Experiment # 7

INSTRUMENTATION AMPLIFIERS

INTRODUCTION:

Instrumentation amplifiers are the correct choice for a large number of industrial problems where a very small signal (differential input) must be amplified in the presence of large amounts of noise or background (common-mode input) voltage.

Upon completion of this experiment you will be able to:

1. measure the differential gain for a basic differential amplifier.
2. measure the common-mode gain and calculate the CMRR for a basic differential amplifier.
3. build and test a discrete three op amp instrumentation amplifier.
4. add an offset voltage to the reference terminal of the instrumentation amplifier.

EXPERIMENTAL WORK:

Part 1: Construct the circuit of Fig. 1. Measure V_1 and V_2 with respect to the ground and calculate the differential input voltage to the amplifier. Is there any common mode in this case? If the answer is yes, what is the value of the common mode voltage? Calculate the differential gain of this differential amplifier and use it to estimate the output voltage, V_0, of the amplifier. Measure the output voltage. Does the measured and the calculated values of the output voltage compare favorably? If the answer is no, what may be the sources of error? What changes must be made to change the gain of this amplifier to 100 and then to 1?

Part 2: Modify the circuit of fig. 1 to include a common mode adjustment as shown in Fig. 2. Connect both inputs together to the common mode voltage V_2. Measure V_2. Now monitor the output voltage, V_0, of the differential amplifier using a voltmeter. Adjust the potentiometer until use measure the **smallest** output voltage possible. This output voltage is the common mode output voltage V_{OCM}. This voltage should be approximately 1 mV. Calculate the common-mode voltage gain. Note that the common mode voltage gain is ideally **zero**. The common-mode voltage gain should be a very small quantity. Using the results of part 1, calculate the CMRR. What change can be made in Fig. 2 to improve (increase) the CMRR?

Part 3: The circuit shown in Fig. 3 is a three op amp instrumentation amplifier, with buffered input (A_1 and A_2) added to increase the input impedance. Differential gain is adjusted by the ***m*R** resistor. The output voltage is a single ended voltage V_o and responds only to the differential voltage $V_{diff} = V_1\text{-}V_2$. Now select an ***m*R** resistor equal to 20 $k\Omega$. Calculate the differential gain. Measure V1, V_2 and V_0. Calculate the measured value of differential gain. Do the calculated values of the differential gain compare favorably? If time allows repeat the same procedure for ***m*R** equal to 100 $k\Omega$. If the measured and calculated values of the differential gain do not compare favorably, what measures can be taken to improve the accuracy?

Part 4: Normally the output voltage of a differential amplifier is the product of the differential input voltage times the differential gain. It may be desirable to offset the output voltage V_o by a DC voltage level. For example, when the output of an instrumentation amplifier drives the pen of a chart recorder, it is often convenient to be able to position the pen at a point other than its mechanical zero. Output offsetting can be accomplished as shown in Fig. 4 by applying a DC voltage to reference voltage pin 6. Construct this circuit using a fourth operational amplifier. Adjust the $1\,k\Omega$ potentiometer until V_{ref} equal 0 V. Now measure the output voltage of the differential amplifier. It must be the same value Vo measured in part 4. Adjust V_{ref}, using the potentiometer, to be 3 V. Measure V_o of the differential amplifier. It must be shifted by 3 V from the previous value. Try to give some applications of adding V_{ref} to the output of a differential amplifier.

BY THE END OF THIS EXPERIMENT WE HOPE THAT YOU WILL BE FAMILIAR WITH THE PHYSICAL MEANING OF THE COMMON MODE VOLTAGE, THE CMRR, THREE OP AMP DIFFERENTIAL AMPLIFIER AND OUTPUT OFFSETTING.

Write a report including your measurements and comments.

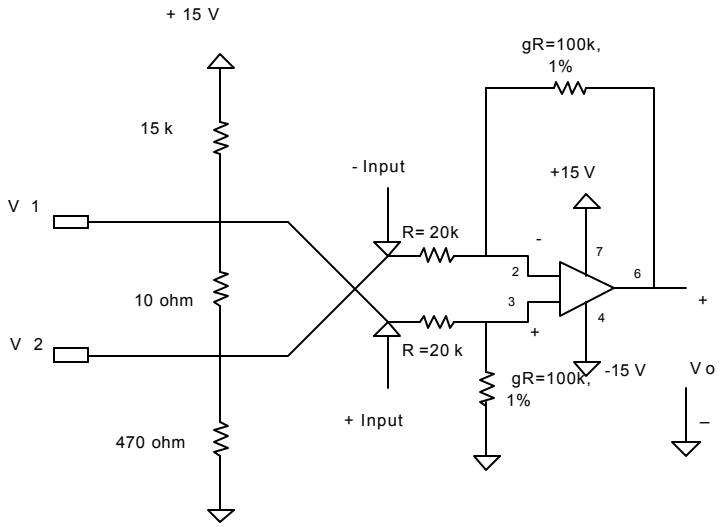

Fig.1: Instrumentation Amplifier with Differential Input

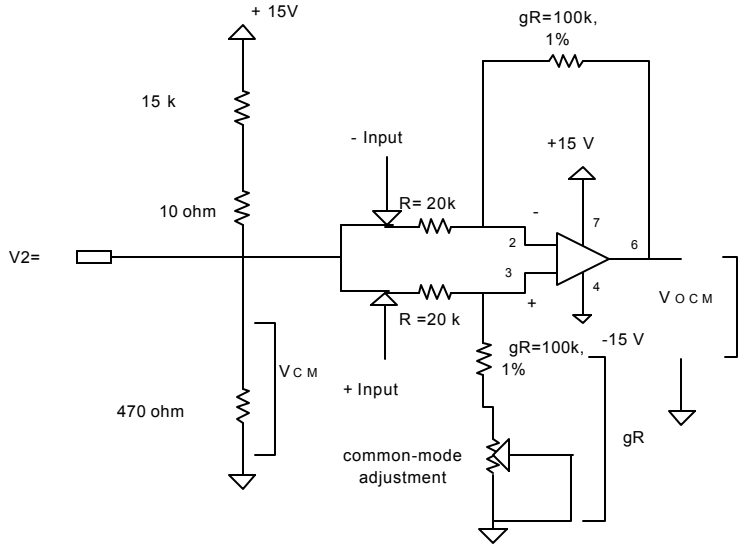

Fig.2: Instrumentation Amplifier with Common Mode Adjustment

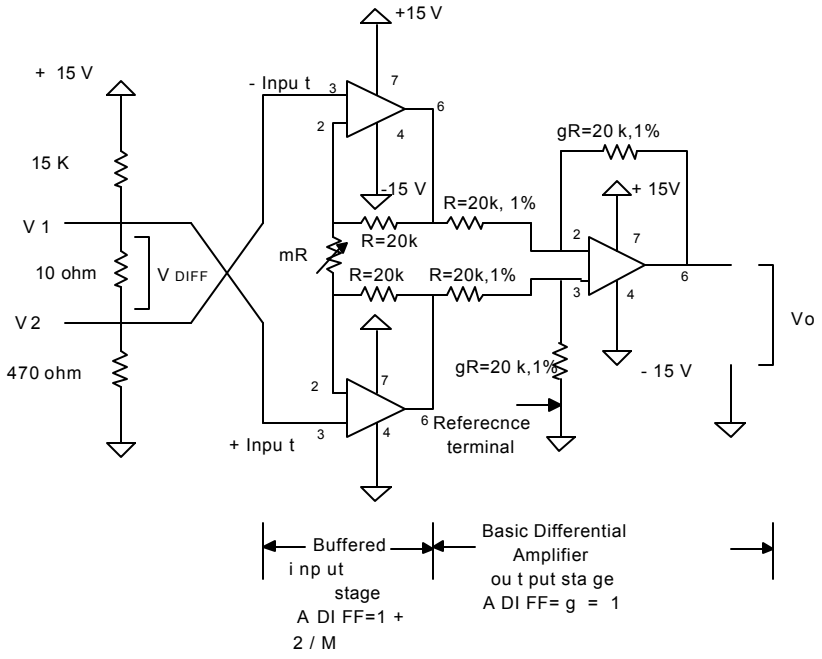

Fig.3: Three Op-Amp Instrumentation Amplifier

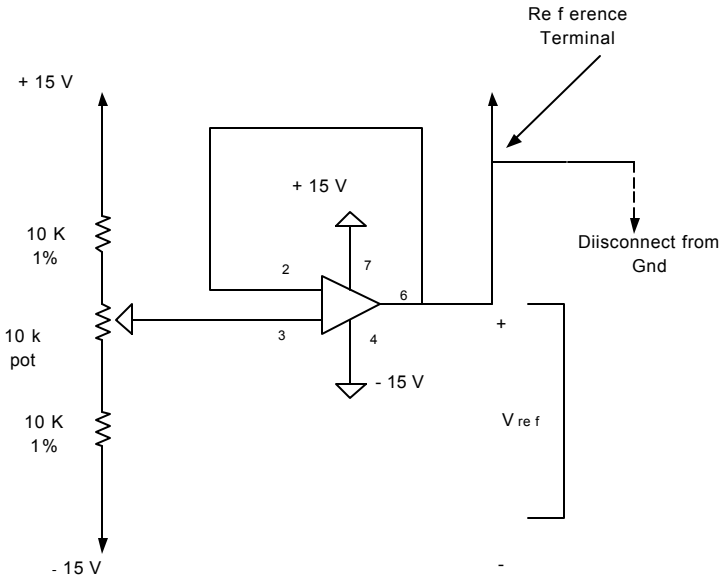

Fig.4: DC Offset Circuit