

Life Is On

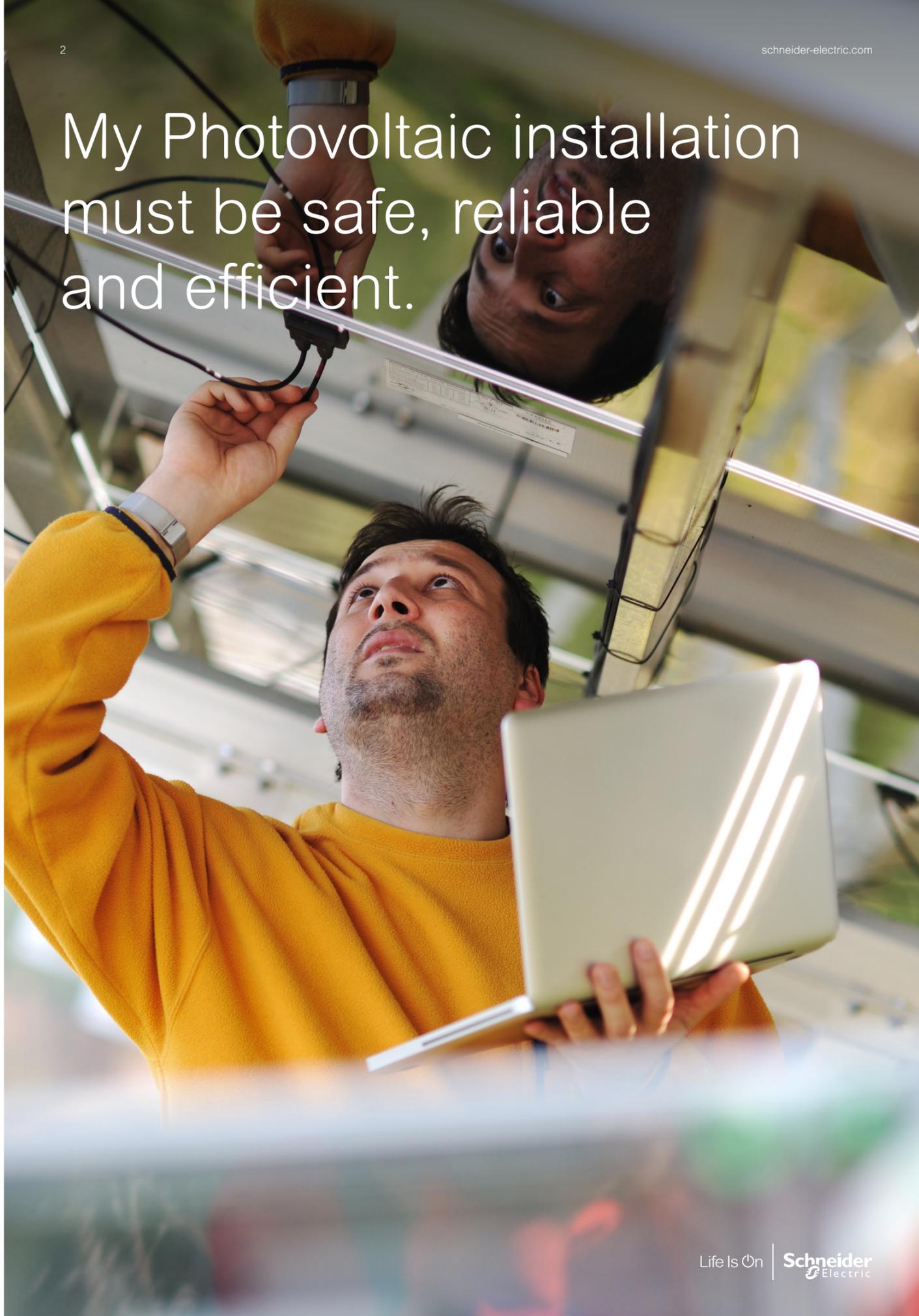
Schneider
Electric

Keep the power running safely in the sun

Vigilohm Insulation Monitoring
For safe and reliable photovoltaic energy generation

schneider-electric.com

My Photovoltaic installation must be safe, reliable and efficient.



What is at stake in Photovoltaic installations?

Photovoltaic (PV) installations, especially solar farms with central inverters, are quite specific installations. Typically, a PV installation is a very large surface covered with photovoltaic modules producing high voltage DC energy. Short circuit currents produced by PV modules are too low to trigger usual protections, as compared to nominal current. Furthermore, PV generators cannot be shut off as long as PV modules are exposed to the sun, and PV farms are often monitored remotely. As for the equipment, it is a challenging mission profile, including high temperatures when the production is on during the day, and low temperatures when the production is off at night. Peak energy generation is up to 3 MW per PV field.

As a result, specific attention must be paid to mitigate all kinds of risks, especially fire, with special attention to roof top PV installations.

Safety is one reason why the PV electrical distribution is ungrounded, allowing insulation resistance to be monitored and faults to ground to be effectively detected. Insulation fault monitoring and its outcomes greatly depend on the grounding system.

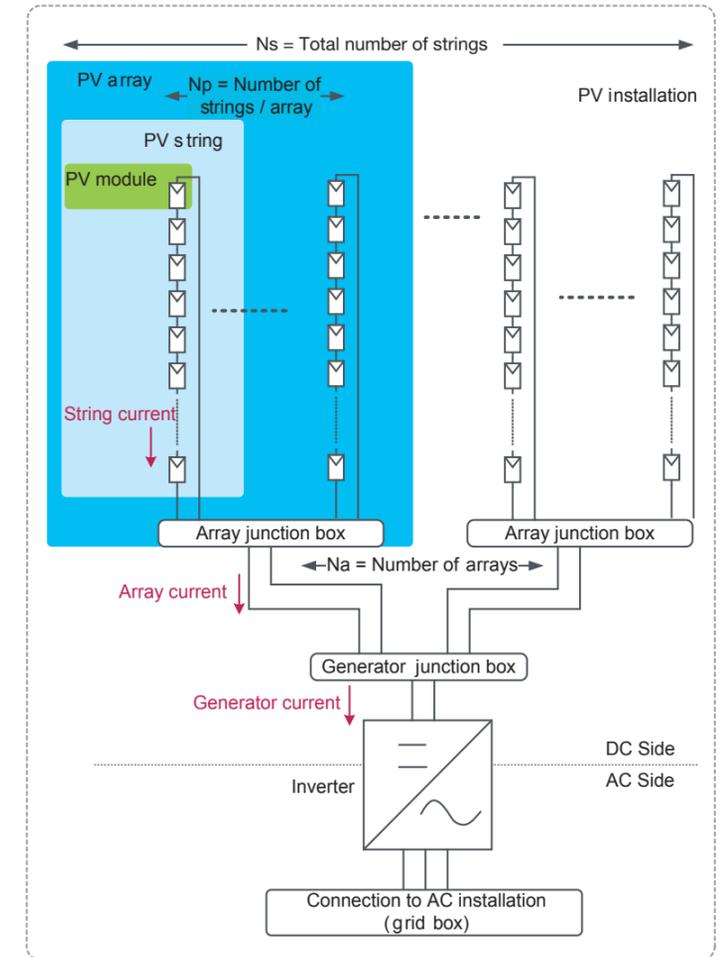


Figure 1



Grounding arrangements

The grounding arrangement depends on PV panel technology, and status of the installation.

Technology	Grounding System At Day (during power generation)	Grounding System At Night (power generation stopped)
Monocrystal and Polycrystal (Mono-Si and Multi-Si) <div style="background-color: #008000; color: white; padding: 5px; border-radius: 10px; display: inline-block;">90% of PV installations</div>	Depending on the manufacturer: Ungrounded Grounding is not required, so an ungrounded system is used to improve continuity of service. <ul style="list-style-type: none"> An IMD continuously monitors insulation. If an insulation fault is detected, operation of the inverter may continue until the end of the day; but the day after, the inverter will not be allowed to start if the fault is still present. Grounded Required by some PV panel manufacturers to avoid Potential Induced Degradation (PID) polarization effect. <ul style="list-style-type: none"> An insulation fault will cause the fuse of the earth connection to be open. 	Ungrounded <ul style="list-style-type: none"> An IMD continuously monitors insulation. If an insulation fault is detected, it must be corrected for the inverter to be allowed to start in the morning.
Thin Film (a-Si and CDTE)	Grounded To avoid Transparent Conductive Oxide (TCO) corrosion risk. <ul style="list-style-type: none"> Manufacturers specify the grounding of the + or - side of the DC string. Only 1 earth connection point. Galvanic insulation between a DC solar system and an AC utility grid is required (IEC 60364). An insulation fault will cause the fuse of the earth connection to be open. 	Ungrounded <ul style="list-style-type: none"> An IMD is connected at night or in the morning. If there is no insulation fault, the inverter is allowed to start (IEC 62109-2).

Ungrounded PV panels refers to situations where there is no earth connection, no ground reference. The network voltage is floating when compared to the ground potential.

Whenever the network is ungrounded, an Insulation Monitoring Device is mandatory to detect the presence of an insulation fault.

Typical insulation resistances in a PhotoVoltaic installation

Insulation resistance to ground of a PV installation shows very broad variations.

PV panels account for 70 to 90% of a solar installation's insulation resistance, which depends widely on the temperature and conditions of the weather at that moment. Weather can affect network insulation resistance and leakage capacitance, as can the time of day.

As a consequence, it is essential to follow the historical evolution of your PV insulation resistance, to set the proper insulation alarm threshold, and anticipate any abnormal behavior.

Insulation resistance may vary broadly, from around 100 kOhm at day in dry conditions, down to 1 kOhm at sunrise, in humid environmental conditions with the influence of dew (Figure 2).

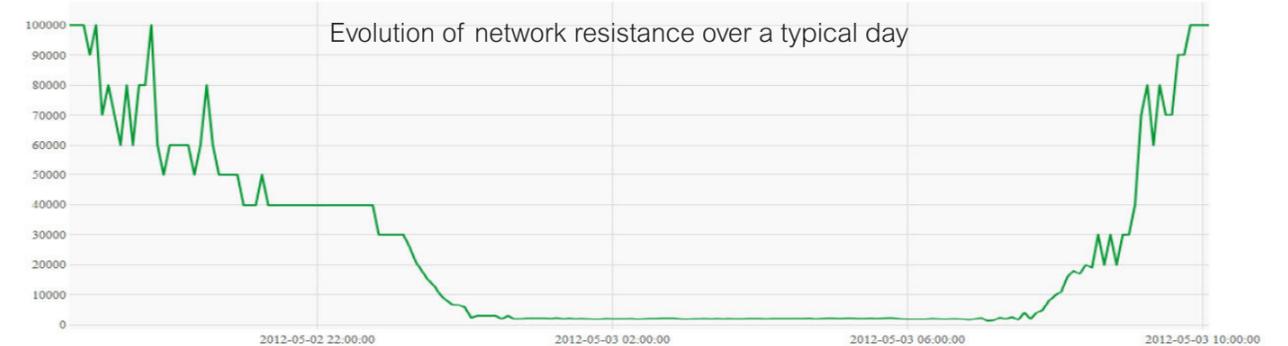


Figure 2

At the same time, the leakage capacitance of the same network varies in the opposite way, with low values during the day, yet extremely high values in the early morning, with the potential of hundreds of μF , possibly a thousand or more. The diagram below shows the variation of the capacitance during the same period of time.

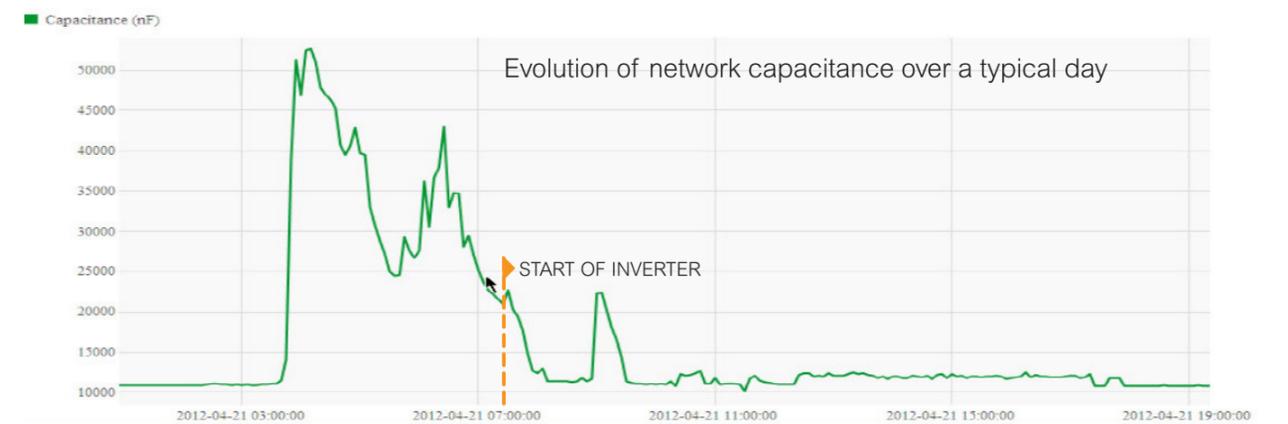


Figure 3

Vigilohm Insulation Monitoring Devices

These large and fast variations of resistance and capacitance are integrated by the Vigilohm insulation monitor, as it undertakes very fast changes from negative temperatures at night to +60 or 70°C once the inverter starts its production. Because of the temperature range, humidity, and dust, the IM400C is recommended for PV installations.

The best place to monitor the network

To meet the standards requirements, an IM400C is located on the DC side of the inverter.

- In the morning, before operations start, the IM400C monitors the PV field and authorizes the inverter to start only if the insulation resistance is satisfactory (above the IMD set threshold).
- At day, insulation resistance is monitored only if the technology of the module allows it, meaning if mono or polycrystallin modules are installed. If thin film modules are installed, the IMD is in stand-by as soon as the inverter starts, until production stops.

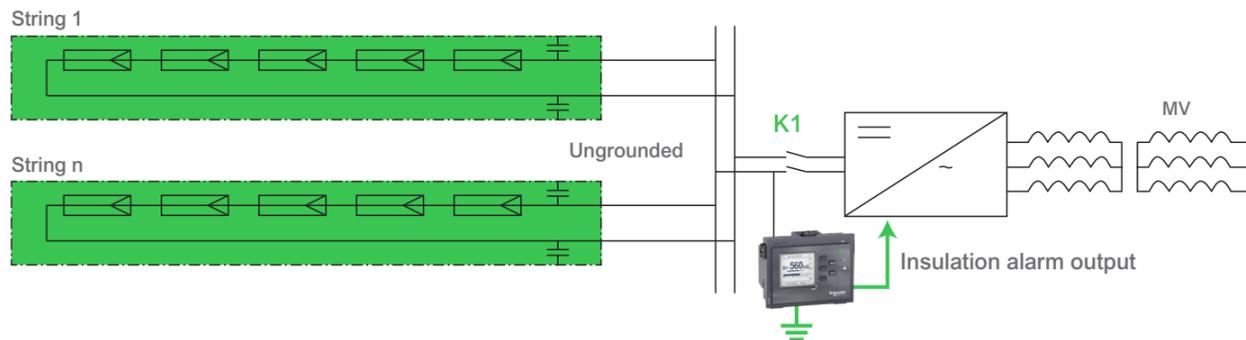


Figure 4

Application Standards for Solar farms

IEC standard 60364 Part 712	Solar photovoltaic power supply systems
IEC standard 62109-1 and -2	Safety of Power Converters for use in PV power systems
IEC TS 62548	Photovoltaic arrays – Design Requirements



The Proven Photovoltaic Solution.

Experience shows that the sources of insulation faults are not that numerous.

Real faults are very seldom, typically related to cable erosion and rodents, incorrectly tightened wires, or strong climatic events damaging the installation or panels or disconnecting cables.

Another type of fault may happen, not related to a true fault, thus called a false alarm. It is mostly seen in the morning, when the environmental conditions change the most and the fastest, specifically at dawn, in conjunction with heavy rain or melted snow. The solution to prevent false alarms is to set an appropriate alarm threshold, not too high, and an alarm delay.

The Schneider Electric Solution

Based on the proven reliability of the IM400C and its voltage adaptor, its very low frequency injected signal (0,0625Hz) reduces the influence of the capacitances. This increases the accuracy of the measurements, gives a reliable detection of insulation faults, and increases the safety and availability of the installation.

Thanks to its high accuracy measurements, the IM400C reduces false alarms and down times, making the installation more profitable.

Because the IM400C monitors AC and DC networks, it monitors from the furthest DC panel to the AC step-up transformer.

Equipped with a native Modbus communication port, the IM400C allows remote data consolidation and trending analysis.

The IM400C and its voltage adaptors IM400-1700C or IM400VA2 are all conformally coated to protect them from the effects of humidity, especially in the morning.

These solid characteristics make the IM400C compliant to tough mission profiles, including PV applications.

Vigilohm provides the Solution for your ungrounded network

Schneider-Electric Solar publications for PV helps your ungrounded network to be properly set, wired and configured.

Vigilohm IM400C is proven compatible with DC networks, UPS, and inverters, and with other potentially load generating disturbances.

One unexpected interruption can cost approximately 8% of the photovoltaic yield per hour. And there are penalties to pay if the target is not achieved, since the PV operating contracts specify a percentage of availability of the installation. Using an ungrounded network with proper insulation monitoring helps improve PV availability and revenues.

Insulation Monitoring Devices Are Needed For:

- Continuous measurement of network insulation resistance to ground
- Measurement of the network's leakage capacitance to ground
- Warning of the existence of a 1st insulation fault on the network, to prevent damages occurring and to notify service people to fix it



Vigilohm Insulation Monitor Key Features

Vigilohm IM400C

- Real-time monitoring of insulation resistance of the complete network, AC and DC sides
- Triggers an alarm at first insulation fault
- Monitors networks with voltages up to 1000V AC / DC with Voltage adaptor IM400-1700C
- Monitors networks with voltages up to 1500V AC / DC with Voltage adaptor IM400VA2
- Injection signal optimized for PV applications at very low frequency
- Alarm thresholds settable from 50 Ohms upwards
- Compliant with networks up to 2000 μ F (typically 1MW peak) with voltage adaptor IM400-1700C
- Compliant with networks up to 5500 μ F (typically 3MW peak) with voltage adaptor IM400VA2
- Suited for harsh environments, including fast ambient temperature swing
- Operating temperature from -25 degrees C/-13 degrees F to +70 degrees C / 158 degrees F
- Relative humidity up to 94%
- Easy to set up, thanks to its large screen and Modbus communication port



IMD-IM400C



IMD-IM400-1700C



IMD-IM400VA2

IM400C meets

IEC61557-8	product standard, including annex C on PV
IEC61010	safety standard
IEC61326-2-4	EMC standard
IEC61364-4-41	Installation
UL508	Safety standard
UL61010	Safety standard
UL FS	UL Functional Safety
UL1998	UL Functional Safety



Going to the next level.... Remote monitoring of a PV field insulation

At Schneider Electric, we have a comprehensive line of gateways and software solutions compatible with our Vigilohm Insulation Monitors. We can build simple solutions to monitor insulation from several PV sites remotely, and to record the historical evolution of each PV site resistance and capacitance. This data can also be correlated with the recording of environmental parameters for deeper analysis.

Vigilohm IM400C natively supports Modbus RS485 and can be integrated into software offers, such as Conext Control.

Vigilohm products are also natively supported in Power Monitoring Expert software and the Com'X 510 Energy Server.

Such systems will provide better understanding of the network insulation over time, allowing the implementation of corrective actions.

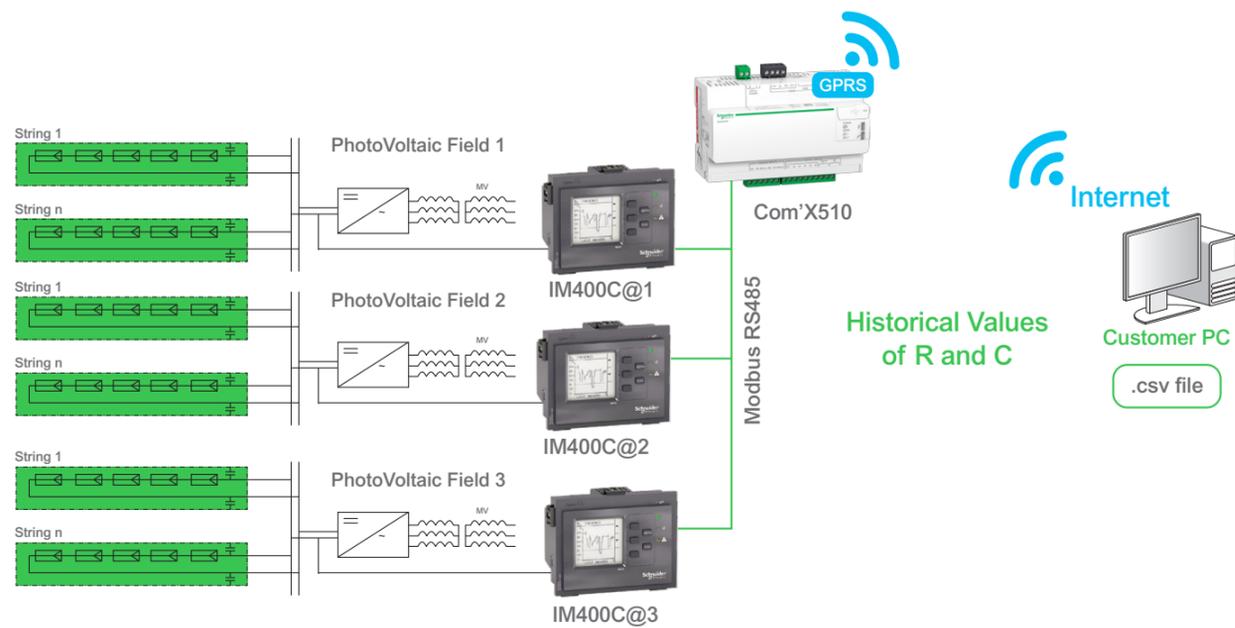


Figure 5



Anticipate insulation faults

A decrease of network insulation due to installation ageing can be recorded; preventive maintenance can be implemented



Keep the Solar Growing and Going.

Solar energy is more than ever one of the major green energy producers. Recent evolutions in this area are also making it cost competitive as the solar KWh is everyday closer to price parity.

Solar solutions are continuously evolving towards more reliability, more efficiency, more flexibility in usage, especially with the growing attraction of energy storage. These evolutions put the Schneider Electric and Vigilohm team at the cutting edge of technology, to serve your current and future needs and solutions.

Schneider Electric has strong solar energy management expertise, and the Vigilohm insulation monitoring team is a key part of the solution. Our experienced team of experts is at your service to facilitate the implementation, commissioning, operation, and maintenance of your solar plant.



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 Electric

Schneider Electric

35 rue Joseph Monier
92500 Rueil-Malmaison, France
Tel : +33 (0)1 41 29 70 00

www.schneider-electric.com

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