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FET Amplifiers
Tutorial 4

1) $I_D = I_{DSS} \cdot \left(1 - \frac{I_D \cdot R_S}{V_{GS(off)}}\right)^2$; $V_{GS} = -I_D \cdot R_S$

$I_D = 4.3 \cdot 10^{-3} \cdot \left(1 - 2 \cdot \frac{I_D \cdot 1.1 \cdot 10^3}{7.7} + \frac{I_D^2 \cdot 1.1^2 \cdot 10^6}{7.7^2}\right)$

$I_D = 4.3 \cdot 10^{-3} - 1.23 I_D + 87.76 I_D^2$

$87.76 I_D^2 - 2.23 I_D + 4.3 \cdot 10^{-3} = 0 \Rightarrow I_D = 2.1 \text{ mA}$

$V_{GS} = -I_D \cdot R_S = -2.31 V$

2) a) $V_G = 0V$; $V_S = 0V$

$V_D = V_{DD} - I_D R_D = 15V - 8mA \cdot 1k\Omega = 7V$

b) $V_G = 0V$

$V_S = -I_D R_D = -3mA \cdot 330\Omega = -0.99 V$

$V_D = -V_{DD} + I_D R_D = -10V + 3mA \cdot 1.5k\Omega = -5.5V$

c) $V_G = \left(\frac{R_2}{R_1 + R_2}\right) \cdot V_{DD} = 3.837 V$

$V_S = 0V$

$V_D = V_{DD} - I_D R_D = 12V - 6mA \cdot 1k\Omega = 6V$

3) $V_D = V_{DD} - I_D R_D = 12V - 2.83mA \cdot 1.5 k\Omega = 7.755 V$

$V_S = I_D R_S = 2.83 V$

$V_{DS} = V_D - V_S = 7.755 - 2.83 = 4.925 V$

$V_{GS} = V_G - V_S = 0V - 2.83V = -2.83 V$

4) $R_d = R_D \| R_L = \frac{1.5 \cdot 10}{11.5} = 1.304 k\Omega$

$A_v = g_m \cdot R_d = 5000 \mu S \cdot 1.304 k\Omega = 6.52$

$V_{out(pp)} = 2\sqrt{2} \cdot 50 mV \cdot 6.52 = 922 mV$

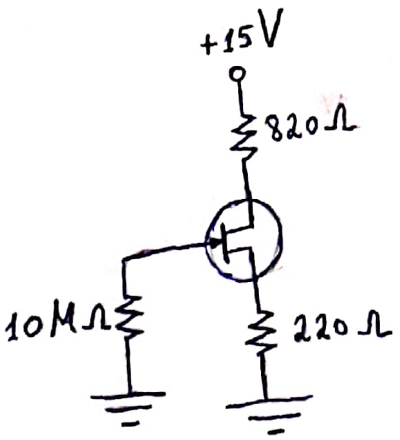
5) a) $R_d = R_D \| R_L = \frac{1.2 \cdot 22}{23.2} = 1.14 k\Omega$

$A_v = g_m \cdot R_d = 3.8 mS \cdot 1.14 k\Omega = 4.332$

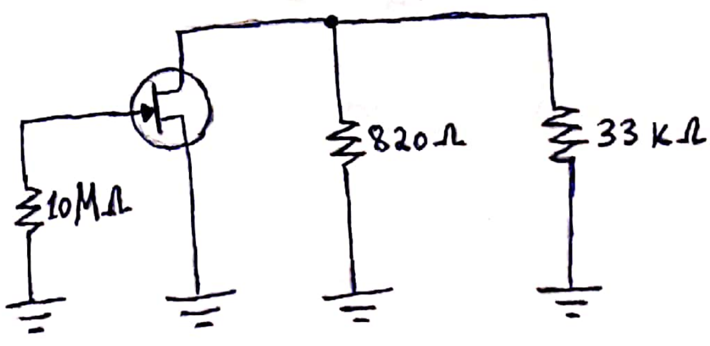
b) $R_d = R_D \| R_L = \frac{2.2 \cdot 10}{12.2} = 1.8 k\Omega$

$A_v = g_m \cdot R_d = 5.5 mS \cdot 1.8 k\Omega = 9.9$

6)



DC equivalent



AC equivalent

7) $R_L' = R_L \parallel 4.7\,k\Omega = \dfrac{3.3 \cdot 4.7}{8} = 1.939\ k\Omega$

$R_d = R_D \parallel R_L' = \dfrac{820 \cdot 1939}{2759} = 576.29\ \Omega$

$A_v = g_m \cdot R_d = 4.41\ mS \cdot 576.29\ \Omega = 2.541$

8) $R_{in\,(gate)} = \left|\dfrac{V_{GS}}{I_{GSS}}\right| = \left|\dfrac{-15V}{25\,nA}\right| = 600\ M\Omega$

$R_{in} = R_G \parallel R_{in\,(gate)} = \dfrac{10 \cdot 600}{610} = 9.84\ M\Omega$

9) $R_s = R_S \parallel R_L = 1.2\,k\Omega \parallel 1\,k\Omega = \dfrac{1.2 \cdot 1}{2.2} = 0.545\ k\Omega$

$A_v = \dfrac{g_m \cdot R_s}{1 + g_m R_s} = \dfrac{5500\,\mu S \cdot 545\,\Omega}{1 + 5500\,\mu S \cdot 545\,\Omega} = 0.75$

$R_{IN(gate)} = \left|\dfrac{V_{GS}}{I_{GSS}}\right| = \left|\dfrac{-15\,V}{50\,pA}\right| = 3 \cdot 10^{11}\ \Omega$

$R_{in} = R_G \parallel R_{IN(gate)} = 10\,M\Omega \parallel 3 \cdot 10^{11}\,\Omega \approx 10\,M\Omega$

10) $A_v = g_m \cdot R_d = 3500\ \mu S \cdot 10\,k\Omega = 35$

$R_{in} = \left(\dfrac{1}{g_m}\right) \parallel R_s = \left(\dfrac{1}{3500\,\mu S}\right) \parallel 2.2\,k\Omega = \dfrac{285.7\,\Omega \cdot 2200\,\Omega}{2485.7\,\Omega} =$

$= 252.86\ \Omega$

11) $R_d = R_D \| R_L = \dfrac{10\,k\Omega \cdot 10\,k\Omega}{20\,k\Omega} = 5\,k\Omega$

$A_v = g_m \cdot R_d = 2000\,\mu S \cdot 5\,k\Omega = 10$

$R_{in(source)} = \dfrac{1}{g_m} = \dfrac{1}{2000\,\mu S} = 500\,\Omega$

$R_{in} = R_{in(source)} \| R_S = \dfrac{500\,\Omega \cdot 4700\,\Omega}{5200\,\Omega} = 451.9\,\Omega$

- V_{DD} is negative, because it is p-channel JFET
- Given semiconductor device is JFET transistor.

12)

V_A	V_B	Q_1	Q_2	Q_3	Q_4	V_{out}
0	0	on	off	off	on	V_{DD}
0	V_{DD}	off	off	off	on	V_{DD}
V_{DD}	0	on	off	off	off	V_{DD}
V_{DD}	V_{DD}	off	on	on	off	0

13)

V_A	V_B	Q_1	Q_2	Q_3	Q_4	V_{out}
0	0	on	off	on	off	V_{DD}
0	V_{DD}	off	on	on	off	0
V_{DD}	0	on	off	on	off	0
V_{DD}	V_{DD}	off	on	off	on	0

14) When the input pulse is at V_{DD}, Q_1 is off and Q_2 is on, connecting output to GND. When the input pulse is at 0, Q_1 is on and Q_2 is off, connecting output to V_{DD}