# ME205 DESIGN LAB-1

## PROJECT: **Measurement of Strain using a Strain Gauge**

by Group TU/C

# Aim

- We aim to employ a strain gauge to obtain the values of localised strain on a beam subject to different loading conditions.

# The working of Strain Gauges:

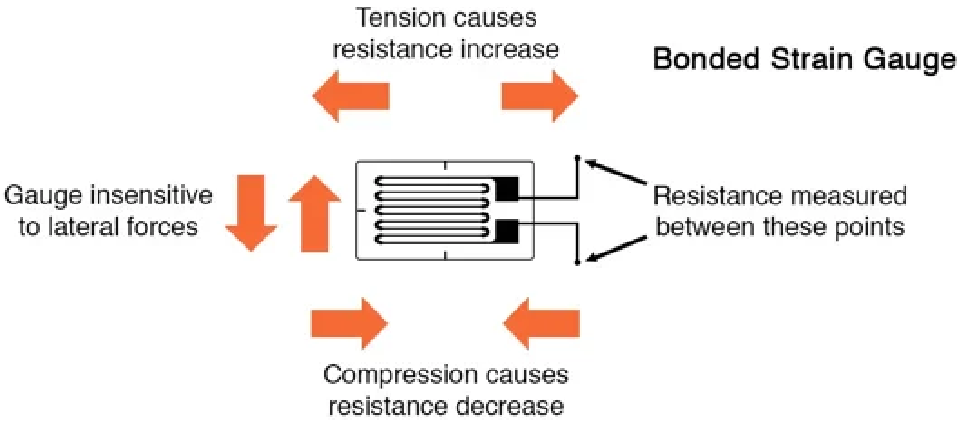


Figure-1: Working of a strain gauge
(Image Source: https://blog.endaq.com/strain-gauges-how-they-work-applications-and-types)

A strain gauge consists of foil made up of multiple small, sensitive wires arranged parallelly. On application of a load, the deformation causes the foil wires to change their length and cross-section area to accommodate for the change. This results in a change of resistance, increasing with a tensile loading, and decreasing with compressive loading. The change in resistance of the strain gauge is directly, linearly related to the axial strain.
Strain is measured as:

$$\in = (1/GF)(\Delta R/R)$$

Where GF is the Gauge Factor of the given gauge and R is the resistance of undeformed strain gauge.

# Approach-1: Wheatstone Bridge

- We started with the conventional method of building a quarter-bridge, balanced Wheatstone circuit and were able to observe qualitative changes in the output voltage and thus, in the resistance of the strain gauge. However, the qualitative readings displayed errors.

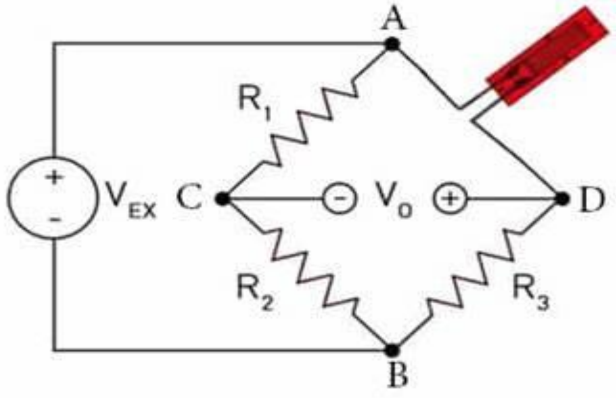


Figure-2: Quarter-bridge Wheatstone Circuit
(Image Source: bestech.com.au)

# Approach-1: Wheatstone Bridge

**Potential Problems to the approach:**

- Non-linearity of the circuit elements(Strain gauge and resistances).
- No thermal compensation in the circuit.
- Energy losses to heat because of multiple resistances.
- Internal resistances of the connecting wires.

# Approach-2: Half-Bridge Wheatstone

To provide better thermal compensation and reduce losses in the circuit, we employed a half-bridge Wheatstone circuit.

This method provided greater accuracy, however was not the most reliable method for obtaining correct numerical values of strain.

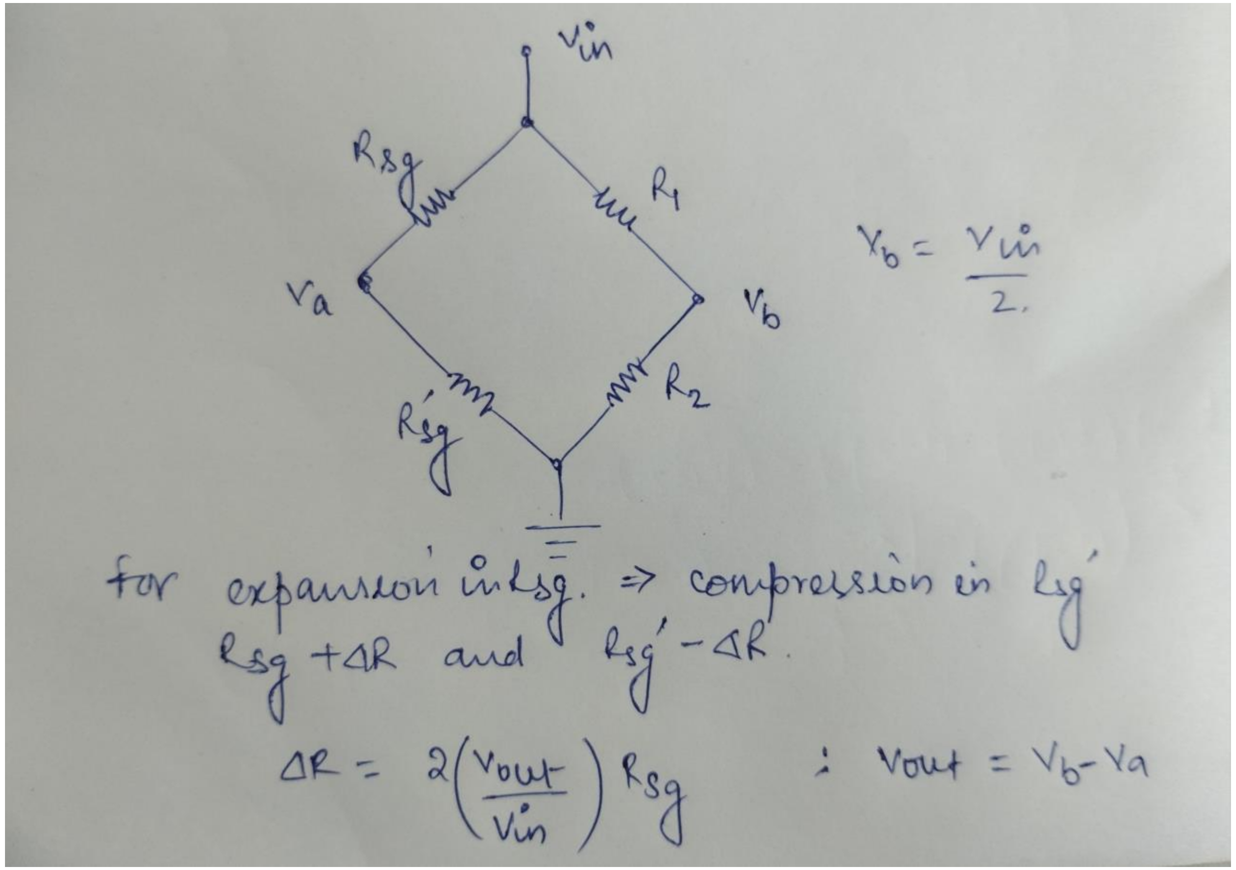


Figure-3: Half-Bridge Wheatstone Circuit

# Code for Arduino Implementation:

```
void setup()
{
  Serial.begin(9600);
  pinMode(A1, INPUT);
}

void loop()
{
  int Rsg = 350;
  int Vin = 5 ;
  double gauge= 2.1;
  int V = analogRead(A1);
  int Vout = map(V, 0, 1023, 0, 5);
  double DeltaR = (2*Vout*Rsg)/Vin;
  double strain = (1/gauge)*(DeltaR/Rsg);
  Serial.println("V out = ");
  Serial.print(Vout);
  Serial.println("change in Rsg Value = ");
  Serial.print(DeltaR);
  Serial.println("Strain in the direction pf strain gauge = ");
  Serial.print(strain);


  delay(1000);
}
```

# Approach-3: Inverting Amplifier using Op-amps

We switched to UA741 CP op-amps because:

- Greater accuracy than a Wheatstone bridge because of fewer energy losses.
- Higher sensitivity to changes in resistance of strain gauge and consequent easier measurement of the same.
- Energy supplied to the op-amp is externally provided, it does not draw energy from the source and therefore does not cause any unwanted potential drops in the circuit.

# Approach-3: Inverting Amplifier using Op-amps

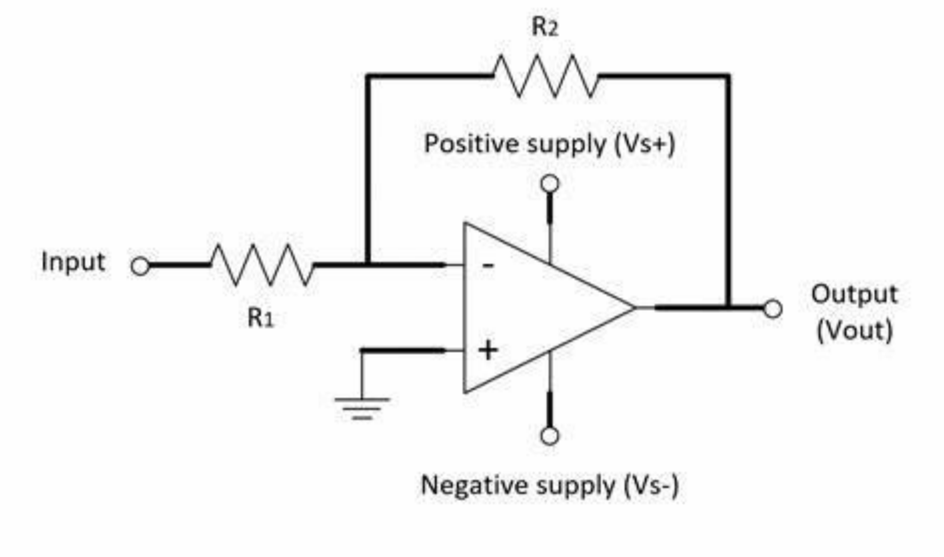


Figure-4: Inverting Amplifier configuration

(Image Source: hyperelectronic.net)

In our circuit, we used strain gauge instead of $R_2$ .

Though the circuit provided only minor errors on measurements via a multi-meter, the same could not be measured via Arduino, as it inputs only positive voltages for measurement.

Measurements on a DSO showed errors due to noise in the signal.

# Approach-4: Instrumentational Op-amps

To provide even greater accuracy to measurements, we used LM324 N instrumentational op-amp. Strain gauge is indicated as $R_{gain}$ .

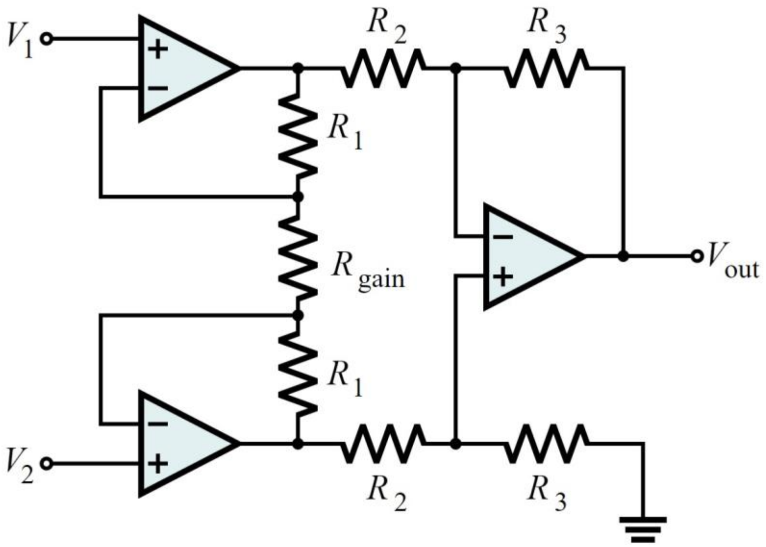


Figure-5: Instrumentational Op-amps circuit
(image source: electronicoscaldas.com)

# Approach-5: Two inverting op-amp amplifiers

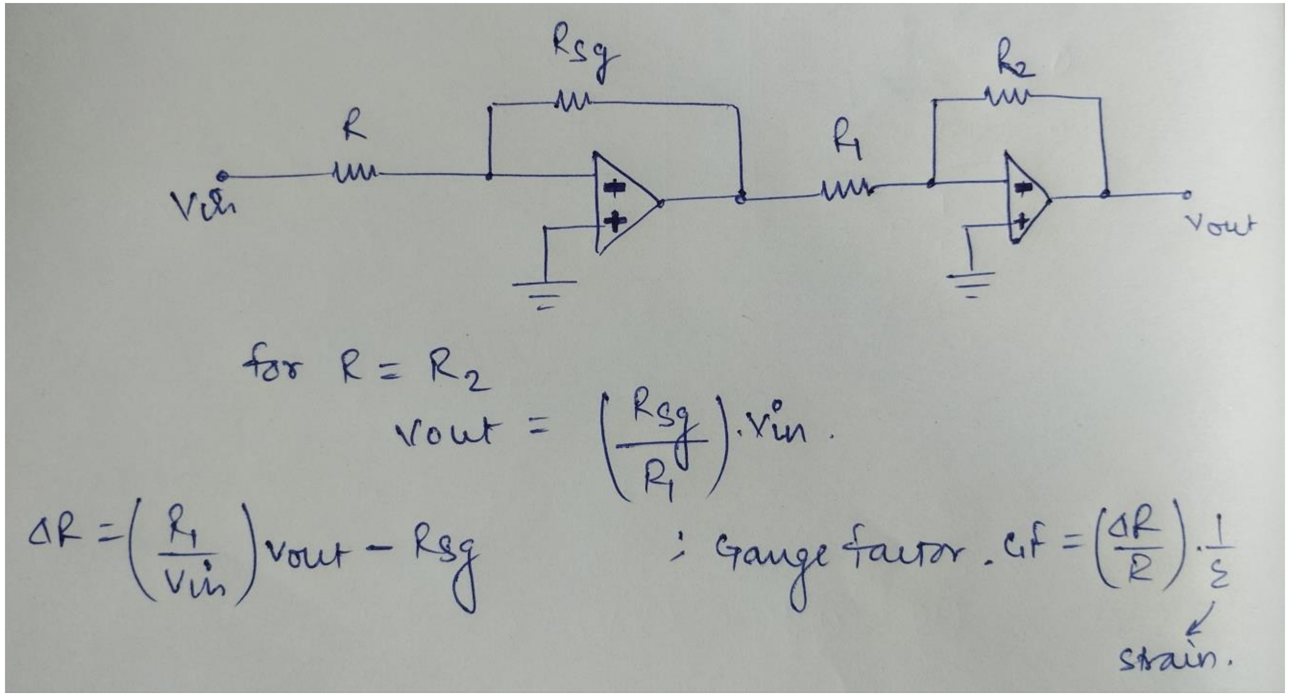


Figure-6: Designed Circuit Diagram

Though the idea appeared to be highly efficient theoretically, practical application was limited due to incompatibly high output gain to Arduino due to absence of required values of resistances and voltage sources to counter them.

# Approach-6: Inverting Amplifier and Subtractor Circuits

In this circuit, we can control the gain of the first op-amp using $R_3$ and $R_2$ and we can also control the output voltage ($V_{out}$) with the help the output from the second op-amp. So that the overall output will be in range which Arduino can measure.

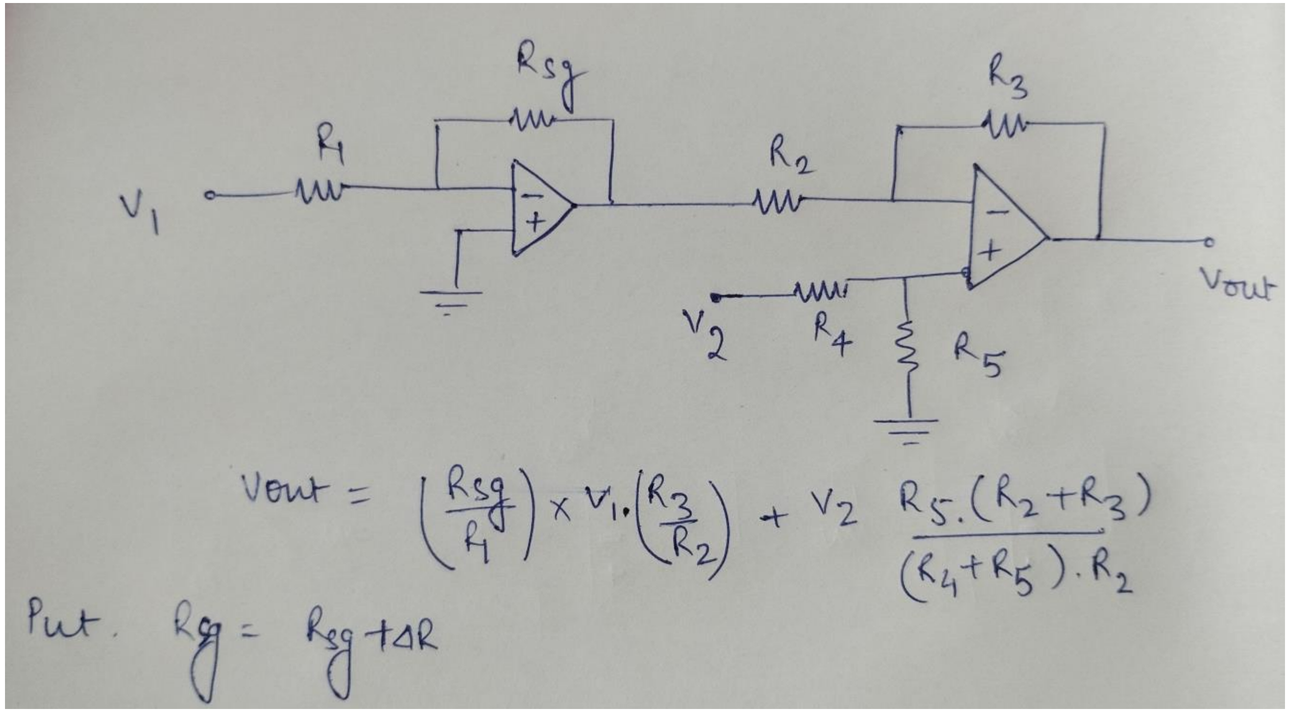


Figure 7: Circuit for Inverting and Subtractor circuit

# Problems to Arduino Implementation:

- The voltage to be measured can be in the range of 0-5 Volts only.
- The output current from the op-amp should be under 20mA.
- Low Sampling rate of Arduino does not provide for measurement of any quick changes in strain.
- Arduino can measure only voltages above 5 mV.
- Required power supply of +/- 15 V not available to power the op-amps.