



Application Guide

Monitoring PV Efficiency & Fault Detection

Applications for Reed Relays

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PV System Monitoring

Solar PV continues to be deployed at scale across utility, commercial and industrial applications. In 2024, PV represented more than 75% of new renewable capacity installed worldwide, while global solar PV generation grew by 30%, adding a record 475 TWh year on year.

That growth makes long-term system performance increasingly important. Utility-scale solar PV is now one of the most cost-effective forms of new electricity generation, with IRENA reporting a global weighted average LCOE of USD 0.043/kWh in 2024. However, the return from a PV installation depends not only on installed capacity, but on maintaining energy yield, uptime and safe operation throughout the life of the system.

Leakage Current

One recurring challenge is leakage current caused by reduced isolation resistance between the PV circuit and earth. This can result from installation issues, damaged cables, connector faults, moisture ingress, module degradation or contamination. Some faults may also be intermittent, appearing only under certain environmental conditions, such as early morning condensation or periods of high humidity.

Monitoring for ground faults and insulation degradation is therefore essential for safety, efficiency and planned maintenance. In leakage detection circuits, the switching component must be able to connect to high voltage while introducing minimal leakage of its own. This is where reed relays are particularly well suited, combining high stand-off

voltage, very high insulation resistance and low leakage in a compact package.

As insulation degrades, the isolation resistance between the PV circuit and earth falls. The acceptable threshold will depend on system voltage, inverter design, installation size, environmental conditions and applicable standards, so RISO values should always be assessed in the context of the specific system.

As a general guide, insulation resistance in the tens of megohms is usually a sign of a healthy system. Values around 20–40 MΩ may still be acceptable, but should be monitored for trends, particularly where readings change with moisture, temperature or time of day. Below around 20 MΩ, further investigation may be required, as this can indicate insulation degradation, moisture ingress, damaged cables, connector faults or contamination.

Values approaching 1 MΩ are much more serious and may trigger inverter alarms, shutdown or fault protection, depending on the equipment and system design. IEC 62446-1-based test guidance commonly uses minimum insulation resistance values in the region of 0.5 MΩ or 1 MΩ, depending on array voltage and test method, although many operators and maintenance protocols apply much higher internal thresholds to identify degradation before it becomes a system-level fault.

In severe cases, low insulation resistance can lead to power loss, inverter shutdown, equipment damage or increased fire risk.



Leak Detection

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.

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 relay must not become part of the problem. In a leakage detection circuit, low relay leakage and high insulation resistance help ensure the measurement reflects the condition of the PV system, rather than leakage through the switching path.

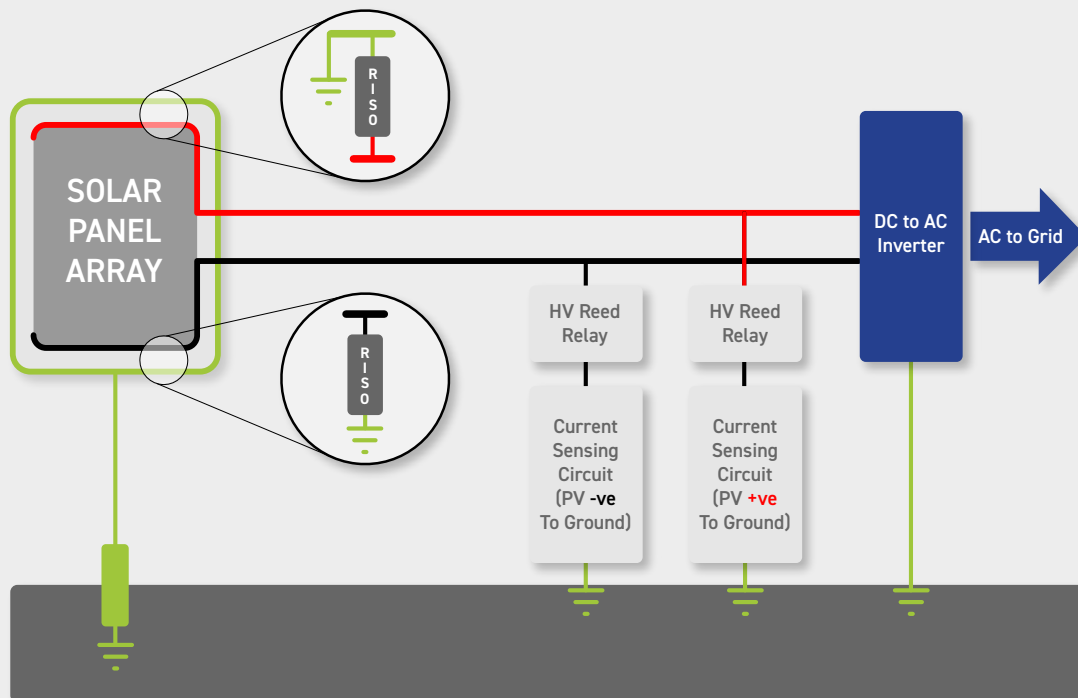
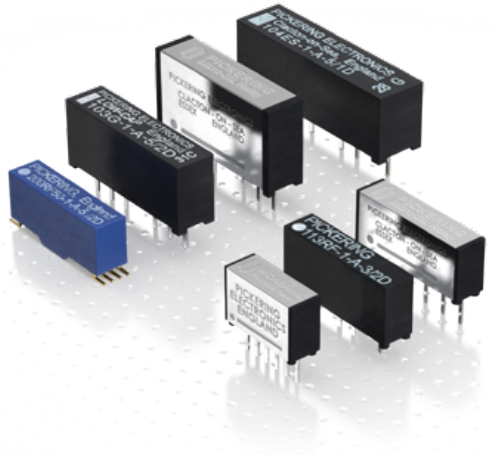


Diagram 1 The current-sensing circuit includes a resistor of a known value (typically a high impedance). When the circuit is switched in, the known resistance will effectively be placed in parallel with the RISO. The current that flows through the sensing circuit can be used to calculate the RISO.

In many high-voltage PV systems, the array voltage can be several hundred volts relative to ground, with utility-scale systems commonly designed around 1,000 Vdc or 1,500 Vdc architectures. The relay used to connect the sensing circuit must therefore provide suitable stand-off voltage, insulation resistance and isolation from the control electronics.

Comparing Relay Technologies

Electromechanical Relays (EMRs)	Mercury Wetted Reed Relays	Solid State Relays (SSRs)
		
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.	The contacts are protected from the atmosphere, so a high standoff voltage can be achieved in a smaller body than an EMR. However, the use of mercury very often means the device must be precisely mounted (within a few degrees of vertical). Also, mercury is bad for the environment, and its use is being banned in many countries.	Solid state relays have no physical contacts, using a semiconductor switching element instead. However, off-state leakage can be significantly higher than with reed relays, which may affect leakage detection circuits. Some failure modes can also compromise isolation between the control and switched sides.
Reed Relays		
		
These devices have very low leakage currents (as low as 1 nA) 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.		

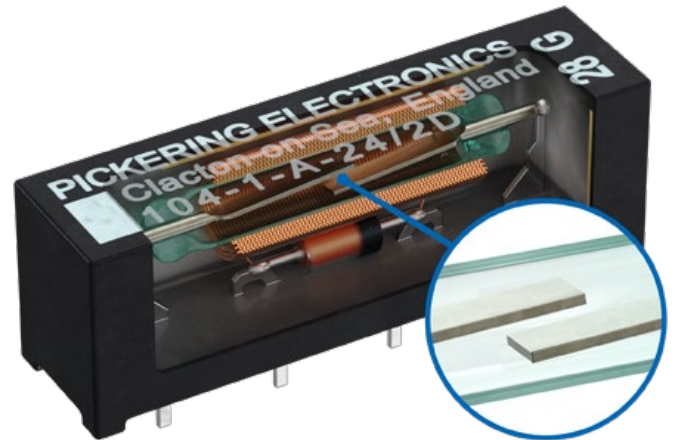
Design Considerations

Term	Definition	Why it Matters in PV Applications
Maximum Switching Voltage	Highest DC or AC (peak) voltage that can be switched safely.	Ensures the relay can handle the voltage without arcing or damage during operation.
Minimum Standoff Voltage	Max voltage that can be applied across open contacts without breakdown.	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.
Coil Voltage	Nominal DC voltage required to energise the relay coil.	Needs to be compatible with control circuitry in the application.
Coil Resistance	Resistance of the coil, usually measured at 25°C.	If energising the coil using a transistor, you need to know the coil resistance to calculate the current the transistor must handle.
Insulation Resistance	Resistance between device pins (ideally $>10^{12} \Omega$, higher for custom parts).	This needs to be very high (ideally greater than $1T\Omega$ (Tera Ohms, so 1×10^{12} Ohms). Accordingly, for 600V, the current would be just 0.6 nA. When measuring low current levels, it's undesirable for your switching circuit to introduce a current leak, which is why solid-state relays are considered unsuitable.
Switch-to-Coil Isolation	Voltage that can be applied between switch contacts and coil before breakdown.	Prevents high voltage from feeding back into control electronics, protecting test equipment.
External Shield Clearance	Distance between external shield and base of relay. 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.
Operating Temperature	The range of ambient temperatures within which a device can function reliably and safely.	Solar farm monitoring equipment is likely to be exposed to temperature extremes, and regular thermal cycling.

For high-voltage reed relays, the contact is sealed in a vacuum, greatly increasing the minimum standoff and maximum switching voltages. 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 EM shielding is on the inside of the device.

Note, maximum switching current is usually less critical in PV leakage detection than stand-off voltage, insulation resistance and leakage performance, because the sensing circuit typically switches very low current. Most high voltage devices will be rated up to 1 A, but applications usually switch just a few μA .

By considering these key factors, you can make a well-informed decision when selecting the appropriate reed relay for your PV application. Other information you will need to consider when designing your high voltage application includes contact configuration and service life.



Contact Configuration (Forms)

Form A	Form B	Form C
Common De-energized Common Energized With the coil de-energized the switch is normally open (NO). If just one switch is present, the form is 1A, meaning single pole single throw normally open (SPST-NO). If two switches are present, the form is 2A, meaning double pole single throw normally open (DPST-NO). With three switches it is 3A (3PST-NO) etc.	Common Energized Common De-energized With the coil de-energized the switch is normally closed (NC). If just one switch is present, the form is 1B, meaning single pole single throw normally closed (SPST-NC). If two switches are present, the form is 2B, meaning double pole single throw normally closed (DPST-NC). With three switches it is 3B (3PST-NC) etc.	De-energized Common Normally Closed Common Normally Open Common Energized Common Normally Closed Common Normally Open These are changeover devices that break their NC contact (and close the NO one) when the coil is energized. If just one switch is present, the form is 1C, meaning single pole double throw (SPDT). If two switches are present, the form is DPDT, 2C (pictured). With three switches it is 3PDT (or 3C) etc.

What's the Service Life?

Service life is one of the most application-dependent figures on any relay datasheet. Under low-level or cold-switching conditions, reed relays can achieve very long operating lives, often around 1×10^9 operations. However, this figure can be higher or lower depending on the exact load and operating conditions.

Key considerations include how close the application is to the relay's voltage, current and power limits, the switching duty cycle, the operating environment, and whether the relay is exposed to inrush currents from capacitive or inductive loads. End-of-life criteria also matter: for example, whether failure is defined by a contact resistance increase of 10%, 20%, or another threshold.

Rest Assured, We're Here to Help

Tell us about your application and we can recommend the most suitable relay, provide guidance on realistic service life and, where required, carry out life testing under customer-specific load conditions.

Speak with our engineers today to find the ideal relay solution for your PV application requirements.

Email: techsales@pickeringrelay.com



Recommended Products

Pickering Electronics has an extensive range of high-performance, high voltage isolation reed relays that are ideally suited to high voltage PV applications. Furthermore, with device footprints starting at just 16 mm², many relays can be accommodated on a single PCB. We particularly recommend the following series.

Series 60 & 65	Series 62 & 63
	
Switching up to 12.5kV. Standoff up to 15kV. Max switch current 3A (to 50W). Max carry current 3.5A.	Switching up to 12.5kV. Min standoff up to 20kV. Max switch current 3A (to 50W). Max carry current 3.5A.
Series 67 & 68	Series 600
	
Switching up to 7.5 kV. Min standoff up to 10kV. Max switch current is 3 A (up to 200 W), max carry current up to 5 A. High power 200 W switch available. 5, 12 or 24 V coils. Optional electrostatic shield available.	Fully customizable, modular design. Up to 20kV standoff, 12.5kV switching & 200W power handling. 5V, 12V, or 24V coils and optional EMF suppression. Forms A, B & C. Vacuum-sealed reed switches, >10¹³Ω insulation. Magnetic/electrostatic shielding.
Series 104	Series 144
	
Switching up to 1.5kV. Min standoff up to 5kV. Max switch current is 1 A (up to 25 W). Max carry current 1.5A. High Temperature option available up to 125°C (up to 150°C as a standard build option). Optional electrostatic shield.	Switching up to 1 kV. Min standoff up to 3kV. Max switch current 2.0A (up to 60W), or 1.0A (up to 80W). Max carry current 3.0A. Optional electrostatic shield.
Series 100HV	Series 119
	
5, 12 or 24 V coils. HV + high coil resistance in Form A & B. 3kV standoff, 1 kV switching. Up to 6800Ω coil resistance.	Switching up to 1 kV. Min standoff up to 3kV. Max switch current 0.7 A (up to 10 W). Max carry current 1.25 A.
Series 131	Series 219
	
Switching up to 1 kV. Min standoff up to 1.5kV. Max switch current 0.7 A (up to 10 W). Max carry current 1.25 A.	Switching up to 1 kV. Min standoff up to 3kV. Max switch current is 0.7 A (up to 10 W). Max carry current is 1.25 A.



Why Pickering Electronics for Reed Relays?

Pickering Electronics has specialised in reed relays since 1968 — it's our core business, and the foundation behind the wider Pickering Group's switching expertise.

Our relays use formerless coils, allowing more winding volume in the same package for improved magnetic efficiency. The result is consistent actuation and long service life, even in demanding operating conditions.

For high-voltage and high-reliability designs, **SoftCenter™** encapsulation cushions the hermetically sealed glass switch with carefully selected materials. This reduces internal mechanical stress, improving contact stability over time.

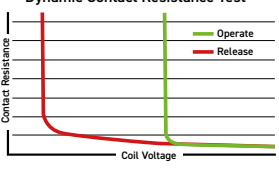
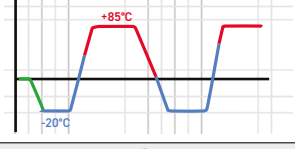
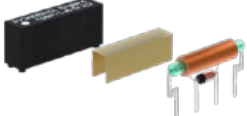
To support dense layouts, internal mu-metal magnetic screening helps minimise magnetic interaction when relays are stacked closely on a PCB — enabling higher packing density and helping protect channel-to-channel performance.

Our internal mu-metal screen is designed to reduce magnetic interaction to around 1-5% in typical conditions; unscreened designs can be significantly higher (often ~30%), depending on relay type and spacing.

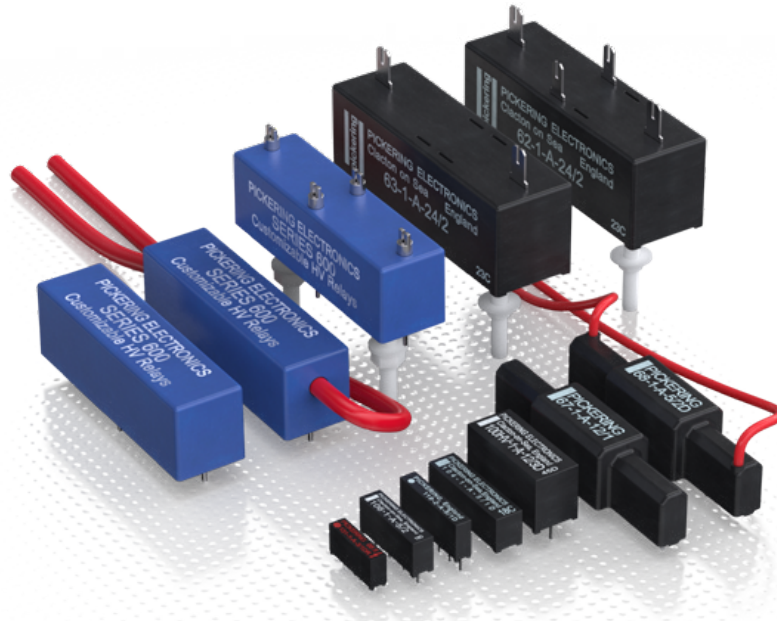
Quality is built in at every stage. Inspection is performed throughout manufacturing, and 100% of relays are tested against operating parameters, including dynamic contact waveform analysis, with full data review to ensure consistency. Manufacturing processes are also stress-tested through repeated thermal cycling (–20 °C to +85 °C to –20 °C, three cycles) to validate robustness.

Every relay recommended in this guide is instrumentation-grade, using contact materials chosen for performance and longevity: rhodium (electroplated), ruthenium (vacuum sputtered), or tungsten for higher-voltage switching — delivering lifetimes typically up to 5×10^9 operations.

10 Key Benefits of Pickering Reed Relays

Key Benefit	Pickering Reed Relays	Typical Industry Reed Relays	
1 Instrumentation Grade Reed Switches	Instrumentation Grade Reed Switches with vacuum sputtered Ruthenium plating to ensure stable, long life up to over 10 billion operations.	Often low grade Reed Switches with electroplated Rhodium plating resulting in higher, less stable contact resistance.	
2 Formerless Coil Construction	Formerless coil construction increases the coil winding volume, maximizing magnetic efficiency, allowing the use of less sensitive reed switches resulting in optimal switching action and extended lifetime at operational extremes.	Use of bobbins decreases the coil winding volume, resulting in having less magnetic drive and a need to use more sensitive reed switches which are inherently less stable with greatly reduced restoring forces.	 Pickering former-less coil Typical industry coil wound on bobbin
3 Magnetic Screening	Mu-metal magnetic screening (either external or internal), enables ultra-high PCB side-by-side packing densities with minimal magnetic interaction, saving significant cost and space. Pickering Mu-Metal magnetic screen - interaction approx. 5%	Lower cost reed relays have minimal or no magnetic screening, resulting in magnetic interaction issues causing changes in operating and release voltages, timing and contact resistance, causing switches to not operate at their nominal voltages. Typical industry screen - interaction approx. 30%	 X-Ray of Pickering mu-metal magnetic screen X-Ray of typical industry magnetic screen
4 SoftCenter™ Technology	SoftCenter™ technology, provides maximum cushioned protection of the reed switch, minimising internal lifetime stresses and extending the working life and contact stability.	Transfer moulded reed relays (produced using high temperature/pressure), result in significant stresses to the glass reed switch which can cause the switch blades to deflect or misalign leading to changes in the operating characteristics, contact resistance stability and operating lifetime.	 Pickering soft center protection of the reed switch Typical industry thermo-setting hard moulded protection of the reed switch
5 100% Dynamic Testing	100% testing for all operating parameters including dynamic contact wave-shape analysis with full data scrutiny to maintain consistency.	Simple DC testing or just batch testing which may result in non-operational devices being supplied.	 Dynamic Contact Resistance Test
6 100% Inspection at Every Stage of Manufacturing	Inspection at every stage of manufacturing maintaining high levels of quality.	Often limited batch inspection.	
7 100% Thermal Cycling	Stress testing of the manufacturing processes, from -20°C to +85°C to -20°C, repeated 3 times.	Rarely included resulting in field failures.	
8 Flexible Manufacturing Process	Flexible manufacturing processes allow quick-turn manufacturing of small batches.	Mass production: Usually large batch sizes and with no quick-turn manufacturing.	
9 Custom Reed Relays	Our reed relays can be customized easily, e.g. special pin configurations, enhanced specifications, non-standard coil or resistance figures, special life testing, low capacitance, and more.	Limited ability to customize.	
10 Product Longevity	Pickering are committed to product longevity, our reed relays are manufactured and supported for more than 25 years from introduction, typically much longer.	Most other manufacturers discontinue parts when they reach a low sales threshold; costing purchasing and R&D a great deal of unnecessary time and money to redesign and maintain supply.	

For more information go to: pickeringrelay.com/10-key-benefits



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.

Contact Pickering

Technical Help

Please go to: pickeringrelay.com/help.

If your questions are not answered here, please e-mail: techsales@pickeringrelay.com

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