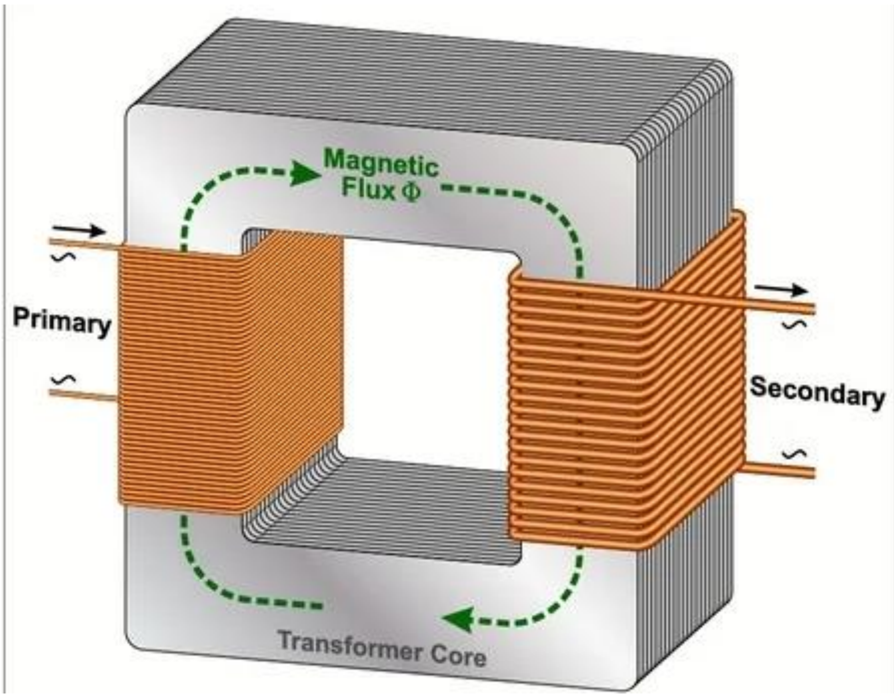
RUGVED Task 3

1. Transformers

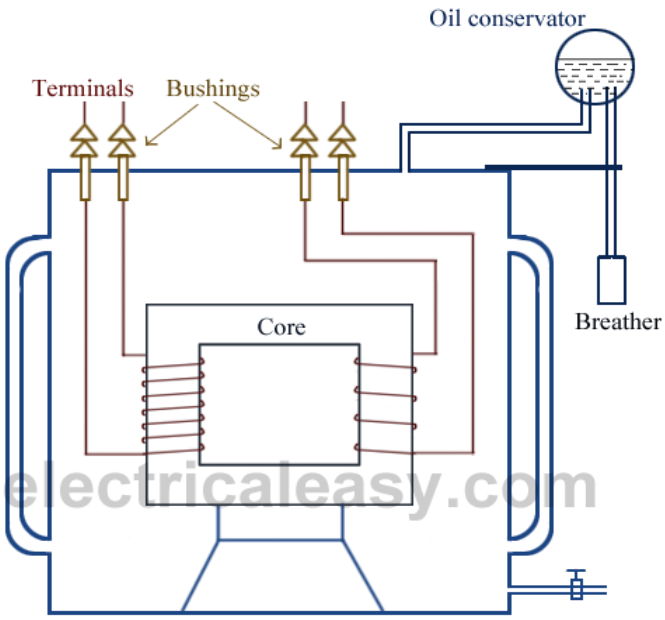
A) Definition

A transformer is an electrical device that uses the principle of electromagnetic induction to transfer energy from one electric circuit to another. It is designed to either increase or decrease AC voltage between the circuits while maintaining the frequency of the current. Transformers do this with no conductive connection between the two circuits. This is possible through the application of Faraday's Law of Induction which describes how a magnetic field will interact with an electric circuit to produce electromotive force (EMF).



B) Construction of a Transformer

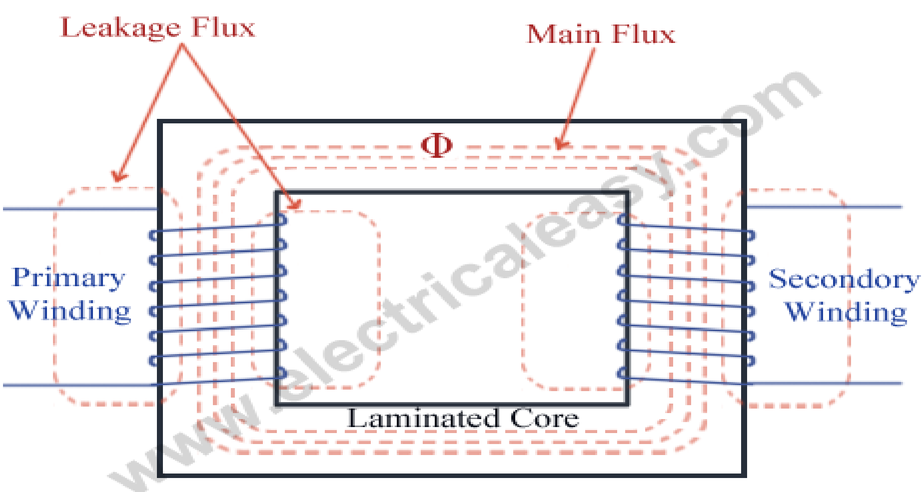
A transformer consists of two inductive windings and a laminated steel core. The coils are insulated from each other as well as from the steel core. A transformer may also consist of a container for winding and core assembly (called as tank), suitable bushings to take the terminals, oil conservator to provide oil in the transformer tank for cooling purposes etc. In all types of transformers, core is constructed by assembling (stacking) laminated sheets of steel, with minimum air-gap between them (to achieve continuous magnetic path). The steel used is having high silicon content and sometimes heat treated, to provide high permeability and low hysteresis loss. Laminated sheets of steel are used to reduce eddy current loss. The sheets are cut in the shape as E,I and L. To avoid high reluctance at joints, laminations are stacked by alternating the sides of joint. That is, if joints of first sheet assembly are at front face, the joints of following assemble are kept at back face.



C) Working of a Transformer

The basic principle behind working of a transformer is the phenomenon of mutual induction between two windings linked by common magnetic flux.

A transformer consists of two inductive coils; primary winding and secondary winding. The coils are electrically separated but magnetically linked to each other. When, primary winding is connected to a source of alternating voltage, alternating magnetic flux is produced around the winding. The core provides magnetic path for the flux, to get linked with the secondary winding. Most of the flux gets linked with the secondary winding which is called as 'useful flux' or main 'flux', and the flux which does not get linked with secondary winding is called as 'leakage flux'. As the flux produced is alternating (the direction of it is continuously changing), EMF gets induced in the secondary winding according to Faraday's law of electromagnetic induction. This emf is called 'mutually induced emf', and the frequency of mutually induced emf is same as that of supplied emf. If the secondary winding is closed circuit, then mutually induced current flows through it, and hence the electrical energy is transferred from one circuit (primary) to another circuit (secondary).



D) Types of Transformers

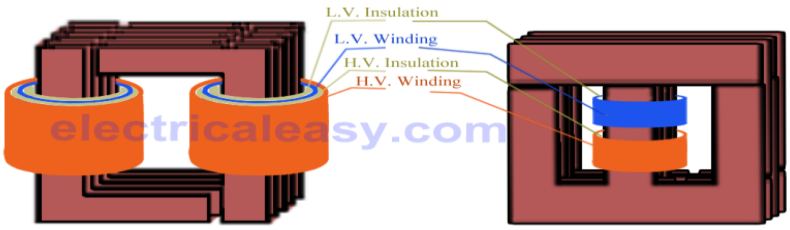
I. Based on construction

(i) Core type transformer

In core type transformer, windings are cylindrical former wound, mounted on the core limbs as shown in the figure above. The cylindrical coils have different layers and each layer is insulated from each other. Materials like paper, cloth or mica can be used for insulation. Low voltage windings are placed nearer to the core, as they are easier to insulate.

(ii) Shell type transformer

The coils are former wound and mounted in layers stacked with insulation between them. A shell type transformer may have simple rectangular form or it may have a distributed form.



Core type Shell type

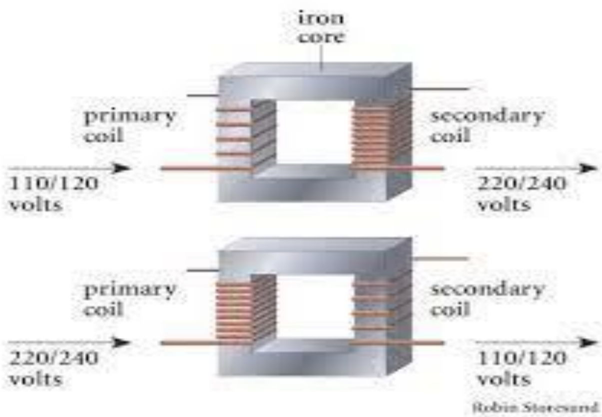
II. Based on their purpose

(i) Step up transformer

Voltage increases (with subsequent decrease in current) at secondary.

(ii) Step down transformer

Voltage decreases (with subsequent increase in current) at secondary



III. Based on their use

(i) Power transformer

Used in transmission network with a high rating.

(ii) Distribution transformer

Used in distribution network, comparatively lower rating than that of power transformers.

(iii) Instrument transformer

Used in relay and protection purpose in different instruments in industries

(Instrument Transformer)

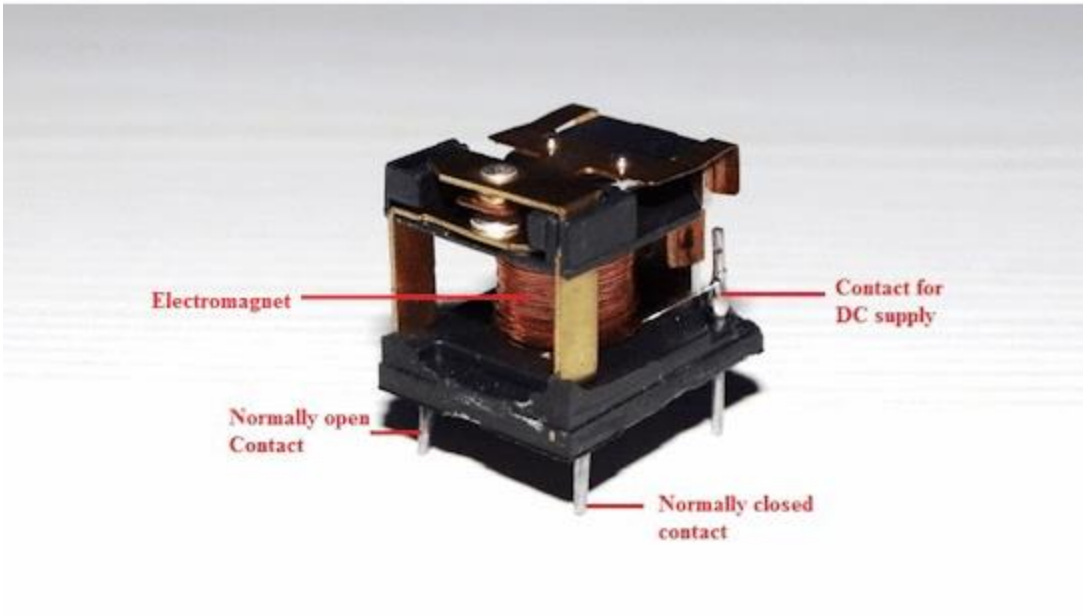
2. Relays

A) Definition

A Relay is a simple electromechanical switch. While we use normal switches to close or open a circuit manually, a Relay is also a switch that connects or disconnects two circuits. But instead of a manual operation, a relay uses an electrical signal to control an electromagnet, which in turn connects or disconnects another circuit.

Every electromechanical relay consists of an consists of an

a. Electromagnet
b. Mechanically movable contact
c. Switching points and
d. Spring



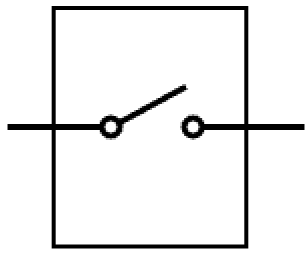
B) Types of Relays

I. Based on Poles and Throw

Relays can switch one or more circuits. Each switch in relay is referred as pole. Number of circuits a relay connects is indicated by throws. There are 4 different types:-

a. Single Pole Single Throw

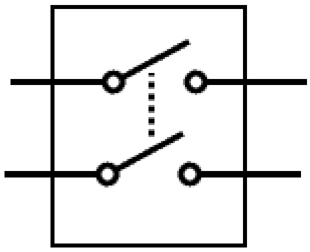
The single pole means that it can control only one circuit while the single throw means its pole has only one position in which it can conduct. SPST diagram is given below.



SPST
Single Pole Single throw

b. Double Pole Single Throw

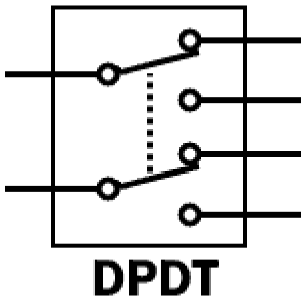
The double pole means it can control two completely isolated individual circuits. The single throw means that each pole has one position in which it can conduct.



DPST
Double Pole Single Throw

c. Double Pole Double Throw

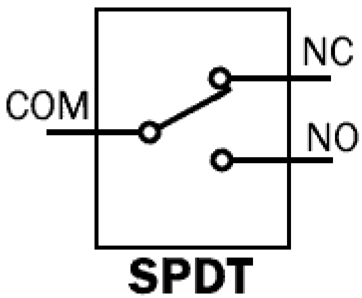
The double pole means it can control two circuits while the double throw means each pole can conduct in two separate positions.



Double Pole Double Throw

d. Single Pole Double Throw

The single pole means it can control only one circuit at a time. The double throw means its pole has two positions in which it can conduct.



Single Pole Double Throw

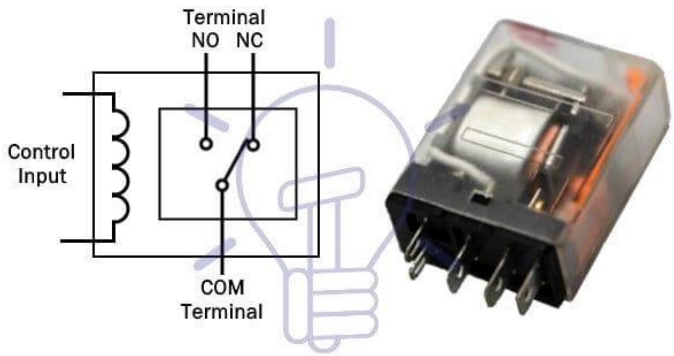
II. Based on Operational Principles

a. Electromechanical Relay

This type of relay has an electromagnetic coil and a mechanical movable contact.

When the coil is energized it produces a magnetic field. This magnetic field attracts the armature (movable contact). When the coil is de-energized the coil loose magnetic field and a spring retract the armature to its normal position.

The polarity of the source in EMR relay does not matter, it energizes the coil in either way but if there is a back EMF diode installed then polarity should be considered.

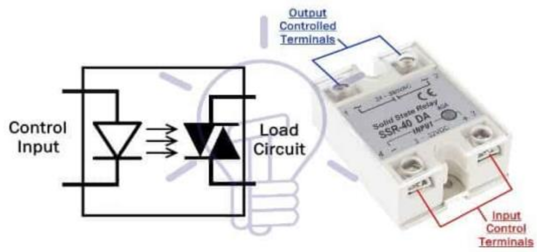


ElectroMechanical Relay

b. Solid State Relay

SSR relay is made up of semiconductors instead of mechanical parts and it works on isolating the low voltage circuit from high voltage circuit using an optocoupler.

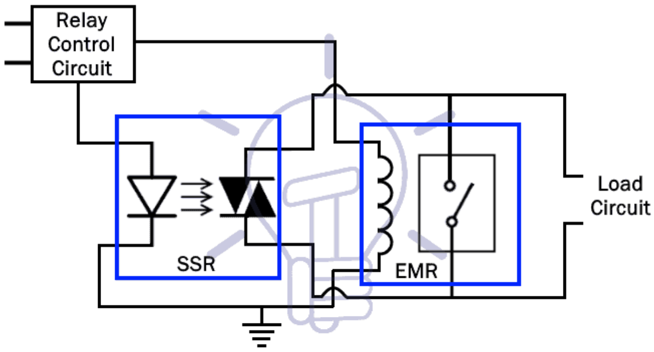
SSR operates on relatively high speed & has very low power consumption as compared to EMR relay. It has a longer lifespan because there are no physical contacts to burn out.



Solid State Relay (SSR)

c. Hybrid Relays

In Hybrid relay, SSR & EMR are used in parallel. A relay control circuit is used for switching the SSR first. The SSR takes the load current. So it eliminates the arching problem. Then the control circuit energizes the EMR coil & its contact closes but there is no arching since the SSR is taking the load in parallel. After some time, when the EMR contact settles down, the control input of SSR is removed. The EMR conducts the entire load current without any loss. Since there is no current flow throw SSR & the EMR takes the entire load, there is no power loss in form of heat. Thus, it eliminates the heat problem too.



Hybrid Relay

C) Applications

Relays are used to protect the electrical system and to minimize the damage to the equipment connected in the system due to over currents/voltages. The relay is used for the purpose of protection of the equipment connected with it.

These are used to control the high voltage circuit with low voltage signal in applications audio amplifiers and some types of modems.

These are used to control a high current circuit by a low current signal in the applications like starter solenoid in automobile. These can detect and isolate the faults that occurred in power transmission and distribution system. Typical application areas of the relays include: -

- Lighting control systems
- Telecommunication
- Industrial process controllers
- Traffic control
- Motor drives control
- Protection systems of electrical power system

3. Optocoupler

A) Definition

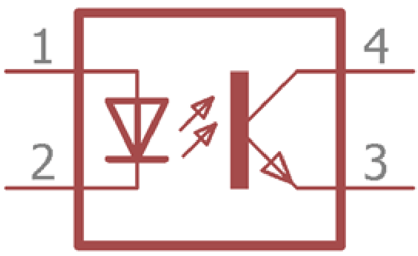
The Optocoupler is an electronic component which can be used in many different applications as an interface between low voltage digital or control circuits and large power electronic devices.

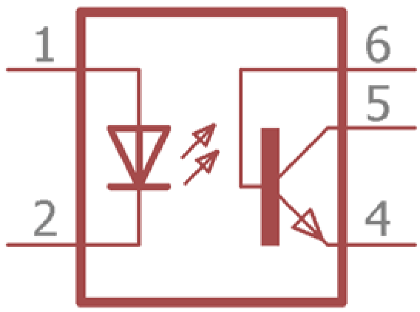
B) Types of Optocouplers

a. Photo-Transistor

Photocouplers (also known as optocouplers) generate light by using a light-emitting diode (LED) to generate a current which is conducted through a phototransistor.

Photo-Transistor can be further of two types depending on the output pin availability. On the second image on the left, there is additional pin out which is internally connected with transistor’s base. This pin 6 is used to control the sensitivity of the photo-transistor. Often the pin is used to connect with ground or negative using a high value resistor. In this configuration, false triggering due to noise or electrical transients can be controlled effectively.

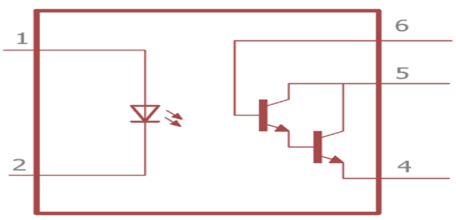




b. Photo-Darlington Transistor Optocoupler

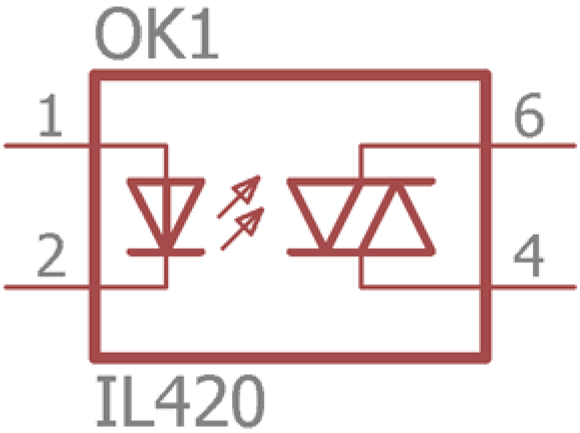
Darlington Transistor is two transistor pair, where one transistor controls another transistor base. In this configuration the Darlington Transistor provide high gain ability. As usual the LED emits infrared led and controls the base of the pair transistor.

This type of opto-coupler also used in DC circuit related area for the isolation. The 6th pin which is internally connected to the base of the transistor, used to control the sensitivity of the transistor.



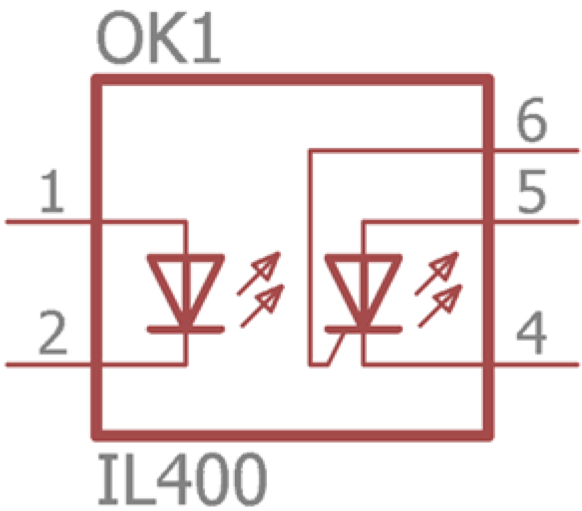
c. Photo-TRIAC Optocoupler

TRIAC is mainly used where AC based control or switching is needed. The led can be controlled using DC, and the TRIAC used to control AC. Opto-coupler provide excellent isolation in this case too. Here is one Triac Application. The photo-TRIAC based opto-coupler examples areIL420, 4N35 etc are example of TRIAC based opto-coupler.



d. Photo-SCR based Optocoupler

SCR stand for Silicon controlled rectifier; SCR also referred as Thyristor. In the upper image a Photo-SCR based opto-coupler's internal construction is shown. Same as like another opto-coupler the LED emit Infrared. The SCR is controlled by the intensity of the LED. Photo-SCR based Opto-coupler used in AC related circuitry.



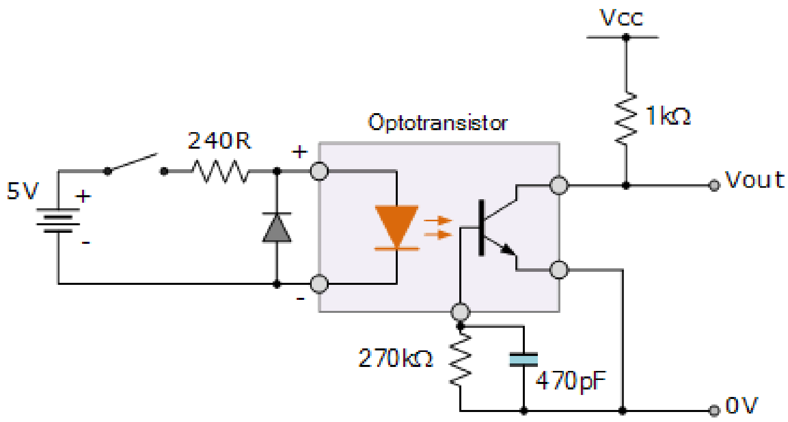
C) Applications

Common applications for opto-couplers include microprocessor input/output switching, DC and AC power control, PC communications, signal isolation and power supply regulation which suffer from current ground loops, etc. The electrical signal being transmitted can be either analogue (linear) or digital (pulses).

a. An Opto-transistor DC Switch

The value of the resistor can be chosen to suit the selected photo-coupler device and the amount of switching sensitivity required. The capacitor stops any unwanted spikes or transients from false triggering the opto-transistors base.

As well as detecting DC signals and data, Opto-triac isolators are also available which allow AC powered equipment and mains lamps to be controlled.



MAJOR DIFFERENCE BETWEEN RELAY AND OPTOCOUPLER

a. The key distinction between optocouplers and solid-state switches is that optocouplers are usually used in low power applications. While solid-state relays are required with even higher power rates up to hundreds of volts or more.
b. Optocouplers typically come as surface mounting devices or leaded semiconductor devices inside limited integrated circuit (IC) packets. In contrast, SSR is found in larger packages and sometimes involving the bolting of a heat-sink.
c. In comparison, solid-state relays are also augmented by circuits-often a full circuit block. We can include the LED drive circuit in the opt transmitter, as well as the burst and transient safety circuits in the output. Some solid-state relays have zero-crossing switching for AC signals in AC applications where the output system flips as the AC waveform moves through the zero-volt location which also results in the reduction of electromagnetic interference (EMI).

4. Voltage Regulator

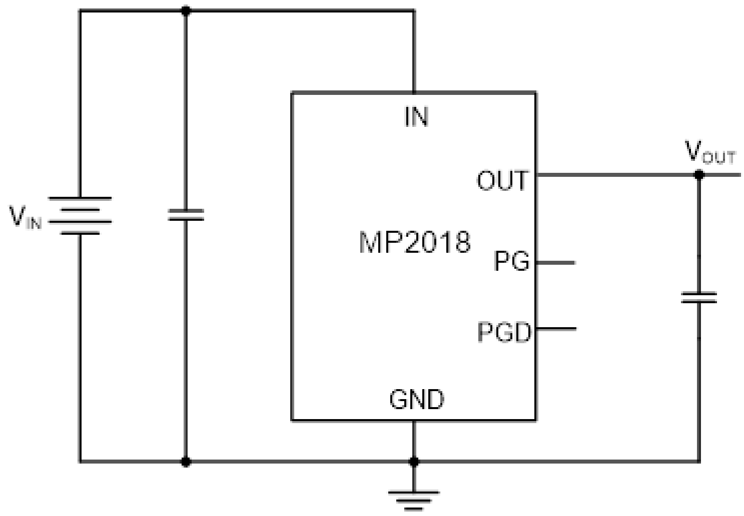
A) Definition

A voltage regulator is a circuit that creates and maintains a fixed output voltage, irrespective of changes to the input voltage or load conditions.
While voltage regulators are most used for DC/DC power conversion, some can perform AC/AC or AC/DC power conversion as well.

B) Types

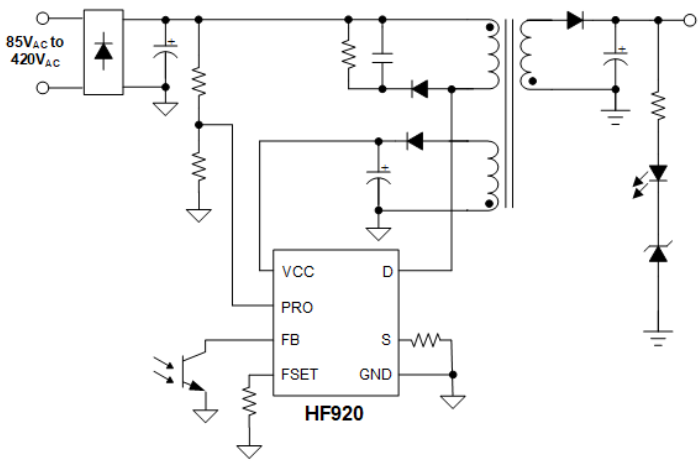
a. Voltage Regulators Linear

A linear voltage regulator utilizes an active pass device (such as a BJT or MOSFET), which is controlled by a high-gain operational amplifier. To maintain a constant output voltage, the linear regulator adjusts the pass device resistance by comparing the internal voltage reference to the sampled output voltage, and then driving the error to zero.
Linear regulators are step-down converters, so by definition the output voltage is always below the input voltage.



b. Voltage Regulator Switching

A switching regulator circuit is generally more complicated to design than a linear regulator, and requires selecting external component values, tuning control loops for stability, and careful layout design. Switching regulators can be step-down converters, step-up converters, or a combination of the two, which makes them more versatile than a linear regulator.
The HF920 is an example of a switching regulator that offers high reliability and efficient power regulation.



C) Difference between Linear and Switching

LINEAR	SWITCHING
LINEAR REGULATORS OPERATE WITH LOW EFFICIENCY	SWITCHING REGULATORS OPERATE WITH HIGH EFFICIENCY.
THEY HAVE FEW EXTERNAL PARTS	THEY HAVE A LOT OF EXTERNAL PARTS
THEY PRODUCE A LOT OF HEAT ENERGY.	THEY PRODUCE LESS HEAT ENERGY

D) Applications

Linear regulators are often used in applications that are cost-sensitive, noise-sensitive, low-current, or space constrained. Some examples include consumer electronics such as headphones, wearables, and Internet-of-Things (IoT) devices. For instance, applications such as a hearing aid could use a linear regulator because they do not have a switching element that could create unwanted noise and interfere with the device's performance.

Switching regulators are beneficial for more general applications, and are especially useful in applications that need efficiency and performance, such as consumer, industrial, enterprise, and automotive applications.
For example, if the application requires a large step-down solution, a switching regulator is better suited, since a linear regulator could create high power dissipation that would damage other electrical components.