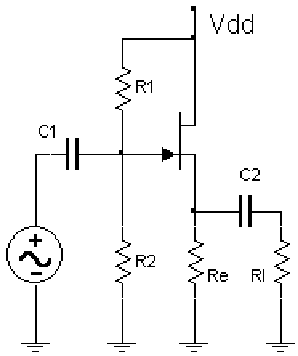
"How many JFETs could Jay fit if JFETs could fit, Jay?"

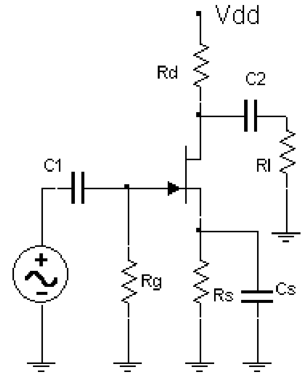
For the circuits below, find their voltage gain and input impedance. Assume V_{DD}=30V, I_{DSS}=16mA and $V_{GS(off)}$=-4V for all circuits. For circuit 1 top left, R_1=100k, R_2=50k, R_S=3k, R_L=2k.

For circuit 2 top right, R_G=1M, R_S=250, R_D=1k, R_L=2k.

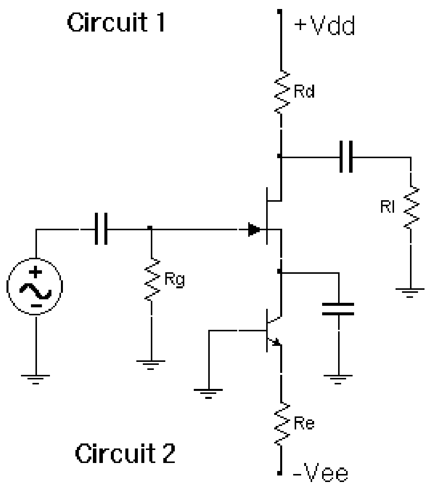
For circuit 3 bottom, V_{EE}=-10V, R_G=500k, R_E=2k, R_D=3k, R_L=4k.



Circuit 1



Circuit 1



Circuit 2

Answers

First, find gm_0 for the device as it is the same for all three circuits. $gm_0 = -2*I_{DSS}/V_{GS(off)}$.
$gm_0 = -2*16mA/-4v = 8\ mS$.

Circuit 1 top left, voltage divider bias, source follower.

$Z_{in} = 100k||50k = 33k$

$V_G = 30v*50k/(100k+50k) = 10v$
Assume $V_{GS} = -2v$ (i.e., 1/2 of $V_{GS(off)}$). as a starting point.
Therefore, $V_S = V_G - V_{GS} = 10v-(-2v) = 12v$
And, $I_D = I_S = V_S/R_S = 12v/3k = 4mA$

Crosscheck: $I_D = I_{DSS}\ (1-V_{GS}/_{GS(off)})^2 = 16mA(1- -2v/-4v)^2 = 4\ mA$ The estimate was perfect. If not, adjust V_{GS} and try again until the two I_D calcs are the same.

$gm = gm_0 \sqrt{(I_D/I_{DSS})} = 8mS \sqrt{4mA/16mA} = 4mS$
$A_v = gm*r_s/(1+gm*r_s)$ $r_s = 3k||2k = 1.2k$
$A_v = 4mS*1.2k/(1+4mS*2k) = .83$

Circuit 2 top right, self bias common source amplifier.

$Z_{in} = 1M$

Using a self bias graph, $gm_0*R_S = 8mS * 250 = 2$, which yields $I_D/I_{DSS} = .38$
$gm = gm_0 \sqrt{(I_D/I_{DSS})} = 8mS \sqrt{.38} = 4.93mS$
$A_v = -gm*r_d$ $r_d = 1k||2k=667$
$A_v = -4.93mS * 667 = -3.29$

Circuit 3 bottom, current source bias common source amplifier.

Zin = 500k

$I_d = (V_{EE}-.7v)/R_E = 9.3v/2k = 4.65mA$
$gm = gm_0 \sqrt{(I_D/I_{DSS})} = 8mS \sqrt{4.65mA/16mA} = 4.31mS$
$A_v = -gm*r_d$ $r_d = 3k||4k = 1.71k$
$A_v = -4.31mS * 1.71k = -7.39$