

Academic Year: 2018 – 2019 (Odd Semester)							
Department: Electronics and Communication Engineering							
Course Code	Course Title	Core/ Elective	Prerequisite	Contact Hours			Total Hrs/ Sessions
				L	T	P	
18ELN14	Basic Electronics	Core		2	2	-	40
Objectives	This course will enable students to: - Understand characteristics, operation and applications of the diodes, bipolar junction transistors, field effect transistors, SCRs and operational amplifiers in electronic circuits. - Understand different number systems and working of fundamental building blocks of digital circuits. - Understand the principle of basic communication system and mobile phones.						
Topics Covered as per Syllabus							
Module -1: Semiconductor Diodes and Applications: p-n junction diode, Equivalent circuit of diode, Zener Diode, Zener diode as a voltage regulator, Rectification-Half wave rectifier, Full wave rectifier, Bridge rectifier, Capacitor filter circuit (2.2, 2.3, 2.4 of Text 1). Photo diode, LED, Photocoupler. (2.7.4, 2.7.5, 2.7.6 of Text 1). 78XX series and 7805 Fixed IC voltage regulator (8.4.4 and 8.4.5 of Text 1). Module -2: FET and SCR: Introduction, JFET: Construction and operation, JFET Drain Characteristics and Parameters, JFET Transfer Characteristic, Square law expression for I_D, input resistance, MOSFET: Depletion and Enhancement type MOSFET- Construction, Operation, Characteristics and Symbols, (refer 7.1, 7.2, 7.4, 7.5 of Text 2), CMOS (4.5 of Text 1). Silicon Controlled Rectifier (SCR) – Two-transistor model, switching action, Characteristics, Phase control application (refer 3.4 upto 3.4.5 of Text 1). Module -3: Operational Amplifiers and Applications: Introduction to Op-Amp, Op-Amp Input Modes, Op-Amp Parameters-CMRR, Input Offset Voltage and Current, Input Bias Current, Input and Output Impedance, Slew Rate (12.1, 12.2 of Text 2). Applications of Op-Amp -Inverting amplifier, Non-Inverting amplifier, Summer, Voltage follower, Integrator, Differentiator, Comparator (6.2 of Text 1). Module-4: BJT Applications, Feedback Amplifiers and Oscillators: BJT as an amplifier, BJT as a switch, Transistor switch circuit to switch ON/OFF an LED and a lamp in a power circuit using a relay (refer 4.4 and 4.5 of Text 2). Feedback Amplifiers – Principle, Properties and advantages of Negative Feedback, Types of feedback, Voltage series feedback, Gain stability with feedback (7.1-7.3 of Text 1). Oscillators – Barkhausen's criteria for oscillation, RC Phase Shift oscillator, Wien Bridge oscillator (7.7-7.9 of Text 1). IC 555 Timer and Astable Oscillator using IC 555 (17.2 and 17.3 of Text 1). Module-5: Digital Electronics Fundamentals: Difference between analog and digital signals, Number System- Binary, Hexadecimal, Conversion- Decimal to binary, Hexadecimal to decimal and vice-versa, Boolean algebra, Basic and Universal Gates, Half and Full adder, Multiplexer, Decoder, SR and JK flipflops, Shift register, 3 bit							

Ripple Counter (refer 10.1-10.7 of Text 1). Basic Communication system, Principle of operations of Mobile phone (refer 18.2 and 18.18 of Text 1).	
List of Text Books	
1. D.P. Kothari, I.J. Nagarath, “Basic Electronics”, 2nd edition, Mc Graw Hill, 2018. 2. Thomas L. Floyd, “Electronic Devices”, Pearson Education, 9th edition, 2012.	
List of Reference Books	
1. D.P. Kothari, I.J. Nagarath, “Basic Electronics”, 1st edn, McGraw Hill, 2014. 2. Boylestad, Nashelskey, “Electronic Devices and Circuit Theory”, Pearson Education, 9th Edition, 2007/11th edition, 2013. 3. David A. Bell, “Electronic Devices and Circuits”, Oxford University Press, 5th Edition, 2008. 4. Muhammad H. Rashid, “Electronics Devices and Circuits”, Cengage Learning, 2014.	
List of URLs, Text Books, Notes, Multimedia Content, etc	
1. K A Navas, T A Suhail, “Basic Electronics” Rajath publishers 2. http://nptel.ac.in/courses/117103063/ 3. http://engineering.nyu.edu/gk12/amps-cbri/pdf/Basic%20Electronics.pdf	
Course Outcomes	After studying this course, students will be able to: 1. Describe the operation of diodes, BJT, FET and Operational Amplifiers. 2. Design and explain the construction of rectifiers, regulators, amplifiers and oscillators. 3. Describe general operating principles of SCRs and its application. 4. Explain the working and design of fixed voltage IC regulator using 7805 and Astable oscillator using Timer IC 555. 5. Explain the different number system and their conversions and construct simple combinational and sequential logic circuits using Flip-Flops. 6. Describe the basic principle of operation of communication system and mobile phones.
Internal Assessment Marks: 40 (3 Session Tests are conducted during the semester and marks allotted based on average of best performances).	

MODULE 1

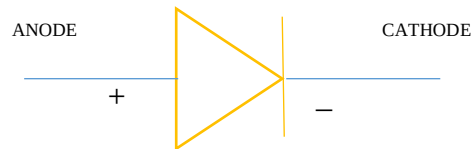
SEMICONDUCTOR DIODE AND APPLICATIONS

Structure

- 1.1 Introduction
- 1.2 P-N Junction Diode
 - 1.2.1 Diode Characteristics
 - 1.2.2. Diode Relationship
- 1.3 Equivalent circuit of Diode
- 1.4 Zener Diode
- 1.5 Zener Diode as a Voltage Regulator
- 1.6 Complement of Binary Numbers
 - 1.6.1. Half wave rectifier
 - 1.6.2 Full wave rectifier
 - 1.6.3 Bridge rectifier
 - 1.6.4. Capacitor filter Circuit
- 1.7 Photo Diode
- 1.8 LED
- 1.9 Photo Coupler
- 1.10 78XX series and 7805 Fixed IC voltage regulator

1.1 INTRODUCTION

Diode is an electrical component that allows the flow of current in only one direction. In circuit diagrams, a diode is represented by a triangle with a line across one vertex.



Diode has a wide range of applications like rectification (converting ac to dc), voltage regulation, protection against high voltage and wave shaping.

There are special purpose diodes like Zener diode, LED- light emitting diode and several other.

1.2 P-N JUNCTION DIODE

When P-type and N-type silicon are placed in contact with one another it forms a PN junction. At this junction an interesting phenomenon occurs, one that is the foundation of solid-state electronics.

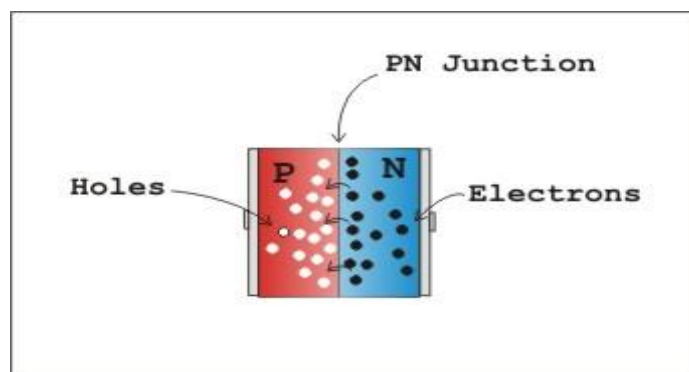


Fig 1

A basic PN junction creates a diode that allows electricity to flow in one direction. We can see in the fig 1 that the N type material has free electrons shown as black dots and the P type material has holes shown as white dots.

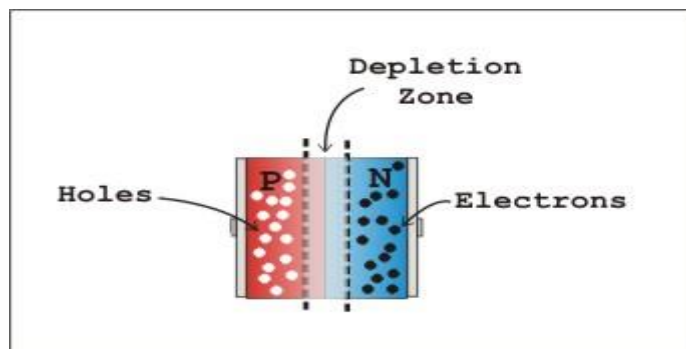


Fig 2

Near the PN junction the electrons diffuse into the vacant holes in the P material causing a depletion zone. This depletion zone acts like an insulator preventing other free electrons in the N-type silicon and holes in the P-type silicon from combining as shown in fig 2.

In addition, this leaves a small electrical imbalance inside the crystal. Since the N region is missing some electrons it has obtained a positive charge. And the extra electrons that filled the holes in the P region, have given it a negative charge. Unfortunately, one cannot generate power from this electrical imbalance. However, the stage is set to see how the PN junction functions as a diode.

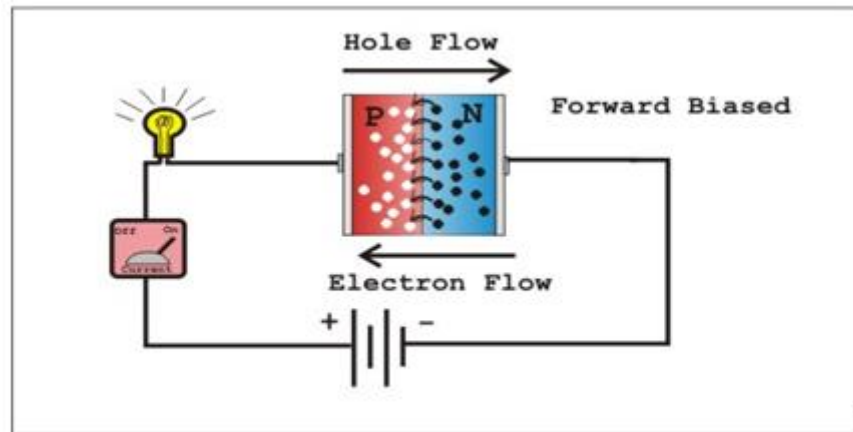


Fig 3

In the fig 3 we have connected an external power source; a battery with a light and current meter that indicate current flow. The negative terminal of the battery is connected to the N-type silicon. Like charges repel, so the free electrons are pushed toward the PN junction. Similarly, the holes are repelled by the positive terminal of the battery toward the PN junction. If the voltage pushing the electrons and holes has sufficient strength to overcome the depletion zone (approximately 0.7 V for typical silicon diode) the electrons and holes combine at the junction and current passes through the diode. When a diode is arranged this way with a power supply it is said to be forward-biased.

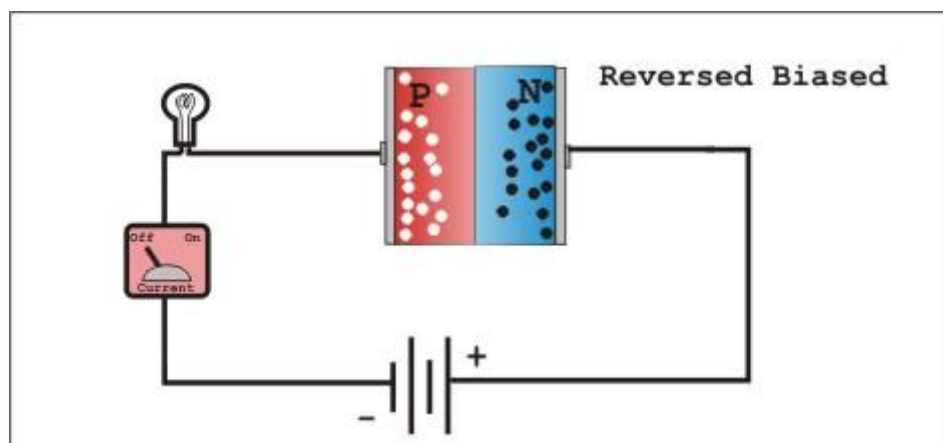


Fig 4

In the fig 4 the battery is connected to the diode so that the negative terminal of the battery connects to the P-type silicon and the positive terminal of the battery connects to the N-type silicon. The negative terminal attracts the positive holes in the P-type silicon and the positive terminal of the battery attracts the free electrons in the N-type silicon. All the charge carriers are pulled away from the PN junction which essentially creates a larger depletion region and no current flows. When a diode is arranged this way with a power supply it is said to be reverse-biased.

1.2.1. DIODE CHARACTERISTICS

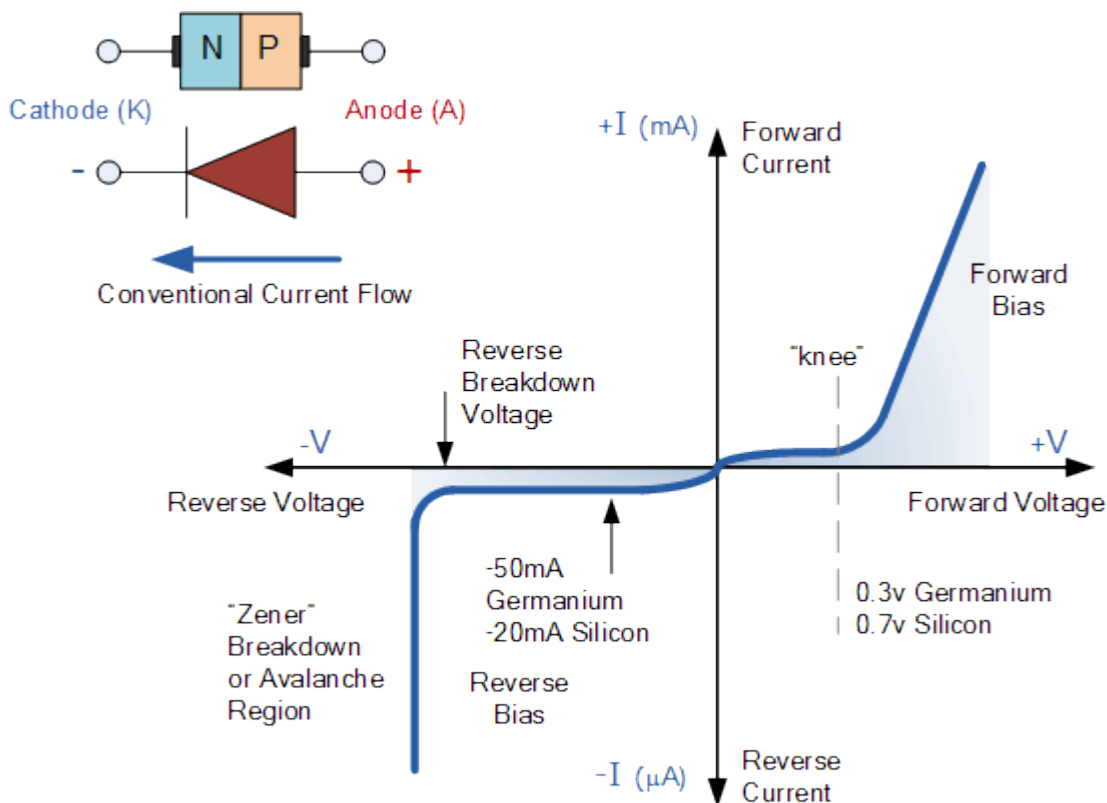


Fig 5

There are two operating regions and three possible “biasing” conditions for the standard Junction Diode as shown in fig 5 and these are:

1. Zero Bias – No external voltage potential is applied to the PN junction diode.
2. Reverse Bias – The voltage potential is connected negative, (-ve) to the P-type material and positive, (+ve) to the N-type material across the diode which has the effect of Increasing the PN junction diode's width.
3. Forward Bias – The voltage potential is connected positive, (+ve) to the P-type material and negative, (-ve) to the N-type material across the diode which has the effect of Decreasing the PN junction diodes width.

1.2.2. DIODE RELATIONSHIP

$$I_D = I_S (e^{kV_d/Tk} - 1) \quad \text{Eq ----- 1}$$

where I_S = reverse saturation current

$k = 11600/\eta$; $\eta=1$ for Ge and $\eta=2$ for Si for low current, below the knee of the curve

$\eta = 1$ for both Ge and Si for higher level of current beyond the knee.

$T_k = T_c + 273^0$ where T_c = operating temperature (25°C).

The plots of equation 1 for Ge and Si diodes are as shown in fig 6. The sharply rising part of the curve extended downward meets the V_D axis, which is indicated as V_T = offset, threshold or firing potential.

It is quite accurate to assume that $I_D=0$ up to V_T and then increases almost linearly at a sharp slope. The value of V_T is 0.7V for Silicon diode and 0.3 for Germanium diode.

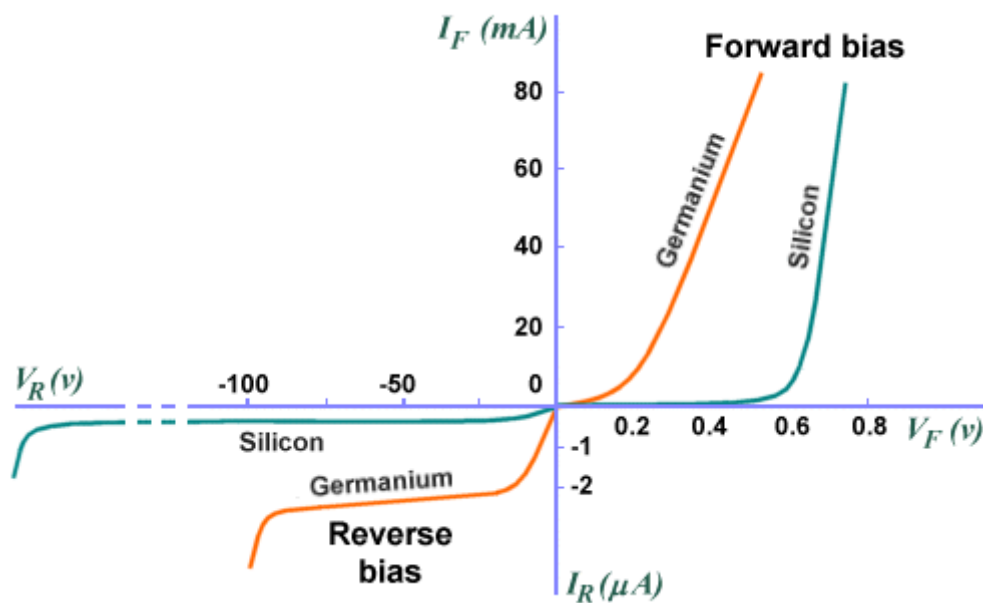


Fig 6 Diode Characteristics

NOTE:

- **ZENER REGION:** When the diode is in the reverse bias condition at some point the reverse bias voltage is so large that diode breaks down and the reverse current increases dramatically. This maximum voltage is called avalanche breakdown voltage and the current is called avalanche current. The maximum negative voltage that a diode can withstand is at Peak Inverse Voltage (PIV rating).
- **ZENER BREAKDOWN:** By heavily doping the N and P Regions, the breakdown voltage V_z can be brought as low as -10V, -5V. this mechanism of breakdown is different from avalanche.

This type of diode is called ZENER diode. When connected at a point in an electronic circuit, it does not allow the potential there to exceed the diode rated voltage.

1.3 EQUIVALENT CIRCUIT OF DIODE

1. Ideal diode

It conducts when $V_D > 0$ as shown below

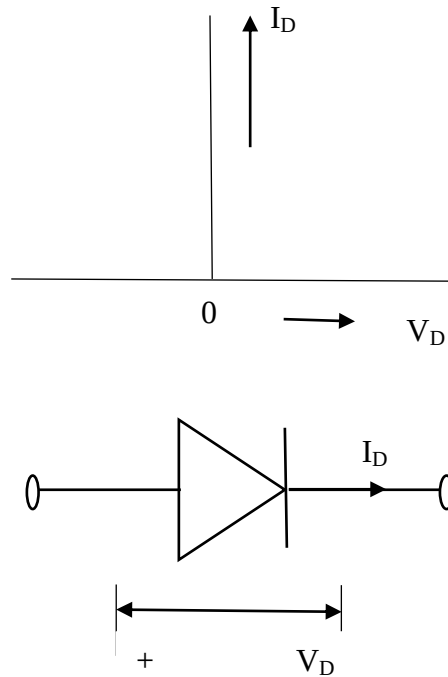


Fig 7

2. Piecewise Linear diode

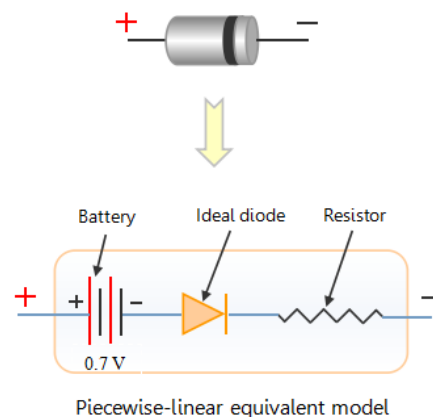
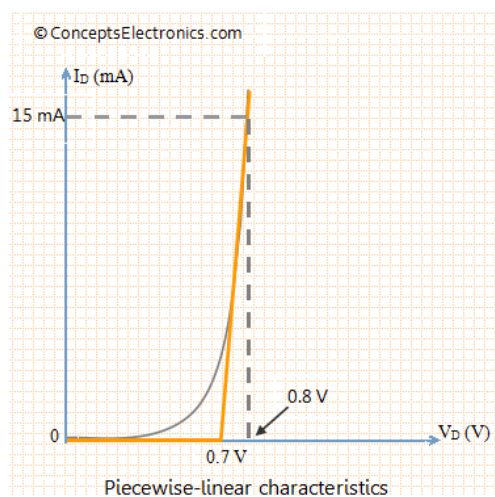


Fig 8

1.5. ZENER DIODE AS A VOLTAGE REGULATOR

Zener Diodes can be used to produce a stabilized voltage output with low ripple under varying load current conditions. By passing a small current through the diode from a voltage source, via a suitable current limiting resistor (R_S), the Zener diode will conduct sufficient current to maintain a voltage drop of V_{out} .

We remember from the previous tutorials that the DC output voltage from the half or full-wave rectifiers contains ripple superimposed onto the DC voltage and that as the load value changes so to does the average output voltage. By connecting a simple Zener stabilizer circuit as shown below across the output of the rectifier, a more stable output voltage can be produced.

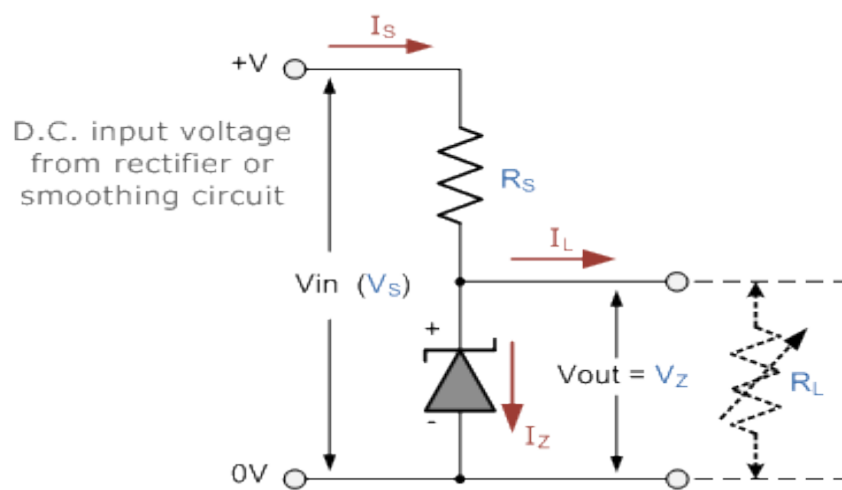


Fig 11

The resistor, R_S is connected in series with the Zener diode to limit the current flow through the diode with the voltage source, V_S being connected across the combination. The stabilised output voltage V_{out} is taken from across the Zener diode. The Zener diode is connected with its cathode terminal connected to the positive rail of the DC supply so it is reverse biased and will be operating in its breakdown condition. Resistor R_S is selected so to limit the maximum current flowing in the circuit.

With no load connected to the circuit, the load current will be zero, ($I_L = 0$), and all the circuit current passes through the Zener diode which in turn dissipates its maximum power. Also a small value of the series resistor R_S will result in a greater diode current when the load resistance R_L is connected and large as this will increase the power dissipation requirement of the diode so care must be taken when selecting the appropriate value of series resistance so that the Zener's maximum power rating is not exceeded under this no-load or high-impedance condition.

The load is connected in parallel with the Zener diode, so the voltage across R_L is always the same as the Zener voltage, ($V_R = V_Z$). There is a minimum Zener current for which the stabilization of the voltage is

effective and the Zener current must stay above this value operating under load within its breakdown region at all times. The upper limit of current is of course dependent upon the power rating of the device.

The supply voltage V_S must be greater than V_Z .

One small problem with Zener diode stabilizer circuits is that the diode can sometimes generate electrical noise on top of the DC supply as it tries to stabilize the voltage. Normally this is not a problem for most applications but the addition of a large value decoupling capacitor across the Zener's output may be required to give additional smoothing.

Then to summarize a little. A Zener diode is always operated in its reverse biased condition. A voltage regulator circuit can be designed using a Zener diode to maintain a constant DC output voltage across the load in spite of variations in the input voltage or changes in the load current. The Zener voltage regulator consists of a current limiting resistor R_S connected in series with the input voltage V_S with the Zener diode connected in parallel with the load R_L in this reverse biased condition. The stabilized output voltage is always selected to be the same as the breakdown voltage V_Z of the diode.

1.6. RECTIFICATION

“Rectifiers are the circuit which converts ac to dc”. Rectifiers are grouped into two categories depending on the period of conduction.

1. Half-wave rectifier
2. Full- wave rectifier.

1.6.1. HALF-WAVE RECTIFIER

The circuit diagram of a half-wave rectifier is shown in Figure.1. 22 below along with the I/P and O/P waveforms.

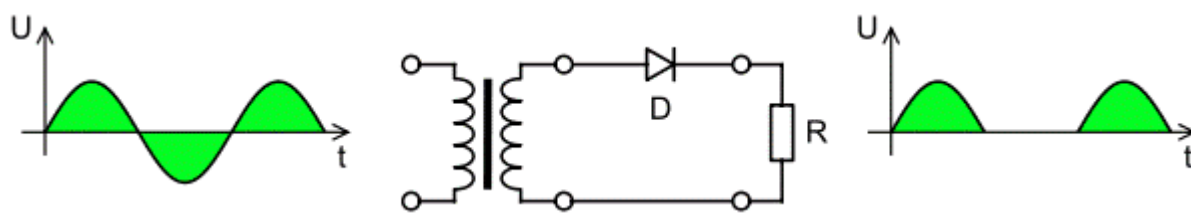


Figure 12 Half wave rectifier and its input output waveforms

The transformer is employed in order to step-down the supply voltage and also to prevent from shocks.

The diode is used to rectify AC signal while, the pulsating DC is taken across the load resistor R_L .

During the +ve half cycle, the end X of the secondary is +ve and end Y is -ve. Thus, forward biasing the diode. As the diode is forward biased, the current flows through the load R_L and a voltage is developed across it.

During the -ve half-cycle the end Y is +ve and end X is -ve thus, reverse biasing the diode. As the diode is reverse biased there is no flow of current through RL thereby the output voltage is zero.

1.6.2. THE FULL WAVE RECTIFIER

In the previous Power Diodes tutorial we discussed ways of reducing the ripple or voltage variations on a direct DC voltage by connecting capacitors across the load resistance. While this method may be suitable for low power applications it is unsuitable to applications which need a “steady and smooth” DC supply voltage. One method to improve on this is to use every half-cycle of the input voltage instead of every other half-cycle. The circuit which allows us to do this is called a Full Wave Rectifier.

Like the half wave circuit, a Full Wave Rectifier Circuit produces an output voltage or current which is purely DC or has some specified DC component. Full wave rectifiers have some fundamental advantages over their half wave rectifier counterparts. The average (DC) output voltage is higher than for half wave, the output of the full wave rectifier has much less ripple than that of the half wave rectifier producing a smoother output waveform. In a Full Wave Rectifier circuit two diodes are now used, one for each half of the cycle. A multiple winding transformer is used whose secondary winding is split equally into two halves with a common centre tapped connection, (C). This configuration results in each diode conducting in turn when its anode terminal is positive with respect to the transformer centre point C producing an output during both half-cycles, twice that for the half wave rectifier so it is 100% efficient as shown below.

Full Wave Rectifier Circuit

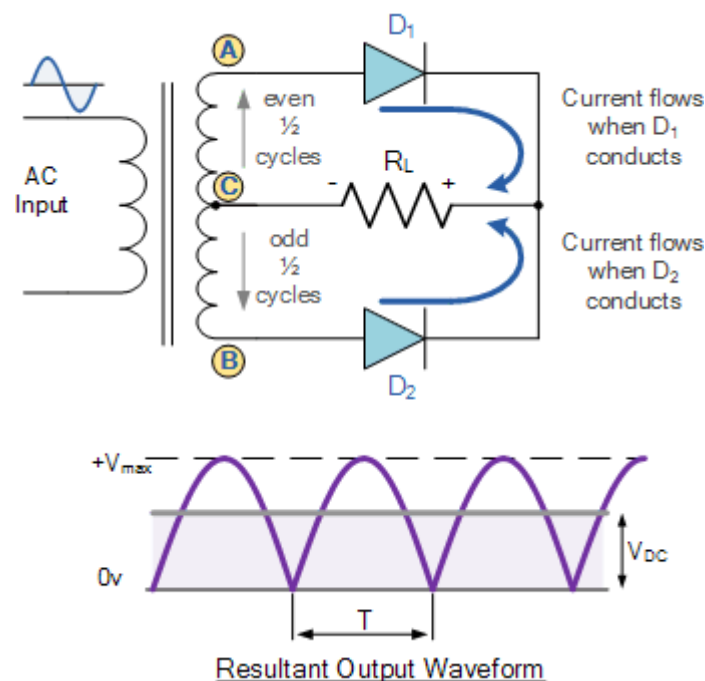


Figure 13. Center tap full wave rectifier and its input output waveforms

The full wave rectifier circuit consists of two *power diodes* connected to a single load resistance (RL) with each diode taking it in turn to supply current to the load. When point A of the transformer is positive with respect to point C, diode D1 conducts in the forward direction as indicated by the arrows.

When point B is positive (in the negative half of the cycle) with respect to point C, diode D2 conducts in the forward direction and the current flowing through resistor R is in the same direction for both half-cycles. As the output voltage across the resistor R is the phasor sum of the two waveforms combined, this type of full wave rectifier circuit is also known as a “bi-phase” circuit.

As the spaces between each half-wave developed by each diode is now being filled in by the other diode the average DC output voltage across the load resistor is now double that of the single half-wave rectifier circuit and is about $0.637V_{\max}$ of the peak voltage, assuming no losses.

$$V_{d.c.} = \frac{2V_{\max}}{\pi} = 0.637V_{\max} = 0.9V_{RMS}$$

Where: $V_{\max}$ is the maximum peak value in one half of the secondary winding and V_{RMS} is the rms value.

The peak voltage of the output waveform is the same as before for the half-wave rectifier provided each half of the transformer windings have the same rms voltage value. To obtain a different DC voltage output different transformer ratios can be used. The main disadvantage of this type of full wave rectifier circuit is that a larger transformer for a given power output is required with two separate but identical secondary windings making this type of full wave rectifying circuit costly compared to the “Full Wave Bridge Rectifier” circuit equivalent.

1.6.3. THE FULL WAVE BRIDGE RECTIFIER

Another type of circuit that produces the same output waveform as the full wave rectifier circuit above, is that of the Full Wave Bridge Rectifier. This type of single phase rectifier uses four individual rectifying diodes connected in a closed loop “bridge” configuration to produce the desired output. The main advantage of this bridge circuit is that it does not require a special centre tapped transformer, thereby reducing its size and cost. The single secondary winding is connected to one side of the diode bridge network and the load to the other side as shown below.

The Diode Bridge Rectifier

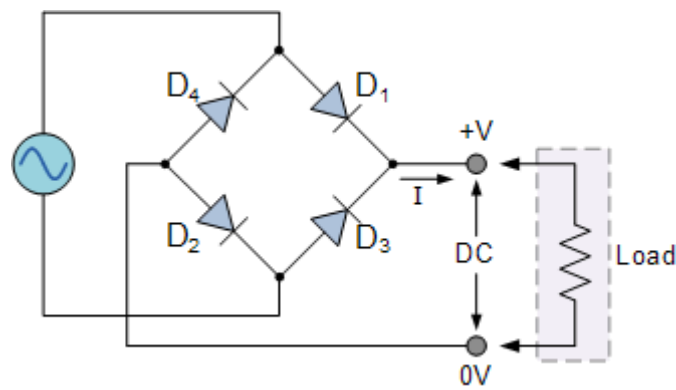


Figure 14 Full wave bridge rectifier and its input output waveforms

The four diodes labelled D1 to D4 are arranged in “series pairs” with only two diodes conducting current during each half cycle. During the positive half cycle of the supply, diodes D1 and D2 conduct in series while diodes D3 and D4 are reverse biased and the current flows through the load as shown below.

The Positive Half-cycle

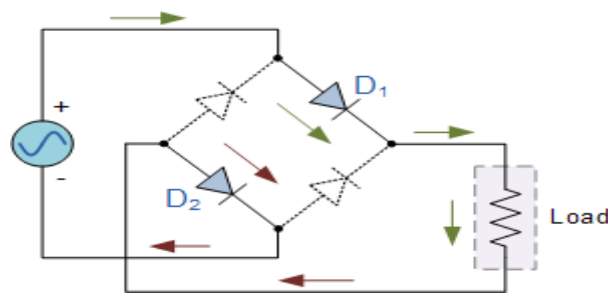


Fig 15

During the negative half cycle of the supply, diodes D3 and D4 conduct in series, but diodes D1 and D2 switch “OFF” as they are now reverse biased. The current flowing through the load is the same direction as before.

The Negative Half-cycle

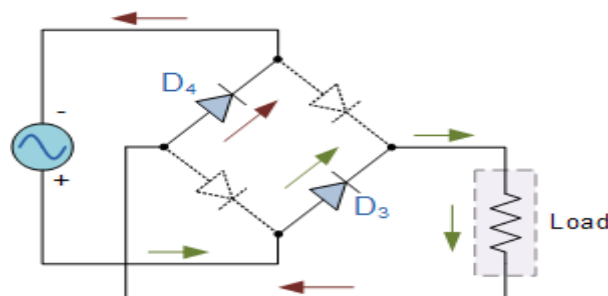


Fig 16

As the current flowing through the load is unidirectional, so the voltage developed across the load is also unidirectional the same as for the previous two diode full-wave rectifier, therefore the average DC voltage across the load is $0.637V_{max}$.



Fig 17

Typical Bridge Rectifier

However in reality, during each half cycle the current flows through two diodes instead of just one so the amplitude of the output voltage is two voltage drops ($2 \times 0.7 = 1.4V$) less than the input V_{MAX} amplitude. The ripple frequency is now twice the supply frequency (e.g. 100Hz for a 50Hz supply or 120Hz for a 60Hz supply).

Although we can use four individual power diodes to make a full wave bridge rectifier, pre-made bridge rectifier components are available “off-the-shelf” in a range of different voltage and current sizes that can be soldered directly into a PCB circuit board or be connected by spade connectors.

The image to the right shows a typical single phase bridge rectifier with one corner cut off. This cut-off corner indicates that the terminal nearest to the corner is the positive or +ve output terminal or lead with the opposite (diagonal) lead being the negative or -ve output lead. The other two connecting leads are for the input alternating voltage from a transformer secondary winding.

1.6.4. THE CAPACITOR FILTER CIRCUIT

The Smoothing Capacitor

We saw in the previous section that the single phase half-wave rectifier produces an output wave every half cycle and that it was not practical to use this type of circuit to produce a steady DC supply. The full-wave bridge rectifier however, gives us a greater mean DC value ($0.637 V_{max}$) with less superimposed ripple while the output waveform is twice that of the frequency of the input supply frequency. We can therefore increase its average DC output level even higher by connecting a suitable smoothing capacitor across the output of the bridge circuit as shown below.

Full-wave Rectifier with Smoothing Capacitor

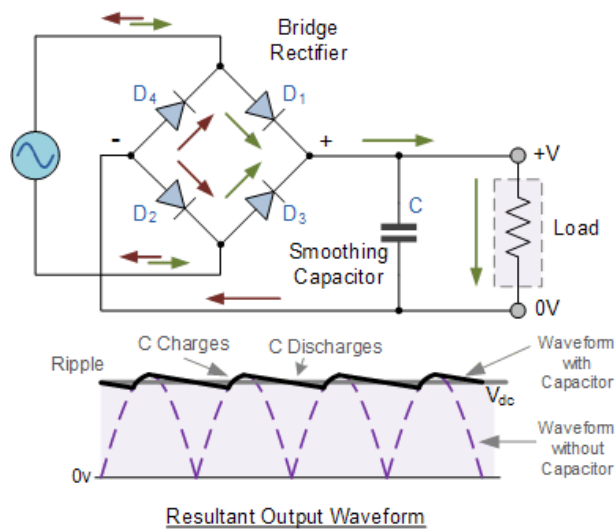


Figure 18. Bridge rectifier with capacitor filter and its input output waveforms

The smoothing capacitor converts the full-wave rippled output of the rectifier into a smooth DC output voltage. Generally, for DC power supply circuits the smoothing capacitor is an Aluminum Electrolytic type that has a capacitance value of 100μF or more with repeated DC voltage pulses from the rectifier charging up the capacitor to peak voltage.

However, there are two important parameters to consider when choosing a suitable smoothing capacitor and these are its *Working Voltage*, which must be higher than the no-load output value of the rectifier and its *Capacitance Value*, which determines the amount of ripple that will appear superimposed on top of the DC voltage.

Too low a capacitance value and the capacitor has little effect on the output waveform. But if the smoothing capacitor is sufficiently large enough (parallel capacitors can be used) and the load current is not too large, the output voltage will be almost as smooth as pure DC. As a general rule of thumb, we are looking to have a ripple voltage of less than 100mV peak to peak.

The maximum ripple voltage present for a Full Wave Rectifier circuit is not only determined by the value of the smoothing capacitor but by the frequency and load current, and is calculated as:

Bridge Rectifier Ripple Voltage

$$V_{(\text{ripple})} = \frac{I_{(\text{load})}}{f \times C}, \text{ Volts}$$

Where: I is the DC load current in amps, f is the frequency of the ripple or twice the input frequency in Hertz, and C is the capacitance in Farads.

The main advantages of a full-wave bridge rectifier is that it has a smaller AC ripple value for a given load and a smaller reservoir or smoothing capacitor than an equivalent half-wave rectifier. Therefore, the fundamental frequency of the ripple voltage is twice that of the AC supply frequency (100Hz) where for the half-wave rectifier it is exactly equal to the supply frequency (50Hz).

The amount of ripple voltage that is superimposed on top of the DC supply voltage by the diodes can be virtually eliminated by adding a much improved π -filter (pi-filter) to the output terminals of the bridge rectifier. This type of low-pass filter consists of two smoothing capacitors, usually of the same value and a choke or inductance across them to introduce a high impedance path to the alternating ripple component

Another more practical and cheaper alternative is to use an off the shelf 3-terminal voltage regulator IC, such as a LM78xx (where “xx” stands for the output voltage rating) for a positive output voltage or its inverse equivalent the LM79xx for a negative output voltage which can reduce the ripple by more than 70dB (Datasheet) while delivering a constant output current of over 1 amp.

In the next tutorial about diodes, we will look at the Zener Diode which takes advantage of its reverse breakdown voltage characteristic to produce a constant and fixed output voltage across itself.

1.7. PHOTODIODE

The field of photoelectrons has quite a variety of applications and has been attracting deep research interest. Here, we will study two types of devices- one in which light controls diode current and the other in which diode emits light when carrying current.

A photodiode is a p-n junction or PIN structure. When a photon of sufficient energy strikes the diode, it creates an electron-hole pair. This mechanism is also known as the inner photoelectric effect. If the absorption occurs in the junction's depletion region, or one diffusion length away from it, these carriers are swept from the junction by the built-in electric field of the depletion region. Thus holes move toward the anode, and electrons toward the cathode, and a photocurrent is produced. The total current through the photodiode is the sum of the dark current (current that is generated in the absence of light) and the photocurrent, so the dark current must be minimized to maximize the sensitivity of the device. It operates in reverse bias region as shown in fig below.

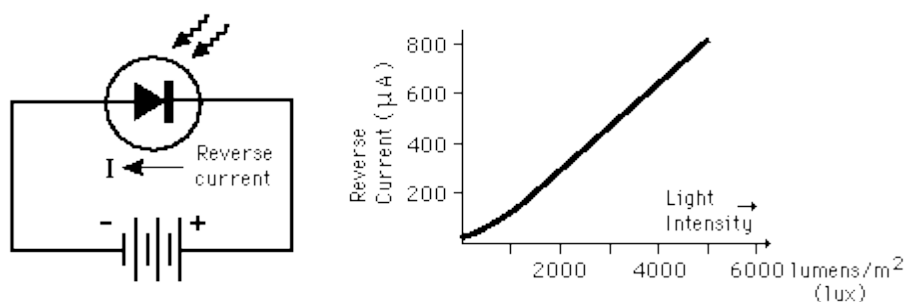


Fig 19. The IV characteristics of a photodiode is as shown in fig below.

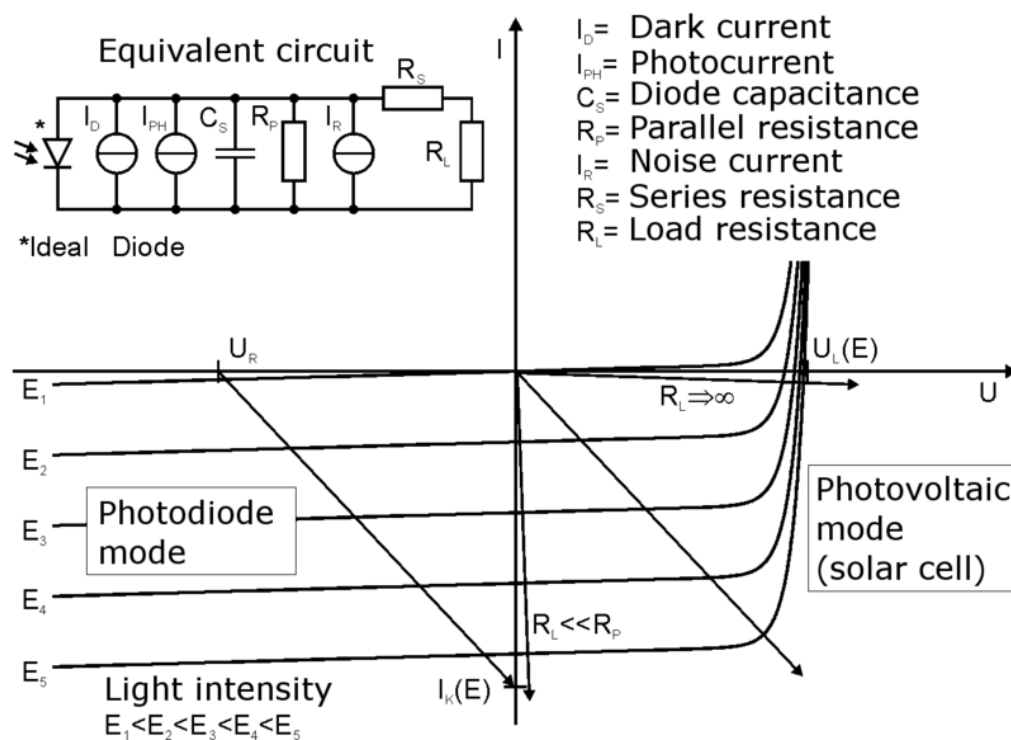


Fig 20. I-V characteristic of a photodiode.

The linear load lines represent the response of the external circuit: $I = (\text{Applied bias voltage} - \text{Diode voltage}) / \text{Total resistance}$. The points of intersection with the curves represent the actual current and voltage for a given bias, resistance and illumination.

1.8. LIGHT EMITTING DIODE (LED)

Light Emitting Diodes or simply LED's, are among the most widely used of all the different types of semiconductor diodes available today and are commonly used in TV's and colour displays.

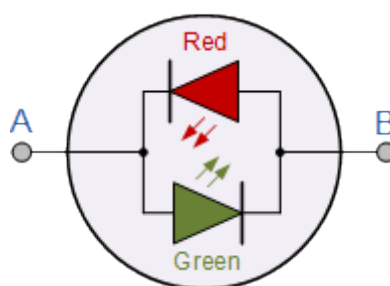


Fig 21

The "Light Emitting Diode" or LED as it is more commonly called, is basically just a specialised type of diode as they have very similar electrical characteristics to a PN junction diode. This means that an LED will pass current in its forward direction but block the flow of current in the reverse direction.

actually emit that much light so the epoxy resin body is constructed in such a way that the photons of light emitted by the junction are reflected away from the surrounding substrate base to which the diode is attached and are focused upwards through the domed top of the LED, which itself acts like a lens concentrating the amount of light. This is why the emitted light appears to be brightest at the top of the LED. However, not all LEDs are made with a hemispherical shaped dome for their epoxy shell. Some indication LEDs have a rectangular or cylindrical shaped construction that has a flat surface on top or their body is shaped into a bar or arrow. Generally, all LED's are manufactured with two legs protruding from the bottom of the body. Also, nearly all modern light emitting diodes have their cathode, (-) terminal identified by either a notch or flat spot on the body or by the cathode lead being shorter than the other as the anode (+) lead is longer than the cathode (k). Unlike normal incandescent lamps and bulbs which generate large amounts of heat when illuminated, the light emitting diode produces a "cold" generation of light which leads to high efficiencies than the normal "light bulb" because most of the generated energy radiates away within the visible spectrum. Because LEDs are solid-state devices, they can be extremely small and durable and provide much longer lamp life than normal light sources. Light Emitting Diode (LED) works only in forward bias condition. When Light Emitting Diode (LED) is forward biased, the free electrons from n-side and the holes from p-side are pushed towards the junction.

When free electrons reach the junction or depletion region, some of the free electrons recombine with the holes in the positive ions. We know that positive ions have less number of electrons than protons. Therefore, they are ready to accept electrons. Thus, free electrons recombine with holes in the depletion region. In the similar way, holes from p-side recombine with electrons in the depletion region. Because of the recombination of free electrons and holes in the depletion region, the width of depletion region decreases. As a result, more charge carriers will cross the p-n junction.

Some of the charge carriers from p-side and n-side will cross the p-n junction before they recombine in the depletion region. For example, some free electrons from n-type semiconductor cross the p-n junction and recombines with holes in p-type semiconductor. In the similar way, holes from p-type semiconductor cross the p-n junction and recombines with free electrons in the n-type semiconductor. Thus, recombination takes place in depletion region as well as in p-type and n-type semiconductor. The free electrons in the conduction band releases energy in the form of light before they recombine with holes in the valence band. In silicon and germanium diodes, most of the energy is released in the form of heat and emitted light is too small. However, in materials like gallium arsenide and gallium phosphide the emitted photons have sufficient energy to produce intense visible light.

1.9. PHOTOCOUPLER

Photo coupler generate light by using a light emitting diode (LED) to generate a current which is conducted through a phototransistor.

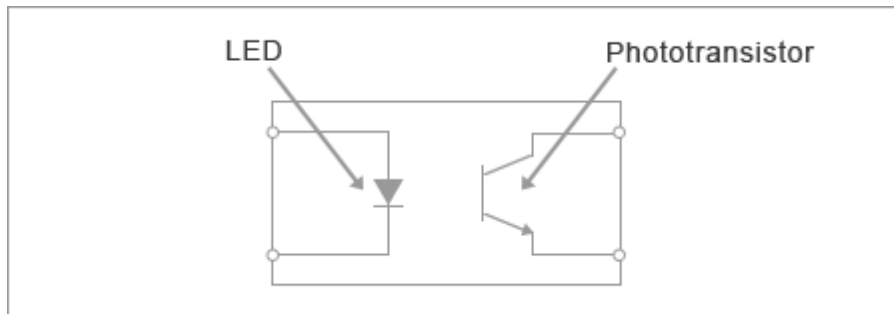


Figure 24 Internal Equivalence Circuit

Here we will describe how a general-purpose Photocoupler with this basic structure is used. Photocoupler are mainly used for the following:

1. As a switching device to transfer pulse signals.
2. To transfer feedback error signals in analog switching regulators
3. The operation of Photocoupler when used as switching devices is more basic, so we will start by describing this operation.

The key advantage of the photocoupler is the electrical isolation between two circuits. It is employed to couple circuits whose voltage level may differ by several thousand volts.

1.10. 78XX series and 7805 Fixed IC voltage regulator

The LM78XX series is typical of the 3-terminal voltage regulators. The 7805 produces an output of +5V, 7806 produces an output of +6V, and 7808 produces an output of + 8V, and so on, up to 7824, which produces an output of + 24V.

Figure 25 shows the functional block diagram for the 78XX series.

VOLTAGE REGULATOR IC - BLOCK DIAGRAM

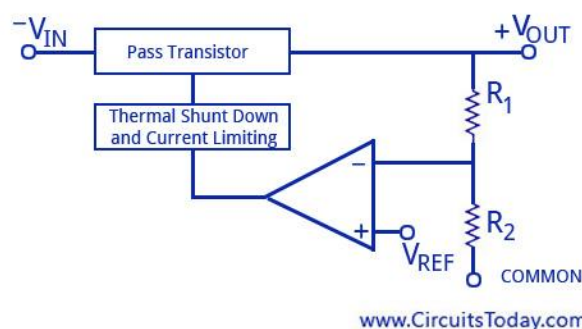


Fig 25

As shown in the block diagram above, the built-in reference voltage. V_{REF} drives the non-inverting input of the operational amplifier. There are many stages of voltage gain for the op-amp used here. This

high gain helps the op-amp to make the error voltage between the inverting and non-inverting terminals to be almost zero. Thus, the inverting input terminal value will also be the same as the non-inverting terminal, V_{REF} . Thus, the current flowing through the potential divider can be written as

$$I = V_{REF}/R_2$$

The resistor R_2 shown in the figure is not an external component connected to the IC, but an internal resistor that is built inside the IC during manufacture. Due to the conditions above, the same current flows through R_1 . Thus the output voltage can be written as

$$V_{OUT} = V_{REF}/R_2 (R_1 + R_2)$$

This shows that the output of the regulator can be controlled by putting desired values for R_1 and R_2 . The IC has a series pass transistor that can handle more than 1.5 A of load current provided that enough heat sinking is provided along with it. Like other IC's, this IC also has thermal shutdown and current limiting options. Thermal shutdown is a feature that will turn off the IC as soon as the internal temperature of the IC rises above its preset value. This rise in temperature may mostly be due to excessive external voltage, ambient temperature, or even heat sinking.

Fixed IC Voltage Regulator

The voltage regulator IC 7805 is actually a member of 78xx series of voltage regulator ICs. It is a fixed linear voltage regulator. The xx present in 78xx represents the value of the fixed output voltage that the particular IC provides. For 7805 IC, it is +5V DC regulated power supply. This regulator IC also adds

a provision for a heat sink. The input voltage to this voltage regulator can be up to 35V, and this IC can give a constant 5V for any value of input less than or equal to 35V which is the threshold limit.

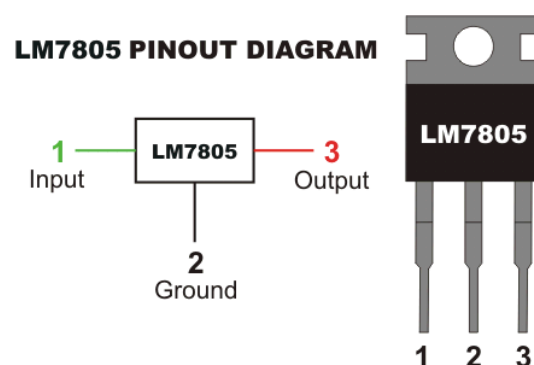


Fig 26

PIN 1-INPUT: The function of this pin is to give the input voltage. It should be in the range of 7V to 35V. An unregulated voltage is applied to this pin for regulation. For 7.2V input, the PIN achieves a maximum efficiency.

PIN 2-GROUND: The ground is connected to this pin. For output and input, this pin is equally neutral (0V).

PIN 3-OUTPUT: This pin is used to take the regulated output.

It has an output voltage of +5 volts and a maximum load current over 1A. The typical load regulation is 10mV for a load current between 5mA and 1.5 A.

The typical line regulation is 3 mV for an input voltage of 7 to 25 V. it also has a ripple rejection of 80 dB.

Applications of Voltage Regulator 7805 IC

1. Current regulator
2. Regulated dual supply
3. Building circuits for Phone charger, UPS power supply circuits, portable CD player etc
4. Fixed output regulator
5. Adjustable output regulator etc.