

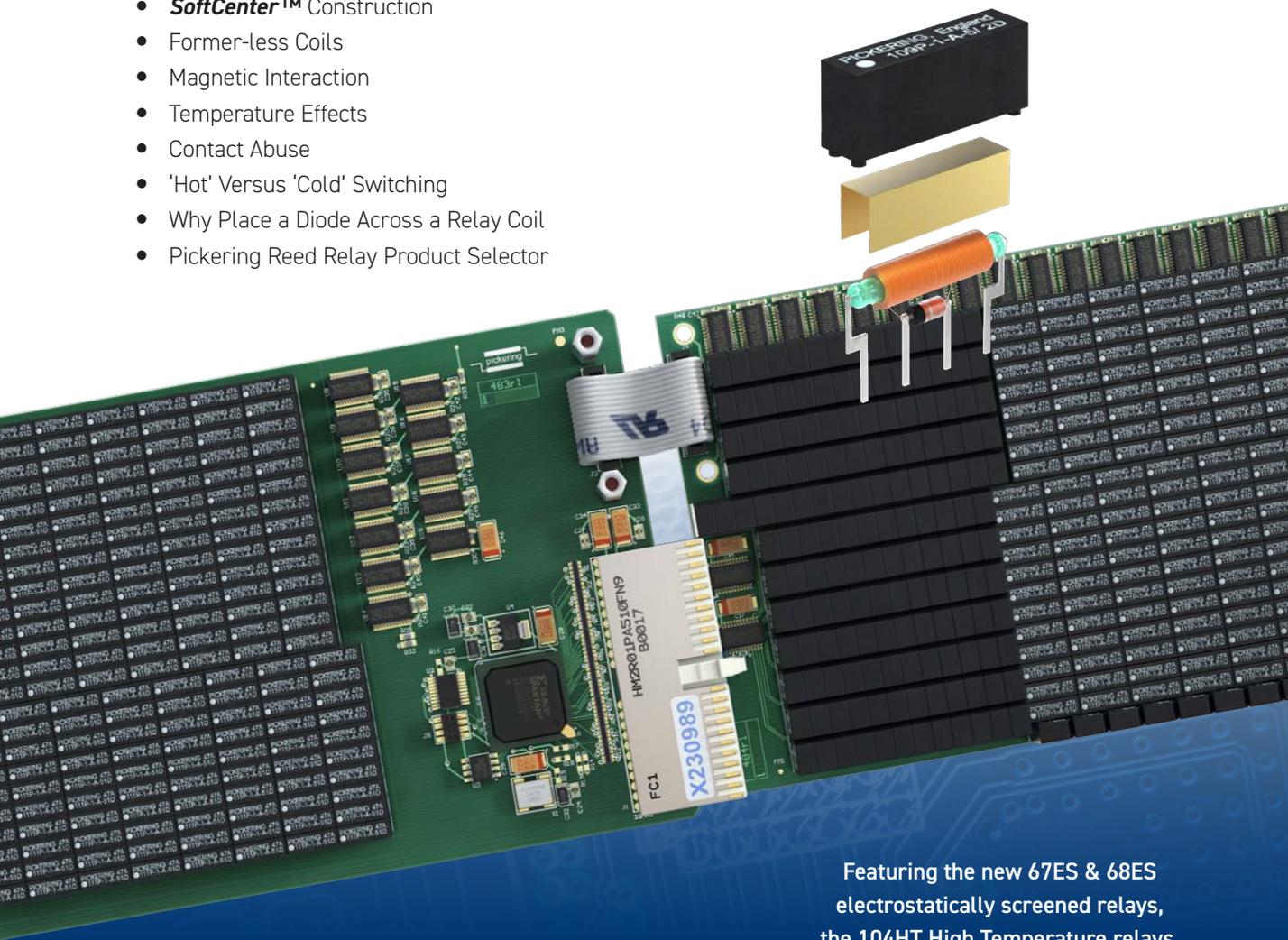
Concise Technical Guide

to Reed Relays

If used correctly, a Reed Relay is a superbly reliable device. The switch contacts are hermetically sealed, so do not suffer from oxidization or contamination in the same way as an open electromechanical relay. Although in reality, relays are often considered slightly mundane and little thought is given to them which sometimes leaves them vulnerable.

This concise technical guide will help you to maximise the reliability of your design. Contents include:

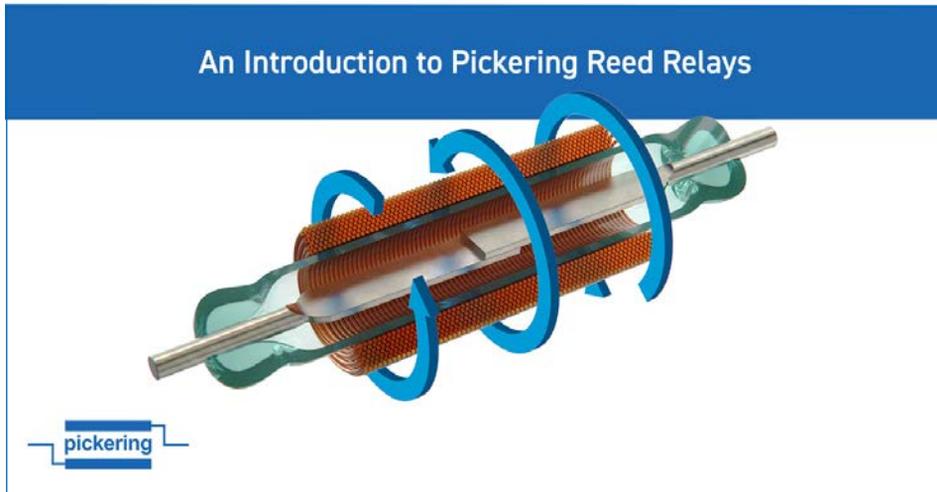
- **SoftCenter™** Construction
- Former-less Coils
- Magnetic Interaction
- Temperature Effects
- Contact Abuse
- 'Hot' Versus 'Cold' Switching
- Why Place a Diode Across a Relay Coil
- Pickering Reed Relay Product Selector



Featuring the new 67ES & 68ES electrostatically screened relays, the 104HT High Temperature relays, and the 219 High Voltage relays.

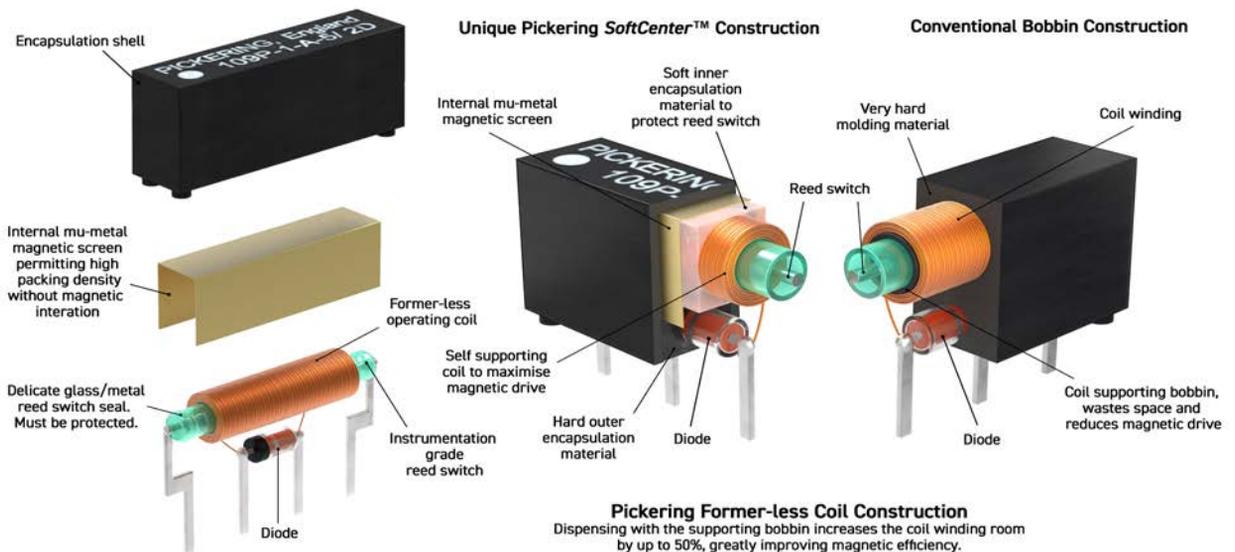
Reed Relay Construction and *SoftCenter*™ Technology

How are Reed Relays Constructed? Please click on the image below to view our website video.



SoftCenter™ Technology

Pickering Reed Relays are encapsulated using a soft inner material to cushion the reed switch capsule. The very hard compounds used by most other manufacturers can cause stresses that can potentially damage the reed switch and degrade contact resistance stability and life expectation. Pickering relay *SoftCenter*™ construction stops this.



Former-less Coil Winding

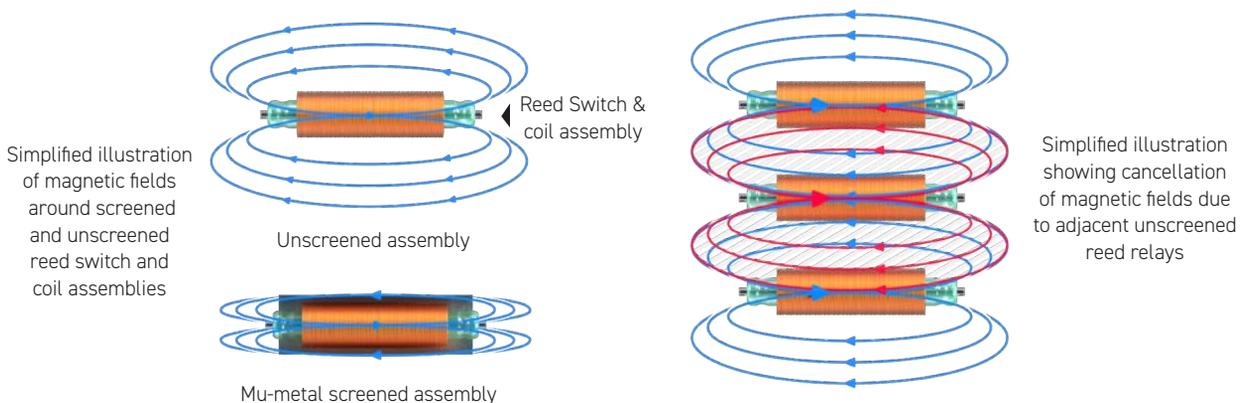
All our Reed Relays are constructed using our **SoftCenter™** technology, which uses a soft inner material to reduce stresses on the reed switch. In addition, contact life and more reliable contact resistance are achieved by our use of Former-less coil winding. Our Former-less coils are manufactured using a fully automated process that provides consistent output quality and repeatability. So what is Former-less Coil Winding and what advantages does it give you? Looking at the above diagram you can see that former-less winding greatly increases the winding 'window', providing the following advantages:

- A much higher magnetic drive level and better magnetic coupling as the smaller diameter of the inner turns are more efficient (more turns per Ohm).
- The number of Ampere Turns (AT) is increased - Reed switches are usually rated in sensitivity by an Ampere Turn number, for example, an AT rating of 15AT is twice as sensitive as one with a 30AT. Because the 30AT switch needs more magnetic drive there is much more 'restoring force', which is the ability to open when the coil drive is turned off. This in turn extends the working life of the reed switch many times.

Learn more about **SoftCenter** Technology and Former-less Coil Winding at pickeringrelay.com/softcenter

Magnetic Interaction

The switch contacts in a reed relay are operated by the magnetic field generated by the coil which is wound around the hermetically sealed switch capsule. When these relays are stacked close together, the field from adjacent relays will partially oppose the magnetic field from the relay alongside, reducing its sensitivity. This means that a higher coil voltage will be required to operate it. For very small relays, this increase could be as high as 40% which means that it may not be possible to operate the relay at its normal coil voltage. Look at the magnetic field illustrations below.



Our relays are fitted with a Mu-metal magnetic screen rather than one made of steel because of its high permeability and very low magnetic remanence. This screen concentrates the magnetic field, greatly improving the device's efficiency and reliability and allowing side by side stacking to maximize density. The high packing densities that can be achieved when using our reed relays is illustrated below on a PXI High Density Reed Relay Matrix Module from our sister company Pickering Interfaces.

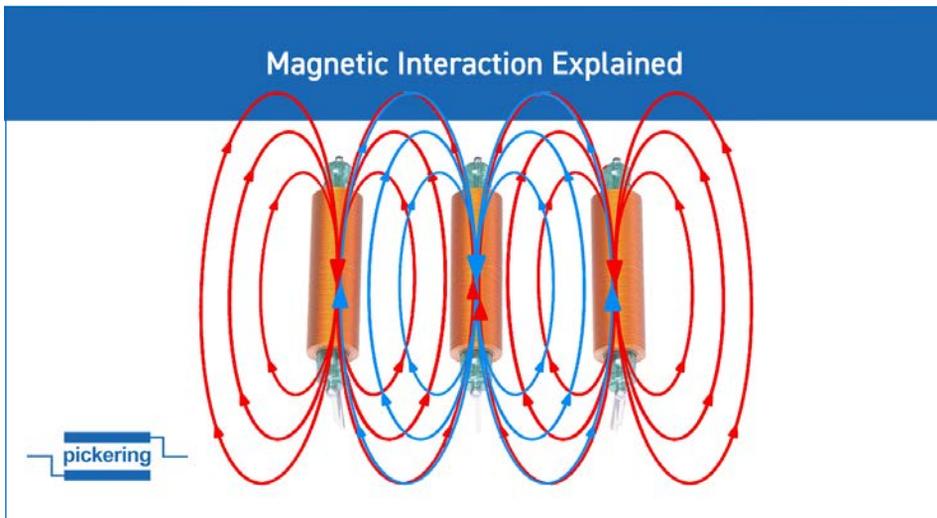
Magnetic Interaction



This module uses **360 Pickering Series 111P** relays, plus **156 Pickering Series 117** relays.
A total of **516 Reed Relays**.

Magnetic screening is absolutely essential for reed relays mounted on a close pitch!

Watch our **Magnetic-interaction video** below, or learn more about magnetic interaction at pickeringrelay.com/magnetic-interaction.

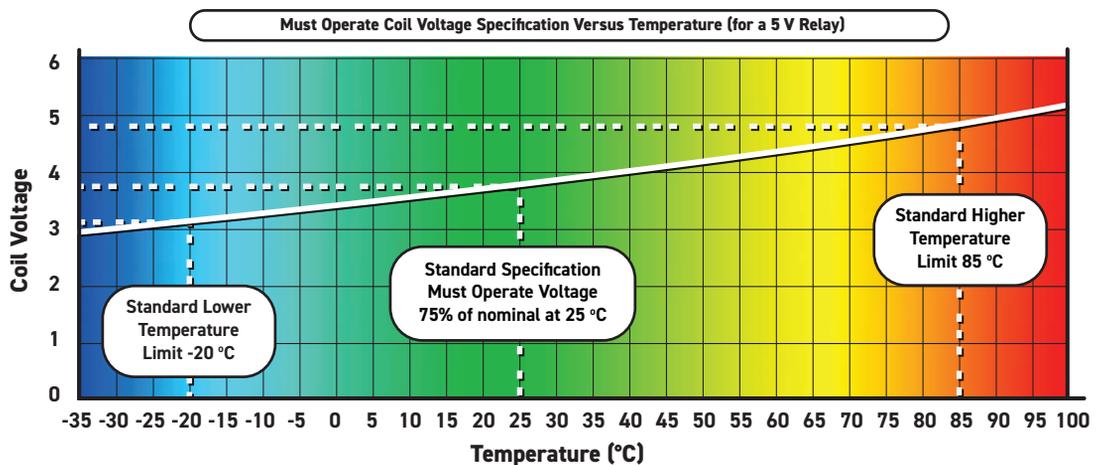
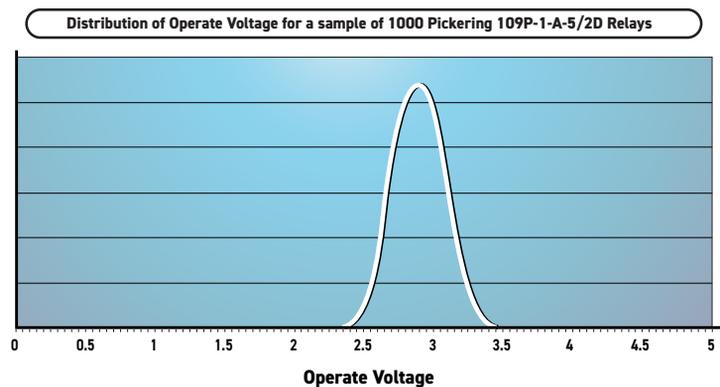


Operating Temperature

Reed Relays are sometimes considered a mundane component by design engineers and often little thought is given to their operating parameters. One of these parameters is operating temperature and failure to consider its effects can lead to the possibility of the relay not operating at high temperatures.

The relay's reed switch is operated by a magnetic field generated by a coil which is wound around it using copper wire. Copper has a positive coefficient of resistance of approximately 0.4% per °C and its resistance will increase with temperature at this rate. As the resistance increases, the current and therefore the level of magnetic field will fall.

The industry standard 'Must Operate Voltage' sometimes called the 'Pull-In Voltage' is 75% of nominal and usually quoted at 25°C. For a 5 V relay this would be equal to 3.75 V, although in practice it will be lower than this figure. The first graph shows the actual distribution of Operate Voltages for a batch of 1000 Pickering relays. In the second graph you can see how this operate voltage figure will change with temperature.



Remember that there will also be a voltage drop in the relay driver that needs to be taken into account. It can be clearly seen that at higher temperatures it is possible that the relay will not operate at its nominal coil drive voltage. For Reed Relays other than those manufactured by Pickering, magnetic interaction with adjacent relays will also need to be considered.

Pickering are able to supply Reed Relays with an increased magnetic drive level to accommodate higher temperatures if requested and also have sensitive 3V coil versions in many ranges.

For more information on temperature effects and increasing the temperature range of reed relays see pickeringrelay.com/pdfs/Increasing-operating-temperature-range.pdf

Contact Abuse

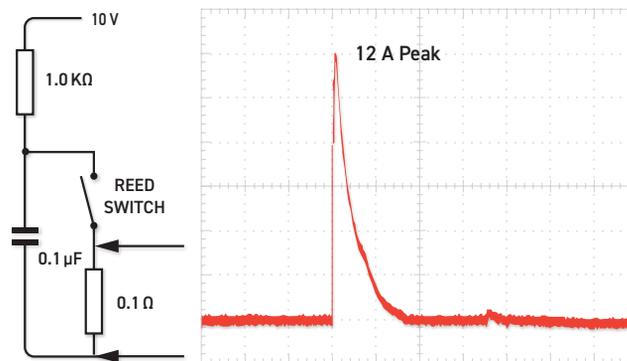
Relay Damage

High current or high power inrushes are the most damaging and most frequent cause of contact damage. Reed Relays have specified maximum Current, Voltage and Power ratings. The Power figure is simply the product of the voltage across the open contacts before closure and the instantaneous current as they first make.

We at Pickering have lost count of the number of times that we have heard something like “I was only switching 5 V at 50 mA onto this CMOS logic board” when the user has completely disregarded the current inrush into the liberal sprinkling of decoupling capacitors and several micro-Farads of reservoir capacitance on that board.

Do not rely on electronic current limiting of power supplies only, to protect relay contacts. Electronic current limiting takes a finite time to react and there are often decoupling capacitors on the output of a power supply. There is nothing better than resistive current limiting.

As well as inrushes due to charging capacitive loads, discharging capacitors can be an even greater issue as the current is often only limited by the resistance of the reed switch and PC tracks. Even capacitors charged to quite low voltages can cause current inrushes of tens of amps and although they may be for microseconds only, they can cause damage to small reed switches.



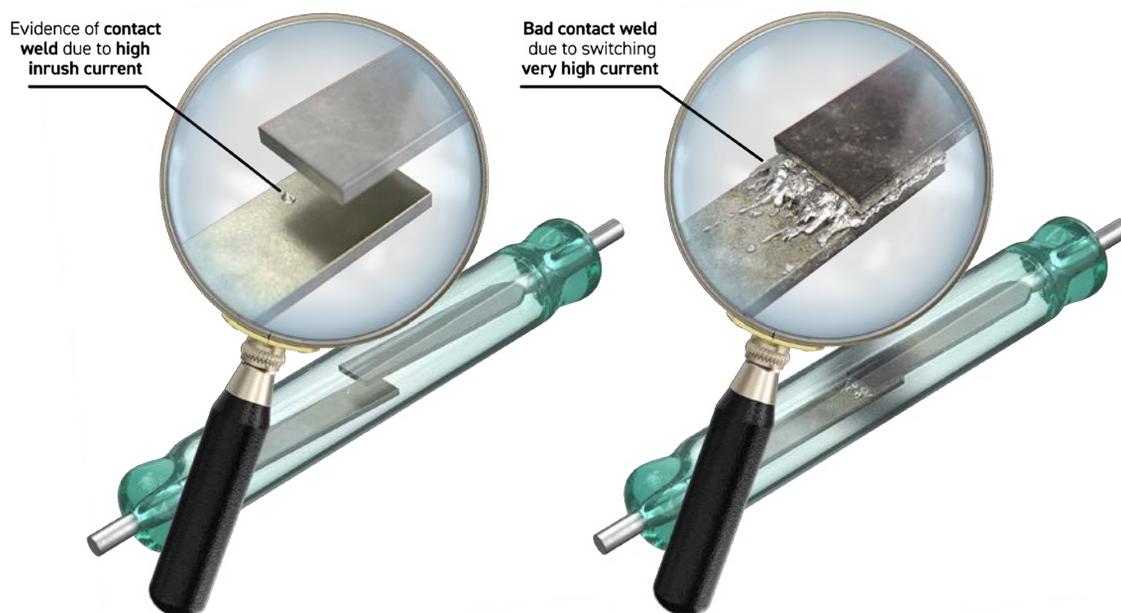
Typical current inrush when discharging a 0.1 μF capacitor at 10 V through a Reed Switch and 0.1 Ω resistor.

As voltages increase for some applications, inrushes can become an even greater issue, for example when discharging cables after high voltage proof testing. The energy stored in a capacitance is equal to $\frac{1}{2} CV^2$ Joules so will increase with the square of voltage. Increasing from 10 V to 1000 V will increase the stored energy by 10,000 times.

If you have ever had a relay contact stick closed, only to free with a slight tap, or had a longer than expected release time, more than likely, it is caused by a micro-weld due to a current inrush.

'Hot' versus 'Cold' Switching

Reed Relays generally have a higher Carry Current rating than their 'hot' Switching Current rating. It is usually during 'hot' switching where contact damage occurs due to the resulting arc across the contacts as they open or close. A severe current overload will quickly melt the contact area causing the two surfaces to fuse together creating a hard weld as soon as the contact closes. Less severe current inrushes will cause a milder weld or gradually build up a 'pip' on one contact and erode a 'crater' on the other according to the direction of current flow. These can eventually lock together. Arcs can occur when contacts open, particularly when the load is inductive and Back EMFs from inductive loads should always be limited, usually by a simple diode in the case of DC loads or by a Snubber or Varistor in the case of AC loads.



One way to reduce or remove these issues is to 'Cold' switch. This is a common technique in Test Instrumentation, where the current or voltage stimulus is not applied to the switch until after the relay has been operated and contact bounce finished. In the same way, the stimulus is removed before the contact is opened. In this way there will be no arcing or switched current inrushes and the relay will achieve maximum life, often into billions of operations.

When calculating the delay time between switching on the relay coil and applying the current to the switch, it is important to consider the effects of high ambient temperature if this is likely to be encountered. The maximum operate time and bounce figures given on the data sheets are at a 25 °C ambient level. At higher temperatures, the resistance of the coil winding will increase at a rate of 0.4 % per °C, this being the coefficient of resistance of the copper coil wire. There will therefore be a corresponding fall in coil current and the level of the magnetic field that is generated to operate the reed switch. This lower drive level will increase the operate time slightly. The timing figures on Pickering data sheets are normally quite conservative so this is unlikely to be an issue up to the normal ambient specification of 85 °C. However, if there is any additional self-heating within the relay due to a high carry current and the switch resistance (I^2R Watts), it will be necessary to consider this and allow a little more time before turning on the current through the switch.

Please contact Pickering Application Engineers at techsales@pickeringrelay.com for further help if required.

'Hot' versus 'Cold' Switching

Learn more about **Hot and Cold Switching** from our website video below.



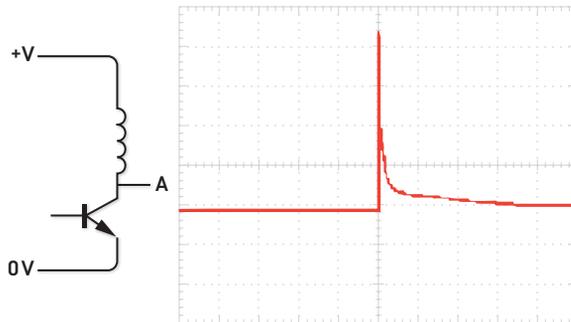
Diodes

In the majority of relay applications, a diode is connected across the relay coil, this could be either externally fitted or commonly integral within the relay. Some relay driver ICs include an internal diode so another is unnecessary.

A reed relay operating coil usually comprises of many hundreds or even thousands of turns of wire wound around a reed switch (effectively a ferro-magnetic core). This operating coil therefore forms an inductor. When a current flows through this coil, a magnetic field is generated which operates the reed switch. A problem arises when the current through the coil is switched off. Generally this is performed by a semiconductor switch of some sort. The collapsing magnetic field will produce a substantial voltage transient in its effort to disperse the stored energy in the inductor and oppose the sudden change of current flow. This voltage transient may be equal to many hundreds of volts and is commonly referred to as a Back EMF. If not suppressed, this will be equal to $-L \times di/dt$ where L is the inductance of the coil in Henrys and di/dt is the rate of change of current. If the current is reduced quickly, di/dt will be a high figure, resulting in a high level of Back EMF. If the current is reduced slowly, di/dt will be smaller resulting in a lower Back EMF figure but a longer release delay time which may not be desirable.

Why place a diode across a relay coil?

The diagram below shows a common method of driving a relay coil using an open collector NPN driver transistor.

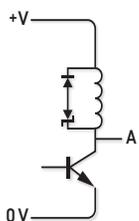
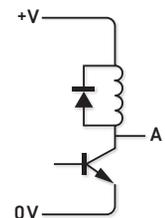


When the transistor is turned on, it will pull Point A to near 0 V turning on the relay. When the transistor is turned off, the stored energy in the inductor will generate a Back EMF pulse. This pulse will be of the opposite voltage polarity to that which was used to energize the coil. You will see from the oscilloscope display that there is a very large voltage spike which can be hundreds of volts more positive than the supply rail.

If not limited, this voltage spike can quite easily damage the semiconductor driver and interfere with the controlling electronics due to the electrical noise generated.

Limiting the Back EMF and the Effect on Release Time

The most usual method of limiting this Back EMF voltage to protect the driver, is by the use of a diode connected across the coil as shown in this circuit. When the driver output at A, rises above the coil supply voltage, the diode conducts and clamps the Back EMF voltage to the Forward Voltage figure of the diode ($V_f = 0.7$ V for a typical silicon diode) so the driver will only be subjected to the supply line voltage plus 0.7 V. Ideally, this diode should be inside the relay or very close to the coil terminals to avoid the risk of RFI as this current is carried along printed circuit tracks.

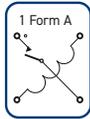


A consequence of using a simple diode in this way is to increase the opening or release time of the relay as the magnetic field will be retained until the energy is dissipated, limited by the coil resistance. The release time of a reed relay is quite fast so this is rarely an issue but in some instances, a faster release time is desired. Using the circuit shown with a Zener diode in series with a normal diode will achieve this by clamping the Back EMF to the Zener voltage plus 0.7 V. As an example, a small reed relay might have a typical release time of around 120 μ s with a simple diode clamp and this could fall to perhaps 50 μ s if a 6.2 volt Zener is added in this way.

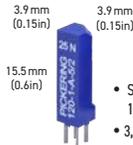
Reed Relay Product Selector

Ultra High Density 4mm²™ Reed Relays

- Highest packing density currently possible - requires a board area of only 4 mm x 4 mm
- Plastic package with internal mu-metal magnetic screen
- **SoftCenter™** Technology

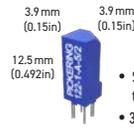


Series 120



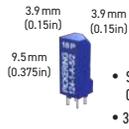
- Switching up to 1A, 20W
- 3, 5 or 12V coils

Series 122



- Switching up to 0.5A, 10W
- 3 or 5V coils

Series 124

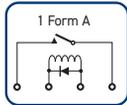


- Switching up to 0.5A, 10W
- 3 or 5V coils

NEW

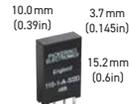
High Density Vertical SIL Reed Relays

- Ideal for Very High and High Density ATE/Instrumentation applications
- Plastic package with internal mu-metal magnetic screen
- 3 V, 5 V, or 12 V coils. Diodes are Optional
- Dry Instrument Grade switches
- **SoftCenter™** Technology

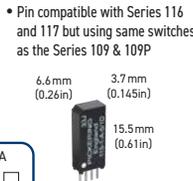


Series 112

Series 110



Series 115



- Pin compatible with Series 116 and 117 but using same switches as the Series 109 & 109P

Series 116



- 10 W, 0.5 A switching, requires a board area of only 0.15 x 0.27 inches

Series 117

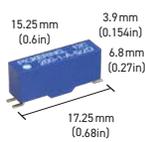


- 10 W, 0.5 A switching in 1 Form A & 2 Form A

Surface Mount Reed Relays

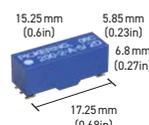
- Ideal for High Density ATE/Instrumentation applications
- High temperature plastic package with internal mu-metal magnetic screen
- Wide range of switching configurations
- Coaxial version for high speed digital or R.F. to 5GHz.
- Series 219 High Voltage version **NEW**
- 3, 5 or 12 V coils with optional diode
- Dry Instrument Grade or Mercury Wetted switches
- **SoftCenter™** Technology

1 Form A, 1 Form A Coaxial

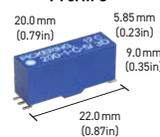


Series 200

1 Form B, 2 Form A

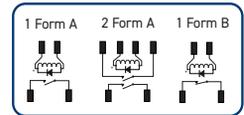
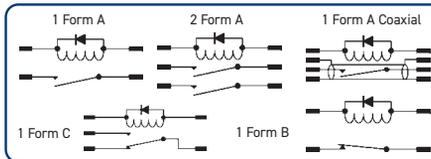
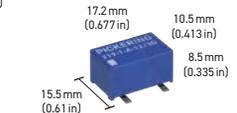


1 Form A HV, Dry or Mercury 1 Form C



Series 219

- High Voltage up to 3000 V
- Up to 3kV Standoff (Switch - Switch)
- Up to 5kV Standoff (Switch - Coil)

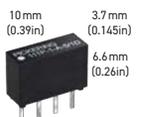


General Purpose SIL Reed Relays

- Ideal for General Purpose and High Density ATE/Instrumentation applications
- Plastic package with internal mu-metal magnetic screen
- 3 V, 5 V, 12 V or 24 V coils. Diodes are Optional
- Dry Instrument Grade switches
- **SoftCenter™** Technology

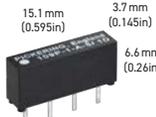
Series 111P

- 1 Form A only



Series 109P

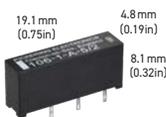
- 1 Form A only



Series 113



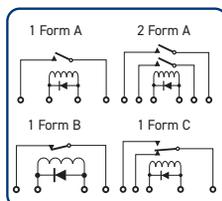
Series 106



Series 105



- Dry or mercury wetted switches



Mu-Metal Package SIL Reed Relays

- Ideal for General Purpose and High Density ATE/Instrumentation applications
- Mu-metal package eliminating the risk of magnetic interaction
- 3 V, 5 V, 12 V or 24 V coils. Diodes are Optional
- Dry Instrument Grade switches
- **SoftCenter™** Technology

Series 111

- 1 Form A only



Series 109

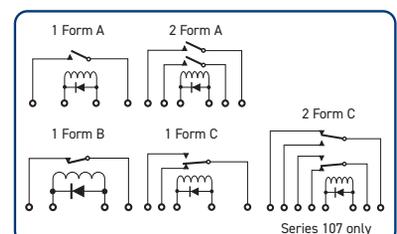
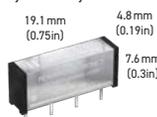


Series 108



Series 107

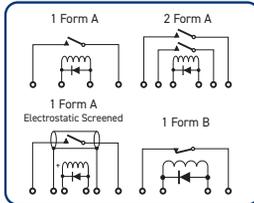
- Dry or mercury wetted switches



Reed Relay Product Selector

High Voltage/High Power Reed Relays

- Ideal for high power/voltage applications
- Plastic package with internal mu-metal magnetic screen
- 3 V, 5 V, 12 V or 24 V coils. Diodes are Optional
- Dry Instrument Grade switches
- **SoftCenter™** Technology



Series 114

- High Power up to 40 W
- Will replace mercury wetted relays in many applications



Series 100HC

- 1 A switching up to 40 W
- Carry up to 3 Amps continuous
- Pulsed Carry > 3 A
- 1 Form A, 1 Form B



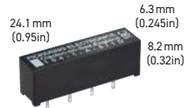
Series 100HV

- High Voltage up to 3000 V
- High Coil Resistance (Up to 6800 Ω) for Low Power Consumption



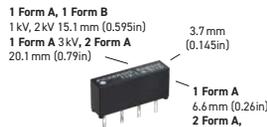
Series 104

- High Voltage up to 4000 V
- Single Pole Relays now up to 4 kV Standoff
- Double Pole Relays up to 2 kV Standoff
- Electrostatically Screened version 104ES
- 104HT High Temperature Versions



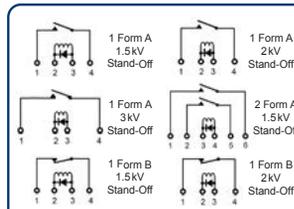
Series 119

- High Voltage up to 3000 V
- Single Pole Relays up to 3 kV Standoff
- Double Pole Relays up to 1.5 kV Standoff



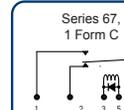
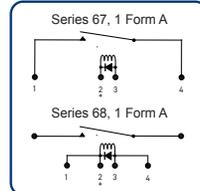
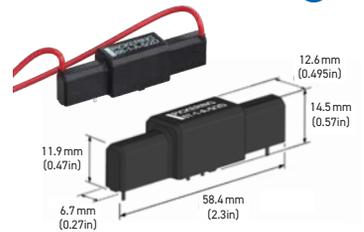
Series 131

- 1 Form A only
- Minimum 1.5 kV Standoff



Series 67/68

- Up to 10 kV standoff at 50 W, 8 kV standoff at 200 W
- Robust 50 or 200 W Tungsten contacts
- Series 67 has pcb pins for all connections. Series 68 has flying leads from the top face for the high voltage connections
- 1 Form A. Standing off 5 kV, switching up to 3.5 kV.
- 1 Form A. Standing off 8 kV, switching up to 6 kV
- 1 Form A. Standing off 10 kV, switching up to 7.5 kV
- 1 Form C. Standing off 5 kV, switching up to 2.5 kV
- Electrostatically Screened Versions 67ES and 68ES



Low Power/Low Thermal EMF Reed Relays

- Ideal for Data Acquisition or thermo-couple switching
- Plastic package with internal mu-metal magnetic screen
- 3 V, 5 V, 12 V or 24 V coils. Diodes are Optional
- Dry Instrument Grade or Mercury Wetted switches
- **SoftCenter™** Technology

Series 118

- 1 Form A only
- High Coil Resistance for Portable Instrumentation



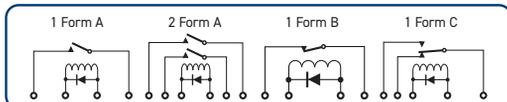
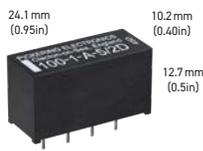
Series 101

- Direct Drive from HC or HCT CMOS



Series 100

- Direct Drive from CMOS



RF/High Speed Digital Reed Relays

- Ideal for High Density ATE/Instrumentation applications
- Mu-metal or Plastic package with internal mu-metal magnetic screen
- 3 V, 5 V, or 12 V coils. Diodes are Optional
- Dry Instrument Grade switches
- **SoftCenter™** Technology

Series 111RF

- Up to 2.5 GHz



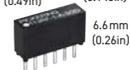
Series 103G

- Up to 2 GHz



Series 113RF

- Up to 3 GHz



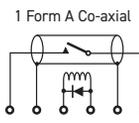
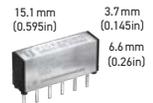
Series 102M

- Up to 1.5 GHz



Series 109RF

- Up to 2 GHz



See also Surface Mount Series 200 Coaxial version.

Try our fully interactive reed relay selector tool online today:
pickeringrelay.com/reed-relay-selector-tool

About Pickering Electronics

Pickering Electronics are a British manufacturer of high quality Reed Relays predominantly used in Instrumentation and Test equipment. Pickering have been designing Reed Relays since 1968 and today, Pickering's Single-in-Line(SIL/SIP) range is by far the most developed in the relay industry, with relays 25 percent the size of many of their competitors. Pickering Relays are available in Surface Mount, Single-in-Line (SIL/SIP) and Dual-in-Line (DIL/DIP), with the option of dry or mercury wetted switches. These small relays are sold in high volumes to large ATE companies throughout the world.

In 1980 Pickering moved to a purpose-built factory of 2200 m² (22000 ft²) in Clacton-on-Sea, Essex, where all manufacturing took place until 2007, when Pickering opened a Czech manufacturing facility located on a site of 12500 ft². Pickering is a privately-owned company and currently employs over 200 people.

Pickering are certified to ISO 9001-2000 and audited by the British Standards Institution. Pickering prides itself on the quality of its products therefore continuous inspection during the manufacturing process is carried out, and Reed Relays are 100 percent tested for all operating parameters.

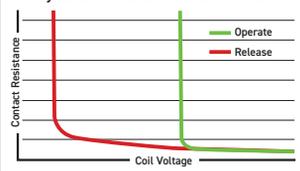
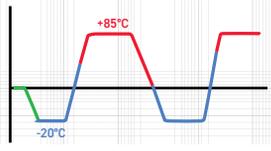
Global Operations



Pickering operates globally with manufacturing facilities in the UK and Czech Republic, along with additional representation in countries throughout the Americas, Europe, Asia and Australasia.

To contact an official Pickering agent please visit: pickeringrelay.com/agents

The Advantages 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 5x10E9 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.	

Reed RelayMate

The **Reed RelayMate** from Pickering Electronics is a publication which looks in detail at reed relays. In it you'll find out how reed relays are constructed, what types there are, how they work, what parameters affect their operation, how to choose the correct relay, a comparison with other relay technologies and how to drive and place reed relay coils.

The Reed RelayMate is available **Free** from the Pickering Electronics' website and is available as printed copy or pdf format.



RoHS

We are committed to RoHS compliance and Lead Free manufacture. We do however, offer non-compliant, mercury options in many of the relay ranges if they are purchased as service replacements, needed to expand existing capacity or go into electrical or electronic equipment already in place prior to 1st July 06.

Free Working Reed Relay Samples for Evaluation

Determining which components to design in can be challenging. Fortunately, here at Pickering Electronics, we offer free working samples to help you evaluate our high-quality Reed Relays.

To claim free Reed Relays now visit: pickeringrelay.com/samples

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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