ENGR 3844 - Basic Electrical Components and Systems
Part-II (Electronics)

**EXP. 3844-2E   OP AMP AND STRAIN GAUGE INTSRUMENTATION SYSTEM**

PURPOSE

To introduce students to the operational amplifier (Op-Amp) and a simple instrumentation system based on resistance strain gauge.
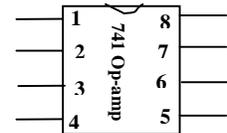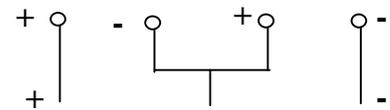
INTRODUCTION

1. Op-Amp

An operational amplifier (Op-Amp) is a direct-coupled high gain amplifier to which feedback is added to control its overall response characteristic. The schematic diagram of an inverting Op-Amp with a feedback resistance R_f is shown in Fig.1.
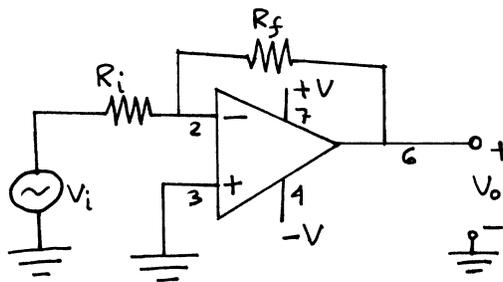
(a) Schematic diagram

(b) PIN diagram of 741 op-amp

(c) Dual power supply

Fig. 1

The gain of the Op-Amp is given by,

$$A = -\frac{R_f}{R_i} \qquad (1)$$

$$\therefore V_0 = AV_i \qquad (2)$$

The differential input and single ended output instrumentation amplifier is often used to amplify inputs from transducers, which convert a physical parameter and its variations into an electric signal. Such transducers are strain gauge bridges, thermocouples, etc. A very simple differential amplifier using Op-Amp is shown in Fig. 2.
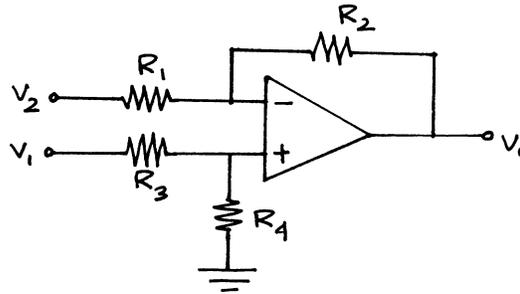

Fig. 2

If $R_2/R_1 = R_4/R_3$, it can be shown that

$$V_0 = -\frac{R_2}{R_1}(V_2 - V_1) \tag{3}$$

2. Strain Gauge Instrumentation

A simple strain gauge instrumentation system is shown in Fig.3. The system consists of two strain gauges mounted on an aluminum bar. The gauges are mounted so that one of them experiences a tensile strain and the other a compression strain.   The associated resistance change relative to the unstrained resistance of the gauges is measured in terms of the potential difference at the output of the Wheatstone bridge arrangement. Since the potential is small, an amplifier circuit is used to amplify the signal at the output of the bridge.
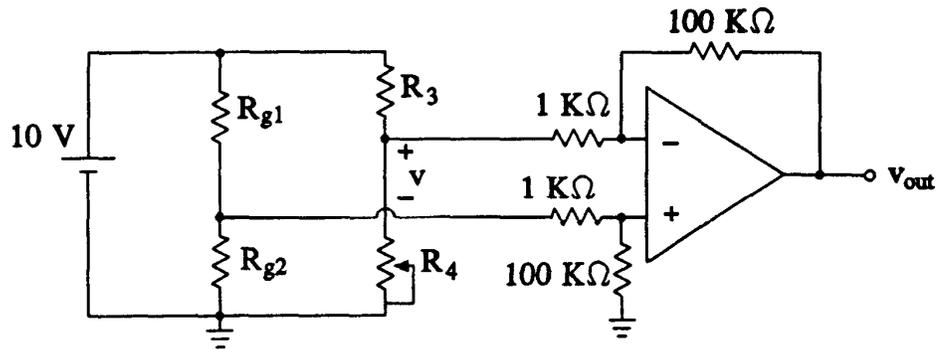

Fig. 3

PRELAB

1. **Read the introduction carefully.**

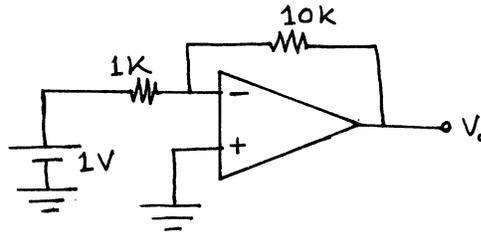2. **Calculate the output of the inverting amplifier given in Fig.4.**

Fig. 4

3. **Design an inverting amplifier to provide an output of 2V from a 2mV source.**

4. **Calculate the strain of an aluminum bar if the output voltage of the Wheatstone bridge is 0.3 V, the supply is 10 V and the maximum gauge factor is 2.**

EXPERIMENT

1. Op-Amp

1.1 Construct an inverting operational amplifier circuit as shown in Fig. 4. Measure the output voltage to verify the operation of the circuit.

1.2 Construct the inverting amplifier circuit with the value obtained in question (3) of the Prelab and measure the output voltage to verify your design.

2. Strain Gauge Instrumentation System

2.1 Measure and record the nominal resistance of the two gauges, R_{g1} (red–white leads) and R_{g2} (black–green leads).

2.2 Construct the Wheatstone bridge circuit using R_{g1} as R_1, R_{g2} as R_2, a nominal 120 Ω resistor in the third arm (R_3) and a 200 Ω variable resistor (pot) in the fourth arm as shown in Fig. 5. Ensure that the source voltage is 10 V after it is connected to the circuit.
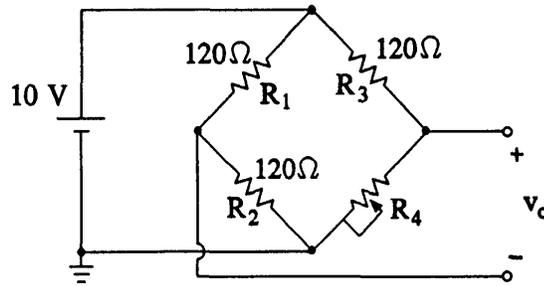
Fig. 5

2.3 With no tension applied to the aluminum bar adjust the pot (R_4) so that v_0 = 0.

2.4 Apply maximum tension to the aluminum bar and measure the output voltage, v_0. Comment on the result and any problems encountered.

2.5 Return the tension to the minimum position and ensure that $v_0 = 0$.

2.6 Construct the amplifier circuit as shown in Fig.6. Verify the operation of the circuit.
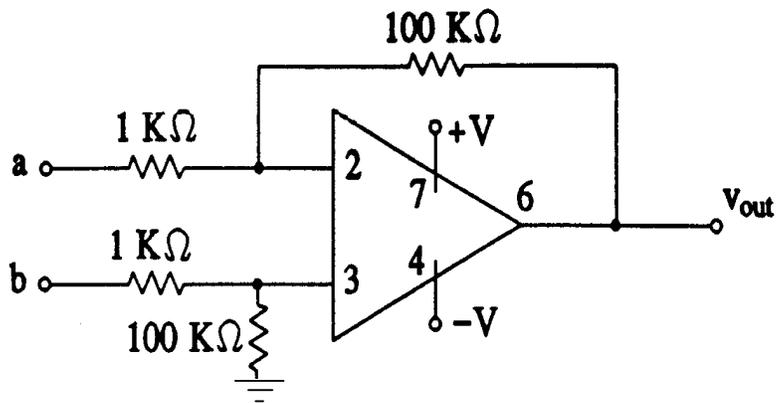

Fig. 6

2.7 Connect the output of the bridge circuit to the input of the amplifier circuit. Measure and record the voltage at the output of the amplifier, V_{out}, for maximum and minimum screw tension. Comment on any difficulties.

2.8 For the maximum screw tension, estimate the strain on the aluminum bar, assuming a gauge factor of 2 and verify with the result obtained in the question (4) of the Prelab.