Application Note

Solid State Relays vs. Electromechanical Relays

Introduction

In a relay's most basic function, the switching of a load circuit is controlled by a low power, electrically isolated input signal. In the past, Electromechanical Relays (EMRs) have been the component of choice, largely due to price, function, and availability. Now, however, the emergence of semiconductor technology has provided the means to manufacture solid state relays (SSRs) which in many applications outperform their predecessors.

Solid state relays provide the advantages of almost infinite switching lives, bounce-free operation, immunity to EMI, higher operating speeds, low level control signals, small package size, and multi-function integration. These advantages can save the design engineer board space, component count, time and money while improving product life, performance, and reliability.

Solid State Optronics (SSO) has been a leader in the design, development, and production of low cost, high performance SSRs for more than 30 years. SSO offers a wide range of MOSFET, SCR, and Triac based relays, complemented by a growing selection of additional isolation components including optocouplers and IGBT/Triac/MOS drivers. By reducing cost and package size while increasing function and performance, solid state relays from SSO now serve as a viable and superior option to electromechanical relays.

This application note will compare the operation of a typical EMR to that of a solid state relay, and examine advantages of each in different types of applications.

Description

The Electromechanical Relay

Figure 01 shows the topology of a typical electro-mechanical relay. An input voltage is applied to the coil mechanism. The input voltage magnetizes the core which pulls the arm towards it. This action causes the output contacts to touch, closing the load circuit. When the input voltage is removed, the spring lever will push the contacts away from each other, breaking the load circuit connection.

Inherent in its design, the EMR must make mechanical contacts in order to switch a load. At the point of these contacts, oxidation breakdown occurs over extended life cycling (typically 10^6 operations), and the relay will need to be replaced. When an EMR is activated, bounce occurs at the contact site. Bounce creates a window of time where the load circuit is flickering between open and closed, a condition which may need to be considered in load design. Because there are internal mechanical components with physical dimension restraints, the package size of an EMR can limit the size of a PCB design. Isolation voltage is another area where EMRs are limited. Most EMRs are typically rated for minimum input to output isolation voltages of 1500 to 2000 V_{AC}.

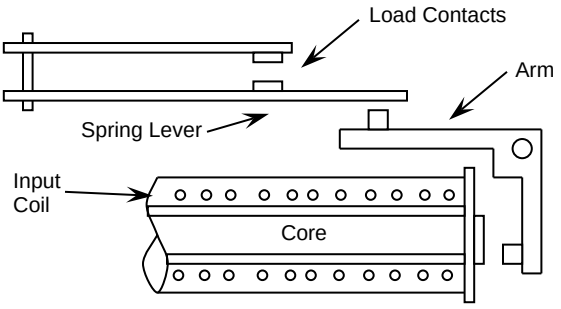


Figure 01: *Electromechanical Relay (EMR)*

The Solid State Relay

Figure 02 shows the topology of a typical 1 Form A, MOSFET based SSR. An input current is applied to the LED, which in most cases is a Gallium Arsenide (GaAs) infrared LED. The emitted light is reflected within an optical dome, generally constructed of a gel-like lensing material, onto a series of photo diodes. The photodiodes generate a resulting voltage which, through driver circuitry, is used to control the gates of two MOSFETs.

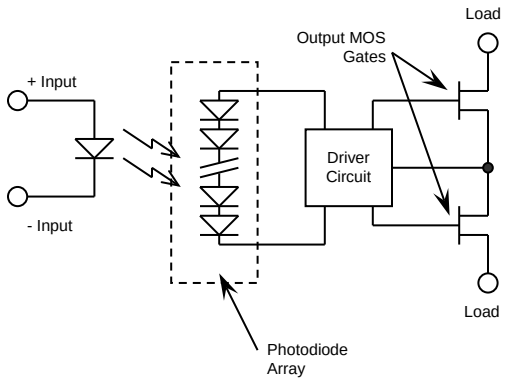


Figure 02: *Solid State Relay (SSR)*

All of the components of a solid state relay are fabricated out of semiconductor material and as a result, the SSR combines many operational characteristics not found in other types of devices. Because there are no moving parts, solid state relays have established switching lives of more than 10^{10} cycles, and exhibit bounce-free operation. The input LEDs require low

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signal levels (<5mA, and in some cases <1mA) to guarantee operation, making SSRs ideal for TTL and CMOS controlled circuits or products where low power consumption is a necessity. The input to output isolation of solid state relays is determined by material properties of the molding compound and lensing material, as well as the package size. These properties allow for minimum isolation voltages of 2500 V_{AC} and up to 5000 V_{AC} in many cases. As semiconductor technology has developed smaller and smaller components, the overall package size of solid state relays has shrunk, allowing the designer to conserve PCB space, and makes them valuable in applications where board space is critical.

SSR Output Types

The most common SSR output type is the low threshold MOSFET. Low threshold devices are more easily controlled by the driver circuitry, and allow for fast turn-on times (<500μS). Design of the driver circuitry also permits fast MOSFET gate discharge, translating into quick turn-off times (<50μS). Two MOSFETs inversely connected in series allows for bi-directional control of DC and AC signals with frequencies into the RF range. Typical blocking voltages range from 60V_{PP} to 1200V_{PP}, with continuous loads of up to 6 amps.

A second type of SSR output is the silicon controlled rectifier (SCR). This type of output is designed for AC loads only, and exhibits tight, zero-volt switching. High dV/dt characteristics allow this type of device to control highly inductive loads (PF > 0.3), and driver circuit design prevents false triggering. Typical blocking voltages range from 400Vpp to 800Vpp, with continuous loads of up to 1.2Amps.

A third type of SSR output is the TRIAC based output. This type of output is also designed for AC loads only but can be controlled by either random phase or zero volt switching circuitry. Typical blocking voltages range from 400Vpp to 800Vpp, with continuous loads of up to 1.2Amps.

SSRs vs. EMRs

By the nature of design, one can see the differences between an electromechanical relay and a solid state relay. In an effort to demonstrate inherent advantages of each type of relay, the following characteristics should be examined: Service Life, Reliability, Isolation Voltage, On Resistance, Capacitance and Package Dimensions.

- *Service Life*: Because of solid state technology, the SSR definitely exhibits a longer operational life. Since there are no moving parts to jam, degrade or warp, the life span is virtually infinite.

- *Reliability*: During initial operation, both types of relay will exhibit similar levels of reliability. Over time, however, the solid state relay will gain the edge for the same reasons it has a longer service life, there are no moving parts. Also, bounce free operation increases reliability and ensures consistent load control.

- *Isolation Voltage*: Again, by the characteristics of construction, the solid state relay will almost always exhibit higher input to output isolation voltages than an electromechanical relay. For many telecommunication and medical and industrial applications, a minimum of 5000V_{AC} is desired, clearly making the SSR the optimal choice in telecom design.

- *On Resistance*: Low On Resistance (R_{ON}) used to be a feature available only to Electromechanical Relays. With the advent of newer technology the gap between SSR and EMR resistances has closed and some relays from Solid State Optronics now boast resistances well below 100mΩ. The low On Resistance values of SSRs allow for greater load current capability and less signal attenuation.

- *Output Capacitance*: Electromechanical relays typically have an output capacitance of less than 1 pF, whereas SSRs typically have a capacitance of greater than 20 pF. Capacitance becomes an issue in high frequency signals, and EMRs are a better option for HF applications. With newer developments in MOSFET technology, SSO does offer a range of relays suited for higher frequency applications.

- *Package Dimensions*: The internal components of the relays control the overall package dimensions. Because there are mechanical parts (coil, core, arm, contact lever arms, spring mechanism) within the EMR, the package size is limited to the physical dimensions of functional internal components. The SSR on the other hand, is limited to only the size of the semiconductor components, and is clearly capable of being manufactured in a much smaller package.

Why Solid State Relays?

Although there are advantages to using both types of relays, solid state relays are fast becoming the better choice in many applications, especially throughout the telecommunication and microprocessor control industries. The high reliability and long life mean less field failures and better product performance. Low input signal levels are ideal for TTL or CMOS applications, and less power consumption translates to longer battery life in portable devices.

The overwhelming advantages of solid state relays lie in the isolation voltage, package dimensions and multifunction capabilities. These advantages are increasingly becoming apparent in the telecom industry.

For most telecommunication applications, especially those in Europe, high input to output isolation voltage is required. Typical standards require a minimum input to output isolation voltage of 2500V_{AC}. Not only do solid state relays meet these requirements, most far surpass them.

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Figure 03 shows a comparison between the package volumes and footprints of an EMR and an SSR.

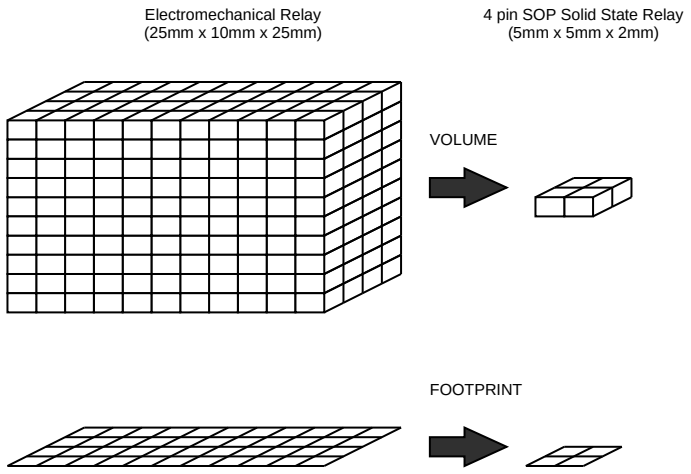


Figure 03: *Package Size/Footprint Comparison*

From the figure, it is evident just how much board space can be saved by using a solid state relay. The lower height lets the solid state relay easily fit into applications requiring low volume or using double sided PCBs where board space is critical. The smaller footprint means less board space, allowing more real estate for other components, and creating fewer design restraints.

Finally, multifunction capabilities place SSRs in a class by themselves. Semiconductor technology has allowed the fabrication of small, multi-purpose telecommunication relays where one device can handle both hook switch and loop current or ring detect functions. Even more complex is a device which combines a 1 Form A relay, Optocoupler, Darlington Transistor, and Bridge Rectifier all within a small, 16 pin SOIC package. These multifunction relays give the design engineer unparalleled flexibility in developing new and innovative fax/modem products.

Cost Issues

In the past there was a rather large gap between the price of an electromechanical relay and the price of a solid state relay. For a basic 1 Form A SSR the price was as high as several times that of an EMR, but with continual advancement in manufacturing technology this gap has reduced dramatically. In today's market, the advantages of solid state technology – particularly the long life, reliability, and smaller size – far outweigh the slight differences in pricing. The features and price points now make SSRs accessible to a growing number of design engineers looking to make the move to solid state switching technology.

Conclusion

The future of solid state relays continues to shine. Advancements in semiconductor fabrication and manufacturing technology have allowed SSO to offer solid state relays that equal or surpass the performance of similar mechanical relays, while keeping price points extremely attractive.

Solid State Optronics continues to be an industry leader by offering innovative, low cost, high performance optically isolated switching devices for a growing number of applications looking to upgrade designs from using EMRs to solid state technology.

Visit www.ssousa.com or contact your local sales agent to learn more.

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