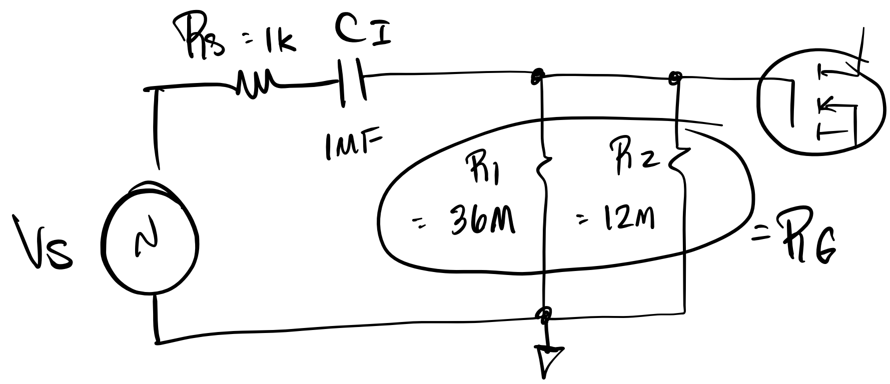
Common-Source LF AC Circuit

∴ like CE, the impedances of the capacitors become important at low frequencies

LF Input Circuit



∴ the equivalent resistance seen by C_I is $R_S + R_G$

$$\therefore f_{L(IN)} = \frac{1}{2\pi \cdot C_I \, (R_S + R_G)}$$

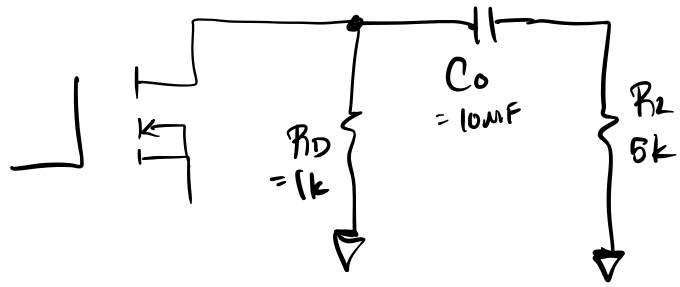
$$f_{L(IN)} = \frac{1}{2\pi \cdot 1\times10^{-6} \, (1k + 9G)}$$

$$f_{L(IN)} = 0.01768 \text{ Hz}$$

∴ high input resistance makes very <u>low</u> cutoff frequency!

LF Output Circuit

∴ assume r_o is sufficiently large to be neglected

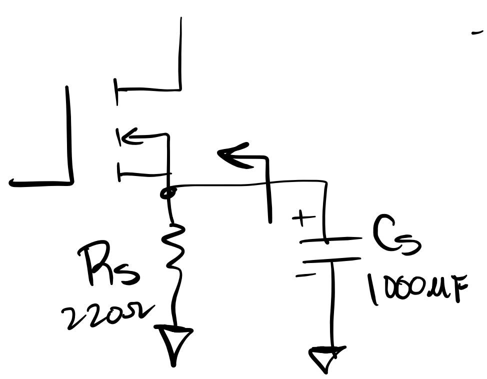
∴ 

∴ thus, the resistance "seen" by C_o is $R_L + R_D$

$$\therefore\ f_{L(OUT)} = \frac{1}{2\pi C_o (R_L + R_D)}$$

$$f_{L(OUT)} = \frac{1}{2\pi \cdot 10\times10^{-6} (5k + 1k)} = 2.653\ Hz$$

LF Source Circuit



∴ we found with the BJT CE amplifier that the resistance seen by C_E is $R_E \parallel \frac{1}{g_m}$

∴ exactly the case with C_S!

$$f_{L(S)} = \frac{1}{2\pi C_S \left(R_S \parallel \frac{1}{g_m}\right)}$$

$$\frac{1}{g_m} = \frac{1}{\underset{\uparrow\, mA/V}{14.11}} = 0.07087\ k\Omega$$

or $\underbrace{70.87\ \Omega}$

$$\therefore\ 220\,\Omega \parallel 70.87\,\Omega = \underbrace{53.60\ \Omega}$$

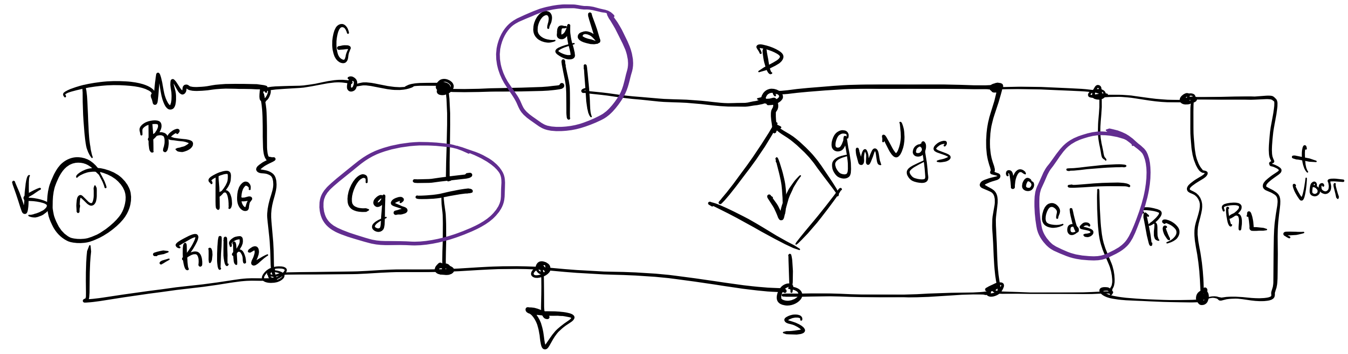
$$f_{L(S)} = \frac{1}{2\pi \cdot 1000\times10^{-6} \cdot 53.60} = \underbrace{2.969\ Hz}$$

- $f_{L(S)}$ and $f_{L(OUT)}$ are very close together; not a dominant pole situation!

- thus, $\underbrace{\text{expected } -3dB\ f_L > f_{L(S)}}$

Common-Source HF SSM

- similar situation as common-emitter; we add gate-to-source and gate-to-drain capacitances; but unlike the BJT, we now have drain-to-source capacitance as well!



∴ FET data sheets don't give us values for these interelectrode capacitances directly; rather, they list C_{iss} (input capacitance), C_{oss} (output capacitance), and C_{rss} (reverse transfer capacitance), from which we must deduce C_{gs}, C_{gd}, and C_{ds}, knowing:

$$C_{iss} = C_{gs} + C_{gd} \quad \leftarrow \text{gate stuff}$$

$$C_{oss} = C_{gd} + C_{ds} \quad \leftarrow \text{drain stuff}$$

$$C_{rss} = C_{gd}$$

$$\therefore \quad C_{gs} = C_{iss} - C_{rss}$$

$$C_{gd} = C_{rss}$$

$$C_{ds} = C_{oss} - C_{rss}$$

∴ in this example:

$$\left.\begin{aligned} C_{iss} &= 40\text{ pF} \\ C_{oss} &= 15\text{ pF} \\ C_{rs} &= 5\text{ pF} \end{aligned}\right\} \text{typical for small, n-channel enhancement-type MOSFET}$$

$$C_{gs} = C_{iss} - C_{rss} = 40 - 5 = \underline{35\ pF}$$

$$C_{gd} = C_{rss} = \underline{5pF}$$

$$C_{ds} = C_{oss} - C_{rss} = 15 - 5 = \underline{10\ pF}$$

$f_{H(IN)}$:

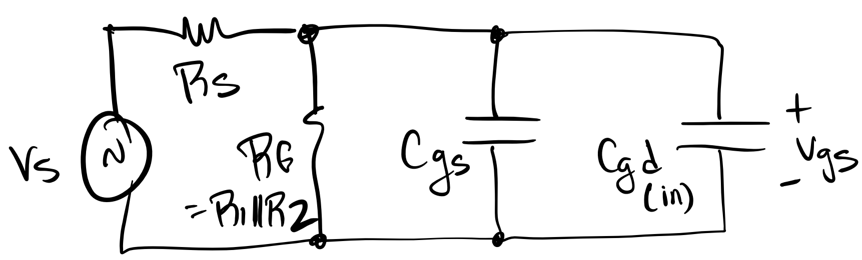
∴ as with the CE amplifier, with C_{gd} between the input and output of an inverting amplifier,

it's Miller Time!

$$C_{gd(IN)} = C_{gd}\,(1 - \overset{-11.52}{A_{v_2}})$$

$$= 5\,(1 - {}^{-}11.52) = \underline{62.6\ pF}$$

equivalent HF SSM at input :



∴ with one source transformation we can show that the equivalent resistance seen by the parallel capacitance is $\underline{R_s \| R_G}$.

thus,

$$f_{H(IN)} = \frac{1}{2\pi (R_S \| R_G)(C_{gs} + C_{gd(in)})}$$

$$f_{H(IN)} = \frac{1}{2\pi \underbrace{(1k \| 9M)}_{=1k!} (35p + 62.6p)}$$

$$f_{H(IN)} = 1.63 \text{ MHz}$$

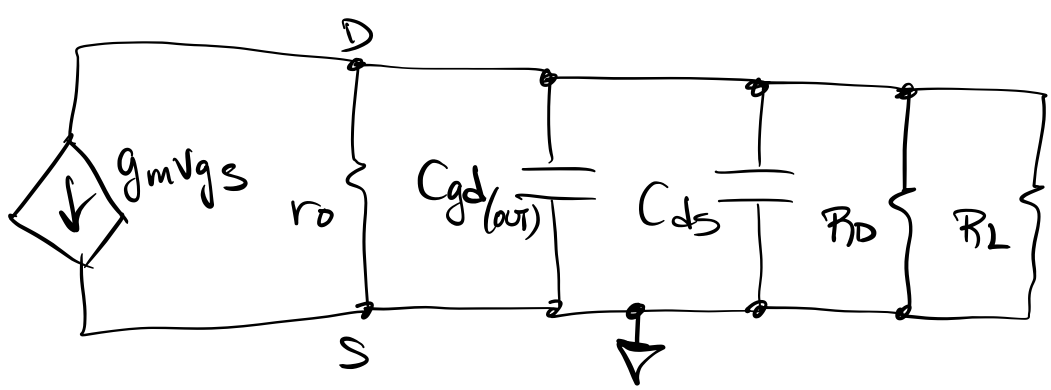
$f_{H(OUT)}$:

∵ Miller Time at the output due to C_{gd} is

$$C_{gd(out)} = C_{gd}\left(1 - \frac{1}{A_{v2}}\right)$$

$$= 5\left(1 - \frac{1}{-11.52}\right) \approx 5pF$$

∴ equivalent HF SSM at output :



∴ equivalent resistance seen by parallel capacitance is

$$r_o \| R_D \| R_L = R_D' \| R_L \;;$$

thus,

$$f_{H(OUT)} = \frac{1}{2\pi (R_D' \| R_L)(C_{ds} + C_{gd(OUT)})}$$

$$= \frac{1}{2\pi (.8164k)(10p + 5p)}$$

$$\uparrow$$
from last lecture

$$f_{H(OUT)} = 13 \text{ MHz}$$

∴ thus, like CE BJT amplifier, the input pole dominates

and $f_H \approx 1.63$ MHz