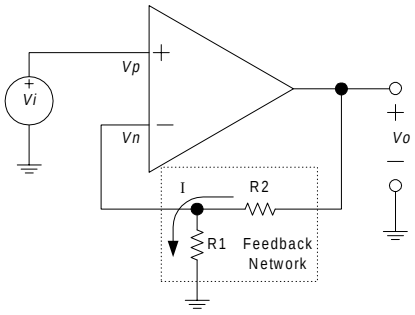
Non-Inverting Amplifier

An ideal op amp by itself is not a very useful device since any finite input signal would result in infinite output. By connecting external components around the ideal op amp, we can construct useful amplifier circuits. Figure 4 shows a basic op amp circuit, the non-inverting amplifier. The triangular gain block symbol is used to represent an ideal op amp. The input terminal marked with a + (Vp) is called the non-inverting input; – (Vn) marks the inverting input.

Figure 4. Non-Inverting Amplifier



To understand this circuit we must derive a relationship between the input voltage, V_i, and the output voltage, V_O.

Remembering that there is no loading at the input,

$$V_p = V_i \tag{11}$$

The voltage at V_n is derived from V_O via the resistor network, R_1 and R_2, so that,

$$V_n = V_o \frac{R_1}{R_1+R_2} = V_o\, b \tag{12}$$

where,

$$b = \frac{R_1}{R_1+R_2} \tag{13}$$

The parameter *b* is called the feedback factor because it represents the portion of the output that is fed back to the input.

Recalling the ideal model,

$$V_O = aV_d = a(V_p - V_n) \tag{14}$$

Substituting,

$$V_O = a(V_i - bV_O) \tag{15}$$

and collecting terms yield,

$$A = \frac{V_o}{V_i} = \left(\frac{1}{b}\right)\left(\frac{1}{1 + \frac{1}{ab}}\right) \tag{16}$$

This result shows that the op amp circuit of Figure 4 is itself an amplifier with gain *A*. Since the polarity of V_i and V_O are the same, it is referred to as a non-inverting amplifier.

A is called the *close loop gain* of the op amp circuit, whereas a is the *open loop gain*. The product ab is called the *loop gain*. This is the gain a signal would see starting at the inverting input and traveling in a clockwise loop through the op amp and the feedback network.

Closed Loop Concepts and Simplifications

Substituting $a = \infty$ (1) into (16) results in,

$$A = \frac{1}{b} = 1 + \frac{R_2}{R_1} \tag{17}$$

Recall that in equation (6) we state that V_d, the voltage difference between V_n and V_p, is equal to zero and therefore, $V_n = V_p$. Still they are not shorted together. Rather there is said to be a *virtual short* between V_n and V_p. The concept of the virtual short further simplifies analysis of the non-inverting op amp circuit in Figure 4.

Using the virtual short concept, we can say that,

$$V_n = V_p = V_i \tag{18}$$

Realizing that finding Vn is now the same resistor divider problem solved in (12) and substituting (18) into it, we get,

$$V_i = V_o \quad \frac{R_1}{R_1 + R_2} = V_o\, b \tag{19}$$

Rearranging and solving for *A*, we get,

$$A = \left(\frac{1}{b}\right) = 1 + \left(\frac{R2}{R1}\right)$$

The same result is derived in (17). Using the virtual short concept reduced solving the non-inverting amplifier, shown in Figure 4, to solving a resistor divider network.