APPLICATION NOTE

Power Supply Test

Using the New Fully Loaded N6700 Power System

Introduction

The first Keysight electronic loads were initially designed as an instrument to test power supplies. They were very simple in function, but over time it evolved into a very versatile piece of equipment offering numerous functionalities. Before we jump into our discussion into the role of electronic loads in power supply testing, we need to understand the importance of a power supply.

A power supply allows the engineer to gain meaningful insight into the design under test whether used for research and development (R&D) work on the bench or test and validation work in a system rack. A power supply gives you a bias to power up a circuit board or to characterize a semiconductor device. Whatever its application, the power supply plays a key role in any setup.

Engineers who design and build power supplies are under tremendous pressure to make products that can live up to these expectations. They must develop and test their power supply designs to ensure it meets specifications for a very demanding customer base. Power supply test is not an easy task, and it requires tools and equipment of the highest performance and function.

Almost any setup in a power supply test requires an electronic load. Testing takes place in both R&D and production. The tests performed in an R&D environment are primarily for power supply design verification. These tests require high performing test equipment that is easily programmable over the front panel.

In contrast, power supply testing in production environments primarily focuses on the overall function based on the specifications determined during the product's design phase. Automation rather than front panel control is often essential due to significant volume testing, which requires high test throughput and test repeatability. Both the R&D and production environment demands sophisticated test equipment such as an electronic load to ensure the power supplies are designed and built to the highest standards.

Why use an electronic load?

1. Dissipate power from a power source
2. Quickly and easily change loading
3. Validate power supply output

Typical Power Supply Test Setup - Where the Load Fits In

There are dozens of tests that you can perform to verify and validate the performance of a power supply. Each test calls for different instruments and test setups. Typical instruments applicable in power supply testing are electronic loads, digital oscilloscope, digital multimeters, true RMS voltmeters, power meters, and programmable AC power sources. The configuration for each type of test is different.

The electronic load is a critical instrument across several common power supply tests. It offers various methods to load down the power supply and dissipating power across its input. These methods come in the form of operating modes: constant current (CC), constant voltage (CV), constant resistance (CR), and constant power (CP). The electronic load is fully programmable and gives you various methods of control such as front panel control and I/O interfaces — LAN, USB, and GPIB. In addition to programmability, it is essential for an electronic load to offer a sophisticated measurement system with digitizing capabilities and data logging. These functions provide you with a full set of tools necessary to be successful in power supply testing. These functions ensure only the highest quality of products reaches the end customer.

Figure 1. N6705C DC Power Analyzer with N6700 power and electronic load modules installed

This application note discusses several common power supply test procedures using the Keysight N6790 Series Modular Electronic Loads:

- Keysight N6790 Series expands the capabilities of the existing Keysight N6700 modular power system
- Compatible with the N6700C low profile mainframes designed for production test
- Flexible N6705C DC Power Analyzer mainframe designed for a bench test has a small and fast platform
- Flexibility with a 100W module (N6791A) and a 200W module(N6792A); available in a 1U form factor
- Command processing time is under 1ms — electronic loads offer fast throughput
- Configurable with power supply modules available in the N6700 modular power system
- Offers four different modes: constant voltage, constant current, constant power, and continuous resistance
- Highly accurate measurement and digitizing capabilities
- Quickly and easily gain insight into the power supply under test

Also, it has a powerful built-in arbitrary waveform function which allows you to emulate complex dynamic load waveforms. The data logging feature gives you an in-depth post analysis of captured measurements. The N6700 platform offers LAN, USB, and GPIB interfaces in every configuration allowing for secure connectivity and programming. It is a must have for any serious power system designer and test engineer.

Load Transient Recovery Time

A constant voltage DC power supply’s design is a feedback loop which continuously acts to maintain the output voltage at a steady-state level. The feedback loop has a finite bandwidth, which limits the ability of the power supply to respond to a change in the load current. If the time delay between the power supply feedback loop input and output approaches a critical value, the power supply becomes unstable and oscillates. It is critical to test the transient recovery/response time of a power supply.

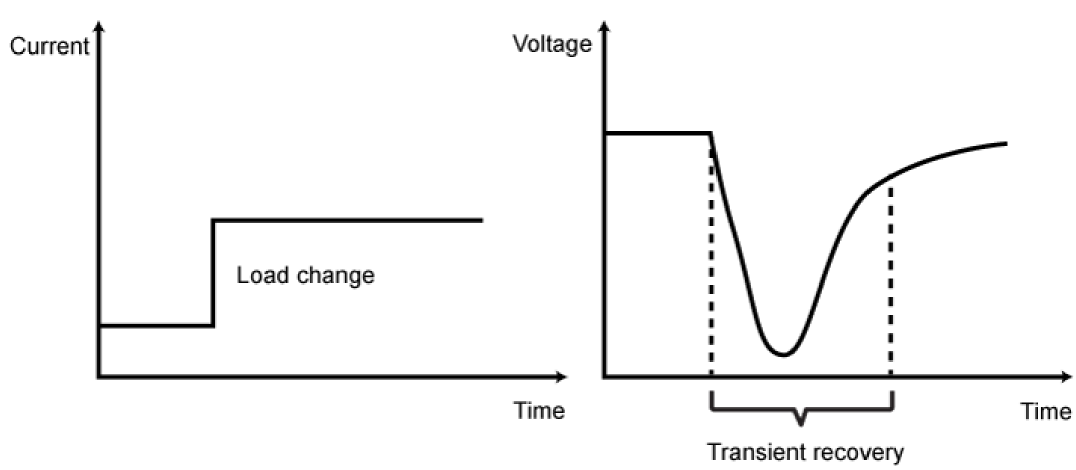

Figure 2. Transient recovery time diagram

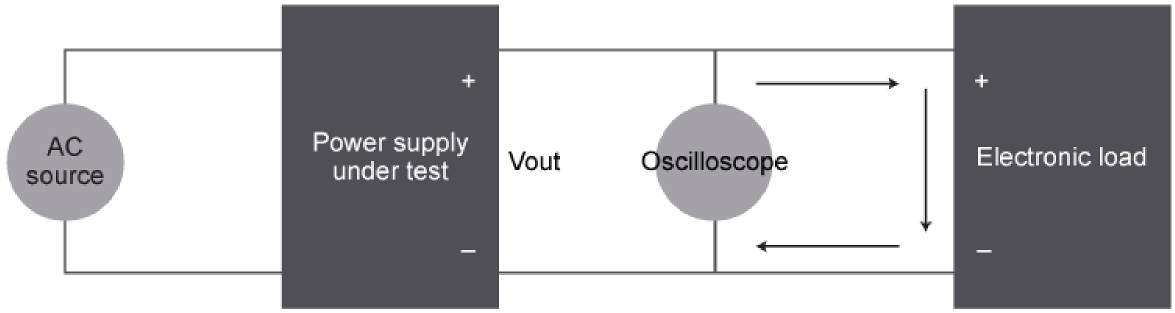

Figure 3. The typical setup for a load transient recovery test

The power supply is programmed in CV mode while the electronic load is in CC mode. The electronic load is programmed to induce a quick change in loading. An oscilloscope captures the voltage response of the power supply at Vout.

The electronic load in this test needs a rise time of at least five times faster than the power supply under test and should operate in CC mode (or CR mode) up to the maximum current rating of the power supply. Measuring the load transient recovery time requires the load to have the capability to pulse between two different values in CC or CR mode.

For continuous load transient testing, the repetition rate of the pulses should be slow enough so that the power supply feedback loop can recover and stabilize after each applied transient. Measurement of Vout of the power supply is made with a digitizing oscilloscope as the load input pulses are applied. Synchronization of the measurement is crucial in obtaining proper measurements. Therefore, a common trigger should start the electronic load and oscilloscope measurements. The CV load transient recovery time is a dynamic measurement of the time required for the output voltage of a CV power supply to settle within a predefined settling band following a load current induced transient.

You can quickly perform this test with the Keysight N6790 Series electronic load module. With a rise and fall time many times faster than most basic power supplies, it meets the loading requirement for the power supply transient recovery test. The N6790 Series electronic load integrates with the N6700C low profile systems mainframe or an N6705C DC Power Analyzer mainframe to perform the transient recovery test. When inside the DC power analyzer, you can quickly and easily configure the transient on the electronic load using the arbitrary waveform function as shown below in Figure 4.

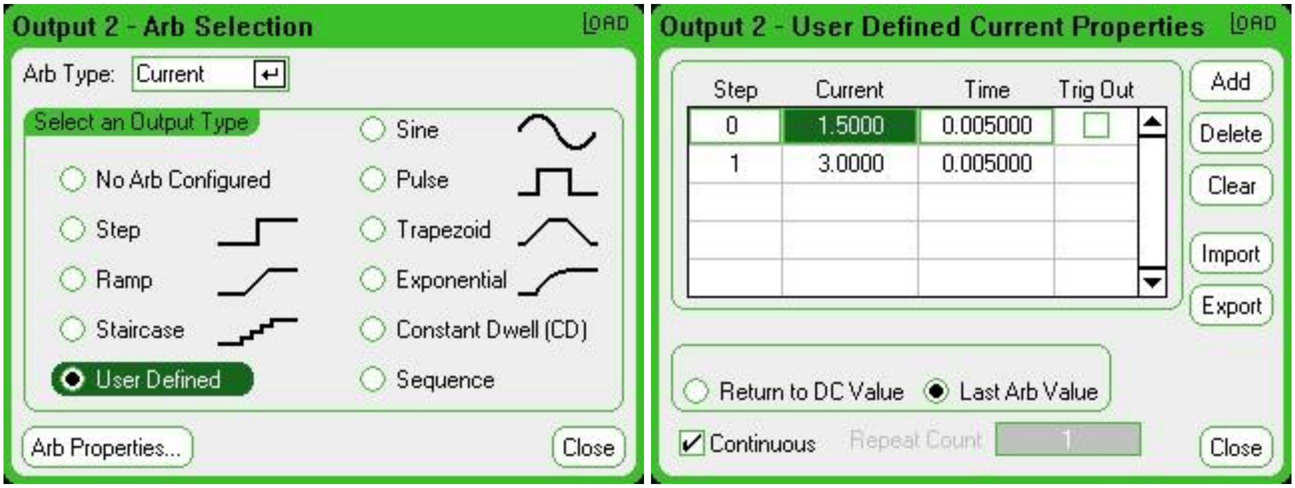

Figure 4. Screenshot of transient recovery setup on the Keysight N6791A

The above screen captures display menu settings which create a transient toggling between 1.5A and 3A at 100 Hz — It is quick and easy to setup. You can also use the digitizing and scope capability of the N6705C DC Power Analyzer to capture the transient recovery waveform as shown in Figure 5.

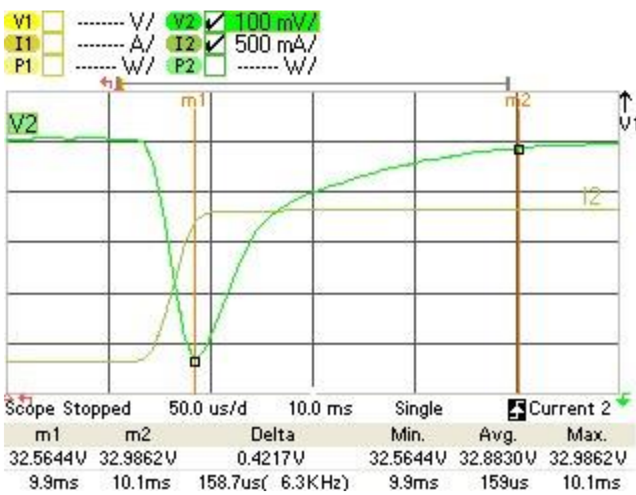

Figure 5. Transient recovery digitized waveform

Figure 5 shows the transient recovery behavior you would expect. V2 is the voltage waveform, and I2 is the current waveform. You can see there is a change in loading shown in I2 which induces a voltage response (dip) in V2 leading to its recovery. The time-space encapsulated by m1 and m2 is the transient recovery time. Processing this test is quick and easy. Typically, this test requires the use of an oscilloscope, but you can eliminate that from the setup by using the N6705C scope with the DC Power Analyzer.

CV Load Effect

This test measures the change in the output voltage of a power supply that results from a change in the output current at steady state after any transient has occurred. This change in output current is typically a change from no load to full load. A programmable AC source is necessary, and the setting is to a predetermined AC input level to ensure the loading change is solely responsible for any change in the power supply's output voltage.

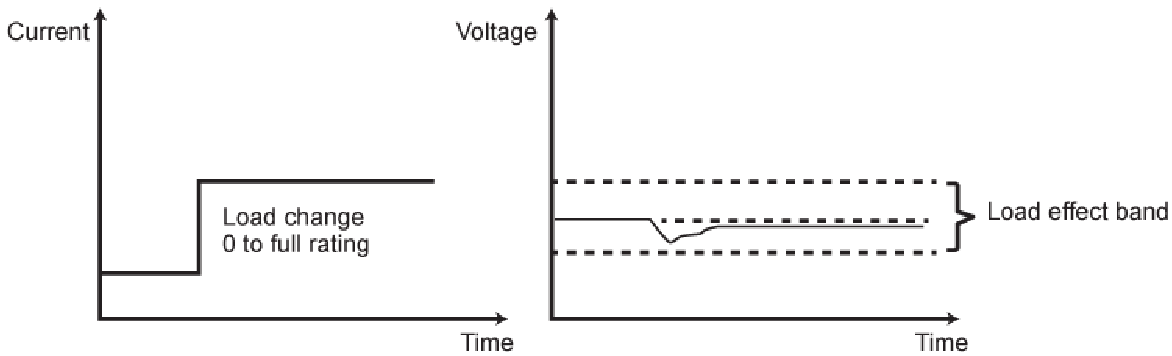

Figure 6. CV load effect time diagram

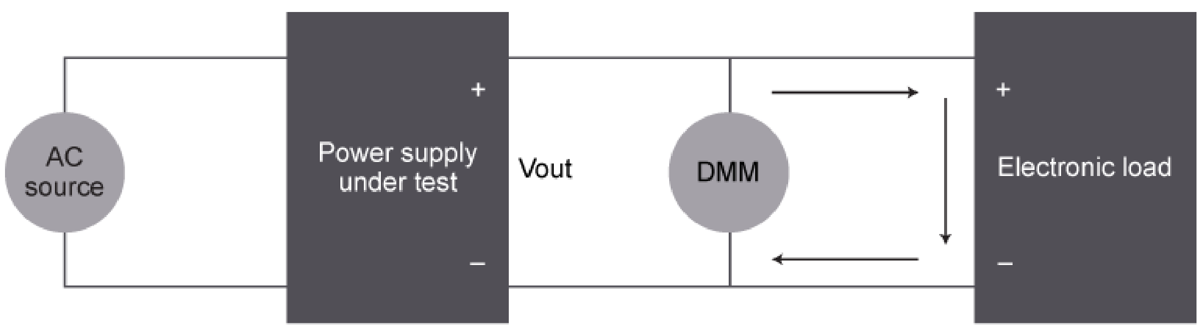

Figure 7. Typical setup for a CV load effect test

Using the Keysight N6790 Series of electronic load modules, you can quickly perform and even simplify this test. It offers four operating modes: CV, CC, CR, and CP. With a waveform generator feature onboard the N6705C DC Power Analyzer mainframe, it allows you to program the change from no load to full load as needed with a very accurate voltage and current measurement system in the electronic load modules.

When connected directly to the power supply under test, it directly takes the voltage measurement of the power supply to the output. In certain test environments where this level of accuracy is sufficient, it would eliminate the need for a standalone DMM and simplify the test configuration. Figure 8 shows how the N6790 Series of electronic load is easily programmable to create a current step from full load to zero load with the waveform generator.

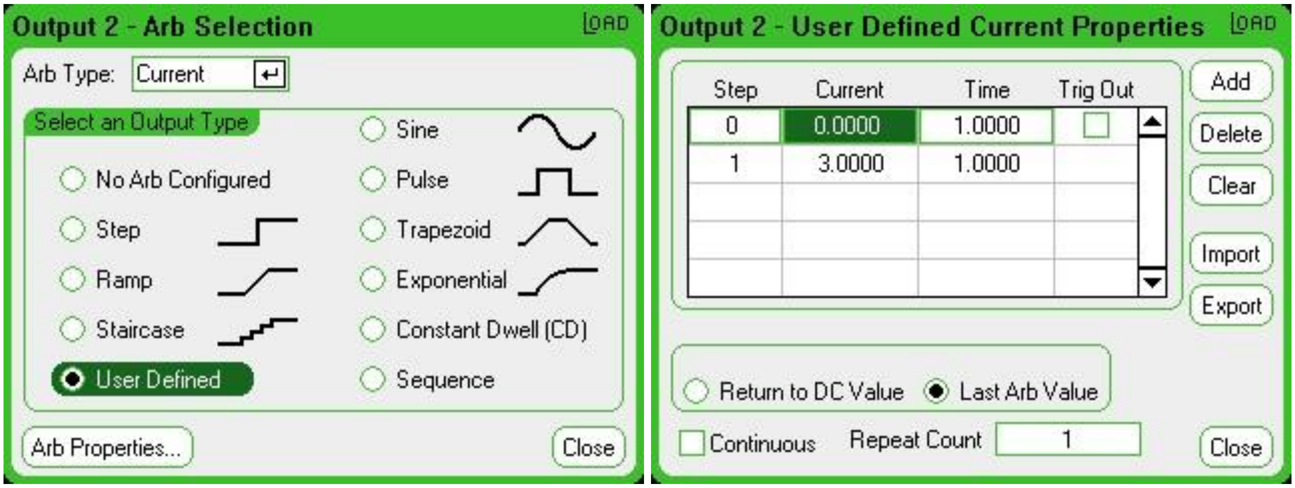

Figure 8. Screenshot of load effect setup on the Keysight N6791A

After sufficient settling time, you can read the voltage measurement directly from the front panel to ensure Vout is within the bounds of its specifications.

Efficiency

The efficiency of a power supply is just the ratio of its total output power to its total input power. For example, the AC-to-DC power supply input connection to a regulated AC source, and the output connection to a regulated DC electronic load. Either the AC source itself or an AC power meter is a requirement to measure the input power. The output power is measurable by a DC power meter or the electronic load.

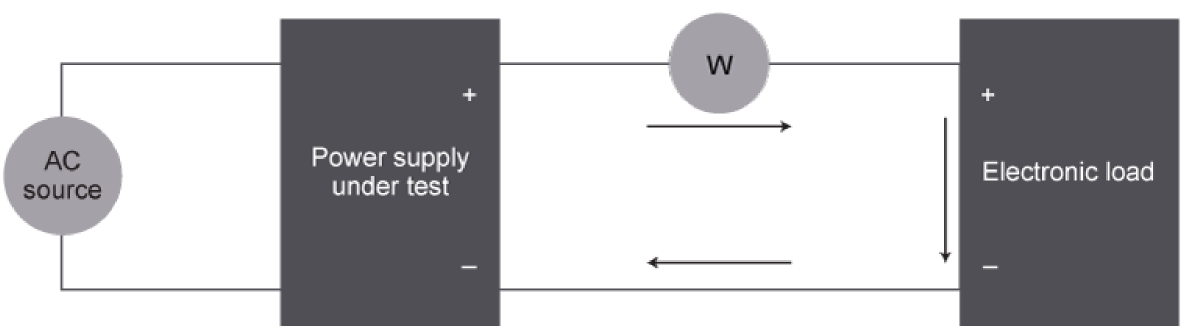

Figure 9. A typical setup for an AC to DC power supply efficiency test

For a DC-to-DC power supply, the input connection is to a regulated DC power supply, and the output is a connection to a DC electronic load. A power meter connection occurs at both input and output to measure the power. Alternatively, you can use the power supply and electronic load to perform the power measurements. Efficiency measurements are taken at steady state with the power supply in CV mode and the load in CC mode.

It is critical to choose an electronic load with the required level of measurement accuracy for efficiency testing. It is especially true if you are using the electronic load to measure the output power. In some test cases, you also want to test efficiency at various loading points since the power supply efficiency varies depending on the loading level. The Keysight N6790 Series electronic load has all the necessary functionality to perform this type of efficiency testing. The measurement system provides accurate measurement insight eliminating the need for a standalone power meter. With a CP operating mode, you can quickly and easily toggle through different loading levels.

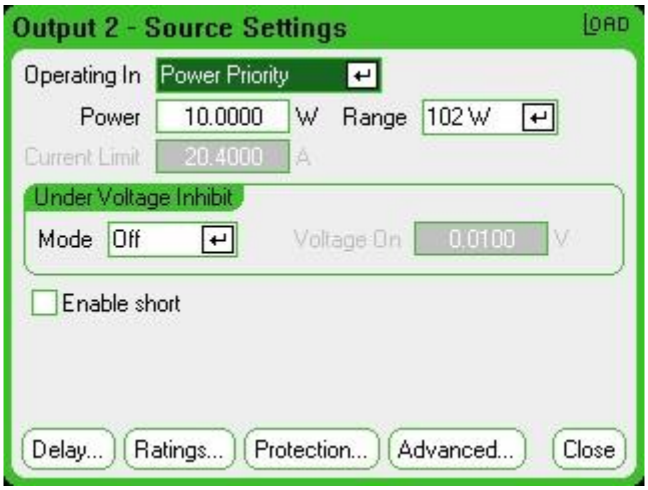

Figure 10. Screenshot of constant power menu setting

In the case of testing a DC-to-DC power supply, you can use the N6700 platform to provide the DC power input and measurement since it offers over 34 DC power supply modules and 2 electronic load modules. It is a true one box solution for DC power conversion efficiency testing to allow for simple programming control and measurement in a single platform. Having both the power and load in a single platform reduces the complexity. Both power and load modules runoff a single timer so executing commands across both power and load are synchronized. No additional work is necessary to ensure that the power supply and electronic loads are linked up concerning communication. This eliminates any hardware or software synchronization.

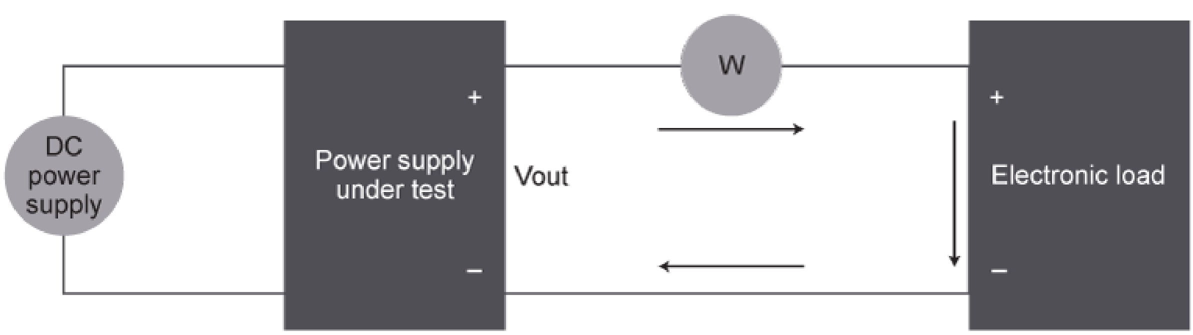

Figure 11. The typical setup for a DC to DC power supply efficiency test

Since commands and measurements are synchronous across both power and load, you can get real-time efficiency data as settings change. Figure 11 displays the DC power input, and DC power output of a DC to DC power supply over time at different DC input settings. You can use the Keysight N6762A precision power module at the input and the Keysight N6790 Series electronic load module at the output. Both modules are within the same N6705C DC power analyzer mainframe. By using the data logger, you can see how the power measurements at the input and output on the same graph with zero additional configuration necessary.

Summary

The Keysight N6790 Series electronic load modules give you unmatched performance and speed for power supply test. For bench or system applications in any testing environment, you can count on high quality and reliability with superior performance and features. It simplifies test system configuration to allow for accuracy and repeatability. Bundled with the N6700 power supply modules and the broad offering of bench and system mainframes, the N6790 Series is a true one box solution for DC power conversion testing.