HIGH-FREQUENCY HYBRID-π TRANSISTOR CUTOFF FREQUENCY CALCULATIONS FOR TWO DIFFERENT COLLECTOR CURRENTS: [CE configuration, +15v V_{CC}; 2N3904]

Equation	Example 1 – 1 mA bias	Example 2 – 10 mA bias
$g_m = 40\lvert I_C \rvert$	40x1mA= 40 mmho	40x10mA=400 mmho
$\beta_o = h_{fe}$ from spec sheet	Approx. 120 @ 1 mA	Approx. 160 @ 10 mA
$r_\pi = \beta_o \div g_m$	120/40 x 10^{-3}= 3000 Ω	160/0.4 = 400 Ω
r_x	estimate; ≈ 25Ω	estimate; ≈ 25Ω
LF Gain: $A_v = -g_m R_L$	-300 [R_L= 7.5k]	-300 [R_L= 750Ω]
$C_\mu = C_{ob}$ [from spec sheet]	1.8 pF at V_{cb} = -7.0 v	1.8 pF at V_{cb} = -7.0 v
f_T from spec sheet	300 MHz	300 MHz
$C_\pi = \frac{g_m}{2\pi f_T} - C_\mu$	=21.2pF – 1.8pF ≈ 20pF	212pF
$C_T = C_\pi + (g_m R_L + 1)C_\mu$ Not good above ≈ 150 MHz!	=20pF + 301 x 1.8pF = 562 pF	=212pF + 301x1.8pF =754 pF
$\frac{v_\pi}{v_s} = \frac{1}{\frac{R_s'}{r_\pi} + 1 + j\omega R_s' C_T}$ [Equation is from HF cutoff paper; $R_s' = R_s + r_x$]	$= \frac{1}{\frac{75}{3000} + 1 + j\omega 75 \times 562\,pF}$ f_{3dB} = 3.8 MHz	$= \frac{1}{\frac{75}{400} + 1 + j\omega 75 \times 754\,pF}$ f_{3dB}=3.3 MHz
If we shunt the input resistance ($r_x + r_\pi$ // C_T) with a 51Ω resistance:	$= \frac{1}{\frac{51}{51} + 1 + j\omega 75 \times 562\,pF}$ f_{3dB} = 7.6 MHz	$= \frac{1}{\frac{51}{45} + 1 + j\omega 75 \times 754\,pF}$ f_{3dB}=5.9 MHz