Keysight Technologies

Protect Against Power-Related DUT Damage During Test

Application Note

Overview

If you want to meet your delivery and budget goals, it is important to protect your devices against damage during test, especially for high-value aerospace/defense and automotive devices, but also for any devices that are time consuming and costly to replace. When the risk of device damage is of significant concern, test planning should include strategy and equipment that can help to reduce such risk. Choosing a power supply with extensive integrated protection features is the best way to avoid power-related damage to your DUT and to reduce test-system development investment by minimizing overall system hardware. In this application note, we will look at how the extensive protection features of the new Advanced Power System from Keysight Technologies, Inc. can protect your DUT from costly damage.

Problem

Controlling power supply output voltage and current to avoid overstressing the DUT under fault or near-fault conditions requires a rapid and effective response to a variety of situations. The primary causes of DUT failure are over-voltage and over-current events, some of which are very short duration while others endure until they are discovered.

An over-voltage or over-current event can occur for a variety of reasons, including:

- Internal circuit failure can cause the output voltage to rise to an undesirable level
- More than one power source, such as another power supply or battery
- Open sense-lead connection
- Local voltage sensing rather than remote sensing
- System controller failure or programming error
- Failure of a power supply operating in constant voltage mode in parallel with one or more power supplies operating in constant current mode
- Countering an over-voltage condition by shorting the power-supply output terminals, leading to a discharging current surge from the DUT
- Large DUT inrush current
- Excessive current caused by overloading of the DUT
- Excessive current related to imminent or actual DUT circuit failure
- Test system wiring short circuit

Protecting against excessive voltage and current

Protecting the DUT from excessive or inadequate source voltage and current can be accomplished with a power supply that has extensive protection features and has an advanced triggering system.

Protecting against over-voltage (OVP) conditions

Programmable remote-sensing OVP with broken and reversed sense- lead detection and with orderly and controlled power-supply output shutdown can help protect a DUT from the application of excessive voltage.

Remote OVP sensing

A DUT drawing a significant current through long power leads with relatively high resistances can generate large voltage drops on the leads. Without remote sensing, obtaining the required voltage at the DUT may require adjusting the output voltage of the power supply to compensate for the voltage drop in the test leads when the device draws maximum current. If the current drawn by the device is interrupted or significantly reduced, a higher-than-acceptable voltage may result. Remote sensing OVP provides configurable over-voltage protection based on sense-lead voltage. Having the OVP circuit monitor the sense -lead voltage rather than the output terminal voltage allows for more precise voltage monitoring directly at the load. A local OVP function provides additional protection. It tracks the programmed OVP setting and trips if the voltage at the + and - output terminals rises more than 1 V + 10% of the unit's voltage rating above the programmed OVP setting.

Broken or reversed sense-lead detection

If remote sensing is enabled by connecting the power supply sense terminals to the DUT at the point where the power leads are connected, it is important to ensure that the sense lead connections are valid. If one or more sense leads are loose or broken and no form of sense protection is available, the voltage at the DUT can potentially rise to unexpected and potentially damaging levels. To protect against the loss of remote voltage sensing, Keysight Advanced Power System (APS) power supplies check for open leads on one or both of the sense wires prior to output turn-on and while the output is on. Continuous sense- lead detection enables the power supply to react to a sense signal interruption while testing is in progress. The unit responds with a fault condition in about 50 microseconds. In addition to detecting open sense leads, the power supply's sense fault-detection feature will disable the output if the sense leads are accidently shorted or if the leads are connected in reverse. Note that it is still important to make sure the sense wires are connected properly, as the protection feature cannot detect miswired sense leads without enabling the output, which briefly subjects the load to unintended voltages.

This feature can be disabled if it creates objectionable disruptions at the DUT or if the lead configuration or load dynamics cause the system to falsely trip. If an APS power supply's sense fault-detection feature is not enabled, and one or both sense leads are not connected prior to turn-on or they become disconnected, the power supply will continue to operate. The voltage at the output terminals will be approximately 1% higher than the programmed value.

Orderly and controlled output shutdown (without crowbar)

For some DUTs, a rapid shorting of the output of the power supply with a crowbar will be a sufficient or the only viable method of protecting from an over-voltage condition. For other DUTs, a more controlled over-voltage protection approach is necessary. The design of the APS power supplies' power output stage allows the output to be turned off to facilitate an orderly and controlled shutdown. Disabling the power supply output, rather than shorting the output stage with a crowbar, may help protect some types of DUTs from damage. Shorting the power supply output may draw an excessive and damaging surge current from the DUT if it retains a significant charge when an over-voltage condition is detected and acted upon.

If the power supply is not in an over-voltage or over-current protection state, and the power supply voltage must be quickly reduced to protect the DUT, the ability to sink current can bring the voltage down rapidly by drawing a current of up to 10% of the supply's rating. For a faster reduction in voltage, you can add an optional external power dissipater that has the ability to draw up to 100% of the power supply's current rating. You can program both the internal load and the external dissipater to the required current level.

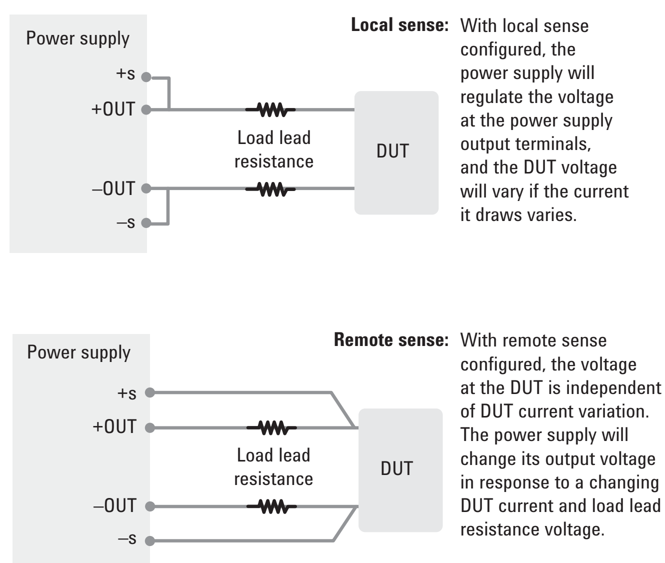

Figure 1. Local versus remote OVP sensing

Protection against over-current (OCP) conditions

Over-current protection (OCP) helps protect a DUT from excessive current draw. In the APS power supplies, the function is user-programmable and can be enabled or disabled. When enabled, the output will be disabled when the output current reaches the current limit setting. If the DUT draws—or is expected to draw—momentary surge currents that would exceed the limit setting, the onset of over-current protection can be programmatically delayed from 0 to 0.255 seconds to avoid nuisance tripping.

Figure 2 shows a screen from an APS power supply where a load current is rapidly increased from 0 to 12 A. With the current limit set to 5 A and with OCP enabled, The APS power supply output is disabled in less than 500 µs and the output current returns to zero.

Figure 3 compares over-current protection and settling time for a basic power supply (top trace) and an APS power supply (bottom trace). The APS model is an order of magnitude faster.

Responding quickly to rapidly changing conditions

Real-time monitoring and fast response in the event of a fault condition are essential for a power supply to help protect the DUT. When a current or voltage applied to a DUT reaches an unacceptable condition or falls out of a predetermined operating window, immediate action may be required. APS's real-time monitoring coupled with its triggering system permits a more rapid response than external instrumentation—such as a current shunt, voltmeter, cabling and controller—can provide.

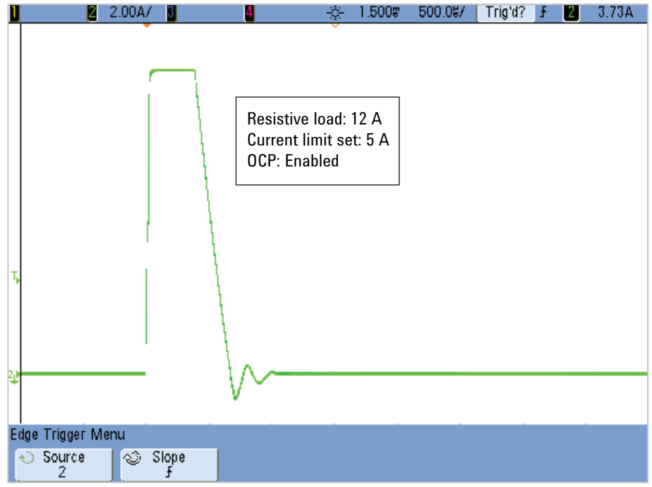

Figure 2. APS power supply over-current protection disables output

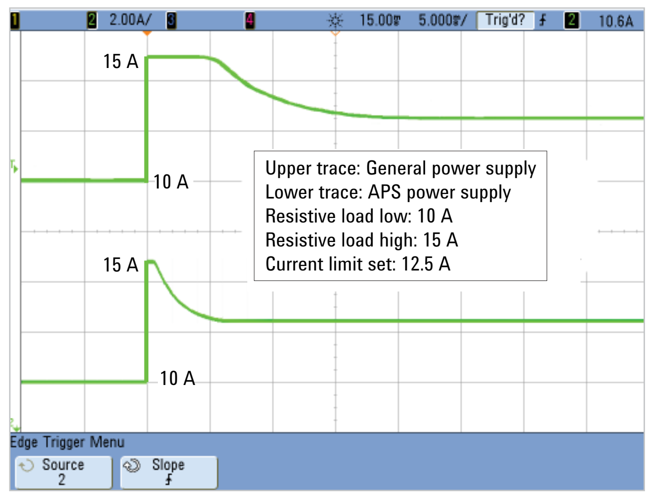

Figure 3. Current limit comparison – upper trace is a general system power supply, lower trace is an APS power supply

Protecting against the loss of controller-to-power-supply I/O

When the safety of a DUT is linked to the operation of an application running on an external controller and the application or controller ceases to properly function, you can use the APS power supply's output watchdog timer to help protect the DUT. In complex devices under test where the function performed by the DUT may be time dependent and the parameters of the test system power supply must be adjusted to match, a malfunctioning application or controller may cause harm. The watchdog timer can help to mitigate the effects of such a malfunction.

The output watchdog timer causes all outputs to go into protection mode if there is no SCPI I/O activity on the remote interfaces (USB, LAN, GPIB) within the user-specified time period. The watchdog delay can be programmed from 1 to 3600 seconds in 1 second increments. When an APS power supply is shipped from the factory, the watchdog timer is set to disable the outputs 60 seconds after all I/O activity has ceased. After the time period has expired, the outputs will be disabled. When a protection condition is entered as the result of I/O inactivity, you can use the APS power supply's smart triggering system to trigger other instruments or an alarm in the test system, if your system has an alarm, or perhaps shut down an entire test system if you enable it to do so.

The APS power supply's internal watchdog timer eliminates the need for a custom-built, standalone external or PC-based watchdog timer that monitors PC I/O activity. It also reduces test system design complexity and risk.

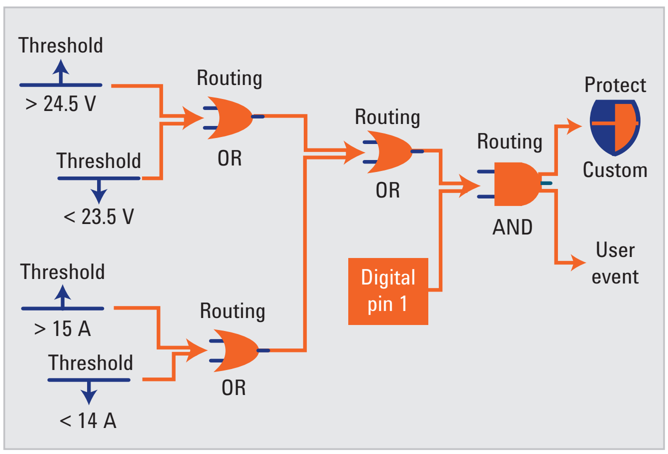

Figure 4. Smart trigger system example

Quickly interrupting test when conditions become questionable

The APS power supply's smart trigger system is designed to accept a trigger in and to send a trigger out. A trigger in can turn the output on or off, can cause a jump to a new setting for output voltage and current, and can start a measurement. A trigger out can initiate action by other instruments in a test rack. Using a combination of in and out triggers to control the power supply and to synchronize with the test system can help you protect your DUT. With APS power supplies, an array of signal inputs from status, trigger and digital port subsystems can be combined with Boolean operators AND, OR, NOT, and parentheses for grouping, to define a protect condition. Having access to real-time signals inside the power supply can result in faster reaction times to questionable test conditions compared to a system that depends on external voltmeters, ammeters, current shunts, and controllers for DUT protection.

Figure 4 shows an example of the APS smart triggering system that can provide a signal to initiate a user-specified event or a custom protection event.

Monitoring and acting on real-time events to protect the DUT

The APS power supply's advanced measurement and smart triggering systems can help you reduce test risk by offering fast reaction times and lower test-system complexity. To achieve a level of output control equivalent to the APS power supplies' would require a custom or discrete measurement system that includes a current shunt, one or more voltmeters, cabling, and a controller with software and drivers. However, the reaction to a fault condition with external measurement and control equipment would be slower.

When an internal trigger occurs during a test cycle, it can be critical to your DUT's safety for your test system to synchronize with or signal events to other test equipment. The APS power supplies have the ability to generate a trigger for an array of events internal to the power supply. Such events include a CV-to-CC state change, a transition of the output to a final value, and a change in the output measurement to a specific value that exceeds a predetermined threshold or falls outside of a specific window. Protecting a DUT is not always dependent on the activation of over-voltage or over-current protection. When a DUT should operate within a predetermined voltage and/or current window and the actual measured operating point falls outside of range or hits a specific value, it may indicate a malfunctioning device. To help protect the device, the power supply can generate a trigger to enter a protection state or to change voltage or current settings and to initiate an action by test-rack equipment such as other power sources and loads.

The APS family of supplies can interact with other equipment in a test rack and even the DUT if it is capable of accepting or generating a trigger signal. From a DUT protection perspective, if conditions in the DUT or other equipment in the test rack indicate an approaching condition that would be harmful, APS power supplies are capable of accepting a trigger that could turn the output on or off or change its output voltage and current settings.

Conclusion

To avoid damage to your DUT under fault or near-fault conditions, your power supply must respond rapidly and effectively to a variety of situations. Choosing a power supply with extensive integrated protection features is the best way to avoid power-related damage to your DUT and to reduce test-system development investment by minimizing overall system hardware. Advanced Power System power supplies offer real-time monitoring and a smart triggering system which provide a faster response than external instrumentation.

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(BP-09-23-14)

Published in USA, August 3, 2014
5991-3093EN
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