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HIGH-TECH TESTING OF BRANCH CIRCUITS

http://www.kennedyelectric.com/SureTest/Suretest-HighTechTesting.htm - Link Now Dead

The reliable operation of computers, copy machines, industrial control equipment, and other microprocessor-based equipment depends on consistently good quality power. Although momentary overvoltages, sags and interruptions occur in even the most reliable power supply systems, when a computer system does crash, more often than not - the cause of the spikes, surges or sags is not with the power supplied by the electric utility, but by conditions created within the building. Electronic equipment failures attributed to poor-quality power may result from deficiencies in the power wiring or the grounding system or from interactions with other loads and the presence of harmonics in the system. These malfunctions range from erratic data losses to total system failures.

Fixed Power Circuits Just as the interconnecting network cables are an integral and vulnerable part of the computer system, so is the fixed power supply wiring. Under load, loose connections, bad splices, defective receptacles, or damaged conductors and other high resistance conditions can starve equipment of needed voltage. Where loads vary within a defective circuit the effect of low voltages may be sporadic, adding to the mystery of a problem's source. The best UPS will not fix a problem caused by power wiring deficiencies.

One of the first components to be checked in a problem system should be the supply power. Testing with conventional multi-meters and "non-load" plug-in type testers identifies conditions of low/high voltage and incorrect wiring such as no ground, no neutral, hot/ground reversed, hot/neutral reversed. However static tests do not measure the current-carrying capability of the circuit under full load, nor do they measure the quality of the power and ground circuits.

When technicians troubleshoot electronic components and systems, they test the boards and components under load to reveal the quality of the components and the system. The same reasoning demands that the power and ground circuits be tested under load. Until recently, routine load tests have been impractical, because they were time consuming, required a couple of devices and instruments, interrupted the circuit's use, and could be unsafe. A multi-meter and separate 1800 watt load can be used for this load test, however if there is a deficiency in the receptacle or wiring, the imposition of that load - and the test itself - could create a hazard. High resistance conditions in fixed wiring are the cause of tens of thousands of fires each year .

New generation, simple-to-use, test instruments are now available that safely test power circuits under load. The one described in this article is The **SureTest® model ST-1THD** dubbed *"the Engineer",* which is both a wiring and harmonics analyzer, manufactured by Industrial Commercial Electronics in Buffalo, NY (800 - 442 - 3462).

This hand-held plug-in tester replaces several instruments and imposes a full load on the circuit for a fraction of a second, while simultaneously measuring several characteristics of the circuit. This patented load test does not disturb computer equipment operating on the circuit. A one button operation allows simple sequencing of tests and access to a sub-menu for further analysis.

The instrument displays errors such as reversed polarity, false ground (the illegal tie of ground-to-neutral at the receptacle), and no-ground conditions. Static line voltage is displayed, and the unit can be left plugged in to study the consistency of supplied power. The sub-menu displays the highest, lowest, average and peak voltages measured during the test period. All measurements are true RMS.

A microprocessor in the tester compares measured voltages at no-load and under a 15 ampere load to display the impedance of the power circuit as **a percentage voltage drop:**

$$\frac{\textbf{V}\text{oltage}_{Line(no\ load)} - \textbf{V}\text{oltage}_{Line(15\ ampere\ load)}}{\textbf{V}\text{oltage}_{Line(no\ load)}}$$

Simple-to-use, the ST-1THD displays % voltage drop under a 15 ampere load to identify loose connections, bad splices, defective receptacles and other high resistance circuit conditions that cause excess voltage drops under load.

How much voltage drop is acceptable? The NEC (article 210-19, FPN 4) recommends that a voltage drop of 5% at the furthest receptacle in a branch wiring circuit is acceptable for normal efficiency. In a 120 volt circuit, this means that there should be no more than a 6 volt drop (to 114 volts) at the furthest outlet when the circuit is fully loaded. It also means that the circuit has a total resistance equal to, or less than 0.4 ohms.

Knowing that a problem exists is one thing - the next step is to isolate it. The SureTest® ST-1THD displays the ohms resistance of each conductor. Loose connections, splices, and damaged conductors can be isolated by using simple logic as tests are made along the branch circuit.

Ground Circuits Grounding problems in computer systems and networks can be troublesome, particularly if you think the system is "grounded" - but it's of poor quality. The IEEE recommends that the resistance of a grounding conductor for sensitive electronic equipment be no more than

0.25 ohms. If the ground circuit is measured with common neon testers, a ground with a 2,000 ohm resistance would test as "grounded" using these devices! A false sense of security results for several reasons:

1. Noise from equipment on the same grounding circuit can interfere with the operation of the computer or other microprocessor equipment.
2. The ground circuit cannot dissipate current surges resulting from over voltages, and surge protection devices cannot function properly to provide the intended protection. Current will flow where it is not intended - in the neutral, network cable shielding, ground pins on the serial ports, etc. - causing computers to malfunction, and/or components to fail. Serial ports, interface cards and cable shielding can be destroyed. Entire UPS computer networks can be shut down.
3. If shock hazards occur, personnel are not properly protected.
4. Computer systems that are poorly grounded can also generate RF signals that interfere with radio communications.

Because the SureTest® ST-1THD measures the ohms impedance of the ground conductor under load, there is no guesswork as to the quality of the ground. A simple adapter also allows determination of an isolated ground, which is particularly important on systems sensitive to noise on the ground circuit (cash registers, ATM machines, etc.).

Another parameter tested by the ST-1THD is the ground-to-neutral voltage, which is an indication of the current flowing in the neutral. In addition to displaying this instantaneous voltage, the analyzer can be left plugged in to study this parameter, and the sub-menu displays the highest, lowest, average and peak voltages measured during the test period. Installers often need to have a dedicated line, and this test will show if there are any other loads present. A very high reading may also indicate the presence of a shared neutral. This might present a problem from noise generated by equipment on the shared neutral, even if the "hot" is not shared.

This instrument also calculates the estimated peak load-on-line during the test period, which is useful to determine the remaining current-carrying capabiity of the circuit. Another unique feature of this instrument is that it determines the watts and power factor of a load when imposed on the same circuit - which is useful in sizing UPS systems.

Harmonics

A growing power supply problem is the increased occurrence of significant harmonics that adversely affect microprocessors. Harmonics often result from use of electronic ballasts in fluorescent lighting, variable frequency drives in motor controls, and the ever-increasing use of computers and other microprocessor-driven equipment that place non-linear loads on the supply transformer. As long as the transformer is large enough, it can handle the non-linear loads, and continue to supply power with a smooth sine wave. As the transformer's capacity to handle harmonic loads is exceeded, its supply of voltage becomes more and more distorted causing varying degrees of computer problems to occur. While the transformer is in the "marginal capacity" range, varying loads will cause the problems to be sporadic, adding to the mystery of a problem's source. The supply power may not be discovered as the cause of the problem until computer problems become more frequent. As a transformer's capacity is reduced by the heating caused by harmonics, the transformer should be de-rated. In extreme cases, the heat generated will destroy the transformer, and fires have resulted.

Harmonics problems become evident when the **line voltage** harmonics become distorted, indicating that the supply transformer cannot supply an undistorted voltage wave form. By measuring the **neutral current** harmonics it is possible to isolate and identify the equipment that is the cause of the harmonics.

Crest Factor is a quick measure of the extent of waveform distortion. It is the ratio of the peak value of a wave form divided by its true RMS value. The number represents the quality of the wave form as compared to a sine wave, which has a crest factor of 1.41. The SureTest® ST-1THD displays the crest factor of the line voltage and the neutral current. It also performs a FFT analysis (Fast Fourier Transform) of the wave form to display the %THD of the hot/neutral and the neutral/ground circuits. Percent THD is the general quantitative measure of total harmonic distortion, and is the sum of all individual Percent harmonic distortions in the system.

Certain harmonics are inherent in the operation of certain equipment and circuits, and are called harmonic signatures. These signatures are the key to locating the source of the harmonics. The SureTest ST-1 THD sub-menu displays the amplitude of individual odd harmonics from the 3rd through the 15th and the balance up to the 31st harmonic. Comparison of these patterns with known signatures can identify the offending equipment. An optional accessory to the SDT-1THD is a plug-in ammeter probe that allows for measurement of amperage and current harmonics on 3-phase power lines to extend the troubleshooting search into the industrial plant.

Sophisticated harmonics measuring and recording instruments can cost more than $10,000. For the computer technicians and field-service engineers, the SureTest® ST-1THD (under $500) will often be sufficient for measurement of the presence and magnitude of harmonics, and the isolation of their source. Long-term recording instruments may then be required to prove and

demonstrate marginal transformer capacity. The combined ability to easily detect problems in power wiring, grounding systems and diagnose harmonics problems, make the SureTest® circuit analyzer a very practical instrument for field service engineers, installers, and technicians. The instrument has a Store & Recall feature that retains readings in Memory for 36 hours, and it also measures the frequency of the supply power in cycles/sec.

Power problems, defective wiring, inadequate grounding, and harmonics can cause service nightmares. Routine load testing of power and ground circuits are simple, take a matter of seconds and can save immeasurably in call-back time.

Test Measurements of the SureTest® ST-1THD Harmonics/Circuit Analyzer

Wiring
Parameter Menu Sub-Menu
Line Volts (V) Static Line Voltage High, Low, Avg. Peak
Voltage drop (%) At a 15 ampere load At a 20 ampere load
N-Gd Voltage(V) Instantaneous N-G Voltage High, Low, Avg. Peak N-G Voltage
ELL, Watts, pf, Frequency
Resistance (Ohms) Hot, Neutral, Ground Conductors
G.F.C.I. Test (ma) Exact trip point
Wave Form
Voltage THD (%) % Line Voltage THD High, Low, Avg., Crest Factor
Line Voltage Harmonics Harmonics 3 - 15th; Bal -31st
Current THD % Neutral Current THD High, Low, Avg., Crest Factor
Neutral Current Harmonics Harmonics 3 - 15th; Bal -31st
Line Frequency (cps)
Clamp on Amp Meter

True RMS Amps 3 - 500 Hi, Low, Avg, Peak
Current THD (%) % Neutral Current THD High, Low, Avg., Crest Factor
Neutral Current Harmonics (%) Harmonics 3 - 15; Bal -31