Gain of the Three Op Amp Instrumentation Amplifier

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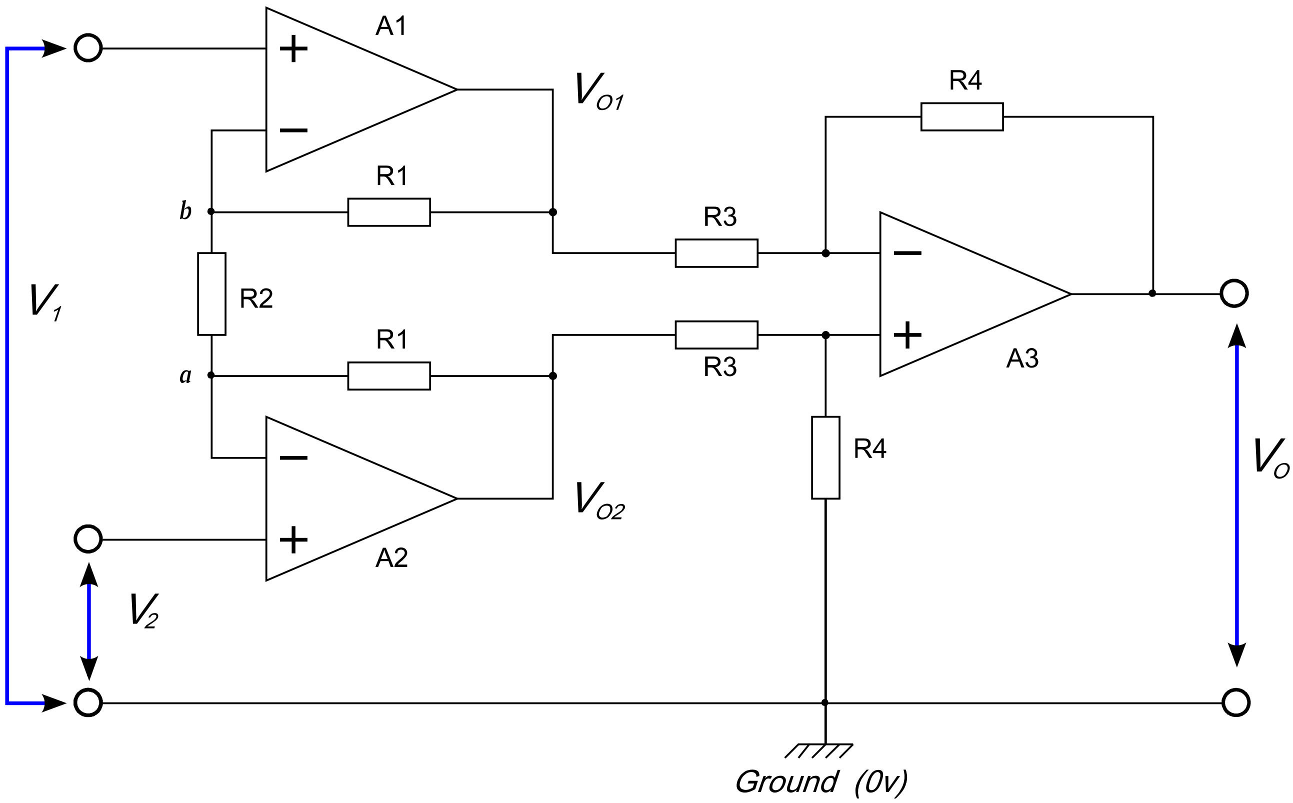

Figure 1.

Consider the amplifier illustrated in Figure 1.

The first stage is a balanced input, balanced output amplifier formed by A1 and A2 which amplifies the differential signal but passes the common mode signal without amplification. The second stage formed by A3 is a differential amplifier which largely removes the common mode signal.

The voltage V_{O1} consists of two components, the voltage due to V_1 and the voltage due to V_2.

If $V_2 = 0$ then point ***a*** will be a virtual earth and amplifier A1 will act as a non inverting amplifier with a gain of

$$V_{O1} = V_1\left(\frac{R1 + R2}{R2}\right)$$

If $V_1 = 0$ then point ***b*** will be a virtual earth and amplifier A1 will act as an inverting amplifier with a gain of

$$V_{O1} = -\left(\frac{R1}{R2}\right)V_2$$

the output from amplifier A1 with respect to ground (0v) will be

$$V_{O1}=\frac{R1+R2}{R2}V_1-\frac{R1}{R2}V_2$$

$$V_{O1}=\frac{(R1+R2)V_1-R1V_2}{R2}$$

$$V_{O1}=(\frac{R1}{R2}+1)V_1-\frac{R1}{R2}V_2$$

$$V_{O1}=\frac{R1}{R2}\{V_1-V_2\}+V_1$$

Similarly the output from amplifier A2 with respect to ground will be

$$V_{O2}=\frac{R1}{R2}\{V_2-V_1\}+V_2$$

These two voltages are fed into a differential amplifier A3, the gain of this amplifier is given by

$$V_O=\frac{R4}{R3}(V_{O2}-V_{O1})$$

If we substitute the equations for V_{O2} and V_{O1} we get

$$V_O=\frac{R4}{R3}(\{\frac{R1}{R2}\{V_2-V_1\}+V_2\}-\{\frac{R1}{R2}\{V_1-V_2\}+V_1\})$$

We can simplify this

$$V_O=\frac{R4}{R3}\{\frac{R1V_2}{R2}-\frac{R1V_1}{R2}+V_2-\frac{R1V_1}{R2}-\frac{R1V_2}{R2}+V_1\}$$

$$V_O=\frac{R4}{R3}\{\frac{2R1V_2}{R2}+V_2-\frac{2R1V_1}{R2}+V_1\}$$

$$V_O=\frac{R4}{R3}(V_2\{1+\frac{2R1}{R2}\}-V_1\{1+\frac{2R1}{R2}\})$$

$$V_O=(V_2-V_1)\frac{R4}{R3}\{1+\frac{2R1}{R2}\}$$

Therefore the differential gain G is

$$G=\frac{R4}{R3}\{1+\frac{2R1}{R2}\}$$