* include ac model, 41 & 43 require you to draw a transfer function and use it to find V_{GS_Q}

Chapter 8 #1, 3, 7, 17*, 21*, 25*, 29*, 32*, 41*, 45*

Note Title 8/11/2018

1) Calculate g_{m0} for a JFET having device parameters $I_{DSS} = 12mA$ and $V_p = -4V$.

$$g_{m0} = \frac{2I_{DSS}}{|V_p|} = \frac{2(12mA)}{4V} = 6\,mA/V = 6mS$$

3) For a JFET having device parameters $g_{m0} = 5mS$ and $V_p = -4V$, what is the device current at $V_{GS} = 0$?

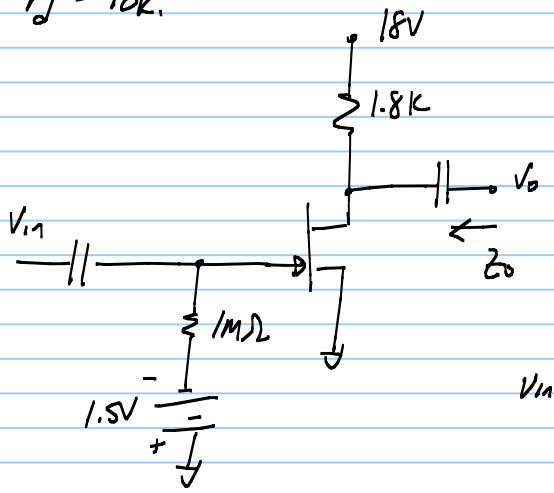
$$g_{m0} = \frac{2I_{DSS}}{|V_p|} \qquad 5mS = \frac{2I_{DSS}}{4} \qquad I_{DSS} = 10mA$$

I_{DSS} is the current when $V_{GS} = 0$.

7) Determine the value of g_m for a JFET ($I_{DSS} = 8mA$, $V_p = -5V$) when biased at $V_{GS_Q} = V_p/4$

$$g_m = \frac{2I_{DSS}}{|V_p|}\left(1 - \frac{V_{GS}}{V_p}\right) = \frac{2(8mA)}{5}\left(1 - \frac{V_p/4}{V_p}\right) = \frac{2(8mA)}{5}\left(\frac{3}{4}\right) = 2.4mS$$

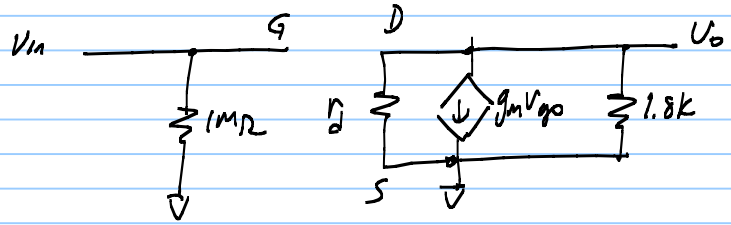
17) Determine Z_{in}, Z_{out} and A_v for the circuit below if $I_{DSS} = 10mA$ and $V_p = -6V$ and $r_d = 40k$.



Fixed bias. $V_{GS_Q} = -1.5V$

$$g_m = \frac{2I_{DSS}}{|V_p|}\left(1 - \frac{V_{GS}}{V_p}\right) = \frac{2(10mA)}{6}\left(1 - \frac{-1.5}{-6}\right)$$

$g_m = 2.5mS$

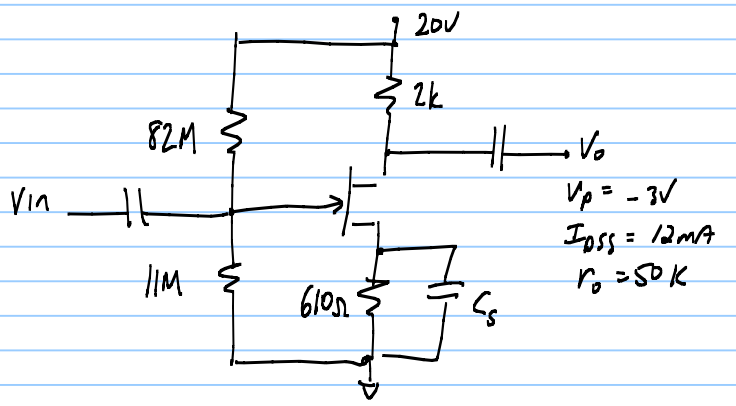


$Z_{in} = 1M\Omega$

$Z_{out} = 1.8K \,//\, 40k = 1.722\,k\Omega$

$A_v = -g_m(r_d \,//\, R_D) = -2.5mS\,(40k \,//\, 1.8k) = -4.3$

25) Determine Z_{in}, Z_{out} & v_o for the circuit below given $v_{in} = 20\,mV$.



ac model

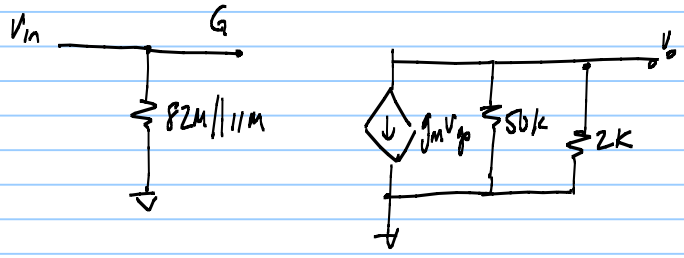
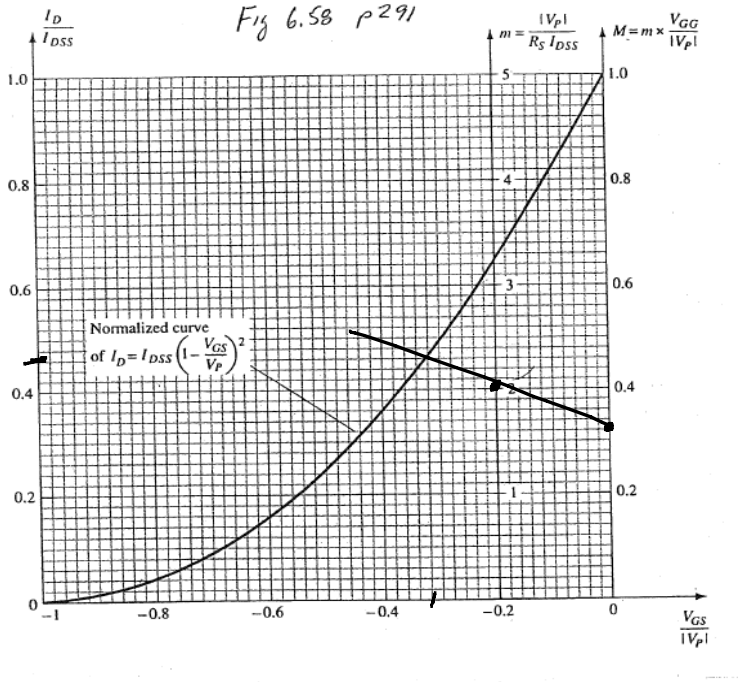


Fig 6.58 p291



$$V_{GG} = \frac{11M}{82M + 11M}(20) = 2.37V$$

$$m = \frac{3V}{(610)\,12mA} = 0.41$$

$$M = 0.41\,\frac{2.37V}{3} = 0.324$$

$$V_{GSQ} = (-0.32)(3) = -0.96V$$

$$g_m = \left(\frac{2\,I_{DSS}}{|V_p|}\right)\left(1 - \frac{V_{GSQ}}{V_p}\right) = \frac{2(12m)}{3}\left(1 - \frac{-0.96}{-3}\right)$$

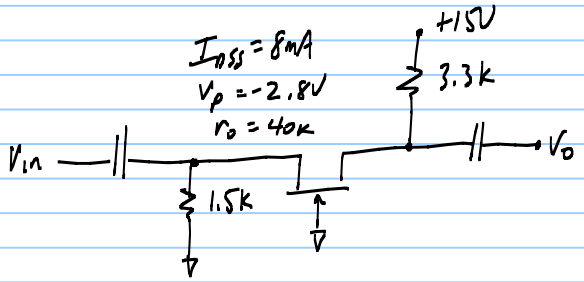
$$g_m = 5.44mS$$

$$Z_{in} = 82M \,||\, 11M = 9.7M$$

$$Z_o = R_D \,||\, r_d = 2K \,||\, 50k = 1.92k\Omega$$

$$A_v = -g_m (r_d \,||\, R_D) = -5.44m\,(1.92k) = 10.46 \qquad V_o = A_v V_{in} = -209.2\,mV$$

19) Determine Z_{in}, Z_{out} & v_o for the circuit below given $v_{in} = 4mV$.



ac model

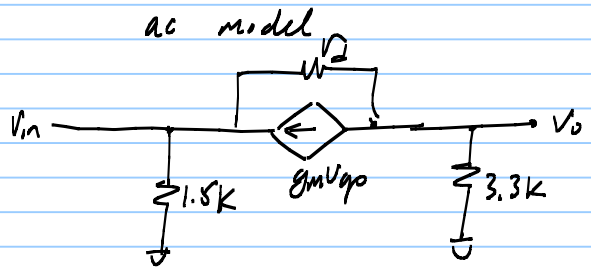
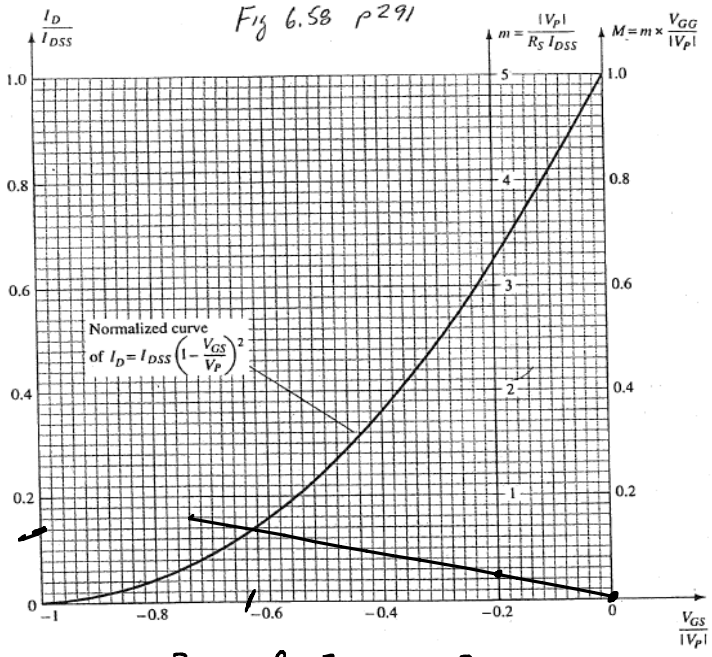


Fig 6.58 p291



$V_{GG} = 0V$

$m = \frac{2.8}{(1.5k)\,8mA} = 0.233$

$M = 0.233\,\frac{0}{3} = 0$

$V_{GSQ} = (-0.64)(2.8) = -1.8V$

$g_m = \left(\frac{2I_{DSS}}{|V_p|}\right)\left(1 - \frac{V_{GSQ}}{V_p}\right) = \frac{2(8mA)}{2.8}\left(1 - \frac{-1.8}{-2.8}\right)$

$g_m = 2.04mS$

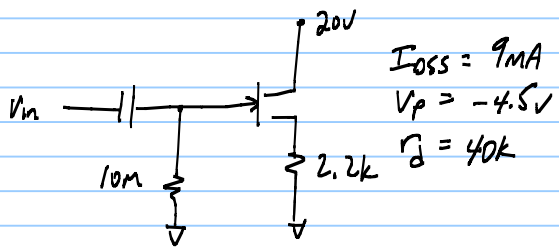
$Z_{in} = R_S \| \left[\frac{r_d + R_D}{1 + g_m r_d}\right] = 1.5 \| \left[\frac{40 + 3.3k}{1 + (2.04)(40)}\right] = 388\Omega$

$Z_{out} = R_D \| r_d = 3.3k \| 40k = 3.04k$

$A_v = \frac{g_m R_D + \frac{R_D}{r_d}}{1 + \frac{R_D}{r_d}} = \frac{(2.04m)(3.3K) + \frac{3.3K}{40K}}{1 + \frac{3.3K}{40K}} = \frac{6.8145K}{1.083} = 6.29$

$v_o = A_v v_{in} = 25.2mV$

32) Determine Z_{in}, Z_{out} & A_v for the circuit below



ac model

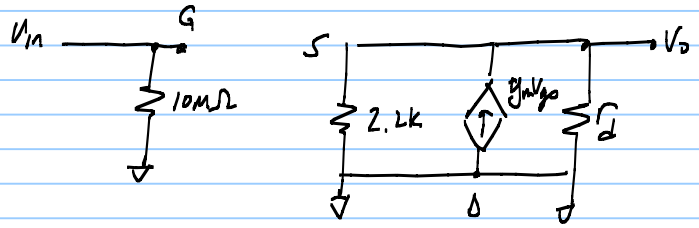
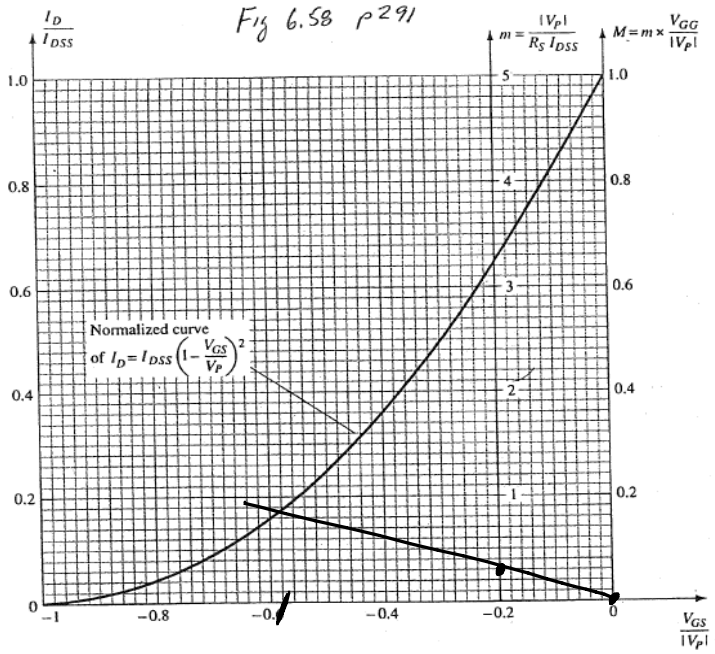


Fig 6.58 p291



$V_{GG} = 0V$

$$m = \frac{4.5}{(2.2k)(9mA)} = 0.227$$

$$M = 0.227\,\frac{0}{3} = 0$$

$$V_{GSQ} = (-0.58)(4.5) = -2.61$$

$$g_m = \left(\frac{2\,I_{DSS}}{|V_p|}\right)\left(1 - \frac{V_{GSQ}}{V_p}\right) = \frac{2(9mA)}{4.5}\left(1 - \frac{-2.61}{-4.5}\right)$$

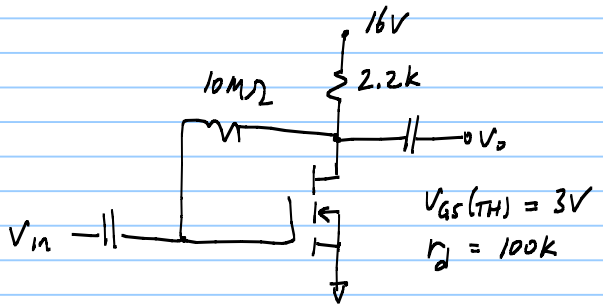
$$g_m = 1.68mS$$

$Z_{in} = 10\,M\Omega$

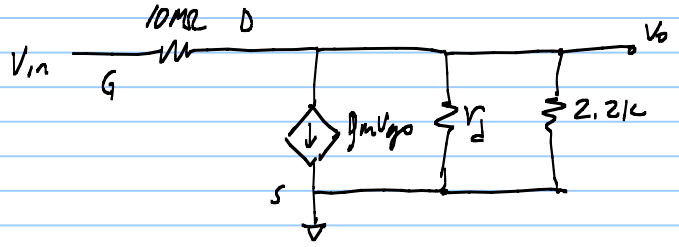
$Z_o = r_d \,||\, R_S \,||\, 1/g_m = 40k \,||\, 2.2k \,||\, 1/1.68mS = 463\Omega$

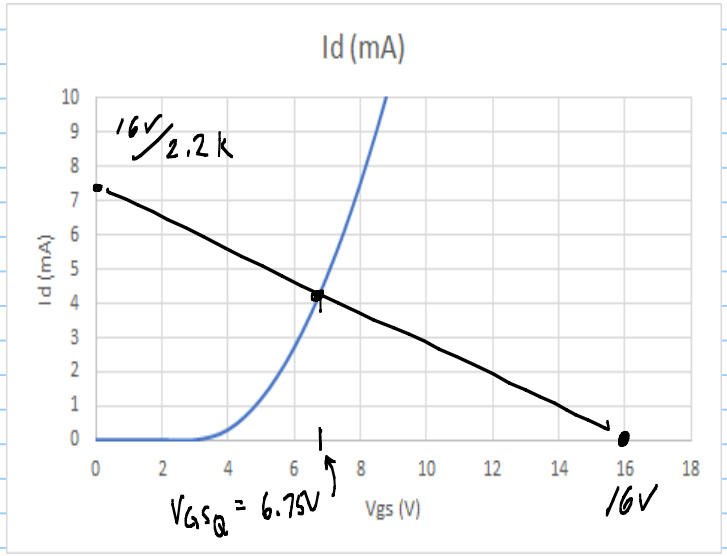
$$A_V = \frac{g_m(r_d \,||\, R_S)}{1 + g_m(r_d \,||\, R_S)} = \frac{1.68m\,(40k \,||\, 2.2k)}{1 + 1.68m\,(40k \,||\, 2.2k)} \approx \frac{3.5}{1 + 3.5} = 0.778$$

41) Determine Z_{in}, Z_{out} & A_v for the circuit below given $k = 0.3 \times 10^{-3}$



ac model





$$g_m = 2k\left(V_{GS} - V_{GS(TH)}\right)$$

$$= 2\,(0.3m)\,(6.75 - 3) = 2.25mS$$

$$Z_{in} = \frac{R_F + r_d \| R_D}{1 + g_m\left(r_d \| R_D\right)} = \frac{10M + \cancel{100K \| 2.2k}}{1 + 2.25m\left(100K \| 2.2k\right)} = \frac{10M}{5.84}$$

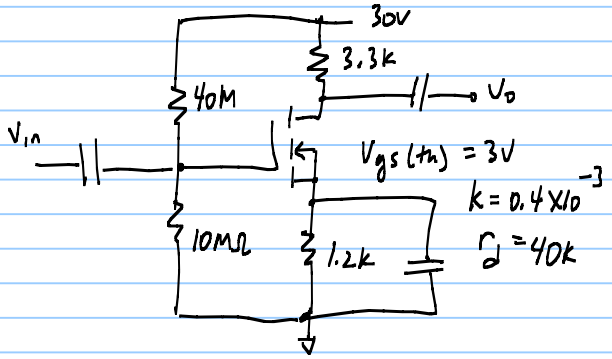
(ignore)

$$Z_{in} = 1.71\,M\Omega$$

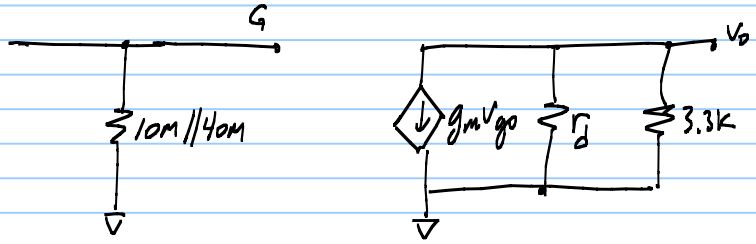
$$Z_o = R_F \| r_d \| R_D = 10M \| 100k \| 2.2k = 2.15\,K$$

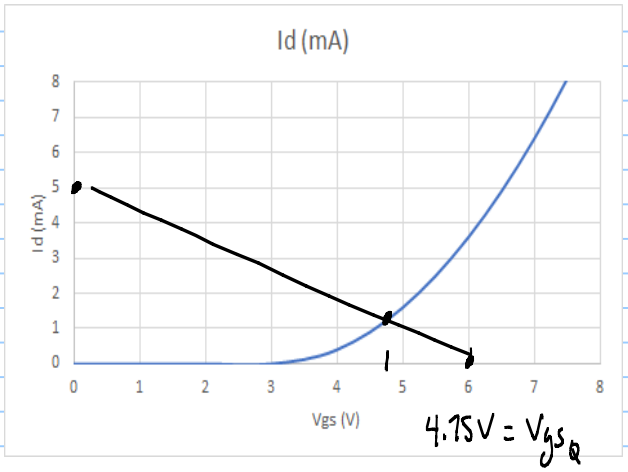
$$A_V = -g_m\left(R_F \| r_d \| R_D\right) = -4.84$$

45) Determine v_o when $v_{in} = 0.8$ mV.



ac model





$4.75V = V_{GS_Q}$

$V_g = \frac{30V(10M)}{10M+40M} = 6V$ $\quad V_{gs} = 6V$ when $I_D = 0$

$I_D = \frac{6V}{1.2K} = 5mA$ when $V_{gs} = 0$

$V_{GS_Q} = 4.75V$

$g_m = 2k(V_{GS} - V_{GS(TH)})$

$= 2(0.4m)(4.75 - 3) = 1.4mS$

$A_v = -g_m(r_d \| R_D) = 1.4mS(40K \| 3.3k) = 4.27$

$v_o = -A_v v_{in} = -3.41$ mV