# Troubleshooting Solar Plant Faults Through Impedance Testing

New solar panel string testing principle based on impedance measurements: the strength of this new technology is both speed and accuracy, plus these measurements are very gentle on the PV array.

Impedance spectroscopy can be used to test and troubleshoot many issues and malfunctions. Among these testing features is a precise ground fault finder.

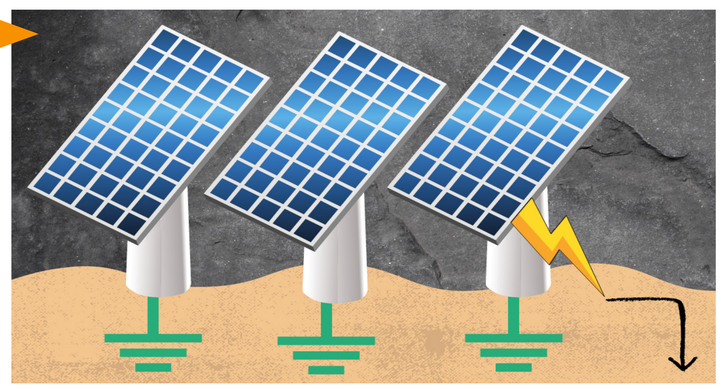
Ground faults are the most common DC fault. Ground faults are a safety hazard. Plus, they lead to a complete system shutdown and not just power loss from the solar panel or conductor.

The material damage causing the ground fault is normally invisible to the naked eye, making the cost of troubleshooting these faults substantial.

## What are Ground Faults?

### Ground Fault

- A condition where current unintentionally flows on grounding conductors.
- Happens when a current carrying conductor makes connection with the equipment grounding conductor.



### Key Term is Riso

- Riso is the electrical isolation resistance of the system.
- When the PV system is installed Riso is typically more than 40 MΩ and it means that there is a very high barrier for current leakage
- Overtime Riso can go down and cause current to flow in the Equipment Grounding Conductor. This condition is a ground fault.

Riso > 40 MΩ = Healthy Array

Riso > 3 MΩ = Potentially Degraded Insulation Materials

Riso < 3 MΩ = Intermittent Ground Faults

Riso < 1 MΩ = Permanent Power Loss and Risk of Fire

## What Causes Ground Faults?

There are many causes of ground faults. Among these many causes are:

Degradation of insulation due to aging.

Insulation cracking over time due to changes in temperature

Damage to insulation by rodents, insects, or birds

Damage to insulation during installation or by future building work

Water ingress to inverter, solar module, junction box, cables, or conduits

If wiring is installed too quickly, it is likely that string wires will be pulled too tight, walked on, or pinched.

The mishandling or poor management of wires can create the conditions for ground faults.

## Traditional Troubleshooting Methods

The challenge is that most known methods for analyzing PV ground faults are less than optimal. In fact, equipment used to assess the safety of PV arrays by measuring Riso are often also relied upon for troubleshooting. However, simple voltage measurements and “voltage pulse” testing is not adequate for pinpointing faults in the early stages.

The “real life“ fluctuating values of Riso, the intermittent nature of faults, and the internal resistance of voltage testers are just some of the factors that make it complex to troubleshoot faults in an accurate way, consistantly. Also note that “voltage pulse” testing, in some cases may cause damage to the PV equipment by ionizing metal parts and thin conductors in the system.

The material damage causing the ground fault is normally invisible to the naked eye, when the PV system is observed in the field. The cost of troubleshooting ground faults can therefore become substantial if the technician is relying on voltage-based testing principles. Such testing methods will not allow early stage detection and localization of faults.

### Insulation Tester

In this test a voltage is applied to the conductors, generating a current on the wire that is measured. That measurement is then compared against a baseline for insulation in good condition. This determines the state of the insulation resistance.

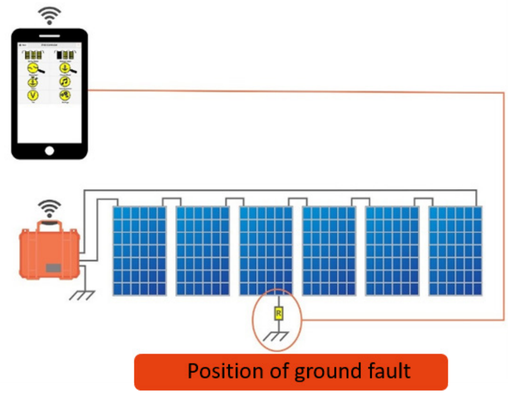
- Standard method
- Testers are cheap
- May ionize PV equipment
- Does not give position of ground fault

### Voltmeter

An electric meter is connected to the solar panel to measure its voltage. The reading is compared to ideal Standard Test Conditions (STC). This determines the voltage of the panel. A multimeter can be used to measure both DC volts and DC AMPs.

- Dangerous (handle energized terminals)
- Testers are cheap
- Does not give position of ground fault
- Can aid in pinpointing faults but that requires deep understanding

## Impedance Testing




Emazys Z200 combines all string parameters with impedance spectroscopy and measures the voltages and currents flowing between string terminals under various DC loads introduced by the instrument. The output is a precise figure for the Riso as well as the position of ground faults.

Unique to impedance measurements, the position of the ground fault can be accurately determined at Riso < 3MΩ. This is well before the inverter shuts down production and it avoids even larger leakage currents. This testing mode can determine the string voltage VOC, the isolation resistance Riso and the position of a ground fault within 60 seconds.

### Works in Cloudy Conditions

Traditional testing methods require a certain amount of irradiance to work. Impedance testing however can work even in cloudy conditions.

### Find Pesky Intermittent Faults

Even if the fault is intermittent, the Z200 can be left in the field to detect a fault, no matter when it is occurring. Impedance testing can catch faults even if they occur at 5am or 7:30pm.

- Safe
- Fully automated
- Requires little training
- Pinpoints fault location, PLUS measures R and other system parameters