Application Guide

Reed Relays for Monitoring PV Efficiency & Fault Detection

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The largescale harvesting of electricity through photovoltaic (PV/solar) cells is extremely popular in the renewable energy sector and continues to reduce our dependence on fossil fuels. However, a 2022 report by the International Energy Agency (IEA) states the cost of new renewable installations (PV and wind farms) has increased, reversing, in the organization's words, "...a decade-long cost reduction trend."

Solar farm efficiency must be high to produce a good ROI, and the most common threat to that efficiency is electrical current leaking to ground. Leaks can be the result of poor installation but, more commonly, they develop over time in the PV panels and in the cables carrying the DC voltage to the inverters for conversion into AC for connection to the grid.

Monitoring for earth leaks is essential to ensure safety, efficient productivity and for scheduling maintenance. Moreover, industry regulations require that PV installations have ground fault detection and isolation mechanisms in place.

The leak is essentially some of the power generated by the PV cells finding a path to ground when the isolation resistance (RISO) between equipment and earth has reduced to less than 40MΩ. Between 20 and 40MΩ, the RISO can still be considered healthy. Less than 20MΩ and there's cause for concern, as the insulation is degrading. A RISO of less than 1MΩ will almost certainly result in power loss and possibly permanent damage, and even fire.

Also, some faults are intermittent. For example, the build-up of moisture/condensation in a panel overnight can cause the RISO to be low during the first few hours of operation in sunlight.

Current leaks to ground can be detected by temporarily placing a current sensing circuitry between the terminals of the PV cells and ground, as per diagram 1.

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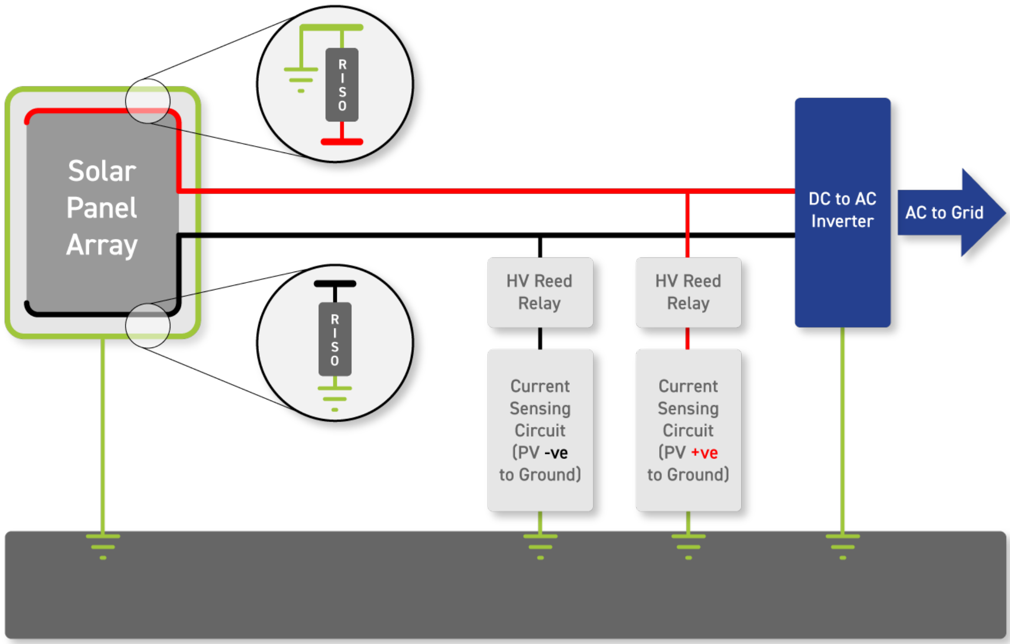
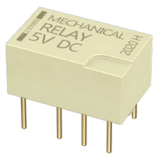
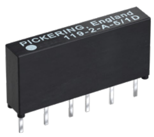


Diagram 1 *The current sensing circuit includes a resistor of a known value (typically a high impedance). When the circuit is switched in, the known resistance will effectively be placed in parallel with the RISO. The current that flows through the sensing circuit can be used to calculate the RISO.*

To engage the current sensing circuit, it is necessary to connect to a high voltage. Relative to ground, the negative and positive outputs of the solar panel will typically be about 600V in direct sunlight.

Switching Technologies

There are essentially three ways to electronically switch a high voltage.

Electromechanical Relays	Solid State Relays	Reed Relays
		
A popular and trusted technology but, because the contacts are not in a vacuum or inert gas, you need a large contact gap (and therefore relay body) to achieve a high standoff voltage.	There are no physical contacts, as the switching element is a transistor. However, their leakage current is relatively high – and that can be an issue when used in a leakage detection circuit. Also, they can fail in such a way that there is crossover between control and switching sides of the device.	These devices have very low leakage currents (as low as 1nA) and very high standoff voltages (a few kV) are achievable in small packaging. Switch contacts (the reeds) are hermetically sealed, so you don't get the same contamination/oxidation issues as with electromechanical relays.

Because there is no need to handle a high current in a PV current sensing circuit, and because low current leakage and high standoff voltage are so important, reed relays are the logical solution.

These are the most important things you need to consider when switching a high voltage with a view to determining a current leak:

- **Maximum Switching Voltage.** The highest DC or AC (peak) voltage that can be switched.
- **Minimum Standoff Voltage.** The devices will cope with a higher voltage as, in the case of Pickering Electronics' high voltage relays, they are tested at 500V above the declared standoff. For your design purposes we recommend you do not exceed the standoff voltage given on the datasheet.
- **Insulation Resistance.** This is the resistance between any of the device pins. This needs to be very high (ideally greater than 1TΩ (Tera Ohms, so 1×10^{12} Ohms). Accordingly, for 600V, the current would be just 0.6nA. Or, to put it another way, if you are trying to measure a low current, the last thing you want is for your switching circuit to introduce a current leak, which is why solid-state relays are considered unsuitable.
- **External Shield Clearance.** Some devices (typically low cost) have an external metal shield to protect against EM interference from neighbouring relays. If the screen extends to the relay base, or is too close to the base, this can cause problems when placed on a PCB carrying high voltages. However, the clearance might not even be stated on the datasheet. You may need to refer to technical drawings or measure the clearance on a sample device. *Note: the relays we recommend below have internal shielding - mu-metal screens around their coils.*

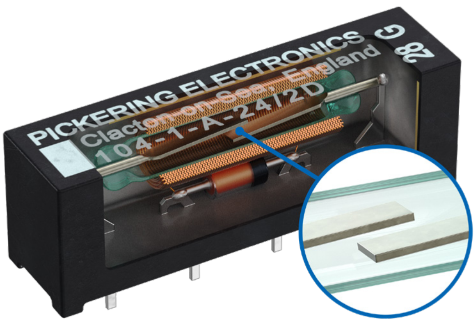


Diagram 2 *The maximum switching and minimum standoff voltages are high in a reed relay thanks to the gap between the reeds (shown in the inset) and the fact that they are in a vacuum. Insulation resistance is high thanks to pin spacing and the relay's base material. As for external shield clearance, this is not an issue when the EMI shielding is on the inside of the device.*

Note, we do not consider **Maximum Switching Current** an essential parameter for PV current leakage detection applications. Most high voltage devices will be rated up to 1A, but you are likely to be switching just a few µA.

Other information you will need to consider, when designing your monitoring circuitry, includes:

- **Coil Voltage.** The DC voltage needed to energize the coil and close the normally open contacts in the reed.
- **Coil Resistance.** If energising the coil using a transistor, you need to know the coil resistance to calculate the current the transistor must handle.
- **Operating Temperature.** Solar farm monitoring equipment is likely to be exposed to temperature extremes, and regular thermal cycling.

What's the Service Life?

This is the one figure on any datasheet, from any manufacturer, that is open to interpretation. We state 1×10^9 operations for most applications, but the fact of the matter is the figure could be higher or lower depending on the exact application. How close to voltage and current limits are you operating? What is the switching duty cycle? Are you likely to see inrush currents? Also, at what point do you consider the device to be failing? When contact resistance increases by 10%? 20%? More?

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We're Here to Help

Tell us about your application and we'll not only recommend the most suitable device, but we'll also give you an indication of the device's realistic service life.

RECOMMENDED PRODUCTS		
Pickering Electronics has an extensive range of high-performance, high voltage isolation reed relays that are ideally suited to use in PV current leakage monitoring applications. Furthermore, with device footprints starting at just 46 mm^2, many relays can be accommodated on a single PCB. We particularly recommend the following series.		
Series 104	**Series 119**	**Series 131**
		
This range has switching voltages up to **1kV** & minimum standoff voltages up to **4kV**. Maximum switch current is **1A** (up to **25W**) & maximum carry current is **1.5A**.	This range has switching voltages up to **1kV** & minimum standoff voltages up to **3kV**. Maximum switch current is **0.7A** (up to **10W**) & maximum carry current is **1.25A**.	This range has switching voltages up to **1kV** & minimum standoff voltages up to **1.5kV**. Maximum switch current is **0.7A** (up to **10W**) & maximum carry current is **1.25A**.

Why Pickering Electronics for Reed Relays?

- ✓ We've been making reed relays since 1968. It's our core business and has laid the foundation for the switching-based solutions of our sister company **Pickering Interfaces**.
- ✓ The relays recommended in this guide are all instrumentation grade and the reed contacts will be plated with either Rhodium (electro-plated) or Ruthenium (vacuum spluttered) to ensure a long life – typically up to $5x10^9$ operations. *As mentioned, RISO faults can be intermittent, so current leak detection tests should be performed several times a day.*
- ✓ They are of a **formerless coil construction**, which increases the coil winding volume, maximizes the magnetic efficiency, and allows for the use of less sensitive reed switches, resulting in optimal switching action and **extended lifetime** at operational extremes.
- ✓ Internal mu-metal magnetic screening enables **ultra-high PCB side-by-side packing densities** with minimal magnetic interaction, **saving significant cost and space**. Our magnetic screen reduces EM interaction to approximately 5%. Low quality relays typically exhibit an EM interaction of 30%.
- ✓ ***SoftCenter™*** technology provides maximum cushioned protection of the reed switch, minimizing internal lifetime stresses and **extending the working life and contact stability**.
- ✓ Inspection at every stage of manufacturing **maintaining high levels of quality**. Also, **100% testing** for all operating parameters including dynamic contact wave-shape analysis with full data scrutiny to maintain consistency. Stress testing of the manufacturing processes, from -20°C to +85°C to -20°C, repeated 3 times.

Customisation

While we've recommended three series of high voltage reed relays as being ideal for PV current leak detection, we have over a thousand catalogue parts, so there's plenty to choose from. However, if you cannot find a product that meets your exact requirements, we offer a **full customization service**.

The 104, 119 and 131 series already boast high switching voltages, high standoff voltages and high insulation resistances, but these can all be increased in a custom design.

We have a well-proven development lifecycle of: agree requirements, design, manufacture, test, approve, and deliver. And if your custom design is based on one of our existing products (which is likely to be the case) you can expect to receive samples in as few as two weeks.

For further information, contact our technical sales team at **techsales@pickeringrelay.com**

About Pickering Electronics

Pickering Electronics was established over 50 years ago to design and manufacture high quality reed relays, intended principally for use in instrumentation and test equipment. Today, Pickering's Single-in-Line (SIL/SIP) range is by far the most developed in the relay industry, with devices 25% the size of our competitors' electrically equivalent devices. These small SIL/SIP reed relays are sold in high volumes to large ATE and semiconductor companies throughout the world.

The privately-owned Pickering Group comprises three electronics manufacturers: reed relay company Pickering Electronics; Pickering Interfaces, designers and manufacturers of modular signal switching and simulation products, and Pickering Connect, which designs and manufactures cables and connectors. The group employs over 500 people primarily in the UK and Czech Republic with additional employees in sales offices in the US, China, Germany, Sweden, and France.

Technical Help

Please go to: **pickeringrelay.com/help**.
If your questions are not answered here, please e-mail: **techsales@pickeringrelay.com**.
Alternatively, please call our Technical Sales Office on **+ 44 (0)1255 428141**.

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