

The first amplifier is a voltage subtractor. The transfer function for the voltage subtractor in the circuit is given by equation (1).

$$V_{out}(s) = -\frac{R_3}{R_1}V_{in}(s) + \frac{R_4}{R_2 + R_4} \frac{R_1 + R_3}{R_1} V_{out}(s) \quad (1)$$

The feedback gain is 0.4. So, the input to the feedforward gain is  $V_{in} - 0.4V_{out}$ . The feedforward gain is 4 and is implemented using an inverting amplifier. The inverting amplifier provides a gain of  $-4$ . Therefore, the subtractor must provide an output of  $-V_{in} + 0.4V_{out}$  to ensure the proper input is provided to the DC machine.

By equation (1),  $\frac{R_3}{R_1} = 1$ . Therefore,  $R_3 = R_1$ . If  $R_1$  is provided,  $R_3$  is determined to have the same resistance.

Substitute  $R_3 = R_1$  into equation (1) and consider  $V_{out}(s)$ 's coefficient.

$$\frac{2R_4}{R_2 + R_4} = \frac{1}{2} \rightarrow 2R_4 = \frac{R_2 + R_4}{2} \rightarrow \frac{3}{2}R_4 = \frac{R_2}{2} \rightarrow R_2 = 3R_4 \quad (2)$$

Therefore, if  $R_4$  is provided, then  $R_2$  is determined to have thrice the resistance.

The inverting amplifier's gain is  $-4$  and also given by  $-\frac{R_5}{R_6}$ . Therefore,  $R_5 = 4R_6$ . If  $R_6$  is provided,  $R_5$  is determined to be  $4R_6$ .

The following ratios must hold in the circuit. Assume that  $R_1$ ,  $R_4$ , and  $R_6$  are free parameters.  $R_3$  could also be a free parameter instead of  $R_1$ ,  $R_2$  instead of  $R_4$ , or  $R_5$  instead of  $R_6$ .

$$R_3 = R_1 \quad (3)$$

$$R_2 = 3R_4 \quad (4)$$

$$R_5 = 4R_6 \quad (5)$$