KEITHLEY

Application Note Series

Number 2260

Burn-in Testing Techniques for Switching Power Supplies

Introduction

One of the consequences of the rapid growth of the telecommunications, desktop computing, and network server markets is a burgeoning demand for switching power supplies and DC-to-DC converters. While these power supplies are typically inexpensive, a high level of quality must be maintained through careful production testing.

Highly accelerated stress screening (HASS) or “burn-in” is a common production step for switching power supplies designed for computers and servers. Extended environmental testing is performed to ensure the product will continue to function properly over its entire service life. It is not uncommon to age and monitor thousands of power supplies at once. When designing this type of test system, the biggest challenge is dealing with the high number of channels the system must monitor and the test system surroundings. Large numbers of switching power supplies can produce tremendous amounts of electrical noise, which can reduce the test system’s measurement performance significantly.

Test Description

High-end power supplies and DC-to-DC converters with outputs from 400W to 2000W are commonly found in many telecom and server applications. These devices typically have four to six voltage outputs that must be verified. Output voltages may vary from 3.3V to 48V, with one output terminal dedicated to 5V. To verify that the entire power supply is functioning properly, the manufacturer often monitors only the 5V output. This implies that all channels are measured during manufacture, but for the purposes of burn-in, only one output is monitored to reduce the number of channels needed for the test system. Reducing the number of channels monitored allows a test system to accommodate more power supplies during the testing cycle, reducing overall cost. Less expensive and less complicated power supplies found in PCs may have up to six outputs, while power adapters for laptop computers will have one output. As in the previous case, only one channel is monitored. The 5V output is monitored as the temperature in the environmental burn-in chamber reaches the upper and lower limits, and the power supply output is repeatedly cycled on/off.

Monitoring Voltage

Figure 1 is a simple schematic of a test for monitoring the voltage output of a power supply. A digital multimeter (DMM) would be connected in parallel with the load resistance to measure the power supply voltage. The load resistance is chosen to emulate the load resistances found in the final application, but may be chosen to reach full output capacity to perform stress testing.

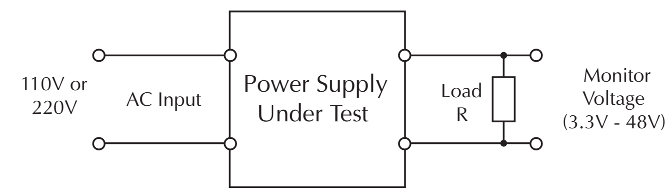

Figure 1. Monitoring the output of a switching power supply.

Output Cycling

To stress the power supplies being tested further, the output is repeatedly turned on and off. If a device is destined to fail, the failure will generally occur when the output is cycled. To capture failure data, the output voltage of each power supply is measured during each time the output is turned on, as shown in ***Figure 2***. After the output is cycled 15 to 20 times, the output is left on and the power supply is left to continue aging. While the output is left on, the voltage is measured only occasionally.

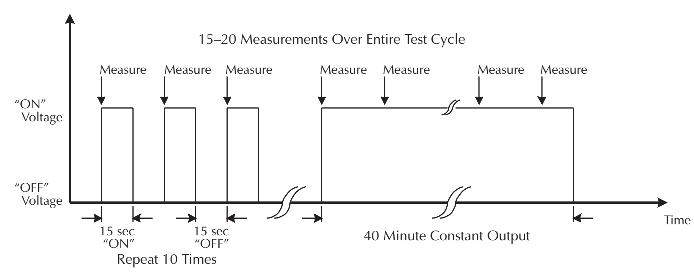

Figure 2. Typical burn-in test cycle.

Test System Description

The basic requirement for burn-in testing is to measure the voltage drop across the load resistor placed across the output of each switching power supply (***Figure 1***) during the entire test cycle. Test cycle duration can range from less than an hour to many days, depending on the quality requirements determined by the manufacturer.

Figure 3 illustrates an example of an 800-channel burn-in system in an environmental chamber, using the Model 2000 6½-digit DMM to make the required voltage measurement on each power supply. Two Model 7002 High Density Switching

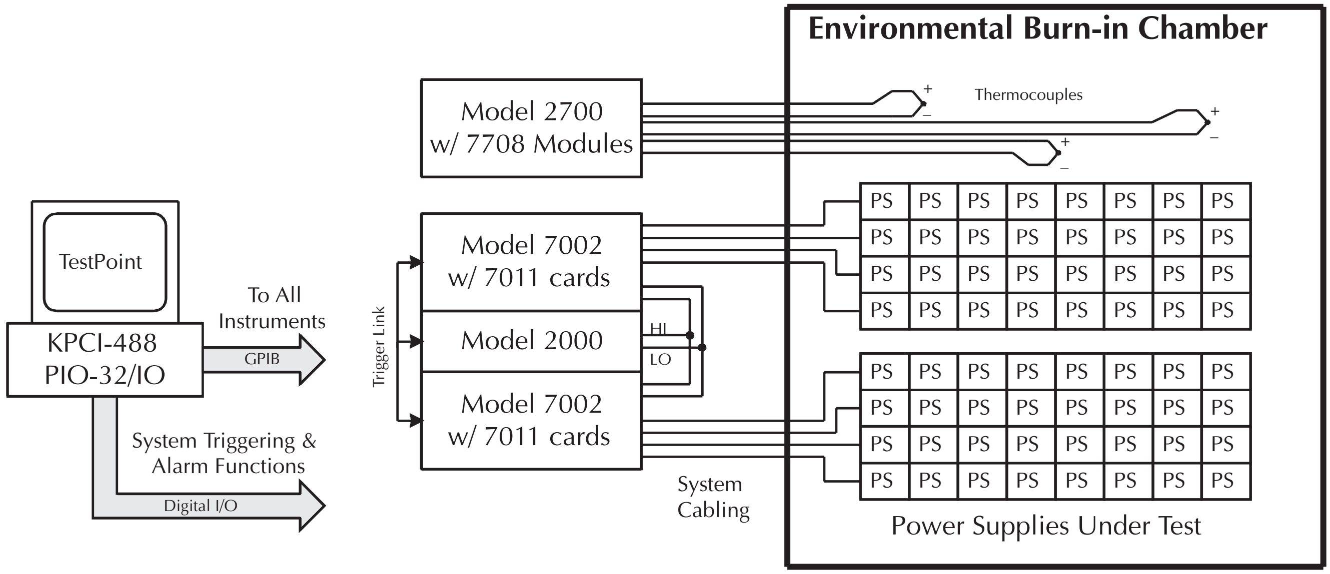

Figure 3. 800-channel switching power supply burn-in test system schematic.

Mainframes are used to connect the inputs of the Model 2000 to each power supply. Each mainframe can accommodate up to ten switching cards or 400 channels. The general-purpose Model 7011-C Multiplexer Card is used in this case because each card can monitor up to 40 channels at 110VDC. Each channel has two connections (HI and LO) for each power supply.

A typical specification for a power supply is to output 5V with 10% accuracy, which presents no measurement problem for a 6½-digit DMM. As shown in ***Figure 2***, when the output is cycled every 15 seconds, the DMM must make measurements on 800 channels during the 15 second "on" time. Setting the integration rate or measurement time to be as fast as possible (NPLC = 0.01), disabling all filters, and using the Trigger Link feature on each instrument makes performing these measurements easy.

The Model 2700 Multimeter/Data Acquisition System is used to verify the temperature profile of the environmental temperature chamber independently. By plugging two Model 7700 20-channel differential multiplexer modules into the Model 2700, the system can accommodate up to 40 thermocouples. Two Model 7708 40-channel differential multiplexer modules can support up to 80 thermocouples.

Methods and Techniques

Synchronization with Trigger Link

The Trigger Link is a hardware handshake bus used by the instruments in the test system to ensure proper test sequencing. It is a standard feature on all newer Keithley instruments, including all instruments mentioned in this application note. When the meter and switch mainframes are connected via two Model 8501 Trigger Link cables, they can trigger each other to allow faster test execution. This built-in bus eliminates the need for direct PC control of most system functions. When the Trigger Link function is used properly, the only functions the PC performs are initiating the test and retrieving data from the system, leaving synchronization to the instruments themselves.

For more detailed information on how to configure synchronized test systems with Trigger Link, refer to Keithley Application Note #810, "Optimizing Switch/Read Rates with Keithley Series 2000 and 7001/7002 Switch Systems."

Typical Sources of Error

Environmental Noise

Placing hundreds of switching power supplies into an environmental temperature chamber makes it extremely difficult to make accurate voltage measurements because switching power supplies radiate high frequency noise. If the ground connection is noisy, traditional data acquisition systems will be unable to make satisfactory measurements. The system described here requires scanning across multiple channels rapidly with the high impedance input of the DMM. In this situation, it can be difficult to distinguish between 5V and 0V on adjacent channels. Even with the Model 2000's superior CMRR, NMRR and 22-bit ADC, making the distinction can be difficult. However, Keithley has developed an algorithm (described elsewhere in this application note) that simplifies this problem.

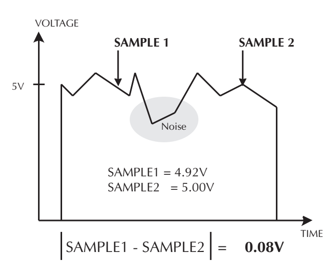

Figure 4a. Good result from multiple samples.

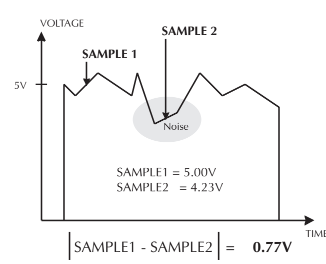

Figure 4b. Bad result from multiple samples.

To determine whether a power supply is good or bad, the test system must not only look at the absolute voltage value, but also at how subsequent readings compare. ***Figures 4a*** and ***4b*** show two different results when sampling a noisy signal. Assuming the power supply being tested is known to be acceptable, the figures show how noise can affect the final outcome of the test. Sample 2 in ***Figure 4b*** was taken when a noise spike was introduced into the system. This illustrates the importance of taking many samples into account from each power supply or increasing the measurement integration rate.

When measuring 5V on one channel and 0V on the next with very fast scan speed, a DMM may not measure 0V for the second channel. Actually, the first reading may be 4.7V and subsequent readings will decrease to 4.3V, 3.7V and gradually down to 0V. This gradual decrease id due to the RC time constant created by the large DMM input impedance and the capacitance in the test system cabling and fixtures. In contrast, if the measured 5V (i.e. power supply is good) twice, the two results will be similar (generally less than 10mV difference). Therefore, Sample 1 – Sample 2 = Delta, and if Delta is less than 10mV and both samples are within in limits the power supply is accepted. Without using this algorithm, setting a higher measurement integration rate will significantly improve the instrument's measurement performance in noisy environments, but the resulting scan rate would not be sufficient for the number of channels and time constraints of this application.

Relay Life

Generally, as the power supplies are being tested, their outputs are turned on. Therefore, as the switch mainframe is scanning across each device, the relays are being opened and closed with voltage across their contacts. Actuating a relay in this manner raises the possibility of arcing, which can severely degrade relay life. The relays on the Model 7011-C are rated for 10^8 closures when voltage is not being switched or for 10^5 closures if a 1A, 110V signal is being continually switched. As the signal levels decrease, the expected life of the relay will increase, so it is important to note the voltage and current levels of each power supply that is to be monitored.

Example Program

Using the TestPoint™ application development package, Keithley has developed an example program to perform a 72-channel switching power supply burn-in test that's similar to the system shown in ***Figure 3***. To download a copy of the program (PSBurnIn.tst), visit Keithley's website at **www.keithley.com**.

NOTE: The test program provided is intended to illustrate the concepts presented in this note. Program modifications may be required to accommodate desired test parameters and timing.

Equipment List

The following equipment is required to assemble the 800-channel switching power supply burn-in test system shown in ***Figure 3***.

- Model 2000 6½-Digit Multimeter.
- Two Model 7002 High Density Switch Mainframes.
- Twenty Model 7011-C Multiplexer Cards.
- Twenty Model 7011-KIT-R 96-pin Female Connect Kit for constructing custom wiring harness to connect to switching power supplies.
- Model 2700 Multimeter/Data Acquisition System and Model 7700 Module (20 thermocouple channels per module) or the Model 7708 Module (40 thermocouple channels per module).
- Model KPCI-488 IEEE-488.2 Interface for the PCI Bus.
- Model PIO-32I/O Isolated 16 Channel Digital Input and 16 Channel Relay Output Board for general system triggering and alarm functions.
- Three Model 7007 IEEE-488 Interface Cables.
- Two Model 8501 Trigger Link Cables.
- TestPoint software.

Alternative Solutions

The Model 2700 Multimeter/Data Acquisition System supports up to 80 channels is a nice fit for smaller and more modular systems. The Model 2700 is optimized for smaller HASS systems, or for smaller production lots of power supplies. The 2700 series of switch cards many solutions for temperature monitoring and analog signal routing up to 300V. Output cycling of the power supplies is accomplished using Keithley's line of PIO digital I/O boards and solid-state relay (SSR) modules.

Test System Safety

Many electrical test systems or instruments are capable of measuring or sourcing hazardous voltage and power levels. It is also possible, under single fault conditions (e.g., a programming error or an instrument failure), to output hazardous levels even when the system indicates no hazard is present.

These high voltage and power levels make it essential to protect operators from any of these hazards at all times. Protection methods include:

- Design test fixtures to prevent operator contact with any hazardous circuit.
- Make sure the device under test is fully enclosed to protect the operator from any flying debris. For example, capacitors and semiconductor devices can explode if too much voltage or power is applied.
- Double insulate all electrical connections that an operator could touch. Double insulation ensures the operator is still protected, even if one insulation layer fails.
- Use high-reliability, fail-safe interlock switches to disconnect power sources when a test fixture cover is opened.
- Where possible, use automated handlers so operators do not require access to the inside of the test fixture or have a need to open guards.
- Provide proper training to all users of the system so they understand all potential hazards and know how to protect themselves from injury.

It is the responsibility of the test system designers, integrators, and installers to make sure operator and maintenance personnel protection is in place and effective.

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