MODULE - 2

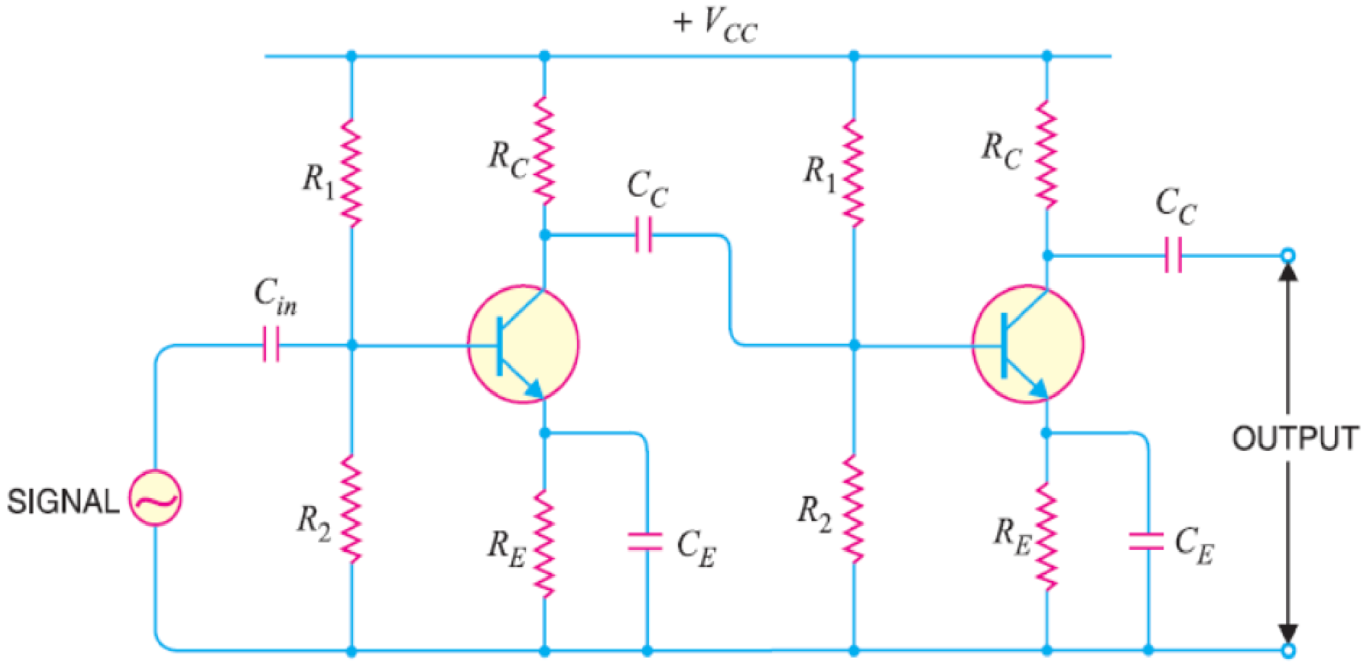
MODULE – 2 (SYLLABUS)

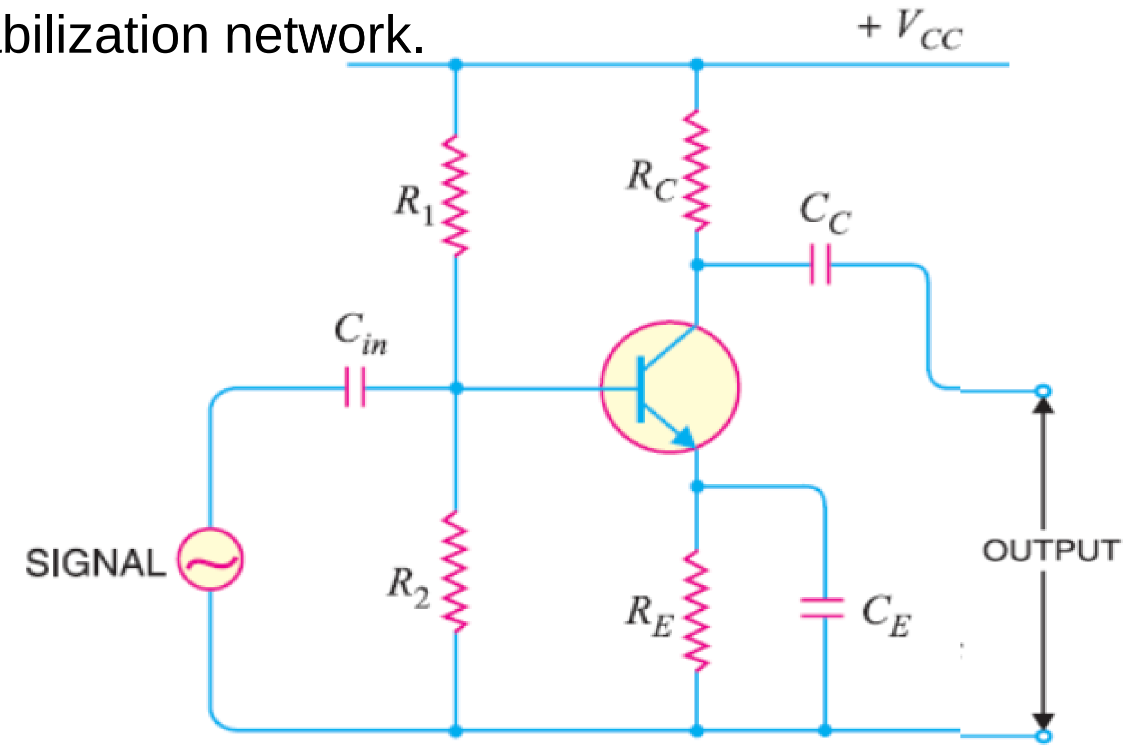
2	**BJT Amplifiers**
2.1	Classification of amplifiers, RC coupled amplifier (CE configuration) – need of various components and design, Concept of AC load lines.
2.2	Small signal analysis of CE configuration using small signal hybrid π model for mid frequency. (gain, input and output impedance).
2.3	High frequency equivalent circuits of BJT, Miller effect, Analysis of high frequency response of CE amplifier. voltage gain and frequency response

RC COUPLED AMPLIFIER

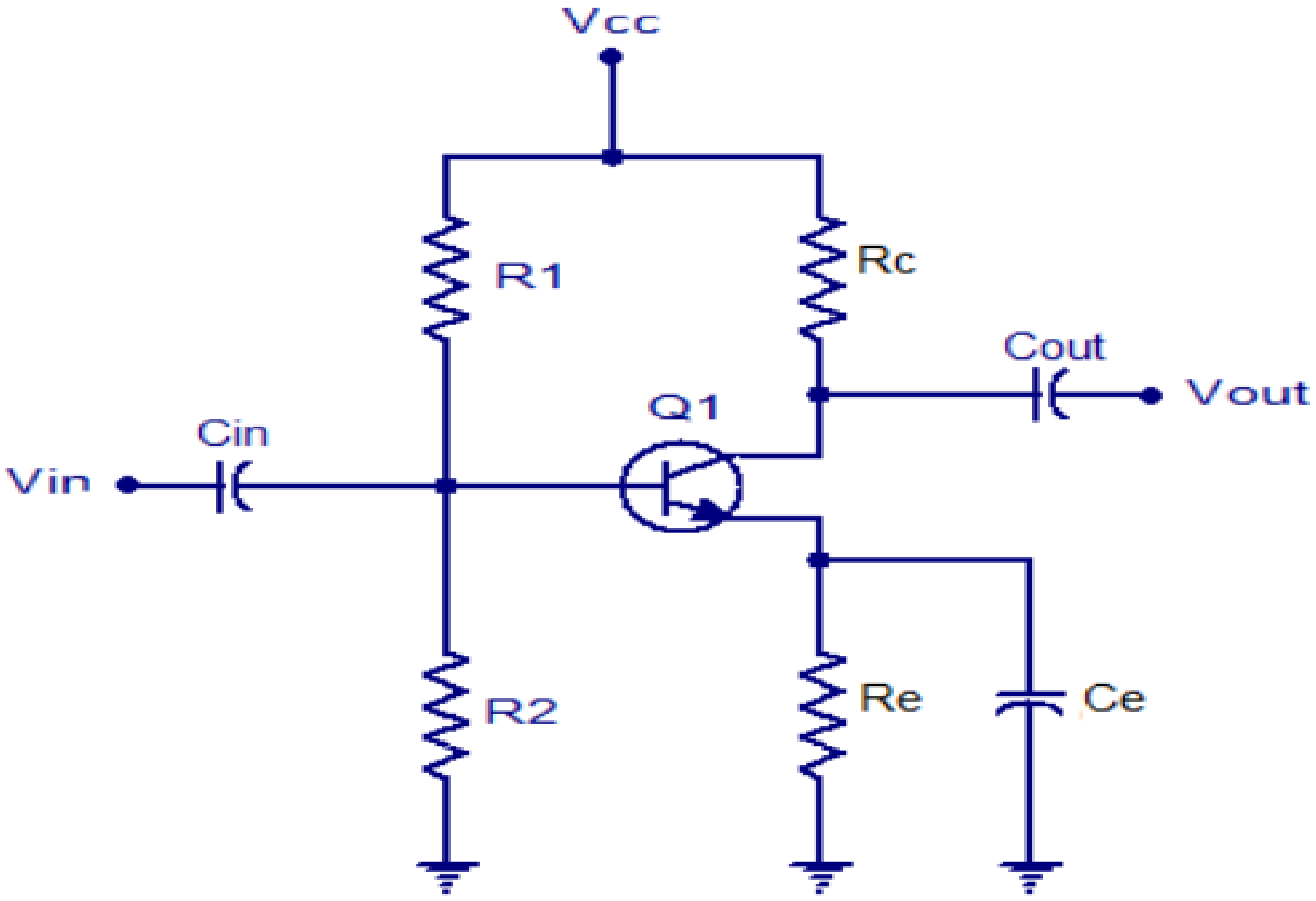
RC COUPLED AMPLIFIER

- An amplifier with Resistance Capacitance Coupling.
- A coupling capacitor C_C is used to connect the output of first stage to the base of the 2nd stage.
  i.e. input of the second stage and this continues when more stages are connected.
- Most of the amplifier circuits use Voltage divider biasing circuit as it provide more stabilization to q-point.
- The resistances R1, R2 and RE form the biasing and stabilization network.



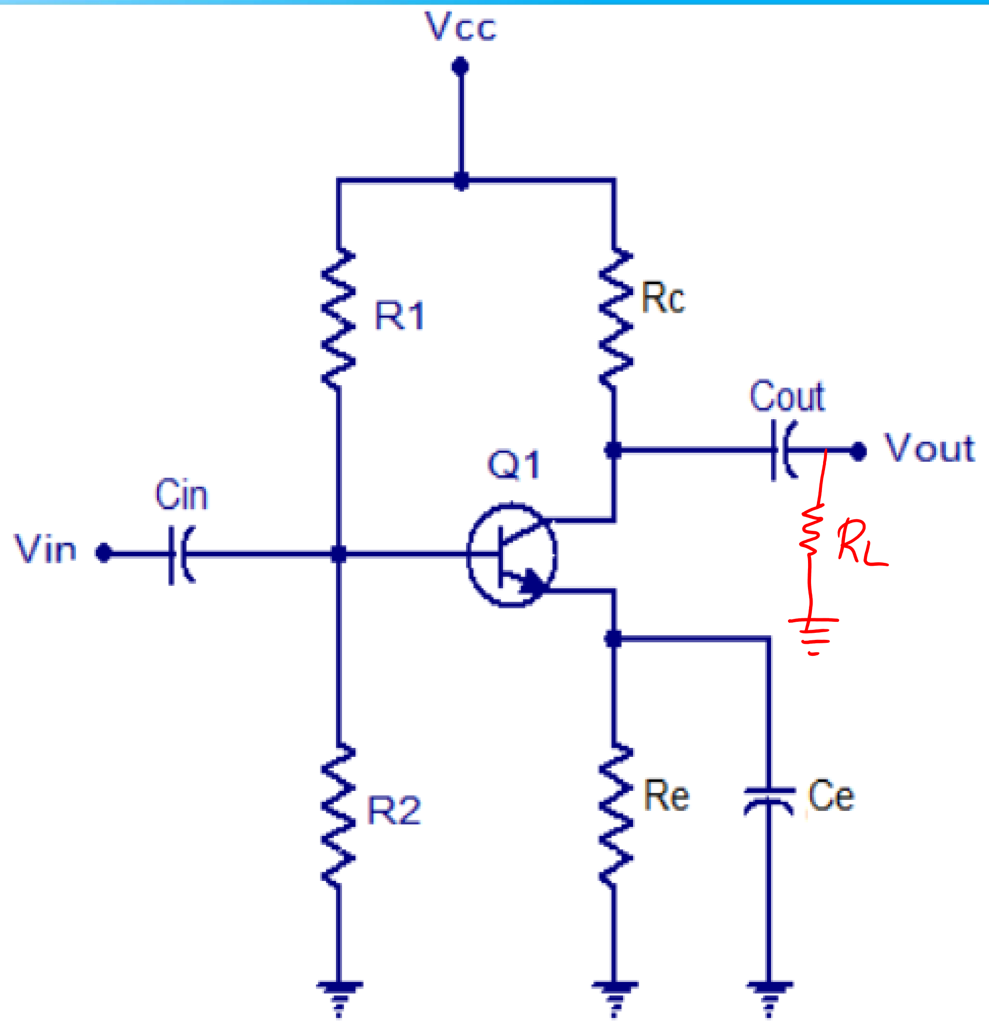


RC COUPLED AMPLIFIER



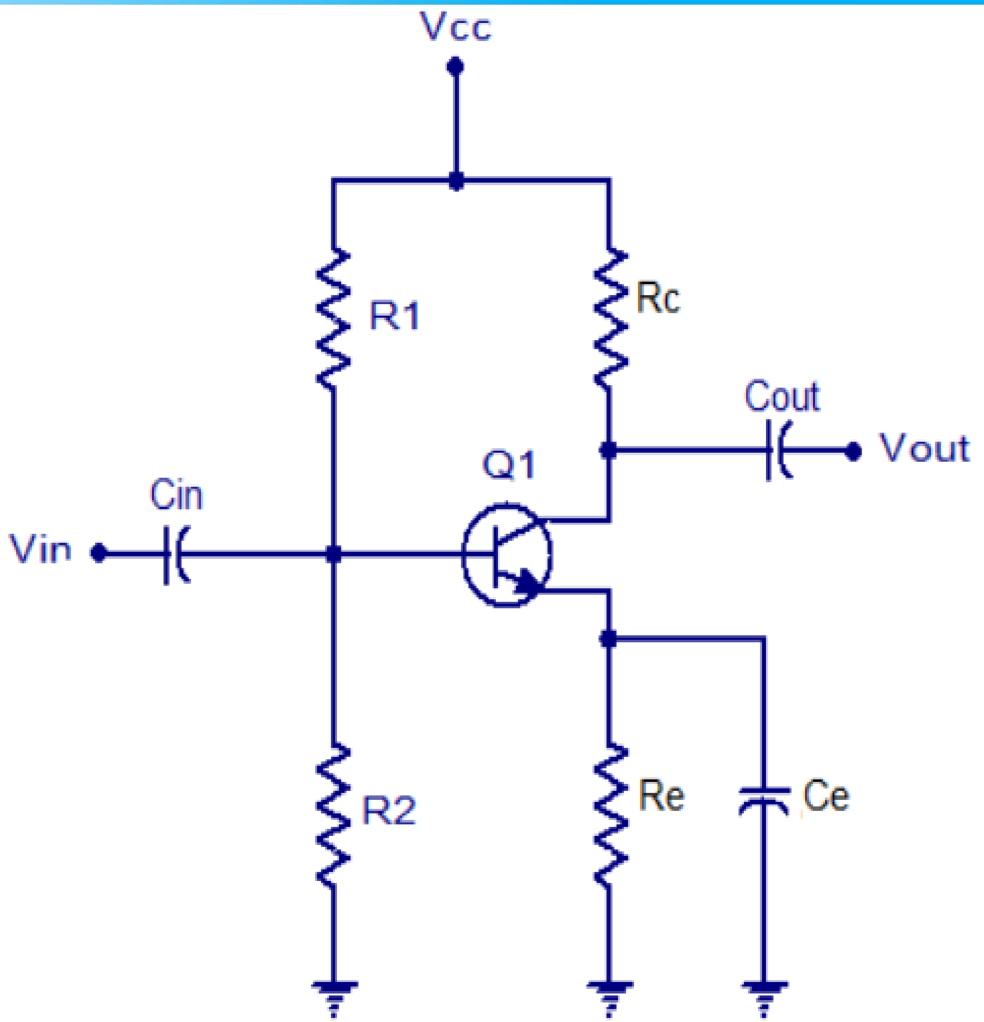
Components - Resistors

- The resistances R_1, R_2 and R_E form the biasing and stabilization network.
- Resistors R_1 and R_2 form Potential or Voltage divider circuit.
- Voltage across R_2 ensures Base Emitter Junction Forward Biased.
- Voltage across R_2 ensures Collector Base Junction Reverse Biased. So that Transistor work in Active Region.
- R_E -keeps Base Emitter Junction Forward Biased. And provides thermal stabilization.
- Load Resistor R_L connected at output.
- To the next stage Amplifier is connected via a Resistor and Capacitor so called RC Coupled Amplifier.
- CE configuration is used as it is having High Voltage Gain.



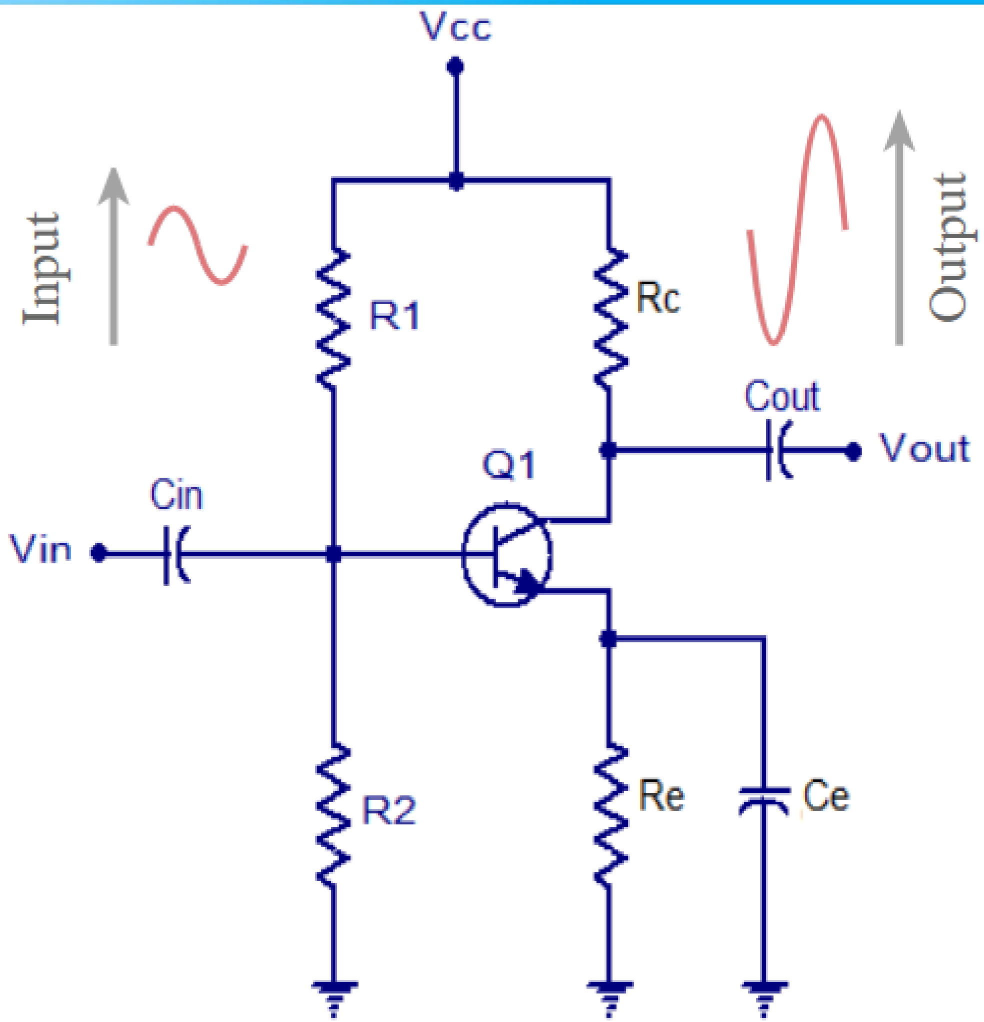
Components - Capacitors

- **C_{in} (Input Coupling Capacitor)**
- Allows only AC signal to pass through and blocks DC, and if it is absent, the supply internal resistance becomes parallel to R_2 and biasing of junction is affected.
- It also determines the lowest frequency f_L which is to be amplified.
- **C_{Out} (Output Coupling Capacitor)**
- Coupling capacitor at the output which block DC signals.
- **C_E(Bypass Capacitor)**
- C_E ensures low reactance path for the AC signals. If C_E is not present the Voltage across R_E changes. So the biasing is affected and q-point will be affected.
- The reactance of C_E should be $1/10^{th}$ of that of resistance R_E



Working of RC Coupled Amplifier

- When no input is applied, the quiescent conditions are formed and no output is present.
- When V_{in} Increases » I_B increases » I_C increases $\boxed{I_C = \beta I_B}$
- Output Voltage, $\boxed{V_O = V_{CC} - I_C R_C}$
- When V_{in} Increases, V_O will increase in Negetive Direction. Thus there is a Phase shift of **180°** between Input and Output.
- CE amplifier has a high input impedance and lower output impedance than CB amplifier.
- Voltage gain and Power gain are high in CE amplifier and hence this is mostly used in Audio amplifiers.



Frequency Response of RC Coupled Amplifier

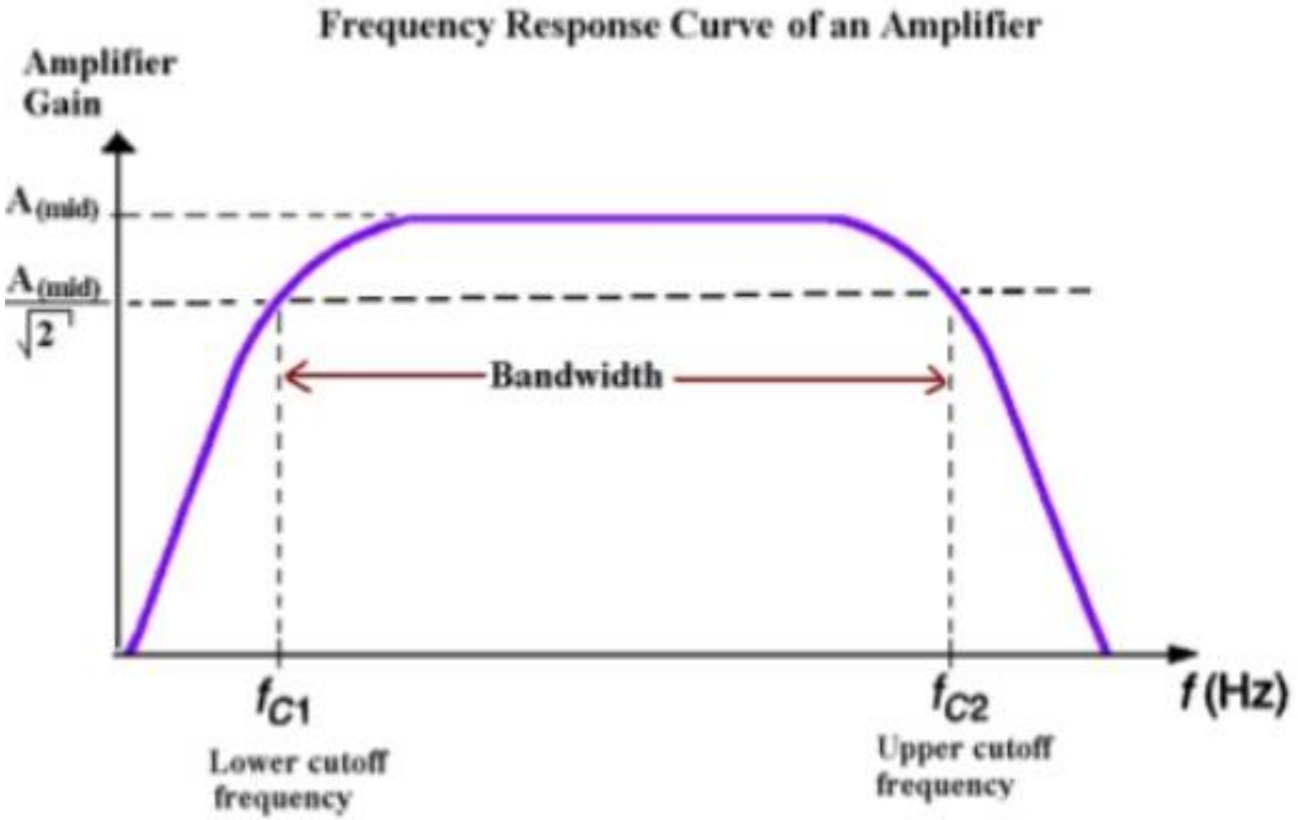
- Frequency response is a graph that indicates the relationship between gain and frequency.
- Gain can be Voltage gain or Power Gain.
- Graph has 3 regions - Low frequency region, High frequency region and Mid frequency region.
- **f_{C1}**- Lower Cut off frequency
- **f_{C2}**- Higher Cut off frequency
- These cut off frequency are those in which

  Voltage gain = Max. Voltage gain / $\sqrt{2}$
- At cut off frequencies the

  Power gain = Max. Power gain / 2

  So, cut off frequency points are called

  Half Power Points.



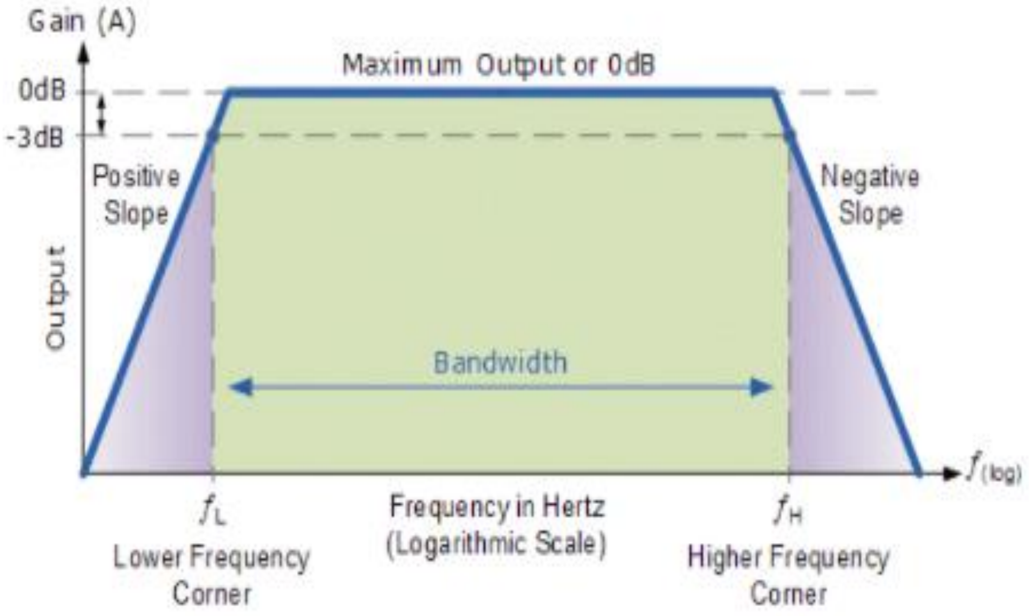
- **Bandwidth = f_{C2} - f_{C1}** = useful operating range of an amplifier

Frequency Response in Decibel (dB)

- Logarithemic measurement of ratio of One power to another or one voltage to another.

Voltage Gain (dB) = 20log(A_V)

Power Gain (dB) = 10log(A_P)



- If A_V is **Greater than One**, dB Gain is **+ve.**
- If A_V is **Less than One**, dB Gain is **-ve.**
- Positive and Negative gain indicates Amplification and Attenuation respectively.
- Maximum gain is Mid frequency range gain is assigned 0dB.
- Value below Mid frequency range expressed as negative dB value.

- Voltage gain at f_L and f_H is less than 3dB of Max. Vol gain.
- f_L & f_H called **3dB frequencies** and bandwidth as **3dB Bandwidth**

Frequency Response of RC Coupled Amplifier

1. AT LOW FREQUENCY REGION:

$$X_C = \frac{1}{2\pi f C}$$

- The capacitive reactance is inversely proportional to the frequency.

  At low frequencies, the reactance is quite high.
- Reactance of the Input Coupling Capacitor is large

  so capacitor doesnot allow much signal to pass through it.
- The reactance of the Output Coupling Capacitor is large

  so capacitor doesnot allow much signal to pass through it.
- The reactance of the emitter bypass capacitor C_E is also

  very high during low frequencies. So it cannot shunt the emitter

  resistance effectively
- Output is reduced, hence gain is reduced.

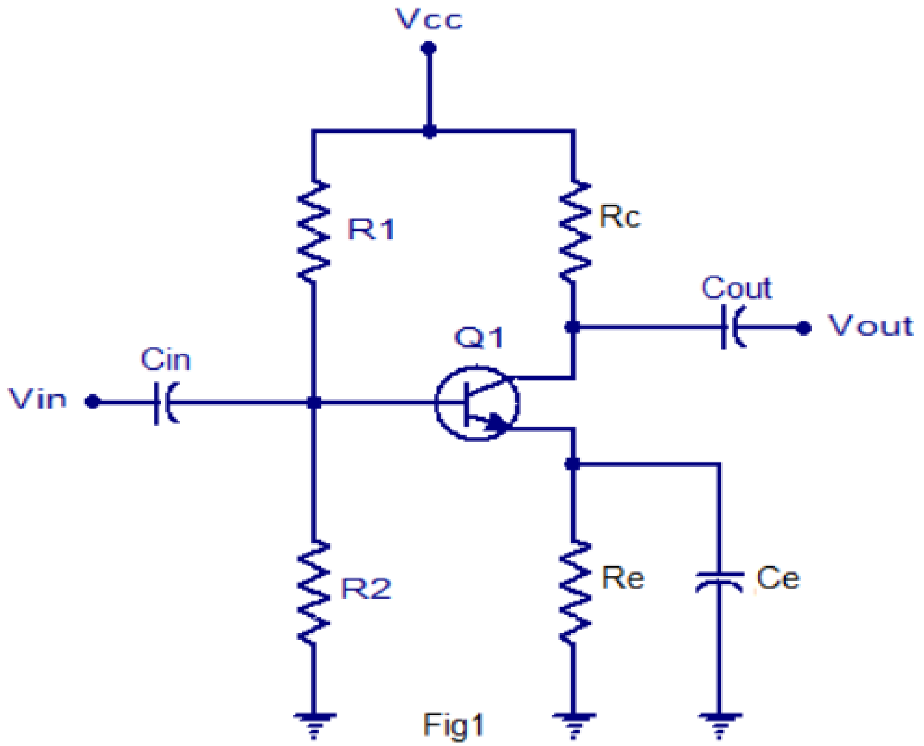


Fig1

Frequency Response of RC Coupled Amplifier

2. AT HIGH FREQUENCY REGION:

$$X_C = \frac{1}{2\pi f C}$$

- At High frequencies, the reactance is quite low.
- Capacitive reactance is low at high frequencies. So, capacitor behaves as a short circuit, at high frequencies.
- The loading effect of the next stage increases, which reduces the voltage gain.
- At high frequency, transistor's internal capacitance reactance is small.
- It will act as a short circuit between input and output of transistor. So input will pass to output without amplification.
- Output is reduced, hence gain is reduced

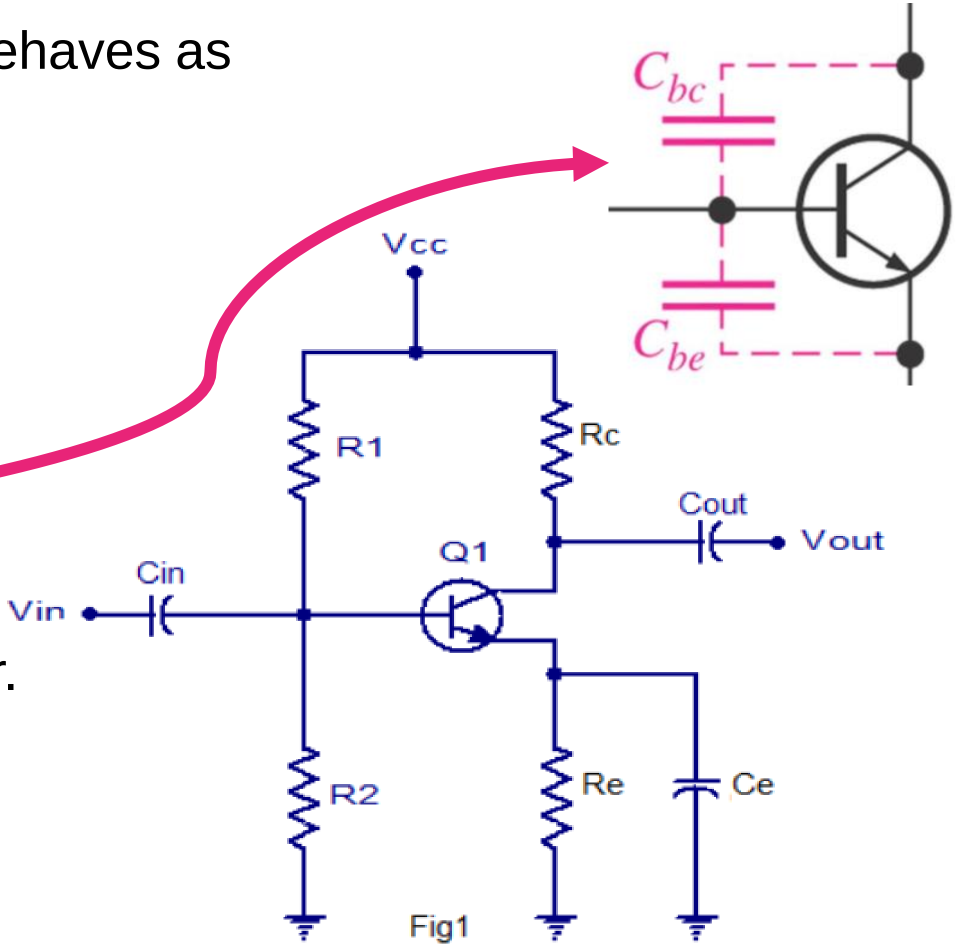


Fig1

Frequency Response of RC Coupled Amplifier

3. AT MID FREQUENCY REGION:

- The voltage gain of the transistor is maintained constant in this range of frequencies.
- If the **frequency increases**, the **reactance** of the **coupling capacitor decreases** which tends to **increase the gain.**
- But this lower reactance of the capacitor 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.

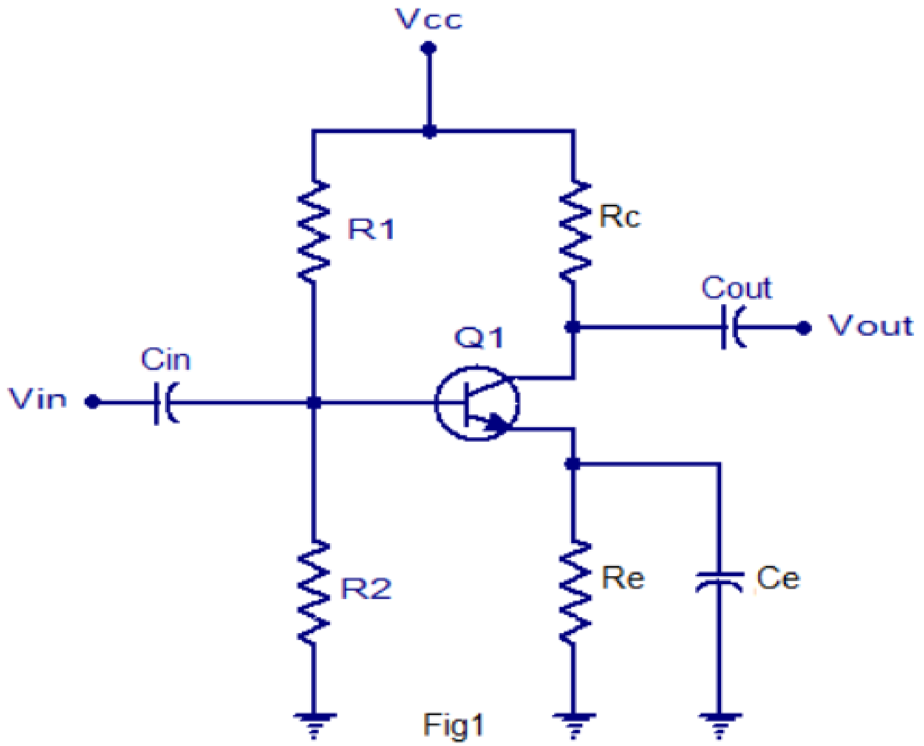


Fig1

Frequency Response of RC Coupled Amplifier

- **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. (20Hz to 20KHz)
- Simple circuits with Low cost components.
- **Applications of RC Coupled Amplifier**
- Used as Preamplifiers.
- Audio frequency applications
- **Disadvantages of RC Coupled Amplifier**
- Produce disturbances in the output when components are aged.

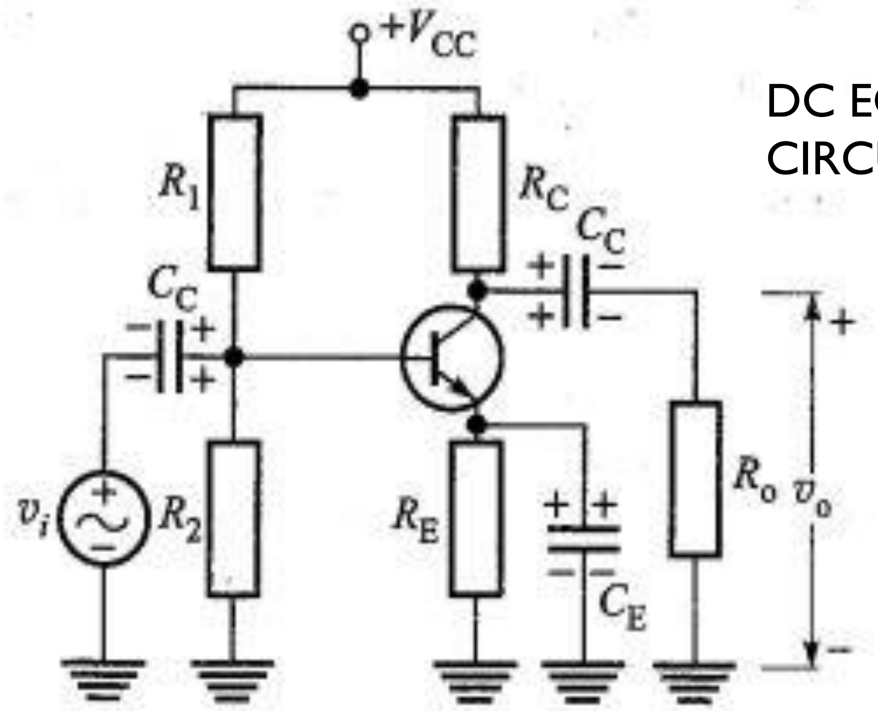
AC LOAD LINE

- **DC load line** of a transistor amplifier is the load line, when no AC signal input is applied.

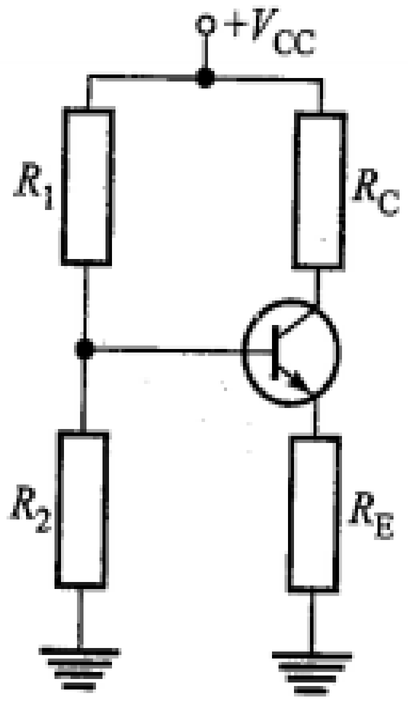
  Load line of DC Equivalent circuit, with no reactive components like Capacitors and Inductors.

- When input signals are applied to an amplifier, input AC signals gets superimposed with the DC Voltages and forms a new load line called **AC load line**.
- AC load line is a straight line drawn through the Q-point or quiescent point of a transistor, with slope of the line equal to AC impedance.

AC LOAD LINE



DC EQUIVALENT CIRCUIT



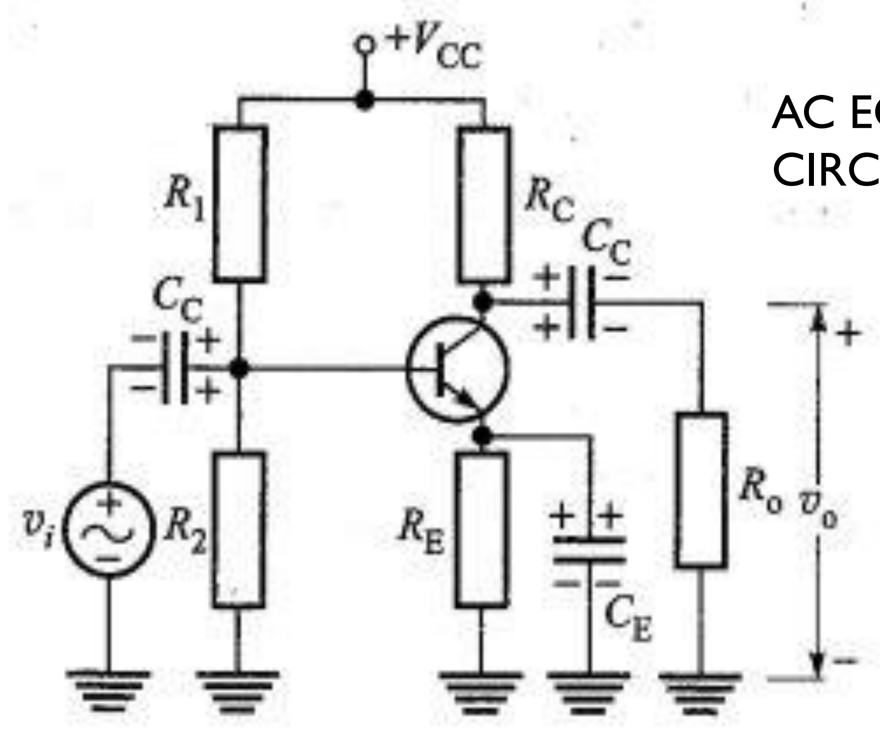
$$V_{CC} = I_C R_C + V_{CE} + I_E R_E$$

$$= V_{CE} + I_C(R_C + R_E) \quad [\text{since } I_C \simeq I_E]$$

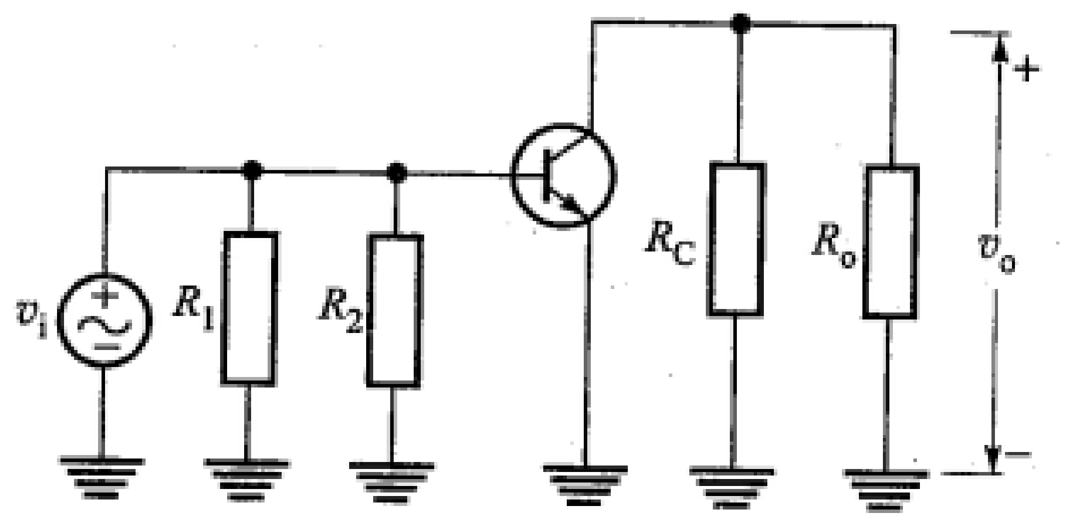
$$\boxed{I_C = \frac{-1}{(R_C + R_E)} V_{CE} + \frac{V_{CC}}{(R_C + R_E)}}$$

SLOPE : $\dfrac{-1}{(R_C+RE)} = \dfrac{-1}{R_{DC}}$

AC LOAD LINE



AC EQUIVALENT CIRCUIT



- Short circuit all the Capacitors.
- Replace all Voltage sources by ground.

$$\text{SLOPE} : \frac{-1}{(R_C \parallel R_O)} = \frac{-1}{R_{AC}}$$

AC LOAD LINE

- The ac load line will have a slope of ($-1/R_{AC}$)
- Q point describes the zero-signal conditions of the circuit, the ac load line should also pass through Q-point.
- To draw such a line, we can first draw any line with the given slope ($-1/R_{AC}$). We can then draw the ac load line parallel to this line and passing through the Q point.