LECTURE - 24

n-p-n TRANSISTOR

SUMMARY → DESIGN OPTIMIZATION

\[ \text{opt} \]

1. \( n^+ \)
   \[ I_E \approx I_{en} \]
   \[ \gamma = \frac{I_{en}}{I_{en} + I_{ep}} \]  NEAR UNITY

2. NARROW BASE WIDTH, LIGHT BASE DOPING
   \[ \alpha_F \rightarrow \text{NEAR UNITY!} \]
\[ \gamma = \frac{I_{e}}{I_{e} + I_{n}} \]

\[ \alpha_F = \frac{I_{c}}{I_{e}} \]

\[ \alpha = \alpha_0 = \frac{I_{c}}{I_{e}} = \alpha_F \delta \]

KCL NODE 1
\[-I_e + I_b + I_c = 0\]

\[I_b = I_e - I_c\]

\[\beta = \frac{I_e}{I_b} = \frac{\alpha}{1 - \alpha}\]

\[\alpha = \frac{\beta}{1 + \beta}\]
Design Optimization Criteria

PnP

\[ P^+ \text{ Ig} \approx J_{ep} \]

\[ Y = \frac{J_{ep}}{J_{ep} + J_{en}} \text{ near unity} \]

Narrow base & width, light base doping!
CIRCUIT CONFIGURATIONS

1. COMMON Emitter
2. COMMON COLLECTOR / Emitter FOLLOWER
3. COMMON BASE

Choice based on application
FORWARD BIASING "ACTIVE REGION"
BE → FB
CE → RB
CURRENT AMPLIFICATION GAIN

\[ \beta = \frac{I_c}{I_b} \]

ONLY VALID FOR FORWARD ACTIVE REGION
i.e. when analyzing a CIRCUIT AND GOING FROM INPUT SIDE TO OUTPUT SIDE

3 BASIC REGIONS OF OPERATION

1. CUTOFF
2. FORWARD ACTIVE "ACTIVE"
3. SATURATION
IV CHARACTERISTICS

nPn

PnP
THINGS TO REMEMBER

1. For cut-off \( V_{BE} (or \ V_{EB}) < V_{to} \) (Turn-on voltage for PN junction)
   \( I_B \approx 0 \quad I_C \approx 0 \)

2. For \( V_{BE} (or \ V_{EB}) > V_{to} \)
   AND
   \( V_{CE} (or \ V_{EC}) \) (Saturation)
   Specification found in datasheet
   Active region

3. If \( V_{CE} (or \ V_{EC}) \leq V_{CE} (or \ V_{EC}) \) (Sat)
   THEN Saturation region