12.

The actual circuit gains are found by conversion of the PB and reset time into values appropriate to the circuit. The 80% PB means that if the input changes by 80% of its range, or, 0.8(5) = 4.0 volts then the output must change by 100% of its range, or, 12 volts. This means the circuit gain is,

$$G_P = 12/4 = 3$$

The 0.03 min reset time means that the integral gain is given by,

$$K_I = 1/T_I = 1/0.03 = 33.33\ \%/(\%\text{-min})$$

We convert this to seconds so that it will be more appropriate to the circuit,

$$K_I = (1\ \text{min}/60\ \text{s})[33.33\ \%/(\%\text{-min})]$$

$$K_I = 0.5556\ \%/(\%\text{-s})$$

The interpretation of this number is that if the input changes by 1% of its range for 1 s, then the output must change by 0.556% of its range. Thus,

$$G_I = (0.005556)(12)/[(0.01)(5)]$$

$$G_I = 1.333\ \text{s}^{-1}$$

Using the circuit of Fig. 10.13 we make,

$$R_2/R_1 = 3 \qquad 1/R_2C = 1.333$$

If we select $C = 2\ \mu\text{F}$ then $R_2 = 375\ \text{k}\Omega$ and so we must have $R_1 = R_2/3 = 125\ \text{k}\Omega$. The inverter resistance can be any convenient value, say 10 kΩ.

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I/p range – 2.5 – 8V

O/p range – 0 – 7V

$PB = 62\%$

$\tau_r = 0.08$ min

$\tau_d = 0.09$ min

$$\therefore K_P = \frac{100}{62} = 1.613\ \%/\%$$

$$G_P = \frac{1.613 \times 7 \cancel{\times 0.01}}{\cancel{0.01} \times 5.5} = 2.053 = \frac{R_2}{R_1}$$

$$\tau_r = 0.08\ \text{min} = 0.08 \times 60\ \text{s} = 4.8\ \text{sec}$$

$$K_I = \frac{1}{\tau_r} = \frac{1}{4.8\ \text{s}} = 0.2083\ \%/\%\ \text{s}^{-1}$$

$$G_I = \frac{1}{R_I C_I} = 0.2083 \times \frac{7}{5.5} = 0.265$$

$$\tau_D = 0.09\ \text{min} = 5.4\ \text{sec} \quad G_D = 5.4 \times \frac{7}{5.5} = 6.873 = R_D C_D$$

$$2\pi R_3 C_D = 0.1 \times \cancel{0.8}\ 8\ \text{min} = \cancel{0.8} = 48\ \text{s}.$$