Department of Electrical Engineering
Indian Institute of Technology, Kanpur

EE 210 **QUIZ 1A** **10.2.21**
Total Marks: 15 **Total Time: 30 Mins.**

An npn BJT has f_{max} of 5 GHz, and its f_α is 1% more than f_T.

a) It needs to be biased such that the following performance requirements are satisfied:
   * r_0 should be 100 kΩ
   * β should be 10 at f = 100 MHz

   Determine the required bias point (I_C, V_{CE}). Assume that the BC junction is *linearly graded* with $V_{0(BC)}$ = 0.7 V. Other data: V_A = 100 V, C_{je0} = 2 pF, and $C_{\mu 0}$ = 1.5 pF. 12

b) Now, keeping I_C constant at the value calculated in part a), if V_{CE} is *increased, state with clear justification* whether the value of β (at 100 MHz) would increase or decrease. 3

a) $f_{max} = \frac{1}{2\pi \tau_F} \Rightarrow \tau_F = \frac{1}{2\pi f_{max}} = \frac{1}{2\pi \times 5\,GHz} = \boxed{31.83\,ps}$

$\frac{f_\alpha}{f_T} = \frac{\beta_0 + 1}{\beta_0} = 1.01 \Rightarrow \boxed{\beta_0 = 100}$

$r_o = \frac{V_A}{I_C} = 100\,k\Omega \Rightarrow I_C = \frac{V_A}{100\,k\Omega} = \boxed{1\,mA} \leftarrow$

$\beta = \frac{\beta_0}{1 + j f/f_\beta}$ at $f = 100$ MHz, $\beta = 10 \Rightarrow f \gg f_\beta$

$\Rightarrow f_\beta = \frac{\beta f}{\beta_0} = \frac{10 \times 100\,MHz}{100} = \boxed{10\,MHz}$ & $f_T = \beta_0 f_\beta = \boxed{1\,GHz}$

$C_{je} = 2 C_{jeo} = \underline{4\,pF}$ $\quad \tau_F g_m = \frac{1\,mA}{26\,mV} \times 31.83\,ps = \underline{1.22\,pF}$

$\Rightarrow C_\pi = C_{je} + \tau_F g_m = \underline{5.22\,pF}$

$f_T = \frac{g_m}{2\pi(C_\pi + C_\mu)} \Rightarrow C_\mu = \frac{g_m}{2\pi f_T} - C_\pi = \frac{1/26}{2\pi \times 1\,GHz} - 5.22\,pF = \underline{0.9\,pF}$

$C_\mu = \frac{C_{\mu 0}}{\left(1 - \frac{V_{BC}}{V_0}\right)^m}$ $\quad m = \frac{1}{3}$ (linearly graded)

$\Rightarrow \left(1 - \frac{V_{BC}}{V_0}\right) = \left(\frac{C_{\mu 0}}{C_\mu}\right)^{1/m} = \left(\frac{1.5}{0.9}\right)^3 = 4.63 \Rightarrow \boxed{V_{BC} = -2.54\,V}$

$V_{CE} = V_{BE} - V_{BC} = 0.7 + 2.54 = \boxed{3.24\,V} \leftarrow$

Bias pt. $(I_C, V_{CE}) \Rightarrow \boxed{(1\,mA,\ 3.24\,V)}$

b) I_C const → g_m const. $V_{CE} \uparrow \Rightarrow V_{CB} \uparrow \Rightarrow$ CB jn. becoming more rev. biased $\Rightarrow C_\mu \downarrow \Rightarrow f_T \uparrow \Rightarrow f_\beta \uparrow \Rightarrow \beta \uparrow$

(C_π remains const) ∵ τ_F remains const.

$\Rightarrow$ $\boxed{\beta \text{ would increase}}$

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EE 210	**QUIZ 1B**	**10.2.21**
Total Marks: 15		**Total Time: 30 Mins.**

An npn BJT has f_{max} of 10 GHz, and the ratio of its f_α and f_T is 1.005. ($V_T = 26$ mV)

a) It needs to be biased such that the following performance requirements are satisfied:
   * r_0 should be 50 kΩ
   * β should be 5 at f = 600 MHz

   Determine the required bias point (I_C, V_{CE}). Assume that the BC junction is *linearly graded* with $V_{0(BC)} = 0.7$ V. Other data: $V_A = 100$ V, $C_{je0} = 1$ pF, and $C_{\mu 0} = 1.7$ pF. **12**

b) Now, if V_{CE} is *decreased*, *state with clear justification* whether the value of β (at 600 MHz) would increase or decrease. Neglect any change in I_C and assume τ_F remains constant. **3**

a) $\boxed{\tau_F = 15.9\,ps}$ $\boxed{\beta_0 = 200}$ $\boxed{I_C = 2\,mA}$ $\boxed{f_\beta = 15\,MHz}$ $\boxed{f_T = 3\,GHz}$

$\boxed{C_{je} = 2\,pF}$ $\boxed{g_m \tau_F = 1.22\,pF}$ $\boxed{C_\pi = 3.22\,pF}$ $\boxed{C_\mu = 0.86\,pF}$

$\boxed{V_{BC} = -4.7\,V}$ $\boxed{V_{CE} = 5.4\,V}$ $\Rightarrow$ $\boxed{\text{Bias Pt. } (2\,mA, 5.4\,V)}$

b) All reverse of Q1A. $\boxed{\beta \downarrow}$

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