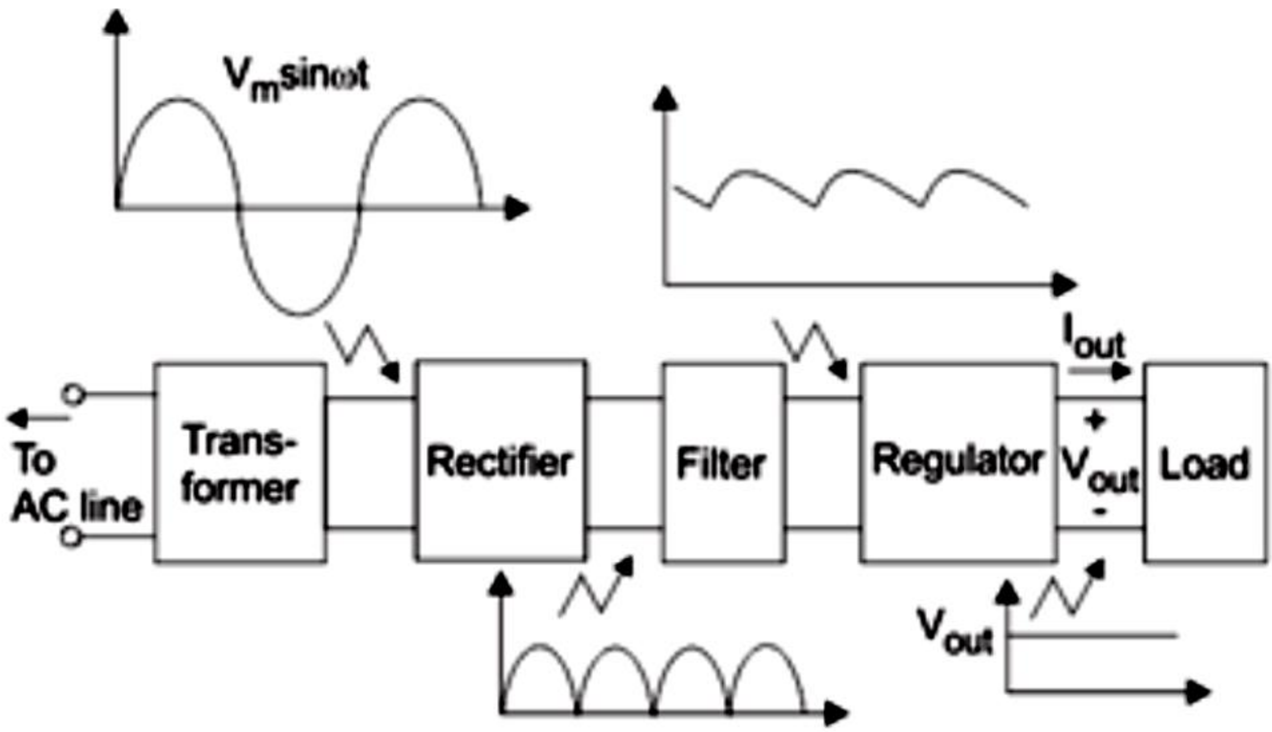
UNIT II
BASIC ELECTRONIC CIRCUITS AND INSTRUMENTTAION

Rectifiers and power supplies: Block diagram description of a dc power supply, working of a full wave bridge rectifier, capacitor filter (no analysis), working of simple zener voltage regulator. Amplifiers: Block diagram of Public Address system, Circuit diagram and working of common emitter (RC coupled) amplifier with its frequency response. Electronic Instrumentation: Block diagram of an electronic instrumentation system.

BLOCK DIAGRAM DESCRIPTION OF A DC POWER SUPPLY

A regulated power supply can convert unregulated an AC (alternating current or voltage) to a constant DC (direct current or voltage). A regulated power supply is used to ensure that the output remains constant even if the input changes. A regulated DC power supply is also called as a linear power supply, it is an embedded circuit and consists of various blocks.

The regulated power supply will accept an AC input and give a constant DC output. Figure below shows the block diagram of a typical regulated DC power supply.



The basic building blocks of a regulated DC power supply are as follows:

1. A step down transformer
2. A rectifier
3. A DC filter
4. A regulator

Step Down Transformer

A step down transformer will step down the voltage from the ac mains to the required voltage level. The turn's ratio of the transformer is so adjusted such as to obtain the required voltage value. The output of the transformer is given as an input to the rectifier circuit.

Rectification

Rectifier is an electronic circuit consisting of diodes which carries out the rectification process. Rectification is the process of converting an alternating voltage or current into corresponding direct (DC) quantity. The input to a rectifier is ac whereas its output is unidirectional pulsating DC. Usually a full wave rectifier or a bridge rectifier is used to rectify both the half cycles of the ac supply (full wave rectification). Figure below shows a full wave bridge rectifier.'

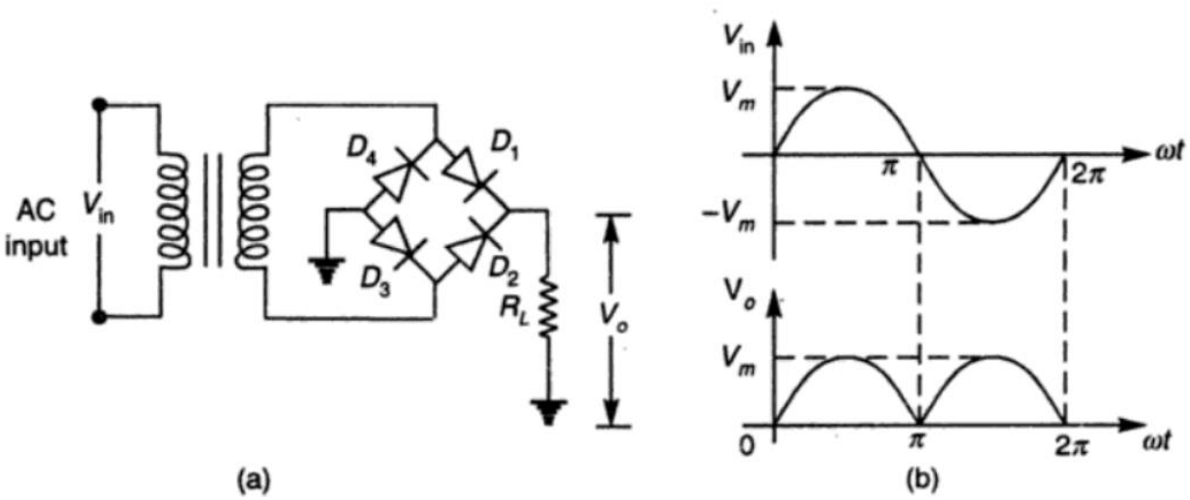
DC Filtration'

The rectified voltage from the rectifier is a pulsating DC voltage having very high ripple content. But this is not we want, we want a pure ripple free DC

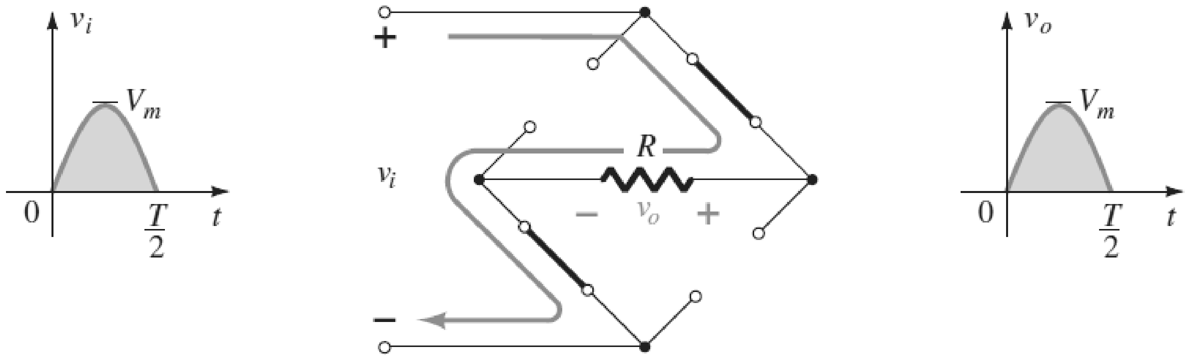
Regulation

This is the last block in a regulated DC power supply. The output voltage or current will change or fluctuate when there is change in the input from ac mains or due to change in load current at the output of the regulated power supply or due to other factors like temperature changes. This problem can be eliminated by using a regulator. A regulator will maintain the output constant even when changes at the input or any other changes occur. Transistor series regulator, Fixed and variable IC regulators or a zener diode operated in the zener region can be used depending on their applications. IC's like 78XX and 79XX are used to obtained fixed values of voltages at the output. waveform. Hence a filter is used. Different types of filters are used such as capacitor filter, LC filter, Choke input filter, π type filter.

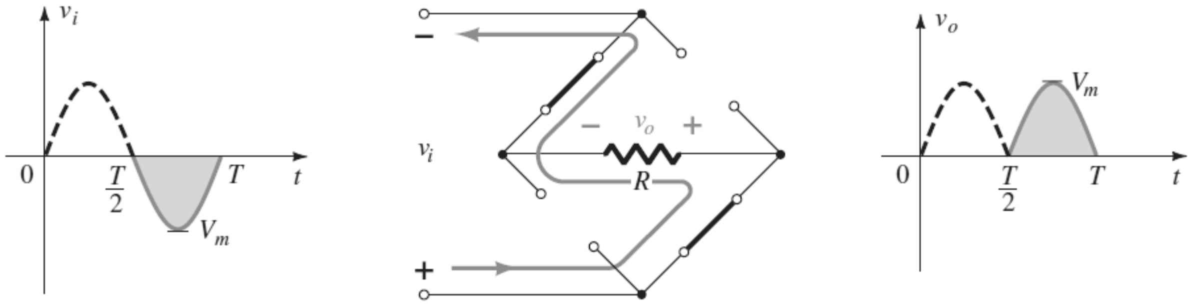
WORKING OF A FULL WAVE BRIDGE RECTIFIER



For the positive half-cycle of the input a.c. voltage, diodes D_1 and D_3 conduct, whereas diodes D_2 and D_4 do not conduct. The conducting diodes will be in series through the load resistance R_L. So the load current flows through R_L.

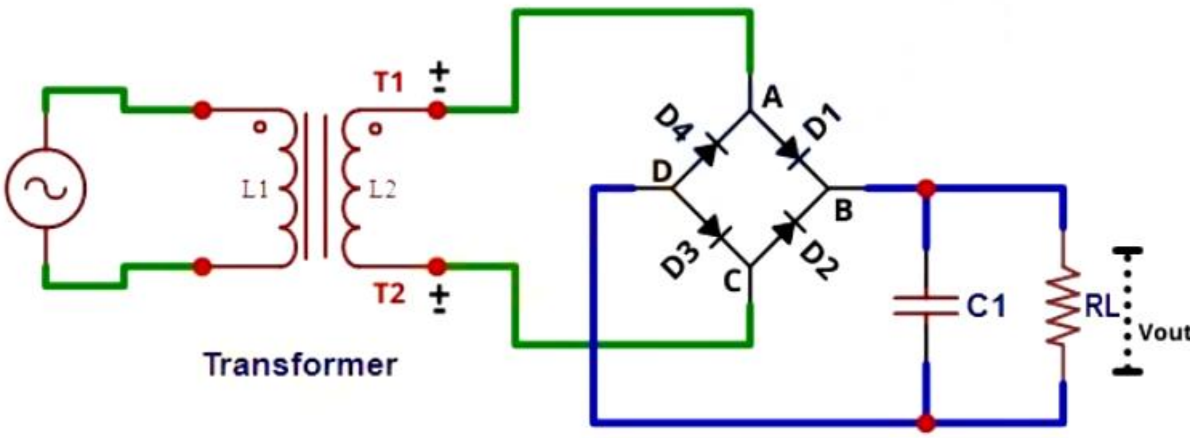


During the negative half-cycle of the input a.c. voltage, diodes D_2 and D_4 conduct, whereas diodes D_1 and D_3 do not conduct. The conducting diode D_2 and D_4 will be in series through the load R_L and the current flows through R_L in the same direction as in the previous half-cycle. Thus a bidirectional wave is converted into an unidirectional one.



FULL WAVE BRIDGE RECTIFIER WITH CAPACITOR FILTER

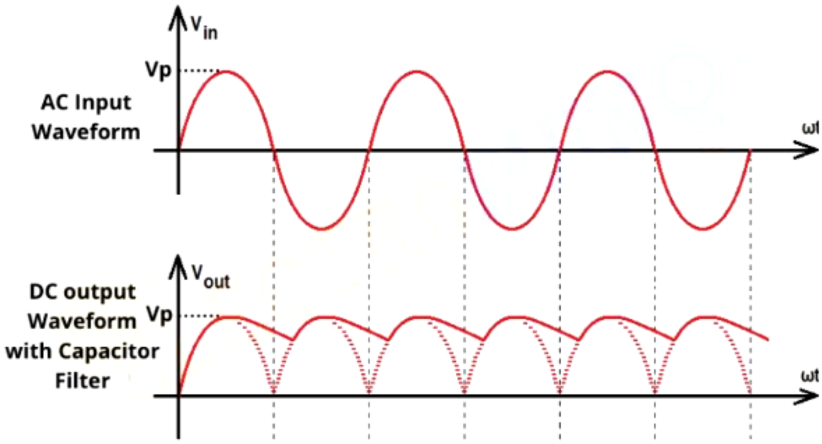
The output of a full-wave bridge rectifier is a pulsating DC voltage with lots of ripples that increases to a maximum and then decreases to zero. Generally, this kind of DC voltage has no practical applications. So, we need to convert pulsating DC voltage into a smooth DC voltage that can be done by a filter. Here we will use a capacitor as a filter that is parallelly connected to the load resistor (RL).



Initially, the capacitor is uncharged. During the first positive half-cycle, the diode D1 and D3 are forward biased, at the same time the capacitor starts charging. The capacitor charging continues until the input reaches its peak value (Vp). At this point, the input voltage is equal to the capacitor voltage. After the input voltage reaches its peak value then it begins to decrease. When the input voltage is less than Vp, at the same time capacitor starts discharging through the load resistor and supplies the load current, until the next peak arrives.

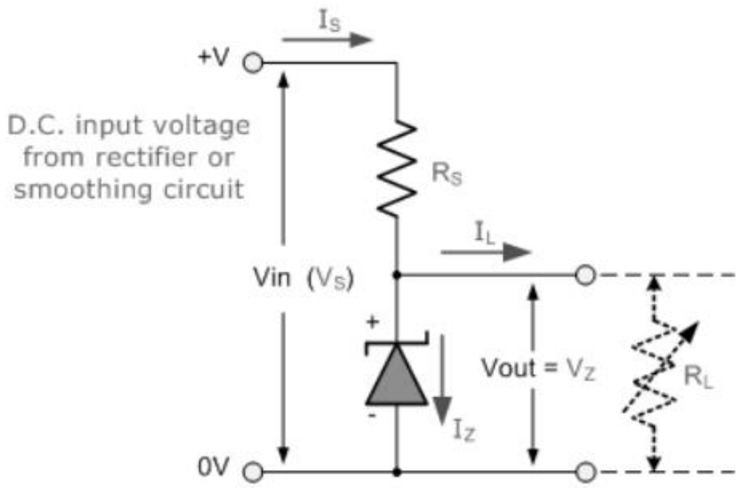
During the negative half-cycle, the next peak arrives, this time diode D2 and D4 are forward-biased. So, again the capacitor starts charging until the input reaches its peak value (Vp). When the input voltage is less than Vp, again capacitor starts discharging through the load resistor and supplies the load current, until the next peak arrives.

This process happens again and again. As a result, we get a Smooth DC output voltage across the load resistor (RL).



ZENER DIODE AS VOLTAGE REGLATOR

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 RS 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 RS will result in a greater diode current when the load resistance RL 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 RL is always the same as the zener voltage, ($V_R = V_Z$).

There is a minimum zener current for which the stabilisation 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 VS must be greater than V_Z.

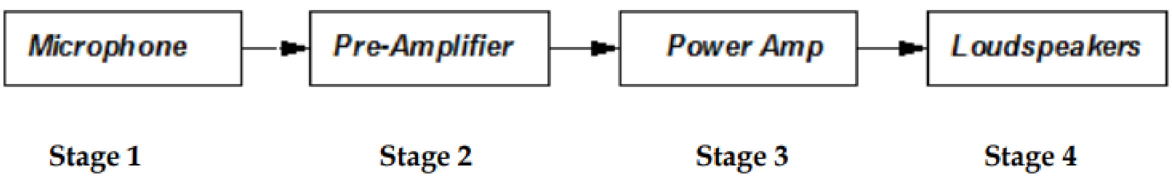
One small problem with zener diode stabilizer circuits is that the diode can sometimes generate electrical noise on top of the DC supply as it tries to stabilize the voltage. Normally this is not a problem for most applications but the addition of a large value decoupling capacitor across the zener's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

A zener diode is always operated in its reverse biased condition. As such a simple 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.

BLOCK DIAGRAM OF PUBLIC ADDRESS SYSTEM

- *A "Public Address" system is anything that amplifies sound so more people can hear it.*
- **A simple public address system** (or PA system) is shown in the following block diagram.



Stage 1: Microphone (Transducer)

The microphone converts sound waves into electrical signals that can be processed by the rest of the system. It is important that the microphone creates a faithful reproduction of the sound wave as an electrical signal – no distortion!

Stage 2: Pre-Amplifier

Its purpose is to take the small electrical signals from the microphone and increase the amplitude of the signal voltage.

Stage 3: Power Amplifier

The power amplifier takes this enlarged voltage signal, and boosts the current so that it is strong enough to drive the loudspeaker.

Stage 4: Loud Speaker

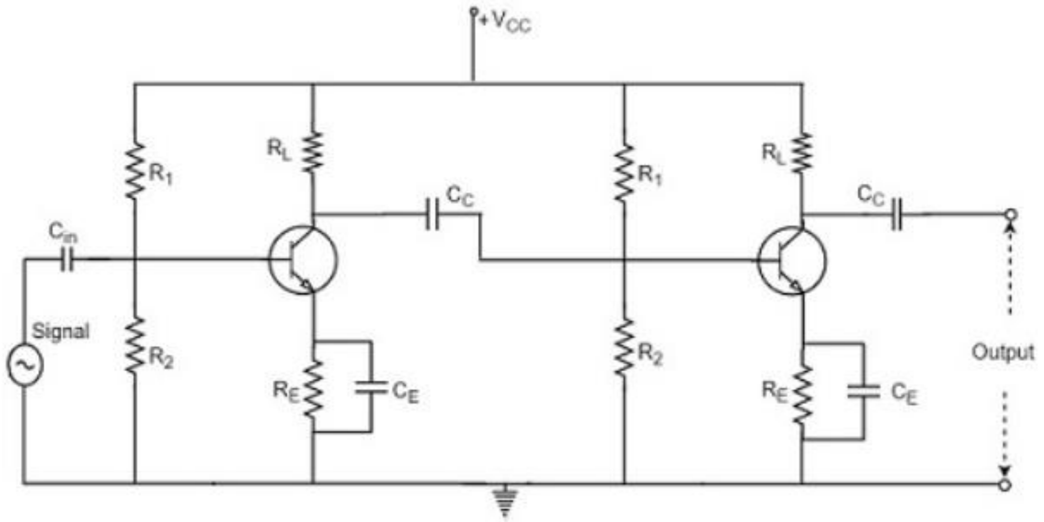
The loudspeaker is the final part of the system where the electrical signal is transformed back into a sound wave.

- If the system has carried out its function correctly, the emerging sound wave will be an undistorted but amplified version of the original.

WORKING OF COMMON EMITTER (RC COUPLED) AMPLIFIER

The constructional details of a two-stage RC coupled transistor amplifier circuit are as follows. The two stage amplifier circuit has two transistors, connected in CE configuration and a common power supply V_{CC} is used. The potential divider network R_1 and R_2 and the resistor R_e form the biasing and stabilization network. The emitter by-pass capacitor C_e offers a low reactance path to the signal.

The resistor R_L is used as a load impedance. The input capacitor C_{in} present at the initial stage of the amplifier couples AC signal to the base of the transistor. The capacitor C_C is the coupling capacitor that connects two stages and prevents DC interference between the stages and controls the shift of operating point. The figure below shows the circuit diagram of RC coupled amplifier.



Operation of RC Coupled Amplifier:

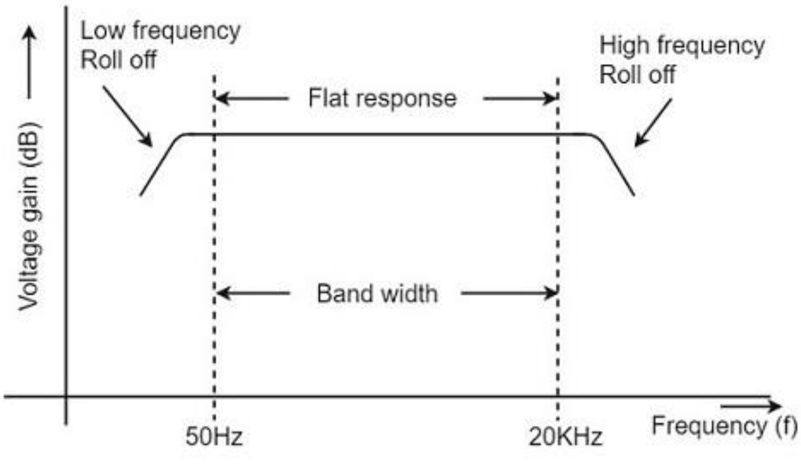
When an AC input signal is applied to the base of first transistor, it gets amplified and appears at the collector load R_L which is then passed through the coupling capacitor C_C to the next stage. This becomes the input of the next stage, whose amplified output again appears across its collector load. Thus the signal is amplified in stage by stage action.

The important point that has to be noted here is that the total gain is less than the product of the gains of individual stages. This is because when a second stage is made to follow the first stage, the **effective load resistance** of the first stage is reduced due to the shunting effect of the input resistance of the second stage. Hence, in a multistage amplifier, only the gain of the last stage remains unchanged.

As we consider a two stage amplifier here, the output phase is same as input. Because the phase reversal is done two times by the two stage CE configured amplifier circuit.

Frequency Response of RC Coupled Amplifier:

Frequency response curve is a graph that indicates the relationship between voltage gain and function of frequency. The frequency response of a RC coupled amplifier is as shown in the following graph.



From the above graph, it is understood that the frequency rolls off or decreases for the frequencies below 50Hz and for the frequencies above 20 KHz. whereas the voltage gain for the range of frequencies between 50Hz and 20 KHz is constant.

We know that,

$$X_C = \frac{1}{2\pi f_c}$$

It means that the capacitive reactance is inversely proportional to the frequency.

At Low frequencies (i.e. below 50 Hz):

The capacitive reactance is inversely proportional to the frequency. At low frequencies, the reactance is quite high. The reactance of input capacitor C_{in} and the coupling capacitor C_C are so high that only small part of the input signal is allowed. The reactance of the emitter by pass capacitor C_E is also very high during low frequencies. Hence it cannot shunt the emitter resistance effectively. With all these factors, the voltage gain rolls off at low frequencies.

At High frequencies (i.e. above 20 KHz):

Again considering the same point, we know that 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. Along with this, as the capacitance of emitter diode decreases, it increases the base current of the transistor due to which the current gain (β) reduces. Hence the voltage gain rolls off at high frequencies.

At Mid-frequencies (i.e. 50 Hz to 20 KHz):

The voltage gain of the capacitors is maintained constant in this range of frequencies, as shown in figure. If the frequency increases, the reactance of the capacitor C_C decreases which tends to increase the gain. But this lower capacitance reactive increases the loading effect of the next stage by which there is a reduction in gain.

Due to these two factors, the gain is maintained constant.

Advantages of RC Coupled Amplifier:

The following are the advantages of RC coupled amplifier.

- The frequency response of RC amplifier provides constant gain over a wide frequency range, hence most suitable for audio applications.
- The circuit is simple and has lower cost because it employs resistors and capacitors which are cheap.
- It becomes more compact with the upgrading technology.

Disadvantages of RC Coupled Amplifier:

The following are the disadvantages of RC coupled amplifier.

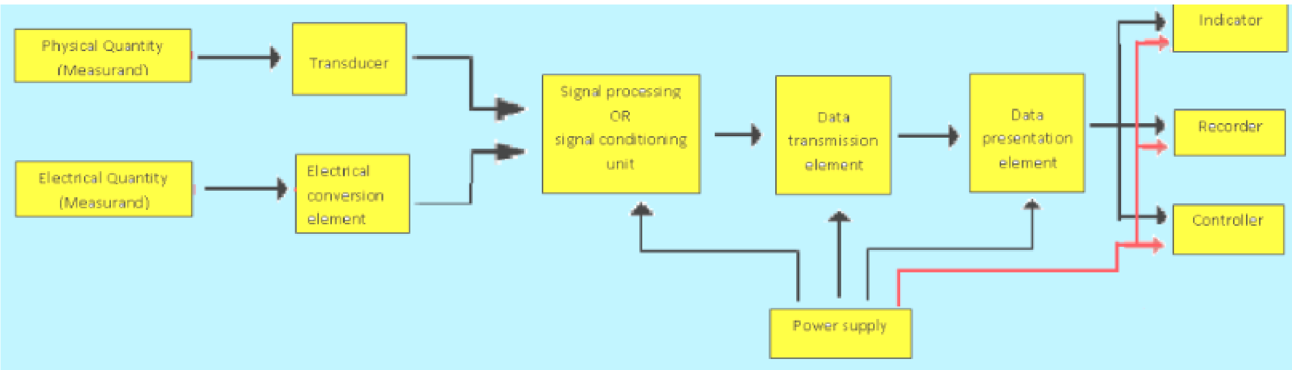
- The voltage and power gain are low because of the effective load resistance.
- They become noisy with age.
- Due to poor impedance matching, power transfer will be low.

Applications of RC Coupled Amplifier:

The following are the applications of RC coupled amplifier.

- They have excellent audio fidelity over a wide range of frequency.
- Widely used as Voltage amplifiers
- Due to poor impedance matching, RC coupling is rarely used in the final stages.

BLOCK DIAGRAM OF AN ELECTRONIC INSTRUMENTATION SYSTEM



- Fig shows block diagram of generalized electronics instrumentation system, in which number of elements worked together to perform a desired function accurately i.e. to measure the measurand quantity and display it or record it.
- We will discuss the different element separately, so it is easy for us to understand the system in detail.

Measurand (physical quantity or electrical quantity) :

- The physical or electrical quantity which is to be measurand is called as measurand. If the input to the instrumentation is parameter like pressure, force, level, strain, displacement, temperature, flow, velocity etc. then these parameters are physical measurand. These measurand are applied to the transducer element.
- If the input is current, voltage and frequency then these parameter are called electrical measurand. These measurand are applied to the electrical conversion element.

Transducer and electrical conversion elements:

- If the measurand is physical quantity then it is converted into equivalent electrical signal with help of element which is called transducer. Transducer is a device which convert one form of energy into another. (physical to electrical).
- Most of the transducer are primary sensors which sense the measurand then convert it into electrical signal with the help of conversion element.
- If the measurand is already electrical signal like voltage, current or frequency then it is give to the electrical conversion element which convert the signal into more suitable form of signals such as 4-20mA, 1-5VDC, 1-10VDC etc.

Signal processing or signal conditioning:

- The output from the transducer elements is given to the signal processing or signal conditioning elements. Signal conditioning is a process to modify the output of transducer so that it can be measured, controlled and acceptable by next stages.
- In electronic instrumentation system, filter, modulator, A/D converters, D/A converter, amplifiers, integrators, differentiators are the important signal conditioning circuits.
- This stage is required to convert the transducer output into an electrical quantity suitable for proper operation of the last stage or indicator.

Data transmission element:

- If the sensing element and data presentation element of the instrumentation system are away from each other (physically separated) in that case data transmission element is very important .
- This element provides a transmission path for the modified signals to travel from transducer element to the rest of instrumentation elements like recorders, controllers, displays etc.
- In electronic instrumentation system, typically the transmission path is a conducting lines (i.e. electrical cables). In electronic instrumentation system some time radio link is used as a transmission path them the system is called telemetry system.
- This element transmits the data to the remote located control room.

Data presentation element:

- The signal from the data lines are provided to the data presentation element. This element converts the signal into such from that it can be presented by some visual or audible means.
- Function performed by this stage may be demodulation, amplification, filtering, A/D conversion etc.
- This element modifies the signals in such a way that the signals are accepted by recorders, displays, indicators, printers, announcing systems etc. The out put of the data presentation element is provided to the recorders, controllers, and indicators as per the requirement of the user or operator or observer.

Output devices:

- The last stage of instrumentation system is required to provide the information about the measurand for immediate reorganization by the operator whatever output is presented on indicator.
- For example, if the system is simple instrumentation with display then measured parameter is displayed directly on the display. If it is required to produce alarm for the

over range then indicator or buzzer is used. If the recorder like strip-chart or X-Y recorder etc. To record the data.

- If the system is control system in that case the measured data not only displayed or recorded but also compared with some reference value and control action is generated which is used to remove the error.

Power supply:

- This is a common unit for all instrumentation system. This provides power to all elements working in the instrumentation setup.
- If the transducer is active transducer (self generating), in that case power supply is not required. For example if that transducer is thermocouple or piezoelectric crystal.
- For passive transducer power supply is required, for example if the transducer is thermistor or RTD, in that case power supply is important to the transducer block.