The State of the Art in Solid State Relays

What are solid state relays, and what are they used for?

The Sensata-Crydom NOVA22 series of solid state relays. (Image courtesy of Sensata Technologies.)

To control high power electrical devices, you will need a relay. Relays are electrically operated switches that control high power loads, typically currents of 10A or higher, with low power signals, typically 3 – 32V DC. For example, a 5V microcontroller output can be used to toggle a 2,400W load (240V and 10A).

There are two common types of relays: electromechanical relays (EMRs) and solid state relays (SSRs). In this article, we'll look at the differences between these two types of relays in order to understand the advantages and applications of SSRs.

The Difference Between EMRs and SSRs

Electromechanical relays are robust, but they require more space and are slower than solid state relays. EMRs use coils, magnetic fields, springs and mechanical contacts to switch a supply. Their operation time is from 5 to 15ms, which is too slow for many applications. Furthermore, as their design includes moving parts, they have a shorter life span than SSRs.

Solid state relays perform the same function as electromechanical relays, with the main design difference being that SSRs do not have any moving parts. SSRs are made up of semiconductors such as silicon-controlled rectifiers (SCRs), triodes for alternating current (TRIACs), and switching transistor outputs instead of mechanical contacts.

SSRs support both AC and DC current switching and provide complete electrical isolation between input and output contacts. They also have a very low resistance when conducting, and a very high (almost infinite) resistance when not conducting. SSRs can provide a wide range of

current, from microamps to hundreds of amps, making them suitable for a variety of applications.

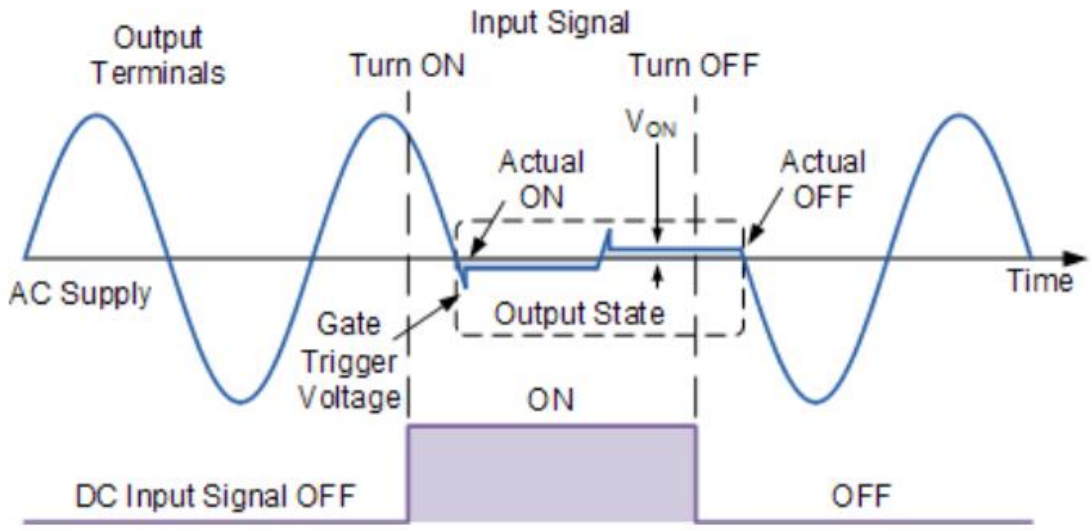
To explore the advantages of solid state relays, we'll look at the Sensata-Crydom NOVA22 series of SSRs. Developed by Sensata Technologies, NOVA22 SSRs provide extremely high power density in a 22.5mm wide package (35A for DIN Rail mount and 95A for Panel Mount package).

The Advantages of Solid State Relays

Compared to electromechanical relays, solid state relays are much faster, as their switching time depends on LED switching time. SSRs are also much smaller than EMRs of similar specifications. Because they contain no moving parts, SSRs are not subject to contact wear and therefore have a longer lifespan than EMRs. However, they are vulnerable to overloads.

Since the operation of SSRs does not involve sparking, they are suitable for use in combustible environments. SSRs are also resistant to other environmental conditions such as mechanical shocks and vibration, humidity and external magnetic fields. They also feature completely silent switching.

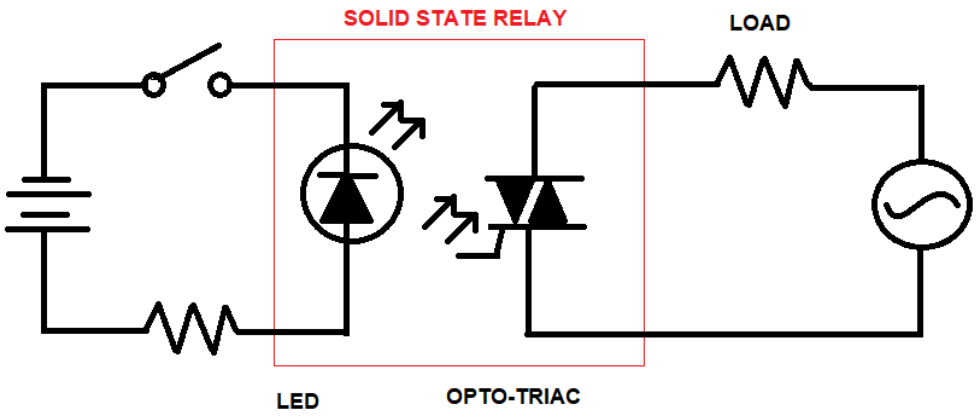
One of the main advantages of SSRs is zero-crossover switching, which allows SSRs to switch off AC loads when the sine load current is zero. This eliminates issues such as arcing, electrical noise and contact bounce associated with electromechanical relays and inductive loads.



Zero-crossover switching is a primary advantage of solid state relays. (Image courtesy of electronics-tutorials.)

Solid state relays use SCRs and TRIACs as switching devices, which tend to open AC circuits only at zero current. Once the input signal is removed, the switching devices continue conducting until the current drops below its threshold value, as illustrated above. In this way, SSRs will never switch off the load in the middle of a sine wave peak. This is very important for inductive loads; otherwise, large voltage spikes can appear.

How Do Solid State Relays Work?



Basic configuration of a solid state relay.

Solid state relays typically include an output device (SCR, TRIAC, or transistor) that is optically coupled to a light source. The relay operation is triggered by illuminating the LED with a low-voltage DC signal.

An optoisolator, or optocoupler, is an essential component of the SSR. It contains an LED which is connected to the SSR's input, and a photosensitive device. SSR activation is performed by applying a low voltage signal to its input. The LED is energized by the current passing through it, and the LED light is focused through the gap to the output device (transistor or TRIAC) which triggers it to turn on.

The opto-coupling isolation (the beam of light) provides high voltage isolation between input and output. The input of the SSR can include a simple current limiting resistor in series with the LED, as well as complex circuits including rectifiers, regulation and protection, and filtering.

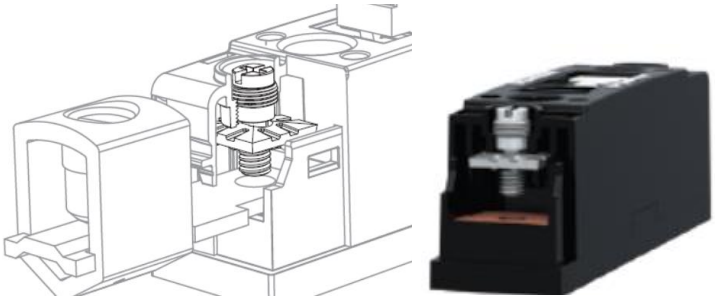
The signal voltage can be applied to the input by using a mechanical switch, a logic gate or a micro-controller. The SSR output can be connected to both AC and DC loads. DC SSRs usually use power transistors (MOSFETs) and AC SSRs use TRIACs, back-to-back thyristors (with high voltage and current capabilities), or a single thyristor together with a bridge rectifier.

There are three basic types of SSRs, depending on their particular input circuit:

- **Reed relay coupled SSRs**: a control signal is applied directly to the reed relay coil. The reed switch operation triggers the thyristor switch.
- **Transformer coupled SSRs**: a low power transformer triggers the thyristor switch when it senses AC current. When a DC input signal is used, a DC-AC converter is used before the transformer. The transformer design determines the input-output SSR configuration.
- **Photo coupled SSRs**: a control signal illuminates a light source (LED) or an infrared source. An output photo-sensitive device, such as a TRIAC, turns on and switches the load. The beam of light is the only "coupling path" that runs between the input and output in the SSR. The isolation between input and output is provided through opto-coupling.

NOVA22 Solid State Relays

Solid state relays are most convenient if they offer a wide range of connections. The NOVA22 series of SSRs provides a versatile solution with DIN rail and panel mount options, relay or contactor terminal configurations, screw or spring cage plug-in input terminals, standard or elevator screws, and the optional use of ring terminals.



The NOVA22's elevator screws allows the use of ring or lug terminals in IP20 housing. (Image courtesy of Sensata Technologies.)

It is also important that SSRs are tested for shock and vibration resistance for applications that will expose them to harsh mechanical conditions. NOVA22 is tested and approved for up to 50g and 500Hz shock and vibration resistance per IEC 60068-2.

NOVA22 solid state relays provide a number of other important features for SSRs, including:

- High current ratings (up to 95A at 600VAC)
- Built-in overvoltage transient protection
- Good thermal performance, as the rating depends on temperature (uses DBC substrate)
- LED input status indicator
- IP20 touch-safe housing (protected against solid objects up to 12mm, e.g., a person's fingers)
- AC or DC control voltage options
- High isolation (4,000VAC optical isolation)

Because of their versatile features, the NOVA22 SSRs are suitable for a diverse range of uses, especially for applications that require higher levels of reliability. NOVA22 SSRs are well suited for demanding applications including plastic machinery, pumps, packaging equipment, HVAC equipment, agricultural machinery, railway vehicles, lighting, heating, refrigeration, food processing equipment and more.