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Design of an Automotive Safety System using Controller Area Network

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***Abstract— Most* of the people are using vehicles which have become the most important part in our life for comfort transportation. In existing system the main snags are cost as well as the first one are glaring effect accidents due to opposite vehicle headlight illumination at night time driving. Second one is the short circuit fault in automotive wiring. Third one is to perceive the gas leakage fire accidents. And the fourth one is faults due to temperature of automotive engine location. The proposed system has two modules Master and Slave, they are communicating through Controller Area Network (CAN) protocol. The Master module has gas leakage detection with protection and temperature monitoring function. The Slave module has Automatic Front Headlight Adjustment system (AFHAS) and short circuit fault line indication function. The hardware has been developed in SMT (Surface Mount Technology) with SMD (Surface Mount Device) components and the hardware uses double layer PCB (Printed Circuit Board) design to optimize the space requirement and power consumption. The proposed system will be in cost effective safety system, reliability, and hardware will be small in size.**

Keywords: Controller Area Network; CAN; Automotive safety; adaptive headlights; Automatic dim/bright; Temperature; Gas Leakage Prevention

I. INTRODUCTION

Vehicle counts are increasing day by day, by various manufacturers with low cost. Most of the costly vehicles have safety measures but low cost automotive has less safety measures. People are like safe and comfort travel with low cost investment. In this proposed system there are four safety measures are included in this system. These safety measures are the most common reasons for road accidents during day and night time driving. The Main motivation of this proposed system is to reduce driving accidents for automotive.

In this proposed system the included measures are, the first one is to reduce night time driving accidents due to opponent headlight illumination by AFHAS (Automatic Front Headlight Adjustment System) because most of the accidents arisen at night time driving.

The headlight cause glaring effect to the vehicle driver at the time of driving driver cannot control the opponent vehicle. Even though driver initiates to dim their headlight signal opponent deriver will not dim headlight illumination. The SAE (Society of Automotive Engineers) rule of automotive illumination in dim mode it should be (380-500 lux) and in bright mode (700-850 lux). While driving in bright mode the illumination to the opponent driver will observe the glaring due to that glaring effect driver eyes may blurred visibility of road path will not clear so it will leads to accidents at night time [3].

The second one is to reduce the short circuit faults at the vehicle wiring connections. In a comfortable vehicle there are lots of wiring connections and power supply lines are passed to various parts of an automotive automation system and there are many movable parts. While moving of any parts in the automotive there is a chance to occur short circuit fault (example: Door open/close sensor wire). If short-circuit occurred then the current flow will be high from battery to the fault location. It results drain the battery power quickly and it leads to fire accidents, but driver cannot find at which place fault occurred.

The third one is the gas leakage detection and prevention. In India local four wheelers are used LPG (Liquefied Petroleum Gas) as fuel for better millage but they don't know about risk in that LPG arrangements and maintenance of the LPG tank setting. Due to ageing of fuel tubes and LPG tank damage may ensued. While travelling or parked in a location damage of the tubes the there is a chance to cause flare, and spirit accidents [4].

The fourth one is a temperature monitoring in an automotive engine location. Approximately the engine will produce 100 to 135 degree Celsius heat. Continuous of engine heat will damage the fuel transfer tubes and control signal wires and power supply wires so it is the reason for sudden ardor misfortunes. The above stated four safety measures are included in this proposed system and provide an active safety system for an automotive [7].

These four measures are converted into two modules one is master module another one is slave module. The master module shown in fig.1 it has LPG gas leakage sensor cum prevention unit and temperature monitoring unit. The slave module shown in fig.2 it has AFHAS (Automatic Front Headlight Adjustment System) and short-circuit identification unit. These two modules are designed in double layer Printed

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Circuit Board (PCB). This proposed system has hardware and software. Surface Mount Device (SMD) Hardware used in this proposed system. Both master and slave modules are communicating through vehicle communication bus Controller Area Network (CAN) protocol.

Controller Area Network (CAN) protocol was initially developed in 1980s by Robert BOSCH. CAN was standardized as ISO-11898 and ISO-11519 [20]. CAN is a message based serial communication protocol which transfers 8 bit data. The CAN bus is specially developed for vehicle communication it can transfers data up to 1Mbps speed (40m distance). Initially it has 11 bit identifiers and now CAN2.0B released in 2012 it has 29 bit identifiers to talk the nodes to other nodes which are connected in the system. CAN protocol needs CAN transceivers to exchange the data from one node to other nodes in this proposed system has MCP2551 CAN transceiver it supports up to 112 nodes.

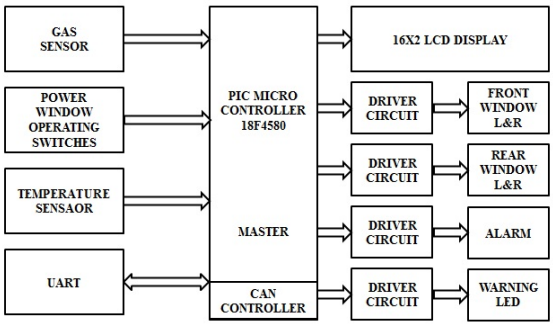

Fig.1 Master Module block diagram

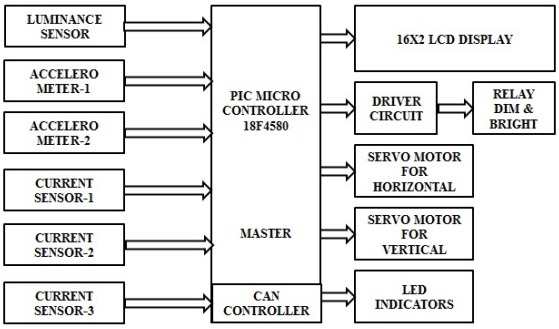

Fig.2 Slave module block diagram

II. HARDWARE

A. Peripheral Interface Controller(PIC)

Pic is a family of revised Harvard Architecture Microcontrollers made by Microchip Technology. It's derived from the PIC1650 initially developed by General Instrument's Microelectronics Division. PIC referred to "Peripheral Interface Controller" but now it's fully called as PIC microcontroller. PICs are popular with both industrial developers and hobbyists alike due to their low cost, wide availability, large user base, availability of low cost or free development tools, and serial programming ICSP In-Circuit Serial Programming (and re-programming with flash memory) capability. In this proposed system PIC18F4580 TQFP (Thin Quad Flat Package) microcontroller have been used, which is small in size (10x10x1.5mm). This microcontroller is designed with Nano watt power consumption technology. The main reason is to choose this particular IC means it has inbuilt Enhanced Controller Area Network (ECAN) The ECAN module is a communication controller, implementing the CAN 2.0A & B protocol as defined in the BOSCH specification.

The features of this MCU are, the module will support CAN 1.2, CAN 2.0A, CAN 2.0B Passive and CAN 2.0B Active versions of the protocol. Flash program memory is 32kbytes in size, 1536 bytes of SRAM, 256 bytes of EEPROM, 36 I/O ports, 11-10bit ADC channels, I2C, and UART are more than enough for proposed system [14].

B. CAN Transceiver

The MCP2551 is a CAN transceiver, which is a high speed Controller Area Network (CAN). This MCP transceiver will act as conduit between physical buses and CAN protocol. It provides differential transmit and receive competence for the CAN protocol controller and it is fully attuned with the ISO-11898 standard. This CAN transceiver supports 1Mbps speed and CAN nodes can be connect up to 112 nodes [25].

C. PCB design

A Printed Circuit Board (PCB) mechanically supports and electrically bonds electronic components using conductive tracks, pads and other features etched from copper sheets laminated onto a non-conductive substrate. PCBs can be single sided (one copper layer), double sided (two copper layers) or multi-layer. Conductors on different layers are connected with plated-through holes called vias. In this proposed system double layer PCB was designed for both master and slave module with the help of Dip Trace CAD tool software [17].

D. Sensor Components

1. Digital light sensor is BH1750-FVI - Which is used to sense the lux level of headlight luminance in digital. This ambient light sensor will acquire the automotive lux in digital up to 65535 lux (max) and transfers the data through I2C (Inter Integrated Circuit) serial communication protocol. I2C is a two wire communication SDA (Serial DATA) and SCL (Serial CLOCK) terminals.

2. Accelerometer ADXL335 – This is an analog accelerometer which is used to obtain the steering angle and vehicle base angle. It gives signal to control the headlight horizontally and vertically. For this proposed system ADC channels are configured to convert the analog signal to digital signal [15].

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3. Current Sensor ACS712-05B – This sensor which is used to get the current flow through the sensor will indicate the current level if short-circuit occurs there will be an abnormal current will flow then the sensor will indicate the controller and displays the line which is faulty line.

4. Gas Sensor MQ-6 – A gas sensor (MQ-6) is a device which detects the presence of various gases within an area, usually as part of a system to warn about gas leakage which is might be harmful to humans who travelling in car. Most of the low cost cars run on gas as a main fuel to transportation. Sometimes if gas leaked in vehicle while travelling or parked in a place it may have a chance to fire or may lead to burst. This proposed system will find gas leakage in automotive then the power windows will automatically get down to mix the oxygen with the auto LPG (iso-butane, propane) gases by doing like this the concentration of gas will reduce to burst [7].

5. Temperature Sensor – Here LM35 is used to monitor the engine location temperature this lm35 is an analog sensor which gives closer value to the accurate value, its resolution also high enough to this proposed system. The maximum temperature of this lm35 sensor is 150 degree Celsius.

III. DESIGN OF CAN BASED ACTIVE SAFETY SYSTEM FOR AUTOMOTIVE

A. Master module

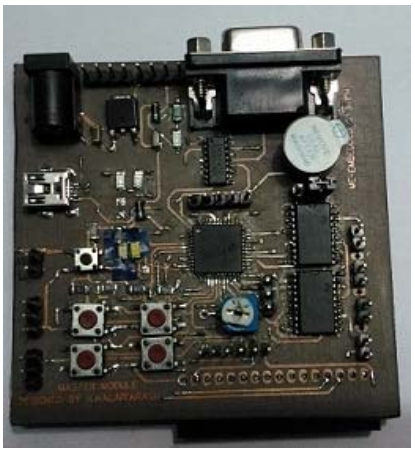

Fig.3 Design of Master Module

This master module has been designed as display unit as well as controls the two functions of this proposed system. Here MQ-6 gas sensor and LM35 temperature sensors were interfaced to the microcontroller. The power windows can be operated by push buttons (switches). Whenever the gas sensor perceives the leakage then the system will indicate in display, gives alarm and the power windows will automatically get down to mix the oxygen with the auto LPG (iso-butane, propane) gases by doing like this the concentration of gas will reduce to burst and it can be prevent from fire accidents. For power windows the actuator is a DC motor and the driver circuit is designed with L293D driver IC. After a particular period of time the power windows will automatically get close. The time can be set by the programmer.

LM35 used as temperature sensor which is produce voltage according to temperature rise. Its resolution is 10mV per degree Celsius. Engine area temperature continuously monitors and reports to the master unit. The engine temperature will not exceed 100 to 115 degree Celsius. This lm35 will withstand up to 150 degree Celsius temperature. The limit of temperature will set as 117 degree Celsius if the engine exceeds the value the driver will alerted by alarm with display value then driver needs to check the engine oil for perfect cooling.

The design of master module was shown in fig.3 which is supports serial communication to PC via USB (Universal Serial Bus) and Serial Port. Master will operates on +5V and +12V dc power supply. The program will burn by ICSP (In Circuit Serial Programming) terminal. This master unit has CAN transceiver to connect with the CAN bus.

The master hardware design information is:

- Height of the designed board = 81.92mm
- Width of the designed board = 78.27mm
- Number of holes (6 types) = 201
- Number of vias (0.4mm) = 117

B. Slave module

Fig.4 Design of Slave module

The slave module incorporated with two functions that are AFHAS and Short-circuit fault line identification. For AFHAS (Automatic Front Headlight Adjustment System) three sensors were used namely ambient light sensor and two accelerometers. Ambient light sensor will detects the opponent

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vehicle headlight luminance value in digitally. It can sense the maximum value nearby value is 65535 lux through I2C communication. By this light sensor the automatic dim/bright operation will activated. While driving at night time if opposite vehicle headlight is presence then automatically dim their headlights by relay unit. If the light passed away, then automatically changes to bright mode. The accelerometer is used to get the angle with respect to gravity. One sensor is place on steering to control the headlights horizontally (left & right) another sensor will place on the base of the vehicle wheel to control vertically (up & down). The servo motor is used as actuator for headlight control. Servo motor has internal feedback system it is suitable for perfect position control. It is very useful for hills area driving and slope road design [24]. This proposed system will automatically adjusts the headlight and provide the clear vision to the driver and also avoid the glaring effect by this proposed system and reduce the night time accidents the above stated sensor acquire value will be displayed in master module by CAN bus protocol communication.

Another one is three current sensors is used in this proposed system which works based on Hall Effect. The current flow is continuously monitors and compared with the reference value. If obtained value exceeds the reference then the exceeding line indicator will blink and that fault line name will send to the master unit. Then driver can manually remove the faulty line or may be fault can be recovered.

The design of slave module is shown in fig.4 it is also has CAN communication, USB, and Serial port communication. The coding will developed and burn through ICSP.

The slave hardware design information is:

- Height of the designed board = 74.62mm
- Width of the designed board = 90.18mm
- Number of holes (6 types) = 199
- Number of vias (0.4mm) = 93

The slave unit can be fixed in field near by headlight and master can be placed in dash board.

IV. CONCLUSION

The proposed system has been designed and this system has two modules namely master and slave which takes required action for the night time driving accidents due to glaring effect of headlight luminance, to provide clear vision for vehicle driver, short-circuit fault line detection, Gas leakage detection cum prevention action and monitoring the engine area temperature by an analog and digital sensor that above stated in this paper. The communication between master and slave module through Controller Area Network serial communication protocol has been implemented and it precedes required actions, values displayed in dashboard for driver assistance. This proposed system achieved the active safety system with low cost.

V. FUTURE WORK

In future, this proposed system can be extended to monitor the additional functions like monitoring of individual wheel pressure and wheel temperature, digital fuel indicator with millage display, automatic horn volume adjust, automatic exhaust gas controller, etc. This proposed system can be extended with 112 nodes.

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