PRINT ME

SAVE AS

PQTN BRIEF

Power Quality Testing Network

Published by the EPRI Power Electronics Applications Center Brief No. 21 June 1994

The Effects of Neutral-to-Ground Voltage Differences on PC Performance

Background

Since the introduction of the modern personal computer (PC), consumers have been looking for ways to prevent untimely and annoying PC lockups and shutdowns. From uninterruptible power supplies to backup tapes, consumers connect gadgets to their PCs, anticipating the often destructive consequences of a "crash." Yet even with a panoply of protective devices, PCs will lock up and shut down occasionally. What causes these problems? Taxing the random access memory certainly causes many PC lockups, and even a very brief loss of power may reset the computer, resulting in a loss of work in progress. Some engineers also speculate that surges and other power line disturbances that create voltage differences between the neutral and grounding conductors of a PC may cause it to lock up. Verifying or excluding neutral-to-ground voltage differences as a cause of PC upsets will bring PC manufacturers one step closer to designing models more compatible with the electrical environment in which PCs must operate.

Objective

The objective of the tests performed at the EPRI Power Electronics Applications Center (PEAC) Power Quality Test Facility was to evaluate the effects of steady-state, momentary, and transient neutral-to-ground voltage differences on personal computers.

Test Setup

A name-brand, off-the-shelf 80286-based PC was tested. With a power supply rated at 200 W, the tested PC included a keyboard, mouse (with adapter card), monitor (with VGA adapter card), $5\frac{1}{4}$-inch disk drive, $3\frac{1}{2}$-inch disk drive, 80-megabyte hard drive, Ethernet card, serial port, and parallel port. Before each test, the PC was operated for 10 minutes to stabilize its temperature. A digital storage oscilloscope recorded the ac voltage between the neutral conductor and grounding conductor of the PC. Four test setups were used during the five tests that simulated neutral-to-ground (N-G) voltage differences caused by 1) a floating ground conductor (miswiring), 2) load switching, 3) lightning, 4) arcing and relay chatter, and 5) utility capacitor switching. A diagnostics program was running and visible on the PC monitor during all tests to verify the continuous operation of the random access memory and the central processing unit. Figure 1 shows the four test setups.

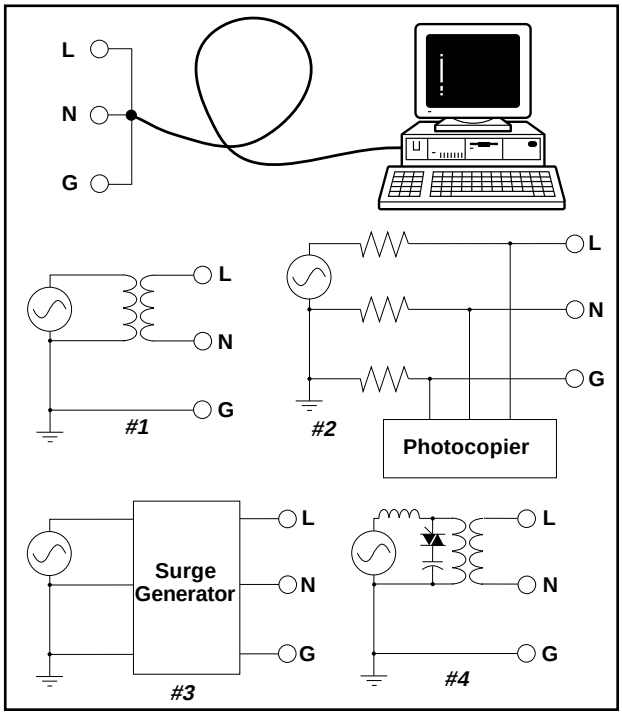

Figure 1. Test Setups

Test Results

Steady-State Overvoltage Test (Test Setup #1)

To create a steady-state (10-minute) overvoltage between the neutral conductor and grounding conductor of the PC, an isolation transformer was connected between the PC and power source without bonding the neutral and ground of the transformer secondary (a real-world miswiring condition). The resulting continuous N-G voltage of approximately 50 V_{rms} did not upset the PC.

Momentary Overvoltage Test (Test Setup #2)

To create a momentary overvoltage between the neutral conductor and grounding conductor of the PC, a photocopier was connected in parallel to the PC at the end of a long branch circuit (#12

gauge). The test was conducted three times, once each for circuit lengths of 100, 200, and 300 feet. When the heater element of the photocopier switched on, the N-G voltage of the PC increased. In the extreme case of a 300-foot circuit—which would violate the National Electric Code but nonetheless can occur when circuits are added to existing wiring—the voltage increased from 3 to 18 V_{peak} for a few cycles. It then stabilized at around 9 V_{peak} while the heater element remained on (see Figure 2). However, the momentary rises in N-G voltage for all circuit lengths did not upset the PC.

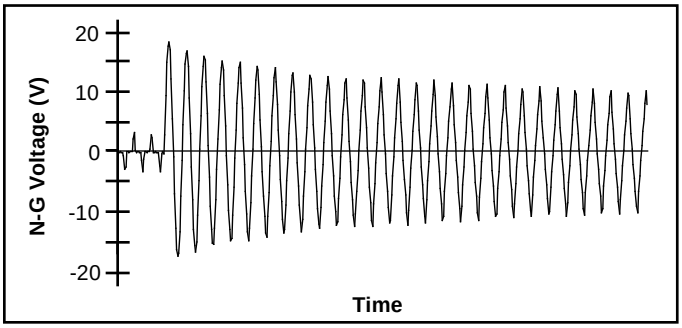

Figure 2. Neutral-to-Ground PC Voltage During Switching of Photocopier Heating Element (Long Branch Circuit)

Surge Test (Test Setup #3)

To simulate a N-G surge caused by lightning, a 0.5-µs-rise, 100-kHz ring wave was applied between the neutral conductor and grounding conductor of the PC. Two surges were applied at the positive peak of the power sine wave for each surge amplitude of 1 kV, 1.5 kV, 2 kV, 2.5 kV, and 3 kV. None of the surges upset the PC.

Electrical Fast Transient Test (Test Setup #3)

To simulate a burst of transients caused by arcing (from welders or chattering contacts, for instance), 0.5-kV electrical fast transients (EFTs) with rise times lasting a few nanoseconds were applied for one minute between a test reference plane (grounded copper surface) and the PC neutral conductor, and then between the test reference plane and the PC grounding conductor. The test was repeated for 1-, 2-, and 4-kV EFTs. Although some of the EFT applications above 1 kV caused the PC's speaker to beep, none of the EFTs upset the PC. Figure 3 shows the N-G voltages caused by the application of a 4-kV EFT to the neutral and then ground conductor.

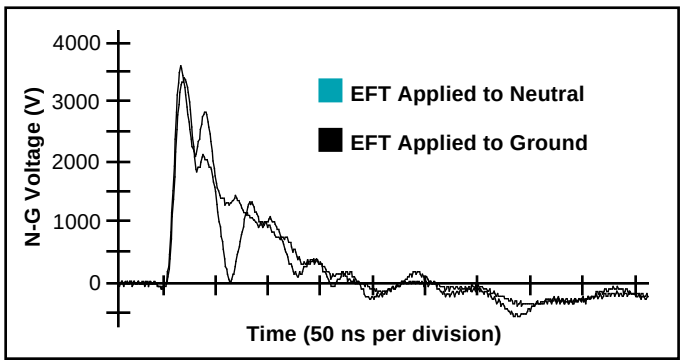

Figure 3. Neutral-to-Ground PC Voltage During Application of 4-kV Electrical Fast Transient

Capacitor Switching Test (Test Setup #4)

To simulate the routine switching on of utility voltage-regulation capacitors, 326 microfarads of capacitance were switched on at the peak of the sine wave using a triac switch. Because neutral and ground were not bonded on the secondary of the supply transformer, Test Setup #4 represents the worst-case PC exposure scenario. The resulting N-G ring wave voltage shown in Figure 4 did not upset the PC.

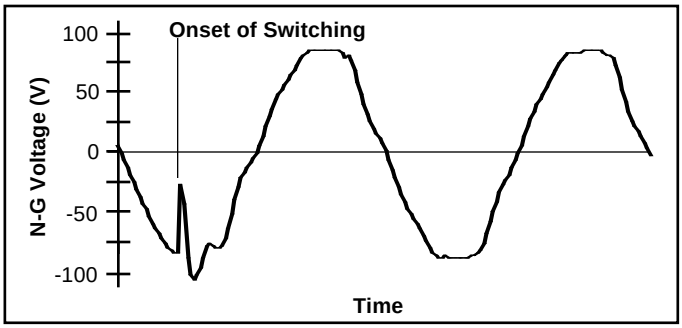

Figure 4. Neutral-to-Ground PC Voltage During Capacitor Switching

DISCUSSION

During the five tests, none of the 21 different applications of various N-G voltage differences upset the PC. The applied voltages ranged from six volts to four thousand volts, and from nanoseconds to steady-state, yet the diagnostics program that ran during all tests confirmed that these N-G voltage differences did not affect the operation of the random access memory or the central processing unit.

SIGNIFICANCE

Test results demonstrate that, contrary to popular belief, an off-the-shelf PC is practically immune to voltage differences applied neutral to ground. However, the results do not indicate how those same potentials affect PC operation when the PC is connected to peripherals via communication ports. N-G overvoltages impinging upon a PC connected to a network, printer, modem, or any other communications peripheral may cause a voltage difference between reference grounds. Such a voltage difference can corrupt the data flowing from one device to another, resulting in a lockup. Future tests to understand the full effects of N-G power quality phenomena may either lead to remedies or eliminate such phenomena as a cause of concern for PC manufacturers and end users.

ACKNOWLEDGMENTS

This work was sponsored by EPRI and was completed at the Power Quality Test Facility in Knoxville, TN.

FOR MORE INFORMATION, CONTACT:

The **EPRI** Power Electronics Applications Center
10521 Research Drive, Suite 400
Knoxville, TN 37932
(615) 974-8288, Fax: (615) 974-8289
Power Quality Hotline: (800) 832-7322

For ordering information, call PEAC (615) 974-8288.