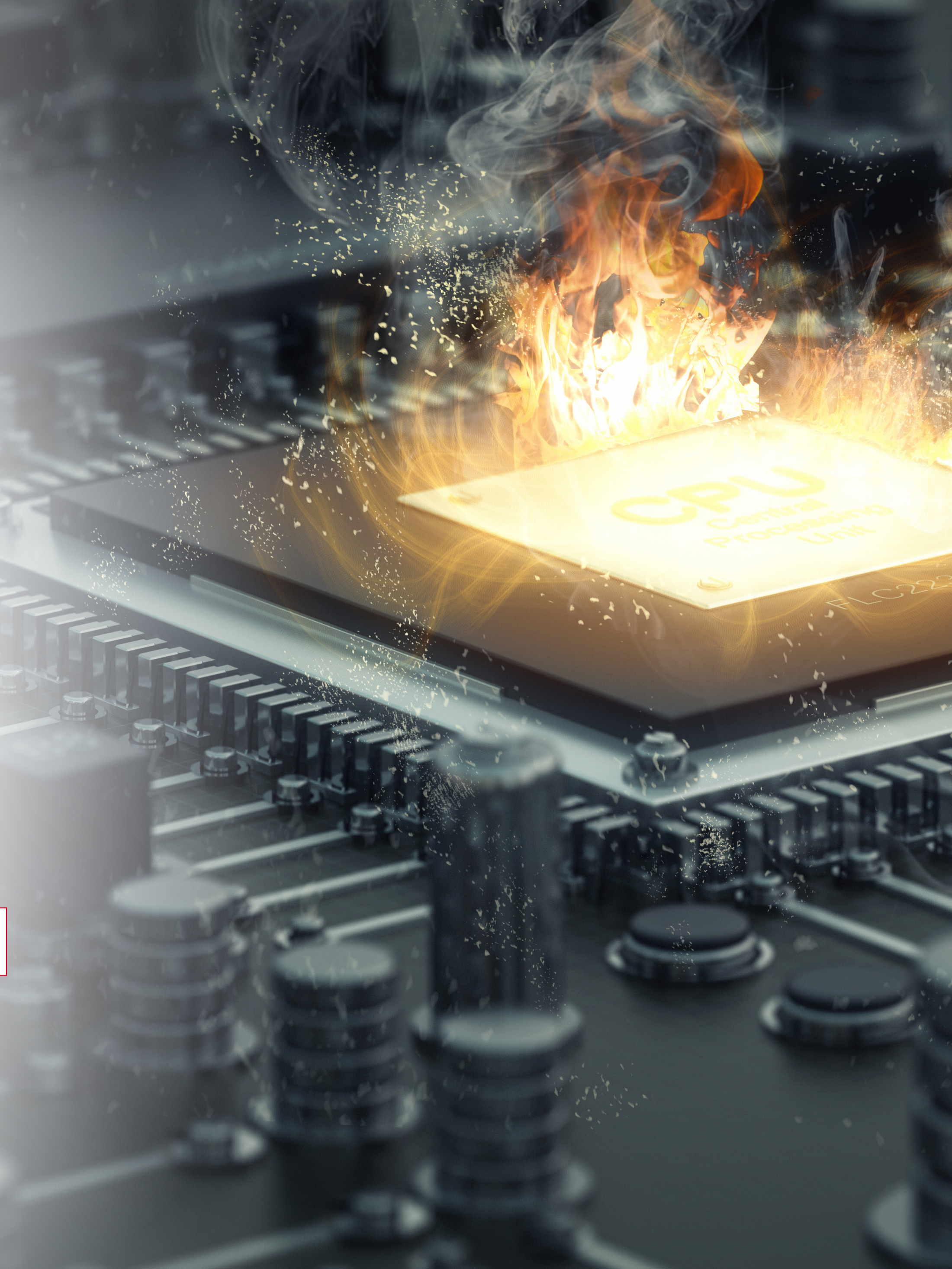
Tip 1: Understanding CV and CC



WANT TO LEARN MORE?

Get the Power Supply Selection Guide

Whether you need a basic power supply or more sophisticated features for specific applications, this guide helps you select the right power supply for your needs. Start by choosing a power supply form factor that meets your needs. Bench power supplies should be small but have large, bright displays and front-panel connectors. The shape of system power supplies minimizes the use of rack space, but their extended depth and loud fans do not belong on a bench.

Key capabilities for a bench power supply

Bench power supplies feature a large display, making it easy to monitor voltages and currents on each channel quickly. They output clean DC power with low noise and independent isolated channels to minimize ground loops. Device protection needs to include both overvoltage and overcurrent protection. A bench power supply is often powering a device most of the day and needs to be acoustically quiet on the bench, making it easy to live with.

What about built-in features?

Newer, high-performance power supplies provide convenient built-in features to eliminate the need for additional equipment, such as a scope, a multimeter, or a second power supply. For example, some power supplies come with built-in multimeter level accuracy, dataloggers that can capture power transients, or even auto-series to cover voltage-current combinations that previously required multiple power supplies. Specialized power supplies may include sophisticated features such as dynamic current characterization or the ability to source and synchronize current.

Get the connectivity you need

Newer power supplies often allow data transfer with a USB thumb drive. More advanced control is available via USB, LAN, or GPIB. Keysight's BenchVue software makes it easy to capture, control, and synchronize multiple instruments.

GET THE POWER SUPPLY SELECTION GUIDE

Selection Guide: *Power Product Solutions*

Check out our 200 W and 400 W E36200 series autoranging power supplies:
http://www.keysight.com/find/E36200