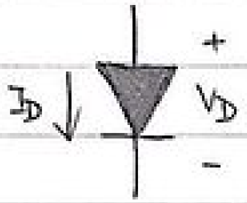
EE2005 Electronic Devices and Circuits

Review on Ch.7-9

Ch.7

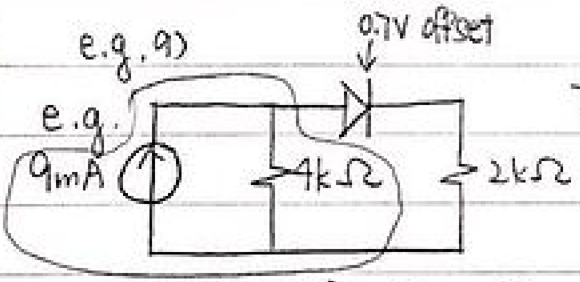
- Diode



$V_D = V_o - V_i = V^+ - V^-$

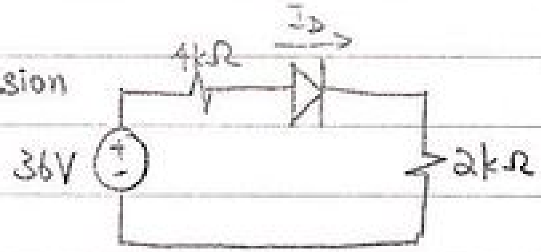
$I_D = \frac{V_o - V_i}{R_{eq}} = \frac{V^+ - V^-}{R_{eq}}$

  - ON
    → $+I_D, +V_D$
    → Short Circuit
  - OFF
    → $-I_D, -V_D$
    → Open Circuit
- Offset model (0.7V)



Source Transmission

⇒



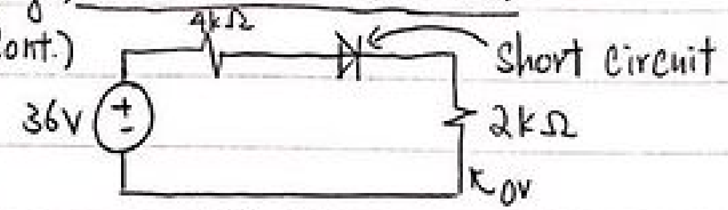
$V = (9\times10^{-3})\times(4\times10^{3})$

$= 36V$

⇒

e.g. a) <u>Assume 1: Diode is ON.</u>

(Cont.)



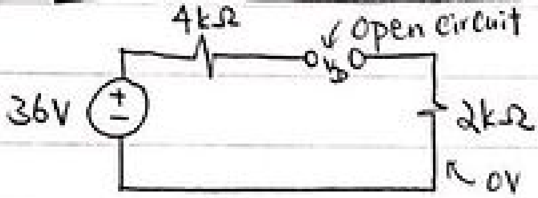
$$I_D = \frac{3.6-0.7-0}{4000+2000}$$

$= 5.8833mA$

> 0

∴ It confirms that the diode is ON.

<u>Assume 2: Diode is OFF.</u>



$V_D = 3.6 - 0.7 - 0$

$= 2.9V$

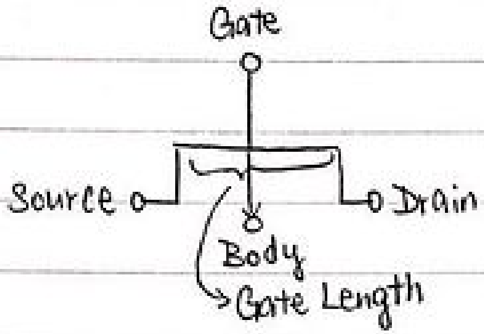
> 0

∴ It contradicts with the case.

b) $V_{2k\Omega} = (5.8833 \times 10^{-3}) \times 2000$

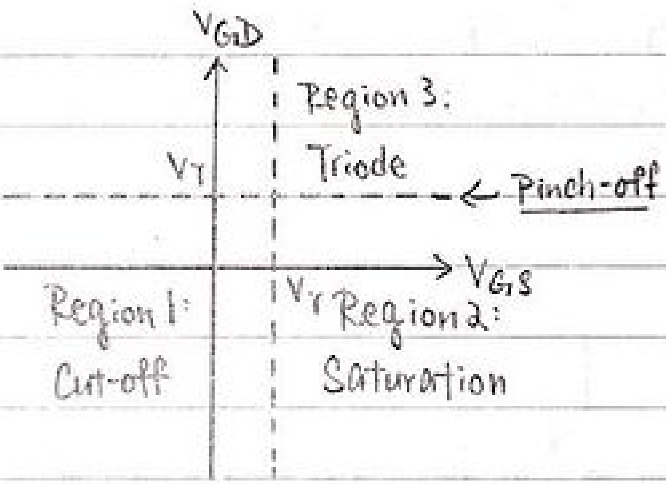
$= 11.7667V$

- MOSFET (Metal-Oxide-Semiconductor Field-Effects Transistor)
  - Structure



  - Junction: BJT
  - Different modes of MOSFET

Type	p-type	n-type
Cut-off Mode	$V_{GS} < V_T$ $V_{GD} < V_T$	$V_{GS} > V_T$ $V_{GD} > V_T$
Triode Mode	$V_{GS} > V_T$ $V_{GD} > V_T$	$V_{GS} < V_T$ $V_{GD} < V_T$
Saturation Mode	$V_{GS} > V_T$ $V_{GD} < V_T$	$V_{GS} < V_T$ $V_{GD} > V_T$



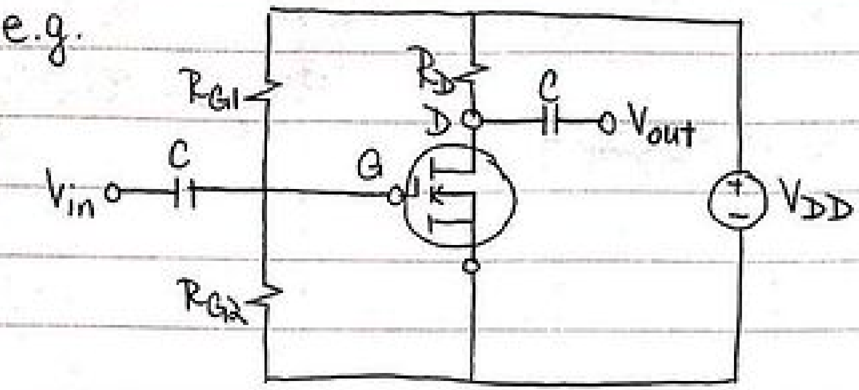
- Analysis on MOSFET

$$V_{DS} + I_D R_D = V_{DD}$$

$$I_D = -\frac{1}{R_D} V_{DS} + \frac{V_{DD}}{R_D}$$

$$V_{GS} = \frac{R_2}{R_1 + R_2} V_{GG}$$

e.g.



$V_{DD} = 8V$, $I_D = 4.5\,mA$, $R_D = 1k\Omega$

Input side:

$$V_G = \frac{R_{G2}}{R_{G1} + R_{G2}} \times V_{DD}$$

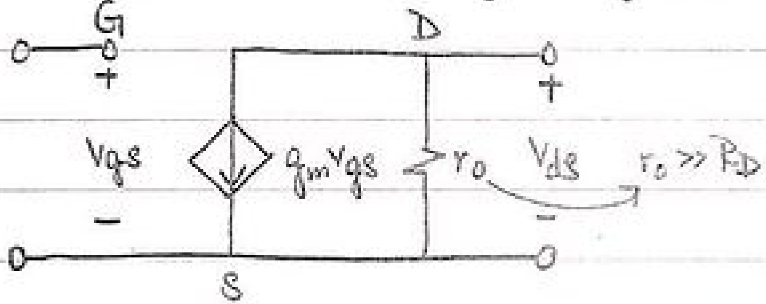
Output side:

$$V_{DD} = V_{DS} + I_D R_D$$

$$8 = V_{DS} + 4.5 \times 10^{-3} \times 1000$$

$$V_{DS} = 3.5V$$

· FET SSEC (Small Signal Equivalent Circuit)

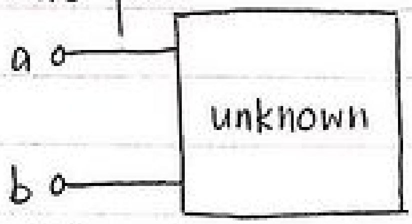


$$V_{out} = -g_m v_{gs} (r_o \| R_D)$$

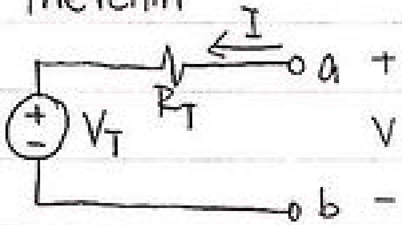
$$V_{in} = v_{gs}$$

$$\frac{V_{out}}{V_{in}} = \frac{-g_m \cancel{v_{gs}} (r_o \| R_D)}{\cancel{v_{gs}}} = -g_m (r_o \| R_D)$$

- One port

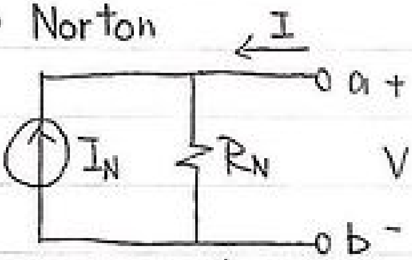


- Thevenin



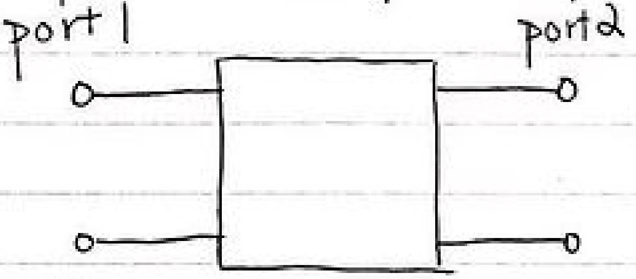
$$V = IR_T + V_T$$

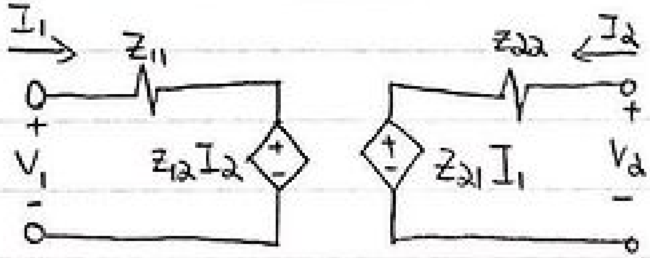
- Norton



$$I_N + I = \frac{V}{R_N}$$

- Two ports
  - Z parameters / Impedance parameters





$$V_1 = z_{11}I_1 + z_{12}I_2$$

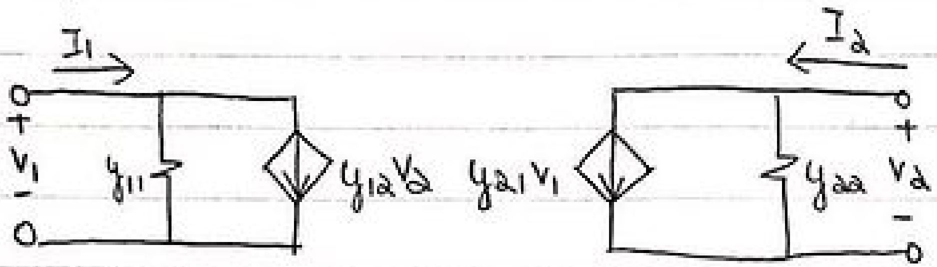
$$V_2 = z_{22}I_2 + z_{21}I_1$$

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} z_{11} & z_{12} \\ z_{21} & z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$\begin{cases} Z_{11} = \left.\dfrac{V_1}{I_1}\right|_{I_2=0} \\ Z_{12} = \left.\dfrac{V_1}{I_2}\right|_{I_1=0} \end{cases}$$

$$\begin{cases} Z_{22} = \left.\dfrac{V_2}{I_2}\right|_{I_1=0} \\ Z_{21} = \left.\dfrac{V_2}{I_1}\right|_{I_2=0} \end{cases}$$

· Y-parameters / Admittance Parameters



$I_1 = y_{11}V_1 + y_{12}V_2$

$I_2 = y_{22}V_2 + y_{21}V_1$

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

· Admittance

$z(\Omega) = \frac{V}{I}$

$y(S) = \frac{V}{I}$

For parallel

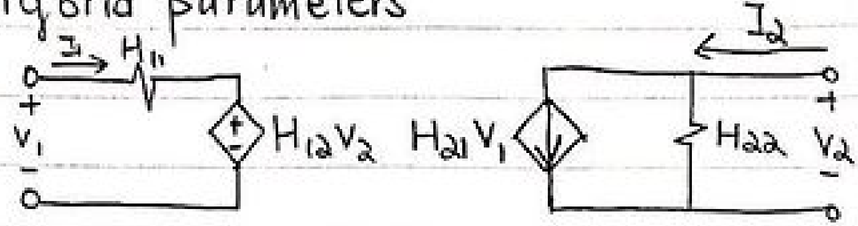
$\rightarrow \frac{1}{z_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$

$y_{eq} = \frac{1}{R_1} + \frac{1}{R_2}$

$$\begin{cases} y_{11} = \left.\frac{I_1}{V_1}\right|_{V_2=0} \\ y_{12} = \left.\frac{I_1}{V_2}\right|_{V_1=0} \end{cases}$$

$$\begin{cases} y_{22} = \left.\frac{I_2}{V_2}\right|_{V_1=0} \\ y_{21} = \left.\frac{I_2}{V_1}\right|_{V_2=0} \end{cases}$$

- Hybrid parameters



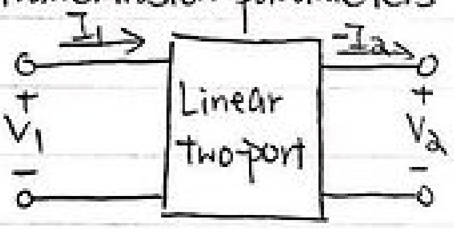
$$V_1 = H_{11} I_1 + H_{12} V_2$$

$$I_2 = H_{21} I_1 + H_{22} V_2$$

$\begin{cases} H_{11} = \frac{V_1}{I_1}\Big|_{V_2=0} & \text{Impedance} \\ H_{12} = \frac{V_1}{V_2}\Big|_{I_1=0} & \text{Reverse voltage gain (dimensionaless)} \end{cases}$

$\begin{cases} H_{21} = \frac{I_2}{I_1}\Big|_{V_2=0} & \text{Forward current gain (dimensionaless)} \\ H_{22} = \frac{I_2}{V_2}\Big|_{I_1=0} & \text{Admittance} \end{cases}$

- Transmission parameters



$$V_1 = AV_2 - BI_2$$

$$I_1 = CV_2 - DI_2$$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

$\begin{cases} A = \frac{V_1}{V_2}\Big|_{I_2=0} & \text{Voltage gain} \\ B = -\frac{V_1}{I_2}\Big|_{V_2=0} & \text{Negative impedance} \end{cases}$

$\begin{cases} C = \frac{I_1}{V_2}\Big|_{I_2=0} & \text{Admittance} \\ D = -\frac{I_1}{I_2}\Big|_{V_2=0} & \text{Negative current gain} \end{cases}$