AC Dielectric (Hipot)
vs.
AC Breakdown Testing

General Description:

DIT-MCO has developed an AC Breakdown test to detect arcs without the cost of complicated electronics previously used to detect resistive leakage in AC testing.

Methods of Arc Detection

There are two (2) methods of detecting arcs. One detects the in-phase current, i.e. setting/programming a small value of resistive current (0.1ma to 2.5 ma), and the other detects the total current. Both methods detect arcs and meet MIL-STD-202F Method 301.

Extensive testing with AC stimulus shows that when a fault in a cable assembly breaks down (arcs), the current goes to the maximum current capability of the AC power source and is independent of the preset value of the in-phase (resistive) current.

MIL-STD-202F Method 301 (Dielectric Withstanding Voltage) describes the test as one that consists of applying a voltage (DC or AC) and monitoring for a disruptive discharge. The standard states that the purpose of the test is not intended to cause insulation breakdown or used for detecting corona, rather it determines whether insulating materials and spacings are adequate. The insulation properties of the insulation material are determined by Method 302 (Insulation Resistance). In Method 302, the value of the leakage resistance is important and is measured using high accuracy DC digital measurement techniques. The method of current detection for Method 301 is not specified by the MIL-STD-202 document.

Commercial Instruments

There are several AC Dielectric Instruments on the market. They each have their own way of detecting arcs. Some detect both **in-phase** and **total** current. Several detect only total current. One manufacture has three modes of AC Dielectric detection: **in-phase** current, **total** current, and an **arc** detection mode. The detection level for arcs is undefined.

DIT-MCO has been in the AC testing business for more than 40 years. It was one of the first to use in-phase detection techniques. However, when an arc occurred, the actual circuit detecting the arc was the total current circuit. DIT-MCO still manufactures the in-phase current detection instruments for customers specifying call out arc detection currents of less than 1 Ma.

Design Considerations in Arc Detection Methods

Selection of the type of instrument to use with regards to **in-phase arc detection versus total current** is more of a theory issue than a practical issue. As defined by MIL-STD-202F, the purpose of Dielectric Withstand Voltage (AC Hipot) testing is to detect disruptive discharges. Both methods, in-phase and total current detection , accomplish this task.

In practice the in-phase detection method allows an easier way to calibrate and verify the instrument. By programming a 1 Ma. detection limit, a resistor can determine that the instrument is operating properly and is calibrated. The total current method is more difficult due to the capacitance effect dependent on the frequency of the stimulus and the high frequency generated by an arc. Arcs are momentary shorts making it difficult to artificially produce a 1 Ma. arc for calibration of the instrument.

This knowledge and DIT-MCO's experience in test equipment design, dictated using the more direct approach for DIT-MCO's newer equipment. The newly designed AC Breakdown detector **uses the total** current detection method. This decision was based on the following:

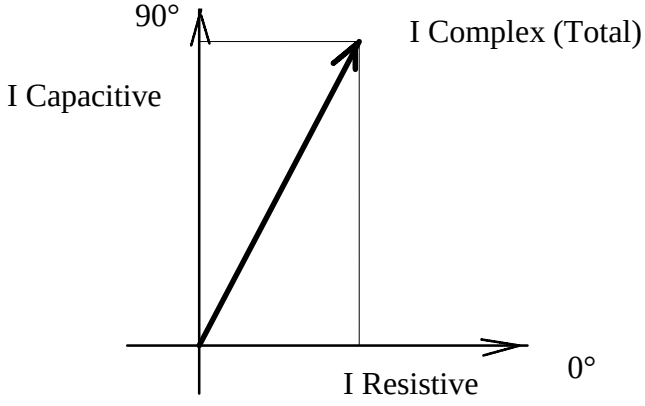
- Meeting MIL-STD-202 Method 301
- Simplifying the approach
- Requiring no user programming

AC Dielectric Testing

The following reviews the complex components of the AC current and their relationship in determining a fault.

Background

The **Total** current flowing through a capacitive circuit has two components, an **in-phase** (resistive), and a **quadrature** (capacitive) component. The resistive component represents the current flow through the resistive elements and is in-phase with the applied voltage. The capacitive component represents the current flow through the capacitive portion and is 90 degrees out of phase with the applied voltage. The total current is a complex (vector sum) of the two components. A diagram of these currents are shown below:



Capacitive Current

The amount of current I Capacitive supplied to a capacitive cable or black-box with capacitance is expressed by the formula:

$$I_c = V 2pfC$$

Where : I_c = Capacitance Current

V = Voltage Applied

C = Total Cable & System Capacitance

If :

V = 1000 Volts AC rms

C = 0.02*m*F

f = 60 Hz

Then :

$$I_c = 1000v * 2p * 60 * 0.02mF$$

$$I_c = 7.54ma$$

In-phase (resistive)

The amount of current I Resistive supplied is the determined by the formula:

$$I_r = V / R$$

Where : I_r = Resistive Current

V = Voltage Applied

R = Total Leakage Resistance of UUT and System

If :

V = 1000 Volts AC rms

R = 1MegOhms

Then :

$$I_r = 1000v / 1MegOhms$$

$$I_r = 1Ma.$$

Complex (Total) current
The Complex (Total) current is the vectored sum of the two currents:

$$I_t = \sqrt{Ic^2 + Ir^2}$$

Where: I_t = Total Current
I_c = Capacitive Current
I_r = Resistive Current

If:

I_c = 7.54M
I_r = 1.0 Ma

Then:

$$I_t = \sqrt{(7.54)^2 + (1.0)^2}$$
$$I_t = 7.60\,Ma.$$

The above equation shows that the I_t (Total) current is 7.60 Ma., which is only 60 μamp greater than the capacitive current (I_c). The resistive component is a small portion and can be neglected in setting the overall detection limit of a Breakdown current. In most cases it is enough to preset the Breakdown current to just below the maximum current of the AC source.

In a typical system with a capacitance of 0.02μF, not uncommon in actual testing of cables and black boxes, the AC Breakdown Detector (Instrumentation) must supply a minimum **total** current of ~ 10ma. The HVC-1 Comparator has a maximum I_t Total current of ~20 Ma. The preset Breakdown current is factory set for approximately 1 Ma. less than the maximum supply current.