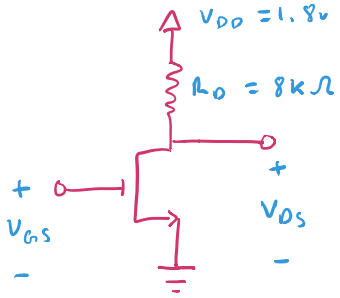
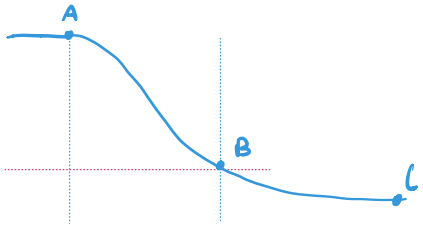


$V_t = 0.4v$

$k'_n = 2 mA/V^2$

$\frac{W}{L} = 2$

(1.) Find Q-point



$$V_{GS1} = V_t + \sqrt{\frac{2k'_n \frac{W}{L} R_D V_{DD} - 1}{k'_n \frac{W}{L} R_D}}$$

$V_{GS_{edge}} = 0.706v$

$V_{GS} - V_t = 0.306v$

$\frac{1}{2}(V_{GS_e} - V_t) = .153$

$V_{DS} = V_{GS} - V_t$; $V_{DS} = 0.306v$

$\boxed{V_{GSQ} = V_t + 0.153 = 0.553v}$

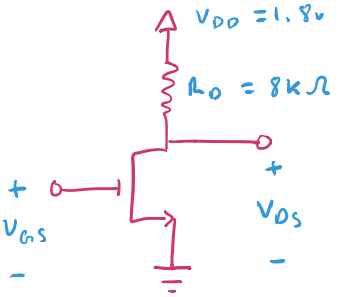
$I_D = \frac{1}{2} k'_n \frac{W}{L} (V_{GSQ} - V_t)^2$

$I_D = \frac{1}{2}(2)(2)(.553 - .4)^2$

$\boxed{I_{DQ} = 0.047 mA}$

$V_{DSQ} = V_{DD} - R_D I_{DQ}$

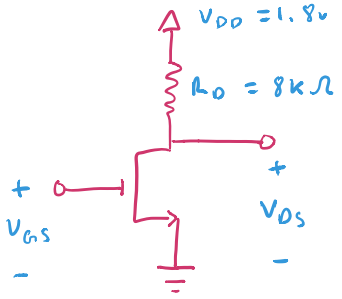
$\boxed{V_{DSQ} = 1.43v}$



$V_t = 0.4v$

$k'_n = 2 mA/V^2$

$\frac{W}{L} = 2$



$V_t = 0.4v$

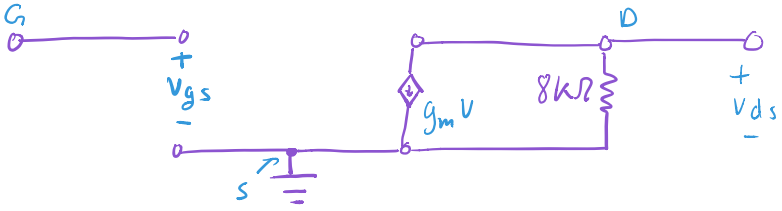
$k'_n = 2mA/v^2$

$\frac{W}{L} = 2$

② Small signal analysis

$$g_m = k'_n \frac{W}{L}(V_{GSQ} - V_t)$$

$$\boxed{g_m = 0.612\ mA/v}$$



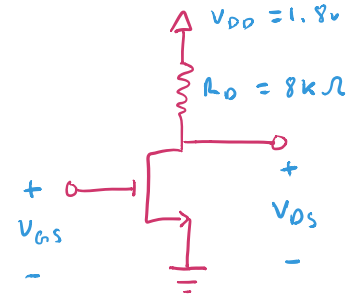
$$A_v = \frac{v_{ds}}{v_{gs}}$$

$$v_{ds} = -g_m v_{gs}(8k\Omega)$$

$$A_v = (-0.612)(8)$$

$$\frac{v_{ds}}{v_{gs}} = -g_m(8)$$

$$\boxed{A_v = -4.9\ v/v}$$



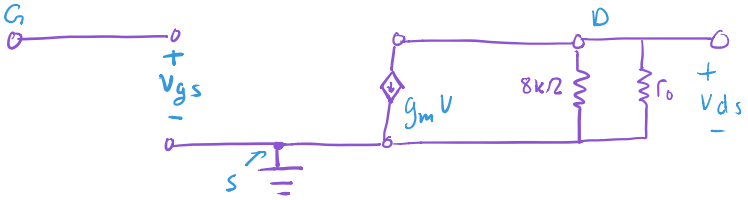
$V_t = 0.4v$

$k'_n = 2mA/v^2$

$\frac{W}{L} = 2$

b.) What happens if $\lambda = 0.04v^{-1}$

$$r_o = \frac{1}{\lambda I_{DQ}} = \frac{1}{(.04)(.047)} = 531.91\ k\Omega$$



$$v_{ds} = -g_m v_{gs}(R_D \| r_o)$$

$$A_v = \frac{v_{ds}}{v_{gs}} = -g_m(R_D \| r_o) = (-0.612)(8 \| 531.91)$$

$$A_v = (-0.612)(7.88)$$

$$\boxed{A_v = -4.82\ v/v}$$

$A_v = -4.9\ v/v$	$A_v = -4.82\ v/v$
$r_o \to \infty$	r_o not ∞

Example 2 — A common source amp w/ Nmos transistor

$V_A = 50V$

$R_D = 20k\Omega$

$R_L = 20k\Omega$

$R_{sig} = 100k\Omega$

$k'_n = 0.2 mA/V^2$

$\frac{W}{L} = 40$

$V_t = 0.5V$

a) If $I_{DQ} = 0.25mA$; $V_{GSQ} = ?$

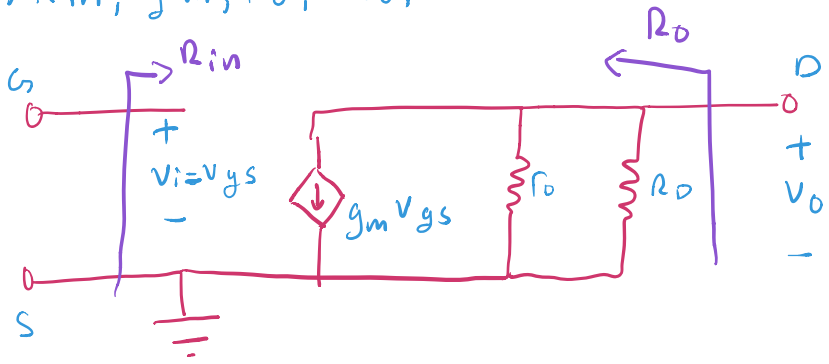
→ Assume Saturation

$$I_{DQ} = \frac{1}{2} k'_n \frac{W}{L} (V_{GSQ} - V_t)^2$$

$$0.25mA = \frac{1}{2}(.2)(40)(V_{GSQ} - .5)^2$$

$$V_{GSQ} = 0.75V$$

b) R_{in}, g_m, R_o, A_{vo}, r_o



$R_{in} = \infty$

$$g_m = k'_n \frac{W}{L}(V_{GSQ} - V_t) = 2mA/V^2$$

$$= (0.2)(40)(0.25) = 2mA/V^2$$

$$r_o = \frac{V_A}{I_{DQ}} = \frac{50}{.25} = 200k\Omega$$

$$R_o = r_o \| R_D = 18.2k\Omega$$

$$A_{vo} = \left.\frac{v_o}{v_i}\right|_{R_L \to \infty} = -g_m(r_o \| R_D) = -2(200 \| 20)$$

$$A_{vo} = -36.4 V/V$$

$V_A = 50V$

$R_D = 20k\Omega$

$R_L = 20k\Omega$

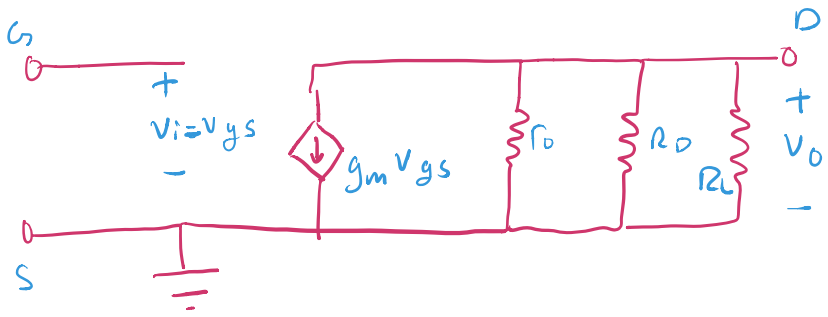
$R_{sig} = 100k\Omega$

$k'_n = 0.2 mA/V^2$

$\frac{W}{L} = 40$

$V_t = 0.5V$

c) $A_v = \frac{v_o}{v_i}$

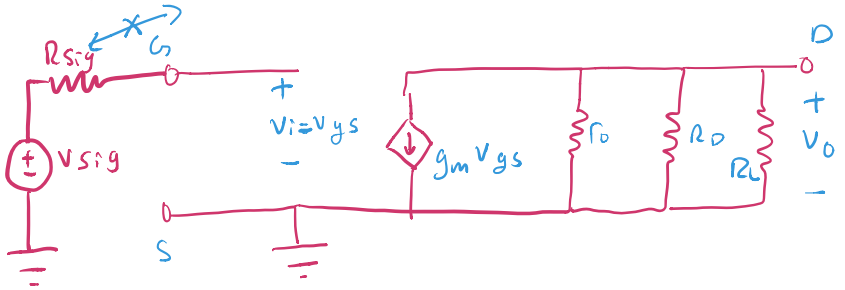


$A_v = -g_m (r_o \| R_D \| R_L)$

$A_v = -2 (200 \| 20 \| 20)$

$\boxed{A_v = -19.05 \, V/V}$

d) G_v



$G_v = A_v = -g_m (r_o \| R_D \| R_L)$

$\boxed{= -19.05 \, V/V}$