Analog Electronic Circuits Lab Report - Experiment 4

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Objective

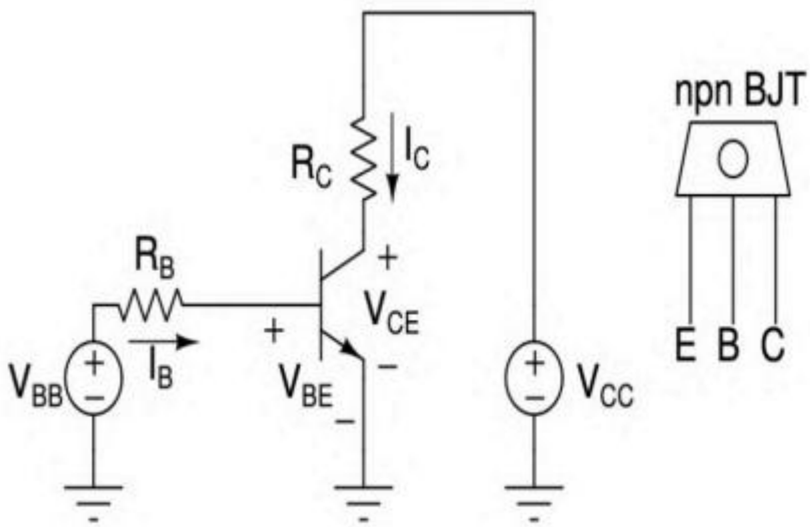
The objective of this experiment is to characterize the Bipolar Junction Transistor (BJT) in the Common Emitter (CE) configuration. Specifically, we aim to:

1. Plot the **VBE vs IB** characteristics of the BJT.
2. Plot the **VCE vs VBB** characteristics of the BJT.
3. Determine the **common emitter current gain (β)** and identify the mode of operation of the BJT (cutoff, active, or saturation) for different values of VBB.

Components Used

- **Resistors:** RB = 10 kΩ, RC = 1 kΩ
- **Voltage Sources**
- **Transistor:** NPN BJT
- **DSO**
- **Breadboard**
- **Multi-meter**
- **Potentiometer**
- **Operational Amplifier**

The circuit for the BJT characterization in the Common Emitter configuration is shown below:



Procedure

1. BJT Characterization (VBE vs IB) & BJT Output Characteristics (VCE vs VBB)

1. Connect the circuit , Use RB = 10 kΩ, RC = 1 kΩ, and VCC = 12 V.
2. Generate a sinusoidal signal with VPP = 4 V and an offset of 2 V. This will sweep VBB from 0 V to 4 V (2+2sin(wt)) .
3. Connect Channel 1 (X-axis) to VBB and Channel 2 (Y-axis) to VBE. Use the XY mode to plot VBE vs VBB.
4. Record the values of VBE and calculate IB using the formula:

   IB =(VBB – VBE)/RB

   IC =(VCC – VCE)/RC

2. Calculation of Current Gain (β)

1. For each value of VBB, calculate the common emitter current gain using the formula:

   β=IC/IB

2. **Identify Mode of Operation:** Based on the values of VBE and VCE, determine whether the BJT is in cutoff, active, or saturation mode.

Observations and Results

1. VBE vs IB Characteristics

VBB (V)	VBE (mV)	IB (µA)
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
1.0	702	29.7
1.2	710	49
1.4	715	68.5
1.6	725	87.5
1.8	725	107.5
2.0	725	127.5
3.0	725	227.5
4.0	725	327.5

VBE vs IB Characteristics

2. VCE vs VBB Characteristics

VBB (V)	VCE (V)	IC (µA)
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
1.0	0.5	11.4
1.2	0.0625	11.93
1.4	0.0625	11.93
1.6	0.0625	11.93
1.8	0.0625	11.93
2.0	0.0625	11.93
3.0	0.0625	11.93
4.0	0.0625	11.93

VCE vs VBB Characteristics

3. Current Gain (β) and Mode of Operation

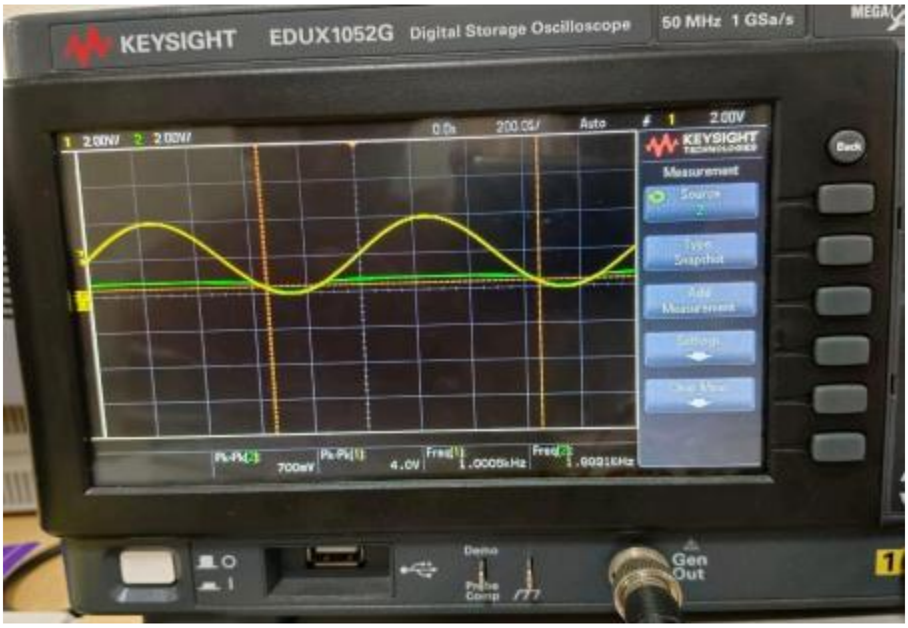
VBB (V)	VBE (mV)	IB (μA)	VCE (V)	IC (μA)	β = IC/IB	Mode
0.2	200	0	12	0	0	Cutoff
0.3	400	-10	12	0	0	Cutoff
0.4	450	-5	11.9375	62.5	0	Cutoff
0.5	600	-10	11.875	125	0	Cutoff
0.6	675	-7.5	10.9369	1.0625	0	Cutoff
0.7	700	0	8.3125	3.69	0	Cutoff
0.8	700	10	5.3122	6.68	669	Active
0.9	700	20	2.8123	9.19	459.5	Active
1.0	702	29.7	0.5	11.4	385.9	Saturation
1.2	710	49	0.0625	11.93	243.4	Saturation
1.4	715	68.5	0.0625	11.93	174.16	Saturation

1.6	725	87.5	0.0625	11.93	136.34	Saturation
1.8	725	107.5	0.0625	11.93	110.97	Saturation
2.0	725	127.5	0.0625	11.93	93.56	Saturation
3.0	725	227.5	0.0625	11.93	52.43	Saturation
4.0	725	327.5	0.0625	11.93	36.427	Saturation

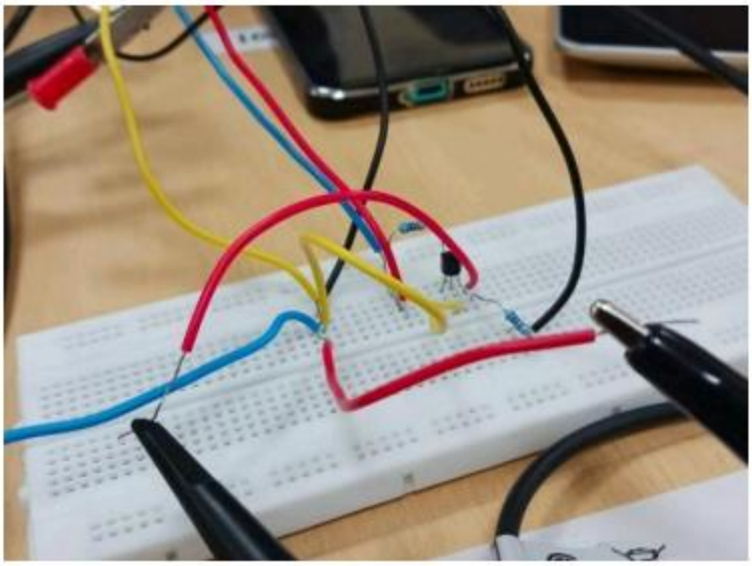
Current Gain (β) and Mode of Operation

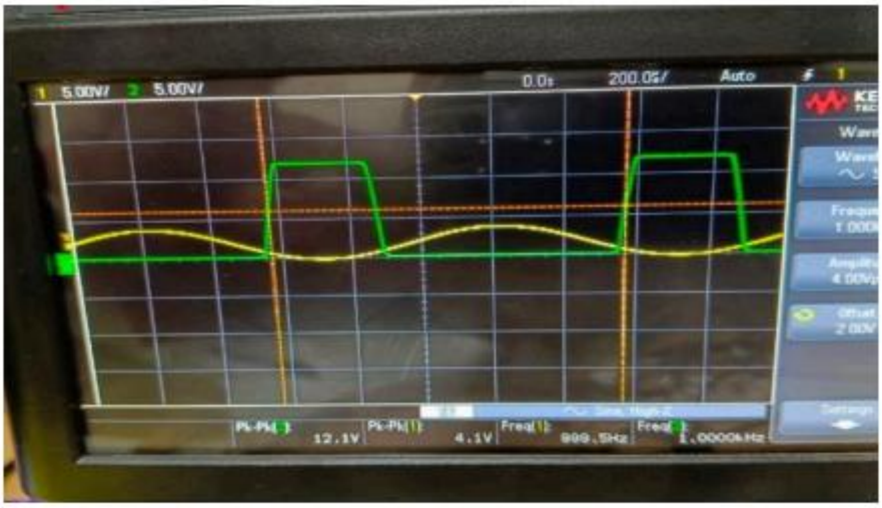
Explanation:

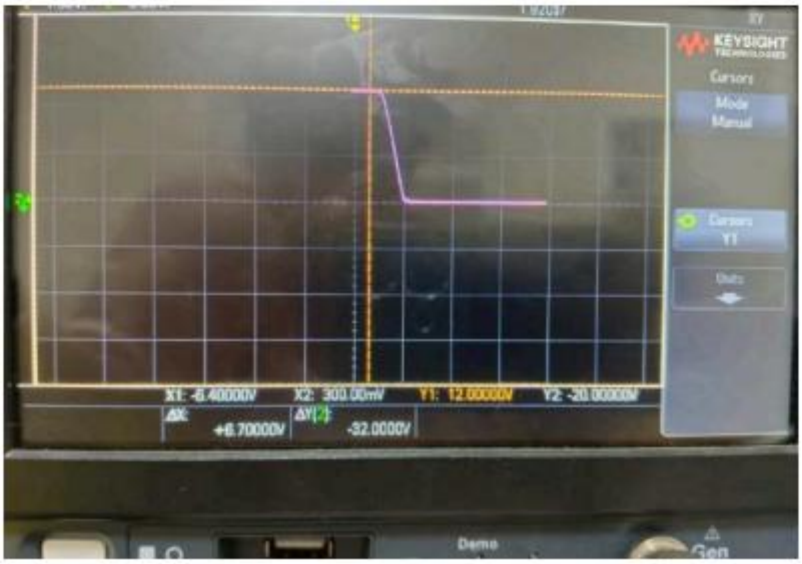
- **For VBB<0.7V, the transistor is in cutoff mode as both the Base-Emitter and Collector-Base junctions are in reverse bias.**
- **For 0.8V<VBB<0.9V, the transistor operates in the active region where the Base-Emitter junction is forward-biased, and the Collector-Base junction is reverse-biased.**
- **For VBB>0.9V*VBB*>0.9*V*, the transistor enters saturation mode where both junctions are forward-biased.**



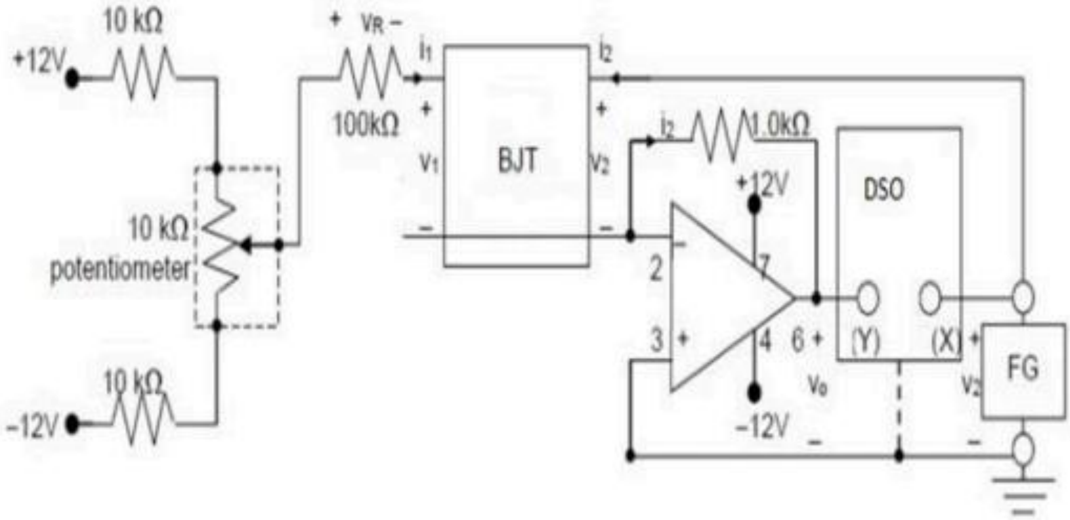

XY
KEYSIGHT
Cursors
Mode
Manual
Cursors
X1
Units
X1: -787.50mV
X2: 0.0V
Y1: 746.900mV
Y2: 746.900mV
ΔX:
+787.50mV
ΔY(2):
+0.0V




5.00V/
5.00V/
0.0s
Auto
Pk-Pk(2): 12.1V
Pk-Pk(1): 4.1V
Freq(1): 999.5Hz
Freq(2): 1.0000kHz


KEYSIGHT TECHNOLOGIES
Cursors
Mode Manual
Cursors Y1
Units
X1: -6.40000V
X2: 300.00mV
Y1: 12.00000V
Y2: -20.00000V
ΔX: +6.70000V
ΔY(2): -32.0000V
Demo

Experiment 2: BJT Output Characteristics

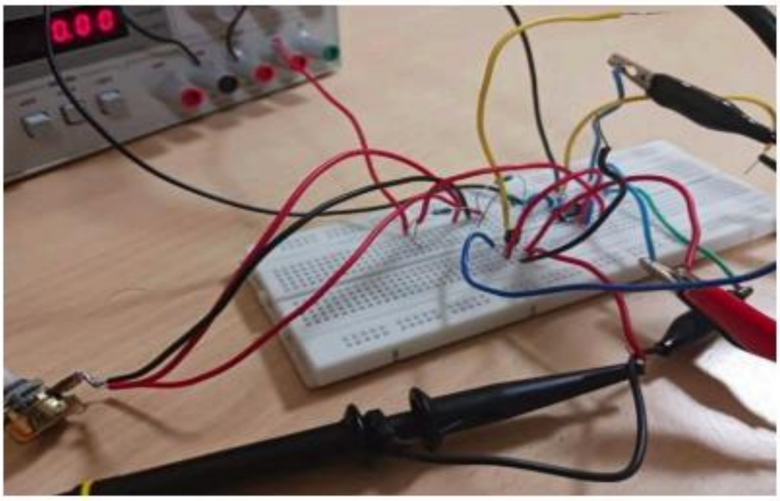


Procedure:

- **Construct the circuit using an operational amplifier to plot the BJT output characteristics.**
- **Verify that the potentiometer output voltage varies between -4V and 4V.**
- **Apply a 100 Hz sine wave input with a peak-to-peak voltage of 8V and an offset of 4V at the collector terminal of the BJT using the function generator.**
- **Connect Channel 1 of the DSO to the collector terminal and Channel 2 to the output of the op-amp (V0).**
- **Vary the base current (potentiometer resistance) and observe the characteristic waveform using the DSO.**
- **Calculate IB*IB*, IC*IC*, and ββ for different VBB*VBB* values.**

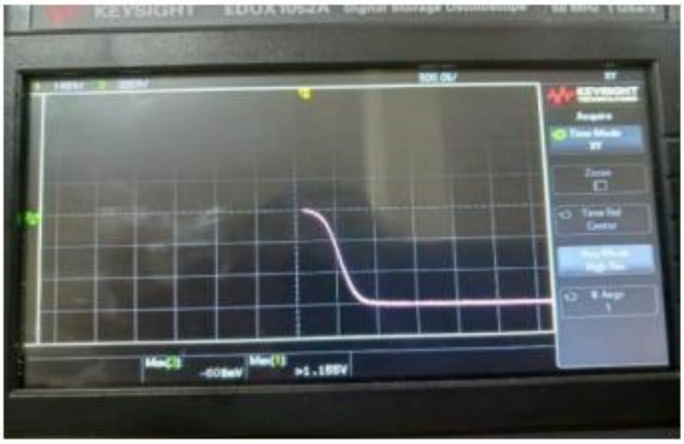
VBB (V)	VBE (mV)	IB (μA)	VCE (V)	V0(V)	IC/(mA)	β=IC/IB	Mode
0.2	160	0.4	3.99	1.4m	-1.4μ	0	Cutoff
0.6	550	0.5	3.98	0.4m	0.4μ	0	Cutoff
1.0	600	4	2.11	-1.03	1.03	257.5	Active
1.2	620	5.8	3.83	-1.2	1.2	206.5	Active
1.6	660	9.4	3.28	-3.21	3.21	341.3	Active
2.0	670	13.3	3.45	-3.87	3.87	290.8	Active

3.0	700	23	3.52	-6.5	6.5	282.6	Active
4.0	725	32.75	2.66	-6.9	6.9	210.6	Active

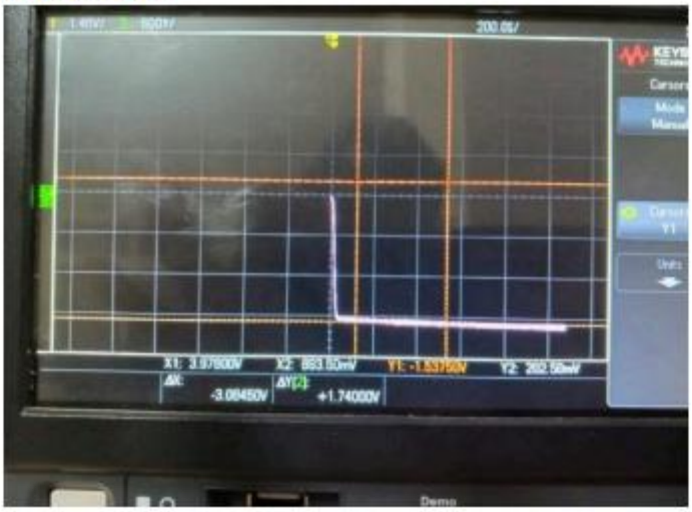


IF vbb=200mV:-

If Vbb=1.6V:-



When Vbb>2v:-



Explanation:

- For 0.2V<VBB<0.6V, the transistor is in cutoff mode.

- For 1V<VBB<4, the transistor operates in the active mode where the Base-Emitter junction is forward-biased, and the Collector-Base junction is reverse-biased.

Conclusion

In this experiment, we characterized the BJT in the Common Emitter (CE) configuration and analyzed its output characteristics. For the CE configuration, we plotted VBE vs IB and VCE vs VBB, calculated the current gain (β=IC/IB), and identified the BJT's operating modes (cutoff, active, saturation). For the output characteristics, we used an operational amplifier to plot IC vs VCE, varied the base current (IB) using a potentiometer, and determined β for different VBB*VBB* values, confirming the BJT's behavior in various operating regions.