

# Chapter 7

## Relays

### PART 2 Solid-State Relays

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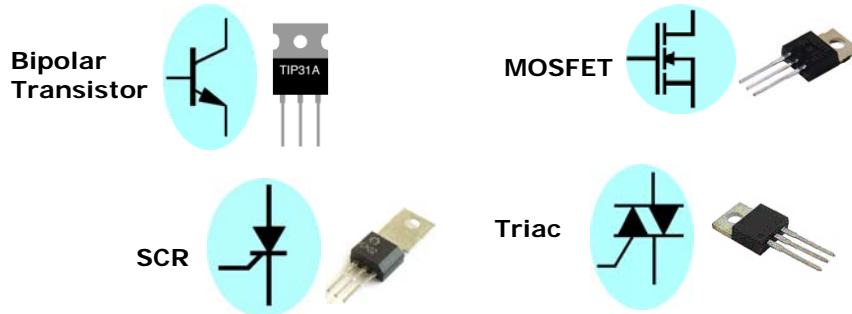
# OPERATION

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A **solid-state relay (SSR)** is an electronic switch, which unlike an electromechanical relay contains no moving parts.

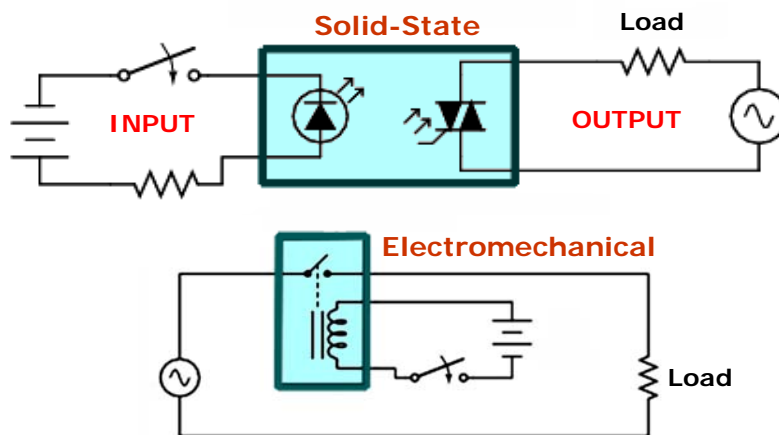


Solid-state relays do not have actual coils and contacts. Instead, they use **semiconductor** switching devices.



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Solid-state relays are constructed to operate as two separate sections: **input** and **output**. The input side receives a voltage signal from the control circuit and the output side switches the load.



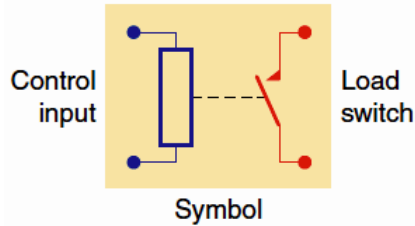
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SSRs are manufactured in a variety of configurations that include both **hockey puck** and **ice cube** types.



Most often a square or rectangle will be used on the schematic to represent the relay.

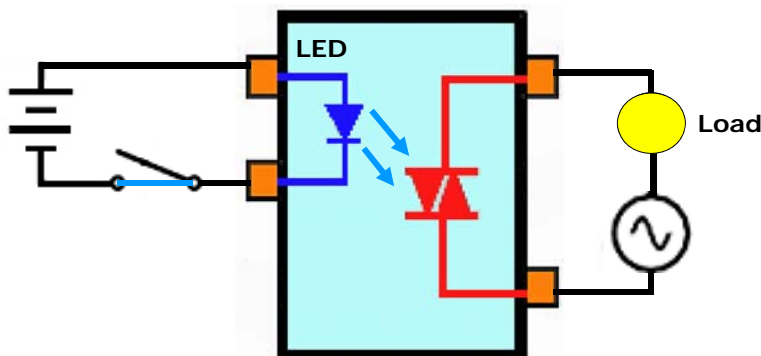


The internal circuitry will not be shown, and only the input and output connections to the box will be given.

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A solid state relay also provides **electrical isolation** between the input control circuit and the switched load circuit.

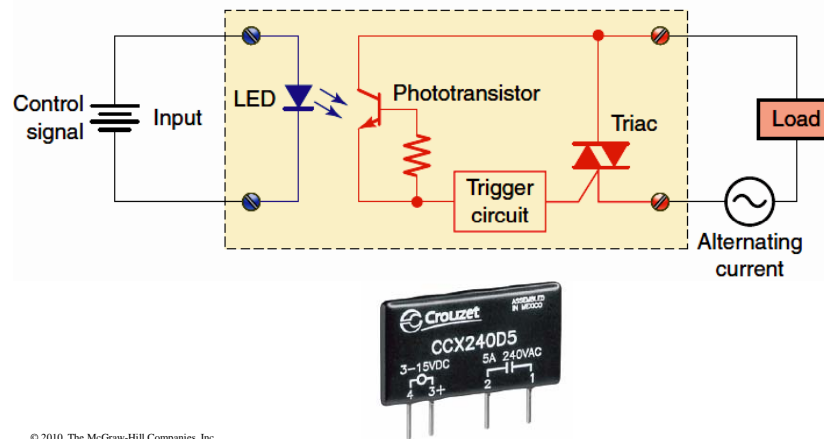
The **opto-isolated method** has the input section illuminate a light-emitting diode (LED) that activates a **phototriac** switching device connected to the output section.



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## Optically coupled SSR used to switch an AC load.

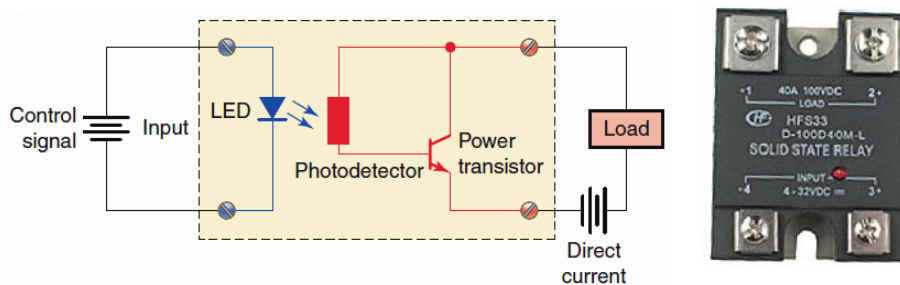
- The LED conducts and shines light on the phototransistor.
- The phototransistor conducts switching on the Triac and AC power to the load.



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## SSRs intended for use with DC loads use a power transistor rather than a Triac.

- The LED section of the relay acts like the coil of the electromechanical relay and requires a DC voltage for its operation.
- The transistor section of the optocoupler inside the SSR is equivalent to the contacts in a relay



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# SPECIFICATIONS

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**Output voltage ratings range from 5 VDC up to 480 VAC.**

**Relays mounted on heat sinks are capable of controlling up to 40 amps.**

**LED indicates when relay is energized.**

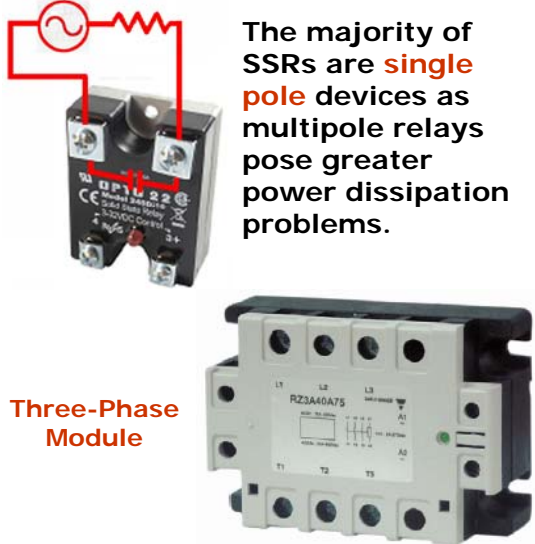
**Applying the specified amount of DC pickup voltage activates the SSR input control circuit of a SSR. Most SSRs have a variable input voltage range.**

**Correct polarity required for DC input signal.**

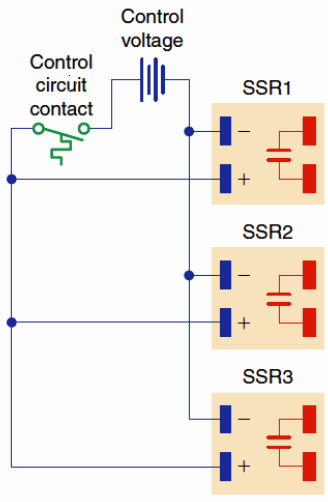
Labels on the relay: 1 LOAD 2, 24-240VAC~ 20A, OMRON G3NA-220B SOLID STATE RELAY 240VAC 20A, MADE IN CHINA, 5-24VDC, -4 INPUT 15X3EH, 3+

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The majority of SSRs are **single pole** devices as **multipole relays** pose greater power dissipation problems.



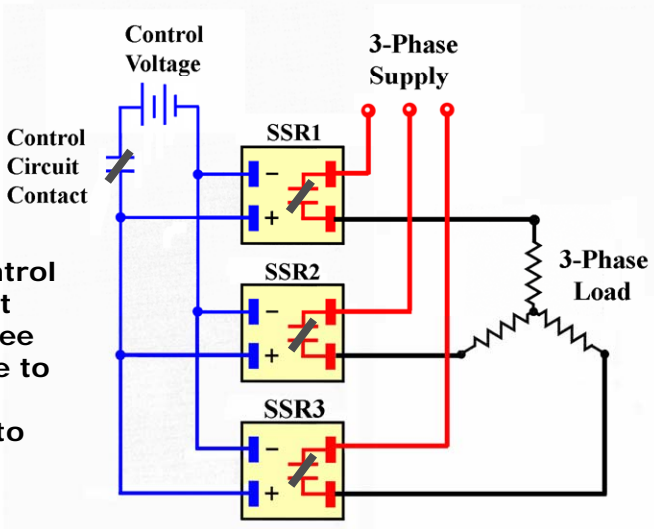
**Three-Phase Module**



When multiple poles are required, a common solution is to wire several SSRs control circuits in **parallel** to provide the equivalent function as a multipole electromagnetic relay.

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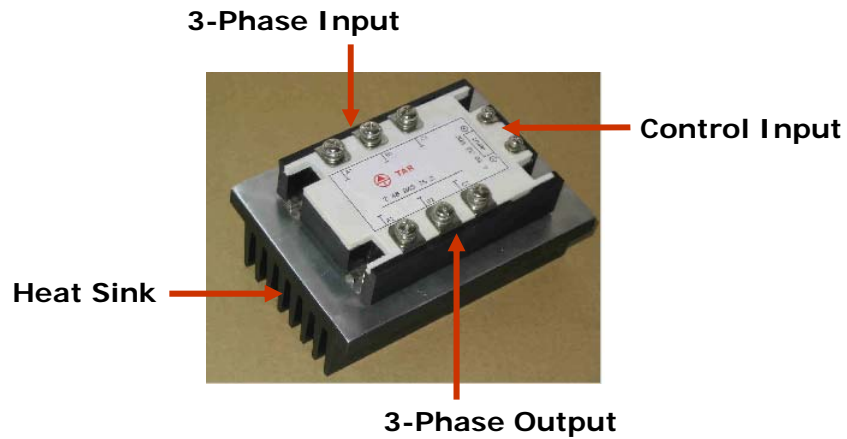
**In this application three single-pole solid-state relays are used to switch current to a 3-phase load.**



When the control circuit contact closes, all three relays actuate to complete the current path to the load.

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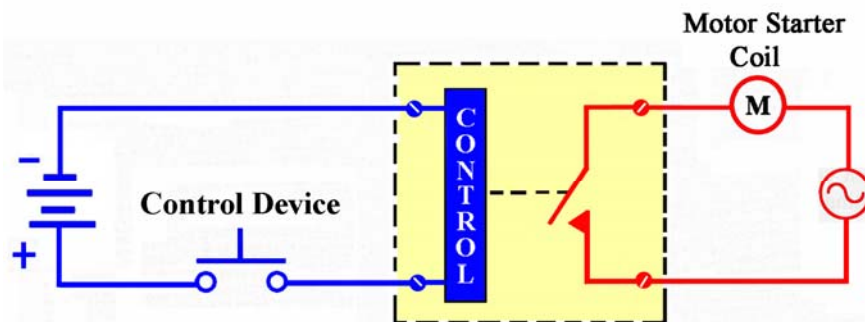
## Single Unit Three-Phase Solid-State Relay



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The standard single-pole SSR configuration works fine with **two-wire** control.

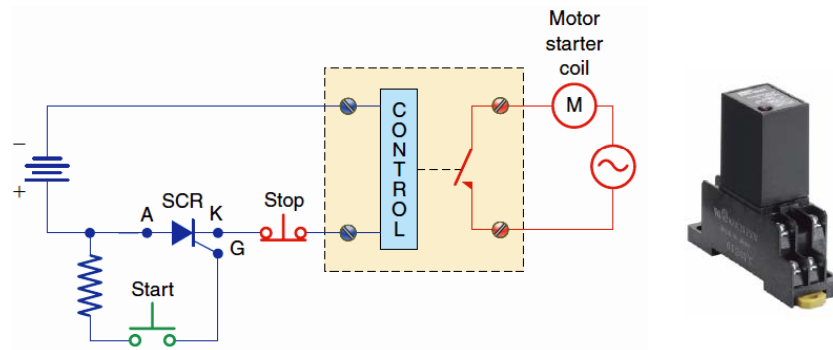
### Solid-State Relay Two-Wire Control Circuit



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### Three-wire control using a SCR.

- When the start button is pressed current flows through the gate, which triggers the anode to cathode section of the SCR and relay control circuit into conduction.
- After the start button is released the SCR remains latched ON until current from the anode-to-cathode is interrupted by momentarily opening the stop button.

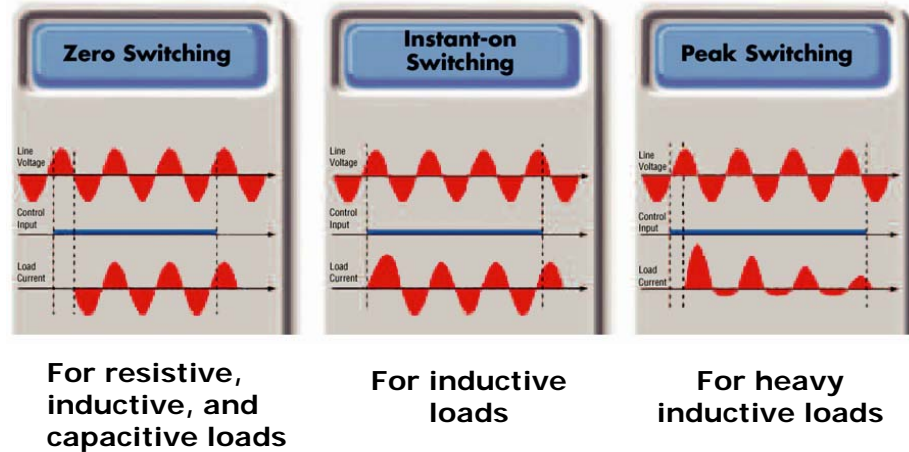


## SWITCHING METHODS

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SSRs operate with several different **switching methods**. The type of **load** is an important factor in the selection of the switching method.

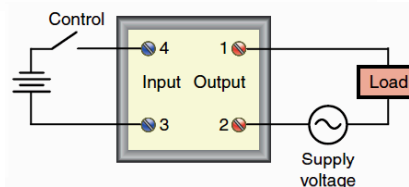
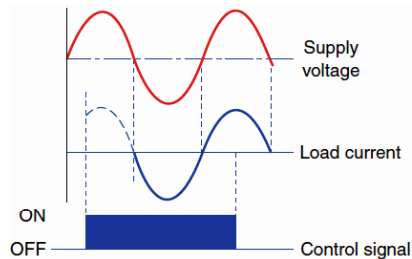


A **zero switching relay** is designed to turn ON an AC load when the control voltage is applied and the voltage at the load passes through zero.

➤ The relay turns OFF the load when the control voltage is removed and the current in the load crosses zero.

➤ This allows resistive loads such as lamp filaments to last longer because they are not subjected to high-voltage transients from switching AC voltage and current when the sine wave is at a peak.

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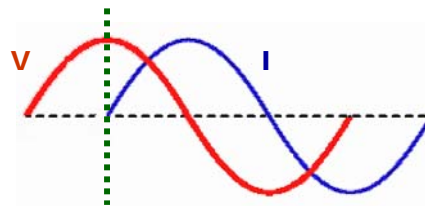
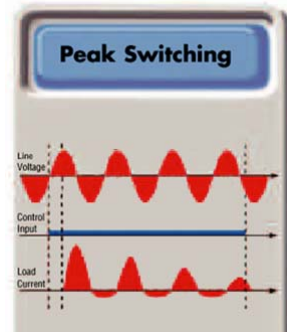


➤ A **peak switching relay** is designed to turn the load ON when the control voltage is present and the voltage at the load is at its peak.

➤ The relay turns OFF when the control voltage is removed and the current in the load crosses zero.

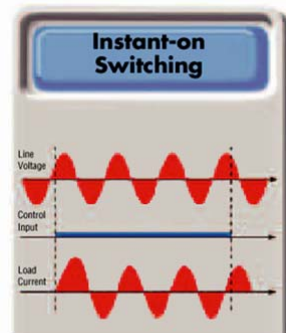
➤ Peak switching is preferred when the output circuit is mostly **inductive** or **capacitive** and the voltage and current are approximately **90 degrees out-of-phase**.

➤ In this case, when the **voltage** is at or near its **peak** value, the **current** will be at or near its **zero** value.

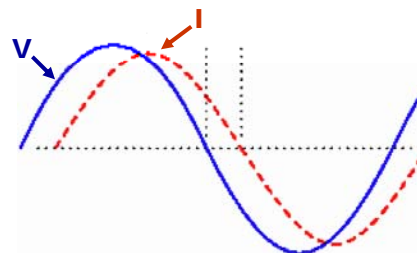


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**Instant-on switching relays** are typically specified when the controlled load is a combination of resistance and reactance.




➤ In this case the voltage and current **phase angle varies** so there is no advantage to disconnecting the load at any specific time on the sine wave.




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## SSRs **versus** EMRs



**Pros**

- The SSR is more reliable and has a **longer life** because it has no moving parts
- The SSR is **compatible** with transistor and IC circuitry and does not generate as much electromagnetic interference.
- The SSR is more resistant to shock and vibration, has a much **faster response** time, and does not exhibit contact bounce.



**Cons**

- The EMR contains semiconductors that are susceptible to damage from **voltage and current spikes**.
- The EMR switching semiconductor has a significant **ON-state resistance** and **OFF-state leakage current**.
- EMRs produce **more heat** during normal operation and if not properly cooled this prolonged heat can reduce the life of the relay.

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