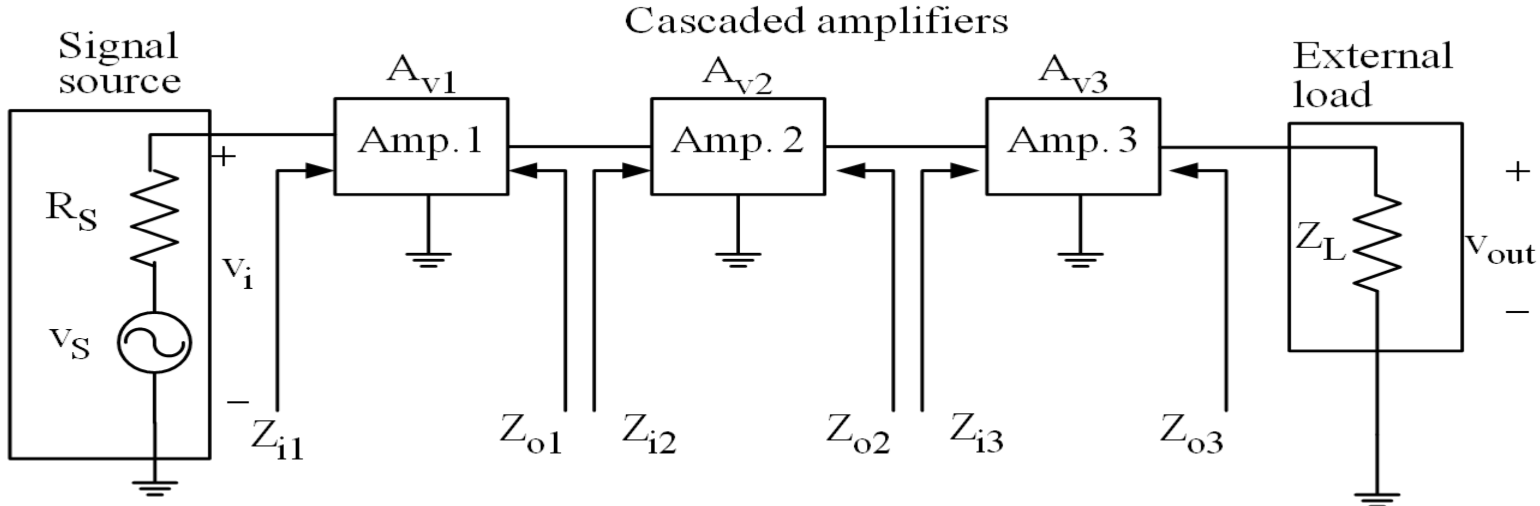
CLASS 5

BJT CONFIGURATIONS AND I-V CHARACTERISTICS

- **CE is the most typical configuration used. For this configuration, the voltage gain, $A_v = V_{out}/V_i$, is high. A high A_v means the amplifier is efficient. The input impedance, Z_i , and output impedance, Z_o of CE are also high. A high Z_i is required to optimize the A_v of a cascaded amplifier circuit. A high Z_i is required to reduce the loading effect.**



- **CC (known also as emitter follower) has $A_v = 1$, a high Z_i and a low Z_o . CC is typically employed as a buffer or impedance transformer.**
- **CB has high A_v but smaller Z_i . This configuration is used for high frequency of operation. CB amplifier can reduce the Miller effect.**

BJT MODE OF OPERATION

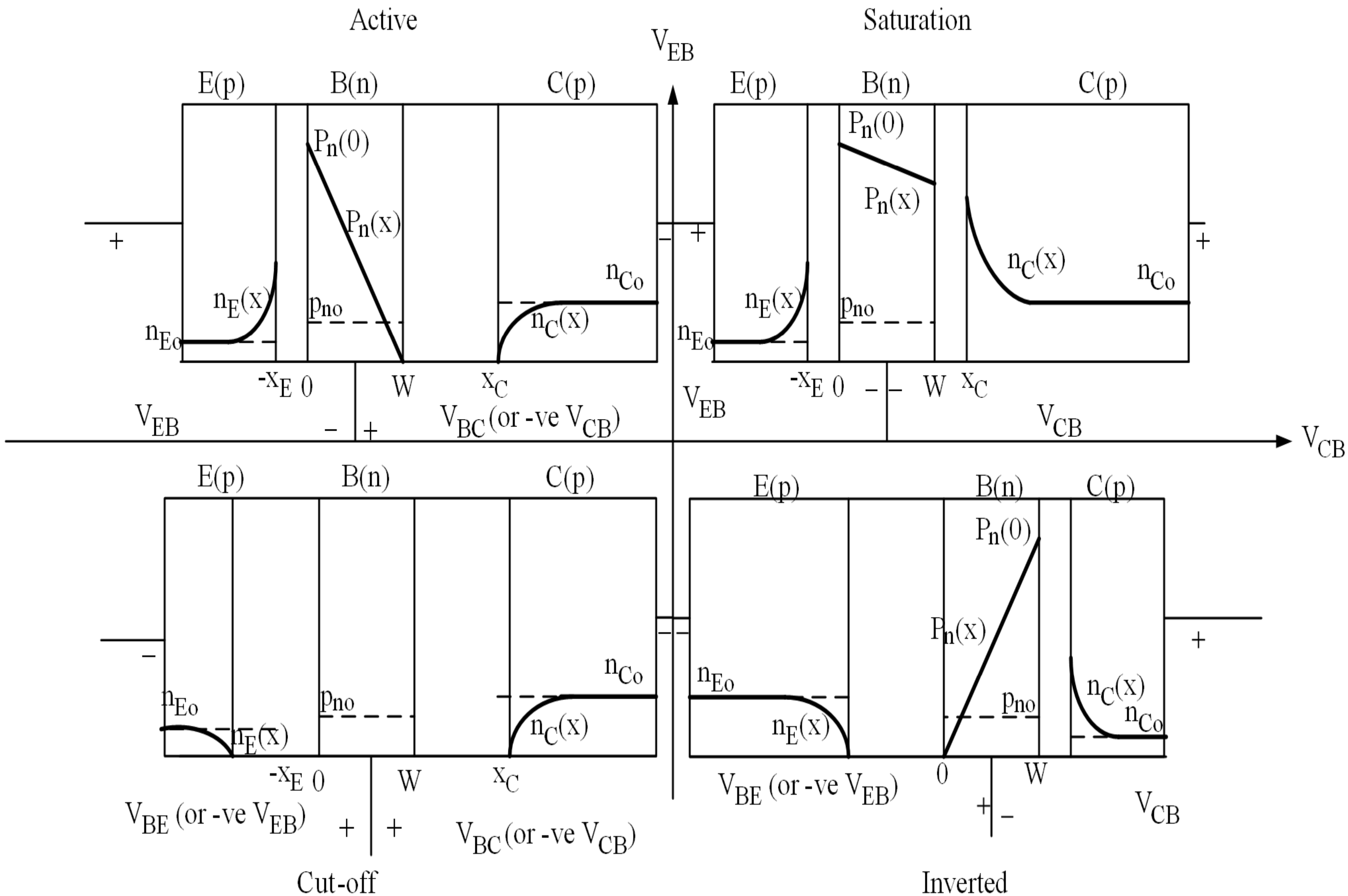
- **There are 4 modes of operation:**

1. **Active mode**
2. **Saturation mode**
3. **Cut-off mode**
4. **Inverted mode**

All the 4 modes are dependent on the biasing voltages, i.e. V_{EB} and V_{BC}.

Active mode:	**E-B junction fb, B-C junction rb**
Saturation mode:	**E-B junction fb, B-C junction fb**
Cut-off mode:	**E-B junction rb, B-C junction rb**
Inverted mode:	**E-B junction rb, B-C junction fb**

Junction polarity and minority carrier distribution for a pnp transistor in 4 different modes of operation.



Observations:

1. **Saturation Mode**

   Non-zero distribution of the minority carriers at the edges of both E-B and B-C depletion regions.

   $$P_n(W) = p_{no} e^{(qV_{CB})/kT}$$

   The bias voltage is small and the output current is large. The transistor is in the conducting state and function of the transistor is as a close (ON) switch.

2. **Cut-off Mode**

   $P_n(0) = P_n(W) \approx 0$. The transistor functions as an open (OFF) switch.

   $I_E = I_B = I_C \approx 0$

3. **Inverted Mode**

   Known also as inverted active mode has C operating as E in the active mode and E operating as C in the active. The current gain for the inverted mode is normally lower than the active mode. This is because the "emitter efficiency" (in this case the C emits holes) is weaker since the doping of C is lower than the doping of B.

General equations for the currents in a BJT for all mode of operations:

$$I_E = qA\left[\frac{D_p p_{no}}{W} + \frac{D_E n_{Eo}}{L_E}\right]\left[e^{(qV_{EB})/kT} - 1\right] - \left[\frac{qAD_p p_{no}}{W}\right]\left[e^{(qV_{CB})/kT} - 1\right]$$

$$I_C = \frac{qAD_p p_{no}}{W}\left[e^{(qV_{EB})/kT} - 1\right] - qA\left[\frac{D_p p_{no}}{W} + \frac{D_C n_{Co}}{L_C}\right]\left[e^{(qV_{CB})/kT} - 1\right]$$

Equations for the BJT currents in the active mode:

$$I_E = \frac{qAD_p p_{no}}{W} e^{(qV_{EB})/kT} + \frac{qAD_E n_{Eo}}{L_E}\left[e^{(qV_{EB})/kT} - 1\right]$$

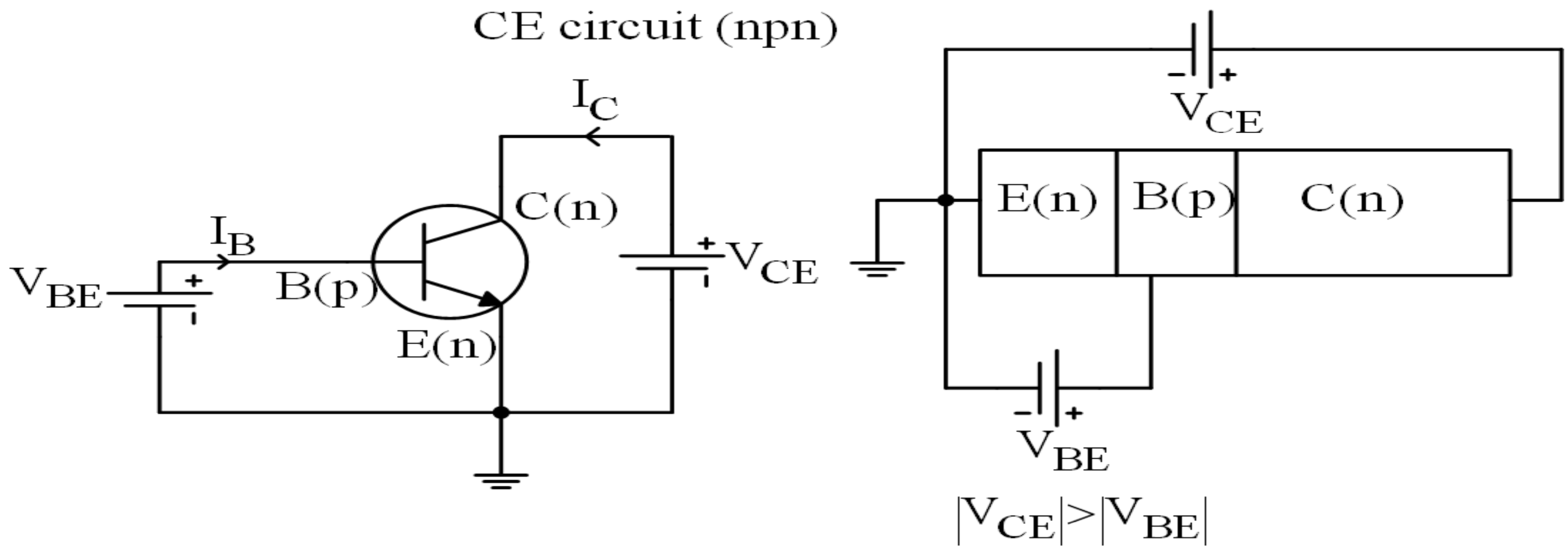
$$I_C = \frac{qAD_p p_{no}}{W} e^{(qV_{EB})/kT} + \frac{qAD_C n_{Co}}{L_C}$$

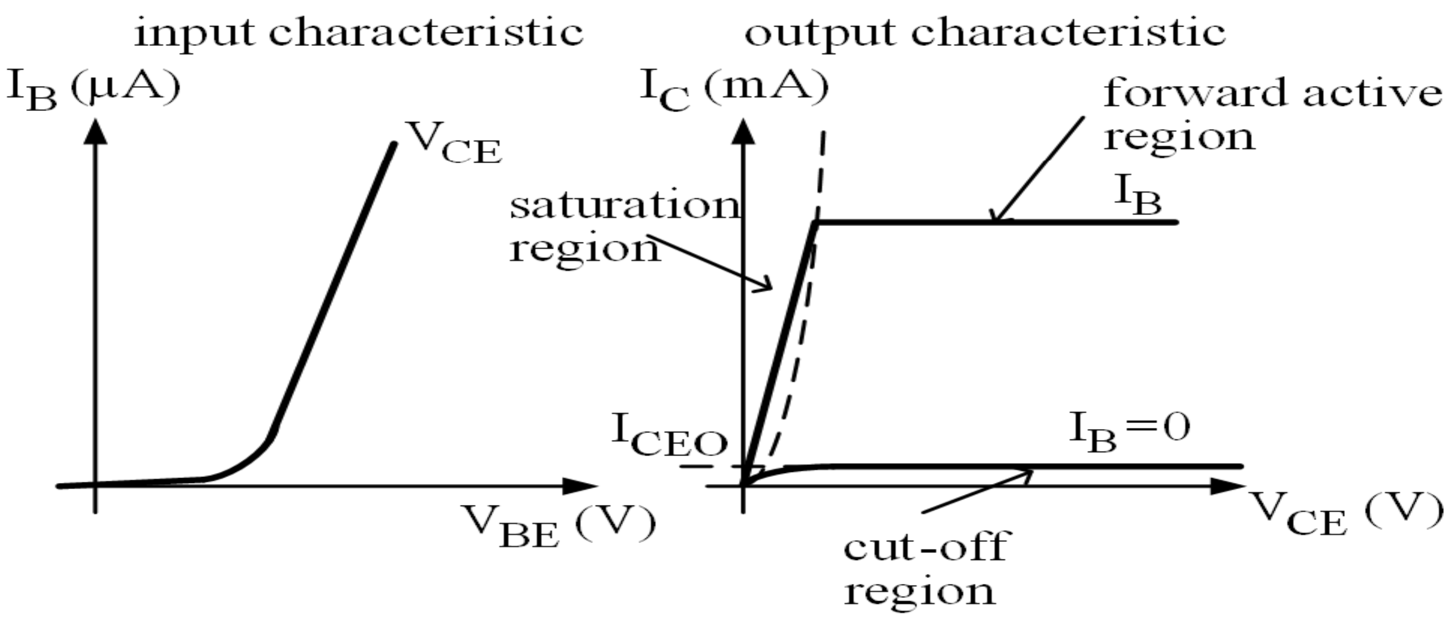
INPUT AND OUTPUT I-V CHARACTERSITICS

- **Each BJT configuration has its own input and output I-V characteristics. From these characteristics, the appropriate voltages and currents that will enable the BJT to be operated as an amplifier (active mode) can be determined.**

- **The input and output characteristics of the BJT is different for each configuration.**

- **Remember that to operate the BJT as an amplifier, the BJT has to be in the active mode i.e. E-B is fb and B-C is rb.**


CE circuit (npn)
I_C
C(n)
I_B
V_BE
B(p)
E(n)
V_CE
V_CE
E(n)
B(p)
C(n)
V_BE
|V_CE|>|V_BE|


input characteristic
I_B (μA)
V_CE
V_BE (V)
output characteristic
I_C (mA)
forward active region
I_B
saturation region
I_CEO
I_B=0
V_CE (V)
cut-off region