Application Guide

Reed Relays for Electric Vehicle and Charge Point Testing

In this application guide:

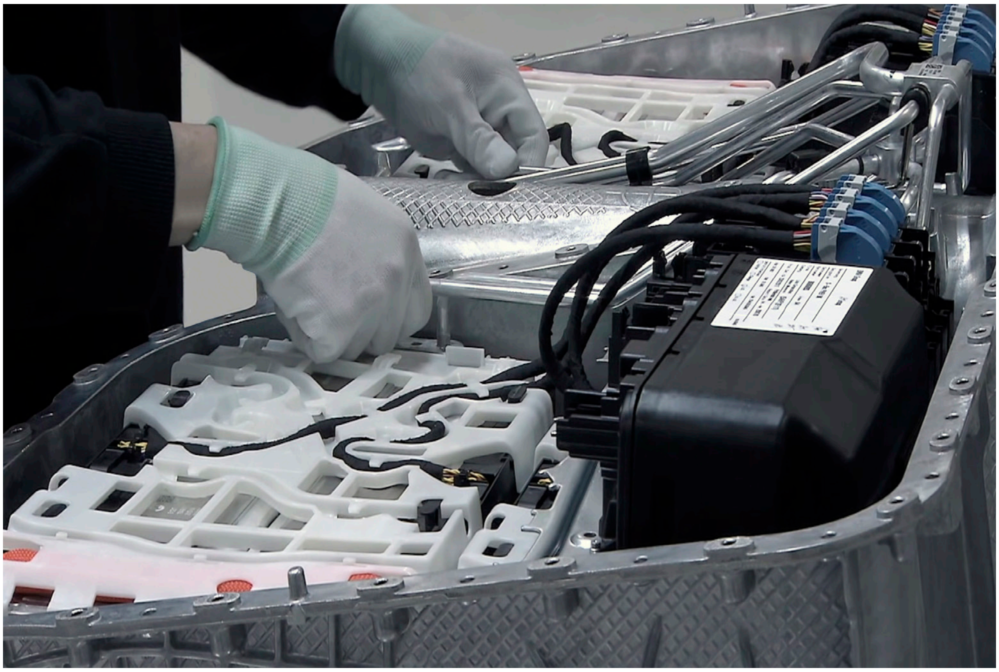
- High Voltage & Insulation Resistance Testing
- Switching Technologies
- Reed Relay Terminology
- Recommended Products
- Why Pickering Electronics for Reed Relays?

50 years 1968 - 2018

High Voltage & Insulation Resistance Testing

The electrification of the drivetrains in pure electric vehicles (EVs), and partial electrification in hybrids and plug-in hybrids (HEVs and PHEVs), is only possible thanks to the presence of high voltage batteries, power inverters and powerful motors. Also, these high voltage components are 'floating', in that none of their power terminals are earthed to chassis. Accordingly, all components and high current-carrying cables are heavily insulated.

The design and manufacture of EVs and their derivatives require specialist equipment and procedures to ensure safety. As these vehicles enter service, their maintenance, repair and recovery will also require the same equipment and procedures.



There are many components and subsystems in an EV, HEV and PHEV where potentially lethal voltages are present.

As the Health & Safety Executive (HSE) notes: "People in the motor vehicle repair and recovery industry are now more likely to come across E&HVs and as a result need to be aware of the additional hazards they may be exposed to when working with these vehicles."

The HSE also notes that, in addition to a wider range of skills and knowledge, those working on the vehicles will need access to specialist tools and equipment to be able to work safely. There is therefore a drive to develop instrumentation to safely test high voltages in the automotive sector.

On an EV, high voltage DC is considered anything above 60V. Most EVs on the road currently use 400VDC battery packs, though some OEMs are switching to 800VDC, as twice the voltage means half the current (for the same power), and it's current that determines wire/cable gauge and therefore weight.

As mentioned, all power cables and HV components are heavily insulated, to protect against short circuiting against anything that is electrically connected to earth and for safety (as it is likely that anyone working on the vehicle will also be in contact with the chassis/earth). In addition to the need to measure high voltages (DC and AC) it is necessary to confirm the integrity of the insulation around HV components and cables. See figure 1.

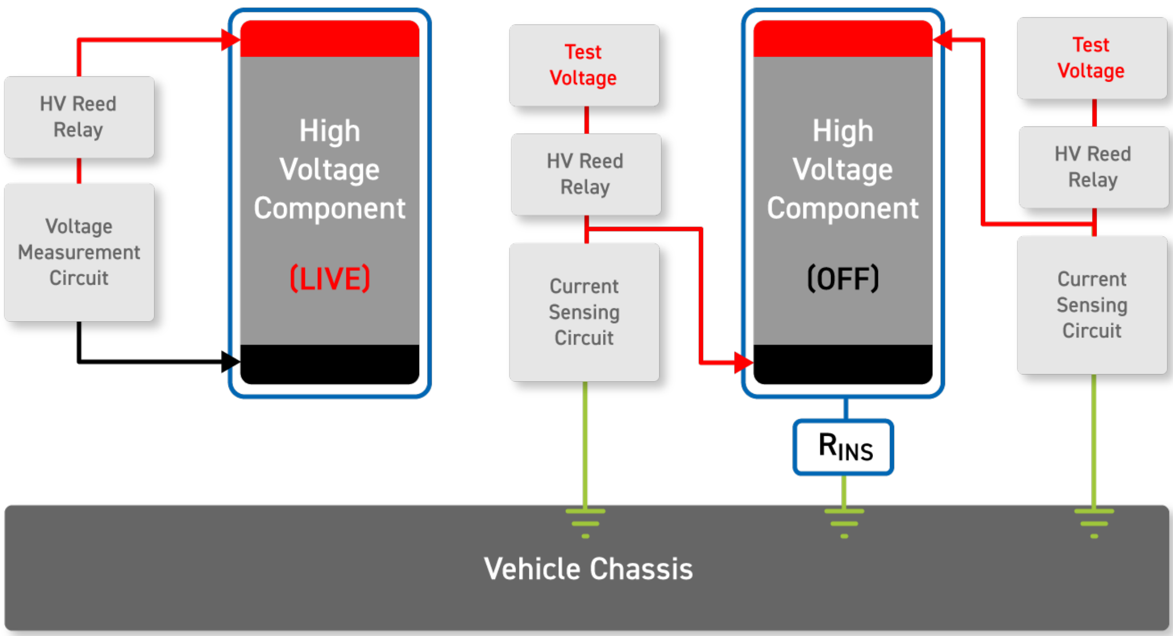
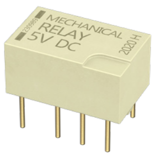


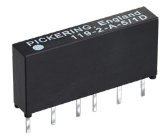
Figure 1 Voltage measurements (on the left) require connecting to a component (such as battery pack terminal) that could be at more than 400VDC. An insulation test (on the right) involves injecting a high voltage into a component and measuring the current that flows through a resistor of a known value (within the current sensing circuit) to the chassis. From that current, the insulation resistance (R_{INS}) can be deduced.

Also requiring high voltage and insulation tests - during product development and once they enter service - are all the charging points needed throughout the world as the number of EVs joining our roads increases. For example, in March 2022, the UK government committed £1.6 billion to expand the country's network of charging points tenfold by 2030. And in the EU - where as of June 2022 there are more than 330,000 charging points - the European Commission is hoping to see 1 million by 2025.

There is therefore a drive to develop instrumentation that can safely measure high voltages and perform insulation tests in charging points too.

<table>
<tr><th colspan="3">Switching Technologies
There are essentially three ways to electronically switch a high voltage.</th></tr>
<tr><td>Electromechanical 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.</td>
<td>Solid State Relays

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.</td>
<td>Reed Relays


These devices have very low leakage currents (less than 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.</td></tr>
<tr><td colspan="3">Because of their small form factor and high isolation, <u>reed relays are the logical choice for EV testing</u> applications where safety is a priority. Reed relays can also switch AC, whereas semiconductor-based solid-state relays cannot.</td></tr>
</table>

Reed Relay Terminology

These are the most important things you need to consider when switching a high voltage and if there is no need to handle more than a few Amperes.

- **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.
- **Minimum Standoff Current.** Most high voltage reed relays are rated at up to 1A, but you are unlikely to need to switch this much current when measuring a high voltage; a few mA will suffice. And an insulation resistance test would require switching just a few µA.
- **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) if the reed relay is to be used in circuitry intended to measure insulation resistance. Or, to put it another way, if you are trying to measure a current leak (indicative of failing insulation), 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.*

email: techsales@pickeringrelay.com

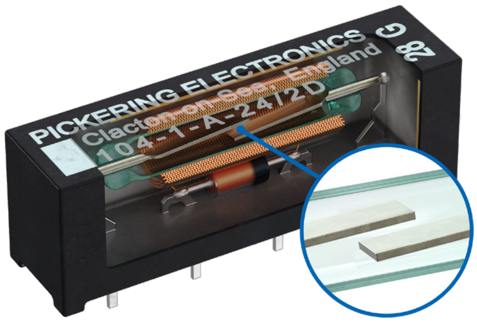


Diagram 2 *The maximum switching and minimum standoff voltages are high in a reed relay thanks to the gap between the reeds (shown in the inset) and the fact that they are in a vacuum. Insulation resistance is high thanks to pin spacing and the relay's base material. As for external shield clearance,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

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

- **Coil Voltage.** The DC voltage needed to energise 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.

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.

Things You Should Consider:

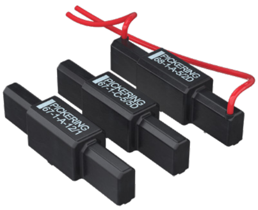
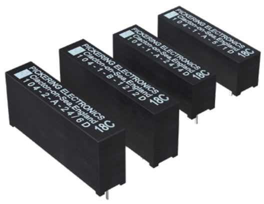
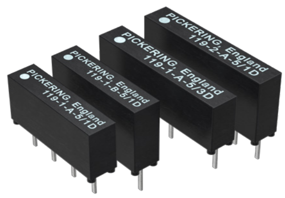
How close to voltage and current limits are you operating? What is the switching duty cycle? Are you likely to see inrush currents? Also, at what point do you consider the device to be failing? When contact resistance increases by 10%? 20%? More?

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 high voltage measurement applications. Furthermore, with device footprints starting at just $46mm^2$, many relays can be accommodated on a single PCB. We particularly recommend the following series.

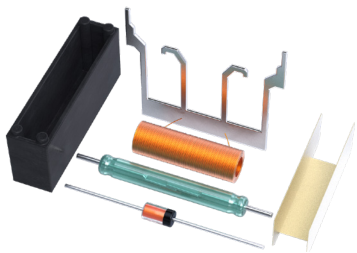
Series 67 & 68	Series 104	Series 119	Series 131
			
Switching voltages up to **7.5kV** & minimum standoff voltages up to **10kV**. Max. switch current is **3A** (at up to **200W**) & max. carry current is up to **5A**. Optional **electrostatic screen**.	This range has switching voltages up to **1kV** & minimum standoff voltages up to **4kV**. Max. switch current is **1A** (at up to **25W**) & max. carry current is **1.5A**. Optional **electrostatic screen**.	This range has switching voltages up to **1kV** & minimum standoff voltages up to **3kV**. Max. switch current is **0.7A** (at up to **10W**) and max. carry current is **1.25A**.	The **smallest** HV reed relay available; switching voltages up to **1kV** & minimum standoff voltages up to **1.5kV**. Max. switch current is **0.7A** (at up to **10W**) & max. 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**.
- ✓ 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 **maintains 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.

Customization

While we've recommended five series of reed relays as being ideal for use in test equipment and instrumentation for performing high voltage and insulation resistance tests on electric vehicles and charging points, 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 67, 68, 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** or visit pickeringrelay.com/custom-reed-relays

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**.

Pickering Electronics Ltd.
Stephenson Road
Clacton-on-Sea
CO15 4NL
United Kingdom

Tel: +44 1255 428141
email: techsales@pickeringrelay.com
Web: pickeringrelay.com

Registered in England no. 857509 VAT no GB103 5366 04
Registered Office: Stephenson Rd, Clacton-on-Sea, Essex. CO15 4NL

ISO 9001 Quality Management Systems CERTIFIED FM 29036