pickering

Application Guide

Optimizing Space Applications with Reed Relay Technology

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- Reed Relay Terminology
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- Why Pickering Electronics for Reed Relays?

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Pickering 55 Years 1968 - 2023

Space Applications

Putting electronic systems into space – be it into a low Earth orbit, our solar system or beyond– is an expensive business. For example, the cost of putting anything into space is estimated to be between $2,000 and $3,000 per kilogram. Understandably, the systems must operate as intended and provide several years of service to justify such high costs. All components used within the system must therefore be reliable and fit-for-purpose.

There are several challenges associated with space applications, the first of which is surviving the high vibration levels and G forces experienced when leaving the Earth, and in the case of a rover, landing on a moon or planet. In addition, the system will experience temperature extremes and ambient radiation levels much higher than those found on Earth (where we are protected by a thick atmosphere and a magnetosphere).

In this application guide, we will explore these harsh environments and discuss the characteristics of reed relays that make them ideal for switching applications; and why electromagnetic relays (EMRs) and solid-state relays (SSRs) can be discounted.

Shock and Vibration

As mentioned, getting the system into space will expose all system components to vibration and G forces. A reed relay is relatively immune to both as it is a simple device with no jointed moving parts. Rather, the reed switch blades deflect under the effects of the coil's magnetic field. This robust construction provides strong resilience to mechanical failure while still delivering high performance. Durability is further assured when the switch is encapsulated in a soft potting compound (as opposed to a thermosetting plastic), and in this respect Pickering uses its Softcenter technology to protect the reed switch.

All Pickering part numbers are typically rated for 50G shock and 20G vibration. These levels of shock and vibration will not cause the switch to activate unintentionally.

Extreme Temperatures

Once deployed - whether as an orbiting satellite, a deep-space explorer, or a lander destined for another planet or moon - the system will face extreme environmental challenges. These include wide temperature fluctuations that can not only affect the operational performance of systems components but also their life expectancy. For example, a geostationary satellite can experience temperatures ranging from -150°C to 150°C, while deep space temperatures drop to around -270°C, just a few degrees above absolute zero.

Note: Most EMRs and SSRs have an operating temperature range of -40°C to +85°C. Above +85°C, both will suffer from degraded performance at elevated temperatures, especially the SSR which may be permanently damaged. All relays (reed and EMRs) experience coil resistances change due to temperature fluctuations, which in turn changes the operate voltage. Pickering can offer reed relays with an extended operating temperature range of -40°C to +150°C, over which there will be minimal change in performance.

Figure 1 compares the operate voltage of a standard 5 Volt reed relay or EMR with an operate voltage of 3.75V at +25°C to a Pickering high temperature 104. With a 5 Volt coil drive, the standard relays would have unstable operation beyond +85°C and would not operate beyond +100°C. The Pickering high temperature 104 maintains the correct overdrive all the way to +150°C ensuring stable performance.

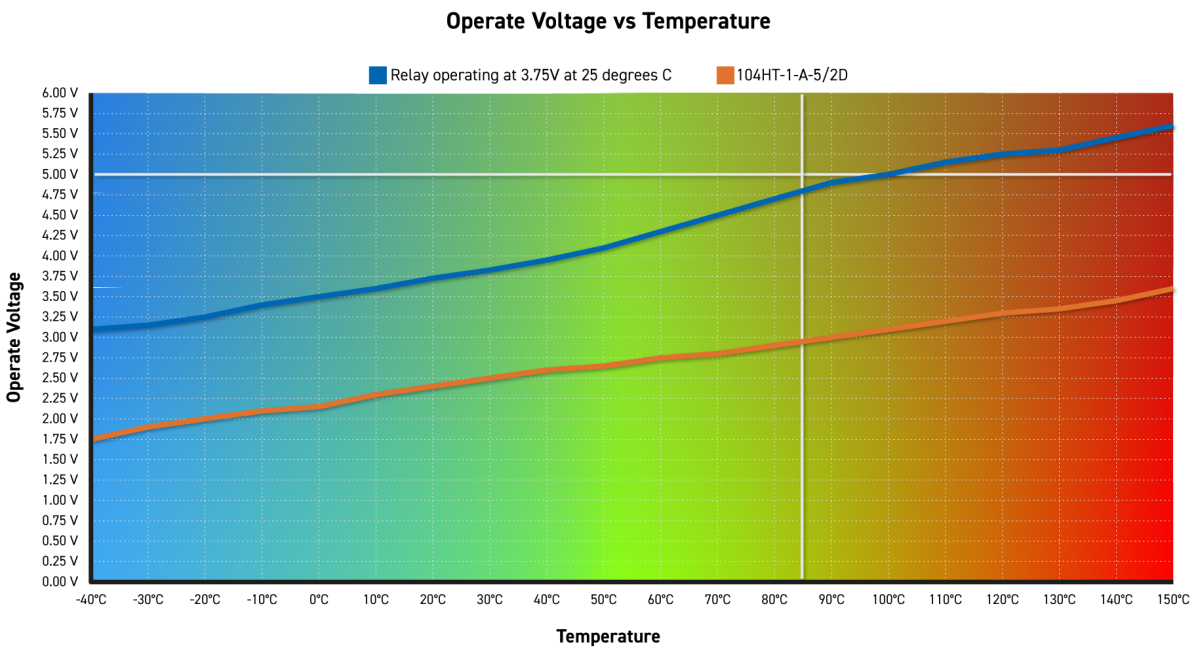


Figure 1. Illustrates how operate voltage will alter with temperature fluctuations.

High Voltage

Many applications, such as the thruster control on a satellite or the drivetrain of a rover, require higher voltage switching capabilities than EMRs of SSRs can provide. For example, achieving precise polarity alternation in a thruster head control is best accomplished with a reed relay.

Pickering's high-voltage reed relays can switch up to 12.5kV and provide standoff voltages up to 20kV in custom designs. Form A types can switch up to 200W, and changeover versions (Form C) are available that are rated for up to 2.5kV (100W). See Contact Configurations table below for details on forms.

Moreover, these relays can be customized for optimal connection options and package sizes, a critical factor in space-constrained systems. For even greater flexibility, Pickering offers designs with top-exit connections rather than base connections, eliminating the need for PCB tracks to carry high-voltage signals, an important consideration for high-reliability space applications.

If the reed relay is being used to monitor a high voltage, as opposed to switching power, then it is worth noting that the devices have very low leakage currents; unlike many SSRs which can be hundreds or even thousands of times higher.

Low Level Signals

There is often also a need to switch very low-level signals in, for example, monitoring/data acquisition circuits that use thermocouples or other transducers that output a very low voltage proportional to the parameter they are observing.

For such applications, the contact resistance (CR) needs to be as low as possible, as any unwanted inline resistance between the transducer and signal conditioning circuitry can lead to a significant error. Because a reed relay's contacts are sealed in a glass tube – containing either an inert gas or a vacuum – the switch blades will not become contaminated, and they can switch low-level signals (as well as higher voltages) accurately and reliably for millions of operations. In contrast, an EMR's switch contacts are not sealed, and tend to have a shorter mechanical lifespan.

As well as CR potentially compromising accuracy and introducing errors, in very sensitive measurements, thermal EMF performance can be key, with high levels introducing unacceptable errors. Pickering offer a range of low thermal EMF reed relays, along with a long experience in getting the best out of these parts in a range of applications.

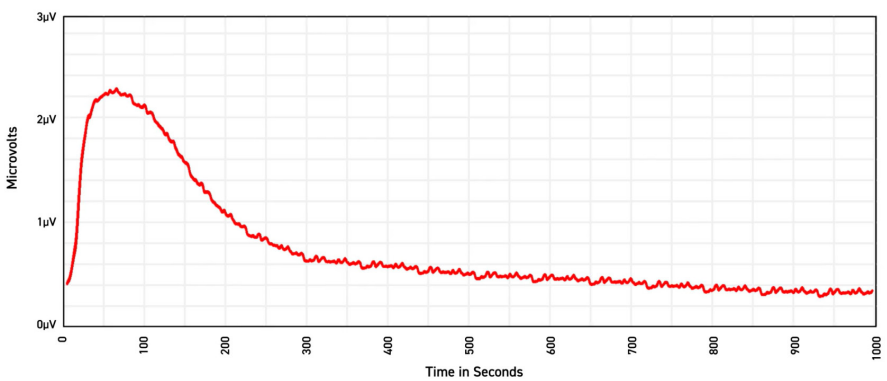


Figure 2 illustrates the typical thermal EMF performance of Pickering's 100-1-A-5/2D reed relay

The operation of the switching device should not introduce noise into sensitive measurement or data acquisition circuitry. The inclusion of a sdiode across the coil within the device (which in most cases does not increase the package size) reduces back EMF noise from the coil on turn off.

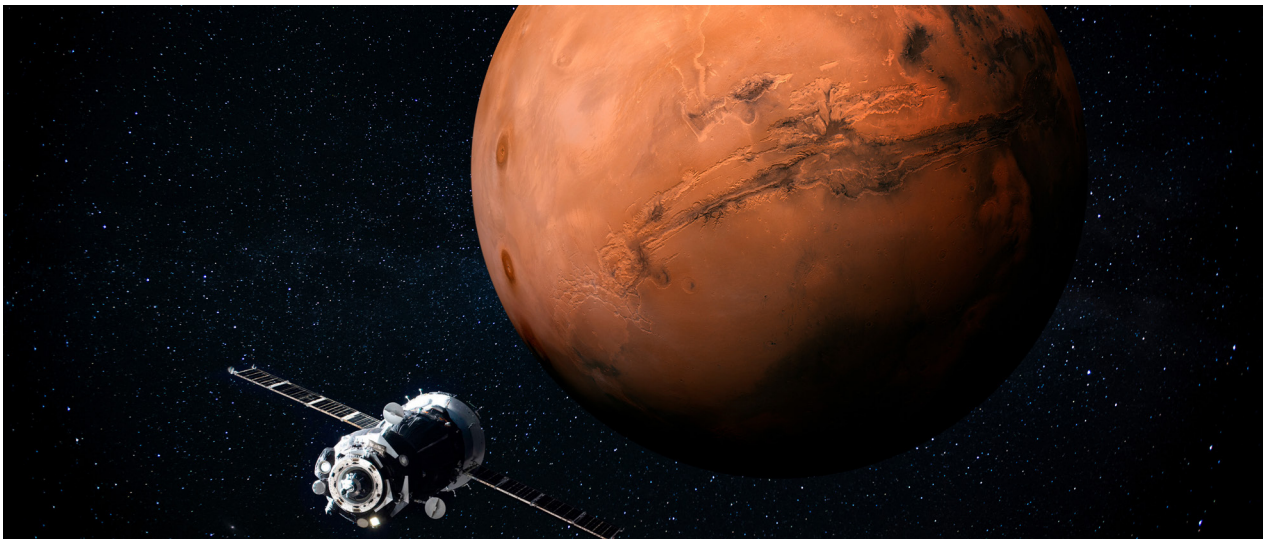
Another source of noise can be the magnetic field generated by the relay's coil when energized. Shielding is important and in this respect most of Pickering's devices include an internal metal shield. It not only reduces the extent to which the magnetic field reaches out from the device, but it also helps focus the field onto the switch; meaning less electrical power is required for operation.

Switching Speed

Speed of operation – the opening and closing of the switch - is also an important factor, certainly within communications satellites, for example. Reed relays can operate within 0.5ms (the time between voltage supplied to the coil and the switch closing – a speed on par with an SSR), whereas EMR operation is typically between 5 and 20ms.

Low Power

The space application system will of course require power, typically supplied by batteries recharged through solar panels. However, this presents a challenge. On Mars, for example, sunlight is only 43% as intense as it is on Earth, significantly limiting the available energy. Scientific satellites venturing into the outer solar system or beyond will receive much less solar power. All electronic components must therefore be extremely power efficient.



A reed relay only draws power when its coil is energized, but this still needs to be factored into the system's power budget. Pickering's use of a former-less design in many of its reed relays means the coil can be wound directly around the reed switch (i.e. no bobbin). This fact, along with the aforementioned focusing effect of the EM screening, helps reduce the power needed to energize the coil.

Also, as mentioned above, SSRs suffer high leakage currents (which equates to power loss). In sharp contrast, the leakage current of a reed relay is extremely low because they have a high isolation resistance. Indeed, Pickering devices offer isolation resistances greater than $10^{12}\Omega$, meaning even with 10kV applied the leakage current is virtually negligible.

For most switching applications - including the switching of low-level signals, power and high voltages – a reed relay is the logical choice, offering distinct advantages over EMRs and SSRs.

Reed relays can operate quickly, perform millions of switching operations, and their simple design makes them remarkably durable and reliable, even under the harsh conditions found in space. As mentioned, SSRs can suffer from degraded performance at elevated temperatures. Granted, so too can EMRs and reed relays because of coil resistance variations, but the latter do not experience the same mechanical wear and are available with high operating temperatures.

In summary, reed relays deliver a balance of speed, efficiency, and reliability that is unmatched by other switching technologies, making them the best solution for space applications.

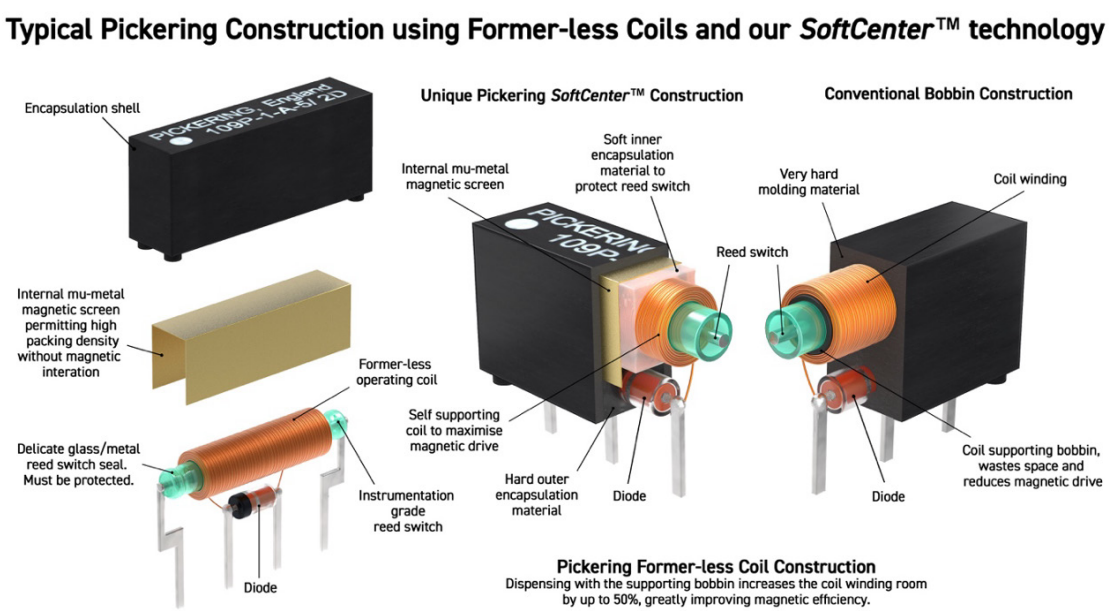
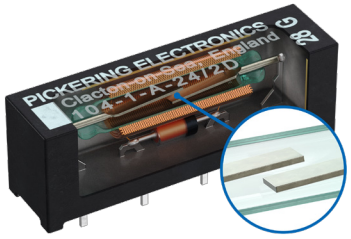


Figure 3 illustrates Pickering's typical relay construction featuring unique technology

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.
- **Maximum Switching Current.** The maximum current the contacts can switch within the constraints of the contact power rating. Note: be mindful of switching (on) to highly capacitive loads and when removing power from highly inductive loads.
- **Coil Voltage.** The nominal DC operating voltage of the relay coil.
- **Coil Resistance.** The nominal resistance of the operating coil, usually specified at 25oC..
- **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 x 10^{12} Ohms)) if you are to keep current leakage to a minimum.
- **Shock.** Peak acceleration 150 G, half sinewave; duration 11 ms. Such a shock will not cause an open switch (no magnetic field present) to close, nor a switch kept closed by an 80 AT coil to open. Pickering reed relays are specified at 50 G shock.
- **Vibration.** Acceleration 20 G; below cross-over-frequency 57 to 62 Hz; amplitude 0.75 mm; frequency range 10 to 2000 Hz; duration 90 minutes. Such a vibration will not cause an open switch (no magnetic field present) to close, nor a switch kept closed by an 80 AT coil to open. Pickering reed relays are specified at 20 G vibration.
- **External Shield Clearance.** Some devices (typically low-cost) have an external metal shield to protect against EM interference from neighboring 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, and you may need to refer to technical drawings or measure the clearance on a sample device. *Note: the relays we recommend below all have internal shielding in the form of mu-metal screens around their coils.*

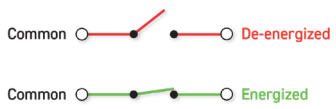
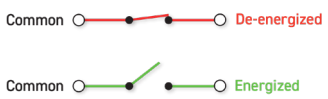
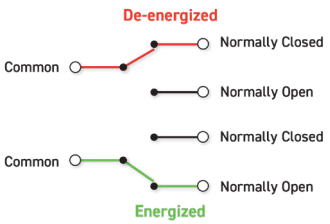


For high-voltage reed relays, the contact is sealed in a vacuum, greatly increasing the minimum standoff and maximum switching voltages. Insulation resistance is high thanks to pin spacing and the relay's base material. As for external shield clearance, this is not an issue when the EM shielding is on the inside of the device.

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

Reed Relay Terminology

Contact Configuration (Forms)

Form A	Form B	Form C
		
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).	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).	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 2C DPDT. With three switches it is 3C.

What's the Service Life?

This is the one figure on any datasheet, from any manufacturer, that is open to interpretation. We state 1 x 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. Considerations are: 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?

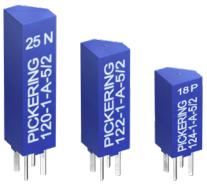
Rest Assured, We're Here to Help

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

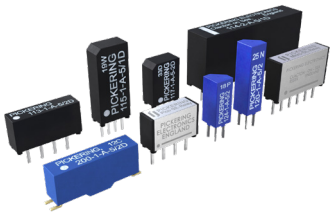
Pickering Electronics has an extensive range of high-performance reed relays that are ideally suited to space applications. What follows are just a few recommendations based on the issues discussed above, i.e., we highlight key features and device properties that are of particular importance.

Ultra-High Density Reed Relays



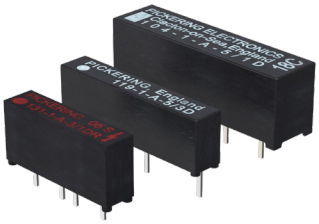
These relays have a maximum switch current of **1 A** (up to **20 W**), and the maximum carry current is **1.2 A**. Fast operate and release times (as low as **80 µs** or less) make these relays suitable for high-speed test systems.
Body dimensions from (W x H x D): 3.9 x 9.5 x 3.9 mm.
Available forms: **1 Form A** contact configuration.

High Density Relays



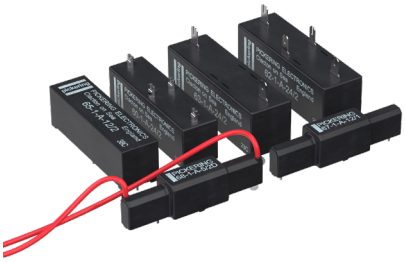
These relays have a maximum switch current of **1 A** (up to **20 W**), and the maximum carry current is **1.2 A**. Switches feature sputtered ruthenium contacts for long life and high reliability.
Body dimensions from (W x H x D): 6.6 x 9.5 x 3.7 mm.
Available forms: **1 Form A**, **1 Form A Coax**, **2 Form A**, **1 Form B**, and **1 Form C** contact configurations.

Miniature High-Voltage Reed Relays



These relays have switching voltages up to **1.5 kV** and standoff voltages up to **5 kV**. The maximum switch current is **1 A** (up to **25 W**) and the maximum carry current is **1.5 A**. High coil resistance options (up to **6.8 kΩ**). Thermal EMF devices are between **3 and 10 µV**. Relays can endure temperatures as high as **150 °C** if requested.
Body dimensions from (W x H x D): 12.5 x 6.6 x 3.7 mm.
Available forms: **1 Form A**, **2 Form A**, and **1 Form B** contact configurations.

High-Voltage Reed Relays



These relays have switching voltages up to **12.5 kV** and minimum standoff voltages up to **15 kV**. The maximum switch current is **3 A** (up to **200 W**) and the maximum carry current is up to **5 A**. Option of PCB pins, chassis, PCB mounting, and flying leads.
Body dimensions from (W x H x D): 58.4 x 19.0 x 12.6 mm.
Available forms: **1 Form A**, **1 Form B**, and **1 Form C** contact configurations.

RECOMMENDED PRODUCTS

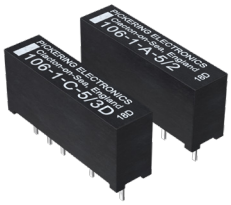
High Coil Resistance Reed Relays

These relays have a maximum switch current of **1A** (up to **20W**), and the maximum carry current is **1.2A**. Featuring high coil resistances (up to **6kΩ**), devices are ideal for portable instruments.
Body dimensions from (W x H x D): 8.13 x 15.24 x 4.8mm. Available forms: **1 Form A**, **2 Form A**, **1 Form B**, and **1 Form C** contact configurations.

Low Thermal EMF Reed Relays

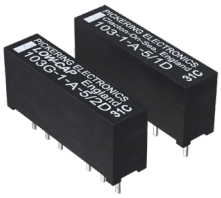
These relays have a maximum switch current of **1A** (up to **20 W**), and the maximum carry current is **1.2 A**. Devices feature low thermal EMF (around 1 **µV** or less) and low power consumption.
Body dimensions from (W x H x D): 20.1 x 9.4 x 7.4 mm.
Available forms: **1 Form A**, **2 Form A**, **1 Form B**, and **1 Form C** contact configurations.

Industry Standard Size Reed Relays



These relays have a maximum switch current of **1A**. (up to **20W**), and the maximum carry current is **1.2A**. Featuring superb contact resistance stability and ultra-high insulation resistance.
Body dimensions from (W x H x D): 19.1 x 7.6 x 4.8 mm.
Available forms: **1 Form A**, **2 Form A**, and **1 Form B, 1 Form C** and **2 Form C** contact configurations.

Low Capacitance Reed Relays



These relays have a maximum switch current of **1A** (up to **20W**), and the maximum carry current is **1.2A**. Ultra-low capacitance levels of typically **0.1 pF**, compared to typically 2.5 pF for a standard device.
Body dimensions from (W x H x D): 19.1 x 8.1 x 4.8 mm.
Available forms: **1 Form A** contact configuration.

Coaxial Reed Relays

These relays have a maximum switch current of **1A** (up to **20 W**), and the maximum carry current is **1.2 A**. Devices with **50 and 75 Ω** coils are suitable for up to **5 GHz**, making them ideal for RF Signal Switching, RF switched tunable filters, and High-Speed Digital Switching. Available in **thru-hole** and **SMT**.
Body dimensions from (W x H x D): 12.5 x 6.6 x 3.7 mm.
Available forms: **1 Form A** and **1 Form B**

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 1 x 10^9 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.

While we've recommended several different reed relays, each with performance characteristics and properties that make them ideal for space applications, we have over a thousand catalogue parts, so there's plenty to choose from. If you cannot find a product that meets your exact requirements, we offer a **full customization service**.

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 vist 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**.

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