

34. For the circuit shown in figure 12 below, JFET parameters are $I_{DSS} = 8mA$, $V_P = -4V$, [10] $r_d = \infty$. The various parasitic capacitance are $C_{gd} = 2pF$, $C_{ds} = 0.5pF$, $C_{gs} = 4pF$, $C_{wi} = 5pF$, $C_{wo} = 6pF$

a) Find the higher cut-off frequency

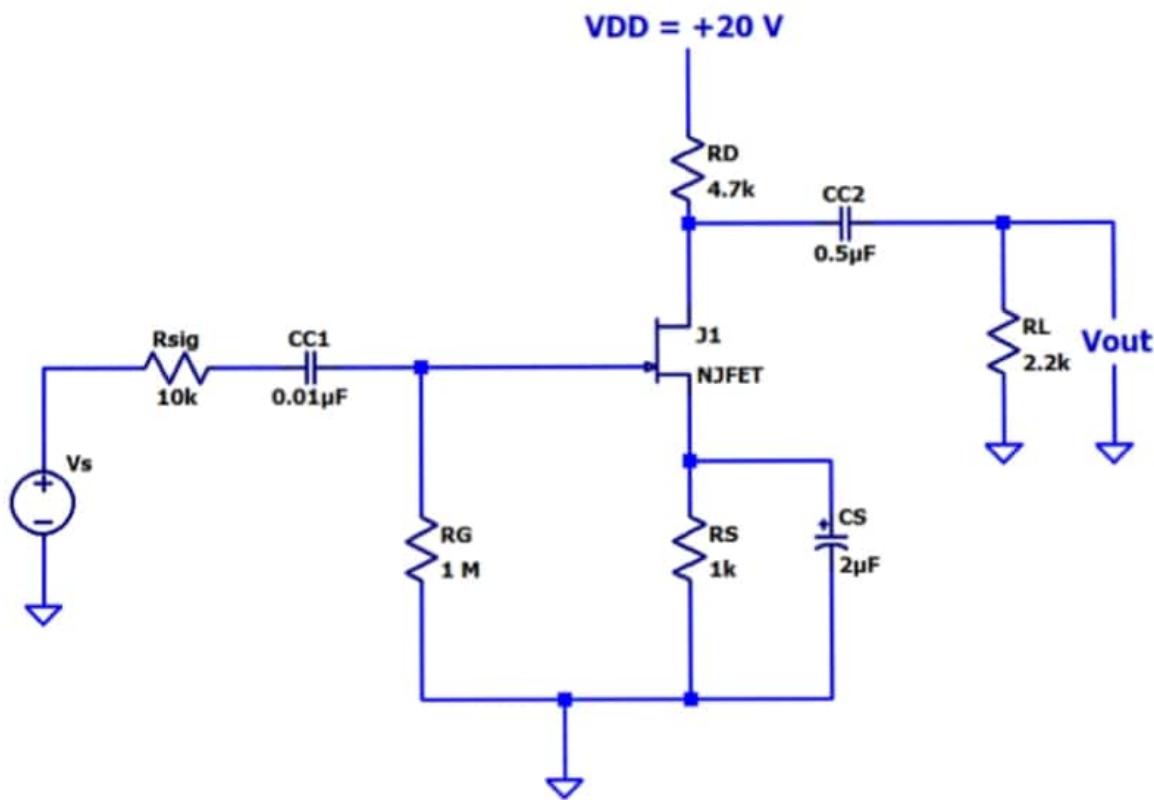


Figure 12: Question 34

Answers: $V_{GSQ} = -2V$ $I_{DQ} = 2mA$ $g_m = 2mA/V$ $A_{VMID} = -2.96$
 $C_{mi} = 7.92pF$ $C_{mo} = 2.675pF$ $C_i = 16.92pF$ $C_o = 9.175pF$ $f_{Hi} = 950.13KHz$
 $f_{Ho} = 11.579MHz$ $f_H = 11.579MHz$

Q34. Given: $V_{DD} = 20V$

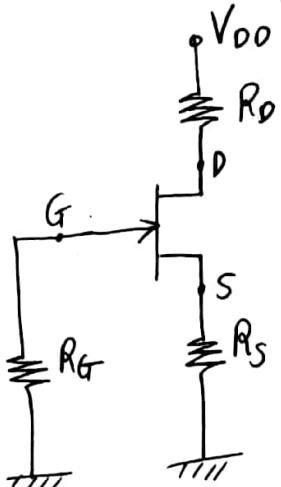
$$C_{gd} = 2\text{pF} \quad C_{ds} = 0.5\text{pF} \quad C_{gs} = 4\text{pF}$$

$$C_{wi} = 5\text{pF} \quad C_{wo} = 6\text{pF}$$

$$I_{DSS} = 8\text{mA} \quad V_p = -4V$$

To find: f_H

Solution: a) DC Analysis :-



$$V_G = 0$$

$$V_{GS} = V_G - V_S$$

$$V_S = I_D R_S$$

$$V_{GS} = 0 - I_D R_S$$

$$V_{GS} = -I_D R_S \quad \text{--- (1)}$$

$$\text{i.e. } V_{GS} = -I_D (1000)$$

$$I_D = I_{DSS} \left(1 - \frac{V_{GS}}{V_p} \right)^2$$

$$I_D = 8 \times 10^{-3} \left(1 + \frac{V_{GS}}{4} \right)^2 \quad \text{--- (2)}$$

Put (2) in (1), we get

$$\rightarrow V_{GS} = -8 \left(1 + \frac{V_{GS}}{2} + \frac{V_{GS}^2}{16} \right)$$

$$V_{GS} = -8 - 4V_{GS} - 0.5V_{GS}^2$$

$$\text{i.e. } 0.5V_{GS}^2 + 5V_{GS} + 8 = 0$$

$$V_{GS} = -2V \quad \text{or} \quad -8V$$

$\checkmark (V_{GS} > V_P)$

$\therefore V_{GSQ} = -2V$

$$I_D = I_{DSS} \left(1 - \frac{V_{GS}}{V_P}\right)^2 = 8 \times 10^{-3} \left(1 - \frac{(-2)}{(-4)}\right)^2$$

$\therefore I_D = 2mA$

b) Small-signal parameters :-

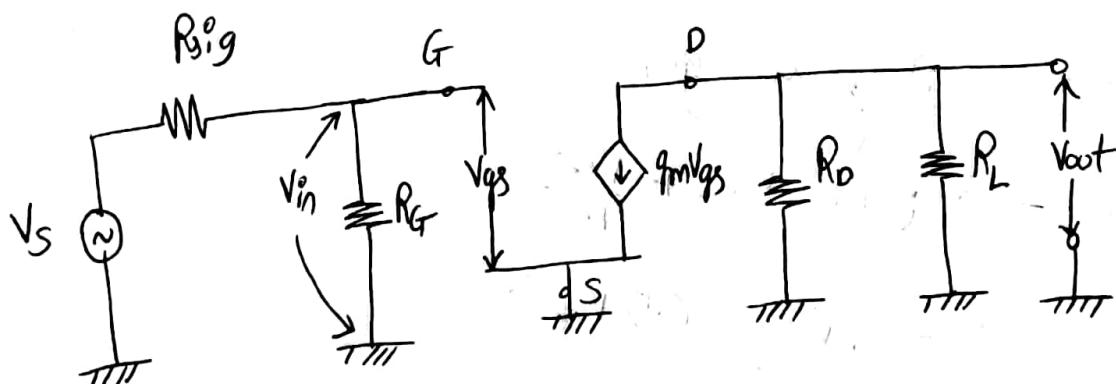
$$g_m = \left| \frac{2I_{DSS}}{V_P} \right| \left(1 - \frac{V_{GS}}{V_P}\right)$$

$$= \frac{2 \times 8 \times 10^{-3}}{4} \left(1 - \frac{(-2)}{(-4)}\right)$$

$$= 4 \times 10^{-3} (1 - 0.5)$$

$g_m = \frac{2mA}{V}$

c) Mid-band gain (A_{vmid}) :-



$$\rightarrow A_{vmid} = \frac{V_{out}}{V_s} = \frac{V_{out}}{V_{in}} \times \frac{V_{in}}{V_s}$$

$$\begin{aligned} \frac{V_{out}}{V_{in}} &= -g_m (R_D \parallel R_L) \\ &= -2 \times 10^{-3} (4.7K \parallel 2.2K) \\ &= -2 \times 10^{-3} (1.498K) \\ &= -2.997 \end{aligned}$$

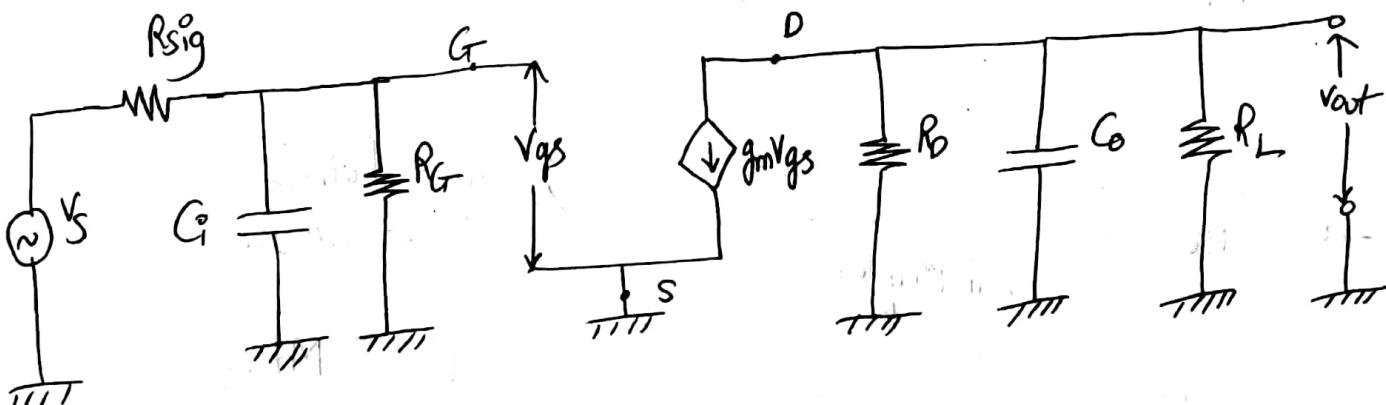
$$\frac{V_{in}}{V_s} = \frac{R_G}{R_G + R_{sig}} = \frac{1 \times 10^6}{1 \times 10^6 + 10K} = 0.99$$

$$\rightarrow A_{mid} = -2.997 \times 0.99$$

$$\boxed{A_{mid} = -2.967}$$

$$\begin{aligned} A_{mid} &= 20 \log_{10} (2.967) \\ &= 9.446 \text{ dB} \end{aligned}$$

d) High-frequency equivalent circuit :-



$$\cdot C_i^o = C_{gs} + C_{mi}^o + C_{wi}^o$$

$$\cdot C_{mi}^o = C_{gd} \left(1 - A_{vmid} \right) = 2 \text{ pF} \left(1 - (-2.967) \right) = \underline{7.93 \text{ pF}}$$

$$\cdot C_i^o = 4 \text{ pF} + 7.93 \text{ pF} + 5 \text{ pF} = \underline{16.93 \text{ pF}}$$

$$\cdot C_o = C_{wo} + C_{mo} + C_{ds}$$

$$\cdot C_{mo} = C_{gd} \left(1 - \frac{1}{A_{vmpd}} \right) = 2 \text{ pF} \left(1 + \frac{1}{2.967} \right) = \underline{2.674 \text{ pF}}$$

$$\cdot C_o = 6 \text{ pF} + 2.674 \text{ pF} + 0.5 \text{ pF}$$

$$C_o = 9.174 \text{ pF}$$

$$\rightarrow f_{H^o} = \frac{1}{2\pi R_{\text{eq}} C_i^o} ; R_{\text{eq}} = R_{\text{sig}} || R_G$$

$$= 10 \text{ k} || 1 \text{ M}$$

$$= \underline{9.9 \text{ k}\Omega}$$

$$= \frac{1}{2\pi \times 9.9 \text{ k} \times 9.174 \text{ pF}}$$

$$\frac{1}{16.93}$$

$$\boxed{f_{H^o} = 949.57 \text{ kHz}}$$

$$\rightarrow f_{HO} = \frac{1}{2\pi R_{\text{eq}} C_o} ; R_{\text{eq}} = R_O || R_L$$

$$= 1.498 \text{ k}$$

$$f_{HO} = \frac{1}{2\pi \times 1.498 \text{ k} \times 9.174 \text{ pF}} = \underline{11.58 \text{ MHz}}$$

\rightarrow Select lowest among f_{HO} and f_{H^o} as the higher cut-off frequency of the circuit

$$\boxed{f_H = 949.57 \text{ kHz}}$$