Difference Amplifier/Instrumentation Amplifier Worksheet

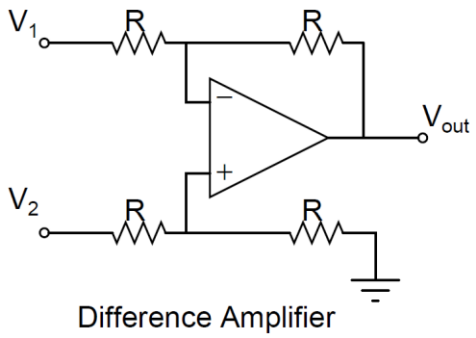

Figure 1. Classic difference amplifier Notice that the "bottom" side has V2 connected to ground through 2 resistors. Power connections are not shown.

1. Figure 1 shows an op-amp configured as a ***difference amplifier.*** It is called a difference amplifier because it computes the difference between the two inputs, V_1 and V_2. Show that:

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

2. Figure 2 shows a difference amplifier, but now there is a reference potential introduced at the 'bottom right', as indicated by red arrow. This connection is not necessarily grounded. Show that the input-output relation is given by:

$$V_{out} = (V_2 - V_1) + V_{ref}$$

In other words, it computes the difference of two inputs, but now the output is centered around the reference potential Vref.

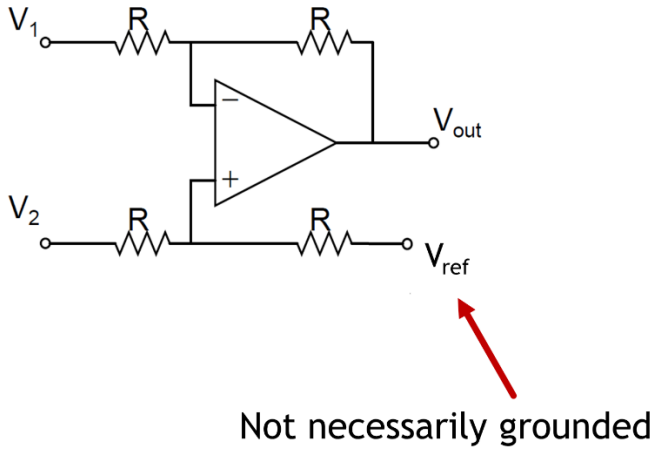

Figure 2. Difference amp with reference potential.

3. List 2 or more practical shortcomings with using the difference amps shown in Figures 2 and 3?

4. The ***instrumentation amplifier*** was invented to solve the issues enumerated in #3 above. This configuration got its name because it was so useful for measuring signals from a variety of lab instruments—strain gauges, temperature gauges, biomedical equipment, etc. Figure 3 shows the internals of an AD623 instrumentation amplifier.

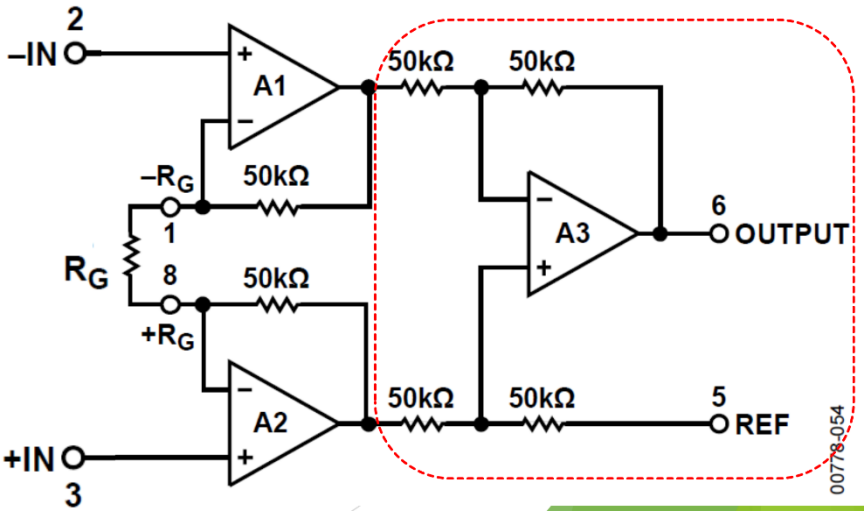

Figure 3. Simplified schematic for AD623 instrumentation amplifier. The two inputs are labed +IN (pin 3) and –IN (pin 2), respectively.

5. Show that this instrumentation amp has an input-output-relation given by:

$$V_{out} = G(V_{in}^{+} - V_{in}^{-}) + V_{ref}$$

Where the ***voltage gain*** is given by:

$$G = 1 + \frac{100k}{R_G}$$

(Do not confuse G here with the decibel gain…only so many letters in the alphabet/unfortunate choice for variable naming…)

6. Imagine you are building a design (for strain gauge or even EMG circuitry) where you want have a single supply system powering at +5V and GND. Therefore, you want the output centered around 2.5V. You also want the voltage gain set for G = 100. Show how you will achieve this in practice, choosing appropriate components values and using a ***rail splitter***, as necessary.