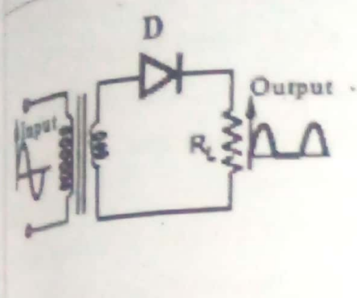
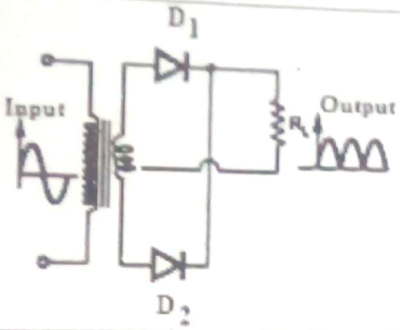
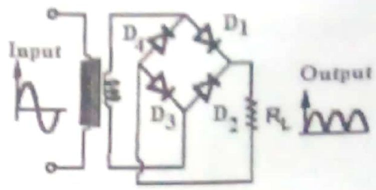
10	TUF	0.287	0.812	0.693
11	Form factor	1.57	1.11	1.11
12	Peak factor	2	$\sqrt{2}$	$\sqrt{2}$
13	Ripple frequency	f	$2f$	$2f$
	Circuit diagrams			
	Half Wave Rectifier	**Full Wave Center Tap Rectifier**	**Full Wave Bridge Rectifier**	
				

1.5 FILTER CIRCUITS

A power supply must provide ripple free source of power from an A.C. line. But the output of a rectifier circuit contains ripple components in addition to a D.C. term. It is necessary to include a filter between the rectifier and the load in order to eliminate these ripples components. Ripple components are high frequency A.C. Signals in the D.C output of the rectifier. These are not desirable, so they must be filtered. So filter circuits are used.

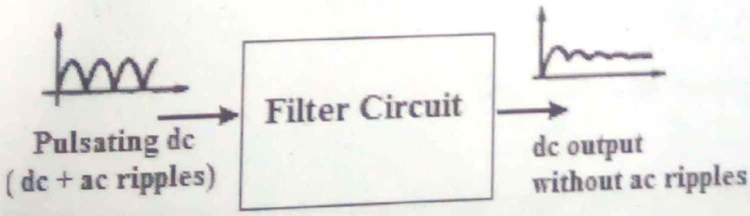


Figure 7: Function of filter circuit

Many types of passive filters are in use such as (1) Shunt capacitor filter (2) Series inductor filter (3) Chock input (LC) filter (4) Pi (π) section filter or CLC filter or capacitor input filter.

1.5.1 Shunt Capacitor Filter **[KTU DEC 2019]**

This type of filter consists of large value of capacitor connected across the load resistor R_L as shown in fig: 8. This capacitor offers a low reactance to the a.c. components and very high impedance to d.c. so that the a.c. components in the rectifier output find low reactance path through the capacitor and only a small part flows through R_L, producing small ripple at the output as shown in figure 8.

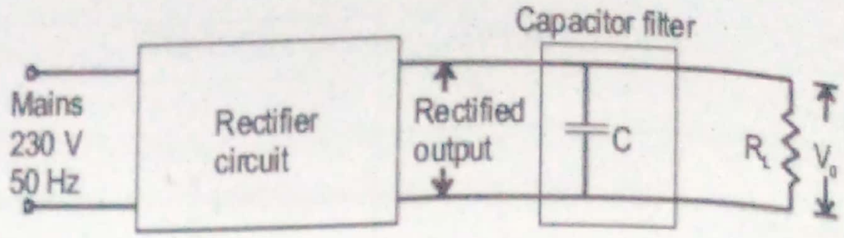


Figure 8: Block diagram of capacitor input filter

Here $X_C = \frac{1}{2\pi f C}$ the impedance of capacitor should be smaller than R_L. Because, current should pass through C and the C should get charged. If the C value is very small, X_c will be large and hence current flows through R_L only and no filtering action takes place. The capacitor C gets charged when the diode (in the rectifier) is conducting and gets discharged when the diode is not conducting through R_L. When the input voltage $v = V_m \sin \omega t$ is greater than the capacitor voltage, C gets charged. When the input voltage is less than that of the capacitor voltage, C will discharge through R_L. The stored energy in the capacitor maintains the load voltage at a high value for a long period. The diode conducts only for a short interval of high current. The waveforms are as shown in figure. Capacitor opposes sudden fluctuations in voltage across it. So the ripple voltage is minimized.

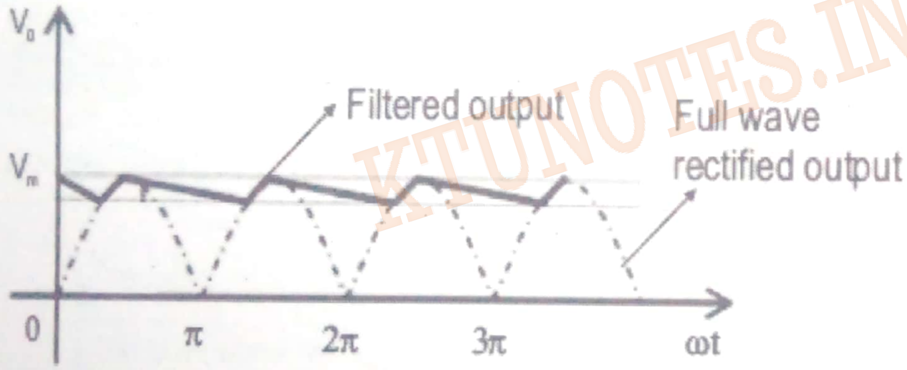


Figure 9: Input and output waveform of a capacitor filter

Note the Point

As the value of C increases the smoothness of the output also increases. The ripple factor of capacitor filter is given by

$$\gamma = \frac{1}{4\sqrt{3} f C R_L}$$

Circuit Diagram of a Bridge Rectifier with Capacitor Filter [KTU JUNE 2016]

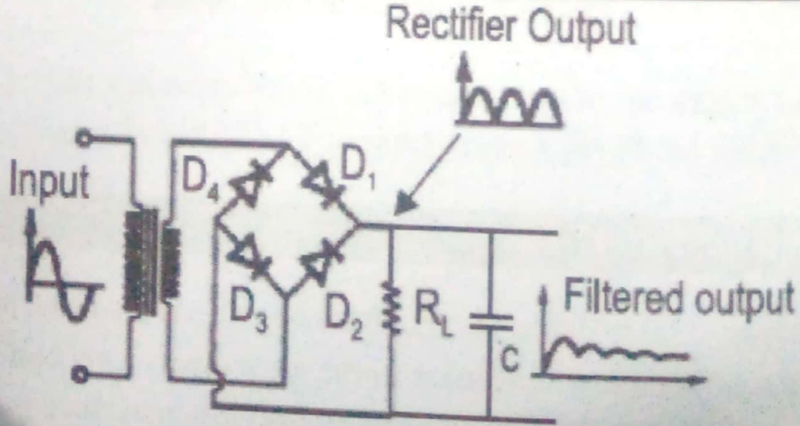


Figure 10: Bridge rectifier with capacitor filter

1.6 VOLTAGE REGULATOR

What is voltage regulator?

Voltage regulator is a circuit whose function is to maintain a constant dc voltage inspite of the ac input fluctuations or changes in load resistance values.

Need of voltage regulator

In an ordinary power supply, the dc output voltage changes appreciably with load current. More over the output voltage changes due to variations in the input ac voltage. This is due to the following reasons.

1. In practice, there are considerable variations in ac line voltage caused by outside factors beyond our control. This changes the dc output voltage. This is not satisfactory for the proper working of most of the electronic circuits.

2. The internal resistance of the ordinary power supply is relatively large. Therefore, the output voltage is affected by the amount of load current drawn from the supply. These variations in dc voltage cause improper operation electronic circuits. Therefore a dc power supply with voltage regulator is the only solution in such situations

1.6.1 ZENER VOLTAGE REGULATOR [KTU APRIL 2018]

A simple Zener diode shunt regulator is shown in figure 11. This is called shunt regulator because the Zener diode is connected in parallel or shunt with the load.

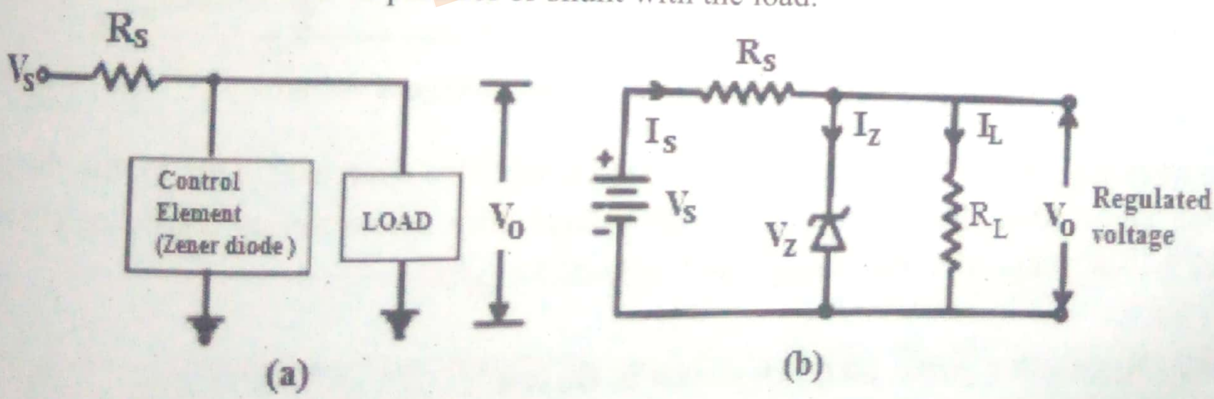


Figure 11: Zener voltage regulator (a) Block diagram (b) Circuit diagram

The resistance R_S is connected to limit the current in the circuit. The output or regulated voltage is obtained across the load resistor R_L. For the operation of the circuit, the input voltage should be greater than Zener diode voltage V_z. Only then Zener diode operates in breakdown region.

Design of load resistance R_L

$$R_L = \frac{V_O}{I_L}$$

$$V_O = V_Z$$

Design of series resistance R_S

$$R_{S\ max} > R_S > R_{S\ min}$$

$$R_{S\ max} = \frac{V_{i\max} - V_Z}{I_S}$$

$$R_{S\ min} = \frac{V_{i\min} - V_Z}{I_S}$$

Note the Points

- % line regulation = $\frac{\Delta V_o}{\Delta V_{in}} \times 100$
- % load regulation = $\frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$

1.6.2 Working of Zener Diode Shunt Regulator

[KTU JUNE 2017]

To explain the working we will consider the two cases.

Case 1: Regulation when input voltage is varied

In this case, the load resistance R_L is kept fixed and the input voltage V_s is varied. When the input voltage increases, the input current I_S is also increased since $I_S = I_z + I_L$.

This increased current I_S, increases the current flows through the Zener diode without affecting the load current I_L. Due to increase in input current I_S, the voltage drop across series resistance R_S also increases and hence keeping the load voltage V_L as constant.

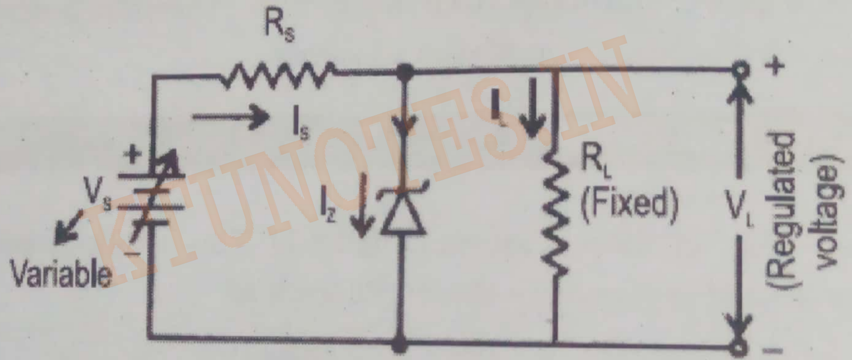


Figure 12: Regulation when Input voltage is varied

Now, when the input voltage decreases, the input current also decreases. Due to this, the current through Zener diode also decreases. Also the voltage drop across series resistance is reduced. Hence the load voltage V_L and load current I_L remains constant.

Case 2: Regulation when load resistance is varied

In this case, the input voltage V_s is kept fixed and the load resistance R_L is varied. When the load resistance R_L decreases, the load current increases .This causes the Zener current to decrease. Due to this, the input current and the voltage drop across series resistance remains constant. Therefore the load voltage V_L is also constant.

Now, when the load resistance R_L increases, the load current decreases. Due to this, the Zener current increases. This again keeps the values of input current and voltage drop across series resistance as a constant. Therefore, the load voltage remains constant.

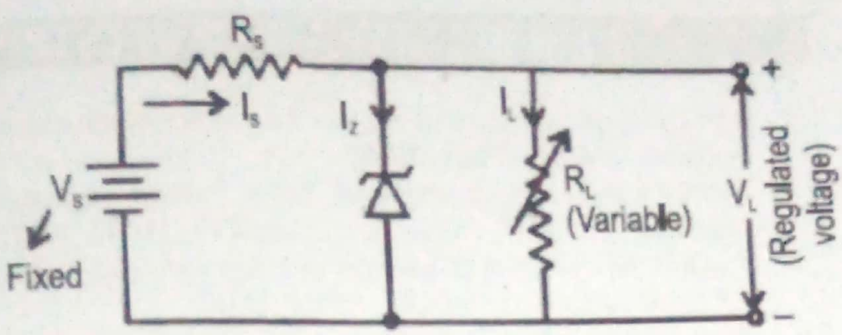


Figure 13: Regulation when load resistance is varied

Line and Load regulation in Zener diode regulator [KTU JUNE 2017]

Line Regulation: In this type of regulation, series resistance and load resistance are fixed only input voltage is changing. Output voltage remains the same as long as the input voltage is maintained above a minimum value.

Percentage of line regulation can be calculated by $\frac{\Delta V_o}{\Delta V_{in}} \times 100$

Load Regulation: In this type of regulation, input voltage is fixed and the load resistance is varying. Output volt remains same, as long as the load resistance is maintained above a minimum value.

Percentage of load regulation can be calculated by $\frac{V_{NL} - V_{FL}}{V_{FL}} \times 100$

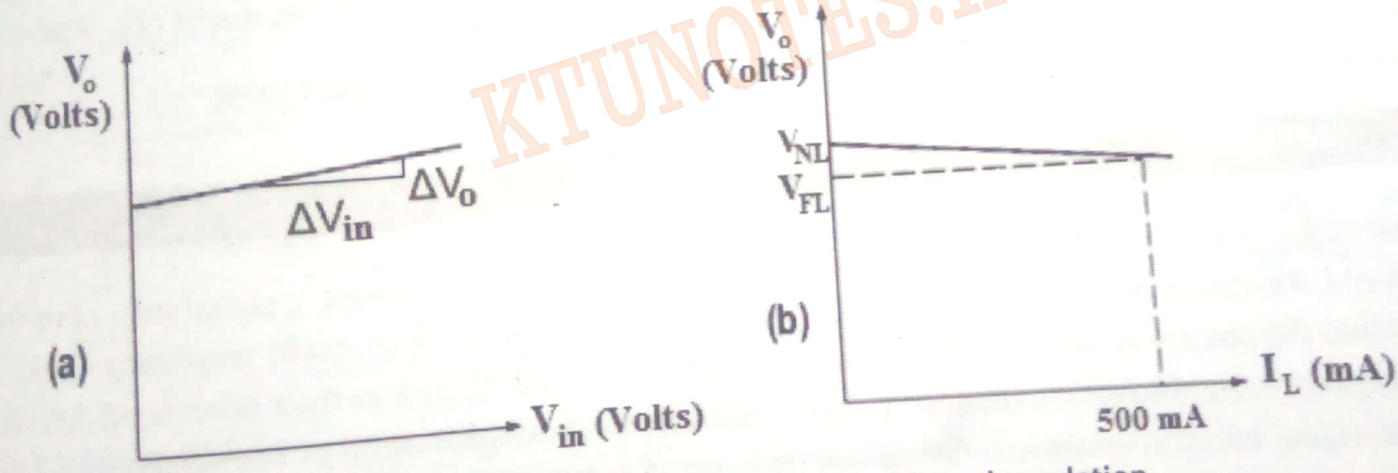


Figure 14: (a) Line regulation (b) Load regulation

Limitations of Zener regulator: Even though the Zener diode provides a very simple means of voltage regulation, these regulators have the following disadvantages.

1. The output voltage of Zener regulator is equal to V_z. This is a constant voltage. Therefore, these voltage regulators cannot be made adjustable.
2. Large power gets dissipated in the Series resistor Rs.
3. Corresponding to large change in the load current, there will be large change in the Zener current. This will result in large power wastage.

FREQUENTLY ASKED QUESTIONS

1. Draw circuit diagram and explain how zener diode can be used as a voltage regulator. [KTU APRIL 2018]
2. Briefly explain the working of Zener voltage regulator. Discuss the line regulation of a zener voltage regulator[KTU JUNE 2017]
3. Explain the operation of a bridge rectifier with circuit diagram and show that the ripple factor is 0.48 [KTU SEPT 2016]
4. What do you mean by ripple factor? Find the ripple factor for full wave rectifier [KTU JAN 2017]
5. With neat circuit diagram explain the working of a simple voltage regulator [KTU JAN 2017,JULY 2017,JUNE 2017,DEC 2018]
6. Define ripple factor and write the values for half wave, centre tapped and bridge rectifiers. [KTU JUN 2016]
7. With neat circuit diagram and waveforms explain the working of a bridge rectifier with capacitor filter. [KTU JUN 2016, JULY 2017]
8. Draw the block diagram of a dc power supply and specify the functions of each block. [KTU JUNE 2017]
9. With necessary diagrams ,explain the working of a centre tapped full wave rectifier.[KTU DEC 2018]
10. Compare the ripple factor and efficiency of half wave, centre tapped and bridge rectifiers.[KTU DEC 2018]
11. Explain the working of zener voltage regulator with a neat diagram. [KTU Dec 2018]
12. Explain the working of a simple zener voltage regulator. [KTU DEC 2109]
13. Narrate how capacitor filter eliminates ripples from the output of a rectifier. [KTU DEC 2019]
14. Explain the working of a bridge rectifier. [KTU DEC 2019]

2. AMPLIFIERS

One of the important characteristics of a signal is its amplitude. Sometimes, a signal may have th desired waveform and frequency and yet cannot be used because of its small amplitude. This i because the circuits or devices that are to be operated with such signals as their input need definit levels of the amplitude of signal for proper operation. Thus amplification or strengthening of th input signal becomes essential. The device that amplifies the input signal is called amplifier.

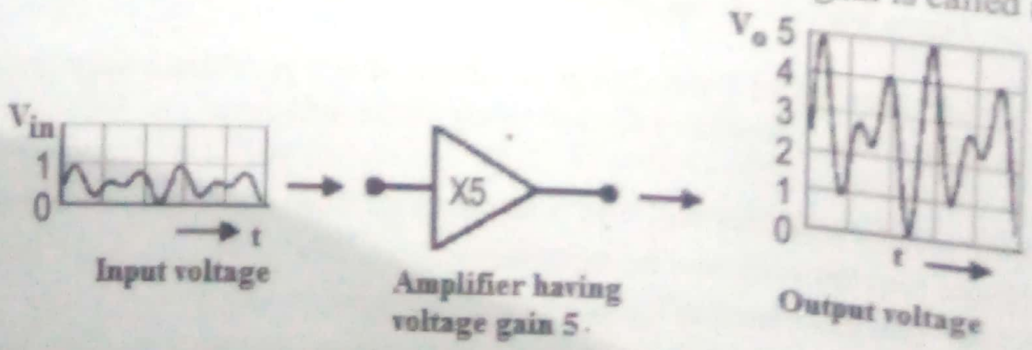


Figure 2.1 Concept of an amplifier

To what extent an amplifier amplifies its input signal is expressed in terms of parameter known as voltage gain.

The voltage gain of an amplifier is given as $A_V = \frac{Output\ AC\, voltage}{Input\ AC\, voltage} = \frac{V_o}{V_{in}}$ where V_o is output voltage and V_{in} is input voltage. Consider the above figure, if V_{in} =1 mV and V_o= 5mV, then voltage gain = (5mV/1 mV) = 5

2. 1 PUBLIC ADDRESS SYSYEM

A public address system (PA system) is an electronic sound amplification and distribution system with a microphone, amplifier and loudspeakers, used to allow a person to address a large public.

Need and Use: The intensity of the sound decreases with distance. Hence when a large a large gathering to be addressed, sound needs to be amplified so that people at a distance from the stage may receive good intensity of sound for comfortable listening. The system which fulfills this function is called public address system or simply PA system. It is used in sports meets, public meetings, auditorium, concerts, functions, etc.

Block diagram of a PA system [KTU DEC 2019]

The basic block diagram of a PA system is shown in figure 15.

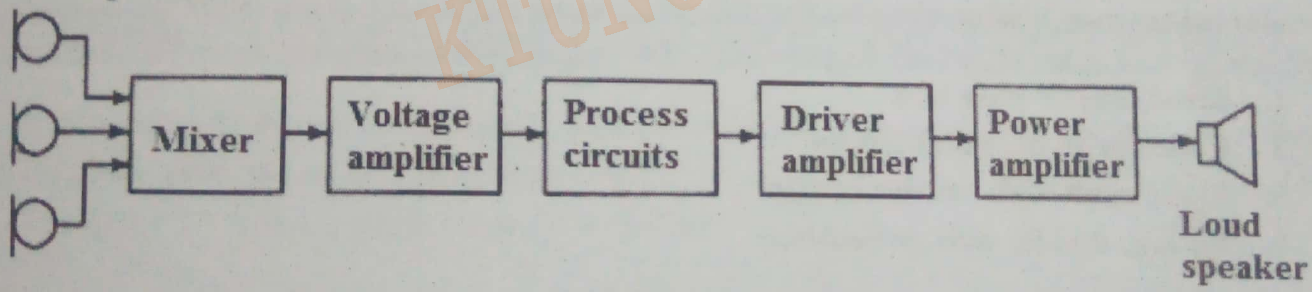


Figure 15: Basic block diagram of a public address system

Microphone: It picks up sound waves and converts them in to electrical variations, called audio signals. Generally amplifiers have provision of two or more microphones and an auxiliary input for tape/ record player.

Mixer: The output of microphones is fed to a mixer stage. The function of the mixer stage is to effectively isolate different channels from each other before feeding to the main amplifier.

Voltage amplifier: It further amplifies the output of the mixer.

Processing circuits: These circuits have master gain control and tone controls (Bass/Treble controls).

Driver amplifier: It gives voltage amplification to the signal to such an extent that when fed to the next stage (power amplifier stage), the internal resistance of that stage is reduced. Thus it drives the power amplifier to give more power.

Power amplifier: It gives desired power amplification to the signal. It uses push pull type of circuit in general.

Loud speaker: It converts electrical audio signals in to pressure variations resulting in sound.

2.2 BIASING OF TRANSISTORS

In order to operate transistor in the desired region, we have to apply external DC voltages of correct polarity and magnitude to the junction of the transistor. This is called biasing of the transistor. Because DC voltages are used to bias the transistor, this is known as DC biasing of the transistor. When we are biasing a transistor, we establish a certain current and voltage conditions for the transistor. These conditions are known as operating conditions or DC operating point or quiescent point or Q point. The operating point must be stable for proper operation of the transistor.

NEED FOR A BIASING CIRCUIT **[KTU SEPT 2016]**

1. To fix the operating point in the center of the active region.
2. To stabilize the collector current against temperature variations.
3. To make the operating point independent of transistor parameter β so that the replacement of transistor by another of the same type in the circuit does not shift the operating point.

Different biasing circuits: Biasing is done to serve the dual purpose of establishing the desired Q point and stabilize it against any variation. The circuits used for this biasing and stabilization purpose is known as biasing circuits. The different biasing circuits are given below.

1. **Fixed bias or Base bias**
2. **Collector to base bias circuit**
3. **Bias circuit with emitter resistor**
4. **Voltage divider bias or Self-bias**

- ***Voltage divider bias or self-bias is the most widely used biasing circuit.***

2.2.1 VOLTAGE DIVIDER BIAS

This is the most widely used biasing circuit. The name voltage divider comes from the voltage divider formed by resistor R_1 and R_2. By suitably selecting this voltage divider network the operating point of the transistor can be made almost independent of β. This is why this circuit is also called biasing circuit independent of β. In the voltage divider network, the voltage across R_1 is given by $V_{R_1} = \frac{(V_{CC}.R_1)}{(R_1+R_2)}$ and voltage across R_2 is given by $V_{R_2} = \frac{(V_{CC}.R_2)}{(R_1+R_2)}$. The voltage across R_2 (V_{R_2}) ensures the forward biasing of base emitter junction. The V_{CC} through R_C ensures the reverse biasing of collector base junction. The resistor R_E provides thermal stabilization. Figure 16 shows voltage divider biasing circuit.

Advantages: Stable Q point, insensitive to temperature and β variations.

Disadvantage: Its input resistance gets shunted by parallel combination of R_1 and R_2.

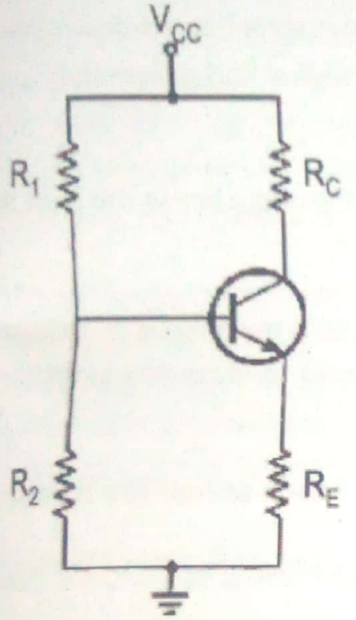


Figure 16: Voltage divider bias

Note the Points

- Biasing is done to serve the dual purpose of establishing the desired Q point and stabilize it against any variation.
- The maintenance of operating point stability is known as stabilization. The stabilization of operating point is essential because of the given reasons.
  1. Temperature dependence of collector current.
  2. Individual variations.
  3. Thermal run away.
- The circuits used for this biasing and stabilization purpose is known as biasing circuits.
- **Voltage divider biasing circuit has more stability, hence it is the most widely used biasing circuit.**

2.3 SINGLE STAGE RC COUPLED COMMON EMITTER AMPLIFIER [KTU JAN 2016, DEC 19]

- ***When only one transistor with associated circuit is used for amplifying a signal, that circuit is known as single stage transistor amplifier***.
- The figure 17 shows a single stage CE amplifier.

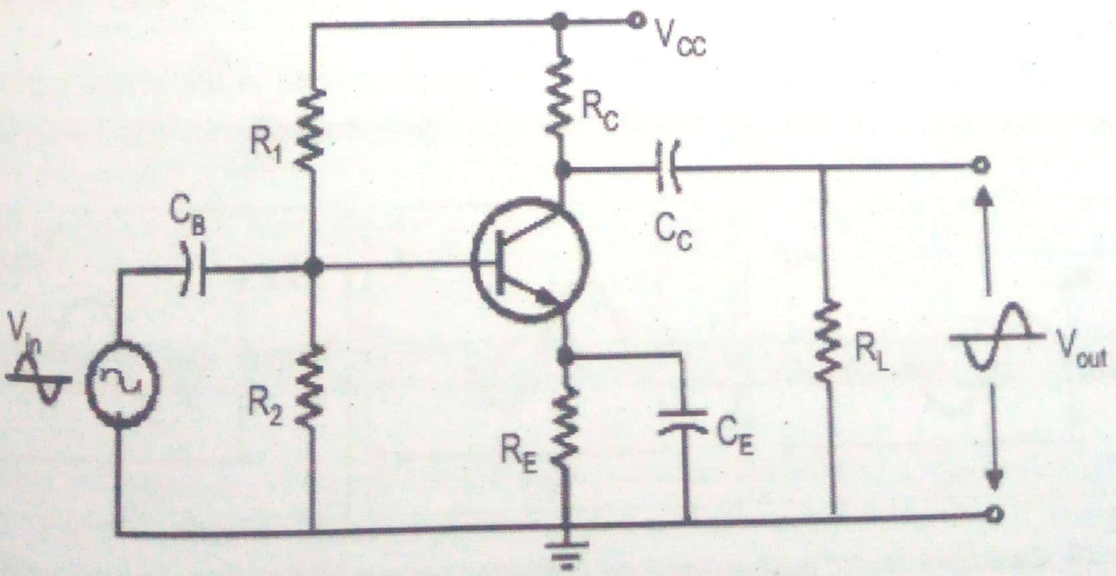


Figure 17: CE amplifier circuit

2.3.1 Functions of each components in a CE amplifier

[KTU JUNE 2016]

Supply Voltage (Vcc): VCC of a bipolar junction transistor is the DC voltage that is supplied to the collector of the transistor. VCC is a very important voltage when biasing the transistor because it determines how much the AC signal can be amplified by the transistor.

Input coupling capacitor (C_B): This capacitor is used to couple the input signal to the base of the transistor. The capacitor C_B blocks any D.C. component present in the signal and passes only a.c. signal for amplification.

Output coupling capacitor (C_C): This capacitor couples the output of the amplifier to the load or to the next stage of the amplifier.

Emitter bypass capacitor (C_E): This capacitor is connected in parallel with the emitter resistance R_E to provide low reactance path to the amplified a.c. signal. It is used to eliminate negative feedback.

Voltage divider bias (R_1 & R_2): The voltage across R_2 is $\frac{(V_{CC}.R_2)}{(R_1+R_2)}$ which ensure the forward biasing of base emitter junction. The V_{CC} through R_C ensures the reverse biasing of collector base junction.

Emitter resistance (R_E): The resistor R_E provides thermal stabilization.

Collector resistance (R_C): The collector resistance decides the value of I_c hence the Q point.

Load resistance (R_L): Across which output is taken

2.3.2 Working of a CE amplifier

[KTU MODEL 2019]

To make the transistor as an amplifier, it is to be biased to operate in the active region. That is, base emitter junction is to be forward biased, while base collector junction is to be reverse biased.

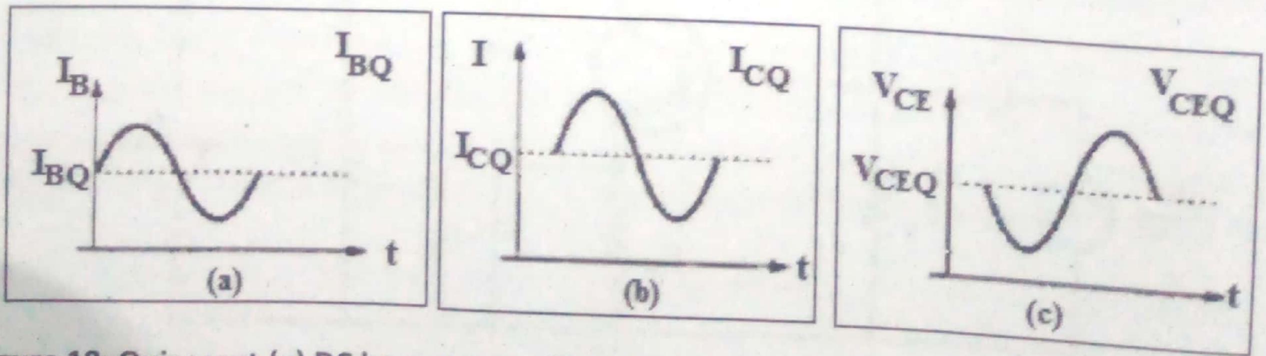


Figure 18: Quiescent (a) DC base current (b) Collector current (c) Collector to emitter voltage

In the absence of input signal, only DC voltages are present in the circuit. This is known as zero signal or no signal condition or quiescent condition for an amplifier. The DC collector emitter voltage V_{CE}, the DC collector current I_C and the DC base current I_B is the quiescent operating point for an amplifier.

On this DC quiescent operating point, we superimpose AC signal by the application of an AC sinusoidal voltage at the input. Due to this, base current varies sinusoidally as shown in figure 18. Since the transistor is biased to operate in the active region, the output is linearly proportional to the input. The output collector current is β times larger than the input base current in the common emitter configuration. Hence the collector current will also vary sinusoidally about its quiescent value I_{CQ}. The output voltage will vary sinusoidally as shown in figure18.

The collector current varies above and below its Q point value in phase with respect to the base current and the collector to emitter voltage varies above and below its Q point value 180° out of phase with respect to the base voltage. When one cycle of input is completed, one cycle of output is also completed. This means the frequency of the output signal does not change, only the magnitude of the output is larger than that of the input.

Voltage Gain: To what extent an amplifier enlarges signals is expressed in terms of its voltage gain. The voltage gain of an amplifier is given as $A_V = \dfrac{Output\ \ AC\,voltage}{Input\ \ AC\,voltage} = \dfrac{V_o}{V_{in}}$ where V_o is output voltage and V_{in} is input voltage.

Example: If V_{in} =50 mV and V_o= 5V, then voltage gain = (5V/50 mV) = 100

INFO PLUS

Why the name single stage RC coupled CE Amplifier?

1. Only one transistor and its associated circuit is used for amplification that is why the term single stage.
2. Resistor and capacitor is used as inter stage coupling elements, that is why the term RC coupled.
3. Common Emitter configuration is used, that is why the name CE amplifier.

2.3.3 Frequency Response of a CE Amplifier [KTU JUNE 2017, KTU MODEL 2019]

The frequency response curve is the graphical representation of the relationship between the amplifier gain and frequency. The frequency response shows the variation of the gain of an amplifier with frequency of input signal. The frequency response of a CE amplifier is shown in figure 19.

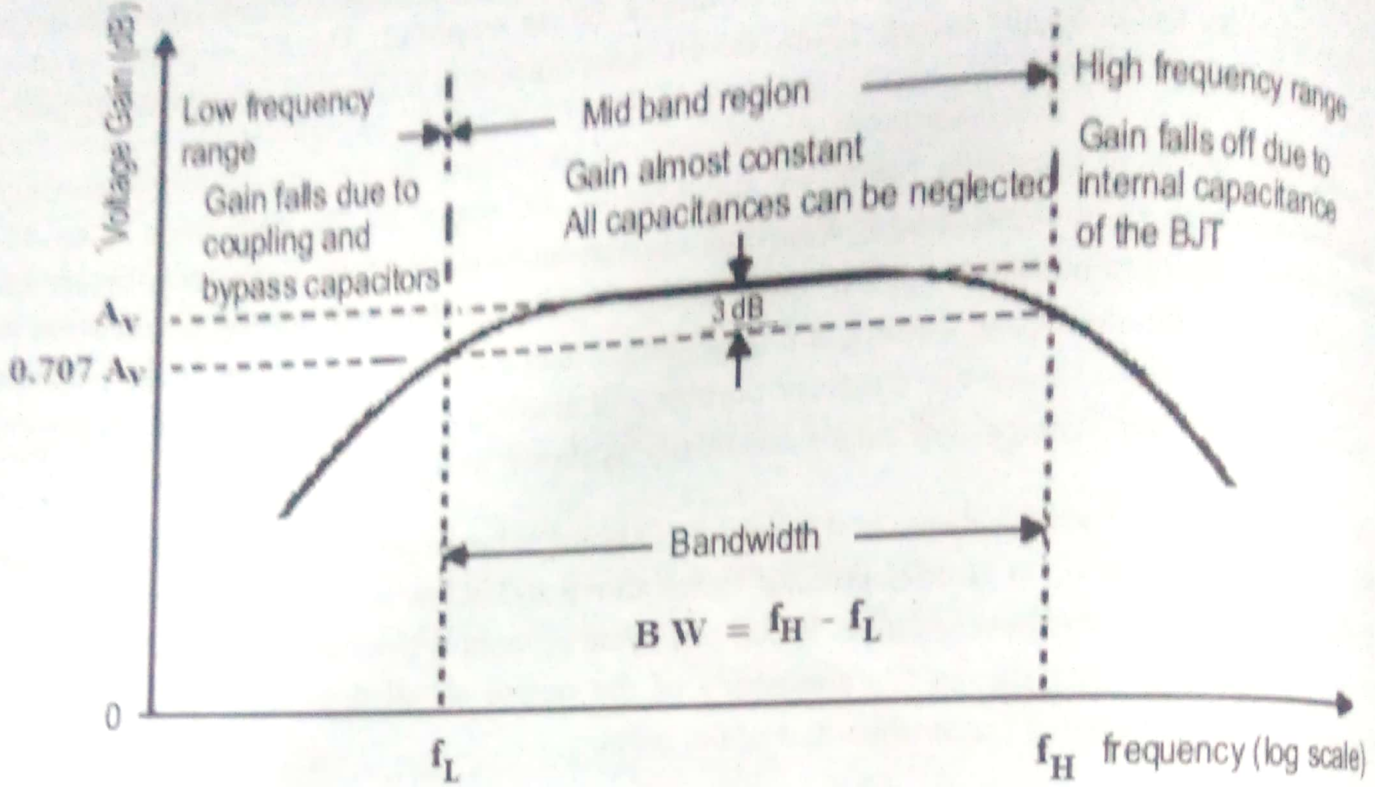


Figure 19: Frequency response of a CE amplifier

Here the gain is plotted in decibel versus frequency of input signal in log scale.

$$\text{Gain in dB} = 20 \log \left(\frac{V_o}{V_{in}}\right)$$

Why the characteristics shows the response is poor at very low and very high frequencies?

We know that, the capacitive reactance $X_c = \frac{1}{2\pi f C}$. This means that, **the capacitive reactance is inversely proportional to the frequency**. At low frequencies, the reactance is quite high. The reactance of input coupling capacitor C_B and the output coupling capacitor C_C are so high. Hence these capacitors allows only small part of its ac input signal to pass. The reactance of the emitter by pass capacitor C_E is also very high during low frequencies. Hence C_E cannot bypasses the ac drops across the emitter resistance effectively to ground. This introduce a small amount of negative feedback, which reduces voltage gain. With all these factors, the voltage gain decreases at very low frequencies.

REASON FOR GAIN FALL AT VERY LOW FREQUENCIES: **[KTU MODEL 2019]**

The reduction in gain at lower frequencies is due to the drop across input coupling capacitor C_B and output coupling capacitor C_C. In addition the bypass capacitor C_E cannot effectively bypass the AC signals to ground. This result in small amount of negative feedback, which reduces gain further.

REASON FOR GAIN FALL AT VERY HIGH FREQUENCIES: **[KTU MODEL 2019]**

The reduction in gain at higher frequencies is due to presence of internal capacitance or parasitic capacitance or short circuiting effect of junction capacitance of the transistor, mainly collector to base and base to emitter capacitance.

The capacitive reactance is low at high frequencies. So, a capacitor behaves as a short circuit, at high frequencies. As a result of this, the loading effect of the next stage increases, which reduces the voltage gain.

Bandwidth [KTU JAN 2016]

The frequency range over which the amplifier can be effectively used is its bandwidth. To get more bandwidth, we usually take the frequencies where the output voltage or gain drops $1/\sqrt{2}$ times the maximum value. $20\log(1/\sqrt{2}) = -3dB$ in log scale

Bandwidth $= f_H - f_L$ where f_H is the upper cutoff frequency and f_L is the lower cut off frequency

Characteristics of an Amplifier [KTU JAN 2017]

1. Gain of the amplifier $\left(\frac{V_o}{V_{in}}\right)$ should be high.
2. The input resistance should be high.
3. The output resistance should be small.
4. Bandwidth should be high.

FREQUENTLY ASKED QUESTIONS

1. Explain with circuit diagram the working of common emitter amplifier. **[KTU APRIL 2018]**
2. What is the need of biasing in transistor circuits? **[KTU SEPT 2016]**
3. Explain the operation of RC coupled amplifier with circuit diagram and frequency response **[KTU SEPT 2016, JULY 2017]**
4. Which are the important desirable characteristics of an amplifier. **[KTU JAN 2017]**
5. Discuss the need for biasing in amplifiers. Explain the functions of each component in RC coupled amplifier with relevant waveforms. **[KTU JUN 2016]**
6. Draw the block diagram of a public address system. **[KTU JUNE 2016]**
7. (a) With a neat circuit diagram, explain the working of an RC coupled amplifier. (b) Draw the frequency response characteristics of an RC coupled amplifier and state the reasons for the reduction of gain at lower and higher frequencies. **[KTU MODEL 2019]**
8. Draw the circuit diagram of an RC coupled amplifier and explain its frequency response. **[KTU DEC 2019]**
9. Draw the block diagram of a public address system and write the role of each block. **[KTU DCE 2019]**
10. Define bandwidth of an amplifier and mark important parameters in frequency response graph. **[KTU JAN 2016]**
11. Briefly explain the working of RC coupled common emitter amplifier. Plot its frequency response showing the cut-off frequencies. **[KTU JUN 2017]**

3. ELECTRONIC INSTRUMENTATION

The measurement of any quantity plays very important role not only in science but in all branches of engineering, medicine and in almost all the human day to day activities. The measurement of a given quantity is essentially an act or result of comparison between a quantity whose magnitude (amount) is **unknown**, with a similar quantity whose magnitude (amount) is **known**, the latter quantity being called a standard. The quantity or variable being measured is called measurand or measurement variable.

The measuring instrument may be defined as a device for determining the value or magnitude of a quantity or variable. An electronic instrument is the one which is based on electronic or electrical principles for its measurement function. The measurement of any electronic or electrical quantity or variable is termed as an electronic measurement.

Selecting the proper instrument for a particular type of measurand needs the knowledge of the performance characteristics of an instrument. The quantity or variable being measured is called measurand or measurement variable.

3.1 Performance characteristics of an instrument

1. **Accuracy:** It is the degree of closeness with which the instrument reading approaches the true value of the quantity to be measured. It denotes the extent to which we approach actual value of the quantity. It indicates the ability of instrument to indicate the true value of the quantity.

Example: Let us assume that voltage across a resistor is 2.45V. Let the voltage be measured by two different voltmeters that have identical manufacturing specifications and are made by the same firm. If one instrument indicates 2.75V, and other meter indicates 2.5V, the later one more accurate than the former one.

2. **Precision:** It is the measure of consistency or repeatability of measurements. It denotes the closeness with which individual measurements are departed or distributed about the average of number of measured values. It may be defined as a measure of the reproducibility of the measurement. i.e. given a fixed value of a variable, precision is a measure of the degree to which successive measurements differ from one another.

Example: Let us assume that a resistor has a true value of 1487 Ω. If its value is measured by an ohm meter one will read it as 1.5KΩ. Even on repeated readings of the scale, the reading arrived will only be 1.5KΩ. This reading is close to the true value because of the fact that one can read the scale by estimation.

3. **Sensitivity:** The sensitivity denotes the smallest change in the measured variable to which the instrument responds. It is defined as the ratio of the changes in the output of an instrument to a change in the value of the quantity to be measured.

Example: A 50 µA is sensitive than a 1mA meter as the former takes only 50 µA to give full scale deflection, whereas the latter one takes 1mA.

4. **Resolution:** It is the smallest increment of quantity being measured which can be detected with certainty by an instrument.

Example: Let us assume that we are measuring the output voltage of a circuit keeping its input constant. If there is an incremental change in the input an instrument with good resolution will show a change in the output. An instrument that produces corresponding change in the measured value for incremental changes in the measured value has good resolution.

5. **Error:** It may be defined as the amount of deviation from the true value of the variable or quantity being measured. The algebraic difference between the indicated value and the true value of the quantity to be measured is called an error. Mathematically it can be expressed as, $\mathbf{e = A_t - A_m}$ where e = error, A_m = measured value of the quantity, A_t = true value of the quantity.

Types of errors

Positive error: When the indicated value of the instrument is more than the true value, the error is said to be positive.

Negative error: If the indicated value of the instrument is less than the true value, the error is said to be negative.

Gross error: The gross errors mainly occur due to carelessness or lack of experience of a human being. These cover human mistakes in readings, recordings and calculating results. These errors also occur due to incorrect adjustments of instruments.

Systematic error, **observational error** and **random errors** other kinds of errors.

3.2 BASIC BLOCK DIAGRAM OF AN ELECTRONIC INSTRUEMENTATION SYSTEM [JAN 17]

Figure 20 shows the basic block diagram of an electronic instrumentation system **(Analog)**.

Figure 20: Basic block diagram of electronic instrumentation system (analog) [KTU JAN 17]

1. **Transducer:** Transducer which converts input signal or measurand (quantity being measured) in to usable electrical signal. A transducer is device that converts one form of energy in to another form. Common examples include microphones, loudspeakers, thermometers, position and pressure sensors, and antenna.
2. **Signal conditioner:** The signal conditioner converts the transducer output in to an electrical quantity suitable for further processing. This involves amplification, attenuation, level shifting,

demodulation, filtering etc. The signal modification is done by this signal conditioner. The output may be analog or digital. Analog signal is converted in to digital if necessary.

3. **Indicating device:** Indicates the value of quantity being measured. The display device may be analog or digital. The indicating device may be a chart recorder, teleprinter, magnetic tape recorder, floppy discs, Semiconductor memories etc.

3.2.1 BLOCK DIAGRAM OF A DIGITAL INSTRUMENTATION SYSTEM

The instruments that are used to express the measuring quantity in numeric format is known as Digital Instruments. A digitized information is somewhat easy to be handled and transmitted thus widely preferred nowadays. Due to several advantages of digital instruments such as high speed, errorless results, better resolution and greater accuracy over analog instruments, the popularity of digital instruments are increasing rapidly. Figure 21 shows the basic block diagram of a digital instrumentation system.

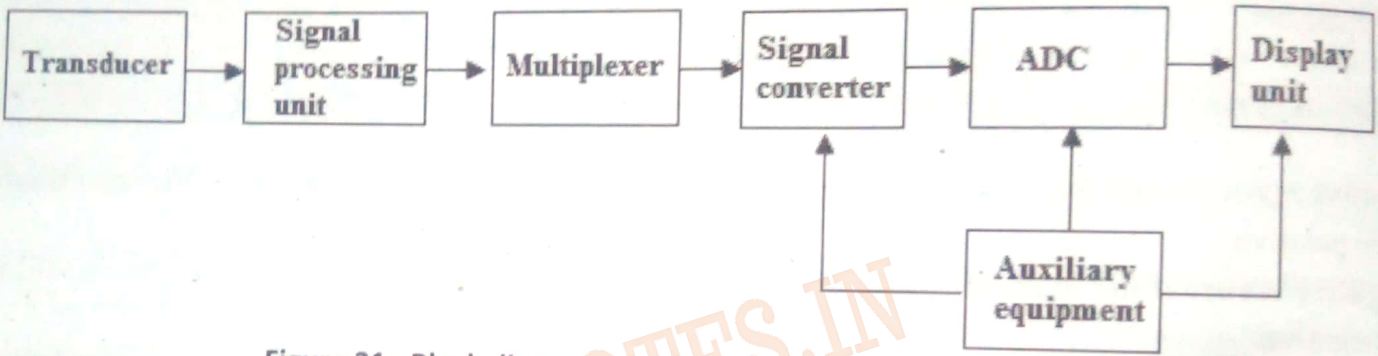


Figure 21 : Block diagram of a digital instrumentation system

As we can see, it consists of various units, the operation of each is discussed below:

1. **Transducer**: A transducer is a device that changes the physical quantity to be measured into its equivalent electrical form. The applied input can be temperature, pressure, velocity, displacement etc. It basically converts a form of energy into another.
2. **Signal processing unit**: This unit is mainly composed of amplification circuitry along with balancing circuits and calibrating elements. The output of the transducer which is the electrical form of the quantity to be measured is fed to the signal processing unit. This basically amplifies or modifies the output of the transducer to such an extent that it can be easily detected and accepted by the other units of the system.
3. **Multiplexer**: Multiplexer mixes the multiple analog signals supplied by the processing unit. It produces an individual signal by multiplexing various applied signals. This signal is then processed further.
4. **Signal converter**: This unit takes the output of the multiplexer and generates such a signal that can be processed by further units of the system.
5. **Analog to digital converter**: ADC plays a crucial role in the digital instrumentation system. It converts the applied analog data signal into its equivalent digital form. This converted digital data is then provided to the display unit.

6. **Display unit**: This unit shows the actual quantity that is to be measured in the numerical form. This can be a CRO or a computer monitor etc. depending on the need of the user.
7. **Auxiliary Equipment**: This unit is responsible for the functioning of the overall system. It basically helps to have linear results and performs tasks like a limit comparison to ensure proper working of the system.

4. MULTIMETER [KTU JUNE 2016]

A **multimeter** or a **multitester** is an electronic measuring instrument that combines several measurement functions in one unit. A typical multimeter may include features such as the ability to measure voltage, current and resistance.

There are two categories of multimeter:

1. **Analog multimeter**: Analog multimeter is a type of multimeter which has a needle moving over a calibrated scale.
2. **Digital multimeter:** Digital Multimeter is a type of multimeter in which the result of the measurement is displayed as discrete numerals in decimal number system.

A multimeter is capable of measuring voltage and current of AC circuits as well as DC circuits. In addition it has a provision for measurement of resistance also.

Figure 21 shows the block diagram of a digital multimeter.

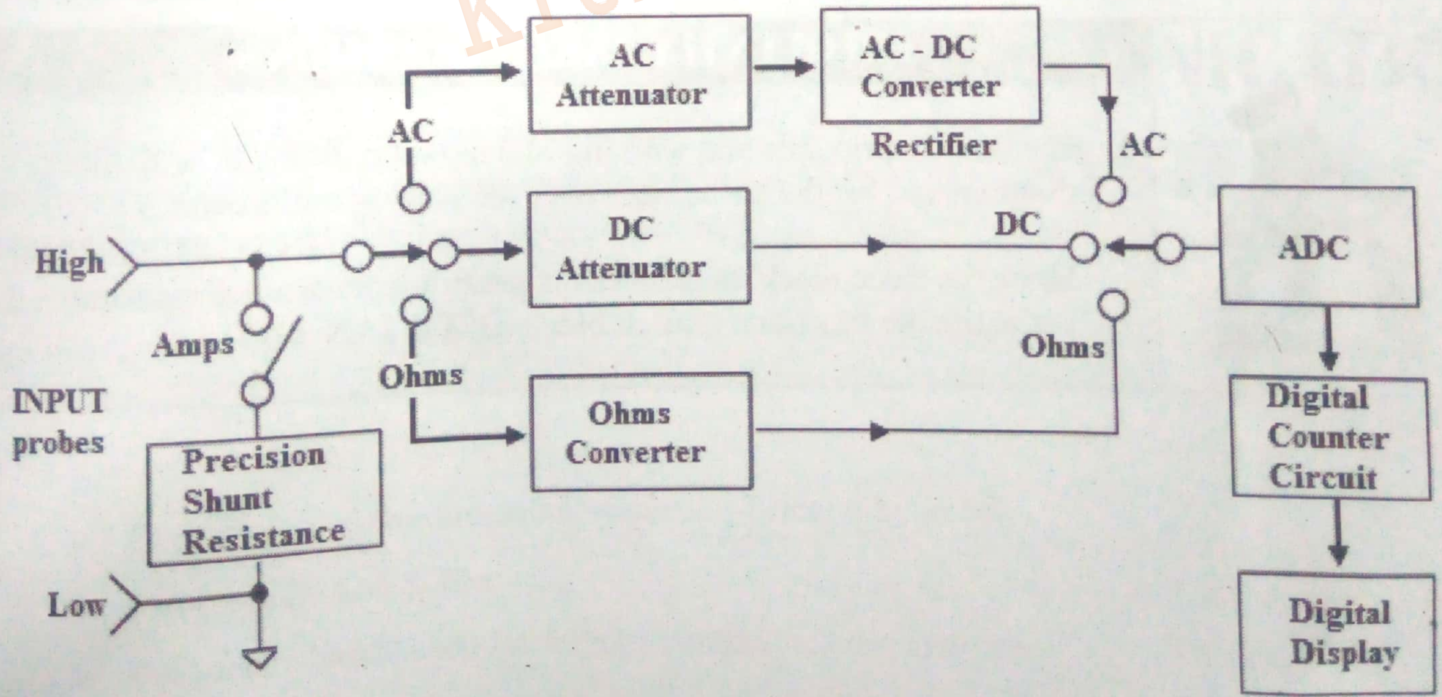


Figure 22 : Block diagram of a digital multimeter

Here all quantities other than DC voltage is first converted to an equivalent DC voltage. AC voltage is passed through a compensated attenuator for range selection of AC voltage. AC – DC converter or rectifier converts AC voltage to DC voltage. DC current is converted to an equivalent DC voltage by passing through a precision shunt resistor. Resistance is converted to an equivalent voltage by passing a known constant current through the resistor. Thus all quantities are converted to an equivalent DC voltage and this DC voltage is converted to digital format using an ADC (analog to digital converter). The output of ADC is in binary form or digital form. This binary output is converted to decimal format using a digital counter circuit (Decade counter or BCD counter) and it is displayed on a seven segment LED display or LCD display

Comparison between digital and analog multimeter [KTU JAN 2016]

Sl no	Parameter	Digital Multimeter	Analog Multimeter
1	Error probability in the reading	No error in the reading	Might be read incorrectly
2	Display type	Digital display	Indication by a pointer
3	Polarity orientation	Indicates negative quantity when polarity is reversed	Pointer attempts to move left of zero when polarity reversed.
4	Roughness in treatment	Not damaged by rough treatment	Damaged by rough treatment
5	Accuracy	High	Low
6	Resolution	High	Low
7	Response time	Display takes few seconds	Pointer responds quickly

FREQUENTLY ASKED QUESTIONS

1. Explain the principle and working of a digital multimeter with block diagram and list the advantages over the Analog multimeter. [KTU JUNE 2016]
2. Draw the basic block diagram of an electronic measuring instrument and write the functions of each block. [KTU JAN 2017]