# Kelvin Technology on Electrical Safety Analysers (ESA)

Over the years, Electrical Safety Analysers have become a “must have” Analyser for most professionals in the production, service and maintenance fields for Electrical Medical Equipment.

Most Manufacturers have Preventive Maintenance procedures that includes Electrical Safety Testing following International standards such as IEC 60601 or IEC62353.

A regular test procedure for grounded Electrical Medical Equipments does include a Protective Earth Resistance measurement.

There is a large number of Medical Equipments concerned by this Protective Earth Resistance test, from small Class I Medical devices (Monitors / Defibrillators / Surgery units….) to permanently installed Medical Equipments (Scanners / IRM / Radiotherapy…..).

With a so large variety of Medical Equipments earth connections……

## Are you sure to make the right measurement ?

According to the IEC standards the measures of a Protective Earth Resistance does have a low value (lower than one Ohm). See the limits below ;

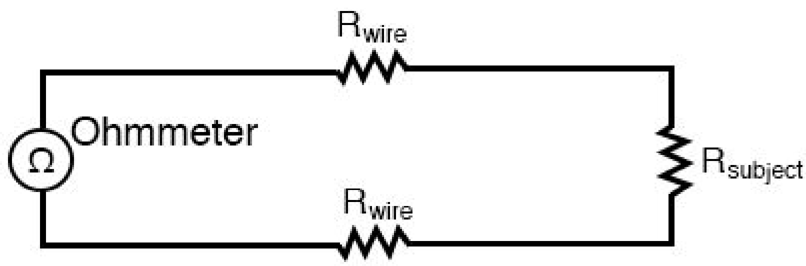
| Standard | EUT Configuration | Limit |
|---|---|---|
| IEC 62353 | *Equipment with detachable power cord: tested with cord connected* | 0.3 Ω |
| | *Equipment with detachable power cord: cord disconnected; measured from chassis to PE terminal of EUT mains input* | 0.2 Ω |
| | *Equipment powered from RCD-protected accessory outlet: measured from EUT chassis to PE of primary mains supply* | 0.5 Ω |
| IEC 60601 | *Equipment with detachable power cord: cord disconnected; measured from chassis to PE terminal of EUT mains input* | 0.1 Ω |
| IEC 61010 | *Equipment with detachable power cord: cord disconnected; measured from chassis to PE terminal of EUT mains input* | 0.1 Ω |
| NFPA 99 | *Equipment with detachable power cord: tested with cord connected* | 0.5 Ω |

The first aspect is that It is well known that a regular 2 wire technic can not accurately measures such low impedance.

The second aspect to consider is the length and size of the cables used for the measurement that does have an impact on the results.

Suppose we would like to measure the resistance of a Medical Equipment located a significant distance away from our Electrical Safety Analyser.  Most of the time, this is the case for permanently installed Medical Equipments that are far away from their power cabinet.

Such scenario is problematic because the Safety Analyser measures *all* resistance in the circuit loop, which includes the resistance of the wires ($R_{wire}$) connecting the Analyser to the component being measured ($R_{subject}$):

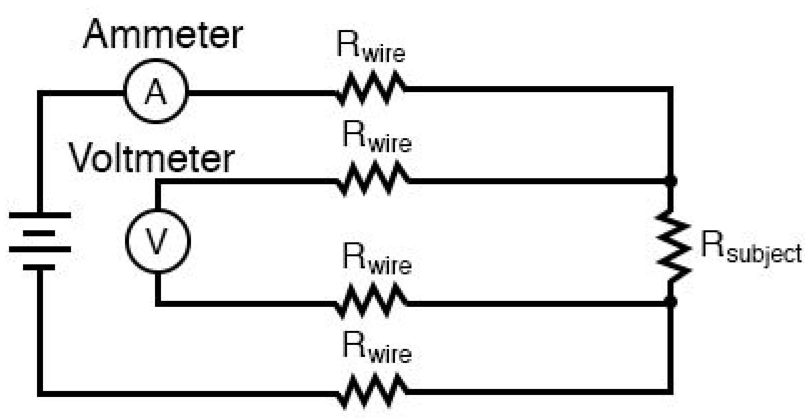



Ohmmeter indicates $R_{wire} + R_{subject} + R_{wire}$

Using a 2 wire method, You can not “Zeroing” your measurement circuit because of the impedance of the cables (several ohms). Your ESA can not even measure a such several Ohms value and even less “Zeroing”.

Considering that usually, wire resistance is very small (only a few ohms per hundreds of feet, depending primarily on the size of the wire) but significant compares to the connection to Earth we would like to measure, and if the connecting wires are very long, and/or the circuit to be measured has a very low resistance anyway, the measurement error introduced by wire resistance will be substantial.

An ingenious method of measuring the subject resistance in a situation like this involves the use of both an ampere meter and a volt meter inside the Electrical Safety Analyser. We know from Ohm’s Law that resistance is equal to voltage divided by current (R = E/I). Thus, we should be able to determine the resistance of the subject component if we measure the current going through it and the voltage dropped across it.



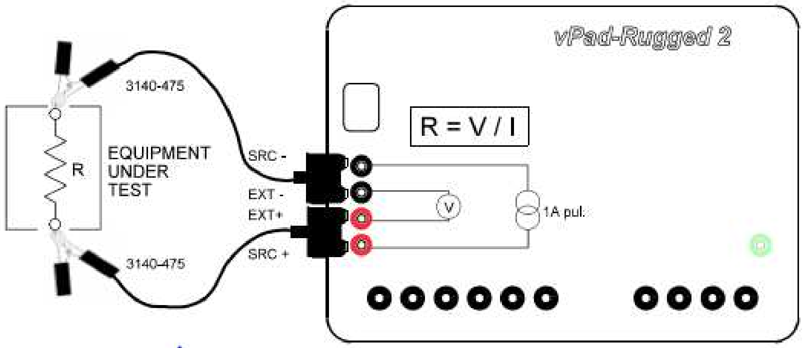

$$R_{subject} = \frac{\text{Voltmeter indication}}{\text{Ammeter indication}}$$

The Electrical Safety Analyser is a source of current which flows in the circuit including the Resistance of the wires and the Resistance to measure. Our Voltmeter is connected across the subject resistance by another pair of wires containing resistance.

There is a miniscule current carried by the voltmeter's wires so the Voltage drop in the cables is not significant and as a result, the impedance of the cables can be neglected.

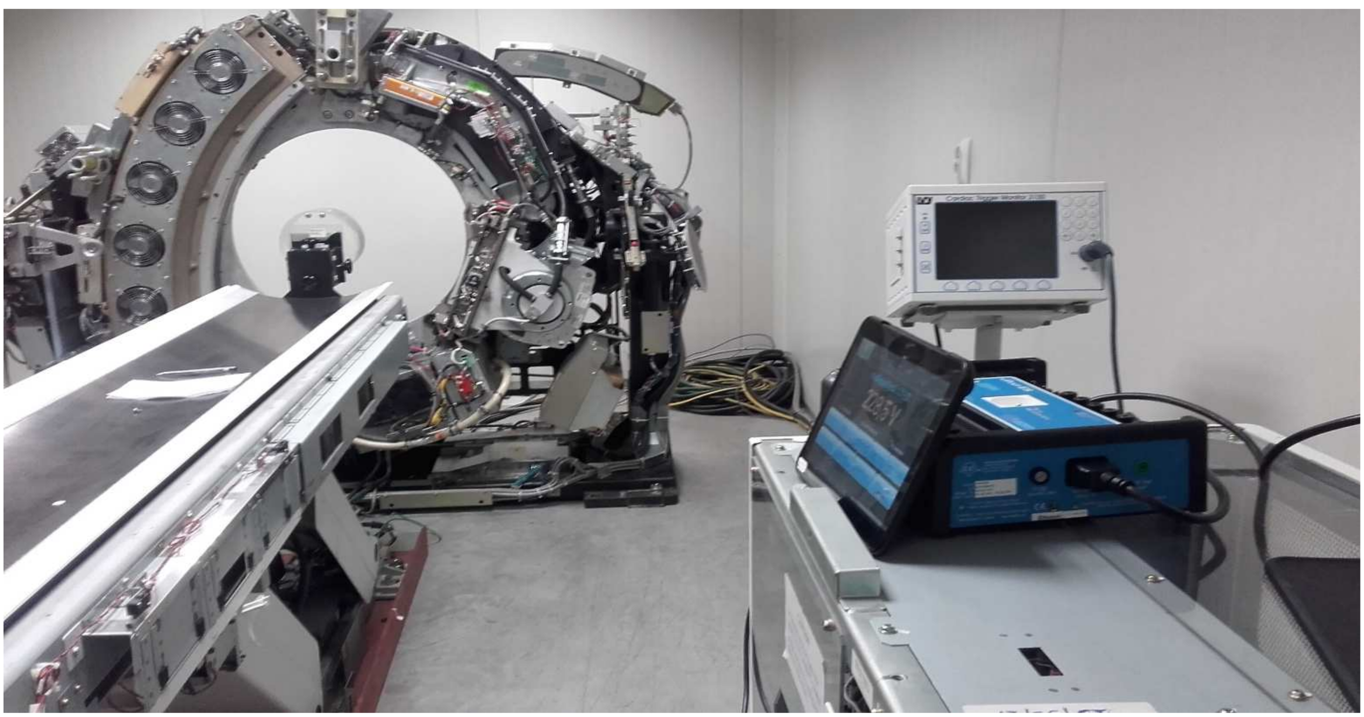
Only the impedance of the Protective Earth is measured and this is done with a good accuracy.

The **Datrend vPad-Rugged 2** / **vPad-ES2** / **vPad-Mini** Safety analysers do use this Kelvin technology. On each of them, you can see the following 4 wires connectors  and how to connect on the diagram :


On the example below, the **Datrend vPad ES 2** is able to measure the different earth circuit of this CT Scan.

One Kelvin cable is connected to the main earth inside the power cabinet and the second Kelvin cable is moved to every points that need to be checked on the scanner itself and the patient table.



Due to the help of the kelvin technology used by Datrend Electrical Safety Analysers, the length of the cables used for this test do  not have any impact of the measurement, even they are 10 meters long here on the example above.

In an hospital, there are numbers of Medical Equipments that are permanently  installed. The needed cables length for such devices could easily increase, up to 25 meters.

Only ESA with Kelvin Technology can be used in these cases.

The Electrical Safety Analyser displays the result with accuracy as below :


In the example of the CT Scan we consider today, according to the Manufacturer PM and IEC62353, the test needs to be performed on every protectively accessible conductive parts.

Thanks to : Wikipedia and [www.allaboutcircuits.com](http://www.allaboutcircuits.com) web site

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