THE IMPLEMENTATION OF A SPEED MEASUREMENT SYSTEM FOR ROAD SAFETY PERSONNEL.

PRESENTED BY.

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A PROJECT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL/ELECTRONICS ENGINEERING, FALCULTY OF ENGINEERING, UNIVERSITY OF ABUJA.

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NIGERIA.

SUPERVISED BY:

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JANUARY, 2024.

DECLARATION

I, **ADENIRAN PRECIOUS ADEBAYO**, affirm that I conducted the project titled **"The Implementation of a Speed Measurement System for Road Safety Personnel."** This work was completed under the guidance of Engr. Dr. Sadiq Umar A, as a fulfillment of the criteria for the Bachelor in Engineering in Electrical and Electronics Engineering. I acknowledge and adhere to the Bachelor of Engineering project guidelines on plagiarism and cheating, ensuring full compliance with these standards in my submission. However, Authors, whose work have been referred to in this project have been acknowledged.

ADENIRAN PRECIOUS ADEBAYO **………………………..**

18245011 **Signature/Date**

CERTIFICATION

This is to certify that this project titled "THE IMPLEMENTATION OF A SPEED MEASUREMENT SYSTEM FOR ROAD SAFETY PERSONNEL" by ADENIRAN PRECIOUS ADEBAYO, Reg. No. 18245011, satisfies the criteria for the Bachelor of Engineering (B.Eng.) in Electrical and Electronics Engineering. It is approved for its notable contribution to scientific knowledge and effective literary presentation.

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DEDICATION

This work is dedicated to Almighty God for His superior act of Love through the course of my studies and my Parent for their financial support toward my academic pursuit and their words of advice and prayers.

ACKNOWLEDGEMENT

To the source and supplier of strength all glory and honour be to him. For the grace he has given unto me for the completion of my project.

My sincere gratitude goes to my supervisor, Engr. Dr. Sadiq Umar A, for unwavering guidance during my project. I’m grateful for the support may God bless you abundantly; I also appreciate the entire department’s lecturers for their guidance. Special thanks to my family, including siblings, relatives and guardians, for their moral and financial backing-my profound gratitude.

My appreciation extends to my friends and course mates, when we started, we were strangers. Today, we have established true friendship. Rest assured that I will always cherish it.

APPROVAL PAGE

This project has been approved for the Department of Electrical and Electronics, Faculty of Engineering, University of Abuja.

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ABSTRACT

The escalating global population and consequent shifts in lifestyle and economic dynamics have intensified human activity, particularly in urban areas, resulting in a heightened demand for a diverse workforce across various sectors. However, reliance on manpower for critical tasks like security monitoring and traffic regulation is susceptible to errors, limitations, and instances of corruption, exacerbating challenges such as over speeding and road accidents. With the World Health Organization reporting alarming statistics on road accident fatalities, especially in regions like Nigeria, urgent interventions are imperative to mitigate risks and enhance road safety. In response, this study proposes the design and implementation of a speed measurement device aimed at alerting road users of speeding violations. Utilizing Proteus 8 software and Arduino Uno microcontroller technology, the device accurately measures speed and distance, offering real-time feedback to enhance driver awareness and compliance. Through meticulous testing and analysis, including error rate calculation and standard deviation assessment, the system ensures precision, compliance with specifications, and continual optimization, ultimately contributing to the reduction of road accidents and the promotion of safer road environments.

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LIST OF ABBREVATION

API – Application Programming Interface

Arduino IDE – Arduino Integrated Development Environment

ASCII – American Standard Code for Information Interchange

ATC – Automatic Traffic Control

AVR – Advanced Virtual RISC

BJT – Bipolar Junction Transistor

CCTV – Closed Circuit Television

DC – Direct Current

DIY – Do It Yourself

EEPROM – Electrically Erasable Programmable Read Only Memory

GPS – Global Positioning System

I/O – Input/output

IC – Integrated Circuit

ICSP – In-Circuit Serial Programming

IDII - Interaction Design Institute Ivrea

IoT – Internet of Things

ITS - Intelligent Transportation Systems

LED – Light Emitting Diode

LFP – Lithium Ferrophosphate

LIDAR – Light Detection and Ranging

MCU – Micro Controller Units

MOS LSI – Metal-oxide-semiconductor Large Scale Integration

MOSFET – Metal-Oxide-Semiconductor Field Effect Transistor

NASA – National Aeronautics and Space Administration

OTP – One time Programmable

PIR – Passive Infrared Sensor

PCB – Printed Circuit Board

PC – Personal Computer

PROM – Programmed Read Only Memory

PWM – Pulse Width Modulation

RADAR – Radio Detection And Ranging

RAM – Random Access Memory

ROM – Read Only Memory

RPM - Revolution Per Minute

SCL – Serial Clock

SDA – Serial Data Pin

TMS – Transacranial Magnetic Simulation

USB – Universal Serial Bus

WHO – World Health Organization.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Over the years, there has been a rise in the population leading to changes in lifestyle and economic progress which result in increase in human activity. This leads high demand of workforce, particularly in urban areas worldwide [1] [2]. To begin with, there is a growing necessity for hiring security personnel to monitor potential intruders [3] [4], traffic officers on highways to regulate traffic flow, caregivers in homes for the old or sick [5], automatic doors [6], washing [7], wireless Sensor-Based Driving Assistant for Automobiles [8] [9] among various other examples. Using manpower for this work is prone to errors and limitations, some security personnel have been found in case of corruption [10], as well as making errors detecting if vehicles on a particular are within the designated speed limit.

The increase in the road accidents has been on the high side and the major cause linked to over speeding on the roads. World Health Organization (WHO) estimates that over 1.3 million people die every year due to road accidents worldwide [11][12]. In Nigeria the death toll due to road accident in a year is estimated by the World Health Organization (WHO) to be Forty-One thousand Six hundred and ninety-three, 2.82 percent of the global total [11]. With the increase in death rate due to road accident recorded, something needs to be done, or the road turns very dangerous for road users.

Hence, the idea to design and implement a speed measurement device which alarm road users if they are discovered speeding.

1.2 STATEMENT OF THE PROBLEM

The continuous increase in death rate caused by road accident led to the innovation of a speed measuring device to help control the rate of over speeding on the roads.

Hence, a device that can measure the speed rate of the vehicles tarring a road and detect if the vehicle is over speeding is designed and developed.

1.3 AIMS OF THE STUDY

The speed measurement device is designed to alert drivers and road users if they are over speeding and in doing that controls the speed of the vehicles on the road.

The aim of this project is to design and fabricate a speed measurement device.

1.4 OBJECTIVES OF THE STUDY

To achieve the above aim the following specific objectives are considered:

i. Design and Construction of a Speed Measurement System.

ii. Comparing the system designed with traditional LIDAR and RADAR.

1.5 SIGNIFICANCE OF THE STUDY

The significance of this project cannot be overemphasized which the continuous increase in road accident leading to the increase in death due to over speeding.

This project work is to focus and come up with a way to reduce road accident caused by over speeding.

1.6 THE SCOPE OF THE STUDY

This project entails the design and implementation of a speed measurement device using an Ultrasonic Sensor, which measures the distance of an object using ultrasonic sound waves Arduino Uno Microcontroller which detect the speed of movement from the gap of 2cm to 400cm [13].

1.7 METHODOLOGY

In this project, a speed measuring device is design, implemented and analyse by using proteus 8 software application packages. The speed measurement device circuit is designed and tested using proteus 8. The output of the ultrasonic sensor is connected to Arduino Uno microcontroller which performs microcontroller operations by receiving instructions from the ultrasonic sensor.

The received instructions are given as input to the program written in Arduino IDE software. Arduino IDE software allows writing program in C++ programming language and uploading it to hardware board.

1.8 STRUCTURE OF THE STUDY

This study comprises five different chapters arranged sequentially, Chapter one discusses the background information, motivation, aims and objectives, scope of the project and methodology use to achieve the work.

Chapter two will discuss Literature Review, review of related works on speed and motion detection. It also explains the operating principles of the various stages in regulating over speeding using Ultrasonic Sensor and Arduino microcontroller.

In chapter three, the design and implementation of the project is fully discussed.

Chapter four focuses on the results, implementation and discussion drawn from the tests performed on the system.

Chapter five gives the conclusion, recommendation and suggestion for further work on the project.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 SPEED MEASUREMENT

Speed measurement is integral across various fields, ensuring safety, efficiency, and performance optimization. Methods include contact-based, non-contact, and indirect techniques, utilizing devices like radar guns, tachometers, laser speed guns, wheel speed sensors, and GPS devices. It finds applications in transportation, sports, manufacturing, and scientific research, contributing to road safety, athletic performance evaluation, industrial productivity, and scientific advancements. Emerging trends include integration with IoT and AI, wireless connectivity, and miniaturization for wearable technology. Overall, accurate speed measurement drives progress and innovation across diverse domains, with ongoing technological advancements enhancing efficiency, safety, and performance optimization.

2.2 SPEED MEASURMENT SYSTEM

A speed measurement plays a crucial role in various fields, including automotive, industrial automation, aerospace and sports [14] [15]. Accurate and reliable speed measuring devices are important for ensuring safety, optimizing performance, and complying with regulations. Speed measuring device is employed to determine the velocity of an object's motion accurately [16].

Speed measuring instrument differs depending on the task it is used for. Whether measuring traveling speed, wind speed, acceleration, or engine speed, there's a specialized tool for each type of speed measurement. For instance, RADAR and LIDAR are used by police to measure traffic speed, while vehicles are equipped with speedometers for travel speed and tachometers for engine speed [17]. Accelerometers are used in conjunction with car speed assessments.

Meteorologists, on the other hand, use anemometers and RADAR to create their weather forecast [18].

In everyday life, measuring the speed of a specific object is important. When assessing a car's performance, speed is a crucial factor. While driving, exceeding the speed limit can lead to unexpected situations. Installing a speed monitoring device on the dashboard of a car enables to control the car speed. When dealing with machinery, performance evaluation often involves observing its speed. In the case of a rotating machine, the standard units like km/hour or m/s cannot be applied; instead, RPM (revolution per minute) is used. In simpler terms, it indicates how many rotations occur in a given time unit.

2.2.1 SUBSYTEM OF SPEED MEASUREMENT

Speed measuring system can be broadly categorized into contact and non-contact methods.

2.2.1.1 CONTACT BASED SPEED MEASUREMENT

Contact-based speed measurement devices are instruments designed to accurately determine the velocity of an object through direct physical contact. These devices are commonly utilized in various fields, including sports, automotive engineering, aerospace, and industrial applications.

2.2.1.1.1 PRINCIPLE OF OPERATION OF CONTACT BASED SPEED MEASUREMENT

Contact-based speed measurement devices operate on the principle of measuring the time it takes for an object to traverse a specified distance. They typically consist of a sensor or transducer that makes physical contact with the object whose speed is being measured. The sensor records the time at which contact is made with the object and again when contact is lost, allowing for the calculation of speed based on the elapsed time and the known distance between contact points.

2.2.1.1.2 TYPES OF CONTACT-BASED SPEED MEASUREMENT DEVICES

- **TACHOMETERS**

This instrument measures rotational speed in machinery and vehicles. It measures the engine speed in revolutions per minute (rpm). Tachometer measures the speed of a shaft or disk in the engine and displays the reading on a calibrated analog dial display on the dashboard of a car, aircraft, or other vehicles. The displayed value helps the driver to determine the best gear and throttle settings, and correct traveling speeds.

High speed driving in conjunction with elevated engine RPMs, may lead to insufficient lubrication, engine overheating due to the cooling system inability to cope and accelerated wear and tear on engine components as they exceed their designed speed limits.

- **SPEED SENSORS**

Speed sensors are essential tools used to measure velocity accurately. They employ various principles, such as magnetic, optical, and mechanical, catering to diverse needs. Magnetic sensors detect changes in magnetic fields induced by moving objects, while optical sensors use light interruptions to measure speed. Mechanical sensors, like tachometers, engage directly with rotating components for speed measurement. These sensors offer high accuracy and versatility, finding applications in automotive, aerospace, manufacturing, and robotics. Despite their benefits, environmental factors, calibration, and compatibility pose limitations. They enable real-time monitoring and control, crucial for optimizing performance and ensuring safety. Emerging trends include wireless connectivity, IoT integration, and miniaturization, promising enhanced functionality. Speed sensors play a pivotal role in advancing efficiency and safety across industries, with ongoing technological advancements expected to further augment their capabilities.

- **CHRONOGRAPHS**

Chronographs are timekeeping devices initially developed for scientific and military purposes, now widely utilized across diverse fields like sports, aviation, and engineering. They operate by recording time intervals between events, employing various types such as analog, digital, mechanical, and quartz. These instruments feature components like pushers, sub-dials, and tachymeter scales, enabling functions like lap timing and precision measurements. Their applications range from sports timing to military operations, benefiting from advantages like accuracy, versatility, portability, and durability. Emerging trends include smart chronographs, hybrid designs, and customization options, promising further integration and innovation. In essence, chronographs remain indispensable for accurate and reliable time measurement, with ongoing advancements enhancing their utility in everyday life.

2.2.1.1.3 ADVANTAGES OF CONTACT BASED SPEED MEASUREMENT SYSTEM

- Contact-based speed measurement devices offer high accuracy and reliability, especially when calibrated correctly and used in appropriate conditions.
- They can provide real-time speed measurements, allowing for immediate feedback and adjustments.
- Many contact-based devices are portable and easy to use, making them suitable for a wide range of applications and environments.
- Some contact-based speed measurement devices, such as radar guns, can measure speed from a distance, reducing the need for close proximity to the moving object.

2.2.1.1.4 APPLICATION OF CONTACT BASED SPEED MEASUREMENT SYSTEM

- Law Enforcement: Radar guns are widely used by police officers to enforce speed limits and monitor traffic.
- Sports: Chronographs are used in various sports, such as track and field, cycling, and motorsports, to measure the speed of athletes or vehicles.
- Automotive Industry: Tachometers and speed sensors are used in vehicle testing, performance monitoring, and research and development.
- Industrial Applications: Speed sensors are employed in manufacturing processes, conveyor systems, and machinery to monitor and control the speed of moving parts.

2.2.1.2 NON-CONTACT SPEED MEASUREMENT SYSTEM

Non-contact speed measurement systems are systems designed to accurately determine the velocity of objects without requiring physical contact. These systems utilize various technologies and principles to achieve precise measurements across a wide range of applications.

2.2.1.2.1 PRINCIPLE OF OPERATION OF NON-CONTACT SPEED MEASUREMENT SYSTEM

Non-contact speed measurement systems operate on the principle of remote sensing, where the speed of an object is determined without direct physical contact. These systems typically use sensors, cameras, lasers, or other remote sensing devices to capture data from the moving object. The data collected is then processed and analyzed to calculate the speed of the object based on its motion characteristics, such as displacement, acceleration, or frequency of occurrence.

2.2.1.2.2 TYPES OF NON-CONTACT SPEED MEASUREMENT SYSTEMS

- **DOPPLER RADAR SYSTEMS**

A RADAR speed gun (also RADAR gun and speed gun) uses radio waves to determine the speed of a moving object; it is widely used in traffic control and meteorology. It is used law-enforcement to measure the speed of moving vehicles and is frequently used in professional spectator sports to measuring bowling speed; pitched baseball velocity, athlete performance, and tennis serve speed [19]. RADAR speed gun is based on a Doppler RADAR unit which calculate the speed of the object at which it is pointed to by detecting a change in frequency of the returned RADAR signal caused by the Doppler Effect [19]. The frequency of the returned signal increases as the object's speed of approach if the object is approaching, and lowered if the object is receding. Modern LIDAR which uses pulsed laser light replaces radar guns from 2001 through 2009 [19] [20] because of its small radar system which uses pulsed laser light instead of radar.

RADAR speed gums, like other types of RADAR, comprises a radio transmitter and receiver. They emit a focused radio signal and subsequently capture its return after it reflects off the target object. The Doppler Effect comes into play here, altering the frequency of the returned radio waves when the object is in motion toward or away from the gun. Utilizing this frequency shift, the RADAR speed gun can perform calculations to determine the speed.

The speed gun calculates the speed of the object from the difference in the frequency of the object when they are approaching and receding [20] [21].

- **LASER SPEED GUNS**

The speed of a vehicle can be measured using LIDAR when the vehicle passes through or breaks the first beam, the embedded microprocessor records the time at which was disconnected [22]. As the vehicle crosses the second beam, it records the moment of the second interrupt. The sensor calculates the vehicle speed base on the distance between the two beams and the time intervals. Placing the sensor on the road surface enables precise measurement for all vehicles in multi-lane settings, greatly reducing the risk of sensor blockage. Furthermore, the sensors can simultaneously measure the speed of vehicles moving in either same or opposite directions.

LIDAR also find its application in meteorology when the American Center for Atmospheric Research employed it for cloud measurements [23, 24]. Its adoption and visibility expanded when NASA astronauts used it to map the lunar surface during the Apollo 15 mission [25]. As described by the US Department of Meteorology and Hydrology, a typical LIDAR system comprises [26]:

- Laser Generator

The choice of laser generator usually ranges from 600 to 1000nm because of it low cost. However, it poses a risk to the eyes, so the regulations prompt a limit on the energy levels. The 1550nm wavelength is safe for the eyes at higher power levels, but the receiver is not as modern, so it is usually not suitable for long-range applications with lower accuracy.

- Scanner

The scanner is used to control the laser to rotate around the environment.

- Receiver

The receiver reflects the laser signal.

For instance, a positioning system can be a GPS sensor and a gravity sensor to determine the direction and location. In this system, the laser goes from the emitter directed towards the scanner, often achieved using a rotating mirror. When the laser beam hits the wall, it is reflected and recorded by the receiver, thereby calculating the distance of the transmitter to the wall [14]. Likewise, in case there's obstacle within the room, the laser reflects in a shorter time, indicating a shorter distance to the transmitter. Continuous rotation of the laser enables the creation of a complete room image through synthesis.

- **ULTRASONIC SENSORS**

Ultrasonic sensors have become prominent in the realm of speed measurement due to their non-contact approach, offering versatility, accuracy, and ease of implementation. Operating on the principle of emitting high-frequency sound waves and detecting echoes reflected from objects, these sensors calculate distance by measuring the time taken for waves to return. This principle enables precise speed determination without direct physical contact, making them ideal for various applications such as traffic management, industrial automation, robotics, and sports analytics.

The advantages of ultrasonic sensors for speed measurement are manifold, including non-contact measurement, high accuracy, and wide applicability across industries, environmental adaptability, and cost-effectiveness. They find usage in diverse scenarios, from traffic monitoring for optimizing flow and enforcing laws to industrial automation for monitoring conveyor belt speeds. Additionally, in robotics, ultrasonic sensors aid in navigation and obstacle avoidance, while in sports analytics, they provide valuable data for training and performance analysis. As technology advances, ultrasonic sensors are poised to further enhance speed measurement methodologies, contributing to safer and more efficient operations across various domains.

- **GLOBAL POSITIONING SYSTEM**

The speed measurement in a GPS-based system is based on calculations between satellites and ground devices like smart phones or GPS trackers [25]. By transmitting signals from the device to satellites and back, this system can measure the speed of an object an accurately. When a vehicle travels on the road, the transmission device sends data to the GPS satellites, receiving real-time information on its location and status. The more data sent out, the more location points are received in return. Based on time and location point, the device will calculate the speed.

2.2.1.2.3 ADVANTAGES OF NON-CONTACT BASED SPEED MEASUREMENT SYSTEM

- Non-invasive: Non-contact speed measurement systems do not require physical contact with the object being measured, reducing wear and tear on equipment and minimizing the risk of damage to delicate objects.
- Remote Operation: These systems can measure the speed of objects from a distance, allowing for safe and convenient operation in hazardous or hard-to-reach locations.
- High Accuracy: With advancements in sensor technology and data processing algorithms, non-contact speed measurement systems can provide highly accurate and reliable speed measurements.
- Versatility: Non-contact speed measurement systems are versatile and can be tailored to suit a wide range of applications and environments, from laboratory research to industrial process monitoring.

2.2.1.2.4 APPLICATIONS OF NON-CONTACT BASED SPEED MEASUREMENT SYSTEM

- Traffic Monitoring and Enforcement: Non-contact speed measurement systems are widely used in traffic management, including speed enforcement, traffic flow analysis, and vehicle counting.

- Industrial Automation: These systems play a crucial role in industrial automation, such as monitoring conveyor belt speeds, controlling robotic movements, and inspecting product quality on production lines.
- Aerospace and Defense: Non-contact speed measurement systems are utilized in aerospace testing, missile tracking, and target tracking applications for research, development, and military purposes.
- Medical Imaging: In medical imaging, non-contact speed measurement systems are employed to measure blood flow velocity, tissue motion, and cardiac function using techniques such as Doppler ultrasound and laser speckle imaging.

2.3 ROAD SAFETY

Road safety is a critical concern worldwide, as road traffic accidents result in significant loss of life, injury, and economic burden. Approximately 1.19 million individuals lose their lives annually due to road traffic crashes worldwide, with between 20 and 50 million sustaining non-fatal injuries [27]. Vulnerable road users like pedestrians, cyclists, and motorcyclists account for over half of these fatalities. These incidents are the primary cause of death for children and young adults aged 5–29, yet two-thirds of the fatalities affect individuals of working age (18–59 years) [28]. Despite low- and middle-income countries having around 60% of the world's vehicles, they bear nine out of ten road traffic fatalities.

Aside from the human toll, road traffic injuries impose a significant economic burden on victims and their families, encompassing treatment expenses for the injured and the loss of productivity for those killed or disabled. This burden extends to national economies, with road traffic injuries costing countries approximately 3% of their annual gross domestic product.

The increase in global road traffic fatalities is primarily caused by the growing number of deaths occurring on roads in low- and middle-income nations, especially within emerging economies. In many middle-income countries, the likelihood of experiencing road traffic injuries is influenced by various social factors, including alcohol consumption while driving, excessive speed, traffic patterns, and the development of urban infrastructure.

Despite efforts by countries in the region to implement interventions aimed at reducing road traffic injuries, progress has been slow. Recognizing the severity and impact of road traffic fatalities and injuries, the UN General Assembly adopted Resolution 64/255 in 2010, establishing the Decade of Action for Road Safety to curb and diminish projected levels of global road traffic fatalities.

In 2011, the Pan American Health Organization (PAHO) endorsed the "Plan of Action on Road Safety" during its 51st Directing Council meeting. This plan, tailored to the region's specific circumstances and aligned with the Decade of Action for Road Safety, provides guidance for member states as they work toward the objective of preventing and managing road traffic fatalities within the region.

Since the inception of the initial Decade of Action (2011-2020), the United Nations has adopted a comprehensive and collaborative approach to managing road safety. This strategy addresses the interplay between speed, vehicles, road user behaviour, and road infrastructure. The five key pillars of the strategy - road safety management, safer vehicles, safer road users, post-crash response, and safer driving environments - offer a holistic framework for understanding road safety within the UN context and guide our efforts in this area. The ambitious goal of reducing road fatalities and serious injuries by 50 percent, as set forth in the Global Decade of Action for Road Safety (2011-2020) and SDG 3.6, was reaffirmed in 2021.

The Second Decade of Action for Road Safety (2021-2030) was established through UN Resolution A/RES/74/299 on Improving Global Road Safety, with the aim of achieving a 50 percent reduction in road deaths and serious injuries by the end of 2030 [29]. The resolution acknowledges that the vast majority of road traffic fatalities and serious injuries are preventable and emphasizes the importance of addressing this issue due to its significant public health and development implications. The Decade of Action is guided by the Global Plan, which provides governments with a roadmap to achieving the 2030 target.

2.4 RELEVANCE OF SPEED MEASUREMENT SYSTEM TO ROAD SAFETY PERSONNEL

The relevance of a speed measurement system to road safety personnel cannot be overstated, as it serves as a crucial tool in their efforts to enhance road safety and enforce traffic regulations.

1. **Enforcement of Speed Limits**: Speed measurement systems enable road safety personnel, such as police officers or traffic wardens, to monitor vehicle speeds and enforce speed limits effectively. By identifying vehicles that exceed speed limits, authorities can take appropriate enforcement actions, such as issuing citations or warnings, to deter speeding behaviour and promote compliance with traffic regulations.

2. **Prevention of Speed-Related Accidents**: Speeding is a significant contributor to road traffic accidents and fatalities. Speed measurement systems help road safety personnel identify high-risk areas where speeding is prevalent, allowing them to implement targeted interventions, such as increased enforcement or the installation of speed calming measures, to mitigate the risk of speed-related accidents and save lives.

3. **Data Collection and Analysis**: Speed measurement systems provide valuable data on vehicle speeds and traffic patterns, allowing road safety personnel to analyze trends, identify problematic areas, and make informed decisions about road safety interventions. By understanding the factors contributing to speeding behavior, authorities can develop targeted strategies to address road safety challenges effectively.

4. **Public Awareness and Education**: Speed measurement systems can also be used as educational tools to raise public awareness about the importance of adhering to speed limits and the consequences of speeding. Displaying real-time speed data or using speed measurement data in public awareness campaigns can help educate motorists about the dangers of speeding and encourage responsible driving behaviour.
5. **Evaluation of Road Safety Initiatives**: Speed measurement systems facilitate the evaluation of road safety initiatives and interventions aimed at reducing speeding and improving road safety. By measuring changes in vehicle speeds and crash rates before and after the implementation of specific interventions, road safety personnel can assess the effectiveness of their efforts and make adjustments as needed to achieve desired outcomes.

Overall, speed measurement systems play a vital role in the work of road safety personnel by enabling them to monitor vehicle speeds, enforce speed limits, prevent speed-related accidents, collect and analyse data, raise public awareness, and evaluate road safety initiatives. Investing in reliable speed measurement technology and providing training to personnel on its use can significantly contribute to improving road safety outcomes and saving lives on our roads.

2.5 RESEARCH ON PREVIOUS WORK DONE

A lot of research has been done on motion detectors approaches to reduce insecurity and other applications. A couple of methods were used like the Passive Infrared (PIR) sensors.

Arduino Uno microcontroller was used to detect the motion of an object or intruder. This study using Arduino Uno initiates other researchers to detect an intruder using light emitting diode (LEDs) and Piezo Buzzer to invent sound signal. The system utilizes an ultrasonic range finder to identify nearby obstacles. This ultrasonic sensor is positioned on a sub micro servo to provide a sweeping view. In addition, a passive Infrared (PIR) sensor is employed to trigger the sonar system when motion is detected [30].

The sensor readings and distance measurements from the device are transmitted via a protocol to the computer for graphical representation. Code running on the microcontroller generates audible alerts through a serial driven voice synthesizer chip connected to a compact speaker. The limitation to the invention was that it was not able to display the distance between the intruder or object and the sensor to the liquid crystal display (LCD).

A motion detector was invented by using ultrasonic sensor and Arduino Uno microcontroller to detect motion and also display the distance using liquid crystal display (LCD). The Motion detector is cost-effective and straightforward, offering precise distance measurements with suitable accuracy and resolution. It serves as a practical solution for non-contact distance measurement and finds applications across various fields [31].

For accurate distance calculation, the device must be positioned perpendicular to the plane of the ultrasonic wave propagation. Thus, the study limitation is that it only function when there is eye focus on the LCD screen because the sensor used has only a visual signal, no sound or a recorded signal.

The study was based on using simple harmonic motion detector, ultrasonic distance sensor and Arduino microcontroller. Pendulum bob was used as the experimental object to be sensed. The simple harmonic motion of a mass on a spring was investigated, and the experiment data was collected by the use of an ultrasonic sensor and Arduino board. The experiment was successful but also has limitation; the study has no other interfaces like the Piezo Buzzer, LCD and LEDs [32].

The design was based on using an ATmega328P microcontroller from Atmel. The system can be used to measure the distance of an object from 2cm to 400 cm, by the use of HC-R0 ultrasonic sensor [13]. The speed of dry air depends on the temperature [34] [35]. The sensor is interfaced to an ATmega328P AVR microcontroller to compute distance from 5cm to 400 cm. Temperature sensors TMP36 from analog devices is interfaced to the microcontroller for measuring temperature of the environment and thereby computing the speed of the sound wave to obtain a more accurate distance measurement [33].

The computed distance displayed via LCD. The accuracy of the designed system is increased by using TMP36 sensor for the temperature compensation [36] since the speed of the ultrasonic wave is affected by change in temperature.

The ultrasonic anemometer which is used to measure the wind speed is designed to store data on a memory card and integrated with IoT to access the measurement on the phone through the Bynk application. Ultrasonic anemometer testing comprises several phases. Initially, the HC-SR04 sensor undergoes characterization and calibration. Subsequently, a Kalman filter is applied to the HC-SR04 sensor and testing is conducted with varying process noise covariance to identify the most suitable filter coefficient [37].

The wind speed and direction are calibrated within wind tunnels. The anemometer is deployed to measure wind speed and wind direction in the field. The anemometer has been made to have error below 1.5% [18] and a Kalman filter is used in the HC-SR04 sensor to reduce the measurement noise of the sensor. The results of the ultrasonic anemometer calibration have wind speed measurements resolution of 0.1m/s, measurement error of 0.14 m/s and have wind direction measurement resolution of 1^{o} with a measurement error of 7^{o} [37,38].

The motivation for this project is due to the research mentioned in references above. The aim is to design speed measurement device using Arduino Uno, LEDs, Piezo Buzzer, Ultrasonic Sensor and subsequently emitting sound while recording signal. In addition, the recorded signal is displayed on LCD screen.

2.6 COMPUTER - BASE SYSTEM METHOD FOR ROAD SAFETY PERSONNEL

A computer-based system designed for road safety personnel can significantly enhance their ability to manage road safety and enforce traffic regulations. It offers centralized data management and analysis capabilities, allowing for the storage and analysis of various types of relevant data such as accident reports, traffic violations, and driver records. Integration with traffic monitoring and surveillance technology enables real-time monitoring of traffic conditions and automated alerts for incidents.

The system streamlines enforcement and citation management processes through automated ticketing and digital record-keeping, while also providing training and educational resources for personnel. Additionally, it facilitates public engagement and communication through online platforms and social media, disseminating road safety information effectively. Performance monitoring and evaluation tools enable the assessment of road safety initiatives, while integration with external systems enhances collaboration and information sharing. Overall, such a system improves operational efficiency, enforcement effectiveness, public engagement, and contributes to creating safer road environments.

2.6.1 SPEED MEASUREMENT USING TRAFFIC CLASSIFIERS (ATC)

Automated Traffic classifiers are computer-based algorithm designed to categorize and manage traffic on networks roadways without human intervention. The primary components within the Real Count TM consist of road sensors, including performed loops and road tubes [39]. Performed loops are linked to Real Count TM units positioned alongside the road, powered by a 12-volt voltage source. The performed loops are connected to I-channel loop detectors, which in turn are linked to a microprocessor. These performed loops serve as instrument for vehicle presence detection and the measurement of vehicle separations, including headways, between successive vehicles moving in groups.

2.6.2 PROBE VEHICLES

Probe vehicle technologies are used in intelligent transportation systems (ITS), such as real-time operational, monitoring, incident detection, and route guidance, while also gathering up-to-the minute traffic data [39]. Although implementing probe vehicle systems involves substantial upfront costs and the establishment of fixed infrastructure, they offer advantages such as cost-effectiveness per unit data collection, and minimal disruption to traffic flow [40]. Probe vehicles are equipped with GPS receivers capable of receiving signals from orbiting satellites. GPS comprises three components: space, control and user segment.

2.6.3 VISION BASED SYSTEM FOR SPEED MEASUREMENT

This system uses an enhanced motion detector and an innovative text detector to efficiently identify vehicle plate number regions, tracked across multiple frames, and corrects for perspective distortion [20]. Vehicle speed is determined by comparing the trajectories of the tracked features with established real-world measurements.

The methodology used in this project is different considering the previous work done in relation to other research work.

CHAPTER THREE

3.0 MATERIAL AND METHODS

3.1 INTRODUCTION

The Arduino microcontroller is used which is economical and efficient [41] [42]. The components are accessible and readily available at electronics suppliers. The programming language employs is user-friendly which is the C++. Its storage minimises space and can reduce congestion [43] [44].

The ultrasonic sensor operates by producing ultrasound waves. The waves are reflected after hitting an obstacle. The distance taken by the waves to hit and be reflected back is recorded in the microcontroller [45]. The Piezo Buzzer generates a sound signal, and the LCD displays the output speed.

3.2 BLOCK DIAGRAM

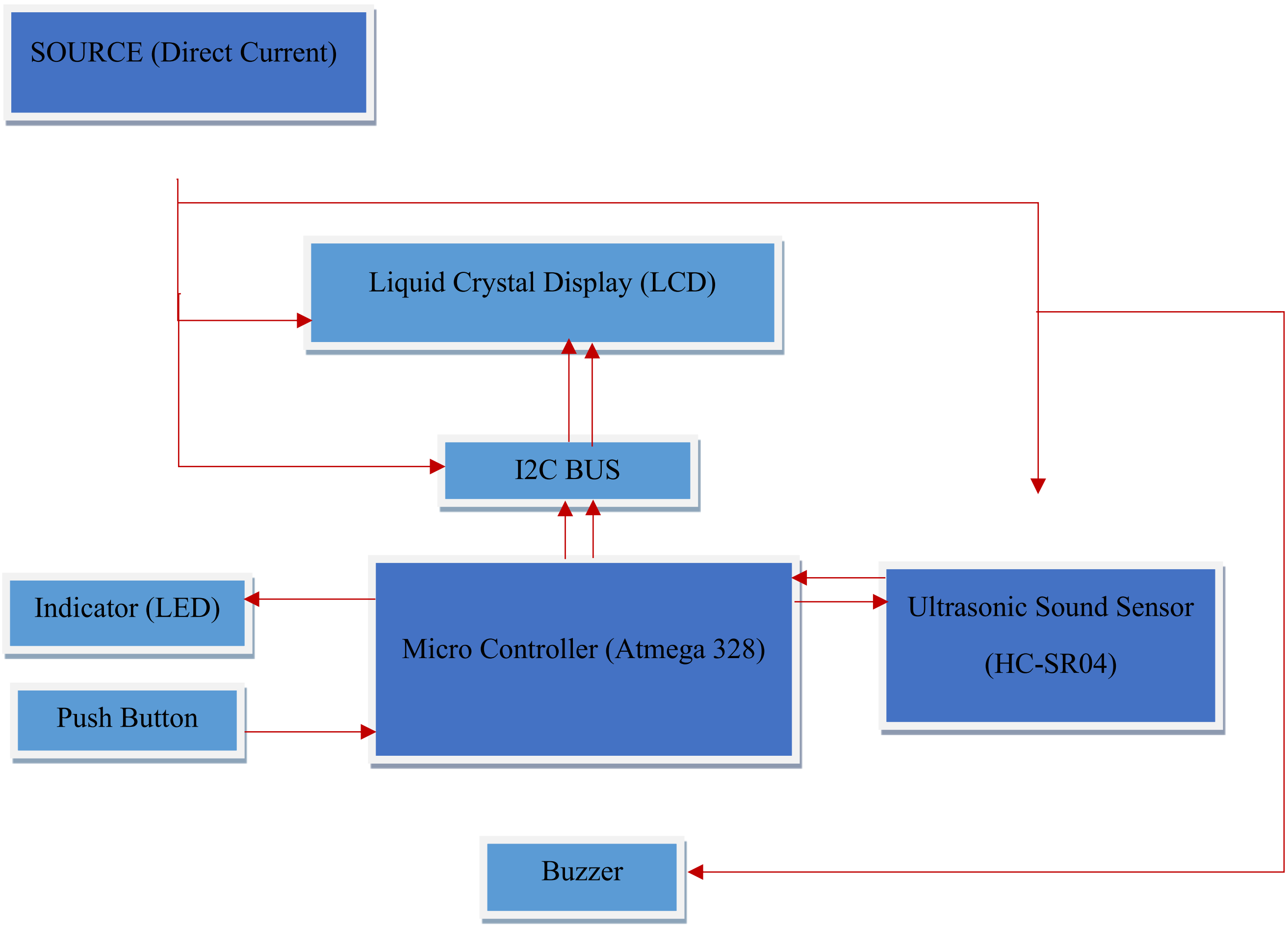

Figure 3.1: Block Diagram

3.3 STUDY AREA

The study area for this project involves exploring the application of ultrasonic technology in developing an efficient and accurate speed measurement system. This project aims to design, implement and evaluate a device capable of determining the speed of objects using ultrasonic waves. The study will delve into the principles of ultrasonic sensing, signal processing techniques and the integration of hardware components to achieve reliable speed measurements. Additionally, it will assess the device's performance and potential applications, contributing to advancements in non-contact speed measurements technologies.

3.4 SYSTEM DESIGN AND IMPLEMENTATION

Designing and implementing a speed measuring device with an ultrasonic sensor involves several key steps spanning hardware selection, circuit design, programming, and testing. In terms of hardware, choosing an accurate ultrasonic sensor, compatible microcontroller, suitable display unit, and appropriate power supply is essential. Circuit design entails connecting the ultrasonic sensor and display unit to the microcontroller while ensuring proper voltage levels and signal routing. Programming encompasses writing code to control the ultrasonic sensor, calculate speed based on distance measurements, and display the results on the chosen output device.

Implementation involves developing the code for the selected microcontroller platform, testing the device with known-speed objects, calibrating if necessary, and designing an enclosure for protection and portability. Additional considerations include implementing noise reduction techniques, incorporating error handling mechanisms into the code, and optionally adding a user interface for enhanced functionality. This step was followed to successfully create a functional and accurate speed measuring device utilizing an ultrasonic sensor.

3.4.1 HARDWARE SUBSYSTEM

The following are the components used;

1. Power supply (Lithium battery 9 Volts)
2. Micro-controller (Atmega 328)
3. Ultrasonic Sound Sensor (HC-SR04)
4. Buzzer
5. Push Button
6. Transistor
7. Resistor

8. Breadboard

9. Potentiometer

10. Jumper wires

11. Liquid Crystal Display (LCD)

12. LED

13. A computer for programming

3.4.1.1 Lithium Battery

A lithium-ion or Li-ion as shown in Figure 3.2 is a rechargeable battery that stores energy by reversibly reducing lithium ions. It’s the primary battery choice for portable consumer electronics and electric vehicles and, it finds substantial uses applications in grid scale energy storage, military, and aerospace sector. It has high energy density, minimal self-discharge, and no memory effect, except for reported instances in poorly manufactured LFP cells.

Figure 3.2: Lithium Battery

3.4.1.2 MICRO-CONTROLLER

The first multi-chip microprocessors, such as the Four-Phase Systems AL1 in 1969 and the Garret AL1 Research MP944 in 1970, uses multiple MOS LSI chips in their designs. The first single-chip microprocessor, the intel 4004 emerged in 1971, fitted on a single MOS LSI chip.

It was developed by Federico Faggin, using his silicon-gate MOS technology, alongside intel engineers Marcian Hoff and Stan Mazor, as well as Busicom engineer Masatoshi Shima.

Subsequently, the 4-bit intel 4040, the 8-bit intel 8008 and the 8-bit intel 8080 followed suit. All of these microprocessors require additional external chips to create a functional system, including the memory and peripheral interface components. Consequently, the overall system cost reached several hundred US dollars in the 1970s, rendering it economically unfeasible for computerizing small appliances.

ARDUINO MICROCONTROLLER

Arduino is an open-source project that develops microcontroller-based kits for constructing digital devices and interactive objects capable of sensing and controlling physical components [46]. These kits are founded on microcontroller board designs, sourced from various manufacturers and utilizing diverse microcontrollers. This system provides sets of digital and analog input/output (I/O) pins that can connect to a variety of expansion boards known as "shields" and other circuits.

The board feature serial communication interfaces, including USB in some variants, to enable program loading from personal computers. For programming the microcontrollers, the Arduino initiative provides an integrated development environment (IDE) based on the Processing programming language, with support for C and C++.

This first Arduino was introduced in 2005, with the goal of offering an economical and user-friendly means for both novices and professional to craft devices that interact with the surroundings through sensors and actuators [47]. Typical examples of such projects aimed at entry-level hobbyists include; simple robots, thermostats, and motion detectors. Arduino boards are available commercially in preassembled form, or as DIY kits. The hardware design specifications as shown in Table 3.1 are openly accessible, allowing anyone to manufacture Arduino boards. E.g. Atmega 328 as shown Figure 3.3.

Table 3.1 Arduino ATMEGA 328 Specifications

Operating voltage	5V
Recommended input voltage	ranges from 7V to 12V
Input voltage	from 6V to 20V
Analog I/O pins	6
DC Current	each I/O pin is 40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB which 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
CLK Speed	16 MHz
Digital I/O Pin	14 (6 provides PWM output)

Figure3.3: AT mega 328 Microcontroller

3.4.1.3 ULTRASONIC SENSOR

An Ultrasonic sensor as shown in Figure 3.4 is an electrical component that measures the distance to an object employing sound waves. An ultrasonic sensor uses transducer to transmit and receive ultrasonic pulses, collecting data regarding an object's closeness. These high frequency sound waves bounce off surfaces, generating distinctive echo patterns. The specification of an ultrasonic sensor is shown in Table 3.2.

Table 3.2 Ultrasonic Sensor Specifications

Operating voltage	5v
Operating current	15mA
Operating Frequency	40 kHz
Measuring angle	15 degrees
Trigger input signal	10 μs high pulse
Dimension	45×20×15mm

Figure 3.4: Ultrasonic Sensor HC-SR04

3.4.1.4 BUZZER

A buzzer as shown Figure 3.5 is an audio signaling like a beeper or buzzer, which can take the form of an electromechanical, piezoelectric, or mechanical device. Its primary purpose is to transform audio signals into audible sounds. Typically, these devices operate on direct current (DC) voltage and find applications in timers, alarm systems, printers, computers, and more.

Depending on their specific designs, they have the capability to produce a range of sounds, including alarms, music, bells and sirens.

The operational principle is based on the idea that when an electric potential is introduced to a piezoelectric material, it induces pressure fluctuations. In a piezo buzzer, piezo crystals are in between two conductors. When a voltage difference is applied to these crystals, they exert force on one conductor while pulling the other due to their inherent properties. This repetitive pushing and pulling motion create a distinct sound wave. The buzzer specification is described in Table 3.3.

Table 3.3 Buzzer Specification

Frequency range	2,300Hz
Rated voltage	6 VDC
Operating Temperature	ranges from -20ºC to +60ºC
Operating voltage	ranges from 4 to 8V DC
Sound pressure level	85dBA or 10cm
Supply current	<30mA

Figure 3.5: Buzzer

3.4.1.5 PUSH BUTTON

A push button as shown in Figure 3.6 is a simple switch mechanism employed to manage various aspects of a machine or a process. These buttons are typically constructed from durable materials, such as plastic or metal, with a surface that is usually flat or contoured to accommodate the human finger or hand for easy depression or activation. Most buttons operate as biased switches, although some unbiased buttons, due to their physical quantities still necessitate a spring to return to their un-pushed state. Terms describing the action of engaging button include; pressing, depressing, mashing, slapping, hitting, and punching.

Figure 3.6: Push Button

3.4.1.6 TRANSISTOR

A transistor as shown in Figure 3.7 is a semiconductor tool used to amplify or switch electrical signals and power. It is one of the basic building blocks of modern electronics. It is equipped with at least three terminals for linking to an electronic circuit. By applying voltage or current to one set of terminals, a transistor controls the current passing through another set. This capacity to amplify a signal arises from the potential for the controlled (output) power to exceed the controlling (input) power. While some transistors are available as standalone units, numerous miniature versions are integrated within microelectronic circuits.

Types of Transistors

1. Bipolar Transistor
2. Diffusion Transistor
3. Avalanche Transistor
4. Dual Gate Transistor
5. Junction Transistor
6. Field Effect Transistor
7. Heterojunction Bipolar Transistor
8. Darlington Transistor
9. Multiple-Emitter Transistor
10. Schottky Transistor

3.4.1.6.1 Bipolar Transistor

Bipolar Transistor are current-controlled devices and are of two types NPN and PNP. In the NPN type, the primary current carriers are electrons, whereas in the PNP type, the primary carriers are holes.

3.4.1.6.2 Heterojunction Bipolar Transistor

Heterojunction bipolar transistors are used in analog or digital microwaves with higher frequency. It has faster switching speeds and provides better lithographic yield. They present better emitter injection efficiency.

3.4.1.6.3 Diffusion Transistor

Diffusion Transistor is one type of Bipolar Junction Transistor and they are formed by diffusion of dopants into a semiconductor substrate. For example, Philco's micro-alloy diffused transistor.

3.4.1.6.4 Avalanche Transistor

It is a type of Bipolar Junction Transistor which process the region of collector-current/collector-to-emitter voltage and which is beyond the voltage of the breakdown of collector-to-emitter also called avalanche breakdown voltage. The operation here is called avalanche-mode operations when it switches between high currents in less than nanoseconds.

3.4.1.6.5 Dual Gate Transistor

The dual gate transistor operates as two MOSFET devices in series. There are two gates which is made-up along the length of the channel. Both gates affect the general MOSFET operation and the output.

3.4.1.6.6 Field Effect Transistor

Field Effect Transistors are voltage controlled and have high input impedance which causes small current to pass through them. They are unable to provide the same type of amplification compare to BJTs.

3.4.1.6.7 Junction Transistor

The junction Transistor is a type of FET transistor that has no PN junctions but the majority of current flows through two electrical connections at either end called the Drain and Source respectively. These are of two types N-channel and P-channel.

3.4.1.6.8 Schottky Transistor

Schottky transistors are formed when a transistor is combined with a Schottky diode. Schottky transistor is introduced to prevent the transistors from saturating by the diversion of extreme input current.

3.4.1.6.9 Darlington Transistor

Darlington Transistor is a specialized configuration that combines two standards NPN or PNP bipolar junction transistors (BJT). In this arrangement, the emitter of one transistor is linked to the base of the other, resulting in a highly sensitive transistor with significantly enhanced current amplification capabilities. This transistor is used for either current amplification or switching is required.

They are constructed by connecting two individual bipolar transistors, or they are obtained as a single integrated device with the customary base, emitter and collector lead in a single package. They are available in a diverse range of case styles and come with various voltage and current ratings, both in NPN and PNP configurations.

Figure 3.7: Transistor

3.4.1.7 RESISTOR

A resistor as shown Figure 3.8 is a passive electrical component with two terminals that serves as a circuit element to introduce electrical resistance. Within electronic circuits, resistors play various roles, including reducing current flows, adjusting signal levels, and dividing voltages, biasing active components, and terminating transmission lines. In certain applications, high-power resistors capable dissipating significant electrical power as heat are employed, such as in motor controls, power distribution systems, or as load components for testing generators.

Fixed resistors have resistances those changes due to factors like temperature, time, or operating voltage. Variable resistor is used in circuit adjustment, like volume controls or lamp dimmers, and as sensors for detecting heat, light, humidity, force, or chemical activity.

Resistors are integral components of electrical networks and electronic circuits, present ubiquitously in electronic devices. They come in various compositions and physical forms when used as discrete components and are also integrated into electronic circuits. The resistance of a resistor which defines its electrical function spans a wide range, with commercial resistors having nominal values within the manufacturing tolerance, indicated on the component.

Figure 3.8: Resistor

3.3.8 BREADBOARD

A breadboard as shown Figure 3.9 is a construction based for prototyping electronic. In the 1970s the solderless breadboard, also known as a plug board or terminal array board, emerged and has since become the commonly recognized. The major advantage of soderless breadboard is that they are reusable, as they eliminate the need for soldering. This feature makes it ideal for creating temporary prototypes and experimenting with circuit design, making them particularly popular in educational settings, including among students.

Unlike older bread boards types such as strip boards or prototyping printed circuit boards like Vero boards, which are commonly used for semi-permanent soldered prototypes or one offs and are not easily reusable. Breadboards can accommodate a wide range of electronic systems, from small analog and digital circuit to complete central processing units (CPUs). In this project a breadboard was employed for prototyping before transferring the design onto a Vero board for permanent soldering.

The solderless features row of sockets designed to secure electronic components for circuit assembly. The two rows running lengthwise (from left to right) on the breadboard are designated for linking to power (red) and ground (blue) lines in a circuit. Each short column (green) on the breadboard is internally connected, but these columns are isolated from each other. This means that components with one "leg" placed in the same green column are interconnected. The central section of the breadboard acts as a separator, effectively dividing it into two distinct unconnected halves.

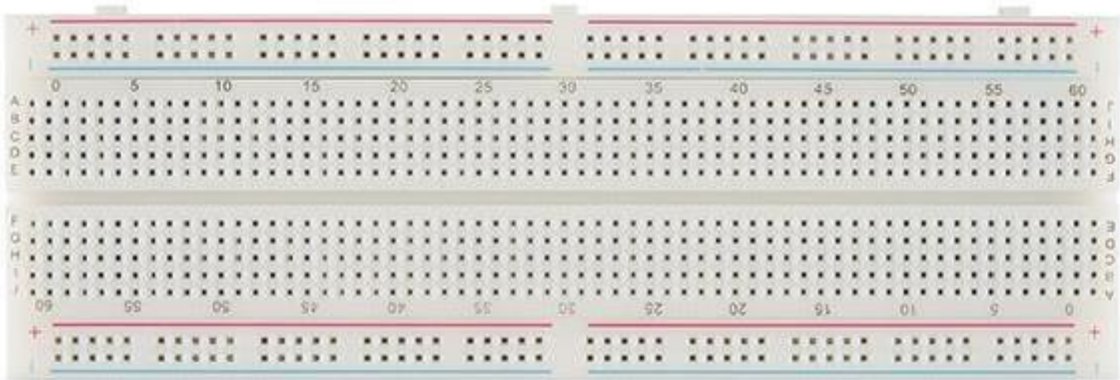

Figure 3.9: Breadboard

3.4.1.9 POTENTIOMETER

A potentiometer as shown Figure 3.10 is a resistor with three terminals, featuring a movable contact that can slide or rotate, effectively creating an adjustable voltage divider. When only one terminal is used, one end and the wiper- it functions as a variable resistor or rheostat.

Potentiometer is an instrument used for measuring electric potential (voltage), essentially operates as a voltage divider. The physical component embodies the same underlying principle, which is why it bears the same name.

Potentiometer finds common application in the control of electrical devices, such as volume adjustments in audio equipment. In cases where they are actuated mechanically, potentiometers can serve as position transducers, for example, in a joystick. However, it's rare to see potentiometers directly controlling substantial power levels (exceeding a watt) due to the dissipated power within the potentiometer nearing that of the load it's meant to control.

Figure 3.10: Potentiometer

3.4.1.10 JUMPER WIRES

Jumper wire as shown figure 3.11 is an electrical wire or a cluster of wires within a cable, featuring connectors or pins at both ends (or occasionally left "tinned" without connectors). These wires are primarily utilized to establish connections between components on a breadboard or within a prototype or testing circuits, either internally or with other devices or components, all without the need for soldering.

The need to attach jumper wires to circuit board assemblies is inevitable. And can be categorized as follows:

Jumper wires that are categorized as integral components of the original design must have their routing, termination, and bonding documented through engineering instructions or drawing notations.

Those added post-original design to effect changes require documentation via engineering change notice instructions or drawing notations. Jumper wires can also be used to rectify defect as needed.

Some of the general rules to be followed when attaching and working with jumper wires and the reason for them are:

1. Jumper wires should place on the component side of the circuit board whenever possible. Typically, this side hosts the majority of the larger components.
2. Jumper wires are routed in X-Y manner with minimal bends, promoting organization, material efficiency, and enhanced reliability.
3. The elevation of the wires should be limited to 3.2mm (.125 inches) above the board surface, ensuring they don't interfere with circuit board mounting to avoid damage.
4. Routing jumper wires on unused component lands or pads should be avoided unless the layout of the assembly prohibits the routing in other areas.
5. If a jumper wire passes over an unused land or pad sufficient slack should be provided so that the jumper wire can be moved out of the way in case a component needs to be added. Jumper wires should not be route over pads or via used test points. Once jumper wires are added have been added to a circuit board the less, they are disturbed or moved, the better.

Figure 3.11: Jumper Wires

3.4.1.11. LIQUID CRYSTAL DISPLAY (LCD)

LCD (Liquid Crystal Display) as shown in figure 3.12 screen is an electronic display module with a wide array of applications. Among these, the 16×2 LCD stands out as a fundamental module commonly employed in various devices and circuits. These modules are favored over alternatives like seven segment displays and other multi-segment LEDs for several reasons.

The key advantages of LCDs include their cost-effectiveness, ease of programmability, and their ability to display not only special characters and animations, which is a limitation in seven-segment displays. In the context of a 16×2 LCD, it signifies the capability to show 16 characters per line across two lines, with each character represented in a 5×7-pixel matrix.

Within the LCD, two registers play essential roles: the Command register and the Data register. The command registers stores instructions provided to the LCD, dictating specific tasks such as initialization, screen clearing, cursor positioning, and display control. On the other hand, the Data register houses the information to be displayed on the LCD, which corresponds to the ASCII value of the character to appear on the screen.

16x2 LCD pinout descriptions:

1. Ground/Source Pin (Pin 1): This pin serves as the ground connection for the display. It's used to connect to the ground terminal of the microcontroller unit or the power source.

2. Voltage Supply Pin (Pin 2): This pin is responsible for supplying voltage to the display. It's connected to the power source's supply pin.

3. Contrast Control Pin (Pin 3): Pin 3 controls the contrast of the display. To adjust contrast, it's linked to a variable resistor (POT) that can provide a voltage range of 0 to 5V.

4. Register Select/Control Pin (Pin 4): This pin determines whether the display should interpret incoming data as a command or regular data. It's connected to a microcontroller unit pin and receives either a 0 (for data mode) or 1 (for command mode).

5. Read/Write Control Pin (Pin 5): Pin 5 is responsible for switching the display between read and write operations. It connects to a microcontroller unit pin and receives either a 0 (indicating a Write Operation) or 1 (indicating a Read Operation).

6. Enable/Control Pin (Pin 6): To initiate the Read/Write process, this pin must be set high. It's connected to the microcontroller unit and is held high continuously during operation.

7. Data Pins (Pins 7-14): These pins are used for transmitting data to the display. They can be connected in either 4-wire mode or 8-wire mode. In 4-wire mode, only four pins (0 to 3) are connected to the microcontroller unit, while in 8-wire mode, all eight pins (0 to 7) are connected.

8. Positive LED Pin (Pin 15): This pin is linked to the positive terminal of the LED backlight and is connected to +5V.

9. Negative LED Pin (Pin 16): Pin 16 is connected to the negative terminal of the LED backlight and is linked to the ground (GND).

Features of the LCD16×2

- Operating voltage 4.7V to 5.3V.
- It consists of two rows, each capable of displaying 16 characters.
- It has low current consumption of 1mA without backlight.
- Each character can be composed of a 5×8-pixel grid.
- Supports alphanumeric characters and numbers.
- Operates in two modes 4-bit and 8-bit.
- It has blue and green backlight options.
- It allows custom-created characters.

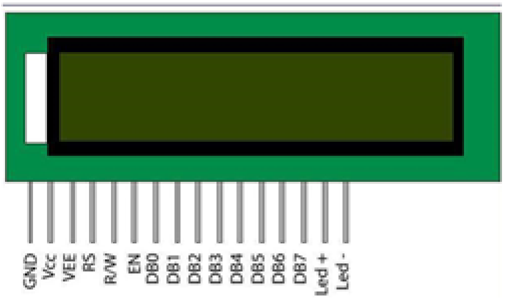

Figure 3.12: LCD (Liquid Crystal Display)

3.4.1.12. LIGHT EMITTING DIODE

Light-emitting diode (LED) as shown in Figure 3.13 is a semiconductor light source comprising two leads. It operates as a p-n junction diode, emitting light upon activation. When an appropriate voltage is applied to the lead's electrons recombine with electron holes inside the device, releasing energy in the form of photons. The phenomenon is known as electroluminescence, with the light's colour determined by the semiconductor's energy band gap.

LEDs are typically small (less than 1mm^2) and may incorporate optical components to shape their light emission pattern. The first LEDs emit low-intensity infrared-light, which is still used in remote-control circuits. The earliest visible light LEDs were limited to red and low intensity.

Modern LEDs cover a wide range of wavelengths including visible, ultraviolet, and infrared, offering high brightness. Initially, LEDs served as indicator lamps in electronic devices, replacing small incandescent bulbs. They evolved into numeric readouts like seven-segment displays and were commonly found in digital clocks. Recent advancements have expanded their use in environment and task lighting.

LEDs have numerous advantages over incandescent bulbs, such as lower energy consumption, longer lifespan, increased durability, compact size and rapid switching. They find applications in aviation lighting, automotive headlights, advertising, general lighting, traffic signals, camera flashes, and also lighted wallpaper.

Figure 3.13: LED (Light Emitting Diode)

3.5 HARDWARE DETAIL SYSTEMS CONNNECTIONS

The components are connected as follows: The Arduino microcontroller is fixed to the breadboard, and the jumper wires is connected in the following sections. One jumper wire from the 5-volt pin on the microcontroller was connected to the lower channel of the breadboard. Another jumper wire connected from the microcontroller ground pin to the upper channel of the breadboard.

The Piezo Buzzer positive terminal is connected to a NPN Darlington transistor to act as switch and amplifier to amplify the frequency of the buzzer. It is then connected to pin A3 of the microcontroller while the negative is connected to a 330 Ohms resistor and then connected to the lower channel of the breadboard. The Ultrasonic sensor has four pins that are $V_{cc,}$ Trig, Echo and ground. The Echo is connected to pin number 7 while Trig being connected to pin number 9 in the microcontroller. The V_{cc} is connected to the upper channel, and ground was connected to the lower channel of the breadboard.

The LCD has 14 terminals, which is connected to the I2C module then 4 terminals from the I2C module is connected to the microcontroller as follows: V_{cc} to the upper channel, the ground to the lower channel of the breadboard, the SDA pin to A4 of the microcontroller and SCL pin to A5 of the microcontroller. The 5V pin from the microcontroller is connected to the positive line on the breadboard, and the ground pin is connected to the bread board's negative part. The Red LED is connected to 330 ohms resistor then connected to the A3 pin of the microcontroller. The Green LED is connected to 330 ohms resistor then connected to A0 pin of the microcontroller. The push button which is used as recheck is connected to the A1 pin of the microcontroller.

The code is generated using a computer with the appropriate Arduino IDE program and transmitted to the Arduino microcontroller to execute the circuit. The connection is then transferred to the dot board after testing on the breadboard for permanent soldering.

3.6 SOFTWARE SUBSYSTEM

The method employed for designing this prototype is a top-down structured architectural software design. This method facilitates easy testing and debugging for programmers, while also enhancing readability and comprehension for readers. The program architecture is divided into four sections, namely:

- The Main parts
- The Program structures
- The libraries and,
- Core specific APIs (Application Programming Interface)

3.6.1 THE MAIN PARTS

This segment of the program architecture comprises three primary components:

- Functions: It is responsible for overseeing the Arduino board, in this instance, the ATMEGA 328, and executing computations. Examples include actions like reading or writing a state to a digital pin, mapping a value, or utilizing serial communication.
- Variables: These include constants, data types, and conversions, such as int, Boolean, and array.
- Structure: It includes the elements of the program code (C++), such as:
  - Sketch (loop(), setup())
  - Control structures (if, else, while, for)
  - Arithmetic operators (multiplication, addition, subtraction)
  - Comparison operators like equal to (==), not equal to (! =), greater than (>), less than (<), and logical operators (&&), or (||).

3.6.2 THE PROGRAM STRUCTURE

The fundamental requirement for an Arduino program is the incorporation of two functions: void setup() and void loop(). The use of "void" indicates that these functions do not return anything upon execution.

- void setup(): It is executed only once when the ATMEGA 328 is powered on, this function is where we define settings like pin mode (input or output), serial communication baud rate, or library initialization.
- void loop(): This is the section where the code intended for repetitive execution is placed. Examples include tasks like toggling an LED based on an input or performing sensor readings at regular intervals.

3.6.3 LIBRARIES

Libraries help to simplify the utilization of intricate code, like reading from a specific sensor, managing a motor, or establishing an Internet connection. Rather than manually composing extensive code for these tasks, one can simplify the process by installing a library. By including the library at the beginning of the program in the Integrated Development Environment (IDE), users gain access to its various functionalities effortlessly. To incorporate a library into your program, you simply include it at the top, as shown below: #include <Library.h>

3.6.4 CORE SPECIFIC API

Each Arduino board necessitates the installation of a "core" or "package" to enable programming. These packages encompass the standard Arduino API, along with a board-specific API that is exclusive to certain boards. In the instance of the ATMEGA 328, being a variant version of the Arduino board, it requires its dedicated package and libraries referred to as "Arduino Uno." These are meticulously crafted and programmed to cater specifically to the functionalities of the ATMEGA 328.

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

The aim of this chapter is to examine and validate the sensor modules employed in developing and operating the Speed Measuring Device. Additionally, it explores programming techniques and system strategies by breaking down each code and configuration into routines and subroutines. This breakdown offers an overall understanding of the program flow and implementation, enabling the microcontroller to accept and execute data and commands.

4.1 CIRCUIT DESIGN

The circuit diagram shown below was done using the Proteus software and the microcontroller used for this simulation was the Arduino Uno board which has 14 digital input/output pins (of which 6 are used as PWM outputs), 6 analog inputs.

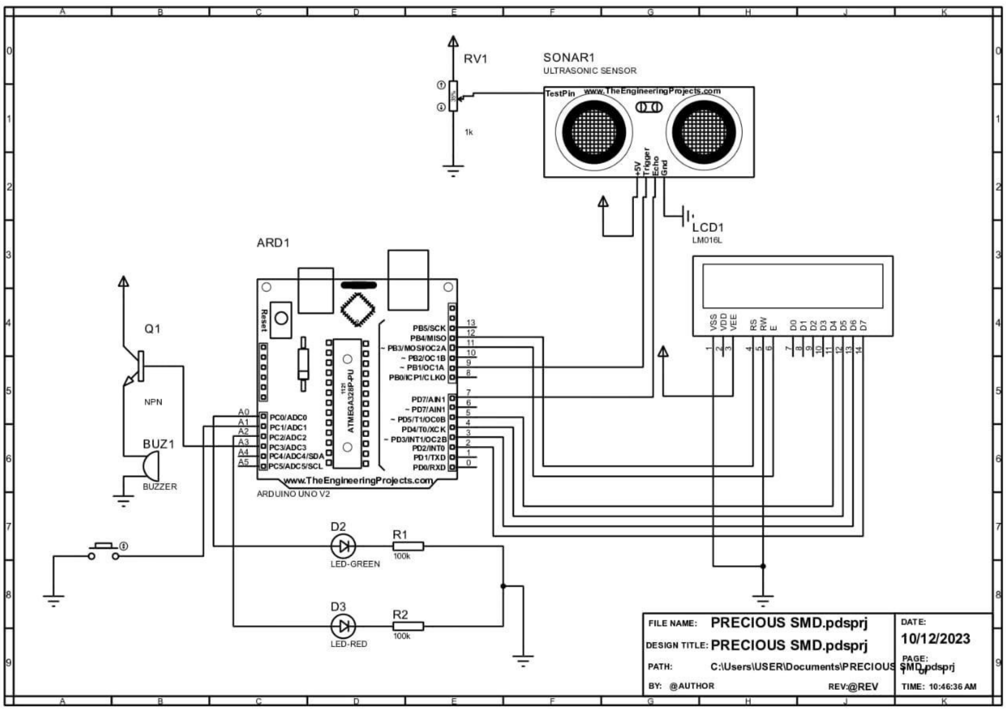

Figure 4.1: Schematic Diagram

4.2 FLOW CHART

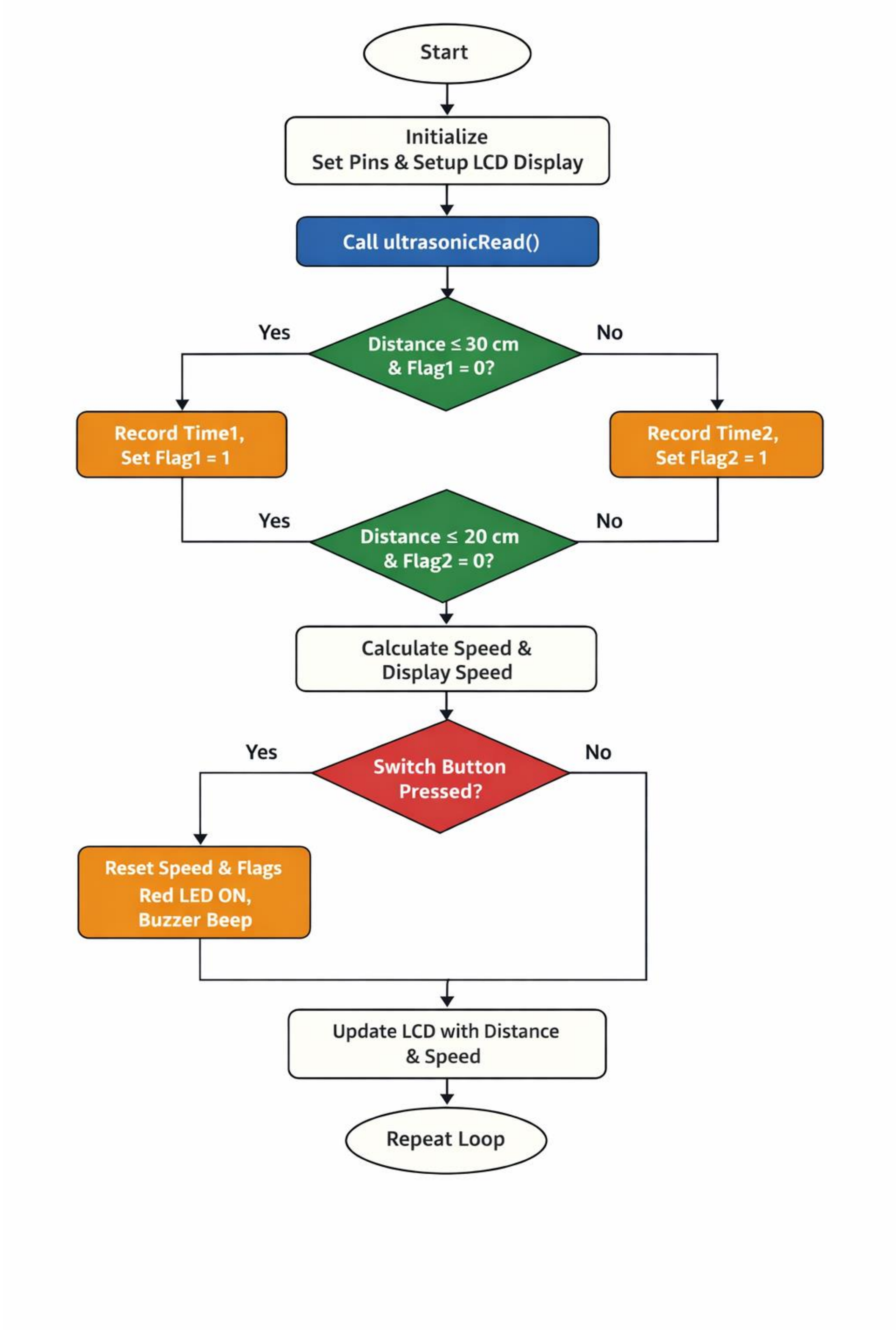

Figure 4.2: Flow Chart

4.3 CALIBRATION OF RESULTS

Calibration of the system involves adjusting the system to ensure that the measured speed corresponds accurately to the actual speed of the moving object. An Arduino IDE calibration code was developed to utilize data from the ultrasonic sensor for determining the speed of a passing object, serving as the reference speed. The code incorporates considerations such as the speed of sound, distance computations, and unique sensor characteristics. Implementation involves calibrating the sensor by leveraging reference distances and speeds. Subsequently, the code is uploaded onto the Arduino Uno of the system, and the measured speed is compared against the expected speed of the reference object to identify any discrepancies. Calibration parameters are fine-tuned to minimize discrepancies. Following adjustments, the system undergoes retesting with the reference objects to ascertain if the measurements now closely align with the actual speeds.

4.3.1 CALIBRATION CODE

```
#define TRIGGER_PIN 9

#define ECHO_PIN 7

void setup() {

  Serial.begin(9600);

  pinMode(TRIGGER_PIN, OUTPUT);

  pinMode(ECHO_PIN, INPUT);

}

void loop() {

  long duration, distance;
```

```
  float speed;

  digitalWrite(TRIGGER_PIN, LOW);

  delayMicroseconds(2);

  digitalWrite(TRIGGER_PIN, HIGH);

  delayMicroseconds(10);

  digitalWrite(TRIGGER_PIN, LOW);

  duration = pulseIn(ECHO_PIN, HIGH);

  distance = (duration / 2) / 28.5;

  // Assuming known distance of 100 cm

  if (distance < 100) {

    // Assuming known time of 1 second for the object to traverse 100 cm

    speed = 100 / (float)duration;

    Serial.print("Speed: ");

    Serial.print(speed);

    Serial.println(" km/s");

  } else {

    Serial.println("Object out of range");

  }

  delay(1000); // Adjust delay as needed

}
```

4.4 DATA ANALYSIS

The data collection process involved the utilization of a toy car as the reference object of study. This entailed a comprehensive approach wherein various parameters were recorded and analyzed. The reference distance, crucial for establishing a baseline for measurement, was measured. This reference distance denotes the distance between the reference object and the system.

The measured speed of the reference object was measured by employing the designated system. This involved employing a calibrated mechanism to accurately ascertain the velocity of the reference object as it traversed its course. The expected distance and error rate were calculated to ensure precision in the analysis. The expected speed was deduced based on theoretical considerations and was compared with the actual measurements to ascertain any disparities, hence facilitating a comprehensive understanding of the data.

$$\text{Speed}= \frac{distance\ (cm)}{Time\ (s)} \text{ ….. eqn i}$$

To determine the expected speed, the formula above was employed, denoted as equation i. This formula provided a structured approach to derive the anticipated speed of the reference object, offering a quantitative insight into its performance. The distance of the object was measured using a tape measure, ensuring accuracy and reliability in the recorded data. The reference object maintained a constant speed throughout the experiment; the measurement of time was crucial. This necessitated the utilization of a stopwatch to meticulously record the duration of the reference object traversal. Multiple readings were conducted to mitigate any potential discrepancies, and an average value was computed to enhance the accuracy and reliability of the data.

In essence, the data collection process was characterized by a meticulous attention to detail, incorporating a systematic approach to capture and analyze various parameters pertinent to the study of the reference object dynamics.

Table 4.1: Performance Evaluation of the System

S/N	Reference Distance (cm)	Measured Speed (km/s)	Expected Speed (km/s)	Error Rate (%)
1	50	0.00035	0.00036	2.78
2	100	0.00069	0.00070	1.42
3	200	0.00146	0.00150	2.66
4	300	0.00199	0.00200	0.50
5	400	0.00290	0.00300	3.33
				$\sum x = 10.69$

$$\text{Mean of the Error rate } (\mu) = \frac{\sum x}{N} = \frac{10.69}{5} = 2.138\%$$

4.5 VALIDATION OF RESULTS

The data was collected at various distances from the system to the reference object for accuracy. The Error rate for each measurement was calculated and the average error rate was calculated which is 2.138%. The error rate can be due to environmental condition like: Temperature, Humidity, Air Density of the environment, Interference from other electronic devices operating on similar frequencies.

The standard deviation of the error rate was calculated as shown below for assessing the precision of the system which is within acceptable limits, estimating the error rate of the system, monitoring performance of the system, ensuring compliance with specifications, and optimizing measurement processes. It provides valuable insights into the reliability and quality of the speed measurement data collected, which enables informed decision-making and for continuous improvement of the systems. The standard deviation of the error rate was calculated to be 1.0606 % as shown below.

Table 4.2: Standard deviation Calculation

S/N	Error Rate X (%)	X - μ	$(X - \mu)^2$
1	2.78	0.642	0.4121
2	1.42	-0.718	0.5155
3	2.66	0.522	0.2725
4	0.50	-1.638	2.6830
5	3.33	1.192	1.4208
			$\sum(x - \mu) = 5.3030$

Standard Deviation of the Error Rate (δ) = $\frac{\sqrt{\Sigma(x-\mu)^2}}{N} = \frac{5.3030}{5}$ = 1.0606 %

4.6 ADVANTAGES, DISADVANTAGES & APPLICATION OF THE SYSTEM

4.6.1 Advantages

- It is easy to implement.
- The circuit is running on + 9v which is easier to generate.
- It provides accurate reading.
- It covers relatively long distance without loss of accuracy.
- Low maintenance costs and increased device longevity.

- Reduction in risk and injury of personnel or damage to equipment since no physical contact is needed.
- It minimizes the labour required from multiple individuals.

4.6.2 Disadvantages

- The circuit might experience failure and causes various problems.
- Interference in the device due to environmental factors like: wind, rain, obstacles e.t.c. in sensor path can affect its accuracy.
- Extreme temperature changes can lead to inaccuracy in the device.
- Ultrasonic signals can be affected by reflective surfaces or materials that refract sound waves, leading to distorted readings.

4.6.3 Application

- Bridge construction.
- Highways.
- Two lane road construction.
- Emergency response.
- Event Traffic control.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Due to the increase in the population and advancing economy necessitate efficient workforce management, especially in urban areas. Manual labor, while essential for tasks like security and care giving, poses limitations and risks such as errors and corruption. The surge in road accidents, largely due to over speeding, highlights the urgent need for proactive road safety measures, emphasized by staggering statistics from organizations like the World Health Organization. Projects like the designed speed measurement device play a pivotal role in addressing these challenges, offering technological solutions to curb speeding-related accidents and foster safer road environments.

By utilizing ultrasonic sensors and microcontroller technology, the system enhances road safety infrastructure, ensuring accuracy through meticulous testing, error rate calculation, and standard deviation assessment. According to the experimental results, the average error rates and the standard deviation of the error rates of the speed measurement system was calculated to be 2.138% and 1.0606% respectively, for the reference object moving from 100cm to 400cm from the system. Real-time feedback to road users further contributes to awareness and compliance, ultimately serving as crucial tools in mitigating accidents and safeguarding lives, showcasing the transformative potential of technology in tackling societal issues.

5.2 RECOMMENDATION

i. This project is designed and implemented to be used in our roads to reduce the rate of road accidents which has claimed so many lives and properties.

ii. It is advisable to proceed with the design and installation of an actual project similar to this after modelling, intended for implementation in vehicles for speed detection.

iii. The use of more powerful designs capable of higher sensitivity and ranging.

iv. It is recommended that LCD screen bigger than 16×2 mm should be used to contain more bold information.

v. It can be further advanced by incorporating a CCTV camera into the circuit. So that if a vehicle surpasses the speed limit, the camera captures the vehicle's number plate, retrieves the owner's address from the transportation database, and issues a fine accordingly.

vi. Standard laboratories should be provided in schools to meet the teaming demand for equipment needed for research purpose.

vii. The design is still in a proto type stage. More tests need to be conducted before the efficiency, durability, and reliability can be demonstrated. Additionally, many improvements can be made to make the system more versatile, customizable, and user-friendly.

5.3 PROBLEMS FACED IN THE PROJECT

While building the project, there were some problems faced:

i. Getting some of the components was hard. Some of the components were ordered online which leads to delay.

ii. It was not easy to solder the components on the dot board, so the method suggested by the guide was, to apply the solder mask.

iii. Coming up with a suitable enclosure for the project was not an easy task, had to innovate and bend plumbing PVC pipe.

5.4 BILL OF MATERIALS

The table below shows the materials used quantities, rates and total amount.

Table 5.1 bill of materials

S/N	COMPONENTS	QUANTITY	RATE (₦)	AMOUNT (₦)
1	Arduino UNO	1	10000	10000
2	Bread board	1	1000	1000
3	Dot board	1	400	400
4	Buzzer	1	300	300
5	Push Button	1	150	150
6	9v Battery	2	300	600
7	Battery Cap	1	100	100
8	Ultrasonic Sensor	1	2500	2500
9	Transistor (TIP122)	1	400	400
10	LED	2	20	40
11	LCD with I2C module	1	9000	9000
12	Resistor	3	20	60
13	Jumper wires (Male-Male and Female-Male)	2	900	1800
14	Soldering led	1	600	600
15	Plumbing PVC pipe	½	3000	1200
16	Spray Paint	1	3300	3300
	TOTAL AMOUNT			**31450**

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APPENDIX 1

SOURCE CODE FOR SPEED MEASURING DEVICE

```
#include <Wire.h>

#include <LiquidCrystal_I2C.h>

LiquidCrystal _I2C mylcd(0×27, 16,2); // Vin, Gnd, A4 and A5

#define echo 7 //Echo Pin

#define trigger 9 //Trigger Pin

#define switch A1 //Select Pin for Switch Button

#define greenLed A0 //Select Pin for Green LED

#define redLed A2 //Select Pin for Red LED

#define buzzer A3 //Select Pin for Buzzer

// DEFINE VARIABLE

float speed = 0, distance = 0, Time= 0;

int flag1 = 0, flag2 = 0;

int time1, time2;

const unsigned int BEEP_FREQUENCY_3000;

void setup() {

  // put your setup code here, to run once:

  pinMode(switch, INPUT); //Set switch as Input

  pinMode(echo, INPUT); //Set echo for ultrasonic sensor as input

  pinMode(trigger, OUTPUT); //Set trigger for ultrasonic sensor as output
```

```
  pinMode(redLed, OUTPUT); //Set red LED as output

  pinMode(greenLed, OUTPUT); //Set green LED as output

  pinMode(buzzer, OUTPUT); //Set buzzer as output

  mylcd.begin(16,2);

  mylcd.clear();

  mylcd.setCursor(0, 0);

  mylcd.print("Speed Measuring");

  mylcd.setCursor(0, 1);

  mylcd.print("Device");

  delay(2000);

  mylcd.clear();

}

void loop() {

  // put your main code here, to run repeatedly:

ultrasonicRead(); //Calls ultrasonicRead() function below

  if(distance <= 30 && flag1 == 0)

  {

    time1 = millis(); flag1 = 1;

  }

  if(distance <= 20 && flag2 == 0)

  {
```

```
  time2 = millis(); flag2 = 1;
}
if(flag1 == 1 && flag2 == 1)
{
  flag1 =2, flag2 =2;
  if(time1 > time2){Time = time1 - time2;
  }
  else if (time2 > time1){Time = time2 - time1;
  }
  Time = (Time/1000); //Convert milliseconds to seconds
  speed = (10/Time); //Speed equals distance divide by time
  speed = (speed * 3600); //Multiply by seconds per hour
  speed = (speed/10000); // Division by meters per km
  digitalWrite(redLed, LOW);
  digitalWrite(greenLed, HIGH);
  tone(buzzer, 200); //Beep when done
}
if(digitalRead(switch)== 0){
  speed = 0;
  flag1 =0, flag2 = 0;
  digitalWrite(redLed, HIGH);
```

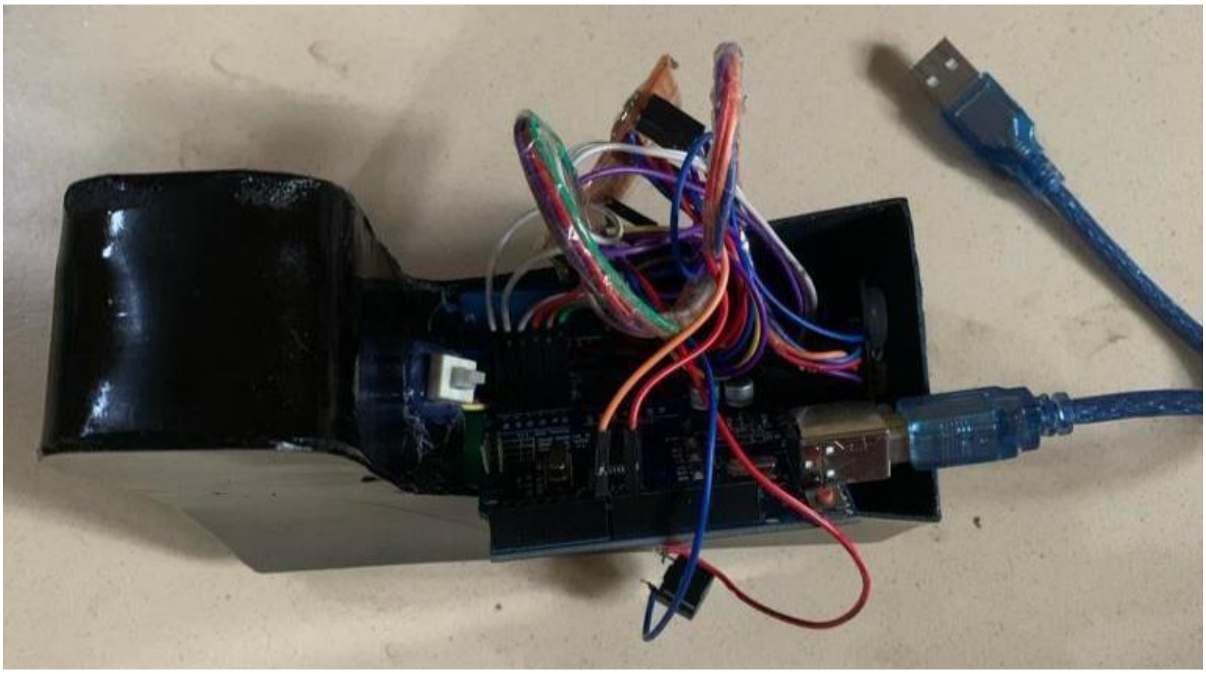
```
    digitalWrite(greenLed, LOW);

    tone(buzzer, 400); //Beep When done

    delay(500); // delay the LCD so it can take another reading

  }

  mylcd.clear();

  mylcd.setCursor(0, 0);

  mylcd.print("Dist. in cm");

  mylcd.print(distance);

  mylcd.print("");

  mylcd.setCursor(0, 1);

  mylcd.print("Speed. Km/Hr");

  mylcd.print(speed);

  delay(10);

}

void ultrasonicRead(){

  digitalWrite(trigger, LOW); //PULSE__|---|__

  delayMicroseconds(2);

  digitalWrite(trigger, HIGH);

  delayMicroseconds(10);

  long time = pulseIn(echo, HIGH);

  distance = time/28.5/2;
```

```
}
```

APPENDIX II

External View of the System

Side View of the System



Internal View of the System