The I-V curves below show an **IDEAL** npn BIPOLAR JUNCTION TRANSISTOR

**IF** $v_{CE} > 0.2 \text{ V}$

- dependence of $i_B$ on $v_{CE}$ negligible
- dependence of $i_C$ on $v_{CE}$ negligible
- equal steps in $i_B$ → equal steps in $i_C$
- $i_B = 0 \rightarrow i_C = 0$

![Diagram of npn Bipolar Junction Transistor](image)

- $\Delta i_C = 100$
- $\Delta i_B \downarrow$
- $\beta = 100$

BJT (nnp) Base Emitter Base Current generated by Input Voltage

INPUT: Voltage
DC BIAS + ac Signal

OUTPUT: Base Current
\( i_B(t) \) = DC+ ac

\[ v_{IN}(t) = V_{BB} + v_{in}(t) \]

\[ v_{in}(t) = 0.4 \sin(2000\pi t) \quad V_{BB} = 1.6 \text{ V} \]

\[ v_{IN}(t) = V_{BB} + v_{in}(t) \]

\( v_{IN}(t) = V_{BB} + 0.4 \sin(2000\pi t) \)

\( V_{CC} = 20 \text{ V} \)

\( R_C = 2 \text{ k}\Omega \)
\( R_C = 40 \text{ k}\Omega \)
\( R_B \)

\( i_C \)
\( i_R \)

\( v_{CE} \)

\( V_{BE} \)

\( v_B(t) \)

\( i_B(t) \)

\( t(s) \)

\( t(s) \)

\( i_B(t) \)

\( i_B(t) \)

\( i_B(t) \)

\( i_B(t) \)

\( i_B(t) \)

\( V_{BE} \)

\( V_{BE} \)

\( V_{BE} \)

\( V_{BE} \)

Modified by Kambiz Alavi 2016
INPUT-OUTPUT OF BJT CIRCUIT

\[ v_{BE}(t) \rightarrow i_B(t) \quad i_B(t) \rightarrow v_{CE}(t) \]

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**Summary**

ac differential gain = -5

\[ v_{CE}(t) = V_{CEQ} + v_{ce}(t) \]

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i_C - v_{CE} Plot Only  © 2000 Prentice Hall Inc. Hambley Electronics 2nd ed
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**INPUT**

DC Bias + ac Signal

\[ V_{BB} (1.6 \text{ V}) + v_{in}(t) (0.8 \text{ V p-p}) \]

**OUTPUT**

DC Q-point + ac Signal

\[ V_{CE} (5 \text{ V}) + v_{ce}(t) (4 \text{ V p-p}) \]
INPUT ac Signal Only:
0.8 V peak to peak

OUTPUT (DC + ac):
DC = $V_{CEQ} = 5\,\text{V}$
ac peak to peak = 4 V and Inverted
ac Amplification = -5
Figure 4.14 Output of the amplifier of Example 4.2 for $v_{in}(t) = 1.2 \sin(2000\pi t)$ showing gross distortion.

Figure 4.15 Amplification occurs in the active region. Clipping occurs when the instantaneous operating point enters saturation or cutoff. In saturation, $v_{CE} < 0.2$ V.