High Frequency Performance of Common-Emitter Amplifier

Design:

1 - Design of CE amplifier, Icq = 10 mA and the output ac resistance, Ro, is 470 Ω. I_R1 = 10*I_Bq, and I_R2 = 9*I_Bq for a robust DC stability take VE = 2.7 V and β = 100.

$$I_B = \frac{I_C}{\beta} = \frac{10\ mA}{100} = 0.1\ mA$$

$$I_{R1} = 10 I_B = 1\ mA$$

$$I_{R2} = 9 I_B = 0.9\ mA$$

$$R_1 = \frac{V_{CC} - V_B}{I_{R1}} \Rightarrow \frac{12\ V - 3.7\ V}{1\ mA} = 8.6\ k\Omega$$

$$R_2 = \frac{V_B}{I_{R2}} \Rightarrow \frac{3.7\ V}{0.9\ mA} = 3.8\ k\Omega$$

$$R_E = \frac{V_E}{I_C} \Rightarrow \frac{2.7\ V}{10\ mA} = 270\ \Omega$$

$$R_0 = R_C = 470\ \Omega$$

2 - mid-band frequency small signal voltage gain, Av, and the input impedance Rin of the amplifier.

$$g_m = \frac{I_C}{V_T} = 0.4\ S$$

$$r_\pi = \frac{\beta}{g_m} = 250\ \Omega$$

$$R_{in} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{r_\pi}\right)^{-1} = 230\ \Omega$$

$$A_v = \frac{V_0}{V_i} = -g_m R_0 = -188$$

3 - input capacitance Cin of the amplifier using the miller effect method.

Datasheet Values:

$C\mu = C_{CB} = 8PF$ (Collector to Base small signal capacitance)

$f_T = 300\ MHz$ (Transient Frequency where Av = 1)

$V_T = 25\ mV$ (Thermal Voltage)

Calculations:

$$C_\pi = \frac{g_m}{2\pi f_T} - C_\mu = 204\ pf$$

$$C_{in} = C_\pi + (1 + A_V)C\mu = 1724\ pf$$

$$C_{out} = \frac{A_V + 1}{A_V} C_\mu = 8\ pf$$

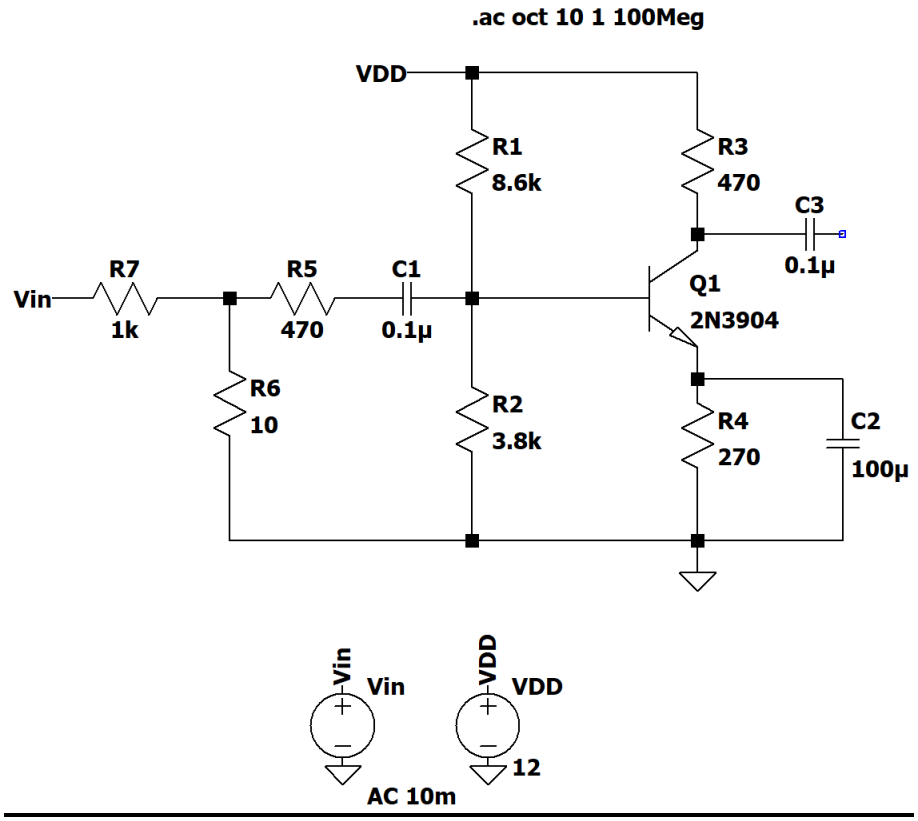
$$T_{out} = (R_C || R_L)C_{out} = R_C C_{out} = 3.76\ ns$$

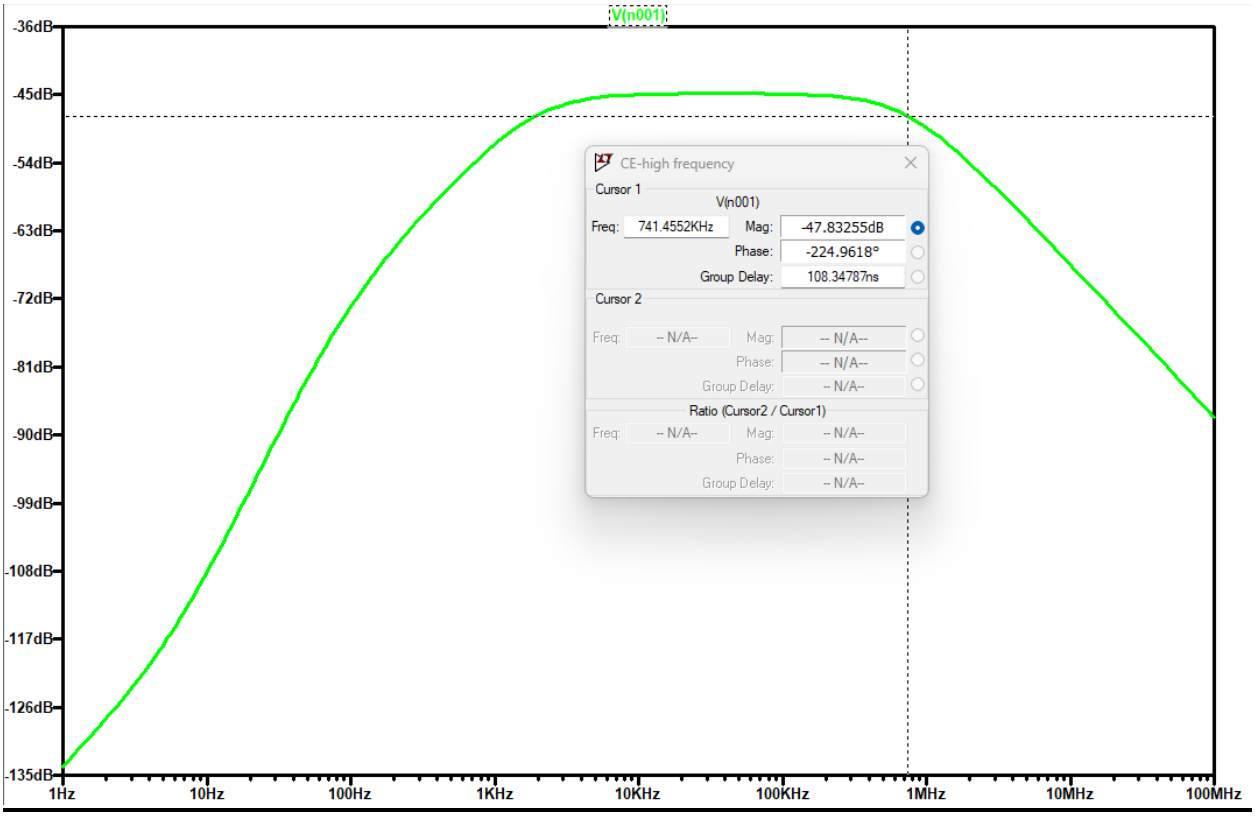
$$T_{in} = \left(\frac{1}{R_g} + \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{r_\pi}\right)^{-1} C_{in} = 265\ ns$$

$$H(j\omega) = \frac{A_v z_{in}}{z_{in} + R_g}\left(\frac{1}{(1 + j\omega T_{in})(1 + j\omega T_{out})}\right)$$

$$f_{cutoff} = \frac{1}{2\pi T_{in}} = 650.5\ kHz$$

Simulation Results:





Measured High-Frequency Response of CE Amplifier

Frequency (kHz)	**10**	**50**	**100**	**200**	**400**	**540**	**700**	**1000**	**2000**	**3000**	**4000**	**6000**	**8000**
v_o(mVpp)	860	860	860	820	700	**610**	520	400	220	160	125	95	75
v_g(mVpp)	15	15	15	15	15	15	15	15	15	15	15	15	15
$A_g = v_o/v_g$	57.3	57.3	57.3	54.7	46.7	**40.7**	34.7						

Results:

Method	**Description**	**Upper Cutoff Frequency f_H**
Hand Analysis	Dominant-pole estimate using Miller-effect input capacitance	≈ 600 kHz
LTspice Simulation	AC sweep with cursor-based −3 dB extraction	≈ 740 kHz
Experimental Measurement	Gain–frequency sweep using signal generator and oscilloscope	≈ 540 kHz

Results Summary:

The common-emitter amplifier exhibited Miller-effect-limited bandwidth, with an analytically estimated upper cutoff frequency of approximately 600 kHz, a simulated cutoff of approximately 740 kHz, and a measured cutoff of approximately 540 kHz. The close agreement confirms that Miller multiplication of the base–collector capacitance dominates the high-frequency response, motivating cascode topologies for bandwidth improvement.