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MOUNTAINOUS ROAD ACCIDENT SAFETY SYSTEM

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Abstract—Road accidents in mountainous regions are mainly due to blind turns and lack of visibility. In the present work, a mountainous road accident safety system is proposed by using Load gauge and Wheatstone circuit to provide an indicator on the other side of the (blind) turn. The system is based on principle of strain gauge. As the vehicle pass over the load gauge, the change in resistance will be communicated on other side, indicating arrival of a vehicle. The indication can be in the form of LED display, which will work even in night time. Thus the system can effectively minimize chances for accidents. The proposed model has been demonstrated on a laboratory scale indicating change in resistance and voltage as the input weight (of vehicle) changes.

Keywords—transducer (load cell), pressure, electrical power

I. INTRODUCTION

In the mountainous region, most of the road accidents occur due to blind turns. This is further worsened due to the lack of vision either due to foggy climate or lack of lighting (in night time). In this paper, we propose and demonstrate a concept to transform the pressure generated by the vehicle into voltage. The voltage can be utilized to glow the LED indicator lamp, indicating arrival of vehicle from other side of the turn.

Researchers have proposed various means to avoid accidents. Jani et al. [3] have proposed a blind turn collision warning system based on infrared (IR) communication. They have used IR transmitter and received on both sides of blind turn along with LED display. A vehicle coming from one side of the blind turn with affect the IR signal on its side. The modified signal will be transmitted to the LED of other side, signalling the approach of a vehicle.

Cheng et al. [4] have proposed and studied visual methods to avoid road accidents in China. They have proposed five measures such as setting perspective barrier, convex mirror, reflection facility, lighting equipment and removing obstacle in order to prevent traffic accidents at the road intersection in night time. Adaptive cruise control systems [5] have been proposed to help cars keep their distance on crowded highways. These adaptive cruise control systems use laser beams or radar to measure the distance from the vehicle they are in to the car ahead and its speed relative to theirs. If a car crosses into the lane ahead, say, and the distance is now less than the preset minimum (typically a 1 or 2-second interval of separation), the system applies the brakes, slowing the car with a maximum deceleration of 3.5 m/s^2 until it is following at the desired distance. If the leading car speeds up or moves out of the lane, the system opens the throttle until the trailing car has returned to the cruise control speed set by the driver

The device incorporated in present system is Load Cell. The electrical resistances of a metallic object changes due to pressure or tension. This phenomenon has been known for a long time. In 1878, Tomlinson quantitatively measured increases in resistance for each unit of resistance (and called it the gauge factor). The use of strain gages to measure force requires careful consideration with respect to rigidity and environment. By virtue of their design, strain gages of shorter length generally possess higher response frequencies (examples: 660 kHz for a gage of 0.2 mm and 20 kHz for a gage of 60 mm in length.

II. LOAD CELL

A load cell is a force sensing module - a carefully designed metal structure, with small elements called as strain gauges mounted in precise locations on the structure. Load cells are designed to measure specific force, and ignore other forces being applied. The electrical signal output by the load cell is very small and requires amplification. Load Cells measure a wide range of force from 25 gm to 3,000,000 lbs [8].

Although there are various types of Load Cells, like hydraulic, strain gauge, pneumatic but we are using strain gauge because of ease of design and low costs.

III. WORKING OF LOAD CELL

Strain-gauge load cells convert the load acting on them into electrical signals. The measurements are done with very small resistor patterns called strain gauges. The gauges are bonded onto a beam or structural member that deforms when weight is applied, in turn deforming the strain-gauge. As the strain gauge is deformed, it's electrical resistance changes in proportion to the load. The changes to the circuit caused by force are much smaller than the changes caused by variation in temperature.

Higher quality load cells cancel out the effects of temperature using two techniques. By matching the expansion rate of the strain gauge to the expansion rate of the metal mounted on it, undue strain on the gauges can be avoided as the load cell warms up and cools down. The most important method of temperature compensation involves using multiple strain gauges, which all respond to the change in temperature with the same change in resistance. Some load cell designs use gauges which are never subjected to any force, but only serve to counterbalance the temperature effects on the gauges that measuring force. Most designs use four strain gauges, some in compression, and some under tension, which maximizes the sensitivity of the load cell, and automatically cancels the effect of temperature.

Other types of load cell exist which have half bridges (two strain gauges) or quarter bridges but they require additional hardware to operate since the bridge must be completed to get the accurate readings.

Fig. 1 Strain gauges

IV. WHEATSTONE BRIDGE

A Wheatstone bridge is an electrical circuit used to measure and unknown resistance by balancing two legs of a bridge circuit. One leg of which contains the unknown value. Wheatstone bridges are made up of four resistors or loads in a square is shown in Fig. 2 with a voltage meter bridging two corners of the square and power/ground connected to the other corners. In the case of a load cell, these resistors are strain gauges.

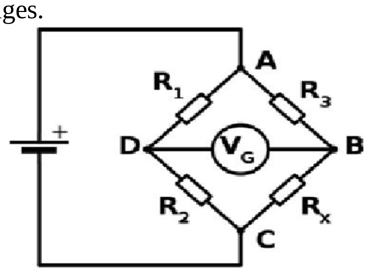

Fig. 2 Generic Wheatstone bridge Configuration

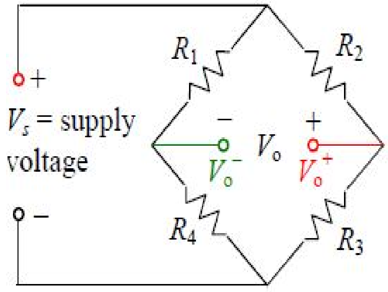

Fig. 3 Wheatstone bridge circuit

As seen in above circuit, a DC supply voltage is supplied (top to bottom) across the bridge, which contains four register (two parallel legs of two resistors each in series). The output voltage is measured across the legs in the middle of the bridge. Output voltage *Vo* is calculated by analysing the circuit. $Vo = Vs\dfrac{(R_3R_1 - R_4R_2)}{(R_2 + R_3)(R_1 + R_4)}$ (1)

If all four resistors are identical $R_1 = R_2 = R_3 = R_4$, the bridge is balanced since the same current flows through the left leg of the bridge. For a balanced bridge, $V_0 = 0$.

More generally (as can be seen from above equation), a Wheatstone bridge can be balanced even if the resistor do not have the same value, as long as the numerator in the above equation is zero, i.e., if $R_3R_1=R_2R_4$, or expressed as ratios, the bridge is balanced if :

$$\frac{R_1}{R_2} = \frac{R_4}{R_3} \qquad (2)$$

V. QUATER BRIDGE CIRCUIT

To measure strain, one of the resistors, in this case R_3, is replaced by the strain gage, as sketched to the right. (Note that one of the other resistors may still be a potentiometer rather than a fixed resistor, but that is not indicated in the circuit diagrams). An arrow through the resistor indicates that its resistance can vary- this time because R_3 is an active strain gage, not a potentiometer.

With only one out of the four available resistors substituted by a strain gage, as in the above schematic, the circuit is called a quarter bridge.

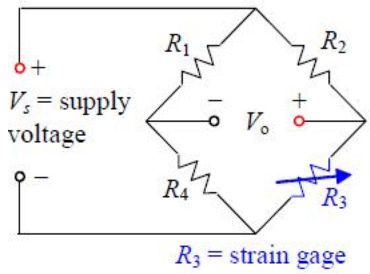

Fig. 4 Quarter Wheatstone bridge circuit.

The output voltage *Vo* is calculated from Ohm's law, as previously, $V_O = V_S \dfrac{(R_3R_1 - R_4R_2)}{(R_2 + R_3)(R_1 + R_4)}$

(3)

Let $R_1 = R_2 = R_4 = 120$ ohm, and let the initial resistance of the strain gage (with no load) be $R_{3,\ initial}$ = 120 ohm.

The bridge is therefore initially balanced when $R_3 = R_{3,\ initial}$, since $R_{3,\ initial}\ R_1 - R_4R_2 = 0$, and V_0 is thus zero.

VI. UNBALANCED QUATER BRIDGE CIRCUIT –TO MEASURE STRAIN

In normal operation, the Wheatstone bridge is initially balanced as above. Now suppose strain is applied to the strain gage, such that its resistance changes by some small amount δR_3. In other words, R_3 changes from ($R_{3,\ initial}$) to ($R_{3,\ initial} + \delta R_3$).

Under these conditions the bridge is unbalanced, and the resulting output voltage *Vo* is not zero, but can be calculated as :

$$V_0 = V_s \frac{(R_{3,initial} + \delta R_3\ )R_1 - R_4R_2}{(R2 + R_{3,initial} + \delta R_3)(R_1 + R_4)} \quad (4)$$

We simplify the numerator by applying the initial balance equation, $R_{3,\ initial}\ R_1 - R_4R_2 = 0$, yielding.

$$V_0 = V_S \frac{(\delta R_3 R_1)}{(R_2 + R_{3,initial} + \delta R_3)(R_1 + R_4)}$$

(5)

[This equation is exact only if the bridge is initially balanced.]

VII. PHYSICAL PRINCIPLE

A. Ohm's Law

Since, resistance is directly proportional to length of a conductor, the ohms law states that

$$R = \frac{\rho L}{A} \qquad (6)$$

Where R is resistance of the conductor, ρ is resistivity, L is length of the conductor and A is area of the conductor.

The change in resistance ΔR in a strain gauge of resistance R is very nearly proportional to the applied strain. Hence:

$\Delta R/R = G$□ (7)

G is a constant known as the gauge factor and □ is the relative strain □ =ΔL/L. The gauges used in this experiment have K = 2.10 ± 0.02

B. Combining Ohm's Law with definition of strain ϵ

$$\frac{\Delta R}{R} = (1 + 2\gamma)\varepsilon + \frac{\Delta \rho}{\rho} = G_\varepsilon$$

Where R is resistance, ΔR is change in resistance, γ is poisson's ratio, □ is strain, ρ is resistivity and G□ is gauge factor.

First Term: Under strain, wire changes dimension, and thus the resistance changes. This term is dominant for metals.

Second Term: change in resistivity due to the change in the crystal lattice of the material under strain (piezoresistive effect.*)* This term is dominant in semiconductor

Foils/filaments inside the strain gauge are 1/1000th inch diameter, made up of basic metal conductors.

VIII. LOAD CELL IMPLEMENTATION

Change in resistivity under strain is linear when Δ*R/R* is less than 1%. This indicates small ΔV (mV level). Wheatstone bridge circuit is used with a strain gauge as one or more of its resistors. Applied force causes small change in resistance in strain gauge this causes change in output voltage across bridge circuit. Output voltage from bridge circuit is amplified using instrumentation amplifier, usually to 0 – 5 or 0 – 10 V range.

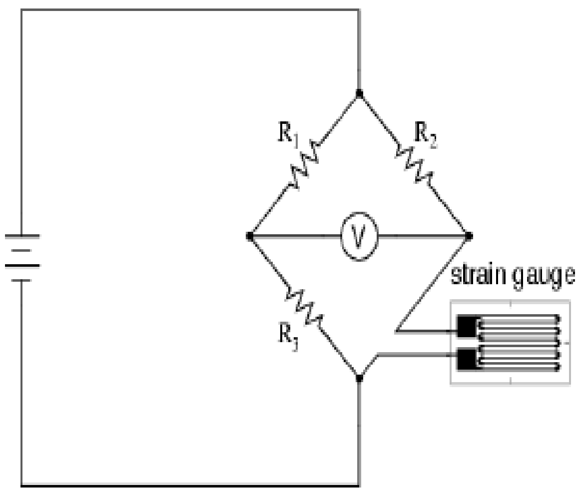

Fig. 5 Quarter-bridge strain gauge circuit

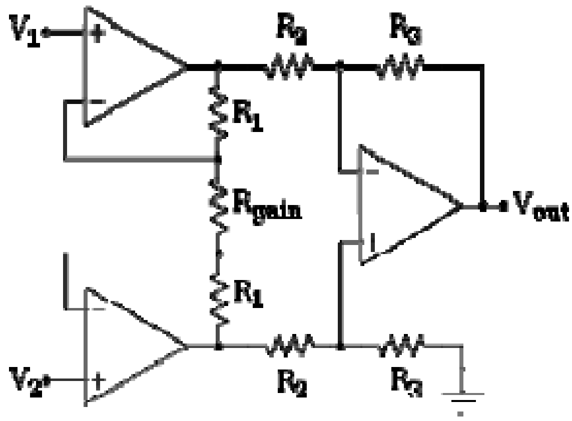

Fig. 6 Circuit of an Amplifier

IX. LOAD CELL SPECIFICATIONS

When comparing load cells, there are a number of specifications to consider. This section lists and defines the properties commonly listed on load cells.

A. Capacity

The maximum load the load cell is designed to measure within its specifications.

B. Creep

The change in sensor output occurring over 30 minutes, while under load at or near capacity and with all environmental conditions and other variables remaining constant.

C. Hysteresis

If a force equal to 50% of capacity is applied to a load cell which has been at no load, a given output will be measured. The same load cell is at full capacity, and some of the force is removed, resulting in the load cell operating at 50% capacity. The difference in output between the two test scenarios is called hysteresis.

D. Excitation Voltage

Specifies the voltage that can be applied to the power/ground terminals on the load cell.

E. Input Impedance

Determines the power that will be consumed by the load cell. The lower this number is, the more current will be required, and the more heating will occur when the load cell is powered. In very noisy environments, a lower input impedance will reduce the effect of Electromagnetic interference on long wires between the load cell and Phidget bridge.

F. Insulation Resistance

The electrical resistance measured between the metal structure of the load cell, and the wiring. The practical result of this is the metal structure of the load cells should not be energized with a voltage, particularly higher voltages, as it can arc into the Phidget Bridge. Commonly the load cell and the metal framework it is part of will be grounded to earth or to your system ground. The maximum difference the sensor will report when exactly the same weight is applied, at the same temperature, over multiple test runs.

G. Operating Temperature

The extremes of ambient temperature within which the load cell will operate without permanent adverse change to any of its performance characteristics.

X. DESIGN OF SYSTEM

The system consists of load cell voltage amplifier and LED lamp. As soon as vehicle passes over the strain gauge of the load cell the pressure is exerted by the vehicle. Due to the pressure created by the vehicle the Wheatstone bridge condition disturbs due to change in one arm of the Wheatstone bridge. Some potential is developed between ports A & B, that potential is fed to amplifier which amplified the voltage, as shown in Fig. 7.

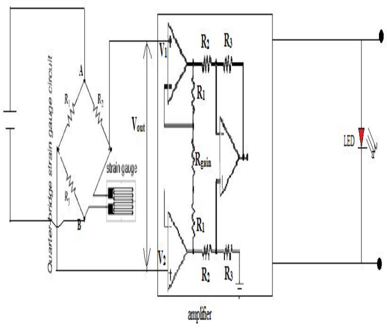

Fig. 7 Schematic diagram of the circuit

The system can be implemented on a mountainous road with a blind turn as shown in Fig. 8.

Fig.8 A diagram of proposed load cell system at a blind turn.

The black circular objects on the road are the positions where the load cells will be installed.

The proposed model has been applied on a small laboratory scale as shown in Fig. 9. A quarter bridge circuit has been designed with one resistor being strain gauge. The load cell can be realized by having the strain gauge at the root of cantilever beam. The free end of the cantilever beam will have external load or weight, which indicates the arrival of a vehicle. The external load causes strain in strain gauge. The strain readings are measured in microstrain. The change in strain causes change in resistance, which further cause change in voltage. The results from these laboratory tests are shown in Fig. 10 – 12.

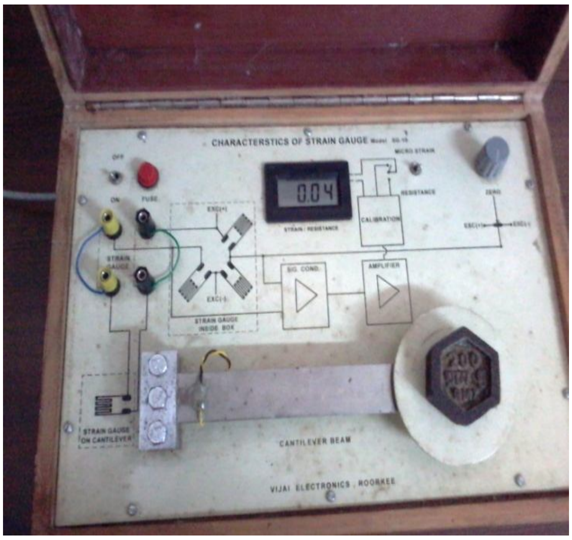

Fig. 9 Figure showing experimental demonstration of a quarter bridge circuit, with one resistor being the strain gauge at the root of cantilever. The free end of cantilever acts as a loading point for maximum stress at the root of cantilever.

XI. RESULTS

The results from a cantilever experiment with strain gauge mounted at the root of cantilever are shown in Table 1 below. The results show that as the weight on the free end of cantilever increases, the microstrain measured by the strain gauge at the root of cantilever also increases. The variation is plotted in Fig. 10. Further, the strain value also reflects in change in resistance. The resistance also increases with increasing weight and is shown in Fig. 11. For a given constant input current (10 *mA*), the change in resistance causes change in voltage which is plotted in Fig. 12. This change in voltage can be indicated by the LED or some type of output display, indicating the arrival of a vehicle.

Table. 1

S. No.	Weight (gm)	Microstrain	Resistance (ohm)	Votage ($V=IR$); $I = 10\ mA$
1.	50	15	0.03	0.3
2.	100	26	0.04	0.4
3.	150	43	0.06	0.6
4.	200	48	0.07	0.7
5.	250	59	0.09	0.9
6.	300	75	0.10	1.0
7.	350	85	0.11	1.1
8.	400	94	0.12	1.2
9.	450	112	0.13	1.3

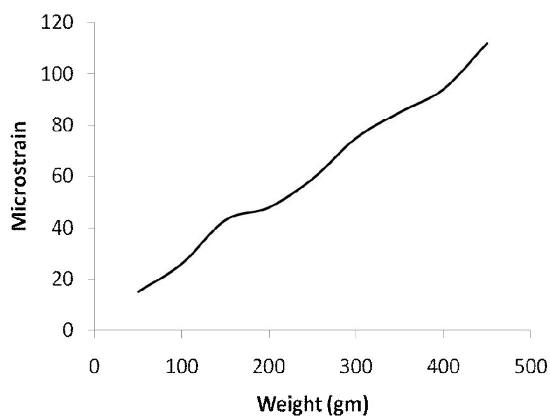

Fig. 10 Plot between microstrain and resistance.

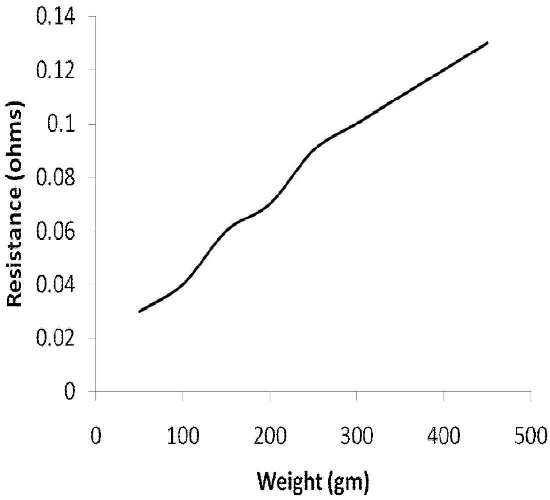

Fig. 11 Plot between resistance and weight.

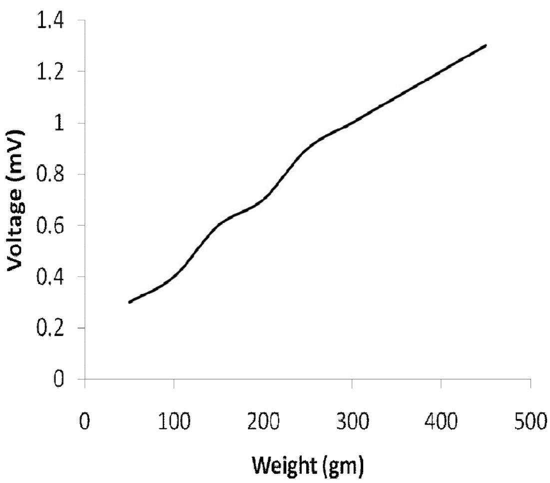

Fig. 12 Plot between voltage and weight

CONCLUSION

In this work, a mountainous road accident safety system has been proposed to minimize accidents due to blind turns or lack of visibility. The arrival of a vehicle on one side can be detected by the load cell. The weight of the vehicle causes change in strain in the load cell. Change in strain further causes change in resistance, which is communicated on the other side by help of Wheatstone circuit. This principle is demonstrated at laboratory scale by conceptualizing a load cell by cantilever beam with strain gauge attached at the root of cantilever. The free end of cantilever acts as a loading position. As the weight of the external load increases, the strain, resistance and voltage also increases. This increase in voltage can be communicated on the other side, indicating the arrival of a vehicle and hence the accidents can be avoided.

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