DESIGNING THE FUTURE

MECHATRONIC DEVICES

SWITCHES & RELAY

SUHAILA I SYAHRAIN

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MECHATRONIC DEVICES

PREFACE

This books is designed mainly for electrical engineering students and those who need a clear understanding of fundamental of electronics. It is also suitable for those who are studying independently or through open-learning system. This book is explaining the fundamental of electronics related to switches and relays applications electronic devices in embedded system and contains sufficient examples to support the concepts.

The entire book is written in a simple way to enable the students understand the concepts quickly and the subject is an easy way. This book shall provide knowledge on the theory, concept and application of electronic devices and to acquire the problem solving skills related to the respective processes.

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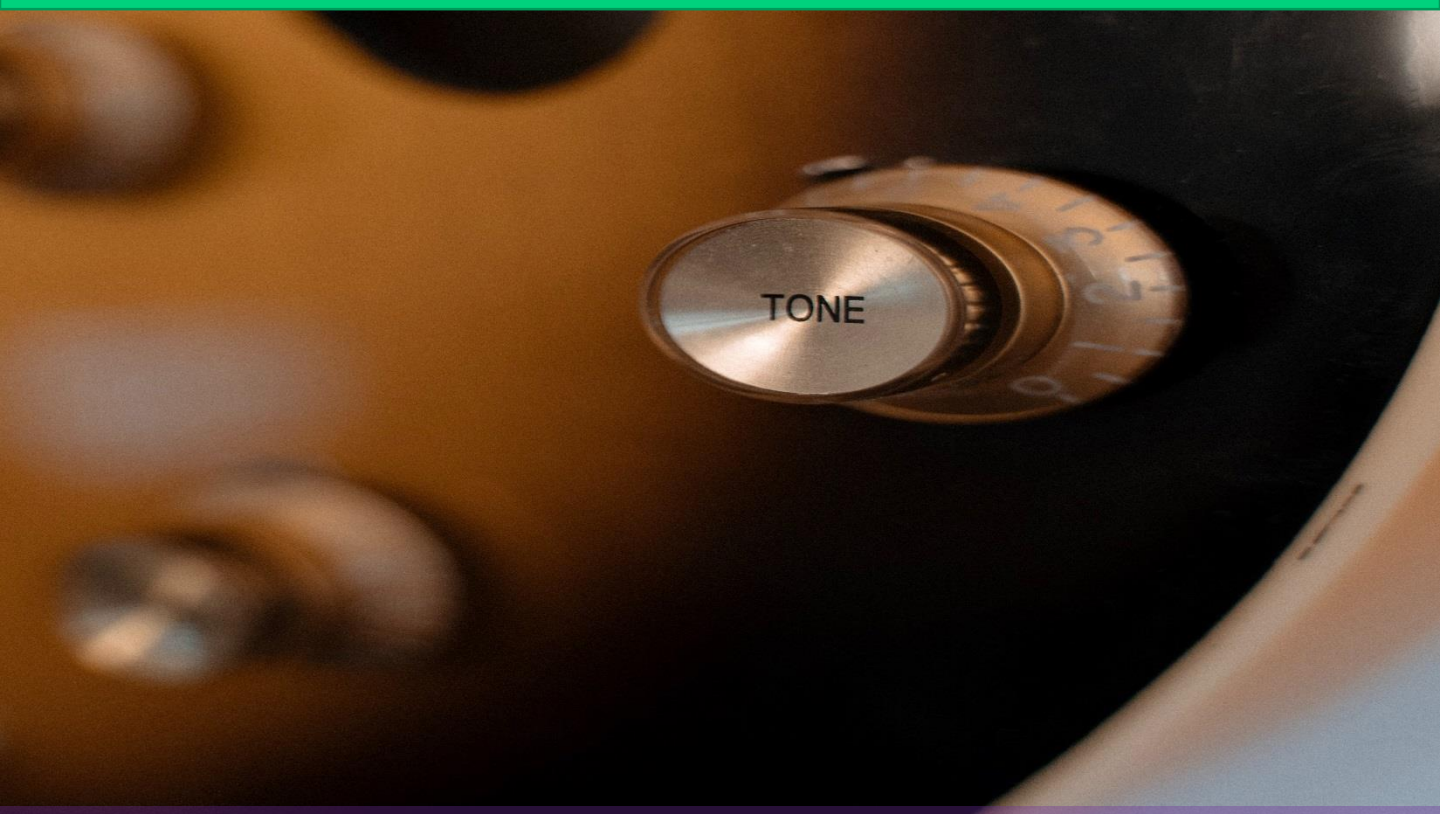


SWITCHES

In electrical engineering, a switch is an electrical component that can disconnect or connect the conducting path in an electrical circuit, interrupting the electric current or diverting it from one conductor to another. The most common type of switch is an electromechanical device consisting of one or more sets of movable electrical contacts connected to external circuits. When a pair of contacts is touching current can pass between them, while when the contacts are separated no current can flow.

Switches are made in many different configurations; they may have multiple sets of contacts controlled by the same knob or actuator, and the contacts may operate simultaneously, sequentially, or alternately. A switch may be operated manually, for example, a light switch or a keyboard button, or may function as a sensing element to sense the position of a machine part, liquid level, pressure, or temperature, such as a thermostat. Many specialized forms exist, such as the toggle switch, rotary switch, mercury switch, push-button switch, reversing switch, relay, and circuit breaker. A common use is control of lighting, where multiple switches may be wired into one circuit to allow convenient control of light fixtures. Switches in high-powered circuits must have special construction to prevent destructive arcing when they are opened.

INTRODUCTION OF SWITCH

A switch is a mechanical, electrical or electronic device that opens or closes a circuit. Switching can also be referred to as making or breaking a circuit.

STRUCTURE AND CONSTRUCTION OF SWITCH

The structure and construction of power electronics switch can be divided into four parts:

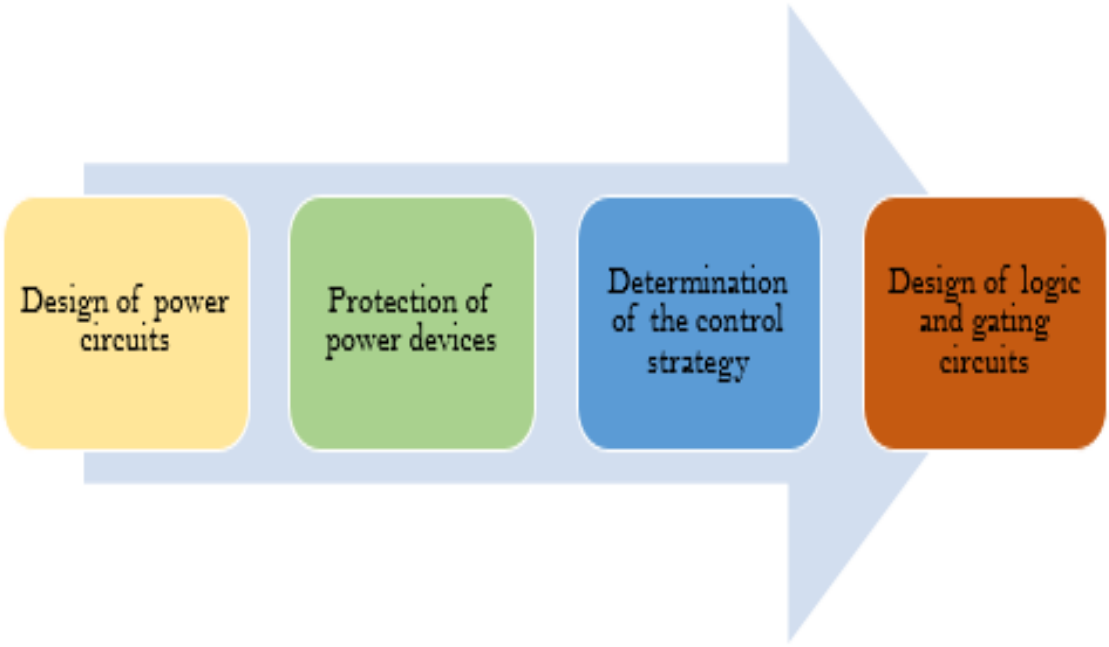


Figure 1.1: The structure and construction of switch

POLES AND THROWS

One way to sort switches is through the connections they establish. Two important factors that determine what kind of connection the switch establishes are:

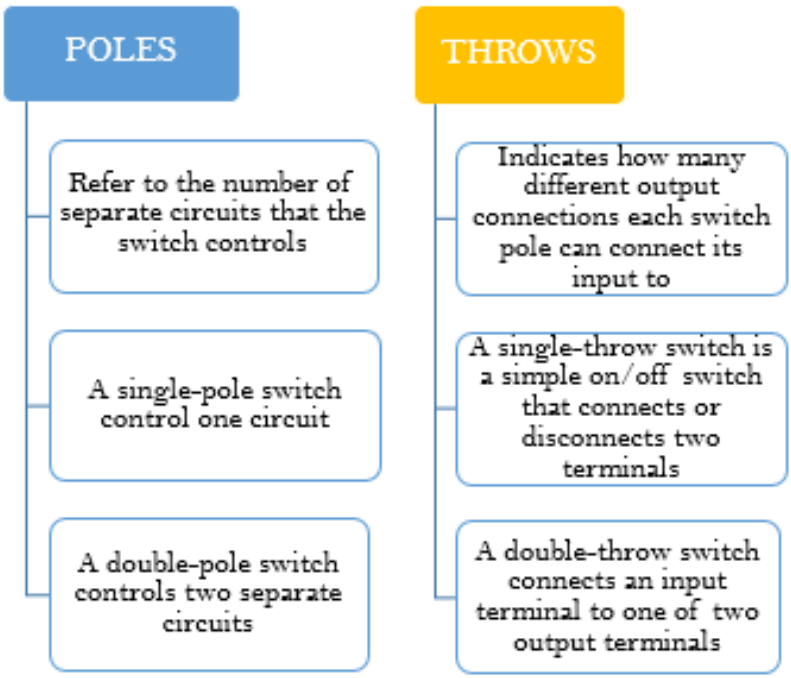
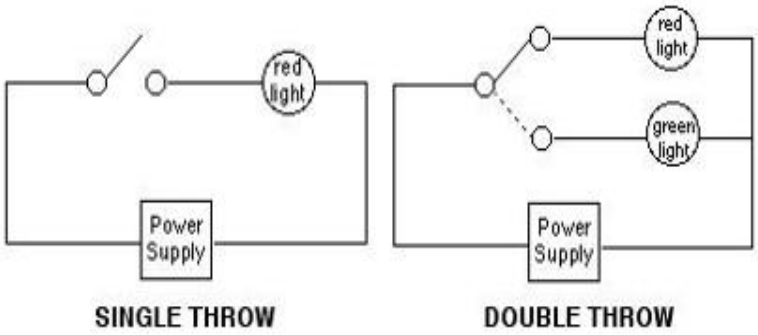
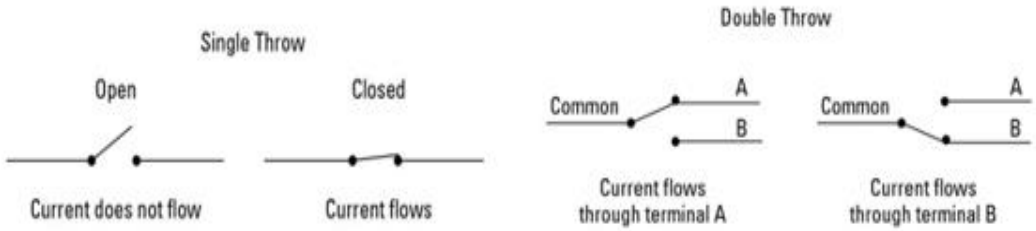


Figure 1.2: Types of connections a switch

Refer to Figure 1.3. When the switch is in one position, the common terminal is connected to terminal A, so current flows from the common terminal to terminal A, but no current flows to terminal B. When the switch is moved to another position, the terminal connection is reversed: current flows from the common terminal to the B terminal, but no current flows through the A terminal.





THE TYPES OF SWITCHES

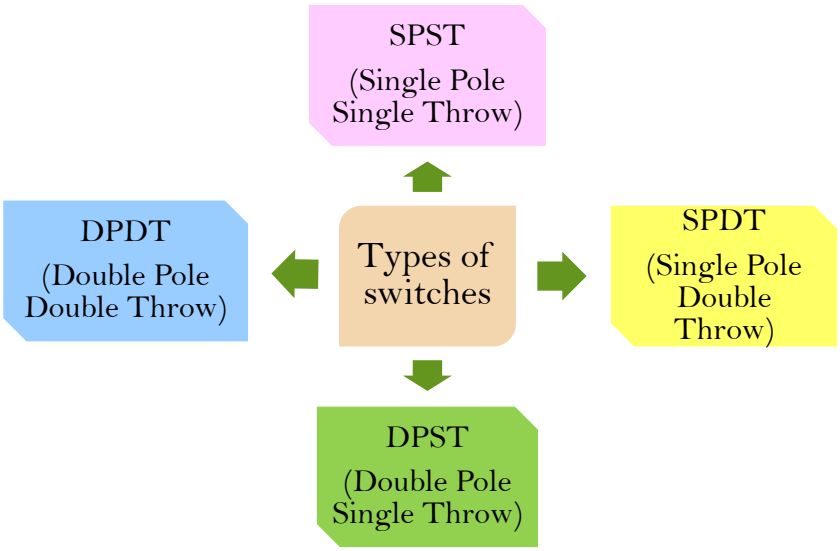
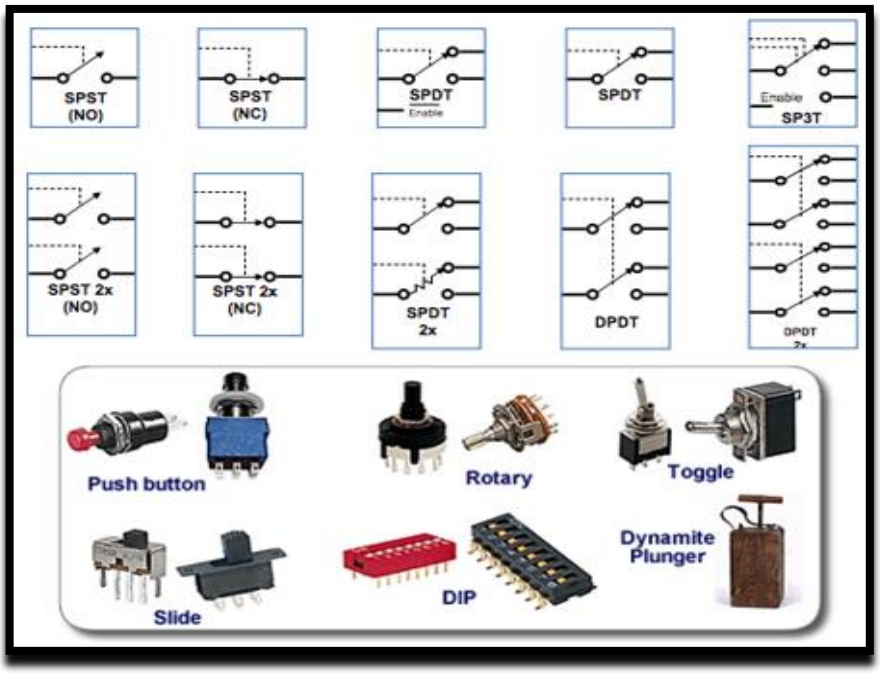


Figure 1.4: The types of switches



SPST (Single Pole Single Throw)

1. SPST is a basic ON/OFF switch, used to connect or disconnect the connection between two terminals.
2. The power supply of the owl circuit is provided by the switch.
3. This type of switch has one input and one output.

Figure 1.6: Single Pole Single Throw

SPDT (Single Pole Double Throw)

1. The SPDT switch is a three-terminal switch, one terminal is used as input, and the other two terminals are used as output.
2. 2. It connects a common terminal to one or the other of two terminals. In the SPDT switch, only the COM terminal is used, and no other terminals are used.
3. The application of SPDT switch mainly involves the three-way circuit, which is used to turn on/off the light from the top and bottom of the stairs.

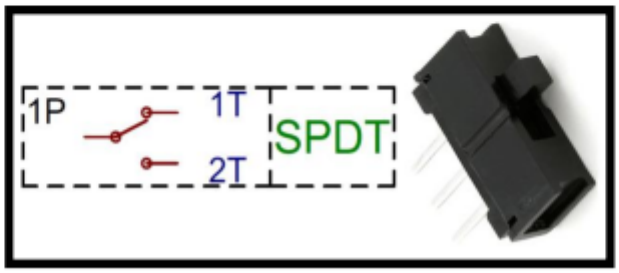


Figure 1.7: Single Pole Double Throw

DPST (Double Pole Single Throw)

1. The DPST switch consists of two poles, which means it includes two identical switches placed side by side.
2. The switch is operated by a toggle switch, which means that two discrete circuits can be controlled at a time with one press.
3. This switch is used to open/close two circuits, and it consists of four terminals, namely two inputs and two outputs.
4. The main purpose of this switch is to adjust 240V equipment, on which both power supply voltages must be ON, and the unbiased wire can always be connected.
5. When this switch is ON, the current starts to flow through the two circuits; when the current is OFF, the current is OFF.

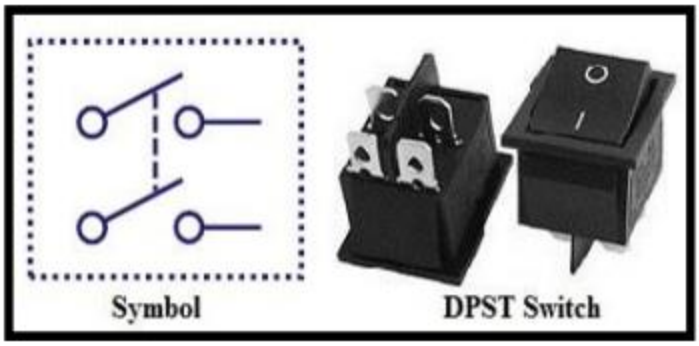


Figure 1.8: Double Pole Single Throw

DPDT (Double Pole Double Throw)

1. This switch is equivalent to two SPDT switches representing two independent circuits, connecting the two inputs of each circuit to one of the two outputs.
2. A variety of switch position control methods, each contact can be connected to two contacts.
3. When in ON-ON mode or ON-OFF-ON mode, their work is similar to two separate SPDT switches operated by similar actuators.
4. Only two loads can be turned on at a time. DPDT switches can be used in any application that requires open and closed wiring systems.

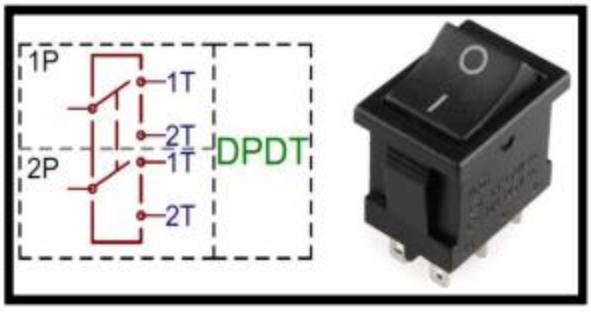


Figure 1.9: Double Pole Double Throw

PUSH BUTTONS SWITCH

1. The button switch is a two-position device, operated by pressing and releasing the button.
2. Most button switches have an internal spring mechanism, which can return the button to its "extended" or "unpressed" position for instantaneous operation.
3. Every time a button is pressed, some button switches will be turned on or off alternately.
4. The other button switches will remain in the "enter" or "press" position until the button is pulled out.

Figure 1.10: A Pushbutton Switch

LIMIT SWITCH

1. The limit switch is a low-power quick-acting device that opens or closes the contact according to the position of the mechanical part.
2. Other limit switches are sensitive to pressure, temperature, liquid level, rotation direction, etc.

Figure 1.11: A Limit Switch.

SLIDE SWITCH

1. A sliding switch is a switch activated by opening or closing two or more contact slides when two buttons are pressed.
2. The button is usually spring loaded to return to its normal position when the pressure is relieved.

Figure 1.12: A Slide Switch.

ROCKER SWITCH

1. The rocker switch is a switch activated by 3 fingers, including 2 finger buttons to open and close 2 circuits.
2. When the button is pressed, the two contacts are opened or closed, forming 2 circuits.
3. The button is usually equipped with a spring at the bottom to return to its normal position after the pressure is removed.

Figure 1.13: A Rocker Switch.

PRECISION SWITCH

1. The precision switch is a switch used to open or close the circuit activated by the scroll wheel mounted on the top of the button.
2. When the button is pressed while moving the load on the top of the scroll wheel, only one contact opens or closes.
3. The button is usually spring loaded to return to its normal position after removing the load on the top of the drum.

Figure 1.14: A Precision Switch

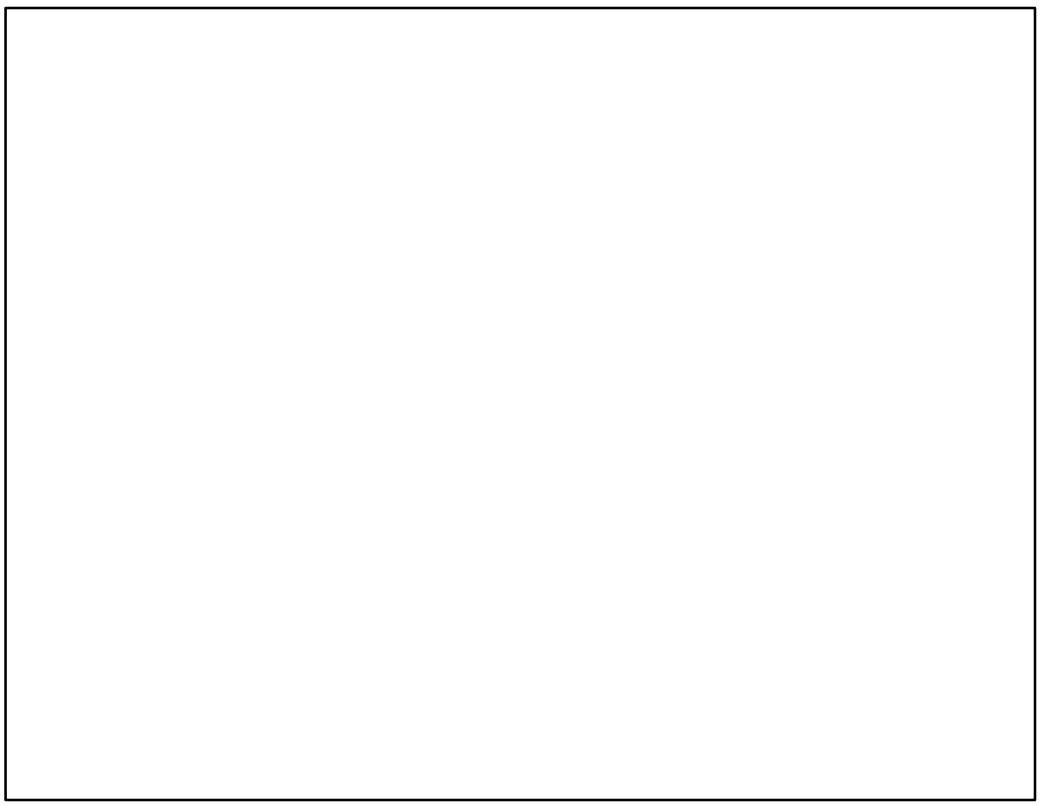
TOGGLE SWITCH

1. A) The toggle switch is actuated by a lever tilted in one of two or more positions. B) The general lighting switch used in home wiring is an example of a toggle switch. C) Most toggle switches will stop at any of their lever positions, while other toggle switches have an internal spring mechanism that can return the lever to a certain normal position to achieve so-called "instantaneous" or “momentary” operation.

Figure 1.15: A Toggle Switch

Activities:

Sketch the Double Pole Double Throw with labelling.



MICRO LIMIT SWITCH

1. The size of the miniature limit switch is much smaller of the ordinary limit switch.
2. This allows them to be used in small spaces that are inaccessible to larger devices.
3. The actuating rod of the miniature limit switch only needs a small movement to change the position of the contact.
4. The basic miniature limit switches have different shell styles and different operating levers.
5. Micro switches are widely used in various applications. For example, most limit switches are snap action.

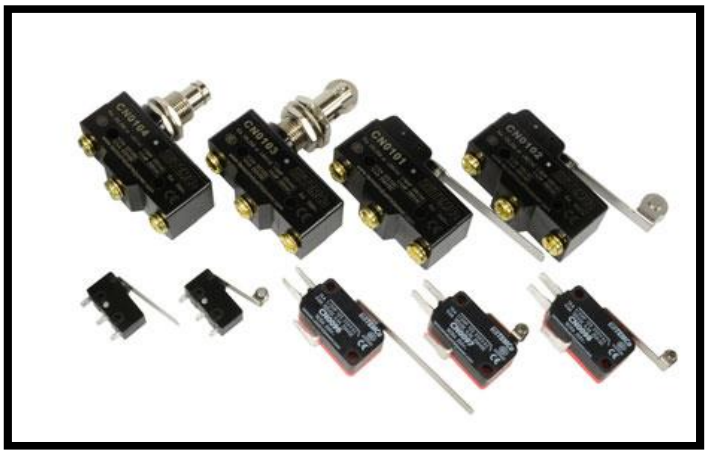


Figure 1.16: A Micro Limit Switch.

PROXIMITY SWITCH

1. The proximity switch induces the proximity of metal machine parts through magnetic or high-frequency electromagnetic fields.
2. As long as the machine parts are close (usually 1 inch or less), simple proximity switches use permanent magnets to drive the sealed switch mechanism.
3. The more complex proximity switch works similarly to a metal detector, which uses high-frequency current to power the coil and electronically monitors the current.
4. If the distance between the metal part (not necessarily the magnetic part) and the coil is close enough, the current will increase and the monitoring circuit will trip.

1. Another form of proximity switch is an optical switch, which consists of a light source and a photocell. Detect the position of the machine by blocking or reflecting the beam.
2. Optical switches are also very useful in safety applications. In safety applications, light beams can be used to detect people entering dangerous areas.

Figure 1.17: A Proximity Switch

PRINCIPLE OPERATION OF SWITCH

1. The switch should follow the International System of Units (SI), which defines ampere (the basic unit of current) as a constant current. If the constant current is maintained in two circular parallel linear contactors with infinite length and negligible cross section A component that generates force between two parallel contactors.

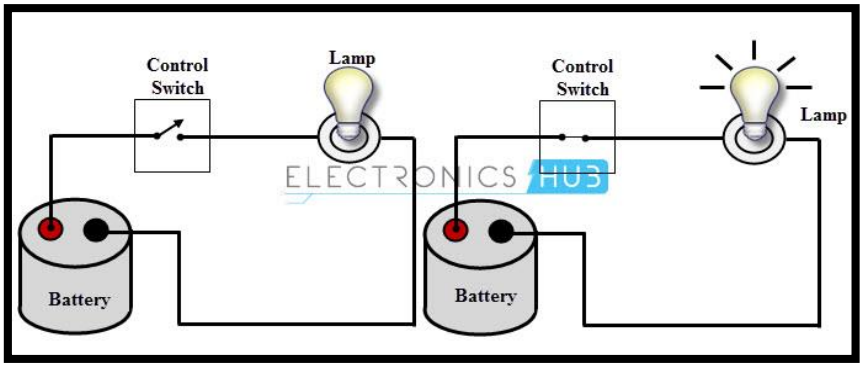


Figure 1.18: Operation of switch

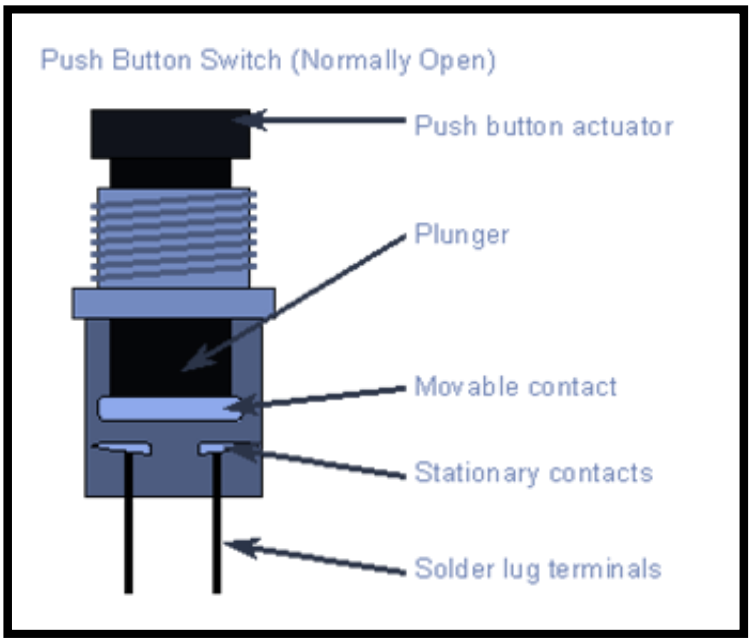


Figure 1.19: Cross section of switch

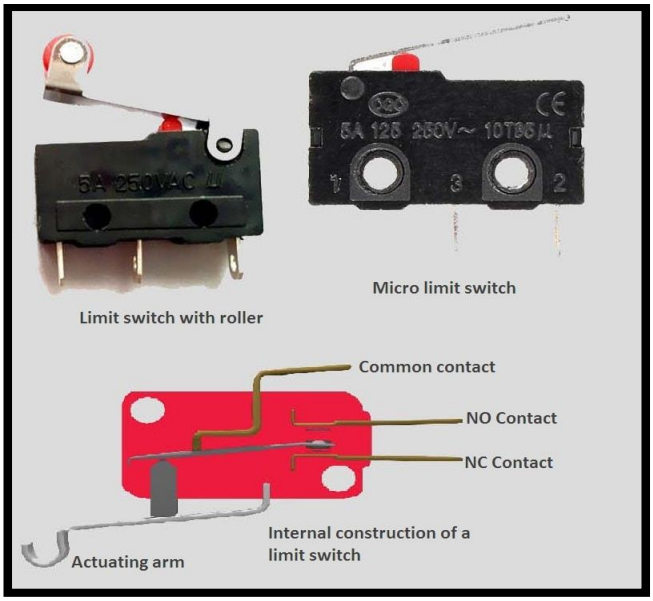


Figure 1.20: Working of Limit Switch

1. In order to understand the working principle of the limit switch, the figure shows the typical forward and reverse operation of the conveyor belt. It should be noted that One.
   a. Both limit switches have two sets of contacts (1 normally open + 1 normally closed).

Activities:

Sketch the Micro Limit Switch with labelling.

a. Three-phase induction motors are used to run conveyors.
b. Contactor A moves the motor (and conveyor belt) forward.
c. d. Contactor B rotates the motor in reverse (by swapping the two power supply phases).

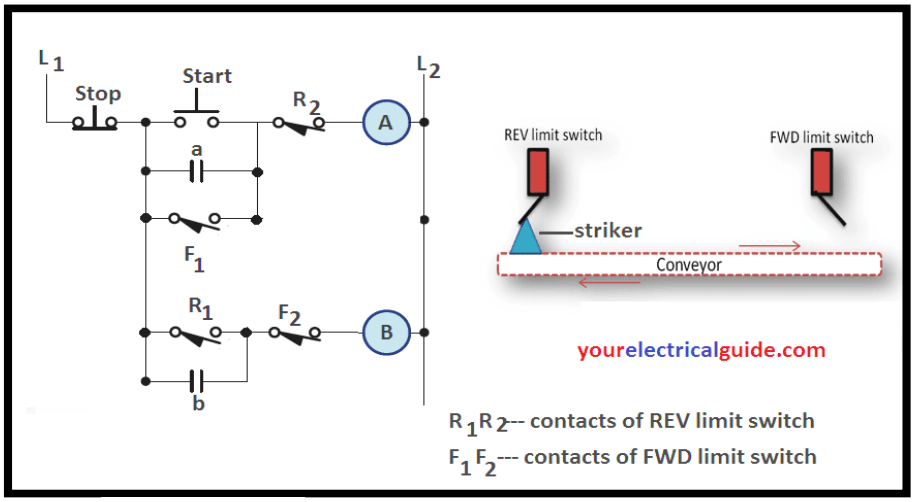


Figure 1.21: A typical forward – reverse operation

1. The operations shown in the circuit diagram can be summarized as follows:

When the start button is pressed,

a. Contactor A is energized.
b. The motor is running forward.
c. The striker connected to the conveyor belt moves in the forward direction.

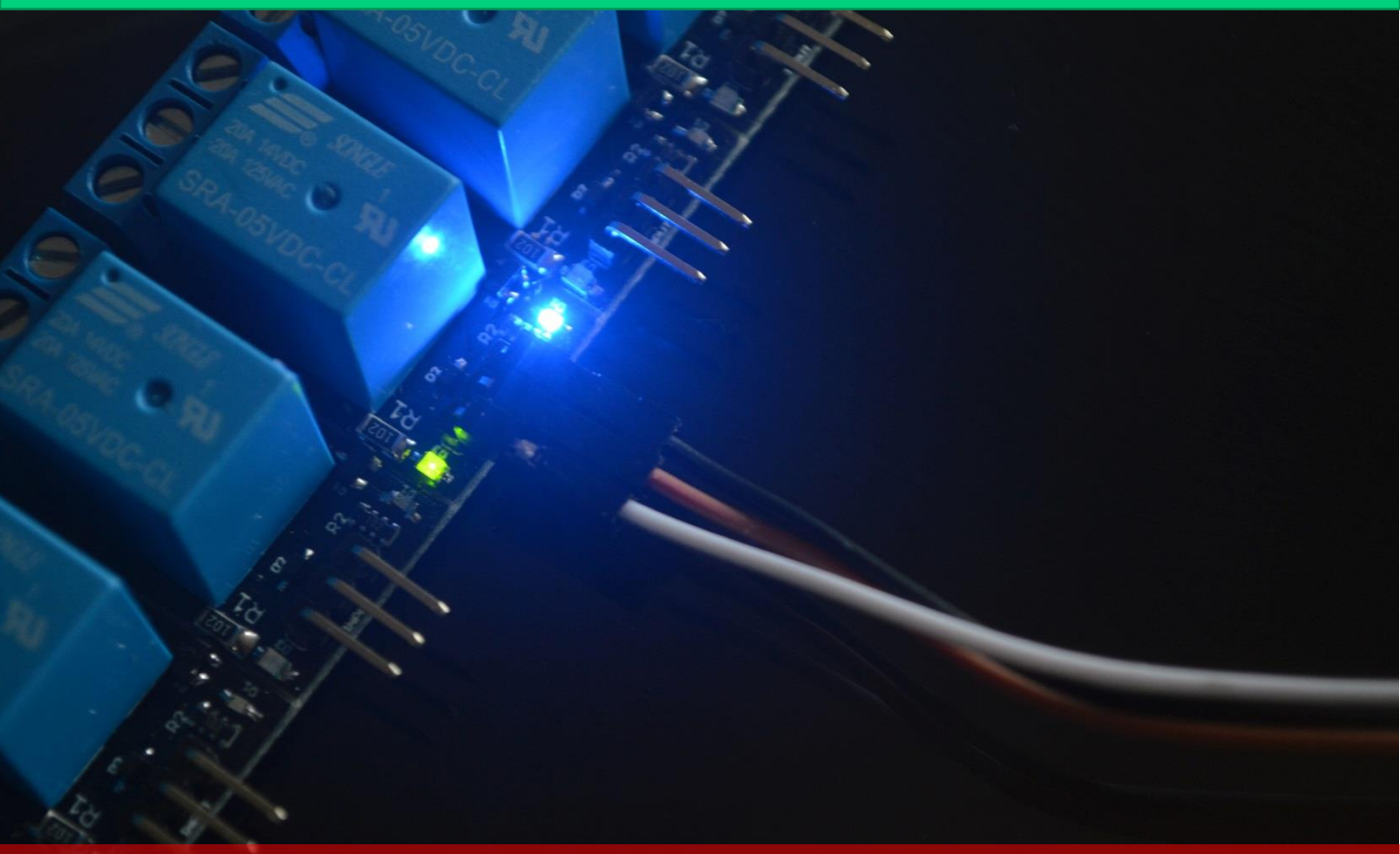
When the striker reaches the vicinity of the REV limit switch, use the limit switch to hit

a. R2 opens, contactor A is de-energized, and the motor stops.
b. R1 is closed, contactor B is energized, and the motor starts to rotate in reverse.

Similarly, when the striker reaches the vicinity of the FWD limit switch, it will be touched by the FWD limit switch, and

a. F2 is opened, contactor B is de-energized, and the motor stops.
b. F1 is closed, contactor A is energized, and the motor starts to rotate forward. The process of forward and reverse rotation will continue until the motor is turned off.

MECHATRONIC DEVICES



RELAY

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof.

Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal. Relays were first used in long-distance telegraph circuits as signal repeaters: they refresh the signal coming in from one circuit by transmitting it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

The traditional form of a relay uses an electromagnet to close or open the contacts, but other operating principles have been invented, such as in solid-state relays which use semiconductor properties for control without relying on moving parts. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called protective relays.

Latching relays require only a single pulse of control power to operate the switch persistently. Another pulse applied to a second set of control terminals, or a pulse with opposite polarity, resets the switch, while repeated pulses of the same kind have no effects. Magnetic latching relays are useful in applications when interrupted power should not affect the circuits that the relay is controlling.

INTRODUCTION OF RELAYS

A switch is a component that opens (closes) and closes (opens) a circuit. A relay is an electrical switch that uses a low-voltage source to control (turn on and off) a high-voltage circuit. The relay completely isolates the low-voltage circuit from the high-voltage circuit.

LATCHING RELAYS

1. The latching relay only needs one control pulse to continuously operate the switch.
2. Another pulse or a pulse with the opposite polarity applied to the second group of control terminals will reset the switch, and the same kind of repetitive pulse will be invalid.
3. The electromagnetic latching relay is very useful in applications where the power failure does not affect the relay control circuit.

PRINCIPLE OF RELAY

1. The relay provides simple ON/OFF switch action according to the control signal.
2. When current flows through the wire coil, a magnetic field is generated.
3. This will pull the movable arm, forcing the contacts to open or close.
4. It can then be used to provide electrical current to motors or electric heaters in temperature control systems.
5. Delay relay is a control relay with delayed switching action.
6. The time delay is usually adjustable and can be activated when current flows through the relay coil or when current stops flowing through the relay coil.

CONSTRUCTION OR RELAY

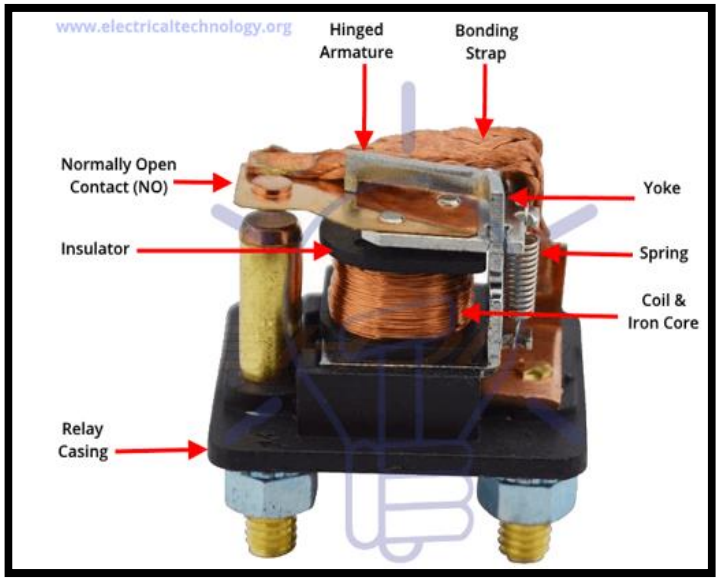


Figure 2.1: Parts of relay

1. The relay operates both electrically and mechanically.
2. It consists electromagnetic and sets of contacts which perform the operation of the switching.

TERMINALS OF RELAY

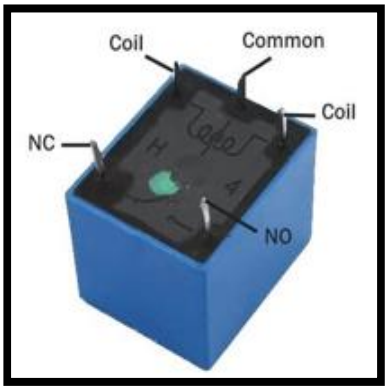


Figure 2.2:Relay terminal

Control Input or Coil Terminals

1. The control input terminals are the two input terminals of the relay that controls its switching mechanism.
2. A low-power power supply is connected to these terminals to activate and deactivate the relay.
3. According to the type of relay, the power supply can be AC or DC.

COM or Common Terminal

1. COM is the common terminal of the relay.
2. This is the output terminal of the relay connected to one end of the load circuit.
3. According to the state of the relay, this terminal is internally connected to one of the other two terminals.

NO Terminal

1. The "normally open" or "normally open" terminal is also the load terminal of the relay. When the relay is not activated, this terminal remains open.
2. When the relay is activated, the NO terminal and COM terminal are closed.

NC Terminal

1. NC or normally closed terminal is another load terminal of the relay.
2. When there is no control input, this terminal is usually connected to the COM terminal of the relay.
3. When the relay is activated, the NC terminal is disconnected from the COM terminal and remains disconnected until the relay is disabled.

POLES AND THROW

1. The pole refers to the switch inside the relay.
2. The number of switches inside the relay is called the number of poles of the relay.
3. The number of circuits controlled by each pole is called relay throwing.
4. The number of poles and the number of throws are the configuration of the relay, where the number of poles is the switch and the number of throws is the number of connections.

1. Single pole single throw is the simplest type of relay, with only one switch and one possible connection.
2. Similarly, SPDT relays have one switch and two possible connections.
3. Single-throw relays can only control one circuit, which is "off" or "open", while double-throw relays can control two circuits, that is, by opening one circuit and closing the other circuit during switching ("open" and "open"). Off") to switch from one circuit to another.

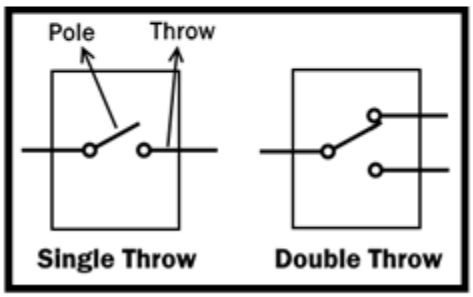


Figure 2.3: Connection of relay

The Contacts

1. There are two mechanical parts inside each relay.
   a. The first is the contact of the relay.
   b. The operation of the contact is similar to that of a simple switch or button. As shown in Figure 2.4, consider the contacts as a pair of metals.
   c. The two terminals are used as switches. When the contact is in the "contact contact" state, current flows from terminal 1 to terminal 2.

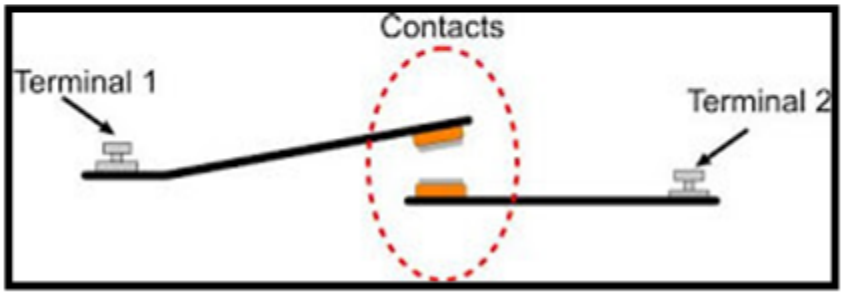


Figure 2.4:The relay contacts

How a NO / NC contact operates by lighting a light bulb?

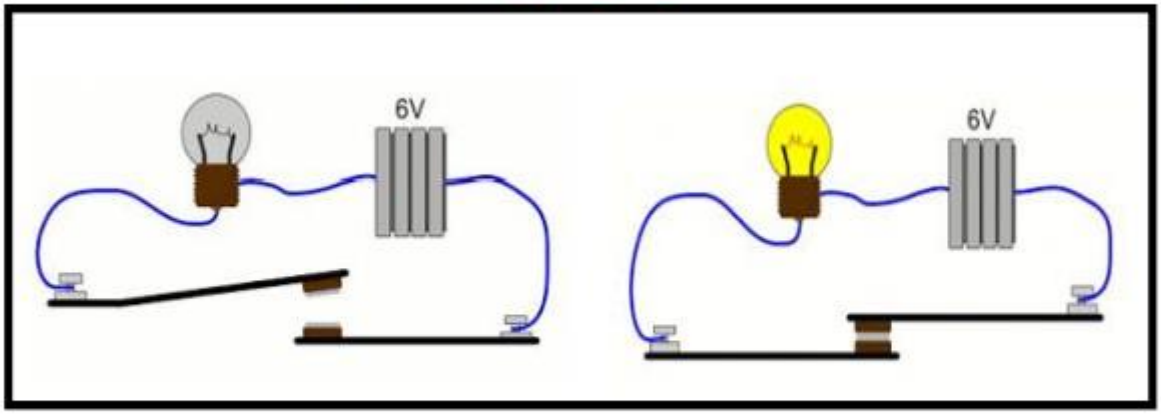


Figure 2.5: Relay contacts operates a bulb

A combination of contacts

1. The relay may have a combination of the above contacts.
2. In this case, there is a third terminal named "COMMON". Normally open and normally closed contacts are called common terminals.
3. There is always no contact between NC and NO contacts.

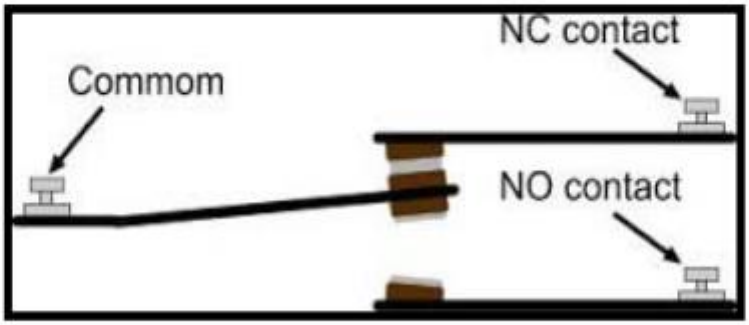
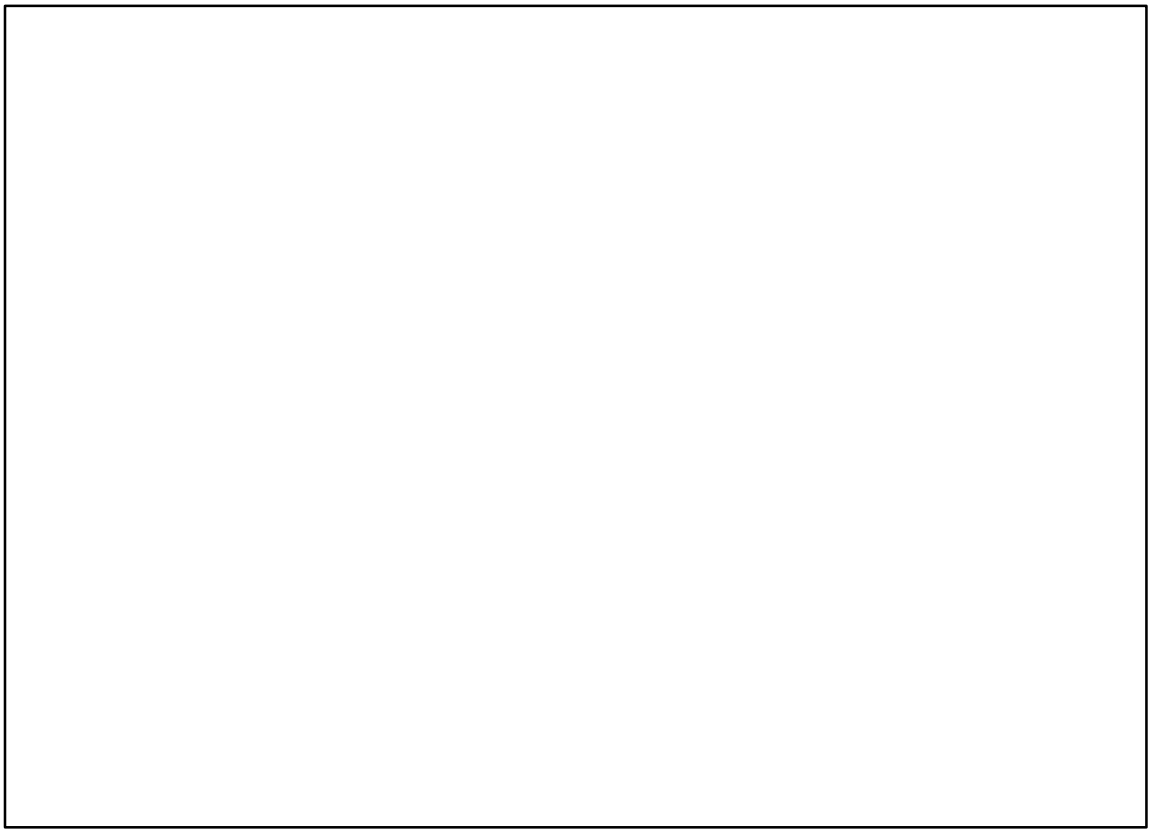


Figure 2.6: Combination of contacts

Activities:

Sketch the Construction of Relay with labelling.



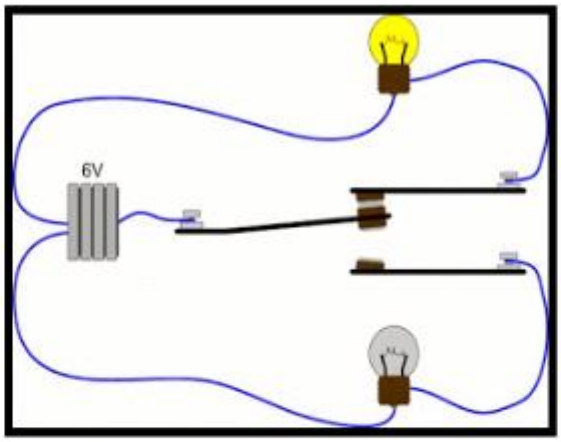


Figure 2.7: A combination contacts operates a bulb

RELAY OPERATION

What defines the NORMAL state?

1. Now consider normally open and normally closed contacts. But which state is considered NORMAL? One step closer to relay operation, we found the spring.
2. The spring determines the normal position of the ordinary contact.
3. Refer Figure 2.8 and Figure 2.9, please note that F force is applied to the COMMON terminal once, and no force is applied the other time. Well, this is actually wrong.
4. There is indeed another force that pulls the contact up, and that force is always applied. This force comes from spring.
5. Now you can see who has been pulling up the COMMON terminal. Therefore, the spring defines what is the normal state, thereby defining which contact is "normally open" and which "normally open".
6. The NORMAL state is defined as the state where no force is applied to the COMMON terminal except the spring.

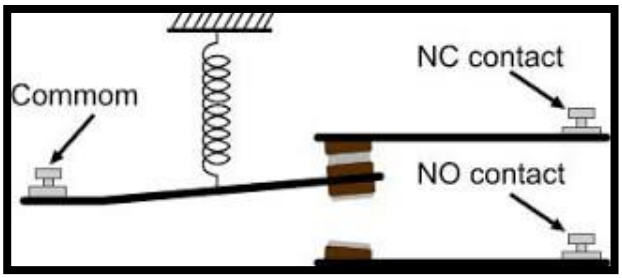


Figure 2.8: Position of common contact

1. The device that forces the terminal to move is actually an electromagnet. The coil is directly below the contact.
2. When current flows through the coil, a magnetic field is generated. This magnetism can overcome the force of the spring and can pull the spring towards the spring, thereby changing the position of the spring. And because the contact is usually a small piece of metal that cannot be pulled by the electromagnet, another piece of metal is fixed on the common terminal.
3. The so-called "armature" of this piece of metal.

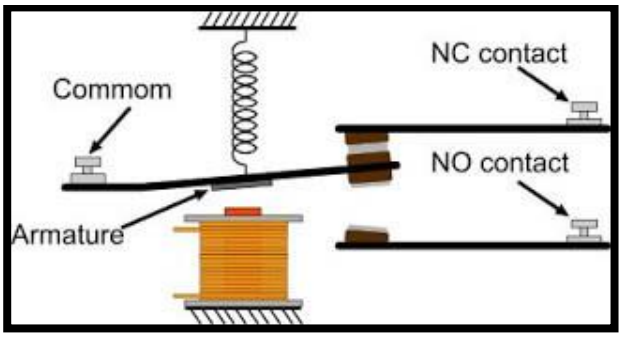


Figure 2.9: The relay operation

Now, suppose someone wants to use the command of a 5 volt battery to control a 220 volt 1 K watt load. Load relays should be used for this application.

1. The coil of the relay is driven at 5 volts.
2. The contact of the relay (NO) will be connected in series with the power supply of the load.
3. Therefore, the load will only work when the relay is activated.

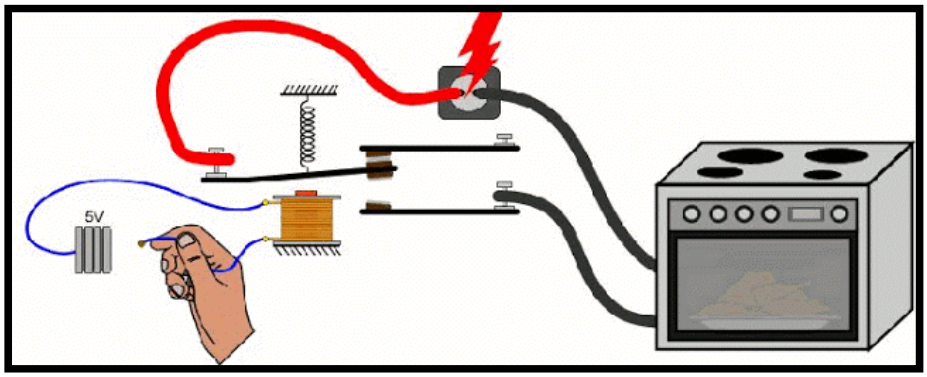


Figure 2.10: An application of relay

Inside the relay

1. It uses octal relays.
2. These relays are easy to open (using screws or clamps) and are large enough to be seen. So this is the open relay:

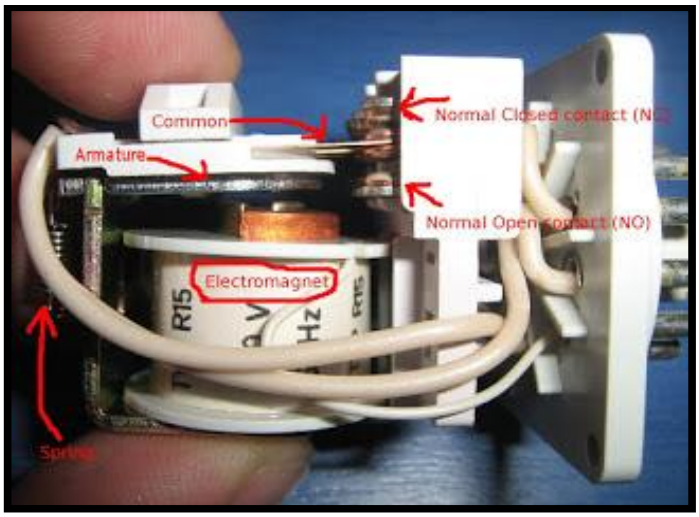


Figure 2.11: An octal-type relay

3. You can clearly see ordinary contacts, normally open contacts and normally closed contacts, as well as solenoid coils and return springs.
4. The armature is a thick metal that fixes the common contact.

SYMBOL OF RELAYS

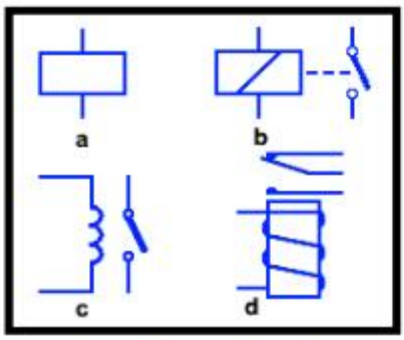


Figure 2.12: A symbol of relays

RELAYS OPERATION

Assume an **SPDT** (single pole double throw) relay

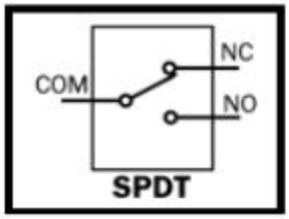


Figure 2.13: Single Pole Double Throw relay

1. In the absence of power, the relay is in an inactive state, and its pole position is maintained on the NC terminal. In the above case, this terminal happens to be the upper terminal. This causes an electrical short circuit between the COM terminal and the NC terminal. Therefore, it allows current to flow through the circuit connected to the COM & NC terminal.
2. When using a low-voltage power supply to switch on the relay power, the pole of the relay moves to the NO terminal. Therefore, the NC terminal is opened and the COM terminal is closed or electrically short-circuited with the NO terminal. Subsequently, the current flows through the circuit connected to the COM & NO terminal.

ELECTROMECHANICAL RELAY

1. An electromechanical relay is an electrical switch actuated by an electromagnetic coil.
2. As switching devices, they exhibit simple "on" and "off" behaviors, with no intermediate states.
   a. A coil of wire wound on the laminated core provides the magnetic field required to drive the switching mechanism. The dotted line represents the influence of the solenoid on the actuation of the relay contacts.
   b. b. This particular relay is equipped with a normally open (NO) switch contact, which means that when the relay coil is de-energized, the switch will be in an open (OFF) state. The "normal" state of the switch is a static state without stimulation. When the coil of the relay coil is not energized, the relay switch contact will be in the "normal" state

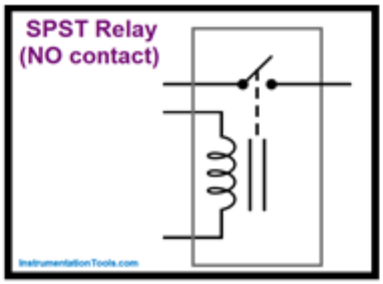


Figure 2.14: The electronic schematic symbol for SPST NO

   c. Single-pole single-throw relays with normally closed (NC) switch contacts will be represented in the electronic schematic, as shown in Figure 2.15 below.

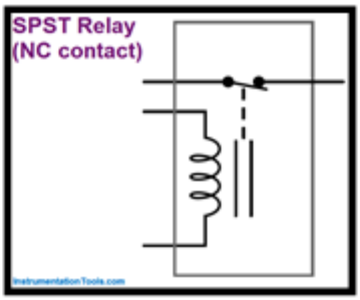


Figure 2.15: The electronic schematic symbol for SPST NC

a. In the field of electrical control, the labels "Form-A" and "Form-B" are synonymous with "normally open" and "normally closed" contacts respectively. Therefore, we can label the SPST relay contacts as "Form-A" and "Form-B" respectively:

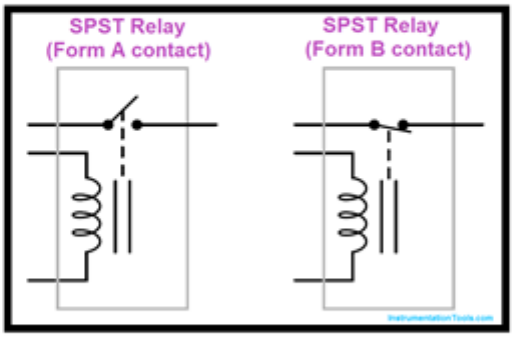


Figure 2.16: The single-pole, single-throw (SPST) relay contact

b. An extension of this topic is single pole double throw (SPDT) relay contacts, also known as "Type C" contacts.
c. This design of the switch provides a normally open and normally closed contact group in a unit, driven by an electromagnetic coil:

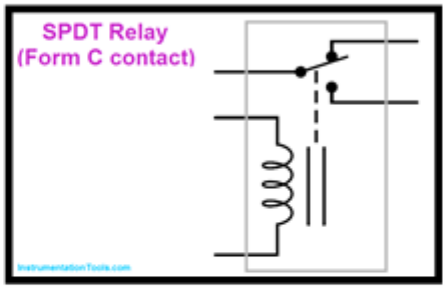


Figure 2.17: The single-pole, double-throw (SPDT) relay contact

d. A further expansion on this topic is the double pole double throw (DPDT) relay contact.
e. This design of the switch provides two sets of C-type contacts in one unit, which are simultaneously driven by electromagnetic coils:

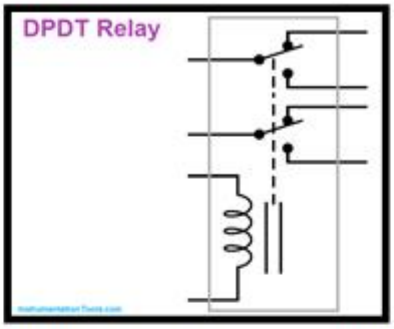


Figure 2.18: The double-pole, double-throw (DPDT) relay contact

a. The Figure 2.19 below shows the DPDT "Ice Cube" relay, which can be inserted into its base (left) and the plastic cover removed to expose two sets of Form-C contacts (right):

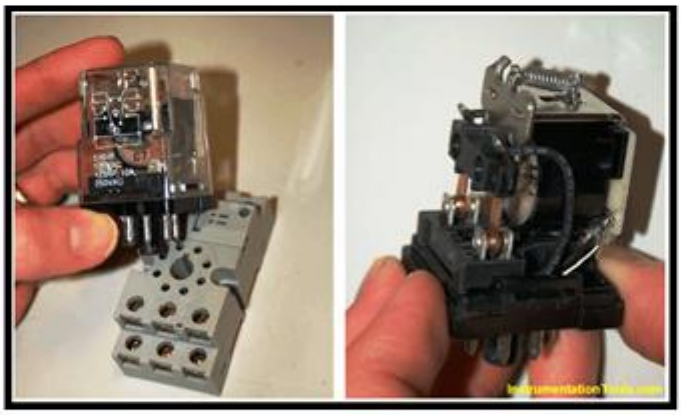


Figure 2.19: A relay plug base (left) and sets of Form-C contacts (right)

a. These relays are connected to the socket via eight pins: three for each of the two Form-C contact sets, and the other two for the coil connection. Due to the number of pins (8), this type of relay base is usually called an octal base.
b. A close-up view of a C-shaped contact shows how the movable metal "leaf" is in contact with one of the two fixed points. The actual contact point is made from the silver-plated "button" at the end of the leaf. The following figure shows a Form-C contact in two locations:

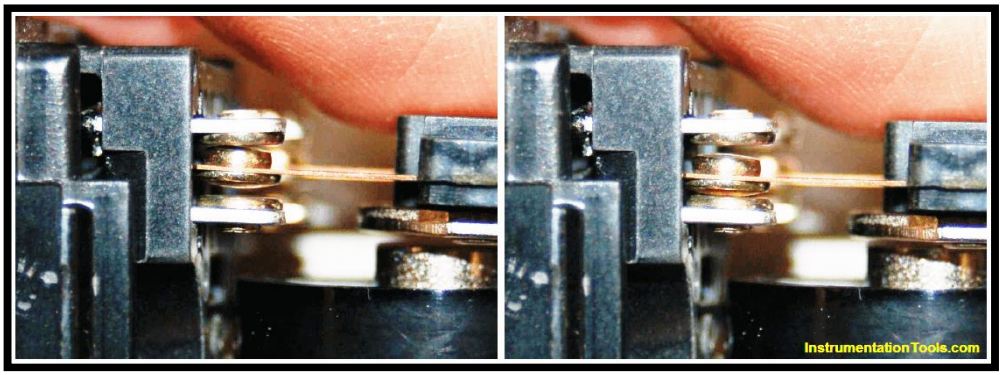


Figure 2.20: A closer view of one Form-C contact

DIAGRAM OF RELAYS

1. Even between relays with the same function, the styles of these diagrams may be different. The Figure 2.21 shown as an example, these pictures were taken on three different brands of DPDT relays:

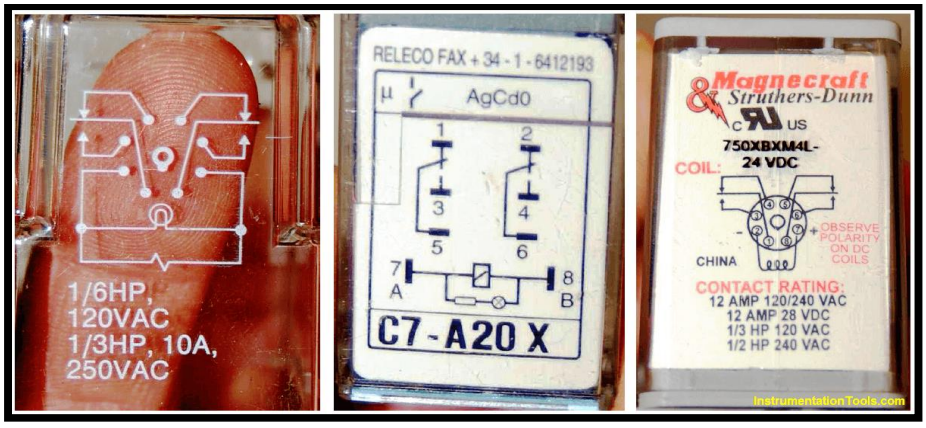


Figure 2.21: A diagrams of relay

2. Please keep in mind that although the physical dimensions and contact ratings (voltage and current capacity) are different, the basic functions (DPDT switching) of these three relays are the same.
3. Only two of the three diagrams shown use the same symbol to represent contacts, and all three use unique symbols to represent coils.

PRINCIPLE OF RELAYS

1. Its working principle is electromagnetic attraction.
2. When the circuit of the relay detects a fault current, it will excite an electromagnetic field that generates a temporary magnetic field.

   a. This magnetic field moves the armature of the relay to open or close the connection. The low-power relay has only one contact, and the high-power relay has two contacts to open the switch.

   b. The inside of the relay is shown in the Figure 2.22 below. It has an iron core wound by a control coil. Power is supplied to the coil through the load and the contacts of the control switch. The current flowing through the coil generates a magnetic field around the coil.

   c. Due to this magnetic field, the upper arm of the magnet attracts the lower arm. Therefore, the circuit is closed and current flows through the load. If the contact has been closed, it will move in the opposite direction and therefore open the contact.

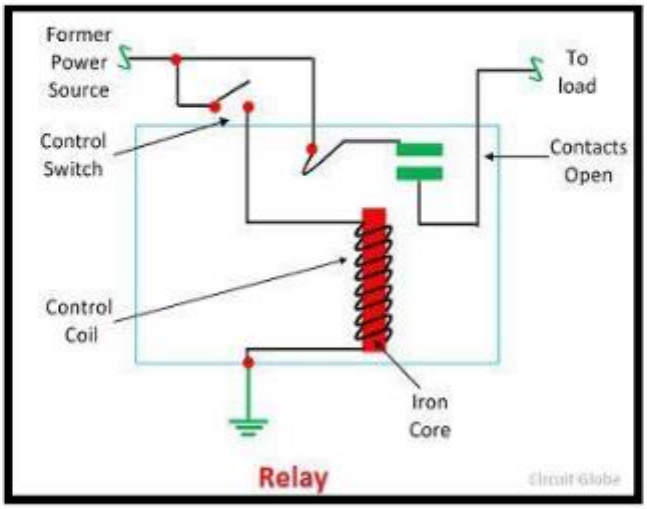


Figure 2.22: Working principle of relay

TYPES OF RELAY

1. There are many types of relays, divided into different categories according to their characteristics.
2. Each type of relay is used for a specific application, and before being used in any circuit, a suitable relay must be selected.

Based on Poles & Throw

The following types of relays are classified according to the number of poles and throws inside the relay.

SPST Relay

1. SPST refers to single pole single throw relay.
2. Single pole means that it can only control one circuit, while single throw means that its pole has only one position where it can be turned on.
3. SPST relay has two states, namely "open" or "closed" circuit.

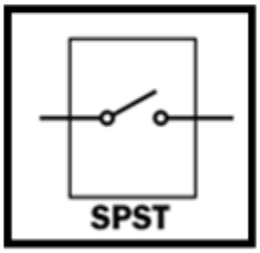


Figure 2.23: Single Pole Single Throw Relay

SPDT Relay

1. SPDT refers to single pole double throw relay.
2. Unipolar means that it can only control one circuit at a time.
3. Double throw means that its rod has two positions where it can conduct electricity.
4. SPDT relay has two states, in each state, one circuit remains closed, while the other circuit remains open, and vice versa

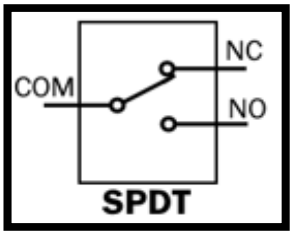


Figure 2.24: Single Pole Double Throw Relay

DPST Relay

1. DPST refers to double pole single throw.
2. Bipolar means that it can control two completely isolated independent circuits.
3. A single shot means that each rod has a conductive position.
4. DPST relay can switch two circuits at the same time, that is, provide a closed or open circuit

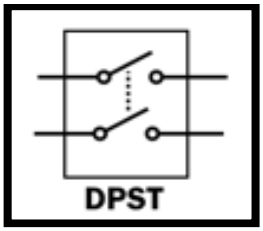


Figure 2.25: Double Pole Single Throw Relay

DPDT Relay

1. DPDT refers to double pole double throw.
2. Double pole means that two circuits can be controlled, double pole means that each poles can be conducted in two separate positions.
3. DPDT relay can be interpreted as two SPDT relays, but their switching is simultaneous.
4. The relay can have up to 12 poles.

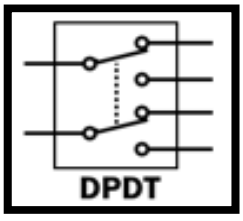


Figure 2.25: Double Pole Double Throw Relay

Normal relays

1. There are basically two types of relays in this category.
2. The first type is an ordinary on/off relay.
3. As long as the electromagnet is activated, the relay will change state, and when the electromagnet is no longer activated, the relay returns to the relaxed state.
4. This is the most common type of relay, widely used in automation.

Figure 2.26: The most common relay type

Toggle relays

1. This relay operates like a trigger.
2. Once the coil is driven, the relay will change state, even if the coil is no longer driven, the relay will maintain that state.
3. It will only change state again on the next pulse that triggers the coil. This is very convenient in modern house lighting.
4. Using this relay instead of a switch, you can use a button to turn the light on and off. Press the button once and the indicator will light up. The light will turn off the next time the button is pressed.

Latching relays

1. The operation of this relay is exactly the same as the R-S flip-flop.
2. It has two different coils instead of one.
3. When the first coil is activated, the relay will turn to the SET position, regardless of whether the coil remains activated or not, the relay will remain in this position.
4. Only when another coil is driven, it will change state (to the reset position).
5. This kind of relay is widely used in applications that need to maintain the state of the relay even after a power failure or restart.

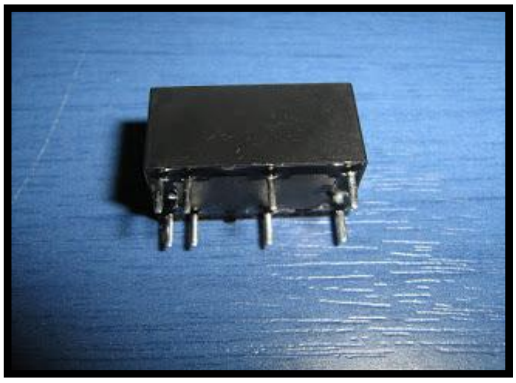


Figure 2.27: A latch relay

RELAY CHARACTERISTICS

The things that characterizes a relay are the followings:

Figure 2.28: Characterizes a relay

1. Coil voltage:
   This is the voltage at which the coil can drive the armature. This value should also indicate whether the current is AC or DC.

2. Coil current:
   This value represents the current that the coil will draw when powered by the specified coil voltage. Very important characteristics to consider when designing a relay driver. The current flowing through the driver must be sufficient to drive the armature.

3. Shut-off voltage:
   This characteristic represents the minimum voltage at which the armature is drawn by the electromagnet. If the voltage drops below this value, the spring will overcome the magnetic force and the relay will change state.

4. Number/type of contacts:
   Is it SPST? DPST? DPDT? Or what?

5. Contact power:
   This characteristic indicates the maximum power that the contact can handle. Some manufacturers will use voltage and amperage, others will use voltage and kilowatts, and others will display all three values.

6. Working temperature:
   The temperature at which the relay can work normally.

7. Switching frequency:
   Maximum on-off frequency.

8. Packaging:
   Some packages come with suitable bases, while others are soldered/connected directly to the PCB/electrical cabinet.

APPLICATIONS OF RELAY

1. Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal.
2. Relays were first used in long-distance telegraph circuits as signal repeaters: they refresh the signal coming in from one circuit by transmitting it on another circuit.
3. Relays were used extensively in telephone exchanges and early computers to perform logical operations.
4. The traditional form of a relay uses an electromagnet to close or open the contacts, but other operating principles have been invented, such as in solid-state relays which use semiconductor properties for control without relying on moving parts.
5. Relays with calibrated operating characteristics and sometimes multiple operating coils are used to protect electrical circuits from overload or faults; in modern electric power systems these functions are performed by digital instruments still called protective relays.
6. The relay is used to isolate the low-voltage circuit from the high-voltage circuit.
7. Relays are used to control multiple circuits.
8. Relays are also used for automatic conversion.
9. The microprocessor uses the relay to control the heavy electrical load.
10. The overload relay is used to protect the motor from overload and electrical failure.

SPECIFICATION OF RELAY ACCORDING TO NEMA

1. The standard voltage of relays used for machine control is 120 volts.
2. The coils on electromechanical equipment (such as relays, contactors and motor starters) are designed to not drop (power off) before the voltage drops to more than 85% of the rated voltage.
3. The relay coil will not start (energize) before the voltage rises to 85% of the rated voltage. This voltage level is set by the National Electrical Manufacturers Association (NEMA).

RELAY CIRCUIT - LADDER DIAGRAM

1. Electromechanical relays can be connected together to perform logic and control functions, acting as logic elements like digital gates (AND, OR, etc.).
2. A very common form of schematic diagram showing the interconnection of relays to perform these functions is called a ladder diagram.
3. In the "ladder diagram", the two poles of the power supply are drawn as the vertical guide rails of the ladder, and the horizontal "step" shows switch contacts, relay contacts, relay coils and final control elements (lamps, solenoids) (motors) inserted Between power rails.
4. Ladder diagrams are different from the conventional schematic diagrams commonly used by electronic technicians, mainly in the strict direction of wiring: vertical power "rails" and horizontal control "steps".
5. The symbols are also slightly different from common electronic symbols: the relay coil is drawn as a circle, and the relay contact is drawn in a similar way to a capacitor:

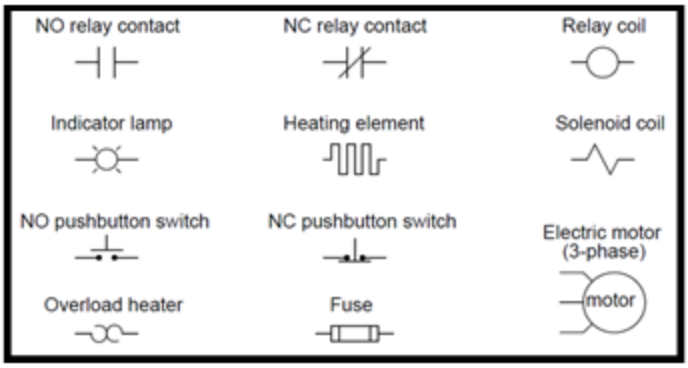


Figure 2.29: A ladder diagram symbols

6. In this case, the word "normal" (whether it is a manual switch, the state of the process switch or the state of the switch contacts inside the control relay) means "resting" or no stimulation.
7. In other words, when the relay coil is not energized, the "normally open" relay contact is disconnected, and when the relay coil is energized, it is closed.
8. Similarly, when the relay coil is not energized, the "normally closed" relay contact is closed; when the relay coil is energized, it opens.

Example 1: A relay control circuit where a pressure switch activates an alarm light

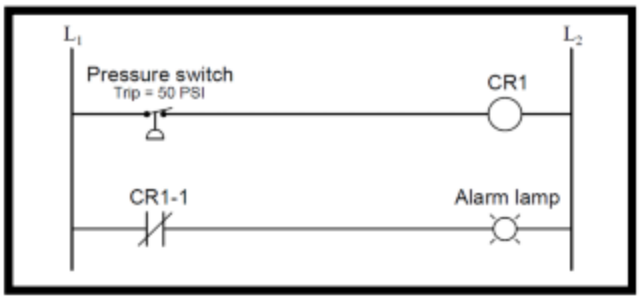


Figure 2.30: A relay control circuit

1. Here pressure switch and relay contact (CR1-1) are drawn as normally closed switch contacts.
2. This means that when the applied pressure is less than its trip point (50 PSI), the pressure switch contact will be closed, and when the relay coil is de-energized, the relay switch contact will be closed.
3. When analyzing the operation of the relay control system, it is best to temporarily indicate the conductive state of the switch contacts and the energized state of the relay coil in some way. **Use the arrow and the "X" symbol to represent the trend, there is no trend. These symbols clearly indicate the status of the components while avoiding confusion with the symbols used to indicate the normal status of the switch contacts.
4. Assuming that the applied pressure is less than 50 PSI, the pressure switch is in the "normal" (closed) state:

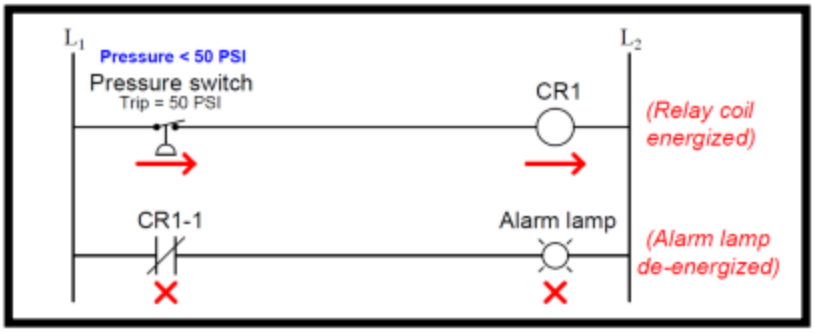


Figure 2.31: The pressure switch less than 50 PSI

1. Since the pressure is insufficient to actuate the pressure switch, its contacts remain in the "normal" state (closed). This sends power to the relay coil CR1, which activates the contact CR1-1 and keeps it in the open state.
2. When the CR1-1 contact is disconnected, the warning light is not energized. In this example, the pressure switch is in the "normal" state and the relay is in the activated state. **Use the arrow and the "X" symbol again to indicate whether there is a power supply in the circuit, and now use a switch pressure greater than 50 PSI to analyze its state:

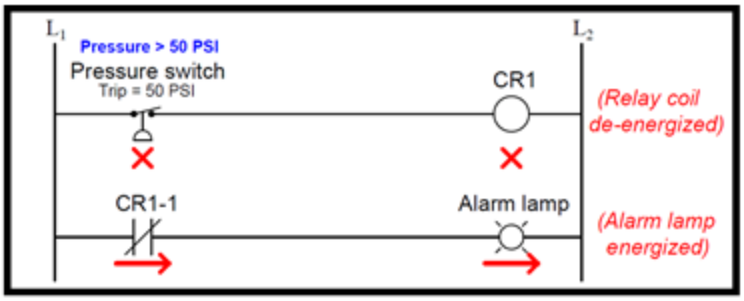


Figure 2.32: The pressure switch more than 50 PSI

3. Now that enough fluid pressure has been applied to the switch to actuate the switch, its contacts are forced to enter the actuation state, and the "normally closed" switch is in the off state.
4. This disconnected state de-energizes the relay coil CR1 and makes the relay contact CR1-1 bounce back to its normal state (closed), thereby supplying power to the warning light.
5. Through this analysis, the lamp can realize the high-voltage alarm function and energize when the applied pressure exceeds the trip point.

Example 2: Relay Latching Circuit using Push Button

1. When the button is pressed, the relay should open. This means using a normally open button, because when the switch is pressed, the power will move forward.
2. When the relay coil is powered, the relay should open. The relay here is operated at 24 V DC.

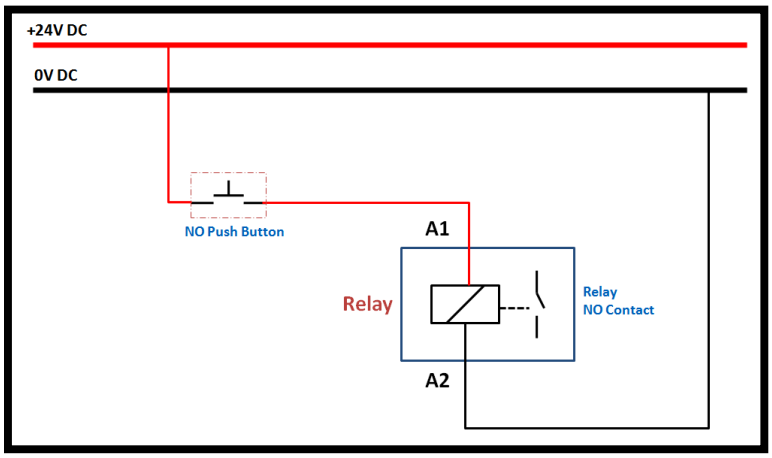


Figure 2.33: Relay Latching Circuit using Push Button

1. Connect the relay and button as shown in Figure 2.34. When the button is pressed, the power will reach the relay A1 point, the relay is turned on, and its contacts change, but when the button is released, the power is cut off and the relay is turned off. But the relay is not outdated. Therefore, please use the relay normally open contact to hold.

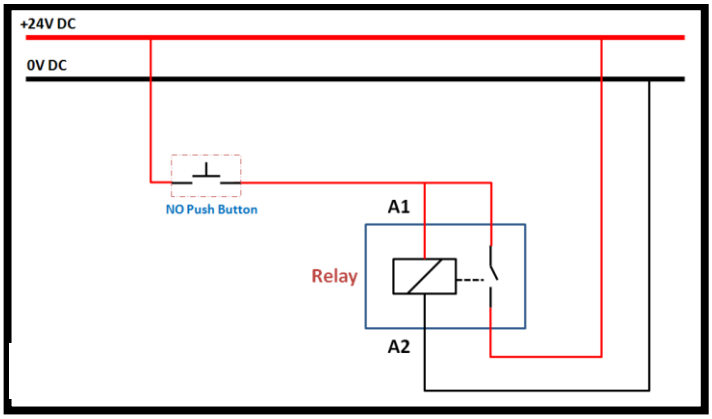


Figure 2.34: Relay Latching Circuit with NO contact

2. Connect +24VDC to the COM point of the relay, and connect the NO point to the A1 point of the relay.
3. Press the button to enter the relay, the relay opens, the contact changes, and the NO point becomes the NC point.

1. Now, the +24VDC power supply is directly connected to A1 and the relay is turned on. If released, the button power will be disconnected from the button, but the power will always come from the NO point, and the relay will be permanently opened or maintained.
2. 7. Use the NC button to disconnect the power.

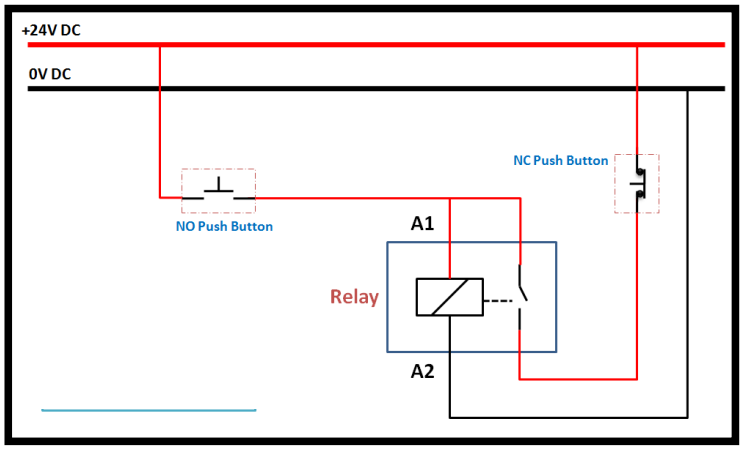


Figure 2.35: Relay Latching Circuit with NC push button

HOW TO READ A RELAY SCHEMATIC

Relay Logic Circuit Example

1. Figure 2.36 is an example of the relay logic circuit, which shows a light (No. 1 light) is turned on through a relay (No. 1 relay).
2. There is a rotary switch in the first row, which is connected to the coil of relay 1. The relay coil is marked as R1.
3. The second wire has a normally open contact from relay 1, which is also marked R1, and it is connected to light 1.
    a. To help understand the relay schematic, read the sequence of events from the first horizontal line down and from the left power rail to the right power rail.
    b. Read from left to right, because the potential difference between the left and right power rails will generate current in that direction. In the example relay schematic, the green line is used to highlight the current in the circuit.

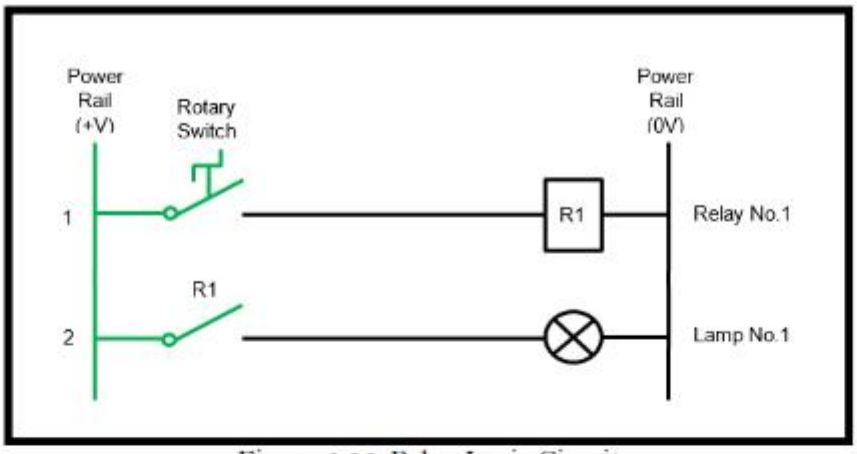


Figure 2.36: Relay Logic Circuit

1. Starting from the left power rail, drive along the horizontal line until it reaches the normally open rotary switch.
2. If the rotary switch is in the "on" state, it means an open circuit and current cannot flow to the right side of the circuit. Therefore, the relay coil (R1) remains de-energized.
3. Turn to the second line. This is because the relay No. 1 coil (R1) is de-energized and the normally open relay contact (R1) remains open.
4. Therefore, there is also an open circuit on the second line, so no current can flow to the lamp, and the lamp remains off.

Basic Relay Logic Circuit Example - With Rotary Switch Off

1. When the rotary switch is turned on, its state changes from "on" to "off".
2. Looking at the first line, starting from the left power rail, and then following the horizontal line until reaching the rotary switch, we can observe that it is in the "closed" state and current can flow to the right side of the circuit.
3. In this case, the relay coil (R1) is energized, and then we reach the end of the right rail.
4. Turning to the left side of the second row, we noticed that since the relay coil is energized, the normally open relay contact (R1) has also changed its state to "closed".
5. Therefore, there is a closed circuit on the second line, so the current can flow to the right side of the circuit, and the No1 light is on.

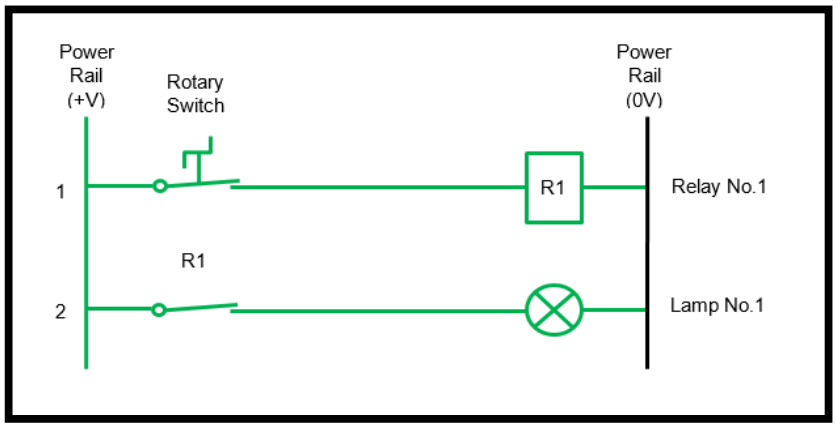


Figure 2.37: Basic Relay Logic Circuit With Rotary Switch Off

Basic Relay Logic Circuit Example – With Rotary Switch On

1. Wire the second relay contact of relay No. 1 as a normally closed contact.
2. Add a second light (light 2) in the new circuit.
3. In this case, the operation of the lamp will be reversed.
4. Therefore, when the rotary switch is OFF, the No. 2 light is ON; when the rotary switch is ON, the No. 2 light is OFF.

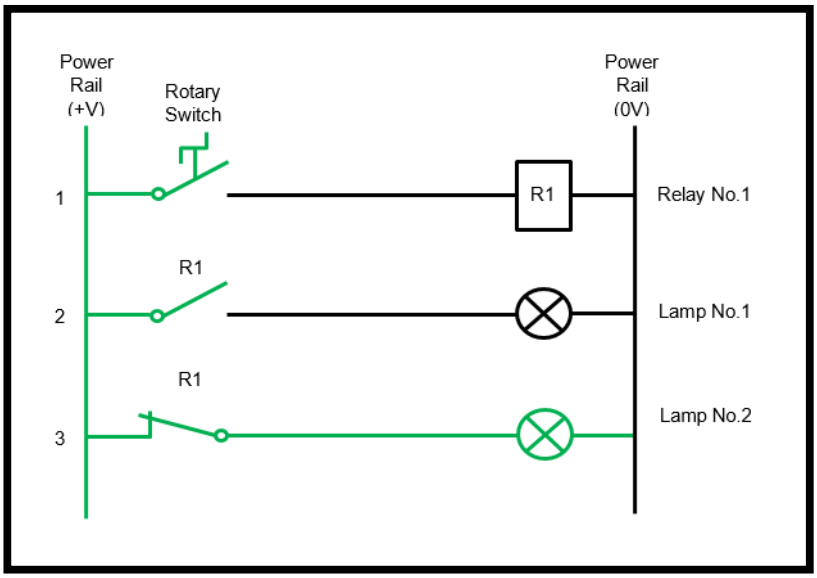


Figure 2.38: Basic Relay Logic Circuit With Rotary Switch On

Relay Reverse Logic - With Rotary Switch Off

1. The new relay contacts in the third row are now normally closed instead of normally open.
2. When the No. 1 relay coil is de-energized, its normally closed contact is in the normal state, that is, "closed".
3. After the No. 1 relay coil is energized, the normally closed contact will become "open".
4. The behavior of normally closed contacts is opposite to that of normally open contacts. Sometimes called reverse relay logic or simply reverse logic.

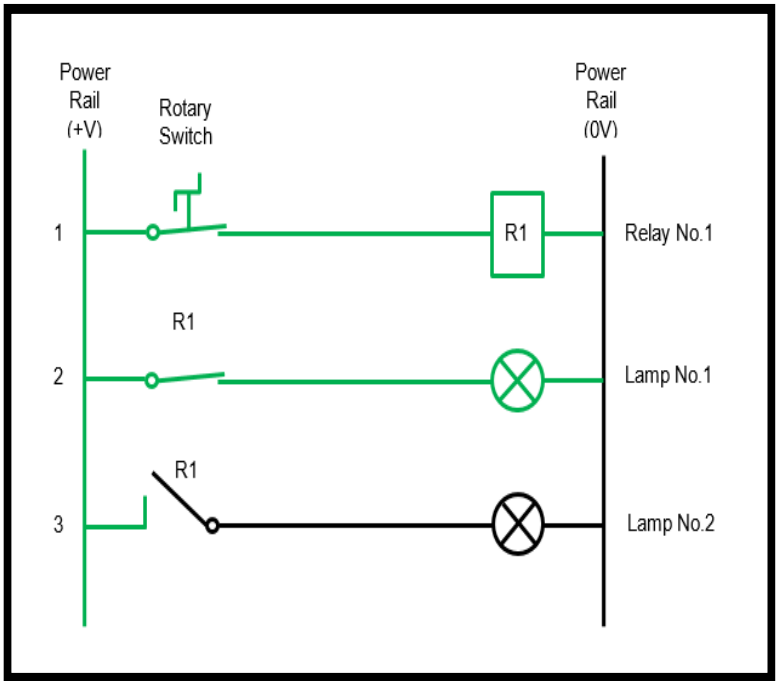


Figure 2.39: Relay Reverse Logic – With Rotary Switch Off

Activities:

Sketch the Relay Logic Circuit with labelling.

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