INDIAN INSTITUTE OF TECHNOLOGY BHUBANESWAR

Introduction to Electronics Laboratory

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Objective:

- **Measuring Input Characteristics of Common Emitter BJT**
- **Measuring Output Characteristics of Common Emitter BJT**
- **Measuring Transfer Characteristics of Common Emitter BJT**
- **Measuring the Base-Emitter Resistance**
- **Measuring the Output Resistance**
- **Measuring the Early Voltage**
- **Measuring the Transconductance**

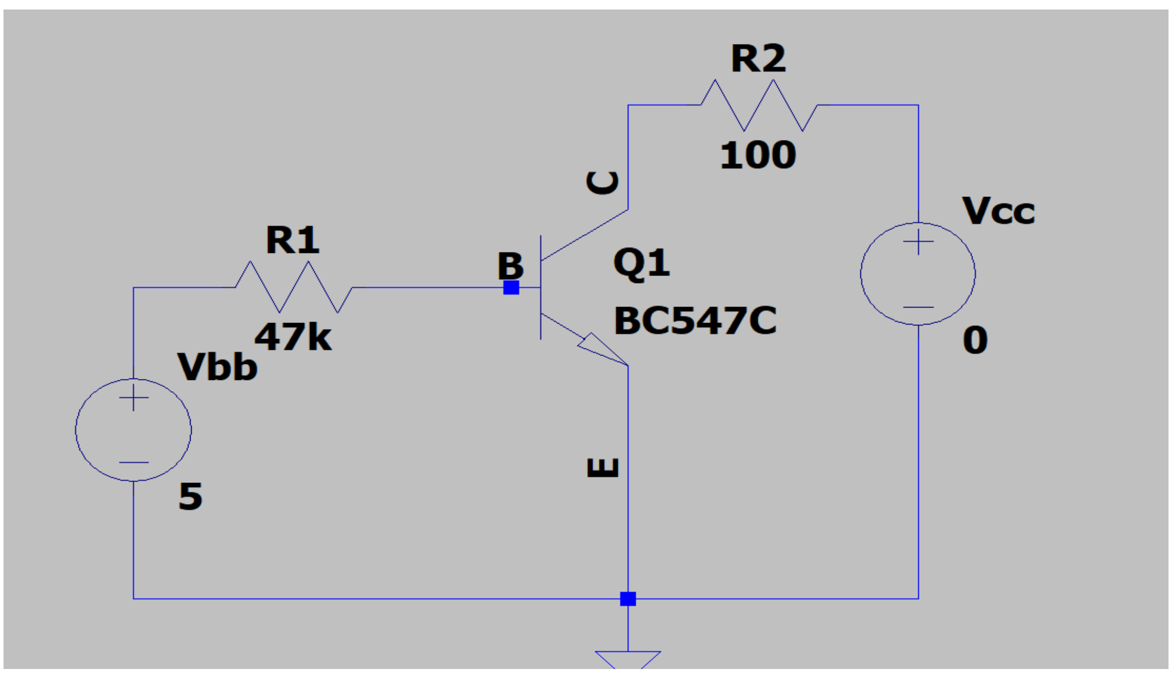
Measuring Input Characteristics:

In this experiment, we will be dealing with Common-Emitter BJT.

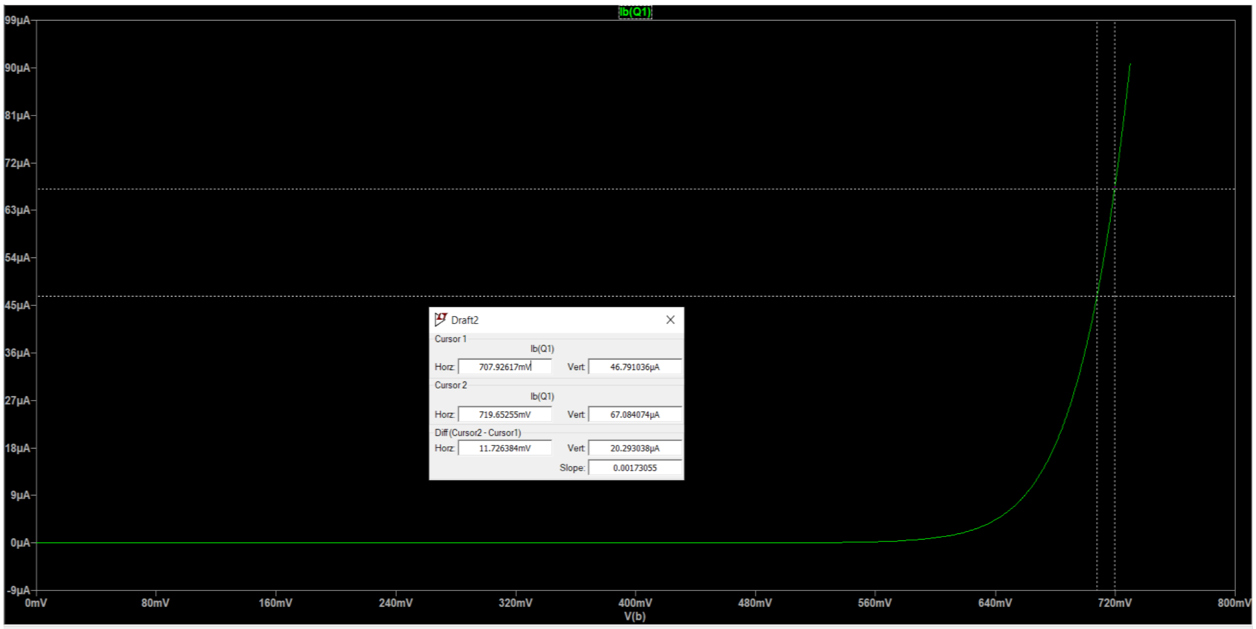
$I_B=I_S e^{Vbe/nVt}$, V_T**=26mV**

$\Delta V_{BE}/\Delta I_B=r_{BE}$= Base-Emitter Resistance

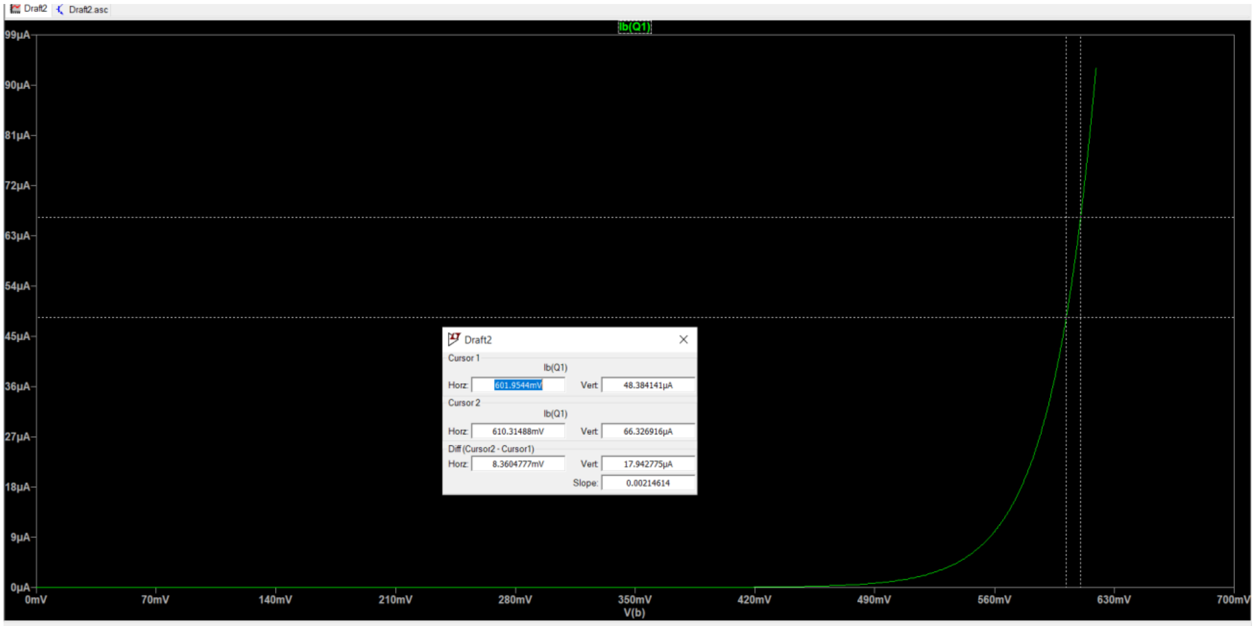
Circuit Diagram:



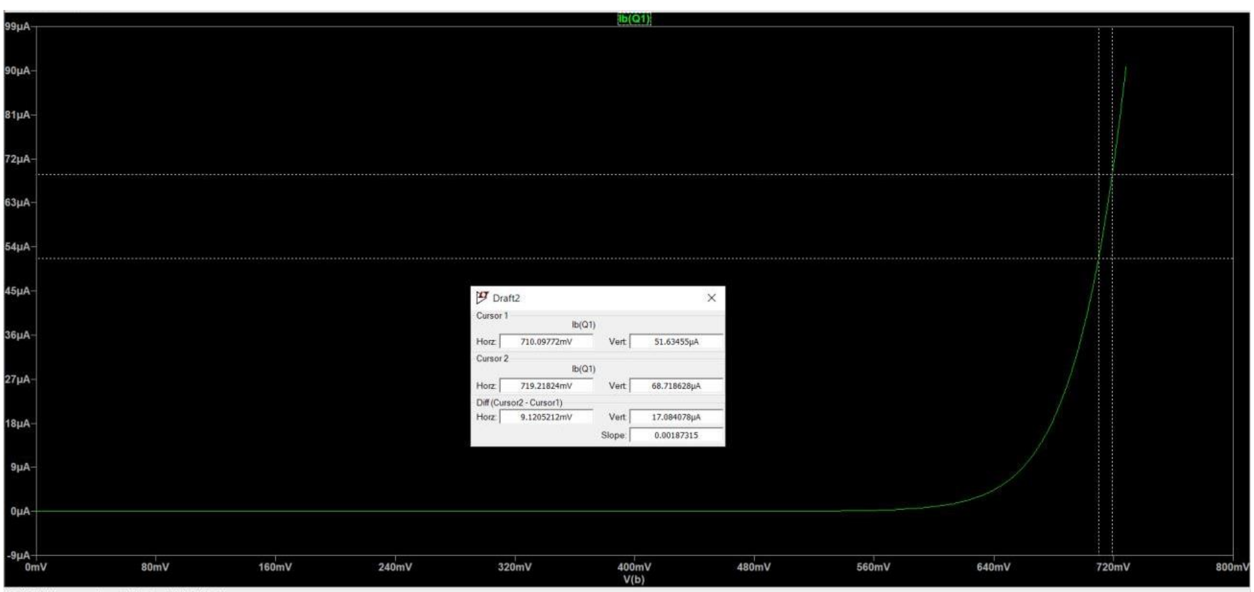
We plotted graph between I_B vs V_{BE} by using DC sweep for V_{BE} and by keeping V_{CC} constant. Here we took 3 different values for V_{CC}.



Here **V_{CC}=20V** ΔV_{BE} =11.726384mV , ΔI_B= 20.293µA and $\Delta V_{BE}/\Delta I_B$= **r_{BE1}= 578ohm.**



Here **V_{CC}=0V** ΔV_{BE}= 8.360477mV , ΔI_B= 17.942775µA and $\Delta V_{BE}/\Delta I_B$**= r_{BE2}=466ohm**.



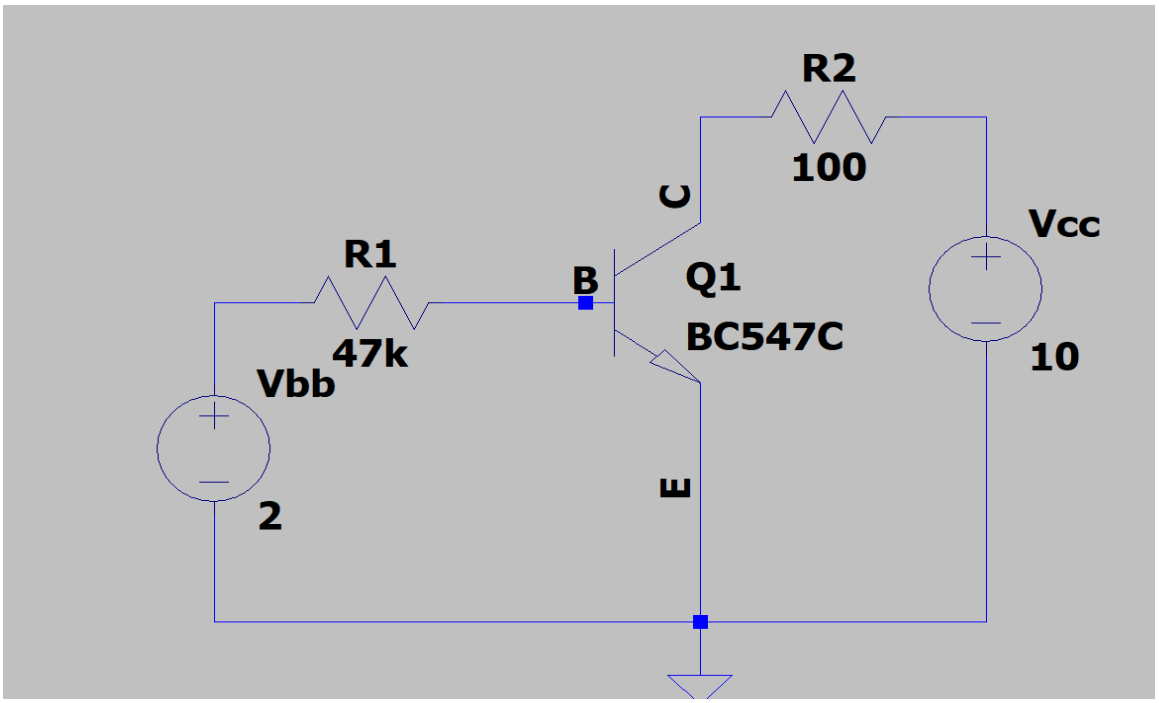
Here **V_{CC}=10V** ΔV_{BE}= 9.12mV , ΔI_B= 17.084µA and $\Delta V_{BE}/\Delta I_B$=**r_{BE3}=533.8ohm**.

Measuring Output Characteristics:

$I_c=I_S e^{Vbe/nVt}(1+ V_{CE}/V_A)$, V_A=Early Voltage.

But ideally V_A is very large .So , $I_c=I_S e^{Vbe/nVt}$.

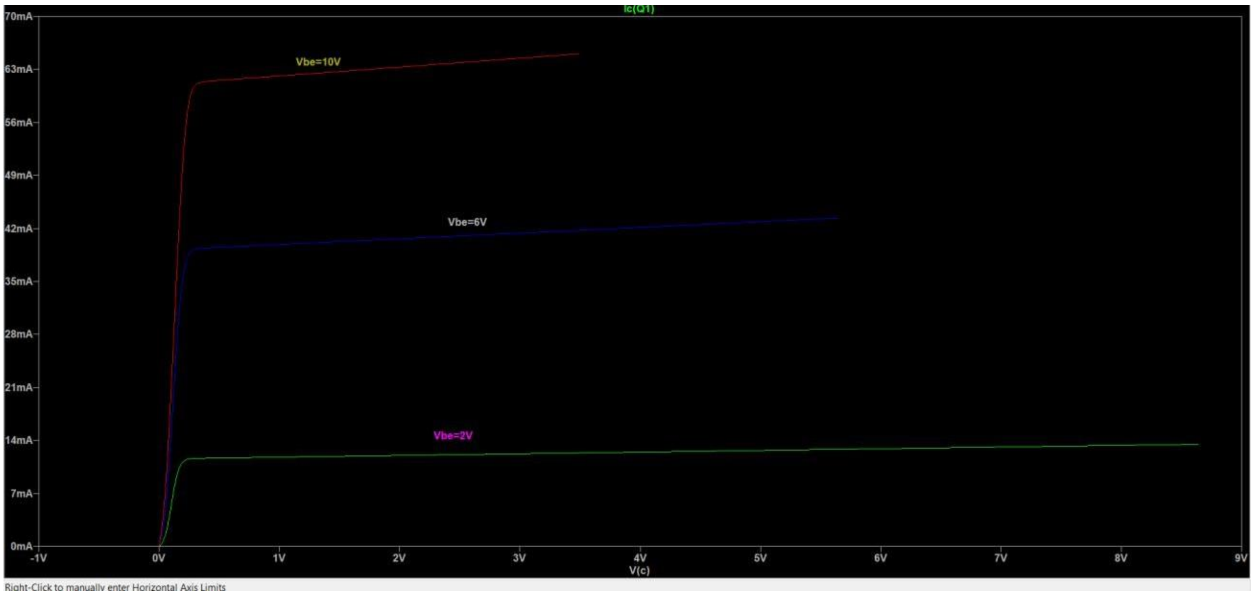
Circuit Diagram:

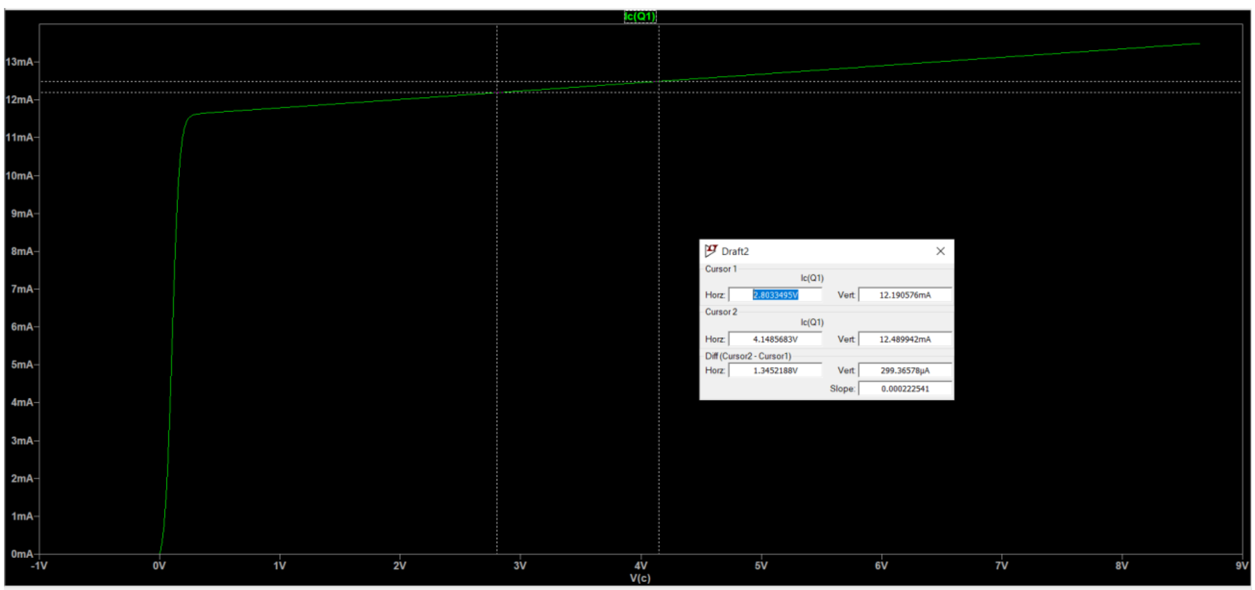


Here we will be using DC sweep for V_{CC} and keep V_{BE} as constant. We will be plotting output characteristics by taking 3 different values for V_{BB}.

And $\mathbf{r_O= \Delta V_{CE}/\Delta I_C = V_A/I_C}$ = output resistance.

I_C vs V_{CE}



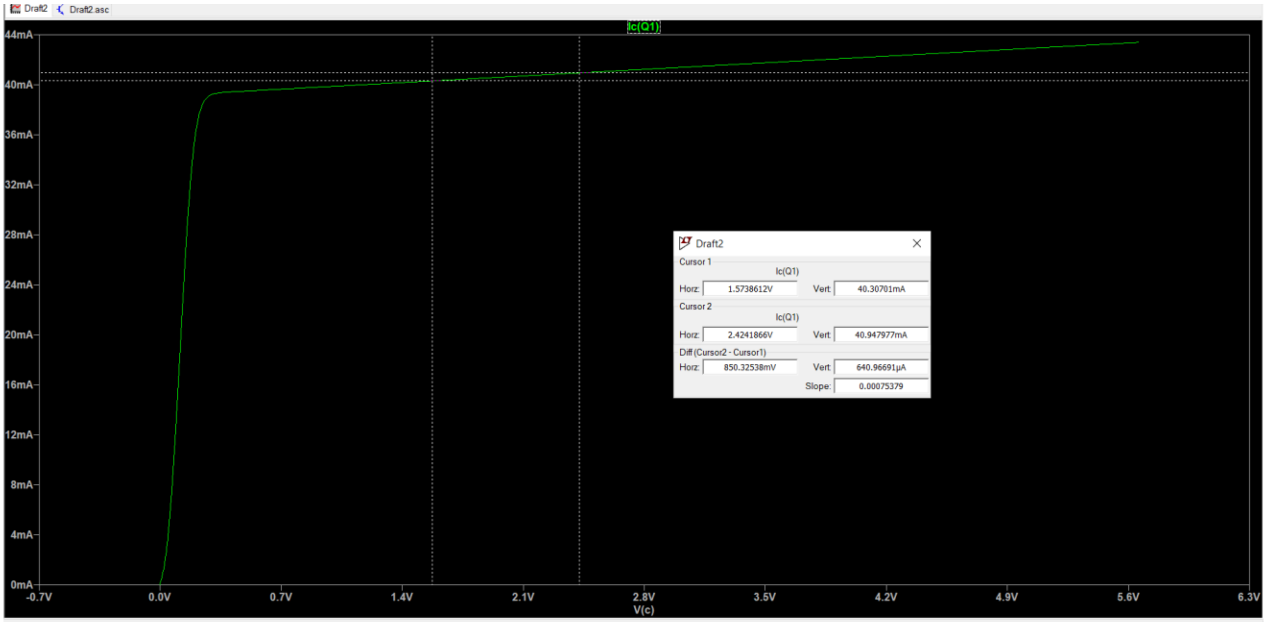


Here $\mathbf{V_{BB}=2V}$ ΔV_{CE}=1.3452V, ΔI_C=299.365µA and $\Delta V_{CE}/\Delta I_C$= $\mathbf{r_O}$**=4493.55ohm .**

We can measure Early voltage by taking the linear part of the graph.

I_C - 12.19mA = slope x (V_{CE} - 2.8033V) and it cuts x-axis at $-V_A$.

So, by keeping I_C=0 we get V_{CE}= -51.97V . So, the Early Voltage **V_A= 51.97V.**

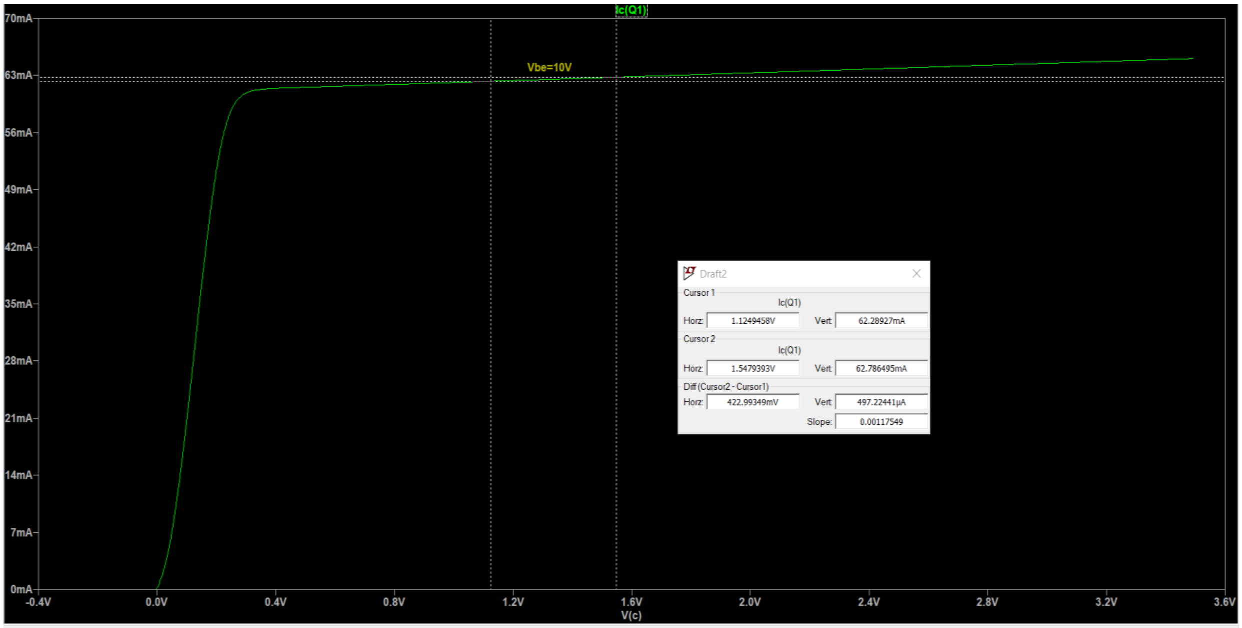


Here **V_{BB}=6V** ΔV_{CE}= 0.85V, ΔI_C= 640.9µA and $\Delta V_{CE}/\Delta I_C$= **r_O= 1326.63ohm .**

We can measure Early voltage by taking the linear part of the graph.

I_C- 40.307mA = slope x (V_{CE} – 1.5738V) and it cuts x-axis at -V_A.

So, by keeping I_C=0 we get V_{CE}= -51.89V . So, the Early Voltage **V_A= 51.89V.**



Here $\mathbf{V_{BB}}$**=10V** ΔV_{CE}= 0.423V, ΔI_C= 497.224µA and $\Delta V_{CE}/\Delta I_C$= $\mathbf{r_O}$**= 850.71ohm .**

We can measure Early voltage by taking the linear part of the graph.

$\mathbf{I_C}$**- 62.289mA = slope x (**$\mathbf{V_{CE}}$ **– 1.12V)** and it cuts x-axis at -V_A.

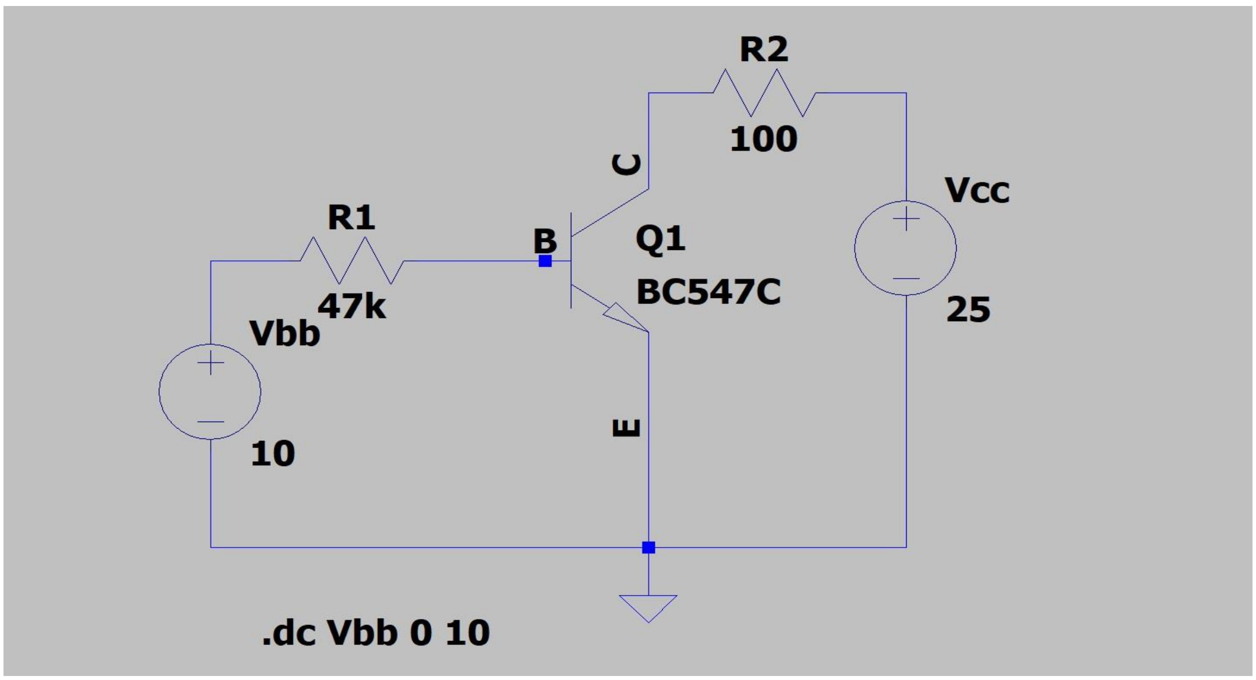
So, by keeping I_C=0 we get V_{CE}= -51.86V . So, the Early Voltage $\mathbf{V_A}$**= 51.86V.**

Measuring Transfer Characteristics:

Here the plot is between I_C and V_{BE}.

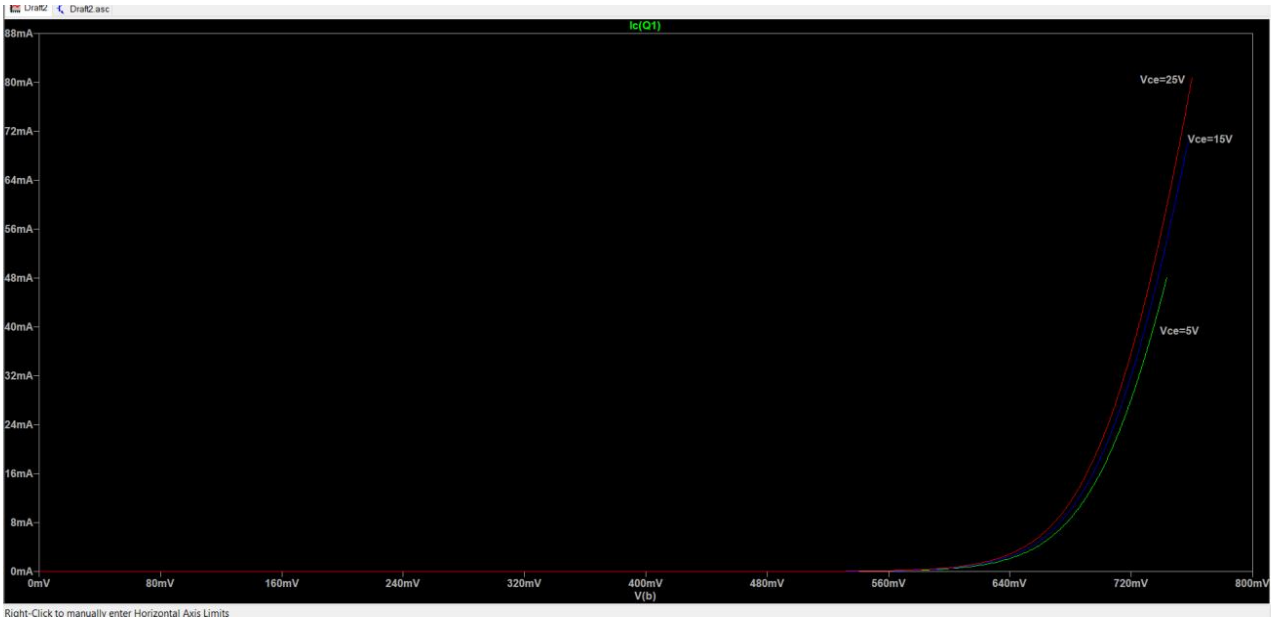
$\Delta I_C/\Delta V_{BE} = g_m$ = Transconductance.

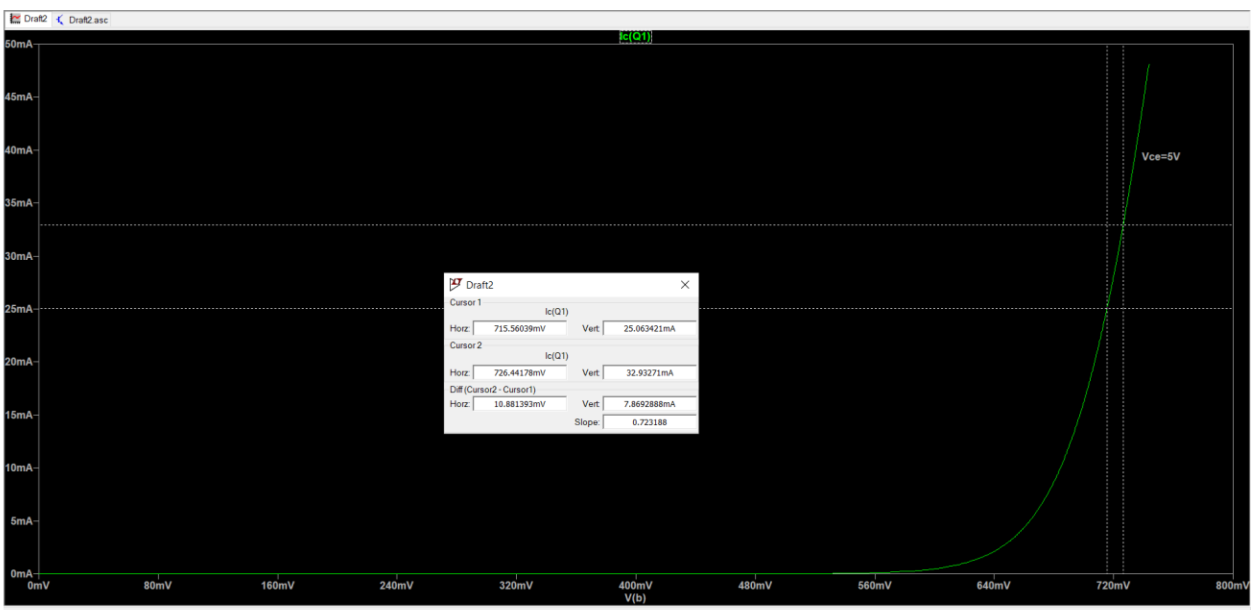
Circuit Diagram:



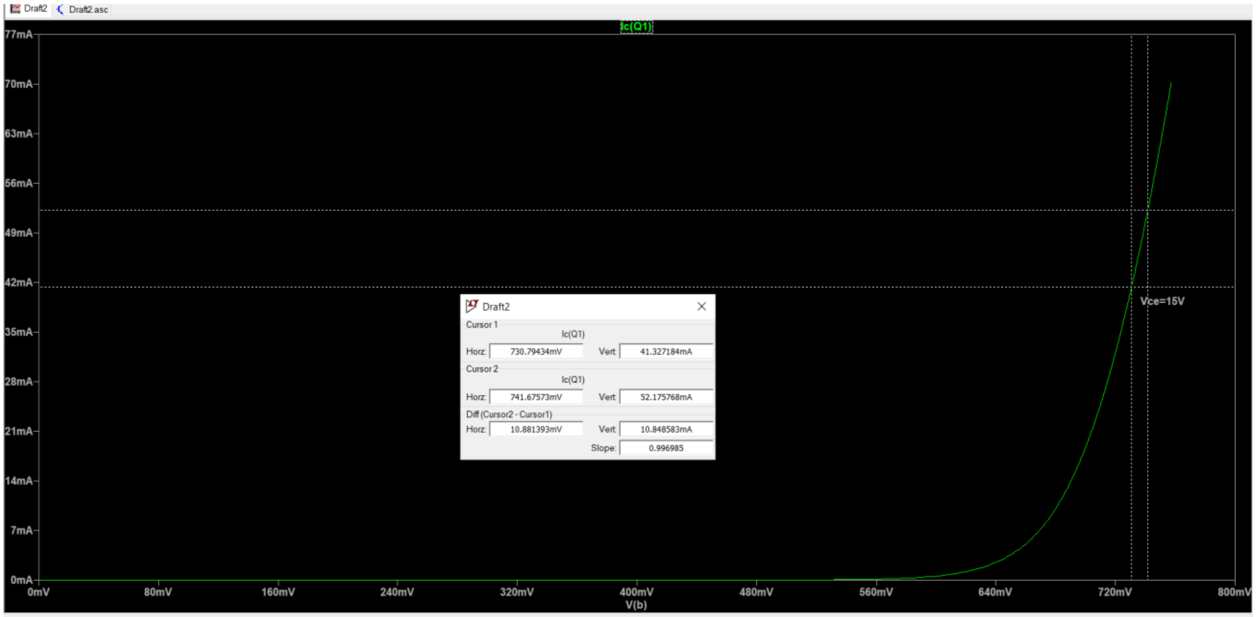
Here we will be using DC sweep for V_{BB} and keeping V_{CE} as constant. We will be plotting transfer characteristics by taking 3 different values of V_{CC} and finding transconductance in each case.

I_C vs V_{BE}

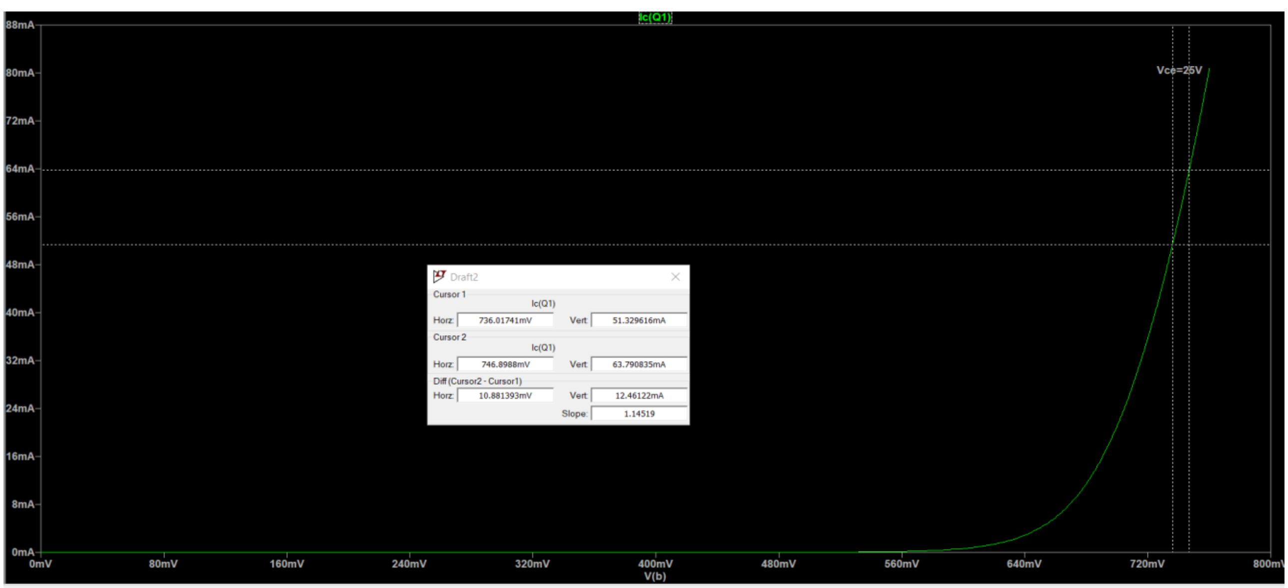




Here **V_{CC}=5V** and ΔI_C = 7.869mA , ΔV_{BE}= 10.88mV **g_{m1}= $\Delta I_C/\Delta V_{BE}$ = 723.188 mA/V**



Here V_{CC}**=15V** and ΔI_C = 10.848mA, ΔV_{BE}= 10.88139mV $\mathbf{g_{m2}= \Delta I_C/\Delta V_{BE} = 996.9\ mA/V}$



Here V_{CC}**=25V** and ΔI_C = 12.4612mA, ΔV_{BE}= 10.881393mV $\mathbf{g_{m3}= \Delta I_C/\Delta V_{BE}=1145.2mA/V}$

CONCLUSION:

In 1st part (input characteristics), we got the Base-Emitter Resistance values as

R_{BE1}=466ohm for **V_{CC}=0V**

R_{BE2}= 533.8ohm for **V_{CC}=10V**

R_{BE3}= 578ohm for **V_{CC}=20V**

So, from this we understand that as we increase the constant V_{CC} value the Base-Emitter resistance increases which indicates slope($1/R_{BE}$) decreases in the linear part of the graph. So, the graph with higher V_{CC} will be less steep.

In Output Characteristics, we got the output resistance and early voltage values as

R_{O1}= 4493.55ohm, V_{A1}=51.97V for **V_{BB1}=2V**

R_{O2}= 1326.63ohm, V_{A2}=51.89V for **V_{BB1}=6V**

R_{O3}= 850.71ohm, V_{A3}=51.86V for **V_{BB1}=10V**

As the constant V_{BB} is increasing output resistance is decreasing. We also have relation that $R_O= \Delta V_{CE}/\Delta I_C= V_A/I_C$. We can clearly observe that the early voltages for different values of V_{BB} are almost same and equal to **$V_A \approx 52V$.**

So this means that when the linear part of the plots are extended they cut the –ve x-axis at same point.

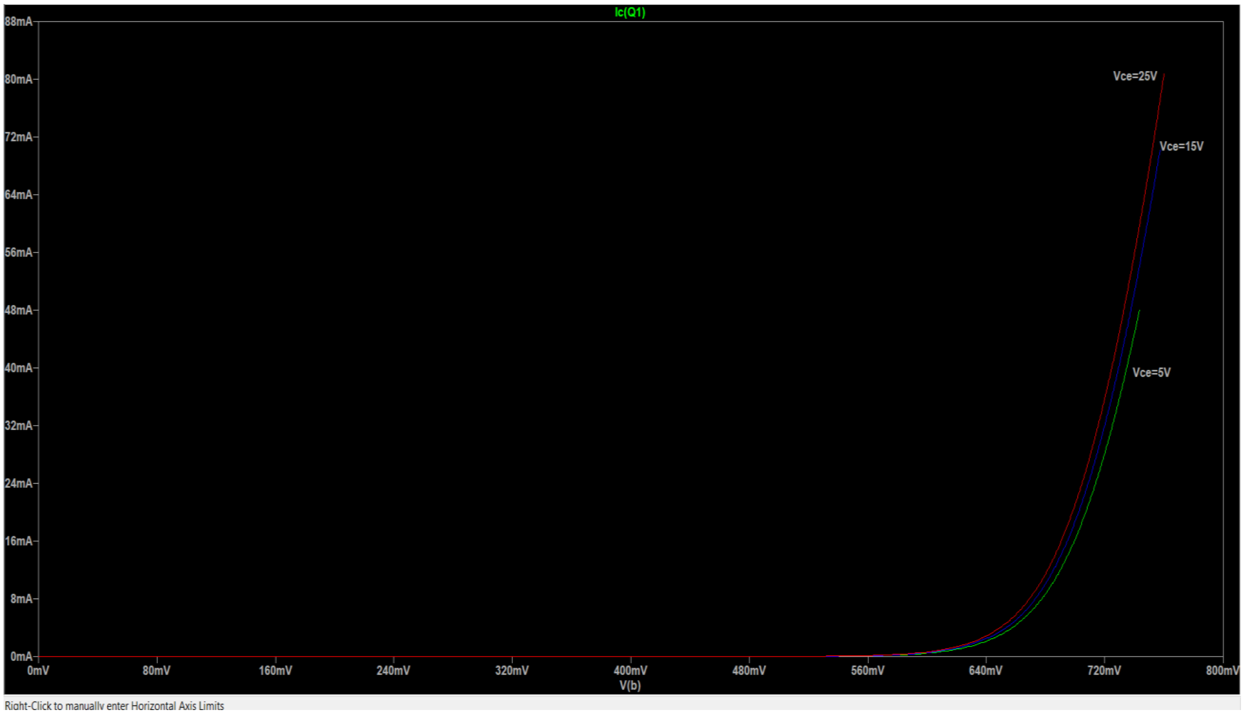
Finally, in transfer characteristics, we got the transconductance values as

g_{m1}= 723.188 mA/V for V_{CC}=5V

g_{m2}= 996.9mA/V for **V_{CC}=15V**

g_{m3}= 1145.2mA/V for V_{CC}=25V

We can observe that as we increase the constant V_{CC} the transconductance increases which implies graph with higher V_{CC} is more steeper and we can verify it from the graph below.


Ic(Q1)
88mA
80mA
72mA
64mA
56mA
48mA
40mA
32mA
24mA
16mA
8mA
0mA
0mV
80mV
160mV
240mV
320mV
400mV
480mV
560mV
640mV
720mV
800mV
V(b)
Vce=25V
Vce=15V
Vce=5V
Right-Click to manually enter Horizontal Axis Limits