Know about Different Types of Relays

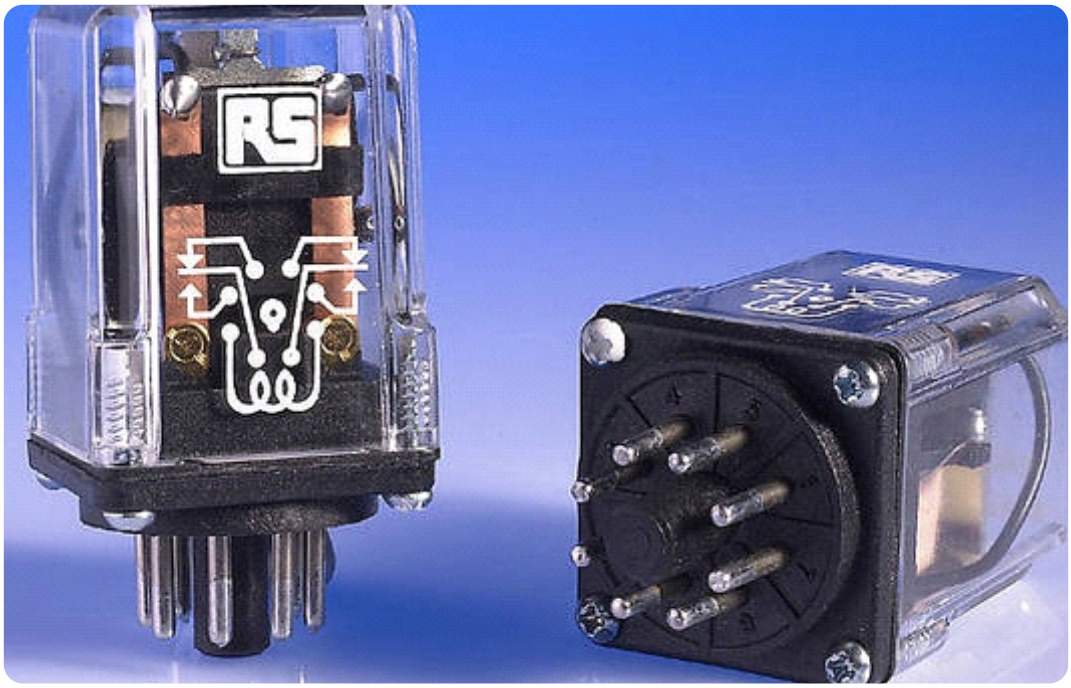
By

EDGEFX
KITS & SOLUTIONS

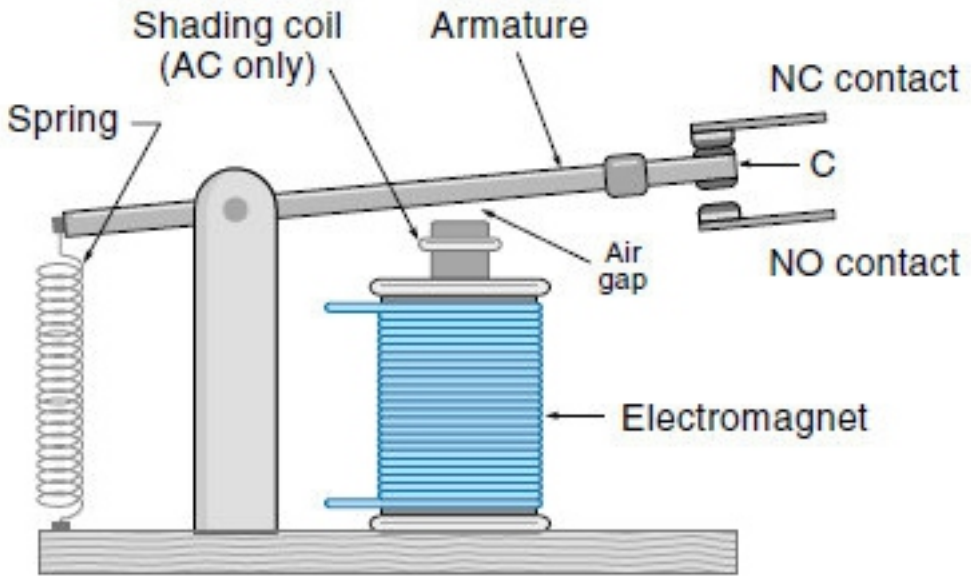
Contents

What Is a Relay and How It Works?

Relays are the primary protection as well as switching devices in most of the control processes or equipment regardless of whether they are electronic or electromechanical. All the relays respond to one or more electrical quantities like voltage or current such that they open or close the contacts or circuits. A relay is a switching device as it works to isolate or change the state of an electric circuit from one state to another. These are found in all sorts of devices. Relays allow one circuit to switch over to a second circuit that can be completely separated from the first. There is no electrical connection inside the relay between the two circuits – the link is magnetic and mechanical only.



Basically a relay consists of an electromagnet coil, an armature, a spring and a series of electrical contacts. The electromagnet coil gets power through a switch or a relay driver and causes the armature to get connected such that the load gets the power supply. The armature movement is caused using a spring. Thus, the relay consists of two separate electrical circuits that are connected to each other only through a magnetic connection, and the relay is controlled by controlling the switching of the electromagnet.



The contacts are usually common (COM) – normally open (NO) and normally closed (NC). The normally closed contact is connected to the common contact if power is not applied to the coil. The normally open contact is opened if power is not applied to the coil. When the coil is energized, the common contact is connected to the normally open contact, and the normally closed contact is left floating. The double-pole versions are same as the single-pole version except when the two switches open and close together.

Applications of Relays

- Control a high-voltage circuit with a low-voltage signal, as in some types of modems or audio amplifiers.
- Control a high-current circuit with a low-current signal, as in the starter solenoid of an automobile.
- Detect and isolate faults on transmission and distribution lines by opening and closing the circuit breakers.
- Time delay functions. Relays can be modified to delay opening or delay closing set of contacts. A very-short delay uses a copper disk between the armature and moving blade assembly.

Typical applications of relays include computer interfaces, telecommunication systems, traffic control, automotive electrical systems, home appliances, lighting control systems, electric motor controllers, tools and machines, air-conditioning and heating systems, and so on.

Classification of Relays

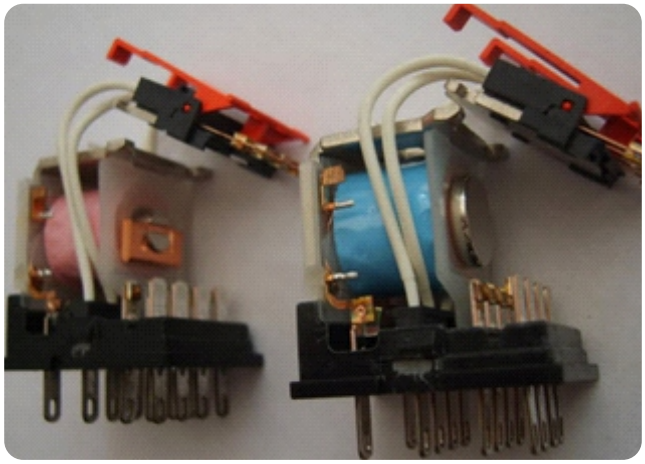
Classification or the types of relays depend on the function for which they are used. Some of the categories include protective, reclosing, regulating, auxiliary and monitoring relays. Protective relays continuously monitor these parameters: voltage, current, and power; and, if these parameters violate from the set limits, the protective relays generate an alarm or isolate that particular circuit. These types of relays are used to protect equipments like motors, generators, and transformers, and so on. Some of these are induction type over current relays, distance relays, differential relays, etc.

Reclosing relays are used to connect various components and devices within the system network, such as synchronizing process, and to restore various devices soon after any electrical fault vanishes, and also to connect transformers and feeders to a line network. Regulating relays are the switches that contact such that a voltage boosts up as in the case of tap-changing transformers.

Auxiliary contacts are used, in circuit breakers and other protective equipments for contact multiplication. Monitoring relays monitor a system conditions such as direction of power and accordingly generates an alarm. These relays are also called as directional relays.
Depending on the operating principle and structural features, relays are of different types: electromagnetic relays, thermal relays, power varied relays, multi-dimensional relays, and so on, with varied ratings, sizes and applications.

1. Electromagnetic Relays

These relays are constructed from electrical, mechanical and magnetic components, and possess operating coil and mechanical contacts. Therefore, when a coil gets activated by a power supply source, these mechanical contacts get opened or closed. The type of supply can be AC or DC.



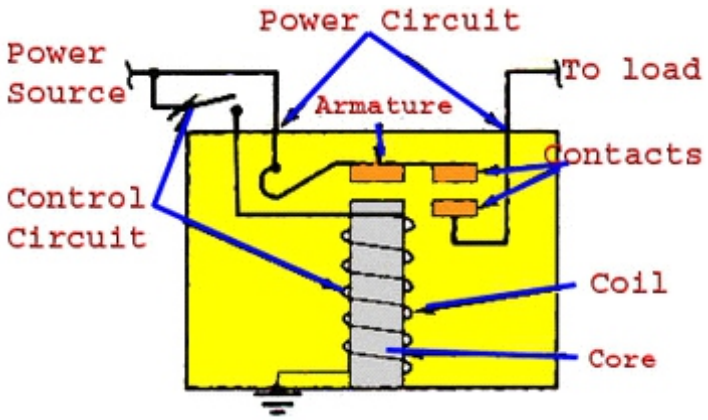
Both AC and DC relays work on the same principle as that of electromagnetic induction, but the construction is somewhat differentiated and also depends on the application for which these relays are selected. DC relays are employed with a freewheeling diode to de-energize the coil, and the AC relays use laminated cores to prevent eddy current losses.

The very interesting aspect of an AC is that, for every half cycle, the direction of the current supply changes; therefore, for every cycle, the coil loses its magnetism since the zero current in every half cycle makes the relay continuously make and break the circuit. So – to prevent this – additionally one shaded coil or other electronic circuit is placed in the AC relay to provide magnetism in the zero current position.

1.1 Attraction Type Electromagnetic Relays

These relays can work with both AC and DC supply and attract a metal bar or a piece of metal when power is supplied to the coil. This can be a plunger being drawn towards the solenoid or an armature being attracted towards the poles of an electromagnet, as shown in the figure. These relays don't have any time delays, so these are used for instantaneous operation. These can be typed like

- Attracted Armature Relay
- Solenoid Type Relay
- Balanced Beam Relay



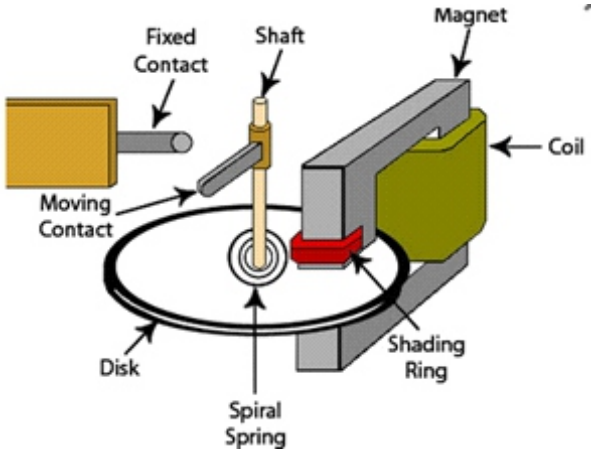
1.2 Induction Type Relays

These are used as protective relay DC systems. The actuating force of contacts, movement is developed by a moving conductor that may be a disc or a cup, through the interaction of electromagnetic fluxes due to fault currents.

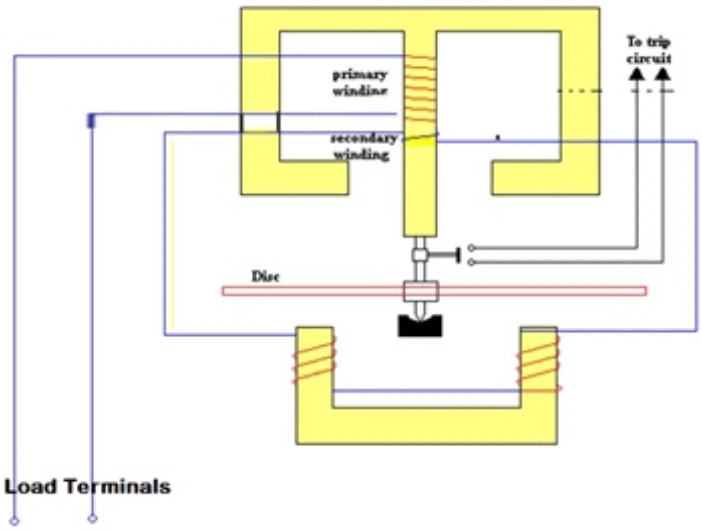
These are of several types like:

- Shaded Pole Type Relays
- Watt-hour Meter Type Relays
- Induction Cup Structure Relays

Shaded pole relay consists of aluminum disc, which is pivoted such that it freely rotates in the air gap of an electromagnet. Shaded ring or copper ring is surrounded on one half of each pole. The induced currents in this shaded ring produce another flux called as shaded flux, which lags behind the flux produced by the unshaded pole by some angle. The phase difference between these two fluxes produces necessary torque to rotate the disc.

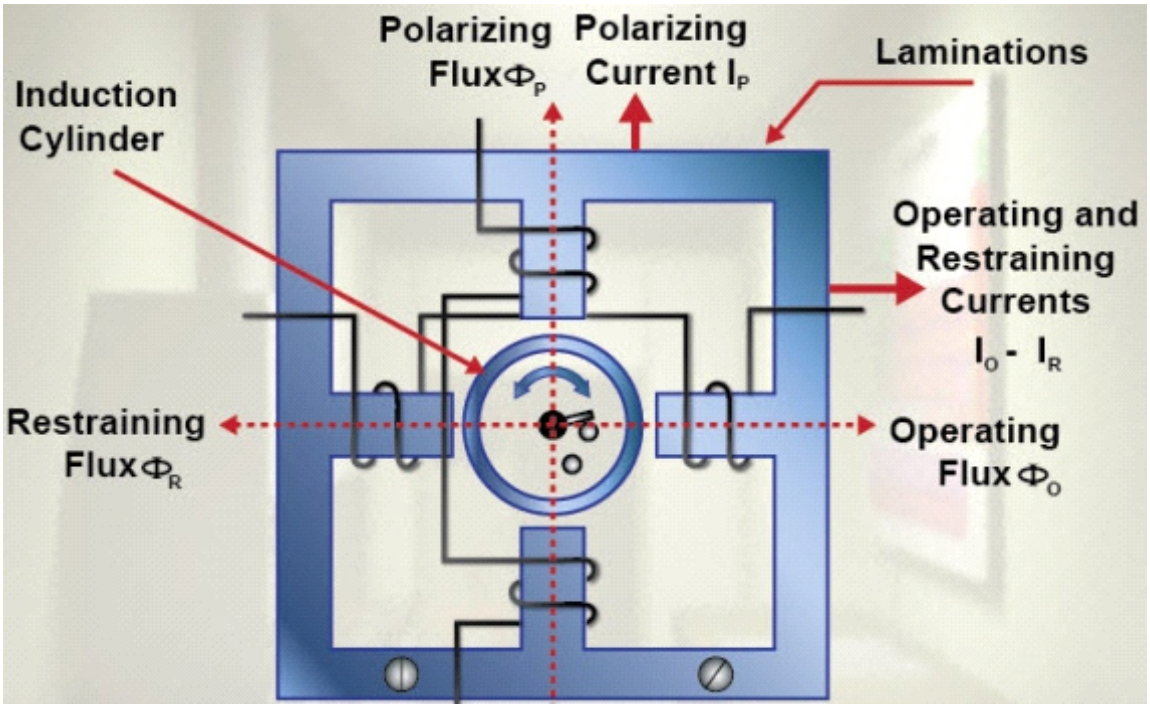


The Watt-hour structure type relay works as an electromagnetic induction type of watt-hour – a meter so named, after it. It consists of two magnets: upper and lower electromagnets and aluminium disc, which is pivoted such that it rotates freely between the two electromagnets. In this relay, the upper magnet consists of two windings: primary and secondary windings, wherein the primary winding carries the relay current and the secondary winding is connected to the lower magnet. This primary current induces EMF in the secondary winding, so it produces a flux that lags behind the main flux by some angle. The phase difference of these fluxes produces torque on the disc, whose magnitude is proportional to the product of these two fluxes multiplied by the sine angle between these two fluxes.



The induction cup structure relay works on similar principle of an induction disc relay. This relay can be four pole or eight pole depending on the number of windings accommodated. Due to the replacement of the disc with an aluminum cup, the inertia of the rotating system is significantly reduced. In this type of relay, the rotating magnetic field is produced by one pair of poles inducing a current in the aluminum cup.

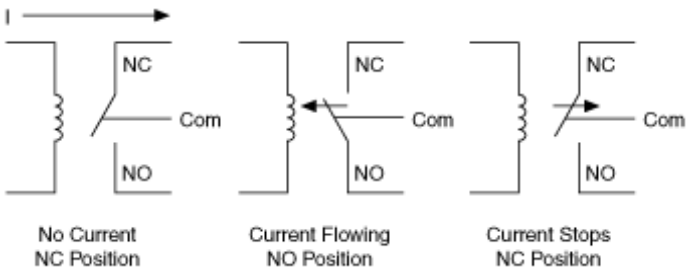
In this relay, the cup movement or torque is produced by the interaction of fields produced by the two pair of poles (as shown in the below figure) that have lagged one another with some angle. In the normal operating conditions, the cup remains standstill, but, in case of any fault, a very high current in the coil causes to move the cup so that the circuit gets isolated from the power supply.



1.3 Latching and Non-Latching Relays

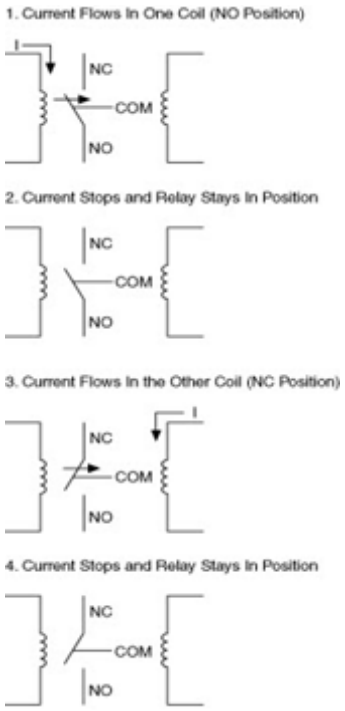
Non-Latching Relays

This type of relays is initially at a normally closed (NC) position which is maintained by the force of a spring or magnet if no current flows through the coil. If a current starts flowing through the relay coil, the normally open (NO) contact is operated by the magnetic field of the coil and when the current stops, it reverts back to the NC position, as shown in the below figure.



Latching Relays

These relays are used in applications where there is a need to limit power dissipation and consumption. These latching relays consist of 1 or 2 coils and have no default position, but when current stops flowing remain in their last position. Once these relays are actuated they didn't require any power to maintain their position, but their reset position is based on the control circuitry. The direction of current flow in one coil relay determines the position of the relay, whereas particular coil current flow determines the position of armature in 2–coil latching relay.

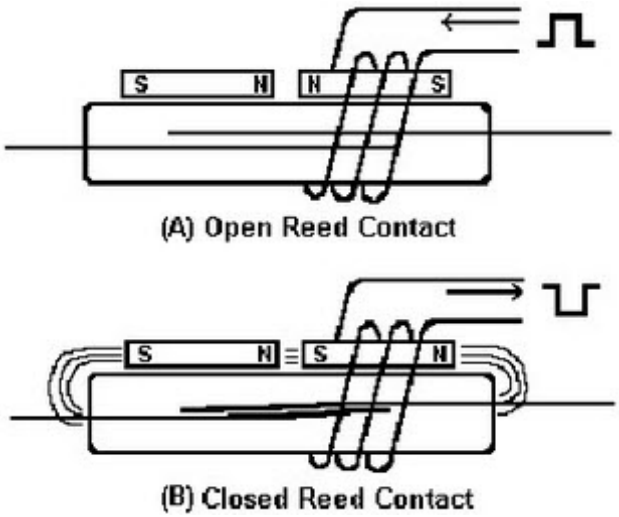


2. Solid State or Electronic Relays

Solid State uses solid state components to perform the switching operation with one or more semiconductor switching devices like a power transistor, thyristor and TRIAC without moving any parts. Since the control energy required is much lower, compared to the output power to be controlled by this relay, which may result the power gain higher compared to the electromagnetic relays. These relays are of different types: reed relay coupled SSR, transformer-coupled SSR, photo-coupled SSR, and so on.

2.1 Reed Relay Coupled SSR

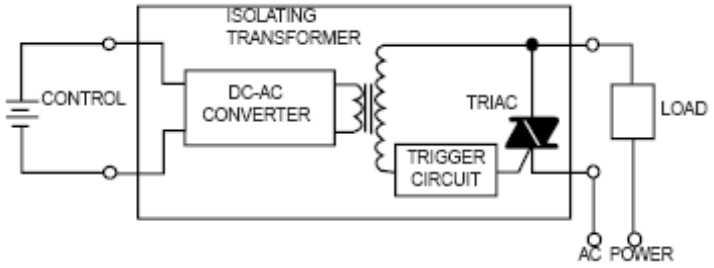
Reed Relays consist of a pair of magnetic strips (also called as reed) that is sealed within a glass tube. This reed acts as both an armature and a contact blade. The magnetic field applied to the coil is wrapped around this tube that makes these reeds move so that switching operation is performed.



Based on the dimensions, relays are differentiated as micro, miniature, subminiature and miniature relays. Also, based on the construction, these relays are classified as hermetic, sealed and open-type relays. Furthermore, depending on the load operating range, relays are of micro, low, intermediate and high-power types.

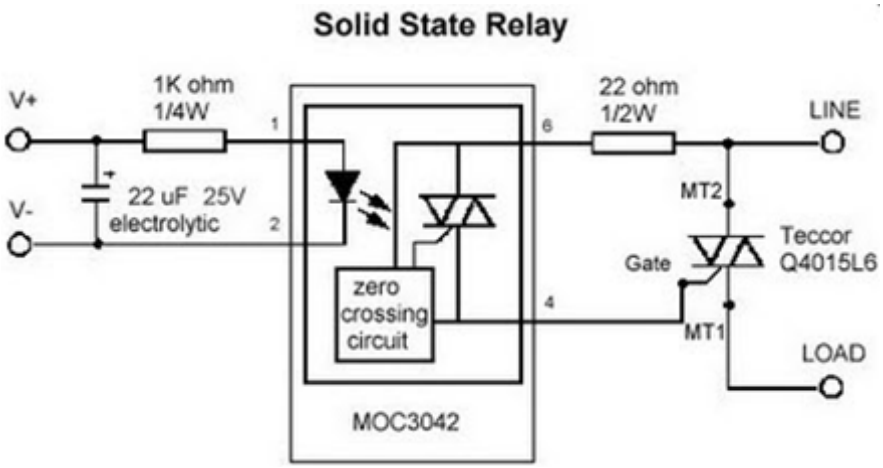
2.2 Transformer Coupled SSRs

In this type of relay, a control signal is applied to the primary of low-power, small transformer through AC to DC converter if the supply is DC, otherwise we can connect directly if it is AC. The secondary excitation is used to trigger the thyristor switch with or without rectification and amplification depending on the type of circuit. The design of the transformer decides the degree of isolation between the input and output.



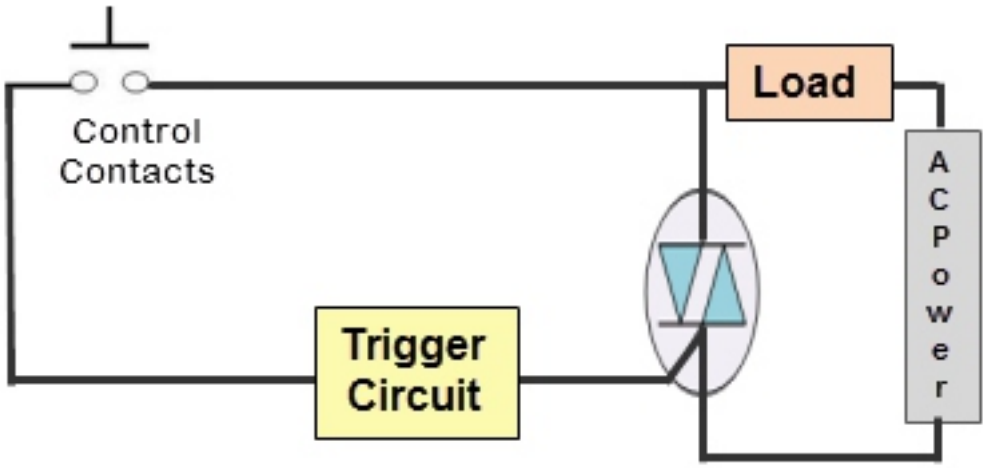
2.3 Photo-Coupled SSRs

The below figure shows a photo-coupled SSR where the control signal is applied by LED and it is detected by a photo-sensitive semiconductor device. The output form this photo detector is used to trigger the gate of TRIAC or SCR that switches the load. The electric isolation between the input and output is high due to optical coupling between them as compared to the magnetic one.



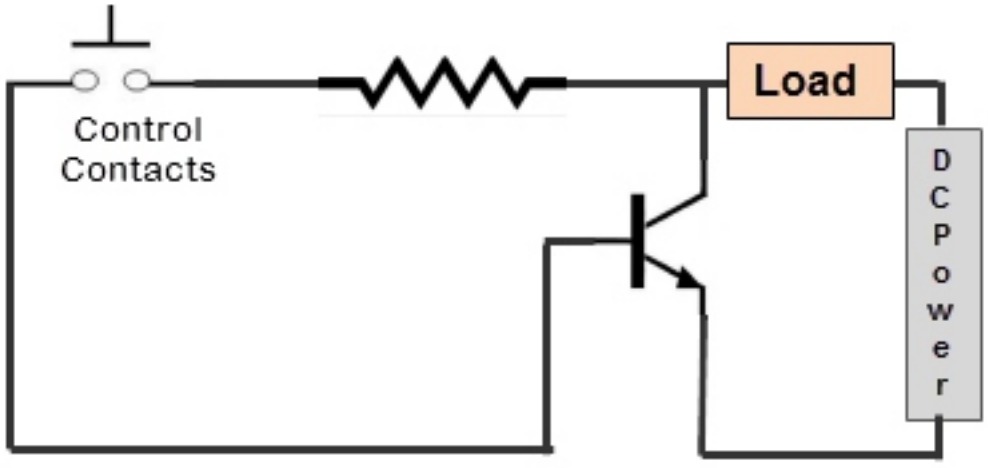
2.4 Direct Control AC SSR Relays

In this relay, operating load circuit AC power is also given to the control circuit to trigger the TRIAC. This is a simple design and less expensive, but it doesn't provide any isolation between the control and power circuit.



2.5 Direct Control DC SSR Relays

As similar to the above one, in this type of relay also the control circuit is energized with the same DC power used in the load circuit. This DC power is utilized to bias the transistor so that it is conducted to pass the current to the load. This is also less expensive and simplest circuit than the more sophisticated designs, but without isolation between the load and the control circuit is the biggest problem or disadvantage.

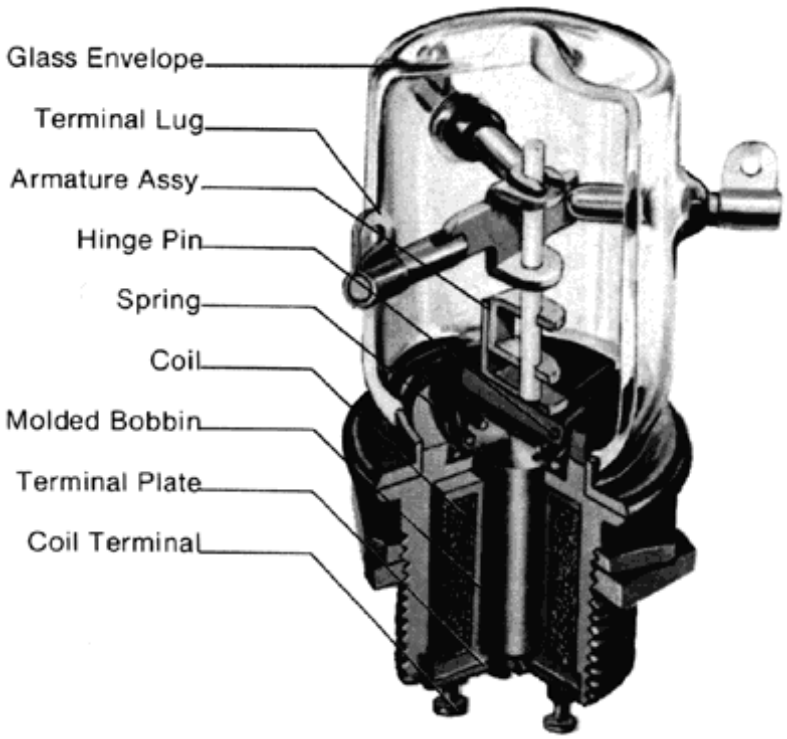


3. High Voltage Relays

These relays are quite similar in function to that of low voltage relays, but the major difference is the contacts which are designed to operate at high voltages. Therefore, a high insulation is provided between the contacts, between the contacts and the earth, and between the activator and contacts. This relay contacts are typically placed in a different medium enclosed by ceramic or glass to prevent arcing at the time of switching. Generally, two kinds of mediums: vacuum and high-pressure gas are used in these relays as contacts medium.

3.1 Vacuum Filled High Voltage Relays

As the characteristics like high-voltage breakdown, fast-recovery rate and an absolutely non-reactive and inert environment, vacuum is the ideal dielectric that contains a very few gas molecules. The dielectric strength of vacuum is 10000V per 0.1mm in vacuum and also due to no air, the contacts become oxidation free. These relays have stable and low-contact resistance, so these are widely employed in Radio Frequency (RF) applications.



The above figure shows the components in a vacuum relay. This type of relay permits the use of low-mass actuators with the small movement, which is enough to operate it. When the load is switched, an arc is formed in between the contacts. Due to the presence of the vacuum, this arc no longer stays, but breakdowns within a moment.

3.2 Gas Filled High Voltage Relays

These relays also provide high dielectric strength and avoids the oxidation. Therefore, these are ideal for high inrush make and capacitive discharge loads such as cable test equipment, ESD test equipment, heart defibrillators, etc. In these relays, a mixture of SF6, sulfur hexa fluoride and nitrogen is used as gas medium. But arc is formed in this relay when the contacts get opened and sustained for longer durations, compared to the vacuum relays.

4. Time Delay Relays

The time-delay relays are used for performing time-delayed switching operations such as starting, protecting and controlling circuits applications. This relay consists of a relay mechanism with a control circuit wherein the control circuit is made with solid state components and timing circuits so that a control operation with a predefined-timing range is performed. This time-delay function includes on delay, off delay, repeat cycle, one shot, re-triggerable one shot, pulse generator, on or off delays, etc. A special type of such relay is a star-delta wherein within a certain time period it changes the terminal connection.

These are of different types like:

- Electromagnetic Time Relays
- Capacitor Time Relays
- Electronic Relays
- Hydraulic and Pneumatic Relays
- Microprocessor-based Time Relays
- Accelerated Time Relays

Along with the above types, time-delay relays can also be differentiated depending on normally open or normally closed contacts with the time delay in the direction of closing or opening. These are of different types like normally-open timed-closed contact (NOTC), normally-open timed-open (NOTO), normally-closed timed-open (NCTO) and normally-closed timed-closed (NCTC) contact type relays.

Depending on the function, these time relays can also be triggered or initiated either with the application of a trigger or input voltage. These initiated signals can be controlled-switch-like push button, limit switch, float switch, etc., or simply a power trigger with voltage excitation.

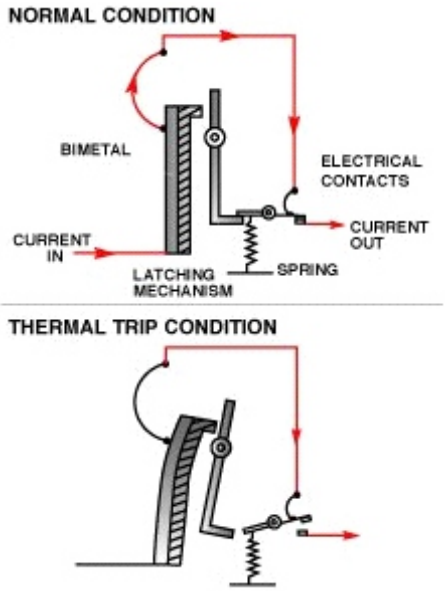
5. Thermal Relay

These relays are based on the effects of heat, which means – the rise in the ambient temperature from the limit, directs the contacts to switch from one position to another. These are mainly used in protecting motor and other inductive loads against single phasing, overload and unbalanced voltages. This relay consists of bimetallic elements like temperature sensors as well as control elements. Thermal overload relays are the best examples of these relays. These are of different types like

- Bimetallic Thermal Realys
- Solid State Thermal Relays
- Melting Alloy Relays
- Temperature Controlled Thermal Relays

5.1 Bimetallic Thermal Relays

When a bimetallic strip heats up, it expands or bends as shown in the figure due to the inequality of linear expansion of two dissimilar metals. For any reason, if the circuit draws heavy or excessive currents, this in turn causes to increase the temperature of winding or conductor so this bimetallic strip also gets expanded, and then finally the circuit contacts become open. These relays can be used to operate either in automatic or manual modes.

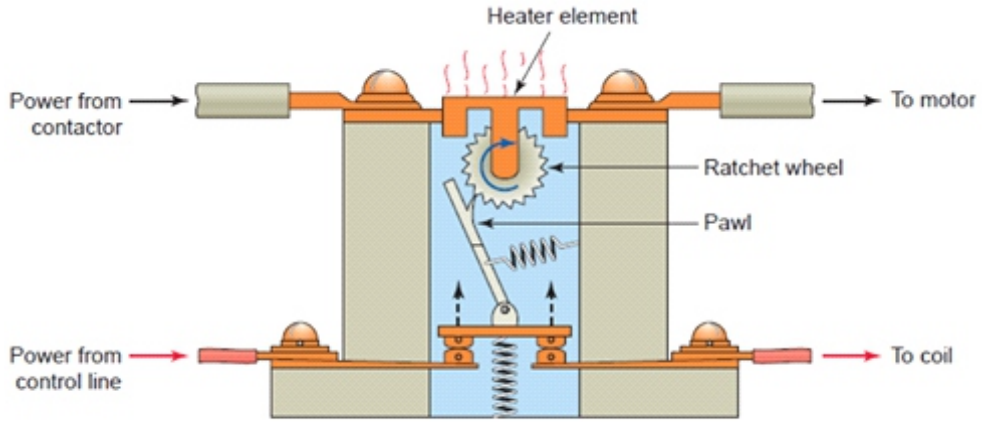


5.2 Solid State Thermal Relays

This relay is built with solidstate electronic components. It continuously monitors the starting and running currents to correspondingly calculates the average motor or load temperature. If the limits of the temperature exceed, then it trips the load.

5.3 Melting Alloy Relays

This relay consists of a eutectic alloy, heater coil and triggering mechanism. The eutectic alloy changes from the solid to liquid state at fixed temperature. This alloy with ratchet wheel acts as a tripping device to open the control circuit contacts. This relay allows the motor current to pass through the heater coil; thus, under an overload condition, this coil heats up the eutectic alloy and melts it. This in turn causes the freeing, and turns the ratchet wheel so that the tripping mechanism is activated.



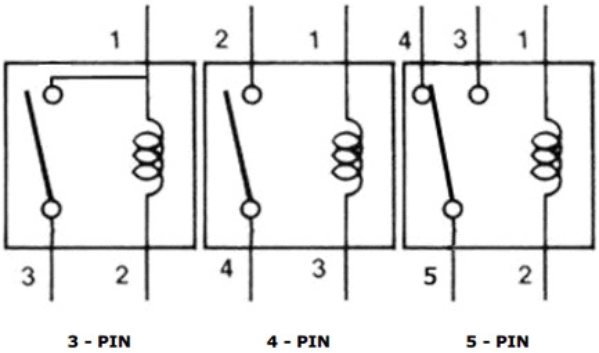
Melting alloy–type thermal overload relay

5.4 Temperature Control Thermal Relays

These relays are used in motor winding protection and use temperature sensors like thermistors and Resistance Temperature Detectors (RTDs). These sensors are embedded in the motor winding which detects the temperature and threshold circuit in its open-relay contacts.

Furthermore, these thermal relays can be Oil Temperature trip (OT), Winding Temperature (WT) Trip and Bearing Temperature Trip types.

Relays are also available with different pin configurations like 3-pin, 4-pin and 5-pin relays. The ways in which these relays are operated is shown in the below figure. Switching contacts can be SPST, SPDT, DPST and DPDT types. Some of the relays are normally open (NO) type and the other are normally closed (NC) types.



These are some basic types of relays commonly used in different applications. Concepts like choosing relays based on capacity and mathematical calculations related to relay operation are exempted in this document for making it simple to understand. Some of the relays like distance relays, directional relays and other power system protection based relays are not included in this document in order to make this document short and precise.

About the Edgefx Team

The credit for each and every bit of information added to this document goes to the team of Edgefx technical writers and authors. The team of Edgefx, has been relentlessly working to ensure that the researched and practically implemented and pragmatically proven written work of this document must serve the purpose of its readers. With the unmatched technical expertise and pioneering works in the field of electronics, electrical and robotic engineering Edgefx Kits and solutions is providing technical solutions and project kits to millions of engineering students around the globe, since 1997. The credit for the projects and the circuits goes to the technical team of the Edgefx.

Right to readers

This information on this document is intended to give brief description on three phase induction motor. Any person interested and looking forward to have this note can enjoy the privilege and authority to download, reprint and distribute this book. However, no person is entitled to make any modifications or alternations to the book and to use it for his or her own monetary profits.

Legal Info

Ways to Interact With the Edgefx Team

If you are an engineering student, looking for projects, then the following link will be of immense help to you:
http://www.edgefxkits.in

If you are looking forward to the technical solutions and information on any topic relevant to electronics, electrical, robotics and communication, then click the links given below:
http://www.elprocus.com/

You can also contact us through the social media by liking the following Facebook pages:
https://www.facebook.com/edgefx
https://www.facebook.com/elprocus