

# A Look at Circuit Theory



- Review of electrical safety tests
- Circuits for electrical safety tests
- What is tested during each test
- Arc Detection and Smart GFI
- Verification

# Meet Our Team



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# Webinar Notes

Please use the Q & A utility to ask us any questions concerning the material being presented.

Please contact Brittany Socha – on the chat line or email [Brittany.socha@ikonixusa.com](mailto:Brittany.socha@ikonixusa.com) if you encounter any issues.

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# Learning Objectives

**Review of electrical safety tests**

**Circuits for electrical safety tests**

**What is tested during each test**

**Arc detection, and Smart GFI®**

**Verification**

# Common Electrical Safety Tests

**Ground Continuity Test**

**Ground Bond Test**

**Dielectric Withstand Test (Hipot)**

**Insulation Resistance Test**

**Touch Current Test (Leakage Current Test)**

# Ground Continuity Test

This test verifies a connection between exposed conductive parts and the ground of the power cord on the product under test.

Routine production line test conducted on Class I products.

A low voltage AC or DC signal is applied from the chassis of the product to the ground pin.

Typically performed at a current under 1A to check that the ground connection is continuous.

# Ground Bond Test

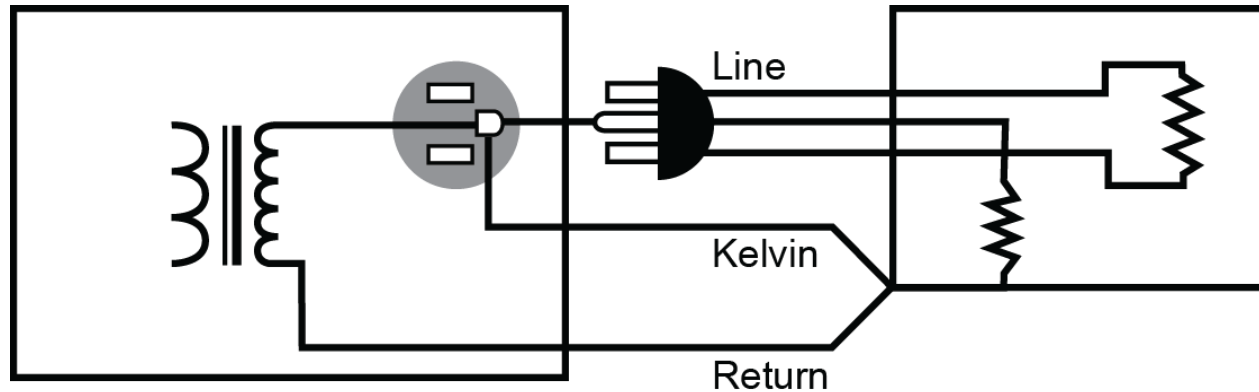
This test verifies the integrity of the ground connection between exposed metal and ground wire of the power cord.

High current is injected into the ground pin of the product's power cord which flows through the chassis.

Determines if the safety ground wire is capable of handling excessive current flow in case a fault occurs and the product's insulation fails.

# Ground Bond Test

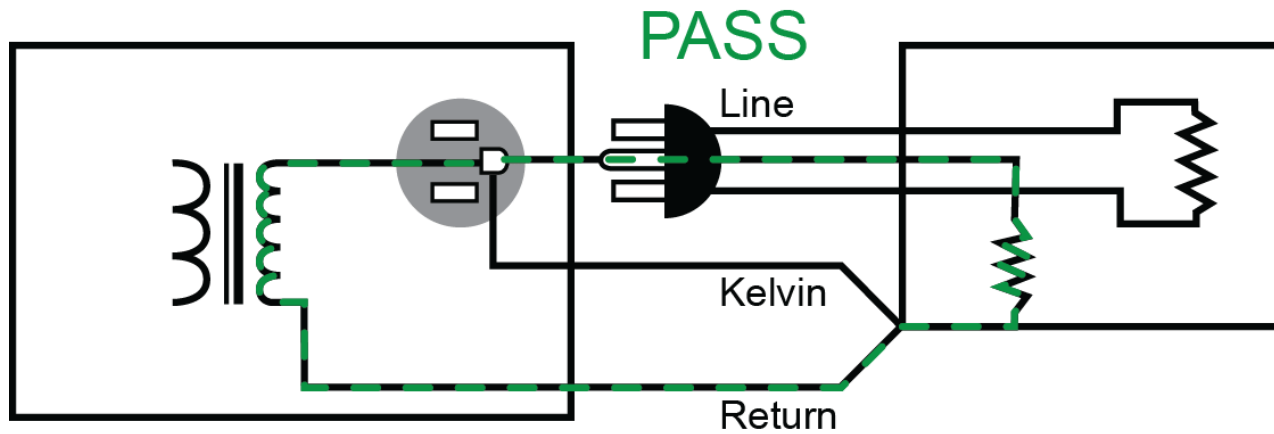
## Circuit for Ground Bond Test



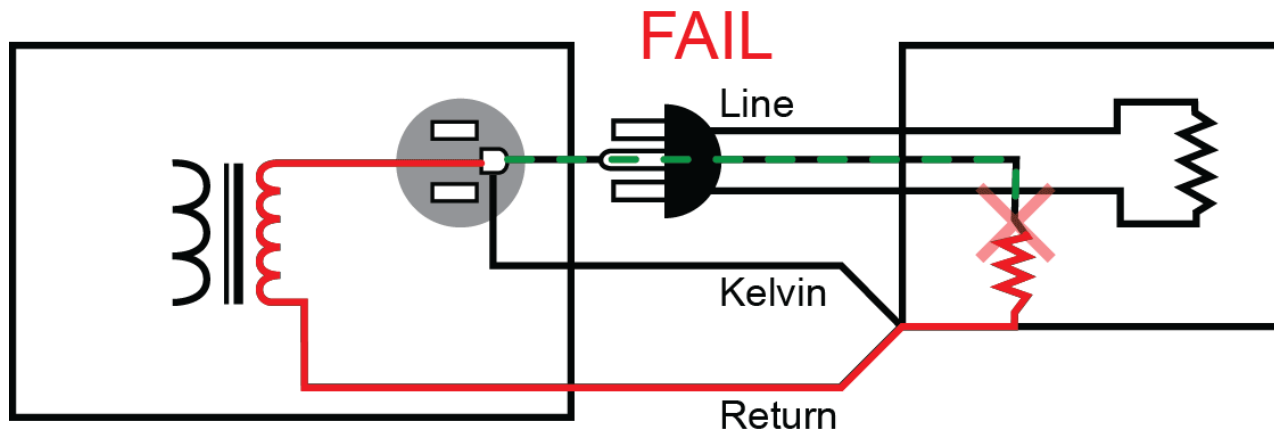
The kelvin method is a standard four wire measurement method used during a Ground Bond test to eliminate the inherent test lead resistance from the test results. The Kelvin Method provides more accurate resistance measurements which are crucial when dealing with the miniscule resistance values measured during a Ground Bond test.



# Ground Bond Test



# Ground Bond Test

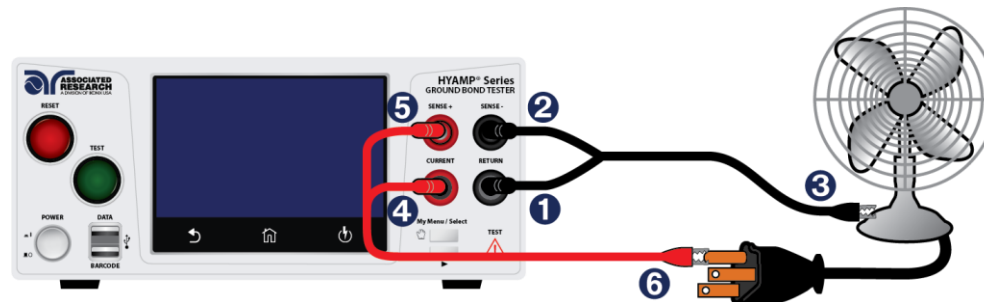


# Ground Bond Test

The Ground Bond test is commonly considered a Type test

The results of this test are displayed in Ohms ( $\Omega$ )

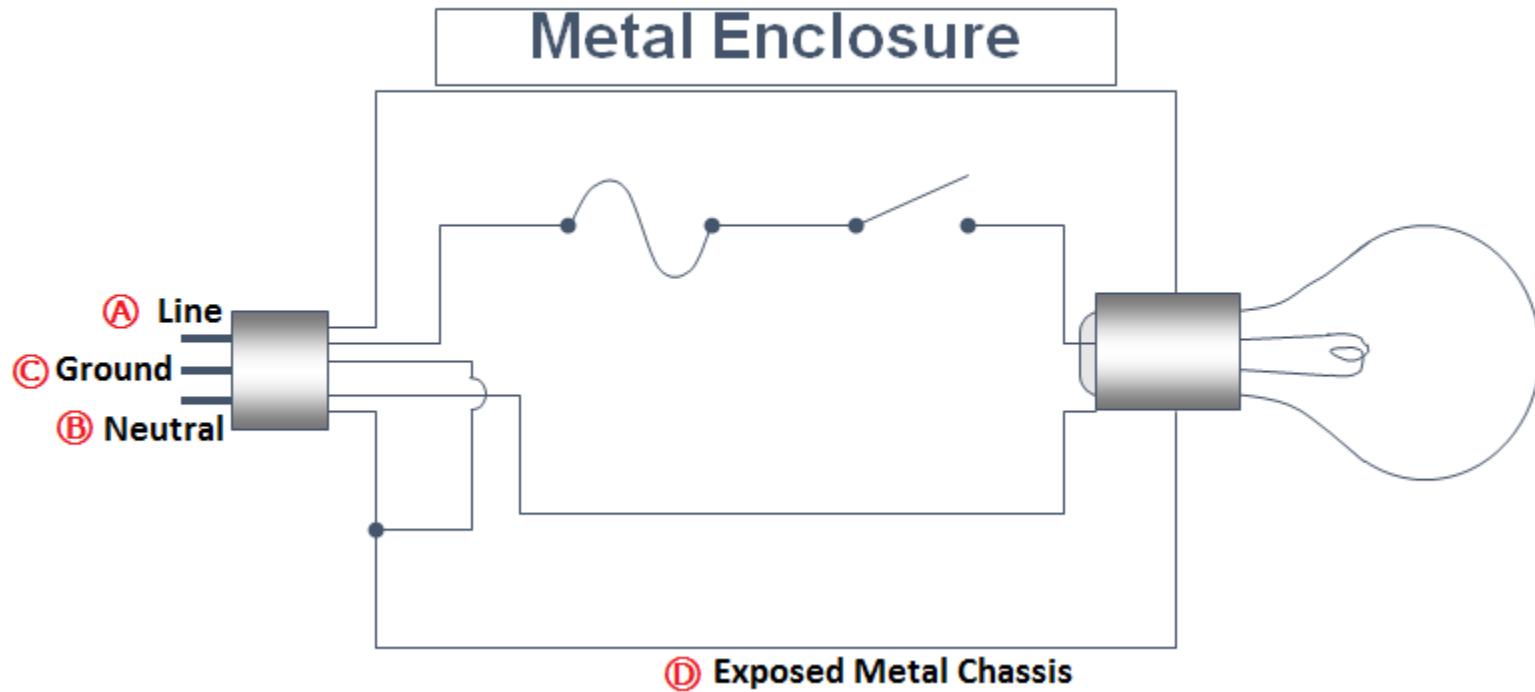
The ground conductor of a product must have a low enough impedance to handle any fault current



# Poll Question

During a Hipot Test, at what point is high voltage applied?

# How to Hipot



# Poll Question

During a Hipot Test, at what point is high voltage applied?

# Dielectric Withstand Test

Commonly referred to as Hipot test, it is used to determine whether the insulation of a product is able to withstand an over-voltage condition without breaking down.

It is a deliberate application of high voltage potential between the mains input and any exposed dead-metal.

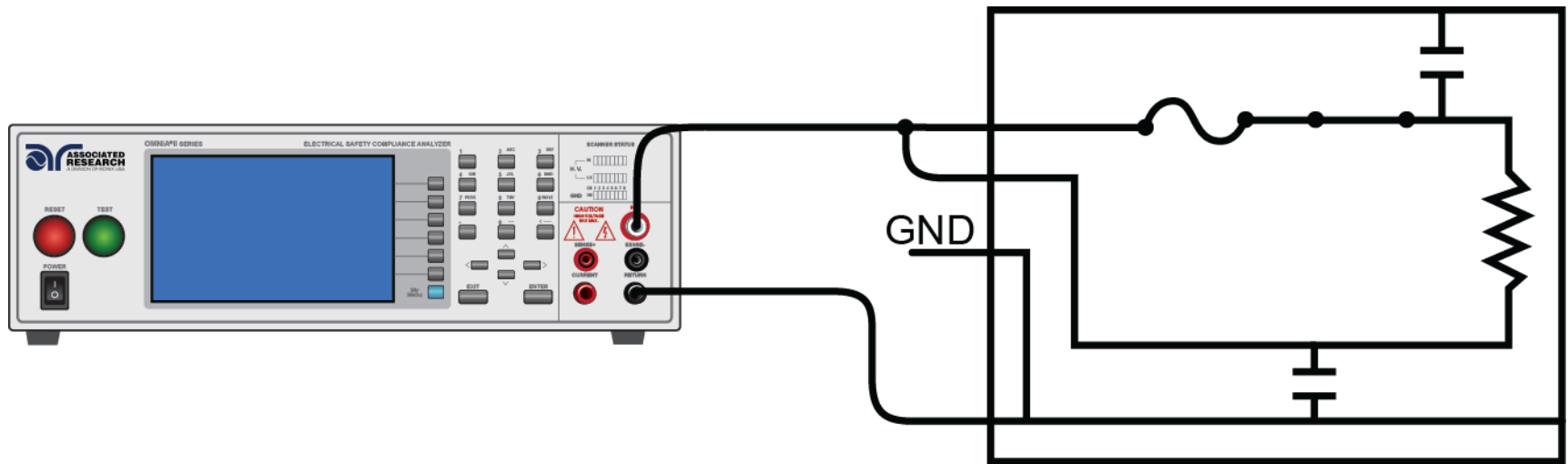
The resulting leakage current is measured to determine whether a product's insulation is able to withstand the high voltage without breaking down.

This test verifies that the insulation of a product is capable of protecting the user from any leakage currents as a result of an electrical fault within the product.

# Dielectric Withstand Test

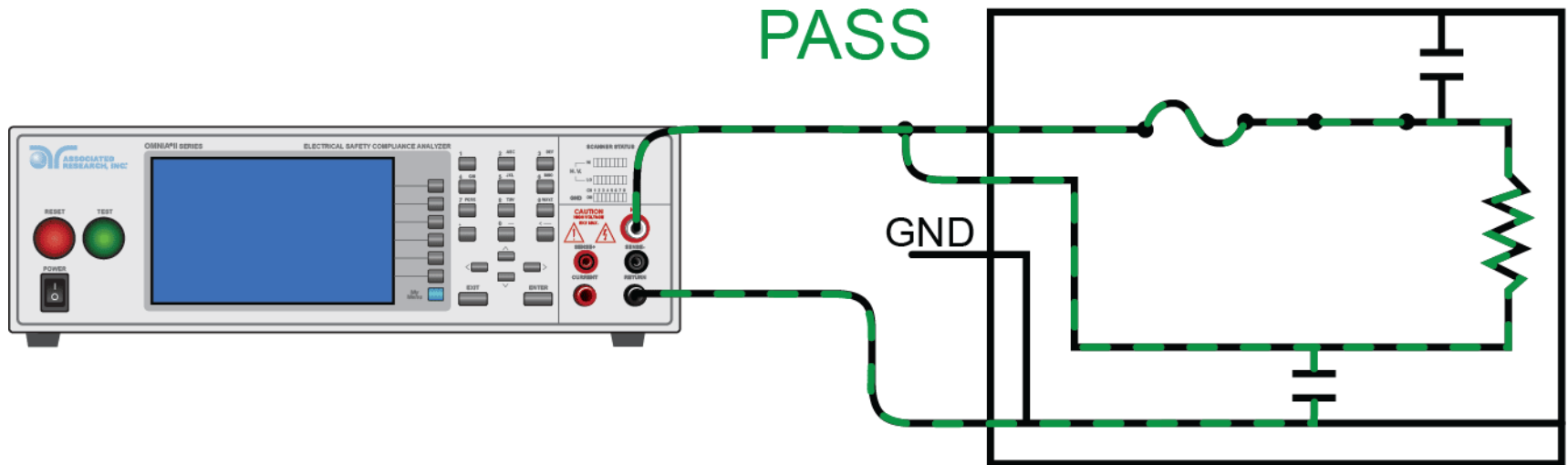
Can be a Type test or a Routine test.

Used to detect possible defects in the design of a product and workmanship defects such as inadequate creepage and clearance distances.

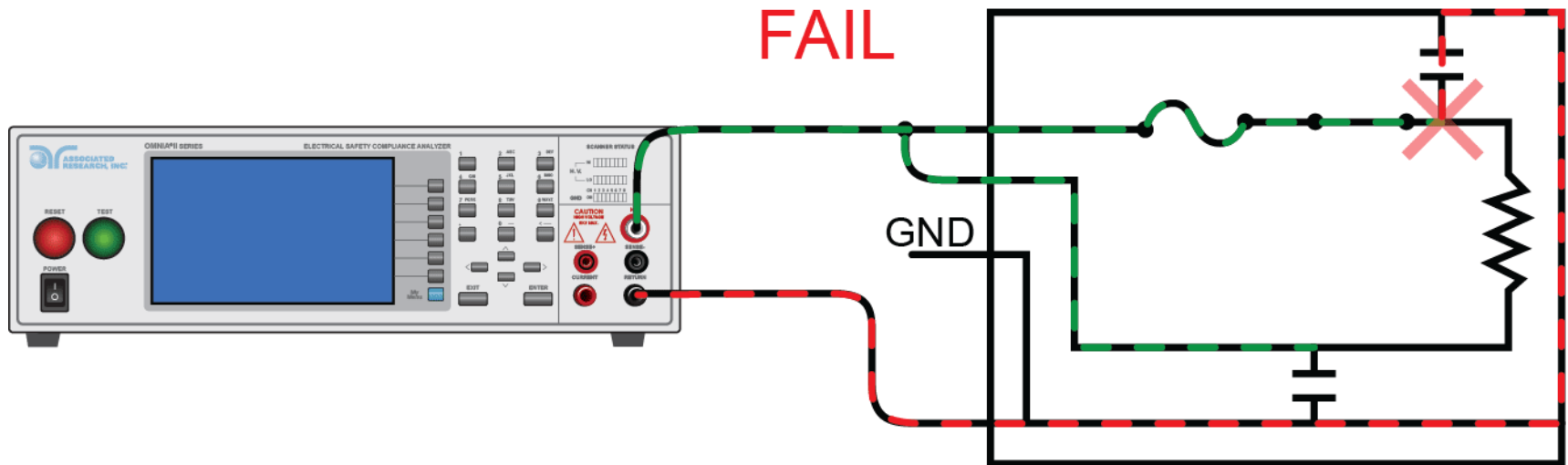




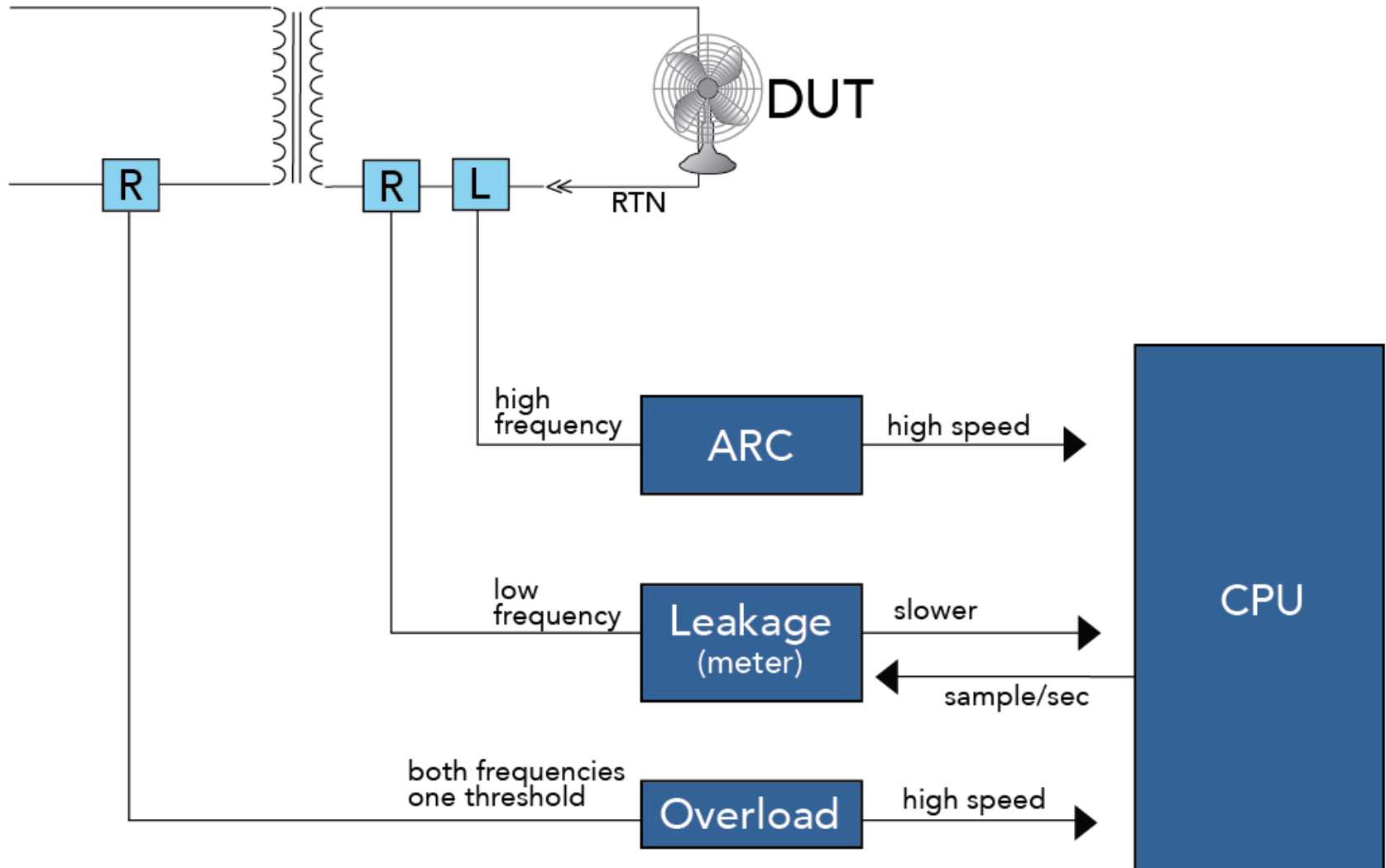
# Dielectric Withstand Test



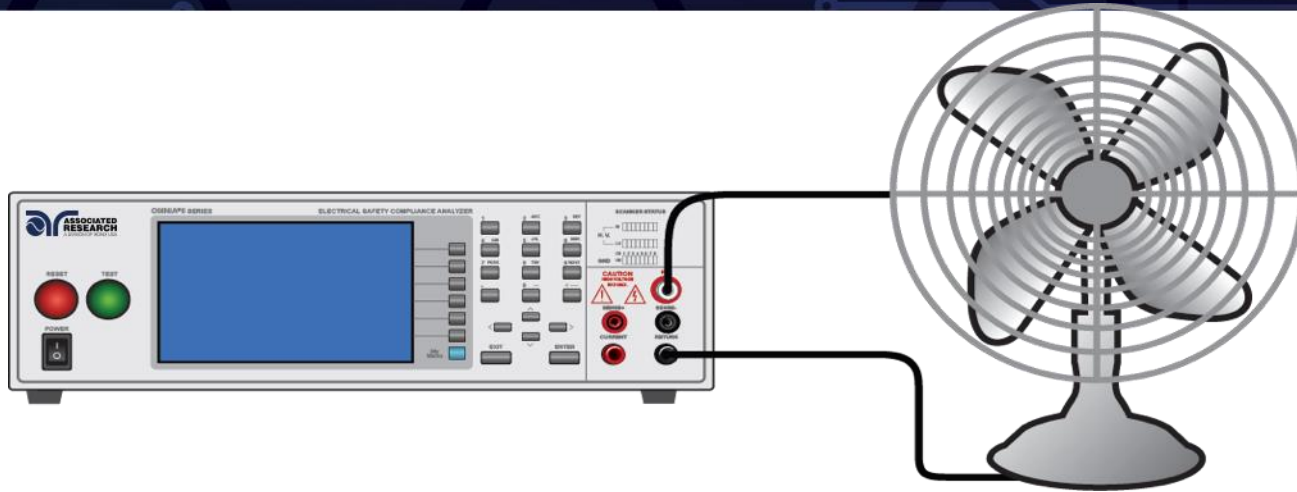
# Dielectric Withstand Test



# Failure Detection



# Dielectric Withstand Test



Leakage current is present in every product to some degree.

Leakage current becomes a problem when it reaches excessive levels due to dielectric breakdown.

Result is displayed in mA or  $\mu$ A depending on test type.

# Dielectric Withstand Test

Test is performed on both Class I and Class II products.

Test can be performed in both AC and DC mode based on the safety standard.

Test voltage and trip settings must be specified by the manufacturer in accordance with the safety standard.

Most standards specify the test voltage to be calculated using the following formula:

$2 \times \text{Products Rated Voltage} + 1000 \text{ Volts}$

# Insulation Resistance Test

Similar to a DC Dielectric Withstand Test and stresses the same insulation on a product as the DCW test and provides a quantifiable value of the product's insulation.

Hence, the least commonly specified electrical safety test.

Commonly performed on serviced and repaired units to verify product integrity.

Results in a resistance measurement .

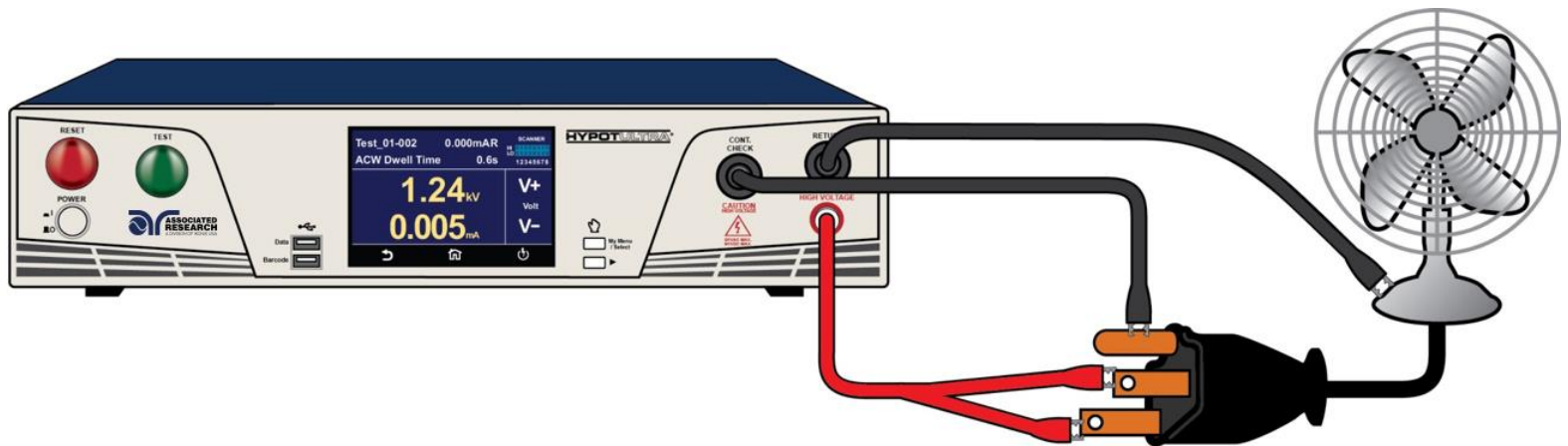
Most standards specify test voltage at 500 or 1000 Volts.

High insulation resistance value indicates good insulation.

# Insulation Resistance Test

Like other electrical safety tests, test parameters vary upon the standard.

EN 60204-1 Safety Of Machinery, specifies a 500 Volts DC test between the power circuit conductors and protective bonding circuit, the resistance shall not be less than 1 M $\Omega$ .



# Leakage Current Test

Line Leakage test is performed on electrical products to measure the leakage current which could flow through a person while the product is operating.

A measuring device (MD) is used to simulate the impedance of the human body under different conditions depending upon the application of the product.

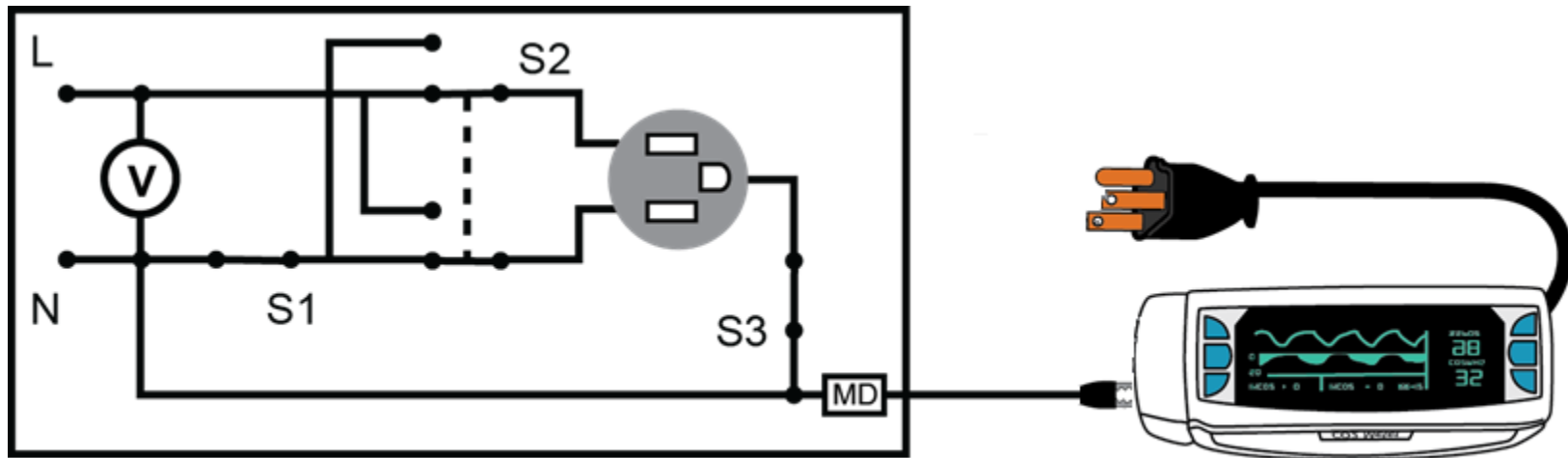
Test is run under both normal and single fault conditions and reversed polarity on the input line power at 110% of rated input.

Most commonly performed on medical equipment.



# Leakage Current Test

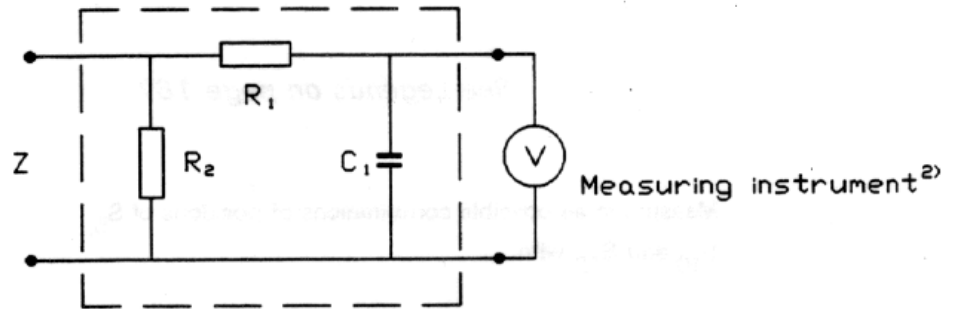
## Typical Circuit for Leakage Current Test



# Leakage Current Test

The MD can vary from standard to standard.

Measuring device for EN 60601-1 Medical Electrical Equipment.



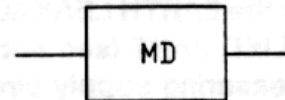
$$R_1 = 10\text{k}\Omega \pm 5\%^{1)}$$

$$R_2 = 1\text{k}\Omega \pm 1\%^{1)}$$

$$C_1 = 0.015\mu\text{F} \pm 5\%^{1)}$$

<sup>1)</sup>Non-inductive components

<sup>2)</sup>Impedance  $\gg$  measuring impedance  $Z$



Equivalent to the above in subsequent figures.



# Poll Question

Are any of the following features listed in your standard operating procedures? Select all that apply

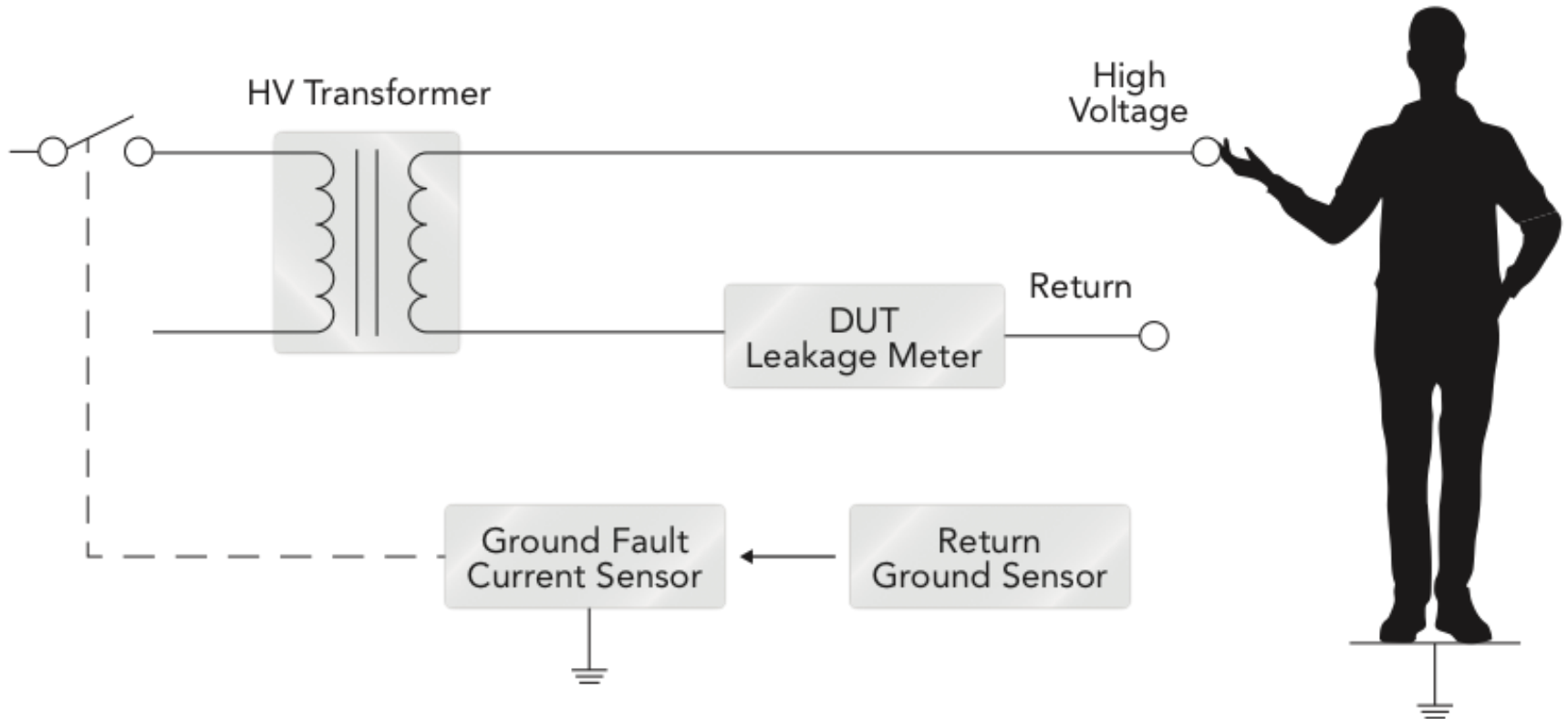
The SmartGFI® is a patented safety feature in all Associated Research high voltage safety testers

The Associated Research's SmartGFI® circuit will shut down high voltage if excess leakage is detected through the ground circuit

This is a high-speed shutdown circuit that disables the high voltage in less than 1 millisecond

It is an active circuit which monitors the configuration of the return connection and automatically sets itself accordingly

# SmartGFI®



# Arc Detection

Arcing is a momentary partial discharge due to the intense concentration of a high voltage electric field across a dielectric material

In Hipot testing, the dielectric is the insulation of the device under test (DUT)

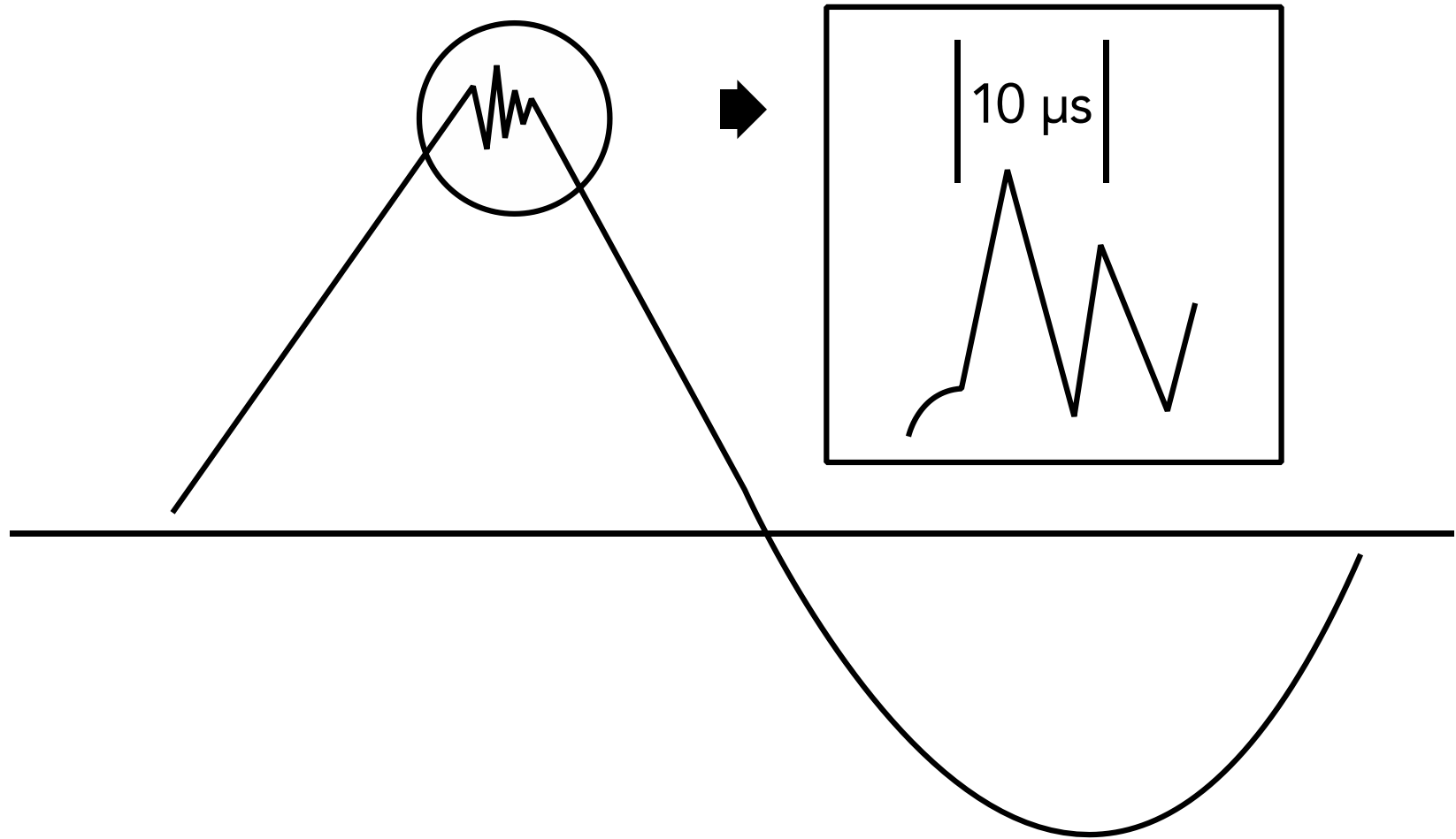
Arcing produces momentary spikes in the nominal leakage current waveform

Arcing is different from dielectric breakdown

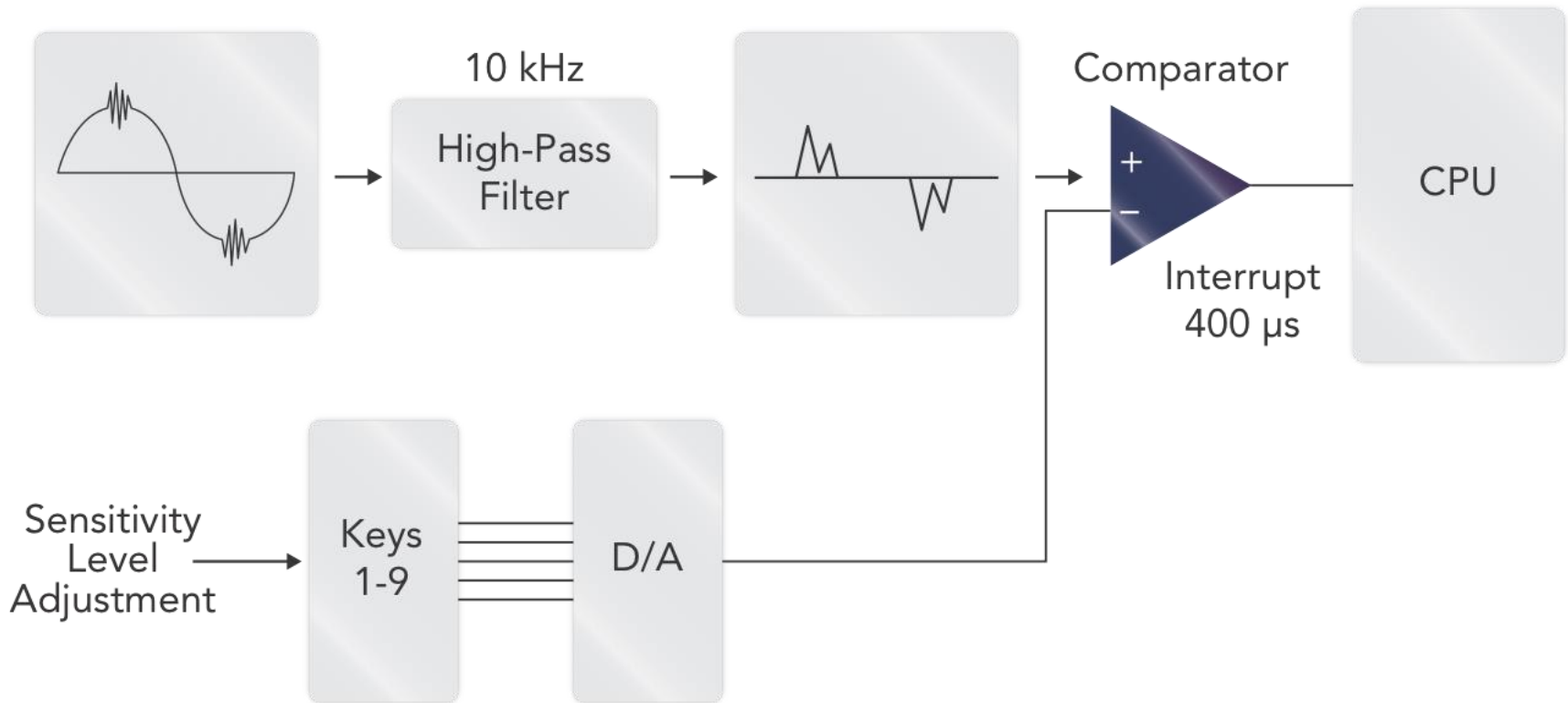
Arc failure does not necessarily mean hipot failure

Arc detection provides useful information about the product's insulation

# Arc Detection



# Arc Detection





# Arc Detection

Arc Setting	mA Trip Level
1	20
2	17.75
3	15.5
4	13.25
5	11
6	8.75
7	6.5
8	4.25
9	2

It's important to remember that this method of arc detection is **NOT** an exact science. There are many variables involved including surface geometry, altitude, atmospheric pressure etc.

# Verification

An electrical safety test is only as good as the test instrument

Simple way of checking if the failure detectors are working correctly

Recently, test standards have started to mention the importance of instrument verification

Some manufacturers perform instrument verification daily or before every shift

Associated Research offers solutions for verification of different test types

Test Verification Boxes: TVB-2 and LVB-2

# Instrument Verification – TVB-2



Ground  
Bond/Continuity

ACW/DCW

Insulation Resistance

Pass/Fail Verification

CE listed

# Instrument Verification – LVB-2



Leakage Current  
Test Verification

Various types of  
LCT's

Multiple Loads

CE Listed

The background features a dark blue world map. Overlaid on the map are numerous hexagonal icons in a lighter blue shade. These icons represent various concepts: a headset, a video camera, a microphone, a lightbulb, a clock, a person with a lightning bolt in their head, a graduation cap, a question mark in a speech bubble, a smartphone, a laptop with a play button, and a person at a computer. The word "ONLINE SEMINAR" is partially visible in some of the hexagons. A large, faint globe icon is also present in the upper right. The word "Questions?" is written in a large, white, sans-serif font across the center of the image.

# Questions?

# Educational Resources

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Our Next Webinar is

# Hipot Test 101

Wednesday, May 16 at 10 A.M. CT







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