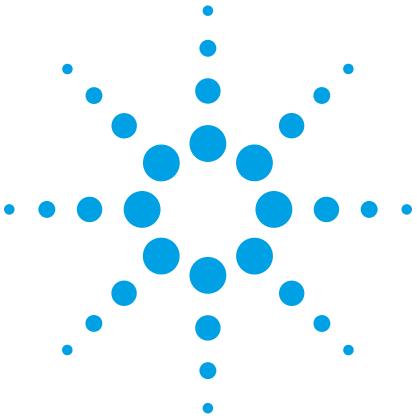
Avoid DUT Damage by Sequencing Multiple Power Inputs Off Upon a Fault Event



Application Note

Overview

There are many testing applications in which a device under test (DUT) is powered by multiple DC input voltages and the DUT is sensitive to the order in which those multiple power sources turn off. For example, individual assemblies used in satellites are especially susceptible to damage during uncontrolled multiple power source turn-off events, and these assemblies are very costly. One unexpected cause of power source turn-off occurs when a fault condition such as an over-voltage or over-current condition is detected on one of the sources that causes it to shut down. Having the ability to control the power supply shut-down sequence built into the power supply system itself can greatly reduce the effort and complexity associated with an external shut-down control method.

Problem

Some devices that are powered by multiple DC power supplies must have their power inputs shut down in a particular order to avoid problems with the device. Subjecting the device to an uncontrolled sequence could cause latch-up or excessive current to flow resulting in compromised reliability or even immediate catastrophic failure of the DUT. Under normal testing circumstances, the multiple inputs must be turned off in a particular sequence, often with specific timing between each input turning off. Additionally, following the detection of a power fault condition such as over-voltage, over-current, or over-temperature on one of the power supply outputs, it is also necessary to follow a similar shut-down sequence.

Creating a controlled shut-down sequence of multiple power sources is a challenging task, especially if it is in response to a fault condition on the power supply itself. A variety of methods have been tried, but each has its own set of issues as shown below.

Challenges with various power sequencing methods

Method	Issues
• Diodes between inputs as clamps	• Variable results • Limited effectiveness
• Relays in series with each input	• Imprecise timing • Introduces variable impedance
• FETs in series with each input	• Requires significant design time • Adds complexity to setup
• Software control	• Slow to respond • Imprecise timing

Solution

The best solution to the problem of providing controlled shut-down of multiple power inputs involves a power supply system that has output sequencing integrated into the system itself. Agilent Technologies offers two such systems that are strongly related to each other: the N6700 Modular Power System and N6705A DC Power Analyzer. The design of the N6700 system is optimized for use in a test system, while that of the N6705A is optimized for use on the bench. Each system can be loaded with up to 4 power supply output modules selected from more than 20 that are available in a variety of power and performance levels. Each system also offers the ability to precisely control the turn-off sequence of the 4 outputs making these systems an ideal choice for applications requiring controlled power input shut-down. Synchronization across mainframe systems is also possible to facilitate timed shut-downs of more than 4 outputs. Using these systems, a controlled shut-down under normal testing circumstances is extremely easy to implement, while doing so in response to a fault condition requires little incremental effort.

Sequenced shut-down under normal testing

These multiple output DC power systems have a Delay feature on each output that is used to delay the turn-off by the corresponding setting. The turn-off delay can be set to any time between 0 and 1.023 seconds in 1 ms increments. (Turn-on delay times are equally easy to set.) As an example, consider 3.3 V, 5 V, and 10 V sources required to shut down in that order all within 20 ms. Figure 1 shows the N6705A front panel screen used to accomplish this task (3.3 V is Output 3, 5 V is Output 1, 10 V is Output 2). Delay times are easily entered in milliseconds for each individual output. The Delay times are utilized any time the N6705A All Outputs On or All Outputs Off front panel key is pressed, or any individual output On key is pressed (toggles output on and off) when outputs are coupled with the Coupled Channels feature. (The Delay times are also active when the corresponding bus commands are used.) Figure 2 shows the outputs during turn-off using the N6705A built-in scope view.

Sequenced shut-down upon fault event

Outputs can be sequenced off as a result of a power supply fault event using the Delay time settings as well. A fault event is any of the following:

- Over-voltage
- Over-current
- Over-temperature
- Inhibit signal
- Power-fail condition
- Power-limit condition (some models)

For outputs to be included in the controlled shut-down sequence upon a fault, they must be coupled using the Coupled Channels feature. Note that this means all coupled outputs will turn off together (or on within the same mainframe) when an out off (or on) command is sent to any one of them. Also, the output experiencing the fault will turn off immediately, thereby ignoring its Off Delay setting.

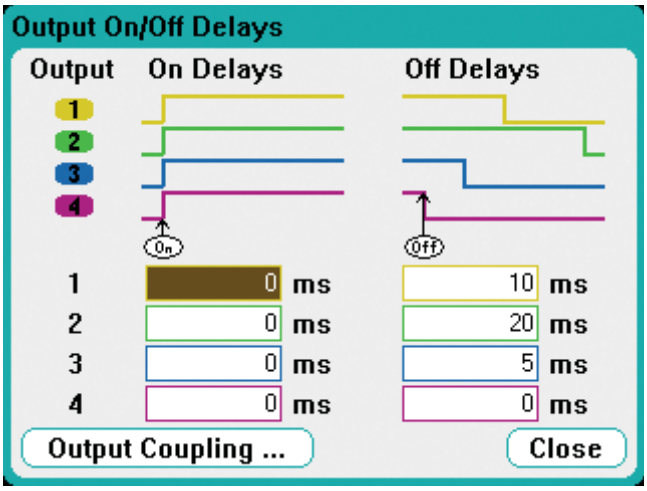


Figure 1. N6705A front panel screen used to set Output Off Delays.

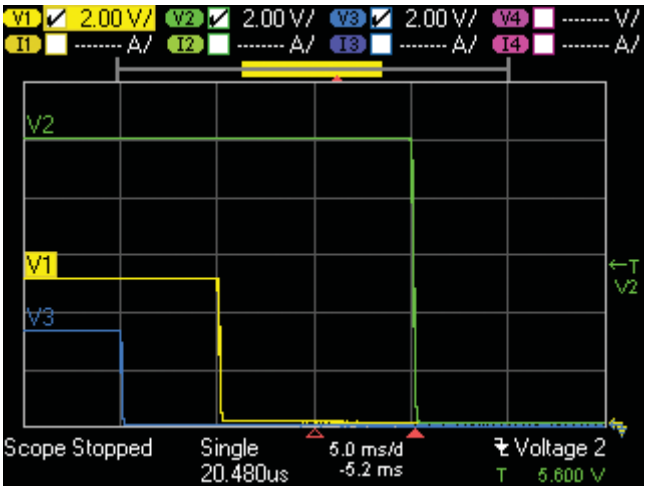


Figure 2. N6705A scope view showing sequenced turn-off of 3 power outputs according to Off Delay settings in Figure 1.

In order to accommodate this sequenced shut-down upon fault event, some additional rear panel wiring and configuration is necessary. See the required steps 1 to 4 in Table 1.

Table 1. Wiring and configuration steps 1 to 4 to produce a sequenced shut-down upon a fault event

	N6705A	N6700B*, N6701A*, N6702A*
Wiring		
1. Wire 8-pin digital port connector on rear panel	• Connect pin 1 (Fault Out – an output) to pin 4** (Off Couple – an input) • Connect pin 2 (Fault Common) to pin 8 (Common) (see Figure 3a)	
Configuration		
2. Set Dig I/O (non-volatile memory)		
From front panel... Key/menu selections:	Menu/Utilities/Digital I/O... /Pin Configuration	Menu/System/IO/DigPort
	Pin 1 settings: • Function: Fault Out • Polarity: Negative	
	Pin 4** settings: • Function: Off Couple • Polarity: Negative (Off Couple function forces Negative polarity)	
... or, over the bus: SCPI commands:	DIG:PIN1:FUNC FAUL DIG:PIN1:POL NEG DIG:PIN4:FUNC OFFC DIG:PIN4:POL NEG	
3. Set Output coupling (non-volatile memory)		
From front panel... Key/menu selections:	Menu/Source Settings/Output Coupling... /Coupled Channels	Menu/Output/Couple
	• Put a check mark in the box for each channel (output) that should be included in the shut down sequence • Other settings on this screen do not affect shut down	• Put a check mark in the box for Enable and for each channel that should be included in the shut down sequence • Other settings on this screen do not affect shut down
... or, over the bus: SCPI commands:	OUTP:COUP:CHAN 1,2,4 (couples channels 1, 2, & 4, as an example)	OUTPUT:COUPLE ON OUTP:COUP:CHAN 1,2,4 (couples channels 1, 2, & 4)
4. Set Output delays (volatile memory)		
From front panel... Key/menu selections:	Settings/Delay.../Off Delays	Menu/Output/Delay/Turn-off delay
	• For each output that will be included in the shut down sequence (determined by Coupled Channels above), set an Off Delay time between 0 and 1023 ms (0 to 1.023 seconds)	
... or, over the bus: SCPI commands:	OUTP:DEL:FALL 0.200,(@1) OUTP:DEL:FALL 0.075,(@2) OUTP:DEL:FALL 0.010,(@4) (fall times shown above are examples for outputs 1, 2, and 4)	

* Models N6700B, N6701A, and N6702A require firmware revision C.01.02 or later.

** Instead of configuring the Off Couple input on digital port pin 4, pin 5, 6, or 7 could have been used.

To accommodate a sequenced shut-down upon fault event across multiple mainframes, all of the steps outlined in Table 1 must first be followed. In addition, it is necessary to connect all pin 1's of the mainframes to each other, and all pin 8's of the mainframes to each other. See Figure 3b.

With the configuration from Table 1, the outputs that are Coupled Channels will shut down according to the Delay time settings when a fault event as defined above occurs. The only exception is that the channel experiencing the fault will shut down as quickly as possible thereby ignoring its Delay time setting in order to avoid damage to the DUT or power supply. For example, if all 4 outputs are Coupled, and the over-voltage setting for output 4 is set to 20 V, when output 4 reaches or exceed 20 V, its over-voltage protection will trip (a "fault") thereby triggering all of the coupled channels to shut down utilizing their Delay settings. See example in Figure 4.

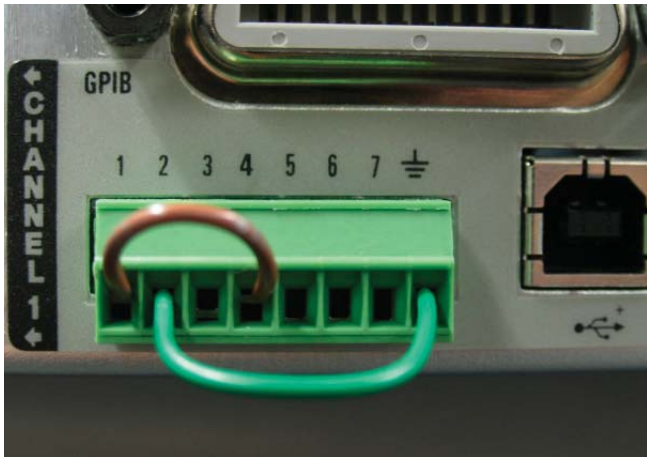


Figure 3a. 8-pin digital port connector wiring for single mainframe

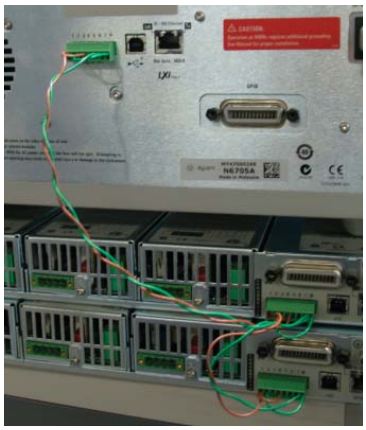


Figure 3b. Multiple mainframe wiring

Over-voltage on output 4 occurs here with all outputs set to respond to a fault:

- Output 4 shuts down immediately due to fault
- Output 3 shuts down 5ms later
- Output 1 shuts down 10ms later
- Output 2 shuts down 20ms later

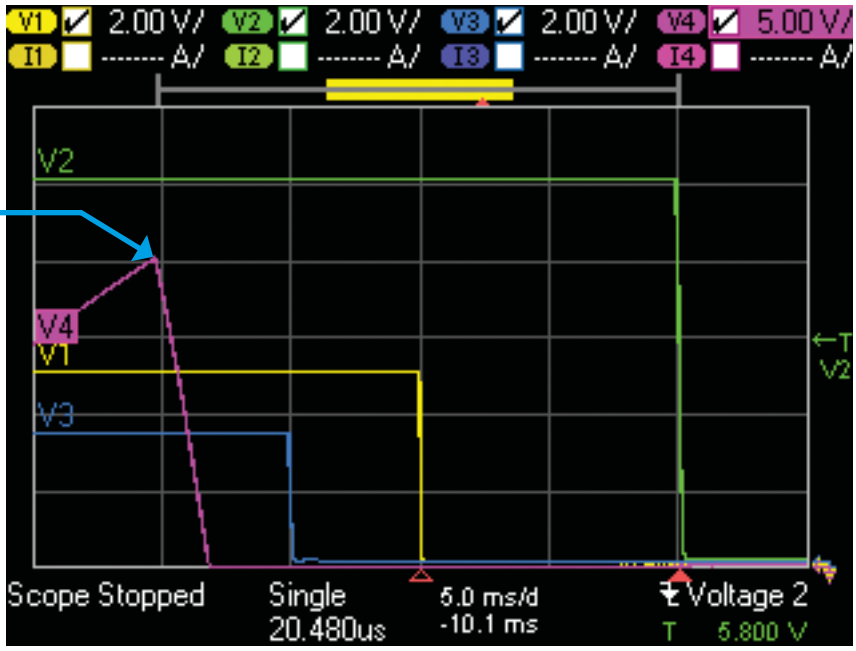


Figure 4 . N6705A scope view showing sequenced turn-off of 3 power outputs upon over-voltage fault occurring at 20V on 4th output.

Summary of Results

Protecting sensitive DUTs by effecting a controlled shut-down of power inputs can avoid damage to expensive circuitry. Creating a sequenced shut-down of multiple power supply outputs, especially in response to a fault condition on one of the power supplies, is very challenging. This challenge is easily met by using the built-in features of the Agilent Technologies N6700 Modular Power System or N6705A DC Power Analyzer.

Related Applications

"*Biasing Multiple Input Voltage Devices in R&D,*" Application note 5989-6454EN

"*Simulating Power Interruptions for DC Input Devices*," Application note 5989-6455EN

"*Simplify Multiple Bias Voltage Sequencing and Ramping for PC Motherboard Test,*" AN1504, Application note 5989-1676EN

Related Products

- N6705A DC Power Analyzer
- N6700B, N6701A, N6702A Low-Profile Modular Power System

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