

Review

Vehicle Rear Anti-Collision Warning System Based on Microcontrollers

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Article information**Received:** May 7th, 2023; **Revised:** July 20th, 2023; **Accepted:** August 2nd, 2023; **Published:** September 12th, 2023**Cite this article**James.Vehicle rear anti-collision warning system based on microcontrollers. 2023; 1(1). doi: <https://doi.org/10.70705/ppp.ltcs.2023.v01.i01.pp12-16>**ABSTRACT**

These days, car accidents are a major problem all across the globe, including Ethiopia, therefore engineers are trying to figure out how to make them less common. In the fight to reduce the number of fatal car accidents, the use of in-car electronic systems is anticipated to make a significant contribution. Therefore, the study's primary objective was to design a microcontroller-based rear-end anti-collision warning system that could determine the distance between two cars traveling in the same lane and sound an alarm to the driver if they were getting too close to an impending accident.

Keywords

Microcontrollers; Mechatronics; Automobile accidents.

INTRODUCTION

In addition to the spread of human immunodeficiency virus/ (HIV)/ acquired immunodeficiency syndrome (AIDS), automobile accidents are a major problem in Ethiopia. Car accidents of all types have claimed the lives of a great many individuals. Here, the average number of fatalities caused by automobile accidents in Ethiopia between 2002/03 and 2006/07 is 2,226 each year, according to the Ethiopian Federal Police Annual Statistical Report on road accidents. According to the same source, the average number of severe injuries during that time was 3,855 while the average number of light injuries was 4,826 (Federal Police of Ethiopia annual data (2002/03-2006/07)).

The increasing number of automobile accidents necessitates concerted action from all relevant entities and society at large. Everyone knows that car accidents produce a socioeconomic, physical, and psychological catastrophe that has to be addressed head-on. To address these issues, further research and studies are needed. (Data from the Federal Police of Ethiopia's annual reports, 2002–2007; World Health Organization, 2004). Publication: Geneva, Switzerland: World Health Organization, 2008; Journal Article: Advances in Transportation Studies, International Journal, Section A 15.

To try to find a different way around this acknowledged issue, this study will focus on creating a model of a domestic anti-collision warning system that can be attached to current vehicle models and notify the driver when they are in a danger zone.

Consequently, instead of leaving the development of integrated active safety systems to the automakers, users could come up with solutions by creating a domestic active safety system model. This model can then be installed to road vehicles of any model or year. The author of this book felt compelled to do his part by building a model that would pave the way for more study into potential alternatives to the current methods of reducing the deadly risk of car accidents in Ethiopia.

VEHICLE ACCIDENTS

A automobile accident is a kind of traffic event that often occurs when one vehicle collides with another vehicle, another road user, or a stationary item on the roadside. This collision may lead to injuries, property damage, or even death. Based on the yearly figures provided by the Federal Police of Ethiopia from 2002/03 to 2006/07, the World Health Organization estimates that 1.2 million people die and forty times as many are injured in road events globally in 2004. ("Statistics of motor vehicle collisions and types of collisions," Road safety Assoc. Korea, 1997, Tech. Rep.), among other statistics, revealed that vehicle-to-vehicle accidents have emerged as a major concern in the modern era. The prevalence of accidents involving vehicles is a critical concern, and one of the most pressing is the need to find ways to reduce rear-end collisions, which are believed to happen more often.

When it comes to the top six causes of mortality, the National Highway Traffic Safety Administration (NHTSA) has you covered. According to a study published in the British Medical Journal on April 10, 2004 (328:851), together with the World Bank and WHO, the drivers pose the most danger to the victims in six of these cases. Driver Fatigue, Aggressive Driving, Distracted Driving, Drunk Driving, Speeding, and Weather are some of these factors.

Vehicle Collisions Classification

Vehicle collisions can be classified by mechanism. Common mechanisms include:

- Head-on collisions,
- Run-off-road collisions,
- Rear-end collisions,
- Side collision, and
- Rollovers are the most common once.

MICROCONTROLLERS

Microcontrollers are a type of microcomputers that consists of a single silicon chip and they are used in many house hold goods and cars. Therefore a microcontroller is a single chip computer. Micro suggests that the device is small, and controller suggests that the device can be used in control applications. Another term used for microcontroller is embedded controller, since most of the micro-controllers are built in to or embedded in the devices they control. The term microcomputer is used to describe a system that includes a minimum of microprocessor, program memory, data memory and input-output (I/O). Some microcomputer systems include additional components such as timers, counters, analogue to digital converters, and so on (Automotive engineering journal, March 1997, pp.86, Thomas Braunl, (2008). Embedded Robotics, third edition, <http://www.st.com>, MICROCONTROLLERS MADE EASY).

Even though there are several types of microcontrollers, the most commonly used in embedded systems are the Basic stamp and the PIC Basic microcontrollers. The BASIC Stamp is a microcontroller developed by Parallax, Inc. (<http://www.parallax-inc.com/>) which is easily programmed using a form of the BASIC programming language. It is called a “Stamp” because it is close to the size of an average postage stamp. The basic stamp is expensive and slower compared to PIC Basic microcontrollers. Due to this the PIC Basic microcontroller is **chosen for this project to develop a low cost model**. The comparison (Table 1) is briefly shown as follows (<http://www.pond.ie/TechInfo/Stamp> and <http://www.lvr.com/files/mibch1.pdf>).

REAR-END COLLISION AND DETECTION METHODS

One of the most common types of car accidents is a rear-end collision. In 2000, 29.7 percent of all automobile accidents were rear-end collisions, according to the National Highway Traffic Safety Administration. In that year, 30.2% of all automobile crashes were side accidents, with rear end collisions coming in at a distant second. According to the same data, the rate of head-on collisions is around

2.2%. According to a study by the National Highway Traffic Safety Administration, “Traffic Safety Facts 2000,” rear-end collisions are a major headache for insurance companies due to how often they happen.

Basic stamp	PIC microcontroller
Expensive	Cheaper
Slower	Faster
Easier to learn	More difficult to learn to use
Free software for programming (PBASIC) can be Downloaded from parallax	Requires a compiler to create software

Also, 23% were rear-end collisions, 1% were head-ons, 16% were single-vehicle accidents, and 60% were others, according to an analysis of the 1992 General Estimates System (GES) database. “Others” includes collisions including angle and sideswipe crashes, backing crashes, and various non-collision types such rollovers, fires, jackknives, and immersions, for which the forward collision warning system may not work. According to Dogan Ibrahim (2006), front collision warning systems have the potential to reduce or eliminate the impacts of about 40% of these types of collisions.

It follows that engineers must work to eliminate the global hazard of rear-end collisions. Various collision avoidance systems have used a wide variety of technologies in the past. One such system relies on ultrasonic sensors, as mentioned by L.H. Nordlund in 1961. To detect the presence of an item in a monitored region, a high-frequency sound wave is blasted into the air and then evaluated for reflected waves of the same frequency. Systems of the ultrasonic kind are unreliable because of their long reaction times and their susceptibility to different types of interference, such as eddies and wind buffeting. Also, these systems rely on ultrasonic transducers, which, when left exposed to the elements, may cause malfunctions due to filth and moisture in the air (George Beggs et al 1991).

Radars, which utilize radio waves to send and receive signals, are another well-known kind of collision avoidance device. These systems have not been widely used in regular passenger cars because to their high price tag, despite their rather effective performance (Masaaki Katsumata, 1978).

There are optical devices that can measure the time it takes for light to travel from the vehicle to the object and back again. The systems in question, however, need both complicated circuitry and costly components (Yoshiyuki Etoh et al., 1988).

USING A PIC MICROCONTROLLER TO DESING AN ANTI-COLLISION WARNING SYSTEM FOR THE REAR END

Design Specification

Figure 1 is a block diagram that shows four inputs that are thought to be part of the system. The following factors are taken into account by the collision warning system: the vehicle’s speed, the posi-

tion of the brake switch, the steering wheel, and the distance to an object or vehicle ahead.

A speed sensor, which may be digital or analog in nature, is essentially what you need to detect the vehicle's speed. Here, however, a potentiometer serves as a stand-in for the speed sensor at various locations. Just like the steering position sensor, a push button may be used to emulate it. Just like the actual automobile, this one uses a push button to detect the location of the brake pedal.

A 5v infrared sensor (GP2D12) is used to determine the distance to an item in front of the vehicle. Objects within a range of 10 to 80 centimeters may be detected by this sensor. Within this range, it can identify an item and, based on the object's distance from the sensor, produce an average analogue voltage between 0.4 and 2.6 volts. So, it's feasible to design a microcontroller to alert the driver to an impending obstacle if the optimal stopping distance is determined by analyzing the relationship between vehicle speed and other elements influencing the stopping distance.

The concept is built on the assumption that the driver can see what's ahead at all times, regardless of whether they're braking or turning. To let the system know about these two items, the brake switch and the steering position sensor are used. Therefore, the system will not provide a warning to the driver in the event that any of the two are identified. For instance, when the brake is pressed or the steering is turned to the left or the right. Considering all of this, the system will only sound an alarm if the car is not changing a direction, brake is not applied and object is in the target. Thus, this system will help the driver informing to take care of an object in front of the vehicle either during night or day driving. Generally the system is demonstrated in a simplified concept block diagram below so that one can easily understand (Figure 1).

Rear-End Anti-Collision Warning Design Using PIC Microcontroller (PIC16F876A)

The rear end collision warning system designed in this project consists of hardware and software part. The hardware part consists of the 10x7.5 mm circuit board, microcontroller, the distance sensor, potentiometers, push buttons, connecting wires, various electronic components used for power supply and timer circuits. Some of the components are shown by the help of block diagram and the picture below taken while constructing experiment boards (Figure 2).

The creation of a model for a rear-end anti-collision warning system has been a long-term goal, and the following procedures have been followed in its design. First, choose the input variables. Second, make a list of all the things you'll need and gather them.

- c) Constructing the hardware for the experiment
- d) Coding the relationship between all the input variables
- e) Inputting the code into the microcontroller
- f) Verifying the software and hardware features
- g) Constructing the model for performance

The system has only four inputs and one output since building a model is the goal. As a result, the project becomes more

manageable and accessible to others. The following parameters are required: vehicle speed, steering angle, braking method, and object separation.

It is essential to take the vehicle's speed into account when determining the minimum distance needed to follow the vehicle or item ahead of it, as this is the primary input element that significantly impacts the stopping distance of a vehicle.

The driver's level of awareness is indicated by various inputs like the brake switch and steering position. The distance sensor provides data about the object's distance, and the microcontroller uses this and other input variables to make the necessary choice.

Interfacing sensors: This project makes use of both analog and digital sensors. While the speed and distance sensors are analog, the brake switch and steering position sensors are digital. A separate complex interface circuit is unnecessary due to the fact that the digital sensors are simple pushbutton. To interface the buttons, however, you need pull-up resistors.

The microcontroller is linked to 5v and logic 1 when the switch is open. When the switch is closed, the microcontroller receives 0v, often known as logic 0.

An interface circuit is unnecessary since the distance sensor already has a signal conditioning circuit built into it, and it also has an analog output. Following the manufacturer-recommended procedure, the only external circuit that has to be constructed is a bypass capacitor with a value of 10 microfarads or more, which must be connected in parallel with the power source and ground connections of the sensor. A potentiometer is also used to emulate the speed sensor; no further interface circuits other than the microcontroller are required. An analog-to-digital converter interface is included inside the microcontroller to convert the analog signals from the distance and speed sensors to digital signals that the microcontroller can process.

Interfacing driver circuits: The LED and the buzzer used as an actuator in this project are using a simple driver circuit. The LED used as a top speed warning is derived directly by connecting an LED to the microcontroller output pin through a series resistor of 330 ohm (Figures 4-10). We know that a standard LED consumes 10mA for normal brightness and the voltage drop across LED is about 2V. But the voltage at the output of the microcontroller is about 5V when the port is at logic one level. As a result of this it is impossible to connect an LED without a series resistor connected to it. Therefore there is a need to determine a current limiting resistor value. So if the output voltage of the port is 5V, to have a voltage drop of 2V, we need to drop 3V across the resistor. The nearest resistor value is 330 Ω .

Other driver circuit used in the project is the one used to drive the buzzer. Two transistors connected as Darlington pair is used to drive the buzzer. The output from the microcontroller port is used only to trigger the transistor so that external 6v source is

supplied to the buzzer.

The complete schematic diagram of the project consists all the above sections and drawn using ISIS professional soft ware as below (Figure 3).

Software Algorithm for Rear-End Anti-collision Warning Using PIC 16F876A

The software algorithm is written using assembly language and it is shown using the flow chart and a sample codes taken from the complete program of the project. The flow chart of the complete program is as below (Figure 4).

Principle of Operation of the Complete System

The rear end anti-collision warning system model made in this project consists of hard and soft wares. The hard ware circuit is made on the printable circuit board and mounted on a simple four wheel car model for demonstration (Figure 5).

The power supply, timer, the microcontroller and hard wires are all in a single board. The distance sensor is mounted on the front bumper of the car so that it can detect an object in front of the car. The car model is driven by a dc motor using other drive circuits which is not part of this project. The potentiometer used to simulate vehicle speed is mounted on the car so that it can be varied manually. There is also a buzzer mounted on the dash board to alert the driver when necessary.

Since it is powered by a basic dc motor, the real speed does not change when operating the vehicle. However, the system's ability to identify objects at various distances in relation to vehicle speed may be seen by adjusting the potentiometer on the automobile to different places.

As the vehicle is being driven, the distance sensor will identify objects and send a voltage signal to the microcontroller, which will then process the signal based on the program stored on the microcontroller. Afterwards, the microcontroller first verifies the vehicle's speed. The controller then determines whether the item is inside the given range at that speed. The procedure will loop and check the object's speed and distance constantly if it is not in the goal. The application will assess the driver's awareness by analyzing the brake switch and steering position whether the item is in the chosen target. The device will reset itself and not sound an alarm if the driver has already depressed the brake. The system will sound an alarm or flash a red light to alert the driver to the need to stop or take other action to avoid colliding with an item ahead in the event that they are not paying attention and the car is not being directed.

It is presumed that the driver is paying attention to everything ahead of them whenever the driver changes directions, i.e. steers a vehicle. Consequently, the software verifies the driver's steering position prior to sounding an alarm. The system will stay awake until the driver presses the brake or turns the steering wheel, after which it will turn off. By reducing the likelihood of a rear-end

collision with an item directly front of the vehicle, this device will be of great assistance to the driver.

PRACTICAL IMPLEMENTATION AND EXPERIMENTAL RESULTS

You may think of the project's practical aspects as falling into four distinct stages. We have done multiple experiments under each step. Below, we will quickly go over some of the primary responsibilities of each stage.

Experiments

An experiment board is constructed and all the required materials are gathered in order to carry out various experiments. The micro-controller and its supporting circuitry, including the power supply, clock signal circuit, and others, make up this experiment board. Mounted on an independent board are the distance sensor and the potentiometers that mimic the vehicle's speed. Several experiments have been conducted on the trial experiment board.

The Relationship Between Sensor Output and Distance

A comprehensive experiment was conducted over the day to record the voltage output of the distance sensor (GP2D12) with various objects at varying distances. To record the outcome, a straight table and a long ruler are used. The data has been compiled. The output pertains to various objects situated at varying distances from the sensor.

Speed in Relation to Object Distance

Using a potentiometer as a speed simulator is the focus of this project. In response to user input, the potentiometer produces an analog voltage. It is set up to detect objects at varied distances depending on the vehicle's speed, as the output voltage indicates the vehicle's speed. Hence, for each speed, 255 distinct speeds may be achieved by using a reference voltage ranging from 0 v to 5 v.

To keep things simple for this experiment, the software only takes five speeds into account, which will allow the system to identify an item at five distinct distances. Consequently, the relevant distance and speed are documented throughout the

Though the PIC16F876A consists of 10 bit analog channels, the higher address register of these analog channels are used which can hold an eight bit value. So we can consider the analog reading as 8 bit number. Therefore the microcontroller can read an analog voltage of 0V to 5V and convert it in to an 8 bit number where 0 V is 0 and 5 V is 255. That is a reading of 51 per volt or a resolution of 1/51V. In another word 1 bit is a voltage reading of 19.6 mV. Based on this resolution, five speeds are represented by an analog reading of 51, 77, 102,128, and 153 which corresponds to a voltage reading of 1 V, 1.5 V, 2 V, 2.5 V and 3V respectively. Similarly five respective distances are sampled as 26, 51, 77, 102, and 128 which correspond to a voltage reading of 0.5 V, 1 V, 1.5 V, 2 V, and 2.5 V respectively. Since the vehicle speed is considered from 0KM/

hr to 180 km/hr and distance from 10 cm to 80 cm. Based on these resolutions, the program has been written and loaded to the microcontroller and.

On actual vehicle the warning distance has to be determined based up on optimized stopping distance of the vehicle to be equipped with rear end ant-collision warning system. This needs another research by itself. Then the programmer has to consider this optimized stopping distance when writing the code for the software development.

DISCUSSION OF RESULTS

Object Distance versus Analog Voltage Output

For the sake of this experiment, we will choose a variety of items and measure the distance between them using the analog voltage output of the distance sensor. The materials used to construct the majority of car bodywork are considered for making the item selection, as are potential roadside artifacts. Consequently, the following materials were chosen: cardboard, glass, metal, black-painted cardboard, and the human body.

There were little discrepancies when the sensor readings for the various items were compared. My mistake in not keeping the item perpendicular to the sensor might be contributing to the discrepancies noticed, as the objects are held manually at varied distances throughout the experiment. There is a correlation between the object's distance and the sensor's analog voltage output since the output is quite comparable.

Another scientific explanation for the fact that various objects produce distinct sensor voltage outputs is that different materials have varying reflexive properties. Among the materials tested, glass emerged as the clear winner. Its strong reflexivity caused the sensor's voltage output to be greater.

CONCLUSIONS AND ACHIEVEMENTS

An anti-collision warning system for the vehicle's back end has been developed and tested on a basic, user-friendly model. The results show that the system is effective.

The GP2D12 infrared distance sensor is used to show the back anti-collision warning system. From 10 to 80 centimeters away from the vehicle model, it may identify an item. The sensor will pro-

vide a voltage signal to the system equal to the object's distance when the item is inside the allowed range. Hence, the microcontroller may alert the driver with an audio buzzer mounted on the dashboard according to the pre-programmed value.

Implementing this technology on a real-life vehicle would need a distance sensor capable of detecting objects from greater distances.

Positive results have been seen from the anti-collision warning system. So, its use in automobiles may be improved with the correct materials.

Anyone interested in researching anti-collision warning systems may use the model as an excellent testimony or demonstration tool. Students may see the model in action while they learn about mechatronics and embedded systems. The course also serves as an introduction to mechatronics and embedded systems, which are widely used in modern machines.

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