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INDUSTRIAL AUTOMATION WITH PLC

WORKING OF A RELAY

From a small traffic signal controller to a complex high voltage switchyard, relays can be found everywhere. To put it in general, relays are just like any other switch which can either make or break a connection that is it can either connect two points or disconnect it, therefore relays are commonly used to turn on or off an electronic load. But, this is a very generalized statement, there are many **types of relays** and each relay behaves differently as required for its application, one of the most popularly used relays is the **electromechanical relay** and hence we will focus more on that for this article. Despite the differences in construction, the basic working principle of a relay is the same, so let's discuss more on basic **relay operation** and take a deeper look into its construction.

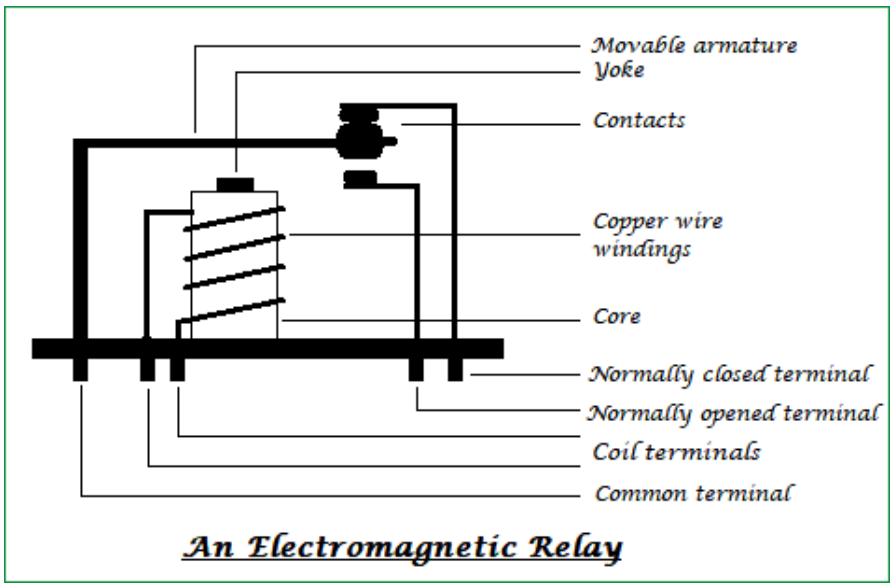
What is Relay?

A Relay is an electromechanical device that can be used to make or break an electrical connection. It consists of a flexible moving mechanical part that can be controlled electronically through an electromagnet, basically, a relay is just like a mechanical switch but you can control it with an electronic signal instead of manually turning it on or off. Again this **working principle of relay** fits only for the electromechanical relay.

There are many **types of relay** and each relay has its own application, a standard, and generally used relay is made up of electromagnets which in general used as a switch. Dictionary says that relay means ***the act of passing something from one thing to another***, the same meaning can be applied to this device because the signal received from one side of the device controls the switching operation on the other side. So the relay is a switch that controls (open and close) circuits electromechanically. The main operation of this device is to make or break contact with the help of a signal without any human involvement in order to switch it ON or OFF. It is mainly used to control a high powered circuit using a low power signal. Generally, a DC signal is used to control the circuit which is driven by high voltage like controlling AC home appliances with DC signals from microcontrollers.

Construction of Relay and its operation:

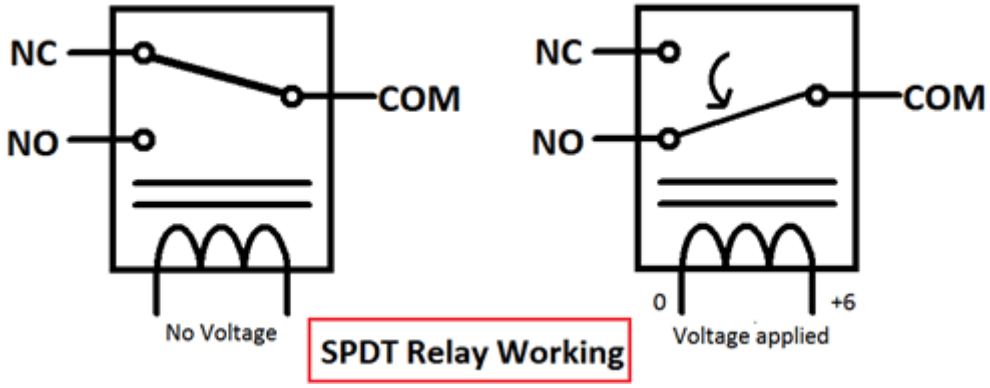
The following figure shows how a Relay looks internally and how it can be constructed.



An Electromagnetic Relay

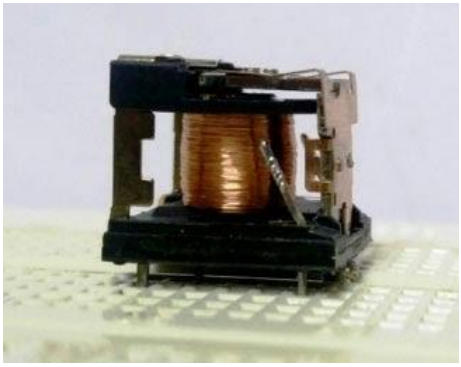
On a casing, a core with copper windings (forms a coil) winded on it is placed. A movable armature consists of spring support or stands like structure connected to one end, and a metal contact connected to another side, all these arrangements are placed over the core such that, when the coil is energized, it attracts the armature. The movable armature is generally considered as a common term that is to be connected to the external circuitry. The relay also has two pins namely ***normally closed and normally opened (NC and NO),*** the normally closed pin is connected to the armature or the common terminal whereas the normally opened pin is left free (when the coil is not energized). When the coil is energized the armature moves and is get connected to the normally opened contact till there exists flow of current through the coil. When it is de-energized it goes to its initial position.

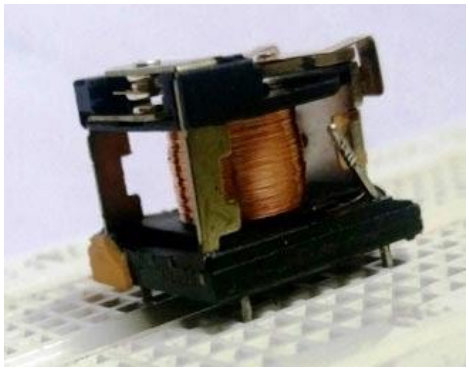
The general **circuit representation of the relay** is as shown in the figure below



What is inside a Relay – Teardown?

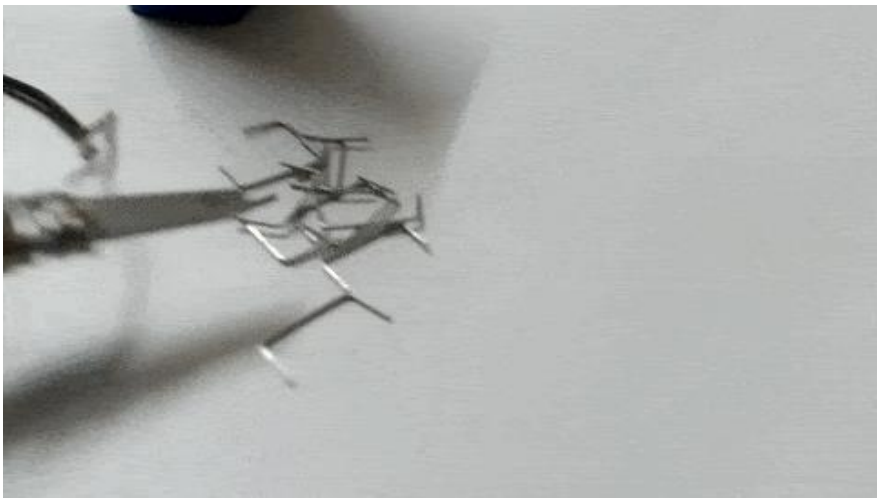
An electromechanical relay is basically designed using few mechanical parts like Electromagnet, a movable armature, contacts, yoke, and a spring/frame/stand, these parts are showing in the **internal pictures of Relay** below. All these are arranged logically to form a relay.





Internal Mechanical Parts of a Relay:

Electromagnet: An Electromagnet plays a major role in the **working of a relay**. It is a metal that doesn't have magnetic property but it can be converted into a magnet with the help of an electrical signal. We know that when current passes through the conductor it acquires the properties of a magnet. So, when a metal winded with a copper wire and driven by a sufficient power supply, that metal can act as a magnet and can attract the metals within its range.



Movable Armature: A movable armature is a simple metal piece that is balanced on a pivot or a stand. It helps in making or breaking the connection with the contacts connected to it.

Contacts: These are the conductors that exist within the device and are connected to the terminals.

Yoke: It is a small metal piece fixed on a core in order to attract and hold the armature when the coil is energized.

Spring (optional): Few relays don't need any spring but if it is used, it is connected to one end of the armature to ensure its easy and free movement. Instead of a spring, a metal stand like structure can be used.

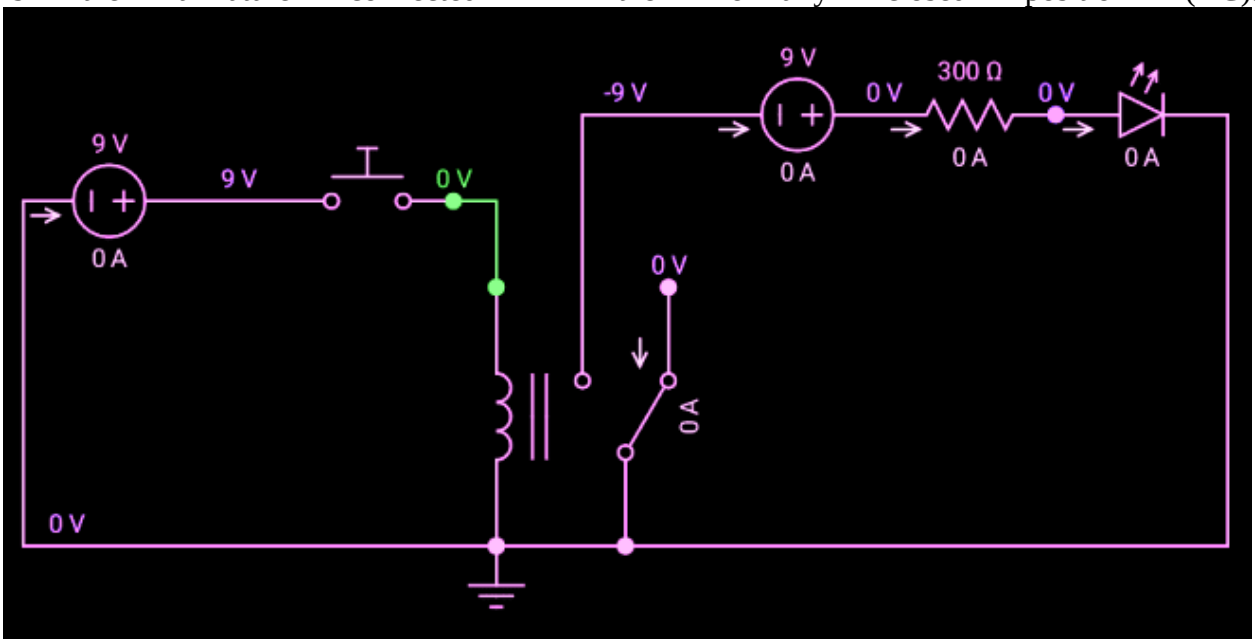
Relay Working Principle

Now let's understand how a relay works in a normally closed condition and normally open condition.

The relay in NORMALLY CLOSED condition:

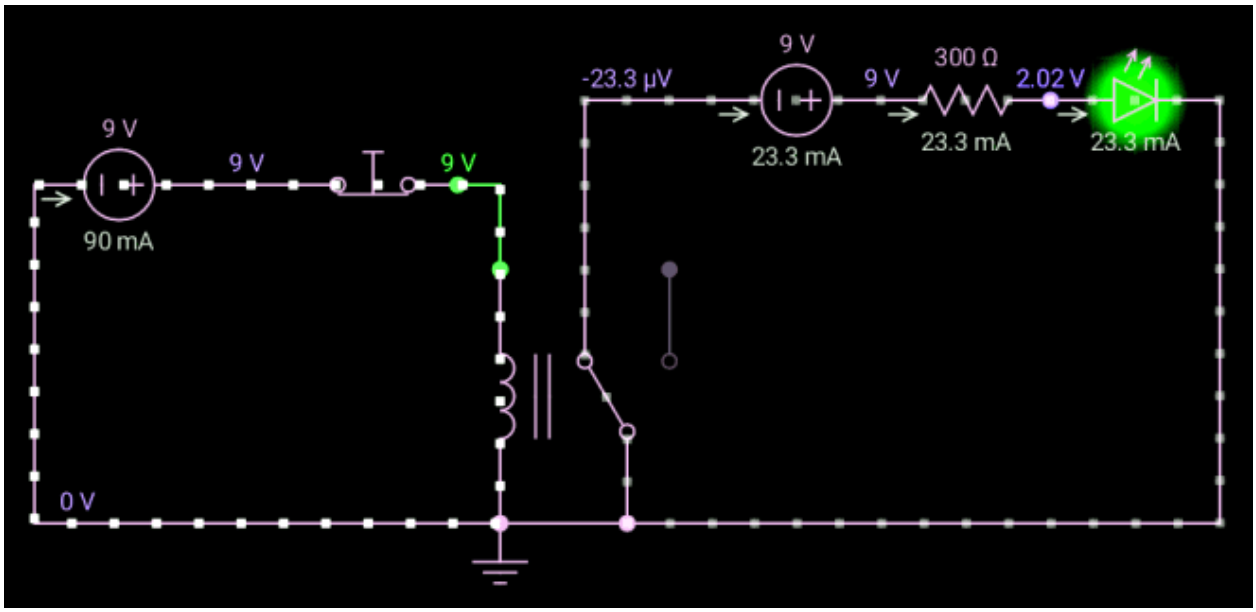
When no voltage is applied to the core, it cannot generate any magnetic field and it doesn't act as a magnet. Therefore, it cannot attract the movable armature. Thus, the initial position itself

is the armature connected in the normally closed position (NC).

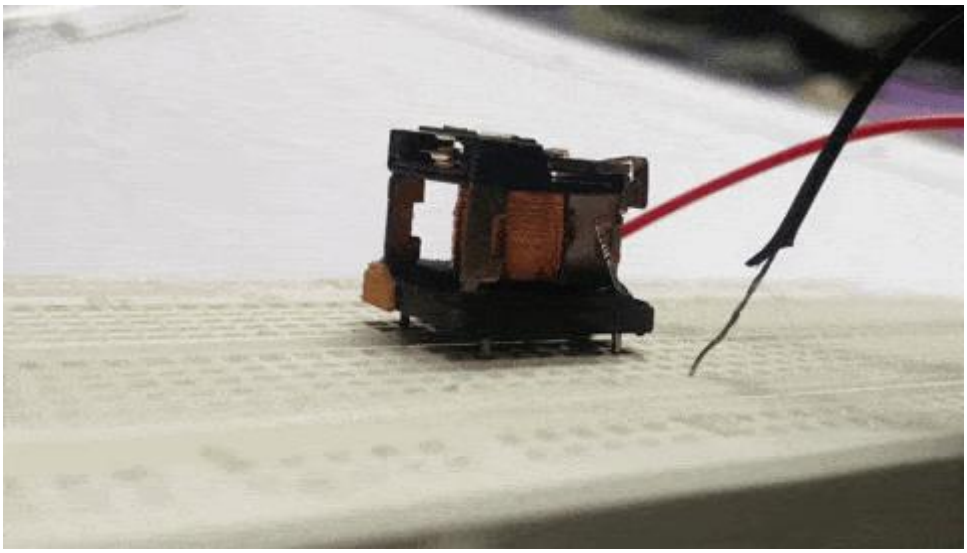


The relay in NORMALLY OPENED condition:

When sufficient voltage is applied to the core it starts to create a magnetic field around it and acts as a magnet. Since the movable armature is placed within its range, it gets attracted to that magnetic field created by the core, thus the position of the armature is being altered. It is now connected to the normally opened pin of the relay and the external circuit connected to it function in a different manner.



Note: The functionality of the external circuit depends upon the connection made to the relay pins. So finally, we can say that when a coil is energized the armature is attracted and the switching action can be seen, if the coil is de-energized it loses its magnetic property and the armature goes back to its initial position.



Different Types of Relay:

Other than the Electromagnetic relay there are many other **types of relays** that work on different principles. Its classification is as follows

Types of Relay Based on the principle of operation

- **Electro thermal relay:**

When two different materials are joined together it forms into a bimetallic strip. When this strip is energized it tends to bend, this property is used in such a way that the bending nature makes a connection with the contacts.

- **Electromechanical relay:**

With the help of few mechanical parts and based on the property of an electromagnet a connection is made with the contacts.

- **Solid-State relay:**

Instead of using mechanical parts as in electro thermal and electromechanical relays, it uses semiconductor devices. So, the switching speed of the device can be made easier and faster. The main advantages of this relay are its more life span and faster switching operation compared to other relays.

- **Hybrid relay:**

It is the combination of both electromechanical and solid-state relays.

Types of Relay Based on the polarity:

- **Polarized relay:**

These are similar to the electromechanical relays but there exists both permanent magnet and electromagnet in it, the movement of the armature depends on the polarity of the input signal applied to the coil. Used in telegraphy applications.

- **Non-polarized relay:**

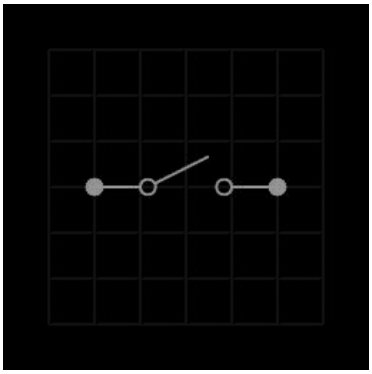
The coil in these relays doesn't have any polarities and its operation remains unchanged even if the polarity of the input signal is altered.

Pole and Throw combinations:

Switches can also be classified based on the number of poles and throw combinations. A ***pole*** can be considered as an input terminal and a movable part connected to it, whereas a ***throw*** can be considered as an output terminal. Its classification is as follows

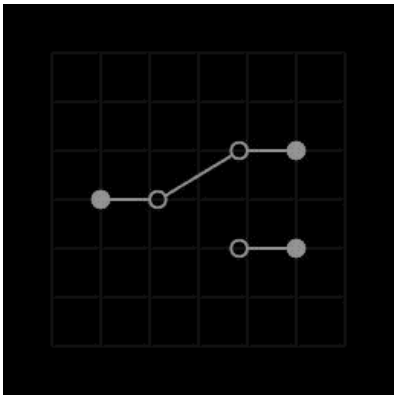
Single pole, single-throw Relay (SPST):

It consists of only one pole and one throw. Generally, the path is either closed or opened (remains untouched to any terminal). A push-button is the best example of this type. When we push the button, the contact is in the closed position and when released the contact is in the open position, which can be understood from the below image.



Single pole, double throw relay (SPDT):

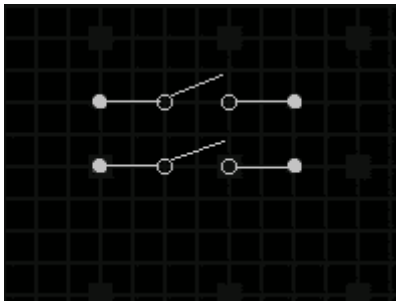
This type of switch consists of only one pole but has two throws. So, the contact is always made to either of the terminals. A slide switch can be considered as its example. The slider is always



connected to either of the contacts i.e., a closed path always exists all the time if both the terminals are connected to a circuit.

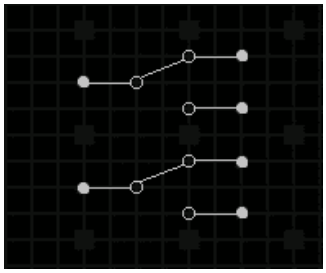
Double pole, single throw Relay (DPST):

It has two poles and a throw. The contacts of it are either opened or closed which is done simultaneously. Toggle switch works on this property. When the switch is toggled from one position to another, both the contacts are moved simultaneously.



Double pole, double throw relay (DPDT):

This type of switch has two poles but the individual pole has two throws. So, it is named as double throw and the switching action is done similarly and simultaneously for both the poles. A switch on a standard trimmer is of DPDT because while we are charging the trimmer and when the switch on the trimmer is in the ON state, it automatically stops charging means the switches are internally opened in the charging circuit.



Applications of Relay:

The **applications of the relay** are limitless, its main function is to control the high voltage circuit (230V circuit AC) with the low voltage power supply (a DC voltage).

- Relays are not only used in the large electrical circuits but also used in computer circuits in order to perform the arithmetic and mathematical operations in it.
- Used to control the electric motor switches. To turn ON an electric motor we need a 230V AC supply but in a few cases/applications, there may be a situation to switch ON the motor with a DC supply voltage. In those cases, a relay can be used.
- Automatic stabilizers are one of its applications where a relay is used. When the supply voltage is other than the rated voltage, a set of relays senses the voltage variations and controls the load circuit with the help of circuit breakers.
- Used for the circuit selection if there exists more than one circuit in a system.
- Used in Televisions. An old picture tube television's internal circuitry works with the DC voltage but the picture tube needs a very high AC voltage, in order to turn on the picture tube with a DC supply we can use a relay.
- Used in the traffic signal controllers, temperature controllers.

Normally Open and Normally Closed Contacts

Normally Open and Normally Closed electrical contacts make up electrical switches, relays, circuit breakers, and most any other electrical component that switches something on/off or can be switched on/off.

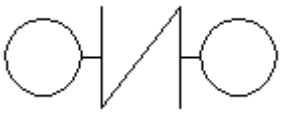
What is open and closed? Before we get into what normally open and normally closed are, let's clarify what "open" and "closed" mean. As with so many topics that we try to simplify by associating with something we are familiar with, associating electrical current flow with water flow causes a tremendous amount of misunderstandings. Whereas we open a water faucet to start water flow, we close an electrical contact to start the current flow, and instead of closing a water faucet to stop water flow, we open an electrical contact to stop current flow.

IMPORTANT CONCEPT:
Closed = Current flow
Open = No current flow

What is normally? This is simply the state that the contact is in when something else is not affecting it. If it is a relay then it is not energized. If it is a switch, then it is off. If it is a high limit such as a temperature alarm then the current temperature is below the limit.

Normally open - This is a contact that does not flow current in its normal state. Energizing it and switching it on will close the contact, causing it to allow current flow.

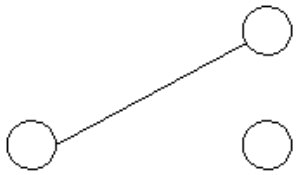
Normally closed - This is a contact that flows currently in its normal state. Energizing it and switching it on will open the contact, causing it to not allow current flow.



Don't overthink these two concepts. That is all there is to it. Also now is a good time to remind you that this is article is talking about the electrical normally open and normally closed symbols which while may look the same as the ladder logic XIC and XIO instructions, are not the same.

Example: Now let's go through a real-world example of normally open and normally closed contacts that we are all familiar with. Rarely are these "familiar" examples good for learning, but a 3-way switch is an excellent example of using normally open and normally closed switches. And maybe we'll clear up a few things for the household electrician or do it yourself. First, let's break it down into the basics.

3 WAY SWITCH
SINGLE POLE DOUBLE THROW (SPDT)



Why do we use 3 ways switches? 3 ways switches are used to turn on a light from two different locations.

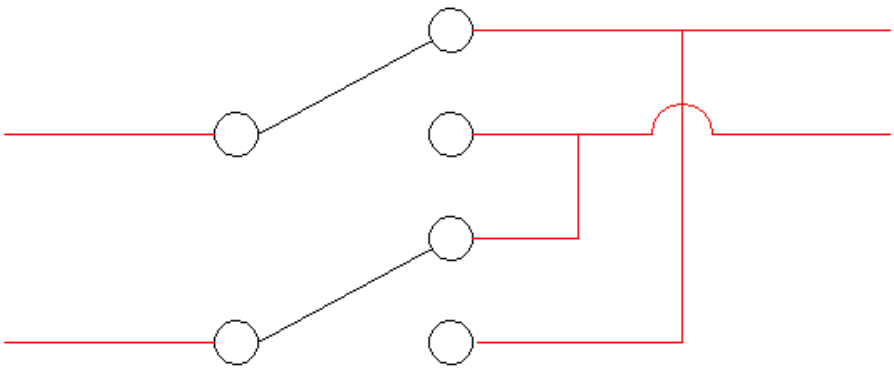
What if I need to turn a light on from more than two locations? Then you use a combination of 3 way and 4-way switches.

What is a 3-way switch? A three-way switch is simply a normally open and normally closed switch in which one side of each contact is tied together. In an industrial environment, we call this a single pole double throw (SPDT) switch.

What is a single pole double throw (SPDT) switch? It has three terminals. A common (COM) which is the left terminal in the image below, a normally closed (NC) terminal which is the top right terminal in the image below, and a normally open (NO) terminal which is the bottom right terminal in the image below.

Why isn't a 3-way switch called a single pole double throw (SPDT) switch? I don't have a good reason for it. There are lots of speculations about it but it was probably someone trying to oversimplify electrical terms. If you know what an SPDT switch is then you will immediately understand what a three-way switch is and the principles of it. If you know what a 3-way switch is then you don't necessarily know what an SPDT switch is or the principles of a 3 ways switch.

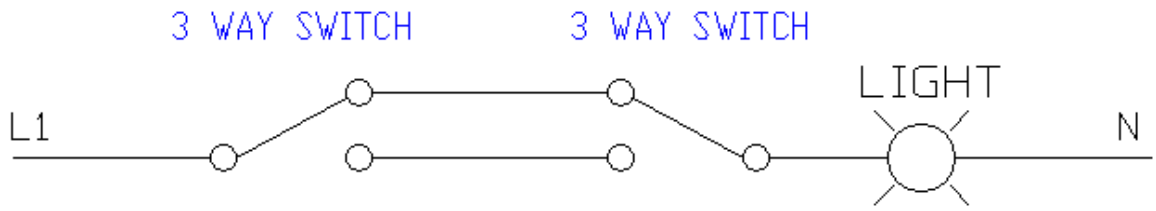
4 WAY SWITCH
DOUBLE POLE DOUBLE THROW (SPDT)



What is a 4-way switch? A 4-way switch is a double pole double throw (DPDT) switch with a few jumpers preinstalled. In the image below, the jumpers that are added to make a DPDT switch a 4-way switch are shown in red.

What is a double pole double throw (DPDT) switch? It is two single pole double throw (SPDT) switches mechanically linked together.

How do you wire a "3-way" circuit or two 3 way switches? Note that this only works with two switches. If you need more than two switches then see the 4 way example further down.



How do you wire a "4-way" circuit? On the end closest to your power and light, use 3-way switches. All other switches in between should be 4-way switches and there is no limit to the number of 4-way switches you can have in the circuit.