

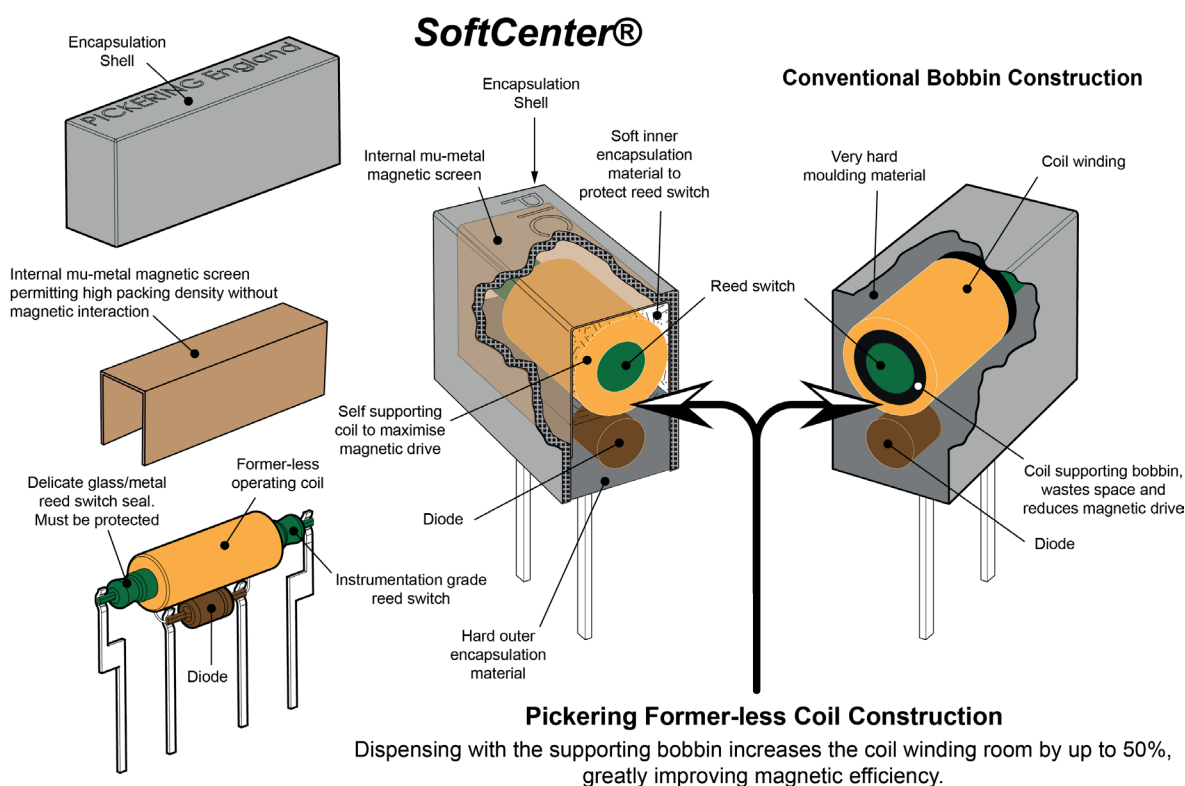
Concise Technical Guide to Reed Relays

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

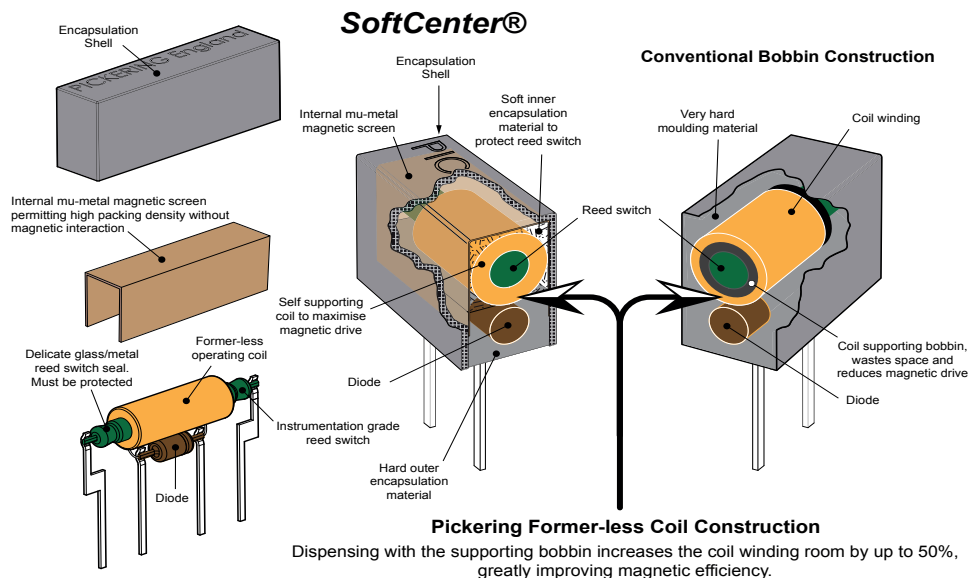
Typical Pickering Construction using Former-less Coils and our **SoftCenter®** technology



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.

Typical Pickering Construction using Former-less Coils and our **SoftCenter®** technology



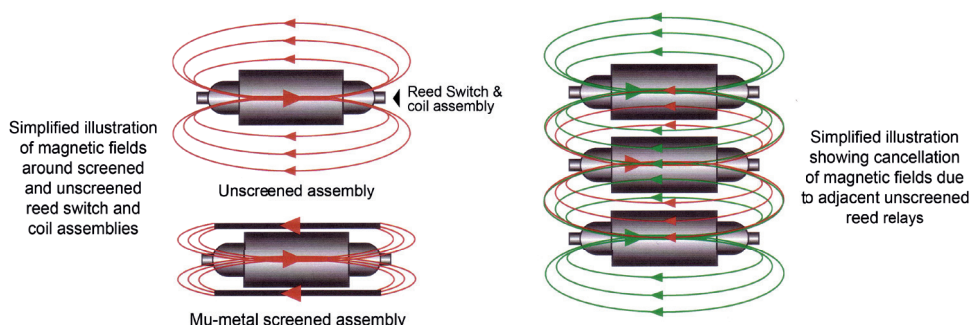
Former-less Coil Winding

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:

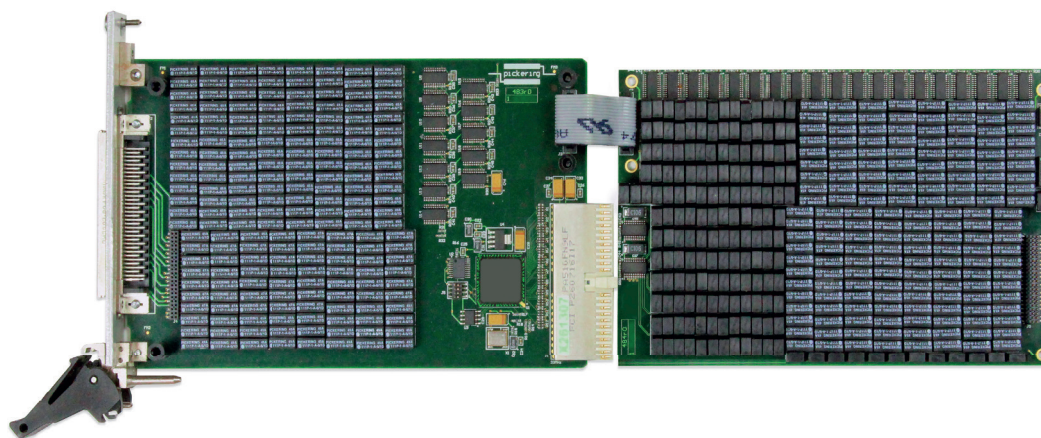
- A much higher magnetic drive level and better magnetic coupling as the smaller diameter of the inner turns are more efficient (more turns per Ohm).
- The number of Ampere Turns (AT) is increased - Reed switches are usually rated in sensitivity by an Ampere Turn number, for example, an AT rating of 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.

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.



*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!

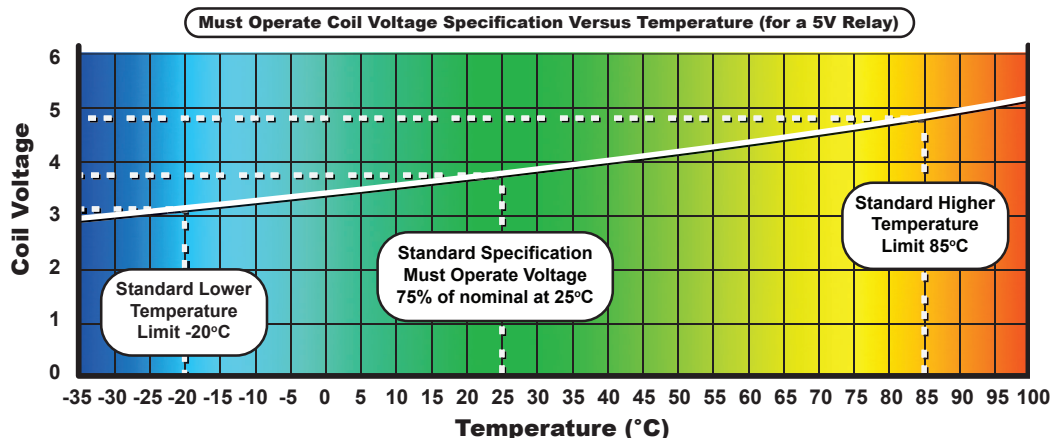
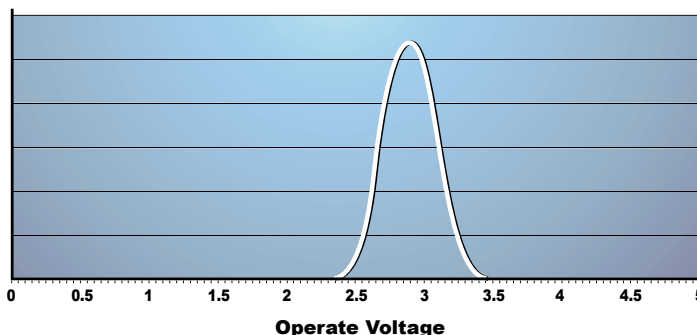
Temperature Effects

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 5V relay this would be equal to 3.75V, 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.

Distribution of Operate Voltage for a sample of 1000 Pickering 109P-1-A-5/2D Relays



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.

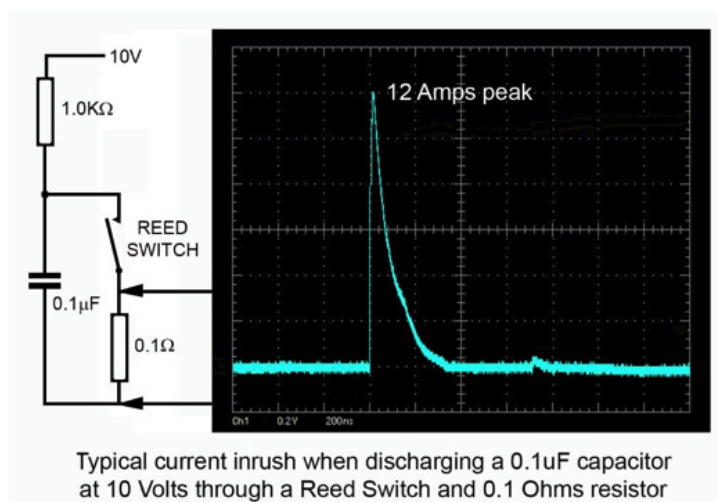
Contact Abuse

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 volts at 50 milliamps 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.

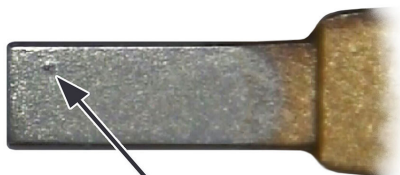


As voltages increase for some applications, inrushes can become an even greater issue, for example when discharging cables after high voltage proof testing. The energy stored in a capacitance is equal to $\frac{1}{2} CV^2$ Joules so will increase with the square of voltage. Increasing from 10 volts to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



Evidence of contact weld due to high inrush current



Bad contact weld due to switching very high current

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.

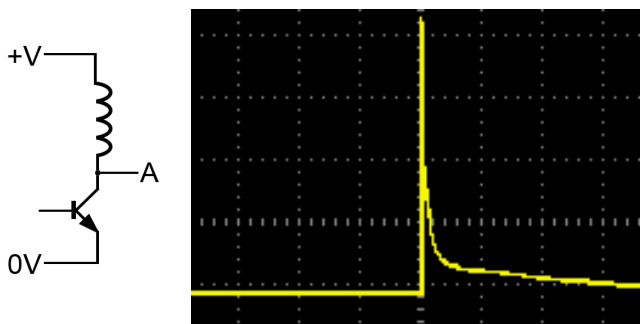
Please contact Pickering Application Engineers at techsales@pickeringrelay.com for further help if required.

Why place a diode across a relay coil?

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 may also include an internal diode so another will not be necessary.

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. The problem arises when the current through this inductive coil is switched off. This will usually be 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 can sometimes 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.

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

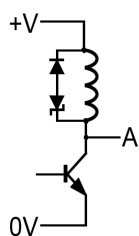
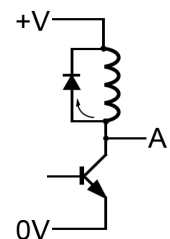


When the transistor is turned on, it will pull Point A to near 0 Volts turning on the relay. When the transistor is turned off, the stored energy in the inductor will generate a Back EMF pulse. This pulse will be of the opposite voltage polarity to that which was used to energize the coil. You will see 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 ($V_f = 0.7$ Volts for a typical silicon diode) so the driver will only be subjected to the supply line voltage plus 0.7 Volts. 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 volts. As an example, a small reed relay might have a typical release time of around 120 microseconds with a simple diode clamp and this could fall to perhaps 50 microseconds if a 6.2 volt Zener is added in this way.

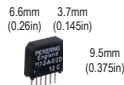
Single-In-Line (SIP) Reed Relays

High Density Vertical Package

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

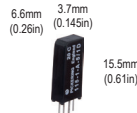
Series 117

- Highest packing density currently possible - requires a board area of only 0.15 x 0.27 inches

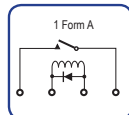


Series 115

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

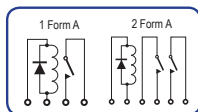
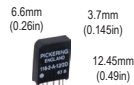


Series 110



Series 116

- 10 Watts version of the Series 117, requires a board area of only 0.15 x 0.27 inches



Series 112

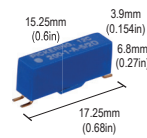


Surface Mount SIL Reed Relays

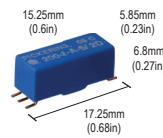
- Ideal for High Density ATE/Instrumentation applications
- High temperature plastic package with internal mu-metal magnetic screen
- Wide range of switching configurations
- Coaxial version for high speed digital or R.F. to 6GHz.
- 3, 5 or 12 volt coils with optional diode
- Dry Instrument Grade or Mercury Wetted switches
- **SoftCenter®** Technology

Series 200

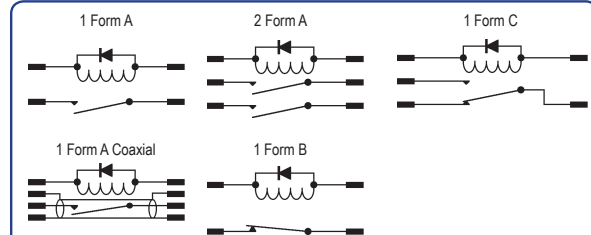
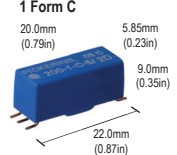
1 Form A, 1 Form A Coaxial



1 Form B, 2 Form A



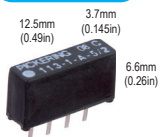
1 Form A - High Voltage, Dry or Mercury



Plastic Package SIL Reed Relays

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

Series 113



Series 111P



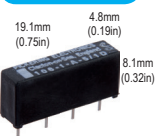
- 1 Form A only

Series 109P

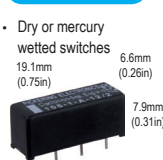


- 1 Form A only

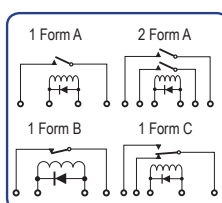
Series 106



Series 105



- Dry or mercury wetted switches



Metal Package SIL Reed Relays

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

Series 111

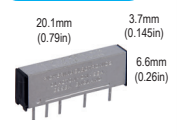


- 1 Form A only

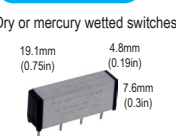
Series 109



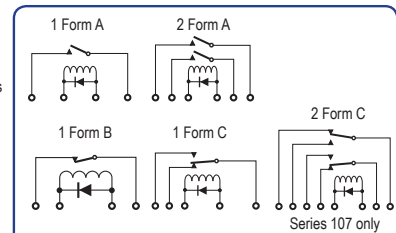
Series 108



Series 107



- Dry or mercury wetted switches



For a **free** evaluation sample call technical sales on **+44 (0)1255-428141**,
or e-mail us at **sales@pickeringrelay.com**

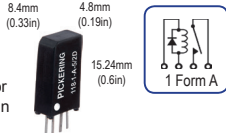
Single-In-Line (SIP) Reed Relays

Low Power/Low Thermal EMF

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

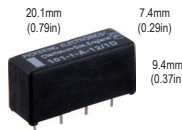
Series 118

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



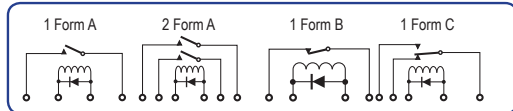
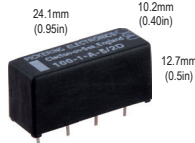
Series 101

- Direct Drive from HC or HCT CMOS



Series 100

- Direct Drive from CMOS

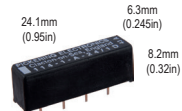


High Voltage/High Power Relays

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

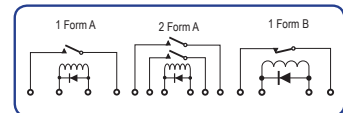
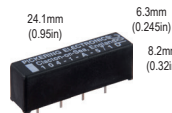
Series 114

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



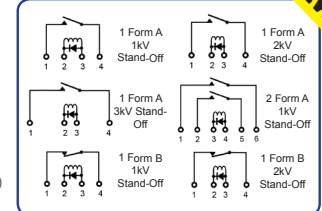
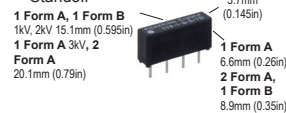
Series 104

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



Series 119

- High Voltage up to 3000V
- Single Pole Relays up to 3kV Standoff
- Double Pole Relays up to 1kV Standoff

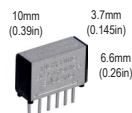


NEW

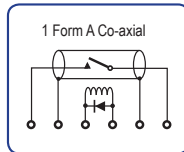
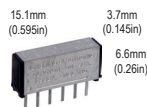
RF/High Speed Digital Reed Relays

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

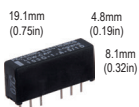
Series 111RF



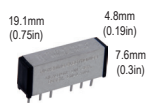
Series 109RF



Series 103G



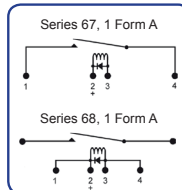
Series 102M



Also see Surface Mount
Series 200
Coaxial version.

Series 67/68

- High Voltage up to 10kV
- Robust 50 Watts 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 5kV, switching up to 3.5kV.
- 1 Form A. Standing off 10kV, switching up to 7.5kV



NEW

Note 1

In most cases dimensions are provided for Single-In-Line 1 Form A versions. Go to pickeringrelay.com for the dimensions of other versions.

Note 2

As well as the parts shown on this leaflet, Pickering Electronics manufacture many other relay types for up to 15kV. If you need any help in selecting the most suitable relay for your application, please contact our technical sales department at techsales@pickeringrelay.com.

For a **free** evaluation sample call technical sales on +44 (0)1255-428141,
or e-mail us at sales@pickeringrelay.com



email: sales@pickeringrelay.com

pickeringrelay.com

Customisation

Pickering manufacture many types of reed relay, but if you can't find one suitable for your needs we can customise our standard relays with:

- Special pin configurations or pin lengths
- Special print with customers own number or logo
- Custom packaging
- Very Low capacitance
- Controlled thermal emf
- Operate voltage
- Coil resistance, especially low power options
- Switch life under specific loads
- Pin forming
- Specific operate & release times
- Specific environmental requirements

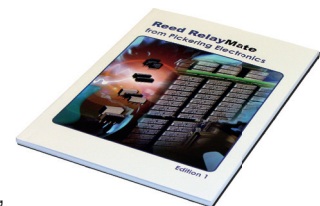
RoHS

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.

Reed RelayMate

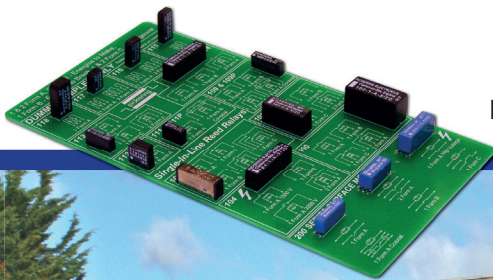
The **Reed RelayMate** from Pickering Electronics is a publication which looks in detail at reed relays. In it you'll find out how reed relays are constructed, what types there are, how they work, what parameters affect their operation, how to choose the correct relay, a comparison with other relay technologies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

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



Technical Help

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



A **Free** PCB containing non-working samples of Pickering Electronics' Reed Relay range is available on request.

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