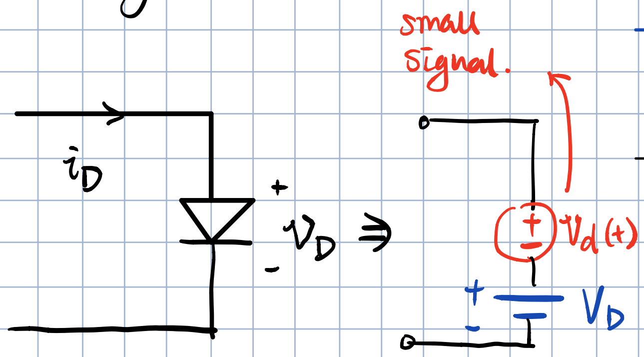
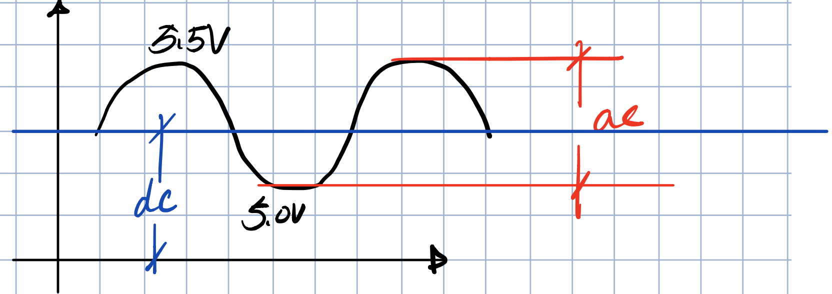
Small Signal diode model.

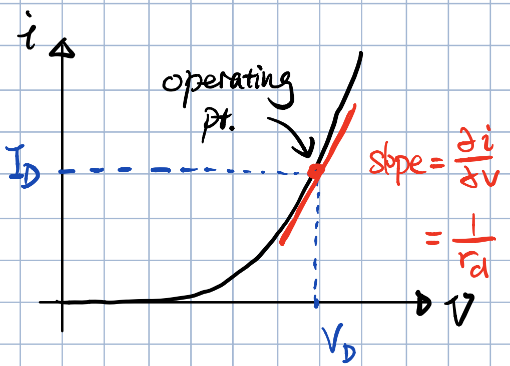




DC : V_D , I_D upper-case

ac : v_d , i_d lower-case

total : (DC+ac) v_D , i_D



I_D: diode DC current

$$i_D(t) = I_S e^{v_D/V_T}$$

$$v_D = V_D + v_d$$

$$i_D(t) = I_S e^{(V_D + v_d)/V_T}$$

$$= \underbrace{I_S e^{V_D/V_T}} \cdot e^{v_d/V_T}$$

$$= I_D \cdot e^{v_d/V_T}$$

assume $\frac{v_d}{V_T} \ll 1 \Rightarrow$

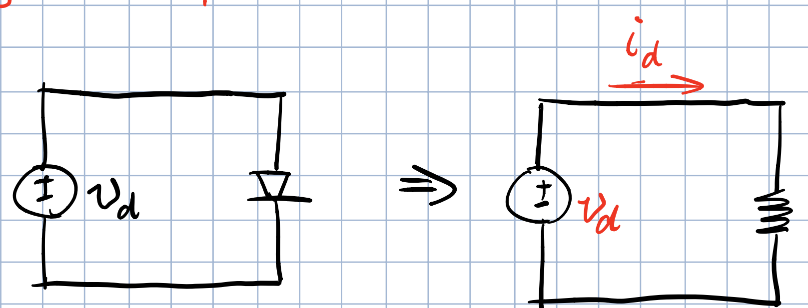
$$\simeq I_D \left(1 + v_d/V_T\right)$$

$$\simeq \underbrace{I_D}_{\text{DC component}} + \underbrace{\frac{I_D}{V_T} v_d}_{\text{ac component}}$$

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

$$\simeq I_D + \frac{1}{r_d} v_d$$

Small-signal model
(only ac component)

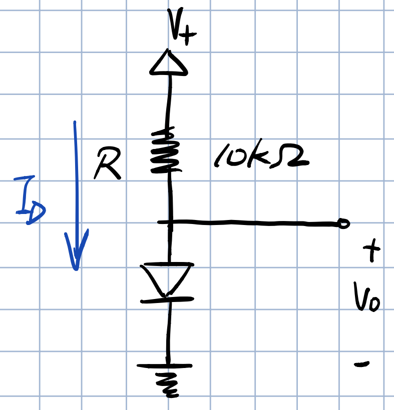


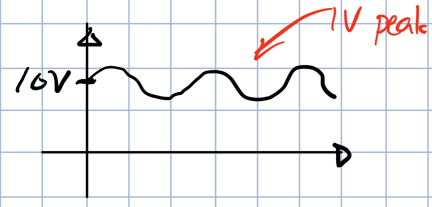
$$r_d = \frac{V_T}{I_D}$$

typical value 25mV

DC operating point.

Example 1





the diode has 0.7V at 1mA.

Step① : find the DC operating point (I_D, V_D)

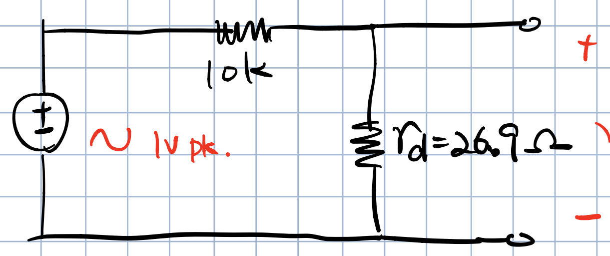
$$I_D = \frac{10V - 0.7V}{10k\Omega} = 0.93mA$$ (very close to 1mA, don't use more iteration)

DC operating pt is (0.93mA, 0.7V)

Step② : use the DC operating pt to calculate r_d

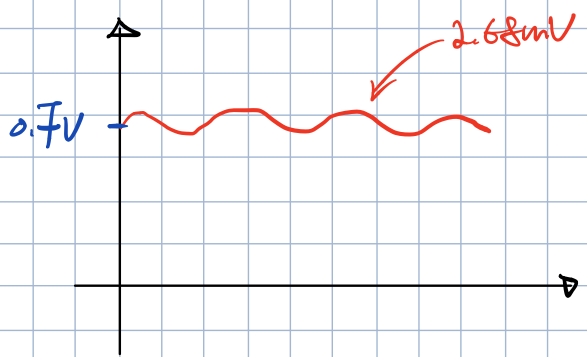
$$r_d = \frac{V_T}{I_D} = \frac{25mV}{0.93mA} = 26.9\Omega$$

Small signal model.



$$v_d = \frac{r_d}{R + r_d} * 1V_{pk} = 2.68mV$$

overall voltage cross the diode.

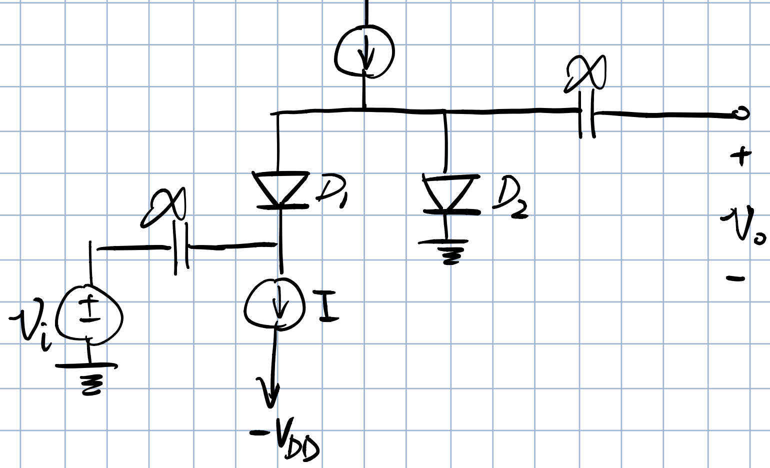


$$v_D = V_D + v_d$$

$V_D \to$ 0.7V, $v_d \to$ ac comp. (2.68mV)

diode is a good regulator! (compare 1V oscillation of 10V & 2.68 mV oscillation of 0.7V)

example 2.



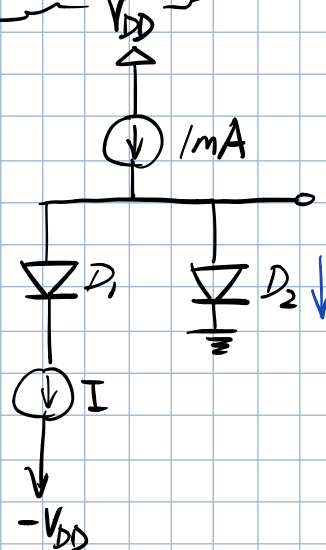
find $\frac{v_o}{v_i}$

① find DC operating pt.

② find r_{d_1} & r_{d_2}

③ find $\frac{v_o}{v_i}$

DC circuit.



0.7V (diode CVD)

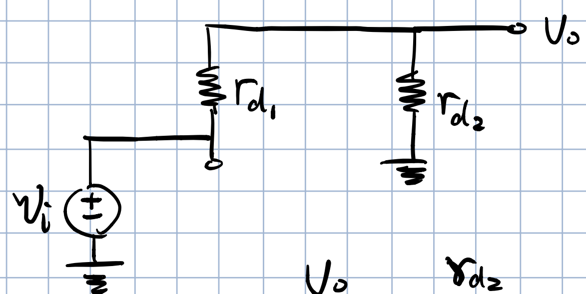
$\downarrow$ 1mA − I

②

$$r_{d_1} = \frac{V_T}{I}$$

$$r_{d_2} = \frac{V_T}{1-I}$$

③ small-signal model



$$\frac{V_o}{V_i} = \frac{r_{d_2}}{r_{d_1}+r_{d_2}}$$

$$= \frac{V_T/1-I}{V_T/I + V_T/1-I}$$

$$= I/1 \quad (V/V)$$

gain is controlled by I

i.e. $I = 0.5mA$

gain $= 1/2$