crydom Solid Statements

Oct 2010

Solid-State Relays (SSRs) vs Electromechanical Relays (EMRs)

A study on worldwide relays market found the market size of solid state relays to be between $200M and $600M, which represent 17% of total market. However, this percentage continues to gradually increase every year.
What are the reasons? Relays are not a significant expense in the manufacturing process while down time is! Consequently, higher-cost solid state relays have an advantage over lower-cost electromechanical relays in industrial automation applications due to higher reliability and longer life, but these are not the only advantages….

Longer life and higher reliability

During initial operation, both types of relay show similar levels of reliability. Over time, however, the solid state relay will gain the edge due to its main advantage: **there are no moving parts.** SSRs employ semiconductor switching elements, such as thyristors, triacs, mosfet and transistors to switch the load current. An EMR generates electromagnetic force when input voltage is applied to the coil, the electromagnetic force then moves the armature that switches the contacts in synchronization. This simple principle of operation makes it possible to manufacture EMRs at a reduced cost. The maximum electrical life of an EMR is the maximum permissible number of switch operations, at a specified contact load and under specified conditions. Electrical/mechanical life is generally rated at 100,000 to max 500,000 operations. SSR data sheets do not carry an electrical life specification like EMRs. Unlike the EMR, where life is dependent on actual switching load and number of cycles, SSR reliability is mainly determined by time-in-operation, rather the number of switching cycles. When SSRs are used within the published specifications, MTBF can be 2 to 4 million hours, depending on the model. A typical estimate for number of operations is between 50 million and 500 million under normal operating conditions, but this is very much application dependent.

Fast Switching

Solid state relays, depending upon the model, can turn on between 20usec and 10msec after the input signal is applied and within 1/2 of an AC cycle after it is removed (DC control versions).

EMRs, depending on type and ratings, can switch at a maximum of 10 to 20 times a second, though the higher the switching frequency of the application,

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the lower the MTBF of the EMR. This makes an EMR impractical in these situations. When used in heating applications, the fast cycling of a SSR can dramatically improve the life of the heater by reducing thermal stress.

Low Input Power Required

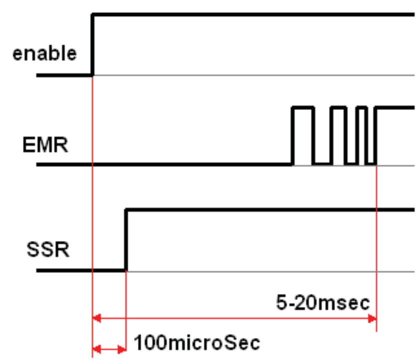
SSRs allow the switching of large loads with very low input power. A low level logic signal (TTL) can activate a relay switching as much as 125 Amps. The required current would normally be around 15mA. Crydom has a range of special SSRs (e.g. HD/HA panel mount SSRs) that require only 2mA of input current. These SSRs have an internal current regulator that always draws 2mA within the input voltage range.

Quiet Operation

Completely silent switching! This is beneficial in medical applications, environmental controls, lighting controls or other areas where quiet operation is desirable. The EMR, especially the contactor, makes an acoustical noise during switching. This can create issues and in a lot of cases disqualifies the EMR to be used in above applications.

No contact arcing and bounce

The bounce time of an EMR is the period from the first to the last closing or opening of a relay contact during the changeover to the other switching position. Bouncing causes short-term contact interruptions and are harmful to contact life and are particularly unwanted in applications where relays are used for pulse counting, where bounce can easily lead to false pulse counting as contacts continue to make and break the circuit. Contact bounce does not occur in semiconductor-based SSRs as there are no contacts to bounce. The diagram below shows the relationship between switching time and contact bounce time in EMRs and SSRs. In a random control SSR the closing time is max 100microsec.



Shock and Vibration

Compared to SSRs, EMRs are more susceptible to physical shock, vibration and acceleration. Further, the orientation of the electromechanical relay relative to the shock or vibration must be considered in designs where physical movement is expected. Ideally, EMRs must be mounted so that any shock or vibration is applied at right angles to the operating direction of the armature. When an EMR's coil is not energized, the shock resistivity and noise immunity are significantly affected by the mounting direction. Determining the orientation of the armature in an EMR package can be a complicating factor in designing applications with EMRs. SSRs, by contrast, do not have moving parts and are not as sensitive to

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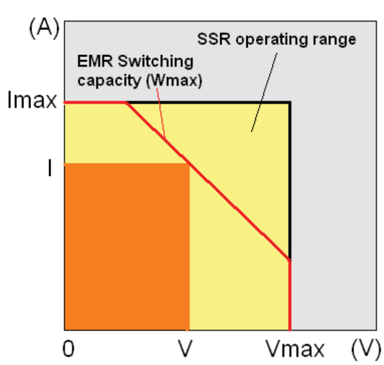
physical shock and vibration. Testing SSRs has shown functional shock resistance greater than 10 times than EMR.

Maximum switching capacity due to contact erosion

EMR manufacturers specify their relays in terms of maximum switching capacity. The maximum switching capacity (usually expressed in Volt-Amps or Watts) is provided in the relay data sheet (see chart). It substantially derates with regard to maximum voltage or current capabilities. In addition, relay users apply derating beyond the recommendations of the manufacturer in an effort to extend the contact life of the relay. Often this derating places the actual load that can be handled by an EMR within the operating range of an SSR. SSRs do not have contacts so **no contact erosion** derating is required.



Other problems concerning contacts in a EMR regard the sensitivity to **corrosion**, **oxidation**, or **contaminates**.

Phase angle control

This is another feature that permit the SSR to be used instead of EMR, thanks mainly to the fast switching times. Phase angle control refers to a control technique that provides a means of varying power to a load by altering the point in an AC half cycle where load current is permitted to flow through the relay. Each successive half cycle is varied in the same manner. More current can be provided to the load by increasing the portion of each half cycle that the relay is in the on-state.
Random turn-on relays are used in phase control circuits because the turn on point is determined by the timing of the control to the relay's input (max 100usec delay). Turn off point is when the current goes through zero. This control is obviously not possible with an EMR.

Limitations

On the other side the SSRs have a few limitations that do not permit them to cover the complete market now covered by the EMR.

- **Cost issue**

This is the main drawback against the EMR. The EMR consists, basically, of a coil and a output contact. In a SSR there are various semiconductor components such as thyristors, opto-isolators, protection devices, etc. In the past there has been a rather large gap between the price of EMR and the price of SSR. With continuous advancement in manufacturing technology, this gap has been reduced dramatically, making it interesting to a wider number of engineers.

- **Thermal dissipation**

One of the major considerations when using a SSR is the generated heat. At the on state, solid state relays have residual voltage. This voltage, associated with the current that flow through the triacs, generates power (heat) that must be dissipated. This must be taken into consideration when installing SSRs. The main effective method of removing heat from the SSR package consists of an adequately sized heat sink. In many cases it is sufficient to mount the SSR to the metal panel housing. This is always dependant of the load current, quality of the SSR, panel material, spacing between components and ambient temperature.

- **Leakage current**

A solid state relay in the blocked state does not have an infinite impedance across its terminals. A low residual current circulates in the load called the leakage current. This leakage current may be harmful in applications controlling very low loads (small solenoid valves, etc) as this current may be sufficient to maintain the load supplied. Considering that this value is normally less then 1mA (10mA when a snubber circuit is included) this is rarely a problem for the application.

There are a few other limitations that are by-passed using various kinds of protection.

- **(dV/dt)** This is the voltage change in relation to time that can arise during switching on, switching inductive loads or mains interference. To avoid this problem, an internal snubber circuit (RC network) is often used.
- **Transient overvoltage**. The AC mains voltage contains all kinds of voltage spikes and transients. These transients may result from other components like motors, solenoids, switches, transformers, contactors, etc. If overvoltage protection is not provided, the thyristors used in SSRs might exceed their breakdown voltage. To protect the SSR an internal (or external) varistor or transorb can be used.

Conclusions

To summarize, it is important to understand the advantages and limitations of the SSR. It then becomes clear as to why, in a technical context, the SSR is almost always preferred to the EMR.

Advantages:
- Long life and reliability
- High switching frequency
- No contact arcing and bounce
- Maximum switching capacity
- Vibration and shock resistance
- No electromechanical noise
- Electromagnetic noise resistance
- Phase angle control mode
- High switching speed
- Logic compatibility
- Low input current

Limitations:
- Higher cost
- Thermal dissipation
- Off-state leakage current

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