

## Operational Amplifiers Explained (part 1)

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*This article explains the basics of how an operational amplifier (op amp) works.*

If you have any suggestions for improving this application note, please drop us a line at: [enquiries@electronworks.co.uk](mailto:enquiries@electronworks.co.uk)

The operational amplifier (op amp) is a simple component in electronics, but one that can be used in hundreds of complex circuit configurations. If you understand it, you are well on your way to being able to understand many electronic circuits.

An op amp is an amplifier – it makes voltages larger. Most of them only have 3 connections: a non inverting input (+) an inverting input (-) and an output. They also have 2 power supply connections. The circuit symbol is shown in FIG 1

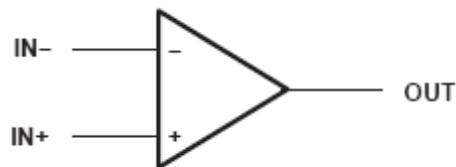


FIG 1

Let's examine some of the circuit configurations of an op amp. FIG 2 shows an op amp as a non inverting amplifier.

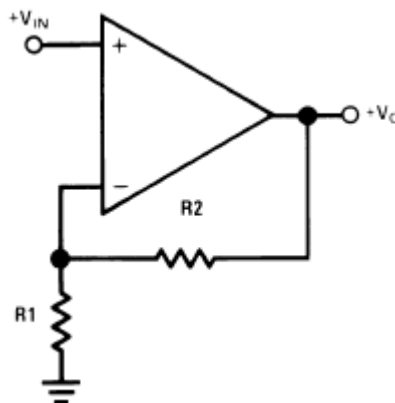


FIG 2

The voltage at the output is determined by the equation:

$$V_o = V_{in} \left( 1 + \frac{R_2}{R_1} \right)$$

So with an input voltage of 1V, if we make  $R_2 = 10k\Omega$  and  $R_1 = 5k\Omega$  then the output voltage is 3V. We have built an amplifier with only 3 components.

Suppose we want to invert the signal. Then we use the non inverting configuration as shown in FIG 3.

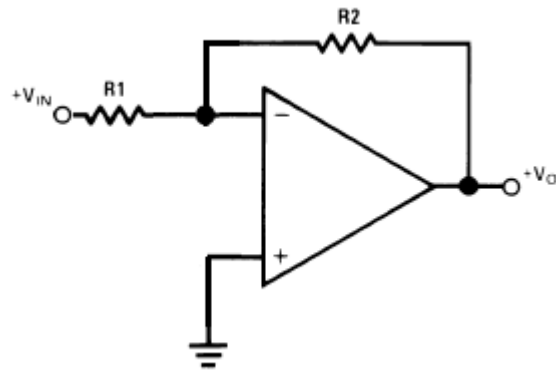


FIG 3

The voltage at the output is determined by the equation:

$$V_o = -V_{in} \left( \frac{R_2}{R_1} \right)$$

Thus applying a signal of 1V at the input, if we make  $R_2 = 10\text{k}\Omega$  and  $R_1 = 5\text{k}\Omega$  then the output voltage is -2V.

Thus it can be seen that the op amp is an extremely elegant solution to amplifying a voltage and these components are used in circuits such as audio amplifiers, CD players, MP3 players and test equipment. Later articles will show that there are many more reasons why an op amp should be used to amplify signals.