Bipolar Junction Transistor and Hetero-junction Bipolar Transistor

Electronic Devices Lab : Experiment 7

Department of Electrical Engineering
Indian Institute of Technology, Bombay

Think it. Make it. Prove it.

Background Information

- BJT is a 3-terminal 2-junction transistor that is used in high-frequency applications (such as RF circuits).
  It has three terminals: Base (B), Collector (C), and Emitter (E).
- A BJT allows a small current injected at its Base to control a much larger current flowing between the Emitter and Collector terminals,making the device capable of amplification and switching.
- Regions of Operation of BJT (NPN):

B-E Junction	B-C Junction	Region
Reverse	Reverse	Cut-off
Forward	Reverse	Active
Reverse	Forward	Inverse-active
Forward	Forward	Saturation

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Background Information (continued)

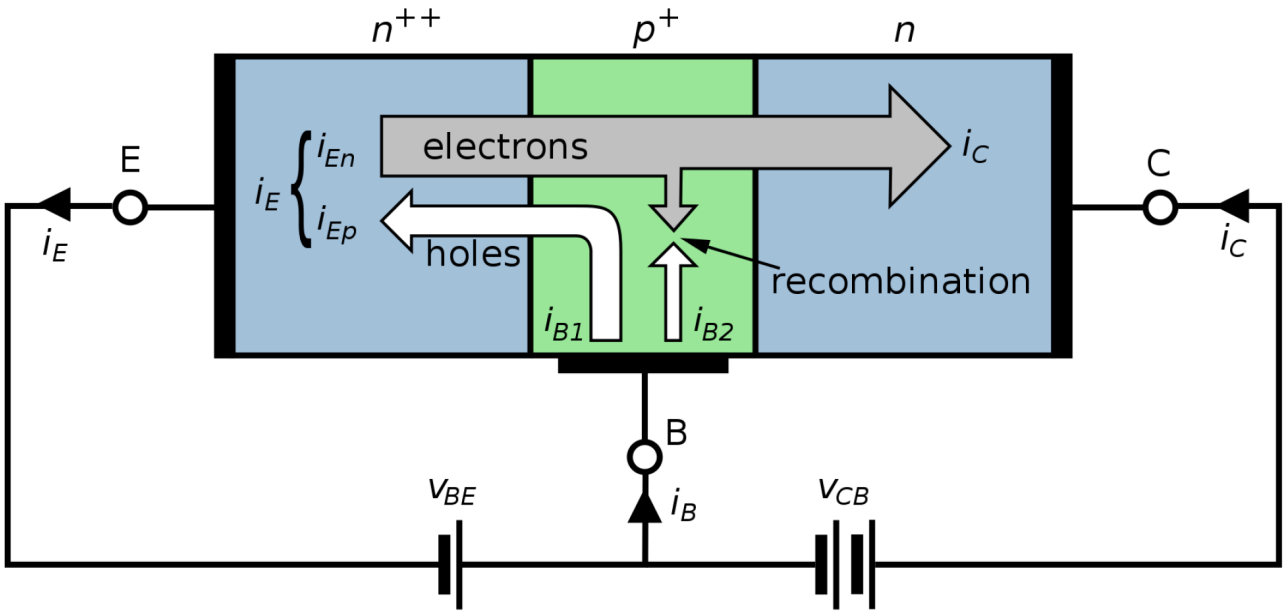

Figure: Current mechanisms in NPN BJT, Active Region

Note that in an NPN BJT, electrons are majority carriers and holes are minority carriers.

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DC parameters of BJT

- Base Transport Factor (α_T) : The fraction of the minority carriers injected into the base that successfully diffuse across the width of the base and enter the collector.

$$\alpha_T = \frac{i_C}{i_E} \tag{1}$$

- Emitter Efficiency (γ) :

$$\gamma = \frac{i_{En}}{i_E} \tag{2}$$

- Common Emitter Current Gain (β):

$$\beta = \frac{i_C}{i_B} \tag{3}$$

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Components Necessary

The following components are needed in order to perform the experiment.

- BC547 BJT
- MT3S1 HBT
- Resistors (PART 1): $1k\Omega$, 470Ω
- Resistors (PART 2): $15k\Omega$,$18k\Omega$,$10k\Omega$,$1.2k\Omega$,250Ω
- Potentiometer: $1k\Omega$
- Capacitor: $4.7uF$
- Breadboard,Multimeters and connecting wires

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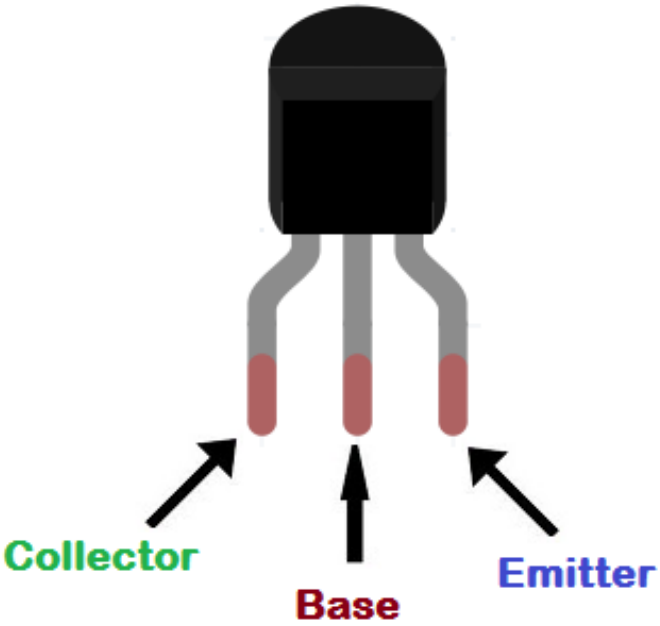
BC547 BJT Pinout



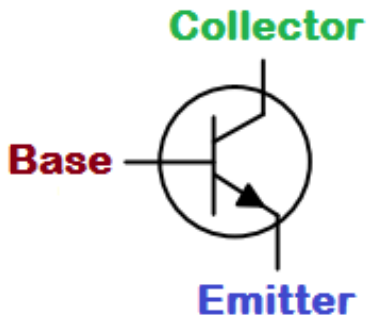


Figure: BC547 BJT Pinout

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PART I: BJT Parameters in CB configuration

- Plot output characteristics of CB configuration (I_C vs V_{CB} for different I_E).
- Determine the parameters α and β assuming $\gamma = 1$.
- Plot collector and base currents (I_C and I_B) against varying base emitter (V_{BE}) voltage at a fixed collector to base bias voltage (V_{CB}).

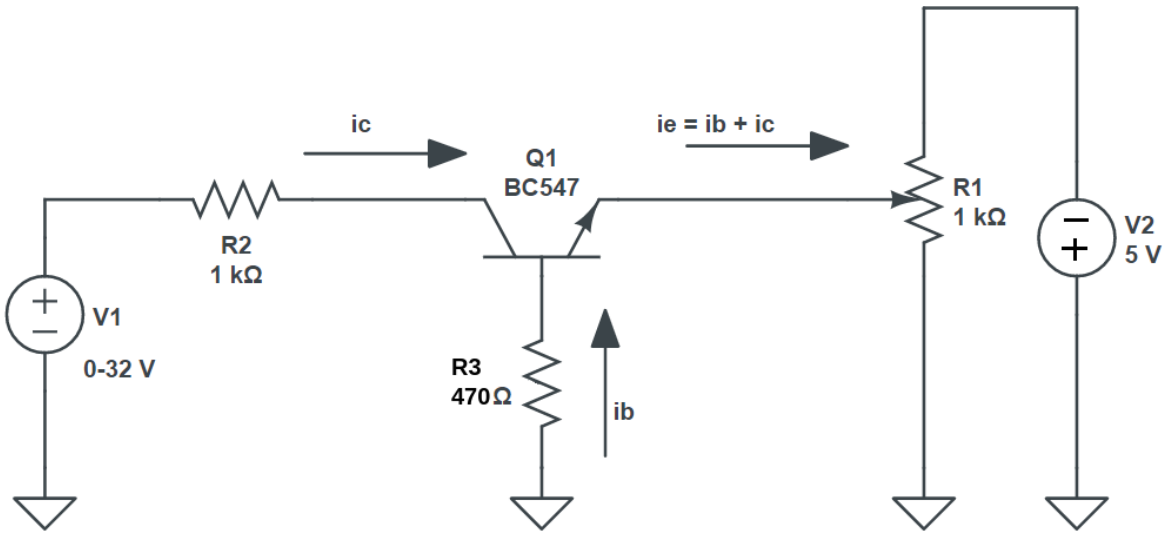

Figure: CB Circuit

Note : Take I_E from 3 mA to 9 mA in steps of 3 mA.
(Ensure collector-base junction is reverse biased, V1 $\geq$ 4V)

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PART II: Frequency response of BJT vs HBT

In this part, the following tasks are to be done:

- Obtain the frequency response of BJT in CE configuration.
- Obtain the frequency response of HBT in CE configuration.
- Plot combined gain vs. frequency response of both on a semi-log scale.

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MT3S11 HBT Pinout

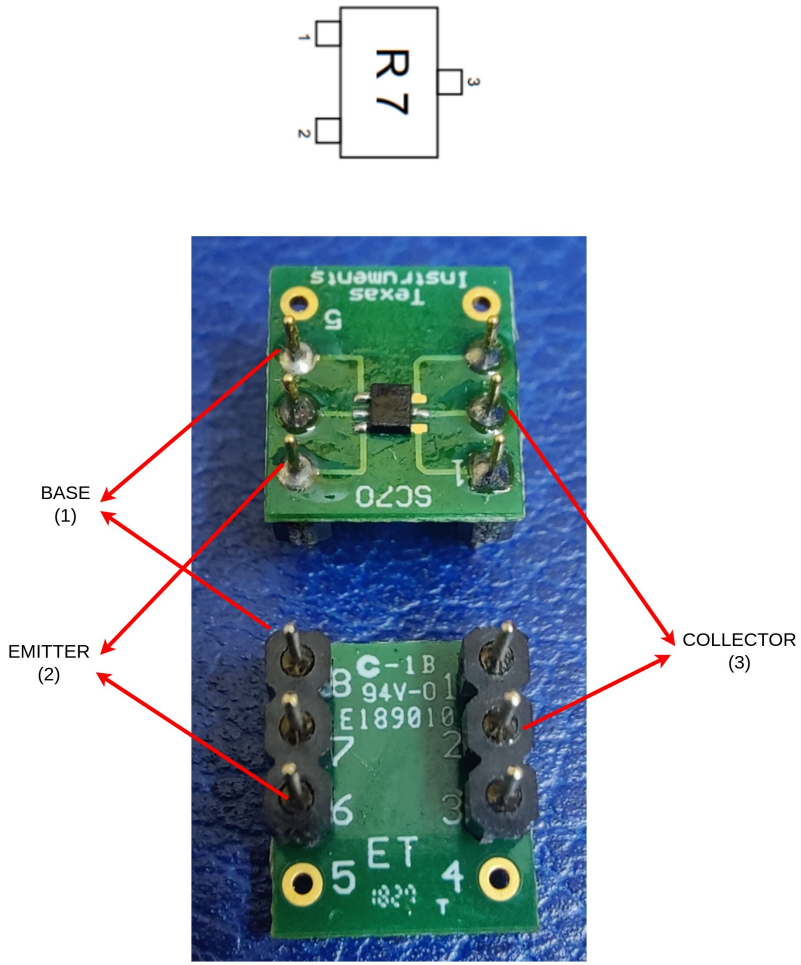

Figure: MT3S11 HBT Pinout

Frequency response of BJT - BC547 (1)

- Use CE configuration to make an amplifier as shown below.

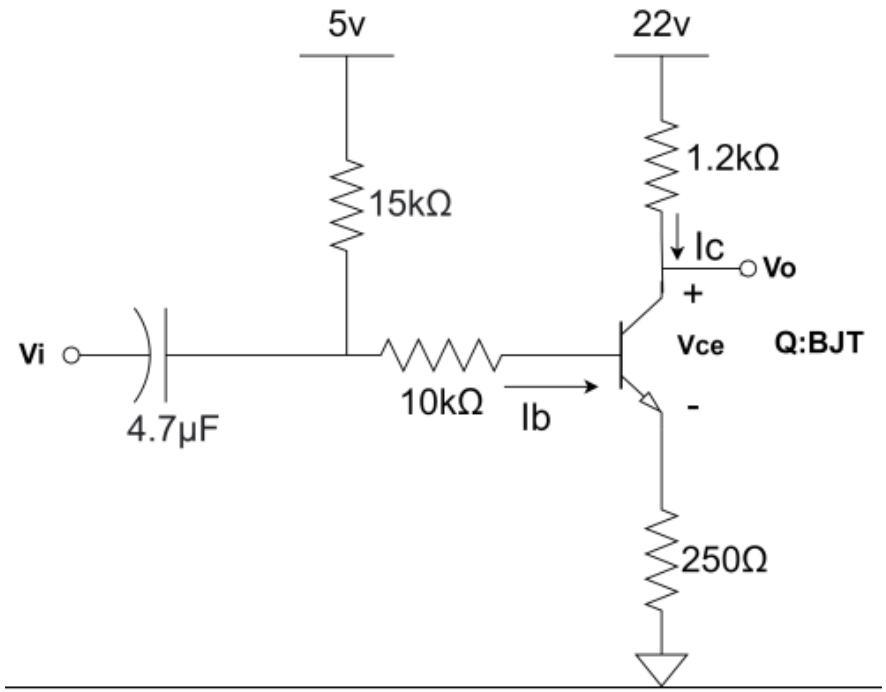

Figure: BJT CE Circuit

- Fix the DC bias operating point in the Common Emitter circuit as: $V_{CE} = 6.0V$ and $I_C = 12\ mA$, $I_B = 50\ uA$.
- Give input small signal as $V_i = 500\ mV$, peak to peak.

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Frequency response of BJT - BC547 (2)

- Vary the frequency of input sinusoid. Frequency steps to be taken: {1k, 5k, 10k, 50k, 100k, 150k, 200k, 250k, 300k, 350k, 400k, 450k, 500k, 550k, 600k}.
- Measure Vout and observe the voltage gain at different frequencies.
- Plot the frequency response and find the 3-dB cutoff frequency.

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Frequency response of HBT (1)

- Use CE configuration to make an amplifier as shown below.

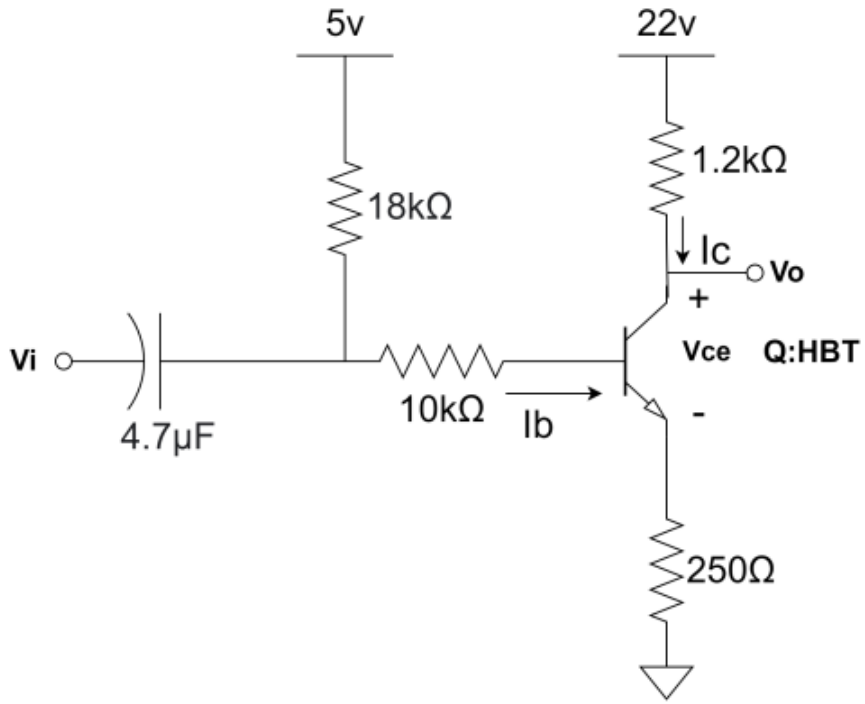

Figure: HBT CE Circuit

- Fix the DC bias operating point in the Common Emitter circuit as: $V_{CE} = 3.5V$ and $I_C = 12\ mA$, $I_B = 50\ uA$.
- Give input small signal as $V_i = 500\ mV$, peak to peak.

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Frequency response of HBT (2)

- Vary the frequency of input sinusoid. Frequency steps to be taken: {1k, 5k, 10k, 50k, 100k, 150k, 200k, 250k, 300k, 350k, 400k, 450k, 500k, 550k, 600k, 650k, 700k, 750k, 800k, 850k, 900k}.
- Measure Vout and observe the voltage gain at different frequencies.
- Plot the frequency response and find the 3-dB cutoff frequency.
- Compare the 3-dB frequency of HBT and BJT, Include in your report an explanation of why HBT exhibits superior performance at higher frequencies.

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