Best Practices for Applying Coto Technology's 9852 Form C Reed Relay

Summary

The 9852 Form C reed relay is ideally suited for two-way signal switching in dense, high pin-count environments where small size, high electrical isolation in the off state and excellent ESD or abusive load resistance are mandatory. The performance and reliability of the relay can be optimized by adopting various strategies during the design-in phase. Making sure that the relay has sufficient electrical overdrive is one of the most important, and this note describes ways to ensure adequate overdrive can be maintained. The Application note concludes with nine suggestions for obtaining the best performance from the 9852 relay

Introduction

If you are considering whether to design in the Coto 9852 Form C reed relay, or are already using the product, this Applications Note will provide some guidelines on how get the best performance and reliability out of the product. The 9852 relay (Figure 1) shares the advantages of other reed relays; small size, high electrical off-isolation, very low on-resistance, and the ability to withstand electrostatic discharge without damage. In addition, the Form C design of the 9852 (often called single-pole double throw or SPDT) reduces circuit complexity and PCB real estate requirements compared to using multiple Form A relays to achieve the same switching topology.

Fig. 1 9852 surface mount Form C relay in gullwing and J-bend configurations

Review of Form C reed relay design

All reed relays contain a coil that generates a magnetic field when an electrical current is passed through it. This magnetic field causes two flexible switch blades to be attracted together, closing an electrical circuit between them. The simplest type of reed relay, a Form A (also called a single pole single throw or SPST relay) is shown diagrammatically in Figure 2. The 9852 relay achieves its Form C capability by incorporating a changeover reed switch that has a common input terminal, a normally closed (N/C) output lead and a normally open (N/O) output. (Figure 3). In this case, when the switch is activated by the coil that surrounds the switch, an internal beam flexes under the influence of the field, opening the N/C contact and closing the N/O contact. When no field is applied, the spring action of the internal beam presses it against the N/C contact, maintaining electrical continuity while no coil current is applied. This means that relay consumes no electrical power in the N/C position, an important energy saving in systems that may contain hundreds or even thousands of relays.

Maximizing Contact Life

Because of higher contact forces on the normally open contact, the life of this contact will typically be higher than that of the normally closed contact. Higher contact forces lead to lower contact resistance which reduces contact heating effects. The faster switching speed associated with larger magnetic driving forces also reduces arcing that can erode the precious metal contacts of the switch. In the case of the 9852, the expected life of the N/O contact is approximately 200 million cycles when switching a low level 1V 10 mA resistive load. In contrast, the life of the N/C contact at the same load is about 100 million cycles. The life at higher switched voltages and currents is likely to be lower than this, and reactive loads with capacitive or inductive characteristics can reduce life further. The underlying technical reason is that the N/O contact is closed by the magnetic forces generated by the coil, while the force on the N/C contact is maintained by the spring action of the common blade. The magnetic force is higher than the spring force (otherwise the switch would not operate), and higher contact force leads to longer life.

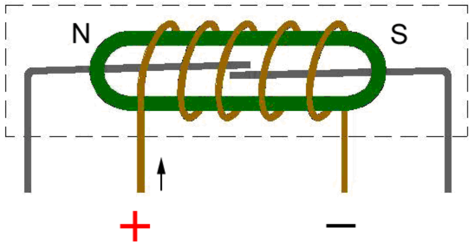

Fig 2. The simplest reed relay using a Form A (single pole, single throw) SPST switch

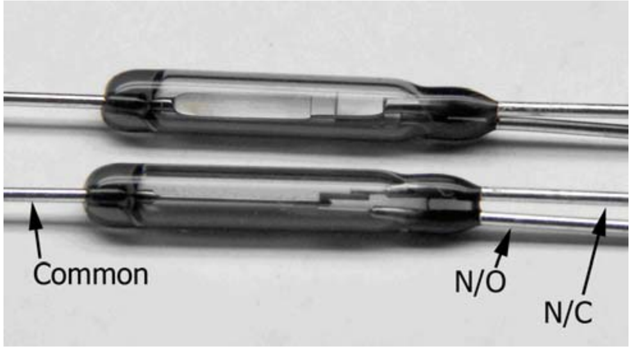

Fig 3. Form C reed switches

So one way to obtain the maximum life of the N/O contact is to provide as high a magnetic field as possible – the most obvious way to do this is to keep the coil current high, by using as high a coil voltage as possible within the specification limit for the relay. This maximizes the overdrive on the relay, where overdrive can be defined as the ratio of the applied coil voltage to the pull-in voltage sufficient to just operate the relay. Another way to maximize life is to only switch the relays when there is no current applied to the contacts, though this is not possible for every application.

There are also more subtle ways to maintain a high magnetic field, which be covered shortly.

Maintaining a healthy N/C contact.

Increasing the coil current does not change the contact force on the N/C contact, for reasons covered above. The contact force is solely based on spring action. Under certain circumstances, like long periods of inactivity, the N/C contact can become “sticky” due to various surface phenomena. Coil activation after a long period of inactivity has sometimes been found to lead to sluggish operation for the first few coil activations, manifested as a higher than normal current needed to cause the switch to operate. This phenomenon is exacerbated at high temperatures, causing the sticking forces to increase. The best way to avoid this potential problem is to use as high a coil current as possible, to maximize the magnetic forces that move the common blade over to the N/O contact. Another useful approach is to exercise the relay by programming a number of regular relay activations before the relay is involved in critical electrical measurements.

Maintaining high switching forces

Keeping the coil current high is important. However, there is another way to maintain as high a switching force as possible. It involves keeping the magnetic interaction between adjacent relays as low as possible. The magnetic field from one relay can interact with others nearby, and depending on whether the electrical currents through the coils are polarized in phase or opposed, the effective pull-in voltage may be increased to a point where the relay does not operate consistently. This effect can be minimized by installing relays in a regular pattern that minimizes magnetic interaction. One such pattern is shown in Figure 4. All Coto relays including the 9852 have coils wound in a consistent direction to allow installation patterning like this. It also helps to maintain as large a distance as possible between the relay on-center distances, since the magnetic interaction effects decrease rapidly with distance. (Roughly, the effects decrease as the inverse square of the distance.)

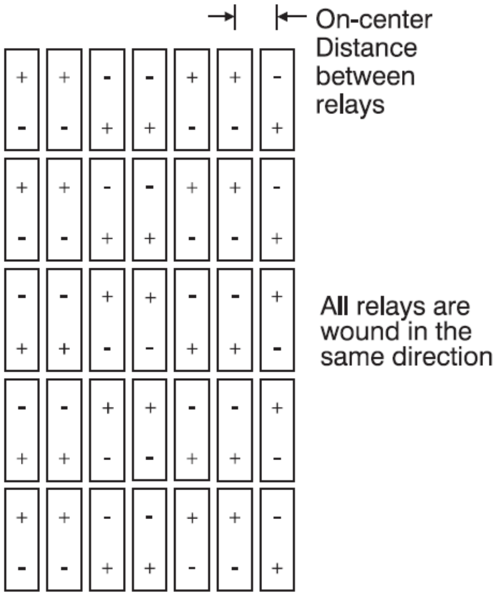

Fig. 4 Relay installation pattern designed to minimize magnetic interaction.

Coto also applies a ferrous metal shell to the 9852 relay. This has the effect of shunting the magnetic field through the shell rather than allowing to penetrate into adjacent relays. The shell also has a secondary benefit, in that it increases the magnetic efficiency of the relay by reducing the coil current needed to cause pull-in, and thereby increases the overdrive applied to the switch. As already discussed, higher overdrive means longer life. It follows that the magnetic shield should never be removed from the relay, and Coto no longer supplies 9852 relays without a shield.

How overdrive losses can stack up

So far, an important conclusion is that the way to the best relay life is to maintain as high a coil voltage (and therefore overdrive) as possible. Magnetic interaction can reduce effective overdrive, but this can be reduced by proper relay layout and the use of a magnetic shield. Exercising the relay regularly can help with low effective overdrive on the first few cycles after a long period of inactivity. It is also desirable to keep the relays as cool as possible, to reduce any "stickiness" of the N/C contact. There is a secondary disadvantage of running relays at high temperature; since the resistance of copper wire increases at approximately 0.39% per degree Celsius, a 30 degree C rise in temperature translates to about 12% higher coil resistance, and a corresponding reduction of 14% in the power supplied to the coil, assuming a constant voltage supply is used.

Using programmable relay coil driver IC's

Relay coil driver IC's are available, and provide a convenient way of supplying multiple relays with regulated programmable power. Some types allow the coil drive current to be backed off by a programmable amount after the relay has closed, reducing power consumption and heating effects. This application relies on the hysteresis exhibited by some types of electromechanical relays, where the coil current required to close the relay is significantly higher than the current needed to simply maintain it in a closed state. (In other words, a significant difference between the pull-in and drop-out voltage.) However, Coto does not recommend the use of programmable relay drivers for small reed relays such as the 9852. The hysteresis of such relays is low, and backing off the coil current after closure can lead to insufficient overdrive and reduced contact life.

Differences between nominal coil voltage and "must operate by" voltage.

The 9852 is specified to operate at no higher than 3.8 V, despite having a 5 V nominal coil voltage. That seems like a generous safety margin, but many factors can contribute to less than 3.8 V effectively reaching the relay coil. First, consider the 0.6 V junction loss of a typical relay drive circuit. That brings an initial 5 V supply down to 4.4 V. Then consider PCB trace losses, perhaps a few tenths of a volt. For example, assume the coil voltage is now down to 4.3 V Subsequent losses due to a 30 deg. C temperature rise would bring the effective voltage to 3.85 V, only slightly higher than the "must operate by" voltage. Add any magnetic interactions due to incorrect relay layout and the application is in potential trouble. The point is, keep the effective voltage applied to the coil as close to the nominal coil voltage as possible, while not exceeding the maximum coil voltage. Ideally the effective coil voltage should be at least 25% higher than the 3.8 V "must operate by" voltage, in order to guarantee at least 25% overdrive for all relays.

CONCLUSIONS

Nine ways to get the best performance from your 9852 relays

1. **Cold switch if possible**.
   It's not always practical, but if you can design your system so the relays only switch when the current is off, the relay life will be greatly extended.

2. **Avoid reactive loads**
   Reed relays are most reliable when switching resistive loads. Heavy inrush currents from capacitive circuits can cause premature contact failure or even contact welding, and inductive loads can cause excessive arcing on break. Contact Coto Technology for technical advice if you expect to be switching a reactive load.

3. **Maintain Overdrive**
   A relay with a nominal coil voltage of 5V will typically have a listed "must operate by" operate voltage of 3.8V. Try to ensure that the voltage applied to the coil is at least 25% higher, i.e. 4.75V. This overdrive of 25% will ensure that the relay contacts are firmly closed, enhancing the relay's life.

4. **Minimize magnetic interaction**
   If relays are to be stacked closely together on a PCB, ensure that they are oriented to minimize magnetic interaction that can increase the effective operate voltage of the relay, reducing the effective overdrive. Typically this means orienting the relays with opposing polarity. Refer to Figure 3 for an optimum layout pattern.

5. **Use a relay with a ferrous metal shell.**
   The 9852 relay is supplied with a ferrous metal shell. Many other Coto relays are offered with a ferrous metal shell that minimizes magnetic interaction and maintains maximum overdrive. Always select a relay with a shell if possible.

6. **Keep the operating temperature low**
   The coil resistance of a reed relay increases by 0.39% for every degree Celsius increase. Assuming you are using a constant voltage coil supply, a 30 degree C increase causes a 12% increase in coil resistance, and a corresponding 14% reduction in the power supplied to the coil. This reduces the overdrive, and could reduce the relay's life.

7. **Maintain coil voltage after relay closure**
   Avoid using relay driver IC's that allow the coil voltage to be lowered after the relay closes to save power. (Or simply turn the programmed reduction off.) Most small reed relays don't have enough differential between the pull-in and drop-out voltages to maintain adequate overdrive this way, and relay life may suffer.

8. **Program an occasional exercise cycle (Form C relays)**
   Form C reed relays that are only activated occasionally spend a lot of time with the normally-closed contact shut. This can sometimes lead to contact sluggishness when

the relay is first activated, or on rare occasions the relay may remain stuck in the normally-closed position. Programming an occasional burst of relay operations before making critical electrical measurements can greatly alleviate this problem.

9. **Use an independent power supply for the relay coils.**
   Relay coils are inductive, and may send potentially damaging spikes down power lines. It is good design practice to provide an independent PSU for the relay coils. Consider external diode inductive spike suppression for relays such as the 9852 that do not have built-in kickback suppression diodes.

DISCLAIMER

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