- The output from a two input noninverting adder is given by:—

$$V_{out} = V_1 + V_2$$

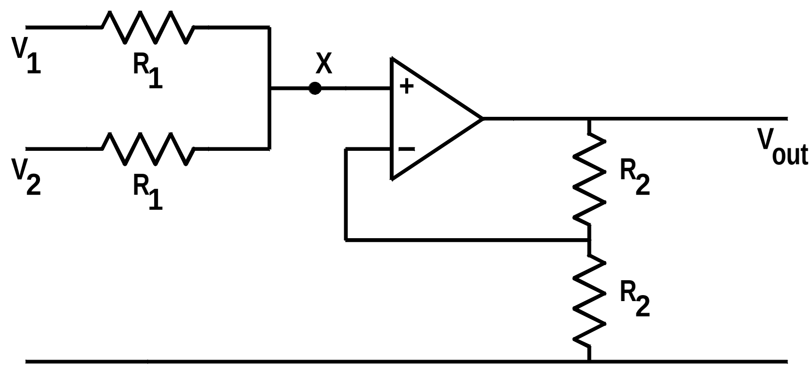
- The output from an inverting adder is given by:—

$$V_{out} = -R_f \left(\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} + \ldots \right)$$

The addition of two voltage signals to get a single output sum is a very common operation in electronics.

We will first look at a noninverting simple adder.

It is a good example of circuit analysis technique where a given circuit can be split into its component parts in order to analyze the operation of the circuit.



Two input noninverting adder.
V_1 and V_2, specified wrt to ground
No current flows into op-amp input terminals

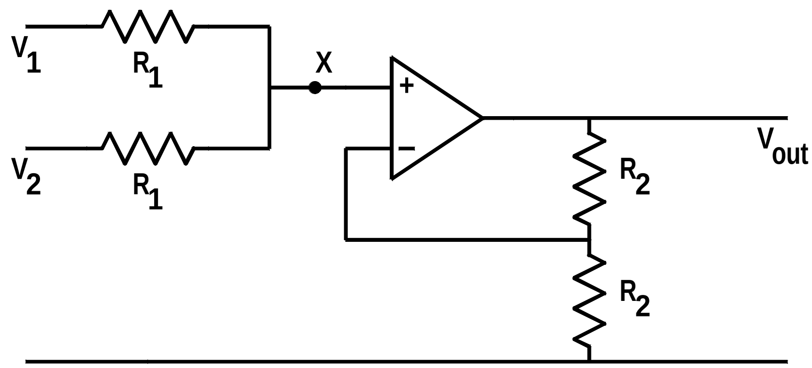
$$I = \frac{V_1 - V_2}{2 \times R_1}$$

The voltage, V_X, at the mid point, X, is:—

$$V_X = V_1 - I \times R_1 = V_1 - \frac{V_1 - V_2}{2 \times R_1} \times R_1$$

$$= V_1 - \frac{V_1}{2} + \frac{V_2}{2} = \frac{V_1 + V_2}{2}$$

V_X is average of V_1 and V_2.



The noninverting amplifier has a gain of:—

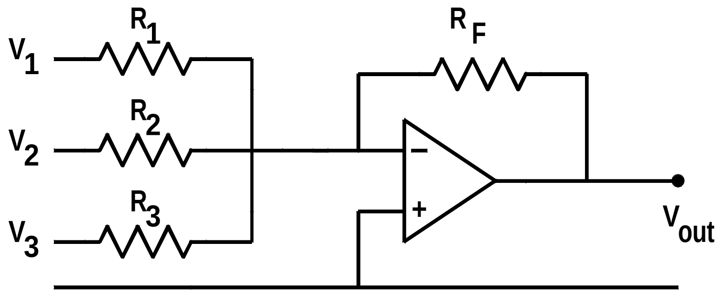
$$A_V = 1 + \frac{R_2}{R_2} = 2$$

The output of the circuit is then given by:—

$$V_{out} = \frac{V_1 + V_2}{2} \times 2 = V_1 + V_2$$

which is the sum of the two input voltages.

The disadvantage of this adder is that no more than two input signals can be added.



Inverting adder.

Voltage at inverting, $(-)$input $\approx 0V$.

This is called a *virtual earth* or *virtual ground*.

Current in R_1 is $\frac{V_1}{R_1}$.

Then $I_1 + I_2 + I_3 = I_f$ and therefore:—

$$\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} = -\frac{V_{out}}{R_f}$$

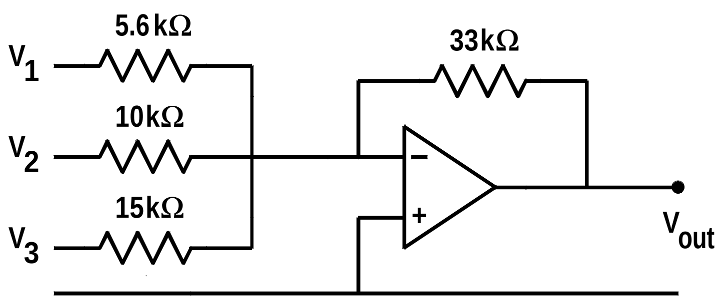
Inverting adder allows scaled or weighted addition

If an output of the form

$$V_{out} = 3.1V_1 - 2.4V_2 - 5.0V_3$$

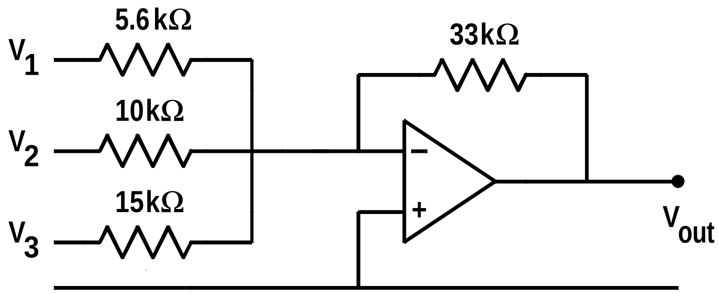
is required, then an inverter can be used on the V_1 input signal before it is applied to the inverting adder so that the effective equation is:–

$$V_{out} = -\left(3.1(-V_1) + 2.4V_2 + 5.0V_3\right)$$



The equation for the output is:

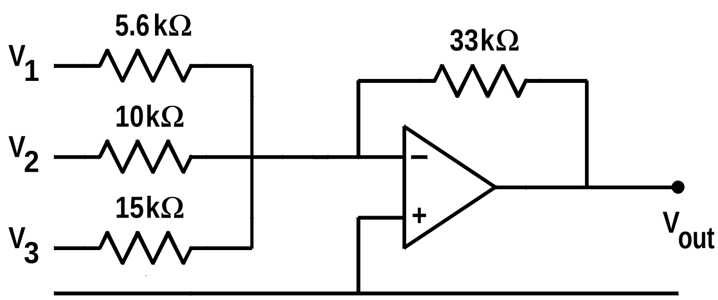
$$
\begin{aligned}
V_{out} &= -\left(\frac{33}{5.6} \times V_1 + \frac{33}{10} \times V_2 + \frac{33}{15} \times V_3\right) \\
&= -5.9V_1 - 3.3V_2 - 2.2V_3
\end{aligned}
$$



Design a test matrix for

$$V_{out} = -5.9V_1 - 3.3V_2 - 2.2V_3$$

Test no.	V_1	V_2	V_3	Calc. V_{out}	Meas. V_{out}
1	0	0	0	0	
2	1	0	0	-5.9	
3	0	1	0	-3.3	
4	0	0	1	-2.2	
5	-1	0	0	+5.9	
6	0	-1	0	+3.3	
7	0	0	-1	+2.2	
8	-1	1	1	+0.4	
9	1	-1	1	-4.8	


5.6 kΩ
33kΩ
V1
10kΩ
V2
15kΩ
V3
Vout