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Product Focus: Relays and Timers

What are relays?

Relays are fundamental devices used for switching electrical circuits on or off. They function like toggle or limit switches but use electrical control signals, instead of human hands or physical contact, for operation. They are typically used to provide electrical isolation and to allow low power circuits to operate higher power circuits.

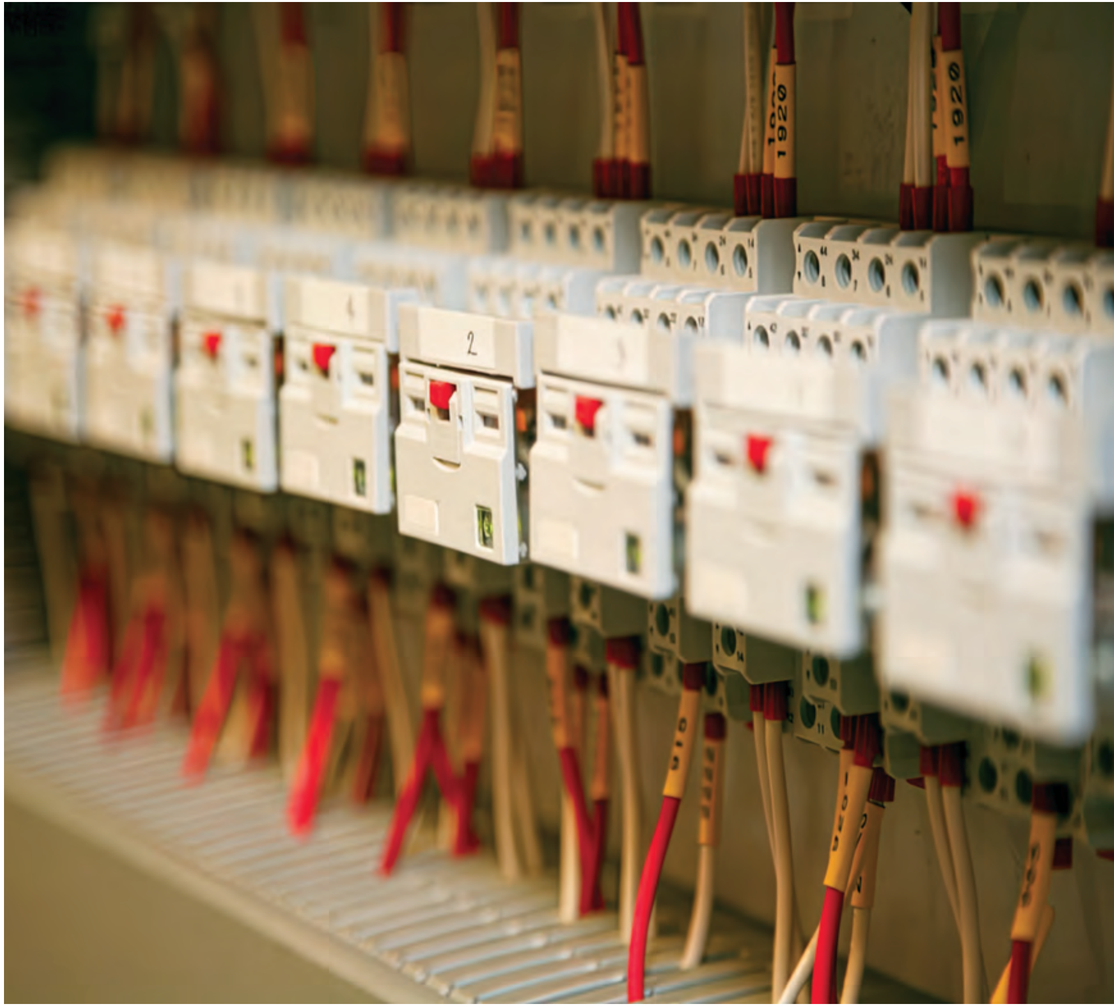
Why are Relays Used?

The purpose of a relay is essentially to amplify a control circuit to drive a larger or different power circuit. Relays allow separate, low-power circuits, such as the digital outputs of a programmable logic controller, to control circuits operating at higher or different voltages and current. The control and power circuits can remain isolated from each other and even use completely different voltages.

Relays can also perform logical functions when their contacts are wired in various series and parallel circuits. Older control systems, such as elevator systems with complicated control schemes, were effectively "programmed" by hard-wiring hundreds of relays and timers in complex combinations. These relays are known as "control relays" because they drive the logic typically used to control power relays.

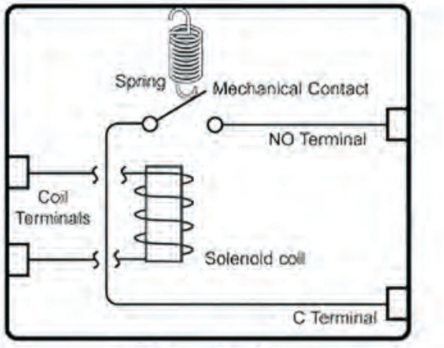
These relay-based control systems were typically mounted near the machinery in large enclosures. As the designs evolved and became more complicated, installing and maintaining these large relay control systems became increasingly difficult. This progression in complexity eventually led to the development of the PLC (programmable logic controller), which has traditionally used ladder style programming logic, readily understood by maintenance electricians and plant engineers.

Today, most automated systems use PCs or PLCs to execute logic and control relays that interface with high-powered equipment. It is a common practice to use relays for isolation and to protect the digital control system; as a result, people often refer to them as "interposing or "interface" relays.



How do relays work?

Common relays are electromechanical devices that have an electric solenoid coil on the "control" side of the circuit that, when energized, moves mechanical contacts on the "load" side.



Electro-mechanical relays use a small electrical control signal to shift contacts operating a separate circuit. The spring opposes the electro-mechanical action and returns the contact to its rest state when the coil is de-energized.

Electrical Ratings

Relay coils are rated to operate at specific voltage and current levels when energized. The minimum voltage required to energize a relay is the "pickup voltage" and is usually about 80% of the rated voltage. The relay will de-energize when the voltage falls below the "dropout voltage." Relays frequently require a higher initial "inrush" current to energize them, but a lower holding current is acceptable to keep them energized.

The output contacts, rated for various voltage and currents, control the high-power side of the load. When the contacts are isolated from the coils energized by the input, which is usually the case, they are called dry contacts. The external voltage connected to a dry contact is often called the wetting voltage.

AC vs DC Relays

Relay coils are available in a variety of AC and DC voltages, so they must be selected to match the available control circuit voltage. AC coils are not polarity-sensitive but may experience hum or slight noise when energized. DC coils are usually polarity-sensitive and must be wired correctly to function.

Because contacts have a voltage rating, they must be selected to handle the requirements of the load. The contacts must be able to suppress the electrical arc that forms as they are opened. The arc is more easily quenched with AC than with DC power. As a result, more robust contacts are required for DC loads than similarly rated AC loads.

Relay contacts are designed to switch the rated current through millions of operations. Contacts rated for high current use special metals and designs to quench arcing. Gold-plated contacts are often required for conducting very low voltages and currents. The contacts are usually designed to slide against each other when making or breaking, creating a mechanical wiping action that protects against the buildup of corrosion and oxidation.

Special Relays

Basic relays are simply on/off devices, reverting to the off position when the coil is de-energized. However, a relay may be bistable or latching, alternating states each time the coil is energized and remaining in the last state until the coil is energized again. Other relays have built-in functions such as timer on-delay and off-delay functions. There are even smart relays that function similarly to tiny programmable PLCs.

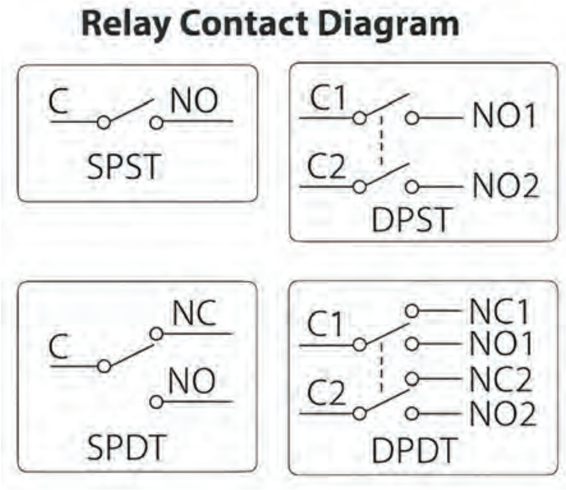
How do relays work? (cont.)

Relay Contacts

The relay contact wiring terminations are designated as normally open (N.O.), normally closed (N.C.), and common (C). Also, three relay forms define the contact action at the terminals:

- Form A - normally open (N.O.) contacts pass power between the Common and N.O. terminals when the coil is energized
- Form B - normally closed (N.C.) contacts interrupt power between the Common and N.C. terminals when the coil is energized
- Form C - N.O./N.C., changeover, or transfer contacts pass power between Common and N.O. terminals and interrupt power between Common and N.C. terminals simultaneously when the coil is energized

Relays can have many different contact arrangements and configurations. The number of "poles" refers to the number of isolated output contacts a relay has. The most common configurations are single-pole (SP) and double-pole (DP). The term "throw" refers to the contact action. A Form A or B contact would be single-throw (ST), and a Form C contact would be double-throw (DT).



Relay Installation

Relays can have screw terminals, pigtail wires, or solder connections. Older style relays and relays designed for higher current may have an open style with exposed electrical connections. Newer, smaller designs are usually touch-safe, so users are less likely to contact the energized parts. For most industrial applications, a relay is used with a socket which can be panel mounted or clipped onto a DIN rail. All the wiring terminations are made at the socket, so the relay can be easily removed and replaced. There are many socket sizes and formats; the two most popular are the blade style and octal pin formats. Smaller control relays are often called ice-cube relays because they resemble a cube of ice.

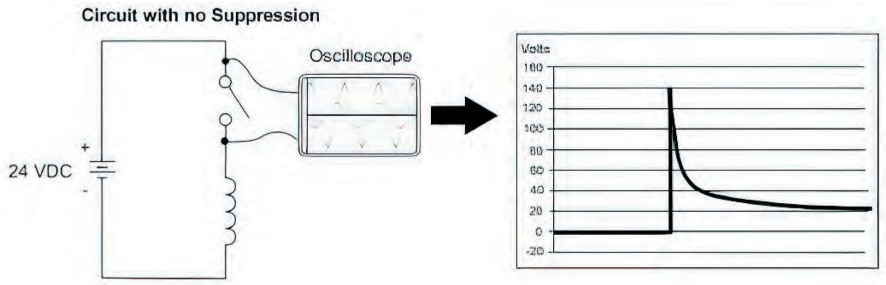
How do relays work? (cont.)

Relay Options

Depending on the need, relays are available with options such as indicator lights, mechanical indicator flag, mechanical push-to-test button, and diode or surge suppression protection.

Surge Suppression

Devices with inductive coils, like solenoid valves and motor starters, can produce high voltage spikes that can damage output devices and nearby electronic equipment. It is always recommended to use some form of surge suppression to eliminate these voltage spikes.



Inductive loads generate transient voltages when their coils are de-energized. These transient voltages can be many times greater than the coil voltage, damaging devices in the circuit and causing unreliable operation in neighboring electronics. It is essential to manage these transients with surge suppressors to extend the life of connected components and provide reliable control system operation.

Electromagnetic interference (EMI) is a destructive side-effect caused by the arcing across relay contacts. The arcing causes a current surge, releasing RF energy along the entire length of the wire, turning the whole circuit into an antenna that radiates RF energy. The RF energy frequently affects adjacent circuits and may disrupt local PLC systems and other sensitive electronics, causing stable control systems to behave unpredictably.

Design Considerations

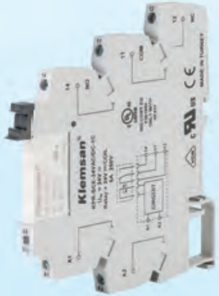
Designers must ensure that control circuits are compatible with relay coils, verifying that a PLC output has enough current to energize the relay. Relays often have separate current ratings for inductive and motor loads than resistive loads because the contacts must also be able to handle the large inrush currents frequently required to start inductive loads. The designer must ensure that the relay contacts are suitable for all operating conditions. Because relay coils consume power and generate heat, designers must also make provisions for the additional heat load.

Specifying surge suppression is essential for PLC systems. Although PLC outputs often include integrated suppression circuits, they cannot handle all transients. So, it is usually necessary to add transient suppressors when interfacing with relays.

Types of Relays

Electromechanical Relays

Electromechanical relays receive an electrical input that magnetizes an internal coil, causing the relay's contacts to open or close. These relays serve a wide range of industrial applications and are available in a variety of styles to fit specific applications.



Slim interface relays are highly compact and lightweight relays, especially useful where cabinet space is a consideration.

Ice cube relays are designed for high power control applications in machines and control panels.

Power relays are highly reliable and durable, can be used for applications requiring a maximum contact voltage of 600 VAC, and are capable of switching load currents up to 40A.

Hazardous location relays are hermetically sealed units for installations in hazardous locations. These relays are vibration/shock resistant and can be used in washdown applications.

Slim card relays are space-saving relay terminal modules containing multiple relays with one contact each, ideal for use as interposing relays between control and power circuits.

Force guided relays provide fail-safe operation by mechanically linking the N.O. and the associated N.C. contact. This ensures that one contact is closed while the other is open, preventing damage to equipment.

Solid State Relays

Solid state relays (SSR) are similar to electromechanical relays because both use a control circuit and a separate circuit for switching the load. Solid state relays use electronic components to switch the circuit on or off. When voltage is applied to the input of the SSR, the relay is energized by a light-emitting diode. The light from the diode is beamed into a light-sensitive semiconductor which signals the control circuit to turn on the output of the solid state switch. With no moving parts, these relays are ideal for applications requiring many contact closures and extended life.

Solid state relays energize in one of two ways:

Zero-crossing relays wait for the AC signal to cross zero before energizing, ideally suited for most commercial and industrial loads such as resistive heating elements, lamps and ballasts, and any other load with low initial impedance or capacitive characteristics. They are preferred in applications with some level of capacitance as they can minimize surge currents during the first conduction cycle.

Random turn-on (asynchronous) relays do not wait for the AC signal to cross zero before energizing and are commonly used with inductive loads (motors, contactor coils, transformers), where the phase shift between voltage and current would be an issue with zero-crossing relays.

Watch https://go2adc.com/relay-vid

Solid state relays are available in several form factors.

Panel-mount relays feature a high load rating in a finger-safe "hockey puck" housing.

DIN-rail mount solid state relays offer energy-efficient current switching in a slim housing ideal for space-saving applications.

Socket-mount solid state relays offer convenient installation and removal.

Electromechanical vs. Solid State Relays

Since the introduction of solid state relays (SSRs) some decades ago, the debate over which is better, solid state or electromechanical relays (EMRs), has gone on. The answer is each one has its good and bad points. But in terms of specific application requirements, clear winners emerge.

When used as intended, solid state relays will perform indefinitely, usually outlasting the equipment in which they're installed. They operate silently and produce little electrical interference. SSRs will function over a wide range of input voltages and consume little power even at the high-voltage limit. They don't produce any arc, making them suitable for hazardous environments. Most AC switching types employ "zero-voltage crossover," which minimizes surge currents.

SSRs have no moving parts, so physical shock, vibration, or changes in altitude won't affect them. SSRs aren't really relays at all, but rather electronic circuits. Typically, an SSR's input consists of an opto-isolator, while its output is a triac, SCR, or FET. One negative aspect of an SSR is that semiconductors are never completely on or off. In the on-state, substantial resistance is present, which can lead to significant heat generation when current is flowing. So SSRs must be mounted on heatsinks, often several times the relay's weight. They're sensitive to ambient heat and must be derated if used in hot environments or with less than optimal heatsinks.

In some applications, the on-state voltage drop can cause problems for loads sensitive to reduced voltage. The resistance goes up when the input is off, but the output circuit path isn't completely open. Off-state resistance permits enough current flow at higher voltages to be objectionable, even dangerous.

Under normal service conditions, SSRs seldom fail. But when they do, they nearly always fail shorted. The user might not realize that the relay has failed. When exposed to surges or spike voltages on the controlled line, SSRs may conduct for as much as one half-cycle after the surge has stopped. Most solid state relays require a minimum load to function and only switch AC or DC loads, but not both.

When an electromechanical relay (EMR) expires, it's usually due to coil failure. While contacts can weld if heavily overloaded, this is a rare occurrence for a properly designed application and is usually self-evident. EMRs can switch any AC or DC load up to their maximum rating. Their contact resistance diminishes as the load increases, eliminating any need for heatsinking. Although EMRs require substantial coil power, they operate at full load over a wide temperature range.

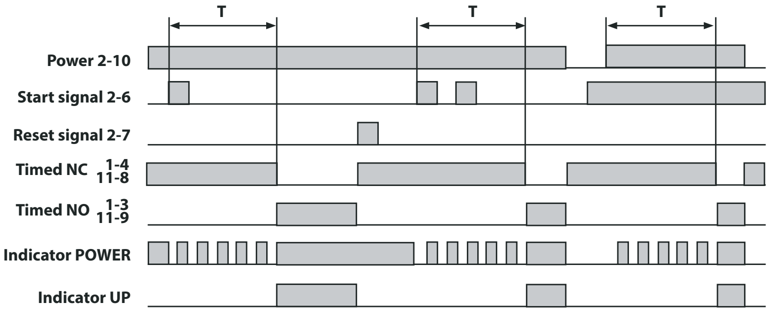
Multi-function Relays

Timer Relays

Timer relays provide simple, cost-effective control of process and machine tools. They are configured via a mechanical dial or an LED digital display. Operation modes may include:

- **On-delay:** the output turns ON after a preset time is reached (timing example below)
- **Fleeting (flicker):** the output cycles between ON and OFF for the duration set by the preset time
- **One-shot (on-interval):** on the rising edge of the start signal, the output turns ON for the duration of the preset time
- **Off-delay:** the output remains high for a preset duration after the input goes low

On-delay (PO)



Counter/Timer/Tachometer

These multi-function devices are versatile relays that can be configured in a number of ways, operating as a digital counter, timer, combination timer and counter, or tachometer.

Programmable Relays

A programmable relay is a device that includes several inputs and outputs providing relay, timer, and counter functions in a single unit that can be programmed with simple logic operations.

A common misconception about programmable relays is that they are easier to program than PLCs, but this is not always true. A programmable relay is very good at executing its configurable, built-in functions but is not nearly as flexible as a PLC for applications requiring customization. Once more than a few I/O points are needed, the coding complexity for a programmable relay is very similar to a micro PLC. The option of coding a programmable relay from its built-in display is not practical for all but the most basic applications.

Although programmable relays provide simple installation, minimal wiring, and user-friendly programming, micro PLCs can make the same claim. Either option works well in small automation applications. However, a micro PLC such as the CLICK series offers more flexibility in I/O configuration and application programming for about the same cost.

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