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Performance Optimisation of a Non-disposable Brake Pad Sensor

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Abstract: Road accidents in the world are re-occurring phenomenon. The accidents are attributed to vehicular brake pad failure. Vehicle safety can be sought through the use of sensors to alert the drivers before the occurrence of any failure due to worn-out brake pad; Hence brake pad sensor serves as an effective way to enhance vehicle safety. In this study, a non-disposable brake pad sensor was designed and fabricated to enable imminent failure alert in order to reduce the risk of road accidents. The research approach involved the development of a software component of the sensor. The software includes a Mikro C Pro (to write the program and compile into machine language) using a microcontroller. The control aspect of the system (sensor) was developed by using Proteus Design Suite. The designed circuitry was fabricated and tested in simulated environment. The test results indicated that, during normal operating condition, the tri-colour LED emits green colour signifying that the brake pad is in good condition (the integrity of the sensor connection is maintained) also the amber appearance signifying that the pad should be replaced.

Key words: Microcontroller, Mikro C, proteus, sensor, tri-LED.

1. Introduction

The 19th century industrial revolution resulted in some fundamental changes in the transport sector and provided more flexibility of movement, speed, and timing. Since then, there has been an upsurge in both human and vehicular motor movement, a situation that has also resulted in some fatal road accident [1]. Although transportation has liberated man makes him more mobile, his increasing reliance on vehicular movement has conferred great facilities on him and his activities. The greatest culprit of all the modes of transport is road of which traffic accident is the most disturbing repercussion of its use [2].

Road traffic injuries and deaths are a growing public health concern worldwide. Studies have shown that road traffic injuries are a major cause of death and disability globally, with a disproportionate number occurring in developing countries [3].

The immediate cause of a road accident may also be attributable to mechanical factor and carelessness in the form of omission to check and maintain the vehicle at the appropriate time [4].

Howell et al. [5] invented a brake pad prognosis system for estimating the thickness of a vehicle brake pad as it wears from use. When the thickness of the brake pad becomes sufficiently small, a mechanical scrapper makes an annoying high frequency noise which is an unfriendly reminder that the brake pad needs to be replaced. Although, the noise does alert the vehicle operator that the brake pad is worn out, it does not give the vehicle operator advanced warning, or a continuous determination of the pad thickness, only that the brake pad has worn down to a low level.

Baldwin and White [6] invented a resistive wear sensor. This invention relates to resistive wear sensors that are used to provide given indications that wear in a component has reached a specific point (the wear point). The invention is particularly concerned with wear sensors of the type that undergo a specific change in resistance at a given wear point; enabling an electrical detection circuit connected to the sensor to respond to the change in resistance [7-10]. The

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drawback with this type of sensor is that false wear point signals can be generated by open circuit failures.

2. Experimental

2.1 System Description

The concept utilized in the design of the sensor system is described by the block diagram shown in Fig. 1. The brake pad sensor system consists of brake pad, contact sensor, battery, microcontroller, capacitors, communication cable and a tri-LED indicator. The concept is based on the principle that if the contact Sensor 1 and 2 is not energized the tri-LED indicator shows green light which implies that the brake pad is in good condition. If contact Sensor 1 energizes the tri-LED indicator shows amber light which implies that the frictional material of the brake pad is almost gone and that replacement of the brake pads is needed. If contact Sensor 2 is energized the tri-LED indicator shows red light which implies that the brake pad is badly worn. The pads must be changed to prevent damage to the rotor. The sensor system development comprises design block diagram, circuitry design, system flow chart and hardware developments.

(1) Block diagram of the system.

(2) The block diagram in Fig. 1 consists of the power supply, inputs, outputs and microcontroller.

(3) Power supply: The required power supply for the circuits is provided by a 9 V battery.

(4) Inputs: The inputs used in the system are contact sensors which are used to monitor the thickness of the brake pad.

(5) Outputs: The outputs used in the system are a tri-LED indicator which indicates the status of the brake pad by displaying green, amber and red light.

(6) Microcontroller: This is used to control the sequence of operation.

2.2 Circuitry Design for the System

2.2.1 Software Description of the System

Software is any information in the form that a computer or microcontroller can use. Software includes instructions or programs that direct hardware. In this system Mikro C Pro was used to write the program and compile into machine language. The control was developed and simulated using Proteus Design Suite. This software was chosen because it had both the schematic and PCB simulator for circuit design flexibility compared to Eagle Design Software and LT spices.

2.2.2 Electrical System Design for the System

The electrical system includes PIC 16F84A, power supply, switch, capacitor, resistor, crystal, sensors, buttons indicators (normal, warning and low indicators) and voltage regulator. In this system all electrical components are operated on 9 V supply because it gives many advantages such as easy to handle, equipment safety, easy to troubleshoot on energized condition.

2.3 Flow Chart

The system flowchart shows the outcome of the brake pad condition under service. The system is designed to display a green light (for good pad); an

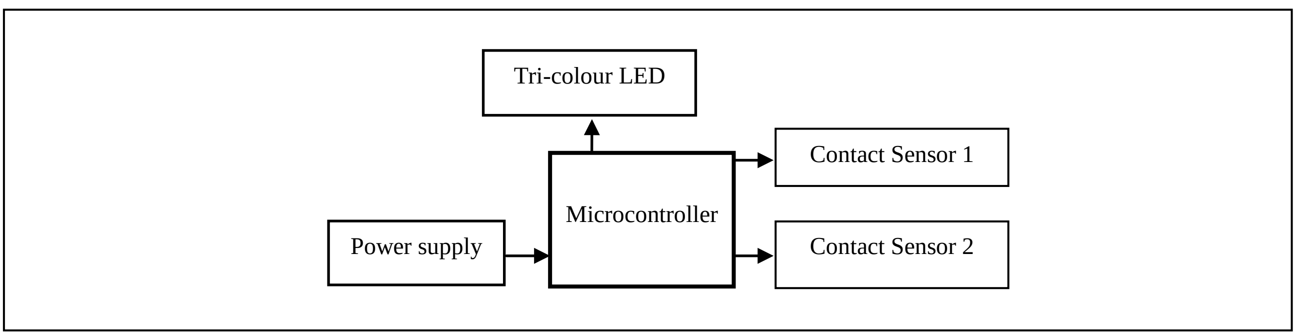

Fig. 1 Block diagram for the sensor system design.

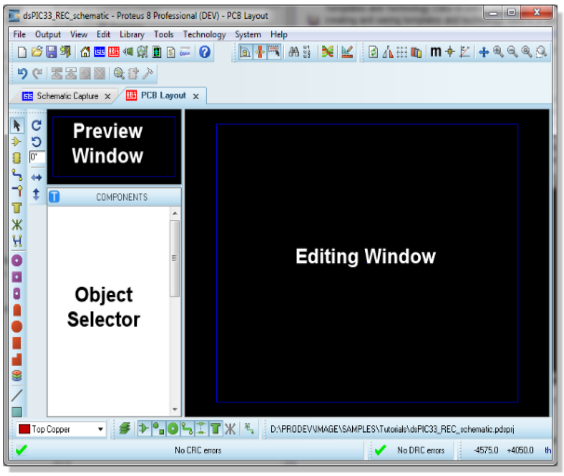

Fig. 2 The integrated development environment.

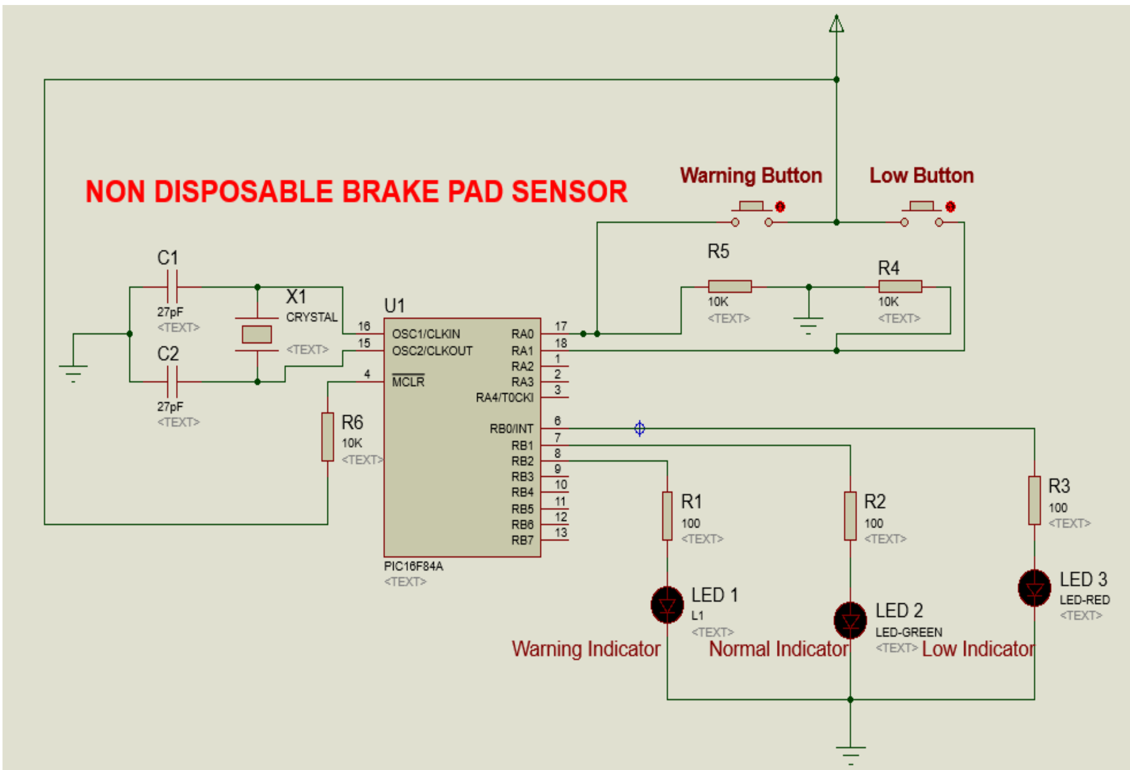

Fig. 3 Shows the circuit diagram for the control system developed.

amber light (fair pad) and a red light (bad brake pad). The contact Sensor 1 indicates two conditions: "Yes" or "No". When the condition is "Yes", it means the contact Sensor 1 had energized with a display of amber light and the "No" condition displays a green light. The contact Sensors 2 either display a red light (when the condition is "Yes") or a green light (when the condition is "No"). The system repeat itself until the condition is satisfied. The flow chart is shown in Fig. 4. The performance of the system was evaluated based on the rate of missed, fake alarm, hit or meeting target over a total number of trials.

3. Experimental Results and Discussion

3.1 Performance Evaluation of the Developed Control System

The output responses of the simulated system are shown in Figs. 5-7. From Fig. 5, it can be seen that the

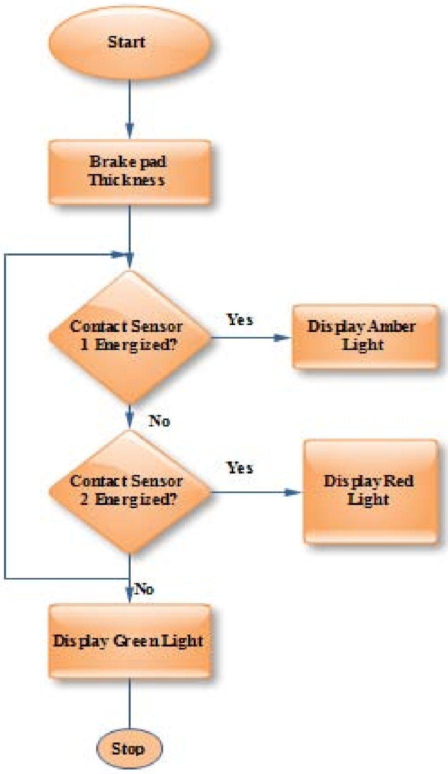

Fig. 4 Project flow chart.

green light of the control system remains on since the brake pad is newly installed. Over the course of usage, the amber light of the control system comes on which implies that about 50 percent of the brake pad has worn out sending a signal to the driver to change the brake pad shown in Fig. 6. Finally, when the driver fails to replace the brake pad, then the red light of the control system lights up which indicates that if the driver did not change the brake pad this may damage some components of the braking system especially the brake disc and can also cause accidents shown in Fig. 7.

From the testing of the non-disposable brake pad sensor, the results indicate that the contact sensor will detect the status of the pad as it approaches the set limit. The simulation process showed that the efficiency of the sensor in terms of detectability, hit or accuracy to be nearly 100%. This indicated that sustainable performance was expected for the real time application of the sensors.

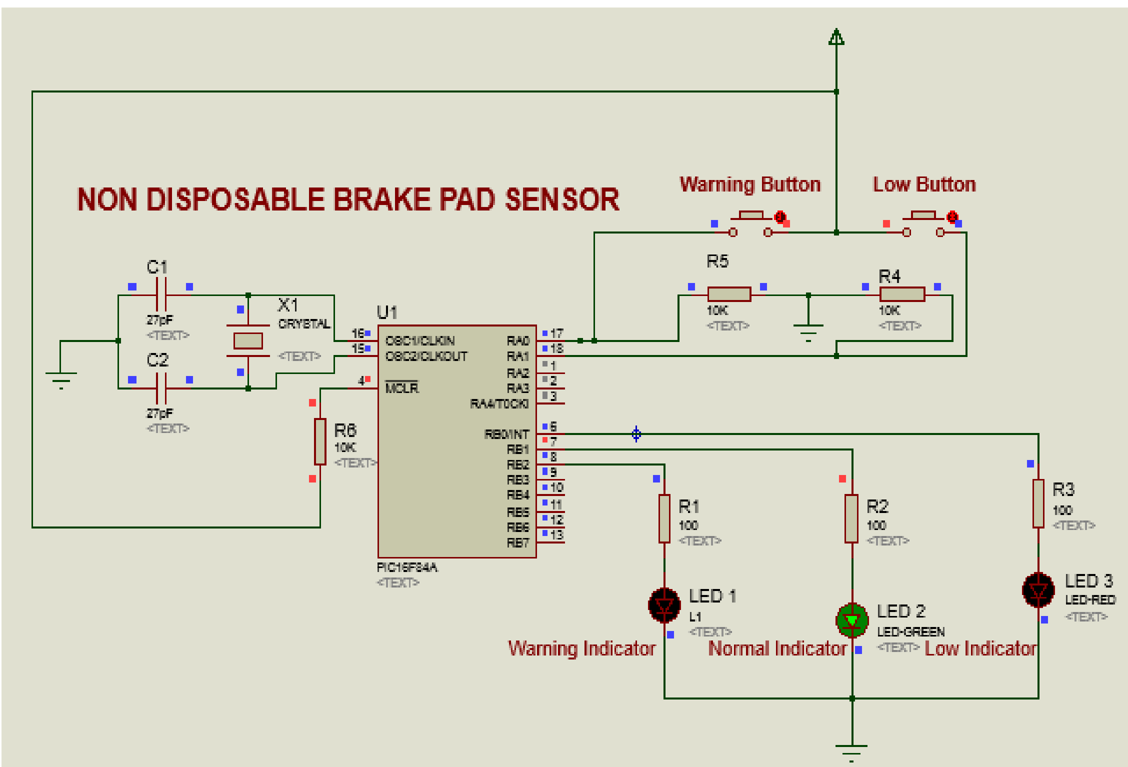

Fig. 5 The output response of the simulated system showing green light.

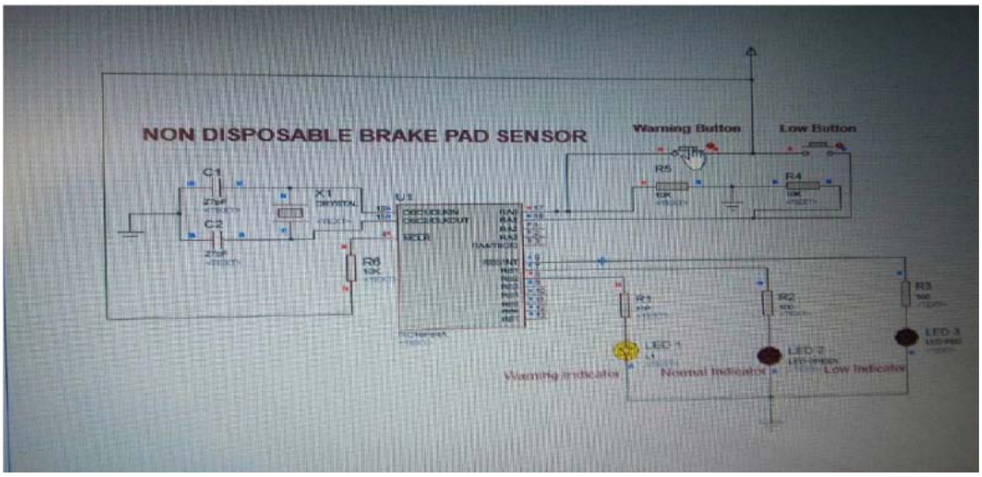

Fig. 6 The output response of the simulated system showing yellow light.

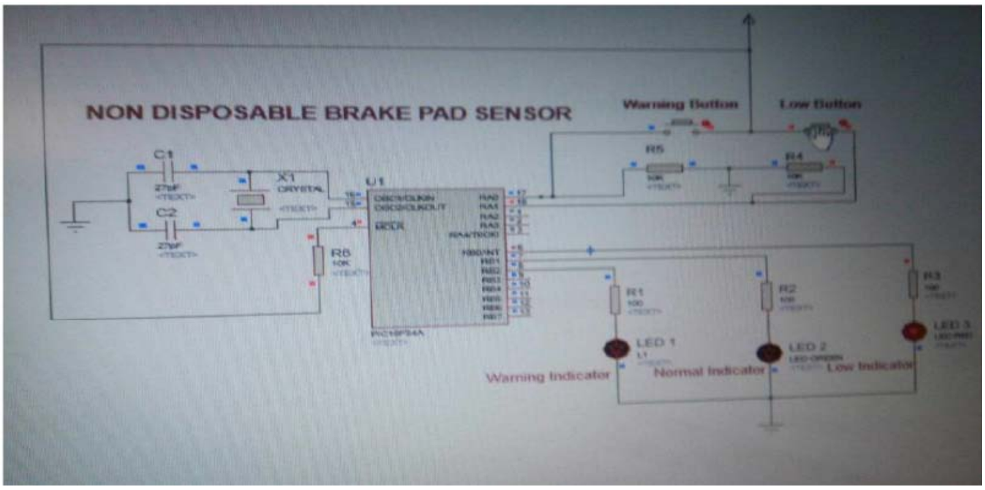

Fig. 7 The output response of the simulated system showing red light.

4. Conclusions

This study is conducted with a view to develop a non-disposable brake pad sensor as a precautionary measure for drivers about the conditions of the brake pad. This is aimed at reducing the risk of road accidents as well as minimizing cost of maintenance.

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