DIELECTRIC WITHSTANDING VOLTAGE TEST | AN-115

INTRODUCTION

All of the world's safety agencies require a Dielectric Withstanding Voltage test (also known as a Hipot or Electric Strength test). This test is used to determine the adequacy of the equipment's insulation mechanisms to protect against electrical shock. While the concept of this test is simple, the application (except at the component level) can be complex. This note describes some of the problems of hipot testing using ac voltages on completed units or subassemblies (power supplies), and suggests some solutions.

DESCRIPTION OF TEST

The hipot test is a test of the insulation surrounding the primary circuits. It involves the application of a high voltage from the primary circuit to the grounding (earth) circuit and to the low-voltage secondary circuits. The potential used for each test is pre-determined by the applicable safety standard. It is based on the ac input voltage, the grade of insulation used in the equipment and the accessibility of the secondary voltages. The following chart lists some of the most common potentials used:

Table 1. Common Potentials

Input Voltage Rating	0-130 V rms	130-250 V rms
Primary Circuit to Ground	1000 Vac	1500 Vac
Primary to Secondary Circuits - NON-SELV	1000 Vac	1500 Vac
Primary to Secondary Circuits - SELV	2000 Vac	3000 Vac

IEC 950, Table XV
Secondary to Ground = 500 Vac

HIPOT FAILURES-GENUINE OR ERRONEOUS

A hipot failure is caused by a breakdown in the insulation. It is indicated by an abrupt increase in the current flowing as a result of the application of the test voltage. A real breakdown is usually obvious: the arc can be seen. Sometimes it cannot be seen but it can be heard. And sometimes the hipot tester indicates a failure that cannot be seen or heard. Insulations are not supposed to break down, and before faulting the insulation, make sure the test is being done properly.

HIPOT TESTERS

When the high voltage is applied, some current flows even when there is no breakdown. This current is caused by a parallel combination of the insulation resistance and capacitance that are formed when two conductors are separated by an insulator. When using an ac test voltage, the capacitance is the major cause of the current flow.

A false indication of failure can occur when the trip current on the hipot tester is too low. Many testers indicate a failure when the current exceeds a preset limit between 0.5 and 20 mA. Any current beyond the trip limit will cause the tester to indicate a failure, even though the current is not caused by a breakdown in the insulation.

To make matters worse, switching type supplies use line-to-ground capacitors to reduce the EMI. When the ac hipot voltage is applied from ac input to ground, the current flow caused by these capacitors will be sufficient to cause some hipot testers to indicate a breakdown that may or may not exist.

If ac voltages are used, any line-to-ground capacitors can be temporarily removed from the circuit. This is permitted for type tests, but is obviously impractical for production testing. A hipot tester with higher current capability must be used.

PRIMARY-TO-SECONDARY HIPOT PROBLEMS

When testing from primary circuits to secondary circuits, extraordinary effort must be made to prevent basic insulation from being overstressed. Safety standards identify the insulation used between primary or secondary circuits and ground as basic insulation. The higher voltages specified for primary to secondary tests will overstress the basic insulation which is intended to support only 1500 V. This can result in a catastrophic failure of the unit.

Most low-voltage secondary circuits are connected to ground. With the secondary circuits grounded, the hipot voltage is unavoidably applied from primary circuits to ground. Arcing across spacings from primary circuits to ground under these conditions does not constitute a failure of the reinforced insulation.

It has been suggested that removing the ground connection from the low-voltage secondary will

solve this problem. This is not necessarily true. The insulation from secondary circuits to ground usually can withstand only a few hundred volts. Most switching supplies use a secondary-to-ground capacitor of at least 10 nF to reduce the EMI and output ripple in the event that the output is not grounded. With the outputs ungrounded, this capacitor is effectively connected in series with the ac line-to-ground capacitors. This series combination acts as a voltage divider. The result is that a portion of the hipot voltage appears between primary circuits and ground and the rest between secondary circuits and ground. Depending on the ratio of the two capacitors, either the basic insulation in the primary circuit or the secondary circuit (frequently both) will be over-stressed.

The best solution to this problem is to perform the hipot test on the individual components that provide isolation between the primary and secondary circuits. These components consist of power transformers, opto-isolators, pulse transformers, printed wiring board, etc. Condor tests all transformers at 4800 Vac. Opto-couplers are 100% tested for 5300 Vac by the manufacturer. All printed circuit boards have at least 4 mm creepage from primary circuits to ground and at least 8 mm from primary to secondary circuits.

It is extremely difficult to test these components on completed assemblies. It may be accomplished by somehow isolating the primary-to-ground components and the secondary-to-ground components from each other. Sometimes removing the PWB from the chassis will achieve this result, but only when separate grounding points to the chassis are used. However, the spacings between primary and ground and/or secondary and ground are probably insufficient for the voltage being applied. Again, arcing across these spacings does not constitute a failure of the primary-to-secondary insulation.

CONCLUSION

The hipot test can be a destructive test; especially when very high test voltages are used. A catastrophic failure of the unit may result if a test voltage greater then 2500 Vac is applied between primary and secondary circuits. The components providing isolation from primary to secondary cannot be tested while installed in the power supply without risk of damage to the unit.