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Brake Pressure Sensing System

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Abstract: ***Brake system testing is normally carried out during various stages of the manufacturing process. It starts in the initial development stage, followed by endurance, lab and track testing, and continues through the production process for added quality assurance. In this application, operators may utilize Load cell as a Pedal Force Sensor, which is equipped with a mounting plate to ease installation. Mounted to the top of the automobile's brake pedal, this pedal force sensor accurately measures and records applied forces during scheduled tests. These tests are carried out to validate the integrity of the brake system. Operators can monitor the data via LCD Digital display. This system can also be utilized for accelerator, clutch, and parking brake pedal testing.***

Keywords: Load Cell, Brake Pressure Sensing System, Event Data Recorder, Car Black Box

1. Introduction

When two cars collide on an isolated road, many a times, there are other witnesses present apart from the drivers and passengers. The same electronic sensor that is used to trigger the deployment of a car's airbags can record and store information of a car's speed whether the seatbelts are fastened and whether the driver hit the brakes before a collision. This device is known as an event data recorder (EDR) or simply a "black box," as it serves a similar function to a flight data recorder in an aircraft.

The information the black boxes usually record are:
- The car's speed
- The engine's speed
- Whether the brakes are applied or not
- The position of gas pedal

The EDR was originally intended as tool for diagnosis to determine what caused a car's air bag to activate, but now insurance agents as well as police can use a car's black box to reconstruct and review what happened before an accident. Event Data Recorders have been used for many years to record the car crash related data, including deceleration characteristics of the vehicle, airplane, train, ship, or highway vehicle. Aviation has long been the proving ground for on-board recording devices.

It also records other information, such as whether the driver was wearing a seatbelt and the force of the collision. Because the memory of the black box is limited, it only retains this information for a few seconds. After a collision, the black box contains a record of what was happening in the last seconds before the impact.

Considering the earlier work done in this field, it has been analyzed that no substantial work has been done to check the fluency of the brakes being applied. Thus, “Brake Pressure Sensing System” determines the amount of applied pressure on the brakes giving the exact information about how swiftly the brakes were pressed.

1.1 Previous Work

The Car Black Box has been studied extensively by researchers for a long period. Some areas which have received lot of attention include automatic traffic violation recognition, Airbag Control Module, Brake pressure displacement using machine vision, vehicle speed and position detection o real time basis etc which provide enough information for determination of various factors in a Black Box.

The method which can detect the attention of the driver using visual information provides key insights for the Car Black Box as in case of an accident, visual data may be representative of the driver’s attention towards driving. The main disadvantage in this method is that only by detecting the eyes, it is not possible to determine whether the driver is attentive or not.

In another method using machine vision, the researchers captured the image of the brake pedal by camera from left side, and images were processed in industry computer. In doing so, average smooth algorithm and wavelet transform algorithm were used to smooth the original image consecutively. Also, edge extracting method was carried out using Roberts’s operator with wavelet analysis which was used to identify the edge of brake pedal, followed by least square method to recognize the characteristic line of brake pedals displacement.

A few more methods were incorporated which considered the different factors for calculating the impact of the brake which include:
- Brake status and Throttle position up to 5 seconds before impact
- Vehicle forward speed and Engine speed up to 5 seconds before impact
- Air bag warning lamp, driver’s seat belt buckle and right front passenger air bag suppression switch status
- Number of ignition cycles at the time of the incident and at the time of the investigation
- In all of the above methods, the one factor which was not given as much attention was the pressure exerted on the

brake pedals. In our paper, we demonstrate how the pressure applied to the brakes can be calculated. Also, how important this factor would be in the investigation purposes on occasion of a car collision or crash.

1.2 Brake Pressure Sensing System

The brake pressure sensing system is a system that can make brake pressure measuring and sensing systems highly accurate and efficient in future. According to the World Health Organization, more than a million people in the world die each year because of transportation-related accidents. In order to react to this situation, the black box system draws the first step to solve problem. "Black Box" technology now plays a key role to motor vehicle crash investigations. A significant number of vehicles currently on the roads contain electronic systems that record in the event of a crash.

In addition to these EDRs (Event Data Recorders) or black boxes we can also include this brake pressure sensing system in order to measure the pressure exerted by the driver on the brakes of a car. We have also set a threshold value of maximum pressure to be applied on the brakes such that, whenever the pressure increases above the set value an LED will glow and sound of buzzer will be heard. This will eventually alert the car driver to decrease the pressure and will further help in investigation on occasion of a car accident.

Brake pressure sensing is used in a Dynamic Brake Control (DBC) system which improves brake effectiveness in emergency "panic stop" situations. In an emergency stop the brake pressure will be distributed to any or all of the wheels in a manner designed to retain directional stability of the car. The system also helps to maintain directional stability when applying brakes at the corners. A brake pressure sensor records the magnitude and speed of the brake pressure change and the sensor communicates these values to the DBC control unit. The control unit compares the values to its stored DBC activation thresholds. DBC will activate only if certain predefined criteria are met. DBC deactivates when the driver releases the brake pedal or if the vehicle slows down below a minimum speed.

This brake pressure sensor is specifically designed for measuring the high pressures in automotive braking systems. It is extremely robust and resistant to brake fluids, mineral oils, water and air.

A load cell is a transducer that is used to create an electrical signal whose magnitude is directly proportional to the force being measured. The various types of load cells include hydraulic load cells, pneumatic load cells and strain gauge load cells.

2. Methodology

2.1 Car Brake Pedal Pressure Monitor System

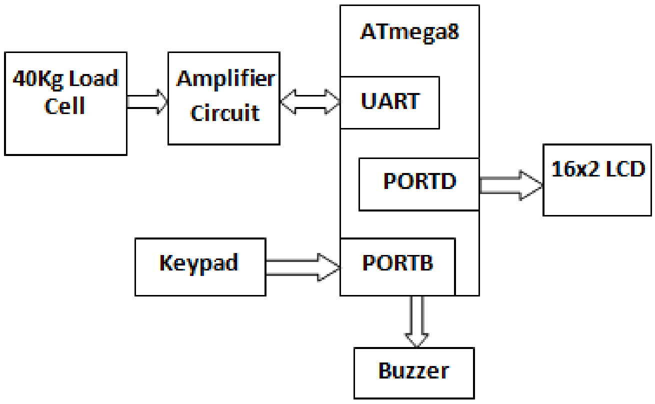

Figure 1: System Block Diagram

A load cell is a transducer that is used to create an electrical signal whose magnitude is directly proportional to the force being measured. Through a mechanical arrangement, the force being sensed deforms a strain gauge. The strain gauge measures the deformation (strain) as a change in electrical resistance, which is a measure of the strain and hence the applied forces.

A load cell usually consists of four strain gauges in a Wheatstone bridge configuration. Load cells of one strain gauge (Quarter Bridge) or two strain gauges (half bridge) are also available. The electrical signal output is typically in the order of a few mili volts and requires amplification by an instrumentation amplifier before it can be used. The output of the transducer can be scaled to calculate the force applied to the transducer.

Strain gauge load cells are the most common in industry. These load cells are particularly stiff, have very good resonance values, and tend to have long life cycles in application.

Strain gauge load cells work on the principle that the strain gauge (a planar resistor) deforms/stretches/contracts when the material of the load cells deforms appropriately. These values are extremely small and are relational to the stress and/or strain that the material load cell is undergoing at the time. The change in resistance of the strain gauge provides an electrical value change that is calibrated to the load placed on the load cell.

Strain gauge load cells convert the load acting on them into electrical signals. The gauges themselves are bonded onto abeam or structural member that deforms when weight is applied. In most cases, four strain gauges are used to obtain maximum sensitivity and temperature compensation. When weight is applied, the strain changes the electrical resistance of the gauges in proportion to the load.

The universal asynchronous receiver/transmitter (UART) takes bytes of data and transmits the individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes. Each UART contains a shift register, which is the fundamental method of conversion between serial and parallel forms. Serial transmission of digital information (bits) through a single wire or other medium is less costly than parallel transmission through multiple wires.

2.2 Signal Flow

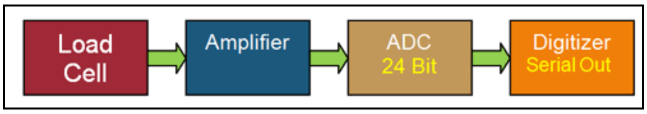

Figure 2: Signal Flow

- The output can be used to connect to microcontroller for further display and processing or can be fed to PC serial port to view on terminal.
- The calibration functions in built in the board giving very accurate, stable and reliable output every time.

2.3 Flowchart

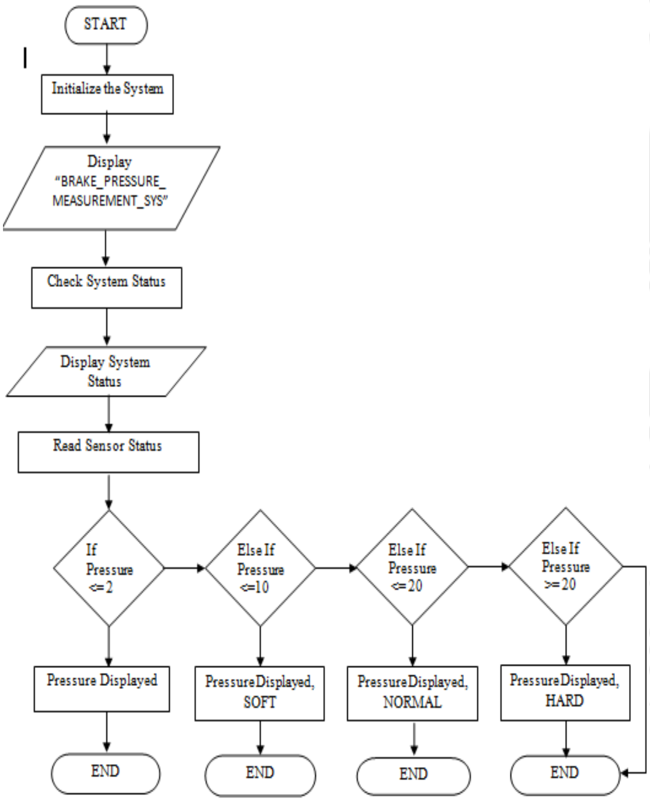

Figure 3: Flowchart

3. Design and Implementation

3.1 Experimental Setup to Measure Brake Pressure

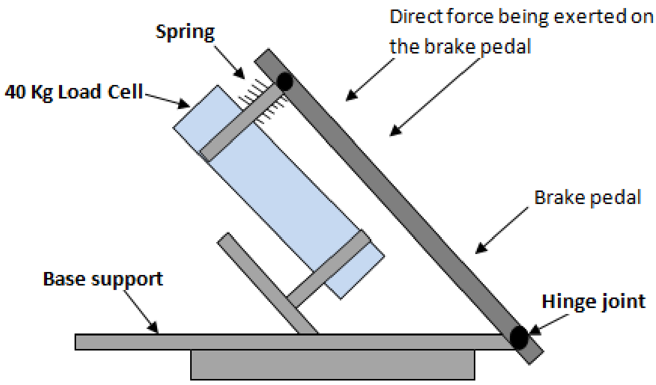

Figure 4: Experimental Setup

- The system shall be built around ATmega8 µC.
- A 40 Kg load cell shall be used to measure the pressure being exerted on the brake pedal by the user.
- The output of the load cell will be monitored by the ATmega8 controller, via an amplifier circuit.
- Serial Communication will take place between ATmega8 µC and the amplifier circuit through on board UART of ATmega8.
- The measured pressure will be displayed on the 16x2 LCD screen.

3.2 Software

The software program is written in C language and compiled in WINAVR Programmers Notepad. WINAVR is a GCC-based compiler for AVR. The 40kg load cell after amplification continuously sends data via UART to IC1 at 9600 baud rate. The code is written in AVRStudio4 which is an IDE (Integrated Development Environment). Atmel (the producer of the microcontroller being used) offers this software, AVR Studio, for free. This IDE has a built in editor, compiler, up loader, emulator, simulator, and etc all in one package.

An Extreme Burner is used which is a GUI (Graphical User Interface) for use with USBasp programmer. USBASP is a cheap and simple USB programmer for Atmel AVR's. It basically consists of an ATMega8 microcontroller and a handful of passive components. It is used to transfer the compiled .hex file to the microcontroller.

3.3 Interfacing

The Pin no. 1 of IC 1190 is grounded whereas Pin no.2 is connected to +VCC. Pin no.3 i.e TX-OUT of the IC is connected to pin no. 10 i.e RXD of microcontroller. Pin no. 4 i.e RX-IN of IC 1190 is connected to Pin no. 11 i.e TXD of the microcontroller.

The UART communicates with the load cell directly which is used for serial communication between the load cell and the microcontroller ATmega8.

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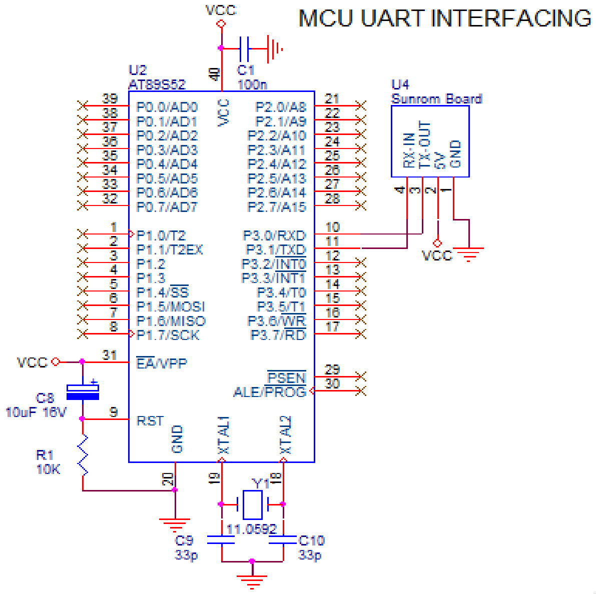

Figure 5: Microcontroller UART and IC1190 Interfacing

An experimental set up of brake pressure sensing system is shown. The circuit has been assembled on the PCB. We have used IC base for microcontroller IC1. A 9V/12V adapter or any other suitable dc source may be used to power the circuit. In order to test the circuit for proper functioning, we need to apply pressure on the brake so that the load cell would sense it and accordingly applied pressure will be shown on LCD screen. If the pressure increases above the threshold value the LED will glow and we will hear sound of buzzer.

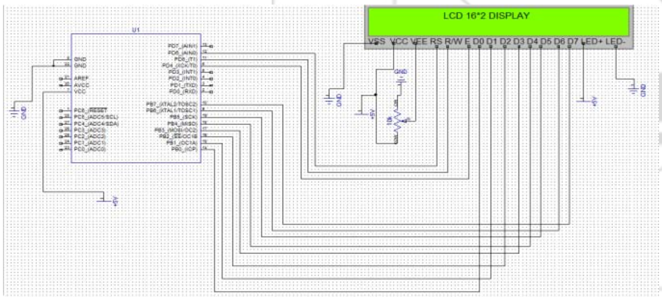

Figure 6: LCD and ATmega8 Interfacing

4. Results

Figure 7: Actual Setup

The above shown is the circuit in which we have implanted our brake pressure sensing module in order to sense the pressure applied by the user in kilograms on the LCD screen. The System shows the deformation in pressure in three different stages as given:

1. Initial Stage
2. Soft Stage
3. Normal Stage
4. Hard Stage

Stage I: Initial Stage

When No pressure is applied (or pressure is less than 2 Kgs)

Figure 8: Initial Stage - Threshold pressure: 2 KG

Stage II: Soft Stage

When pressure is greater than 2 Kg and less than 10 Kg

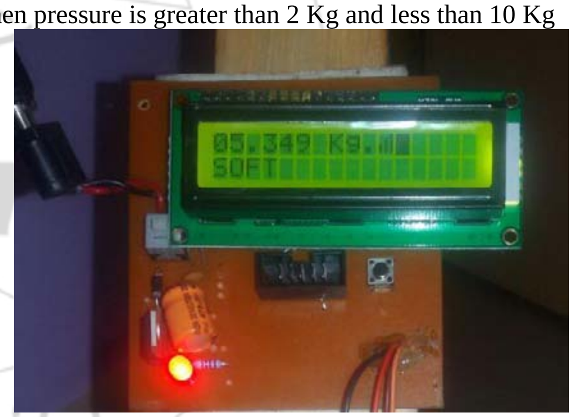

Figure - 9: Soft Stage
Threshold Pressure > 2KG and <= 20 KG

Stage III: Normal Stage

When the pressure is greater than 10 KG but less than 20 KG

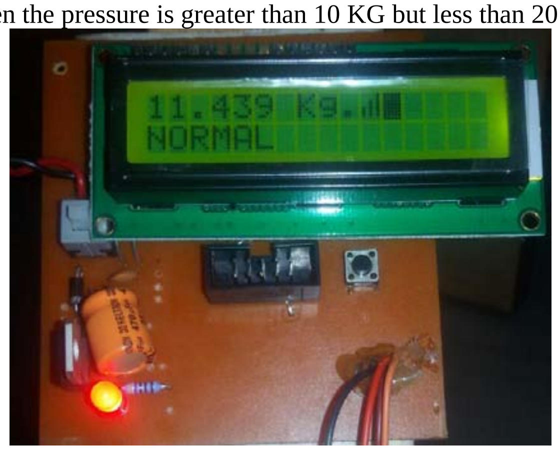

Figure 10: Normal Stage
Threshold Pressure > 10KG and < 20 KG

Stage IV: Hard Stage
When the pressure applied would be greater than 20 KG

Figure - 11: Hard Stage
Threshold Pressure > 20 KG

5. Conclusions

Brake pressure sensing is basically used for measuring the pressure applied on the brakes of a car by its user. In this project, we have designed an assembly for the complete car brake pressure sensing system. After applying pressure it is displayed on the LCD screen and if it goes beyond the predefined values, respective pressure values in Kilograms will be displayed on the LCD screen with the LED glowing as an indication of the activation of brake pressure system.

6. Future Scope

The brake pressure sensing system can be used in the EDR i.e. the Event Data Recorder to record the pressure applied on the brakes of a car. This pressure can be recorded using an SD card, EPROM or any other storage device by interfacing it with the ATMega8 microcontroller IC.

Since this project senses the pressure applied, it can further be modified for a different project where the main focus is on sensing the pressure, measuring, and recording it.

Further modifications can be done so that the system could store the pressure for a long time. And after certain period it should again sense the pressure eliminating the pressure measured before. In other words the storage device should have read writable memory so that it can store data at different time.

This system can also be used in the car black boxes to know everything about the pressure being applied on the brakes on the occasion of a car crash.

Further, the system can be modified for sending the data to a remote computer on a timely basis using GPS or CAN bus protocol which will enable to wireless transfer of the data to and from the Black Box.

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