More Office Hours

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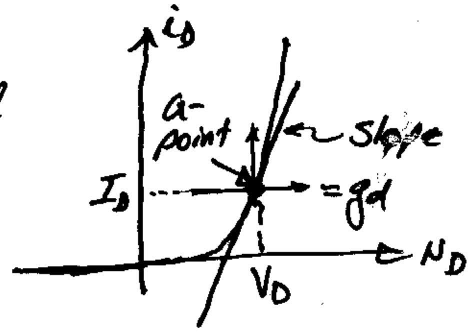
Room E292 VL (outside Dr. Allen's office)
MWF – 12–1pm Tues. 9:30–11am

Continue Review of ECE 3040

1.) Small-signal diode model

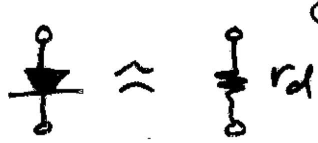


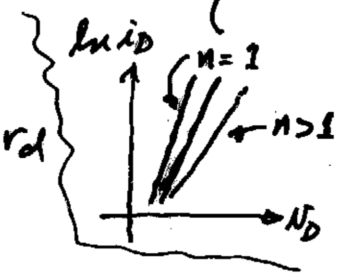
$$i_D = I_S\left[\exp\left(\frac{v_D}{V_T}\right) - 1\right]$$

Small-signal ⟹ Linear

$$\left.\frac{\partial i_D}{\partial v_D}\right|_Q = \frac{I_S}{V_T}\left[\exp\left(\frac{v_D}{V_T}\right)\right] \approx \frac{I_D}{V_T} \qquad I_D \approx I_S \exp\left(\frac{V_D}{nV_T}\right)$$

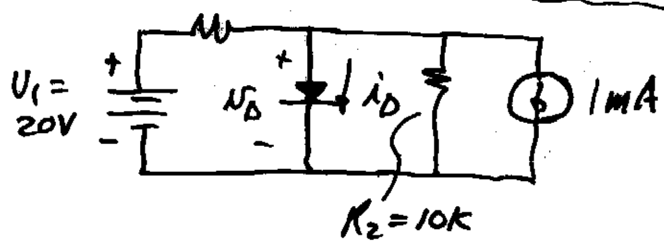
$$\therefore\ g_d = \frac{1}{r_d} = \frac{I_D}{V_T}$$





2.) Example 1

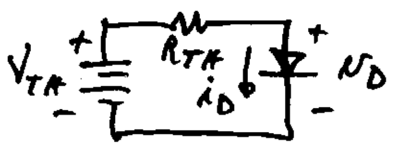
a.) Find the dc operating point assuming $V_T = 25mV$, $n = 1$, and $I_S = 100fA$.



b.) If the 20V voltage source, V_1, has a peak-to-peak sinusoidal voltage of 10mV superimposed on it, find the peak-to-peak value of v_d and i_d.

Solution –

a.) Find a Thevenin eq. circuit seen from diode

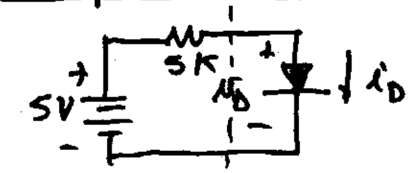


$$V_{TH} = \frac{R_2}{R_1 + R_2} 20V - (R_1 \| R_2)\, 1mA = 5V$$

($R_1 \| R_2$ = 5K)

$$R_{TH} = R_1 \| R_2 = 5K$$

Example ~ Cont'd



$5V = i_D 5k + v_D$ $\quad$ $i_D = 100fA \times \exp\left(\frac{v_D}{V_T}\right)$

$i_D = \frac{5 - v_D}{5K}$

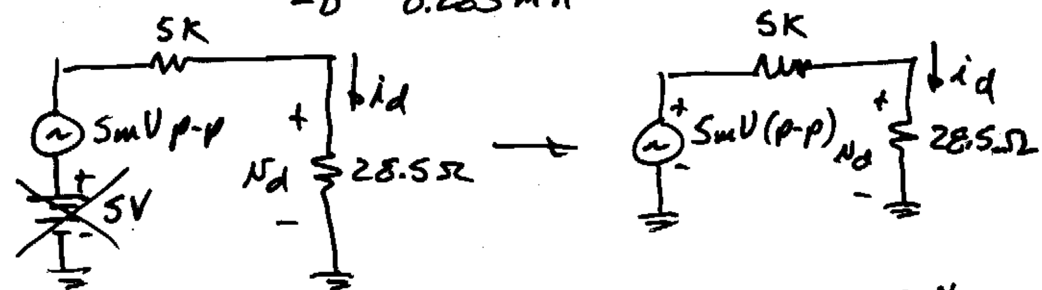
$\therefore I_D = 0.885mA$

$V_D = 0.573\ V$

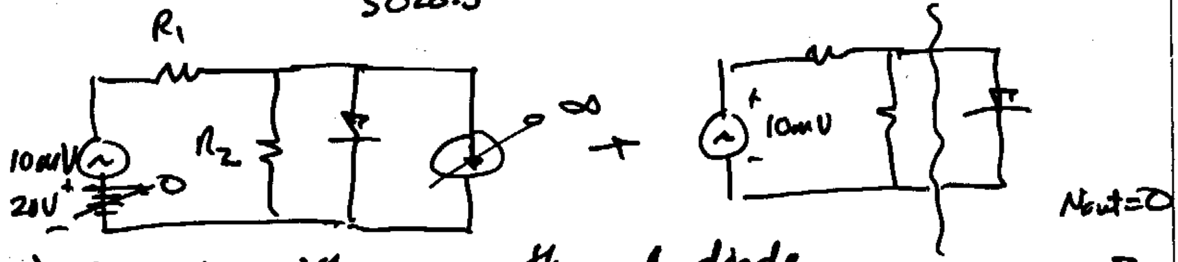
Iteration –

Guess for V_D	$I_D = \frac{5V - V_D}{5K}$	$100fA \exp\left(\frac{V_D}{25mV}\right)$
0.6	0.88mA	2.331mA
0.57	0.886mA	0.798mA
↓		
0.5726	0.8854mA	0.88528mA

b.) Find $r_d = \frac{V_T}{I_D} = \frac{25mV}{0.885\ mA} = 28.5\Omega$

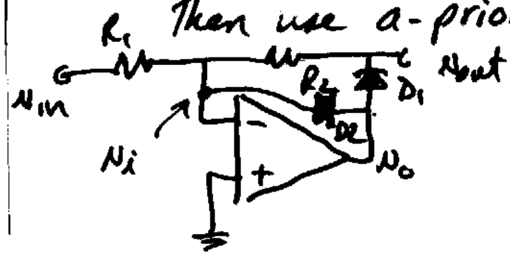


$v_d = 5mV \frac{28.5\Omega}{5028.5} = 0.028mV \rightarrow i_D = \frac{5mV}{5028.5} = 0.994\mu A$



3.) Circuits with more than 1 diode

Examine all possible states (ON or OFF) and Then use a-priori to indentify the valid states.



$v_i > 0 \rightarrow v_o < 0 \rightarrow$ D2 ON & D1 OFF

$v_i < 0 \rightarrow v_o > 0 \rightarrow$ D2 OFF & D1 ON

$v_{out} = -\frac{R_2}{R_1} v_{in}$

Other topics

1.) Voltage regulation

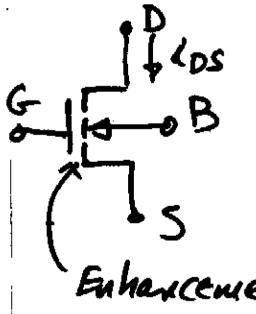
2.) Rectification
   - Half-wave
   - Full-wave

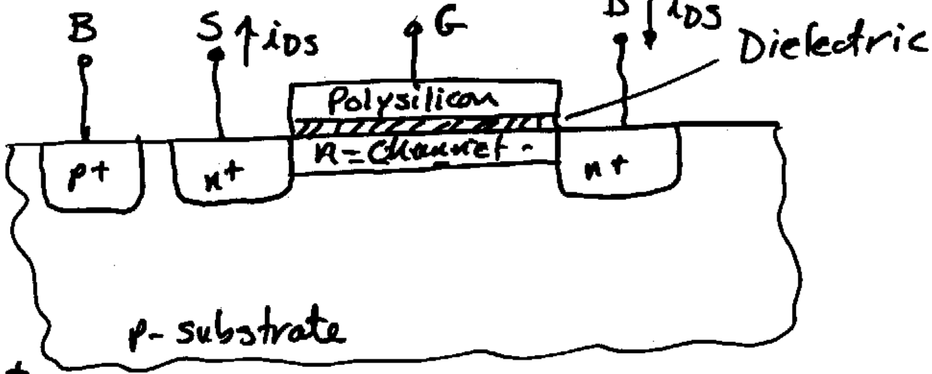
3.) Dynamic (time dependence) of diodes

→ Delay due to charge storage

Chapter 4 - Jaeger - Transistor

MOSFET





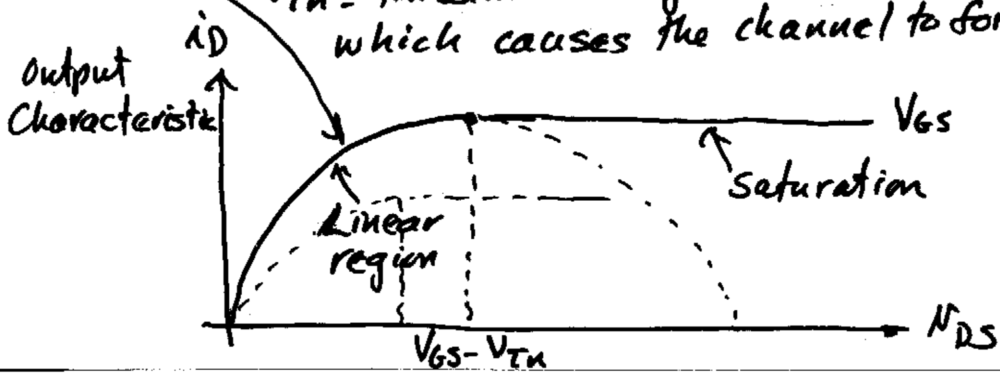
Regions of operation-

a.) Linear

$$i_{DS} = K_n' \frac{W}{L}\left(v_{GS} - V_{Tn} - \frac{v_{DS}}{2}\right) v_{DS}$$

K_n' = gain constant with units of A/V^2

V_{Tn} = threshold voltage (the value of v_{GS} which causes the channel to form)



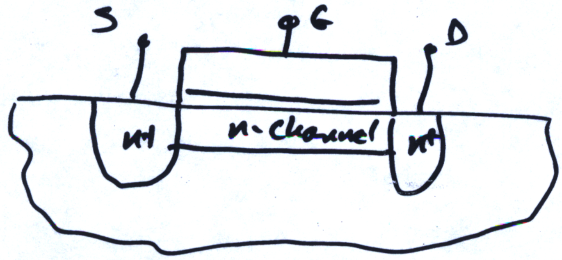
b.) Saturation

Let $v_{DS} = v_{DS}(sat) = V_{GS} - V_{TN}$

$$i_{DS} = K_n' \frac{W}{L}\left(\frac{v_{GS}-V_{TN}}{2}\right)(v_{GS}-V_{TN}) = \frac{K_n' W}{2L}(v_{GS}-V_{TN})^2$$

Depletion –

The channel always exists.



Use the same model as for enhancement let $V_{TN} < 0$