Bipolar Junction Transistor and Hetero-junction Bipolar Transistor

Electronic Devices Lab : Experiment 7

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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

Background Information (continued)

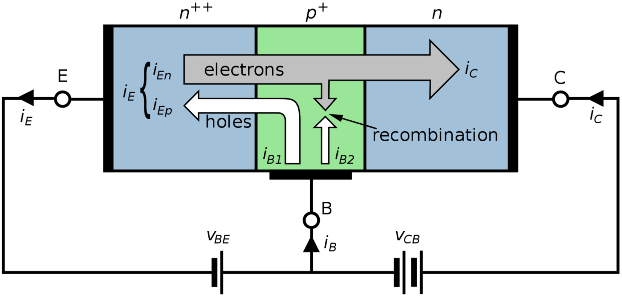

Figure: Current mechanisms in NPN BJT, Active Region

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

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

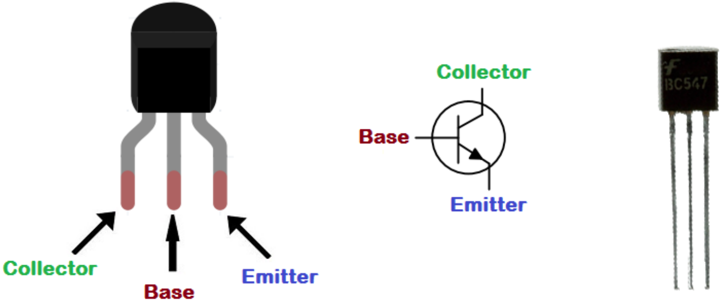

Figure: BC547 BJT Pinout

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}).

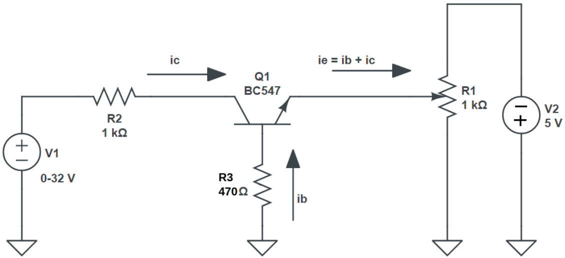

Figure: CB Circuit

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)

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

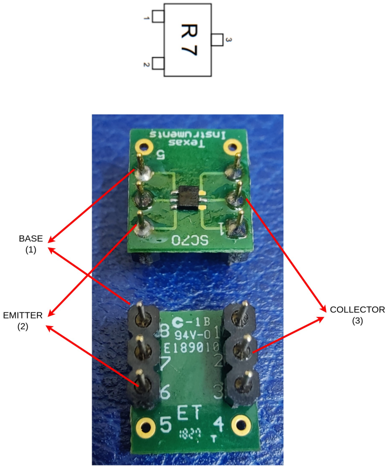

Figure: MT3S11 HBT Pinout

Frequency response of BJT - BC547 (1)

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

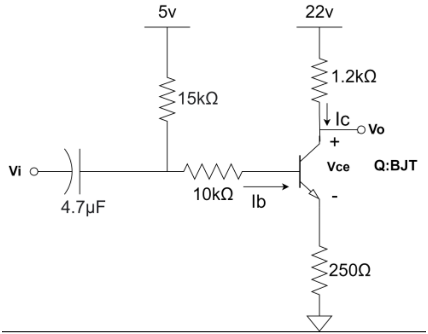

Figure: BJT CE Circuit

- 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.

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.

Frequency response of HBT (1)

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

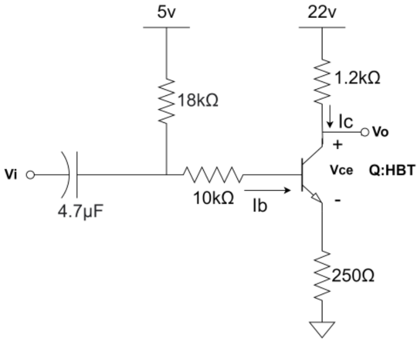

Figure: HBT CE Circuit

- 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.

- 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.

Explanation of HBT Performance
HBTs generally exhibit superior performance at higher frequencies compared to BJTs due to:
  Higher Electron Mobility:
  Reduced Base Transit Time:
  Increased Gain-Bandwidth Product: