电子学基础——第七次作业

LXQ

2019.11.11

3.1 Plot the I/V characteristic of the circuit shown in Fig. 3.63.

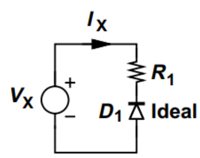


Figure 3.63

Solution The figure is shown in Figure p3.1.

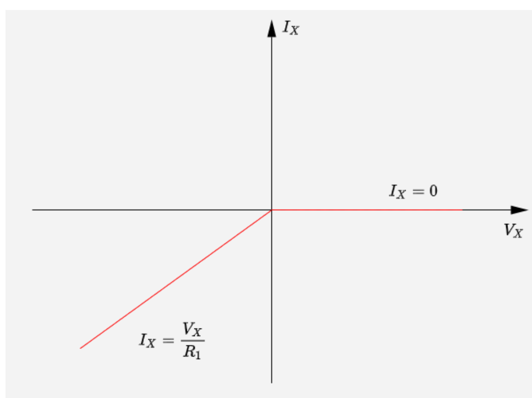


Figure p3.1

3.2 If the input in Fig. 3.63 is expressed as $V_X = V_0 \cos \omega t$, plot the current flowing through the circuit as a function of time.

Solution

$$I_X = \begin{cases} \dfrac{V_0}{R_X} \cos \omega t, & \dfrac{4k\pi + \pi}{2\omega} \le t < \dfrac{4k\pi + 3\pi}{2\omega} \\ 0, & \dfrac{4k\pi + 3\pi}{2\omega} \le t < \dfrac{4k\pi + 5\pi}{2\omega} \end{cases}$$

The figure is shown in Figure p3.2.

3.20 In the circuits depicted in Fig. 3.72, assume $I_{in} = I_0 \cos \omega t$, where I_0 is relatively large. Plot V_{out} as a function of time using a constant voltage diode model.

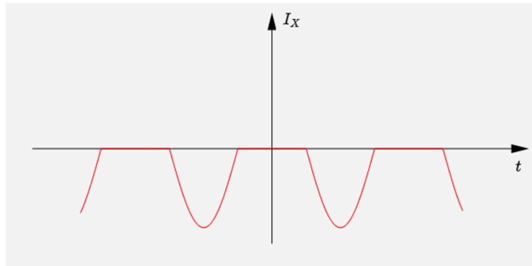


Figure p3.2

Solution The figures as shown in Figure p3.20

(a)

$$V_{out} = \begin{cases} I_{in}R_1, & -I_{in}R_1 + V_B < V_{D,on} \\ V_B - V_{D,on}, & -I_{in}R_1 + V_B \geq V_{D,on} \end{cases}$$

(b)

$$V_{out} = \begin{cases} I_{in}R_1 + V_B, & I_{in}R_1 + V_B > -V_{D,on} \\ -V_{D,on}, & I_{in}R_1 + V_B \leq V_{D,on} \end{cases}$$

(c)

$$V_{out} = \begin{cases} V_B + I_{in}R_1, & -I_{in}R_1 < V_{D,on} \\ V_B - V_{D,on}, & -I_{in}R_1 \geq V_{D,on} \end{cases}$$

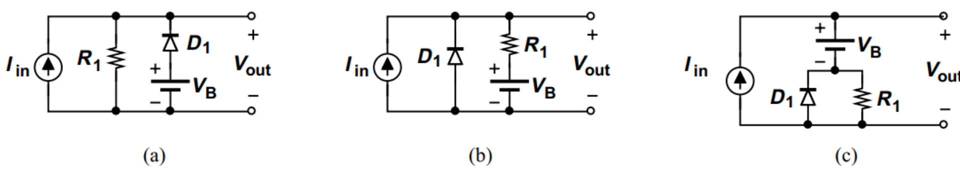


Figure 3.72

6.12 It is possible to define an "intrinsic time constant" for a MOSFET operating as a resistor:

$$\tau = R_{on}C_{GS}$$

where $C_{GS} = WLC_{ox}$. Obtain an expression for τ and explain what the circuits designer must do to minimize the time constant.

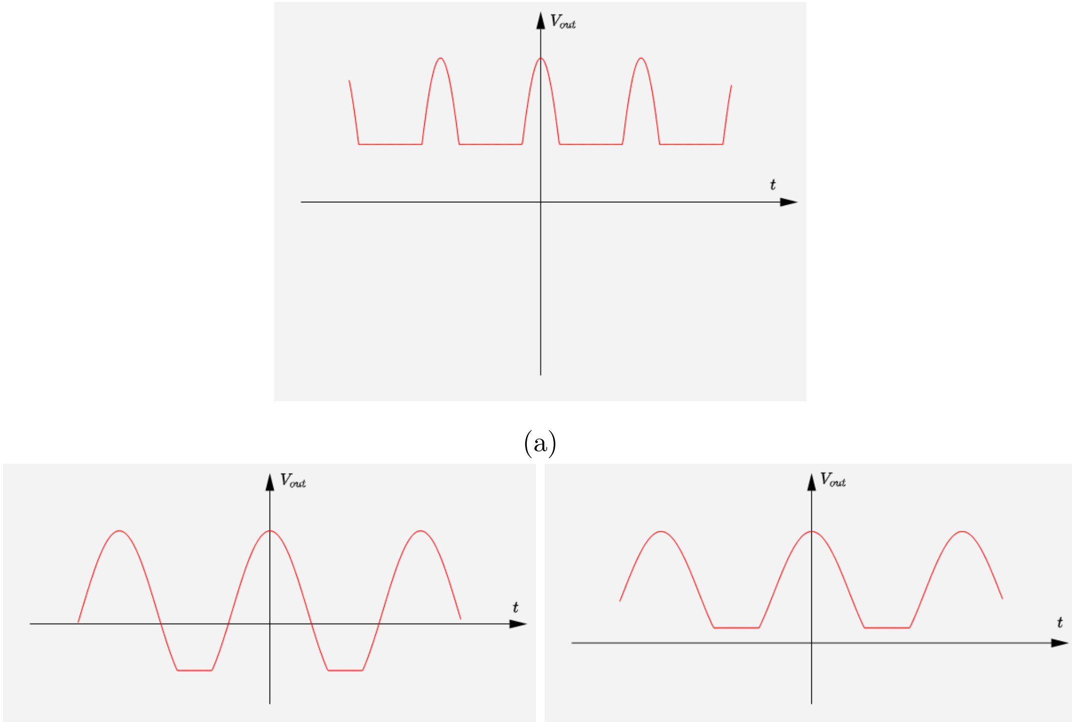
Solution It is known that when a MOSFET works as a resistor,

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}[2(V_{GS} - V_{th})V_{DS} - V_{DS}^2] \approx \mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{th})V_{DS}$$

$$\therefore R_{on} = \mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{th})$$

$$\tau = \mu_n C_{ox}^2 W^2 (V_{GS} - V_{th})$$

Therefore, in order to minimize the time constant τ, the designer should reduce the width W and the capacitance C_{ox}.



(a)

(b)

(c)

Figure p3.20

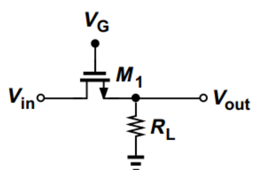


Figure 6.37

6.13 In the circuit of Fig. 6.37, M_1 serves as an electronic switch. If $V_{in} \approx 0$, determine W/L such that the circuit attenuates the signal by only 5%. Assume $V_G = 1.8\text{V}$ and $R_L = 100\Omega$.

Solution

$$V_{out} = 0.95V_{in}$$

$$\therefore V_{DS} = 0.05V_{in}, V_{GS} = 1.8 - 0.95V_{in}$$

$V_{in} \approx 0$, which means that the MOSFET works as a resistance:

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}[2(V_{GS} - V_{th})V_{DS} - V_{DS}^2] \approx \mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{th})V_{DS}$$

Assume $V_{th} = 0.5\text{V}, \mu_n C_{ox} = 100\text{mA/V}^2$, and we can obtain that

$$W/L = 1460$$

6.25 Calculate the bias current of M_1 in Fig. 6.43 if $\lambda = 0$.

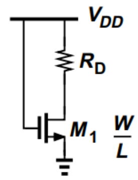


Figure 6.43

Solution

$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{th})^2$$
$$I_D R_D + V_{GS} = V_{DD}$$
$$\therefore I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{DD} - I_D R_D - V_{th})^2$$

The solution of the equation is:

$$I_D = \frac{2R_D k V_S + 1 - \sqrt{4R_D k V_S - 1}}{2kR_D^2}$$

where $k = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}, V_S = V_{DD} - V_{th}$.

6.26 Compute the value of W/L for M_1 in Fig. 6.44 for a bias current of I_1. Assume $\lambda = 0$

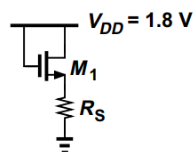


Figure 6.44

Solution

$$\begin{cases} I_1 = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{th})^2 \\ I_D R_S + V_{GS} = V_{DD} \\ V_S = I_1 R_S \\ V_{GS} = V_{DD} - V_S \end{cases}$$

$$\therefore \frac{W}{L} = \frac{2I_1}{\mu_n C_{ox}(V_{DD} - I_1 R_S - V_{th})^2}$$

6.27 In Fig. 6.45, derive a relationship among the circuit parameters that guarantees M_1 operates at the edge of saturation. Assume $\lambda = 0$.

Solution

$$\begin{cases} I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{th})^2 \\ V_{DD} = V_{GS} > V_{th} \\ V_{GD} = I_D R_D < V_{th} \end{cases}$$

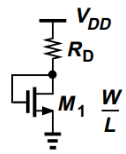


Figure 6.45

$$\therefore V_{th} < V_{DD} < \sqrt{\frac{2V_{th}L}{R_D C_{ox} W}}$$