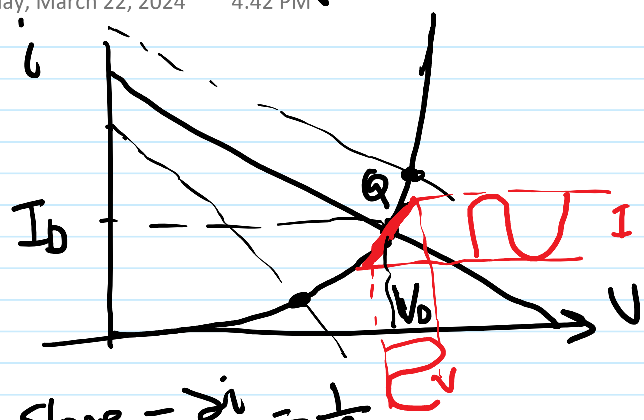
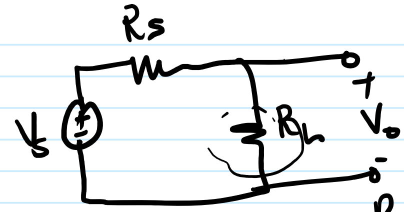
Small Signal Analysis

Friday, March 22, 2024 4:42 PM





$$V_o = \frac{R_L}{R_s + R_L} V_s$$

$$V_o / V_s = \frac{R_L(I_s)}{R_L(I_s) + R_s}$$

$$\text{Slope} = \frac{\partial i}{\partial v} = \frac{1}{R}$$

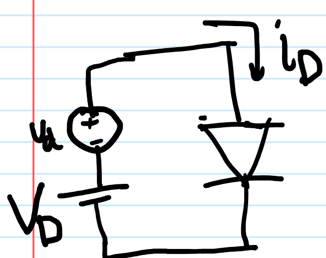
$$i = I_s\left(e^{v/nV_t} - 1\right)$$

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \ldots$$

If x is small

$$e^x \simeq 1 + x$$

<u>Linearization</u>



$X_Y \rightarrow$ DC Voltage/current

$x_Y \rightarrow$ DC + Small signal "

$x_y \rightarrow$ Small signal "

$$i_D = I_D + i_d$$

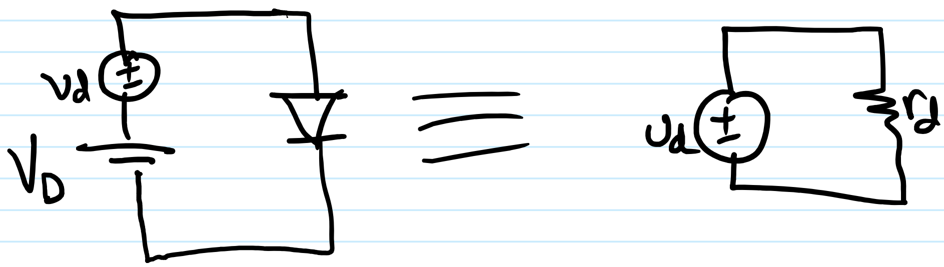
$$g_d = \frac{\partial i_D}{\partial v_D} = \frac{\partial}{\partial v_D}\left(I_s\left(e^{v_D/nV_T} - 1\right)\right) = I_s \frac{e^{\frac{v_D}{nV_T}}}{V_T}\Bigg|_Q$$

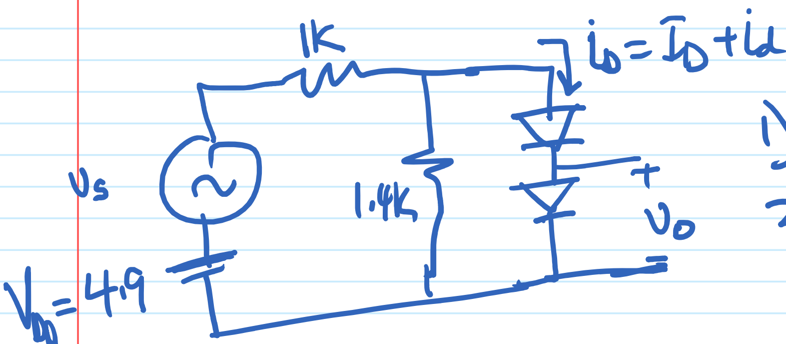
$$g_d = \frac{i_D}{V_T}\Bigg|_Q = \frac{I_D}{V_T}$$

$$r_d = \frac{1}{g_d}$$

$$\boxed{r_d = \frac{1}{g_d} = \frac{V_T}{I_D}}$$

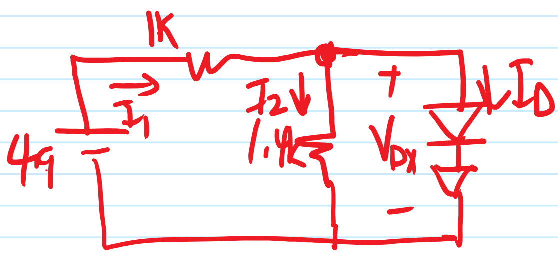
SS.





1) Find r_d
2) Find v_o
3) Find i_d

DC



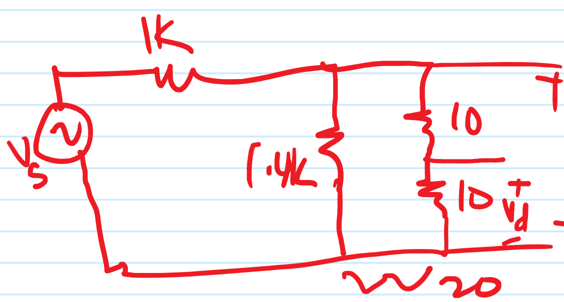
$I_2 = \frac{V_{Dx}}{1.4K} = \frac{1.4}{1.4K} = 1mA$

$I_1 = \frac{4.9-1.4}{1K} = 3.5mA$

$I_D = 3.5m - 1m = 2.5mA$

(1mA, 0.7), $V_{Dx} = 0.7+0.7 = 1.4V$

1) $r_d = \frac{V_T}{I_D} = \frac{25mV}{2.5mA} = 10\Omega$



$\frac{v_{dx}}{v_s} = \frac{20}{1K+20} = 0.0196\ V/V$

$\frac{v_d}{v_s} = \frac{1}{2}\frac{V_{dx}}{v_s} = \frac{10}{10+1K} = 0.0099\ V/V$

$i_d = \frac{v_d}{10} = \frac{v_s}{10+1K} = 0.99\times10^{-3}\ v_s$