LAB REPORT-3

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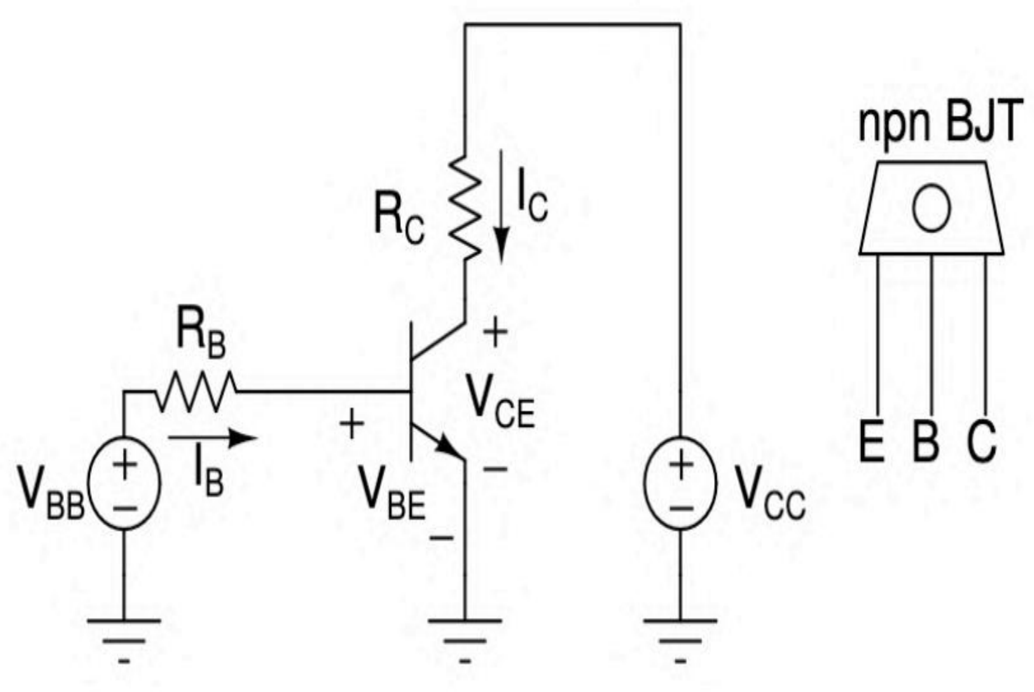
BJT Characterization

1.BJT Characterization:

we constructed the circuit as below diagram.

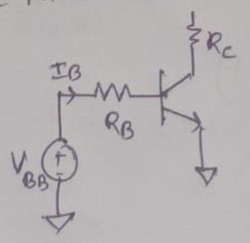


Our aim is to observe and plot the current-voltage (i-v) characteristics exhibited by the transistor.

By using Acquire button and x-y mode in oscilloscope,
plot V(be) (Channel 2) (Y-axis) vs V(bb) (Channel 1) (X-ais) for V(bb) = 0 V to V(bb) = 4 V .
And for sweeping V(bb), we use a sinusoidal signal from ‘Wave-gen’ (V(peak to peak) = 4 V and offset = 2 V).

1. V_{BE} vs I_B plot :

We know oscilloscope plot only voltages,



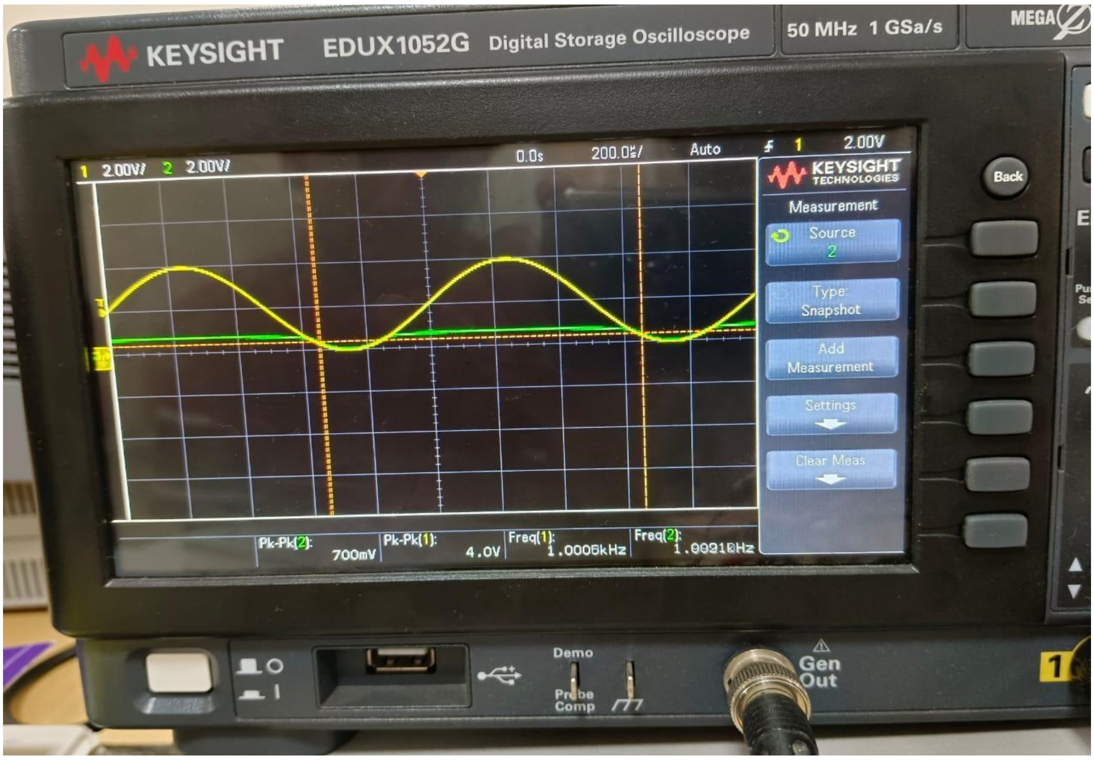
KVL :

$$0 + V_{BB} - I_B R_B = V_{BE}$$

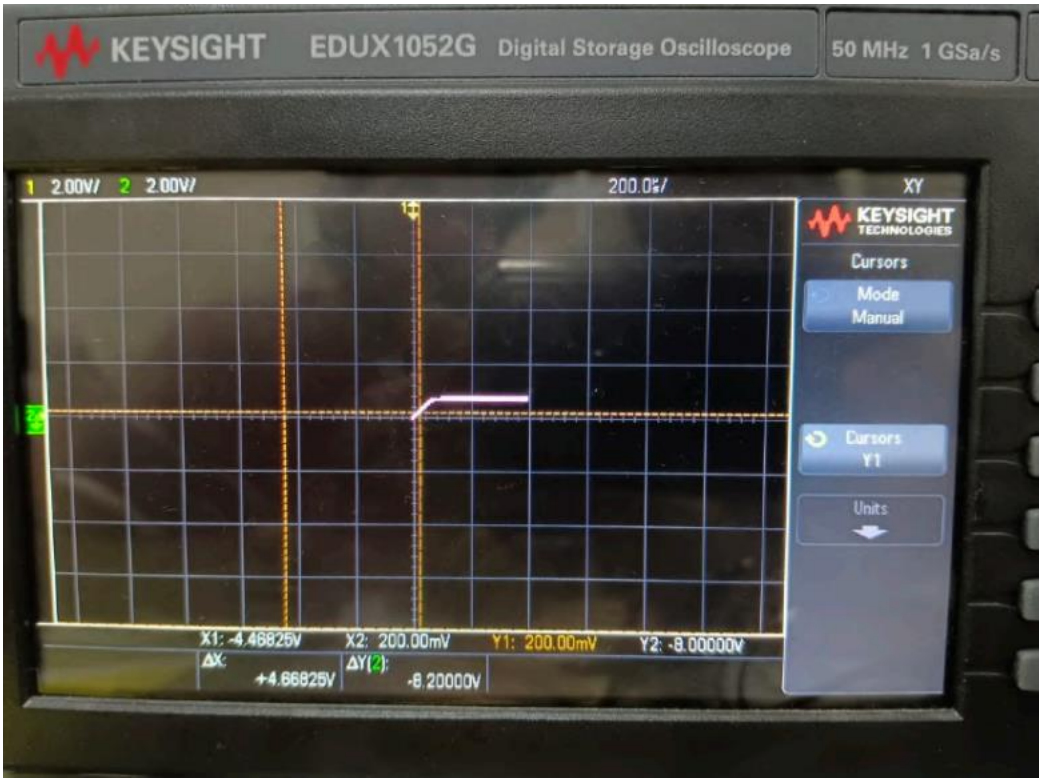
$$\boxed{I_B = \frac{V_{BB} - V_{BE}}{R_B}}$$

∴ $I_B \propto V_{BB}$. We calculate I_B from plot of V_{BB} & V_{BE}.

VBE vs VBB:

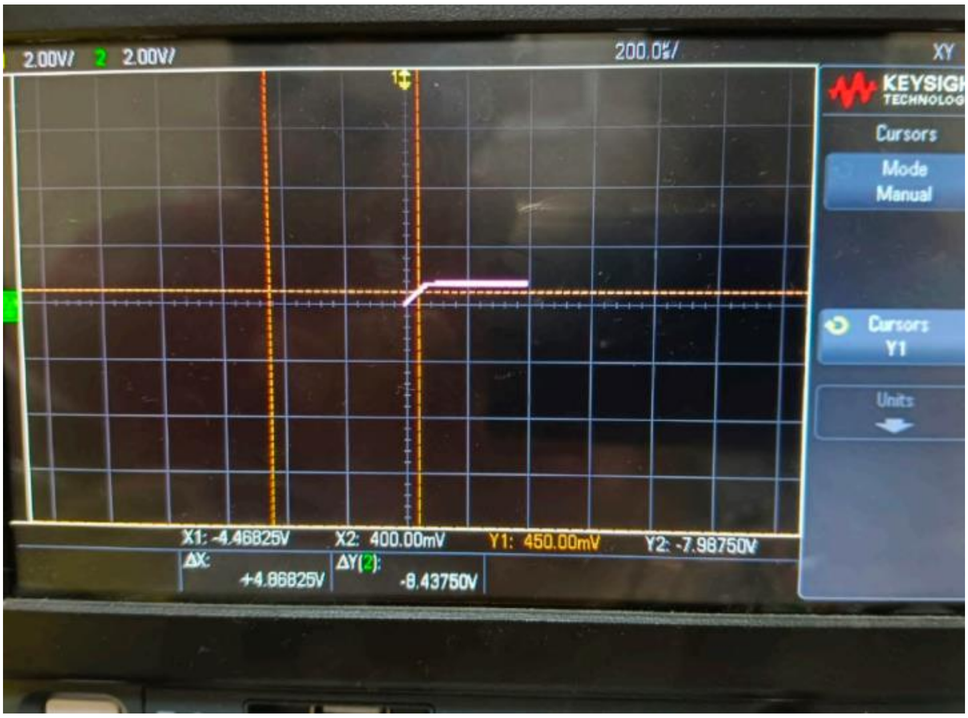


VBB=200mv;VBE=275mv.

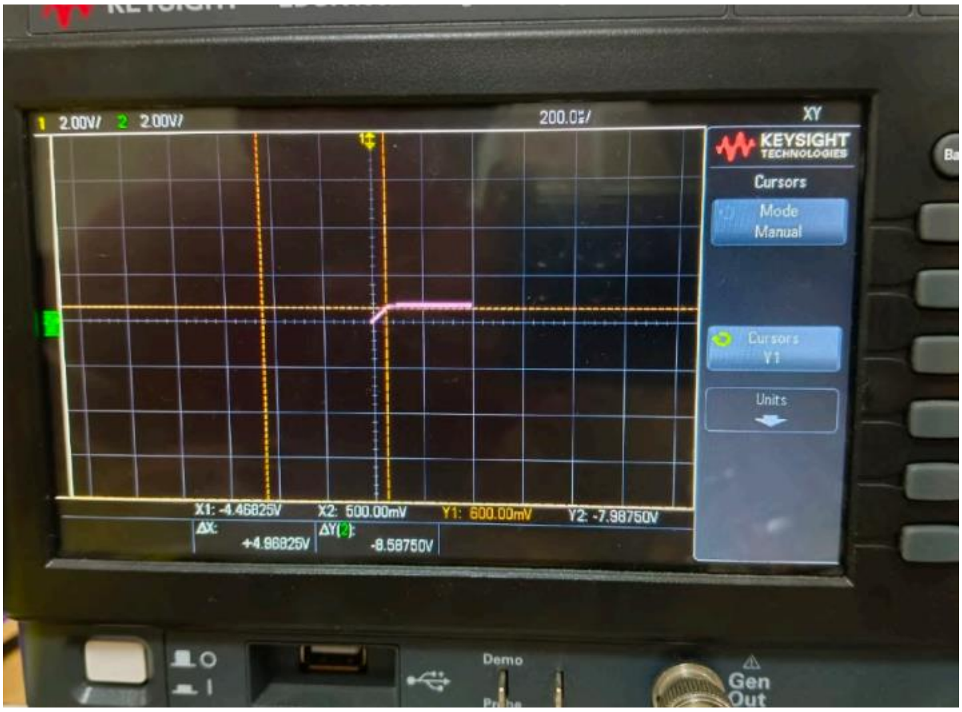


VBB=300mv;VBE=400mv.

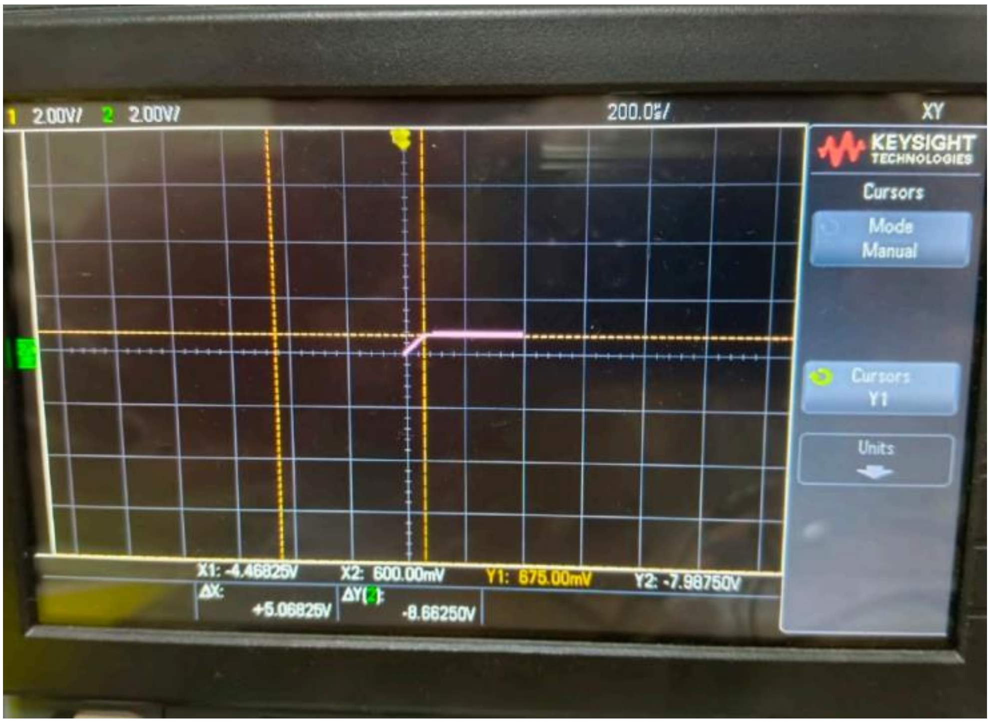
VBB=400mv;VBE=450mv.



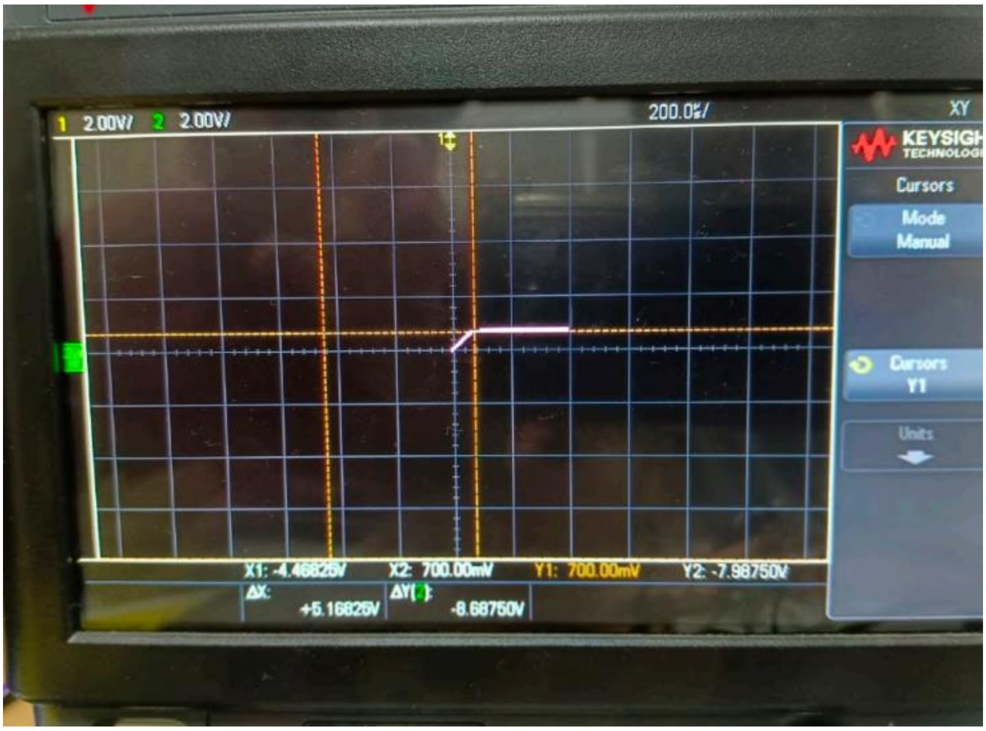
VBB=500mv;VBE=600mv.



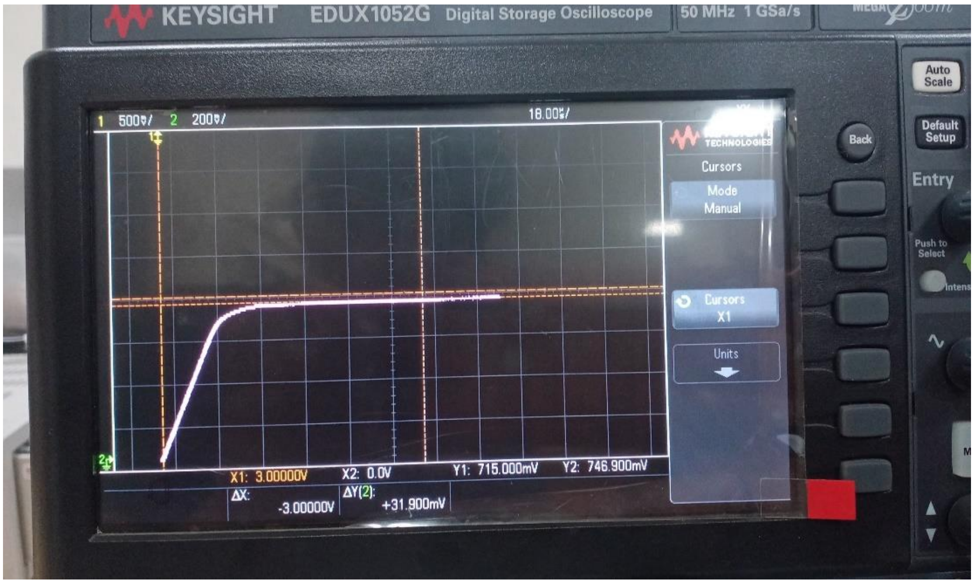
VBB=600mv;VBE=675mv.

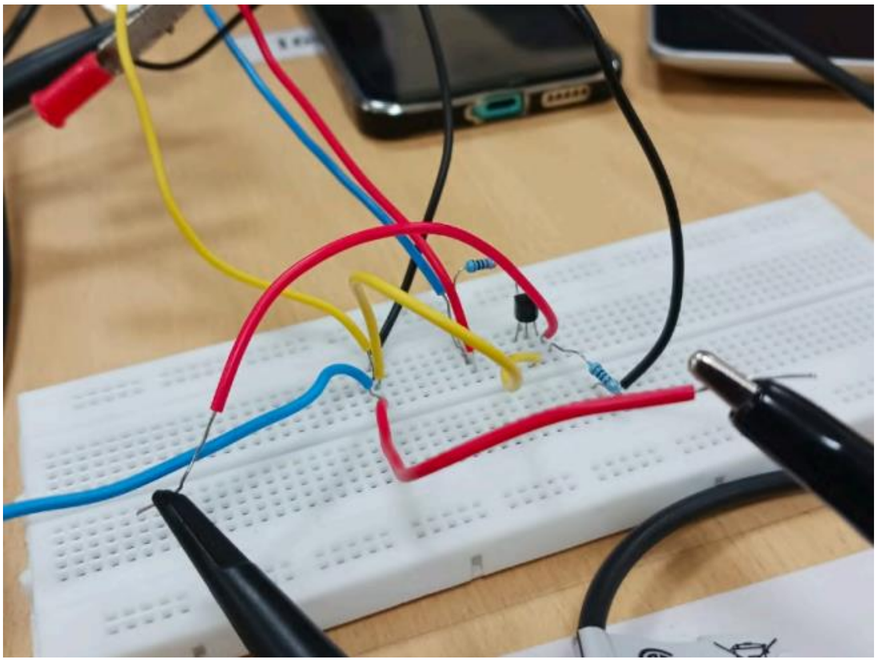


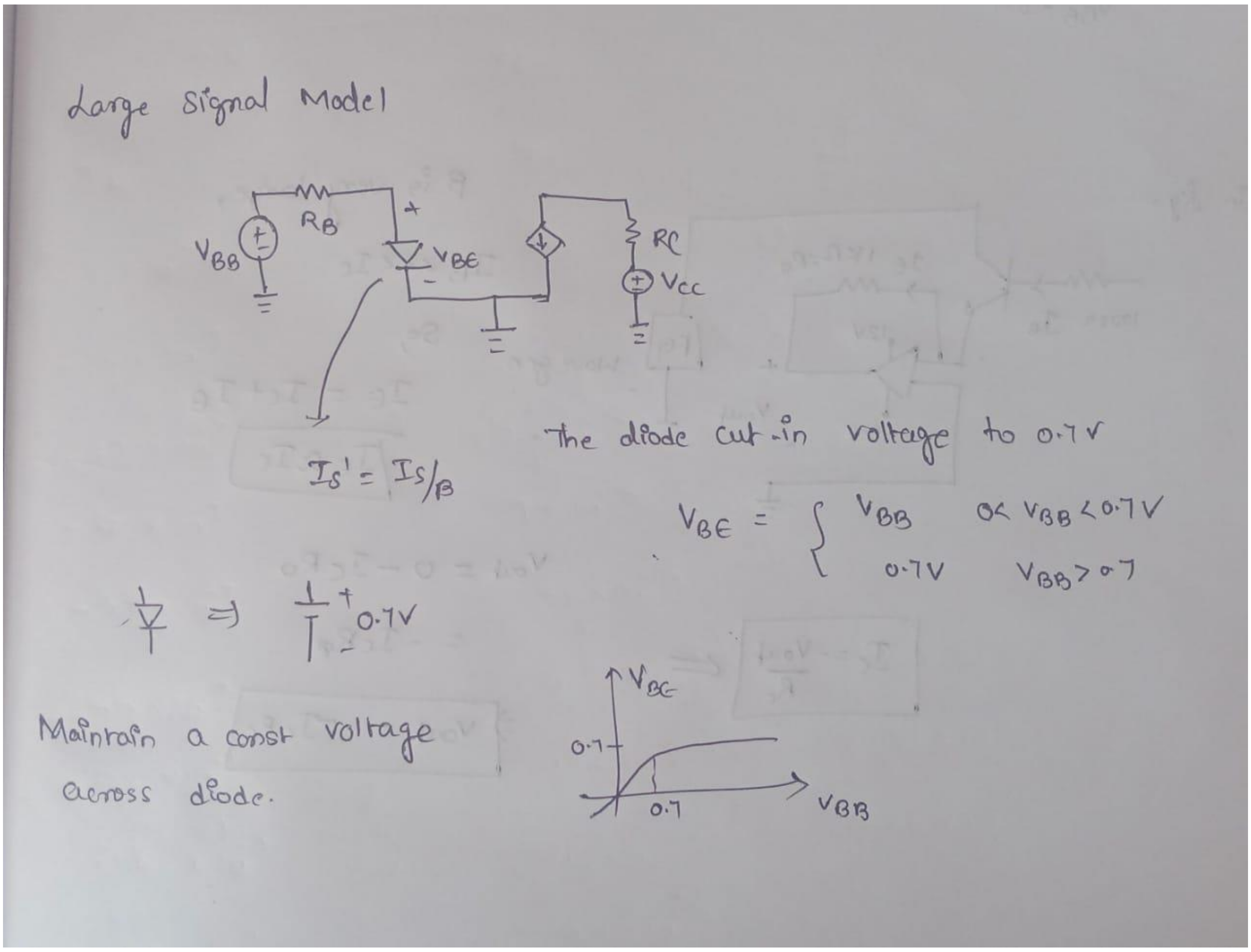
V(bb)=700mV ; V(be)=700mV



V(bb)=3V ; V(be)=715mV







Large Signal Model

$I_S' = I_S/\beta$

The diode cut-in voltage to 0.7V

$$V_{BE} = \begin{cases} V_{BB} & 0 < V_{BB} < 0.7V \\ 0.7V & V_{BB} > 0.7 \end{cases}$$

$\Rightarrow$ + 0.7V -

Maintain a const voltage across diode.

VBE vs IB plot:

In oscilloscope we know that we can only plot voltage quantities. However, we can find the value of current by KVL and ohm's law. In our circuit base and collector currents (IB & IC) can be calculated as follows:

IB =(VBB – VBE)/RB ,

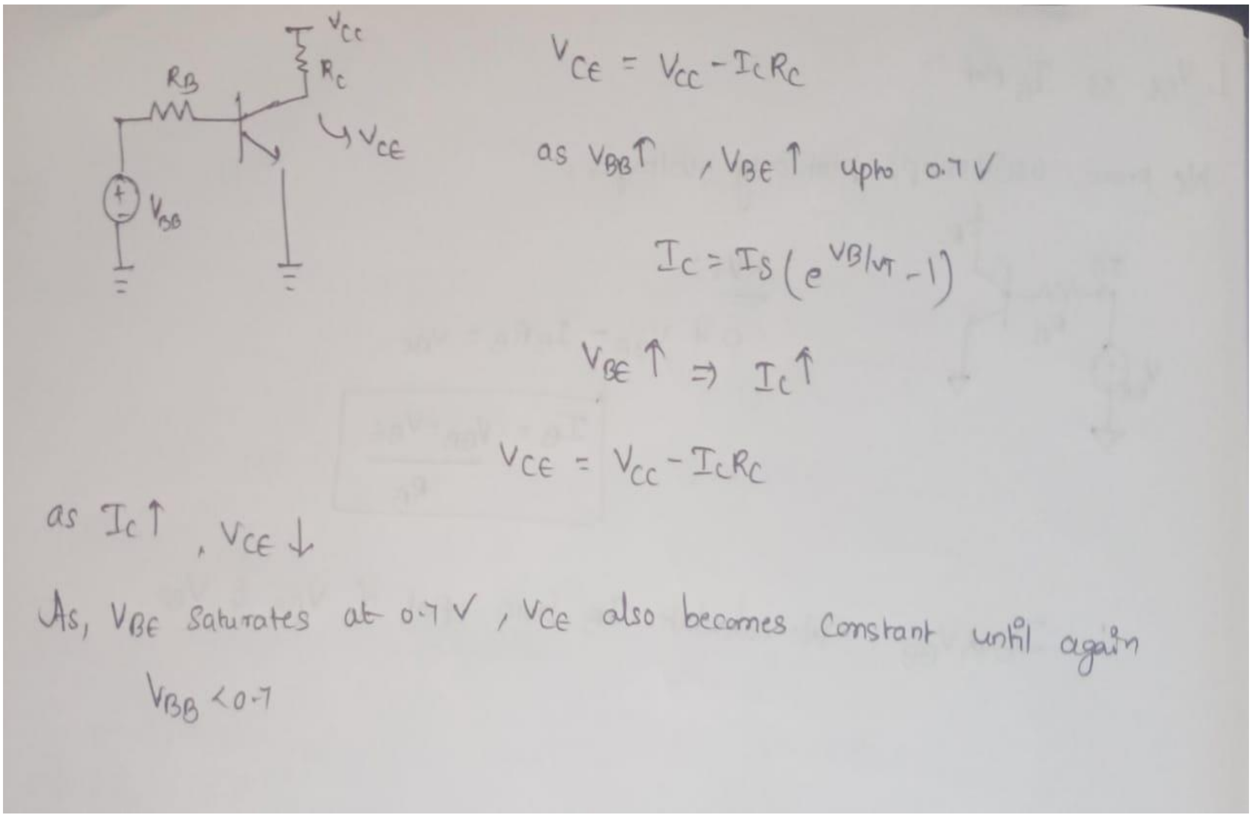
IC =(VCC – VCE)/RC

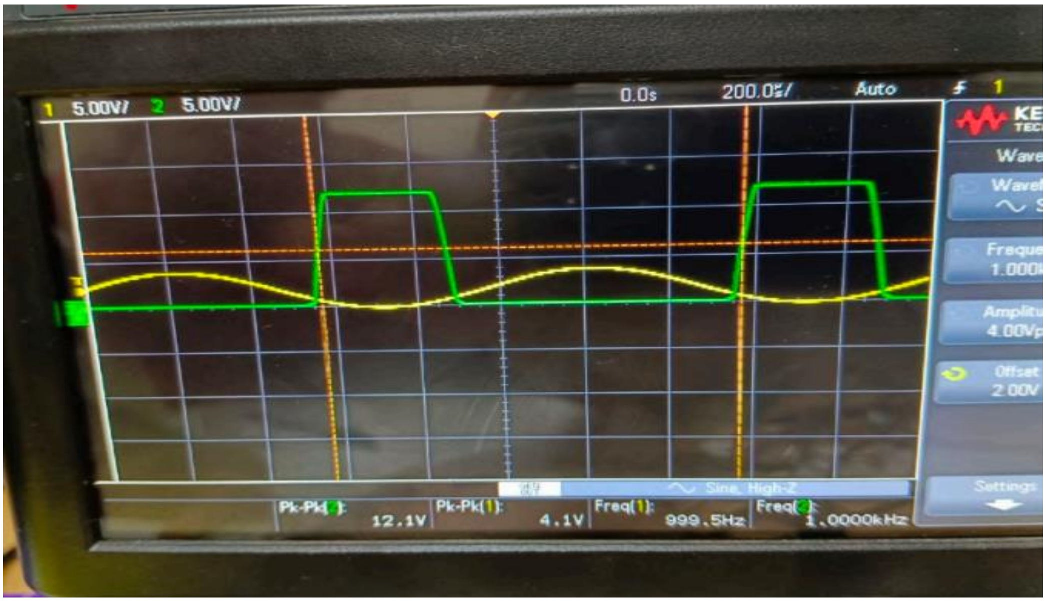
V(bb)	V(be) mV	I(b)(uA)
0.2	200	0
0.3	400	-10
0.4	450	-5
0.5	600	-10
0.6	675	-7.5
0.7	700	0
0.8	700	10
0.9	700	20
1	702	29.7
1.2	710	49
1.4	715	68.5
1.6	725	87.5
1.8	725	107.5
2	725	127.5
3	725	227.5
4	725	327.5

b)

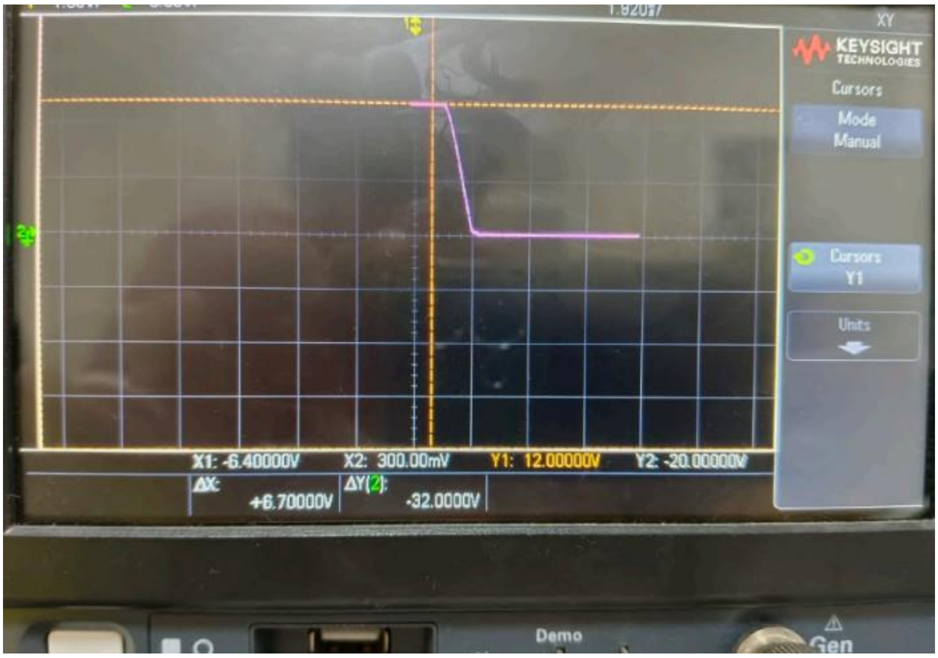
Now plotting VCE (Channel-2) with respect to VBB (Channel 1):

We know that we can't measure circuit currents, we instead plot them against the base input voltage VBB, which is proportional to IB. We generate the following plots by varying the value of VBB from 0 to 4V using a sinusoidal input with a V(peak-peak)= 4V and a DC offset of 2V."

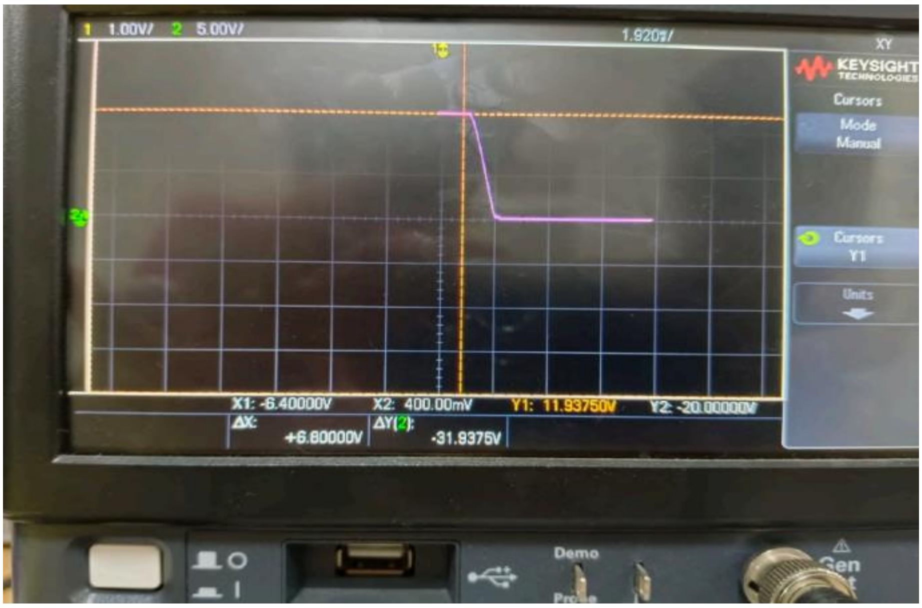




When VBB=300mV, VCE=12V:

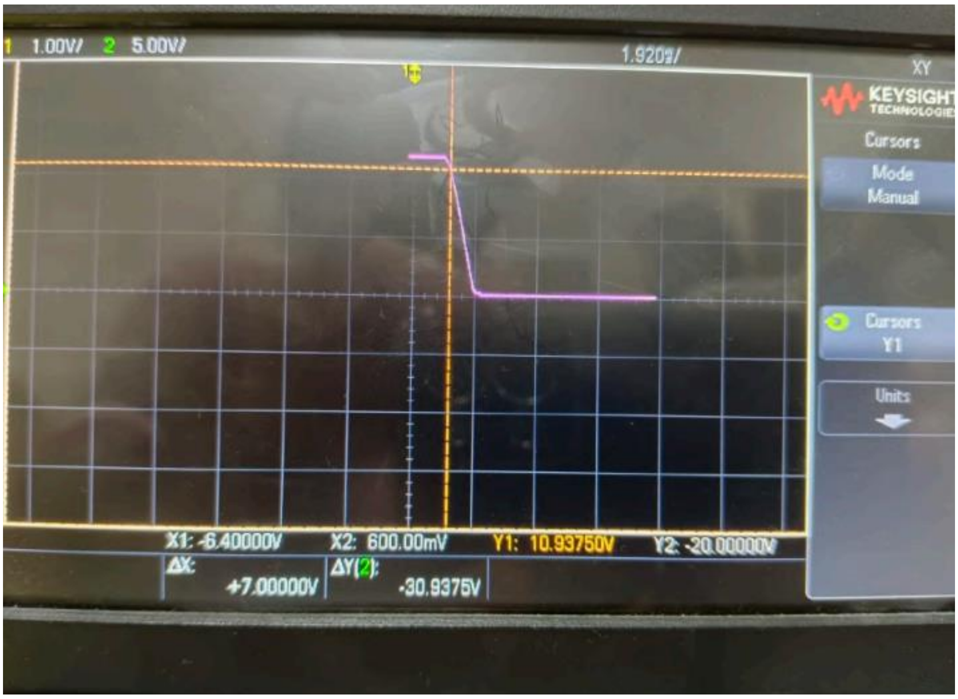


When VBB=400mV, VCE=11.937V:

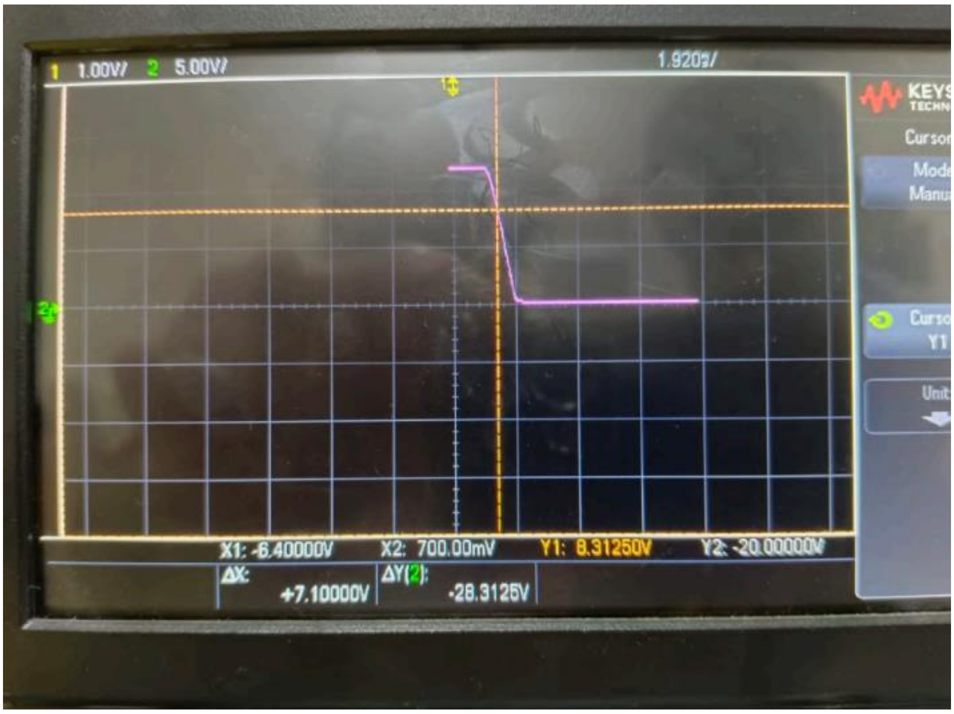


When VBB=500mV, VCE=11.875V:

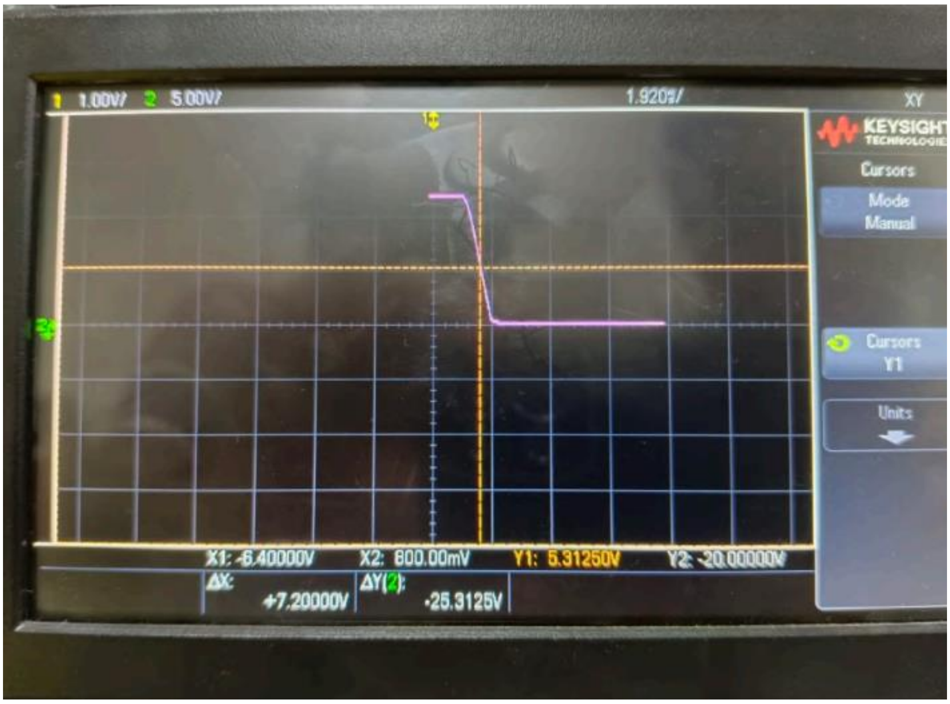
When VBB=600mV, VCE=10.9375V :



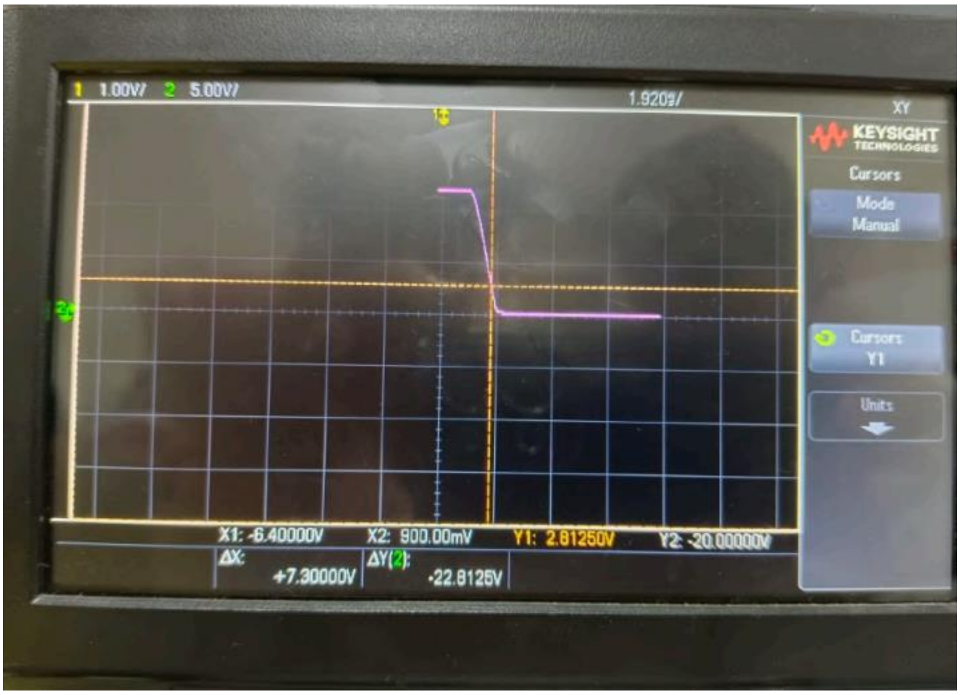
When VBB=700mV, VCE=8.3125V:



When VBB=800mV, VCE=5.3125V:

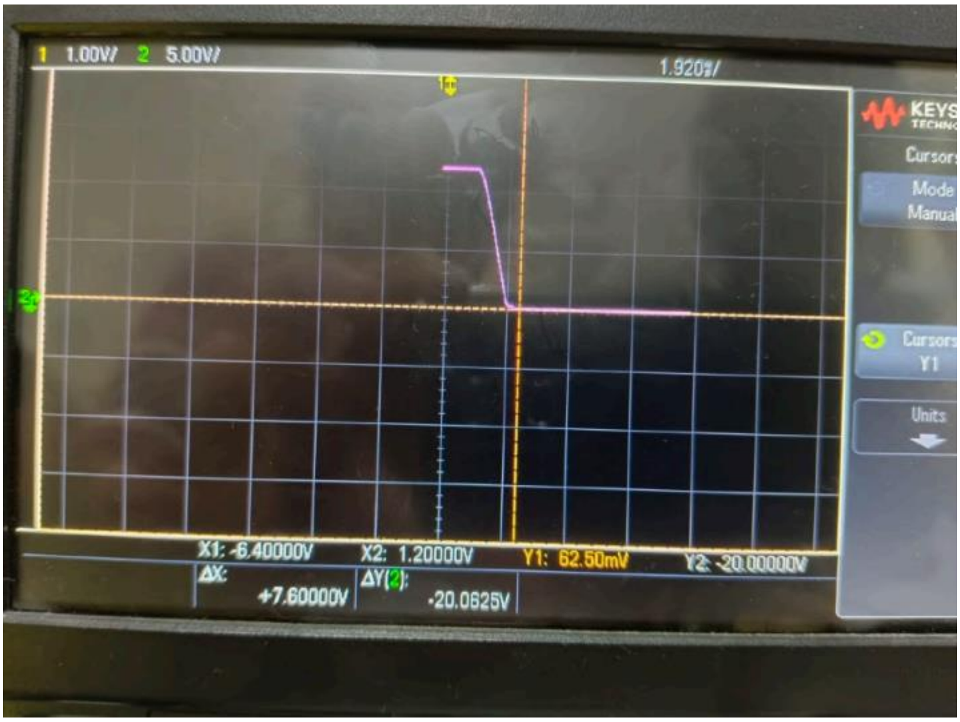


When VBB=900mV, VCE=2.812V



When VBB=1V, VCE=500mV:

When VBB=1.2V, VCE=62.5mV:



V(bb)	V(ce)	I(c) (uA)
0.2	12	0
0.3	12	0
0.4	11.9375	62.5
0.5	11.875	125
0.6	10.9369	1.0625
0.7	8.3125	3.69
0.8	5.3122	6.68
0.9	2.8123	9.19
1	500	11.4
1.2	62.5	11.93
1.4	62.5	11.93
1.6	62.5	11.93
1.8	62.5	11.93

2	62.5	11.93
3	62.5	11.93
4	62.5	11.93

c)
We compiled a table displaying the values of base-emitter voltage (VBE) and collector-emitter voltage (VCE) alongside their corresponding base current (IB) and collector current (IC) values for each VBB. Also calculated the common emitter current gain (β) for each case. The last column indicates the transistor's mode of operation: Using RB=10k,
RC=1k, IB =(VBB – VBE)/RB ,
IC =(VCC – VCE)/RC ,Vcc=12v;(VBB is in mv.) we get:

The output of 1^{st} experiment are entered in following table.::--

V(bb)	V(be) mV	I(b)(uA)	V(ce)	I(c) (uA)	B(beta)=Ic/Ib	Mode
0.2	200	0	12	0	0	cutoff
0.3	400	-10	12	0	0	cutoff
0.4	450	-5	11.9375	62.5	0	cutoff
0.5	600	-10	11.875	125	0	cutoff
0.6	675	-7.5	10.9369	1.0625	0	cutoff
0.7	700	0	8.3125	3.69	0	cutoff
0.8	700	10	5.3122	6.68	669	active
0.9	700	20	2.8123	9.19	459.5	active
1	702	29.7	500	11.4	385.9	saturation
1.2	710	49	62.5	11.93	243.4	saturation
1.4	715	68.5	62.5	11.93	174.16	saturation
1.6	725	87.5	62.5	11.93	136.34	saturation
1.8	725	107.5	62.5	11.93	110.97	saturation
2	725	127.5	62.5	11.93	93.56	saturation
3	725	227.5	62.5	11.93	52.43	saturation
4	725	327.5	62.5	11.93	36.427	saturation

For 0.2v<VBB<0.7v: cut-off mode
As VBE < VCE(both Base-Emitter junction and Collector Base junction are in reverse Bias).

For VBB>0.9:saturation mode
As VBE>VD(cut-in voltage(0.7)), VBE > 0 and VBE > VCE(both Base-Emitter junction and Collector Base junction are in Forward bias)

For VBB=0.8 and VBB=0.9: active mode as VBE<VD(cut-in voltage(0.7)), VBE > 0 and VBE <VCE(Base-Emitter junction is in Forward bias and Collector Base junction is in reverse bias).

2. BJT Output Characteristics (IC vs VCE):

To determine voltage and current values across a Bipolar Junction Transistor (BJT), additional measurements are required beyond KVL or KCL.

An operational amplifier (op-amp) is employed to plot BJT characteristics.

In the setup below, V2 represents VCE, and V0 represents the negative value of IC multiplied by R0 (approximately), where R0 is 1kΩ.

$V2 = VCE$

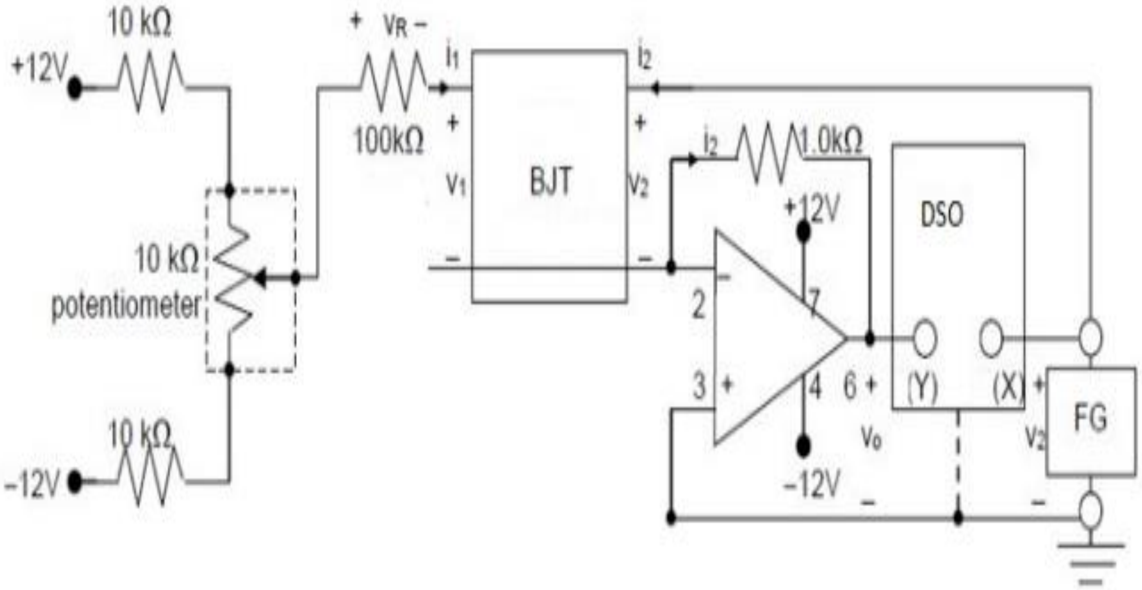
$V0 = -I2 \times R0$

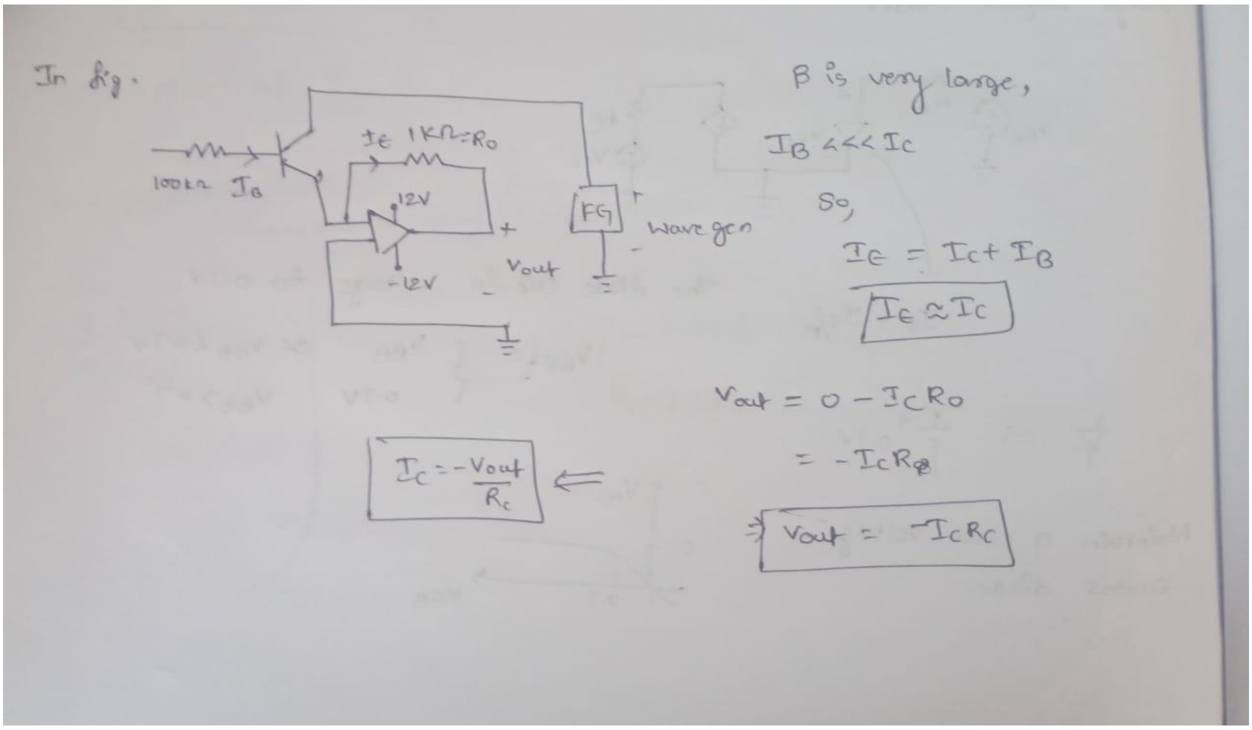
$= -IE \times R0$

$\approx -IC \times R0$

Thus, the plot of IC is proportional to V0, achieved by varying V2 (VCE) using a function generator.

Build the circuit as shown in fig:

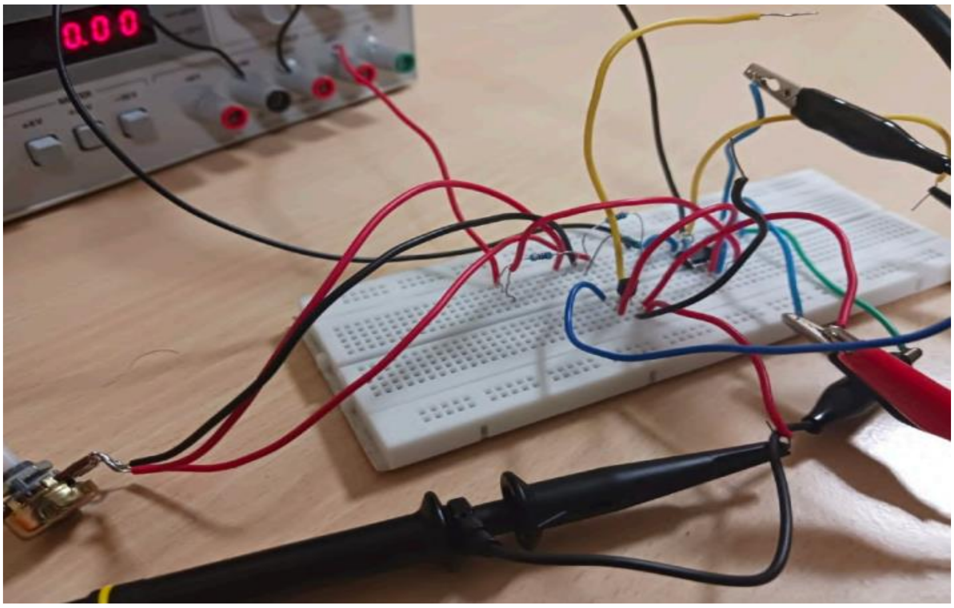




For the first part a, the potentiometer output voltage as verified to be varying between -4 and +4.The DSO pictures of the following.

Min Value=-4

Max Value=4



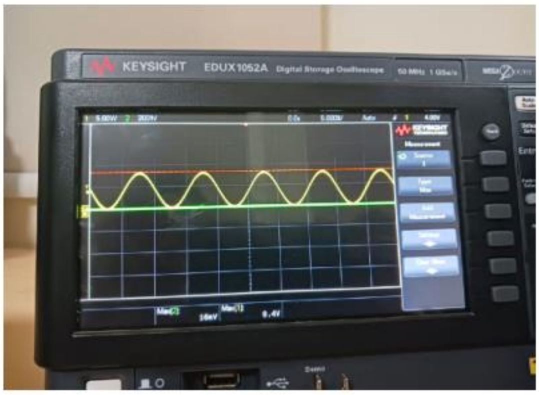
Obsevation:

The output voltage varies between -4 V and 4V as we can see above.

The potentiometer is a variable resistor which enables adjustment of the base current to achieve desired readings.

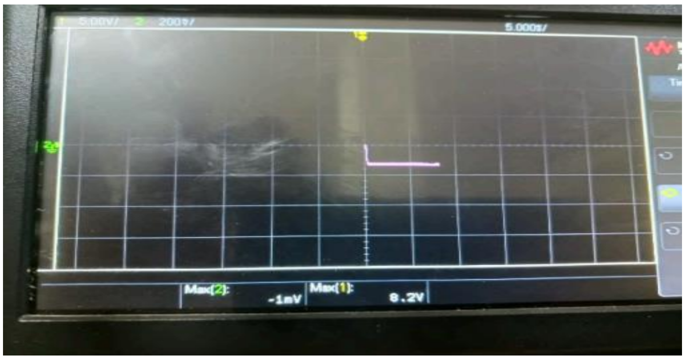
By modifying the potentiometer's resistance, both the base current and the base voltage VBE can be altered. Ideally, the voltage range of VBE should span between -4V and 4V, as depicted in the images above.

b) when VBB=200mv:

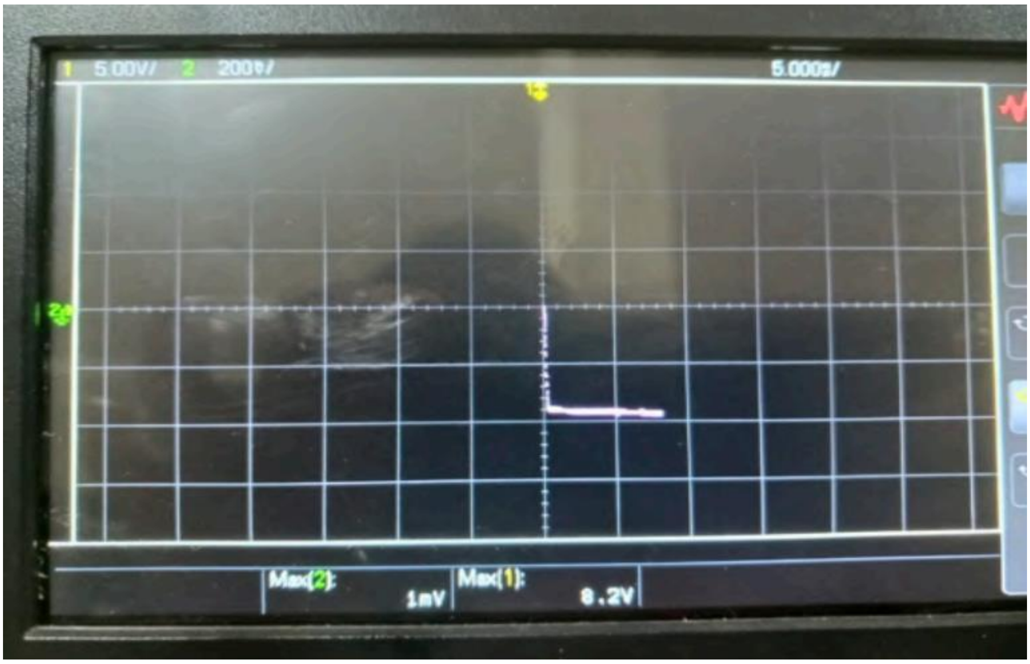


When VBB=600mv:

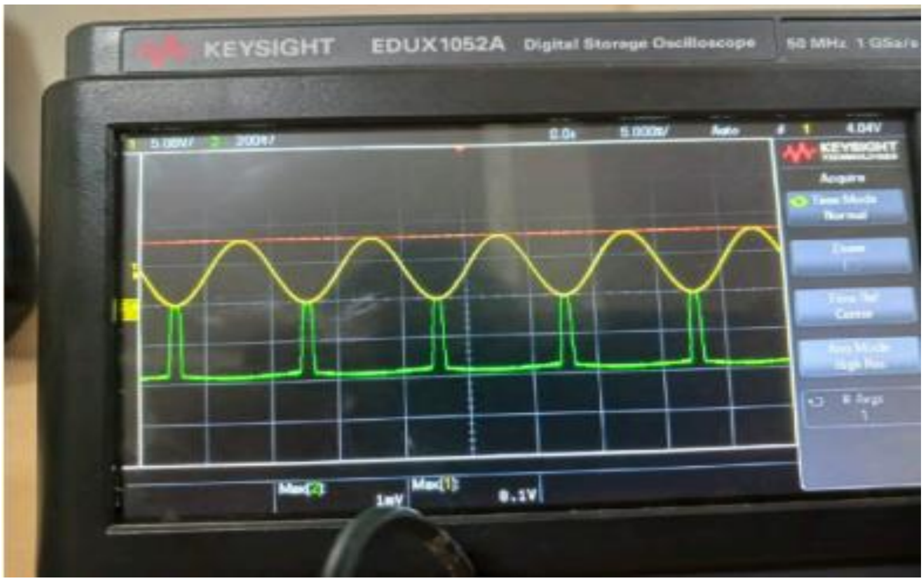
When VBB=1v:

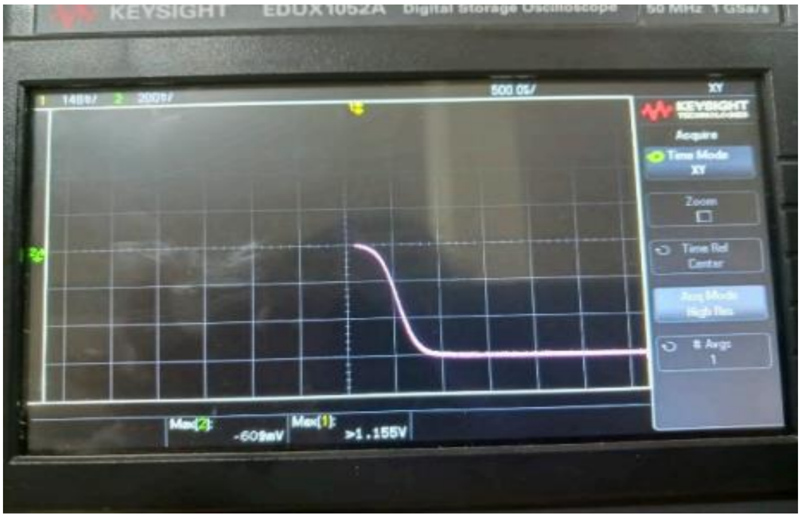


When VBB=1.2V:

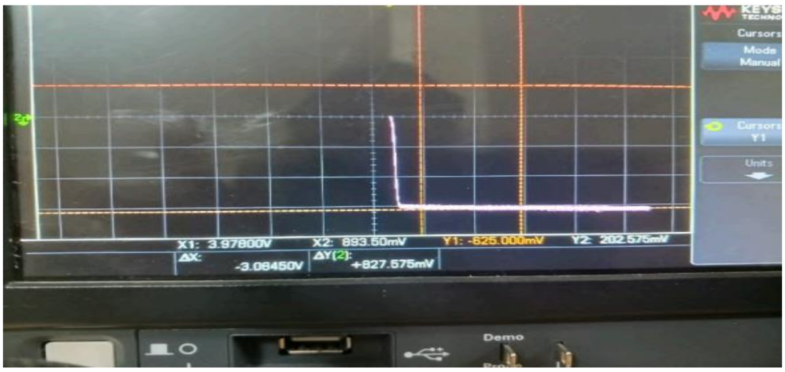


When VBB=1.6:

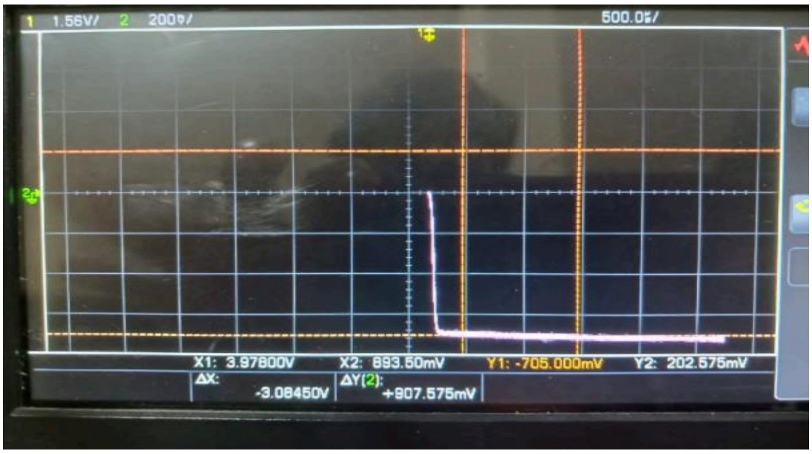




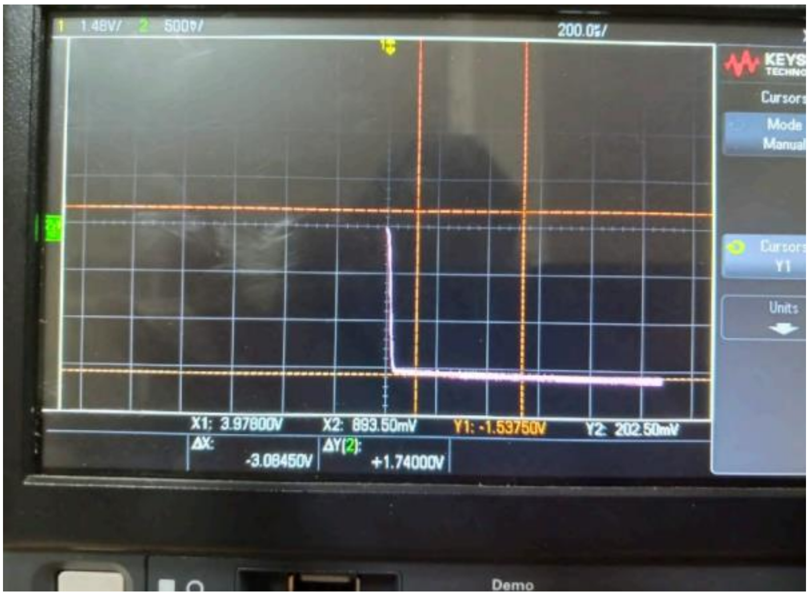
When VBB=2V



When VBB=3V



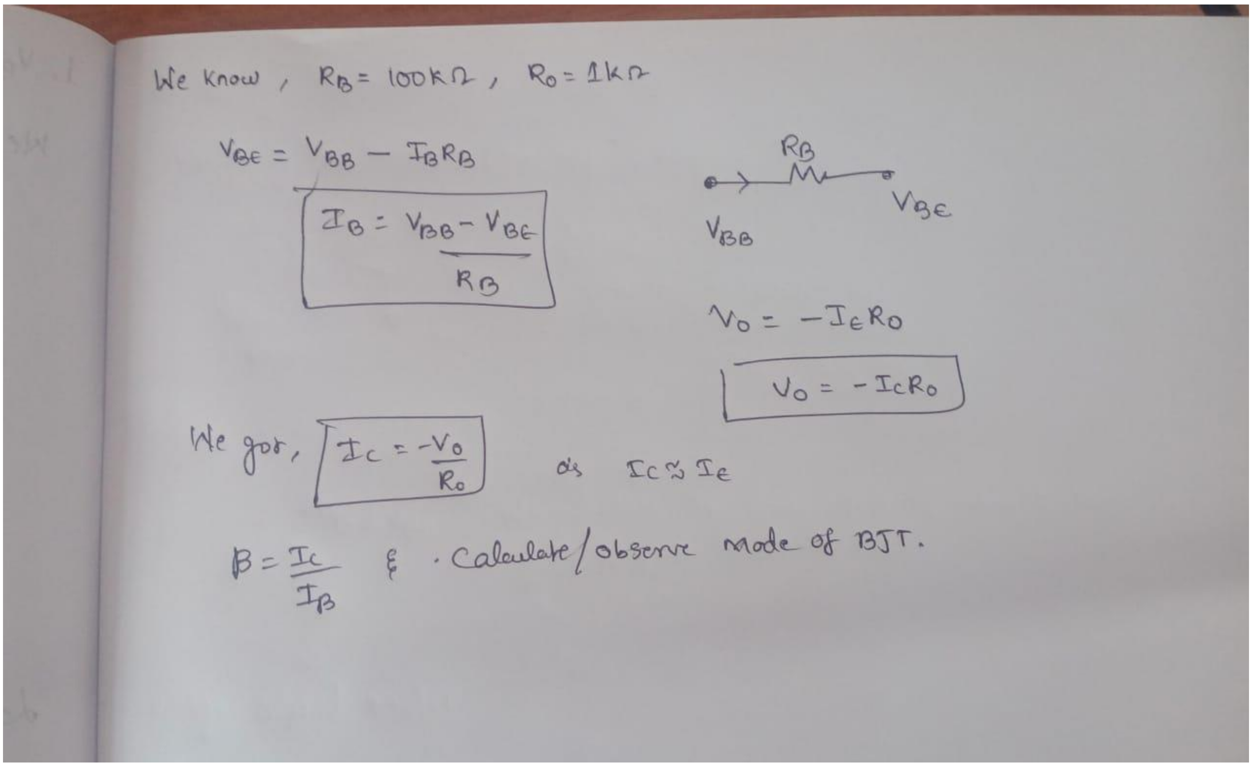
When VBB=4V



At the collector terminal of the BJT, we apply a sinusoidal input signal with a peak-to-peak voltage of 8V and a 4V offset. By adjusting the potentiometer resistance to control the base current (VBB), we can obtain different readings for VCE and VO (op-amp output).

Using these measurements, we can calculate the values of the base current (IB), collector current (IC), and common emitter gain (β) or current gain using RB=100k0hm,R0=1Kohm IB=(VBB-VBE)/RB β=IC/IB

IC=(VCC-VCE)/RC



We know, $R_B = 100k\Omega$, $R_o = 1k\Omega$

$V_{BE} = V_{BB} - I_B R_B$

$$\boxed{I_B = \frac{V_{BB} - V_{BE}}{R_B}}$$

$V_o = -I_E R_o$

$$\boxed{V_o = -I_C R_o}$$

We got, $\boxed{I_C = \frac{-V_o}{R_o}}$ as $I_C \approx I_e$

$\beta = \frac{I_C}{I_B}$ & · Calculate/observe mode of BJT.

V(bb)	V(be) (mV)	I(b) (uA)	V(ce) (V)	Vo	I(c)	B=Ic/Ib	Mode
200mv	160	0.4	3.99	1.4mv	-1.4µA	0	Cutoff
600mv	550	0.5	3.98	0.4mv	0.4 µA	0	Cutoff
1v	600	4	2.11	-1.03v	1.03mA	257.5	Active
1.2v	620	5.8	3.83	-1.2v	1.2 mA	206.5	Active
1.6v	660	9.4	3.28	-3.21v	3.21 mA	341.3	Active
2v	670	13.3	3.45	-3.87v	3.87 mA	290.8	Active

3v	700	23	3.52	-6.5v	6.5 mA	282.6	Active
4v	725	32.75	2.66	-6.9v	6.9 mA	210.6	Active

For 0.2v<VBB<0.6v: cut-off mode
As VBE < VCE(both Base-Emitter junction and Collector Base junction are in reverse Bias).

For 1v<VBB<4v: active mode
as VBE<VD(cut-in voltage(0.7)), VBE > 0 and BE <VCE(Base-Emitter junction is in Forward bias and
Collector Base junction is in reverse bias).