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Converters:

① A D/A converter has 6 bits and a reference voltage of 10V. Calculate the minimum value of R such that the maximum value of o/p current doesnot exceed 10mA. Find also the smallest quantized value of o/p current.

⇒ We have:

$$V_o = V_{ref}\left(-\frac{R_f}{R}\right)\left[1 + \frac{1}{2} + \frac{1}{2^2} + \cdots + \frac{1}{2^{n-1}}\right]$$

$$= V_{ref}\left(-\frac{R_f}{R}\right)\left[\frac{1\cdot(1-1/2^n)}{1-1/2}\right] \quad \left[\because S_n = \frac{a(1-r^n)}{1-r} \text{ for } r<1\right]$$

$$= V_{ref}\left(-\frac{R_f}{R}\right)\left(\frac{2^n-1}{2^n}\times 2\right]$$

$$= V_{ref}\left(-\frac{R_f}{R}\right]\left[\frac{2^n-1}{2^{n-1}}\right]$$

For max^m current, all the bits = '1', so the value of all switches = 1 ~~& then~~ n = 6

$$\frac{V_o}{R_f} = \frac{V_{ref}}{R} \times \frac{2^6-1}{2^5}$$

or, $$I_{max} = \frac{10}{R} \times \frac{63}{32}$$

or, $$R = \frac{10}{10\times10^{-3}} \times \frac{63}{32}$$

$\therefore R = 2000\,\Omega$

Now, Smallest quantized current = Current with LSB

$$\therefore (i_o)_{LSB} = \frac{V_{ref}}{R} \times \frac{1}{2^{n-1}} = \frac{10}{2K} \times \frac{1}{32} = 156\,\mu A$$

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② Consider a 6-bit D/A Converter with a resistance of $320k\Omega$ in LSB position. The converter is designed with weighted resistive network. The reference voltage is 10V. The o/p of the resistive n/w is connected to an op-Amp with a feedback resistance of $5k\Omega$. What is the o/p voltage for a binary i/p of 111010?

⇒ Here,

$$V_0 = V_{ref}\left(\frac{R_f}{R}\right)\left[S_1 + \frac{S_2}{2} + \frac{S_3}{2^2} + \frac{S_4}{2^3} + \frac{S_5}{2^4} + \frac{S_6}{2^5}\right]$$

$$\text{or, } I_0 = \frac{V_0}{R_f} = \frac{V_{ref}}{R}\left[S_1 + \frac{S_2}{2} + \frac{S_3}{2^2} + \frac{S_4}{2^3} + \frac{S_5}{2^4} + \frac{S_6}{2^5}\right] \quad \text{--- (1)}$$

and resistance at LSB position $= 2^{n-1}R$

$$320k = 2^{6-1}R$$

$$\therefore R = 10k\Omega$$

Now, from eqⁿ (1),

$$I_0 = \frac{10}{10 \times 1000}\left[1 + 0.5 + 0.25 + 0 + 0.0625 + 0\right]$$

$$= 10^{-3} \times 1.8125$$

$$= 1.8125mA$$

The o/p voltage $= I_0 \times R_f$

$$= 1.812m \times 5k$$

$$= 9.0625V$$

$\therefore E_0 = -9V$ [∵ inverting confⁿ of op-Amp]

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(3) Find the Successive approximation A/D output for a 4-bit Converter to a 3.217V i/p if the reference voltage is 5V.

⇒ The o/p of DAC is given by

$$V_0 = V_{ref}\left[\frac{d_0 \times 2^0 + d_1 \times 2^1 + d_2 \times 2^2 + d_3 \times 2^3}{2^4}\right]$$

$$= \frac{V_{ref}}{16}\left[d_0 + 2d_1 + 4d_2 + 8d_3\right] \quad \text{--- (1)}$$

If digital o/p be $d_3 d_2 d_1 d_0$ then,

(i) Set $d_3 = 1$,

$$V_0 = \frac{5}{16}\left[0+0+0+8\right] = 2.5V$$

Here $3.217 > 2.5 \therefore d_3 = 1$

(ii) Set $d_2 = 1$

$$V_0 = \frac{5}{16}\left[0+0+4+8\right] = 3.75$$

Here $3.217 < 3.75, \therefore d_2 = 0$

(iii) Set $d_1 = 1$

$$V_0 = \frac{5}{16}(0+2+0+8) = 3.125V$$

Here, $3.217 > 3.125, \therefore d_1 = 1$

(iv) Set $d_0 = 1$

$$V_0 = \frac{5}{16}(1+2+0+8) = 3.4375V$$

Here $3.217 < 3.4375, \therefore d_0 = 0$

Hence the digital o/p = $d_3 d_2 d_1 d_0 = 1010$