Solution of Chapter 1 Problems

Problem 10

$$V_{LSB} = \frac{V_{ref}}{2^{12}\text{ bits}} = \frac{10\,V}{4096\text{ bits}} = 2.44\text{ mV/bit}$$

$$V_{MSB} = \frac{V_{ref}}{2} = 2^{11} \times V_{LSB} = \frac{10V}{2} = 5\,V$$

$$(100100100100)_2 = (2^{11}+2^8+2^5+2^2) \times 2.44\text{ mV/bit} = 2340 \times 2.44\text{ mV} = 5.71\,V$$

Problem 12

$$V_{LSB} = \frac{V_{FS}}{2^8} = \frac{5V}{256\text{ bits}} = 19.53\text{ mV/bit}$$

$V_i = 2.77\,V$ corresponds to $\frac{2.77}{5} \times 2^8 = 142$ bits

$$142_{10} = (128+8+4+2)_{10} = (2^7+2^3+2^2+2^1)_{10} = (10001110)_2$$

Problem 15

$$V_{LSB} = \frac{V_{FS}}{2^{12}} = \frac{5.12\,V}{4096\text{ bits}} = 1.25\text{ mV/bit}$$

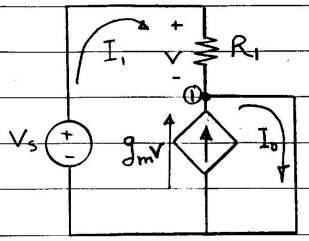
$$(101111011011)_2 = (2^{11}+2^9+2^8+2^7+2^5+2^4+2^3+2^1+2^0)_{10} = 3003_{10}$$

$$\therefore V_i = 3003 \times V_{LSB} \pm \frac{V_{LSB}}{2} = 3.754V \pm 0.0625\text{ mV}$$

So the range of input voltages is 3.753V to 3.755 V

Problem 25

First we calculate the short circuit current I_o

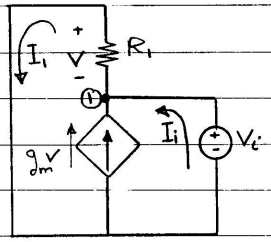


KCL at node 1 $\quad I_o = I_1 + g_m V$

but $V = I_1 R_1$ & $I_1 = V_s / R_1 \Rightarrow V = V_s$

$$\therefore I_o = \frac{V_s}{R_1} + g_m V_s = \left(\frac{1}{R_1} + g_m\right) V_s \Rightarrow I_o \simeq 0.025\, V_s$$

Now, we calculate R_{th} as follows:



KCL at node 1 $\quad I_i = I_1 - g_m V$

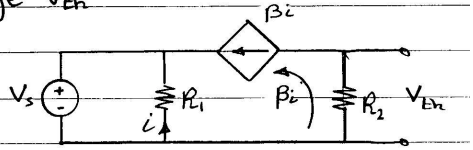
$V = -V_i \Rightarrow I_i = I_1 + g_m V_i$

& $I_1 = V_i / R_1 \quad \therefore I_i = (1/R_1 + g_m)\, V_i$

$$\therefore R_{th} = \frac{V_i}{I_i} = \frac{1}{1/R_1 + g_m} = 39.96\ \Omega \simeq 40\ \Omega$$

Problem 26

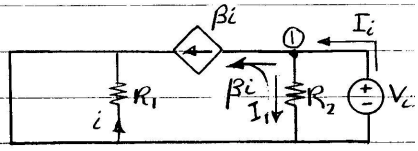
(A) First we calculate the open circuit voltage V_{th}



$V_{th} = -\beta i\, R_2$

but $i = -V_s / R_1 \Rightarrow V_{th} = +\dfrac{\beta R_2}{R_1} V_s = 58.5\, V_s$

Now, we calculate R_{th} as follows:

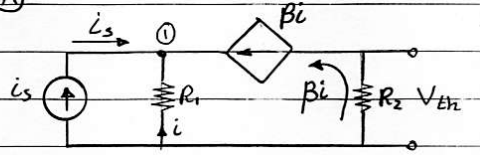


$\therefore R_1$ is short circuited $\Rightarrow i = 0$

KCL at node 1 $\quad I_i = I_1 = V_i / R_2 \Rightarrow R_{th} = R_2 = 39\ k\Omega$

Problem 26

(B) Following the same procedure as in part (A)

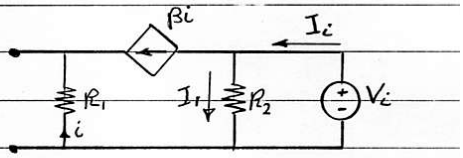


$V_{th} = -\beta i R_2$

KCL at node 1 $\quad i_s + i + \beta i = 0 \quad \therefore i = -\frac{i_s}{1+\beta}$

$$\Rightarrow V_{th} = -\beta\left(\frac{-i_s}{1+\beta}\right)R_2 = \frac{\beta R_2}{1+\beta} i_s = 38741.72\, i_s \simeq 38700\, i_s$$

$R_{th} = V_i / I_i$

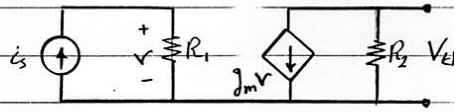


we've $\beta i = -i \Rightarrow (1+\beta) i = 0 \quad \therefore i = 0$

$\therefore I_i = I_1 = V_i / R_2 \Rightarrow R_{th} = R_2 = 39\ k\Omega$

Problem 29

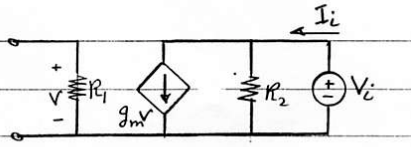
Again following the same procedure as in previous problems



$V_{th} = -g_m v R_2 \quad \& \quad v = R_1 i_s$

$\therefore V_{th} = -g_m R_1 R_2 i_s = -2 \times 10^8\, i_s$

After removing the independent current source



$\Rightarrow v = 0 \quad \therefore g_m v = 0$

$\therefore V_i = R_2 I_i \Rightarrow R_{th} = R_2 = 1\ M\Omega$

Problem 32

$$A = \frac{2 \angle 36^\circ}{10^{-5} < 0^\circ} = 2 \times 10^5 \angle 36^\circ$$

$$\Rightarrow |A| = 2 \times 10^5 \;\&\; \angle A = 36^\circ$$

Problem 33

a. $$A\Big|_{f = 2500\ Hz} = \frac{10^{-2} \angle -45^\circ}{2 \times 10^{-3} \angle 0^\circ} = 5 \angle -45^\circ$$

b. $$A\Big|_{f = 1500\ Hz} = \frac{10^{-1} \angle -12^\circ}{10^{-3} \angle 0^\circ} = 100 \angle -12^\circ$$