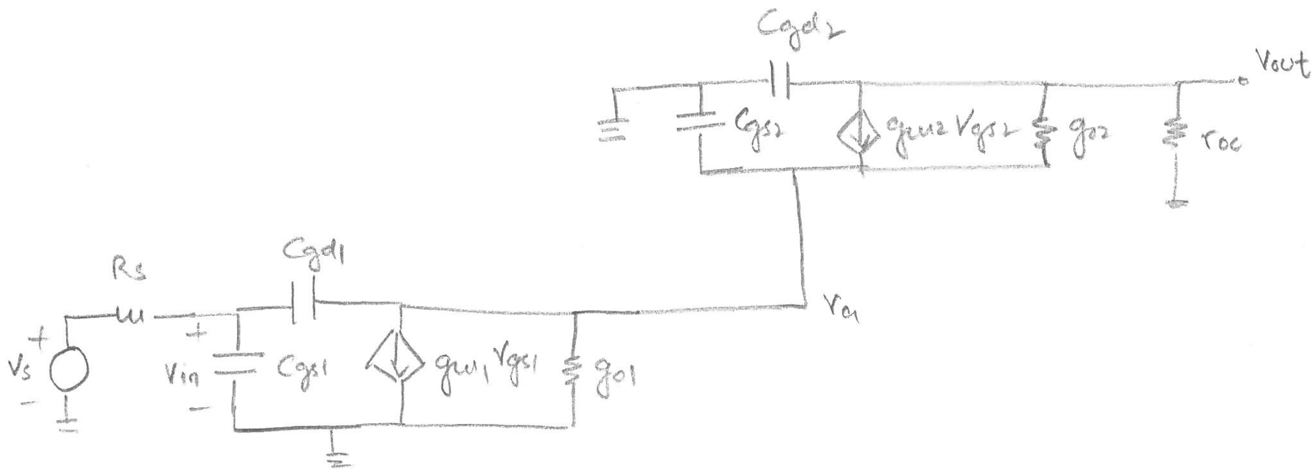
10.2)

a)



b) $g_m \cong \sqrt{2k_n I_D} = .0057$ S $\quad g_o \cong \lambda_n I_D = 8\times10^{-5}$ S

g_m is $\sim$ 70 times larger than g_o

c)
$$\frac{V_{out}}{r_{oc}} + (V_{out} - V_a)g_{o2} - g_{m2}V_a + V_{out}\, j\omega C_{gd2} = 0$$

$$\Rightarrow \frac{V_{out}}{V_a} = \frac{g_{m2} + g_{o2}}{\frac{1}{r_{oc}} + g_{o2} + j\omega C_{gd2}} \approx \frac{g_{m2}}{\frac{1}{r_{oc}} + g_{o2} + j\omega C_{gd2}} = \frac{g_{m2}(r_{oc}\|r_{o2})}{1 + j\omega C_{gd2}(r_{oc}\|r_{o2})} = H_2(\omega)$$

d) see attached plot.

e)
$$V_a g_{o1} + g_{m1}V_{in} + j\omega C_{gd1}(V_a - V_{in}) + V_a j\omega C_{gs2} + g_{m2}V_a + (V_a - V_{out})g_{o2} = 0$$

$$\Rightarrow \frac{V_a}{V_{in}} = \frac{-g_{m1} + j\omega C_{gd1}}{g_{o1} + g_{o2} + g_{m2} + j\omega(C_{gd1} + C_{gs2}) - g_{o2}H_2(\omega)} = H_1(\omega).$$

f) See attached plot.

g) $$\frac{V_{in} - V_s}{R_s} + V_{in}\, j\omega C_{gs1} + (V_{in} - V_a)\, j\omega C_{gd1} = 0.$$

$$\frac{V_{in}}{V_s} = \frac{1}{1 + j\omega(C_{gs1} + C_{gd1})R_s - j\omega C_{gd1} R_s H_1(\omega)} = H_0(\omega).$$

h) See the attached plot

i). $|H_2(\omega)|^2$ has a 3dB freq of ~ 2.5 GHz.

$|H_1(\omega)|^2$ has a 3dB freq of ~ 1.58 GHz.

$|H_0(\omega)|^2$ has a 3dB freq of ~ 1.29 GHz.

So the first and the second stage limit the freq. bandwidth of the amplifier.

j) $$\frac{V_{out}}{V_s} = \frac{V_{out}}{V_a} \cdot \frac{V_a}{V_{in}} \cdot \frac{V_{in}}{V_s} = H_2(\omega)\, H_1(\omega)\, H_0(\omega) = H_T(\omega)$$

See the attached plot. The 3dB frequency for $|H_T(\omega)|^2$ is ~ 0.80 GHz.

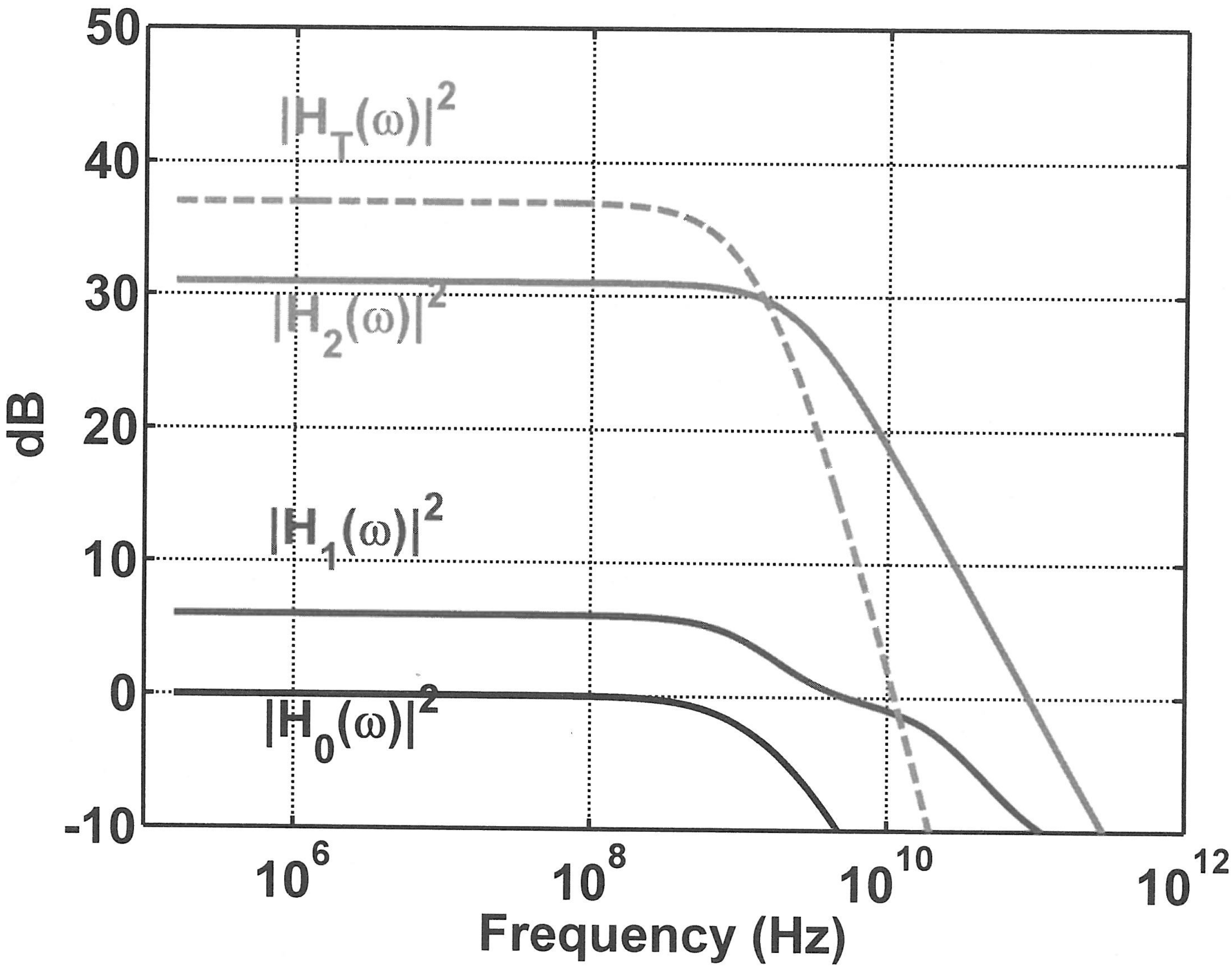
k) See the attached plot.

The 3dB freq. of the Common Source amp is ~ 0.18 GHz.

The Cascode has ~ 4.4 times larger 3dB frequency compared to the Common Source.

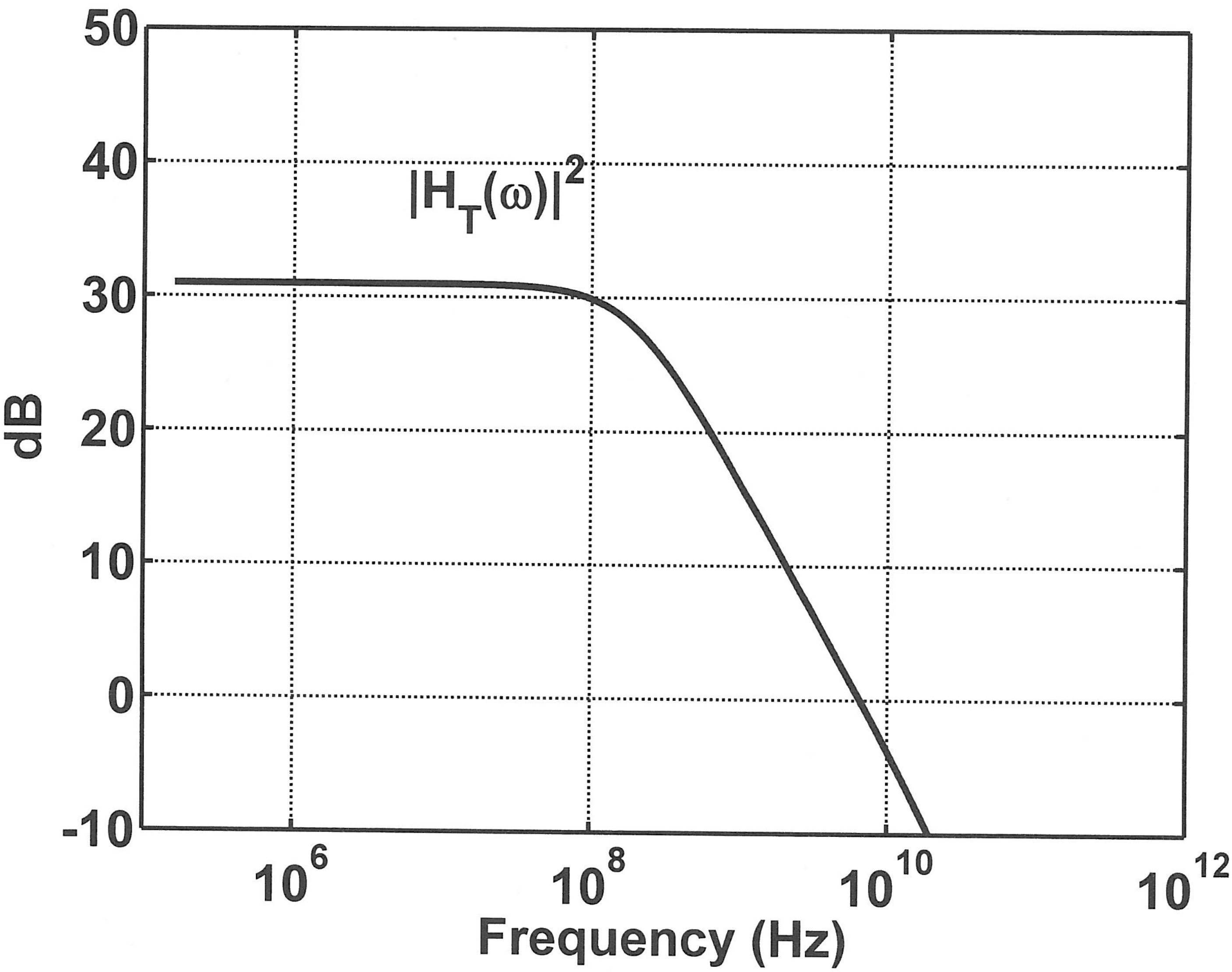
e) Common drain does not suffer from the Miller effect as there is no gain provided by this stage.

{ Cascode }



see (i)(j) for the 3dB frequencies of each curve

(Common Source)



10.1)

a) For forward active region.

$$V_{CE} \geq V_{CE-SAT}$$

$$V_{CE} = V_{DD} - I_C R. \quad I_C = \beta_F I_B = \beta_{F0}\left(1+\frac{V_{CE}}{V_A}\right) I_B. \quad I_B \in [5, 50]\,\mu A$$

$$\Rightarrow V_{CE} = V_{DD} - \beta_{F0} R\left(1+\frac{V_{CE}}{V_A}\right) I_B \quad \Rightarrow V_{CE} = \frac{V_{DD} - \beta_{F0} I_B R}{1+\beta_{F0} I_B R/V_A}$$

$$\Rightarrow \frac{V_{DD} - \beta_{F0} I_B R}{1+\beta_{F0} I_B R/V_A} \geq V_{CE-SAT}, \quad \text{So } R_{max} = \frac{V_{DD} - V_{CE\_SAT}}{\beta_{F0} I_B \left(1+\frac{V_{CE\_SAT}}{V_A}\right)}$$

$R_{min} = 0$.

The plot is attached in the end.

b) $V_{out} = 2.5V$. $I_C = 1mA$

$$I_C = \beta_F I_B = \beta_{F0}\left(1+\frac{V_{CE}}{V_A}\right) I_B, \quad V_{out} = V_{CE} \Rightarrow I_B = \frac{I_C}{\beta_{F0}\left(1+\frac{V_{OUT}}{V_A}\right)} \approx 9.5\,\mu A$$

$$V_{CE} = V_{DD} - I_C R \Rightarrow R = \frac{V_{DD} - V_{CE}}{I_C} = 2500\,\Omega$$

c)d) $R = 2500\Omega$. $V_{CE} > V_{CE\_SAT}$. $V_{CE} = V_{DD} - I_C R = V_{DD} - \beta_{F0}\left(1+\frac{V_{CE}}{V_A}\right) I_B R$

$$\Rightarrow V_{CE} = \frac{V_{DD} - \beta_{F0} I_B R}{1+\beta_{F0} I_B R/V_A} > V_{CE\_SAT}$$

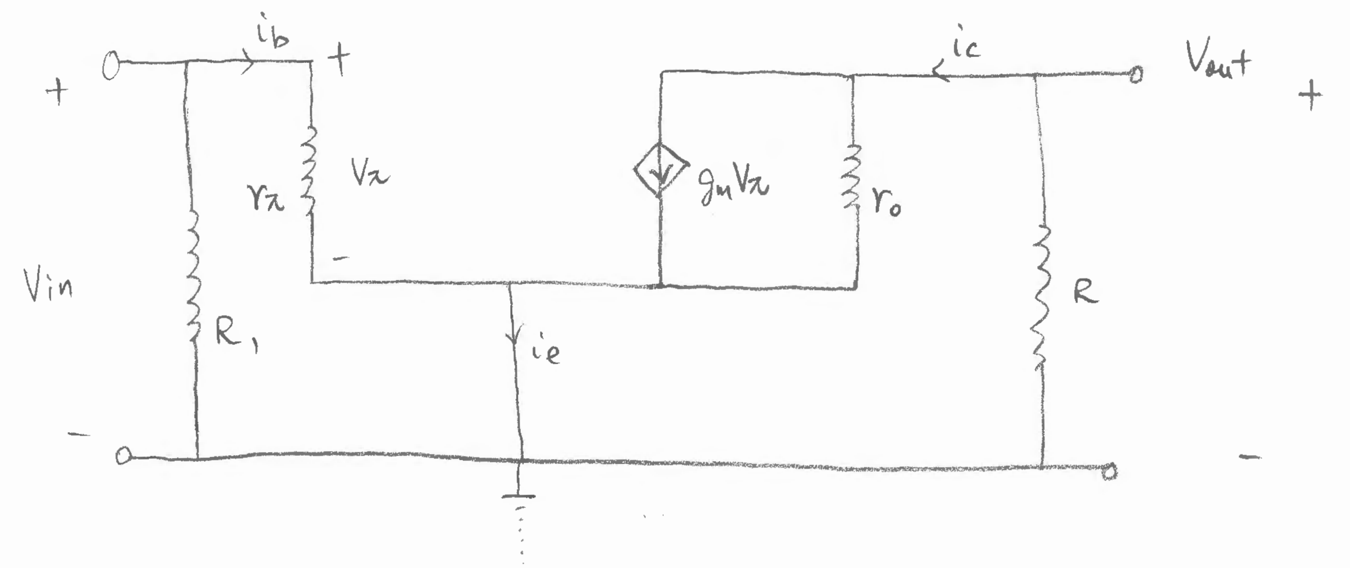
$$\Rightarrow I_{B\_max} = \frac{V_{DD} - V_{CE\_SAT}}{\beta_{F0} R\left(1+\frac{V_{CE\_SAT}}{V_A}\right)} \approx 19\,\mu A, \quad I_B \in [0, 19]\,\mu A$$

$V_{CE} = V_{out} > V_{CE\_SAT}$ so $V_{out} \in [0.2, 5]\ V$

e)

$$R_1 = \frac{V_{DD} - V_{BE\_ON}}{I_B} = 462000$$

f)



$$A_v = \frac{V_{out}}{V_{in}} = -g_m (r_o // R)$$

Note that the input resistance of the CE stage is (R1 || r_π)

If R1 is very small, the input resistance is then essentially R1. If there is any series resistance Rs associated with the voltage source, then the input voltage vs would have been divided across Rs and R1 and a small R1 would then make vin small compared to vs.

g) $A_v = -g_m (r_o // R)$. $g_m = \frac{q I_c}{kT}$. $r_o = \frac{1}{g_o}$. $g_o = \frac{I_c}{V_A}$

$I_c = 1\,mA$. $V_A = 50V$. $A_v \approx -92$

h)

$$A_v = -\frac{q I_c}{kT} \frac{\frac{V_A}{I_c} R}{\left(\frac{V_A}{I_c} + R\right)} = -\frac{q V_A}{kT} \frac{1}{\left(\frac{V_A}{R I_c} + 1\right)}.$$

$V_{OUT} = V_{DD} - R I_c$.

If V_{out} is fixed at 2.5V, $R I_c$ is fixed. the A_v is fixed.

So no, we can't.