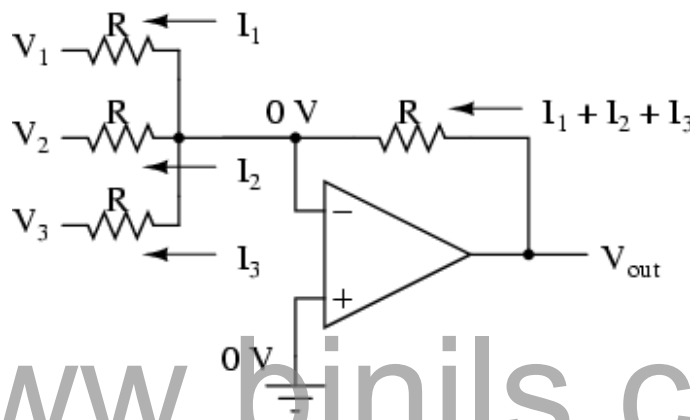


4.3 DIGITAL TO ANALOG CONVERTER

The binary-weighted-input DAC, is a variation on the inverting summer op-amp circuit. If you recall, the classic inverting summer circuit is an operational amplifier using negative feedback for controlled gain, with several voltage inputs and one voltage output. The output voltage is the inverted (opposite polarity) sum of all input voltages:

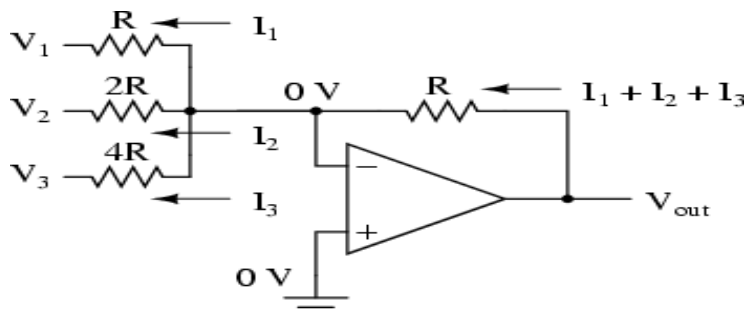
Inverting summer circuit



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$$V_{\text{out}} = - (V_1 + V_2 + V_3)$$

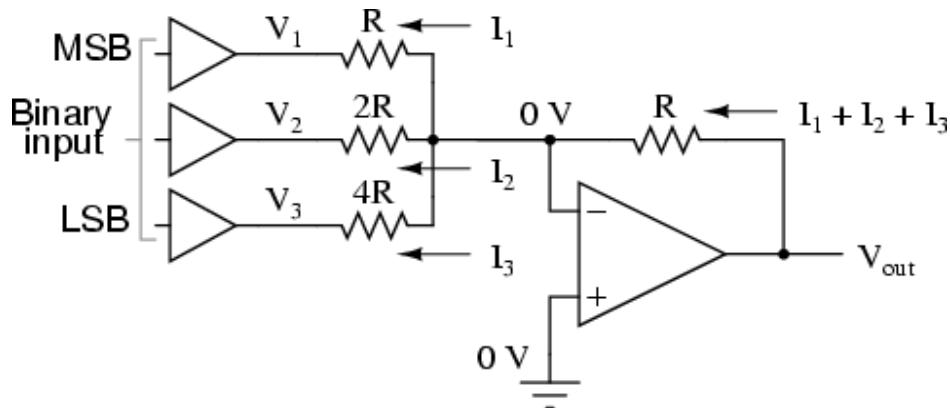
For a simple inverting summer circuit, all [resistors](#) must be of equal value. If any of the input resistors were different, the input voltages would have different degrees of effect on the output, and the output voltage would not be a true sum. Let's consider, however, intentionally setting the input resistors at different values. Suppose we were to set the input resistor values at multiple powers of two: R, 2R, and 4R, instead of all the same value R:



$$V_{\text{out}} = - \left(V_1 + \frac{V_2}{2} + \frac{V_3}{4} \right)$$

Starting from V_1 and going through V_3 , this would give each input voltage exactly half the effect on

the output as the voltage before it. In other words, input voltage V_1 has a 1:1 effect on the output voltage (gain of 1), while input voltage V_2 has half that much effect on the output (a gain of $1/2$), and V_3 half of that (a gain of $1/4$). These ratios were not arbitrarily chosen: they are the same ratios corresponding to place weights in the binary numeration system.



If we chart the output voltages for all eight combinations of binary bits (000 through 111) input to this circuit, we will get the following progression of voltages:

Disadvantages:

- 1) When number of binary input increases, it is not easy to maintain the resistance ratio.
- 2) Very wide ranges of different values of resistors are required. For high accuracy of conversion, the values of resistances must be accurate.
- 3) Different current flows through resistors, so their wattage ratings are also different.
- 4) Accuracy and stability of conversion depends primarily on the absolute accuracy of the resistors and tracking of each other with temperature.
- 5) Since 'R' is very large, op-amp bias currents gives a drop which offsets output.

Resistances of switches may be comparable with smallest resistor.

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