Tutorial

CHAUVIN ARNOUX

Diagnosing insulation in a photovoltaic installation

To maintain the correct functioning of the photovoltaic installation over time, the primary objective of professionals is to ensure DC energy and effective energy production.

This control requires numerous operations, including insulation testing, which checks for faults in the earth connection.

Insulation problems can occur on the photovoltaic module, on the power transmission cables or on the inverter. They are mainly caused by water or moisture ingress into the module's junction boxes.

Photovoltaic tester: FTV 500

The sum of the leakage values of these components constitutes the leakage current. It is equal to the total amount of electrical current discharged to earth. These leaks result in energy loss from the system and a risk of electrocution.

Each photovoltaic system has a different potential relative to earth. Only secure insulation from earth prevents currents from the photovoltaic system from flowing to earth and avoids any risk of contact and additional losses.

Insulation control allows **the measurement of the electrical resistance of individual photovoltaic modules, components or the entire photovoltaic chain** by examining their behaviour at a high test voltage.

To be compliant with legislation, a photovoltaic system must meet basic parameters, known as R_{ISO} (insulation resistance), which impose minimum values for the electrical resistance of conductor cables and components. This ensures safe operation (EN 62446 and IEC 64-8 standards require a minimum insulation resistance of 1 MΩ and test voltages of 500 V or 1,000 V).

To perform your diagnosis, follow the steps below

Tools and evaluation methods

1. To measure voltage

Use the voltmeter: **CA 5293, F404**

2. To measure insulation resistance

- With the megohmmeter: **CA 6526**
- Use a measuring instrument that independently dissects the potential of the module/string during insulation resistance measurement to safely disconnect and short-circuit the photovoltaic modules: **FTV500 photovoltaic tester**

Only use an instrument that is suitable for measuring insulation resistance

3. To perform a measurement of the voltage and identify the defective module on a string

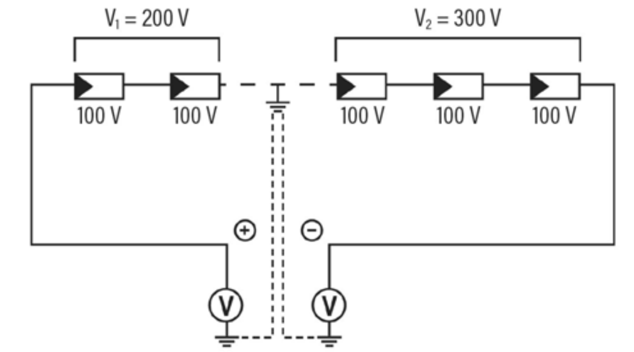
This procedure allows for the measurement of the voltages in the installation and, based on the balance between V(+) and V(-) relative to earth, identifies the probable location of the fault. Steps to follow:

- Measure the voltages between the negative and positive terminals V(0)
- Measure the voltages between the positive terminal and earth potential V(+)
- Measure the voltages between the negative terminal and the earth's potential V(-)

If there is a fault in the earthing lead (poor insulation), there will be different voltage values, e.g.:

- Voltage measurement V(0) = 500 V (result of 5 modules * 100 V each)
- Voltage measurement V(+) = 200 V
- Voltage measurement V(-) = 300 V

By dividing the results of the V(+) and V(-) voltages by the individual module voltage, **the position of the faulty module will be located between the second and third photovoltaic modules.**



Measurements on a string, V+ and V- voltages with a voltmeter

If it is not possible to measure a ground fault, the insulation resistance must be measured using a megohmmeter or a photovoltaic tester equipped with a megohmmeter function.

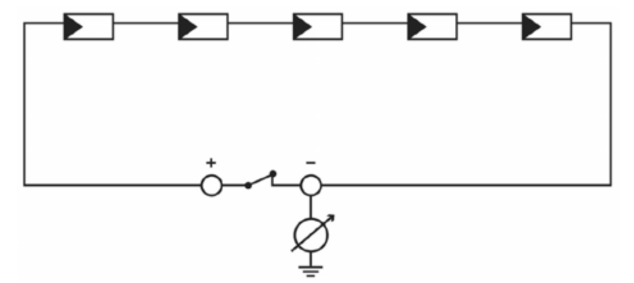
Warning

This verification procedure provides reliable results when performed taking into account the following:

- Single string disconnected from the inverter, any surge arresters and earth connections
- Absence or upstream connection of any blocking diodes
- Environmental conditions similar to those in which the fault was flagged

4. Why measure insulation resistance?

Measuring insulation resistance can provide more accurate results than voltage measurement, which may be less accurate in indicating ground faults.



Schematic representation of the measurement

5. To calculate the insulation resistance of a photovoltaic system

Before measuring the system, the theoretical value of the insulation resistance of the string/module must be identified, which will be used as a comparison parameter.

The total expected resistance of the photovoltaic system or individual string is calculated using this formula:

$$R_{ISO} = \frac{1}{\left(\frac{1}{R_{MODULE\_1}}\right) + \left(\frac{1}{R_{MODULE\_2}}\right) + \dots + \left(\frac{1}{R_{MODULE\_3}}\right)}$$

To obtain the precise insulation resistance of a photovoltaic module, you have three options:

- Request it from the module manufacturer
- Find it in the technical data sheet
- Look it up in standards EN 61646 and EN 61215, which define the minimum value that the photovoltaic module must have: **R_{ISO} > 40 MΩ per m^2 of surface area**

Examples:

- A photovoltaic module with a surface area of 1 m^2 must have an insulation resistance of at least 40 MΩ
- A photovoltaic module with a surface area of 2 m^2 must have an insulation resistance of at least 20 MΩ

Once you have determined the theoretical insulation resistance value of the string/module to be tested, you can proceed with the actual measurement using a megohmmeter or a photovoltaic tester with a megohmmeter function.

In both cases, the insulation resistance is performed using a device that allows the photovoltaic modules to be safely disconnected and short circuit (e.g. a DC disconnect switch for photovoltaic systems).

6. To follow the verification procedure with a megohmmeter

1. Calculate the expected theoretical insulation resistance for each string
2. Disconnect the module/string from the system (disconnect all poles of the module/string connected to earth)
3. Install the short circuit device to reduce the voltage in the circuit to zero
4. Connect the insulation resistance meter
5. Short-circuit one string
6. Set the test voltage. Its value must be as close as possible to the maximum voltage of the photovoltaic module system, without exceeding it (see module data sheet)
7. Perform a measurement of the insulation resistance
8. Remove the short-circuit
9. Measure the remaining strings using the same procedure
10. If the insulation resistance of a string deviates significantly from the calculated theoretical value, there is an earthing lead fault in the string concerned

7. To follow the verification procedure with a measurement instrument

Only those equipped with an automatic module/string potential interruption function

1. Calculate the expected theoretical insulation resistance for each string
2. Disconnect the module/string from the system (disconnect all poles of the module/string connected to earth)
3. Install the DC disconnect device downstream of the module/string
4. Connect the insulation resistance meter upstream of the module/string
5. Set the test voltage. Its value must be as close as possible to the maximum voltage of the photovoltaic module system without exceeding it (see module data sheet)
6. Perform a measurement of the insulation resistance
7. Open the DC disconnector
8. Perform the measurement of the other strings using the same procedure
9. If the insulation resistance of a string deviates significantly from the calculated theoretical value, there is an earthing lead fault in the string concerned

Our selection of instruments

TRMS digital multimeter

Ref. P01196803
AC/DC voltage measurements up to 1000 V

CA 5293

TRMS digital multimeter clamp

Ref. P01120944
Voltage measurements AC/DC
up t 1200 VAC / 1700 VDC

F404

Multifunction photovoltaic tester

Ref. P01129600
Voltage measurements AC/DC
up t 700 VAC / 1000 VDC
250-500-1000 V insulation test
Insulation test with and without power

FTV 500

Digital megohmmeter

Ref. P01140826
250-500-1000 V insulation test

CA 6526

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Chauvin Arnoux Group
12-16, rue Sarah Bernhardt
92600 Asnières-sur-Seine - France
Tel. +33 1 44 85 44 85
info@chauvin-arnoux.fr
www.chauvin-arnoux.fr

CHAUVIN ARNOUX GROUP