Solid State Relay

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Abstract: The many benefits that Solid State Relays (SSRs) offer over conventional electromechanical relays have led to a surge in interest in SSRs in recent years. This paper provides a thorough analysis of the benefits, uses, and functioning of SSRs. The first section of the paper gives a summary of the fundamental ideas of SSR functioning, emphasizing its lack of moving components and its use of semiconductors for switching, such as MOSFETs, thyristors, and triacs. The benefits of SSRs over electromechanical relays are then thoroughly covered, including their ability to operate noiselessly, have longer lifespans, improved dependability, and faster switching rates. This paper concludes by highlighting the increasing importance of SSRs in contemporary electronic systems and underscoring the necessity of more research and development to improve their functionality and broaden their range of application.

Keywords: Solid state relay, Light emitting diode, switching circuit, Coupling circuit.

I. INTRODUCTION

Solid state relays are any kind of relay that don't have a moving contact (SSR). SSRs function similarly to mechanical relays with moving contacts in terms of operation. On the other hand, SSRs use semiconductor switching components such transistors, diodes, thyristors, and triacs. With everyone's need for energy growing, protective circuits have a wide range of uses. As the population grows, so does the demand for energy, and meeting that demand has become more important. In a nation like India, losses and process errors are the main issues with distribution and transmission. Occasionally, malfunctions can pose a serious risk to the machinery involved in the production, distribution, and consumption of electricity. These days, a lot of protection technologies are utilized to prevent the effects of errors.

II. RELAY

Relays are one kind of this kind of safety equipment. Additionally, a circuit breaker is used to isolate the problematic component from the working circuit. An electronic switch that operates on the basis of electromagnetic induction is called a relay. An electromagnet is used to help switch the dev device between the ON and OFF positions, negating the requirement for a human presence. Relays are capable of controlling far more power-hungry devices like circuit breakers and isolators with very little power. Relays are used, for instance, to control the air conditioner in your house. The required power for an AC device is around 220VAC at 30A, or about 6600 Watts. A relay's long life, great accuracy, relative simplicity, and shown high reliability make it similar to a remote-control switch with a wide range of uses. These come in very handy when we need to use a modest electrical signal to regulate a large amount of voltage or current.

III. TYPES OF SOLID-STATE RELAY

Relays can be widely categorized based on how they are made and used. Relays come in three different construction types: electromechanical, static, and numerical.

1. Electromechanical Relay

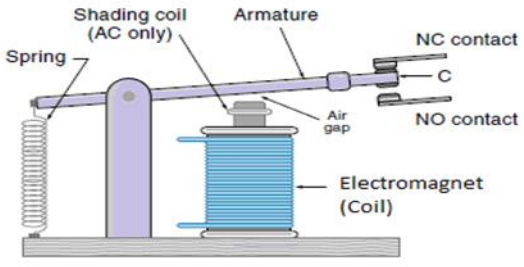


Fig. electromechanical relay

A spring is used to maintain the separation between the two contacts. The two contacts are drawn together when the electromagnet is energized. When utilized appropriately, electromechanical relays can facilitate the integration of power and control circuits. The lack

of a heat sink requirement, reduced cost, multiple pole availability, and simple switching in both AC and DC are benefits of electromechanical relays.

2. Static relay (Solid State Relay)

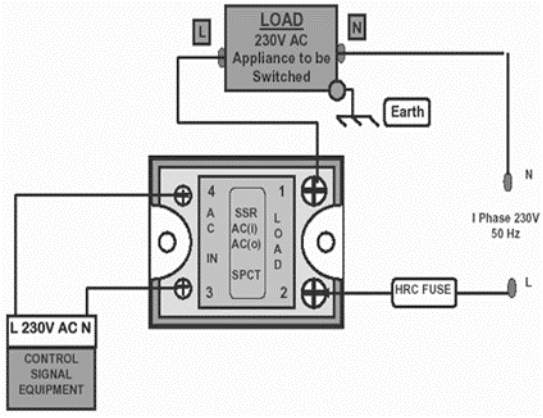
With this kind of relay, a static circuit that generates an output signal for tripping a circuit breaker compares or measures electrical quantities. Since they lack any moving parts, they are referred to as static. In this sort of relay, the relay characteristics are created by analog electronic devices rather than magnetic coils or mechanical components, and analog circuits rather than digital ones monitor the incoming current or voltage waveforms. These are not affected by shock, vibration, or gravity. These relays occasionally employ microprocessors, although they aren't really microprocessor relays as they don't have the characteristics of a digital or numeric relay. Semiconductor components such as power transistors, TRIACs, SCRs, and diodes are used by these relays to conduct loads.

Unlike mechanical relays with contacts, SSRs lack the mechanical moving parts. Rather, they are made up of electronic components and semiconductors. Through the use of these electronic circuits, SSRs electrically turn on or off signals, currents, or voltages.

3. Numerical Relays

Using digital technology, numerical relays, also known as digital relays, are made to protect a variety of electrical equipment, including motors, transformers, generators, transmission lines, and others. For the purpose of detecting electrical faults, they employ microcontrollers that are equipped with software protection algorithms. These rely on digital technology and are mostly impervious to temperature variations, aging, and other external factors that may cause variations or drifts in the characteristics of individual components like OP-AMPS, etc. Utilizing digital signals improves the circuit's dependability. These could include self-test, metering, and protection features. These relays are programmable varieties. It is possible to program both the behaviour and the properties of this kind of relay. It is applicable to carry out different protective features by making the necessary software changes. This can be accomplished either with the same hardware or by making minor adjustments to the device.

IV. SOLID STATE RELAY



An electronic switching device called a solid-state relay (SSR) regulates electrical loads without the need of moving parts, like electromechanical relays do. SSRs, on the other hand, carry out the switching process using semiconductor switching devices including MOSFETs, triacs, and thyristors (SCRs).

Control Input: To initiate the switching process, an SSR usually features a control input that takes a low-power control signal, such as a voltage or current input. For security and noise immunity, the control input is frequently segregated from the output circuit.

Input Circuit: The SSR's input circuit receives the control input signal. An optocoupler, which separates the control input from the output circuit, is typically used in this circuit. The optocoupler makes use of an LED (light-emitting diode) and to send the control signal without a direct electrical connection between the input and output circuits, a photosensitive semiconductor device (such as a phototransistor).

Switching Element: A semiconductor switching element, such as a MOSFET or thyristor, is located inside the SSR and regulates the current flowing through the output circuit. The switching element activates in response to the applied control signal, letting current to pass through the load attached to the SSR.

Output Circuit: The load is connected to the SSR's output circuit. This can be an inductive load (such as motors or solenoids) or a combination of both resistive and inductive loads (such as heaters). Depending on the state of the control input signal, the SSR turns the load on or off.

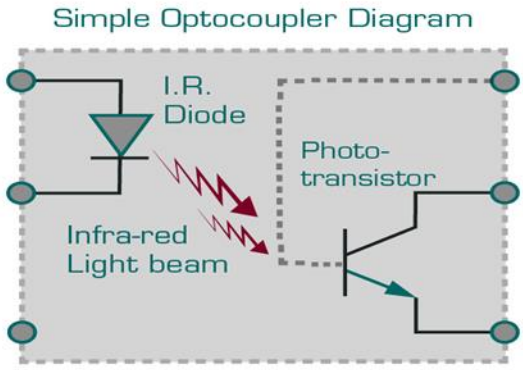
Heat Dissipation: SSRs produce heat during operation as a result of power dissipation, much like any other semiconductor device. To disperse this heat and

guarantee the SSR operates properly and lasts a long time, heat sinks or other cooling systems are frequently utilized.

Optional Zero-Crossing Detection: Certain SSRs provide circuity for zero-crossing detection. By ensuring that the SSR only turns on or off when the AC voltage reaches zero, this feature lowers electromagnetic interference and increase the lifespan of both the SSR and the load.

All things considered, solid-state relays are superior to conventional electromechanical relays in a number of ways, such as quicker switching rates, longer operational lifetimes, silent operation (no clicking noise from the mechanism), and increased dependability in challenging conditions. They are extensively employed in many different applications, including lighting control, temperature control systems, and industrial automation.

i. Optocoupler



Optocouplers are light-source components (often LED or infrared) that allow switching to occur.

The transmitter (Tx) and receiver (Rx) are located within the SSR and powered by the signal control. Once powered, the optocoupler opens or closes the circuit, allowing the full voltage signal to travel through the SSR's output.

Generally speaking, an optocoupler is formed of two independent components, one for transmitting the signal and another for receiving; nonetheless, it is more commonly referred to as a whole unit.

ii. Transistor

The MOSFET (metal-oxide-semiconductor field-effect transistor) is a semiconductor device made up of two metal oxide semiconductors device made up of two metal oxide semiconductor field effect transistors (MOSFETs), one N-type and one P-type, that are combined on a single silicon chip. MOSFET is commonly used to switch DC loads.

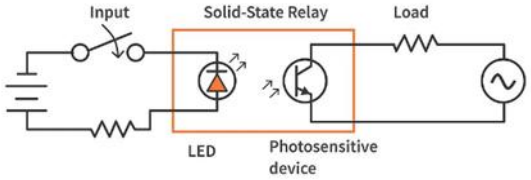
iii. TRIAC

A triac is an electrical component that is roughly similar to two silicon-controlled rectifiers coupled in inverse parallel (parallel but with the polarity inverted) and their gates connected together. This creates a bidirectional electrical switch that can conduct current in either way. Triacs are ideal for switching resistive AC loads.

iv. MOSFET

Metal-oxide-semiconductor field-effect transistor is referred to as MOSFET. It is a MOS-structured field-effect transistor. The gate (G), drain (D), and source (S) terminals of a MOSFET are typically located on three terminals. A voltage that is provided to the gate (G) terminal controls the amount of current that flows between the drain (D) and source (S). In terms of operating at relatively high speeds and minimal losses, MOSFETs perform better when compared to bipolar transistors. P and N types are identified by channel polarity, whereas depletion types are identified by control mechanism as normally on (deactivated with gate voltage 0 V) and enhancement types are identified by normally off (gate voltage 0 V off).

Inside a Solid-State Relay



An SSR is a four-terminal device with one pair for the input side and the other for the load/output side. A single case contains an LED light source and a photosensitive device, such as a phototransistor, separated by an air gap. Depending on whether the load is AC or DC, the photosensitive switching device on the output side could be a photodiode, thyristor, MOSFET, or TRIAC.

SSRs with larger current capacity feature additional circuitry on the load side, in addition to the photo-sensitive device, to boost the current output. The control signal is a tiny DC input signal that controls

the input LED. When the LED is activated, the emitted light.

V. APPLICATION OF SOLID-STATE RELAY

1. Industrial Automation: To switch motors, heaters, solenoids, and other electrical loads, SSRs are frequently utilized in industrial control systems.
2. Temperature Control: SSRs are frequently used in systems that regulate temperature to precisely control heating elements like incubators, furnaces, and ovens.
3. Lighting Control: In both commercial and residential contexts, SSRs are used in lighting control systems to dim, switch, and regulate the intensity of lighting fixtures.
4. Medical Equipment: SSRs are utilized in medical imaging, diagnostic, and patient monitoring systems, among other devices.
5. Traffic Control: In solid state logic elevator controllers, integrated circuit boards and transistor circuits are the constituent parts. It provides easier fault identification, lower power consumption, and more reliability than relay controllers.
6. Elevator Control: Transistor circuits and integrated circuit boards are components of solid-state logic elevator controllers. Compared to relay controllers, it offers simpler fault identification, reduced power usage, and increased dependability.

VI. ADVANTAGE OF SOLID-STATE RELAY

1. Industrial Automation: SSRs are frequently used to switch electrical loads such as motors, heaters, solenoids, and other items in industrial control systems.
2. Temperature Control: To precisely regulate the heating elements in ovens, furnaces, and incubators, SSRs are frequently used in temperature control systems.
3. Lighting Control: SSRs are used in lighting control systems to switch, dim, and adjust the brightness of lighting fixtures in both homes and businesses.
4. SSRs are used in medical equipment, including patient monitoring systems, diagnostic tools, and medical imaging equipment.
5. Heat Dissipation: Maintaining the SSR's longevity and performance depends on proper heat dissipation. It is important to supply sufficient cooling as needed, either with forced air cooling or heat sinks.
6. Voltage and Current Ratings: There are different voltage and current ratings available for SSRs.

VI. CONCLUSION

Solid state relays (SSRs) are essential components of modern electrical systems. Different varieties of SSRs, such as AC and DC SSRs, have distinct characteristics and are utilized in a variety of applications, including industrial controls, medical equipment, and heating systems.

VII. REFERENCES

[1] Nidhi Verma, Kartik Gupta, Sheila Mahapatra "Implementation of Solid-State Relays for Power
[2] System Protection" INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 4, ISSUE 06, JUNE 2015
[3] Three phase solid state relays – POWERSEM www.powersem.net
[4] Anil Kumar Reddy. K, Sirisha. S. "A ZVS DC-DC CONVERTER WITH SPECIFIC VOLTAGE GAIN FOR INVERTER OPERATIONUSED FOR 3-PHASE INDUCTION MOTOR OPERATION" International Journal of Advanced Research in Electrical Engineering, Vol. 2, Issue 8, August 2013
[5] Relay Systems, by I. T. Monseth and P. H. Robinson, McGraw-Hill Book Co., New York, 1935