

# **Design and Development of Driver Speed Warning System for Curved Road**



By

Aschalew Aynalem

A Thesis Submitted to

The Department of Mechanical Engineering

School of Mechanical, Chemical and Materials Engineering

Presented in Partial Fulfillment of the Requirement for the Degree of Masters in  
Automotive Engineering

Office of Graduate Studies

Adama Science and Technology University

December, 2021

Adama, Ethiopia

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Advisor: Dr. Tafesse Asrat

Co-Advisor: Dr. Ramesh Babu

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## DECLARATION

I hereby declare that this Master Thesis entitled “Design and Development of Driver Speed Warning System for Curved Road” is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Aschalew Aynalem

Name of the student

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Signature

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Date

## RECOMMENDATION

We, the advisors of this thesis, hereby certify that we have read the revised version of the thesis entitled “Design and Development of Driver Speed Warning System for Curved Road” prepared under our guidance by Aschalew Aynalem submitted in partial fulfillment of the requirements for the degree of Masters of Science in Automotive Engineering. Therefore, we recommend the submission of revised version of the thesis to the department following the applicable procedures.

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## APPROVAL PAGE

We, the advisors of the thesis entitled “Design and Development of Driver Speed Warning System for Curved Road” and developed by Aschalew Aynalem, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

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## **ACCRRONYMS AND ABBREVIATIONS**

|        |                                             |
|--------|---------------------------------------------|
| ACC :  | Adaptive Cruise Control                     |
| ADAS : | Advance Driver Assistance System            |
| CC :   | Cruise Control                              |
| CWS :  | Curve Warning System                        |
| CHDV:  | Conventional Human Driven Vehicles          |
| ECU :  | Electronic Control Unit                     |
| ESP :  | Electronic Steadiness Program               |
| EBD :  | Electronic Brake Dispersion                 |
| GPS :  | Global Positioning System                   |
| GSM :  | Global System for Mobile Communications     |
| ICSP : | ICSP : In-Circuit Serial Programming        |
| IDE :  | Integrated Development Environment          |
| IR :   | Infrared Radiation                          |
| ISA:   | Intelligent Speed Adaptation                |
| LCD :  | Liquid Crystal Display                      |
| LED :  | Light Emitting Diode                        |
| OBU :  | On Board Unit                               |
| PWM :  | Pulse Width Modulation                      |
| Rx :   | Receiver module                             |
| RF :   | Radio Frequency                             |
| RAM :  | Random Access Memory                        |
| RPM :  | Revolution per minute                       |
| RTAs : | Road Traffic Accidents                      |
| RTC :  | Real Time Clock                             |
| RSU :  | Road side unit                              |
| Tx :   | Transmitter module                          |
| TTR :  | Time to Rollover                            |
| UART:  | Universal Asynchronous Receiver/Transmitter |
| USB :  | User Serial Bus                             |
| V2I :  | Vehicle to Infrastructure                   |
| VSS :  | Vehicle Speed Sensor                        |

## ABSTRACT

*It is obvious that there is a high tendency of vehicles' crash occurrence in curved road sections unlike that of straight highways as a result of centrifugal and centripetal forces naturally experienced in those areas which are responsible for vehicles stability concern. The effect of these forces can be minimized by optimizing the speed of vehicles. Among the class of vehicles that are difficult to manage in this particular area mostly are trucks and other heavy-duty vehicles due to their large size and carrying capacity which makes them not simple to handle during turn taking. This study designed and developed a curve speed warning system for tanker truck that can aware and alert the drivers the required speed at which the vehicles have to be driven to ensure safety and comfort. This is achieved by implementing wireless vehicles to roadside infrastructures communication using an on board unit (OBU) that is mounted in the vehicles and roadside unit (RSU) which is fixed near roads. The thesis incorporated two-way communication of OBU and RSU that enables the system to serve multiple functions like recording the plate number of cars in case the recommended speed is violated or if a stolen car has passed through that road. In addition, it gives drivers the information about that area like the availability of helping centres if any. This work also created a web interface that controls the RSU, which can be monitored and regularly followed by authorised body from remote by utilizing internet access. Selecting materials, writing the algorithm for the system, designing the circuit and making a prototype for its functionality were the major approaches followed during the work. The administrator panel is designed for registering the RSU with a given RSU identification (RSU ID), Location, Curvature type, maximum speed and weather condition. The location of each RSU is based on the calculated triggering distance which considers a smooth transition of maximum vehicle speed to a desired curve speed. This system regularly updates RSU, instead of defining a fixed speed limit in order to determine the appropriate speed with the corresponding weather condition. To prepare the prototype, microcontroller, ESP8266 module, 433MHz RF transmitter and receiver, geared motor, motor driver and IR sensor were used. It is recommended that applying this system will significantly help as a key factor to avoid the possible crash occurrence in curvatures. Further research is needed to implement it in other irregular road types such as steep summits and valleys that could strengthen the effectiveness and compatibility of this system. Finally, the system prototype that shows OBU and RSU communication is prepared for demonstration.*

**Keywords:** *Arduino Uno microcontroller, curvature, geared motor, IR sensor, web interface*

# **CHAPTER ONE**

## **INTRODUCTION**

### **1.1. Background**

Many Driver Assistance systems for speed control have been developed so as to prevent accidents. One of them is cruise control system (CC) that is capable of maintaining pre-defined speed and its later evolution version Adaptive Cruise Control (ACC) which keeps the automobile at pre-defined safer distance from the preceding vehicle (Sattibabu et al., 2014). But these systems fail to detect the curved roads where the speed of the vehicles has to be reduced to avoid the accidents. Later Curve Warning Systems (CWS) came into existence to detect the curved roads by using Global Positioning System (GPS) and the digital maps accessed from the Geographical Information Systems (GIS) to warn the drivers approaching the curved road. But these maps need to be updated regularly and are not useful if there are unpredictable road diversions. Here this thesis implements a system that warns the driver of the vehicle according to the data frame that is transmitted by the roadside unit. The data frame is received by the on board unit mounted in vehicles which warn the drivers to control the speed of vehicle when approaching the curved roads (Sattibabu et al., 2014).

### **1.2. Research Motivation**

Vehicle-to-Infrastructure (V2I) communication is a communication mode that exchanges information between vehicles and the road side infrastructures. Infrastructure components include road signs, lane markings, traffic lights, and other smart road infrastructure connected via wireless connection. This technology allows to replace the already existing traditional road signs which are placed aside of the road. Additionally, the major advantage of this technology is that the ease of reusing the same infrastructure for different purpose.

### **1.3. Statement of the Problem**

It is clear that there is a high tendency of vehicles' crash occurrence in curved road sections unlike that of straight highways as a result of centrifugal and centripetal forces naturally experienced in those areas which are responsible for vehicles stability concern and these forces are directly related the speed of the vehicles. The reason why the study was focused on tanker truck is because of these types of vehicles accident have been subject to this specific road section frequently due to their large size and carrying capacity property that make them not easy to manage especially in dangerous road ways like sharp curves.

Electronic system based Curve Warning system are developed in so many ways in order to reduce crash in sharply curved road. These systems were either composed of GPS based, Infrared Radiation based or Gyroscope based. These the above mentioned systems are based on instantaneous computation of location and angle of inclination which is not reliable for checking usually a specific road environment and result in lateral errors. Also the indication of maximum speed at highly curved road segments have been set in static manner without considering many variable factors such as weather conditions which can directly affect the coefficient of friction value between roads and tires. Weather status such as rainy, foggy and other conditions should be taken into account to determine the optimum speed of the vehicles at those curved road ways.

## **1.4. Objectives**

### **1.4.1. General Objective**

The general objective of this thesis work is to design and develop Curve Speed Warning System to prevent Tanker truck crash on curved roads in the case of the road at Dire Dawa to Dengego highway.

### **1.4.2. Specific Objectives**

- ✓ To analyze road curvature using radius of curvature and calculate maximum speed for selected road segment to avoid accident of vehicles by creating speed limit database.
- ✓ To determine the location of Road Side Unit based on triggering distance
- ✓ To design Road Side Unit (RSU) and On Board Unit (OBU)
- ✓ To establish the Wireless communication of OBU, RSU and Administrator interface
- ✓ To implement the prototype of curve speed warning system in curved roads portion and alerting the drivers via LCD and buzzers

## **1.5. Limitation**

In this thesis work, the major limitations were

- ✓ The coordination of Php and Xamp softwares with arduino had taken long time to interface
- ✓ Irregular inflation and high cost increment of electronics devices and some devices were not available in nearby market centres.
- ✓ Lack of native related works and sufficient locally available accident record data for tanker truck crash

## **1.6 Significance of the Study**

This work is intended to contribute for technologies improvement to the transport sector in Ethiopia in particular and the world in general. The results of the study will enhance the best way of controlling vehicles speed in curved roads efficiently, which can directly provide positive guaranty to car manufacturers and users safety wise.

## **1.7 Delimitation (Scope)**

This thesis work includes the literature survey of the existing system, designing an internet based wireless communication of on board and road side unit which is monitored by authorised body using web interface as a central server . This work also included the preparation of prototype for demonstration of the functionality.

## **1.8 Beneficiaries**

This curve speed warning system provides an efficient and fast means of avoiding the occurrence of accident in sharply curved road segments by creating early awareness to drivers to manage the speed of their vehicles properly. The followings such as: Federal Government of Ethiopian and Non-Governmental Organizations, vehicle owners, passengers, the transport associations, society (including traffic police and workers) will be benefitted with this thesis work.

## **1.9 Organization of the Study**

The general outline of the thesis is summarized as follows:

Chapter One: Describes basic definitions and concepts of the thesis

Chapter Two: Presents different literatures and works related to the thesis

Chapter Three: Describes materials and methods used in the thesis

Chapter Four: Explains the proposed results and discussions.

Chapter Five: Presents conclusions, recommendations and future works.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1. Introduction**

Minimizing the rate of accidents and their most exceedingly bad results are the foremost challengeable assignments for the vehicle producers, authorized transport officials of government, vehicle owners and researchers. The main issue for the drivers to be aware while driving the vehicle in irregular roads is the concern of the required optimum speed value at that specific zone. They should get a help by the drivers' assistant systems in any term either audibly or visually early before getting into the roads' potential danger portions. In expansion, these systems are accessible in today's vehicle and as uncommon included within the vehicles advertisement, and long-term vehicle requires higher security in driving controls as per scholarly people of the field suggest. Road transport is a major sort of transportation system used in Ethiopia. Our country has a different curved road sections in its several parts, which are irregular road profiles that require careful drive to ensure safe transportation.

To move forward one country's economy, transportation pays an awesome role as a backbone. Progression in transportation systems has made a way of life characterized by flexibility of development, trade-in factory-made properties and administrations, high benefit levels and social versatility. The commercial thriving of a nation has been closely tied to competent means of transportation system. The fast advancement of a specific country particularly in giving great system facilities to the individuals has always important to be an imperative motivation to the government.

#### **2.2. Relationship between Road Geometry and Vehicle Speed on Curved Roads**

Autonomous vehicle route has been a challenging field of study where nowadays the main goal is to ensure safety. In order to achieve that, vehicle control has to perform precise path tracking; in other words, it ought to minimize the horizontal separation between the vehicle's position and the characterized way. In real driving scenarios, speeding is one of the most causes for traffic accidents (Muhlrad et al., 2011), which has been considered for Advance Driver Assistance Systems (ADAS).

The relationship between speeding and horizontal error has been a lot researcher's study focus to achieve the objective of speed managing ways and so, safety-related issues will depend on vehicle's speed control. Intelligent Speed Adaptation (ISA) systems have been demonstrated in several studies to decrease accidents by regarding speed limits (Amulya & Karuna, 2018; Carsten & Tate, 2005) (Lai et al., 2012; Vlassenroot et al., 2007). Nevertheless, a few other variables have to be considered for exact speed control. One of the major ones includes road geometry. Analyzing road structure will allow the distinguishing proof of straight and curved sections ahead while driving, permitting the horizontal system to adjust vehicle speed.

Geometric arrangement is a vital component in roadway plan. Due to the high extent of serious crashes that happen on curved segment(Enokela & Agbo, 2015),they are seen to be areas with critical potential dangers for crashes(Afghari et al., 2018; Easa & You, 2009).The study of crashes on a curved road fragments has gotten an extraordinary bargain of consideration in later decades. The curvatures along numerous other factors such as long-term ignored support, lacking signage, markings and roadside risks are found to influence road security(Dhahir & Hassan, 2019; Khan et al., 2012; Popoola et al., 2018).. In expansion, most considerations in geometric arrangement of roadways were centered on crashes along straight sections without considering either vertical section or combined curvature in the neighborhood road (Malaghan et al., 2020).

Curves of course are exceptionally common components of roadway system and distinctive in appearance and design. They may well be within the frame of horizontal curve, vertical curve of combined horizontal and vertical curves. A level curve happens at the area where two tangent roadways intersect. It gives a slow move between two roadways sections, permitting vehicle to center a turn at a consistent turning rate with the radius decided by the law of material physics. Past studies have watched that most extreme damage crashes have a high tendency of occurrence on horizontal curves(Wang & Li, 2019).For instance, the publication (Malaghan et al., 2020) conducted studies about security advancement on horizontal curve and found out that as these areas are more likely to record a crash than the straight road section. Moreover the crash rate on the roadway fragment where the radius of horizontal curve is 100 feet was over 28 times the crash rate on the straight fragment on the same roadway (Wang & Li, 2019).

Vertical curves as other critical roadway geometry component have not drawn much consideration in local roadway security. The vertical curve is delivered when the height of the roadway slowly changes (up or down). In expansion, the vehicle take after such changes at progressive rate (Cavalcanti et al., 2013) conducted road security or safety think in Indiana where they found that vertical curves are essentially more likely to be related with debilitating damage crashes.

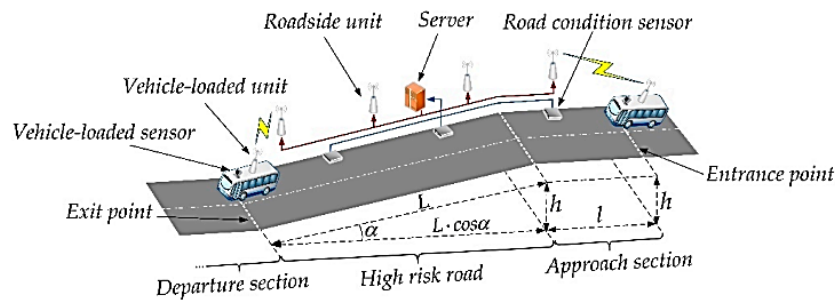


Figure 2.1: Long-steep downhill road (Jiang et al., 2020)

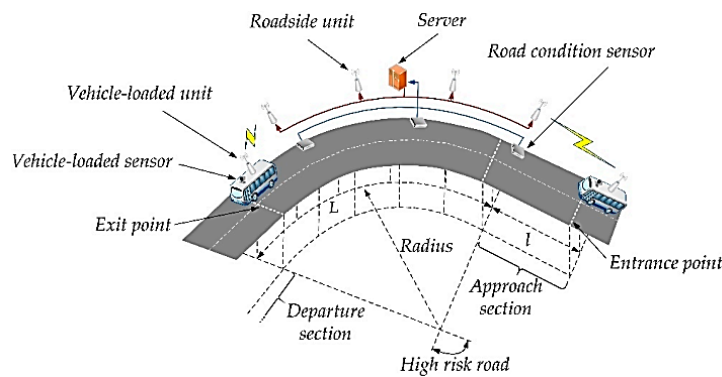


Figure 2.2: Horizontal sharply curved road (Jiang et al., 2020)

Commonly happening accidents on curved road are sideslip or rollover. The nearness of horizontal curves is related with expanded probabilities of high-severity outcomes in a middle rollover crash (Rodríguez, 2014), especially those curved to the correct (Chen & Peng, 2001). So far, a few national and universal investigations on anti-sideslip or anti-rollover speed caution and path keeping concerning bended curved roads have achieved important accomplishments. For illustration, (Hu & Donnell, 2011) proposed an anti-rollover control calculation based on the time-to rollover (TTR) metric, during which the directing and coordinate yaw moment control inputs were built to calculate the TTR in real-time.

(Fay, 1967) Explored rollover anticipation techniques for a truck/semitrailer combination based on a sliding mode controller and differential braking. (Ahangarnejad et al., 2020) Designed a speed control system to help the driver accomplishing more secure and more comfortable curve taking after execution. They decided a desired curve speed profile for the approaching curve concurring to an outline database and controlled the vehicle speed toward the required speed. (Liu et al., 2021) displayed a strong controller plan strategy for vehicle rollover avoidance utilizing dynamic directing. Their controller was based on keeping the magnitude of the vehicle load exchange proportion (LTR) underneath a certain level within the presence of driver steering inputs, which can reduce the transient magnitude of the LTR while maintaining the steady state steering response of the vehicle.

### **2.3. Review of Research Works on Speed Controlling Mechanisms on Curved Roads**

Most research works concentrated on avoiding the collision of the vehicle due to its over speeding within the speed restricted zones. This is done through the in-embedded systems and the RF transmitter and recipient modules. When the vehicle enters in the speed limited zone, driver needs to decrease the speed of the vehicle physically. On the off chance that the driver did not moderate down the vehicle, the electronic controller would take the lead to control and decrease the speed of the vehicle by getting the signal from the transmitter in that zone. By that gotten signal, the Arduino microcontroller would prepare to provide a signal to the engine to control the speed. Here primarily they use the radio frequency transmitter and recipient to distinguish the confined zone (Amulya & Karuna, 2018).

They clarified the working of their system in three distinctive zones where the speed needs to be decreased consequently by using ZigBee innovation. They are typical zone, quiet zone, speed restrain zone. The speed is decreased by switching the motor turning heading through the microcontroller 8051. The ZigBee transmitter is set at that zone for illustration clinic and when the vehicles come to that region, the signal is received by the ZigBee collector within the vehicle. The speed of the vehicle is compared with the decided speed in that range. On the off chance that speed is higher for that zone, the microcontroller takes in activity to decrease the speed of the vehicle and on the off chance that it is silence zone it impairs to form a horn (Sathiskumar et al., 2020).

The most point of the creators to control the speed of the vehicle to avoid the accidents within the restricted zone, curve roads and different cuts are due to over speed. This will be done with the ZigBee technology with the arm-7 microcontroller.

The endorsed speeds at that restricted zone are joined within the transmitter module and when the collector within the vehicle facilitates that, the flag arm-7 microcontroller would check whether the driver is decreasing the speed for a constrained time. After the clock passes the constrained time, the microcontroller makes the flag to diminish the speed of the engine, which makes the vehicle decelerate without the activity of the driver (Thombare et al., 2018).

The objective was to design the electronic display controller for vehicle speed control and screen the zones with the assistance of the embedded systems and they outlined to show the data on the dashboard about the zone. To realize this they use two units, which are zone status transmitter unit and electronic display and control unit (Arm-7).

Here on the off chance that the sensible zone is identified by the recipient in a vehicle the signal forms within the controller and cautions the driver by displaying it, and gives a buzzer sound. There is a clock for driver activity to diminish speed in the event that the time passes at that point the vehicle naturally sets to craved predefined speed (Prakash, 2019).

#### **2.4. Importance of Speed Controller Design to Avoid Crash on Curved Roads**

The objective of the designating speed controller is to upgrade driving security and progress fuel efficiency for huge vehicles running on long-steep downhill and sharp-curved roads by optimizing their longitudinal speed, whereas minimizing the unfavorable impacts on activity portability. There are four highlights of this ideal controller (Jiang et al., 2020):

**Braking stability and lateral stability:** Huge vehicles, particularly those that need an assistant brake, have much higher dangers of brake wear, sideslip, and rollover than small vehicles due to their more prominent mass and higher center of gravity. To improve the driving security of these vehicles, the proposed controller ensures the braking impact and sidelong movement work at their ideal levels.

**Driving safety priority:** Designing a controller that gives the most secure and smoothest speed advisories for heavy-duty vehicles to attain braking stability and sidelong soundness. The controller puts driving security a better need than other execution pointers. It upholds the running costs of the controlled vehicle to upgrade its driving security.

**Ecology and mobility:** Designing controller which advance progress fuel productivity and keeps up activity versatility at an ideal level based on improving driving security. From a vitality change and vehicle elements viewpoint, the generation rate of the brake's thermal energy, the yaw rate of the entire vehicle, and the horizontal stack exchange of the vehicle body have a close relationships with vehicle longitudinal speed and increasing speed.

**Partially connected vehicles' environment:** Proposing the controller that points at being functional beneath blended activity conditions comprising of two sorts of vehicles. One type is associated vehicles, which stack the proposed controller and communication device, trade data with both the other associated vehicles and road foundation by means of V2I innovation, and run agreeing to the ideal speed profile created by the controller. The other is unconnected vehicles, known as "conventional" human-driven vehicles, in which no ideal speed controller or communication devices are introduced.

The equipment comprising the control system in different curved road includes the following (Jiang et al., 2020)

- ✓ Road condition sensors and communication devices introduced along both high-risk roads and their drawing closer segments. Road condition sensors screen the contact coefficient of road surface in real-time by infrared ghostly investigation innovation, which is free from reliance on data of climate and temperature around the sensors. Communication devices give road plan and surface conditions for associated heavy-duty vehicles (CHDVs) named "Roadside units".
- ✓ Communication devices introduced on CHDVs to empower communication between different vehicles or between vehicles and roadside units called "Vehicle-loaded units"
- ✓ Sensors installed on CHDVs to obtain the state of their preceding unconnected vehicles.
- ✓ Sensors introduced on CHDVs to get the state of their going before unconnected vehicles.

## **2.5. Introduction to Electronic Devices for Vehicle Management**

From the mid-1990s to 2010, automotive electronic control innovation as designing technology has developed. At this stage, the electronics industry for the automotive industry offers a part more advanced steady control supply, sensors, and have eight or 16 large-capacity memory, microprocessor.

On this premise, the general plan of the vehicle's mechanical and electrical system is based on coordination and center on the by and large plan of automotive mechatronics.

Automotive electronic control innovation will be centered on solving the issue of programmed control vehicle parts or get together, started to broadly used computer organize and IT improvement to create vehicles more computerized, brilliantly innovation, car and social integration and to resolve issues such as the exchange (Greenovation, 2014).

As the automotive electronic control technology, developed in the various systems of competing auto electronic control device. Automotive vehicle electronic control technology is not just the development of the application itself, but rather a comprehensive major project. There are factors of production and opened utilization, improve the efficiency of the system, personnel management, vehicle production process through advanced management methods and means to achieve the purposes of automotive electronic control technology applications (Zongbao, 2015).

Due to inescapable electronics systems in vehicle operations, producers have been able to progress the driving execution, proficiency of fuel, and both the driver and riders' comfort (comfort). It is momentous to note that the number of electronic components is dynamically expanding with time since they are reliable from fuel efficiency and driver security point of view. As a result, more components are being changed from mechanical systems to electronic ones. Essentially, in a matter of around three decades, the high-tech vehicles of 1980s have turned into auto electronic motors with computer-controlled systems.

Nowadays, an advanced vehicle is prepared with about hundreds of electronic systems. Advancement in automotive hardware innovation has turned unimportant driving into an advanced pleasurable involvement. Implanted systems have ended up the center of each automobile's design. They are used in security airbags, anti-lock brake, radio, music system, telematics, stopping capacity, and part more. In expansion, it is vital that these electronic parts can carefully control most of the vehicle's operations. Integration of hardware in center building of vehicles such as the motor, its transmission, brakes, and auto control directing proceed to extend. The electronic systems introduced in a vehicle can be classified as motor hardware, chassis hardware, and security device hardware.

### **2.5.1. Electronic Device Usage for Emergency Control**

As the car electronic control, innovation is within the improvement of car electronic control unit and competition systems improvement. Vehicle chassis is one of the vehicle issue that incorporates anti-lock brake control system, anti-skid control, electronic control, electronically controlled programmed transmission, electronically controlled control controlling, electronically flexible suspension, four-wheel controlling and voyage control system (Zhou, 2016).

**The drive-slip control and anti-lock brake control:** All-important car security device ASR and ABS, ASR is an extra condition to be kept up, the driving drive of the full electronic control unit. The motor torque and the vehicle brake system and control measures to control the beginning and driving the vehicle increasing speed powers to diminish the attachment of the tire and the road surface to anticipate intemperate control and result in turn of the wheel slip, and keep up ideal driving drive to move forward the vehicle's directional soundness and maneuverability control.

#### **The electronics controlled transmission.**

The programmed transmission electronics role is to control throttle opening angle and the vehicle speed, the throttle opening angle sensor and the speed sensor. In this system the input signal is changed into an electrical signal in time ECU electronic control unit ECU, concurring to the solenoid valve and the shift plan change characteristic of the yield signal, the solenoid valves controlling the water powered circuit, thereby accurately controlling the transmission proportion of the vehicle to get the finest the move time and the best booth (Greenovation, 2014).

#### **The electronically controlled power steering**

This is the premise of the directing point connected to the required electronic control system of the power controlling drive on the controlling wheel. The torque, speed sensors and the programmed control are adjusted so that the vehicle is halted or driven at low speed, the directing wheel is turned, the need to increase the control, i.e., beneath distinctive driving conditions is to realize the ideal constraint required on the directing wheel.

**The suspension system control:** Suspension system concurring to diverse road conditions and vehicle working conditions, the degree of control of the body naturally alter the suspension damping and versatile solidness, move forward vehicle taking care of, steadiness and ride comfort.

### **2.5.2. Types of Electronic Technology for Vehicle Control System**

An automotive electronic control innovation is within the improvement of automotive electronic control unit and competition systems advancement. In common, the electronic control mature automotive electronic control systems of the most motor, chassis control, body devices control and data transmission that incorporates the taking after parts in each part. specifically car hardware are dispersed systems, which can be classified into diverse sorts based on diverse spaces like Motor Hardware, Transmission Devices, Chassis Devices, Inactive Security, Driver Help, Traveler Comfort, Amusement Systems, Electronic, and Coordinates Cockpit Systems (Li, 2015).

**Engine Electronics:** The ECU or motor control unit is a basic electronic portion in automobiles. This unit can arrange one of the greatest real-time objectives since the motor used in automobiles is complex and quick. The gadgets, which are used in automobiles, the computer control of the ECU, are the most extreme like a 32-bit processor. The nowadays vehicles may have up to 100 ECUs while, within the commercial vehicle, it has up to 40 ECUs.

**Transmission Electronics:** It is used for controlling the transmission systems, generally whereas moving the gears for upgraded move comfort & to lesser torque hinder. The operation of a programmed transmission can be done by utilizing the controls & a few semi-automatic transmissions incorporate a completely programmed clutch. The communication between ECU and the transmission control can be done by trading data, control and sensor signals for their handle.

**Chassis Electronics:** The chassis system incorporates electronic subsystems in a vehicle, which control diverse parameters and controls effectively like ABS (Anti-lock Braking Systems), EBD (Electronic Brake Dispersion), FCS (Footing Control Systems), DAD (Stopping Help) and ESP (Electronic Steadiness Program).

**Passive Safety:** The passive security system is all around learning & practicing of arrangement, building, device and instruction to decrease the occurrence and result of activity mishaps of engine vehicles. These systems are continuously set to function when there is a crush in advancement something else to stop it once it recognizes an unsafe condition like airbags, control of slope plunge and crisis brake help system.

**Driver Assistance:** The ADAS or Progressed driver-assistance system makes a difference while driving a vehicle. This can be planned with a secure HMI (human-machine interface). These systems are used for expanding automotive and road security. This system incorporates distinctive help systems like path, speed, park, blind-spot discovery and control systems just like the versatile journey.

**Passenger Comfort:** The automotive electronics used in a vehicle for traveler comfort basically incorporate programmed climate control, programmed wipers, alteration of the electronic situate with memory, programmed headlamps for programmed pillar alteration, and programmed cooling for altering the temperature.

## **2.6. Development of a Microcontroller Based Car Speed Controller**

Nigeria and the sweeping statement of the nations within the world lose an extraordinary number of their citizens in cases of street traffic accident each year (Aa et al., 2010). The report by the Government Street Security Commission (GSSC) of Nigeria in 2013 appears that as much as 32% of all mishaps that happened that year were credited to speed related issues (Government Street Security Corps 2013). Distinctive sorts of innovations have been sent over the past three decades with a see to controlling the speed of automobiles to decrease the cases of deadly accidents. Protected an automatic car speed controller whose driving circuit is worked by the contrast between the actual car speed and the memorized car speed; the difference signal is used to function an electromagnetic clutch.

A comparative systems is additionally detailed in the systems examined in this study have been rendered out of date by more up to date and made specialized car fabricating innovations (Enokela & Agbo, 2015). More present day systems that use electro-hydraulic braking systems and electronic control of throttles are detailed by(Santoshi, G.V.L., Hima, B.N. & Uma, n.d.) (Eswaramoorthy, P. & Arunkumar, n.d.) (Saivignesh, H., Mohamed, SM., Nagaraj, M., Sharmila, B. & Nagaraja, n.d.) and (del Bianco, V., Luigi, L. & Marco, n.d.)used the documentation of the Bound together Modeling Dialect (UML) to hypothetically show a car speed controller.

An electronic systems to control car speed using two variable resistors for creating speed control signals that are prepared and changed into a computerized flag for controlling the driving speed of an electric car is talked about within the work by (Byum, n.d.). A systems that employments the Radio Recurrence Recognizable proof (RFID) for recognizable proof of activity signals on the street and for foundation to vehicle communication is detailed by (Perez, J., Seco, F., Milanés, V., Antonio, J., Diaz, J.C. & de Pedro, n.d.).

This expand systems not as it were controls the speed of vehicle and appears its area using the worldwide situating systems (GPS) but moreover is additionally capable of dodging vehicle to road systems collisions. This system uses numerous sensors and hardware and this truth will make it to be costly. Other systems that are based on RFID and RF transmitter-recipient sets are detailed in (Madhu, Adhauya, R., Singh, S., Sambhavi, & Chauhan, n.d.) (Thomas, L., James, S.A., Joseph, S., Arya, K.B., Narah, T. & Pangu, n.d.) (Kameswari, U.J., Satwik, M., Lokesh, A. & Reddy, n.d.). The most cutting edge independent systems that employments the GPS for the area of vehicles and control of speed is the Cleverly Speed Adjustment (ISA) ((2008), n.d.) (Carsten, O. & Tate, n.d.) (Paine, M., Paine, D., Griffiths, M. & Germanos, n.d.). These systems employ the GPS inside the vehicle to decide its area. A memorized digital outline included within the systems empowers the speed restrain of the area to be decided so that the driver can be appropriately exhorted to remain inside this endorsed speed limit.

## **2.7. Classification of Microcontrollers used for Vehicles Control System**

The use of diverse sorts of microcontrollers to handle distinctive operations like automobiles, electrical systems and other applications has expanded quickly. Applications of microcontrollers are found in different huge equipments to little devices such as centralized server computers, air conditioning units, and plane route systems, digital watches, PDAs and cell phones.

In particular, the presence of different microcontrollers in automobiles plays an imperative part, as confirmed by the presence of 25-35 ECU (electronic control unit) within the commonplace portage vehicle. This article surveys the diverse microcontrollers used in automobiles and their applications. This article audits the distinctive microcontrollers used in automobiles and their applications.

The use of different microcontrollers is increasing in automobile's devices together with the rest of the electronic control units. Diverse sorts of microcontrollers used in automobiles are AVR microcontroller, 8051 microcontrollers, PIC microcontroller and etc. These sorts of microcontrollers require a chip that comprises a CPU, RAM (random-access memory), program memory, and programmable Ps /O/Ps. Display microcontrollers and improve the control of automobiles in extent. This run is from 8bit-32bit Harvard engineering with low-cost CPUs, tall execution and proficient information capacity in memory

### **2.7.1. Infineon Tri-core Microcontroller**

Tri-core may be a 32- bit microcontroller, which is created by Infineon. These microcontrollers are assembled in over 50 car brands, which implies, each moment vehicle outlined nowadays incorporates a Tri-core based microcontroller. It is responsible for keeping the exhaust emissions and fuel utilization as low as possible. Tri-core microcontrollers are used within the gearboxes to control the infusion, central control units for combustion engines' start: Continuously, they are moreover being used in electrical and half breed vehicle drives.



Figure 2.3: Tri-core Microcontroller

### **2.7.2. Atmel AVR Microcontroller**

Atmel AVR (Alf-Egil-Bogen-Vegard-Wollan-RISC) microcontrollers disseminate the control, execution and adaptability for vehicle applications. This microcontroller comprises of the Harvard architecture. So the run is exceptionally quick with a diminished number of machine level instruction. The AVR microcontrollers are classified into three sorts: Little AVR, Mega AVR and Xmega AVR. The most highlights of AVR microcontrollers compared to other microcontrollers incorporate inbuilt ADC, 6-sleep modes serial information communication and inside oscillator, etc.

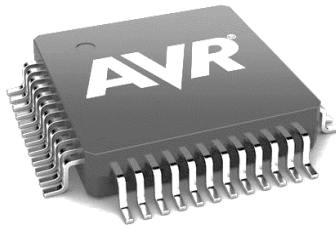


Figure 2.4: Atmel AVR Microcontroller

### 2.7.3. PIC Microcontroller

The brief shape of the peripheral interface microcontroller is PIC. It is modified and controlled in such a way that, it performs numerous assignments and controls era line. These microcontrollers are used in various applications like phones, automobiles, sound embellishments and therapeutic devices. The directly accessible PIC microcontrollers within the advertisement are PIC16F84 to PIC16C84, which are reasonable streak microcontrollers. Where, PIC18F458 and PIC18F258 microcontrollers are broadly used in automobiles.



Figure 2.5: PIC Microcontroller

### 2.7.4. Renesas Microcontroller

Renesas is the most recent car microcontroller family, which offers high execution and low control utilization over a wide degree of things. This microcontroller offers implanted security characteristics and utilitarian security for progressed car applications.

These microcontrollers offer the foremost useful microcontroller families within the world. For case, RX family offers different sort of devices with memory varieties from 32K flash/4K slam to an unimaginable 8 flash/512K RAM. This RX family microcontroller employments 32 bit improved Harvard CISC engineering to achieve exceptionally high execution.



Figure 2.6: Renesas Microcontroller

### 2.7.5. 8051 Microcontroller

The 8051 microcontroller is 40 pin microcontroller and is based on Harvard design wherein the program memory and information memory is diverse. This microcontroller is used in a huge number of machines like automobiles because it can be effortlessly coordinates around a machine.



Figure 2.7: 8051 Microcontroller

## 2.8. Arduino

Arduino may be a single-board microcontroller implied to create the application more open which are interactive objects and its environment. The hardware highlights with an open-source hardware board designed around an 8-bit Atmel AVR microcontroller or a 32-bit Atmel ARM. Current models comprise a USB interface, 6 analog input pins and 14 advanced I/O pins that permits the client to join different expansion sheets.

The Arduino Uno board is a microcontroller based on the ATmega328. It has 14 digital input/output pins in which 6 can be used as PWM outputs, a 16 MHz ceramic resonator, an ICSP header, a USB connection, 6 analog inputs, a control jack and a reset button. This contains all the specified back required for microcontroller.

In order to get started, they are basically connected to a computer with a USB cable or with an AC-to-DC connector or battery. Arduino Uno Board changes from all other sheets and they will not use the FTDI USB-to-serial driver chip in them. It is featured by the Atmega16U2 (Atmega8U2 up to form R2) modified as a USB-to-serial converter(Louis, 2016).

Arduino Uno microcontroller can sense the environment by receiving input from an assortment of sensors and can influence its environment by controlling lights, engines, and other actuators. The microcontroller is modified using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Preparing).

## 2.9. Microcontroller Growth in the Automobile

Development of the microcontrollers in automobiles is categorized into three types such as low-end vehicles, mid-range vehicles and extravagance vehicles which is shown in figure below.

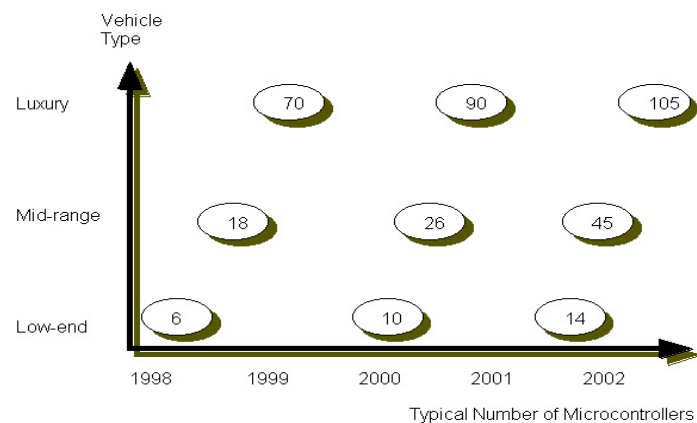


Figure 2.8: Microcontroller Growth in Automobiles

Most of the electronic control systems in automobiles are upgraded. For a case, consider the airbag systems wherein two frontal airbags are common nowadays. These are jointly assisted by the raise traveler airbags and a few other airbags. Moreover, directing, suspension, braking, body control capacities and control prepare will be assistant systems created by executing more progressed electronic systems.

## 2.10. Sensors and Modules used in Vehicle Speed Control

Modern technology affects everything that we use. Almost every part of your car engine including the electronic engine control (ECC) utilizes information from the speed sensor. Depending on the make and model of the car some speed sensors are more refined and expensive. All they do is they give vital information on the engine speed of the car. You need to know that when a problem strikes, a faulty speed sensor can cause all manner of problems. Different types of vehicle speed sensors exist and are designed for different kinds of vehicle. In modern vehicles, the speed information is used to share information between the various car modules. Always make sure that your sensor is giving the right information and is well synchronized with the car electronic engine control system. To fully grasp the vehicle speed sensor technology, we will have a look at how a speed sensor works. A Vehicle Speed Sensor (VSS) measures vehicle's speed. The sensor measures speed by calculating the actual gear ratio of the transmission while the car is in motion. Two sets of speed sensors are installed on every car to get the input and the output shaft speed.

## **2.11. Alerts and Warning Systems**

The new vehicle performance has been continuously improved and the study results relating to the safety of car driving have also been continuously reported and demonstrated, it is trying to find a balance point between the development of vehicle speed limit and the protection of driver's safety. In the current study and development of various products, no matter it is in the enforcement of vision system, radar detection or the tracing and control is always asking the driver to watch or handle the possible issues after the occurrence of accidents or alerting them early before hazard happens.

## **2.12. Advantages of Electronic technology for Vehicle Speed Control**

The benefits of electronic technologies for vehicle control are to a great extent unnoticed by most drivers since the point is to form the vehicle power-train characteristics consistently reliable independent of winning conditions, such as motor temperature, elevation, and accessory loads. Electronic throttle control is additionally working 'behind the scenes' to significantly progress the ease with which the driver can execute adapt changes and deal with the sensational torque changes related with quick increasing speeds and decelerations.

Electronic throttle control encourages the integration of highlights such as cruise control, traction control, stability control, and pre-crash systems and others that require torque administration, since the throttle can be moved independent of the position of the driver's quickening agent pedal. ETC gives a few advantage in ranges such as air-fuel ratio control, deplete emanations and fuel utilization diminishment, additionally works in coordination with other innovations such as gasoline coordinate injection. Electronic vehicle speed control moreover has its own advantage over system reliability, low cost, low control utilization, speedy reaction, solidness, simple adjustment in vehicle speed and high security of the system.

## **2.13. Literature Summary**

From the above study the speed of vehicles is controlled using different controller in relation to the structure and curvature of the road condition. The stability of huge vehicles is done by using proper controller and electronic device around the curved road. Different sensors are used in this review to control the speed of the vehicle at different horizontal and vertical curves of the road.

In addition, the designating of speed control depends on improving different materials used by vehicle expressed on the so far stated literature reviews for the improvement of the safety of the passengers.

The above study also included a high effect on the design and components determination of the automatic vehicle speed control system and inferred that ZigBee remote communication can be used rather than RF communication module and RFID tag within the system for real-time working systems within the vehicle. The strategy for recognizing the restricted zone is done through the ZigBee transmitter within the zone and the ZigBee receiver is set on the vehicle which is induced from the survey. The content from the above-mentioned reviews is taken into thought for the design and improvement of the vehicle speed control system consequently.

## **2.14. Research Gap**

Electronics system based curve-warning systems development were discussed and analysed in numerous journals in many different ways in order to reduce crash in sharply curved roads. These systems were either composed of GPS based, Infrared Radiation based or Gyroscope based. These the above mentioned systems are based on instantaneous computation of location and angle of inclination which is not reliable for checking usually a specific road environment to be careful about. Also the determination of maximum speed at highly curved road segments have been set in static manner without considering many variable factors such as weather conditions which can directly affect the coefficient of friction value changes between roads and tyres. Weather statuses such as rainy, foggy and other conditions should be taken into account to determine the optimum speed of the vehicles at that particular area

## CHAPTER THREE

### MATERIALS AND METHODS

#### 3.1 Introduction

To have a complete structure of the system ;433 MHz RF transmitter and receiver antenna, two Arduino Uno microcontrollers, ESP8266 module, LCD, Geared Motor, Motor Driver (L293), Buzzer, LED, IR sensor and suitable software programs were used and explained in detail.

#### 3.2. Materials

To design and develop the proposed system, all the required materials and equipment both hardware and utilized software that are needed to design on board unit and roadside unit are briefly explained. Table 3.1 shows the required materials with their specification.

Table 3.1: Hardware materials and specification

| No | Items               | Unit | Specification | Quantity |
|----|---------------------|------|---------------|----------|
| 1  | Microcontroller     | Pcs  | Arduino Uno   | 2        |
| 2  | 433MHz RF Tx and Rx | Pcs  | 433MHz        | 4        |
| 3  | LCD Display         | Pcs  | 16x2          | 1        |
| 4  | Buzzer              | Pcs  | 5V            | 1        |
| 5  | LED                 | Pcs  | 2.2V          | 5        |
| 6  | ESP8266             | Pcs  | 5V            | 1        |
| 7  | Geared motor        | Pcs  | 9V            | 3        |
| 8  | Motor driver        | Pcs  | L293D         | 1        |
| 9  | IR sensor           | Pcs  | 5V            | 2        |

##### 3.2.1 Arduino Uno Microcontroller

The Arduino Uno board is a microcontroller based on the ATmega328. It has 14 digital input/output pins in which 6 can be used as PWM outputs, a 16 MHz ceramic resonator, an ICSP header, a USB connection, 6 analog inputs, a control jack and a reset button. This contains all the specified back required for microcontroller. In order to get started, they are basically connected to a computer with a USB cable or with an AC-to-DC connector or battery.

Arduino Uno Board changes from all other sheets and they will not use the FTDI USB-to-serial driver chip in them. It is featured by the Atmega16U2 (Atmega8U2 up to form R2) modified as a USB-to-serial converter (Louis, 2016).

The hardware highlights with an open-source hardware board designed around an 8-bit Atmel AVR microcontroller or a 32-bit Atmel ARM. Current models comprise a USB interface, 6 analog input pins and 14 advanced I/O pins that permits the client to join different expansion sheets.

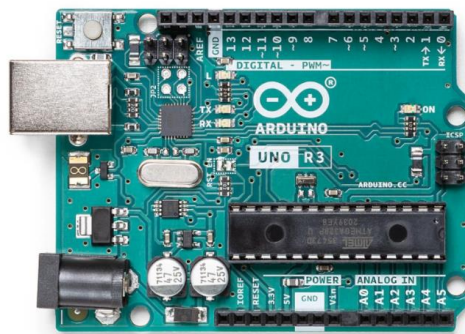


Figure 3.1: Arduino Uno

Arduino Uno microcontroller can sense the environment by receiving input from an assortment of sensors and can influence its environment by controlling lights, engines, and other actuators. The microcontroller is modified using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Preparing).

### Arduino UNO Technical Specifications

Table 3.2: Arduino technical specification

|                           |                                           |
|---------------------------|-------------------------------------------|
| Microcontroller           | AT mega- 8-bit AVR family microcontroller |
| Operating Voltage         | 5V                                        |
| Recommended Input Voltage | 7-12V                                     |
| Input Voltage Limits      | 6-20V                                     |
| Analog Input Pins         | A0-A5                                     |
| Digital I/O Pins          | 14 (Out of which 6 provide PWM output)    |
| DC Current on I/O Pins    | 40 A                                      |
| DC Current on 3.3V Pin    | 50 A                                      |
| Flash Memory              | 32 KB (0.5 KB is used for Boot loader)    |
| SRAM                      | 2 KB                                      |

### 3.2.2. 433MHz RF Modules (Antenna)

Basically the RF modules are 433 MHz RF transmitter and receiver modules. The transmitter draws no power when transmitting logic zero while fully suppressing the carrier frequency thus consume significantly low power in battery operation. When logic one is sent carrier is fully on to about 4.5mA with a 3volts power supply. The data is sent serially from the transmitter which is received by the tuned receiver. Transmitter and the receiver are duly interfaced to two microcontrollers for data transfer.

#### 3.2.2.1. 433MHz RF Transmitter

433MHz RF Transmitter is one of the best and most efficient RF modules. This module is used to design RSU that is used as a data source for OBU. It is simple to use and easy to implement. It is the first part of 433MHz RF communication. This module uses a serial data input and transmits it to the 3 Meter range but the range is extendable up to 100 Meters. It uses ASK (Amplitude Shift Keying) which makes it easy to interface with any microcontroller. In some microcontrollers, it needs to control through programming but some decoders also help to avoid complex programming. 433MHz RF Transmitter Module consists of 4-pins which makes it operate. This picture presents a pinout diagram of this RF transmitter module.

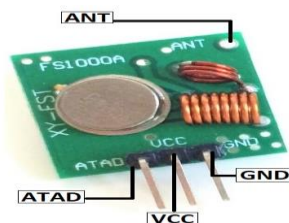


Figure 3.2: 433MHz RF Transmitter

#### 433MHz RF Transmitter pin configuration

- VCC: This is the power input pin of the RF module to make it functional.
- GND: Ground pin helps the module to make the common ground with the controllers and encoder/decoders.
- ATAD: This is the data pin of the transmitter. It takes the data from the input device in encoded form and broadcast it.
- ANT: The antenna pin is not necessary to use. The module can operate max 3 meters without antenna but its range is also extendable up to 100 meters by using a small wire as an antenna.

### 3.2.2.2. 433MHz RF Receiver

RF receiver module 433MHz is the most common and cheapest RF receivers for commercial use. This module is used for receiving the data transmitted from RSU. This module helps to receive the 433MHz frequency commonly but it also has a node on it which is changeable by users for different frequencies. The module can receive the data but it is unable to decode and view the data from the receiver without using any third device. Most of the time smart boards and microcontrollers interface with the receiver. The output of the module comes in an encoded form that is decodable through programming and encoders. On the other hand, it works well with the 433MHz RF transmitter module shown in figure 3.3. 433MHz RF receiver has 6 pins, which offers 4 types of functions. The pinout diagram depicts the functionality of all these pins.

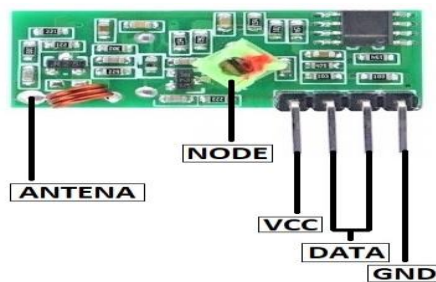


Figure 3.3: 433MHz RF Receiver pin configuration

#### Pin Configurations Description

**VCC Pin:** VCC is the power input pin for the RF module. The power will activate the internal circuit to make it functional.

**GND Pin:** For common ground, the RF module has only one ground pin. The module needs to use with other devices and the common ground will help the RF module to interface with external devices.

**Data Pin:** 433MHz RF Module has two data input pins which are internally common with each other. Only data should receive from one pin at a time.

**Antenna Pin:** This module has an antenna pin which helps to connect the external wire to extend the range up to 100 meters. The size of the antenna will depend on the operating frequency.

### 3.2.3. Liquid Crystal Display (LCD)

A liquid crystal display or LCD draws its definition from its title itself. It could be a combination of two states of matter, the solid and the fluid. LCD uses a liquid crystal to create an obvious picture. Liquid crystal display share super-thin innovation display screens that are for the most part used in tablet computer screens, TVs, cell phones, and convenient video diversions. LCD's innovations permit shows to be much more slender when compared to a cathode beam tube (CRT) technology (Sawant, Amey, Vinayak Ikke, Jyoti Khandale, Nilam Chavan, 2016). Liquid crystal display is composed of a few layers, which incorporate two polarized board channels and cathodes. LCD innovation is used for showing the picture in a scratch pad or a few other electronic devices like scaled down computers. Light is anticipated from a focal point on a layer of liquid crystal. This combination of colored light with the grayscale picture of the crystal (shaped as electric current streams through the crystal) forms the colored picture (<https://www.elprocus.com/ever-wondered-lcd-works>).

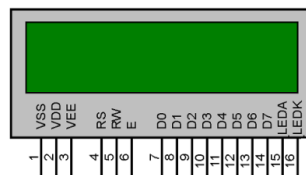


Figure 3.4: 16x2 LCD display

16×2 LCD is named so since; it has 16 Columns and 2 Rows. There are a lot of combinations accessible like, 8×1, 8×2, 10×2, 16×1, etc. But the foremost used one is the 16\*2 LCD, consequently utilizing it here will the over said LCD shown above will have 16 Pins and the programming approach is additionally the same.

### 3.2.4. Buzzer

A buzzer or beeper could be a signaling device, ordinarily electronic, used in automobiles, family apparatuses such as a microwave stove, or amusement appears. It most commonly comprises of a number of switches or sensors associated to a control unit that decides in case and which button was pushed or a preset time has passed, and ordinarily enlightens a light on the fitting button or control board, and sounds a caution within the shape of a nonstop or discontinuous buzzing or beeping sound. More often than not these were snared up to "driver" circuits which shifted the pitch of the sound or beat the sound on and off (Automatic Vehicle over Speed Detection with Audio Buzzer Alert System, n.d.).



Figure 3.5: Buzzer

Dynamic buzzer 5V Evaluated control can be directly associated to a continuous sound, this area devoted sensor extension module and the board in combination is a total a basic circuit plan. The buzzer is used to caution the driver to require an advance security activity like discouraging the clutch pedal in to anticipate the stack on the motor during automatic braking.

### **3.2.5. Light Emitting Diode (LED)**

LED is the acronym for “Light Emitting Diode”. LEDs are semiconductor devices that produce light. These were initially used as indicator lights but are now used extensively for indoor and outdoor lighting. In the simplest terms, a light-emitting diode (LED) is a semiconductor device that emits light when an electric current is passed through it. Light is produced when the particles that carry the current (known as electrons and holes) combine within the semiconductor material.



Figure 3.6: LED

### **3.2.6. ESP8266 Wi-Fi module**

Wireless fidelity network operates with 11 Mbps or 54 Mbps data rate in the unlicensed 2.4 GHz and 5GHz radio frequency band. Devices which have Wi-Fi enabled can sent and receive data wirelessly from locations which are equipped with wireless access.

Access points which are located in a Wi-Fi location transmit RF signal for the Wi-Fi enabled devices. These Wi-Fi enabled devices can receive the signal if they are located within access point range. The speed of data transmission depends upon the speed of pipeline fed into the access point.

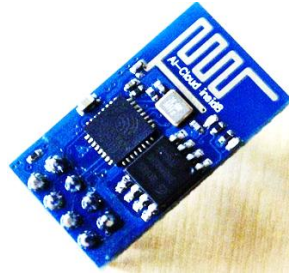


Figure 3.7: ESP8266 Wi-Fi module

### 3.2.7. Geared DC motor

A DC motor is a mechanically commutated electric motor powered from direct current. The stator is stationary in space by definition and therefore the current in the rotor is switched by the commutator to also be stationary in space. This is how the relative angle between the stator and rotor magnetic flux is maintained near 90 degrees which generates the maximum torque. Dc motors have a rotating armature winding (winding in which a voltage is induced) but non-rotating armature magnetic field and a static field (winding that produce the main magnetic flux) or permanent magnet.



Figure 3.8: Geared Dc motor

### 3.2.8. Motor driver

A motor driver is an integrated circuit chip which is usually used to control motors in autonomous robots. Motor driver act as an interface between Arduino and the motors. The most commonly used motor driver IC's are from the L293 series such as L293D, L293NE, etc. These ICs are designed to control 2 DC motors simultaneously. L293D consist of two H-bridge. H-bridge is the simplest circuit for controlling a low current rated motor. We will be referring the motor driver IC as L293D only. L293D has 16 pins.

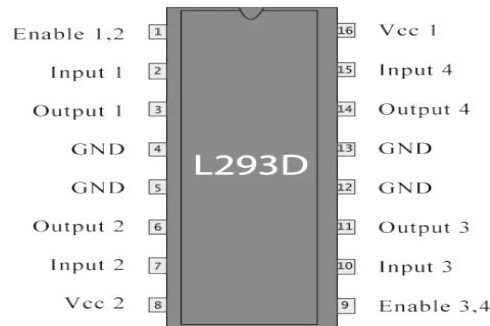


Figure 3.9: L293D motor driver

### Pin No. - Pin Characteristics

- 1 - Enable 1-2, when this is HIGH the left part of the IC will work and when it is low the left part won't work.
- - INPUT 1, when this pin is HIGH the current will flow through output 1
- - OUTPUT 1, this pin should be connected to one of the terminals of motor
- 4,5 - GND, ground pins
- 6 - OUTPUT 2, this pin should be connected to one of the terminals of motor
- 7 - INPUT 2, when this pin is HIGH the current will flow through output 2
- 8 - VCC2, this is the voltage which will be supplied to the motor.
- 16 - VCC1, this is the power source to the IC. This pin should be supplied with 5 V
- 15 - INPUT 4, when this pin is HIGH the current will flow through output 4
- 14 - OUTPUT 4, this pin should be connected to one of the terminals of motor
- 13,12 - GND, ground pins
- 11 - OUTPUT 3, this pin should be connected to one of the terminals of motor
- 10 - INPUT 3, when this pin is high the current will flow through output 3
- 9 - Enable 3-4, when this is high the right part of the IC will work and when it is low the right part won't work.

### 3.2.9. Infrared Ray Sensor

IR sensor is an electronic device that emits the light to sense a few objects from the environment. An IR sensor can measure the heat of an object as well as identifies the movement. More often than not, within the infrared range, all the objects radiate a few form of thermal radiation. These form of radiations are imperceptible to our eyes, but infrared sensor can distinguish these radiations(Shiny et al., 2015).

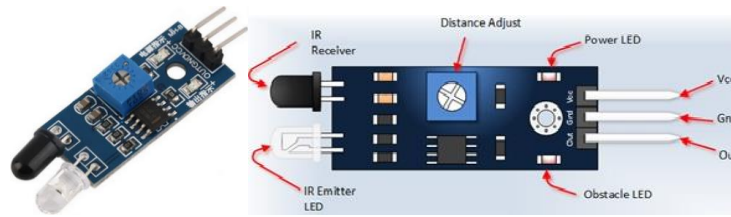


Figure 3.10: IR (Infrared Sensor) Sensor

The emitter is essentially an IR Driven (Light Transmitting Diode) and the locator is basically an IR photodiode. Photodiode is delicate to IR light of the same wavelength, which is transmitted by the IR LED. When IR light falls on the photodiode, the resistances and the output voltages will alter in extent to the magnitude of the IR light received. There are five essential components used in a normal infrared discovery system: an infrared source, a transmission medium, optical component, infrared locators or collectors and signal handling. Infrared lasers and Infrared LED's of particular wavelength used as infrared sources. The three fundamental sorts of media used for infrared transmission are vacuum, air and optical filaments. Optical components are used to center the infrared radiation or to restrain the ghastrly reaction.

### Working Principle of IR Sensor

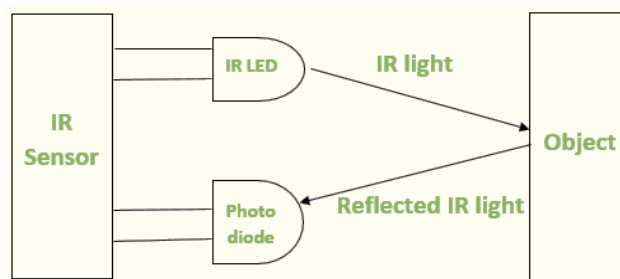


Figure 3.11: Working principle of IR sensor

From the figure above Infrared Transmitter may be a light emitting diode (Driven) which radiates infrared radiations called as IR LED's. Indeed, in spite of the fact that an IR Driven looks like a typical LED, the radiation emitted `by it is undetectable to the human eye. Infrared collectors or infrared sensors identify the radiation from an IR transmitter. IR recipients come within the frame of photodiodes and phototransistors. Infrared Photodiodes are diverse from ordinary photo diodes as they distinguish as it was infrared radiation. The emitter is an IR LED and the detector is an IR photodiode. The IR photodiode is sensitive to the IR light radiated by an IR LED. The photo-diode's resistance and yield voltage alter in extent to the IR light received (Kumar, 2020).

In vehicle speed control the vehicle will get identified within the low speed zone by the assistance of IR Transmitters and IR Receivers. As before long as the IR Receiver within the vehicle identifies the low speed zone the throttle valve within the speed constraining component will closed and the stream of the petrol will diminish slowly.

### **3.3. Software**

The microcontroller was programmed using Arduino IDE,XAMPP and PHP Strom. The software used to design and develop curve speed warning system are described below.

#### **3.3.1. Arduino Integrated Development Environment (IDE)**

The Arduino Integrated Development Environment (IDE) is a cross-platform application for the various operating systems that is written in functions from C language. The software allows programmers to combine the different features of writing a computer program and used to write and upload programs to Arduino compatible boards. The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the wiring project, which provides many common input and output procedures. An IDE allows developers to start programming new applications quickly because multiple utilities don't need to be manually configured and integrated as part of the setup process. The features such as to save time, to organize the workflow, and solve problems.

The Arduino IDE employs the program argued to convert the executable code into a text file in a hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware. By default, argued is used as the uploading tool to flash the user code onto official Arduino boards.

Arduino IDE is coding software that makes the programming world more accessible to beginners with its simple interface and community-driven system. However, Arduino IDE makes coding so much simpler for beginners. It is, in essence, a text processor with programming-specific functions.

#### **3.3.2. PHP Strom**

PHP Storm is one of the most popular developer tools used for web front end and back end development.

### **3.3.3. XAMPP**

XAMPP is a cross-platform web server that is free and open-source. XAMPP is a short form for Cross-Platform, Apache, MySQL, PHP, and Perl. XAMPP is a popular cross-platform web server that allows programmers to write and test their code on a local webserver. It was created by Apache Friends, and the public can revise or modify its native source code. It includes MariaDB, Apache HTTP Server, and interpreters for PHP and Perl, among other computer languages. Because of XAMPP's simplicity of deployment, a developer can quickly and easily install a WAMP or LAMP stack on an operating system, with the added benefit that common add-in apps like WordPress and Joomla can also be loaded.

## **3.4. Methods**

In order to achieve the thesis work objectives, the following methods are followed.

### **3.4.1. Literature Review**

Based on the literature survey, it is possible to use various type sensors to design and develop wireless communication system between vehicles and infrastructure to alert the drivers in dangerous road sections to drive and pass by optimum speed to ensure safety and comfort of passengers. Literature survey about both the existing system and the proposed system is the key methodology of this thesis that would help to have enough knowledge about what others already have done and identify where the problem does exist so that the proposed work will fill the gap that exists.

### **3.4.2. Data Analysis**

#### **3.4.2.1. Primary Data**

The primary necessary data collected for the thesis are as follows-

- ✓ Interview is a main tool for this proposal to collect data which is related to the limitations and challenges of the existing system
- ✓ Field survey at the particular area and observe the challenges of the existing system at those locations
- ✓ Studying the GPS and IR oriented vehicles characteristics

### 3.4.2.2. Secondary Data

According to the Ethiopian federal police commission's ten years total traffic accidents statistical data report, traffic accident is serious and gradually increasing cause for death, serious injury, light injury, and property damage. According to the report, all parameters are increasing year to year. This shows traffic accident in Ethiopia is very serious and need a serious attention.

Compared to other means of transportation, cargo transportation takes relatively lower numbers of death, serious injury and slight injury but higher property damage which contributes great role in destruction of the economy of the country. All cargo means of vehicles includes pick-ups up to 1-tonne capacity, trucks from 1 ton to 4-tonne capacity, trucks from 5 tons to 10-tonne capacity, heavy tracks with trailer and tanker trucks. As it is shown in Table 3.3, property loss takes the maximum credit from the rest three parameters.

Table 3.3: Traffic Accident Record of Ethiopia since 2010 G.C (Ethiopian Federal Police Commission)

| Parameters      | Public means of transportation vehicles | Cargo means of transportation vehicles | Machinery type Vehicles |
|-----------------|-----------------------------------------|----------------------------------------|-------------------------|
| Death           | 16640                                   | 11121                                  | 1023                    |
| Serious injury  | 25456                                   | 9963                                   | 1093                    |
| Slight injury   | 19386                                   | 7834                                   | 1818                    |
| Property damage | 136373                                  | 58982                                  | 3040                    |

Additionally, when seen in economical point view the report shows traffic accident is the serious and gradually increasing causes of property damage. Because of these accidents our country Ethiopia losses in billions.

Table 3.4: Aggregate property damage in Ethiopia (Ethiopian Federal Police Commission)

| Year(E,C) | Total property damage in ETB |
|-----------|------------------------------|
| 2006      | 1,001,604,812                |
| 2007      | 668,322,806.8                |
| 2008      | 874,611,141.5                |
| 2009      | 1,187,486,803                |
| 2010      | 920,771,314.8                |
| 2011      | 872,884,881                  |

This study was carried out at Dire Dawa Dengego high way situated in Dire Dawa, Oromia, Ethiopia, its geographical coordinates are located in latitude and longitude of 9° 36' 0" North, 41° 52' 0" East near to Dire Dawa. Figure below shows the satellite location of Dire Dawa to Dengego.

Table: Statics of National Traffic Accident from 2002-2011 E.C (Ethiopian Federal Police Commission)

| Tanker Trucker |            |                |               |                 |
|----------------|------------|----------------|---------------|-----------------|
| Year (E.C)     | Death      | Serious Injury | Slight Injury | Property Damage |
| 2002           | 43         | 8              | 30            | 46              |
| 2003           | 79         | 26             | 33            | 125             |
| 2004           | 102        | 35             | 44            | 318             |
| 2005           | 47         | 42             | 8             | 163             |
| 2006           | 64         | 45             | 24            | 195             |
| 2007           | 29         | 20             | 38            | 112             |
| 2008           | 91         | 20             | 9             | 205             |
| 2009           | 125        | 24             | 41            | 114             |
| 2010           | 123        | 30             | 45            | 54              |
| 2011           | 121        | 25             | 23            | 134             |
| <b>Total</b>   | <b>824</b> | <b>275</b>     | <b>295</b>    | <b>1466</b>     |



Figure 3.12: Satellite location from Dire Dawa to Dengego

### 3.4.3. Research Approach in Research Site

The design of OBU (On Board Unit) and RSU (Road Side Unit) to aware the driver with highway profile such as sharply curved road segment with their smooth communication is mandatory for proper functioning. In order to achieve this, each component with their specification is required. To fulfill the desired functionality each device should be kept on the correct place and a source voltage for all electronic devices should be regulated accordingly. To control the process of the embedded C language operating system the codes of a program should be written clearly. Whenever the vehicle having OBU reaches the RF coverage area and range, the antenna receives an electromagnetic wave then the communication takes place between the vehicle and RSU. Furthermore ‘curve analysis extraction’ and ‘speed limits database creation’ are also parts of our methods. An algorithm that analyzes the speed limit database that contains information about the different speed limit zones, location of RSU, weather condition of RSU for each curve segment path is also developed. The speed limit database contains information about the different speed limit zones for each traveled path.

These two approaches, speed limits database creation and curve extraction, are performed off-line including the preprocessing step.

- Extract position information of sharp curves and speed limit zones
- Compute the recommended speed for each sharp curve
- Obtain the speed limits for the path,
- Compute the triggered distance at which the vehicle needs to start decelerating to ensure smooth transition
- Aware the driver for speed transition

#### **3.4.4. Curve Speed Estimation**

The analysis of traffic accidents on curves has been a major concern of vehicle safety for several years (Dhahir & Hassan, 2019). No matter the efforts made to highlight dangerous curves with traffic signs (Malaghan et al., 2020), drivers are still confused with the speed they need to reach to have an appropriate control over the steering wheel. Nowadays, in the era of autonomous navigation, various solutions have been proposed to try to overcome this problem. One of them focused on analyzing human behavior while driving in curves.

Curve speed warning systems correspond to semi-autonomous solutions, which consist of informing the driver, through sound or display, about the recommended speed (Khan et al., 2012) proposed a system that goes beyond curves, considering also factors such as wet roads and visibility conditions (darkness) to compute the appropriate speed and inform the driver visually or audibly. Alternatively, the warning signal may come through some force applied to the throttle (accelerator) to prevent speeding. That is the case of (Malaghan et al., 2020), who proposed a curve warning system for motorcyclists through a force feedback throttle or a haptic glove.

Driving through an unknown sharp curve is always risky if the speed is not adapted to control the vehicle. In real life, the driver should be able to maneuver the steering wheel and reduce speed simultaneously in order to stay in the lane and pass the curve with comfort and safety. The same principle should be applied for autonomous control systems (reduce speed before going through a curve). In order to control the vehicle's speed appropriately, curve identification needs to be performed for the traveled GPS path to proceed with the computation of convenient speeds for each curve. Extracted and classified curves considering road data from Geographic Information Systems (GIS).

GIS store different types of information providing very accurate road geometry, but this is not always available. In our work, curvature analysis is performed using GPS data following the technique in (Malaghan et al., 2020) with minor modifications and extending its curve estimation to identify sharp curves. Curve analysis is a very important step for deciding the optimum speed value. According to the recorded RTK-GPS information,

- ✓ Define start and end points.
- ✓ Identify positions where speed limits change.
- ✓ Compute the distance ( $d_i$ ) from the speed limit change point to the reference starting point in the path.
- ✓ Save the distance ( $d_i$ ) for every speed limit change position identified together with its respective speed limit value ( $v_i$ ).

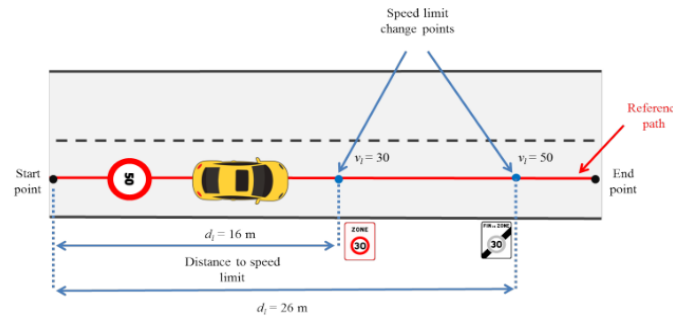


Figure 3.13: Speed limit definition (Jiang et al., 2020)

The creation of the speed limits database is performed off-line and only after GPS information is preprocessed. The description of the datasets and their speed limits identified is provided briefly.

#### 3.4.4.1. Sharp Curve Estimation

Sharp curves are defined as dangerous curves if their radii are small or central angles are big (Dhahir & Hassan, 2019). This type of curves deserve special attention due to the fact that they correspond to locations where the vehicle needs to decrease speed in order to take the curve as safely, keeping small lateral errors (Kumar, 2020). In order to identify sharp curves, we first localized all possible curves in the traveled GPS path based on work. Localizing curves means identifying their start and end points, which are also called points of tangency (PT) and points of curvature (PC), respectively. Once these points are identified, their curve characteristics can be computed: point of intersection (PI), curve length ( $L$ ), radius ( $R$ ) and central angle ( $\theta$ ). An illustration of all these characteristics is shown in Figure below.

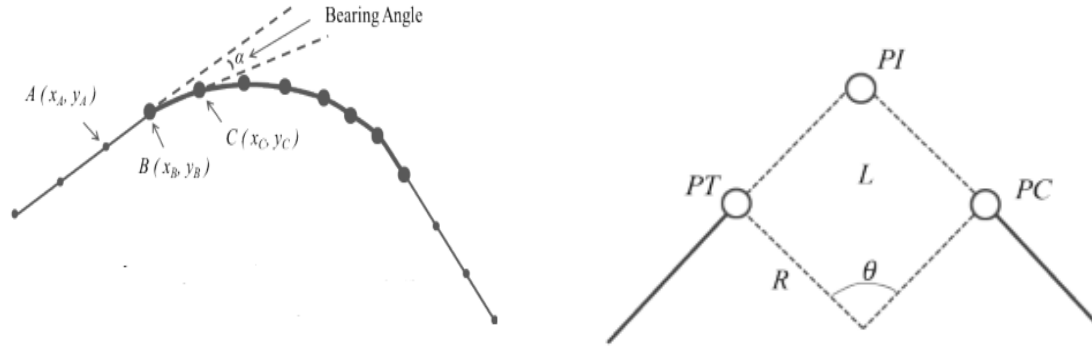


Figure 3.14: Speed estimation on a sharply curved road

Classifying points as being part of a curve or of a straight segment is the first step to be able to identify start and ends (PT and PC) in a curve. This procedure is performed by computing the bearing angle ( $\alpha$ ) between two consecutive segments formed with three points (A, B, C), as seen in the figure 3.14.

$$\alpha = \cos^{-1} \left( \frac{(x_B - x_A)(x_B - x_C) + (y_B - y_A)(y_C - y_B)}{\sqrt{(x_B - x_A)^2 + (y_B - y_A)^2} \times \sqrt{(x_C - x_B)^2 + (y_C - y_B)^2}} \right) \times \frac{180}{\pi} \quad (3.1)$$

Once the bearing angle is computed, a threshold value is assigned to determine if the point B is considered as part of a curve or not. If the angle  $\alpha$  is bigger than the defined threshold, the center point B is described as being part of a curve. Choosing the right threshold is a very important step, since curvature identification depends on this value. In this work, a threshold value of  $1.25^\circ$  was chosen as proposed in (Dhahir & Hassan, 2019) after evaluating curvature identification with different values. It is worth mentioning that values smaller than  $1.25$  are not relevant, as almost every point was considered as being part of a curve, and values bigger than  $1.25$  regarded long and smooth curves.

Based on work (Dhahir & Hassan, 2019), curves were classified as simple or compound. A compound curve is a curve formed with at least two consecutive curves separated by a certain distance between each other. In our datasets, this distance was set to 10.5 m, which is the approximation of considering three consecutive points in our preprocessed GPS path. An example of the two types of curves is illustrated in Figure 3.14.

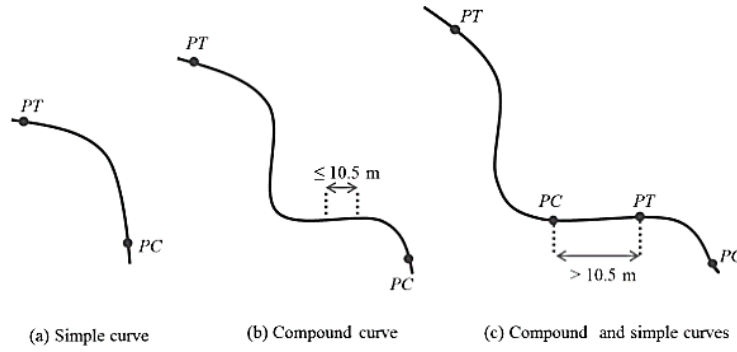


Figure 3.15: Types of curve

After each curve is defined by its start and end points (PT and PC), its geometric information, consisting of its radius (R), length (L) and central angle ( $\theta$ ), is computed through Equations below. In order to perform these computations, the center point of the curve (O) is identified following the work(Dhahir & Hassan, 2019).

$$R = \sqrt{(x_{PC} - x_O)^2 + (y_{PC} - y_O)^2} \quad (3.2)$$

$$C = \sqrt{(x_{PT} - x_{PC})^2 + (y_{PT} - y_{PC})^2} \quad (3.3)$$

$$\theta = 2 \times \sin^{-1}\left(\frac{C}{2R}\right) \times \frac{180}{\pi} \quad (3.4)$$

Curve length (L) was estimated by summing up the Euclidean distances between the segments that form the curve. As it is intended in considering only dangerous curves, sharp curves were categorized if their angle ranges from  $30^\circ$  to  $180^\circ$ , or their radius is between 5 and 18 m according to the American Association of State Highway and Transportation Officials' (AASHTO's) "A Policy on Geometric Design of Highways and Streets" (Sawant, Amey, Vinayak Ikke, Jyoti Khandale, Nilam Chavan, 2016). Figure 3.15 shows an example of the curve classification according to and marked in circles are the sharp curves identified with the method.

#### 3.4.4.2. Speed Computation for Sharp Curves

Curve speed estimation depends on centripetal and centrifugal forces. Centripetal force, which relies on the friction between tires and the roadway, is the one that makes the vehicle follow the curve, while centrifugal force tries to move the vehicle outwards from the curve. In order to compensate this last force, road curves are designed with an inclination known as a banked angle ( $\theta$ ) or super-elevation angle (e).

In other words, ideal speed in curves will be computed depending on the curvature of the path ( $k$ ), friction coefficient ( $\mu$ ) and super-elevation angle ( $e$ ), as shown in figure 3.16, where  $N$  is the normal force,  $f$  is the friction force,  $\mu$  is the friction coefficient,  $m$  is the vehicle mass,  $g$  is the gravity and  $F_{net}$  is the net force.

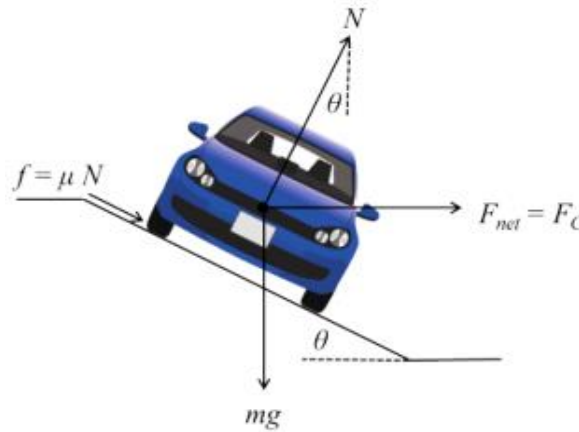


Figure 3.16: Forces on a sharply curved road

Through the normal force ( $N$ ), friction force ( $f$ ) and weight force ( $mg$ ) vectors, the centripetal force is defined as:

$$F_c = \frac{mv^2}{r} \quad (3.5)$$

where  $m$  represents vehicle mass,  $v$  vehicle speed and  $r$  the curve radius.

Summing up the vertical components, normal force can be described by using the following Equation.

$$N \cos \theta = mg + f \sin \theta \quad (3.6)$$

$$N = \frac{mg}{\cos \theta - \mu \sin \theta} \quad (3.7)$$

The net force is calculated through the horizontal components:

$$F_{net} = N \sin \theta + N \mu \cos \theta \quad (3.8)$$

Substituting the normal force in Equation above,

$$F_{net} = \left( \frac{mg}{\cos \theta - \mu \sin \theta} \right) (\sin \theta + \mu \cos \theta) = \frac{\tan \theta + \mu}{1 - \mu \tan \theta} mg \quad (3.9)$$

Since the friction coefficient ( $\mu$ ) usually varies from 0.1 to 0.16(Jiang et al., 2020) the value in the denominator tends to be around one, so it can be discarded. Now, the net force can be defined as the centripetal force ( $F_{\text{net}} = F_{\text{centripetal}}$ ), obtaining the following equation:

$$(\tan\theta + \mu)g = \frac{v^2}{r} \quad (3.10)$$

Using super-elevation  $e = \tan\theta$  and curvature information  $r = \frac{1}{k}$ , we substitute both terms into Equation above. The ideal speed will be given by the next formulae, which is exactly the same definition as in.

$$v = \sqrt{\frac{(e + \mu)g}{k}} \quad (3.11)$$

Following this equation, convenient speeds for each sharp curve ( $v_c$ ) were estimated considering a super-elevation value between 6% and 12%, which, according to the American Association of State Highway and Transportation Officials (AASHTO)(Sawant et al., 2016), is the value defined for rural and urban roads.

$k$  is the curvature information computed as the reciprocal of the radius,  $k = \frac{1}{r}$ . Finally, given a sharp curve detected in the traveled GPS path, we computed the distance ( $d_c$ ) from the reference start point of the path to each curve starting point (PT). This distance together with its respective curve lengths ( $l_c$ ) and the convenient speed ( $v_c$ ) are the parameters passed to the speed negotiation algorithm, detailed in the next subsection.

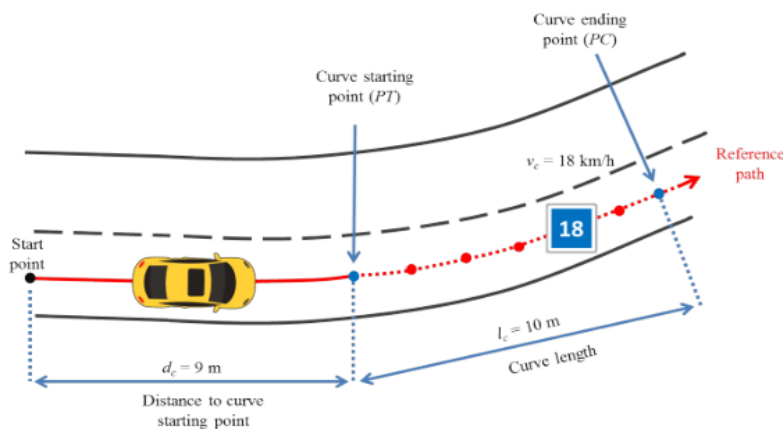


Figure 3.17: Distance estimation with curved road (Jiang et al., 2020)

### 3.4.5. Speed Negotiation

In typical manual driving situations, drivers notice the upcoming speed limit sign or curve and slow down or accelerate (depending on the current driving speed) to handle the road properly. Automating this procedure in ground vehicles requires knowledge ahead to adjust the vehicle's speed before entering a sharp curve or arriving at a new speed limit zone.

The speed negotiation algorithm tries to simulate human driving behavior based on the knowledge extracted from curves and speed limits to decide the ideal speed ( $v_{ideal}$ ) at which the vehicle should be traveling.

This negotiation depends mainly on the actual vehicle position in the GPS path, and the analysis of the input parameters coming from curve and speed limits. Initially, the lateral control system computes the lateral error ( $\epsilon$ ) and the current vehicle traveled distance ( $d_{current}$ ) in the path. This computation is estimated by projecting the current vehicle position on the reference path through spline interpolation to match the GPS points.

Once the projected vehicle's position is known, the speed negotiation algorithm analyses which type of road segment (curve or speed limits) is closer to the current vehicle position and computes a trigger distance.

This trigger distance ( $d_{trig}$ ) has the objective to take into account a smooth deceleration behavior to reach the ideal speed with comfort. It is calculated with the following equation:

$$d_{trig} = \frac{v_{target}^2 - v_{current}^2}{2a} \quad (3.12)$$

Where: •  $v_{target}$  is either the speed limit ( $v_l$ ) or curve speed ( $v_c$ ),

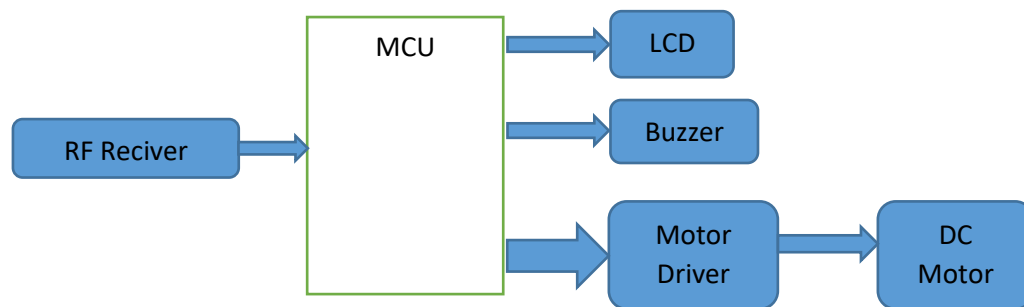
- $v_{current}$  is the current vehicle's speed and
- $a$  is the deceleration value to be applied.

An appropriate deceleration value is considered according to a study made by (Malaghan et al., 2020), which compares several deceleration behaviors at different speeds in various vehicle types. In our case, we set a maximum acceleration ( $a_{max}$ ) and deceleration ( $a_-$ ) of 2 m/s<sup>2</sup> to provide a comfortable transition between speeds and avoid longitudinal jerks. If sharp curved positions overlap with zones where a speed limit is lower than 50 km/h, our algorithm gives priority to the lower speed, which is usually the curve speed. Considering all aspects discussed above, the speed negotiation algorithm works as follows.

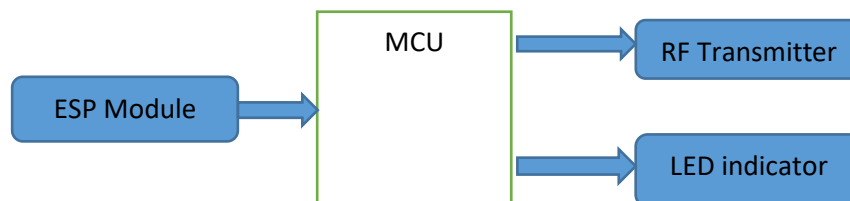
At each time step, an ideal speed ( $v_{ideal}$ ) results from the speed negotiation algorithm. This speed is used by the lateral control system to calculate an appropriate angle ( $\theta$ ) to be applied by the vehicle steering wheel. During every control cycle, the lateral control system sends to the vehicle speed and angle parameters to provide a smooth tracking performance. The goal of reducing the speed before arriving at a curve or a speed limit zone will provide the passenger comfort, avoiding abrupt rapid decelerations. At the same time, respecting the ideal speed definition will increase safety and provide more time in case hazardous situations occur.

### 3.4.6. System Design Modules

#### 3.4.6.1. Block Diagram of OBU



#### 3.4.6.2. Block Diagram of RSU



#### 3.4.6.3. On Board Unit(OBU)

In this section identification and classification of the arriving vehicle is authenticated by a microcontroller. In the detection process, the detectable connection is the basic speed measurement unit. The length of the detectable link is determined by the detection range.

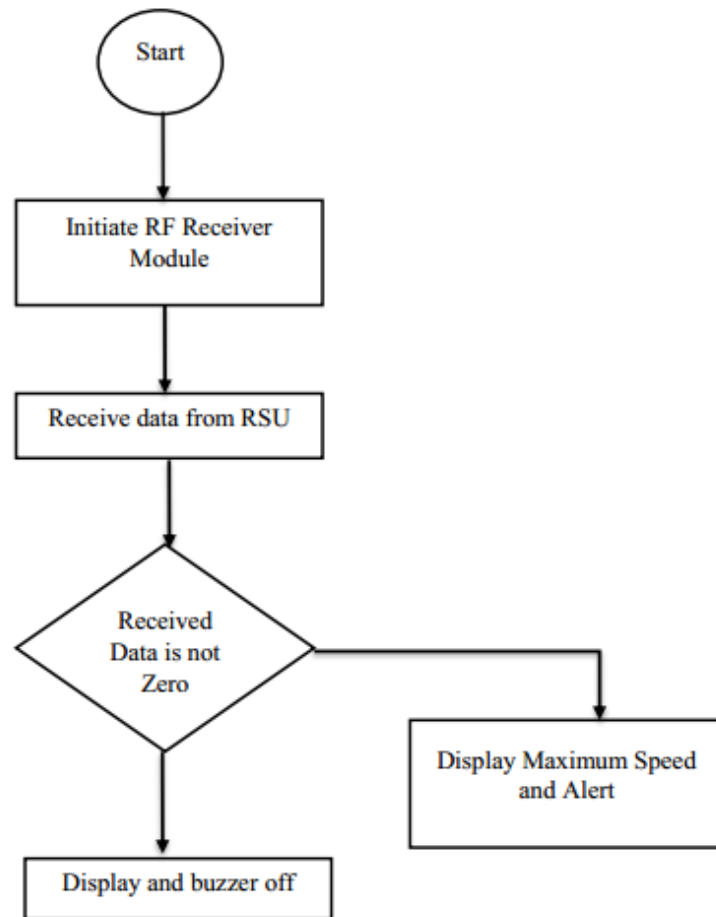


Figure 3.18: Flow chart for on board unit

#### 3.4.6.4. Road Side Unit(RSU)

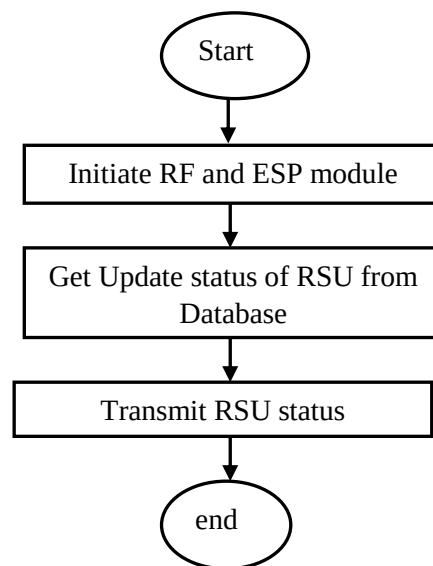


Figure 3.19: Flow chart for road side unit

### 3.4.6.5. Administrator (Control Panel)

The admin panel is mainly responsible for regular update of RSU by authorized body. This interface helps a given RSU multiple function which can be defined by administrator. The function of this module starts from initializing a given RSU module by giving its location (latitude and longitude), maximum allowed speed, weather condition and curve type. This information can also be updated whenever necessary.

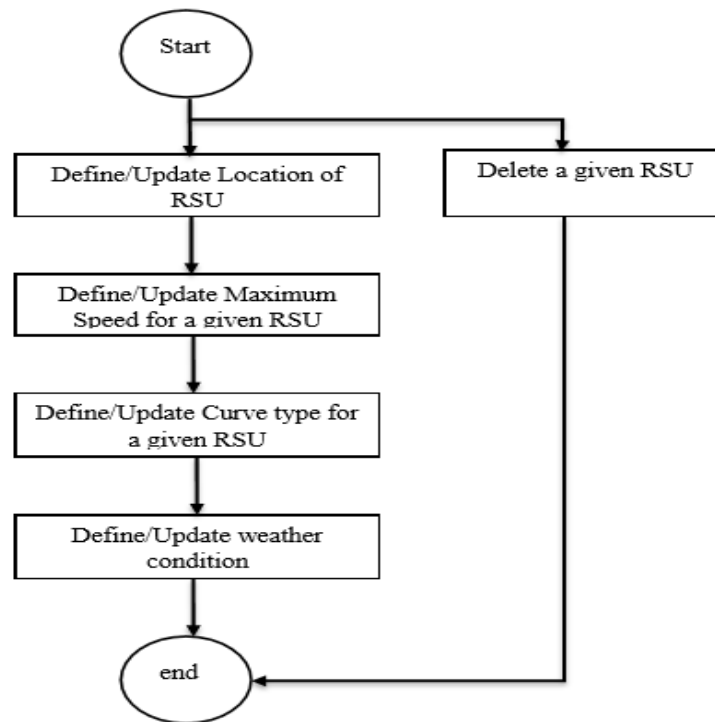


Figure 3.20: Flow chart for administrator control

## 3.5. System Design

### 3.5.1. Braking Force

The total braking force required can simply be calculated using Newton's Second Law.

$$F_b = mag \quad (3.13)$$

Where:  $F_b$  – Braking force

m – Total vehicle mass

a – Deceleration (g units)

g – Acceleration due to gravity

$$F_b = 16200 \text{ kg} \times 1 \times 9.81 \frac{\text{m}}{\text{s}^2} = 158922 \text{ N}$$

## Wheel lock

The braking force can only be generated if the wheel does not lock because the friction of a sliding wheel is much lower than a rotating one. The maximum braking force possible on any particular axle before wheel lock is given by:

$$F_b = m_{Dy} \times g \times \mu_f \quad (3.14)$$

Where:  $F_b$  – wheel lock

$m_{Dy}$  – Dynamic axle load

$g$  – Acceleration due to gravity

$\mu_f$  – Coefficient of friction between road and tire

For this parameter the thesis considers two cases:

Case 1: for normal tire and dry road condition the value of the coefficient of friction between road and tire ( $\mu_f = 0.7$ ) (Jones and Childers, 2001)

$$F_b = 10530 \text{ kg} \times 9.81 \frac{\text{m}}{\text{s}^2} \times 0.7 = 72309.5 \text{ N}$$

Case 2: For normal tire and wet road condition the value of the coefficient of friction between road and tire ( $\mu_f = 0.4$ ) (Jones and Childers, 2001)

$$F_b = 10530 \text{ kg} \times 9.81 \frac{\text{m}}{\text{s}^2} \times 0.4 = 41319.5 \text{ N}$$

### 3.5.2. Design Analysis

Table 3.5: Vehicle Specification

|                              |                                                                                             |                                                         |
|------------------------------|---------------------------------------------------------------------------------------------|---------------------------------------------------------|
| Cabin                        | Driving type                                                                                |                                                         |
|                              | HW 76cab with one bed and air condition 70 <sup>0</sup> hydraulically tillable to the front |                                                         |
| Vehicle main dimension       | Overall dimension(LXWXH)mm                                                                  | 11500x2500x3500                                         |
|                              | Wheel base                                                                                  | 1800+4600+1350                                          |
|                              | Wheel truck(front/rare/)mm                                                                  | 2020/1830                                               |
| Weight in kg                 | Tare weight                                                                                 | 15000                                                   |
|                              | Payload                                                                                     | 40000                                                   |
|                              | Front axis loading capacity                                                                 | 2x7000                                                  |
|                              | Rear axis loading capacity                                                                  | 2x16000                                                 |
| Maximum driving speed(km/hr) |                                                                                             | 90                                                      |
| Engine                       | Brand                                                                                       | SINOTRUCK                                               |
|                              | Model                                                                                       | WD615.45                                                |
|                              | Type                                                                                        | 4-strock direct injuction,6 cylinder with water cooling |
|                              | Horse power                                                                                 | 371HP                                                   |
|                              | Emission standard                                                                           | Euro                                                    |
| Gear box                     | HW19710 forward and reverse gear                                                            |                                                         |
| Clutch                       | Reinforce diaphragm clutch diameter 400                                                     |                                                         |
| Steering                     | ZF8098,power steering hydraulic steering with power assistance                              |                                                         |
| Oil tank                     | 400 liter                                                                                   |                                                         |
| Tire                         | 12R255tubless tire 13 PCS including one spare tire                                          |                                                         |
| Tank specification           | 30000 liter                                                                                 |                                                         |
| Tank material                | Q235 end plate thickness 6mm,tanker body thickness 5mm                                      |                                                         |

Table 3.6: Engine specification

| Model                               | WD615.62                                                                      | WD615.87 | WD615.69 | WD615.47 |
|-------------------------------------|-------------------------------------------------------------------------------|----------|----------|----------|
| Type                                | 6 cylinder inline ,4 stroke water cooled turbo charged air to air intercooled |          |          |          |
| Ignition sequence charged           | 1-5-3-6-2-4                                                                   |          |          |          |
| Valves                              | 2                                                                             |          |          |          |
| Distance between cylinder valve(mm) | 16                                                                            |          |          |          |
| Bore and stroke                     | 126*130                                                                       |          |          |          |
| Displacement                        | 9.726                                                                         |          |          |          |
| Compression ratio                   | 17.01                                                                         |          |          |          |
| Rated power kw                      | 196(266)                                                                      | 213(290) | 247(236) | 273(271) |
| Rated speed (rev/min)               | 2200                                                                          |          |          |          |
| Max torque (NM)                     | 1100                                                                          | 1160     | 1350     | 1500     |
| Speed at max torque(rev/min)        | 1100-1600                                                                     |          |          |          |
| Idling speed(rev/min)               | 600±50                                                                        |          |          |          |
| Specified fuel consumption(g/kwh)   | ≤193                                                                          |          |          |          |
| Noise db.(A)                        | ≤98                                                                           |          |          |          |
| Bare mass(kg)                       | 850                                                                           |          |          |          |
| Emission                            | euro II                                                                       |          |          |          |

### 3.5.2.1 Speed Analysis with Radius of Curvature

While the truck is taking a turn, three major couples were produced. These are the parameters which affect the stability of the vehicle. These are:

1. Wheel gyroscopic couple
2. Engine gyroscopic couple
3. Centrifugal couple

In order to know the maximum turning speed these couples have to be known. In order to know these couples the equations which are given below are used:

✓ **Wheel gyroscopic couple due to the rotation of the wheel**

$$C_W = 12 I_W \omega_w \omega_p \quad (3.15)$$

Where,  $I_W$  = Wheel mass moment of inertia

$C_W$  = Wheel gyroscopic couple

$\omega_p$  = Angular precision velocity

$\omega_w$  = Angular velocity of the wheel

Since, the truck has twelve wheels the gyroscopic couple of the truck is multiplied by twelve.

✓ **Engine gyroscopic couple**

$$C_E = I_E \omega_E \omega_p \quad (3.16)$$

Where,  $I_E$  = engines mass moment of inertia

$\omega_p$  = angular precision velocity

$\omega_w$  = angular velocity of the wheel

$C_E$  = engine gyroscopic couple

✓ **Centrifugal couple**

$$C_C = F_c \times h \quad (3.17)$$

Where,  $F_c$  = centripetal force

$C_C$  = centrifugal couple

$h$  = height of center of gravity

In order to know these couples, all the unknown parameters should be calculated. The first step is finding the radius of gyration which is used to calculate gyroscopic couple of the wheel and the engine.

$$K = \sqrt{a_1^2 + a_2^2} \quad (3.18)$$

Where  $K$  = Radius of gyration

$a_1$  = Distance of the trucks center of mass from the front axle

$a_2$  = Distance of the trucks mass Center from the rear axle

$$a_1 = \frac{2l}{mg} F_2 \quad (3.19)$$

According to the specification of the truck

Where  $F_2$  = load on the rear axle = 160,000 N

$F_1$  = load on the front axle = 70,000 N

$l$  = wheel base = 7.75 m

$m$  = Mass of the truck = 46,000 Kg

$$a_1 = \frac{2(7.75m)}{(46,000Kg)(9.81m/s^2)} (160,000 N)$$

$$a_1 = 5.5m$$

Then,

$$a_2 = l - a_1 \quad (3.20)$$

$$a_2 = 7.75m - 5.5m = 2.25m$$

Finally,  $K = 2.78m$

#### Mass Moment of Inertia of the Wheel

$$I_w = mk^2 \quad (3.21)$$

Where:  $m$  = mass of the wheel and according to the specification given by the truck manufacturer 52 kg

$$I_w = (52Kg)(12.375m^2) = 643.5Kgm^2$$

#### Mass Moment Inertia of the Engine

$$I_E = mk^2$$

Where:  $m$  = mass of the wheel and according to the specification given by the truck manufacturer 850 kg

$$I_E = (850Kg)(12.375m^2) = 10,518.75 Kgm^2$$

Assume the truck is taking a right turn and  $R = 100m$  (radius of curvature of the road)

#### Wheel gyroscopic couple

Gyroscopic couple due to the rotation of the wheel

$$C_w = 12 I_w \omega_w \omega_p \quad (3.22)$$

Where,

$$\omega_w = \frac{V}{r_w} \text{ and } \omega_p = \frac{V}{R}$$

Therefore;

$$C_w = 12 \times 643.5 \text{Kgm}^2 \times \frac{V}{0.54\text{m}} \times \frac{V}{100\text{m}} = 143V^2$$

Due to the wheel's gyroscopic couple there is a weight transfer from inner wheel to the outer wheels. Let  $P_1$  be the weight transfer from inner wheel to the outer wheels and it is subtracted from the inner wheels and added to the outer wheels.

$$\frac{P_1}{2} = \frac{C_w}{2a} = 35.4V^2$$

Where:  $a$  = is the track width of the truck

### Engine gyroscopic couple

Gyroscopic couple due to the rotation of the engine

$$C_E = I_E \omega_E \omega_p \quad (3.23)$$

Where,

$$G = \frac{\omega_E}{\omega_w} = 5$$

Therefore;

$$C_E = 10,518.75 \text{ Kgm}^2 \times \frac{5V}{0.54\text{m}} \times \frac{V}{100\text{m}} = 973.95V^2$$

Due to the engine's gyroscopic couple there is a weight transfer from the front wheel to the rear wheels. Let  $P_2$  be the weight transfer from front wheel to the rear wheels and it is subtracted from the front wheels and added to the rear wheels.

$$\frac{P_2}{2} = \frac{C_w}{2 \times l} = 62.8V^2$$

Where:  $l$  = is the wheel base of the truck

### Centrifugal Couple

Due to centrifugal couple there is a weight transfer from inner wheel to the outer wheel.

$$C_c = F_c \times h \quad (3.24)$$

Where;

$$F_c = \frac{mV^2}{R} \quad (3.25)$$

Therefore;

$$C_c = 805V^2$$

Due to the centrifugal couple there is a weight transfer from inner wheel to the outer wheels. Let Q be the weight transfer from inner wheel to the outer wheels and it is subtracted from the inner wheels and added to the outer wheels.

$$\frac{Q}{2} = \frac{C_c}{2 \times a} = 199.3V^2$$

Critical wheel is inner front wheel and the critical speed is given below.

Where  $W_F$  = Weight on the front inner wheel

$$W_F = 7000\text{Kg} \times 9.81\text{m/s}^2 = 68670\text{N}$$

The loads at the front inner wheel at critical speed is:

$$W_F - \frac{P_1}{2} - \frac{P_2}{2} - \frac{Q}{2} = 0$$

$$68670\text{N} - 35.4V^2 - 62.8V^2 - 199.3V^2 = 0$$

$$V^2 = 230.82 \text{ m}^2/\text{s}^2$$

$$V = 15.2 \text{ m/s} = 54.72 \text{ Km/hr}$$

Therefore, the maximum speed at which the truck makes a turn is 54.72 km/hr

## CHAPTER FOUR

### RESULTS AND DISCUSSIONS

#### 4.1. Review of Results and Discussions

As per the proposal to develop curve speed warning system, which involves the coordinated operation of OBU, RSU and web interface system are discussed in detail based on the specific objectives set at the introductory section. In this chapter the RSU update, the removal, the registration, the criminal detections and related uses of the system are shown on the following pages. The prototype image is also included at the end of the chapter.

#### 4.2. Triggering Distance Determination with Various Deceleration Rates

Table 4.1: Triggering distance

| No | Initial Speed(km/hr) | Triggering distance(m) with deceleration of 2m/s <sup>2</sup> | Triggering distance(m) with deceleration of 3m/s <sup>2</sup> | Triggering distance(m) with deceleration of 4m/s <sup>2</sup> |
|----|----------------------|---------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
| 1  | 20                   | 2                                                             | 4                                                             | 5.714                                                         |
| 2  | 30                   | 4.5                                                           | 9                                                             | 12.86                                                         |
| 3  | 40                   | 8                                                             | 16                                                            | 22.86                                                         |
| 4  | 50                   | 12.5                                                          | 25                                                            | 35.71                                                         |
| 5  | 60                   | 18                                                            | 36                                                            | 51.43                                                         |
| 6  | 70                   | 24.5                                                          | 49                                                            | 70                                                            |
| 7  | 80                   | 32                                                            | 64                                                            | 91.43                                                         |
| 8  | 90                   | 40.5                                                          | 81                                                            | 115.7                                                         |
| 9  | 100                  | 50                                                            | 100                                                           | 142.9                                                         |

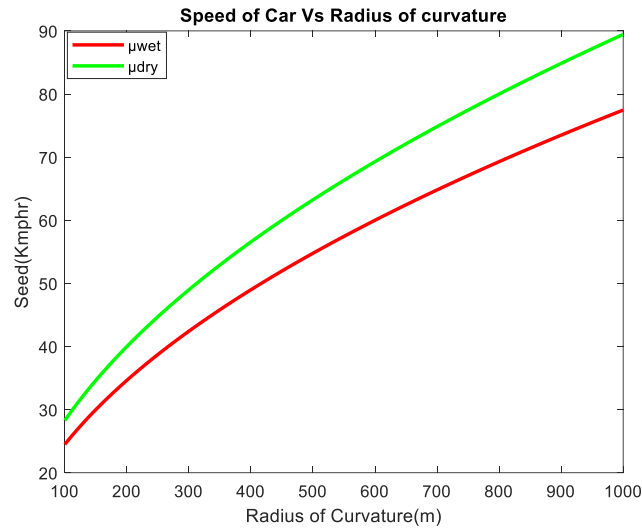


Figure 4.1: Relationship between radius of curvature and the speed of vehicle

Fig 4.1 shows the relationship between radius of curvature and the speed of vehicle with different frictional coefficient of road. We can clearly see that the triggering distance will increase when the coefficient of friction of the road decrease. This scenario is illustrated during rainy condition. However the triggering distance shows a great improvement for dry road condition. Table 4.2 also shows the relation between radius of curvature and speed in tabular form.

Table 4.2: Radius of curvature and Speed of vehicle relationship with different road condition

| No | Radius of Curvature(m) | Speed of Car on Dry road( $\mu=0.8$ ) | Speed of Car on Wet Road( $\mu=0.6$ ) |
|----|------------------------|---------------------------------------|---------------------------------------|
| 1  | 100                    | 28.28                                 | 24.49                                 |
| 2  | 200                    | 40                                    | 34.64                                 |
| 3  | 300                    | 48.99                                 | 42.43                                 |
| 4  | 400                    | 56.57                                 | 48.99                                 |
| 5  | 500                    | 63.25                                 | 54.77                                 |
| 6  | 600                    | 69.28                                 | 60                                    |
| 7  | 700                    | 74.83                                 | 64.81                                 |
| 8  | 800                    | 80                                    | 69.28                                 |

## Triggering distance graph

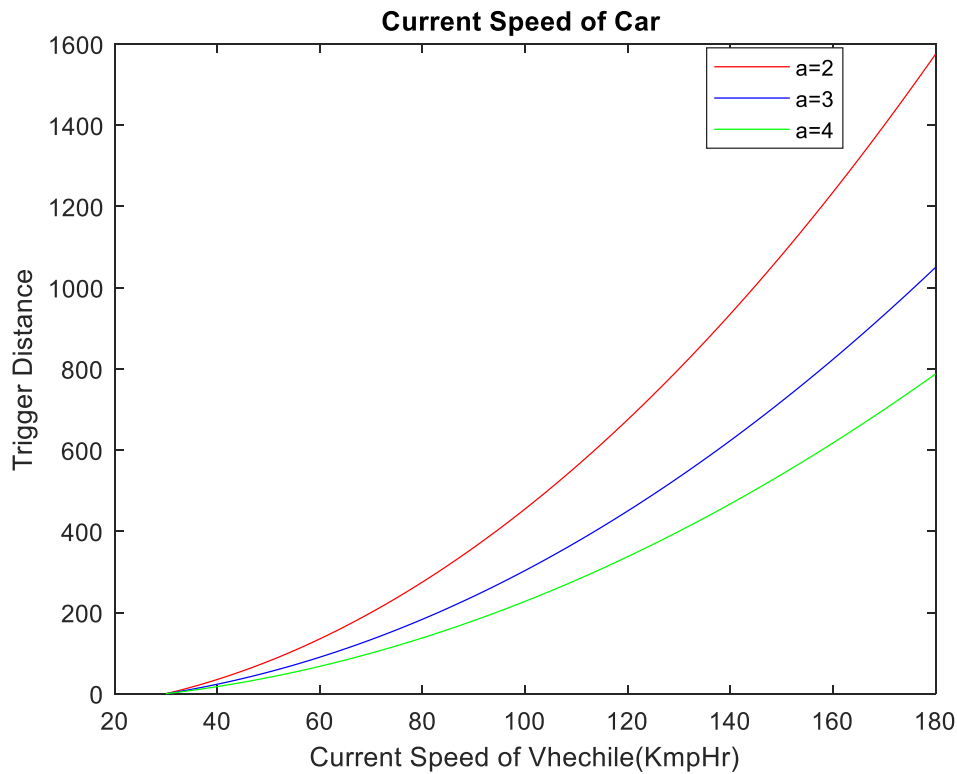


Figure 4.2: The relationship between trigger distance and current speed of vehicle

Fig 4.2 shows the relationship between trigger distance and current speed of vehicle with different deceleration rate i.e.( $a=2$ ,  $a=3$ ,  $a=4$ ). The graph shows that the triggering distance is increasing exponentially for the increasing of vehicle speed. This clearly shows that at what distance the driver should be alerted in order to achieve the target speed. Additionally the effect of increasing deceleration rate is demonstrated with triggering distance. It can be shown that increasing the deceleration rate can greatly decrease the triggering distance. At this point we should consider a smooth transition from the current speed of vehicle to desired speed. This safe, smooth and comfortable transition is  $2\text{m/s}^2$  according to literatures. Based on the triggering distance the location of RSU is determined in order to aware the driver early. Table below shows the relation between triggering distance with current speed of vehicle.

Table 4.3: The relationship between triggering distance with current speed of vehicle

| No | Current Speed<br>(Km/hr) | Triggering<br>distance for<br>(RSU 1) | Triggering<br>distance for<br>(RSU 2) | Triggering<br>distance for<br>(RSU 3) |
|----|--------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| 1  | 40                       | 35                                    | 23.3                                  | 17.5                                  |
| 2  | 50                       | 80                                    | 53.33                                 | 40                                    |
| 3  | 60                       | 135                                   | 90                                    | 67.5                                  |
| 4  | 70                       | 200                                   | 133.3                                 | 100                                   |
| 5  | 80                       | 275                                   | 183.3                                 | 137.5                                 |
| 6  | 90                       | 360                                   | 240                                   | 180                                   |
| 7  | 100                      | 455                                   | 303.3                                 | 227.5                                 |
| 8  | 110                      | 110                                   | 373.3                                 | 280                                   |

### 4.3. Administrator Panel

Figure 4.3 shows the administrator panel for creating RSU with a given RSU Identification (RSU ID), Location, Curvature type, maximum speed and weather condition. RSU registration is the first step in order to implement curvature warning system. The location of each RSU is based on the calculated triggering distance which considers a smooth transition of maximum vehicle speed to a desired suitable curve speed.

The screenshot shows the 'RSU Registration' form in the administrator panel. The form has a teal header and a light blue background. On the left, there is a dark sidebar with navigation options: 'RSU Registration', 'Weather Status', 'RSU Edit' (with a 'New' badge), 'View RSU Status' (with a 'New' badge), and 'Remove RSU' (with a 'New' badge). The main form area contains the following fields:

- RSU ID:** A text input field containing 'DD\_DG\_01'.
- RSU Location(Lat.):** A text input field containing '12.89'.
- RSU Location(Long.):** A text input field containing '45.09'.
- RSU Type:** A dropdown menu with 'Slight Curve' selected.
- Max. Speed (Km/h):** A text input field containing '60'.

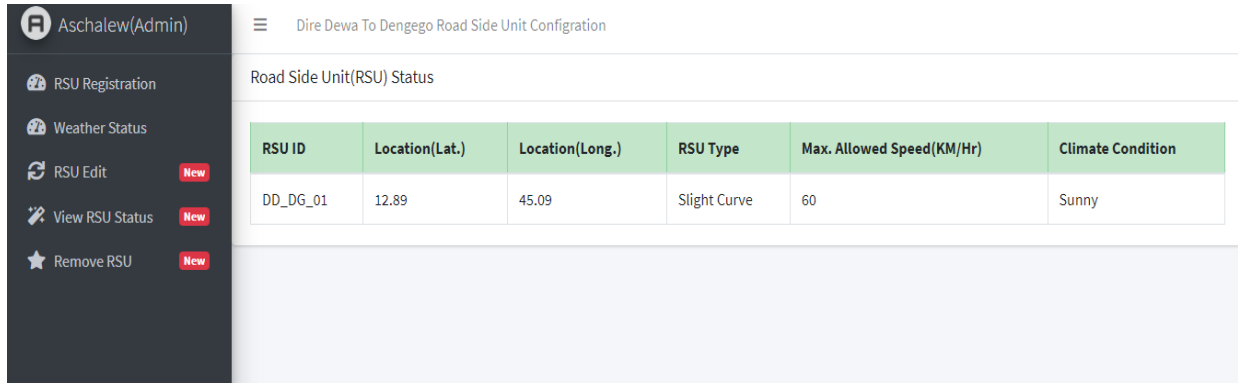
A teal 'Register' button is located at the bottom right of the form.

Figure 4.3: RSU Registration

### 4.3.1. Road Side Unit (RSU)

#### Status (Admin) View

Figure 4.4 shows the administrator panel for viewing a registered RSU status with a given RSU Identification (RSU ID), Location, Curvature type, maximum speed and weather condition. A registered RSU having its own property is displayed in this section.

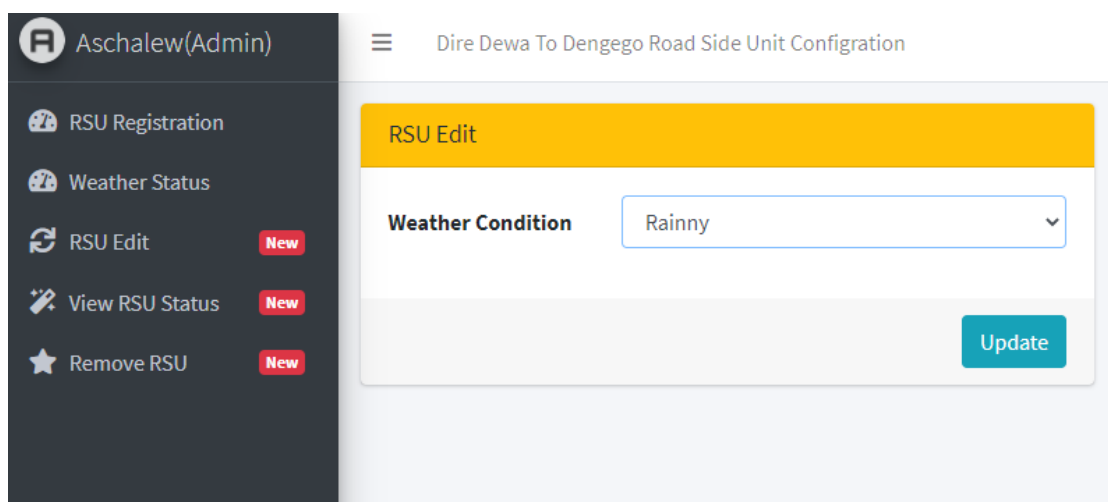


| RSU ID   | Location(Lat.) | Location(Long.) | RSU Type     | Max. Allowed Speed(KM/Hr) | Climate Condition |
|----------|----------------|-----------------|--------------|---------------------------|-------------------|
| DD_DG_01 | 12.89          | 45.09           | Slight Curve | 60                        | Sunny             |

Figure 4.4: RSU View Section

### 4.3.2. Update Weather Status

Figure 4.5 shows the controlling mechanism of RSU based on the environmental weather condition. Instead of defining a fixed speed limit on RSU, a regular update of RSU can benefit to determine the appropriate speed with the corresponding weather condition. This functionality is used to consider the variable road friction which varies according to the wetness and dryness of the road.



RSU Edit

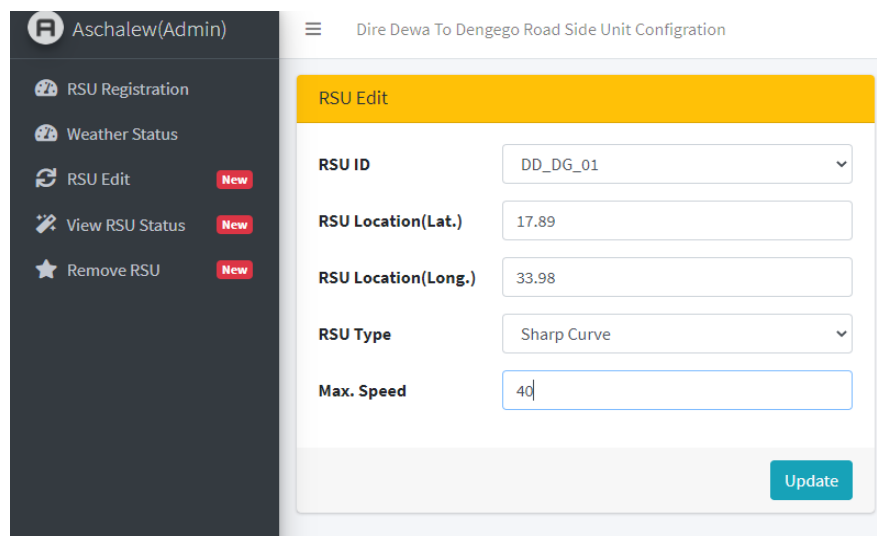
Weather Condition: Rainny

Update

Figure 4. 5: Update Weather Conditions

### 4.3.3. Edit Road Side Unit (RSU)

Figure 4.6 shows how a given defined RSU manipulated its already defined property. For instance, a given RSU ID given by DD\_DG\_01 is first initialized with location of (12.89 ,45.09), with slight curve and a maximum speed of 60 Km/hr. Due to environmental condition such as newly constructed road the previous property of that RSU might be no longer needed. Instead a new property of RSU is updated. This can be done by selecting a particular RSU ID to modify its property. The main advantage of this functionality is that a given RSU can be programmed remotely and its functionality is changed easily purpose wise.



The screenshot shows the 'RSU Edit' form in the Aschalew(Admin) dashboard. The form is titled 'RSU Edit' and is located under the 'Dire Dewa To Dengego Road Side Unit Configuration' section. The form contains the following fields:

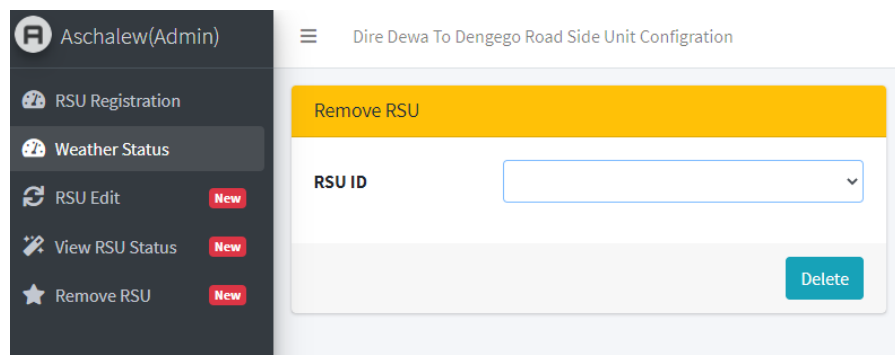
- RSU ID: A dropdown menu with 'DD\_DG\_01' selected.
- RSU Location(Lat.): A text input field with '17.89'.
- RSU Location(Long.): A text input field with '33.98'.
- RSU Type: A dropdown menu with 'Sharp Curve' selected.
- Max. Speed: A text input field with '40'.

An 'Update' button is located at the bottom right of the form.

Figure 4.6: Update RSU

### 4.3.4. Remove Road Side Unit (RSU)

Figure 4.7 shows the functionality of the system used to remove a defined RSU. Due to many reasons like a change of road, a location of RSU might be changed and even RSU can be removed permanently. Besides, it shows how a given RSU can be removed for good by selecting its particular RSU ID.



The screenshot shows the 'Remove RSU' form in the Aschalew(Admin) dashboard. The form is titled 'Remove RSU' and is located under the 'Dire Dewa To Dengego Road Side Unit Configuration' section. The form contains the following fields:

- RSU ID: A dropdown menu.

A 'Delete' button is located at the bottom right of the form.

Figure 4.7: Delete RSU

## 4.4. Criminal Registration

Figure 4.8 shows the registration process of criminal vehicle. Another application of RSU and OBU is to help criminal investigation process. This is implemented in such a way that the OBU broadcast the Vehicle property such as Plate Number, Motor Number and chassis number. This message is captured by any nearby RSU to communicate with the server where authorized persons have the access. During the registration of RSU, its location is determined in terms of longitude and latitude which helps to determine the location of Vehicle.

The screenshot shows the 'Criminal Registration Form' within the 'Aschalew(Admin)' application. The form includes the following fields:

- Plate Number:** A text input field with placeholder text 'Plate No.'.
- Chasis Number:** A text input field with placeholder text 'Chasis Number'.
- Vehicle Type:** A dropdown menu currently showing 'Bus'.
- Case:** A dropdown menu currently showing 'Over Speed'.
- Date:** A date input field with placeholder text 'mm/dd/yyyy' and a calendar icon.

A red 'Register' button is located at the bottom right of the form.

Figure 4.8: Criminal Registration

### 4.4.1. Criminal List

Figure 4.9 shows the user interface of administrator for criminal list. Once the vehicle is identified as violent it is registered in the criminal's record. This list is useful to look the summary of violent drivers.

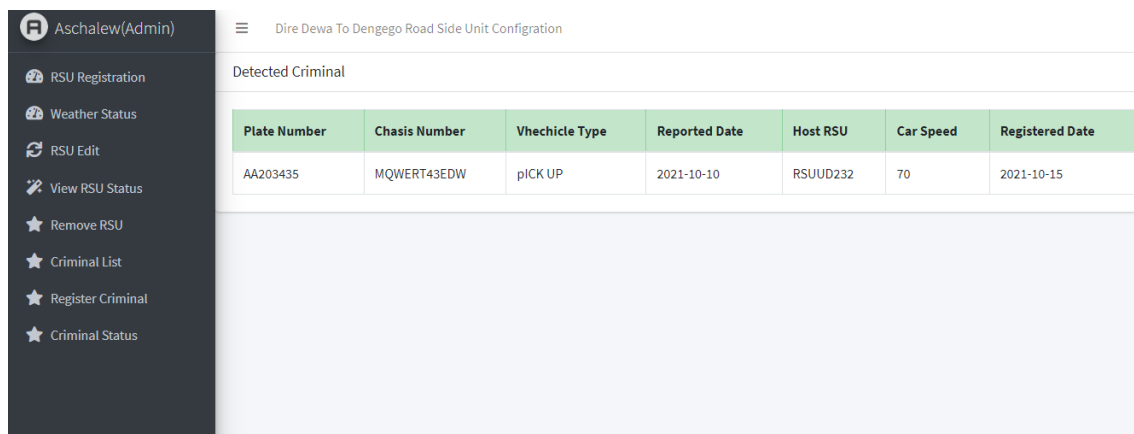
The screenshot shows the 'Criminal List' table within the 'Aschalew(Admin)' application. The table has the following columns: Plate Number, Chasis Number, Vhechicle Type, Criminal Case, and Registered Date.

| Plate Number | Chasis Number | Vhechicle Type | Criminal Case     | Registered Date |
|--------------|---------------|----------------|-------------------|-----------------|
| plateno      | 123           | Isuzu          | Stolen Car        | 2021-10-25      |
| 123          | 123           | Isuzu          | Traffic Violation | 2021-10-07      |
| AA08765      | CFG54JULKA34  | Automobile     | Over Speed        | 2021-10-13      |
| AA08766      | M2Q091783     | PickUp         | Stolen Car        | 2021-10-30      |

Figure 4.9: Criminal List

#### 4.4.2. Detected Criminals

Figure 4.10 shows the user interface of detected criminals. Once the vehicle is identified as violent it should be handcuffed. When the driver is not willing to obey the law other systems like this is very crucial. This system will store the vehicle information in wanted list, meanwhile the OBU will broadcast the vehicle basic information. Whenever the vehicle pass through RSU transmitting zone the RSU will identify the vehicle and report to central server. Then the system will generate a summary of the detected criminal with all information.



| Plate Number | Chasis Number | Vhechicle Type | Reported Date | Host RSU | Car Speed | Registered Date |
|--------------|---------------|----------------|---------------|----------|-----------|-----------------|
| AA203435     | MQWERT43EDW   | pICK UP        | 2021-10-10    | RSUUD232 | 70        | 2021-10-15      |

Figure 4.10: Detected Criminals

#### 4.5. Circuit Diagram of the On Board Unit (OBU)

Fig 4.11 shows the circuit design of On Board Unit (OBU) interface. OBU is used to display information for the driver by receiving information from Road Side Unit. This system has both visual and auditory warning that is very necessary for warning the driver. Whenever the vehicle is in the range of RSU coverage area corresponding information is received from the RSU. This warning information is displayed by using LCD and auditory system i.e. buzzer.

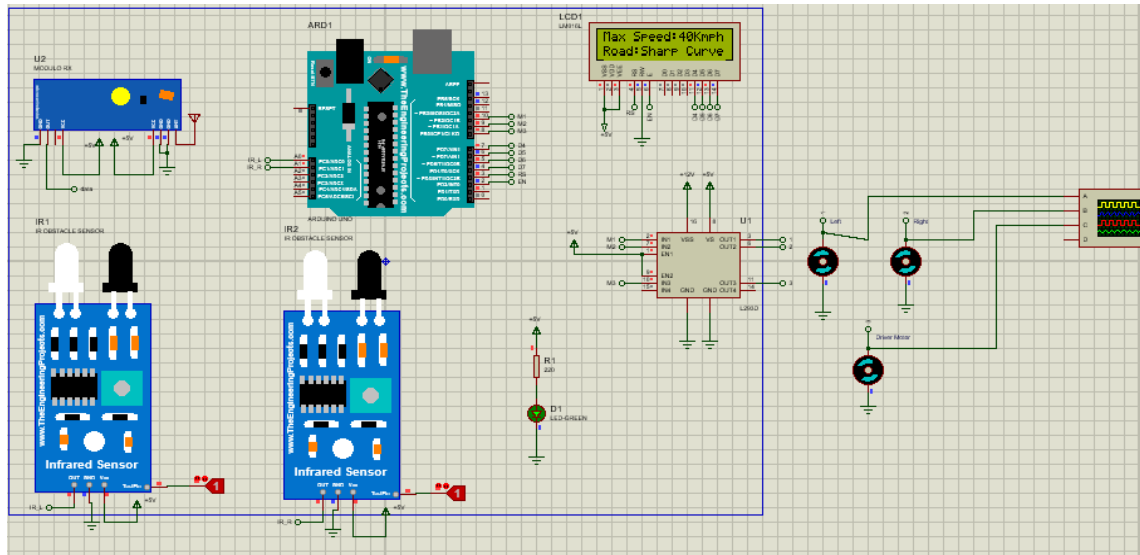


Figure 4.11: On board unit

#### 4.6. Circuit Diagram of the Road Side Unit (RSU)

Figure 4.12 shows the circuit diagram of RSU. A given RSU is responsible for transmitting warning information for OBU locating at a calculated distance found by the triggering distance. The information transmitted by a given RSU can also be manipulated. This property enables RSU to be accessed and monitored remotely. Each RSU is connected to central server i.e. speed limit database.

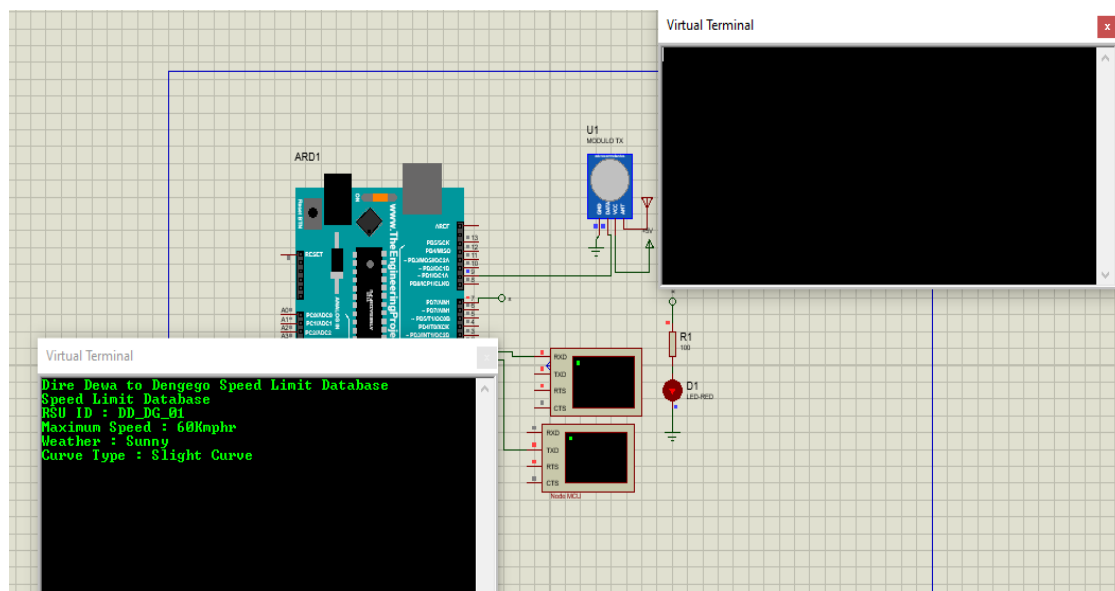


Figure 4.12: Road Side Unit

Table 4.4: Comparison of the new system and the existing one

| Comparison              | New Proposed | Gyroscope based | IR Based | GPS Based |
|-------------------------|--------------|-----------------|----------|-----------|
| Continuous computation  | Not Required | Required        | Required | Required  |
| Environmental Awareness | Yes          | No              | No       | No        |
| Remote Access           | Yes          | No              | No       | No        |
| Outdoor operation       | Yes          | Yes             | No       | Yes       |
| Measurement Error       | No           | Yes             | No       | Yes       |
| Smooth Transition       | Yes          | No              | Yes      | No        |

#### 4.7. Prototype Simulation Images of Road Side Unit (RSU) and On Board Unit (OBU)

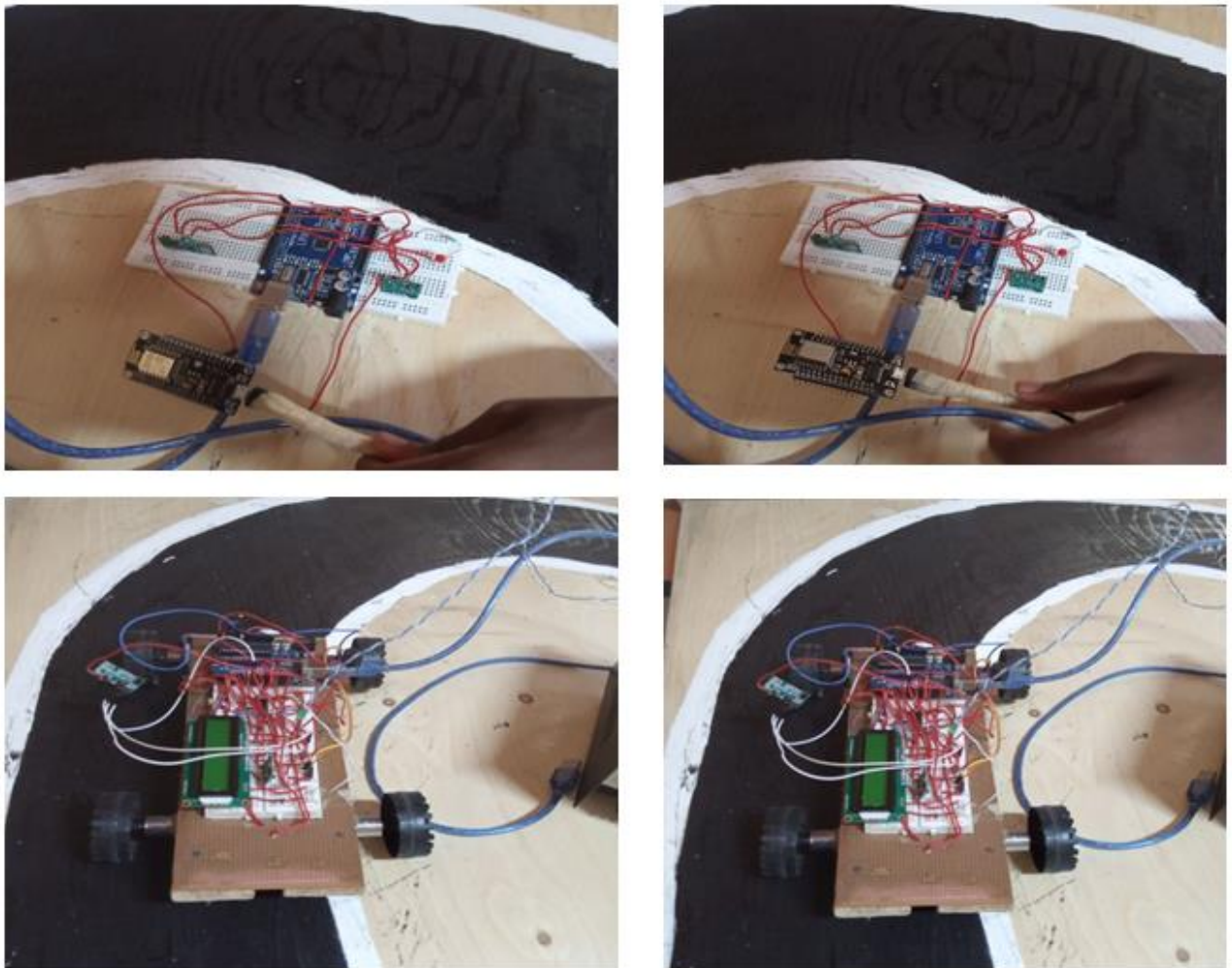


Figure 4.13: Prototype Image

## **CHAPTER FIVE**

### **CONCLUSIONS AND RECOMMENDATIONS**

#### **5.1 Brief Summary of the Study**

As it has been indicated in the introduction part, the main objective of this thesis work was to design and develop a curve speed warning system to prevent tanker truck crash on curved roads. The designed system mainly used Arduino UNO, ESP module, IR sensor, buzzer, LED and the Liquid Crystal Display.

This study set the optimum speed at which the vehicles have to be driven to ensure safety by implementing vehicles to roadside infrastructures communication wirelessly using on board unit (OBU) and roadside unit (RSU). The thesis incorporated two-way communication of OBU and RSU, which enables the system to serve multiple functions like recording the plate, number of cars in case the recommended speed is violated or if a stolen car has passed through that road. It gives drivers the information around that area like the presence of cafe, oil stations and other helping centres and this work created a web interface that controls the RSU, which can be monitored regularly followed by authorised body from remote buy using internet access.

#### **5.2. Conclusion**

In this thesis, the use of V2I communication is used in order to reduce vehicle crash in sharply curved road. This is implemented by designing roadside unit (RSU) and on board unit (OBU). The first functionality of this system is providing visual and auditory information by using LCD and buzzer. RSU transmitting road condition such as curvature and maximum speed allowed at that road segment will help the driver to adjust its speed accordingly and keep in focus. Additionally, for smooth transition of vehicle speed to desired level, triggering distance is considered for RSU positioning. Moreover, the curvature warning system is can receive updated information through RSU internet interface. This will allow calculation of maximum speed in different environmental condition. For instance, the friction between road and tire will be different during sunny and rainy condition. So in such case environmental factors notifying system is mandatory. Here is a summary for the comparison of new proposed system and existing system.

### **5.3. Recommendations**

Vehicle to infrastructure communication is highly implemented to reduce traffic accident in so many situations such as sharp road curvature. In this thesis, OBU and RSU are implemented in order to warn the driver in sharply curved road. The following issues are the future scope of this thesis.

- ✓ The most recent technology i.e. Vehicle-to-Vehicle communication can also be analyzed to reduce accident in sharply curved road.
- ✓ The transport sector of the country should work on legalizing and obligating vehicle owners to implement this system to make sure a safe transportation system.
- ✓ The authorized body that administrates the RSU should pay a serious attention at updating the system in accordance with weather status of the area

### **5.4 Recommendation for Future work**

The technology used in this system can be further improved for compatibility and safety in areas such as:

- ✓ Valleys and summit road conditions by following proper investigation to decide the right RSU positioning place.

## **Research Fund Acknowledgment**

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## APPENDICES

### OBU Code

**The onboard unit is programmed as under**

```
int motor_r = 9;
int motor_l = 10;
int motor_drive = 8;
int IR_L = A0;
int IR_R = A1;
int data = 0;
int powerkey_prev = 0;
int powerkey_stat = 0;
int ir_status_l, ir_status_r;
//////////RX area
const int led_pin = 13;
const int receive_pin = 11;
#include <VirtualWire.h>
#include <LiquidCrystal.h>
const int rs = 3, en = 2, d4 = 7, d5 = 6, d6 = 5, d7 = 4;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);
void setup() {
    //////////RX area
    delay(1000);
    Serial.begin(9600); // Debugging only
    Serial.println("setup");
    vw_set_rx_pin(receive_pin);
    vw_set_ptt_inverted(true); // Required for DR3100
    vw_setup(2000); // Bits per sec
    vw_rx_start(); // Start the receiver PLL running
    pinMode(led_pin, OUTPUT);
    ////////////
```

```

lcd.begin(16,2);
pinMode(powerkey_stat,INPUT);
pinMode(motor_r,OUTPUT);
pinMode(motor_l,OUTPUT);
pinMode(motor_drive,OUTPUT);
pinMode(IR_L,INPUT);
pinMode(IR_R,INPUT);
lcd.print("Max Speed:40Kmphr");
lcd.setCursor(0,1);
lcd.print("Road:Sharp Curve");
}

void loop() {
    // put your main code here, to run repeatedly:
        no_turn();
        //lcd.clear();
// lcd.print("Max Speed:40Kmphr");
//delay(150);
//lcd.clear();
rf_rx();
// delay(150);
//lcd.setCursor(10,0);
//////////

    ir_status_l = digitalRead(IR_L);
    ir_status_r = digitalRead(IR_R);
    if (ir_status_l && ir_status_r == 1)
    {
        motor_stop();
    }

    else if(ir_status_r == 1)
    {

```

```

    turn_left();
}
else if(ir_status_l == 1)
{
    turn_right();
}
else
{
    no_turn();
}
delay(100);
*/
void buzzer_on()
{
    // analogWrite(speaker,125);
}
void buzzer_off()
{
    // analogWrite(speaker,0);
}
void turn_left()
{
    digitalWrite(motor_drive,HIGH);
    digitalWrite(motor_r,HIGH);
    analogWrite(motor_l,100);
}
void turn_right()
{
    digitalWrite(motor_drive,HIGH);
    analogWrite(motor_r,254);
    digitalWrite(motor_l,HIGH)
}

```

```

void no_turn()
{
    digitalWrite(motor_drive,HIGH);
    digitalWrite(motor_r,HIGH);
    digitalWrite(motor_l,HIGH);
}

void motor_stop()
{
    digitalWrite(motor_drive,LOW);
    digitalWrite(motor_r,LOW);
    digitalWrite(motor_l,LOW);
}

void rf_rx()
{
    uint8_t buf[VW_MAX_MESSAGE_LEN];
    uint8_t buflen = VW_MAX_MESSAGE_LEN
    if (vw_get_message(buf, &buflen)) // Non-blocking
    {
        int i;
        digitalWrite(led_pin, HIGH); // Flash a light to show received good message
        // Message with a good checksum received, dump it.
        Serial.print("Got: ");
        for (i = 0; i < buflen; i++)
        {
            Serial.print(buf[i]);

```

## ADMIN SAMPLE CODE

The following procedure shows how the administrator panel is coded

```
<div class="card-footer">
    <button type="submit" class="btn btn-info float-right"
name="Submit">Register</button>
</div>
</form>
</div>
<?php
if(isset($_POST['Submit']))
{
    $climate = "Sunny";
    $RSU_ID = $_POST['rsuid'];
    $Latitude = $_POST['Latitude'];
    $Longitude = $_POST['Longitude'];
    $RSU_Type = $_POST['rsutype'];
    $MaxSpeed = $_POST['MaxSpeed'];
    $query = "select * from roadsideunit where RSUID ='$RSU_ID'";
    $run_query = mysqli_query($con,$query);
    if(mysqli_num_rows($run_query) > 0)
    {
        echo "RSU Already Exists";
    }
    else
    {
        $sql = "INSERT INTO roadsideunit (RSUID, Latitude, Longitude,
RSUTYPE, MaxSpeed,climate) VALUES ( '$RSU_ID',
'$Latitude','$Longitude','$RSU_Type', '$MaxSpeed','$climate')";
        $run_query = mysqli_query($con,$sql);
        if($run_query)
        {
            echo "New RSU Created Sucessfully";
        }
    }
}
```

## CRIMINAL CODE

**Here is the step to be followed to code crime committed vehicles**

```
<?php
include "db.php";
?>
<!DOCTYPE html>
<html lang="en">
<head>
  <meta charset="utf-8">
  <meta name="viewport" content="width=device-width, initial-scale=1">
  <title>Dashboard</title>
  <!-- Google Font: Source Sans Pro -->
  <link rel="stylesheet"
href="https://fonts.googleapis.com/css?family=Source+Sans+Pro:300,400,400i,700&display=
=fallback">
  <!-- Font Awesome -->
  <link rel="stylesheet" href="plugins/fontawesome-free/css/all.min.css">
  <!-- Ionicons -->
  <link rel="stylesheet"
href="https://code.ionicframework.com/ionicons/2.0.1/css/ionicons.min.css">
  <!-- Tempusdominus Bootstrap 4 -->
  <link rel="stylesheet" href="plugins/tempusdominus-bootstrap-4/css/tempusdominus-
bootstrap-4.min.css">
  <!-- iCheck -->
  <link rel="stylesheet" href="plugins/ichack-bootstrap/ichack-bootstrap.min.css">
  <!-- JQVMap -->
  <link rel="stylesheet" href="plugins/jqvmap/jqvmap.min.css">
  <!-- Theme style -->
  <link rel="stylesheet" href="dist/css/adminlte.min.css">
  <!-- overlayScrollbars -->
  <link rel="stylesheet" href="plugins/overlayScrollbars/css/OverlayScrollbars.min.css">
  <!-- Daterange picker -->
```

```

<link rel="stylesheet" href="plugins/daterangepicker/daterangepicker.css">
<!-- summernote -->
<link rel="stylesheet" href="plugins/summernote/summernote-bs4.min.css">
</head>
<body class="hold-transition sidebar-mini layout-fixed">
<div class="wrapper">
  <!-- Navbar -->
  <nav class="main-header navbar navbar-expand navbar-white navbar-light">
<!-- Left navbar links -->
<ul class="navbar-nav">
<li class="nav-item">
<a class="nav-link" data-widget="pushmenu" href="#" role="button"><i class="fas fa-
      .
      .
      .
      .
      .
    <!-- Main Sidebar Container -->
<script src="plugins/overlayScrollbars/js/jquery.overlayScrollbars.min.js"></script>
<!-- AdminLTE App -->
<script src="dist/js/adminlte.js"></script>
<!-- AdminLTE for demo purposes -->
<script src="dist/js/demo.js"></script>
<!-- AdminLTE dashboard demo (This is only for demo purposes) -->
<script src="dist/js/pages/dashboard.js"></script>
</body>
</html>

```

## PHP CODE

```
<?php
include "db.php";
?>

<!DOCTYPE html>

<html lang="en">

<head>

    <meta charset="utf-8">

    <meta name="viewport" content="width=device-width, initial-scale=1">

    <title>Dashboard</title>

    <!-- Google Font: Source Sans Pro -->

    <link rel="stylesheet"
href="https://fonts.googleapis.com/css?family=Source+Sans+Pro:300,400,400i,700&display=
fallback">

    <!-- Font Awesome -->

    <link rel="stylesheet" href="plugins/fontawesome-free/css/all.min.css">

    <!-- Ionicons -->

    <link rel="stylesheet"
href="https://code.ionicframework.com/ionicons/2.0.1/css/ionicons.min.css">

    <!-- Tempusdominus Bootstrap 4 -->

    <link rel="stylesheet" href="plugins/tempusdominus-bootstrap-4/css/tempusdominus-
bootstrap-4.min.css">

    <!-- iCheck -->

    <link rel="stylesheet" href="plugins/ichack-bootstrap/ichack-bootstrap.min.css">

    <!-- JQVMap -->

    <link rel="stylesheet" href="plugins/jqvmap/jqvmap.min.css">

    <!-- Theme style -->

    <link rel="stylesheet" href="dist/css/adminlte.min.css">

    <!-- overlayScrollbars -->

    <link rel="stylesheet" href="plugins/overlayScrollbars/css/OverlayScrollbars.min.css">

    <!-- Daterange picker -->

    <link rel="stylesheet" href="plugins/daterangepicker/daterangepicker.css">
```

```

<!-- summernote -->

<link rel="stylesheet" href="plugins/summernote/summernote-bs4.min.css">
</head>
<body class="hold-transition sidebar-mini layout-fixed">
<div class="wrapper">

    <a class="nav-link" data-widget="pushmenu" href="#" role="button"><i class="fas fa-bars"></i></a>

    </li>

    <li class="nav-item d-none d-sm-inline-block">

        <a href="" class="nav-link">Dire Dewa To Dengego Road Side Unit Configuration</a>

<!-- Main Sidebar Container -->

<aside class="main-sidebar sidebar-dark-primary elevation-4">

    <!-- Brand Logo -->

    <a href="" class="brand-link">

        .

        .

        .

        .

        .

<script src="dist/js/adminlte.js"></script>

<!-- AdminLTE for demo purposes -->

<script src="dist/js/demo.js"></script>

<!-- AdminLTE dashboard demo (This is only for demo purposes) -->

<script src="dist/js/pages/dashboard.js"></script>

</body>
</html>

```

## ESP CODE

```
<?php
include "db.php";
?>
<?php
{
    if(!empty($_POST['RSUID']) )
    {
        $RSU_ID = $_POST['RSUID'];
        $Latitude = $_POST['Latitude'];
        $Longitude = $_POST['Longitude'];
        $RSU_Type = $_POST['RSUTYPE'];
        $MaxSpeed = $_POST['MaxSpeed'];
        $climate = $_POST['climate'];

        $query = "select * from roadsideunit where RSUID ='$RSU_ID'";
        $run_query = mysqli_query($con,$query);
        {
            $sql = "INSERT INTO roadsideunit (RSUID, Latitude, Longitude, RSUTYPE,
MaxSpeed,climate) VALUES ( '$RSU_ID', '$Latitude','$Longitude','$RSU_Type',
'$MaxSpeed','$climate')";

            $run_query = mysqli_query($con, $sql);
            if ($run_query) {
                echo "New RSU Created Sucessfully";
            } else {
                echo "not";
            }
        }
    }
}
```

## WEATHER STATUS CODE

```
<?php
include "db.php";
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="utf-8">
    <meta name="viewport" content="width=device-width, initial-scale=1">
    <title> Dashboard</title>
    <!-- Google Font: Source Sans Pro -->
    <link rel="stylesheet"
href="https://fonts.googleapis.com/css?family=Source+Sans+Pro:300,400,400i,700&display=
fallback">
    <!-- Font Awesome -->
    <link rel="stylesheet" href="plugins/fontawesome-free/css/all.min.css">
    <!-- Ionicons -->
    <link rel="stylesheet"
href="https://code.ionicframework.com/ionicons/2.0.1/css/ionicons.min.css">
    <!-- Tempusdominus Bootstrap 4 -->
    <link rel="stylesheet" href="plugins/tempusdominus-bootstrap-4/css/tempusdominus-
bootstrap-4.min.css">
    <!-- iCheck -->
    <link rel="stylesheet" href="plugins/ichack-bootstrap/ichack-bootstrap.min.css">
    <!-- JQVMap -->
    <link rel="stylesheet" href="plugins/jqvmap/jqvmap.min.css">
    <!-- Theme style -->
    <link rel="stylesheet" href="dist/css/adminlte.min.css">
    <!-- overlayScrollbars -->
    <link rel="stylesheet" href="plugins/overlayScrollbars/css/OverlayScrollbars.min.css">
    <!-- Daterange picker -->
    <link rel="stylesheet" href="plugins/daterangepicker/daterangepicker.css">
    <!-- summernote -->
```

```

<link rel="stylesheet" href="plugins/summernote/summernote-bs4.min.css">
</head>
<body class="hold-transition sidebar-mini layout-fixed">
<div class="wrapper">
  <!-- Navbar -->
  <nav class="main-header navbar navbar-expand navbar-white navbar-light">
    <a class="nav-link" data-widget="pushmenu" href="#" role="button"><i class="fas fa-bars"></i></a>
    <li class="nav-item d-none d-sm-inline-block">
      <a href="" class="nav-link">Dire Dewa To Dengego Road Side Unit Configration</a>
  <!-- Main Sidebar Container -->
  <aside class="main-sidebar sidebar-dark-primary elevation-4">
    <!-- Brand Logo -->
    <a href="" class="brand-link">
      .
      .
      .
      .
      .
    <script src="dist/js/adminlte.js"></script>
    <!-- AdminLTE for demo purposes -->
    <script src="dist/js/demo.js"></script>
    <!-- AdminLTE dashboard demo (This is only for demo purposes) -->
    <script src="dist/js/pages/dashboard.js"></script>

```

## RSU EDITING CODE

```
<?php
include "db.php";
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="utf-8">
    <meta name="viewport" content="width=device-width, initial-scale=1">
    <title>Dashboard</title>
    <!-- Google Font: Source Sans Pro -->
    <link rel="stylesheet"
href="https://fonts.googleapis.com/css?family=Source+Sans+Pro:300,400,400i,700&display=
=fallback">
    <!-- Font Awesome -->
    <link rel="stylesheet" href="plugins/fontawesome-free/css/all.min.css">
    <!-- Ionicons -->
    <link rel="stylesheet"
href="https://code.ionicframework.com/ionicons/2.0.1/css/ionicons.min.css">
    <!-- Tempusdominus Bootstrap 4 -->
    <link rel="stylesheet" href="plugins/tempusdominus-bootstrap-4/css/tempusdominus-
bootstrap-4.min.css">
    <!-- iCheck -->
    <link rel="stylesheet" href="plugins/icheck-bootstrap/icheck-bootstrap.min.css">
    <!-- JQVMap -->
    <link rel="stylesheet" href="plugins/jqvmap/jqvmap.min.css">
    <!-- Theme style -->
    <link rel="stylesheet" href="dist/css/adminlte.min.css">
    <!-- overlayScrollbars -->
    <link rel="stylesheet" href="plugins/overlayScrollbars/css/OverlayScrollbars.min.css">
    <!-- Daterange picker -->
    <link rel="stylesheet" href="plugins/daterangepicker/daterangepicker.css">
    <!-- summernote -->
```

```

<link rel="stylesheet" href="plugins/summernote/summernote-bs4.min.css">
</head>
<body class="hold-transition sidebar-mini layout-fixed">
<div class="wrapper">
  <!-- Navbar -->
  <nav class="main-header navbar navbar-expand navbar-white navbar-light">
    <a class="nav-link" data-widget="pushmenu" href="#" role="button"><i class="fas fa-bars"></i></a>
  <!-- Main Sidebar Container -->
  <aside class="main-sidebar sidebar-dark-primary elevation-4">
    <!-- Brand Logo -->
    <a href="index.php" class="brand-link">
      
      .
      .
      .
      .
      .
    </a>
    <script src="dist/js/adminlte.js"></script>
    <!-- AdminLTE for demo purposes -->
    <script src="dist/js/demo.js"></script>
    <!-- AdminLTE dashboard demo (This is only for demo purposes) -->
    <script src="dist/js/pages/dashboard.js"></script>
  </body>
</html>

```

## RSU REMOVAL CODE

```
<?php
include "db.php";
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="utf-8">
    <meta name="viewport" content="width=device-width, initial-scale=1">
    <title> Dashboard</title>
    <!-- Google Font: Source Sans Pro -->
    <link rel="stylesheet"
href="https://fonts.googleapis.com/css?family=Source+Sans+Pro:300,400,400i,700&display=
fallback">
    <!-- Font Awesome -->
    <link rel="stylesheet" href="plugins/fontawesome-free/css/all.min.css">
    <!-- Ionicons -->
    <link rel="stylesheet"
href="https://code.ionicframework.com/ionicons/2.0.1/css/ionicons.min.css">
    <!-- Tempusdominus Bootstrap 4 -->
    <link rel="stylesheet" href="plugins/tempusdominus-bootstrap-4/css/tempusdominus-
bootstrap-4.min.css">
    <link rel="stylesheet" href="plugins/ichack-bootstrap/ichack-bootstrap.min.css">
    <!-- JQVMap -->
    <link rel="stylesheet" href="plugins/jqvmap/jqvmap.min.css">
    <!-- Theme style -->
    <link rel="stylesheet" href="dist/css/adminlte.min.css">
    <!-- overlayScrollbars -->
    <link rel="stylesheet" href="plugins/overlayScrollbars/css/OverlayScrollbars.min.css">
    <!-- Daterange picker -->
    <link rel="stylesheet" href="plugins/daterangepicker/daterangepicker.css">
    <!-- summernote -->
    <link rel="stylesheet" href="plugins/summernote/summernote-bs4.min.css">
```

```

</head>

<body class="hold-transition sidebar-mini layout-fixed">

<div class="wrapper">

  <!-- Navbar -->

  <nav class="main-header navbar navbar-expand navbar-white navbar-light">

    <a class="nav-link" data-widget="pushmenu" href="#" role="button"><i class="fas fa-bars"></i></a>

  </li>

  <li class="nav-item d-none d-sm-inline-block">

    <a href="" class="nav-link">Dire Dewa To Dengego Road Side Unit Configuration</a>

      .
      .
      .
      .
      .

  <script src="plugins/overlayScrollbars/js/jquery.overlayScrollbars.min.js"></script>

  <!-- AdminLTE App -->

  <script src="dist/js/adminlte.js"></script>

  <!-- AdminLTE for demo purposes -->

  <script src="dist/js/demo.js"></script>

  <!-- AdminLTE dashboard demo (This is only for demo purposes) -->

  <script src="dist/js/pages/dashboard.js"></script>

</body>

</html>

```

## CRIMINAL REGISTRATION CODE

```
<?php
include "db.php";
<!DOCTYPE html>
<html lang="en">
<head>
    <meta charset="utf-8">
    <meta name="viewport" content="width=device-width, initial-scale=1">
    <title>Dashboard</title>
    <!-- Google Font: Source Sans Pro -->
    <link rel="stylesheet"
href="https://fonts.googleapis.com/css?family=Source+Sans+Pro:300,400,400i,700&display=
=fallback">
    <!-- Font Awesome -->
    <link rel="stylesheet" href="plugins/fontawesome-free/css/all.min.css">
    <!-- Ionicons -->
    <link rel="stylesheet"
href="https://code.ionicframework.com/ionicons/2.0.1/css/ionicons.min.css">
    <!-- Tempusdominus Bootstrap 4 -->
    <link rel="stylesheet" href="plugins/tempusdominus-bootstrap-4/css/tempusdominus-
bootstrap-4.min.css">
    <!-- iCheck -->
    <link rel="stylesheet" href="plugins/ichack-bootstrap/ichack-bootstrap.min.css">
    <!-- JQVMap -->
    <link rel="stylesheet" href="plugins/jqvmap/jqvmap.min.css">
    <!-- Theme style -->
    <link rel="stylesheet" href="dist/css/adminlte.min.css">
    <!-- overlayScrollbars -->
    <link rel="stylesheet" href="plugins/overlayScrollbars/css/OverlayScrollbars.min.css">
    <!-- Daterange picker -->
    <link rel="stylesheet" href="plugins/daterangepicker/daterangepicker.css">
    <!-- summernote -->
```

```

<link rel="stylesheet" href="plugins/summernote/summernote-bs4.min.css">
<body class="hold-transition sidebar-mini layout-fixed">
  <nav class="main-header navbar navbar-expand navbar-white navbar-light">
    <a class="nav-link" data-widget="pushmenu" href="#" role="button"><i class="fas fa-bars"></i></a>
    <li class="nav-item d-none d-sm-inline-block">
      <a href="" class="nav-link">Dire Dewa To Dengego Road Side Unit Configuration</a>
    <!-- /.navbar -->
  <!-- Main Sidebar Container -->
  <aside class="main-sidebar sidebar-dark-primary elevation-4">
    <!-- Brand Logo -->
    <a href="" class="brand-link">
      
      .
      .
      .
      .
      .
    </a>
    <script src="dist/js/adminlte.js"></script>
    <!-- AdminLTE for demo purposes -->
    <script src="dist/js/demo.js"></script>
    <!-- AdminLTE dashboard demo (This is only for demo purposes) -->
    <script src="dist/js/pages/dashboard.js"></script>
  </body>
</html>

```

## DATA BASE CODE

```
<?php
$servername = "localhost";
$username = "root";
$password = "";
$db = "rsu";

// Create connection

$con = mysqli_connect($servername, $username, $password,$db);

// Check connection
if (!$con) {
    die("Connection failed: " . mysqli_connect_error());
}
else {
    //echo "Connected";
}
```