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Adaptive Cruise Control Implementation using Controller Area Network Protocol

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ABSTRACT:

This paper is an embedded system based application. The main design and aspect of CAN Based accident avoidance system is to avoid the accidents by using CAN protocol. This project describes a design of effective accident avoidance system that detects an automotive vehicle condition while travelling, with the help of ultrasonic sensors and this signal can be used to control the braking system (ABS). In present scenario, maximum number of deaths is due to accidents. The main reason for accidents is due to negligence of drivers. In order to solve this problem we have used CAN base accident avoidance system to overcome the above mentioned scenario. The simulation of the circuit design and its implementation is carried out using PROTEUS software. Inculcating hardware implementation, ensuring, user friendliness are some of the valuable features enlisted in this paper.

KEYWORDS:

Ultrasonic sensor; RF transmitter and receiver; CAN protocol; Braking system; PROTEUS software

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1. Introduction

Control Area Network (CAN) is a serial communication bus protocol designed to allow microcontrollers and devices to communicate within vehicle without host computer. It's a multi master broad cast serial bus standard for connecting electronic control units. The devices connected by CAN are typically sensors, actuators, transmitters, airbags, antilock braking/ABS, cruise control, electric power steering etc., the biggest processor being the engine control unit. Present automobiles are being developed by more of electrical parts for efficient operation. Generally a vehicle was built with an analogue driver-vehicle interface for indicating various vehicle statuses like speed, fuel level, engine temperature etc. The overall functional block diagram is shown in Fig. 1.

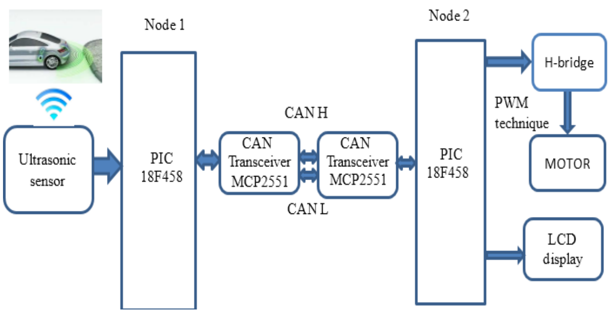

Fig. 1: Block diagram of adaptive cruise control

This paper presents the development and implementation of a digital driving system for a semi-autonomous vehicle to improve the driver-vehicle interface. It uses a PIC based data acquisition system that uses ADC to bring all control data from analogue to digital format and visualize through LCD. The communication module used in this project is embedded networking by CAN which has efficient data transfer. It also takes feedback of vehicle conditions like vehicle speed, engine temperature etc., and controlled by main controller.

2. Control motor using PWM technique

2.1. Ultrasonic sensor

Fig. 2 shows a photograph of an ultrasonic sensor. Ultrasonic parking sensor works by ultrasonic pulse from the sensor (transducer) to issue, reflected by the surface acoustic wave sensor to receive the same after the conversion into electrical signals, then, through the time of transmitting and receiving sound waves to calculate the distance from the sensor to the measured object as shown in Fig. 3. When close to a safe distance when reversing, it can tell the driver his around obstacles by voice or a more intuitive display case. The relationship between the distance up to the object L and the reflecting time T is expressed by $L = C*T/2$. Where C is the velocity of sound. Active ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor, measuring the time interval between sending the signal and receiving the echo to determine the distance to an object. Passive ultrasonic sensors are basically microphones that detect ultrasonic noise that is present under certain conditions, convert it to an electrical signal, and report it to a computer.

Fig. 2: Ultrasonic sensors

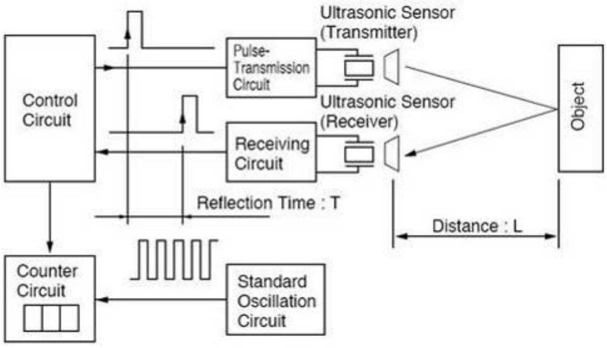

Fig. 3: Block diagram of transmitter and receiver (sensors)

2.2. Interfacing ultrasonic sensor with PIC microcontroller

The demonstration we are using Ultrasonic Distance Sensor with ASCII Output. It can be easily interfaced with a PIC microcontroller using USART by just connecting the output pin of the sensor to RX pin of the microcontroller as shown in Fig. 4. In every 500ms this sensor transmits an ultrasonic burst and listens for its echo. The sensor sends out ASCII value corresponds to the time required for the ultrasonic burst to return to the sensor. The UART of the sensor is operates at a band rate 9600 and the sensor can be powered by a 5V DC supply. The ASCII output of the sensor will be equal to the distance to the obstacle in cm.

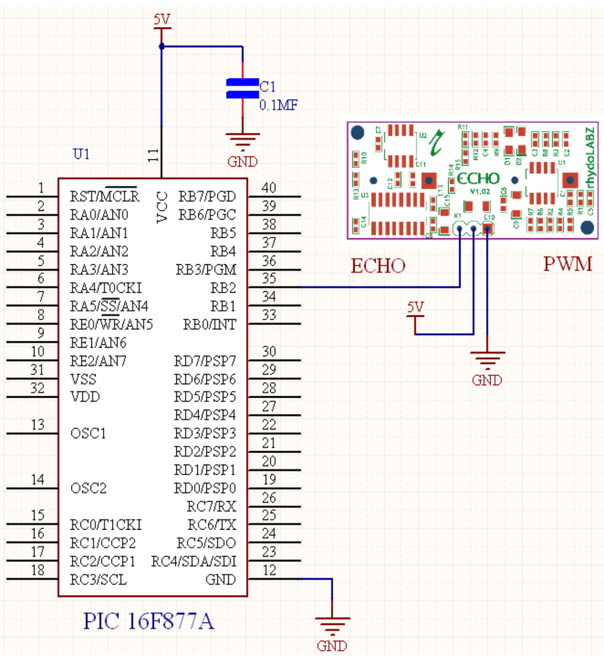

Fig. 4: Interfacing ultrasonic sensor with PIC microcontroller

2.3. LCD module

16×2 LCD module is a very common type of LCD module that is used in 8051 based embedded projects. It consists of 16 rows and 2 columns of 5×7 or 5×8 LCD dot matrices. The module we are talking about here is type number JHD162A which is a very popular one. It is available in a 16 pin package with back light, contrast adjustment function and each dot matrix has 5×8 dot resolution. The pin numbers, their name and corresponding functions are shown in Table 1.

Table 1: Interfacing with PIC microcontroller

Pin No.	Symbol	External connection	Function
1	V_{ss}		Signal ground for LCM
2	V_{oo}	Power supply	Power supply for logic for LCM
3	V_o		Contrast adjust
4	RS	MPU	Register select signal
5	R/W	MPU	Read/write select signal
6	E	MPU	Operation (data read/write) enable signal
7-10	DB0-DB3	MPU	Four low order bi-directional three-state data bus lines, used for data transfer between the MPU and the LCM. These four are not used during 4-bit operation.
11-14	DB4-DB7	MPU	Four high order bi-directional three-state data bus lines, used for data transfer between the MPU.
15	LED+	LED BKL	Power supply for BKL
16	LED-	power supply	Power supply for BKL

2.4. Interfacing with PIC microcontroller

VEE pin is meant for adjusting the contrast of the LCD display and the contrast can be adjusted by varying the voltage at this pin. This is done by connecting one end of a POT to the Vcc (5V), other end to the ground and connecting the center terminal (wiper) of the POT to the VEE pin as shown in Fig. 5.

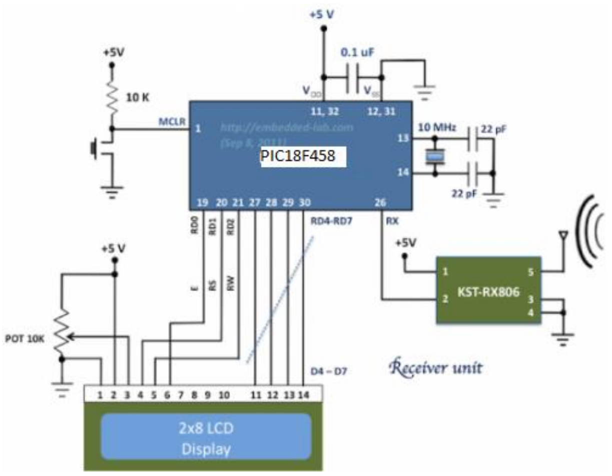

Fig. 5: Interfacing with PIC microcontroller

The JHD162A has two built in registers namely data register and command register. Data register is for placing the data to be displayed, and the command register is to place the commands. The 16×2 LCD module has a set of commands each meant for doing a particular job with the display. We will discuss in detail about the commands later. High logic at the RS pin will select the data register and low logic at the RS pin will select the command register. If we make the RS pin high and the put a data in the 8 bit data line (DB0 to DB7) the LCD module will recognize it as a data to be displayed. If we make RS pin low and put a data on the data line, the module will recognize it as a command. R/W pin is meant for selecting between read and write modes. High level at this pin enables read mode and low level at this pin enables write mode. E pin is for enabling the module. A high to low transition at this pin will enable the module. DB0 to DB7 are the data pins. The data to be displayed and the command instructions are placed on these pins.

2.5. RF module

An RF module (Radio Frequency module) is a small electronic device used to transmit and/or receive radio signals between two devices. In an embedded system it is often desirable to communicate with another device wirelessly. This wireless communication may be accomplished through optical communication or through Radio Frequency (RF) communication. For many applications the medium of choice is RF since it does not require line of sight. RF communications incorporate transmitter and or receiver (see Fig. 6). RF modules are widely used in electronic design owing to the difficulty of designing radio circuitry. Good electronic radio design is notoriously complex because of the sensitivity of radio circuits and the accuracy of components and layouts required achieving operation on a specific frequency. In addition, reliable RF communication circuit requires careful monitoring of the manufacturing process to ensure that the RF performance is not adversely affected.

Finally, radio circuits are usually subject to limits on radiated emissions, and require conformance testing and certification by a standardization organization such as ETSI or the U.S. Federal Communications Commission (FCC). For these reasons, design engineers will often design a circuit for an application which requires radio communication and then "drop in" a pre-made radio module rather than attempt a discrete design, saving time and money on development. RF modules are most often used in medium and low volume products for consumer applications such as garage door openers, wireless alarm systems, industrial remote controls, smart sensor applications, and wireless home automation systems. They are sometimes used to replace older infra red communication designs as they have the advantage of not requiring line-of-sight operation.

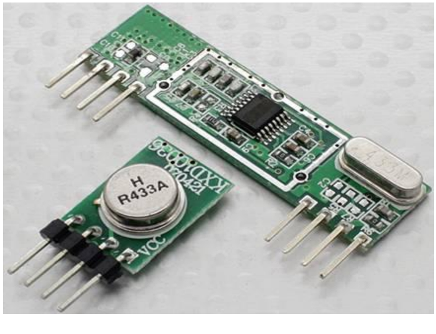

Fig. 6: RF transmitter and receiver

2.6. Types of RF module

The term RF module can be applied to many different types, shapes and sizes of small electronic sub assembly circuit board. It can also be applied to modules cross a huge variation of functionality and capability. RF Modules typically incorporate a printed circuit board, transmit or receive circuit, Antenna, and serial interface for communication to the host processor. Most standard, well known types are covered here:

- Transmitter module
- Receiver module
- Transceiver module
- System on a chip module

2.6.1. Transmitter modules

An RF transmitter module is a small PCB sub-assembly capable of transmitting a radio wave and modulating that wave to carry data. Transmitter modules are usually implemented alongside a micro controller which will provide data to the module which can be transmitted. RF transmitters are usually subject to regulatory requirements which dictate the maximum allowable transmitter power output, harmonics, and band edge requirements.

2.6.2. Receiver modules

An RF receiver module receives the modulated RF signal, and demodulates it. There are two types of RF receiver modules: super heterodyne receivers and super-regenerative receivers. Super-regenerative modules are usually low cost and low power designs using a series of amplifiers to extract modulated data from a carrier wave. Super-regenerative modules are generally imprecise as their frequency of operation varies considerably with temperature and power supply voltage. Super heterodyne receivers have a performance advantage over super-regenerative; they offer increased accuracy and stability over a large voltage and temperature range. This stability comes from a fixed crystal design which in turn leads to a comparatively more expensive product.

2.6.3. Transceiver modules

An RF transceiver module incorporates both a transmitter and receiver. The circuit is typically designed for half-duplex operation, although full duplex modules are available, typically at a higher cost due to the added.

2.6.4. System on a chip (SoC) modules

A SoC module is the same as a transceiver module, but it is often made with an on-board micro controller. This micro-controller is typically used to handle radio data packet or managing a protocol such as an IEEE 802.15.4 compliant module. This type of module is usually used for designs that require additional processing for compliance with a protocol when the designer does not wish to incorporate this processing into the host micro-controller may use a UART interface.

2.6.5. Interfacing with PIC microcontroller

Interface PIC16F876A with RF transmitter as mention early, this RF transmitter has 3 pins (Vcc, GND and data). In this project, Vcc pin is connected to 5V and GND pin is connected to GND of circuit board. The data pin should be connected to pin 17 (RC6/TX/CK) of PIC16F876A. Interface PIC16F876A with RF receiver.

There are 4 pins for the receiver (Vcc, GND and 2 data pins). The 2 data pins are internally connected each other, thus connecting either one to PIC is sufficient. Same as transmitter, 5V is given to Vcc pin and GND pin is connected to GND of circuit board. The data pin should be connected to pin 18 (RC7/RX/DT) of PIC16F876A.

3. CAN protocol

3.1. MCP2551

The MCP2551 is a high-speed CAN, fault-tolerant device that serves as the interface between a CAN protocol controller and the physical bus. The MCP2551 provides differential transmit and receive capability for the CAN protocol controller and is fully compatible with the ISO-11898 standard, including 24V requirements. It will operate at speeds of up to 1 Mb/s. typically, each node in a CAN system must have a device to convert the digital signals generated by a CAN controller to signals suitable for transmission over the bus cabling (differential output) as shown in Fig. 7.

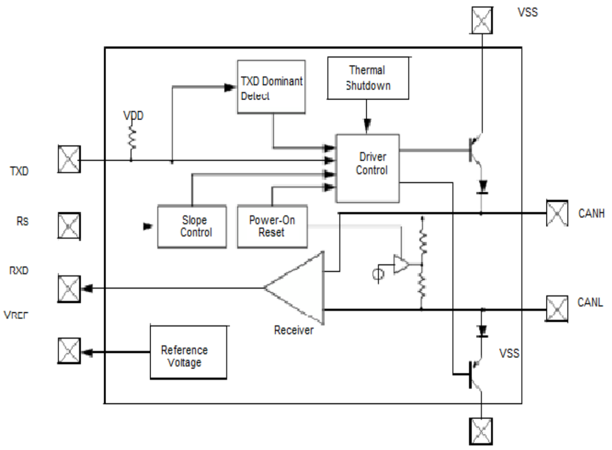

Fig. 7: Block diagram MCP2551

3.2. Controlling motor using PIC microcontroller

Control system design and analysis technologies are widely suppress and very useful to be applied in real-time development. Some can be solved by hardware technology and by the advance used of software, control system are analyzed easily and detail. DC motors can be used in various applications and can be used as various sizes and rates as per our applications. In this project we have control the actual speed of DC motor as per ours requirement. This can be achieved through PIC microcontroller. The microcontroller computes the actual speed of the motor by sensing the terminal voltage and displayed on LCD. In this project firstly we are giving the supply to PIC microcontroller. Then controller generates the pulse generally 5 volt DC. The generated pulse is nothing but PWM signal input to driver circuit. The function of this driver circuit is to generate 12v DC pulse. It is a special circuit, by using the 4 switches we can control the direction of DC motor. VDD and VSS of the PIC microcontroller are not shown in the circuit diagram. VDD should be connected to + 5V and VSS to GND. We can drive two DC Motors with one L293D, in this example we are using only the first pair of drivers to drive one DC Motor. First pair of drivers is enabled by connecting EN1 to logic high. IN1 and IN2 are connected to RB0 and RB1 of PIC microcontroller respectively which are used to provide control signal to the DC Motor. DC motor is connected to OUT1 and OUT2 of the L293D as shown in Fig. 8.

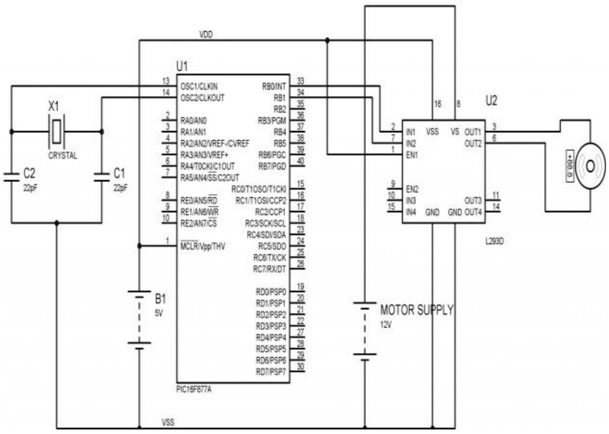

Fig. 8: Interfacing DC Motor with PIC microcontroller and L293D circuit diagram

4. Results and discussion

Proteus was initially created as a multiplatform (DOS, Windows, UNIX) system utility, to manipulate text and binary files and to create CGI scripts. The language was later focused on Windows, by adding hundreds of specialized functions for: network and serial communication, database interrogation, system service creation, console applications, keyboard emulation, ISAPI scripting (for IIS). Most of these additional functions are only available in the Windows version of the interpreter. Figs. 9 and 10 detail the architecture of simulation steps and architecture.

Ultrasonic parking sensor works by ultrasonic pulse from the sensor (transducer) to issue, reflected by the surface acoustic wave sensor to receive the same after the conversion into electrical signals, then, through the time of transmitting and receiving sound waves to calculate the distance from the sensor to the measured object. When close to a safe distance when reversing, it can tell the driver his around obstacles by voice or a more intuitive display case. The distance that is measured is seen in the LCD device. This distance is sent to node 2 from node 1 through a CAN protocol. CANH and CANL are protected against battery short-circuits and electrical transients that can occur on the CAN bus. This feature prevents destruction of the transmitter output stage during such a fault condition. The device, as shown in Fig. 10, is further protected from excessive current loading by thermal shutdown circuitry that disables the output drivers when the junction temperature exceeds a nominal limit of 165°C. All other parts of the chip remain operation.

Depending upon our power requirements we can make our own H-bridge using Transistors/MOSFETs as switches. It is better to use readymade ICs, instead of making our own H-bridge. L293D and L293 are two such ICs. These are dual H-bridge motor drivers, i.e. by using one IC we can control two DC motors in both clock wise and counter clockwise directions. We can drive two DC motors with one L293D, in this example we are using only the first pair of drivers to drive one DC motor as shown in Fig. 11. First pair of drivers is enabled by connecting EN1 to logic high. IN1 and IN2 are connected to RB0 and RB1 of PIC microcontroller respectively which are used to provide control signal to the DC Motor. Thus if any object is detected, the speed will be reduced automatically. If no object is detected the loop continues and the motor starts running.

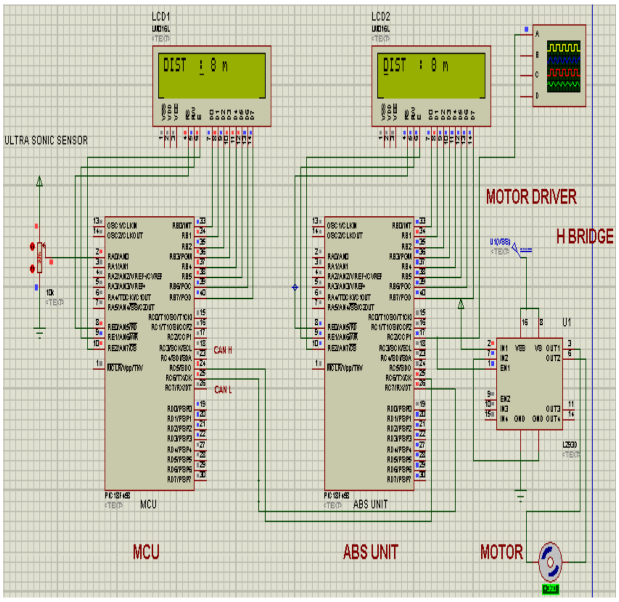

Fig. 9: Diagram of simulation result

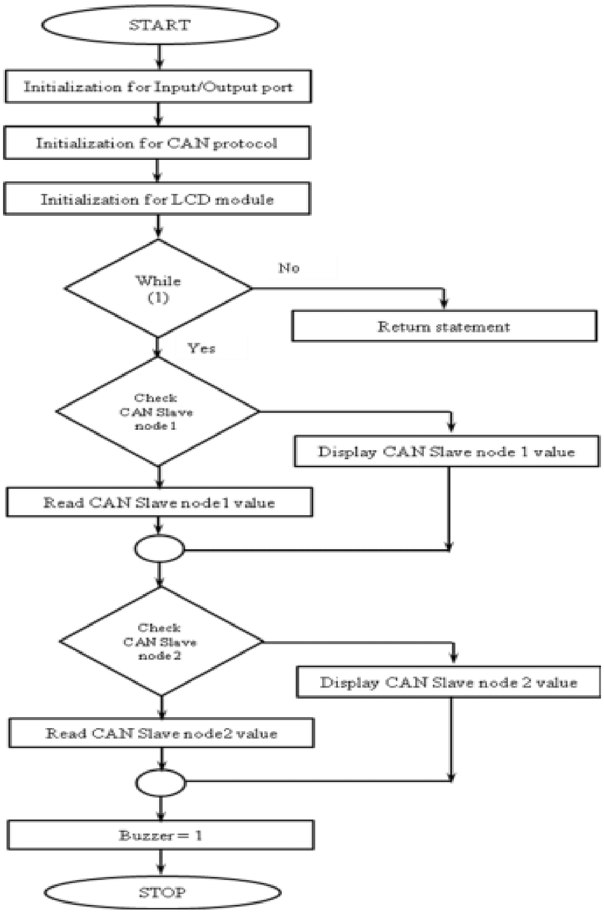

Fig. 9: Flow chart of software structure

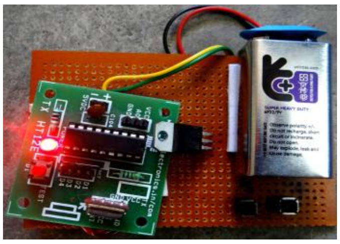

Fig. 10: RF transmitter and receiver

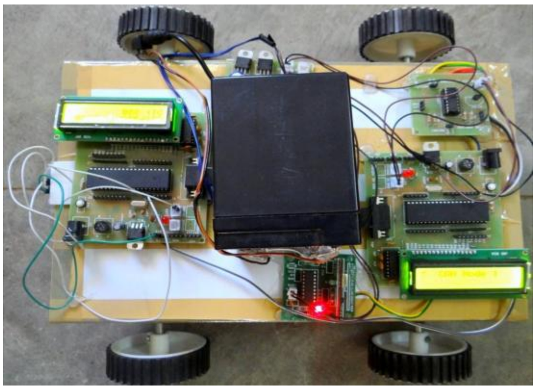

Fig. 11: Hardware implementation of adaptive cruise control

5. Conclusions

Thus the proposed CAN based accident avoidance system to avoid the accidents by using CAN protocol was developed. This project describes a design of effective accident avoidance system that detects an automotive vehicle condition while travelling, with the help of ultrasonic sensors and this signal can be used to control the braking system. This project introduces an embedded system with a combination of CAN bus systems. The simulation of the circuit design and its implementation is carried out using PROTEUS software.

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