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Using a Real OpAmp

The Non-Idealities of Real OpAmps

An ideal OpAmp shown in *figure 1* has infinite input impedance, infinite gain (*A* approaches infinity), and zero output impedance. Real OpAmps have many limitations which must be realized before building real feedback circuits. These limits are all represented in *figure 2*. Three distinct differences between real OpAmps and ideal OpAmps is that the real ones have a finite input impedance (although it may be large), finite gain, and finite output impedance (although it may be small). Other significant differences are the required supplies, and a limited slew rate (the capacity to drive current). There must be both a positive and negative supply to power an OpAmp. The input and output cannot go above or below the given supply levels or the OpAmp will fail to work properly (it will clip the input or output signal). The limited slew rate means that it has a limit on the amount of current it can source and drain at the output. These effects can be ignored assuming that you don't push the limitations of the particular OpAmp you are using.

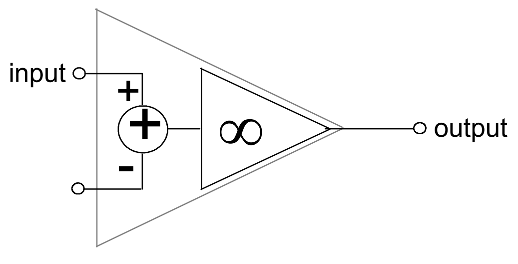

Fig 1: The Ideal OpAmp

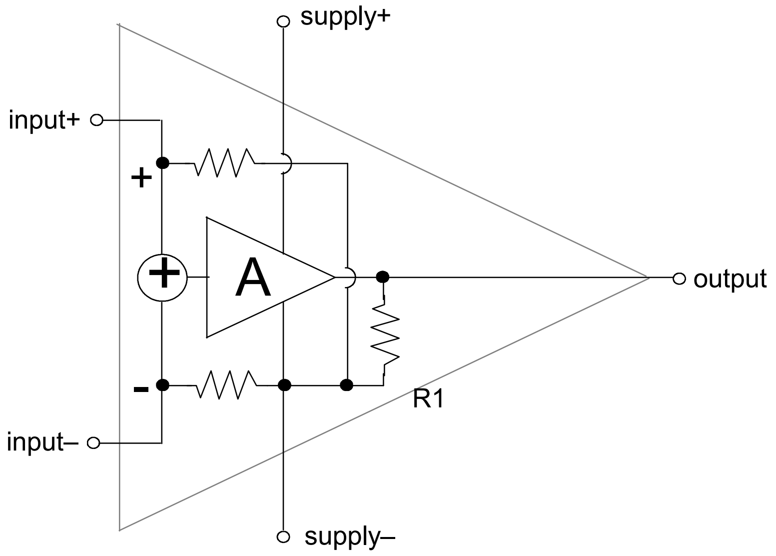

Fig 2: The Real OpAmp

Placing a Real OpAmp in a Simple Feedback Loop

The first consideration when powering an OpAmp is to define its positive and negative rails by setting up a supply. This supply can be defined by a single voltage source (potential) setup between both supply terminals as shown in *figure 3*. This defines the range of outputs you can have at the output and input of your OpAmp. OpAmps do not have rail-to-rail (the full range from positive to negative supply limits) inputs, but some do have rail-to-rail outputs. For most applications, money can be saved by going for the less robust amplifiers without the rail-to-rail output.

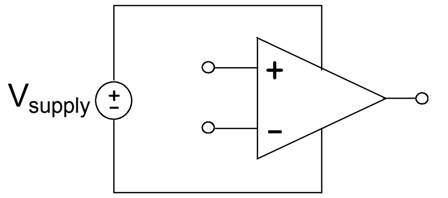

Fig 3: Supplying the OpAmp

The second consideration should be the position of the common ground for the circuit. Because this point represents a *zero* value at the input of the OpAmp, it must be somewhere between the positive and negative supplies of the OpAmp. One way to do this is by using resistors, or an additional voltage source to center it's position, as shown in *figure 4*. If resistors are used, about 10KΩ resistors are reasonable given the typical resistances found at the input of an OpAmp.

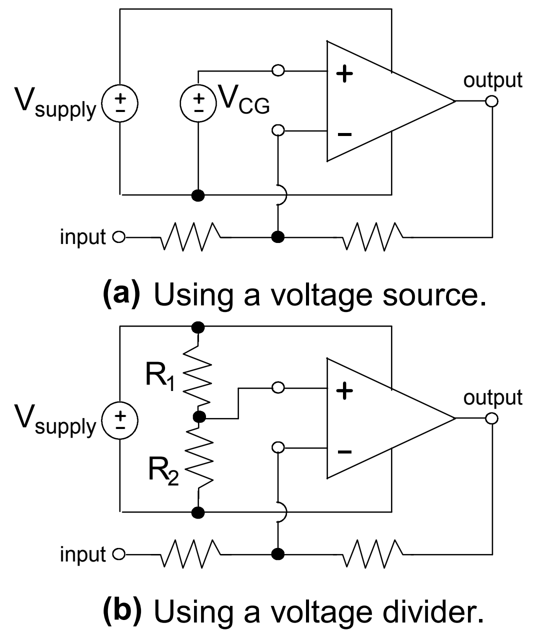

Fig 4: Defining the Common Ground

The third consideration is the amount of current you expect the OpAmp to drive. Given the feedback circuit in *figure 4*, you can tell that it must be able to drive whatever current is needed to make the voltage at negative input terminal of the OpAmp as equivalent as possible to the positive input terminal of the OpAmp. If a large voltage is placed at the input and a small resistor is placed between the input and the negative input terminal, a large current will flow through the feedback circuit. If the OpAmp cannot pull or push enough current, the voltage at the negative input terminal will not be able to equal the voltage at the positive input terminal, instead it will be some value between that of the positive input terminal and the voltage found at the input.

Choosing and Using an OpAmp: *LM741*

When it comes to choosing an OpAmp, you must find a datasheet to give you an idea of its functionality, and how to place it in your circuit. Many companies make the *LM741* OpAmp, which is a generic, yet useful OpAmp. A typical device can have a supply rails of up to +/-18V, an input resistance of 1MΩ, and a maximum output current of 10mA. Datasheets can often be located by going to the correct website (eg., www.national.com) and then searching for the component's name.

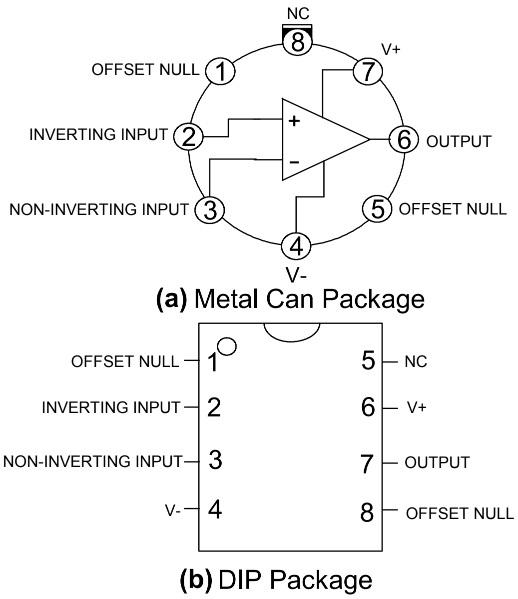

Fig 5: LM741 Package Pin Outs

The two common types of packages that the *LM741* comes in is the dual-inline pin (DIP) and metal can packages. Both have unique pinouts as shown in *figure 5*. The V^+ and V^- terminals are the positive and negative supply rails respectively. The *inverting input* is the negative input terminal, and the *non-inverting input* is the positive input terminal. The *output* is simply the output. The remaining pins are beyond the scope of this paper (simply remember not to connect anything to them and leave them floating).