PQTN BRIEF

Power Quality Testing Network

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Low-Voltage Ride-Through Performance of a Personal Computer Power Supply

Background

Used extensively in personal computers (PCs) and other electronic equipment, switch-mode power supplies (SMPSs) have displaced linear power supplies because of their greater efficiency and performance during momentary low voltages. SMPSs rectify ac input voltage and store that energy in high-capacity electrolytic capacitors. The dc regulator reduces and regulates the unregulated dc voltage across the storage capacitors by switching current on and off. Because this type of regulation limits energy losses, SMPSs are generally more efficient than linear power supplies, which draw current continuously. The SMPS is lighter because a transformer is not required to reduce voltage from the ac line to logic circuit levels. SMPS storage capacitors, which have a high voltage rating, also store more energy than their linear counterparts. Because a PC with an SMPS can draw from this stored energy, it tolerates, or *rides through*, most momentary low voltages. Low-voltage ride-through performance, however, varies among different PC designs containing the same-sized capacitors. By investigating the performance of the SMPS during low ac voltages, the design parameters that affect ride-through performance can be identified and modifications to SMPS designs to improve ride-through performance can be suggested.

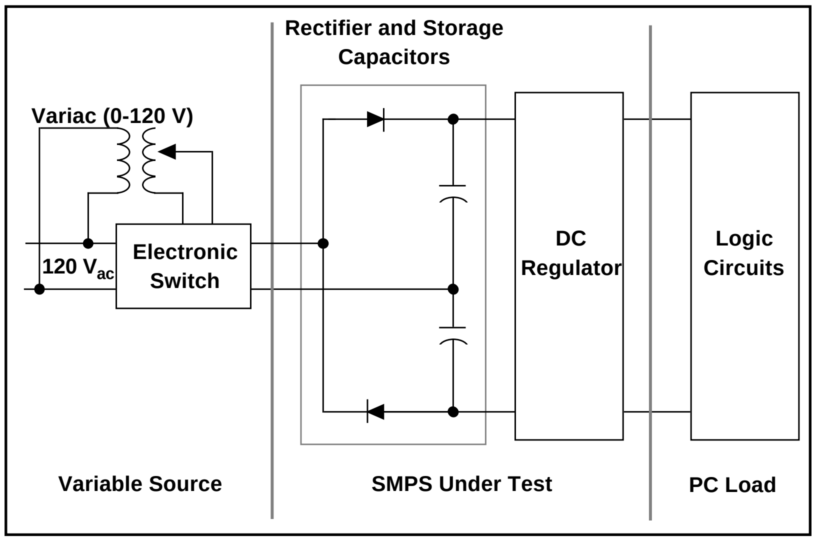

Figure 1. Diagram of Test Setup

Objective

The objectives of the tests performed at the EPRI Power Electronics Applications Center (PEAC) Power Quality Test Facility were to identify and investigate key ride-through performance characteristics of a typical PC switch-mode power supply during typical ac low voltages.

Test Setup

A typical off-the-shelf 80386-based PC was tested. The unit contained two standard 470-µF energy-storage capacitors. The PC was powered at 120 V_{ac}, with approximately 50 W of internal power consumption. A separately powered computer monitor was connected, and a user-program was running and displayed on the monitor screen. Momentary low voltages were created by electronically switching from the 120 V_{ac} line to a reduced-voltage source and then back. Low voltages were timed at zero-crossings and adjusted in half-cycle (8-ms) increments. Test events covered a range from 0 to 120 V_{ac} and from 0.5 to 20 cycles (8 to 320 ms). A digital storage oscilloscope monitored and recorded ac input voltage and current, unregulated dc voltage, and regulated dc voltage. Figure 1 shows the diagram of the test setup.

Test Results

Voltage Interruption Response Test

The PC was tested for Reponse ride-through performance during a loss of ac input voltage for 18 cycles (300 ms). Figure 2 shows the ride-through performance of the PC during this test. After about the first 7 cycles (117 ms), the regulated dc voltage began to drop from 5.1 V_{dc}. After about 10.5 cycles (175 ms), the unregulated dc voltage dropped below the limit required to sustain PC operation, and the dc regulator shut down at about 2.4 V_{dc}. The unregulated dc voltage held at about 90 V_{dc} after the shutdown because no energy was being removed from the storage capacitors. When the ac input voltage returned, a typical inrush of current recharged the storage capacitors from 90 V_{dc} to 340 V_{dc}, the nominal unregulated dc voltage.

Note that PC low-voltage ride-through time is determined not only by energy-storage capacity but also by the

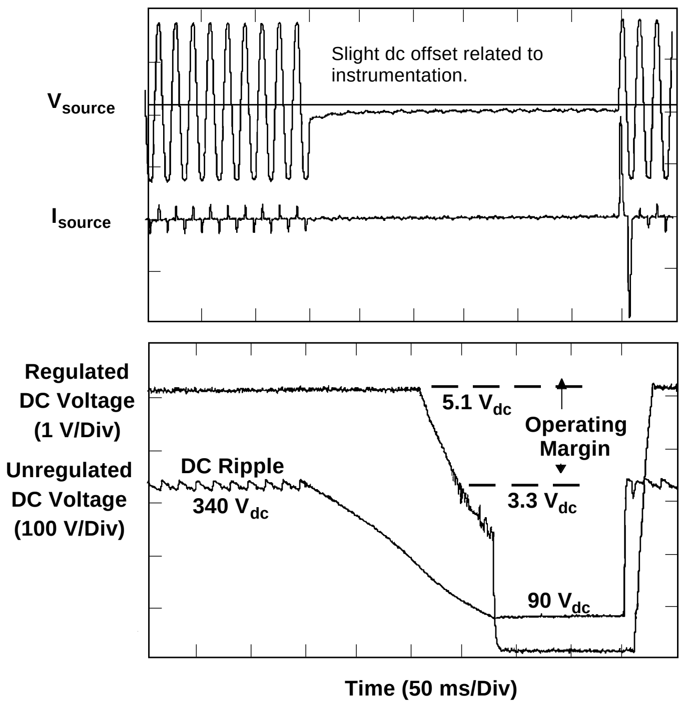

Figure 2. Unsuccessful Ride-Through During Momentary Interruption of Supply Voltage

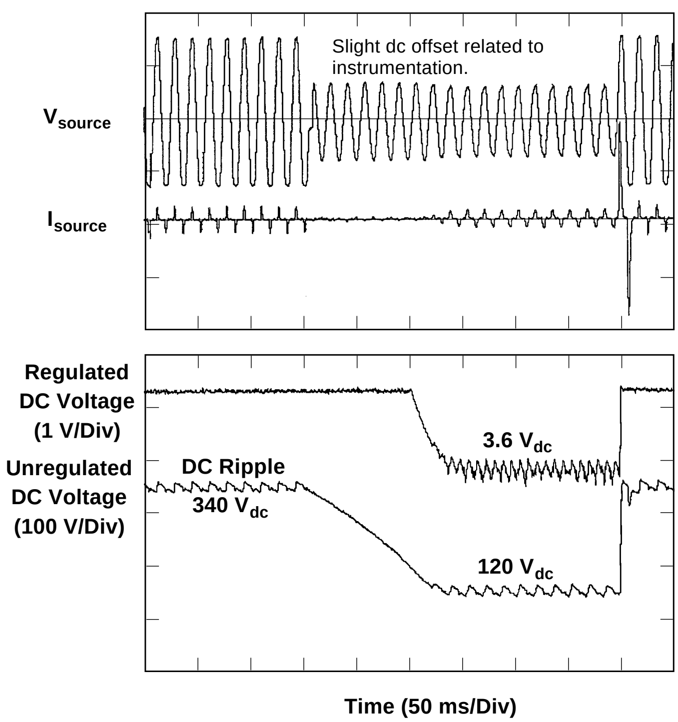

Figure 3. Successful Ride-Through During Voltage Sag to 50% of Supply Voltage

margin of the logic circuits for operating at a reduced unregulated dc voltage. The operating margin is the range of regulated dc voltage in which the PC can operate, from the nominal regulated dc voltage (about 5.1 V_{dc}) down to the recovery limit of the CMOS logic circuits (about 3.3 V_{dc}). The PC operates in the margin when the regulated dc voltage begins to decay. The operating margin provides added ride-through time during a low voltage because the PC can continue to draw energy from the storage capacitors.

Voltage Sag Response Test

The PC was tested for ride-through performance during a voltage sag to 50% of the normal ac input voltage (60 V_{ac}) lasting 18 cycles (300 ms). Figure 3 shows the ride-through performance of the PC during this test. The ac current initially disappeared for about the first 8 cycles of the voltage sag while the PC drew energy from the storage capacitors. After about 8 cycles, the unregulated dc voltage dropped from about 340 V_{dc} to about 120 V_{dc}. At this level of unregulated dc, the PC operated properly in its operating margin, with the steady-state regulated dc voltage at about 3.6 V_{dc}.

DISCUSSION

Test results show that a typical PC can operate indefinitely with ac input voltage as low as 50% and can ride through several cycles of power outage. PC immunity to low voltages depends not only on the size of the storage capacitors but also on the design of the dc regulator, which determines the operating margin. These related design parameters vary significantly from one PC model to another.

SIGNIFICANCE

In many ac power systems, the most common severe low voltages last only 5 to 10 cycles (83 to 167 ms). A switch-mode power supply designed to ride through these common disturbances will be valuable to many end users. Tests indicate that SMPS designs can have reasonable immunity to voltage sags and momentary interruptions. In the future, built-in capacitor storage and lower logic energy requirements (≈3-volt logic) may economically increase PC immunity to momentary low voltages.

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