CHAPTER -3
FEEDBACK AMPLIFIERS

- Feedback & types of feedback
- Principle of negative feedback in amplifier
- Gain of amplifier with negative feedback
- Transistor amplifier circuit with negative voltage feedback
- Advantages of negative feedback amplifiers
- Transistor amplifier circuits with negative current feedback
  1) Common-Emitter circuit without by-pass capacitor
  2) Emitter Follower

FEEDBACK

The process by which a fraction of output energy of a device (Amplifier) is injected back to its input is known as feedback.

- Two types of feedback :
  1. positive feedback
  2). negative feedback

1) **Positive feedback** – when the feedback energy is in phase with the input signal, is called positive feedback.
2) Negative feedback – when the feedback energy is 1800 out of phase with the input signal, is called negative feedback.

The Feedback Can Also Be Classified On Basis Of Electrical Quantity.

(I) Voltage Feedback – The Signal Feedback Is Proportional To The Output Voltage Irrespective To The Load Impedance.

(Ii) Current Feedback – The Signal Feedback Is Proportional To The Output Current Irrespective To The Load Impedance.

At The Same Time, Both Voltage And Current Can Be Fed Back To The Input Either In Series Or Parallel, Then They May Be Named As :

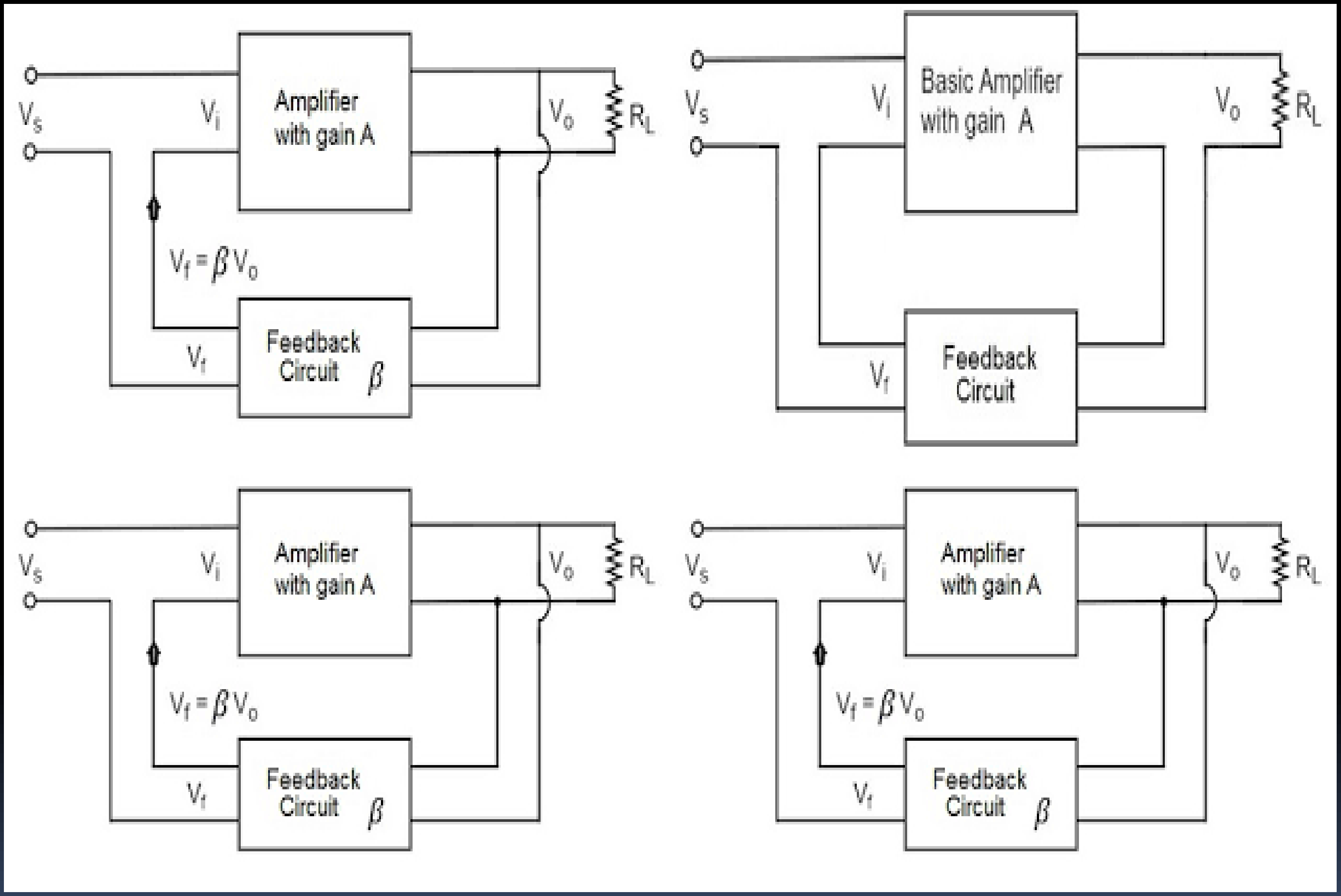
(a) Series-voltage Feedback

(b) Series-current Feedback

(c) Shunt-voltage Feedback

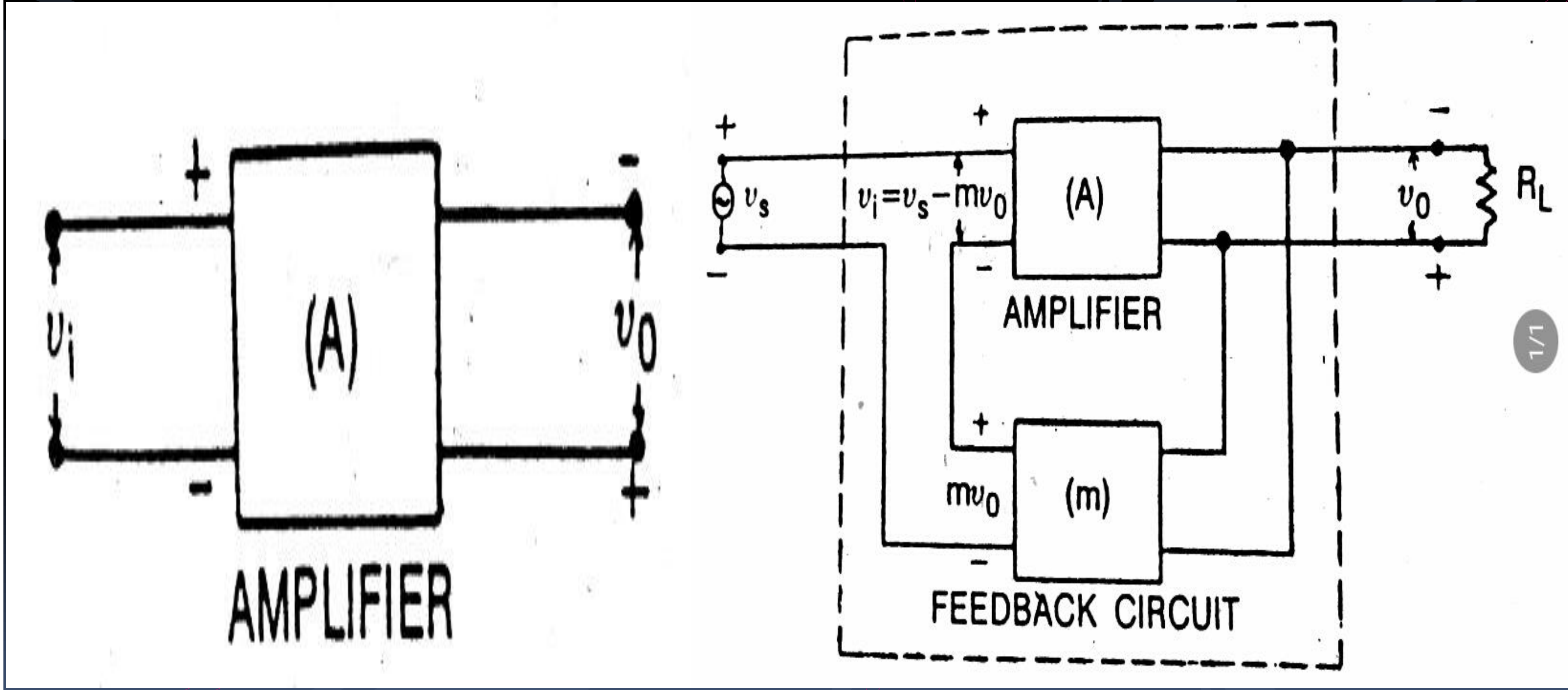
(d) Shunt-current Feedback

CIRCUIT DIAGRAM :



PRINCIPLE OF NEGATIVE FEEDBACK IN AMPLIFIER :

CIRCUIT DIAGRAM :



The basic principle of negative feedback in amplifiers, a basic amplifier here, vi is the input signal and v_o the output Gain of the amplifier is given as

$$A = v_o/v_i$$

The input remain unaffected even if the output changes due to any reason. Such a system is called open-loop or non feedback system.

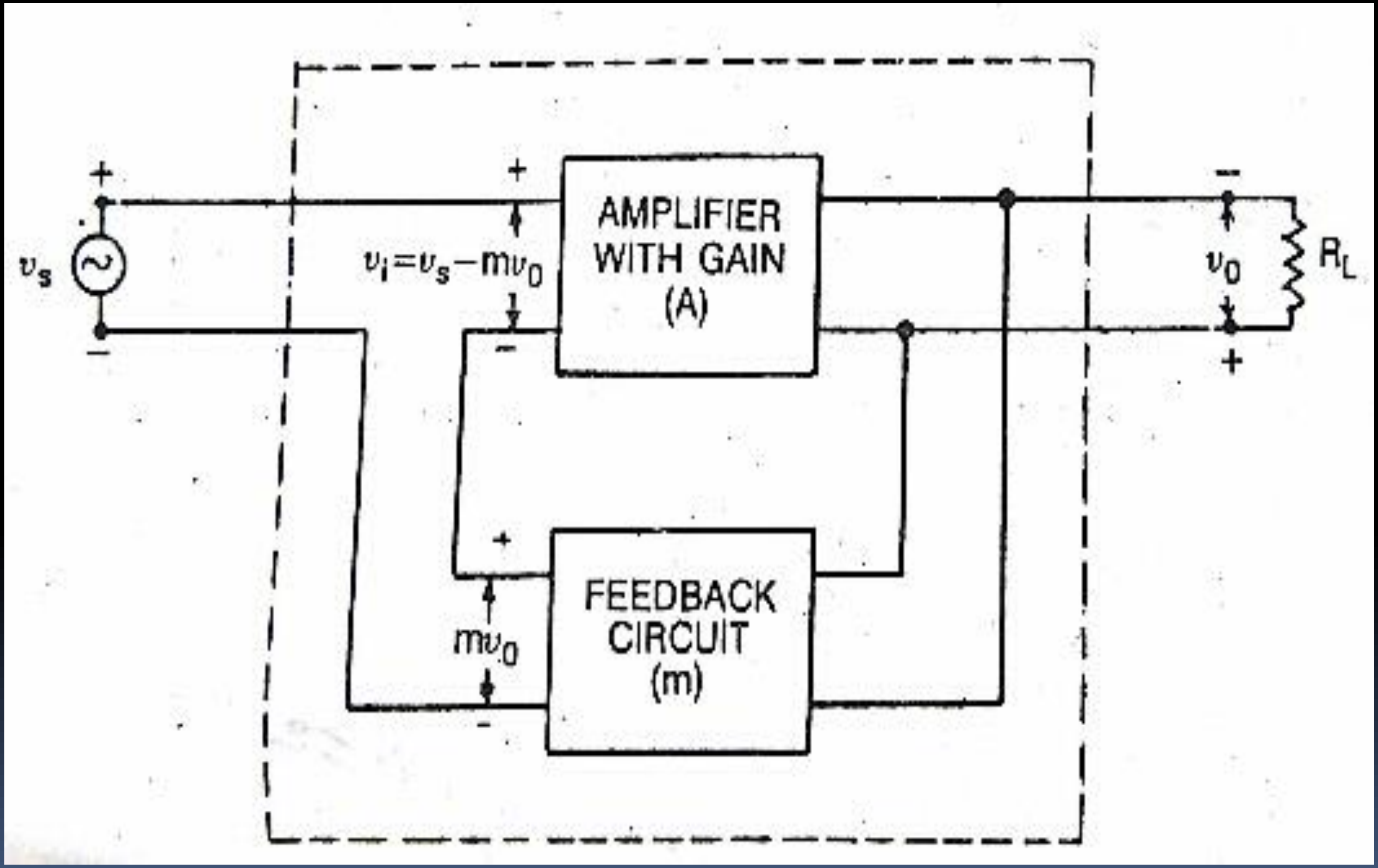
Therefore, actual input voltage vi applied across the input terminal of the amplifier is not the signal voltage v_s but it is $v_s - mv_o$ since the feedback is negative. Thus,

Gain of amplifier with feedback, $A = v_o/v_i = v_o/v_s - mv_o$ ...(i)

Fraction of output feedback $= mv_o/v_o = m$ ...(ii)

Gain of amplifier with feedback. $A_{fb} = v_o/v_s = v_o/v_i + mv$ $(v_i = v_s - mv_o)$ ...(iii)

GAIN OF AMPLIFIER WITH NEGATIVE FEEDBACK :



Consider an amplifier with negative feedback

Here,

v_s = signal voltage

v_o = output voltage

A = gain of the amplifier without feedback

*m = fraction by which output voltage is reduced and fed back at the input. It is also called feedback factor.

Fraction of voltage fed back to the input = mv_o

This feedback is negative as it is shown clearly by the signs.

Input to the amplifier, $vi = v_s - mv_o$

Now, gain, $A = v_o/v_i = v_o/v_s - mv_o$

Or $(v_s - mv_o)A = v_o$

Or $Avs - Amv_o = v_o$

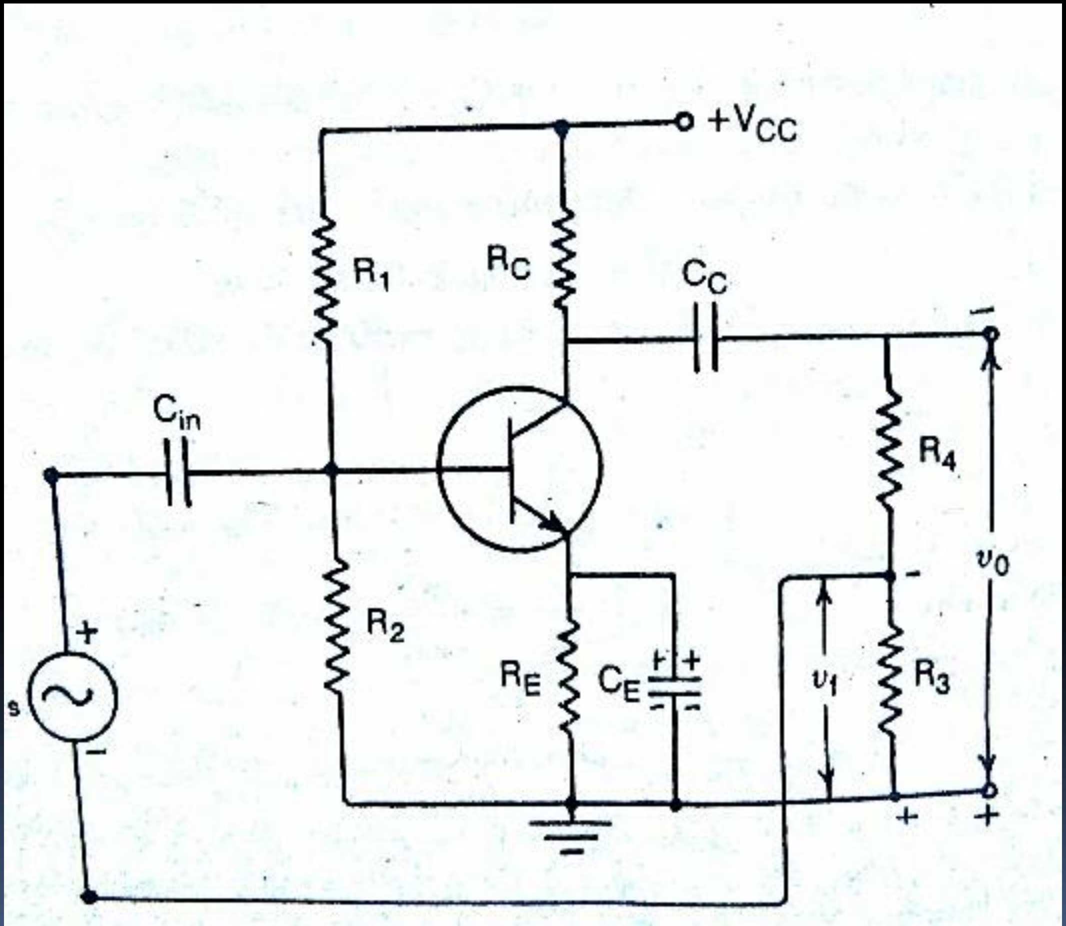
Or $v_o(1 + Am) = Av_s$

Or $v_o/v_s = A/1 + mA$

As ratio of output voltage to the signal voltage with feedback circuit is called voltage gain with negative feedback (A_{fb})

*$A_{fb} = A/1 + mA$

Transistor Amplifier Circuit With Negative Voltage Feedback :



The negative feedback is introduced in an actual transistor amplifier circuit. Here, R1,R2 and R_E provide the necessary biasing and stability to the circuit and Rc is the collector load resistor. Cin and Cc are input and output coupling capacitor respectively whereas, C_E is the emitter bypass capacitor. All these component have their usual function as discussed earlier.

The new component introduced in this circuit are R3 and R4. let the voltage fed back is Vf i.e. fraction of output voltage v_o developed across R3.

therefore,

Advantages of Negative Feedback Amplifiers :

1. **Improves gain stability :**

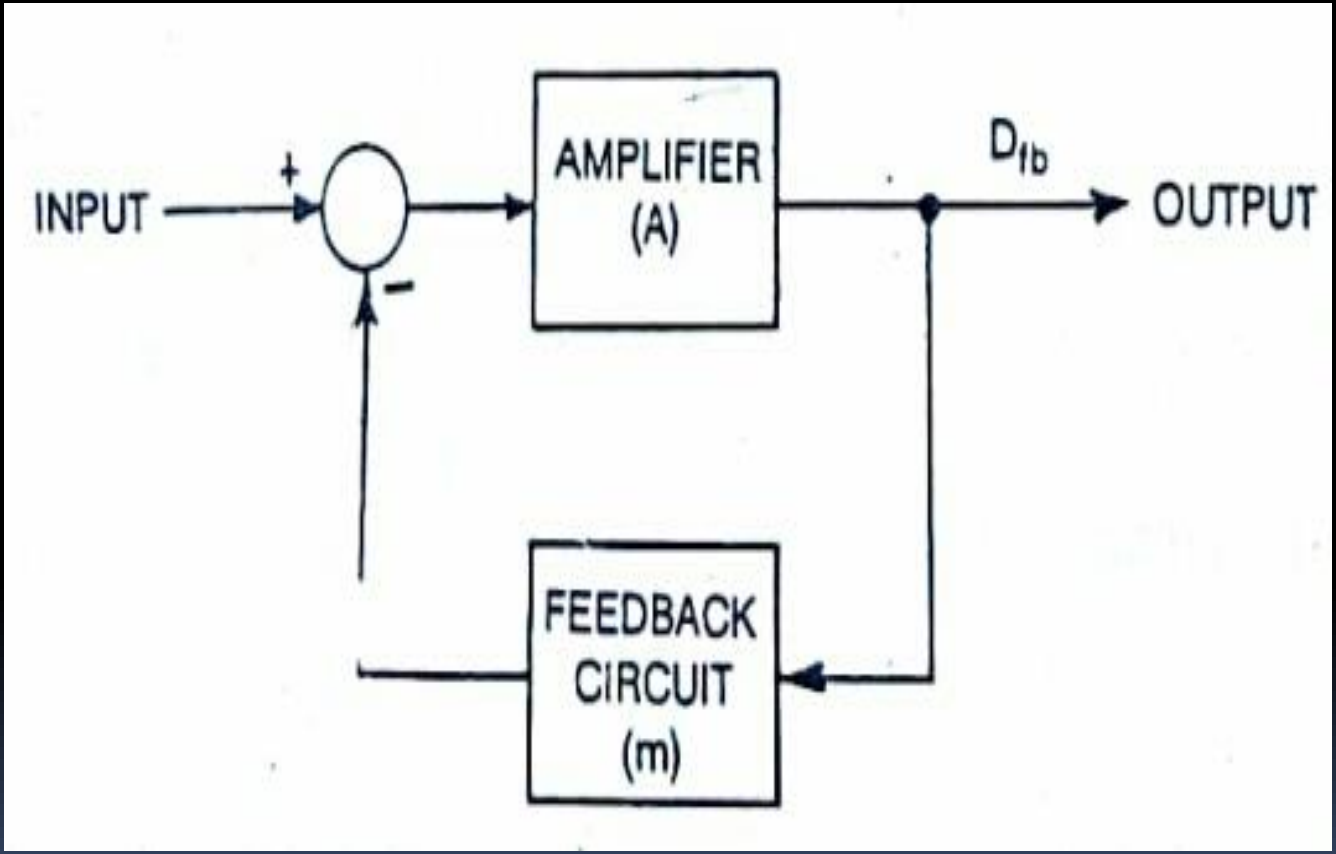
   the gain of an amplifier with negative feedback is given by the expression ;

$$A_{fb} = A/1 + Am \qquad \ldots(i)$$

If we make Am >> 1, then the denominator of the eqn. (i), we can neglect 1 as compared to Am, then the equation can be written as

$$A_{fb} = A/Am = 1/m \qquad \ldots(ii)$$

Reduce Distortion and Noise :



A part $(m\, D_{fb})$ of the distortion D_{fb} is fed back

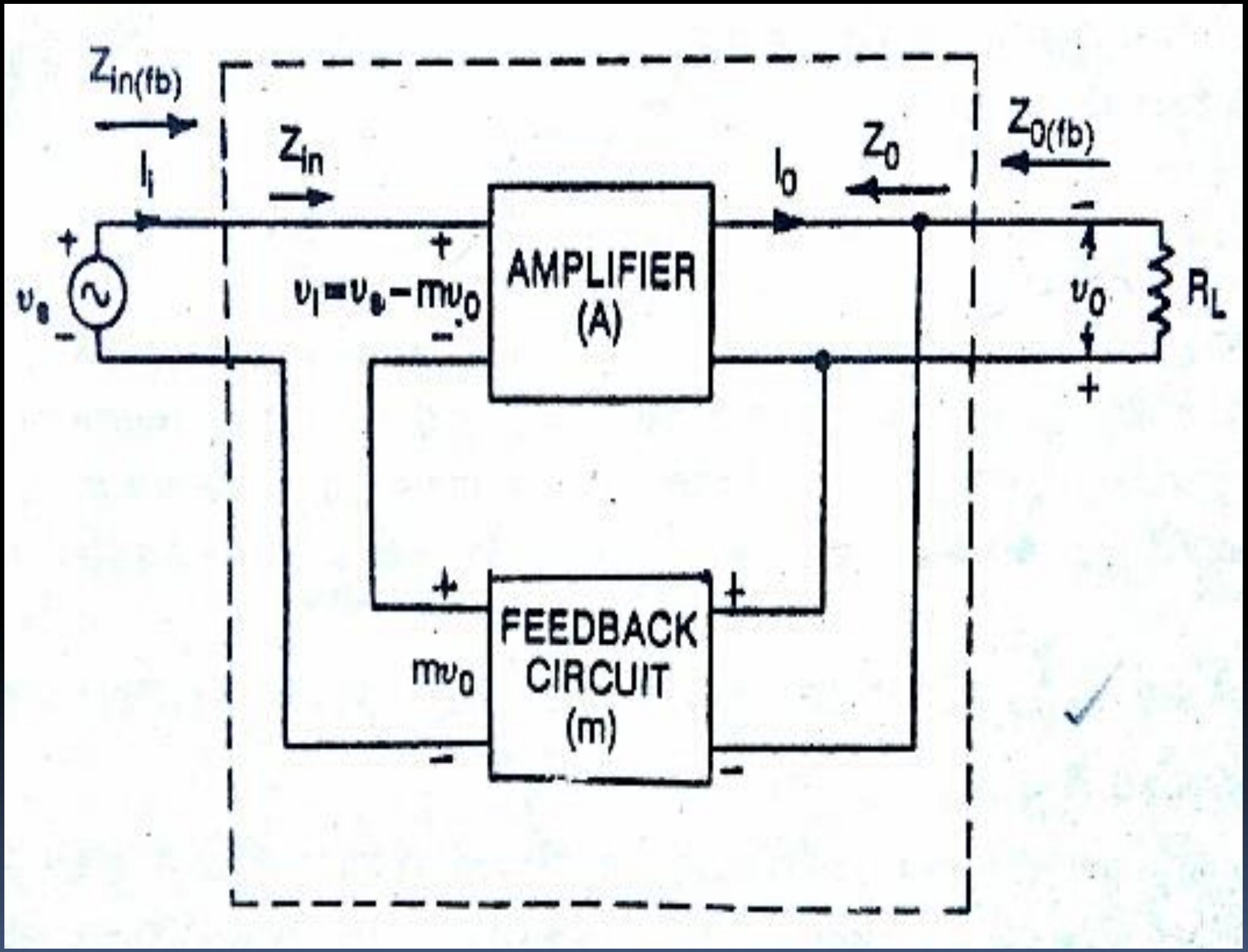
to the input. This part is amplified A times by the basic amplifier and becomes AmD_{fb}. This gets added up to the original distortion D and becomes D_{fb} .

$D_{fb} = D – AmD_{fb}$

$D_{fb} = D/1 + Am$ …(iii)

The distortion is reduced by a factor 1/1 + Am

INCREASE THE INPUT IMPEDANCE :



A negative feedback has the ability to increase the input impedance of an amplifier.

Let

zin = input impedance without feedback

zin (fb) = input impedance with feedback

vs = signal voltage

vi = input voltage to the basic amplifier

ii = input current

Now, input impedance of the feedback amplifier,

$zin\ (fb) = v_s/i_i$ ...(iv)

Input voltage to the basic amplifier, $v_i = v_s - mv_o$ ...(V)

$Zin = v_i/i_i$ ...(vi)

Since, $v_o = av_i$ substituting this value in equ. (V), we get,

$$v_i = v_s - mav_i$$

$$V_s = v_i(1 + ma)$$

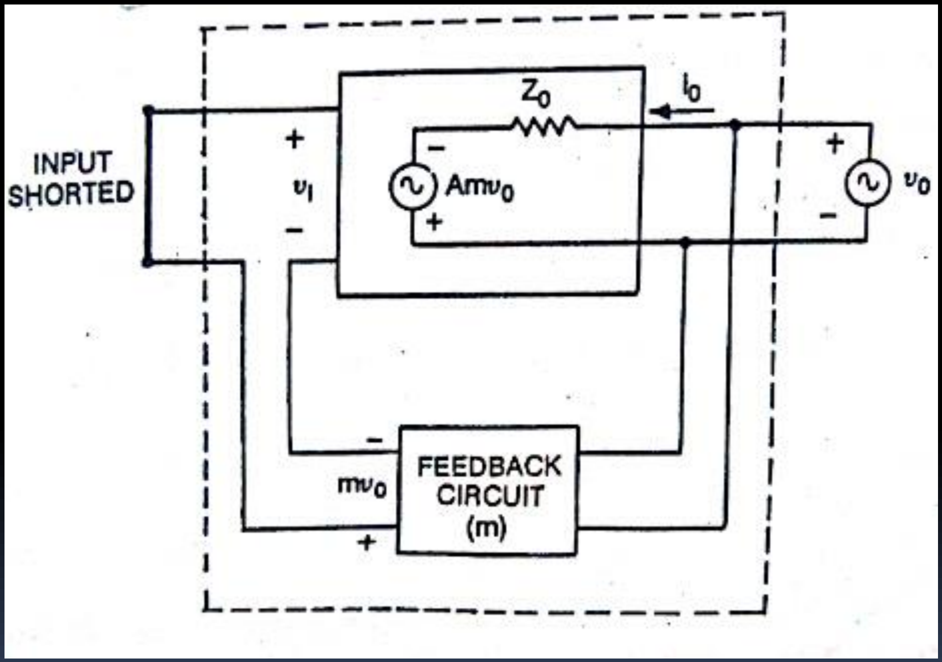
Dividing the above equation by i_i, we get,

$$v_s/i_i = v_i/i_i\ (1 + ma)$$

$$zin\ (fb) = zin\ (1 + ma)$$

The equation (vii) clearly shows that the input impedance of an amplifier with negative feedback is increased by A factor (1 + ma).

DECREASE OUTPUT IMPEDANCE :



- The output side has been replaced by an equivalent source Amv_o in series with the impedance z_o.
- The loop equation for the output ciruit

$$v_o + Am\, v_o - i_o Z_o = 0$$

$$v_o(1 + Am) = i_o Z_o$$

$$v_o/i_o = z_o/1 + Am$$

$$Z_o(fb) = Z_o/1 + Am \qquad \ldots(viii)$$

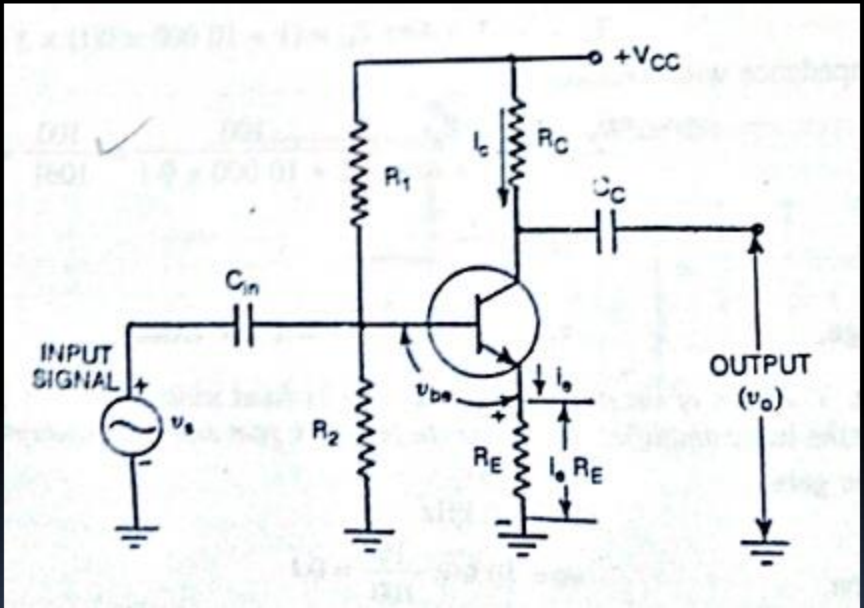
The output impedance of an amplifier with negative feedback is decreased by a factor $(1 + Am)$.

Transistor Amplifier Circuits with Negative Current Feedback :

1. common-emitter circuit without By-pass capacitor :

In the common-emitter amplifier circuit a capacitor C_E connected across R_E is called by -pass capacitor. However, obtain negative current feedback this by-pass capacitor C_E is removed.

CIRCUIT DIAGRAM :



OPERATION :

when the ac signal voltage vs is applied at the input and voltage increases during positive half cycle, the emitter-base junction becomes more forward biased. Because of the collector current i_c increase and so does the ac emitter current i_e in the direction marked in the figure. This develops an ac voltage i_eR_E across emitter resistor. This voltage opposes the signal voltage vs as it is in opposite direction to the signal. Thus the negative voltage (i_eR_E) is feedback to the input. Since, the negative voltage fed back to the input is proportional to the output current (i_c or i_e) hence the name current feedback circuit.

MATHEMATICAL ANALYSIS :

When signal is applied ; collector current ;

$$i_c = -v_o/Rc$$

The negative sign with vo shows that the output is 1800 out of phase to that of input signal voltage.

Base emitter voltage,

$$v_{be} = v_s - i_e R$$

$$v_{be} = v_s - i_c R_E \qquad (i_e = i_c)$$

Or $\quad v_{be} = v_s + nv_o/Rc * R_E \qquad (i_c = -v_o/Rc)$

Or $\quad v_{be} = v_s + R_E/R_C * v_o$

Or $\quad v_{be} = v_s + mv_o \qquad \text{...(i)} \; (m = R_E/R_C)$

Now, $\quad A_{fb} = 1/m \qquad (\text{when } Am >> 1)$

Or $\quad A_{fb} = R_C/R_E \qquad \text{...(ii)}$

The expression (ii) gives the effective voltage gain of the circuit.

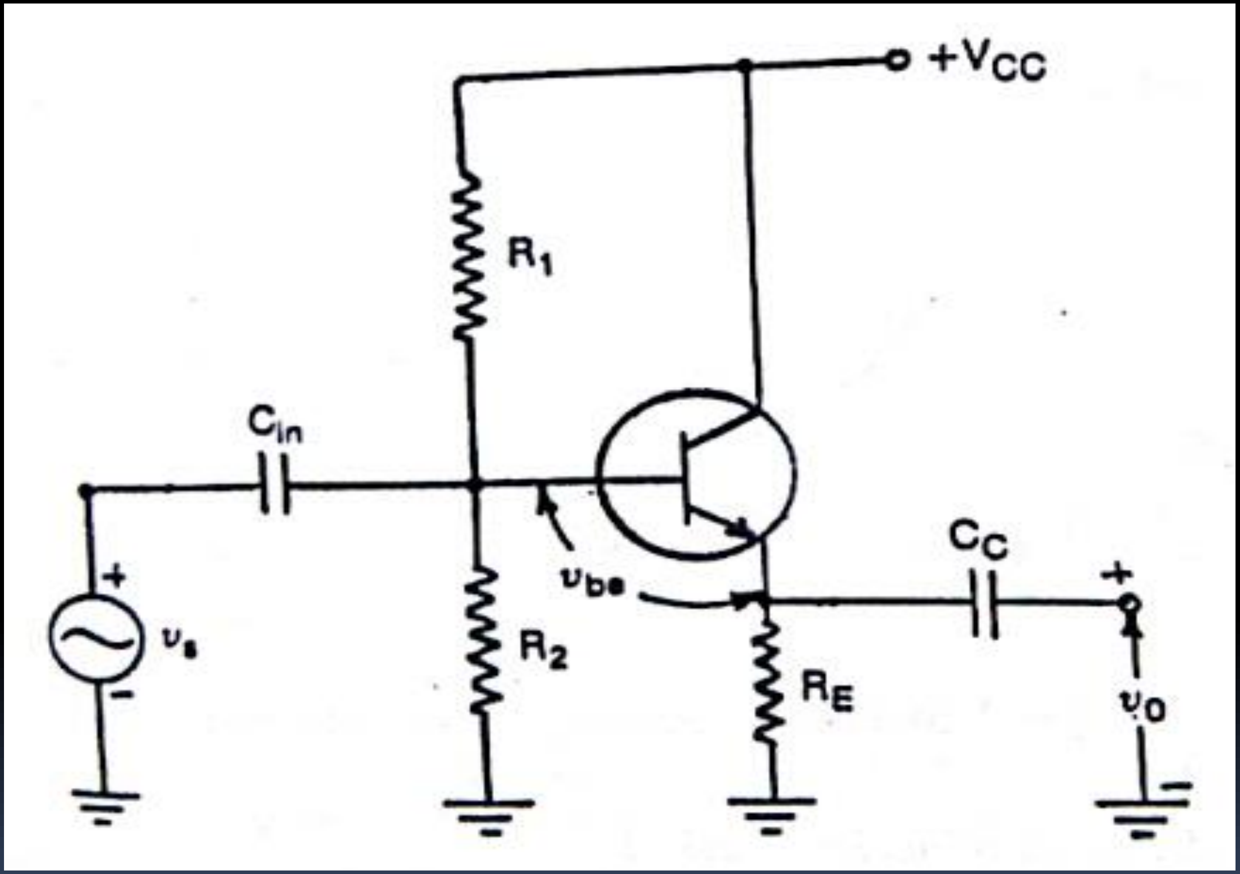
EMITTER FOLLOWER :

An emitter follower is a very useful negative current feedback circuit. The most important characteristics of this circuit are its high input impedance and low output impedance. This make it an ideal circuit for impedance matching.

CIRCUIT ANALYSIS :

In the common-emitter amplifier circuit, if the collector resistance Rc is reduced to zero an output is taken from the emitter terminal instead of collector terminal, we get an emitter- follower circuit as shown in figure. In this circuit, the only difference is that biasing is provided by base resistor method, otherwise it is a Similar circuit. Usually, this circuit is employed because of its simplicity.

CIRCUIT DIAGRAM :



OPERATION :

when ac signal vs is applied at the input, resulting current i_e flow through RE and produces an output voltage across it (i.e. $v_o = i_e R_E$). This voltage opposes the signal voltage thus provides negative feedback. This voltage (v_o) fed back to the input is proportional to the emitter current hence the circuit is called a negative current feedback circuit. The output voltage just follows the input voltage and hence the name emitter follower.

The emitter follower circuit is also called common-emitter the input is given between base and collector and the output appears between emitter and collector hence the circuit is called common-collector circuit.

MATHEMATICAL ANALYSIS :

$i_e = - v_o/R_E$ (output = $- v_o$)

Base emitter voltage,

$$V_{be} = V_s - i_e R_E$$

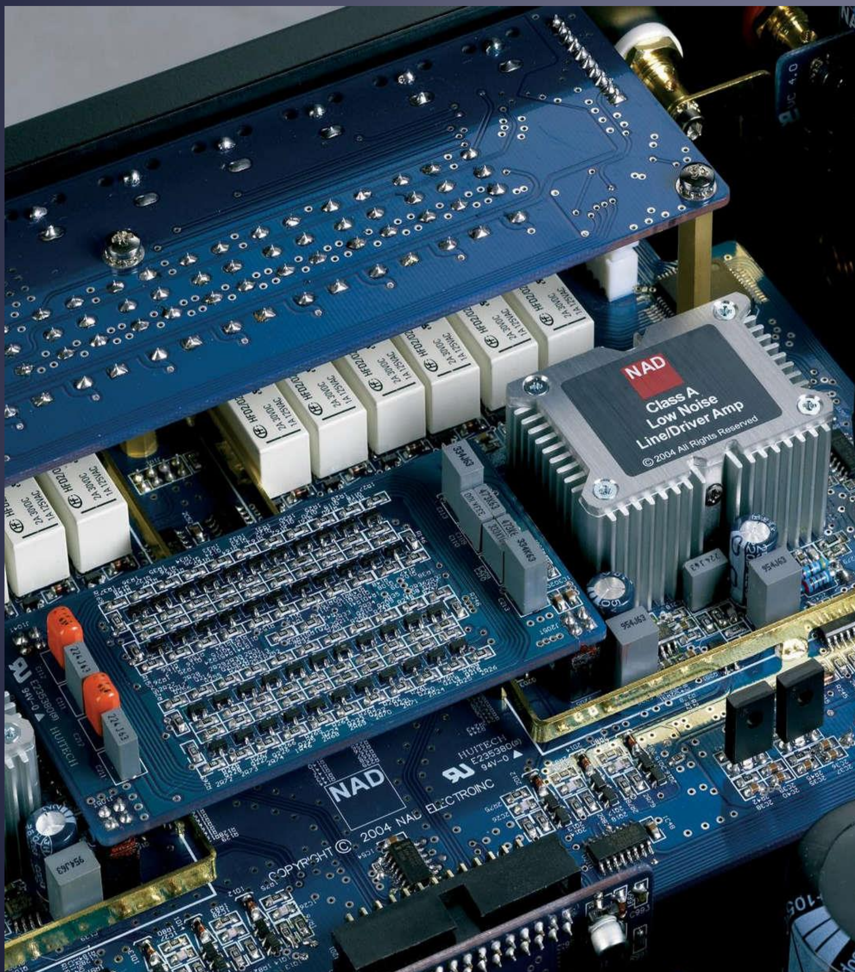
Or $$V_{be} = V_s - (- v_o/R_E)\, R_E$$

Or $$V_{be} = V_s + V_o$$

It is clear that feedback fraction in this case is 1 i.e., m = 1 or 100%. Consequently, feedback voltage gain is nearly one.

Similarly, it can be shown that current gain of this circuit is less than 1.

MULTISTAGE TRANSISTOR AMPLIFIER



CONTENT

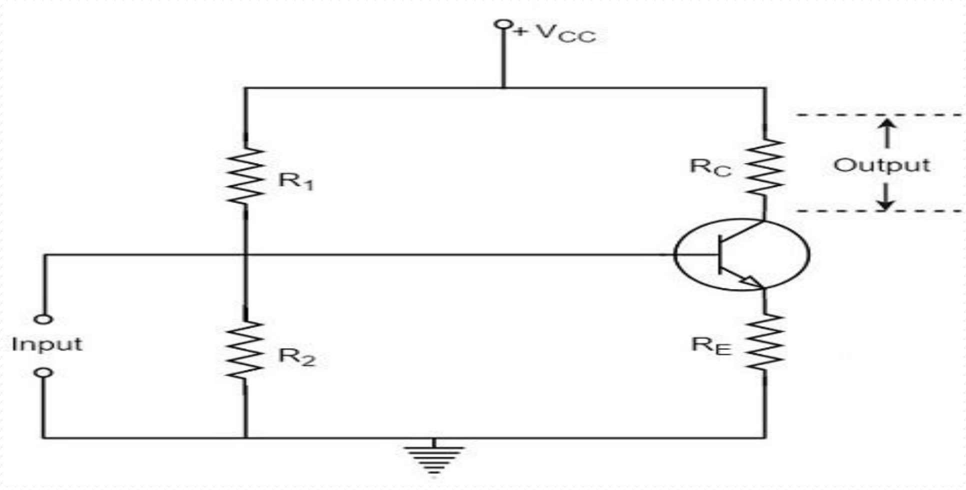
1. Single Stage Transistor Amplifier
2. Multi Stage Transistor Amplifier
3. Need Of Multi Stage Transistor Amplifier
4. Important terms : Gain , Decibel Gain , Frequency Response , Band Width
5. R – C Coupled Transistor Amplifier
6. Transformer Coupled Transistor Amplifier
7. Direct Coupled Amplifiers

CONTENT

1. Single Stage Transistor Amplifier
2. Classification of Amplifiers
3. Multi Stage Transistor Amplifier
4. Need Of Multi Stage Transistor Amplifier
5. Important terms : Gain , Decibel Gain , Frequency Response , Band Width.
6. Gain of Multistage amplifier
7. Coupling and its Functions
8. Types of multistage amplifier- RC Coupled, Transformer Coupled & Direct Coupled Amplifiers

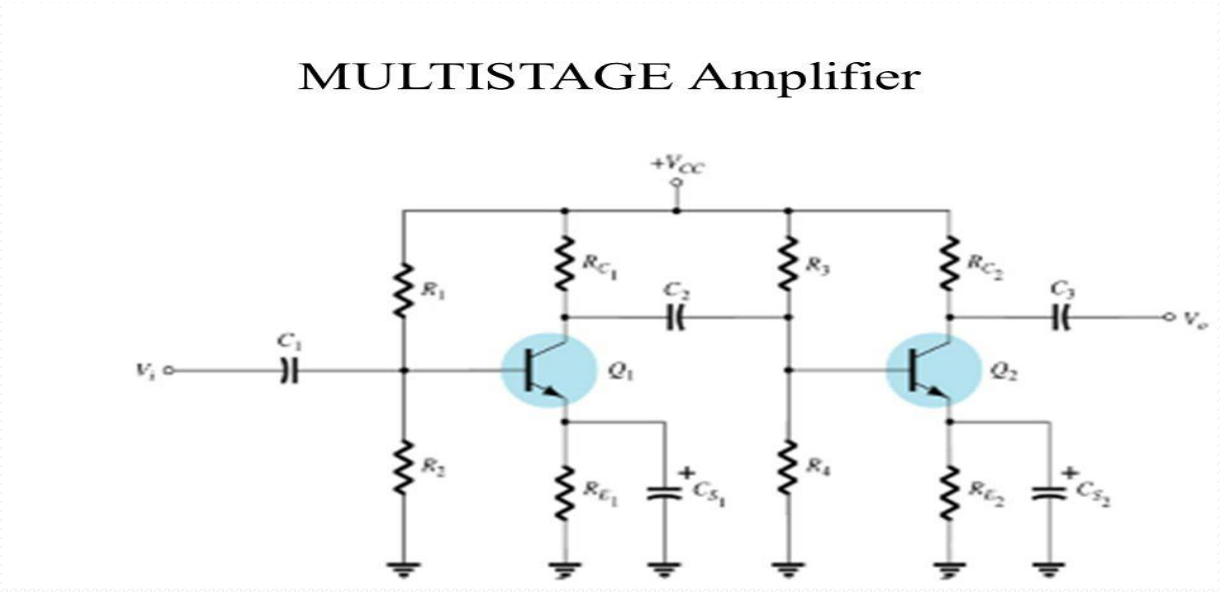
SINGLE STAGE TRANSISTOR AMPLIFIER

- When only one transistor with its associated circuitry is used to increase the strength of a weak signal , the complete circuit is known as Single Stage Transistor Amplifier.



MULTI STAGE TRANSISTOR AMPLIFIER

- A transistor circuit in which a number of amplifier stages are used in succession is called a Multi Stage Transistor Amplifier or Cascaded Amplifier.



NEED OF MULTI STAGE TRANSISTOR AMPLIFIER

- The amplification obtained from a single stage transistor amplifier is inadequate to drive the output devices like speaker , indicating instruments etc.Therefore , to amplify the signal to the required level a number of amplifier stages are used in successions in such a way that output of one stage is coupled to the next stage .

GAIN

- The ratio of output to the input of an amplifier is called its gain.

Although no unit is assigned to gain , since it is the ratio of output to the input of an amplifier. However telephone industry proposed a logarithmic unit named BEL .

BEL is defined as the common logarithm of power gain.

DECIBEL GAIN

- For practical purpose it has been found that the unit bel is quite large unit. Therefore,one-tenth of this unit is considered to be more covenient. This smaller unit is called decibel (*dB).
- REASON OF EXPRESSING GAIN IN dB :

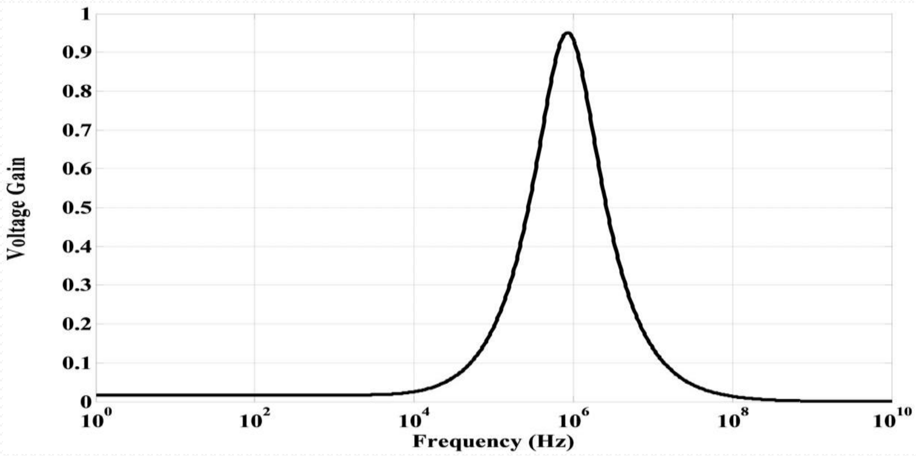
1. When the gains are expressed in dB,the overall gain of a multi stage amplifier can be determined by just adding them.

2. The output of most of the amplifiers is ultimately converted into sound.

FREQUENCY RESPONSE

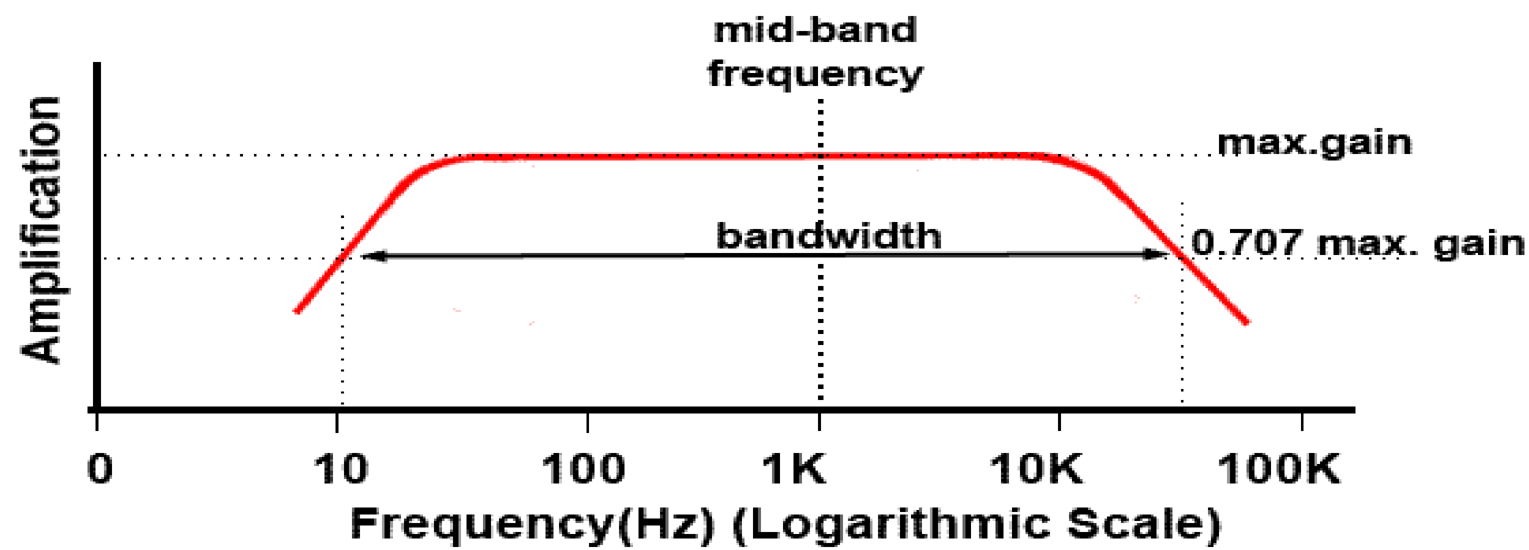
- The curve drawn between voltage gain and signal frequency of an amplifier is known as its frequency response.

The voltage gain of an amplifier is not constant, rather it varies with the signal frequency.



BAND WIDTH

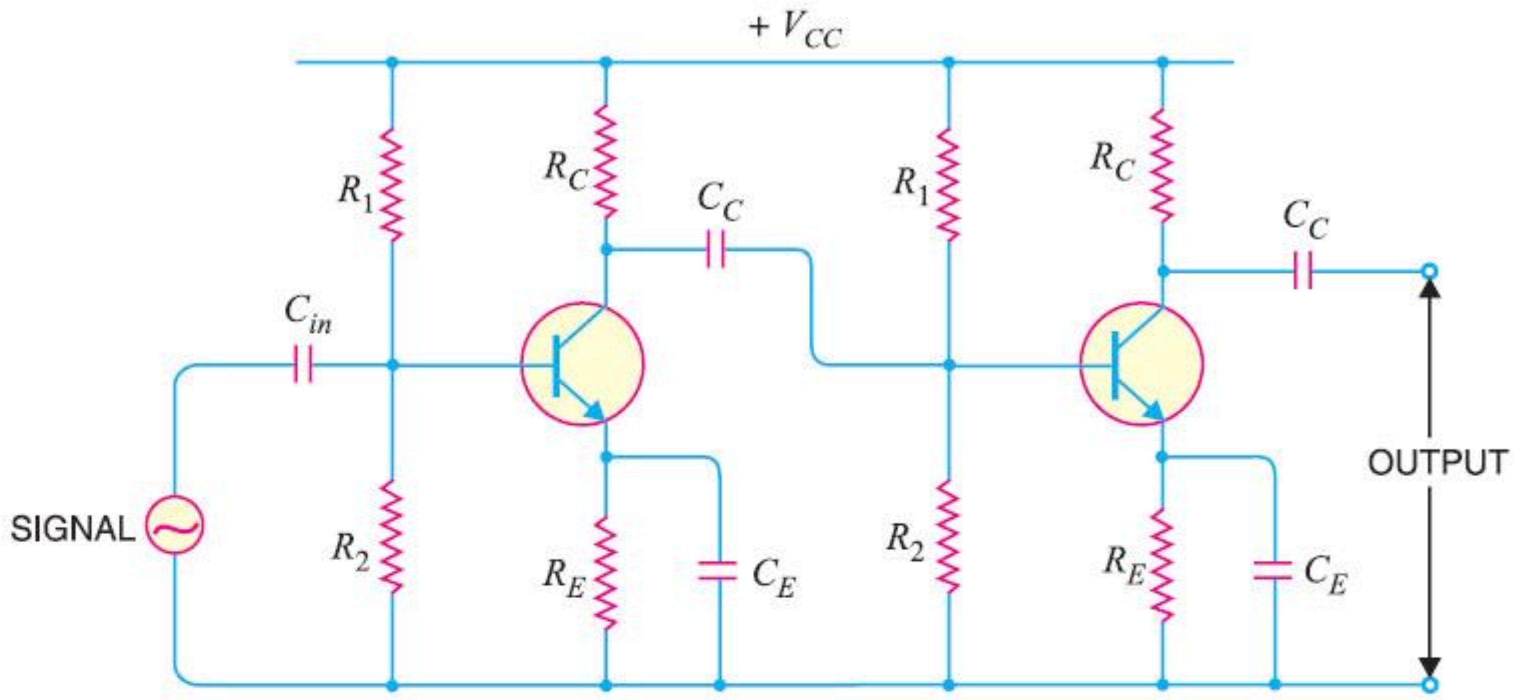
- The range of frequency over which the gain of an amplifier is equal or greater than *70.7% of its maximum gain is known as band width.



R – C COUPLED TRANSISTOR AMPLIFIER

- CIRCUIT ANALYSIS : Cin allows only a c signal to flow in whereas emitter bypass capacitor C_E offers low reactance path to the signal. The resistor R_1,R_2 and R_E provide the necessary biasing and stabilisation .The coupling capacitor *Cc allows amplified a c signal of one stage to pass on to the next stage but blocks d c .

CIRCUIT DIAGRAM



WORKING :

When a c signal Vin is applied to base of transistor Tr_1 its amplified form appears across the collector resistor Rc. This amplified signal developed across Rc is fed to the base of next transistor Tr_2 through coupling capacitor Cc.The second stage further amplifies the signal .

ADVANTAGES :

- 1. The cost is low , because low cost of coupling capacitor and resistors.
- 2. They occupy less space because of small size of resistor and capacitor.

DISADVANTAGES :

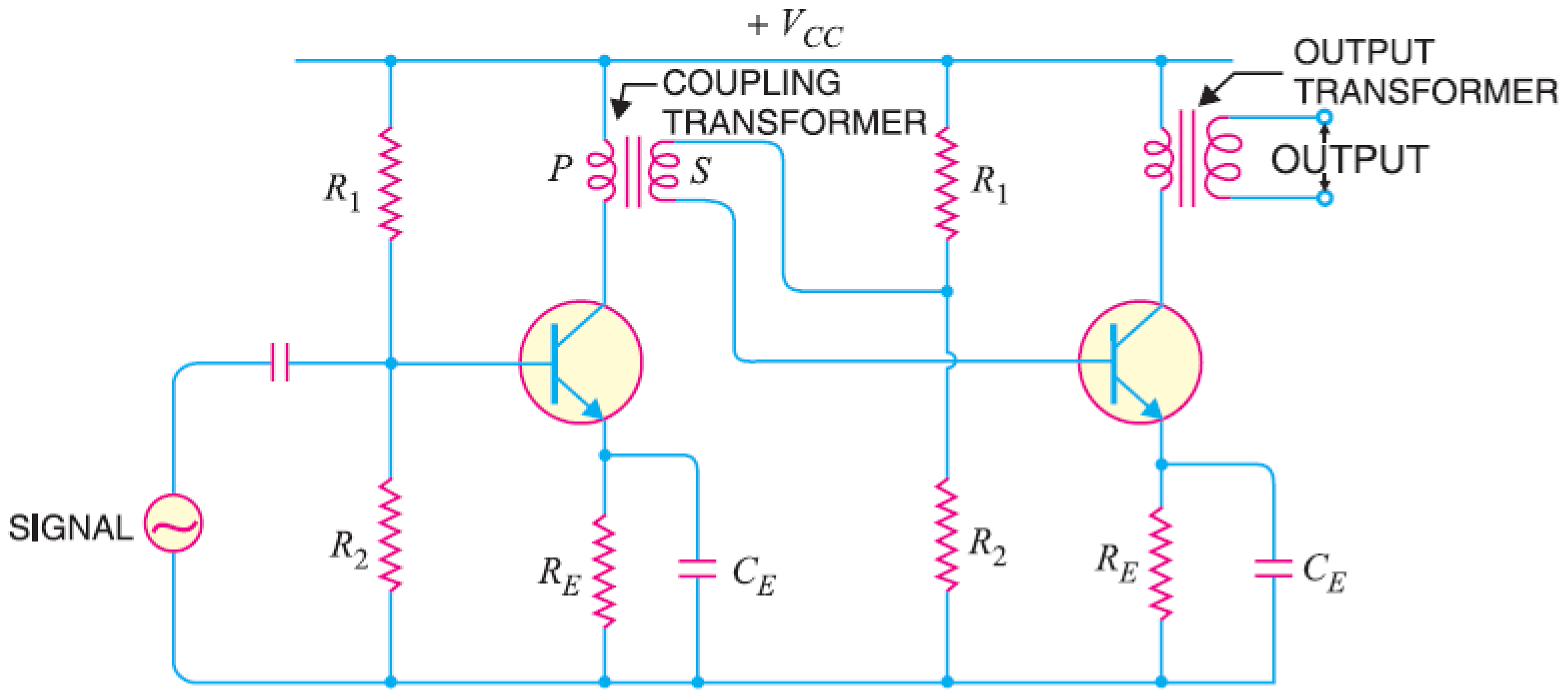
- They have smaller gain.
- Impedence matching is poor.

TRANSFORMER COUPLED TRANSISTOR AMPLIFIER

- CIRCUIT ANALYSIS :

  Cin allows only a c signal to flow in whereas emitter bypass capacitor C_E offers low reactance path to the signal. The resistor R_1,R_2 and R_E provide the necessary biasing and stabilisation .The coupling capacitor *Cc allows amplified a c signal of one stage to pass on to the next stage but blocks d c . The output of first stage appears across the primary of coupling transformer ,transferred to the secondary of the transformer by transformer action and is fed to the base of transistor of next stage.

CIRCUIT DIAGRAM



WORKING :

When an input a c signal (Vin) is applied at the base of the first transistor, an amplified ac flows through the collector circuit of the transistor and hence through primary P of the coupling transformer . This amplified output is transferred to the secondary side of the coupling transformer and is fed to the base of the transistor of next stage. The may be connected to these terminals.

ADVANTAGES :

- 1. Higher gain can be obtained by using step up coupling transformer.
- 2. An excellent impedence matching can be achieved.

DISADVANTAGES :

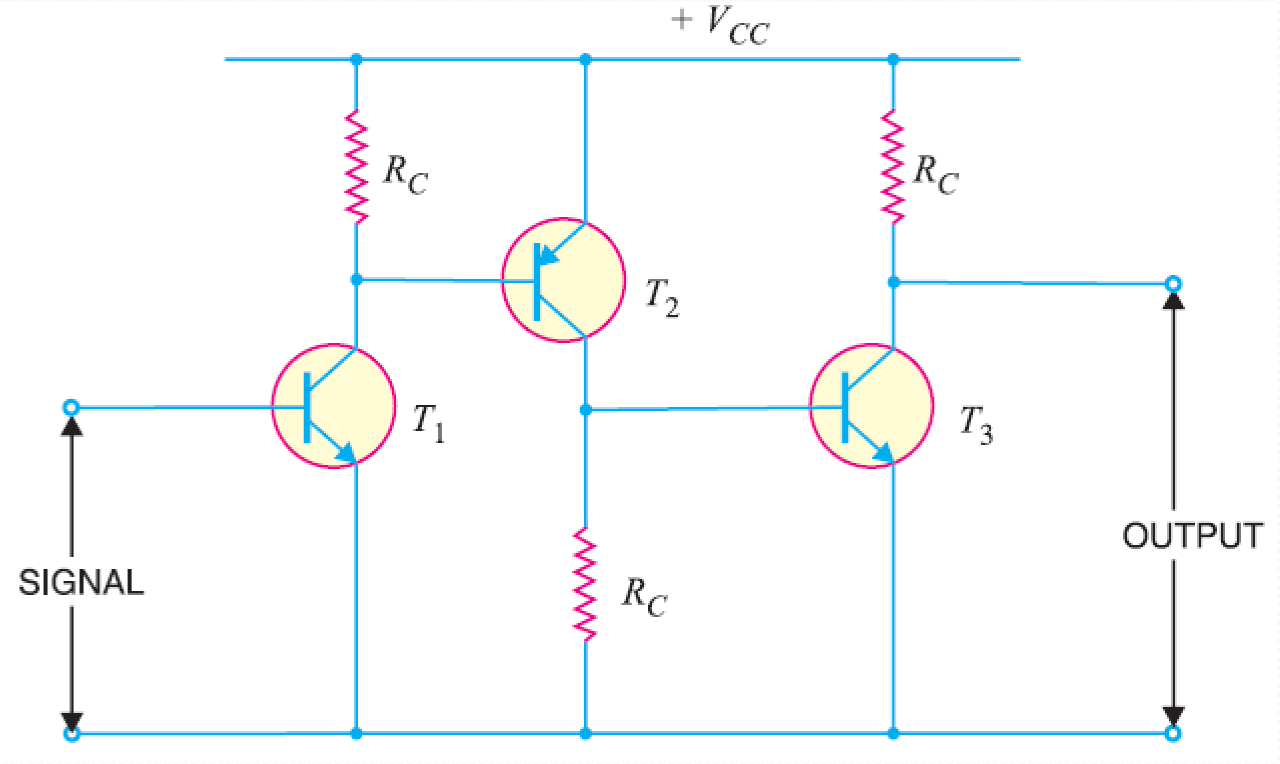
- They are larger in size.
- They are costlier and bulky.

DIRECT COUPLED AMPLIFIERS

- CIRCUIT ANALYSIS :

  In this method of coupling complementary transistors are used. Thus if npn transistor is used in the first stage then pnp transistor is used in the second stage and so on. The output of one stage is directly fed to the input of next stage.

CIRCUIT DIAGRAM



WORKING :

A weak signal of very low frequency (<10 Hz) is applied to the base of first transistor Tr_1 . Due to transistor action, an amplified signal is obtained across the collector resistor Rc . This amplified signal is further fed to the base of next transistor and so on.

ADVANTAGES :

- The circuit arrangement is simple as few components are used.
- The cost of this circuit is low.

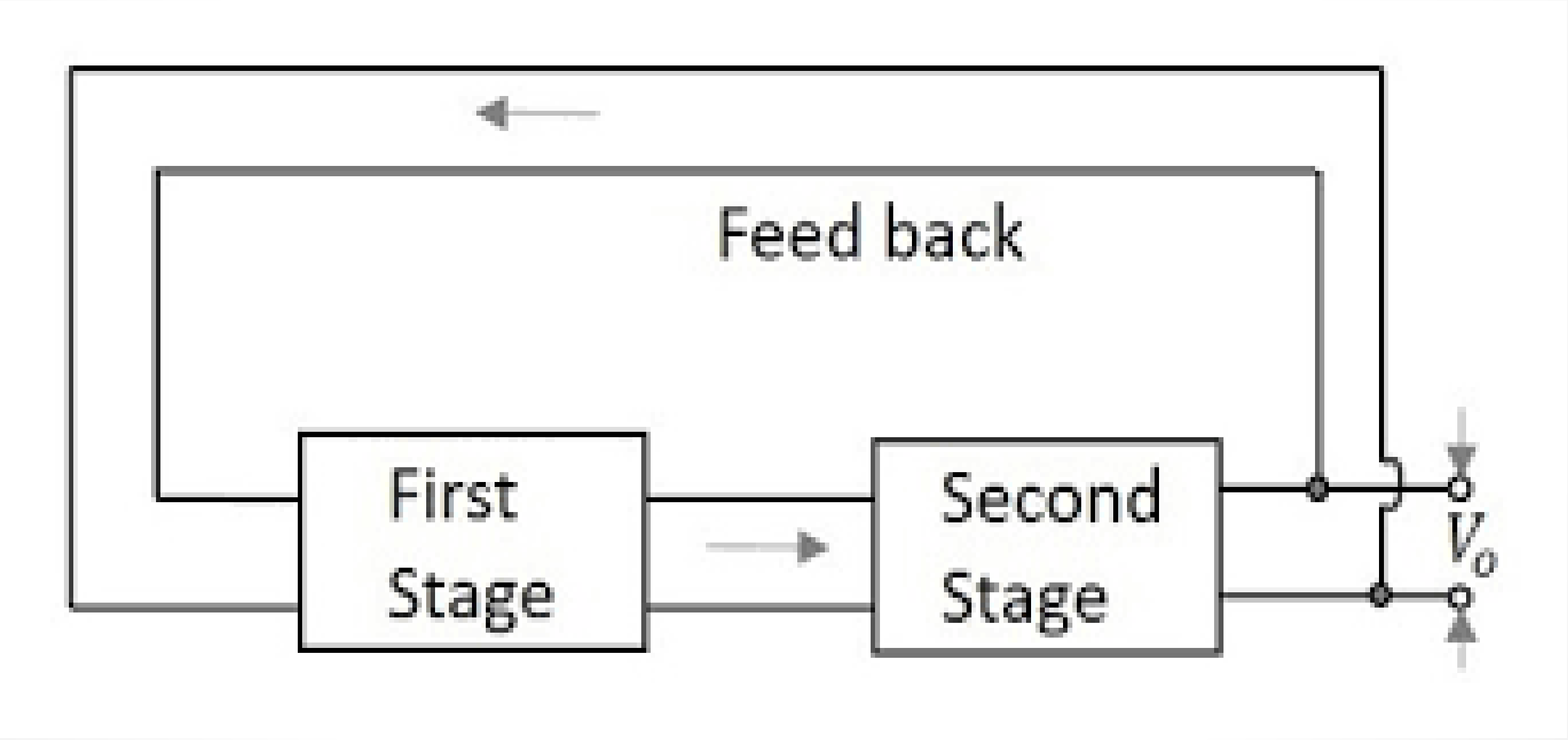
DISADVANTAGES :

- It cannot be used to amplify high frequency signals.
- Temperature may shift the operating point.

Multivibrator circuits

- It is a two stage RC couple amplifier with positive feedback from the output of one amplifier to the input of other.
- It is also defined as receiver that generates non – sinusoidal waves such as square waves, rectangular waves, sawtooth waves. It is a switching circuit because in the multivibrator each amplifier stage supplies feedback to the to the other stage in such a manner that one transistor is driven to saturation and other to cut off this is known as the state of the multivibrator.
- There are 3 types of multivibrator :-
- Astable multivibrator
- Monostable multivibrator
- Bistable multivibrator

Multivibrator



What is a switch?

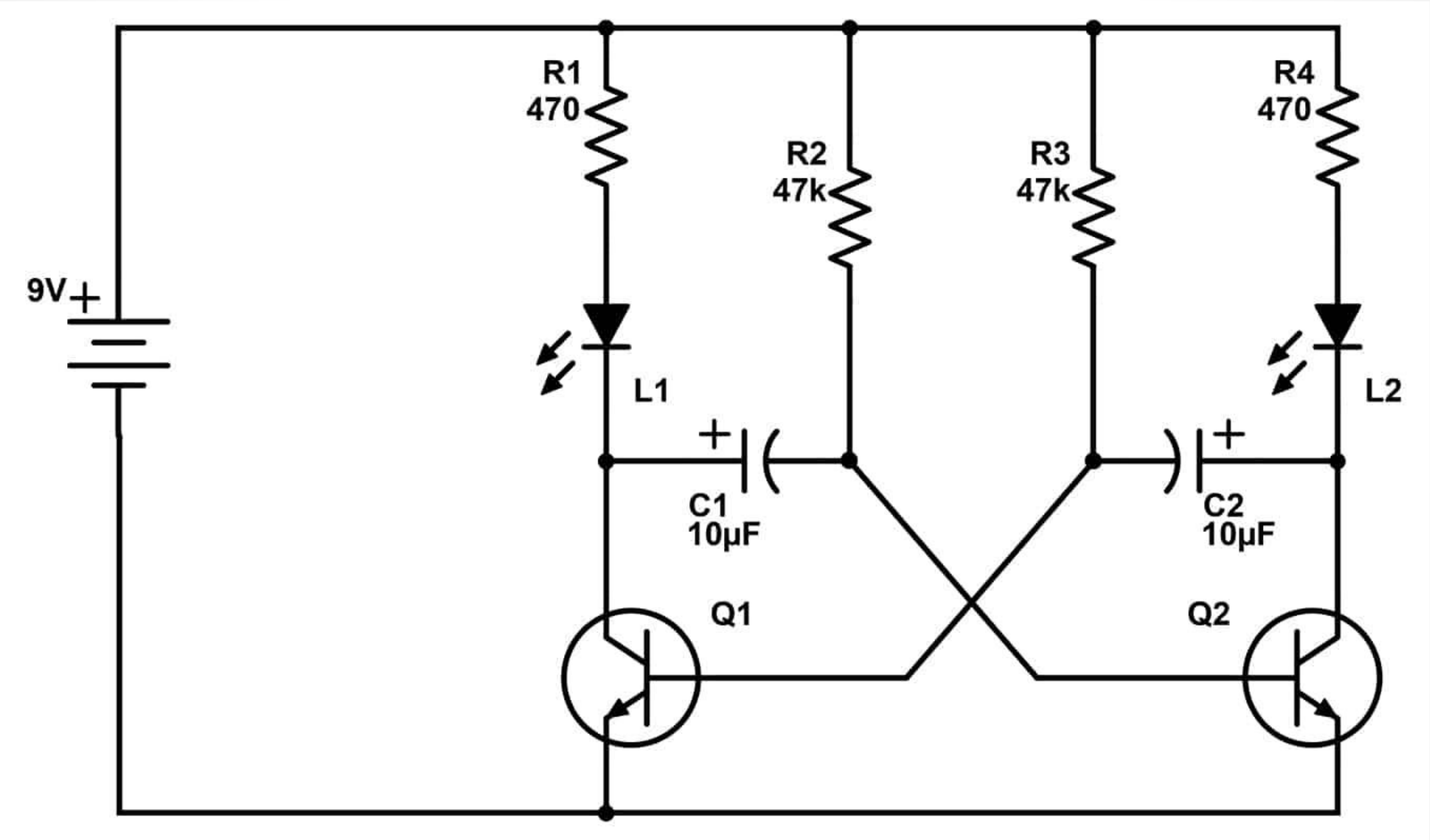
- A switch may be defined as a device which can turn ON and OFF in the electronic circuit. On the other hand, a circuit which can turn ON and OFF current in the electronic circuit is known as switching circuit. It consists of a switch and associated circuiting.

Astable Multivibrator

- Regenerative switching circuits such as **Astable Multivibrator** are the most commonly used type of relaxation oscillator because not only are they simple, reliable and ease of construction they also produce a constant square wave output waveform.
- **Astable Multivibrator** has automatic built in triggering which switches it continuously between its two unstable states both set and reset.
- The **Astable Multivibrator** is another type of cross-coupled transistor switching circuit that has **NO** stable output states as it changes from one state to the other all the time. The astable circuit consists of two switching transistors, a cross-coupled feedback network, and two time delay capacitors which allows oscillation between the two states with no external triggering to produce the change in state.

- In electronic circuits, astable multivibrators are also known as **Free-running Multivibrator** as they do not require any additional inputs or external assistance to oscillate. Astable oscillators produce a continuous square wave from its output or outputs, (two outputs no inputs) which can then be used to flash lights or produce a sound in a loudspeaker.
- The basic transistor circuit for an **Astable Multivibrator** produces a square wave output from a pair of grounded emitter cross-coupled transistors. Both transistors either NPN or PNP, in the multivibrator are biased for linear operation and are operated as Common Emitter Amplifiers with 100% positive feedback.
- This configuration satisfies the condition for oscillation when: ($\beta A = 1\angle 0^{\circ}$). This results in one stage conducting "fully-ON" (Saturation) while the other is switched "fully-OFF" (cut-off) giving a very high level of mutual amplification between the two transistors. Conduction is transferred from one stage to the other by the discharging action of a capacitor through a resistor

Basic stable multivibrator



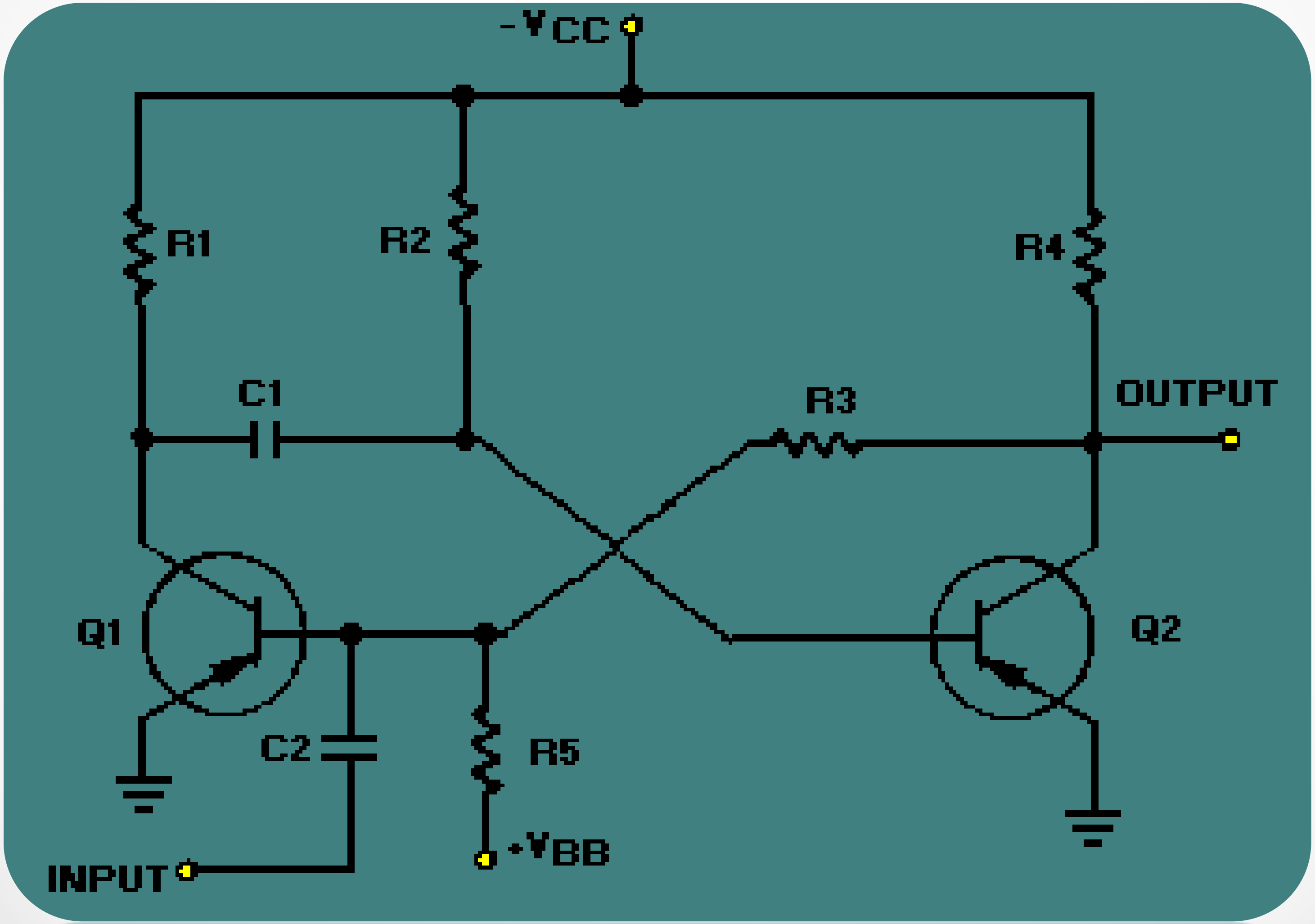
What is Monostable multivibrator?

- **Monostable Multivibrators** have only **ONE** stable state (hence their name: "Mono"), and produce a single output pulse when it is triggered externally. Monostable Multivibrators only return back to their first original and stable state after a period of time determined by the time constant of the RC coupled circuit.
- Consider the MOSFET circuit on the left. The resistor R and capacitor C form an RC timing circuit. The N-channel enhancement mode MOSFET is switched "ON" due to the voltage across the capacitor with the drain connected LED also "ON".

- The basic collector-coupled transistor **Monostable Multivibrator** circuit and its associated waveforms are shown above. When power is firstly applied, the base of transistor TR2 is connected to Vcc via the biasing resistor, R_T thereby turning the transistor "fully-ON" and into saturation and at the same time turning TR1 "OFF" in the process. This then represents the circuits "Stable State" with zero output. The current flowing into the saturated base terminal of TR2 will therefore be equal to $Ib = (Vcc – 0.7)/R_T$.
- If a negative trigger pulse is now applied at the input, the fast decaying edge of the pulse will pass straight through capacitor, C1 to the base of transistor, TR1 via the blocking diode turning it "ON". The collector of TR1 which was previously at Vcc drops quickly to below zero volts effectively giving capacitor C_T a reverse charge of -0.7v across its plates. This action results in transistor TR2 now having a minus base voltage at point X holding the transistor fully "OFF". This then represents the circuits second state, the "Unstable State" with an output voltage equal to Vcc.

- Timing capacitor, C_T begins to discharge this -0.7v through the timing resistor R_T, attempting to charge up to the supply voltage Vcc. This negative voltage at the base of transistor TR2 begins to decrease gradually at a rate determined by the time constant of the R_T C_T combination. As the base voltage of TR2 increases back up to Vcc, the transistor begins to conduct and doing so turns “OFF” again transistor TR1 which results in the monostable multivibrator automatically returning back to its original stable state awaiting a second negative trigger pulse to restart the process once again.
- **Monostable Multivibrators** can produce a very short pulse or a much longer rectangular shaped waveform whose leading edge rises in time with the externally applied trigger pulse and whose trailing edge is dependent upon the RC time constant of the feedback components used. This RC time constant may be varied with time to produce a series of pulses which have a controlled fixed time delay in relation to the original trigger pulse

Monostable multivibrator

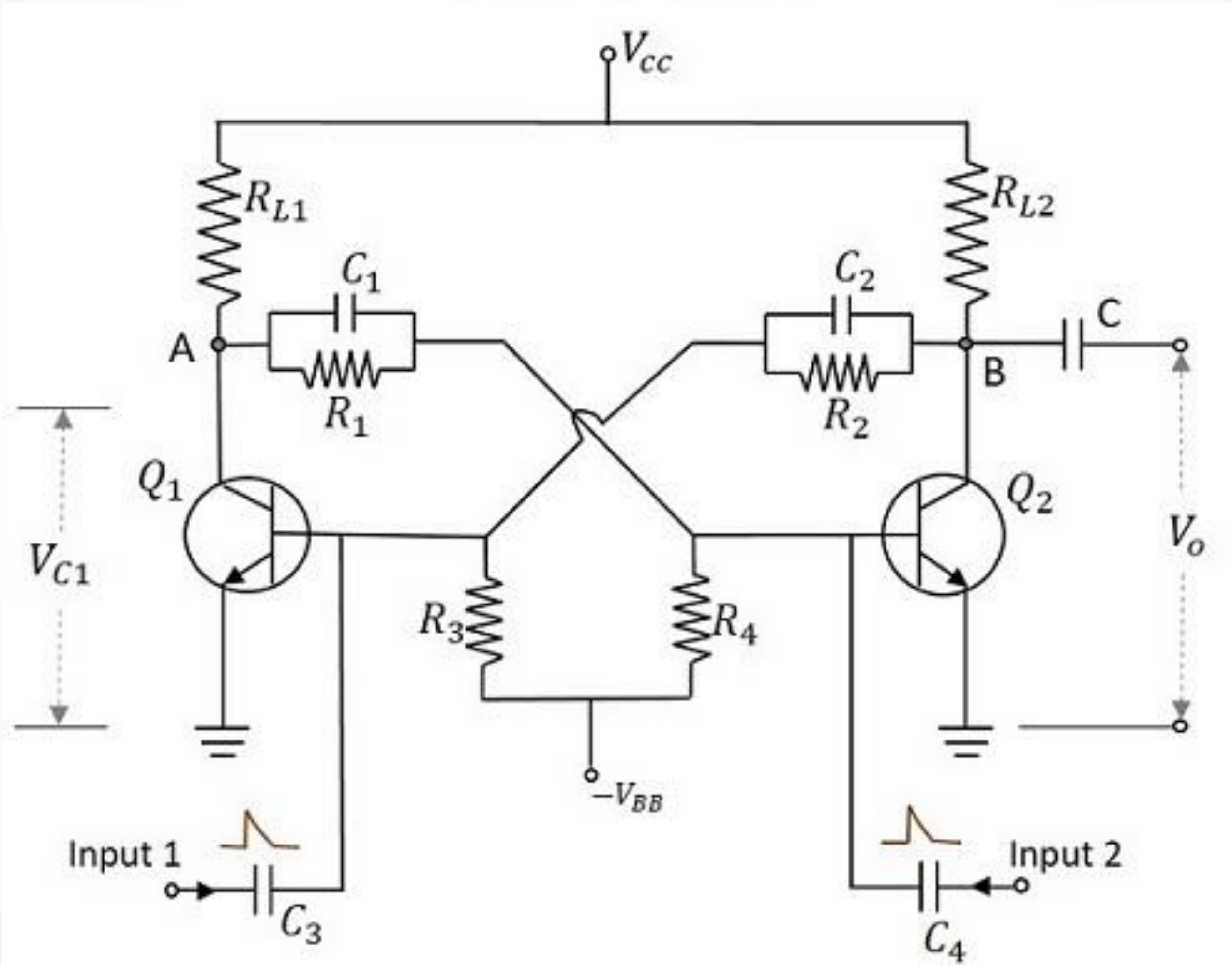


What is Bistable Multivibrator

- Bistable Multivibrator have **TWO** stable states (hence the name: “Bi” meaning two) and maintain a given output state indefinitely unless an external trigger is applied forcing it to change state.
- The bistable multivibrator can be switched over from one stable state to the other by the application of an external trigger pulse thus, it requires two external trigger pulses before it returns back to its original state. As bistable multivibrators have two stable states they are more commonly known as Latches and Flip-flops for use in sequential type circuits.

- The discrete **Bistable Multivibrator** is a two state non-regenerative device constructed from two cross-coupled transistors operating as “ON-OFF” transistor switches. In each of the two states, one of the transistors is cut-off while the other transistor is in saturation, this means that the bistable circuit is capable of remaining indefinitely in either stable state.
- To change the bistable over from one state to the other, the bistable circuit requires a suitable trigger pulse and to go through a full cycle, two triggering pulses, one for each stage are required. Its more common name or term of “flip-flop” relates to the actual operation of the device, as it “flips” into one logic state, remains there and then changes or “flops” back into its first original state.

Bistable Multivibrator circuit



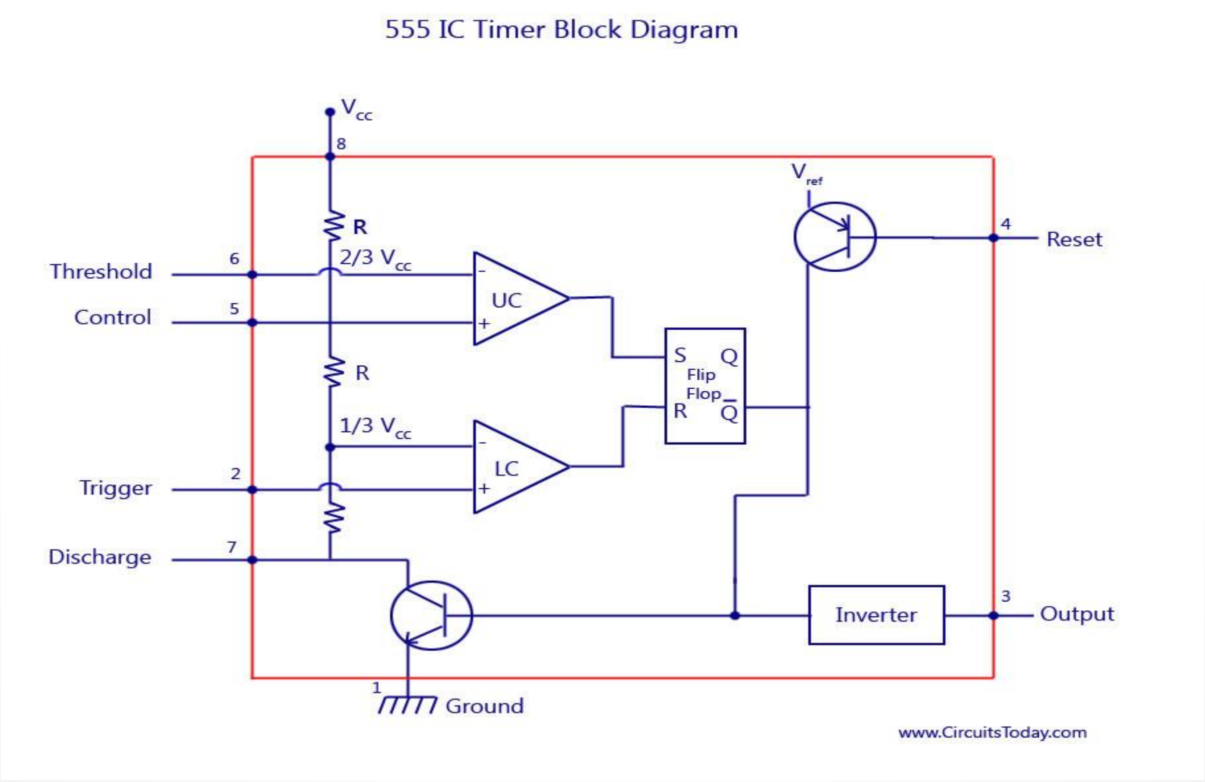
Applications of **Astable, Monostable** and **Bistable**

- Astable :-
- Square wave oscillator
- Voltage control oscillator
- Monostable:-
- Timer
- Missing pulse detector
- Bistable:-
- As a flip – flop
- As a memory element

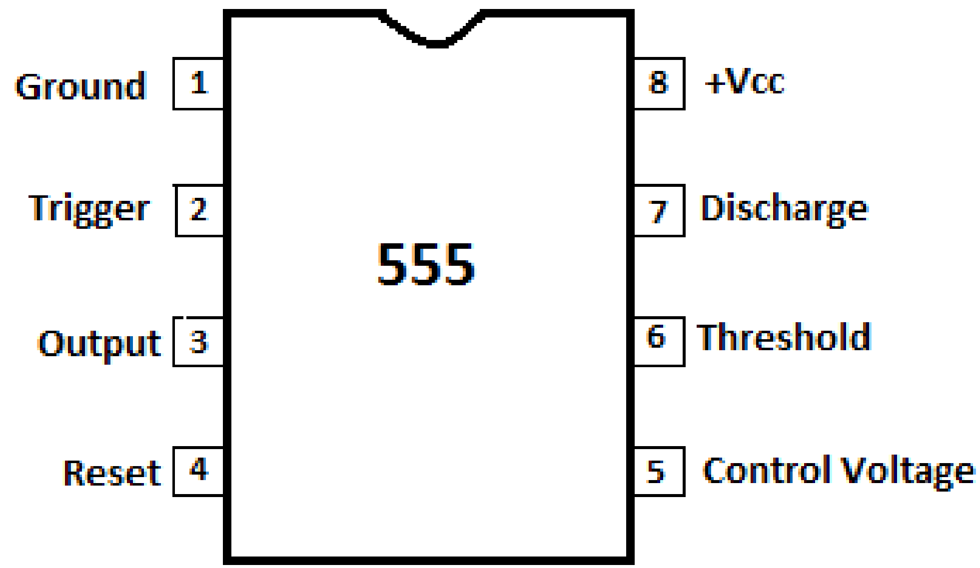
What is IC 555?

One of the most popular time integrated circuited is IC 555

The time IC was introduced by Signetics coperation of us in year 1972.



Pin diagram of IC 555



- Pin no 1 Ground :- This reference or ground point of IC is to be connected to the ground terminal of the dc voltage source used to supply power ton the timer IC.
- Pin no 2 Trigger input:- a triggering pulse or a train of triggering to this pin when he lower comparator output goes high when switches the timer output high and also turns off the discharge transmitter Tr1.
- Pin no 3 Output:- This is the output of the timer and had to be connected to this pin. The status of output pin is decided by the two comparators.
- Their re two ways to connect a told the output terminal. Pin 3 and ground pin or between pin 3 and supply voltage +Vcc. These loads are known as ”normally OFF” and “normally ON”loads.

State the following of IC 555

- It has “8” pins.
- Supply voltage range 6 to 18 volts.
- High temperature stability.
- Timing can be adjusted from micro second 2 Hertz.
- Duty cycle of the output is adjustable.
- Output is compatible with CMOS and TTI.
- Good timing stability against supply voltage.
- Low cost

Applications of IC 555

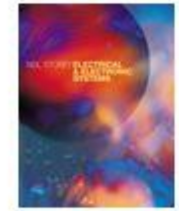
- Missing pulse detector.
- FSK generator
- Schmitt trigger
- As a domestic timer.
- As a sequential timer in industrial applications.
- Ramp- generator square wave, rectangular wave generator.

ELECTRONIC DEVICE AND CIRCUIT

TRANSISTOR POWER AMPLIFIER

CONTENT

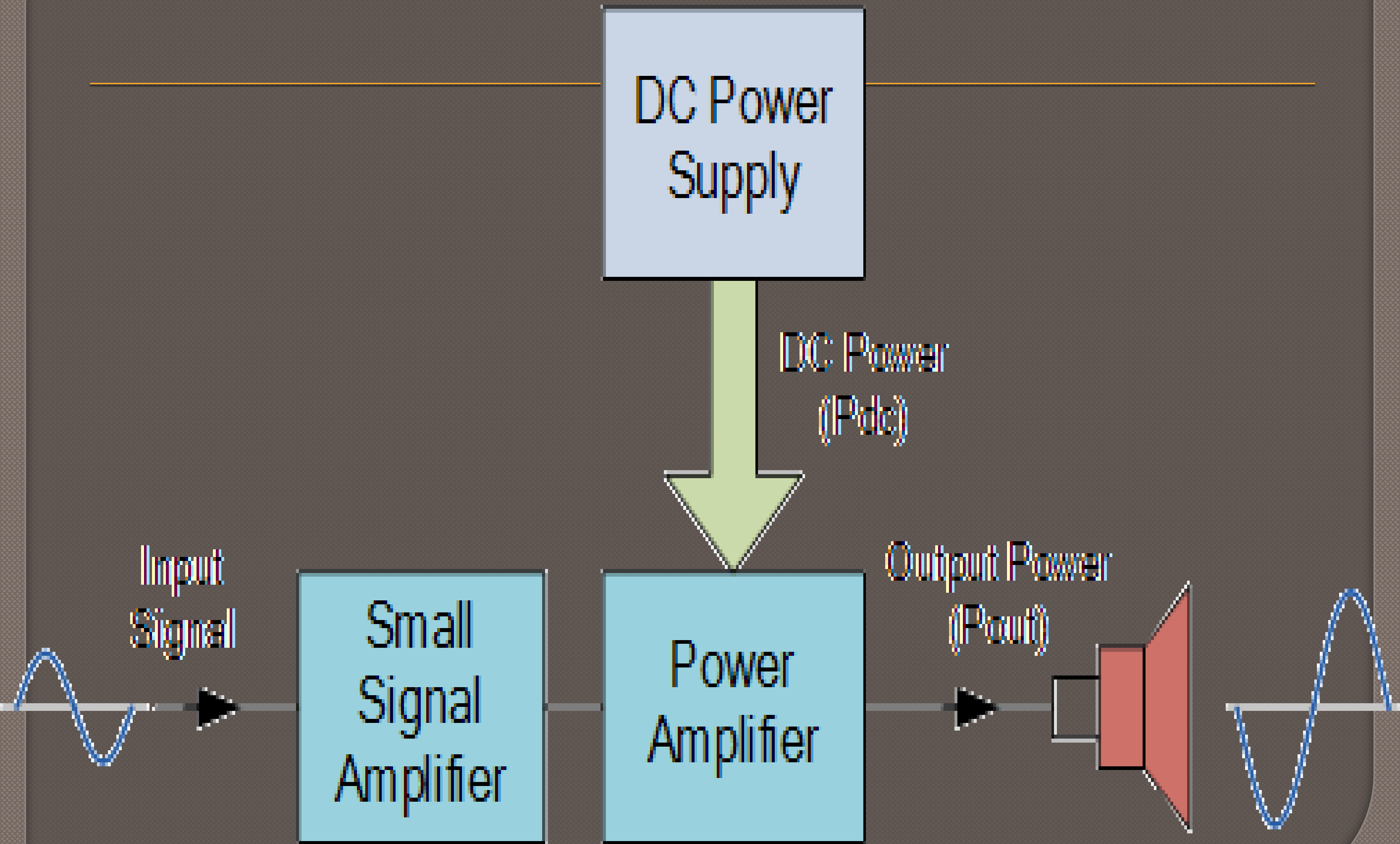
- Introduction
- Comparison of voltage and power amplifiers
- Process of power amplification
- Classification of power amplifiers
- Concept of heat sinks
- Collector dissipation curve and its importance
- Stages of power amplifier
- Push-pull amplifier
- Complementary-symmetry push-pull amplifier
- Harmonic distortion in power amplifiers



Introduction

- Amplifiers that produce voltage amplification or current amplification also produce power amplification
- However, the term **power amplifier** is normally reserved for circuits whose main function is to deliver large amounts of power
- These can be produced using FETs or bipolar transistors, or using special purpose devices such as **thyristors** and **triacs**

Stages of different amplifier



Difference between voltage and power amplifier

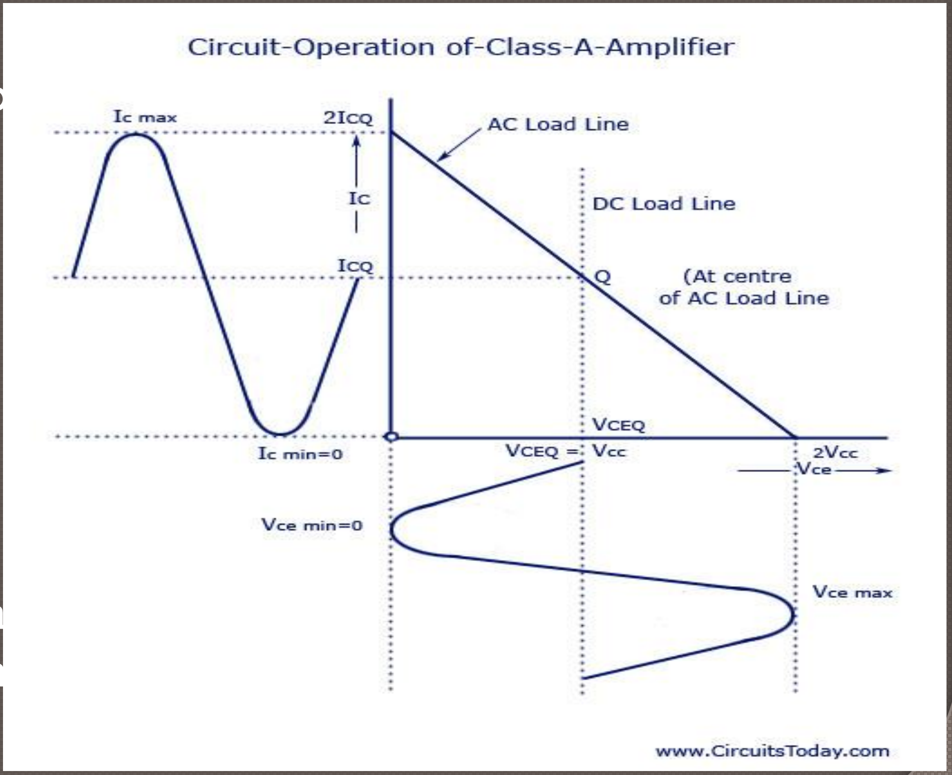
VOLTAGE AMPLIFIER	POWER AMPLIFIER
It raises voltage level of the input signal .	It raises power level of the input signal.
Employed at initial stage of the multistage amplifier.	Employed at final stage of the mutlistage amplifier .
Used as RC Coupled.	Used as Transformer Coupled amplifier .
It also named as small signal amplifier .	It also known as large signal amplifier.
They have thin base.	They have thick base .
Transistor size is small.	Transistor size is large .
No heat sinks is required.	Heat sinks is required.
Low input resistance.	High input resistance .
High collector load resistance.	Low collector load resistance.

CLASSIFICATION OF POWER AMPLIFIER

Transistor power amplifier usually handle large signal .So many of them are driven so hard by the input signals that the collector current reaches either in the cut-off or in the saturation regions during its peak values . Therefore , the usual practice to classify power amplifiers is according to their mode o operation i;e the portion of the input cycle during which the collector current flows through the circuit .

- CLASS-A AMPLIFIERS
- CLASS-B AMPLIFIERS
- CLASS- C AMPLIFIERS
- CLASS-AB AMPLIFIERS

CLASS-A AMPLIFIERS- The power amplifiers in which the operating poin is so adjusted that the collector curren flows during whole cycle of the input signal are known as Class –A amplifier.

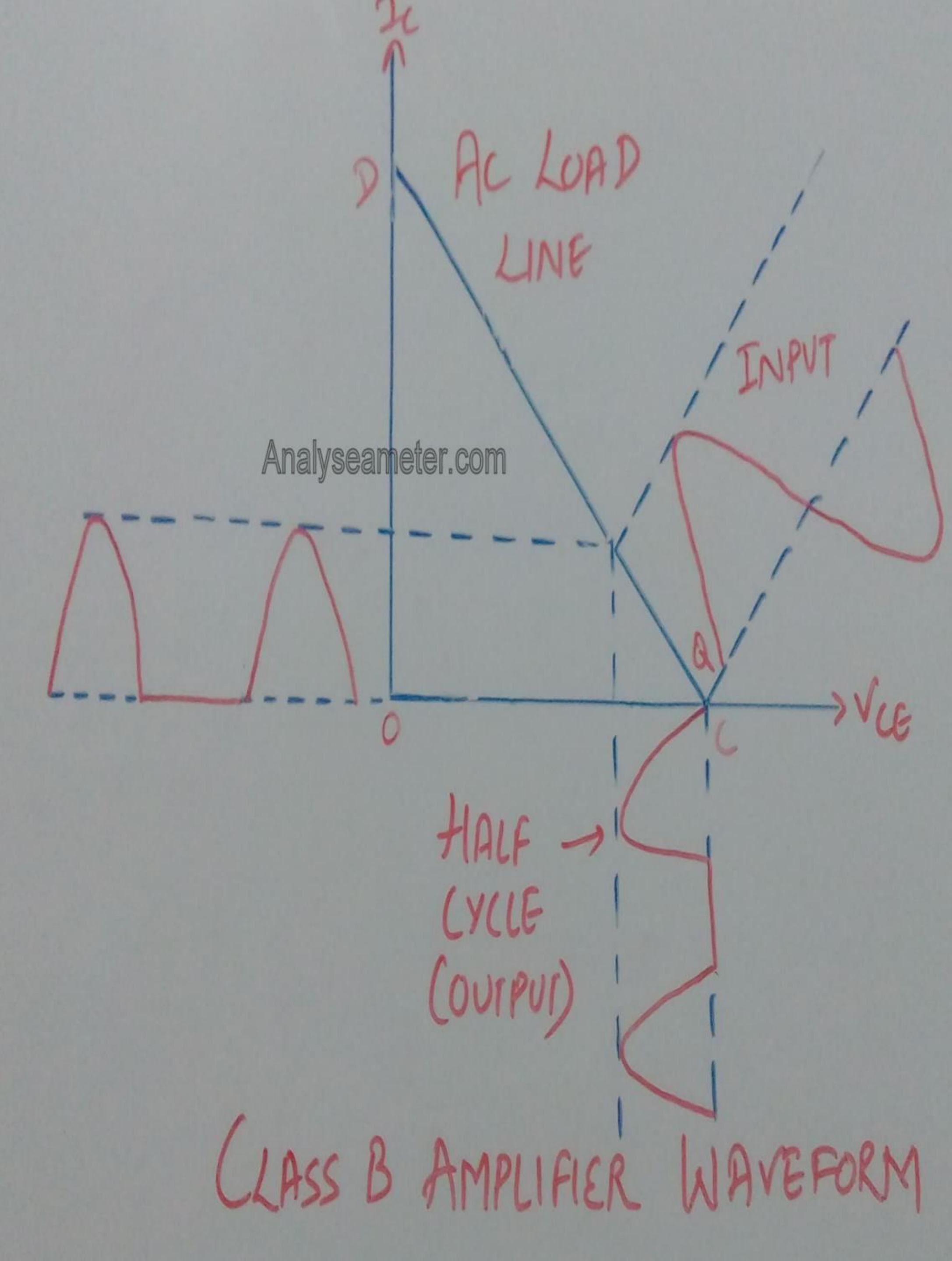


❑CLASS–B AMPLIFIER

- The power amplifiers in which the operating point is so adjusted that the collector current flows only during the positive half cycle of the input signal are known as Class B .

-APPLICATION:

Such amplifiers are mostly used for power amplification in push - pull arrangement Amplifier.

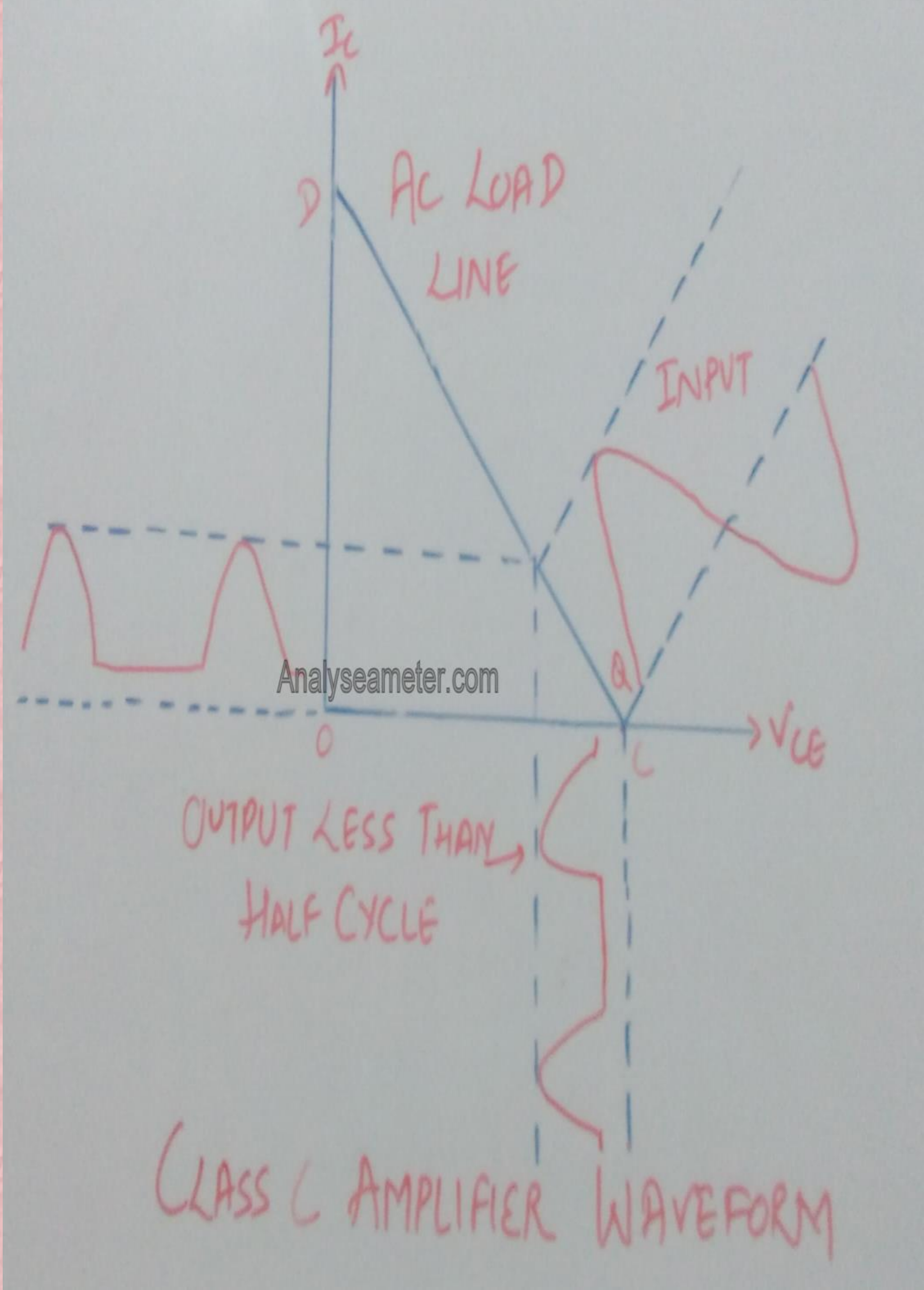


CLASS –C AMPLIFIER

The power amplifiers in which collector current flows for less than half – cycle of the input signal are known as Class –C amplifiers.

APPLICATION:

They are used as tuned amplifiers to amplify a narrow band of frequencies because of their higher collector efficiency nearly 80%.

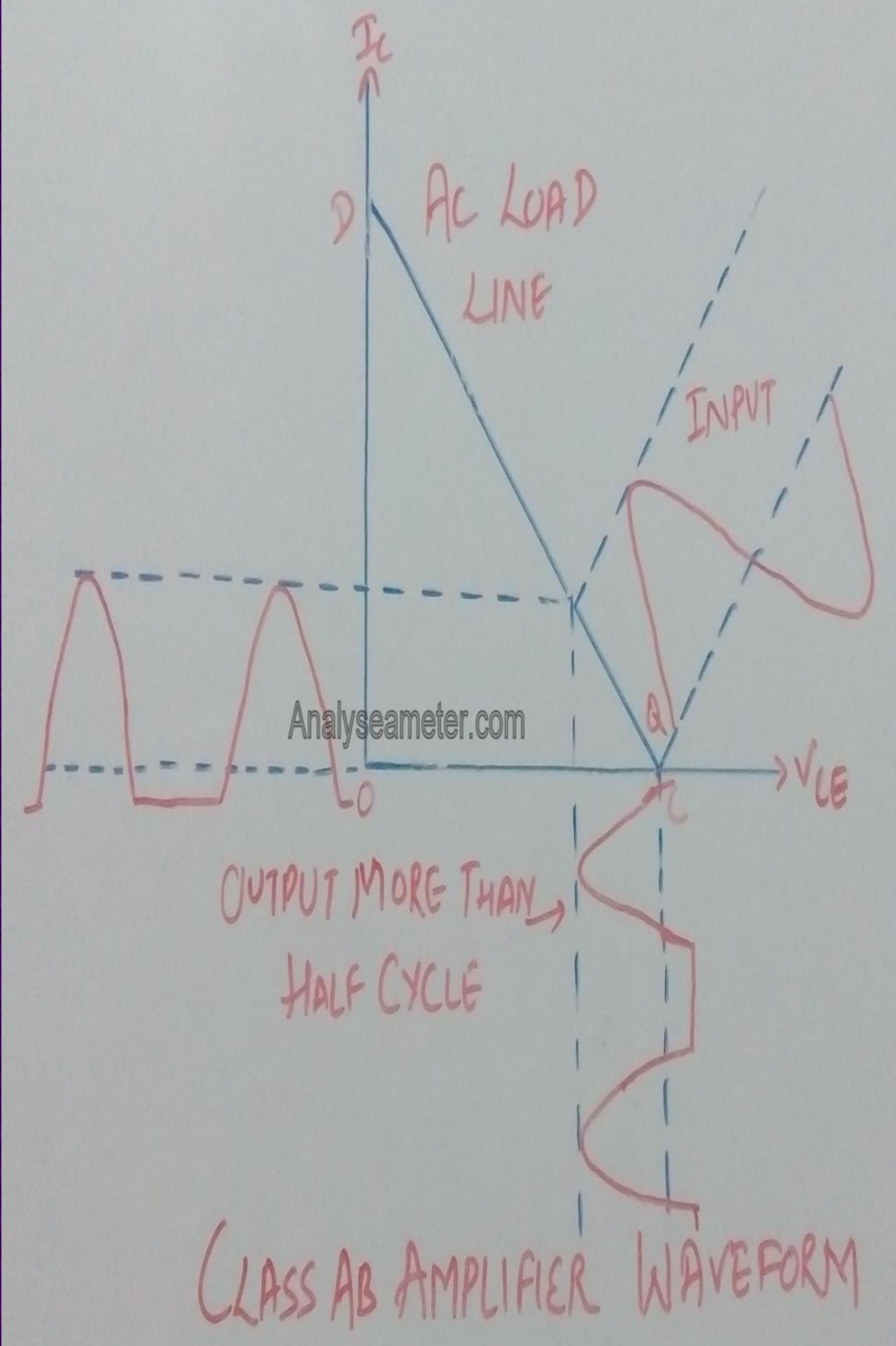


❑CLASS-AB AMPLIFIER:-

The power amplifiers in which the operating point is so adjusted then the collector current flows for more than half-cycle but less than full-cycle of the input signal are known as Class-AB amplifiers.

DISADVANTAGE:-

It creates more distortion.

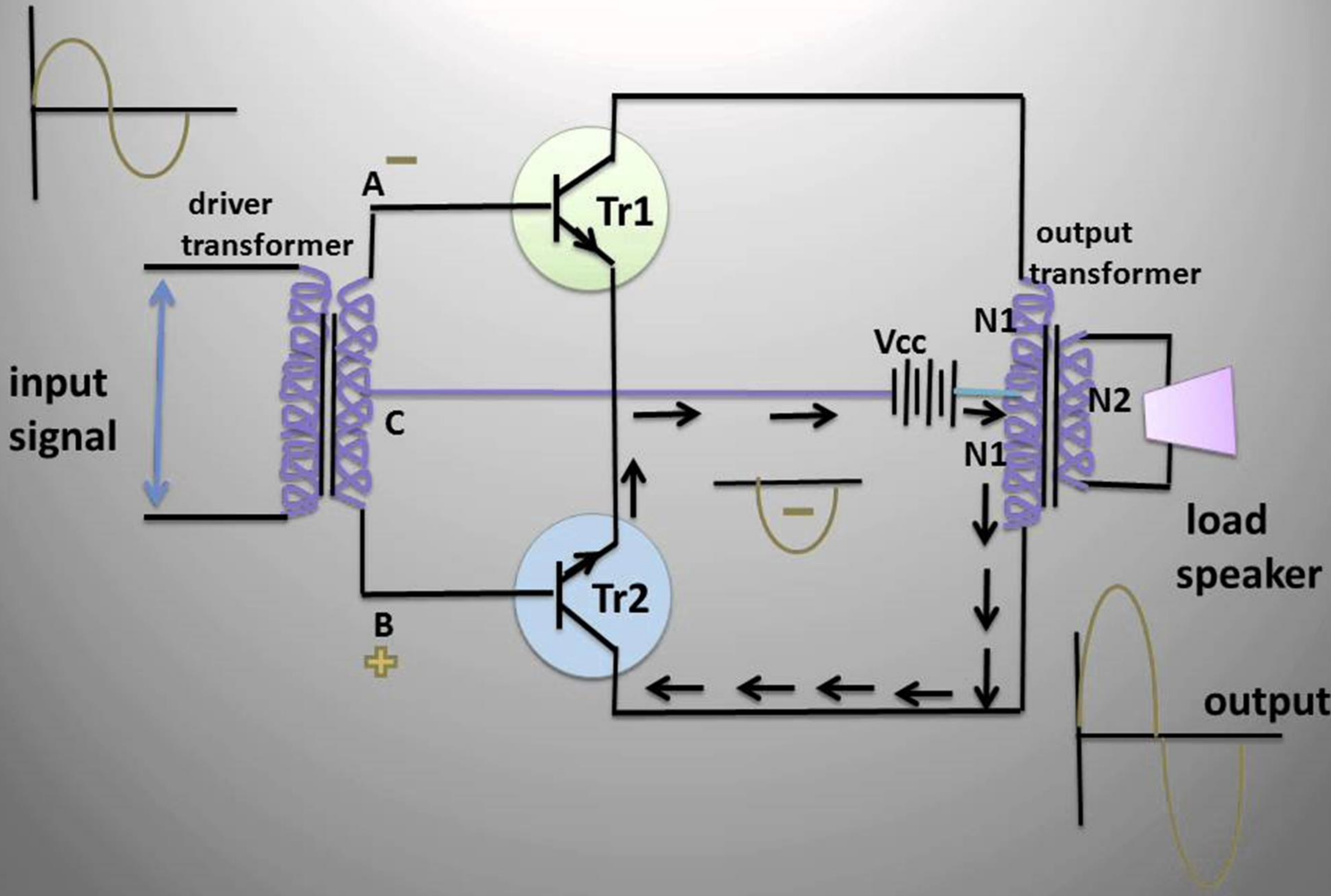


PUSH- PULL AMPLIFIERS;-The class B amplifiers, which have higher efficiency ,are used at the output stage in push-pull amplifier arrangement.

CIRCUIT ANALYSIS-A simple circuit arrangement of a push-pull amplifier. Here , two transistors Tr1 & Tr2 are placed back to back .Both the transistors are operated in class- B operation i;e the collector current is almost zero in the absence of the signal. The input signal is given to the circuit from the driver stage through a driver transformer. The secondary of the driver transformer is center-tapped which supplies equal &opposite voltages .

OPERATION:-The input signal appears across the secondary terminal AB of the driver transformer. During the first half-cycle(+) of the signal , end A becomes positive and end B negative. This will make the base – emitter junction of transistor Tr1 forward biased and that of transistor Tr2 reverse biased. Whereas , transistor Tr2 is in the cut-off state and will not conduct any current. During the second half-cycle (+) of the signal , end B becomes positive end A negative . This will make the base- emitter junction of transistor Tr2 forward biased and Tr1 reverse biased or cut-off state. Where transistor Tr1 is in the cut-off state and will not conduct any current.

PUSH - PULL AMPLIFIER



Advantage:

1.Collector efficiency is quite high about 75%.
2. Distortion free output is obtained.
3.Push pull amplifier which used for only class B with the use of two transistor .(a) Pushing (+ half cycle) (b)pulling (-- half cycle)

DISADVANTAGE : (a) Two identical transistors are required.
(b)Circuit bulky and costlier.
(c) It requires two equal and opposite voltages .

APPLICATION : -Almost all the audio power amplifiers used in radio receiver transistor, tape recorders, record player etc make use of this arrangement.

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COMPLEMENTARY- SYMMETRY PUSH –PULL AMPLIFIER- It is push-pull amplifier works on the same principle . .

CIRCUIT ANALYSIS : The circuit arrangement of a complementary-symmetry push –pull amplifier . The circuit employs two transistor , one npn and other one pnp . There is no centre –tapped transformer is employed.However, an ordinary output transformer is employed for impedancematching to get maximum output across the load.

OPERATION : The input signal appears across the terminal AB. During the positive half –cycle of the input signal , the transistor Tr1 (npn) conducts current while transistor Tr2 (pnp) does not conduct as it is at cut-off state. During the negative half- cycle of the input signal, the transistor Tr2 (pnp) conducts while transistor Tr1(npn) doesn't. Hence, npn transistor amplifies the positive half – cycle whereas pnp transistor amplifiers the negative half-cycle . The amplified signal appears across the primary which is transferred to the secondary or the load .

ADVANTAGES : (a) Efficiency is high .
(b) It prevents bulky ness and take minimum cost.

DISADVANTAGES: (a) Requirement of two batteries .
(b) Difficult to get a pair of transistors (npn and pnp) having exactly same characteristics.

IMPORTANT KEYWORDS

Power dissipation capability: The ability of a power amplifier to dissipate heat developed in it during operation is known as its power dissipation capability.

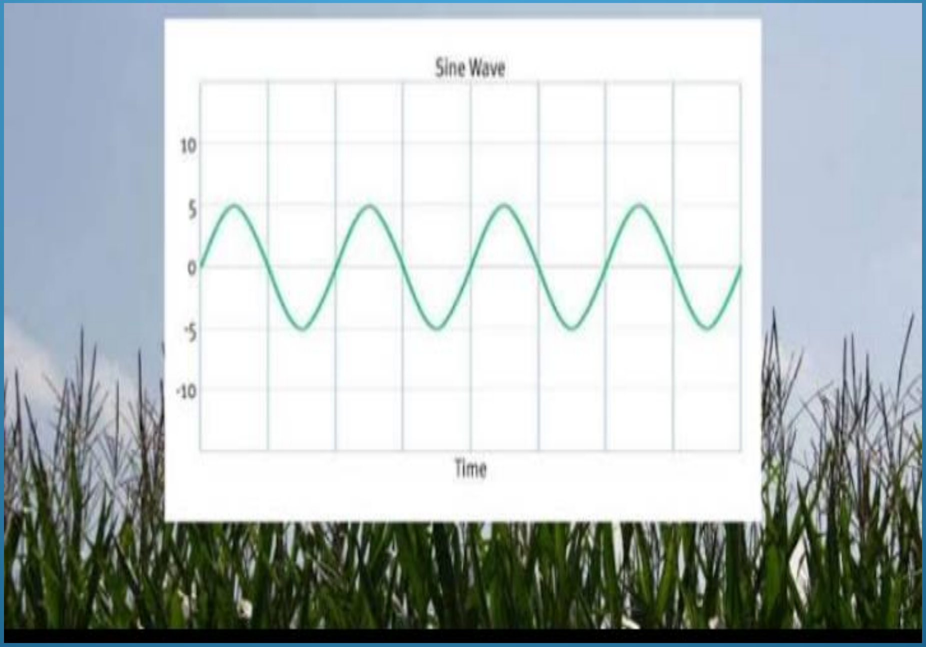
Heat sinks : It is the mechanical device or metal sheet which improves the heat dissipation capability a power transistor and keeps it temperature with in the permissible limits.

Harmonics distortion :These are non- linear which leads to harmonie distortion .The output contains frequency which are multiples of original frequency. These high order harmonics cause distortion in output .

✓ CONTENTS :

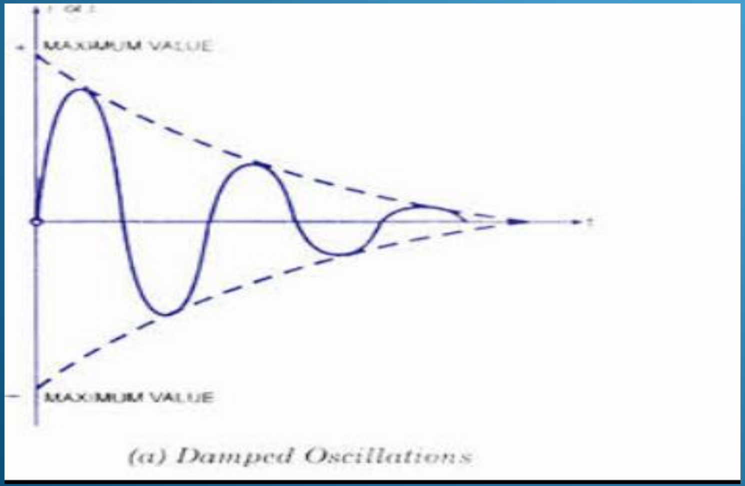
Sinusoidal oscillator :

A static electronic device that produce sinusoidal oscillations of desire frequency is called a sinusoidal oscillator .

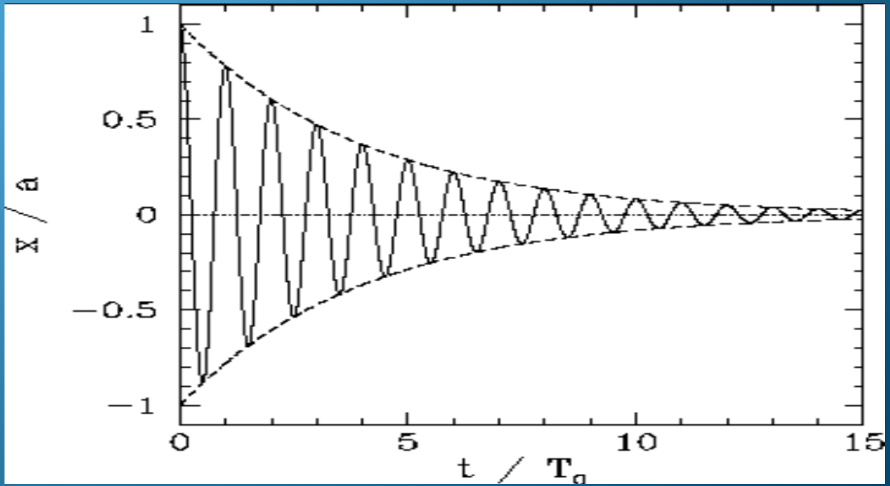


Types of Electrical Oscillation :

- DAMPED OSCILLATION : The electrical oscillation in which amplitude decrease with time are known as damped oscillation .

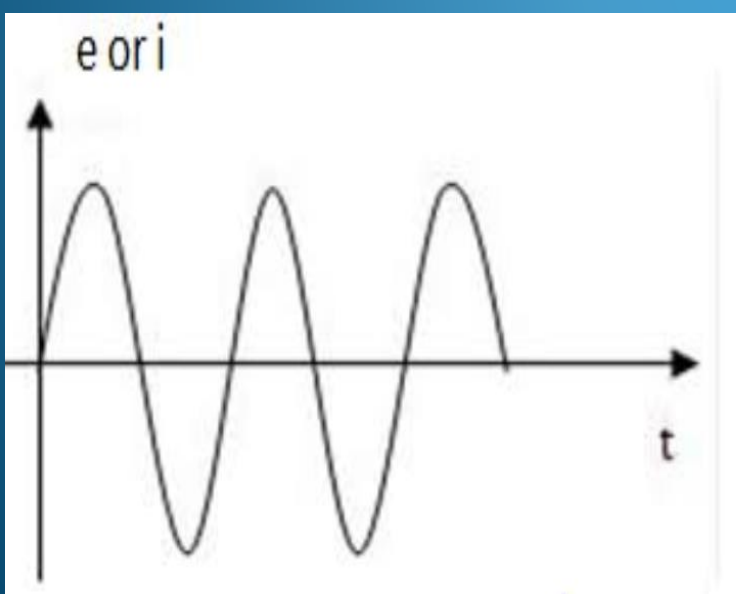


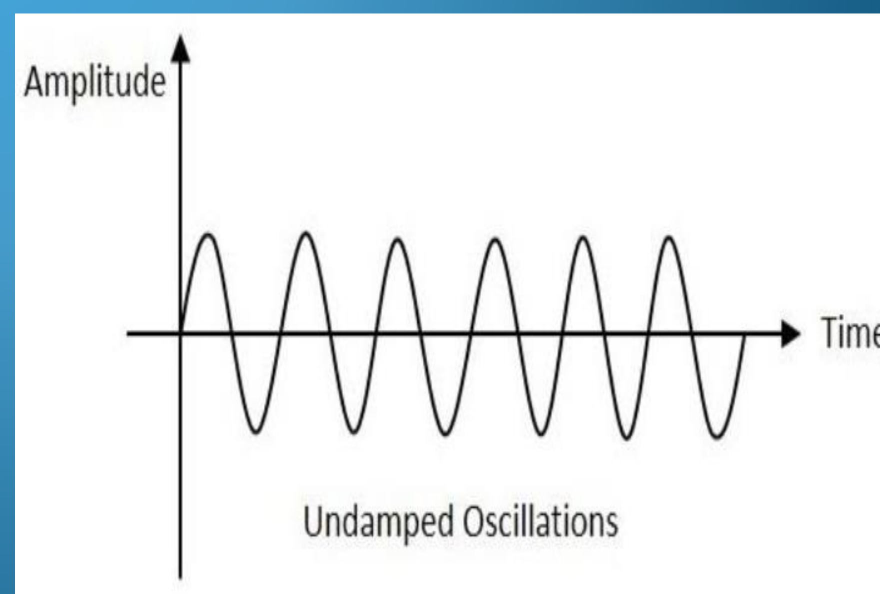
(a) Damped Oscillations



Undamped Oscillation :

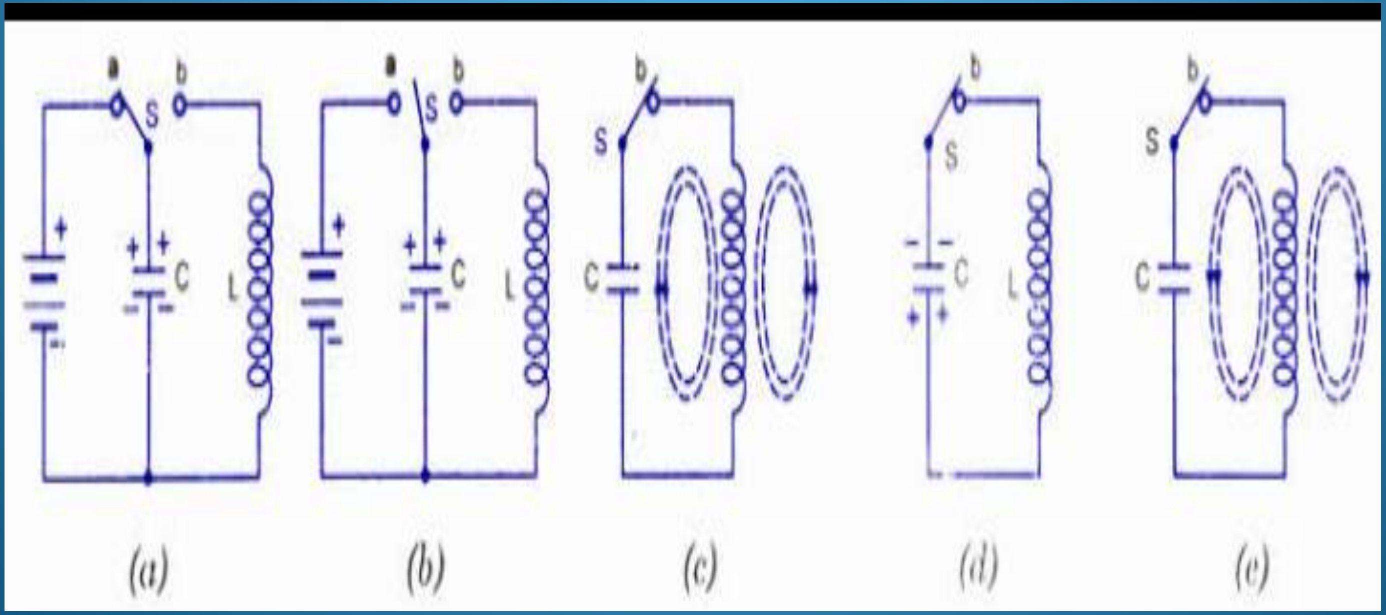
The electrical oscillation in which amplitude does not change with time are known as undamped oscillation .



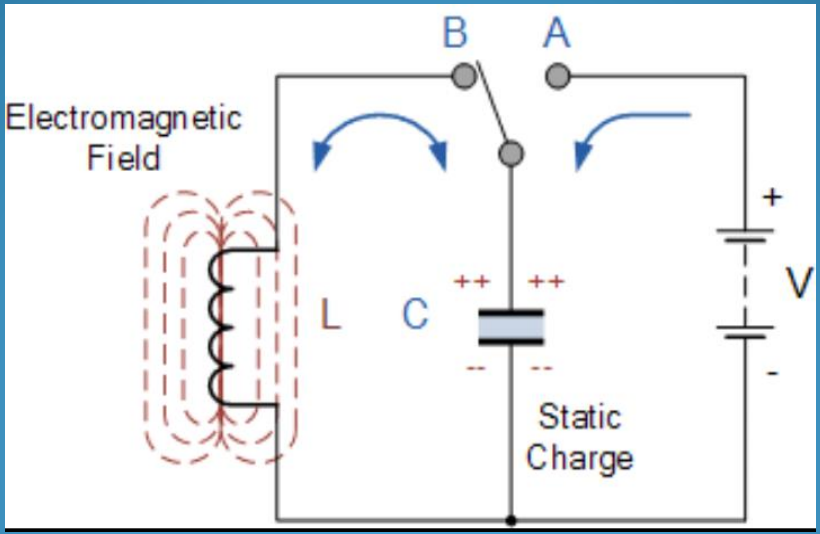


OSCILLATORY CIRCUIT :

A circuit that produces electrical oscillation of a desired frequency is known as an oscillation circuit or tank circuit . It is the parallel connection of L and C .

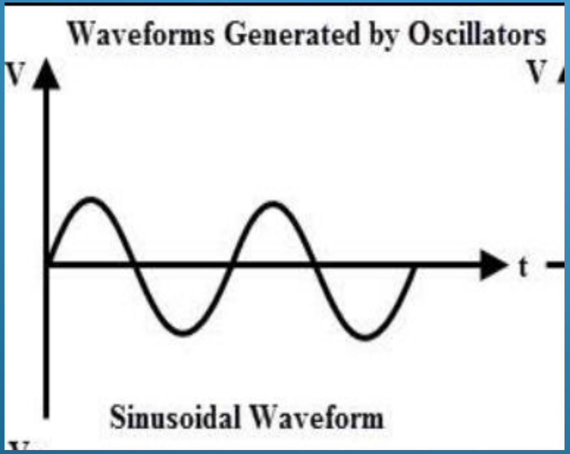


The circuit arrangement to charge the capacitor of an oscillatory circuit .



When switch S is through stud B the capacitor C is charged at the battery potential in the direction. Now threw the switch to stud A ,the capacitor will discharge through inductor L, the excess

Of electron on plate B travel through L and reach at plate A. The flow of current sets up magnetic field around the coil. Due to inductive effect, the current builds up slowly and attain its max. value when the capacitor is fully discharge, the electrostatic field energy at the capacitor is converted into magnetic field energy around the coil.

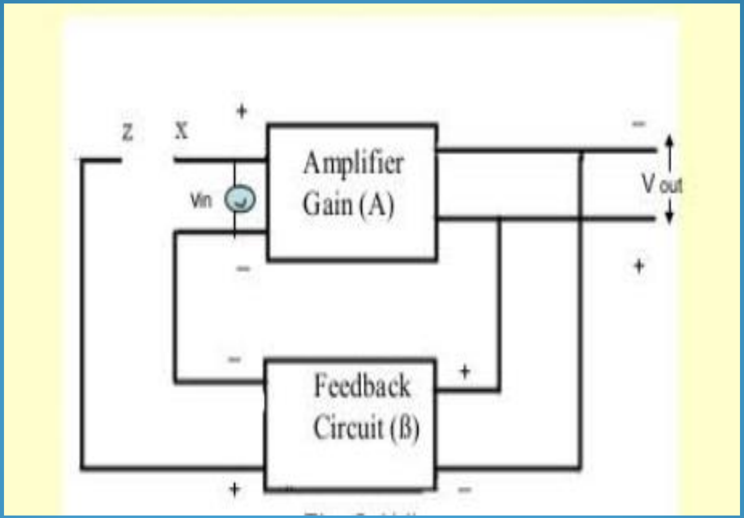


WAVE SHAPE : In the L-C circuit, during each cycle there are resistive and radiation losses in the capacitor. Therefore the amplitude of oscillating current decrease gradually and eventually become zero. Thus damped oscillation are produced by this circuit.

Frequency of oscillation :

$$Fr = 1/2\prod\sqrt{LC}$$

Positive feedback amplifier as an oscillator :



The negative feedback is employed in amplifier for their stability . An oscillator is a device that generates ac output signal without any input ac signal . A fraction of output is fed back to the input, the feedback signal is the only input to the internal amplifier.

If mA<1, mA<V and the output signal will damped oscillation. If mA> V and output signal built up ,when mA=1, no , change occur in output. We get an constant magnitude.

$$Afb=A/1-mA$$

$$mA=1$$

$$Afb=A/1-1$$

$$=A/0 \qquad = \infty$$

$$Afb = \infty$$

Different types of a Transistor Oscillator :

A transistor can work as an oscillator to produce continuous undamped oscillation of any desired frequency if oscillatory and feedback circuit are properly connected to it.

- Tuned collector Oscillator
- Hartley Oscillator
- Colpitt 's Oscillator
- Phase Shift Oscillator
- Wein- Bridge Oscillator
- Crystal Oscillator.

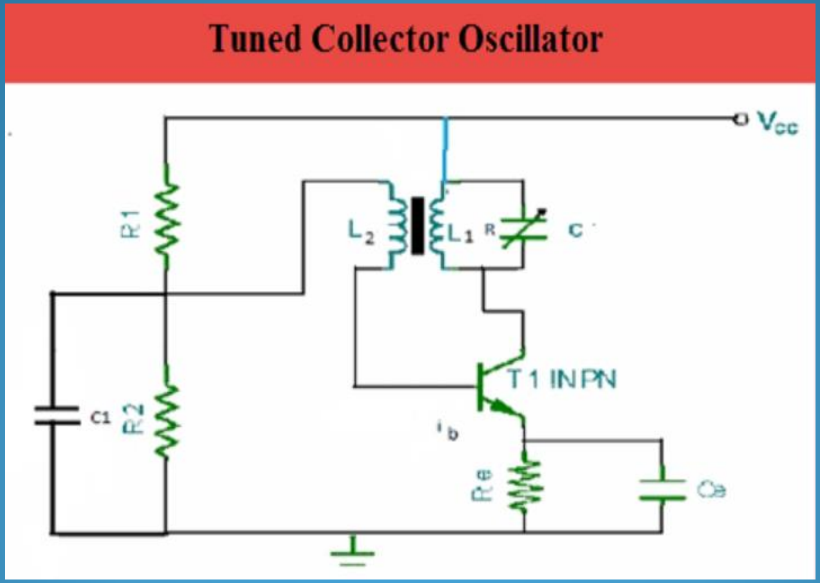
Tuned Collector Oscillator:

This circuit contains a tuned circuit in the collector of the transistor and hence tuned collector oscillator.

Circuit Analysis : This oscillator employs an oscillatory circuit L_1,C_1 in the collector. The frequency of oscillation depend upon the values of L_1-C_1 .

$$f = 1/2\pi\sqrt{L_1 - C_1}$$

OPERATION :



As long as the switch is open, there is no collector current . When switch is closed, the collector current start rising, thus charging capacitor C1. Capacitor will discharge through coil L1 setting up oscillation of frequency.

$f = 1/2\prod\sqrt{L_1C_1}$

- These oscillation which are set up in the oscillatory circuit will induce an e.m.f. in the coil L_2 magnetically linked with L_1. The frequency of e.m.f induced in coil L_2 is same as the oscillatory circuit but the magnitude depend upon the coupling and turn ratio b/w coil L_2 & L_1 .

- A phase diff. of 180° is created in the e.m.f of L_1 & L_2. The energy supplied to the oscillatory circuit to overcome losses occuring is in phase with the generated oscillation .

HARTLEY OSCILLATOR :

It is probably the most popular and commonly used in radio receiver . It is because of its easy adaptability to a wide range of frequencies .

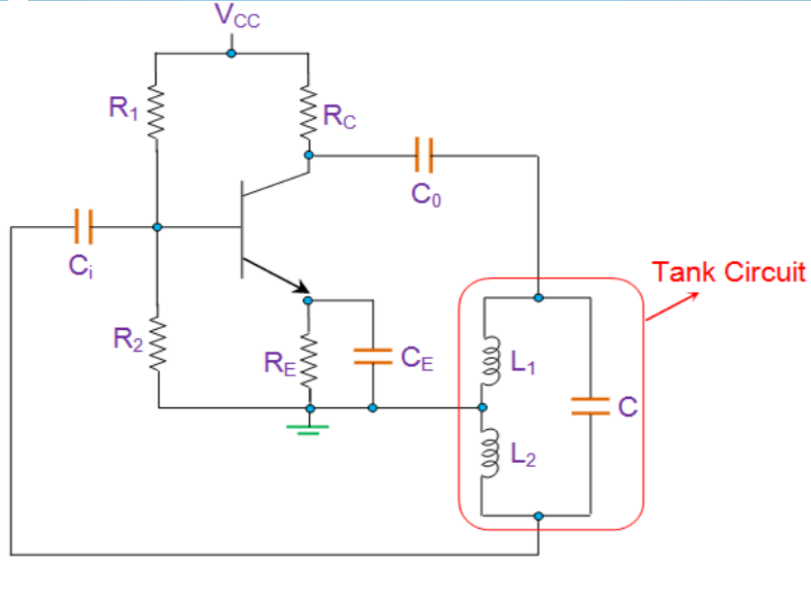


Figure 1 Hartley Oscillator

CIRCUIT ANALYSIS :

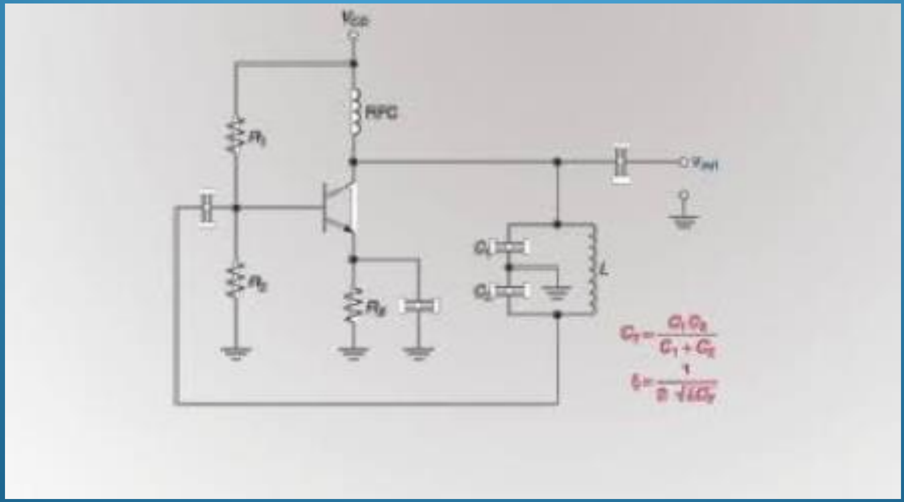
- It is similar to tuned collector oscillator in operation. It consist of two coils L_1 & L_2 wound over the same core. A capacitor is connected across the combinational of L_1,L_2 form of L-C circuit. The resistance b/w the collector and base provides the necessary biasing. The capacitor blocks the d.c. component . The frequency is determined by L_1,L_2 &C_1.

- When switch S is closed, capacitor C_1 is charged. The capacitor will discharge through L_1 and L_2.

$$f = 1/2\pi\sqrt{C_1(L_1+L_2)}$$

$$= 1/2\pi\sqrt{C_1(L_1+L_2+2M)}$$

- **COLPITT'S OSCILLATOR** : It is similar to Hartley oscillator. The only diff. is that in case of Colpitt's oscillator , coupling is capacitive instead of being inductive.



CIRCUIT ANALYSIS :

The tank circuit consist of an inductive coil L in parallel with two capacitor C_1 and C_2 which are in series.

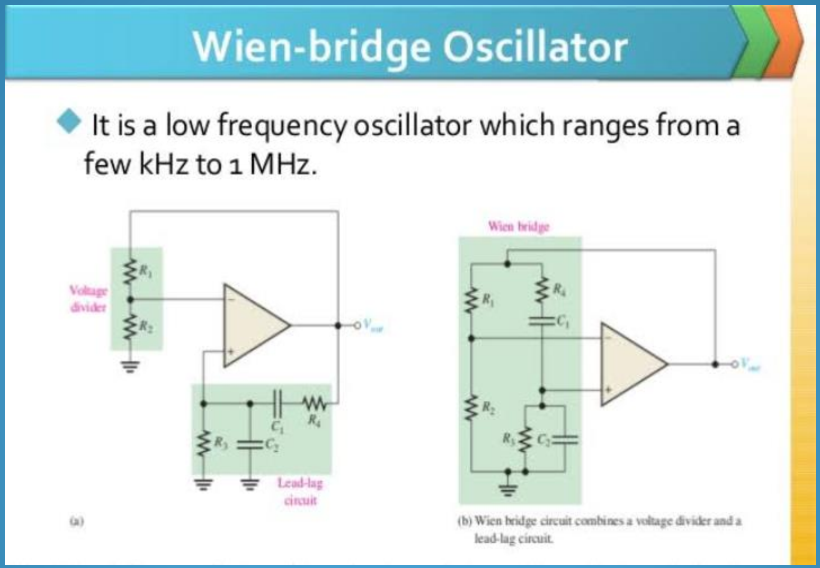
The frequency of oscillation is :

$$f = 1/2\pi\sqrt{LCT}$$

Where :

$$CT= C_1C_2/C_1+C_2$$

WEIN BRIDGE OSCILLATOR :



In the wein bridge oscillator, phase shift is produced by using two transistor. Each transistor produce a phase- shift of 180° and hence a phase- shift of 360° obtained.

OPERATION :

When circuit is closed through switch S, the bridge circuit produce the oscillation of frequency determined by the expression :

$$f = 1/2\pi\sqrt{R_1C_1R_2C_2}$$

$$R_1 = R_2 = R \quad \text{AND}$$

$$C_1 = C_2 = C$$

$$f = 1/2\pi RC$$

A –ve feedback ensure stability and constant output. The amplitude of output tend to increase, more current would provide more negative feedback .

ADVANTAGE :

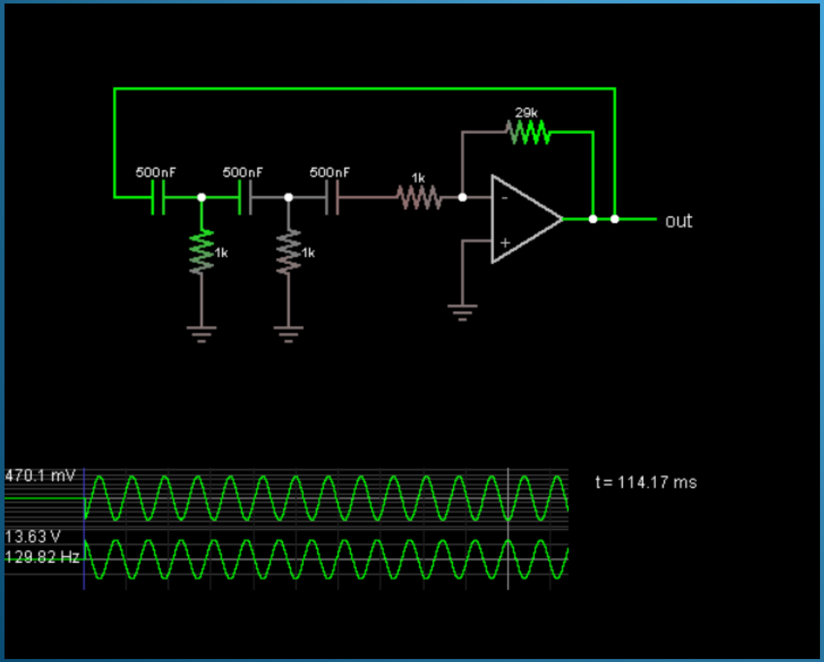
a) It has far better stability .
b) Output is constant .
c) It's working is quite simple and easy .
d) Frequency of oscillation can be easy .

DISADVANTAGE :

a) Costlier as more component are used .
b) Can not be used to generate very high frequency .

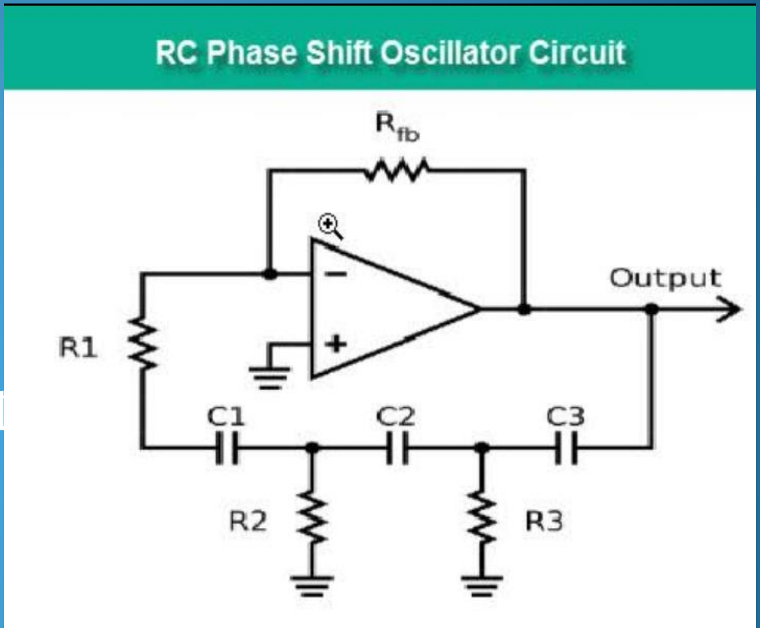
PHASE- SHIFT OSCILLATOR

A phase- shift oscillator employs an R-C network and is commonly called R-C phase shift oscillator .



CIRCUIT ANALYSIS :

The collector is conne-
ct to the base through
Phase shift network .
They have three similar
Section; R1C1,R2C2,
R3C3. The values are so selected that each section produce a phase shift 60°. Thus the total phase shift of 180° is produce by three section .



OPERATION :

When the circuit is switched on, current through R_3 start increasing because of biasing. A further phase shift of 180° is produced due to the transistor . So a total phase shift of 360° is produce. The fraction of the o/p fed to the i/p is in phase with it .

Frequency of oscillation : When $R_1 = R_2 = R_3 = R$ and $C_1 = C_2 = C_3 = C$,

$$f = 1/2\pi CR\sqrt{6}$$

ADVANTAGE :

i. It does not require transformers or inductor , therefore, less bulky.
ii. Cheap and simple circuit as it contains resistors and capacitor only .
iii. Wave form is sinusoidal and harmonic distortion are absent as no transformer is used.

DISADVANTAGE :

i. It gives only small o/p due to smaller feedback .
ii. It require high voltage battery Vcc > 12 v.

Characteristics of Crystal :

Quartz crystal are usually employed in crystal oscillator because of their high mechanical strength, easy availability and simple manufacturing. The shape of crystal is hexagonal but it is cut in diff. ways .

$$f = k/t$$

Where K is constant and depend upon the dimensions of the crystal . Its frequency b/w 25 KHz to 5 MHz .

The crystal has two Resonant frequencise :

- Series resonant freq.

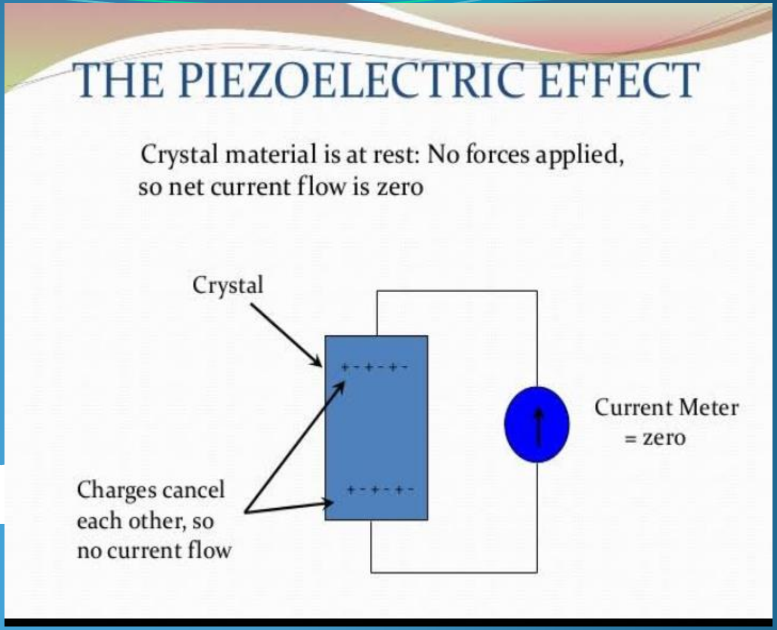
  $fs = 1/2\pi\sqrt{LC}$ Hz

- Parallel resonant freq

  $fp = 1/2\pi\sqrt{LCt}$

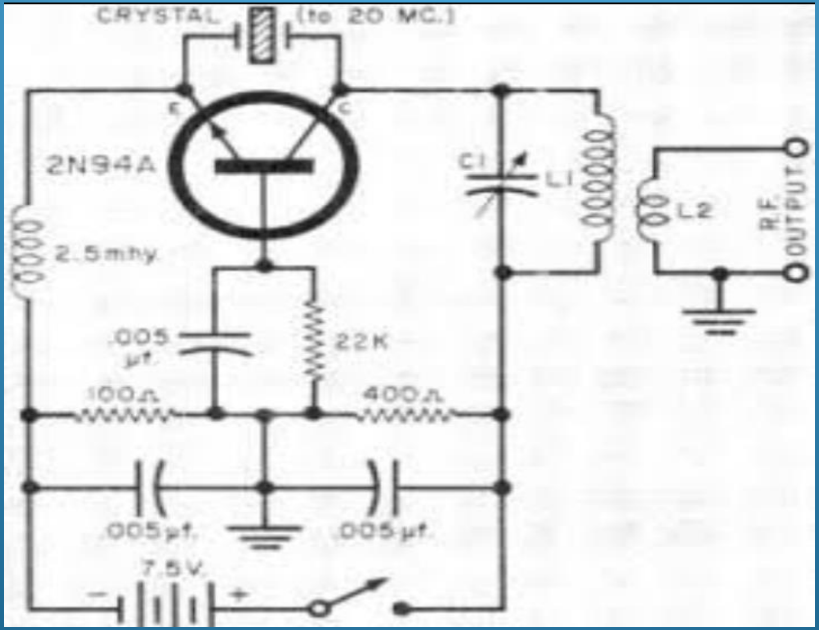
Where

$Ct = C*Cm/C + Cm$



Transistor Crystal Oscillator :

When a constant high frequency (25 KHz to 5MHz for radio broadcasting transmitter) is required a transistor crystal oscillator is always preferred .



Circuit Analysis :

A tank circuit L_1-C_1 is placed in the collector and the crystal is connected in the base circuit through feedback coil L_2. Where L_2 is inductively coupled to the coil L_1. The coil L is inductively coupled to L_1 to obtain o/p .

OPERATION : When power is turned on by closing the switch S , capacitor C_1 is charged . when it discharge through L_1 it sets up oscillation .

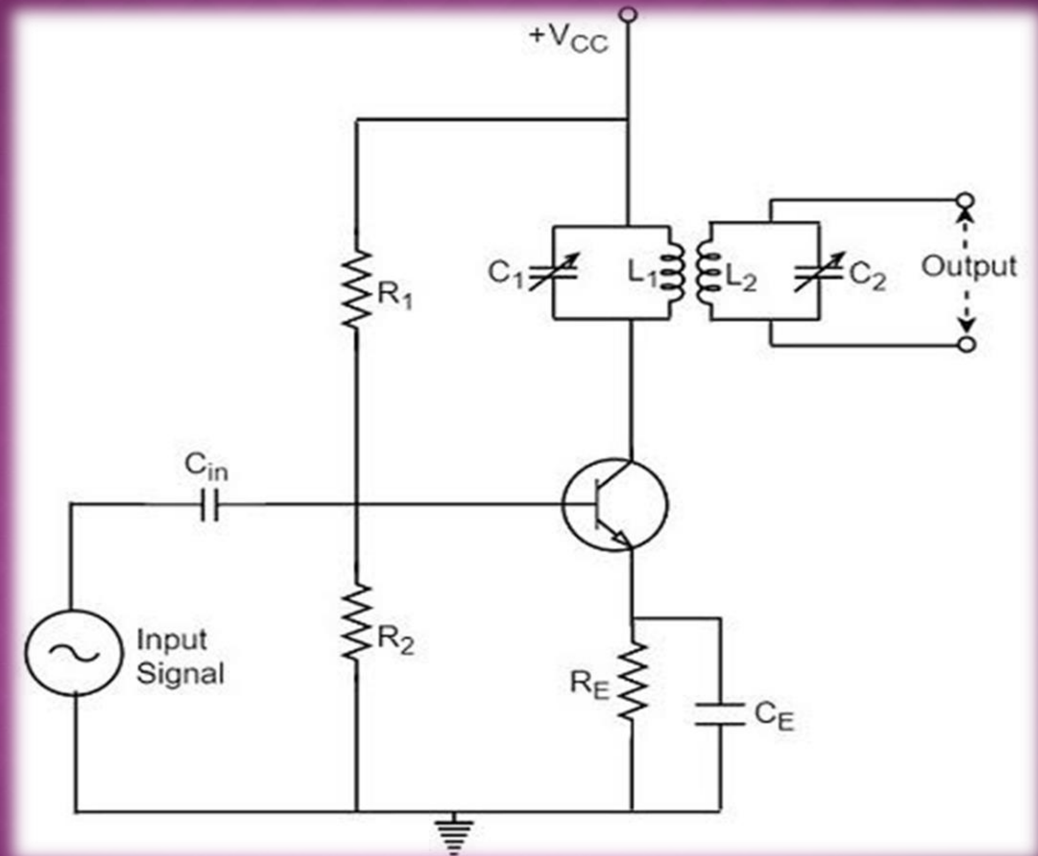
ADVANTAGE :

1. As frequency of crystal is independent of temp. these oscillation have a high order of frequency stability .
2. The quality factor of crystal is very high .

- DISADVANTAGE :

1. Frequency of oscillation can not be changed if desired .

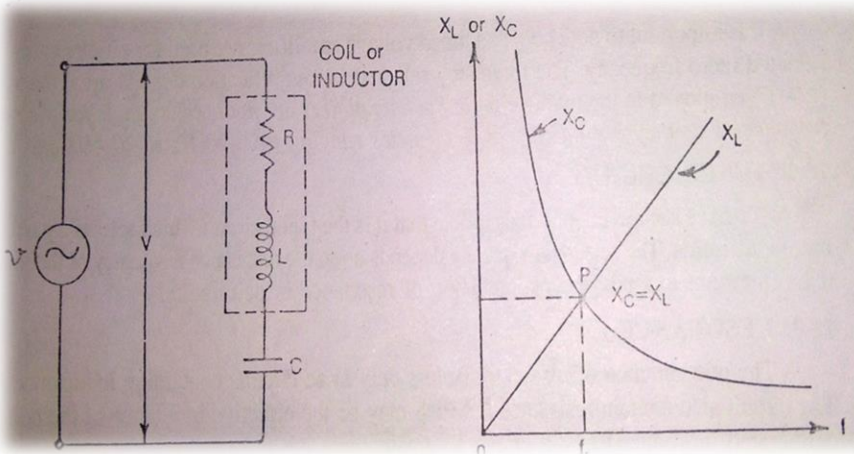
TUNED VOLTAGE AMPLIFIER



CONTENTS

ANALYSIS OF SERIES RESONANT CIRCUIT

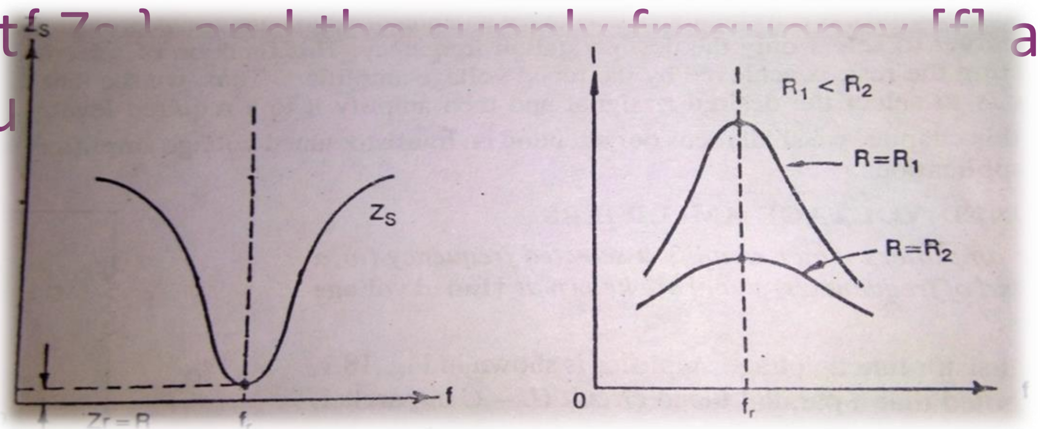
In a series resonance circuit, an inductor and capacitor are connected in series across an ac source as shown in figure. The frequency of the supply source can be varied.



CHARACTERISTICS OF SERIES RESONANT CIRCUIT

- **Effect of frequency on the Impedance of the Circuit**

The value of the circuit impedance is minimum at resonant frequency and its value increases when frequency decreases or increases than the resonant frequency. The effect is insulated by the curve plotted between impedance of series circuit{ Zs } and the supply frequency [f] as shown in figu



RESONANCE CURVE

The curve plotted between current drawn by the series resonance circuit and the supply frequency is called resonance curve of series resonance circuit.

The Quality factor Q and its significance

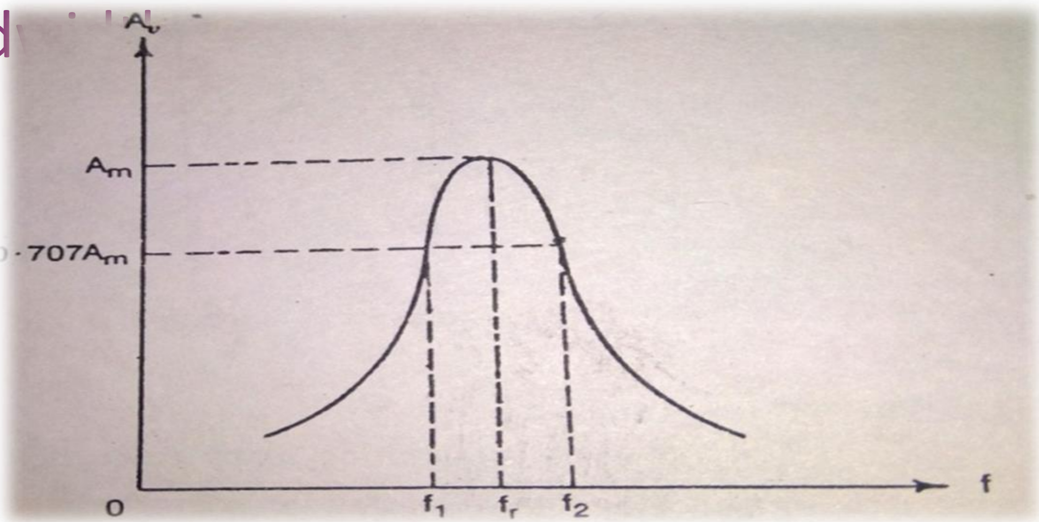
The ratio of voltage drop across L or C [$I_r X_L$ or $I_r X_C$] to the voltage drop across R at series at series resonance is called quality factor Q of the circuit. It is also called figure of merit.

BAND WIDTH

Figure shows a typical series resonance circuit. The circuit current is equal to or greater than 70.7% of maximum current {$I_r = V/R$} between frequency range f_1 to f_2

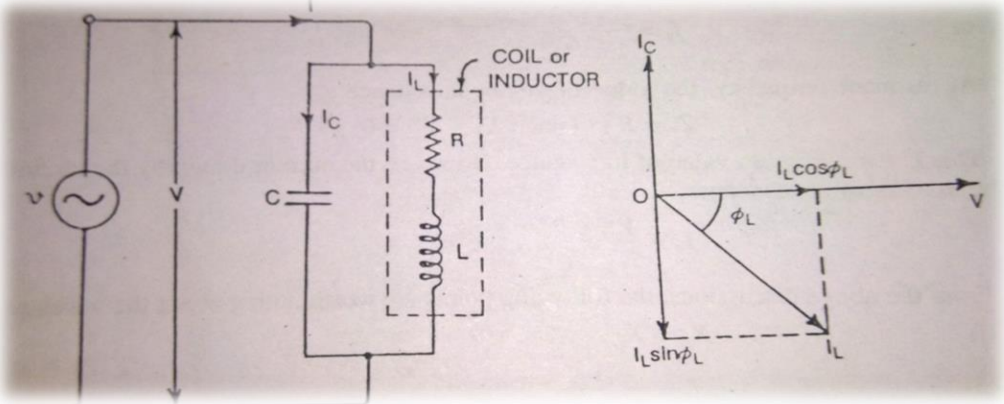
Band Width, BW = $f_1 - f_2$

Hence, higher the value of Q, the smaller is the band



ANALYSIS OF PARALLEL RESONANCE CIRCUIT OR TUNED CIRCUIT

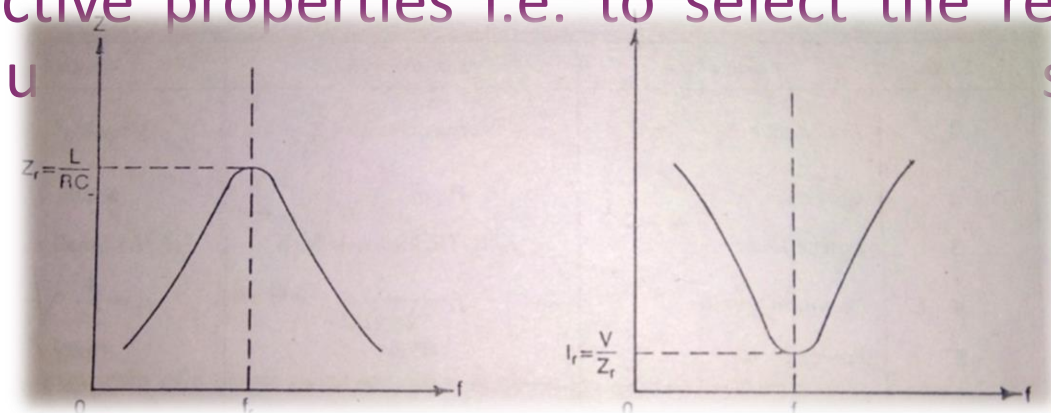
In a parallel circuit or tuned circuit an inductor and a capacitor are connected in parallel across an ac source as shown in figure. The frequency of the supply source can be varied.



CHARACTERISTICS OF PARALLEL RESONANT OR TUNED CIRCUIT

- **Effect of frequency on the impedance of circuit**

However, the impedance of the circuit decreases rapidly when the frequency is changed above or below the resonant frequency. This an important characteristics of the parallel tuned circuit which provides it the selective properties i.e. to select the resonant frequ



s.

RESONANCE CURVE

- The curve between the current drawn by the parallel resonance circuit and the supply frequency is called ** **resonance curve** of the parallel resonance circuit.

  The line current drawn by the parallel resonance circuit at resonant frequency is given by the relation

$$Ir = V/ Zr$$

Band width

- In this the band width is measured in terms of their impedance

COMPARISON OF SERIES AND PARALLEL RESONANT CIRCUITS

S.No.	Particulars	Series Circuit	Parallel Circuit
1.	*Impedance*	Very small, $Z_r = R$	Very high, $Z_r = \frac{L}{CR}$
2.	*Current*	High, $I_r = \frac{V}{R}$	Small, $I_r = \frac{V}{Z_r}$
3.	*Power loss*	$(I_r{}^2 R)$ High as I_r is high	$(I_r{}^2 R)$ Small as I_r is small
4.	*Resonant frequency*	$f_r = \frac{1}{2\pi\sqrt{LC}}$	$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$
5.	*Power factor*	Unity	Unity (*same*)
6.	*Q-factor*	$Q = \frac{X_L}{R} = \frac{2\pi f_r L}{R}$	$Q = \frac{X_L}{R} = \frac{2\pi f_r L}{R}$ (*same*)
7.	*Frequency response or band width*	Same	Same

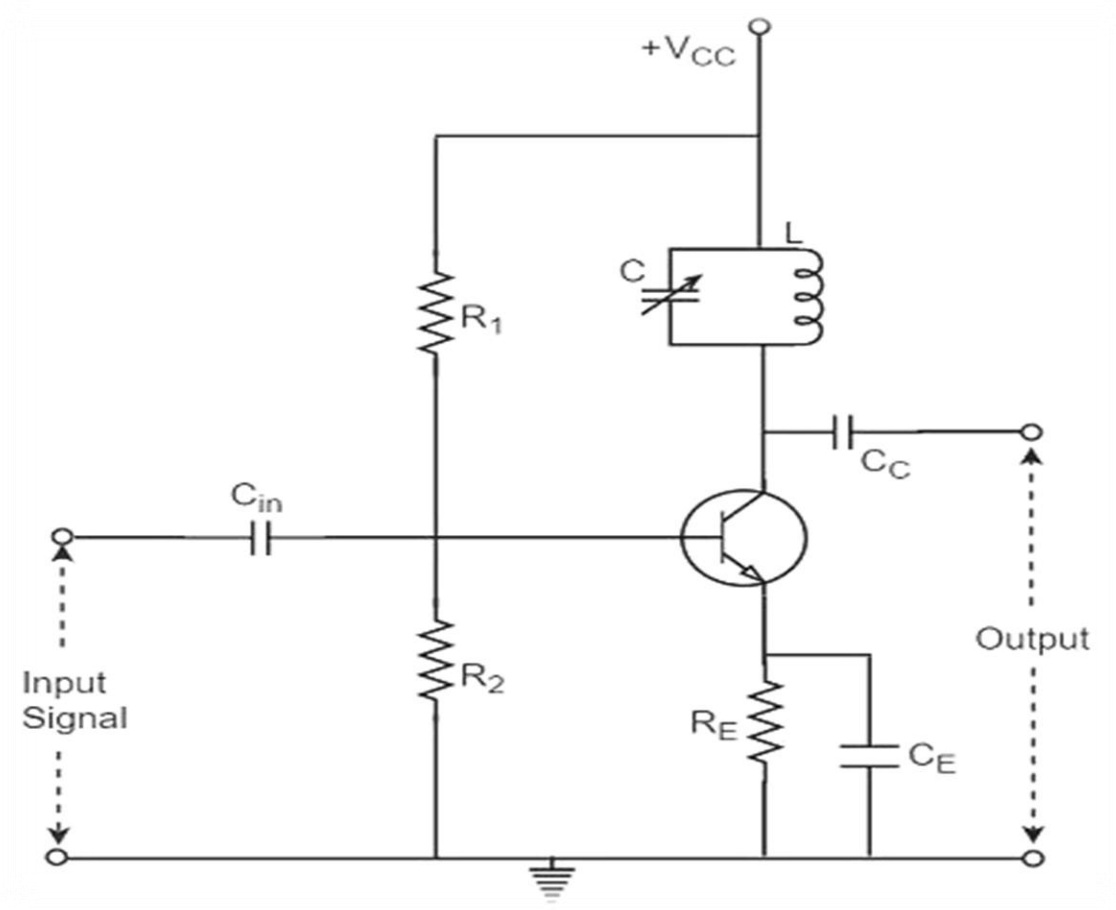
MERITS OF TUNED AMPLIFIER

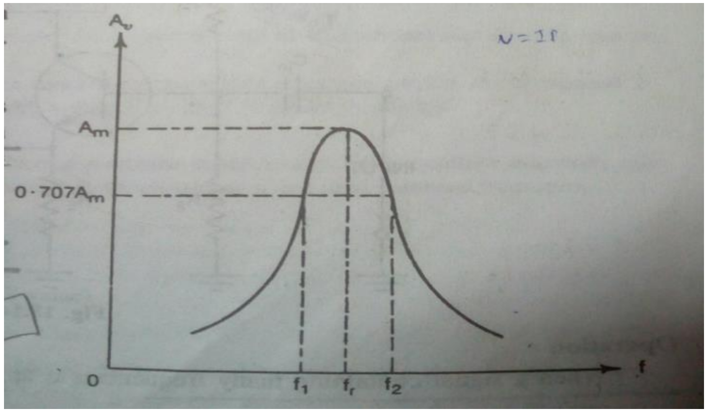
- **Smaller power loss** - A tuned parallel circuit employed as load in these amplifiers which contain a very small that to because of resistance of the coil itself. Therefore, power loss in these circuits is very small.
- **High selectivity** - It is because of the characteristics such as large Q-factor, narrow, bandwidth, etc. of this parallel resonance circuit.
- **Smaller collector supply voltage Vcc** - As the resistance of the tuned parallel circuit is very small, a little voltage drop occur in the collector load and most of the voltage reaches for transistor operation. Hence , a small collector supply voltage is needed.

SINGLE TUNED VOLTAGE AMPLIFIER

A single tuned amplifier is shown in figure. A parallel resonance circuit is connected in the collector . Usually, capacitor used in the resonance circuit is variable. The value of L and C are so selected that its resonant frequency is equal to the signal frequency to be amplified . The biasing network is designed for class – C operation . The output of the amplifier may be obtained either (i) by a coupling capacitor Cc or (ii) by a secondary coil magnetically coupled to the inductive coil of resonant circuit.

DIAGRAM :-





LIMITATION OF SINGLE TUNED AMPLIFIERS

- Higher Q-factor reduces the band width to large extent. This results poor reproduction. This is the major drawback with the single – tuned voltage amplifier. However , this drawback is over come by using a double - tuned amplifier circuit .

DOUBLE – TUNED VOLTAGE AMPLIFIER

To obtain high selectivity, high gain and required band width , double – tuned voltage amplifiers are used.

CIRCUIT ANALYSIS :-

A double tuned voltage amplifier circuit is shown in figure. In the circuit arrangement, it may be noted that all other circuit components are the same except collector circuit. This circuit contains two tuned circuits ; one (L1 C1) in the collector and the other (L2 C2) in the output. The two coils L1 and L2 are magnetically coupled and usually placed over ** ferrite rc

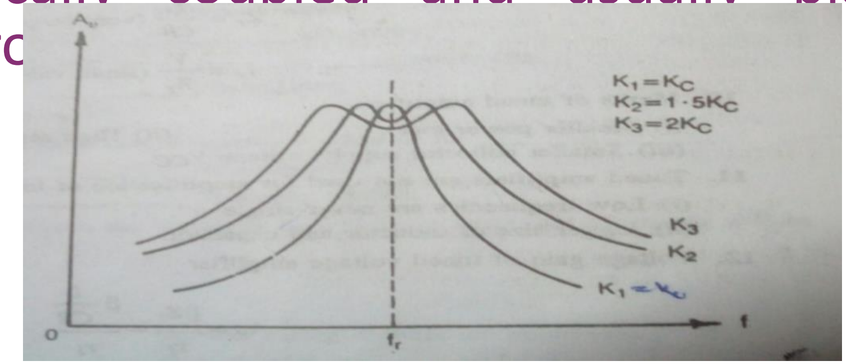


DIAGRAM :-