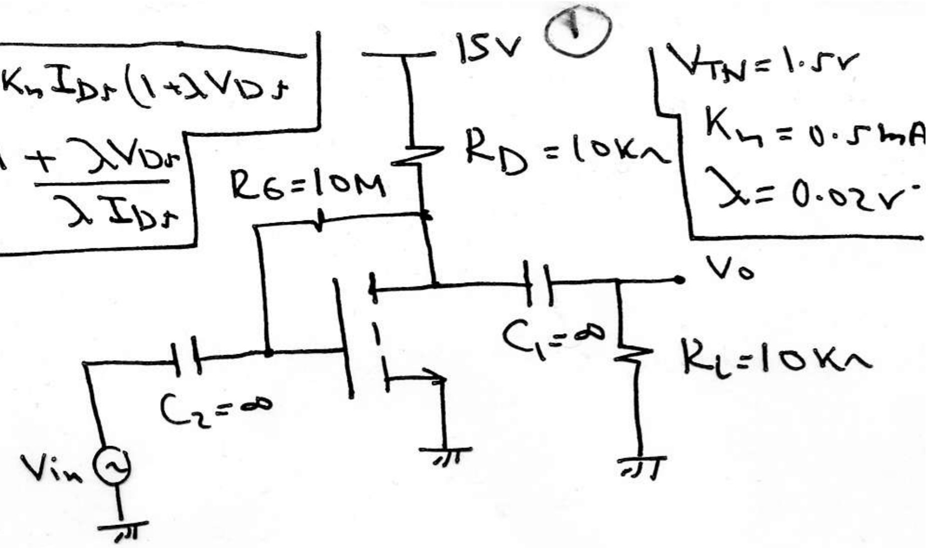
$g_m = \sqrt{2K_n I_{DS}(1+\lambda V_{DS})}$

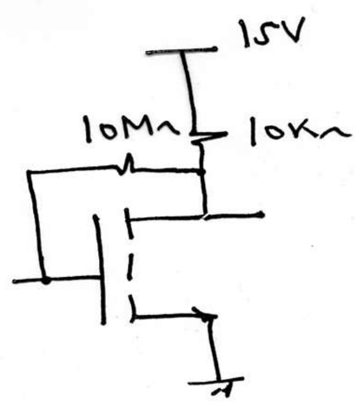
$r_o = \dfrac{1+\lambda V_{DS}}{\lambda I_{DS}}$



Determine the gain of this circuit.

Ignore λ for DC Analysis

DC Circuit



$15 = 10 I_{DS} + V_{DS} = 10 I_{DS} + V_{GS}$ ($V_{GS} = V_{DS}$)

$I_{DS} = \frac{K_n}{2}(V_{GS} - V_{TN})^2$

$\frac{15 - V_{GS}}{10} = \frac{0.5}{2}(V_{GS} - 1.5)^2$

$$15 - V_{GS} = 2.5\left(V_{GS}^2 - 3V_{GS} + 2.25\right)$$

$$2.5\,V_{GS}^2 - 6.5V_{GS} - 9.375 = 0$$

⇓

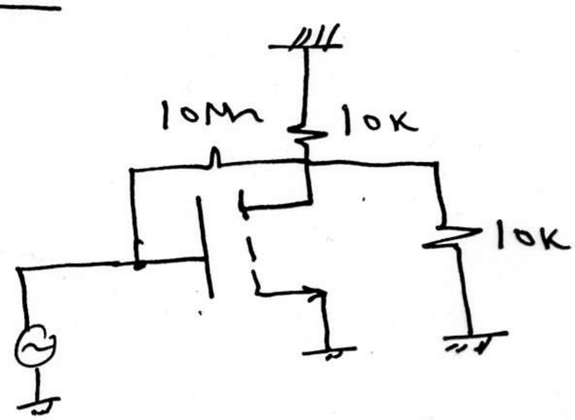
$$V_{GS}^2 - 2.6\,V_{GS} - 3.75 = 0$$

$$V_{GS} = \frac{2.6 \pm \sqrt{6.76 + 15}}{2} = 3.632\,V$$

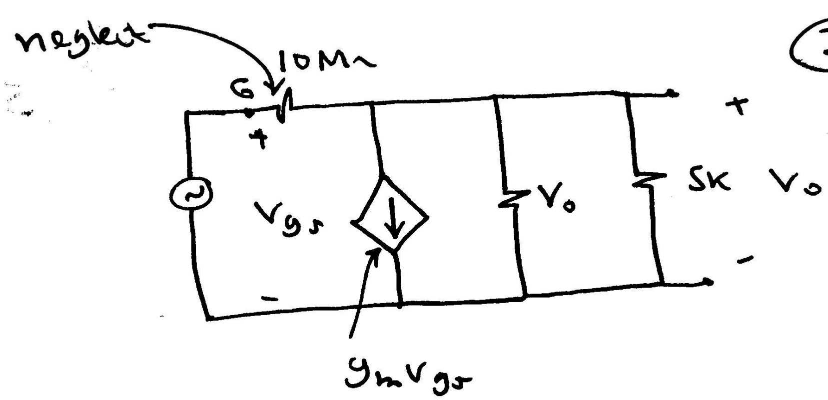
$\therefore\ I_{DS} = 1.06\,mA$

Q-point $(I_{DS}, V_{DS}) = (1.06\,mA, 3.632\,V)$

SS Analysis



(3)



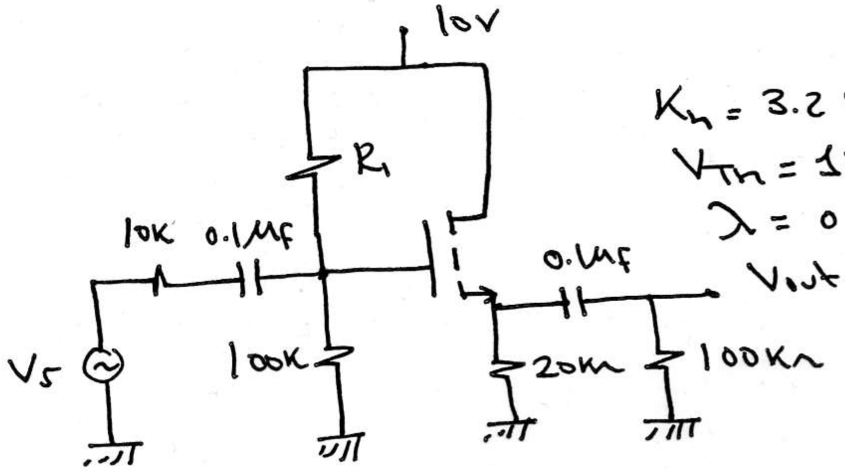
$$g_m = \sqrt{2 K_n I_{DS} (1+\lambda V_{DS})}$$

$$g_m = \sqrt{2 * 0.5 * 1.06 * (1.07264)} = 1.0662 \text{ mA/V}$$

$$r_o = \frac{1+\lambda V_{DS}}{\lambda I_{DS}} = \frac{1.0726}{0.02 * 1.06} = 50.5 K\Omega$$

$$V_o \simeq -g_m V_{gs} (r_o \parallel 5K)$$

$$V_o = -1.0622 * 4.525 \; V_{gs} = -4.8 \; V_{gs}$$



$K_n = 3.2\ mA/V^2$
$V_{TN} = 1$ Volts
$\lambda = 0$

* Determine R_1 to set $V_{DS} = 6$ Volts
* Determine the gain V_{out}/V_s

Solution: if $V_{DS} = 6V \Rightarrow V_S = 4V$

$\therefore I_{DS} = \frac{4}{20K} = 200\mu A$

Assuming saturation

$$I_{DS} = \frac{K_n}{2}(V_{GS} - V_{TN})^2$$

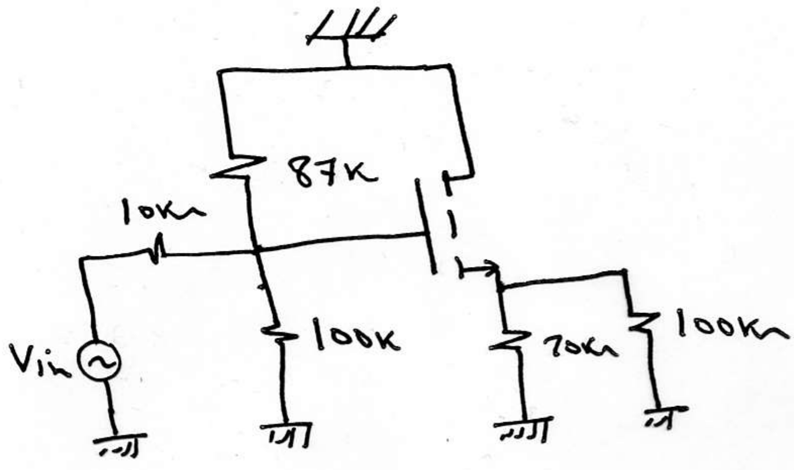
$$0.2*10^{-3} = 1.6*10^{-3}(V_{GS} - 1)^2$$

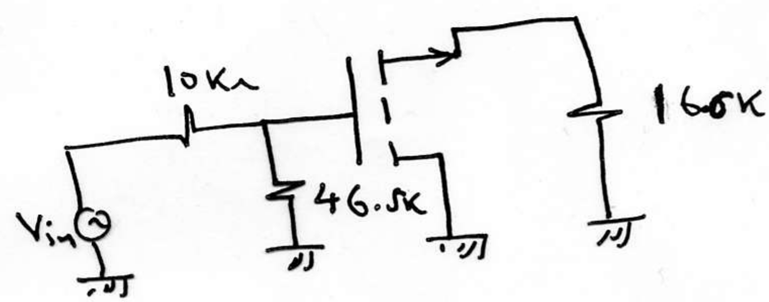
$$0.125 = (V_{GS} - 1)^2 \Longrightarrow V_{GS} = 1.35V$$

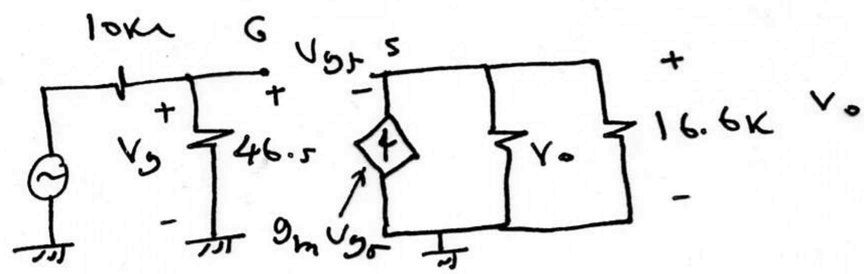
$$\therefore V_G = 5.35V = \frac{10 \quad *100K}{100K + R_1}$$

$$5.35 R_1 = 465 \Longrightarrow R_1 = 87K$$

SS Analysis (5)







$\lambda = 0 \Longrightarrow r_o = \infty$

$g_m = \sqrt{2K_n I_{DS}} = \sqrt{2 * 3.2\times10^{-3} * 200\times10^{-6}}$

$g_m = 1.1313 \text{ mA/V}$

$$V_o = g_m V_{gs} \times 16.6K$$

$$V_o = g_m (V_g - V_o) \times 16.6K$$

$$(1 + g_m \times 16.6K) V_o = g_m \times 16.6K \, V_g$$

$$188.807 V_o = 187.807 V_g$$

$$\therefore \frac{V_o}{V_g} = 0.9947 \qquad \text{But } V_g = \frac{V_{in} \times 46.5}{46.5 + 10}$$

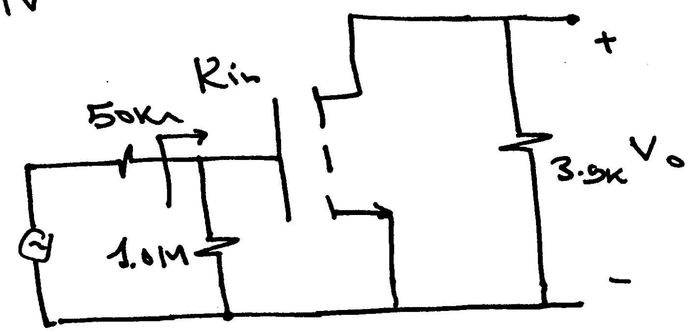
$$V_g = 0.823 \, V_{in}$$

$$\therefore \frac{V_o}{V_{in}} = 0.9947 \times 0.823 = 0.8186$$

$K_n = 1.0\,mA/V^2$

$V_{Tn} = 1.0V$

$\lambda = 0\,V^{-1}$



The figure shows the AC equivalent circuit. The operating point is $(I_{DS}, V_{DS}) = (2.0mA, 7.5V)$. Determine the voltage gain & input resistance

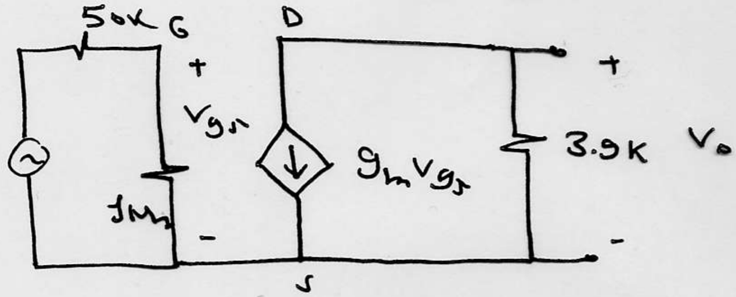
Solution: $r_o = \infty \quad (\lambda = 0)$

$g_m = \sqrt{2K_nI_{DS}}$

$g_m = \sqrt{2\times10^{-3}\times2\times10^{-3}}$

$g_m = 2mA/V$

SS Analysis



$$V_o = -g_m V_{gs} = -7.8\, V_{gs}$$

but $V_{gs} = V_{in} \dfrac{1000}{1050} = 0.95\, V_{in}$

$$\therefore \frac{V_o}{V_{in}} = -7.8 * 0.95 = -7.4$$

$$R_{in} = 1\,M\Omega$$