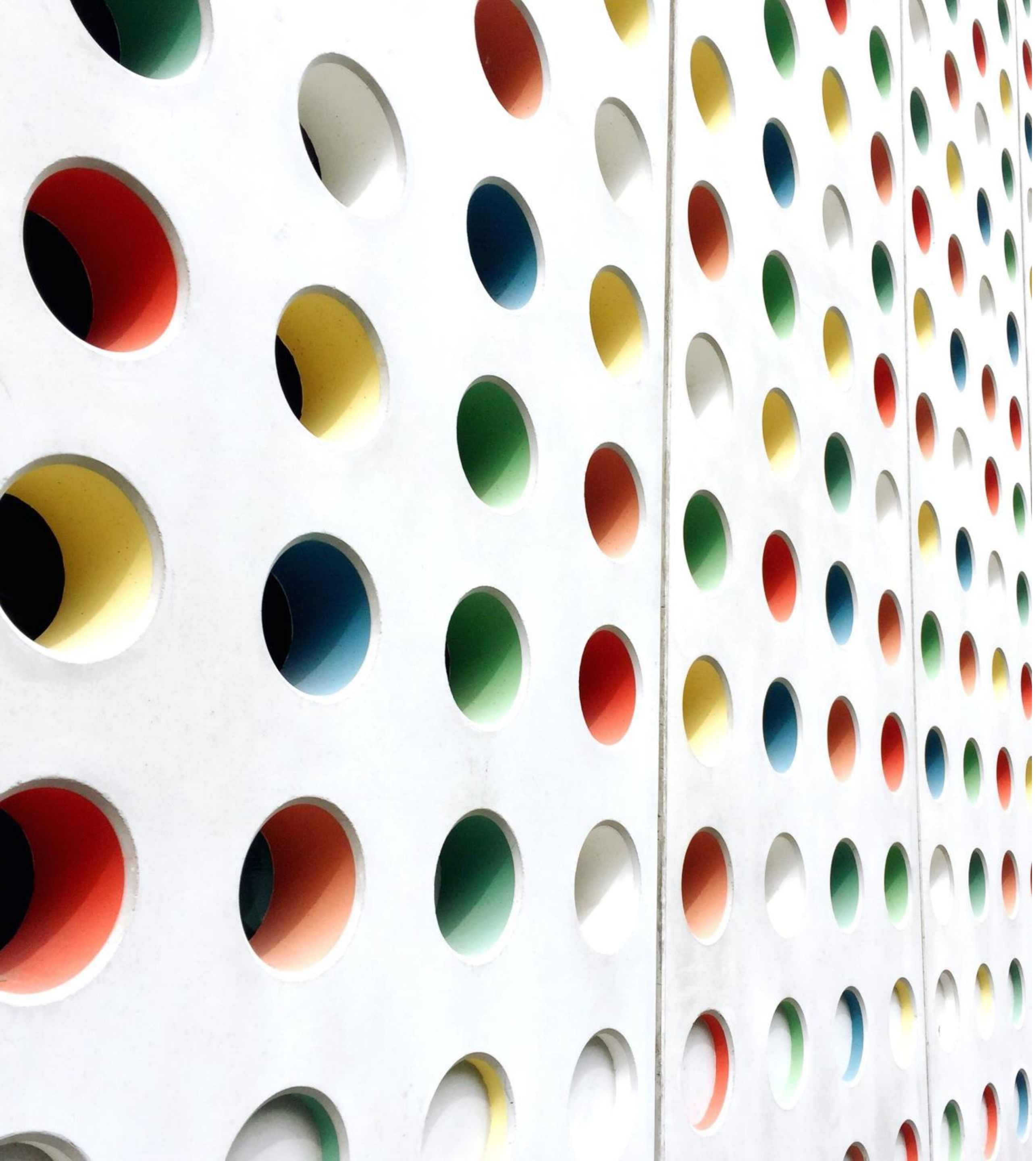
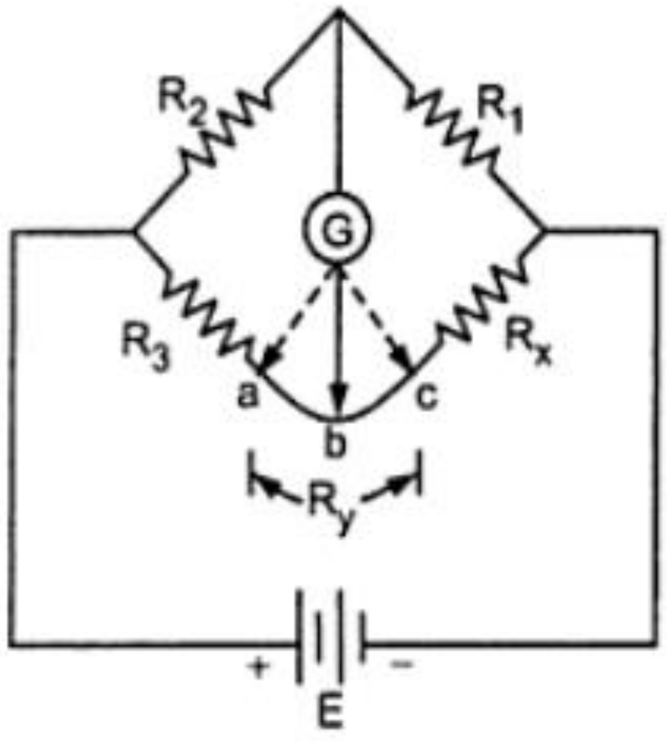


DC Bridges-II

KELVIN DOUBLE BRIDGE AND BRIDGES WITH STRAIN GAUGE AND TEMPERATURE SENSORS

DC BRIDGES – **KELVIN** DOUBLE BRIDGE

- It is used to solve the problem of connecting leads.
- It has two balanced ratio and can measure small resistance (0.0001Ω) with error 0.1%
- Kelvin bridge is a modified version of the Wheatstone bridge.
- The purpose of the modification is to eliminate the effects of contact, and lead resistance when measuring unknown low resistances.
- Resistors in the range of approximately 1microohm to 1ohm may be measured with a high degree of accuracy using a bridge called the *Kelvin* *bridge*

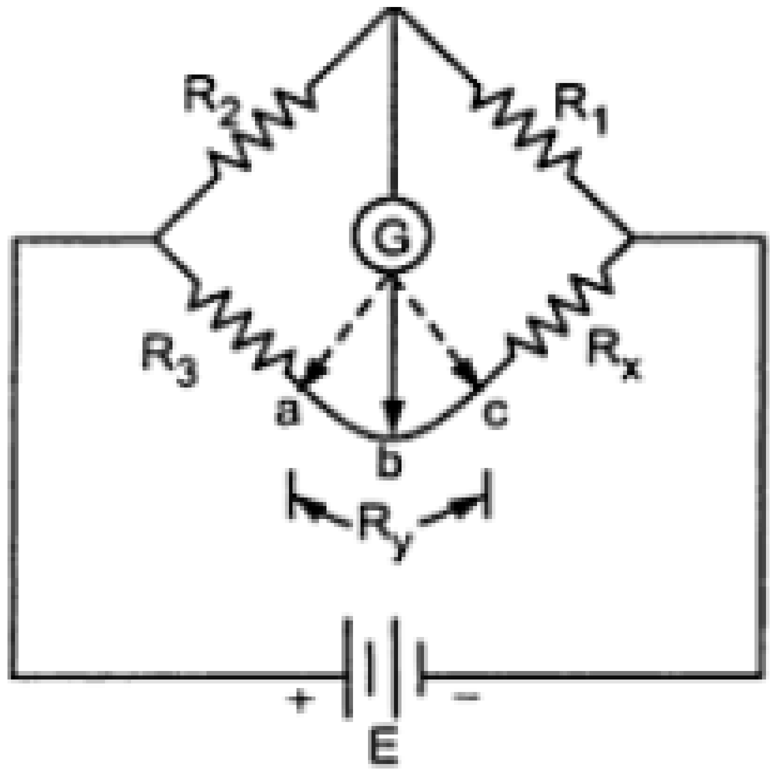


Contd..

The resistance Ry is the resistance from R3 to Rx.

Where Rx is Unknown resistance

$R_{cb}/R_{ab}=R_1/R_2$ (1)



Bridge in Balance form is

R2Rx=R1R3 (2)

R3 is changed to R3+Rab and Rx is changed to Rx+Rcb

Modify equation (2) as

R2(Rx+Rcb)=R1(R3+Rab) (3)

Contd..

$$(R_x + R_{cb}) = \frac{R_1}{R_2}(R_3 + R_{ab}) \qquad (4)$$

Now

$$\frac{R_{cb}}{R_{ab}} = \frac{R_1}{R_2}$$

$$\frac{R_{cb}}{R_{ab}} + 1 = \frac{R_1}{R_2} + 1$$

$$\frac{R_{cb} + R_{ab}}{R_{ab}} = \frac{R_1 + R_2}{R_2}$$

but $R_{cb} + R_{ab} = R_y$

$$\frac{R_y}{R_{ab}} = \frac{R_1 + R_2}{R_2}$$

$$R_{ab} = \frac{R_2 R_y}{R_1 + R_2}$$

Contd..

Similarly

$$(R_x + R_{cb}) = \frac{R_1}{R_2}(R_3 + R_{ab}) \qquad (4)$$

$$R_{cb} = \frac{R_1 R_y}{R_1 + R_2}$$

Substitute value of Rcb and Rab in eq (4)

$$R_x + \frac{R_1 R_y}{R_1 + R_2} = \frac{R_1}{R_2}\left(R3 + \frac{R_2 R_y}{R_1 + R_2} \right)$$

$$R_x = \frac{R_1 R_3}{R_2}$$

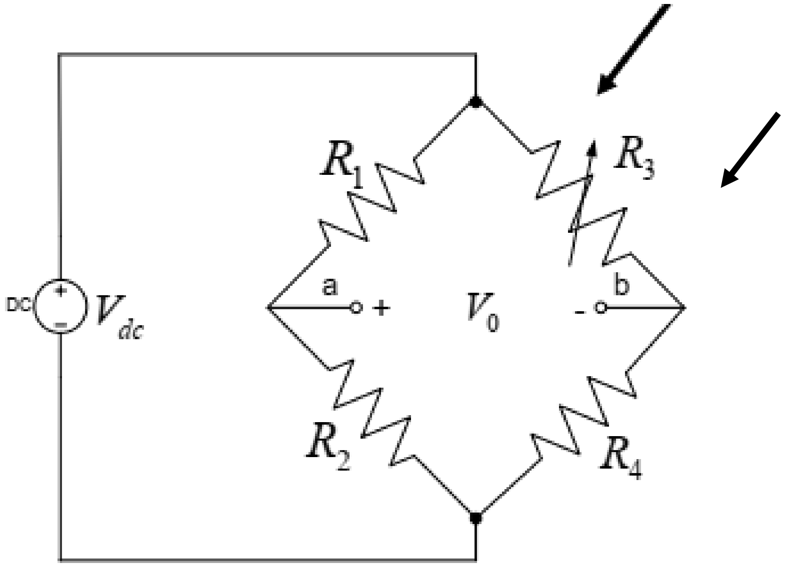
BRIDGE AMPLIFIER WITH STRAIN GAUGE

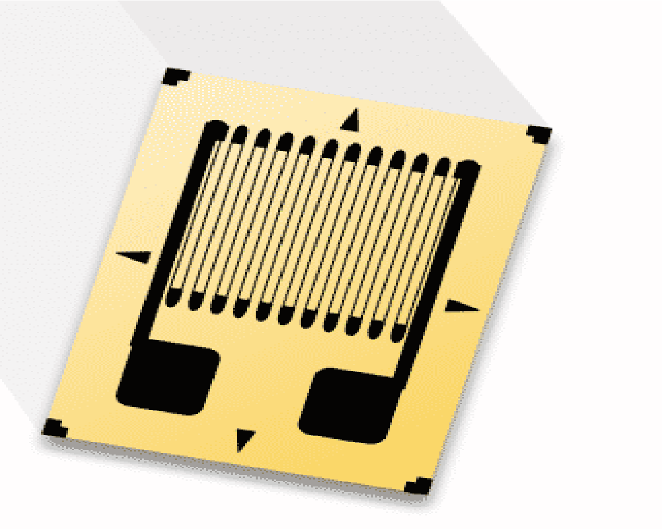
Gauge factor, G_F

$$G_F = \frac{\Delta R / R_0}{\Delta L / L} = \frac{\Delta R / R_0}{\varepsilon}$$

$$R_3 = R_0 + \Delta R = R_0\left(1 + \Delta R / R_0\right)$$

$$R_3 = R_0(1 + G_F \varepsilon)$$





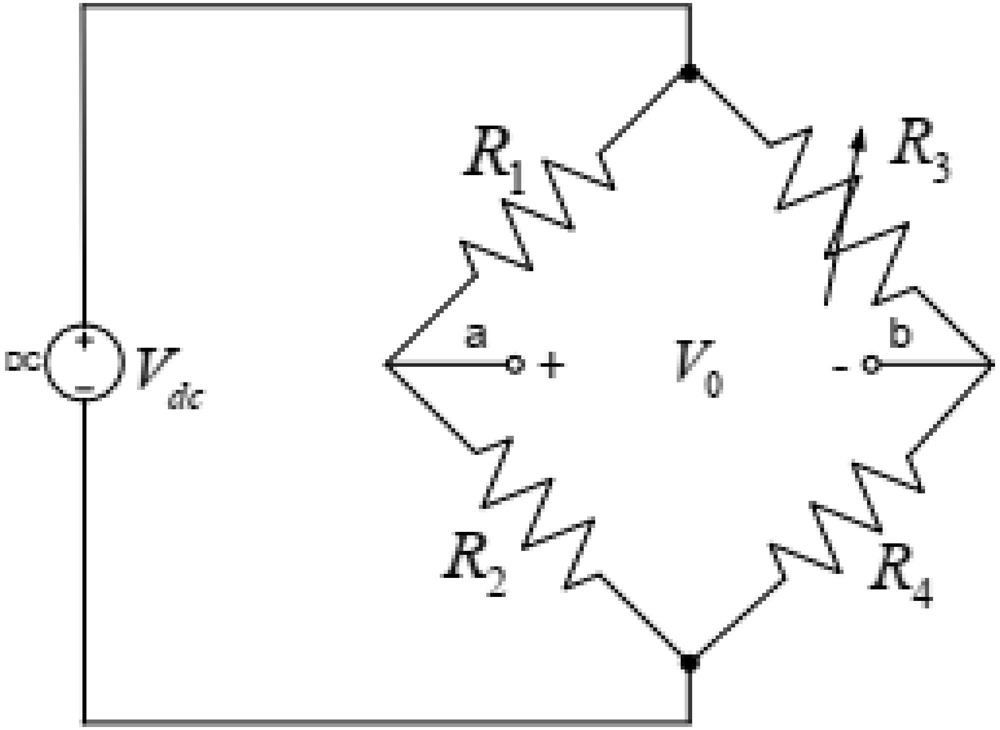
Measurement of strain

$$V_0 = V_{dc}\left[\frac{R_2}{R_1+R_2} - \frac{R_4}{R_3+R_4}\right]$$

$$but \quad R_3 = R_0(1+G_F\varepsilon)$$

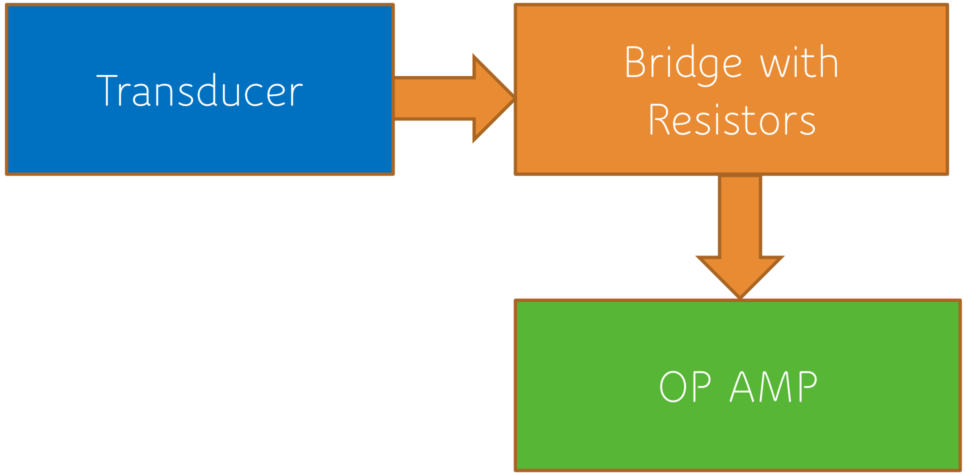
$$V_0 = V_{dc}\left[\frac{R_2}{R_1+R_2} - \frac{R_4}{R_0\left(1+G_F\varepsilon\right)+R_4}\right]$$

$$\varepsilon = \frac{R_4}{G_F R_0}\left[\frac{1}{\left(\frac{R_2}{R_1+R_2} - \frac{V_0}{V_{dc}}\right)} - 1\right] - \frac{1}{G_F}$$



BASIC BRIDGE AMPLIFIER

- A Basic bridge amplifier is consist of an Op Amp, four resistors and transducer.
- The transducer is device that converts non electrical quantity to electrical one or vice versa.
- A strain gauge is also a transducer whose resistance change with the strain.
- A **Photoconductive cells** are light-sensitive resistors in which resistance decreases with an increase in light intensity when illuminated is another type of transducer.



CIRCUIT ANALYSIS

The resistance of transducer is represented by

$$R_{transducer} = R_{ref} + \Delta R \quad (1)$$

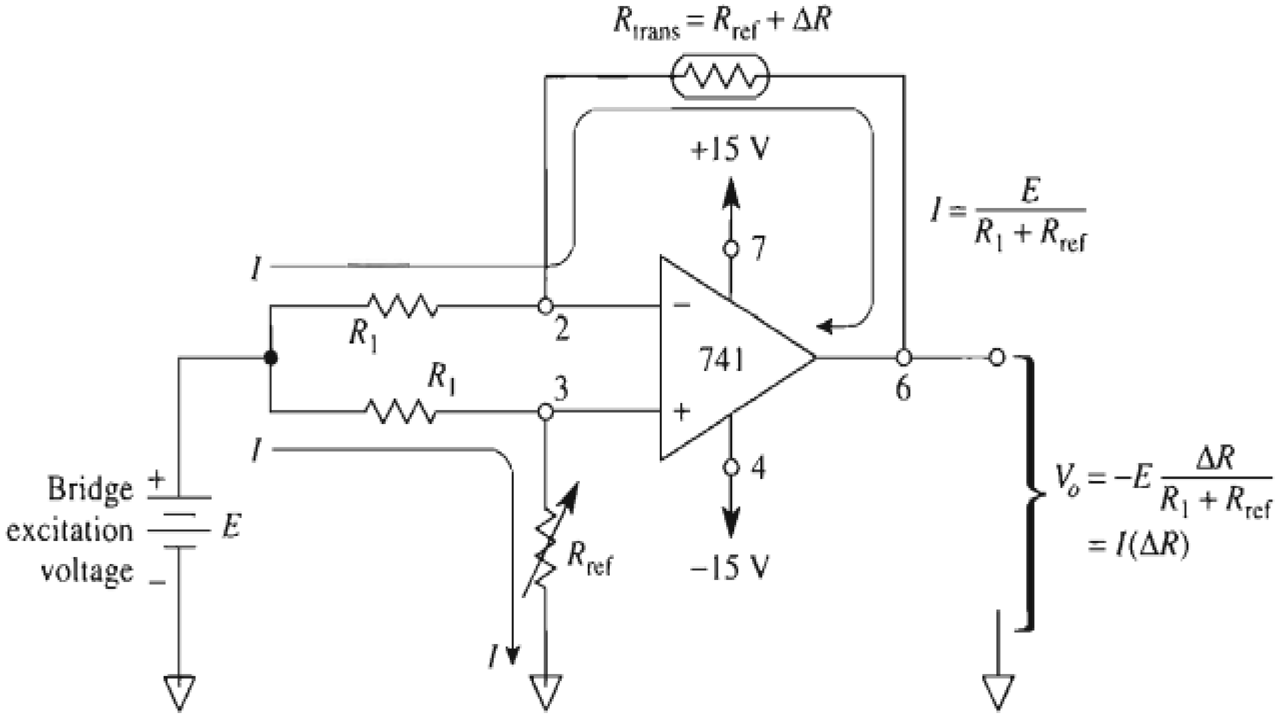
ΔR=amount of change in R.

A thermistor has resistance of 10,000Ω at temperature of 25˚C.

A temperature change of 26 ˚C results in resistance of 9573Ω.

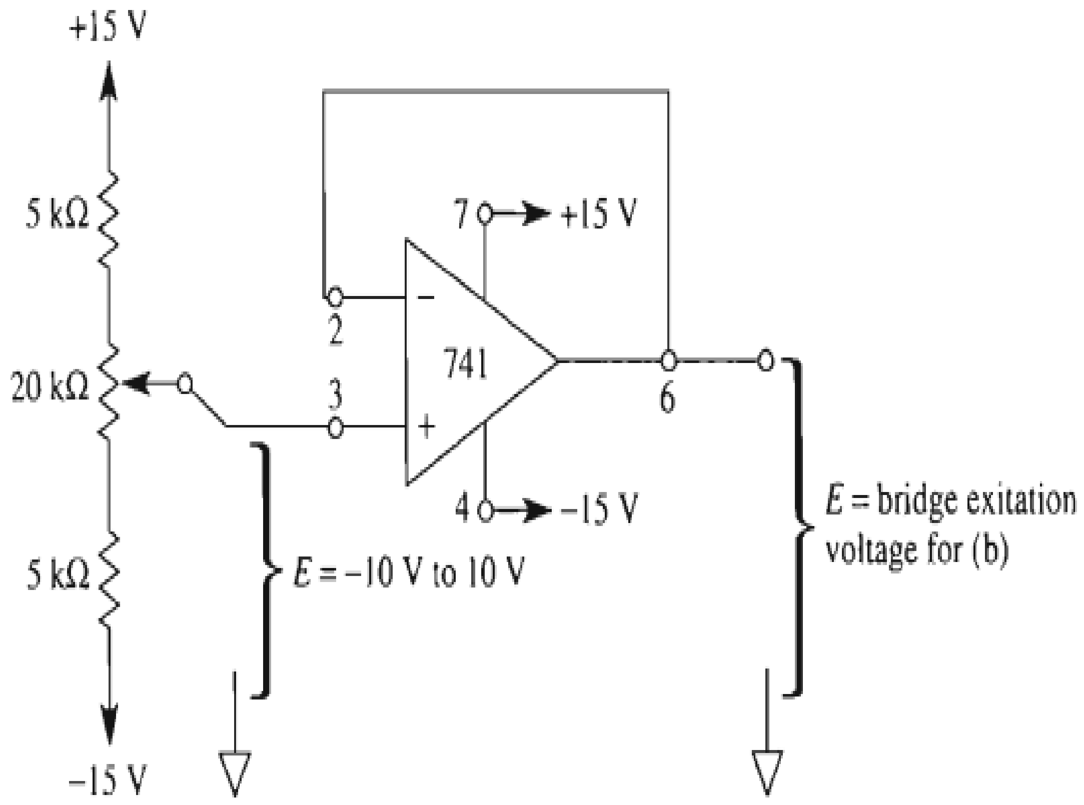
So using equation (1)

$$\Delta R = -427\Omega$$



Contd..

- This Bridge amplifier requires a stable dc or ac supply E.
- The power supply should have small internal resistance than R.
- So a specific circuit is used for generating of the stable power supply in which voltage divider circuit is used together with op amp.
- The OP amp act as voltage follower and E can be adjusted between +10 and -10 V.



Temperature measurement with Thermistor

Step1 Select any thermistor such as 701033 or UUA41J1

Step2 Connect this to one arm of the bridge amplifier.

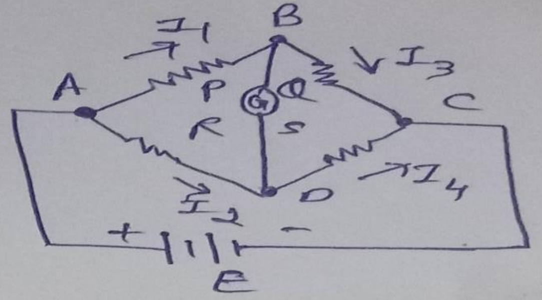
Step 3 Select the reference temperature. e.g. 20 degree C

Step 4 At reference temperature the voltage should be zero and calculate the resistance at this value.

Step 4 Predict the voltage temperature characteristics and calculate the I and V for each

Sensitivity of Wheatstone Bridge

let for unbalance R is changed to $R+\Delta R$



$$e = E_{AD} - E_{AB} = I_2(R+\Delta R) - I_1 P$$

$$= \frac{E}{R+\Delta R+S}(R+\Delta R) - \frac{E}{P+Q}P$$

$$= E\left[\frac{R+\Delta R}{R+\Delta R+S} - \frac{P}{P+Q}\right]$$

As $\frac{P}{Q} = \frac{R}{S}$ or $\frac{P}{P+Q} = \frac{R}{R+S}$

$$= E\left[\frac{R+\Delta R}{R+\Delta R+S} - \frac{R}{R+S}\right] = \frac{ER}{R+S}\left[\frac{1+\frac{\Delta R}{R}}{1+\frac{\Delta R}{R+S}} - 1\right]$$

$$= \frac{ER}{R+S}\left[\left(1+\frac{\Delta R}{R}\right)\left(1-\frac{\Delta R}{R+S}+\frac{(\Delta R)^2}{(R+S)^2}+\ldots\right)-1\right]$$

Contd..

$$= \frac{ES\Delta R}{(R+S)^2}$$

Let S_V be voltage sensitivity of galvanometer

Galavanometer Deflection $\theta = S_V e = S_V \frac{ES\Delta R}{(R+S)^2}$

Let S_B is bridge senc tivity → It is deflection of galvanometer per unit fractional change in unknown resistance

$$S_B = \frac{\theta}{\frac{\Delta R}{R}} = \frac{S_V ESR}{(R+S)^2}$$

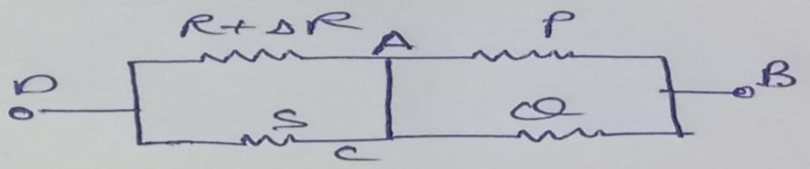
Contd..

$$S_B = \frac{S_v E}{\frac{(R+S)^2}{RS}} = \frac{S_v E}{\left(\frac{R}{S} + 2 + \frac{S}{R}\right)} = \frac{S_v E}{\frac{P}{Q} + 2 + \frac{Q}{P}}$$

For bridge with unity arm resistance

$$R = S = P = Q$$

$$S_B = \frac{S_v E}{1+2+1} = \frac{S_v E}{4}$$



$$R_{th} = \frac{RS}{R+S} + \frac{PQ}{P+Q}$$

If $P = Q = R = S$

$$R_{th} = \frac{R \cdot R}{R+R} + \frac{R \cdot R}{R+R} = \frac{R^2}{2R} + \frac{R^2}{2R} = \frac{\cancel{2}R(R)}{\cancel{2}R} = R$$

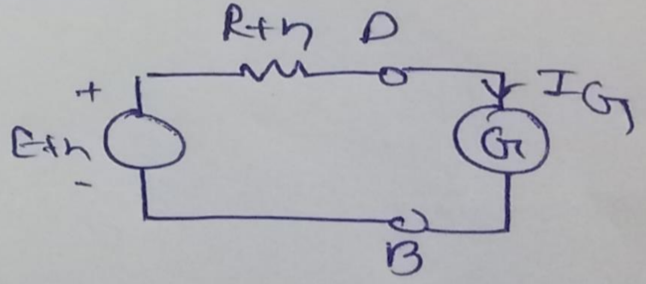
$$E_{th} = E\left[\frac{R+\Delta R}{R+\Delta R+S} - \frac{P}{P+Q}\right] = E\left[\frac{R+\Delta R}{2R+\Delta R} - \frac{1}{2}\right]$$

Contd..

4R

$$I_g = \frac{E_{th}}{R_{th}+R_g}$$

$$= \frac{E\frac{\Delta R}{4R}}{R_{th}+R_g}$$



$$\theta = \frac{S_v E S R}{(R+S)^2}$$

deflection

$$S_v = \frac{S_i}{R_{th}+R_g}$$

Current sensitivity of galvanometer

$$\theta = \frac{S_i E S R}{(R+S)^2 (R_{th}+R_g)}$$

For $P=Q=R=S$

$$\theta = \frac{S_i E \Delta R}{4R(R+R_g)} \qquad S_B = \frac{S_i E}{4(R_{th}+R_g)}$$

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