Expert Answer

General Guidance

The answer provided below has been developed in a clear step by step manner.Step: 1

To find:

% change in length of the beam = $\frac{\Delta L}{L} \times 100$

Given values:

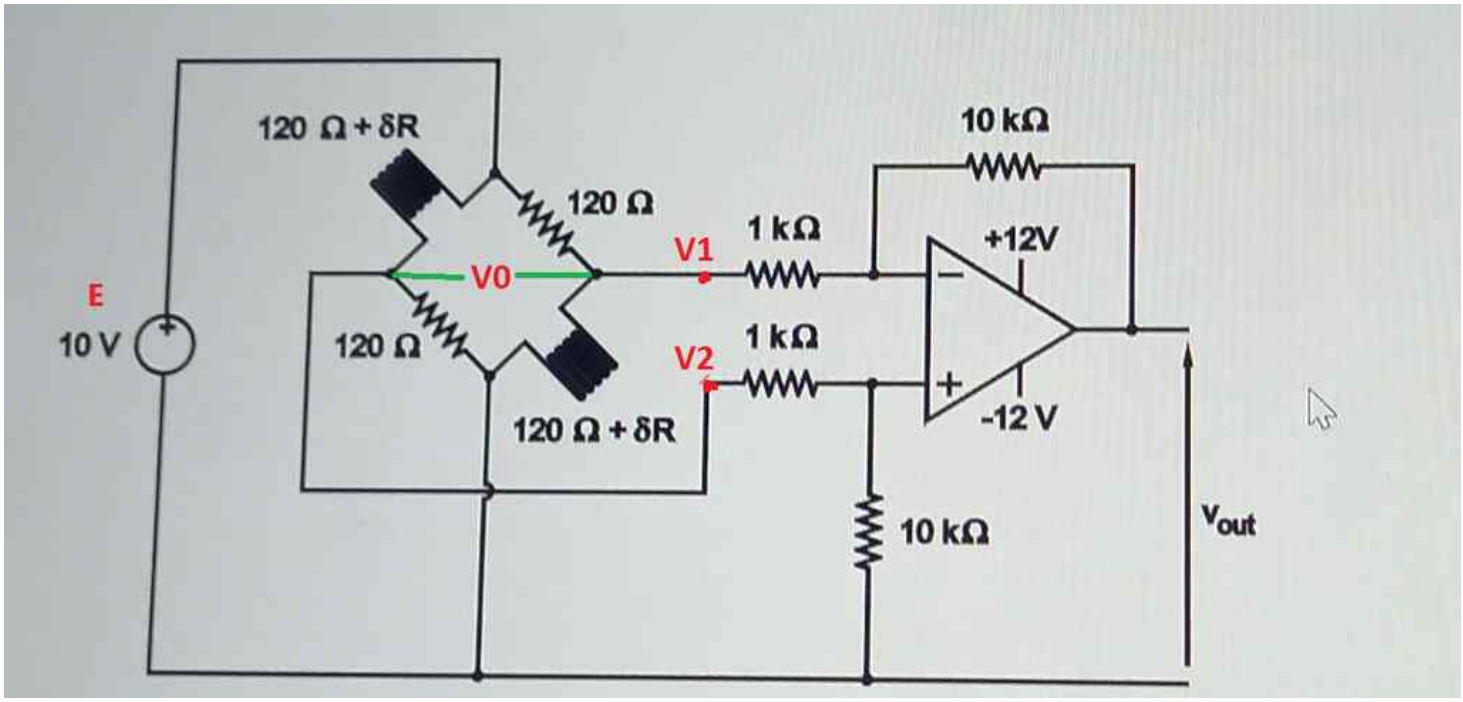
- Gauge factor of strain gauge = **S = 2.1**
- Output of difference amplifier = **V_{out} = 2 V**
- Resistance of undefromed strain gauge = **R = 120** Ω
- Excitation voltage of bridge = **E = 10 V**

Assignments:

- V1 = Input to negative terminal of op-amp
- V2 = Input to positive terminal of op-amp
- V0 = Output of strain gauge = V2 - V1 (since output of strain gauge is fed as input to difference amplifier as shown in Fig. 1 below)

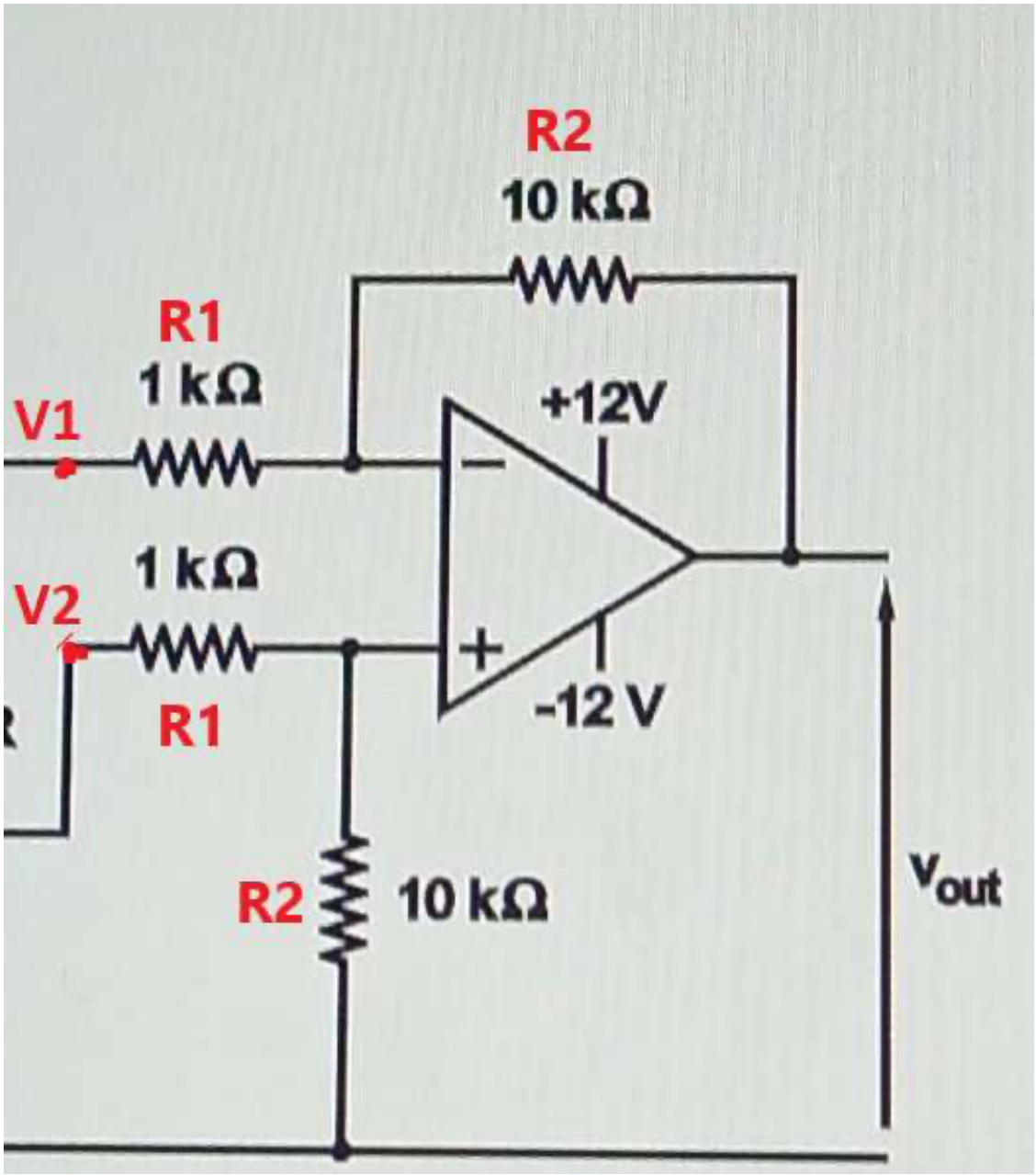
Explanation of circuit:

- Two strain gauges are connected to from a bridge cicuit.
- Bridge circuit is excited by E = 10 V
- Output of bridge circuit V0 is amplified to V_{out} by using a difference amplifier based on op-amp



Explanation:Please refer to solution in this step.Step: 2

Step 1: Calculation of differential input of Difference amplifier (V2 - V1)
Circuit of op-amp as difference amplifier is shown in Fig. 2 below:



Equation of a Differential amplifier is given by Eq. 1 below:

$$\text{vout} = \left(\frac{\text{R2}}{\text{R1}}\right) \times (\text{V2} - \text{V1})$$

This is re-written as:

$$(\text{V2} - \text{V1}) = \left(\frac{\text{R1}}{\text{R2}}\right) \times \text{v out}$$

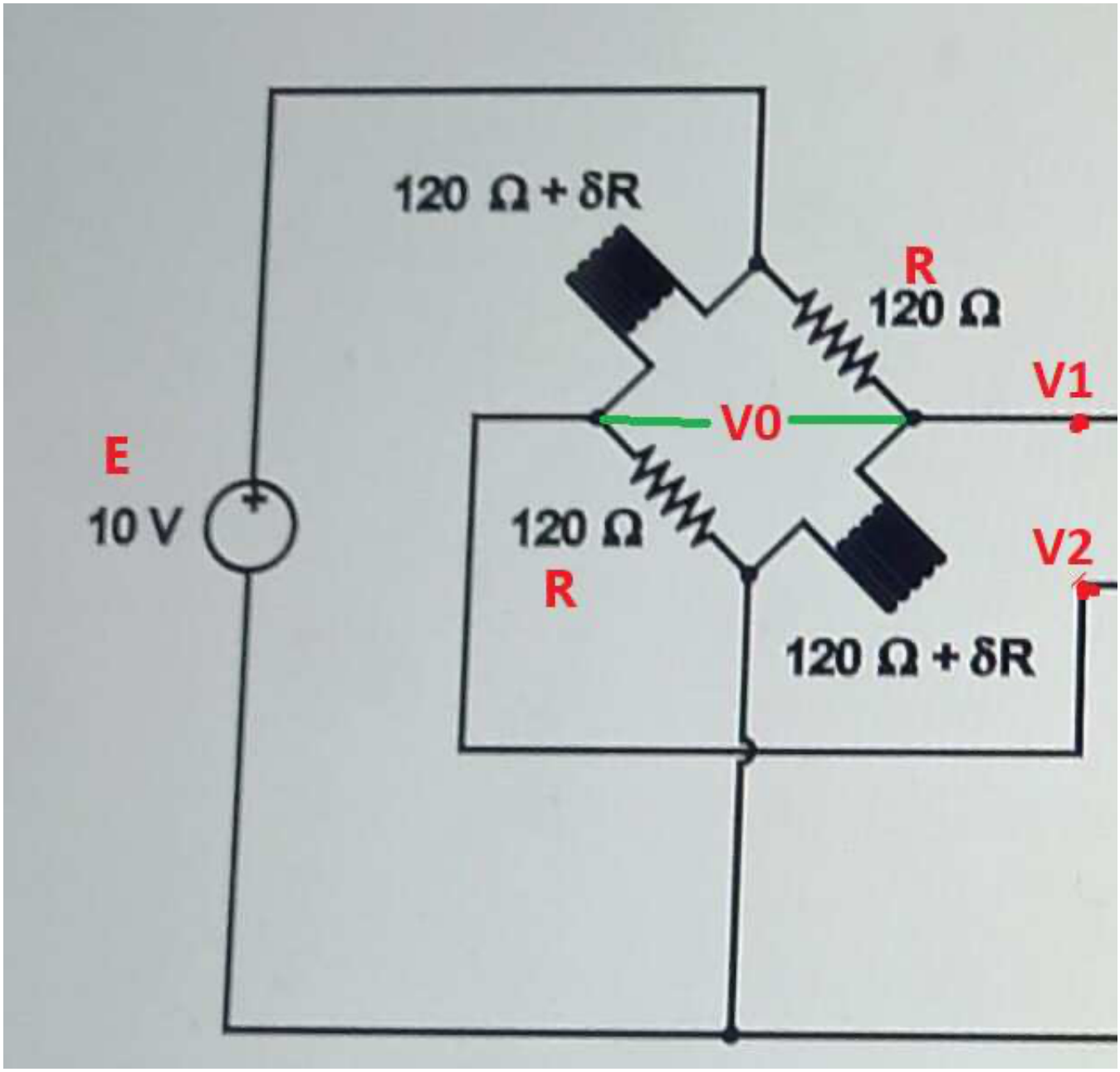
$$(\text{V2} - \text{V1}) = \left(\frac{1\text{k}\Omega}{10\text{k}\Omega}\right) \times 2\text{V}$$

$$= 0.2\text{V}$$

Explanation:Please refer to solution in this step.Step: 3

Step 2: Calculation of change in resistance of Strain gauge (δR)

Circuit of bridge circuit is shown in Fig. 3 below:



Equation of the bridge circuit is given by Eq. 2 below:

$$V0 = \left(\left(\frac{R}{2R+\delta R} \right) - \left(\frac{R+\delta R}{2R+\delta R} \right) \right) \times E$$

$$V0 = \left(\frac{-\delta R}{2R+\delta R} \right) \times E$$

Substituting known values, we get

$$V0 = \left(\frac{-\delta R}{(2 \times 120\Omega)+\delta R} \right) \times 10V$$

Since, Output voltage of bridge circuit is fed as input to difference amplifier, we can write **V0 = V2 - V1** = 0.2 V (Ref. step 1) in the above equation

Hence, the equation becomes

$$0.2 = \left(\frac{-\delta R}{(2 \times 120)+\delta R} \right) \times 10$$

Solve this equation to obtain 'Change in resistance of strain gauge' δR

$\delta R = -4.7\Omega$ (i.e., the strain gauge resistance decreased by 4.7Ω)

Explanation:Please refer to solution in this step.Step: 4

<u>Step 3:</u> Calculate 'Percentage deflection of L' ($\frac{\delta L}{L} \times 100$)

Equation of gauge factor (S) of strain gauge is given by Eq. 3 below:

$S = \left(\frac{\frac{\delta R}{R}}{\frac{\delta L}{L}} \right)$

This is re-written as:

$\frac{\Delta L}{L} = \frac{\frac{\Delta R}{R}}{S}$

Hence, Percentage change in length is:

$\frac{\delta L}{L} \times 100 = \frac{\frac{\delta R}{R}}{S} \times 100$

$= \frac{\frac{4.70}{120}}{2.1} \times 100$

= 1.87 %

≈1.9 %

Thus, the beam was deflected approximately by 1.9 % of L

Explanation:Please refer to solution in this step.

Answer:

Thus, the beam got deflected approximately by 1.9 % percentage of L