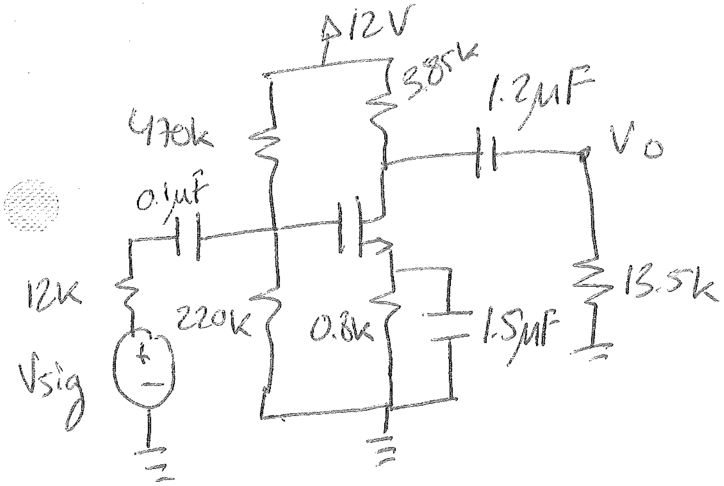
11/14/2016

Madhu



$k = 1.5\,mA/V^2$

$V_T = 0.75V$

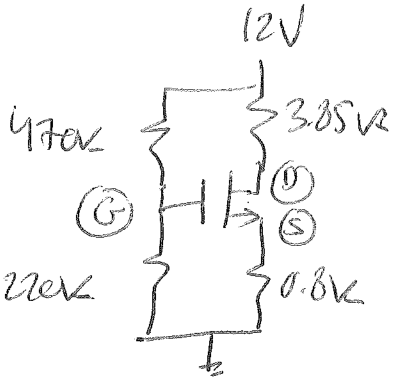
$C_{gs} = 5pF$

$C_{gd} = 3pF$

$C_{ds} = 25pF$

- DC
- small-signal mid-band gain
- ω_{Lo}
- ω_{Hi}

DC Analysis



$\rightarrow V_G = 12V \cdot \frac{220k}{220k + 470k} = 3.826V$

$\rightarrow V_G - 0.8\overset{k\Omega}{} I_D = V_{GS}$

$\rightarrow V_{GS} = 3.826V - 0.8\overset{k\Omega}{} \cdot \frac{1}{2}\, 1.5mA/V^2 (\cancel{3.826}^{V_{GS}} - 0.75)^2$

$3.826 - 0.6V_{GS}^2 + 0.9V_{GS} - 0.3375 = V_{GS}$

$V_{GS} = 2.329V$

$\rightarrow$ and $I_D = 1.87mA$

$\rightarrow$ Also $V_D = 12 - (1.87mA)(3.85k\Omega) = 4.801V$

$V_{DS} > V_{GS} - V_T$

$V_{GD} = -0.975 < V_T$

$\therefore$ Sat. ok.

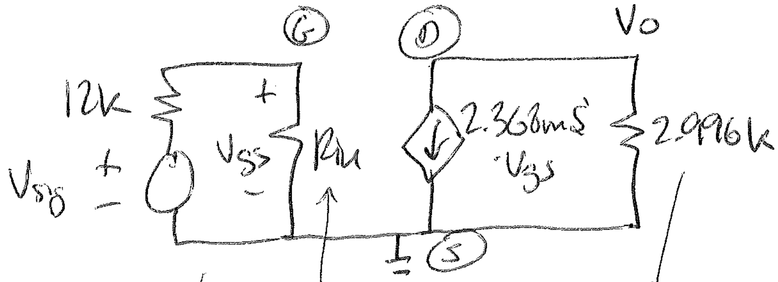
~~small signal~~

$\rightarrow g_m = 1.5mA/V^2 (2.329 - 0.75) = 2.368\,mS$

Mid-band gain

Small capacitances are opens. Large caps are shorts.

Small-signal eq. circuit:



$R_{in} = (470 \| 220) = 149.8k$ $R_{eq} = R_D \| R_L = 13.5k \| 3.85k = 2.996k$

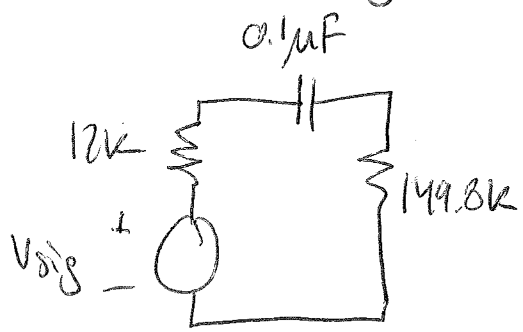
$\rightarrow \dfrac{V_o}{V_{gs}} = -g_m \cdot R_{eq} = (-2.368mS)(2.996k) = -7.094 \ V/V$

$\rightarrow \dfrac{V_{gs}}{V_{sig}} = \dfrac{R_{in}}{R_{in} + 12k} = \dfrac{149.8k}{149.8 + 12k} = \dfrac{149.8}{161.8} = 0.9258.$

$\rightarrow \boxed{A_{mid} = \dfrac{V_{gs}}{V_{sig}} \cdot \dfrac{V_o}{V_{gs}} = (0.9258)(-7.094) V/V = -6.568 \ V/V}$

Low-freq. response.

① C_1 acting alone.



$\omega_{C_1} = \dfrac{1}{\tau} = \dfrac{1}{(0.1\mu F)(12k + 149.8k)} = 61.81/s$

$\tau = R_{TH} \cdot C$ $\times 10^{-6} F$ $\times 10^3$

cont'd

7 cont'd

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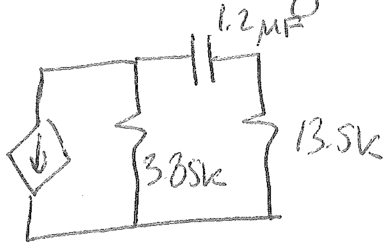
② C_2 acting alone:

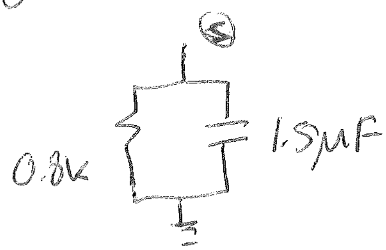


$$\omega_{C_2} = \frac{1}{\tau} = \frac{1}{(1.2\times10^{-6}F)(385k + 13.5k)}$$

$$\omega_{C_2} = 48.03 \text{ r/s}$$

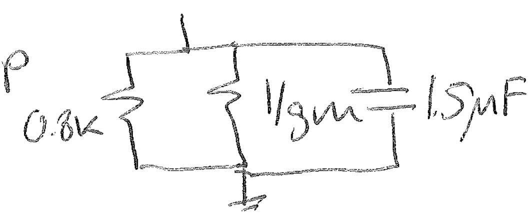
③ Bypass C_S acting alone:

ω_z



$$\omega_z = \frac{1}{(1.5\times10^{-6}F)(0.8\times10^3\,\Omega)} = 833.3 \text{ r/s}$$

ω_p



$$\omega_p = \frac{1}{(1.5\times10^{-6}F)(276.4\,\Omega)} = 2412 \text{ r/s}$$

$g_m = 2.368$ mS

$\rightarrow \frac{1}{g_m} = 0.4223k$

$\rightarrow (0.8k \,||\, 0.4223k) = 0.2764\,k\Omega$

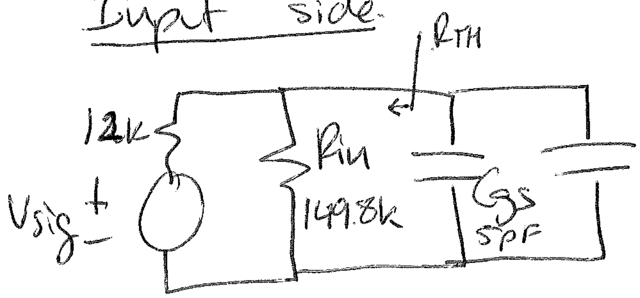
→ $\boxed{\text{Take 2412 r/s as dominant frequency } \omega_{Low}}$

↑ completes low frequency analysis.

11/14/2016

High frequency analysis

Input side



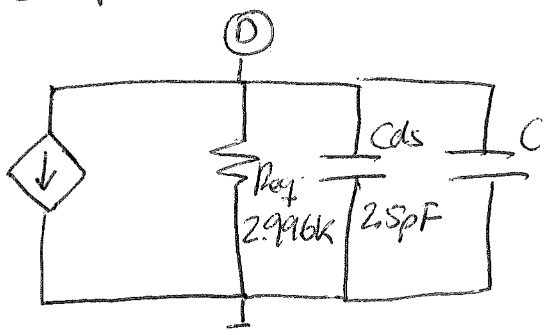
$C_M = C_{gd}(1 + g_m R_{eq})$
$= 24.28pF$

$C_{gd} = 3pF$
$g_m = 2.368mS$
$R_{eq} = 2.996k$

$$\omega_{hi(in)} = \frac{1}{RC} = \frac{1}{(11.11k\Omega)(29.28\times10^{-12}F)} = 3.074\times10^{6}\ r/s$$

$R_{TH} = [(149.8k)\,||\,(12k)] = 11.11k\Omega$
$C = 29.28pF$

Output side:



$C'_M = C_{gd}\left(1 + \frac{1}{g_m R_{eq}}\right) = 3.423pF$

$$\omega_{hi(out)} = \frac{1}{RC} = \frac{1}{(2.996k\Omega)(5.923\times10^{-12}F)} = 5.635\times10^{7}\ r/s$$

$R = 2.996k$
$C = 5.923pF$

$\therefore \boxed{\omega_{hi} = 3.074\times10^{6}\ r/s}$

completes analysis.

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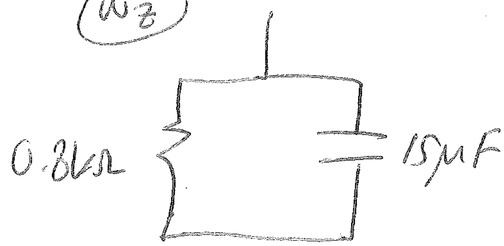
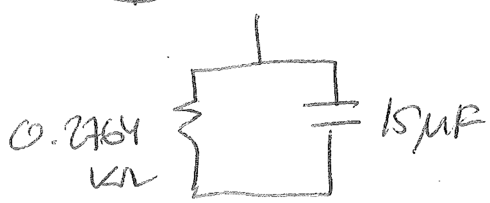
↳ Now changing bypass capacitor to 15 μF.

ω_z



$$\omega_z = \frac{1}{(15\times10^{-6}F)(0.8k\Omega)} = 83.33 \text{ r/s}$$

ω_p



$$\omega_p = \frac{1}{(0.2764k\Omega)(15\times10^{-6}F)} = 241.2 \text{ r/s}$$

?) Take this as a non-dominant situation.

→ Then find $\omega = ?$ when gain is $0.707 \cdot A_{mid}$ by making $A_{mid} = 1$ (normalized)

$$\therefore \quad \text{Gain} = \frac{s^2(s+\omega_z)}{(s+\omega_{c1})(s+\omega_{c2})(s+\omega_p)}$$

$s = j\omega$

$$\left|\frac{-\omega^2(83.33+j\omega)}{(61.8+j\omega)(480+j\omega)(241.2+j\omega)}\right| = 0.707$$

$$\therefore \boxed{\omega_{low} = 238.6 \text{ r/s}}$$