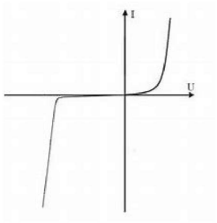
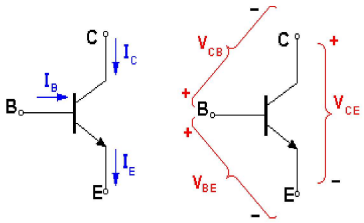
BJT Characteristics

Number of Variables in a BJT

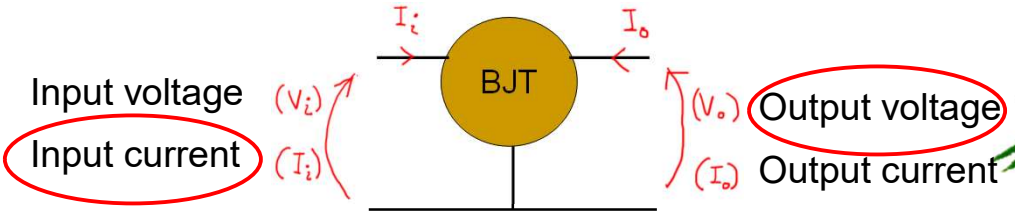
- Diode
  - One current and one voltage



- BJT
  - Three currents and three voltages!
  - They are interdependent
  - How many characteristic graphs?

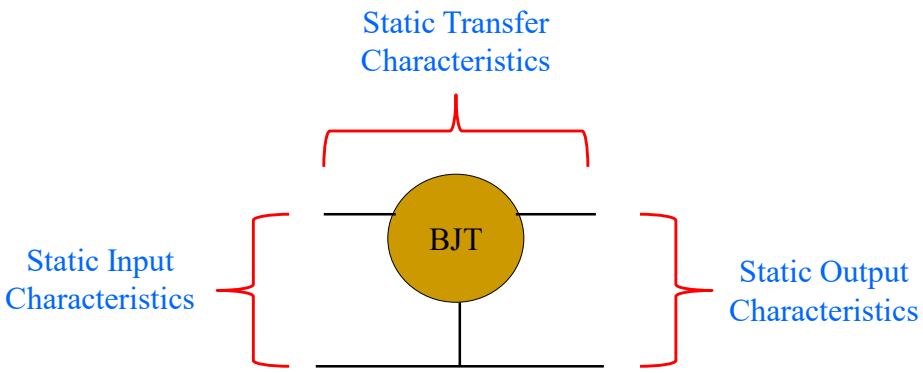


Number of Variables in an Amplifier Configuration

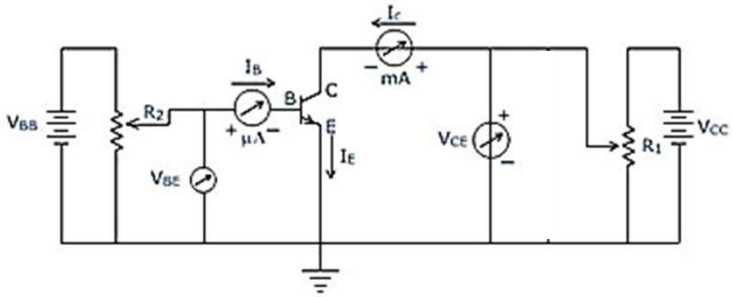


Four Variables
V_i, I_i, V_o, I_o

Three Characteristics of a BJT in an Amplifier Configuration



Test Circuit for CE Configuration

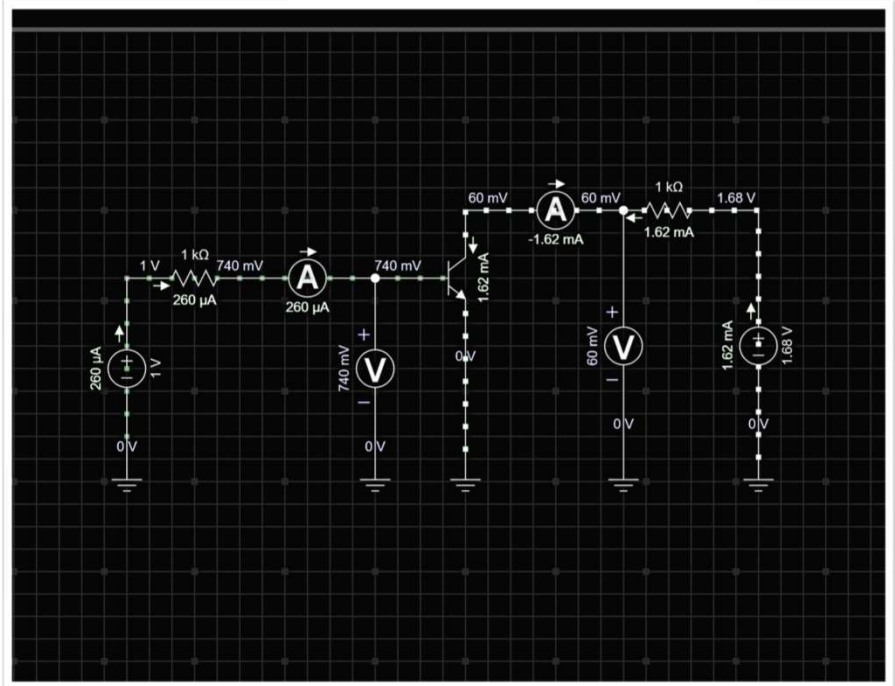


Three Characteristics of a BJT in an Amplifier Configuration

- ☑ Static Output Characteristics
- Static Input Characteristics
- Static Transfer Characteristics
  - Mutual Characteristics

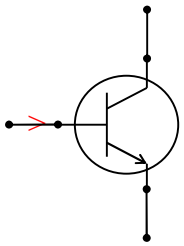
Static Input Characteristics

- The plot of input current(I_i) against input voltage(V_i)
  - Keep the output voltage(V_o) constant
  - Plot one curve for each constant V_o value
  - Multiple curves in the graph

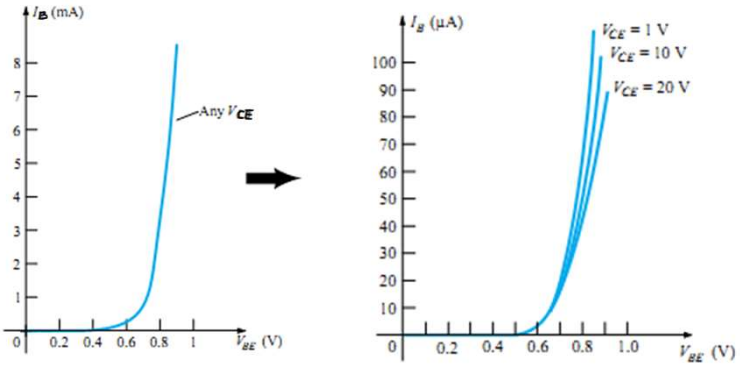


Static Input Characteristics for CE Configuration

- For CE configuration it is the plot of Base current(I_B) vs Base voltage(V_{BE})
  - Collector voltage(V_{CE}) is kept constant
  - Remember the shape of diode characteristics



Static Input Characteristics

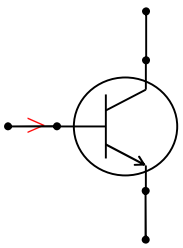


Static Output Characteristics

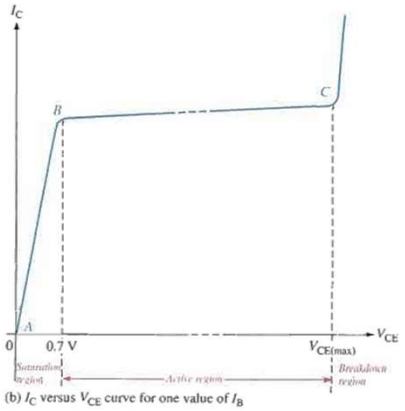
- The plot of output current(I_o) against output voltage(V_o)
  - Keep the input current(I_i) constant
  - Multiple curves will be drawn. One each for a constant value of (I_i)

Static Output Characteristics

- For CE configuration it is the plot of Collector current(I_C) vs Collector voltage(V_{CE})
  - Base current(I_B) is kept constant
  - One curve for each value of I_B.

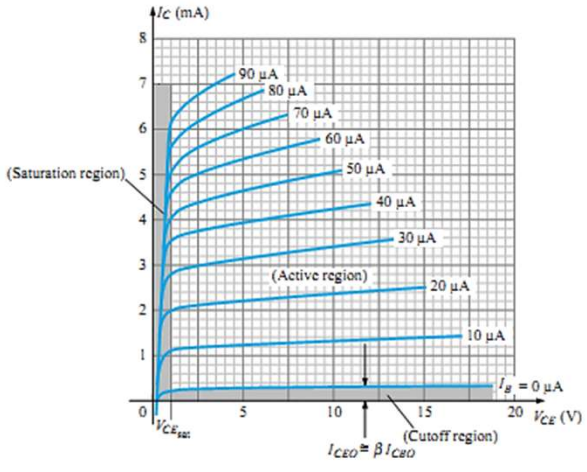


Static Output Characteristics



(b) I_C versus V_{CE} curve for one value of I_B

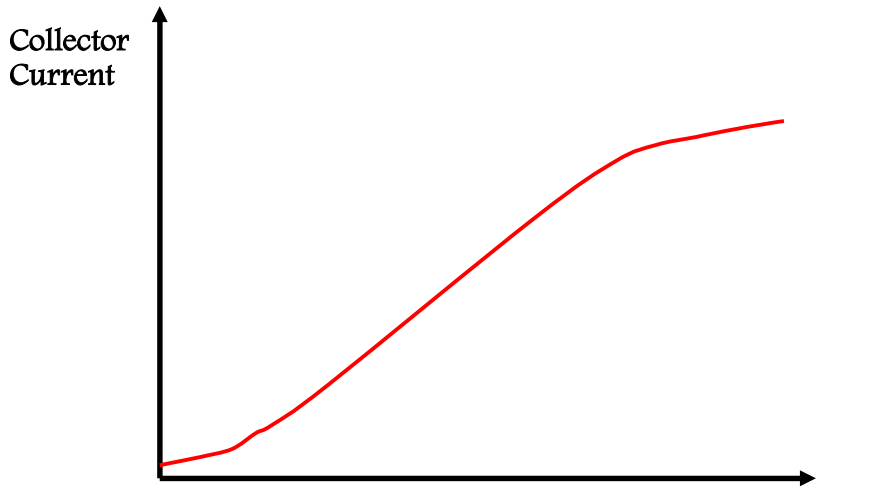
Static Output Characteristics



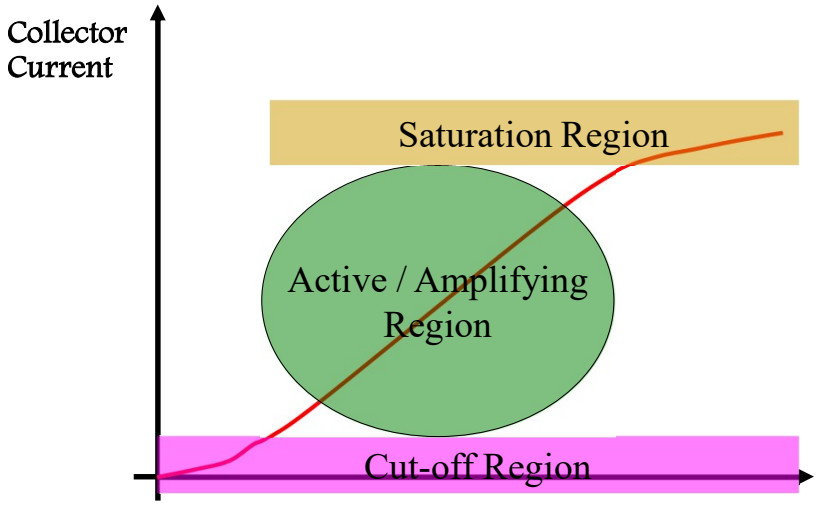
Static Transfer Characteristics

- The plot of output current(I_o) against input current(I_i)
  - Keep the output voltage(V_o) constant
  - Multiple curves for each constant value
- For CE configuration it is the plot of Collector current(I_C) vs Base current(I_B)
  - Collector voltage(V_{CE}) is kept constant
  - Linear behaviour

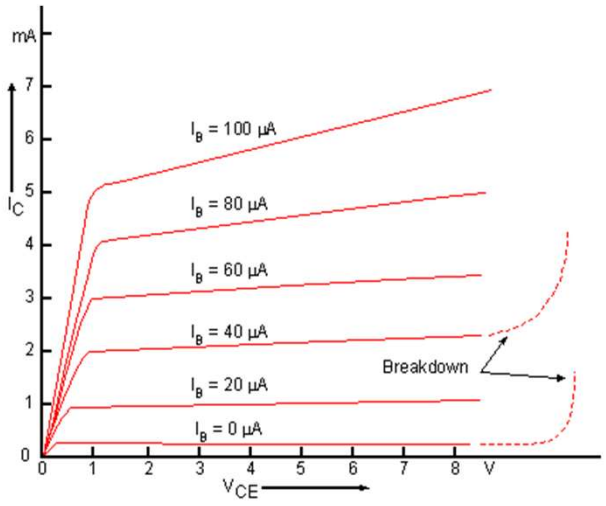
Controlled Vs. Controlling



Controlled Vs. Controlling

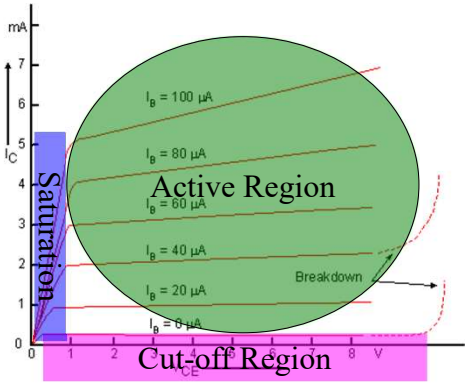


Typical Static Output Characteristics for CE

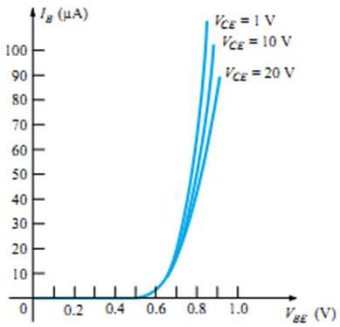


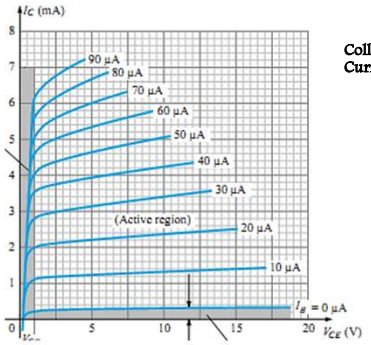
Three Regions

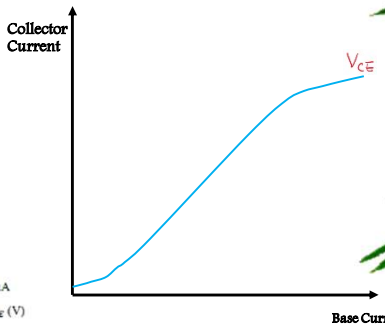
- Cut-off Region
- Saturation Region
- Active Region
  (Amplifying Region)

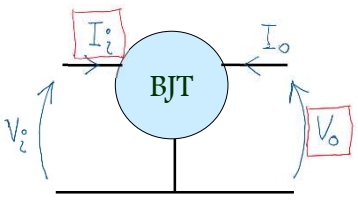


Summary of BJT Characteristics

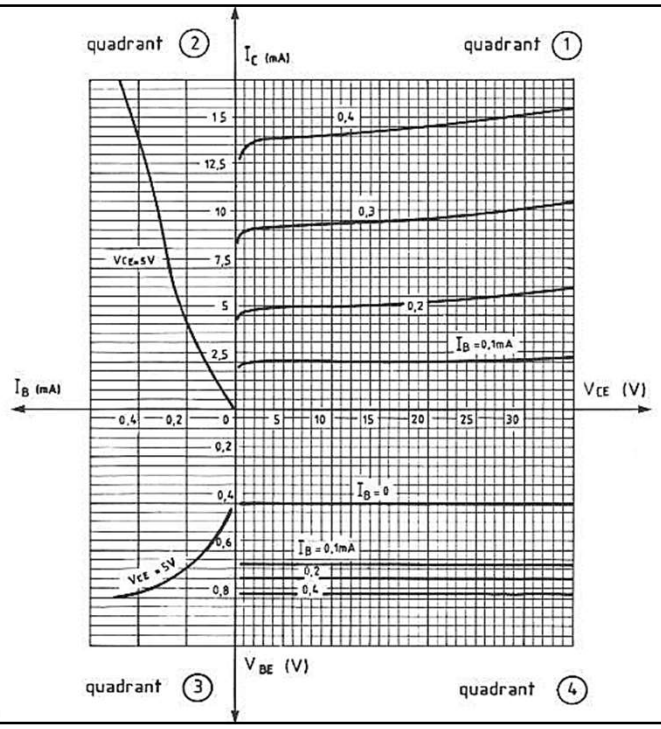






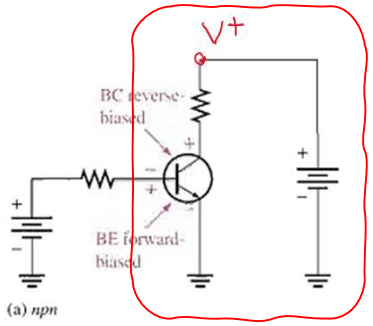


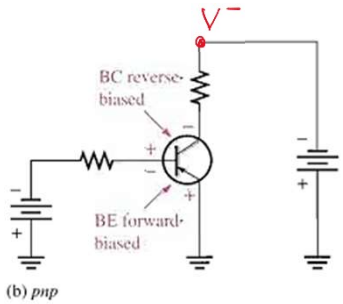
All Characteristics in one diagram



BJT in Common Emitter Amplifier Configuration

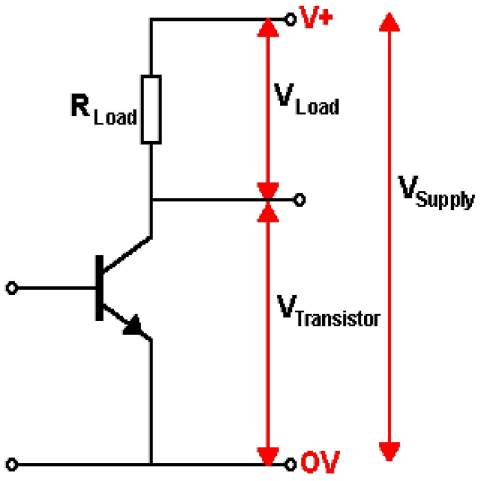
Biasing to Amplifying Mode in CE Configuration





Let us first consider this output Side …

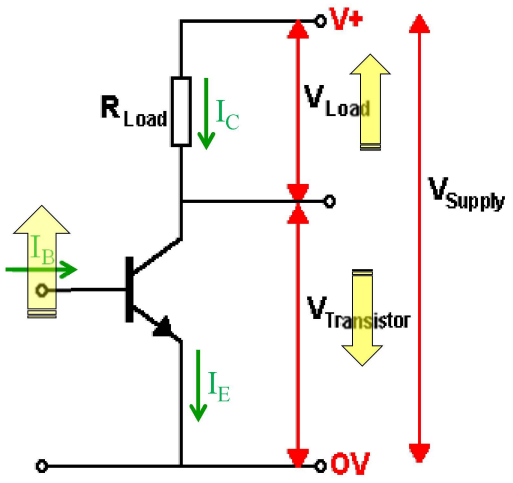
Output Side is a Potential Divider…



Kirchoff's Voltage Law

$$V_{Load} + V_{Transistor} = V_{Suppy}$$

Negative Resistance Effect



Activity

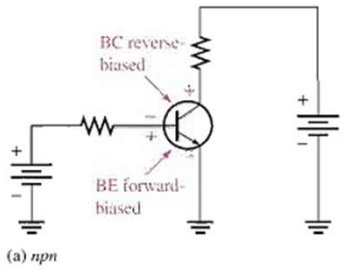
When collector current is increased voltage across ……. rises and voltage across ……. decreases. When the input voltage increases, collector current ……., and the voltage across the load …… . The output voltage is the C-E voltage across the transistor. It ……, as a result of the increase in load voltage.

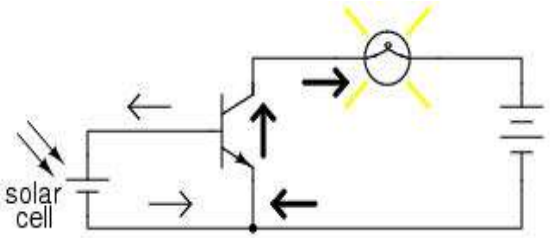
Answer

When collector current is increased voltage across the LOAD rises and voltage across TRANSISTOR decreases. When the input voltage increases, collector current RISES, and the voltage across the load RISES AS A RESULT. The output voltage is the C-E voltage across the transistor. It DROPS, as a result of the increase in load voltage.

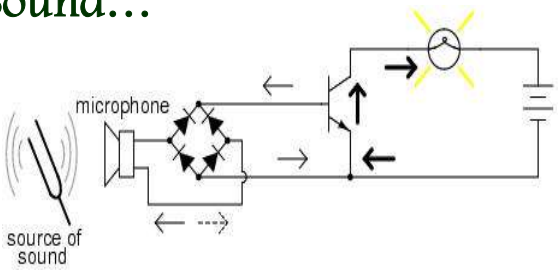
Conceptualizing …

Proportional Lighting in Amplifying Mode

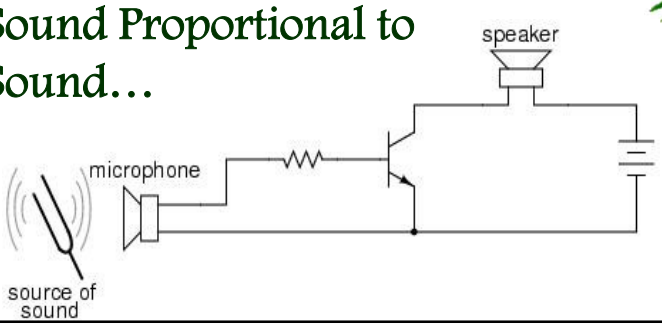




Lighting Proportional to Sound…

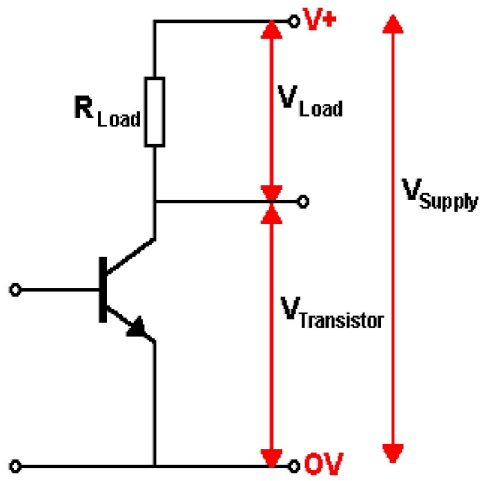


Sound Proportional to Sound…



Plotting DC Load Line

DC Load Line



$V_{Transistor} + V_{Load} = V_{Supply}$

$V_{Transistor} = V_{CE}$

$V_{Load} = I_C \times R_L$

$V_{Supply} = V^+ = V_{CC}$

Substituting…

$V_{CE} + I_C \times R_L = V_{CC}$

DC Load Line

$$V_{CE} + IC.RL = VCC$$

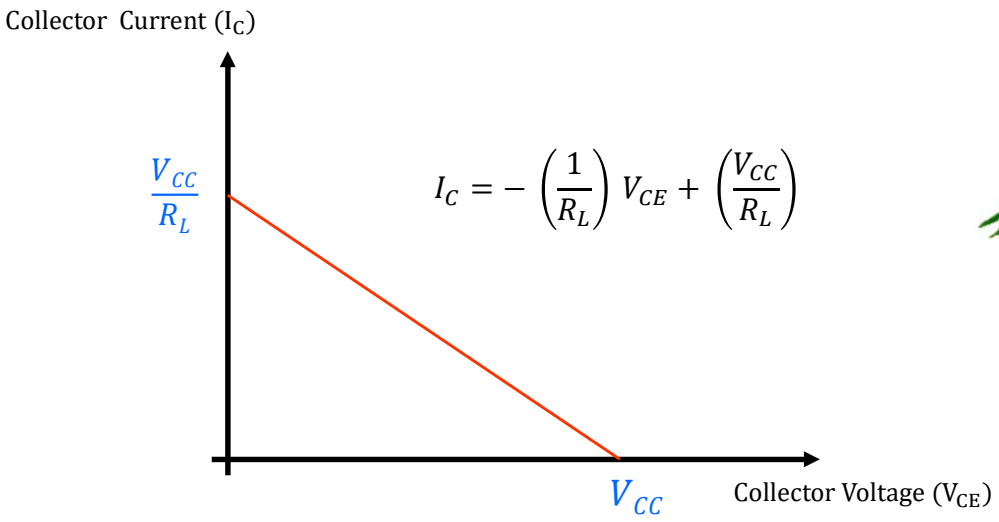
$$I_C.RL = -(V_{CE}) + V_{CC}$$

$$I_C = -\left(\frac{V_{CE}}{R_L}\right) + \left(\frac{V_{CC}}{R_L}\right)$$

$$I_C = -\left(\frac{1}{R_L}\right) V_{CE} + \left(\frac{V_{CC}}{R_L}\right)$$

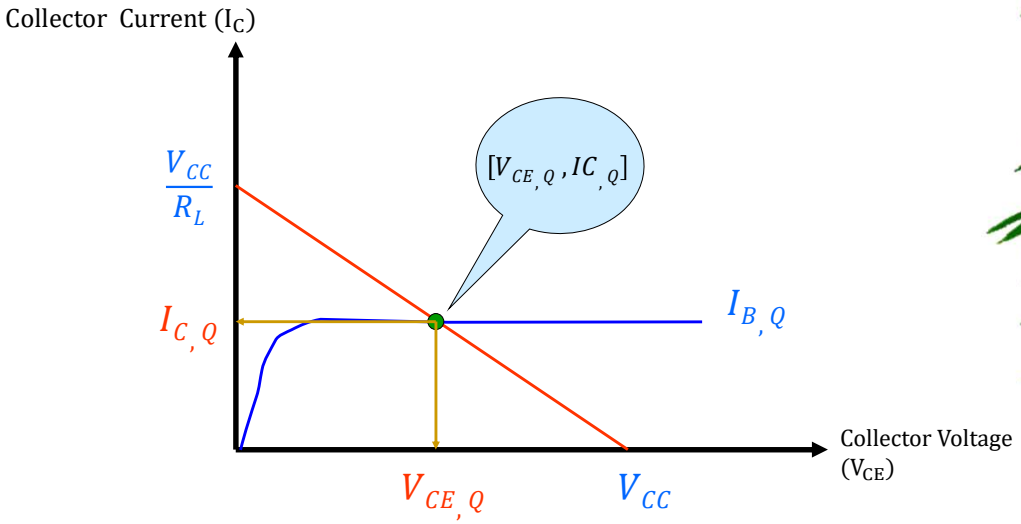
$$Y = m.X + C$$

DC Load Line is KVL in Graphical Form

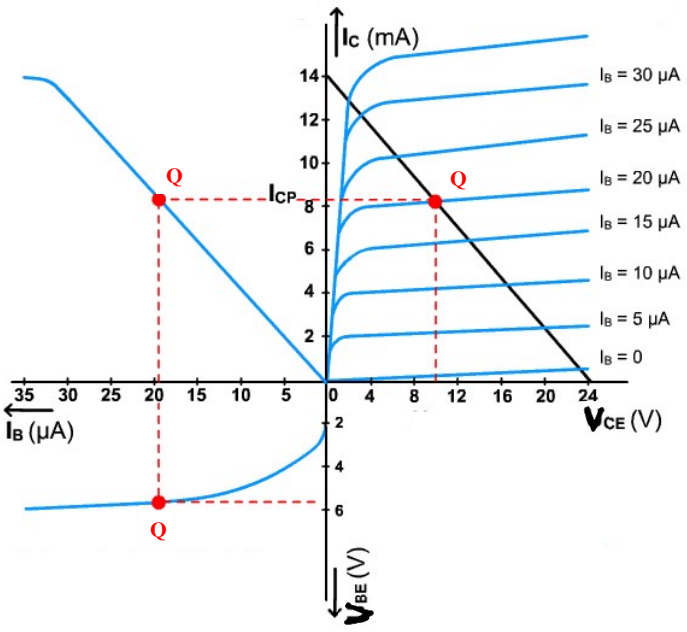


$$I_C = -\left(\frac{1}{R_L}\right) V_{CE} + \left(\frac{V_{CC}}{R_L}\right)$$

Operating Point (Q Point)



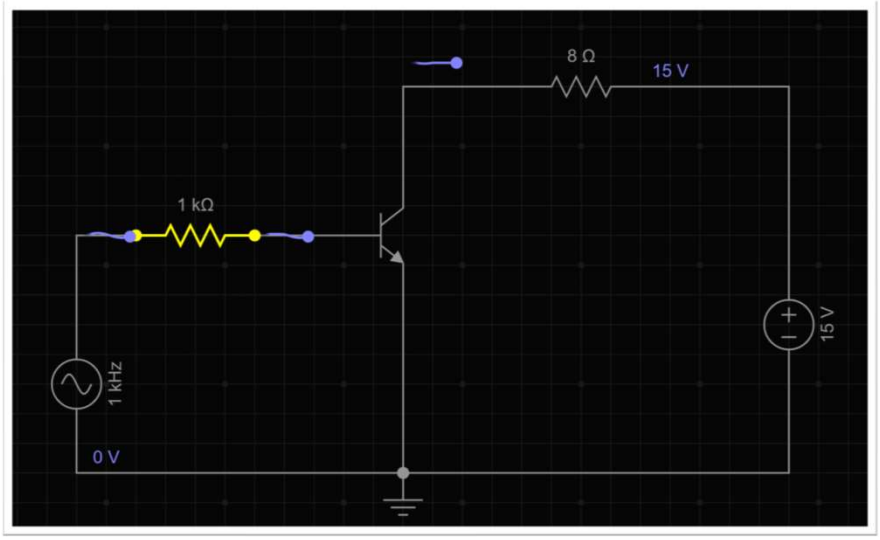
Operating Point (Q Point)



BJT Biasing Techniques

1. Base Bias
2. Fixed Bias
3. Collector Feedback bias
4. Potential Divider Bias

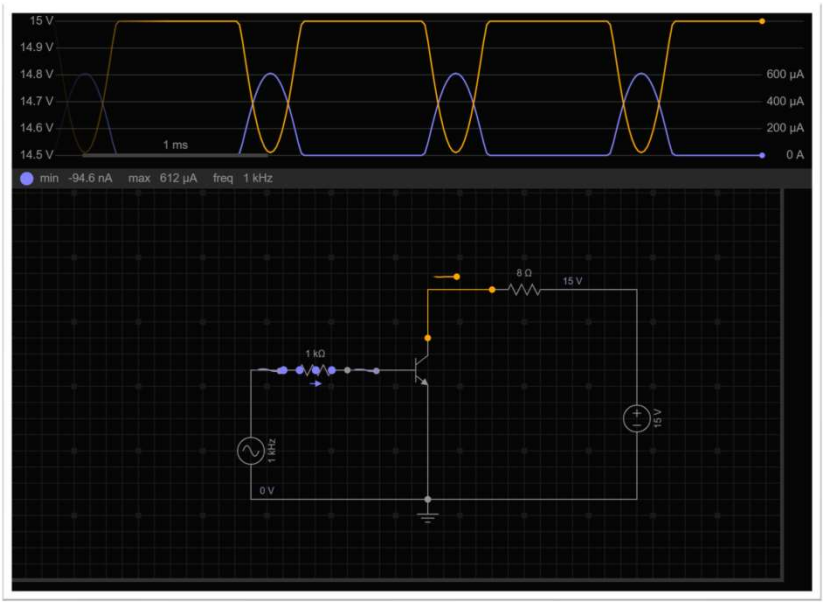
Ex. Find the biasing issue in this circuit



Amplitude 1.5 V

Frequency 1 kHz

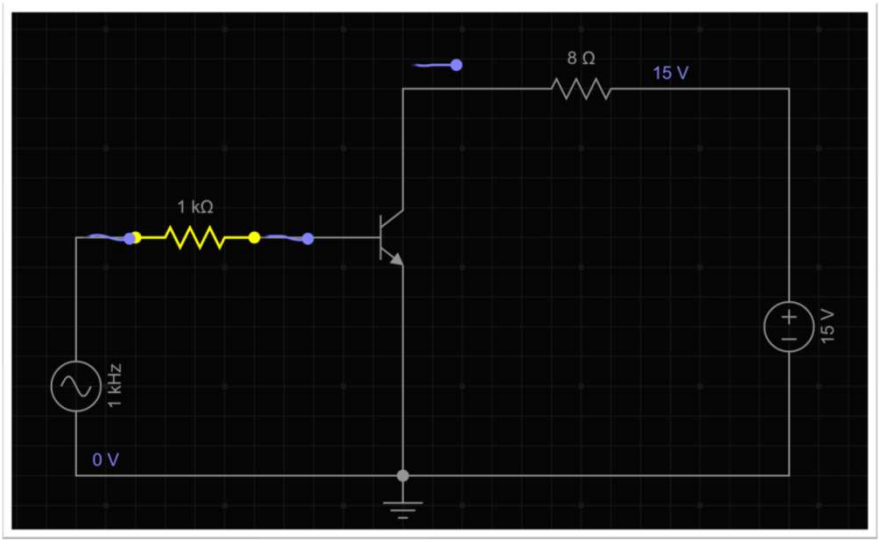
Output is half wave Rectified



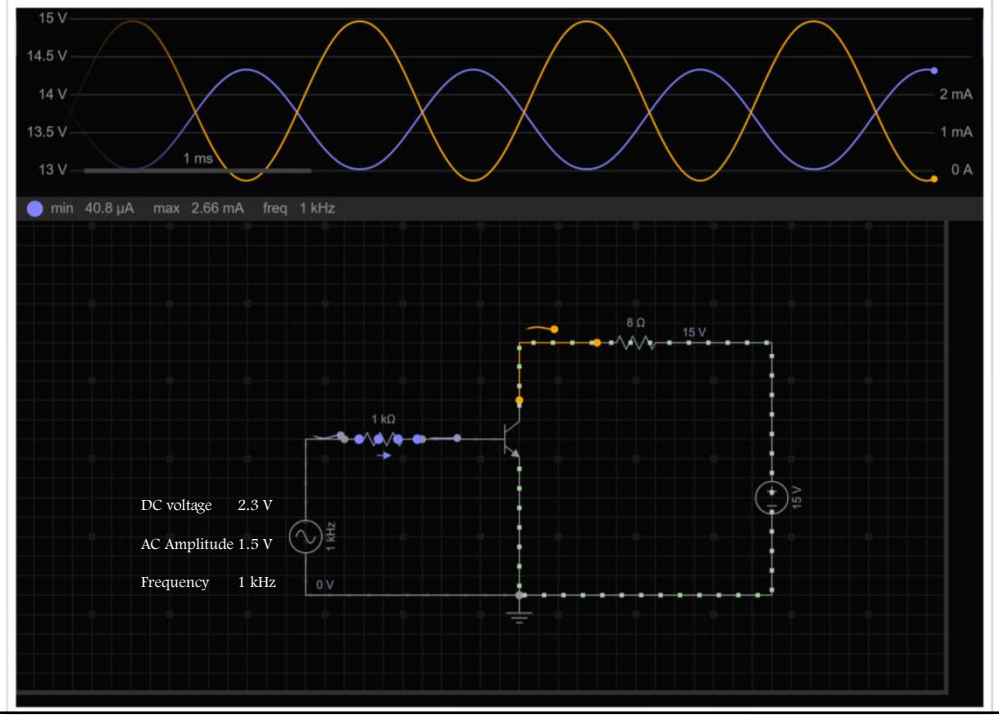
DC Bias of BJT Junctions

- Transistor must be in its active mode throughout the entire cycle of the input AC signal.
  - This is called 'Class A' operation.
- Solution :
  - Superimpose the small input AC signal on a DC voltage.

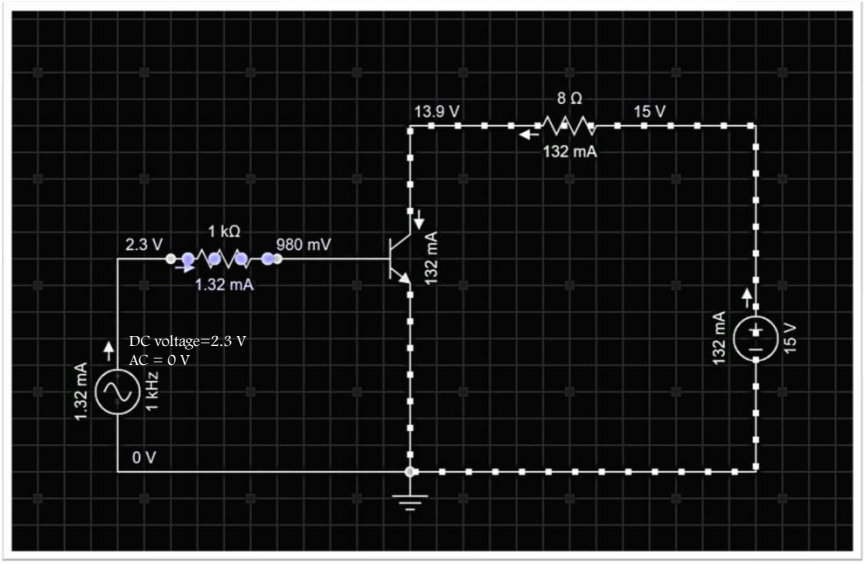
The Base Bias



DC bias 2.3 V
Amplitude 1.5
Frequency 1 kHz

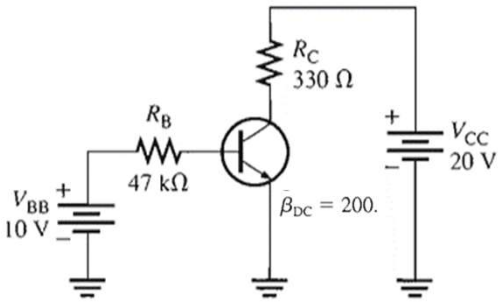


DC Analysis



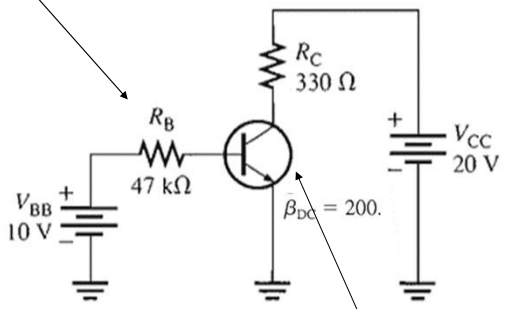
Tutorial Question

Analyze this circuit. Find I_B, I_C and V_{CE} and plot the DC load line



$$I_B = \frac{V_{BB} - V_{BE}}{R_B} = \frac{10 - 0.7}{47} = 198\mu A$$

$$I_C = \beta I_B = (200).(0.198) = 39.6mA$$



$$V_{CE} = V_{CC} - I_C R_C = 20 - (39.6).(330) = 6.93V$$

DC Load Line

$$I_C = -\left(\frac{1}{R_L}\right) V_{CE} + \left(\frac{V_{CC}}{R_L}\right)$$

$$I_C = -\left(\frac{1}{0.33}\right) V_{CE} + \left(\frac{20}{0.33}\right) mA$$

$$I_C = -(3.03)V_{CE} + 39.6mA$$