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DEVELOPMENT OF AN AUTOMATIC BRAKING SYSTEM FOR A 4-WHEEL DRIVE

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Abstract

Internal Combustion Engines have been advanced a lot such that its speed is becoming a major catastrophe. Vehicles with advanced automatic braking systems have better braking techniques. It modifies an automobile entire braking system and works with the concept of an automatic braking System, providing a solution. This work is designed with ultrasonic transmitter, ultrasonic receiver, Arduino UNO R3 board with PIC microcontroller, DC gear motor, servomotor and mechanical braking arrangement. The Ultrasonic Sensor produces a frequency signal of 0.020-20 KHZ. It's sent out by an ultrasonic transmitter. The ultrasonic receiver receives the reflected wave in front of the vehicle, which is then sent to the ultrasonic wave generator unit, where the incoming wave is amplified and compared to reference signals to maintain a constant ratio, and this signal is sent to the microcontroller, which controls the DC gear motor and Servomotor, resulting in the application of brakes. The prototype, which depicts the technology, was created and tested under simulated settings.

Keywords: Automotive control, Mechatronics, Braking system, 4-wheel.

1.0 Introduction

There has been considerable advance in modern vehicle braking system in recent years. For example, electronically controlled ABS for emergency braking, electronically controlled hydraulically actuated individual brake-by-wire (BBW) system for saloon cars and electronically controlled pneumatically actuated systems for heavy goods vehicle. For the majority of people,

driving is a common activity. The number of people who own automobiles is steadily increasing. Simultaneously, transportation congestion has become a global issue. This problem is mainly due to human driving which involves reaction time delay and judgment errors that may affect traffic flow and cause accidents (Bamigboye and Obaje, 2016). Gopalakrishnan (2012) asserted that, many of the accidents that are taking place are avoidable if the drivers are not distracted and unable to apply the brake on time. Road accident is most unwanted thing that happens to road users and have wasted many lives untimely. WHO reported that approximately 1.3 million people die each year as a result of road traffic crashes, while drivers were responsible for 70% of the causes of the road crashes (FRSC, 2021). Technology has evolved significantly in recent years, resulting in increased speed. Maintaining time over longer distances requires a high level of speed. However, when the driver is not there, this speed becomes a major source of collisions. The major source of car accident is human error. These accidents are mostly caused by either by delay of the driver to press the brake or brake failure. The basic approach of this work is to develop a system which will prevent such accidents by continuously keeping the record of the distance to vehicles (Dhivya and Murugesan, 2015; Luo *et al*., 2016, Navudu *et al*, 2021). There had been tremendous development in vehicle brake system. Gissinger *et al*., (2003) designed a brake that could be controlled continuously and not cyclically as with classic ABS systems.

Considering the offences of drivers, these include; distracted driving, lack of full concentration, inattentiveness, sleepiness, and sending messages on cellphone while driving, an automatic braking system will help to minimize property damage in the event of an accident as well as save lives (Proctor Acura, 2022). Collision prevention systems notify the driver of an imminent collision by using a combination of an auditory and visual alert on the instrument panel or windshield, as well as seat belt tightening. The 2014 Acura MDX, for example, uses many auditory alarms as well as visual cautions such as a light flashing on the dashboard and the word BRAKE flashing on the Multi-Information Display, making it difficult for the driver to ignore (Lyo *et al*, 2016).

Mehdi *et al*., (2009) developed a methodology of robot mapping and navigation to assist living environments. Mishra *et al.* (2019) used an ultrasonic sensor based on the HCSR-04 to detect the closeness of a car in a parking slots by determining the status of the parking zone's occupancy. A car's automated braking system is a critical component of its safety technology. It's a sophisticated technology that's designed to either avoid a collision or slow down a moving vehicle before colliding with another car, a person, or something else (Suryawanshi and Sarode, 2021). When the sensor detects an obstruction, the ultrasonic braking system's principal goal is for the car to automatically brake. This is a technology for automobiles to sense an imminent forward collision with another vehicle or an obstacle, and to brake the vehicle accordingly, which is done by the braking circuit (Berns and Mehdi, 2010). This system includes two ultrasonic sensors, which are ultrasonic wave emitter and ultrasonic wave receiver. The ultrasonic wave emitter in front of an autonomous braking system car produces and emits ultrasonic waves at a predetermined distance in front of the vehicle. While a front-mounted ultrasonic wave receiver receives the reflected ultrasonic wav signal from the barrier. The distance between the vehicle and the obstacle is calculated using the reflected wave (detection pulse). The DC gear motor is connected to the vehicle's wheels and is powered by the circuit board. The PIC microcontroller controls the servo motor based on detection pulse information, and the servo motor regulates the vehicle's braking automatically. Many researchers had developed an automatic car braking system using ultrasonic

as ranging sensor while their function is based on ultrasonic wave. (Chowdhury *et al.* 2014; Sai Ram, 2017; Allam *et al.* 2019).

As a result, this new system is designed to address the issue of drivers being unable to brake precisely at the needed moment, but the vehicle being able to stop automatically by sensing an impediment to prevent an accident. The primary objectives of this work is to develop a safety car braking system using ultrasonic sensor and to design a system with less human attention to the driving.

2.0 Materials and Methods

2.1 Materials used

The following Materials are used in the fabrication of the automatic braking system for a four-wheel drive; PIC microcontroller, resistor, 6'' wheels x 4**,** irf46 x8**,** capacitor**,** printed circuit board, support frame, jumpers**,** ultrasonic sensor, header (female/male), screw, bolts and nut, IC socket**,** battery charger**,** etching materials**,** solenoid braking mechanism**,** and driver motor. The ultrasonic sensor has a range of .2m to 4m. This sensor is attached to the front of the body and emits waves to analyze the vehicle's speed and the distance between it and the impediment (vehicle) in front of it. The microcontroller code receives real-time input from these sensors. The vehicle will be equipped with an alarm system that will notify the driver even before the brakes are deployed. An alarm system is fitted to the drive that will alert the driver even before it's braking system is been applied. Here relay switch is included to activate the actuator to pull drag wire to operate brakes. Relay switch are electro-mechanical switch which operates when electrical when electric current passes through them. Sensors allow electric current to flow. When the sensor detects an obstruction, it sends a signal to the MCU Unit, which then delivers current to the switch to turn it on. When the relay switch is turned on, the actuator is turned on. Overall, this system is self-contained. This device will be powered by a lithium-ion battery.

2.2 Principal Components of Automatic Braking System

Sensing and controlling unit

The sensing and controlling unit is the part of this system which senses the object or obstruction in front of the car, ultrasonic transducer, and a power source. The Arduino is programmed using the Arduino 1.6 software, which is a free source coding language advocated by the same-named business (Carvalho *et al*. 2016). The ATmega328P is used in the Uno, which is a microcontroller board. It features 14 digital input/output pins (six of which can be used as PWM outputs), six analog inputs, a 16 MHz quartz crystal, a USB port, a power jack, an ICSP header, and a reset button. It has everything that is needed (Figure 1).

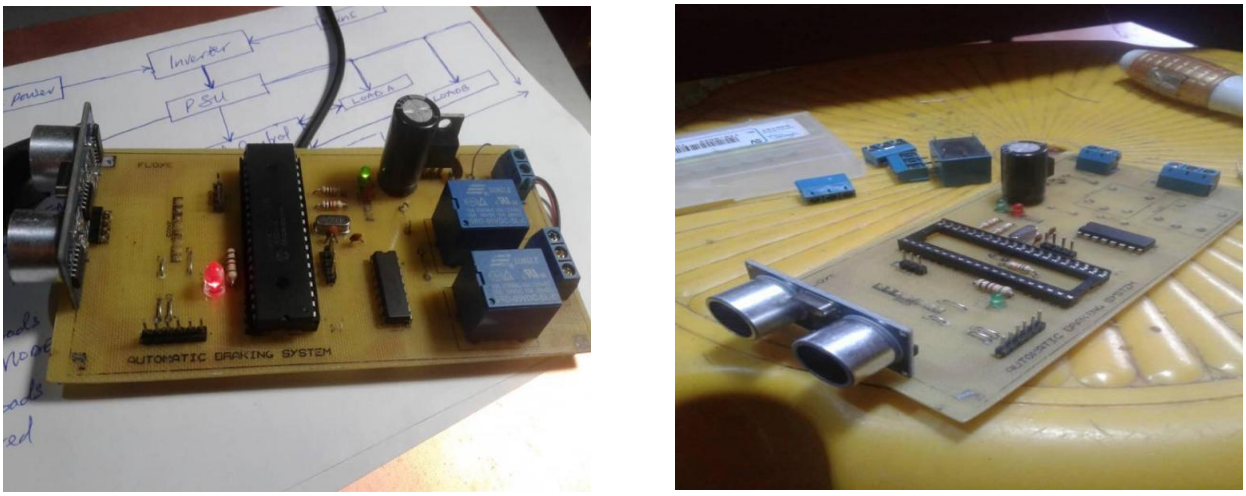


Fig. 1 Sensing and controlling unit

Each of the 14 digital pins on the Uno can be used as an input or output. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA and has an internal pull-up resistor of 20-50 ohms. In addition, some pins have specialized functions: These pins are connected to the corresponding pins of the ATmega8U2 USB - TTL Serial chip. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value. There is a built-in LED connected to digital When the pin is HIGH value, the LED is on, when the pin is LOW, its off. Ultrasonic transducers are transducers that convert ultrasound waves to electrical signals or vice versa. Those that both transmit and receive may also be called ultrasound transceivers; many ultrasound sensors besides being sensors are indeed transceivers because they can both sense and transmit. These devices work on a principle similar to that of transducers used in radar and sonar systems, which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively.

P**IC - Microcontroller**

PIC is a family of microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General instrument's microelectronics division (Figure 2). The name PIC initially referred to Peripheral Interface Controller. At present, PIC microcontrollers are extensively used for industrial purpose due to low power consumption, high performance ability and easy of availability of its supporting hardware 98 and software tools like compilers, debuggers and simulators. PIC (peripheral Interface Controller) is the world's smallest microcontroller that can be programmed to carry out a vast range of tasks. PIC microcontroller is an IC and its architecture comprises of CPU, RAM, ROM, timers, counters and protocols like SPI, UART, CAN which are used for interfacing with other peripherals. One of the most useful features of a PIC microcontroller is that you can re-program them as they use flash memory. ICSP serial interface can also be built into each PIC Microcontroller for programming and even do programming while it's still plugged into the circuit.

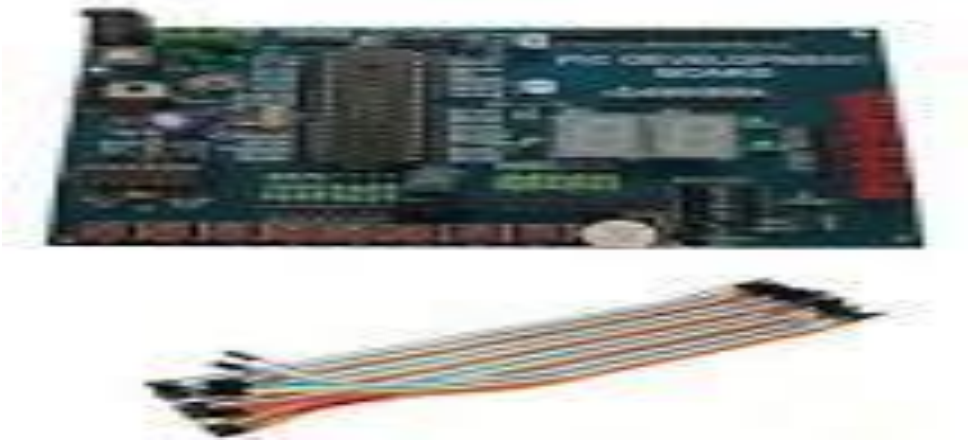


Fig. 2. PIC Microcontroller

Braking circuit

The amplified digital signal is sent to the braking circuit. PIC (Peripheral Interface Controller or Programmable Interface Controller). The microcontroller used is PIC 16F84 which is 8-bit microcontroller. PIC microcontrollers are made by microchip technology. PICs are used in this system due to their low cost and wide availability. The numbers of instructions to perform a variety of operations vary from 35 instructions in low-end PICs to about 70 instructions in high-end PICs. It is programmed by using C language. The signal from the ADC is processed by the PIC microcontroller, and it gives an instruction as an output, based on the condition of the signal, to the servo motor. The signal received from the ADC can also be displayed on the LCD display (which gives an audio-visual warning on the windshield in the driver's field of view), and it gives the distance between the front of the vehicle and the obstacle (Basseville, 1989). The distance value at which automatic braking should start is already stored in the microcontroller. When the measured distance reaches this value, the PIC automatically sends the signal to the servo motor which in turn controls braking through mechanical arrangements (Figure 3).



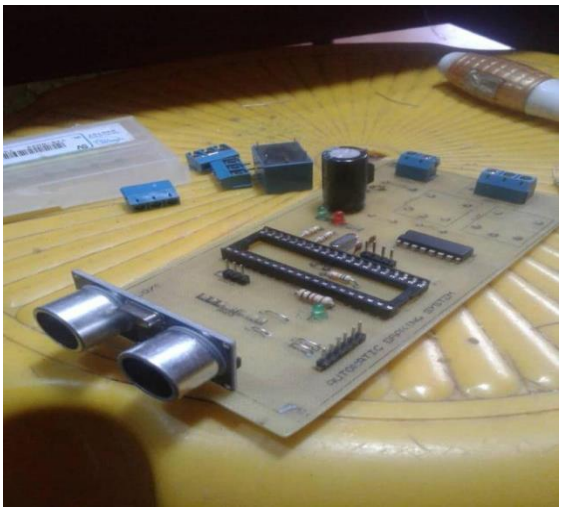


Fig.3 Braking circuit materials

Buzzer

A buzzer is an electrical device that is used to make a buzzing sound for example, to attract someone's attention. The buzzer consists of an outside case with two pins to attach it to power and ground. Inside is a piezo element, which consists of a central ceramic disc surrounded by a metal (often bronze) vibration disc. Changing this then causes the surrounding disc to vibrate. It is mainly divided into piezoelectric buzzer and electromagnetic buzzer, represented by the letter "H" or "HA" in the circuit. According to different designs and uses, the buzzer can emit various sounds such as music, siren, buzzer, alarm, and electric bell.

Driver Motor

Motor drivers acts as an interface between the motors and the control circuits. Motor require high amount of current whereas the controller circuit works on low current signals. So the function of motor drivers is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor. One of the easiest and inexpensive way to control DC motors is to interface L298N motor driver with Arduino. It can control both speed and spinning direction of two DC motors. And as a bonus, it can even control a bipolar stepper motor like NEMA 17.

Solenoid Braking Mechanism

A solenoid brake is an electrically controlled brake. The brake is turned on and off by an electrical solenoid. Typically, a spring engages the brake when unpowered, and the solenoid releases it when powered. These are used along with a mechanical brake to manage the load on a cargo winch. The brake mechanism usually consists of two or more brake shoes which are pushed against the rotating element by solenoid actuated linkages. Solenoid brakes are often included as a safety back up to mechanical braking systems. One such application is the reverse brake lock-out on trailers. These systems use the back-up light signal to activate a solenoid that disengages the trailers brakes while reversing. Many vehicles also feature solenoid brake systems which lock their brakes until such

time as the motor is running. This prevents stationary, unattended heavy vehicles from starting to roll inadvertently.

Modelling of Detection System for Obstacle

The time that will take the ultrasonic waves to hit the obstacle and return back is the time of flight. Real time therefore is the distance between two transporting vehicles, or a non-moving vehicle or pedestrian and a transporting vehicle (Bassey and Udofia, 2019).

$$\text{Real time, } d = \frac{time\ of\ flight}{2}\ x\ velocity\ of\ sound \quad (1)$$

Since the velocity of pedestrian or dead object walking is negligible when compare with the moving car, the critical braking distance is given as Eqn. 2 ((Bassey and Udofia, 2019).

$$d_c = V_A(t_r + \frac{ti}{2}) + \frac{VA2}{2\mu g} + d_{min} \quad (2)$$

Where,

V_A = velocity of the car

d_c = real time distance between the vehicle and non-moving obstacle

where the real time $d > d_c$, the vehicle will keep the original velocity without hitting the obstacle. If $d \leq d_c$, because it's a dangerous state, automatic braking deceleration will be carried out by antilock braking system after obtaining signals from the sensor to stop the car.

3.0 Results and Discussion

Result shows that the function of each part is working well and the whole system is successfully accomplished. The safety distance is determined then the vehicle system stops when the obstacle is detected. The ranging accuracy of ultrasonic sensor in this prototype is about 2cm to 1m and works effectively within the prescribed limit. This technique is eco-friendly and this work is an attempt to reduce accidents while in critical driving conditions. We have tested the working of the system by placing various objects ahead as obstacles. The system responded by reducing the speed of the vehicle when the obstacle is placed at various distances from it. Also the system stopped automatically in restricted areas. It gave very accurate measurement according to limit of values interpreted. Ultrasonic sensors work by sending out a sound wave at a frequency above the range of human hearing. It sends an ultrasonic pulse out at 40kHz which travels through the air and if there is an obstacle or object, it will bounce back to the sensor.



Fig. 4 Fabrication process of an automatic braking system for a 4-wheel drive



Fig. 5 Mechanical and electrical components of the automatic braking system

4.0 Conclusion

This work presents the implementation of an Automatic Braking system for forward collision avoidance, intended to use in vehicles where the drivers may not brake manually, but the speed of the vehicle can be reduced automatically due to the sensing of the obstacles. It reduces the accident levels and tends to save the lives of so many people. The incorporation of all components in automatic braking system will maximize safety and also give such system a bigger market space and a competitive edge in the market. This work can be adopted in the transport industry level to prevent road accidents and thereby save human lives.

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