Simulating Power Supply Interrupts

Application Note

Introduction

As an embedded systems designer, you face various power optimization and power characterization hurdles throughout your design process. You know what you want to output, simulate, and measure, but you need a whole "toolbox" of instruments and hardware to do the job. Not only is this toolbox costly, but properly configuring the hardware and software into an accurate, dependable solution can be time consuming.

The power challenges you face can be divided into three categories: properly powering on and off multiple power inputs, characterizing power needs under dynamic load conditions and simulating real-world power conditions. This application note focuses on simulating sudden device power interrupts in portable battery-powered embedded system designs. We will also introduce you to an all-in-one benchtop solution that can simulate one- or multiple-channel real-world power supply interrupts.

This is the third in a series of application notes that addresses power optimization, characterization, and simulation challenges in embedded designs.

Power Supply Interrupts

Input power for embedded system designs is supplied by a continuous, relatively low-noise DC source, or sources, depending on the design. The problem: Embedded system designs that are used in portable battery-powered applications often face sudden power interrupts in real-world use. These interrupts can be caused by sudden collision impacts that occur when the device is dropped or jarred. At impact, the battery can lose contact with the load causing the device to experience a short-duration total loss of power.

Another scenario your device might encounter: An impact to the device may not be enough to cause the battery to lose total contact with the load, but it may lead to a short interval when the contact area is greatly reduced. During this interval, the resistance of the contact area sharply increases, causing a large voltage drop to occur at the contact, which results in less voltage being supplied to the load. These conditions can lead to unpredictable behavior from the device. For instance, a short-duration sharp voltage drop could cause some ICs in the design to go into a reset mode while others that can withstand the voltage drop stay active. When this happens, your device may enter an unknown state or just freeze up.

To prevent these problems, when you design your device, you need to test the components that make up the embedded design and the embedded design as a whole to determine their tolerance to power interrupts. When you know the tolerance, you can add appropriate protection features to your design, so when a power interrupt occurs, the device will either reset/shutdown or be able to withstand the event and continue operating normally.

Current Solution

The two most common ways designers simulate these power interrupts for testing:

- **Use a function/arbitrary waveform generator.** A function generator is capable of producing DC levels with a triggered burst of fast pulses. However, function generators are low-power instruments, and therefore it is difficult or impossible to find a function generator capable of sourcing enough power for this kind of test. Also, most function generators do not have built-in voltage or current measurements for quick read back to verify everything is operating as expected.
- **Use a fast, wide-bandwidth power supply** such as a bipolar power supply. A DAC is also required to create the fast pulse amplified by the power supply. While this solution is capable of generating the required pulse, introducing additional instruments increases noise, system complexity and cost. Also, the high peak currents from inrush current could cause oscillations on the output of the bipolar power supply because of its high bandwidth. To reduce the output noise from the power supply, you may need to add a capacitor at the DUT. This solution is bulky, noisy, costly and complex.

Solution

You can overcome the power interrupt simulation challenges of embedded designs with Agilent's N6705A DC Power Analyzer.

The N6705A combines the functionality of four power supplies, a function/arbitrary waveform generator, an oscilloscope, a data logger, a voltmeter, and an ammeter into a single benchtop instrument. The N6705A's power supply modules employ digitizers that capture the output current profile or the output voltage profile—or both—from its outputs. The digitized data can be logged in non-volatile memory as well as displayed on the N6705A's scope-like display.

The N6705A provides up to four power supply outputs in a single mainframe, and each output is defined by a plug-in module. There are 21 different modules available that vary in power range, measurement capabilities and speed. **Table 1** on page 4 provides a list of modules that are a great fit for embedded design testing and shows their key specifications.

For measuring low-level sleep and leakage currents, the N6705A offers plug-in modules with a 200-μA measurement range that allows you to capture current levels accurately down to microamp levels. N6705A features that are valuable for embedded design testing:

- An oscilloscope-like display shows voltage, current and power versus time on multiple channels. This feature allows you to view in real time the voltage, current and power events of your designs.
- A built-in data logger continuously logs time-stamped data to a large color display and to a file. You can log data on all four outputs at the same time. Data log files can be saved to internal memory or to an external USB memory drive.
- Built-in function/arbitrary waveform capability
- Built in hardware-timed power on/off sequencing and slew rate control

The function/arbitrary waveform generator feature allows you to easily simulate power supply interrupts. You can simulate a simple interrupt using the built-in pulse waveform. For interrupts with more complex shapes, the N6705A allows you to define an arbitrary waveform using up to 64 k points. The N6705A can output power interrupts on a single channel or multiple channels simultaneously. You can easily add delays between the multichannel interrupts via the front panel with delay times that are carried out in hardware to ensure high-accuracy timing. The scope-like display on the N6705A allows you to capture a visual picture of the outputted interrupt. The N6705A also allows you to view, measure and export the dynamic current profile of your embedded design before, during and after the interrupt. Capturing the dynamic current during the interrupt provides more insight into what effect the interrupt had on the operation of the device.

The following section provides a detailed example, complete with screen shots, of using the N6705A to test the response of an embedded design under various interrupt conditions.

Example: Using the N6705A to simulate power interrupts

For the first example, we will demonstrate how easy it is to simulate a simple power interrupt using the N6705A's built-in pulse waveform. **Figure 1** shows the setup screen for defining the time and amplitude parameters of our built-in pulse waveform. For our example, the following parameters were used for the interrupt: DC power supply 3.3 V and interrupt duration of 5 ms.

The pulse waveform that we just created can be set up to trigger off a front-panel pushbutton, a software command, an external trigger, or it can be operated continuously. **Figure 2** shows a screen shot from the N6705A's scope-like display of the interrupt simulation that was just created.

In the next example, we created a much more complex interrupt simulation using the arbitrary waveform capabilities of the N6705A. The waveform in **Figure 3** is based on an interrupt caused by dropping the device under test (DUT), which causes the battery to lose contact temporarily. Then the battery experiences some contact bounce that dampens off.

The interrupt simulated in Figure 3 was based on a real-world interrupt that was captured using a scope. The digitized information was downloaded from the scope into a .csv file. The digitized points in the .csv file were compressed to 641 points to fit the 10-µs rate of the N6705A arbitrary waveform generator. The arbitrary waveform was then created by uploading the .csv file to the N6705A via a LAN \connection and the N6705A's Web browser interface. The .csv file also could have been uploaded to the N6705A via the USB memory-stick port on the front panel. Arbitrary waveforms can be created directly from the front panel of the N6705A as well.

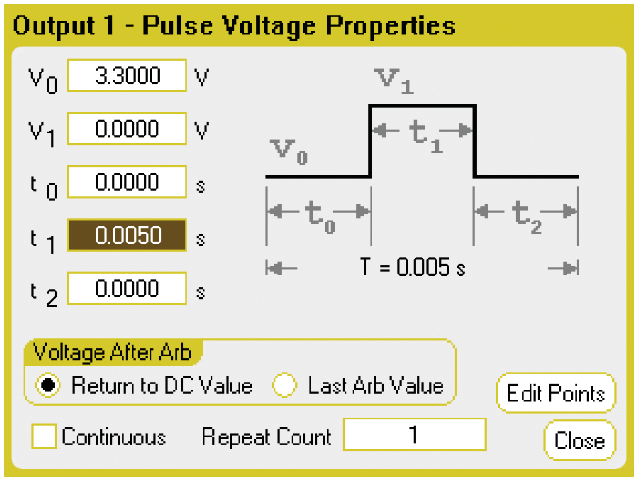

Figure 1. *Pulse waveform setup screen*

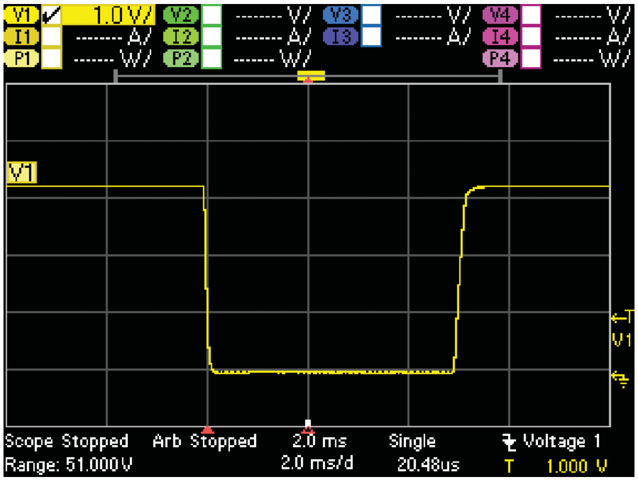

Figure 2. *Screenshot of simulated interrupt*

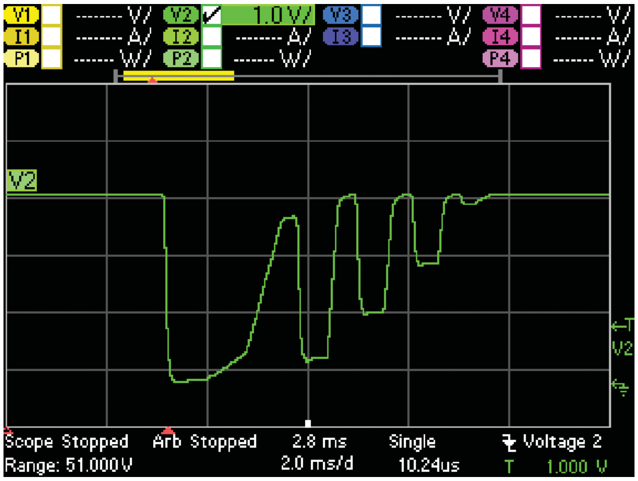

Figure 3. *Interrupt with contact bounce simulation using an arbitrary waveform*

Conclusion

Embedded system design is done with a continuous, relatively low-noise DC source(s) supplying input power. The problem is embedded system designs that are used in portable battery-powered applications often face sudden power interrupts in real-world use. These interrupts can be caused by a sudden impact to the device. At impact, the battery can lose contact with the load, causing the device to experience a loss or drop in power. These conditions can lead to unpredictable and undesirable behavior from the device.

In the past, a solution for simulating a power interrupt consisted of multiple hardware pieces that required significant configuration time. The N6705A DC Power Analyzer overcomes those obstacles by providing a single benchtop solution that can be easily set up to accurately simulate power supply interrupts on one or multiple channels.

Table 1:
Key specifications of N6705A modules ideally suited for embedded design

		N6751A/52A	N6754A	N6761A/62A
DC output ratings	Voltage	50 V	60 V	50 V
	Current	5 A / 10 A	20 A	1.5 A / 3 A
	Power	50 W / 100 W	300 W	50 W / 100 W
Max up-programming time with full R load (Time from 10% to 90% of total voltage)	Voltage change	0 to 10 V	0 to 15V	0 to 10 V
	Time	0.2 ms	0.35 ms	0.6 ms
	Voltage change	0 to 50 V	0 to 60 V	0 to 50 V
	Time	1.5 ms	2.0 ms	2.2 ms
Voltmeter/ammeter measurement accuracy (at 23°C ± 5°C) voltage	Voltage high range	0.05% + 20 mV	0.05% + 25 mV	0.016% + 6 mV
	Voltage low range (5.5 V)	N/A	N/A	0.016% + 1.5 mV
	Current high range	0.1% + 4 mA	0.10% + 8 mA	0.04% + 160 µA
	Current low range (^{2} 100 mA, at 0 - 7 V)	N/A	N/A	0.03% + 15 µA
	(^{2} 100 mA, at 0 - 50 V)	N/A	N/A	0.03% + 55 µA
	(≤200 µA)	N/A	N/A	0.5% + 100 NA (Option 2UA)

Related Agilent Literature

Publication title	Publication type	Pub number
Agilent N6705A DC Power Analyzer	Data sheet	5989-6319EN
Power Toolbox for Embedded System Design: Properly Powering On and Off MultiplePower Inputs in Embedded Designs	Application note	5990-4043EN
Power Toolbox for Embedded System Design: Dynamic Current Profiling	Application note	5990-4399EN
Powering DC-to-DC Converters Using the Agilent N6705A DC Power Analyzer	Application note	5989-6452EN
Biasing Multiple Input Voltage Devices in R&D	Application note	5989-6454EN
FPGA Circuit Design: Overcoming Power-Related Challenges	Application note	5989-7744EN
Simulating Power Interruptions for DC Input Devices	Application note	5989-6455EN

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