Megger.

5 kV and 10 k Insulation testing

BE ON GUARD FOR EFFECTIVE TESTING

- **What does a GUARD terminal do?**
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Introduction:

The development of the insulation tester by Evershed & Vignoles is part of our electrical history. Insulation testers produced by Megger Instruments in Dover dates back to before to 1897.

Voltage outputs are now available up to 10 kV to suit all industrial and commercial applications. On the higher voltage testers (2.5 – 10 kV), which incorporate very high insulation ranges, is where the GUARD TERMINAL becomes a major benefit, when testing various devices that have long surface leakage areas of insulation.

These include:

    Larger diameter cables
    Porcelain bushings
    Power transformers
    H.V. circuit breakers

Such products exhibit long creepage paths across their insulation by the nature of their size. This will cause the unwanted surface leakage resistance to introduce errors, and is the reason the Guard terminal is used to enhance the accuracy of the measurement.

What does a GUARD terminal do?

During insulation testing we are often so preoccupied with the resistance of the actual insulator we forget the resistance path on the outer surface of the insulation material. However this resistance path is very much a part of our measurement and can dramatically effect our measurements. For example if dirt is present on the outer surface of a bush the surface leakage current can be up to ten times that flowing through the actual insulation.

The surface leakage is essentially a resistance in parallel with the true insulation resistance of the material being tested. By using the guard terminal, performing a so-called **three terminal test,** the surface leakage current is ignored. This may be important when high values of resistance are expected such as when testing high voltage components like insulators, bushings and cable. These tend to have large surface areas that get exposed to contamination resulting in high surface leakage currents across them.

The **total current** that flows during an insulation resistance test is made up of three main components:

1. The **charging current**, which is charging up the objects capacitance.

2. An **absorption current** is the current which is being drawn into the insulation by the polarising of the electrons, initially high but drops over time, but at a slower rate than the charging current

3. The **conduction** or **leakage current** which is the small steady state current which divides into two parts:
    a. The conduction path **through** the insulation
    b. The current flowing **over the surface*** of the insulation.

*Surface leakage is the component of the insulation we do not want to measure if we just want to measure the insulation resistance of the material. By using the guard terminal, which is available on most HV insulation testers, the surface leakage can be excluded from the measurement.

In applications with lower insulation resistance values (<100MΩ), such as in L.V. building wiring applications, this is not necessary, but with values of insulation above the 100MΩ as found in H.V. insulation applications the use of the guard terminal is often very important.
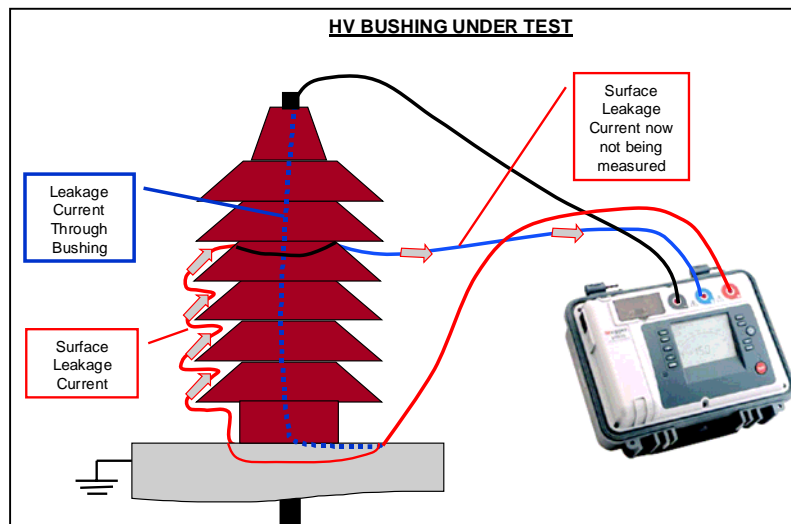
How does it work?

Here we have a typical application for the GUARD terminal, testing an HV bushing. Without the GUARD terminal means that the leakage current flowing though the bushing and across the surface is combined and therefore measured together by the instrument.
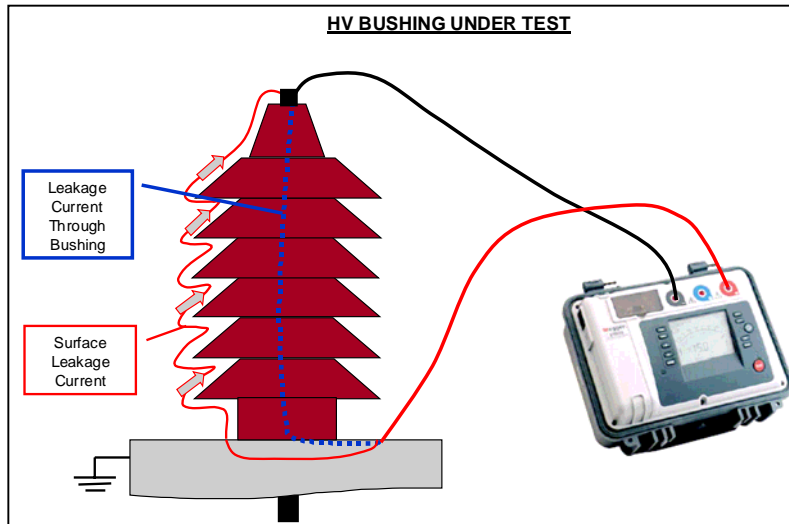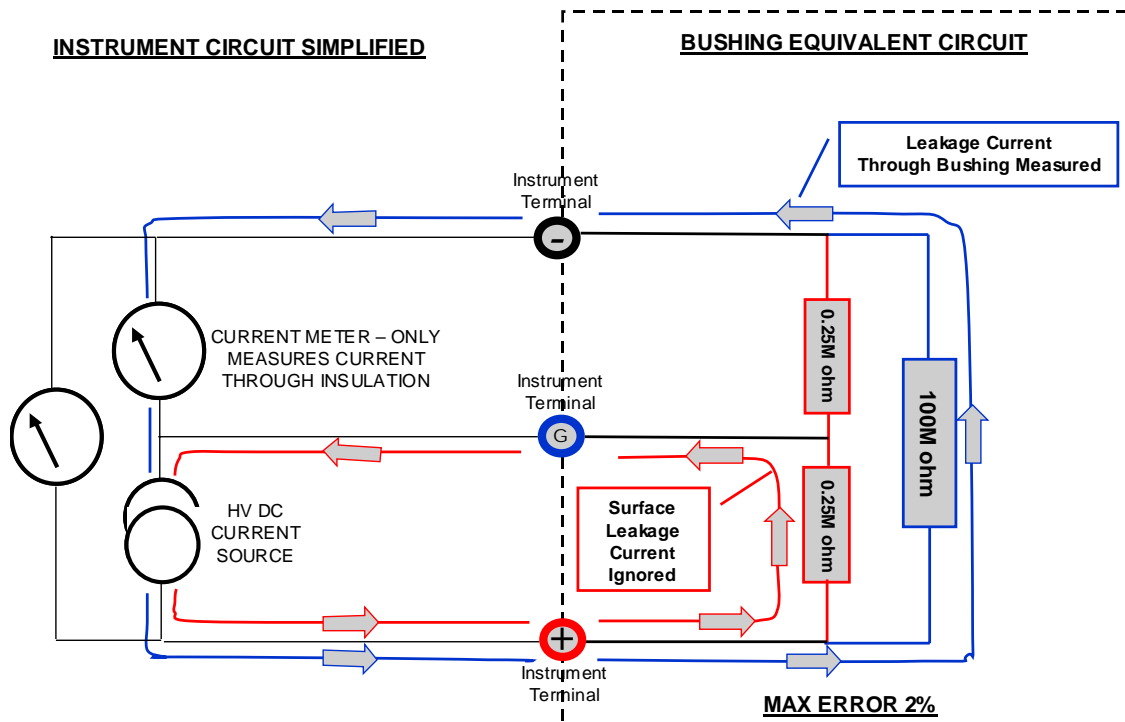

Now with the GUARD terminal now in use:

Wire has been wrapped around the bushing and connected to the GUARD terminal, now the surface leakage flows to the GUARD terminal. Current flowing into the GUARD terminal is NOT measured by the instrument and so is ignored by the insulation resistance measurement.

To better understand what is actually happening within the instrument we can look at the following diagram. Put simply the insulation tester has three main elements; the H.V. d.c. current source, the H.V. voltmeter and the current meter. The insulation resistance measurement is simply ohms law, measured voltage divided by the measured current. The GUARD terminal allows leakage current to bypass the current measurement, and so be ignored in the measurement.

INSTRUMENT CIRCUIT SIMPLIFIED

BUSHING EQUIVALENT CIRCUIT

Leakage Current Through Bushing Measured

Instrument Terminal −

CURRENT METER – ONLY MEASURES CURRENT THROUGH INSULATION

0.25M ohm

100M ohm

Instrument Terminal G

Surface Leakage Current Ignored

0.25M ohm

HV DC CURRENT SOURCE

Instrument Terminal +

MAX ERROR 2%

However the story doesn't end there, as you can see we have added example values to the above diagram. In this circumstance any instrument in the Megger MIT or S1 range of insulation testers will provide measurements with no more than 2% additional error. This is an important part of the comprehensive specification these instruments provide.

MIT and S1 5 kV and 10 kV range specify the GUARD terminal performance as:

2% Error guarding 500 kΩ leakage with 100 MΩ load

Why does Megger specify GUARD performance?

To put it simply it is part of the uncertainty of the measurement. The more leakage current bypassing the current measurement means less left to measure. This then becomes a real test of the instruments ability to accurately measure this remaining test current and therefore give an accurate measurement of the insulation resistance.

The Megger specification reassures the user of its ability to cope under these conditions and provide meaningful results, and therefore properly diagnose the true condition of the insulation. Remember effective predictive maintenance relies on reliable trending of test results to provide early indication of failure. Time taken to carefully compensate for temperature variation can easily be wasted by poor results due to surface leakage not being correctly guarded.

Where does this fit in with other instrument specifications?

Safety?

These days we are more and more recognising the importance of test instrument safety. Insulation testers are not an exception. The complete range of Megger MIT and S1 5 kV and 10 kV insulation testers are CATIV 600 V to give the user maximum confidence.

So how does this relate to the performance of the GUARD terminal? Well, to be able to meet the stringent requirement of CATIV 600 V set out in IEC1010-1: 2001 the instrument has to be protected against 8 kV high-energy impulses on ALL terminals. The challenge is to maintain both impulse protection and the test performance of the instrument.
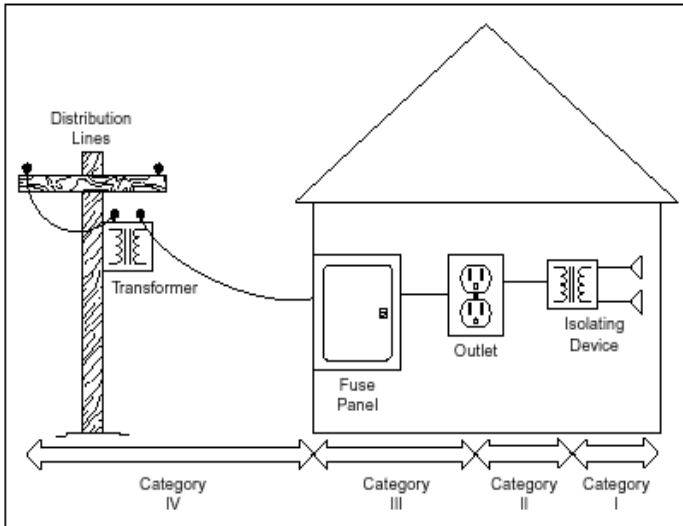
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- **IEC1010-1:2001**
  - •Protection against input transients between any terminals

- **CATIV 600 V**
  - •8 kV transient protected

- **Challenge is to maintain protection and GUARD terminal performance**

Short circuit test current?

The Megger range of MIT and S1 5 kV and 10 kV insulation testers have at least 3 mA into short circuit capability. This is not just to allow the instruments to quickly charge capacitive loads such as long cables. This also means the instruments have the power to maintain test voltage across lower resistances.
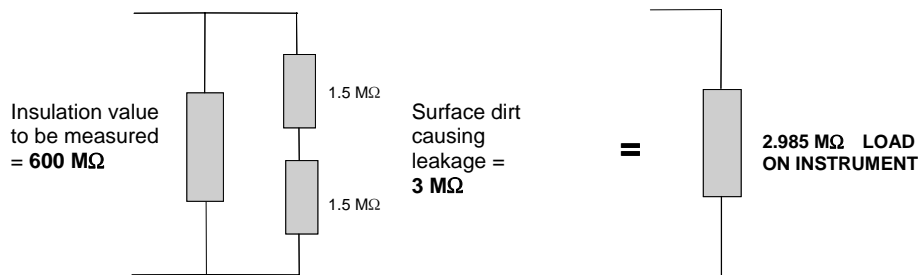

This circuit quickly demonstrates how a 600 MΩ insulation resistance can soon present a less than 3 MΩ load to the instrument with surface leakage. High power maintains the test voltage across the insulation and provides enough test current to accurately measure the insulation.

What about testing transformers?
(Measuring from two different 'insulated conductors' - earth)

The two windings both H.V. and L.V. of any particular phase, in a three phase transformer (Fig 1) can be measured with respect to each other, the guard terminal eliminates the surface leakage current flowing over the outside of the contaminated insulator and down to earth, hence the value of the inter winding resistance will be read more accurately by the insulation tester.
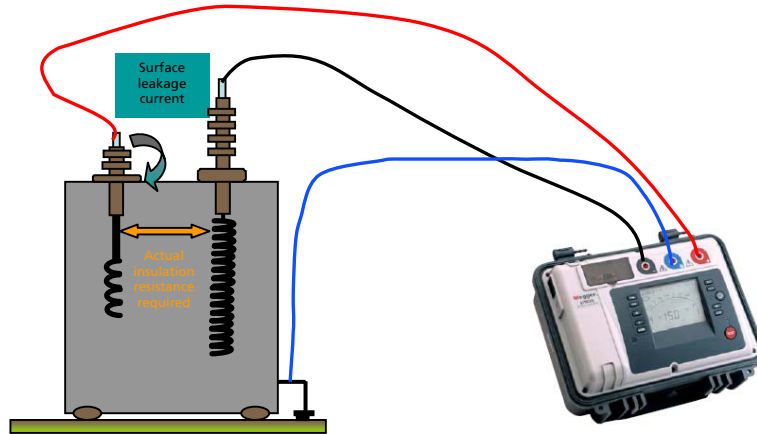
(Fig 1) Transformer winding insulation test with the guard used 'to eliminate false readings', due to the surface leakage path across dirty porcelain insulators

NOTE: In practice both windings on a three-phase transformer are wound concentrically on an insulated former on the same limb of the iron core. They are, therefore, subject to inter-turn or inter-winding breakdown, and hence the need to insulation test between the two.

What are the real benefits of using the GUARD terminal?

In addition to the big improvements in the reliability of insulation condition diagnosis and predictive maintenance discussed above there's one more big benefit:

The GUARD terminal is an important diagnostic tool!

By performing two tests, one using the GUARD terminal and one without we can quickly identify when surface leakage is present and how much. Setting the instrument to display leakage current makes it easy to subtract the measurement taken with the GUARD in place from the measurement without. The result tells you exactly how much current is surface leakage.

There have been many instances of poor insulation resistance measurements leading to bushes etc. being replaced needlessly at huge cost. Only to find later, by employing the GUARD terminal, that they simply needed a good clean!

For more information on **three terminal testing** see the Megger Limited publication 'A Stitch in Time' the complete guide to Electrical Insulation Testing available at www.Megger.com.