SWITCHES AND CONNECTORS

A switch is a device which is designed to interrupt the current flow in a circuit, in other words, it can make or break an electrical circuit. Every electrical and electronics application uses at least one switch to perform ON and OFF operation of the device.

Switches can be of mechanical or electronic type:

Mechanical switches must be activated physically, by moving, pressing, releasing, or touching its contacts.

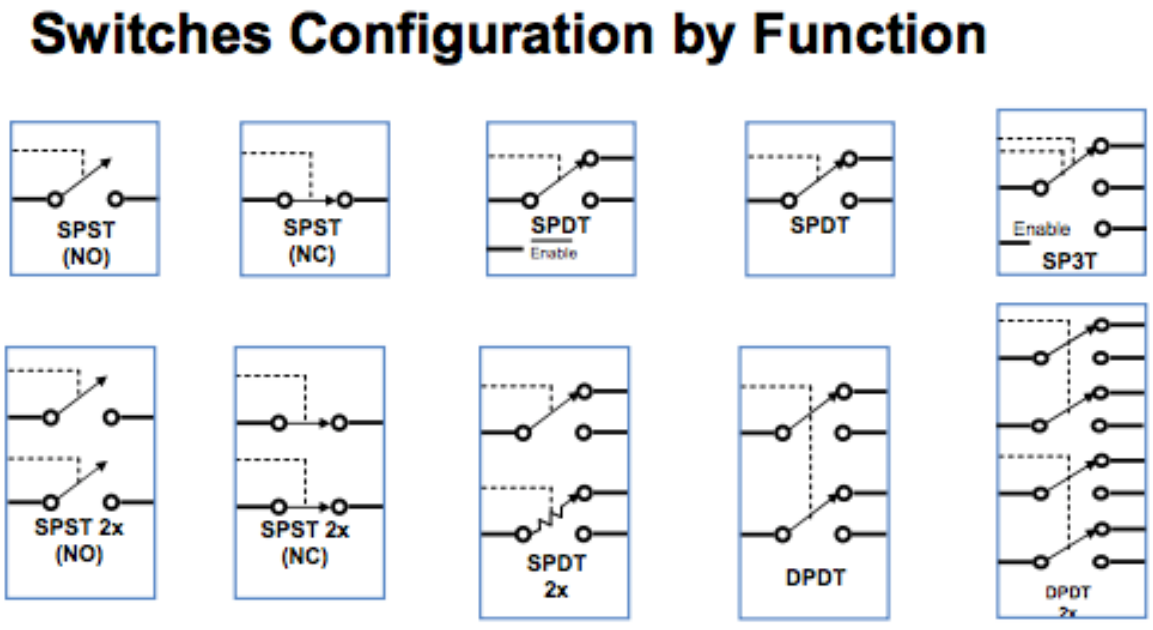
Electronic switches do not require any physical contact in order to control a circuit. These are activated by semiconductor action.

Mechanical Switches

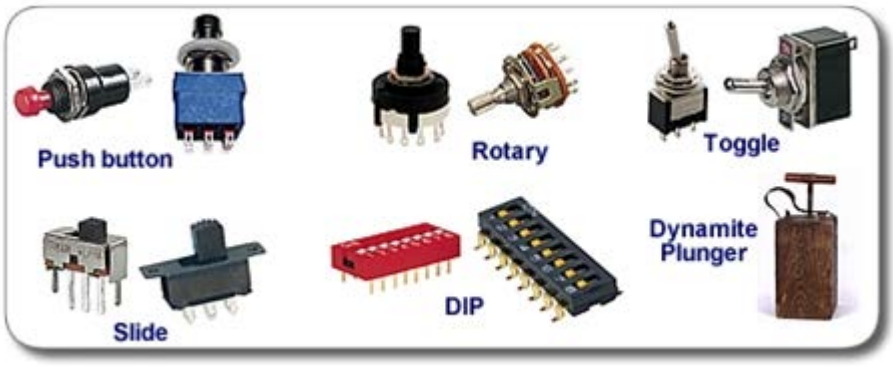
On basis of no of poles and throws:

The **pole** represents the number of individual power circuits that can be switched. Most of the switches are designed have one, two or three poles and are designated as single pole, double pole and triple pole.

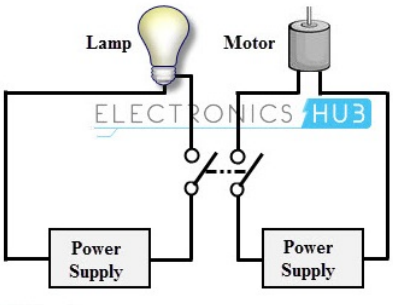
The number of **throws** represents the number of states to which current can pass through the switch. Most of the switches are designed to have either one or two throws which are designated as single throw and double throw switches.



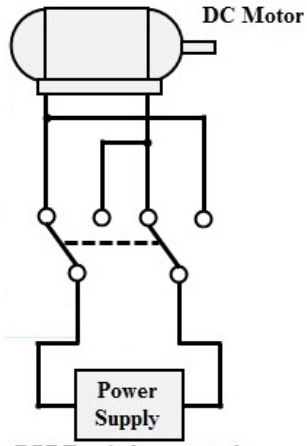
On basis of method of actuation/construction:



Operating independent networks using DPST SWITCH

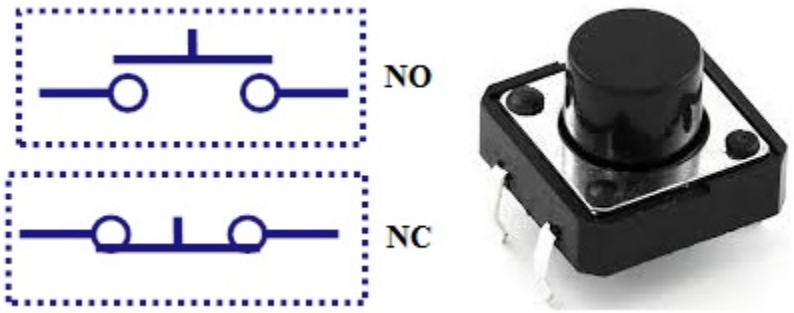


Operating a bi-directional motor using DPDT Switch



DPDT switch to control motor direction of rotation

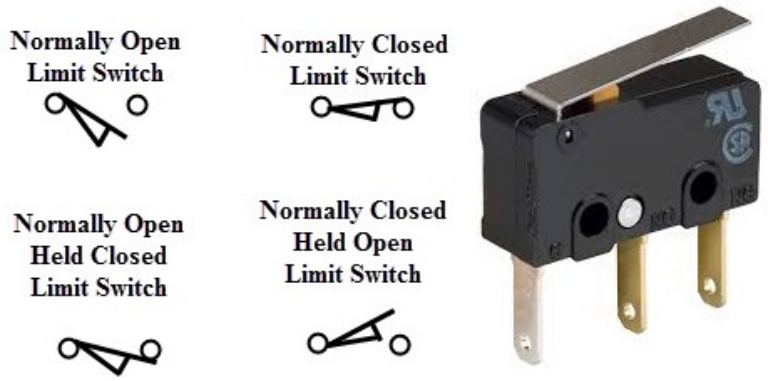
Push Button Switch



- It is a momentary contact switch that makes or breaks connection as long as pressure is applied (or when the button is pushed).
- Generally, this pressure is supplied by a button pressed by someone's finger.
- This button returns its normal position, once the pressure is removed.
- The internal spring mechanism operates these two states (pressed and released) of a push button.
- It consists of stationary and movable contacts, of which stationary contacts are connected in series with the circuit to be switched while movable contacts are attached with a push button.
- Push buttons are majorly classified into normally open, normally closed and double acting push buttons as shown in the above figure.
- Double acting push buttons are generally used for controlling two electrical circuits.

Toggle Switch

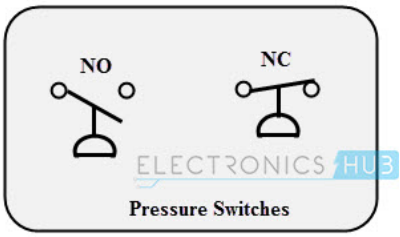
Limit Switch



- **Limit Switch**

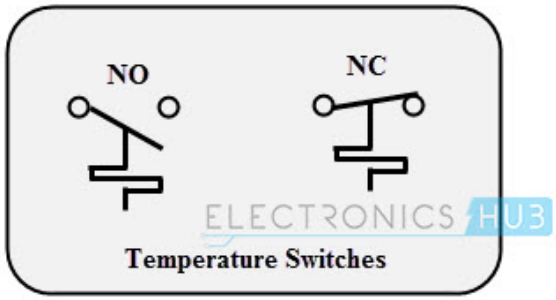
- The control schemes of a limit switch are shown in above figure, in which four varieties of limit switches are presented.
- Some switches are operated by the presence of an object or by the absence of objects or by the motion of machine instead of human hand operation. These switches are called as limit switches.
- These switches consist of a bumper type of arm actuated by an object. When this bumper arm is actuated, it causes the switch contacts to change position.

Pressure Switches



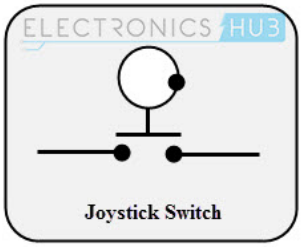
- These switches are commonly used in industrial applications in order to sense the pressure of hydraulic systems and pneumatic devices.
- Depends on the range of pressure to be measured, these pressure switches are classified into diaphragm operated pressure switch, metal bellow type pressure switch and piston type pressure switch.
- In all these types, pressure detection element operates a set of contacts (which can be either double pole or single pole contacts).
- This switch symbol consist a half-circle connected to a line in which flat part indicates a diaphragm. These switches may be either normally open or normally closed type configurations.

Temperature Switches



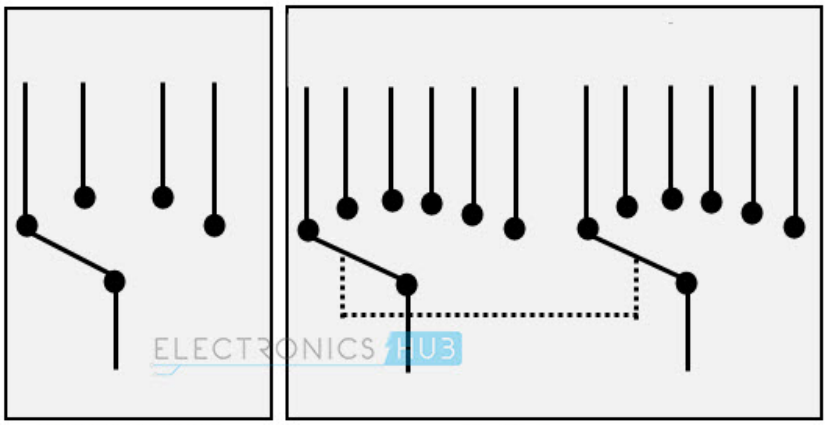
- The most common heat sensing element is the bimetallic strip that operates on the principle of thermal expansion.
- The bimetallic strips are made with two dissimilar metals (that are having different thermal expansion rates) and are bonded with each other.
- The switch contacts are operated when the temperature causes the strip to bend or wrap. Another method of operating the temperature switch is to use mercury glass tube.
- When the bulb is heated, mercury in the tube will expand and then generates pressure to operate the contacts.

Joystick Switch



- Joystick switches are manually actuated control devices used mainly in portable control equipments.
- It consists of a lever which moves freely in more than one axis of motion.
- Depending on the movement of the lever pushed, one or more switch contacts are actuated.
- These are ideally suited for lowering, raising and triggering movements to the left and right.
- These are used for building machinery, cable controls and cranes. The symbol for the joystick is shown below.

Rotary Switches



Single pole 4-way selector switch

2-pole 6-way Selector Switch

- These are used for connecting one line to one of many lines.
- Examples of these switches are range selectors in electrical metering equipment, channel selectors in communication devices and band selectors in multi-band radios.
- It consists of one or more moving contacts (knob) and more than one stationary contact.
- These switches are come with different arrangement of contacts such as single pole 12-way, 3-pole 4-way, 2-pole 6-way and 4-pole 3-way.

Kill switch

A kill switch is a mechanism used to shut down or disable machinery or a device or program. The purpose of a kill switch is usually either to prevent theft of a machine or data or as a means of shutting down machinery in an emergency. In manufacturing, for example, a kill switch (also called a *big red button*) might be used to shut down machinery if a worker is in danger. Kill switches are usually designed to be noticeable, even to an untrained operator or a bystander.

Ignition Switch

An ignition switch or starter switch is a switch in the control system of an internal combustion engined motor vehicle that activates the main electrical systems for the vehicle. Besides providing power to the starter solenoid and the ignition system components (including the engine control unit and ignition coil) it also usually switches on power to many "accessories" (radio, power windows, etc.). The ignition switch usually requires a key be inserted that works a lock built into the switch mechanism. It is frequently combined with the starter switch which activates the starter motor. The ignition locking system may be bypassed by disconnecting the wiring to the switch and manipulating it directly; this is known as hotwiring.

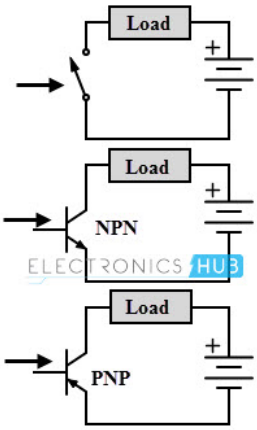
Electronic Switches

The electronic switches are generally called as solid state switches because there are no physical moving parts and hence absence of physical contacts. Most of the appliances are controlled by semiconductor switches such as motor drives and HVAC equipments.

Bipolar Transistors

A transistor either allows the current to pass or it blocks the current as similar to working of normal switch.

In switching circuits, transistor operates in cut-off mode for OFF or current blocking condition and in saturation mode for ON condition. The active region of the transistor is not used for switching applications.

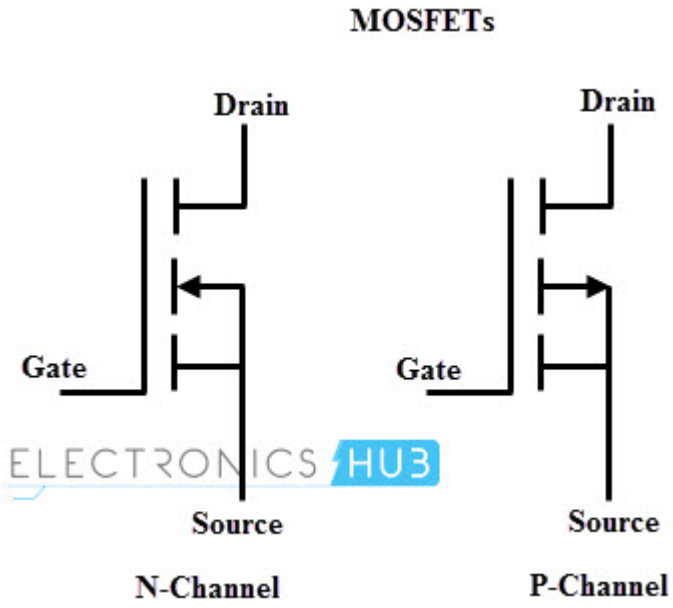


Both NPN and PNP transistors are operated or switched ON when a sufficient base current is supplied to it. When a small current flows though the base terminal supplied by a driving circuit (connected between the base and emitter), it causes to turns ON the collector-emitter path.

And it is turned OFF when the base current is removed and base voltage is reduced to a slight negative value. Even though it utilizes small base current, it is capable to carry much higher currents through the collector- emitter path.

Metal Oxide Semiconductor Field Effect Transistor (MOSFET) is a unipolar and high frequency switching device. It is a most commonly used switching device is power electronic applications. It has three terminals namely drain (output), source (common) and gate (input).

It is a voltage controlled device, i.e., by controlling input (gate to source) voltage, resistance between the drain and source is controlled which further determines the ON and OFF state of the device.



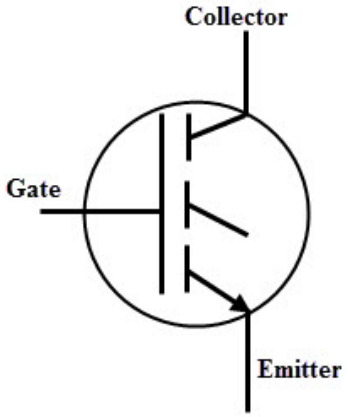
MOSFETs can be a P-channel or N-channel devices. The N-channel MOSFET is tuned ON by applying a positive VGS with respect to the source (provided that VGS should be greater than threshold voltage).

P-channel MOSFET operates in a similar manner of N-channel MOSFET but it uses reverse polarity of voltages. Both VGS and VDD are negative with respect the source to switch ON the P- channel MOSFET.

IGBT

IGBT (Insulated Gate Bipolar Transistor) combines the several advantages of bipolar junction power transistor and power MOSFET. Like a MOSFET, it is a voltage controlled device and has lower ON state voltage drop (less than that of MOSFET and closer to power transistor).

It is a three terminal semiconductor high speed switching device. These terminals are emitter, collector and gate.

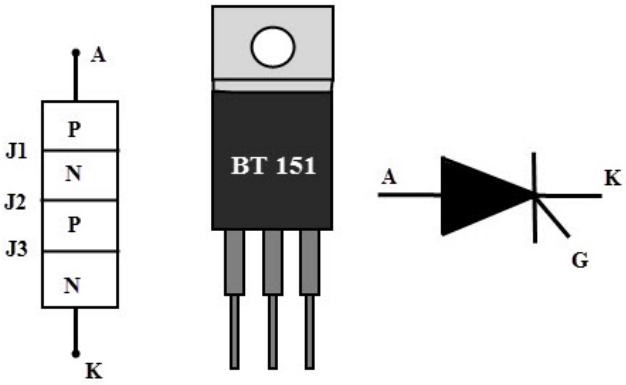


Similar to the MOSFET, IGBT can be turned ON by applying a positive voltage (greater than the threshold voltage) between the gate and emitter. IGBT can be turned by reducing the voltage across the gate-emitter to zero. In most of the case it needs negative voltage to reduce turn OFF losses and safely turn OFF the IGBT.

SCR

A Silicon Controlled Rectifier (SCR) most widely used high speed switching device for power control applications. It is a unidirectional device as a diode, consisting of three terminals, namely anode, cathode and gate.

An SCR is turned ON and OFF by controlling its gate input and biasing conditions of the anode and cathode terminals. SCR consists of four layers of alternate P and N layers such that boundaries of each layer forms junctions J1, J2 and J3.

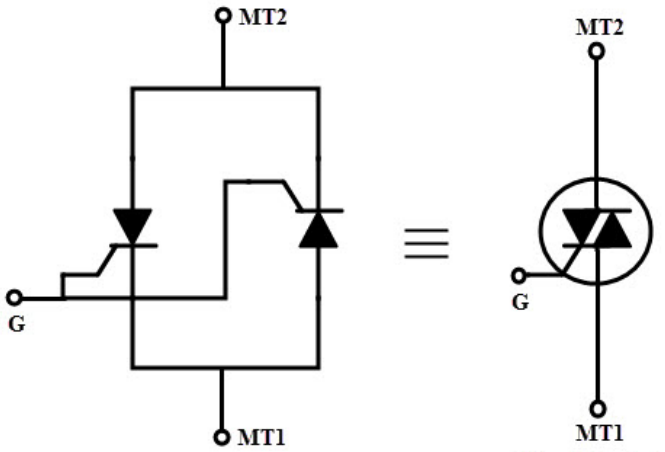


Silicon Controlled Rectifier (SCR)

TRIAC

Triac (or TRIode AC) switch is a bidirectional switching device which is an equivalent circuit of two back to back SCRs connection with one gate terminal.

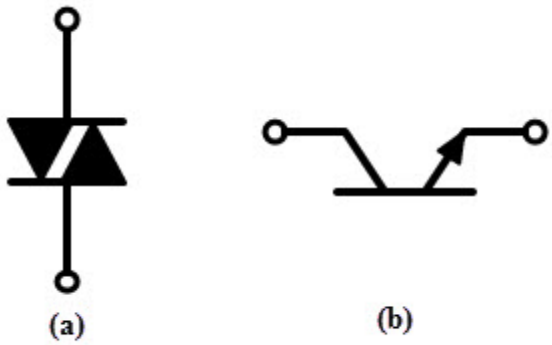
Its capability to control AC power in both positive and negative peaks of the voltage waveform often makes these devices to be used in motor speed controllers, light dimmers, pressure control systems, motor drives and other AC control equipments.



Two Thyristor Analogy | Circuit Symbol

DIAC

A DIAC (or DIode AC switch) is bidirectional switching device and it consists of two terminals which are not named as anode and cathode. It means that a DIAC can be operated in either direction regardless of the terminal identification. This indicates that the DIAC can be used in either direction.



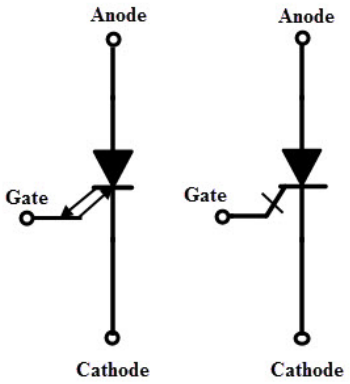
Symbols Used for DIAC

When a voltage is applied across a DIAC, it either operates in forward blocking or reverse blocking mode unless the applied voltage is less than the breakover voltage. Once the voltage is increased more than breakover voltage, avalanche breakover occurs and device starts conducting.

Gate Turn-Off Thyristor

A GTO (Gate Turn off Thyristor) is a bipolar semiconductor switching device. It has three terminals as anode, cathode and gate. As the name implies, this switching device is capable to turn OFF through gate terminal.

A GTO is turned ON by applying a small positive gate current triggers the conduction mode and turned OFF by a negative pulse to the gate. GTO symbol consists of double arrows on the gate terminal which represents the bidirectional flow of current through gate terminal.



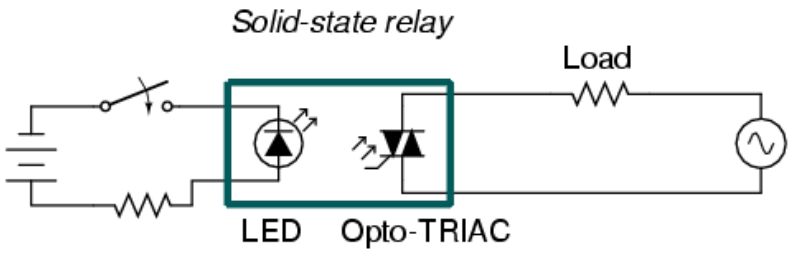
Gate Turn-Off Thyristor Symbols

Relays and contactors

What are relays?

A relay is an electromagnetic switch operated by a relatively small electric current that can turn on or off a much larger electric current. The heart of a relay is an electromagnet (a coil of wire that becomes a temporary magnet when electricity flows through it). You can think of a relay as a kind of electric lever: switch it on with a tiny current and it switches on ("leverages") another appliance using a much bigger current. Why is that useful? As the name suggests, many sensors are incredibly *sensitive* pieces of electronic equipment and produce only small electric currents. But often we need them to drive bigger pieces of apparatus that use bigger currents. Relays bridge the gap, making it possible for small currents to activate larger ones. That means relays can work either as switches (turning things on and off) or as amplifiers (converting small currents into larger ones).

In order to avoid any damage to microcontroller or any other control circuit used to trigger the relay, There is no direct connection between the VCC given to the relay and the heavy load the relay is used upon. An LED- Optotriac arrangement, as shown below is used.



How to Specify a Relay:

1. What are the switching requirements: What voltage? How much current is being switched?
2. Coil voltage: is the power source AC or DC? What voltage is available to power the coil?
3. What is the contact arrangement:
- Form A contacts
- Form B contacts
- Form C contacts
4. How many poles are required? (Number of circuits being switched)
5. What is the mounting type:
- Surface Mount
- PC Board
- Plug-in socket
- Plug-in terminal socket
- Top mount
- Top mount - PC board

CONTACTORS

A contactor is a special type of **Relay** used to switch on or off electrical circuit. It is basically used where the current carrying capacity needs to be more. Also it is compact in size and can easily be mounted in the field. A contactor like a **Relay** has many contacts which can be used for different purposes

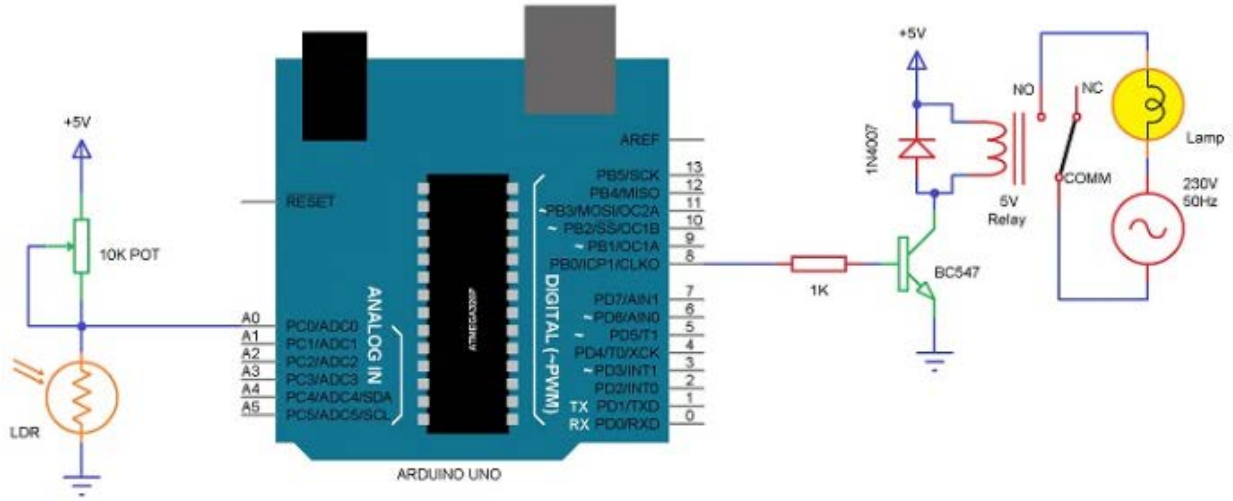
Using a 5VDC relay with an Arduino to operate a high voltage AC appliance:

Required Components

- Arduino UNO (or any other Arduino board)
- 5V Relay
- 1N4007 Diode
- BC547 – NPN Transistor

- Red LED (can be used as a Power ON LED)
- Green LED (can be used as a Relay ON LED)
- 2 x 1K Ohm Resistors (1/4 W – for Red and Green LEDs)
- Lamp
- Wires for connecting DC Voltage components
- Wires for connecting AC Mains and lamp

CIRCUIT DIAGRAM



Working of the Project

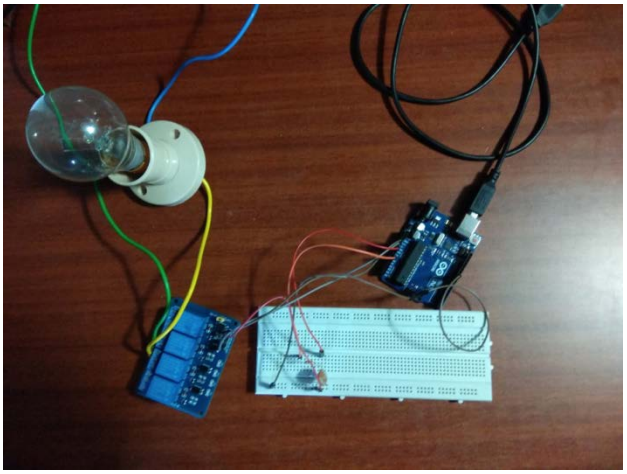
The working of the project is based on the functioning of the Relay and the ability of Arduino to control the relay. By interfacing Arduino with 5V relay module, we intend to operate an AC load like lamp. Instead of using it directly, we designed a small application where an LDR is used to detect the light intensity and automatically turn on or off the relay.

Under normal lighting conditions, the output from the LDR will be in the range of 80 – 90 (range is 0 – 255). When the lighting conditions go dark (can be done by covering the LDR with hand), the output from the LDR will jump to 130 – 140. This condition can be used to trigger the 5V Relay and turn on the light.

Arduino code:

```
const int relay=8;
const int Ainput=A0;
int ldrValue = 0;
int range = 0;
void setup()
{
pinMode(relay,OUTPUT);
digitalWrite(relay,HIGH); // My Relay is an active LOW Relay.
Serial.begin(9600);

}

void loop()
{

  ldrValue = analogRead(Ainput);

  range = map(ldrValue, 0, 1023, 0, 255);

  Serial.println(range);
  if(range>125)
  digitalWrite(relay,LOW);
  else
  digitalWrite(relay,HIGH);
}
```

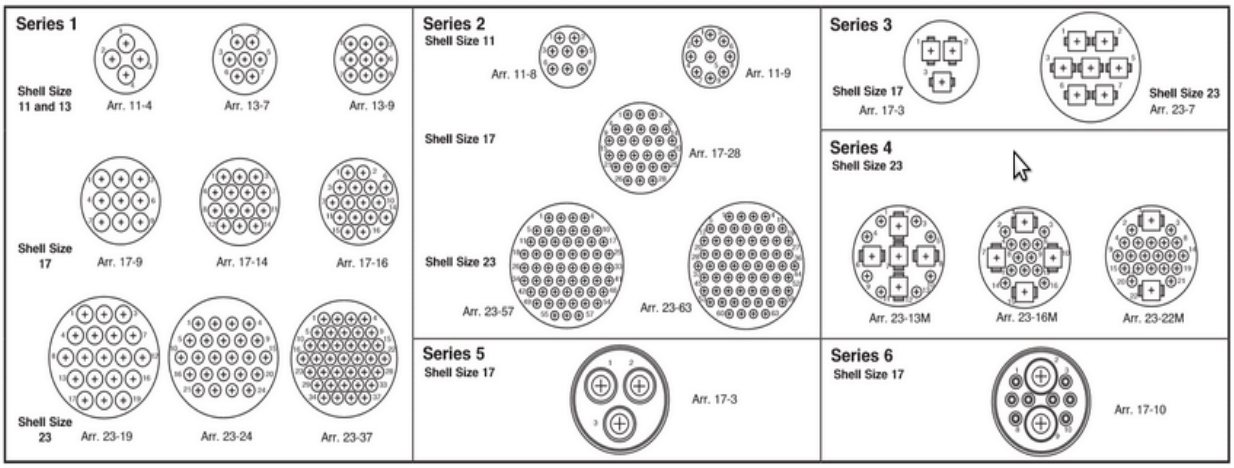
My attempt:



TYPES OF CONNECTORS

Circular Connectors

TE Connectivity CPC (circular plastic connector). These are circular connectors capable of holding up to 63 conductors. The pins/sockets are rated for 28AWG – 8AWG wire. You get the rotating locking mechanism similar to mil-spec metal connectors for a reduced cost and weight.



To properly make a connection there are several components that you need to purchase:

Receptacle (a & b) – This is that side that has the pins that you will connect to. You can get Receptacles with a flange for mounting on a panel. There are also reverse sec connectors that have sockets in the receptacle, these are good for cases where power is in the receptacle and not coming from the plug side.

Plug (c) – This is the side that has the sockets that will connect to the receptacle.

Pins (d) – for the receptacle (assuming standard gender)

Sockets (e) – for the plug (assuming standard gender)

Backshell/Strain Relief –So that when people yank on the cable it is not pulled from the connector. These also help seal dirt from getting into the connector. In certain cases where you are tight for space you can leave these off.

Cover – This goes on the front mating surface of a receptacle or plug to help prevent damage or contact with the mating surface.

Keying Plugs – While I highly recommend using different connectors where things can get confused and plugged into the wrong place it is not always possible to do this. For these cases it is good to choose a connector with some extra conductor holes and uses keying plugs to make connectors not be mateable with ones that it should not mate with.

A good source of these connectors (and the source of these images) is mouser. While many distributors sell these connectors the best way to them is by going to the online catalog on mousers website and search for the connectors. They have good pictures that show the different connectors available and the options.

A similar type is the AMPHENOL Circular Mil Spec connectors. These are similar to the CPC connectors above but are made from metal. Since they are made from metal they are stronger, more resistant to wear and tear, and cost more.

Deutsch

The Deutsch line of connectors is very good and is commonly used in cars and heavy vehicles. There are many to choose from with different current capacity and conductor counts. The Deutsch connectors are easier to assemble and more resistant to water and dust then the CPC connectors. Once the pins/sockets are inserted into the housing there is a little clip that gets inserted to strengthen and seal the connector. The primary reason I do not like them and use CPC's instead is that they do not have any strain relief for the connectors. You need to provide some external way to strain relief those about 3 inches behind the end of the connector. For connectors that just hang in the air or sit in the robot this is not always feasible.
A good source for more information is from LADD and they have a connector selection guide that is worth looking at.

Anderson Powerpole

Anderson power pole connectors are great connectors for high current devices such as batteries. These connectors can go up to 350A, however they have different sizes based on current needs. The connectors are each for one wire, however they can slide into each other to create a larger connector of the shape and configuration that you choose. The nice thing with these are the two ends are the same however because of how they are designed they will only connect in one direction so you do not mess up and plug them in wrong. There is a notch between the connectors when you slide them together that is designed for a plastic insert to keep them from sliding apart. In practice I find a zip tie to work just as well (if not better).

D-Sub and HD D-Sub

D-Sub connectors are the ones we are used to seeing for things like (old) printers, serial ports, and VGA monitor ports. While we are used to seeing DB9 (9 pins), DB15 (15 pins high density (HD)), and DB25 (25 pins) connectors there are many other configurations. Some of the configurations can have data pins as well as power pins within the same connector. There are also a wide range of D-sub connectors available such as extra slim versions and waterproof versions. As with some other connector types you can get solder buckets built onto the connector or connectors that accept crimped pins and sockets (I advocate for the crimped versions).
When you purchase D-Sub/HD-Sub connectors you can also purchase back shells that act as strain relief for the cable. Some extra thin or panel mount versions do not have a back shell option. You should also be careful since the pins/sockets do not always work in connectors from a different manufacturer, and the D-Sub and HD-sub use different size pins/sockets with a different crimp tool.

Molex

Molex makes a wide assortment of wire to wire connectors. The reason I do not like them is that the metal pins/contact are a bit exposed, they are the least protected from the elements from the connectors presented, there is no strain relief, the pins/sockets can separate from the shell with repeated use, and the pins bend easily. The good things that I will say about them are that they are low-cost and most styles are good at preventing people from plugging them in the wrong way, several of the styles have a locking tab that helps hold the connector together.

Ethernet, USB, RF

For random ethernet, USB, and RF connectors head to L-com. There are a bunch of wire to wire connectors as well as some panel mount options. Many of these will have covers that you can put over the connector to seal them when not in use. There are also cable shrouds that are molded plastic that fit over your cables to seal them to the connectors.

There are many types of common RF connectors. With all of these you need to watch for the maximum power, the maximum frequencies it can carry, and the resistance of the cables/connectors (cables are often not labeled if they are 50 ohms or 75 ohms). Here are some of the more common RF connectors:

u.fl – This is one of the smaller connectors and is usually connected direct to a PCB. It has a very limited number of connection cycles.

SMA – This is another small connector that is on many commercial radios.

RP-SMA – This is the reverse polarity version of the SMA connector above (note the center socket instead of a pin). This is designed for consumer applications were “non-trained” end users can change the cables/antennas. This is common on home routers.

BNC – This is an easy to use type of connector that is not suitable for outdoor use. This is often found on electronics test gear (oscilloscopes, function generators, etc..).

TNC – This is a threaded version of the BNC above.

N – N connectors are very popular with antennas, and are nice, since they are both threaded and waterproof. They are also the largest physical size of these connectors here.