DEVELOPMENT OF ENGINE SHUTOFF MECHANISM FOR PROTECTION OF ENGINE DURING VEHICLE ROLLOVER

Abraham Berhanu Gonfa

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 Master of Science in Automotive Engineering

Office of Graduate Studies

Adama Science and Technology University

September, 2023

Adama, Ethiopia

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CANDIDATE'S DECLARATION

I hereby declare that this Master Thesis entitled "Development of engine shutoff mechanism for protection of engine during vehicle Rollover" 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.

Abraham Berhanu Gonfa	____________________	____________
Name of student	Signature	Date

RECOMMENDATION

I, the advisor of this thesis, hereby certify that I have read the revised version of the thesis entitled "Development of engine shutoff mechanism for protection of engine during vehicle Rollover" prepared under my guidance by Abraham Berhanu Gonfa submitted in partial fulfillment of the requirements for the degree of masters of Science in Automotive Engineering.

Therefore, I recommend the submission of revised version of the thesis to the department following the applicable procedures.

N. Ramesh Babu (PhD)	_______________	_____________
Advisor	Signature	Date

APPROVAL OF BOARD OF EXAMINERS

We, the advisors of the thesis entitled “Development of engine shutoff mechanism for protection of engine during vehicle Rollover” and developed by Abraham Berhanu Gonfa, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

N. Ramesh Babu (PhD)	________________	______________
Major Advisor	Signature	Date
__________________________	________________	______________
Co-advisor	Signature	Date

We, the undersigned, members of the Board of Examiners of the thesis by Abraham Berhanu Gonfa have read and evaluated the thesis entitled “Design and Development of engine shutoff mechanism for protection of engine during vehicle Rollover” and examined the candidate during open defense. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the degree of Master of Science in Automotive Engineering.

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ACKNOWLEDGEMENT

First of all, I would like to thank immensely my Lord, the Lord God for all His Provisions and Blessings throughout my life and the thesis work. I would also like to thank my parents Demeku Nega, Berhanu Gonfa, Eng. Yordanos and Dr. Jerusalem for their support and encouragement. I would like to express my sincere gratitude for my Advisor N. Ramesh Babu (PhD) for his excellent guidance, moral support and constructive criticism. Finally, I thank my friends (Eng. Cherinet Girma and Eng. Jafer Adem) for their suggestions and helps they provided for me.

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ACRONYMS

CI	Compression Ignition
DEC	Damaged Engine Cost
ECU	Electronic Control Unit
EII	Ethiopian Insurance Industry
EOH	Engine Over Heated
FWROA	Forward Rollover Angle
HL	Hydro locked
HF1	Height of Front Axle on level road
HF2	Height of Front Axle while front is elevated
HTCG	Center of Gravity Height
ICE	Internal Combustion Engine
IG	Ignition
LSROA	Lift Side Rollover Angle
LTB	Width of Wheel Truck Base
LWB	Length of Wheel Base
OIC	Oromia Insurance Company
OS	Oil Starvation
RAS	Rollover Angel Sensor
RSROA	Right Side Rollover Angle
RSROA	Rearward Rollover Angle
RTCD	Road Traffic Crash Data
VEOT	Vehicle Engine Rollover
WBCG	Wheelbase Center of Gravity
WF	Front Axle Wight
WR1	Rear Axle Wight
WR2	Rear Axle Wight Modified
WTCG	Wheel truck Center of Gravity

ABSTRACT

Automobile safety performance has quickly become the top consideration for more and more individuals due to the industry's rapid expansion. Vehicle rollover accident is a critical problem. As the vehicle gets rollover, it brings about the loss of lives, destruction of properties, and unexpected maintenance costs. Controlling engine component parts damage during vehicle rollover are fundamental from unexpected destruction and maintenance cost. This development focused on the investigating vehicle engine damage by rollover accident and its possible solution particularly focuses on Toyota land cruiser vehicle. To develop a simulation model of the engine rollover mechanism the researcher used the proteus software. Based on the above issues the engine shut off mechanism during vehicle rollover accident is developed to avoid the engine component parts to be damaged. The vehicle rollover protection system uses four sensors to monitor the vehicle roll angle. If the roll angle stays within a safe range, the system will not activate. However, if the roll angle exceeds a safe threshold, the system will sound an alarm and flash a warning light. The system will also disable the fuel delivery to the engine, preventing the vehicle from rolling over. The most optimal angle that the researcher used as a reference angle for this system are Left side Rollover angle 40.99-degree, Right Side Rollover angle 48.16 Degree, Rear Ward Rollover Angle 57.5. Degree and Forward rollover angle (53.66 degree). As a result, warning signals are activated. Therefore, the engine shutoff mechanism protects the possibility of the vehicle engine component parts damage. Like drivers and passengers, traffic accident is highly affecting the population of developing countries population.

***Keywords**: Development, engine shut off, Fuel Cut- off Rely, rollover angles, Vehicle accident, and warning signals.*

CHAPTER ONE

INTRODUCTION

1.1. Background

A motor vehicle rollover is a serious traffic safety incident that results in both physical and material loss. The vehicle engine works when all systems function together at operating conditions, any obstacle or failure any one of the systems of the engine may cause (J Xu, 2010). Engine damage occur during rollover due to malfunctioning of the engine parts. Rollover occurs due to improper handling of the vehicle because of defects in vehicle systems like, steering system, braking system, electrical systems, loss of traction leading to spinning of wheels, etc. It may occur even due to improperly functioning control systems because of the errors in the programing for which manufacture is liable. During rollover the lubricant oil flows to upper parts of the engine and the engine gets damaged if it's running also some parts may damage due to engine oil starvation (Syed & Wani, 2021).

Figure 1. 1. Vehicle rollover accident

Due to oil starvation, Figure 1.2 shows how the engine oil pump seized and ruined the pump gears. Oil goes from the oil sump at the bottom of the engine to the combustion chamber at the top, and the oil pump continues to operate even though there is no oil available. Oil pump and crankshaft splashing lubricate the engine of the vehicle. Engine parts that are visible from above are lubricated by an oil pump through oil galleys or orifices. The oil pump lubricates the overhead engine's component parts through oil galleys or orifices. The engine oil pump becomes stuck and damaged. The overhead components, such as the cam shaft, cam shaft bearings, rocker arm, rocker arm shaft, and rocker arm shaft bearings, as well as the valves (intake and exhaust), valve spring, pushrod, and tappet, become oil-starved.

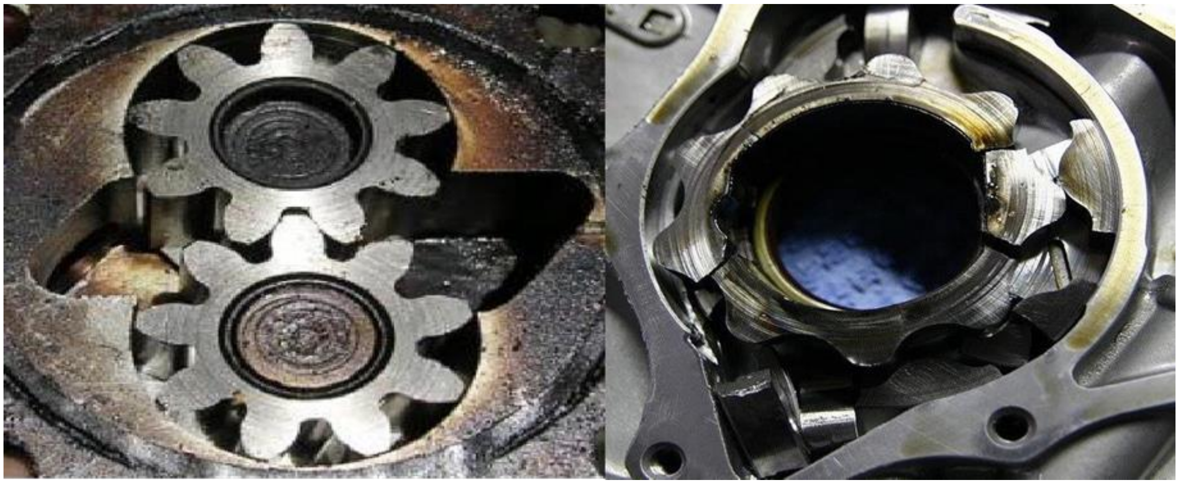

Figure 1. 2. Engine oil pump seized

Figure 1.1 shows a Toyota Land Cruiser rollover accident. The wind shield pillars, doors, roof, and body pillars of the vehicle are severely damaged (deformed), and the driver is hurt and unable to turn off the engine during the rollover. The engine may continue to run until it stops due to hydraulic lock and seizure.

The extent of the engine crankshaft main journal and crank pin bearing damage is seen in Figure 1.3. Due to a shortage of engine oil, the bearing's coated layer rubs against the crankshaft main journal and crank pin, causing chips to build up in the lubricant channel and block the oil gallery. When lubricant oil pours from the oil sump into the combustion chamber, the lower rotating components are first vulnerable to damage, particularly the main journal bearing at the crank shaft, which can suffer serious damage for a brief period of time and become splashed with oil.

Figure 1. 3. Crank shaft main journal and connecting rod shell bearing

Because the oil jut used to deliver lubrication oil to the piston becomes blocked, the piston rings cause the engine cylinder wall or cylinder liner to scrape. The connecting rod may bend if engine hydraulic lock oil seeps into the piston ring end gap and into the combustion chamber, preventing the connecting rod from rotating. When the engine RPM is lower during a vehicle rollover, the severity of the bent connecting rod reduces and can only relatively affect the engine cylinder wall. When the engine is in a rollover, the engine's high RPM increases the magnitude of the bent connecting rod, which can cause the cylinder block to crack. The engine piston and piston pin may be damaged by the commutation of engine oil in the combustion chamber (engine hydraulic lock) and the upward force of the connecting rod.

Several engine accessories can potentially sustain damage during a vehicle rollover. The rubber support for the engine develops cracks or ruptures. The engine rubber is installed between the engine unit and the vehicle's chassis structure, the engine assembly shifts to the vehicle's rollover side as it flips over, and the engine rubber support breaks or bursts, causing the engine to be misaligned from where it was originally attached. Damage to the cooling radiator, fan shroud, and spinning cooling fan are all possible. The air filtering element and turbocharger can be dangerous because the engine oil can get into the intake manifold through the open intake valves and submerge the air filtering element. Additionally, due to oil starvation, the turbocharger shaft (which connects the impeller and turban wheels) becomes frictional. In addition, engine oil flows through the open exhaust valve and into the exhaust manifold, where it can damage the turbine wheel oil seal on a turbocharger. The process of rebuilding an engine also involves the use of consumable parts that cannot be reused after the engine has been disassembled, such as piston rings, cylinder head gaskets, overall gaskets, engine oil, air cleaner filtering elements, and oil filters, as well as labor costs for disassembling and reassembling the engine and measurements made by a machining shop using the manufacturing manual.

There is a need to stop the engine by any mechanism to prevent the engine damage. Engine shutdown mechanisms are safety features that stop engine parts from operating and becoming damaged following a rollover accident.

1.2. Statement of the problem

Vehicle rollover problems can have serious consequences, including engine damage. This can lead to serious injuries or death for the driver and passengers. One of the most dangerous aspects of engine damage from a rollover is that it can cause the engine to lose oil pressure. Without oil, the engine will quickly overheat and seize, causing catastrophic damage. This can happen even if the engine is turned off, as the momentum of the rollover can cause the engine parts to continue spinning and rubbing against each other.

Another danger of engine damage from a rollover is that oil can leak into the combustion chamber. This can cause the engine to misfire and detonate, which can damage the pistons, connecting rods, and cylinder walls. In severe cases, this can lead to complete engine failure. Even, if the engine damage is not severe enough to cause complete failure, it can still lead to costly repairs. Replacing an engine can be a very expensive proposition, and in some cases, the cost of repairs may exceed the value of the vehicle.

In addition to the financial costs, engine damage from a rollover can also have a significant impact on the driver's life. If the vehicle is totaled, the driver may have to purchase a new car, which can be a major financial burden. Even if the vehicle is not totaled, the driver may have to go without a car for a period of time while it is being repaired. This can be disruptive to the driver's work, school, and social life.

Overall, engine damage from a vehicle rollover is a serious problem that can have a significant impact on the driver and passengers. It is important to take steps to prevent rollovers from happening in the first place, such as driving safely and avoiding excessive speeds.

It is important to note that the severity of engine damage from a rollover will vary depending on a number of factors, such as the speed of the rollover, the type of vehicle, and the condition of the engine. However, even minor engine damage can lead to costly repairs and downtime.

1.3. Objectives

1.3.1. General objective

The general objective of this thesis work is development of shutoff mechanism for protection of engine during vehicle rollover.

1.3.2. Specific Objectives

The Specific objectives of this thesis work are as follows:

- Collect and interpret vehicle rollover accident.
- Compute and determine vehicle rollover angle of the proposed vehicle.
- Develop a shut off mechanism to cut off vehicle rollover engine.
- To develop a simulation model of the engine rollover mechanism using the proteus software.

- Evaluate the mechanism at a vehicle rollover conditions.

1.4. Significance of the Study

The significance of the thesis work is;

- The study can help to improve the safety of vehicles and reduce the number of engine damage accidents.
- The study can help to reduce the cost of engine repairs.
- The study can help to prevent the loss of vehicles.
- It provides job opportunities for those in need by assembling, installing, and setting the shut-off mechanism for the specified vehicle. By selling for its services for ensuring engine safety, the shut-off mechanism can be used to make money.

In general, this Engine shut-off mechanism benefits the automotive sector, supplier corporations, vehicle owners, insurance companies, society, and the entire country as a whole.

1.5. Scope of the thesis work

The scope of this work includes the following: -

- ✓ Extent of damage on engine by rollover accident.
- ✓ The application of the proteus software.
- ✓ The development of a simulation model of the engine rollover mechanism.
- ✓ The analysis of the simulation results.

1.6. Limitation of the study

This study was conducted on only one model of Toyota Land Cruiser vehicle, but other models of vehicles need to be studied and analyzed. Due to limited time, developing shut-off mechanisms for other vehicles was not considered. In addition to the lack of available data on engine rollover accidents and the shortage of literature reviews, there is also a lack of financial resources and facilities for developing a realistic simulation model of the engine rollover mechanism.

1.7. Organization of the thesis

This study consists of five chapters. The first chapter is an introduction to the study. It includes: Background of the study, Statement of the problem, Objectives of the study, Significance of the study, Scope of the study, Limitation of the study, and Organization of the study. The second chapter focuses on several literatures that placed a strong emphasis on the investigation of engine damage caused by vehicle rollover accidents. The resources and procedures utilized to conduct this job are described in chapter three. The discussion of numerous comparisons between earlier work and interpretation of the findings is covered in the fourth chapter. Finally, the fifth Chapter provides an overview of the investigation's significant findings, observations, a recommendation, and potential directions for further research.

CHAPTER TWO

LITERATURE REVIEW

Literature review part mainly includes causes of traffic accident which occur in different countries with different vehicle accident and vehicle stability control systems. It also includes reviewing of previous studies to choose appropriate analysis type on the given data of previousaccident occurrence trends around the study area.

2.1. Vehicle rollover accident

Only a few research have been done to examine rollover collisions. Rollover accidents have a high risk of serious and fatal injuries among motor vehicle crashes. In the results of rollover tests presented no indication of any improved protection for the tests (Neil K.cooperider, Teery. M Thomas, Selim A. Hammoud, 2004), Analysis was done on the relationship between the likelihood of a vehicle rollover and the driver, vehicle, and roadway environment. Factors for vehicle rollover accident (Nguyen T. , 2023), Rollover is a dangerous phenomenon. It is closely related to the vehicle roll angle. The greater the roll angle, the greater the risk of rollover. The stability and safety of the vehicle are crucial concerns that require complete attention. Several phenomena may be used to illustrate the instability of a moving car on the road, with vehicle rollover being the most hazardous. Rollover incidents can have severe repercussions for individuals and items (Duc Ngoc Nguyen and Tuan Anh Nguyen, 2023), the phenomenon of rolling over happens when the wheels are completely pushed off the road, i.e., when the dynamic force at the wheels approaches zero (A. J. Anarkooli, M. Hosseinpour, and A. Kardar, 2017) . Regarding the problem of rolling, the wheel cannot return to its previous position after being lifted off the road. Once the vertical force on the wheel is zero, the roll angle may reach its highest limit (Nguyen T. A., 2021) . Rollovers typically occur when a vehicle steer to avoid an obstruction or enters a roundabout (A. N. Tuan and B. H. Thang, 2019). Then, centrifugal force may appear. This force will create a moment that tilts the vehicle body. There are four typical reasons for rollovers. Initially, external elements such as wind force might influence a vehicle’s performance in inclement weather (Q. Zhang, C. Su, Y. Zhou, C. Zhang, J.Ding, and Y. Wang, 2020). Nevertheless, the value of the lateral wind force is typically insignificant. A few instances of heavy truck rollover are due to the lateral wind force. The second factor contributing to this occurrence is road conditions (N. Ikhsan, A. Saifizul, and R. Ramli, 2021). Besides, the size of the vehicle also affects this problem. The roll moment of a car will grow according to the track width and height, and this was emphasized by Nguyen et al. (D. N. Nguyen, T. A. Nguyen, T. B. Hoang, and N. D. Dang, 2021) . Because adjusting the size of the vehicle may impact its performance, it is not simple to do so. The third factor relating to this phenomenon is the vehicle’s speed. This is considered the primary source of the occurrence of rollover. If the velocity is more, the centrifugal force will grow according to the velocities square. Consequently, the risk of a rollover will increase. Lastly, the value of the steering acceleration and steering angle significantly impact the issue of vehicle instability. If these values rise, the rollover limitation will reduce fast, making the vehicle more susceptible to rolling.

2.2. Shut-off Mechanism

The majority of traffic fatalities in India are due to accidents that involved drunk driving. Due to the fact that drunk drivers are still permitted to operate motor vehicles, this happens. By implementing a system that automatically turns off the car's engine when a certain level of alcohol is found in the driver's breath, we hope to avoid this problem. (Dr. S.P.V. Subba Rao, B. Manoj Kumar,M. Prasanna Kumar and G. Anil Kuma, 2022). The microcontroller stops the vehicle's engine and blasts a siren to alert nearby drivers when alcohol is found. The LCD panel included into the system flashes the phrase "Alcohol Detected" when something is wrong with the vehicle, allowing anyone nearby to evaluate the severity of the issue and alert the necessary authorities to prevent any incident. When this technology is placed in cars, it will not only serve to minimize the overall number of accidents that arise from drunk driving but will also help to prevent fatalities and property damages caused by it. In addition, the immediate stop of the car will make individuals in other vehicles or pedestrians much safer.

The majority of deadly agricultural all-terrain vehicle accidents result from rollover collisions. A passive safety structure called a crush protection device could shield the operator from rollover accidents. Regarding the efficiency of the Crush Protection Device in defending the operator in rollover occurrences, the findings of earlier research contain significant discrepancies. Additionally, no study examined the functioning of damaged engines following agricultural rollover accidents, which often occur at moderate speeds. Shutoff mechanism is designed to control or prevent the engine damage occurrence during rollover by controlling the vehicle rollover angle when exceeded the minimum rollover angle shutoff mechanism turned off the engine by cut-off the fuel.

2.3. System Components

Fuel Cutoff Relay Module

An electrical switch that uses an electromagnet is a relay module. A different low-power signal from a tiny regulator activates the magnets. The electromagnet pulls to one side to open or stop an electrical circuit when it is activated.

At least one bunch of the moving contacts is attached to the mobile armature, which is pivotal to the yoke. When the relay is turned off, the armature, which is held in place by a spring, breaks the magnetic circuit. At this time, one of the two contact arrangements is closed while the other's remaining components are open.

When electrical current passes through a loop, it creates a magnetic field that causes the armature to turn on. This portable device's evolution either strengthens or weakens a connection with the fixed contact. The confined configurations of contacts open and break the connection when the relay is de-energized, and the opposite is true if the contacts were open. When the curl's current is switched off, the armature is compelled reset to its default position. Although a spring is typically used to provide this force, gravity can also be used in some situations. The majority of force transfers are designed to operate quickly. On the other hand allocations of force in high current applications.

Figure 2. 1. Relay mode

Relay pinout

The relay module pinout is depicted in the following diagram.

Figure 2. 2. Relay module pinout

The six pins on the relay module's left half connect high voltage, and the pins on the right side connect the Arduino pins, which need low voltage.

Main voltage connections

Two connectors with three sockets each, common (COM), normally closed (NC), and ordinarily open (NO), are enclosed on the high-voltage side.

Figure 2. 3. Main voltage connections of the relay module

- COM: common pin
- NC (Normally Closed): When the transfer needs to be shut by default, this design is used. As a result, the current will flow unless you send a message from the Arduino to the relay-off module to open the circuit and stop the current.

NO (Normally Open): the typically open setup works the reverse way around: the relay is consistently open, so the circuit is broken except if you convey a message from the Arduino to close the circuit

It's wiser to use a typically open circuit arrangement to periodically turn on a lighting.

Pin wiring

A set of four pins and a set of three pins are present on the low-voltage side.

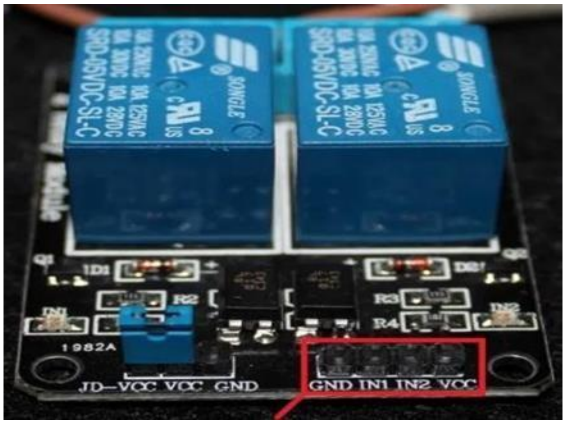

Figure 2. 4. Pin wiring

The set to the right includes inputs 1 (IN1) and 2 (IN2) for controlling the bottom and top relays, respectively, as well as VCC and GND for powering up the module.

GND, VCC, and JD-VCC pins make up the second set of connectors. The electromagnet of the relay is powered by the JD-VCC pin.

The connections between the Arduino and relay module are straightforward

- Goes to ground (GND)
- IN1: This pin will be connected to an Arduino digital pin and controls the first relay.
- Controls the second relay is IN2.
- VCC: switches to 5V

Piezoelectric

The piezoelectric variety employs the piezoelectric impact and pulse current of the piezoelectric ceramic to make the metal plate vibrate and produce sound, as the name implies. This type of buzzer is constructed utilizing a piezoelectric plate, housing, impedance matcher, resonance box, several resonators, and other components. Some of the ringers are also designed with LEDs.

Accelerometer

An accelerometer is a tool that gauges a structure's vibration or acceleration of motion. The mass "squeezes" the piezoelectric material under the influence of vibration or acceleration, which results in an electrical charge corresponding to the force acting upon it. Applications requiring tilt sensing can use it.

Analog voltage output is proportional to the acceleration along the X, Y, and Z axes when acceleration is measured along these three axes. Static forces and dynamic forces are the two different categories of acceleration forces. An object is subjected to static forces all the time, such as friction and gravity. Dynamic forces, which can include vibration or the force delivered to a cue ball during a game of pool, are "moving" forces that are applied to the item at different speeds. This is the reason why, for instance, accelerometers are employed in automotive crash safety systems. The airbags deploy when a car is subjected to a strong dynamic force; the accelerometer detects a quick deceleration and transmits a signal to an inbuilt computer.

These voltages can be processed by microcontrollers by employing ADC to turn them into digital signals.

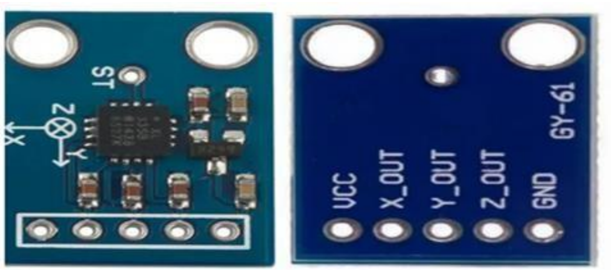

Figure 2. 5. Accelerometer

Accelerometer pinout

Arduino can read the pins that provide the acceleration values for the x, y, and z axes.

- ✓ This is the power pin, VCC. Connect 3.3 or 5 volts from an Arduino Uno to this pin.
- ✓ XOUT: The analog value produced in proportion to acceleration along the X axis is output by the X out pin.
- ✓ YOUT: The analog value produced in proportion to acceleration along the Y axis is output by the Y out pin.
- ✓ ZOUT: The Z out pin emits an analog value proportional to the acceleration along the Z axis.
- ✓ GND: This ground pin is connected to the Arduino Uno's ground pin.
- ✓ Self-test pins allow us to determine whether a sensor is operational or not.

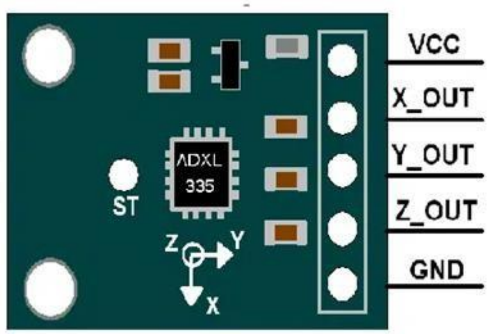

Figure 2. 6. Accelerometer pin

Arduino

An open-source electronics platform called Arduino uses easy-to-use hardware and programming. Arduino boards can interpret inputs, such as light on a sensor, pressure on a button, or a tweet, and translate them into outputs, such as starting a motor, turning on an LED, or disseminating information online.

By sending a large number of instructions to the board's microcontroller, you may control it. To do this, use the Arduino programming language (in light of Wiring), as well as the Arduino Software (IDE), in light of Processing.

Over time, Arduino has served as the brains behind countless projects, from simple everyday objects to sophisticated logical instruments. Around this open-source platform, a large local community of creators, including students, professionals, craftsmen, software engineers, and experts, has come together. Thanks to their contributions, an enormous amount of free information is now available that can be of great help to both students and professionals.

The Arduino board started changing when it reached a larger community in order to meet the demands and challenges presented by these changes, shifting its focus from simple 8-bit boards to products for apps, wearable technology, 3D printing, and embedded environments. The complete open-source nature of every Arduino board encourages users to build them anyway they see fit before customizing them to suit their needs. Additionally, the product is open-source and developing thanks to the dedication of customers worldwide.

What is in the Arduino board?

There are several different types of Arduino boards that are used for multiple applications. Several boards seem to be different from the one below, however realistically speaking, most Arduino boards use the same parts.

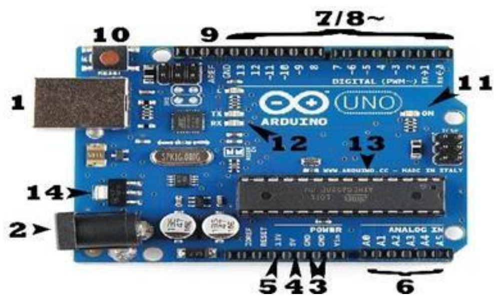

Figure 2. 7. Arduino board

Power (USB / Barrel Jack)

Each Arduino board requires a method of connecting to a power supply. A USB connection from your PC or a divider power source (like this one) that ends in a barrel jack are used to control the Arduino UNO. Association is identified and the barrel jack is indicated in the image over the USB.

The USB connection is also used to upload code to your Arduino board. Our Installing and Programming Arduino instructive exercise has more information on the most effective way to program with Arduino.

NOTE: Arduino will be overpowered (and ultimately destroyed) if you use a power supply higher than 20 Volts. The recommended voltage range for the majority of Arduino units is between 6 and 12 Volts.

Pins (5V, 3.3V, GND, analogue, Digital, PWM, AREF)

The Arduino's pins are where you connect wires to create circuits—most likely using a breadboard and some wire—on your device. Typically, they contain black plastic "headers" that let you plug a cable straight into the board. The pins on the Arduino come in a few different varieties, each of which is identified on the board and has a specific function.

- GND (3): Abbreviation for ground. Any of the Arduino's GND pins can be used to ground your circuit.
- (4) & (5) 5V & 3.3V: The 5V pin delivers 5 volts of electricity, while the 3.3V pin delivers 3.3 volts. The majority of the basic Arduino components happily

operate at 5 or 3.3 volts.

- Analogue (6): Analogue in pins are located in the area of the UNO marked by the letters A0 through A5. These pins can read an analog sensor's signal and turn it into a readable digital value.
- The digital pins (0 to 13 on the UNO) are located across from the analogue pins. These pins can be used for both digital output (such as activating an LED) and digital input (such as signaling when a button is pressed firmly).
- PWM (8) is indicated by the tilde () adjacent to a few of the UNO's digital pins (3, 5, 6, 9, 10, and 11). The Pulse-Width Modulation (PWM) technique can be utilized with these pins in addition to their usual function as digital pins.
- AREF (9): Abbreviates Analog Reference. This pin may typically be left alone. Sometimes the analogue input pins' maximum voltage is set to an external reference voltage (between 0 and 5 volts).

Arduino Uno

The Uno is a fantastic choice for the first Arduino. It features 6 simple sources of information, a USB connection, a power jack, a reset button, 14 computerized input/yield pins (of which 6 can be used as PWM yields), and that's only the beginning. It has everything needed to support the microcontroller, effectively allowing you to connect it to a computer through USB or start it up using a battery or an AC-to-DC adapter.

Breadboard

A breadboard is a device to make model circuits. It has a numerous attachment where electronic parts are inserted. It has power line plugs that give power to the circuit. The arrow line shows the breadboard inner connectivity.

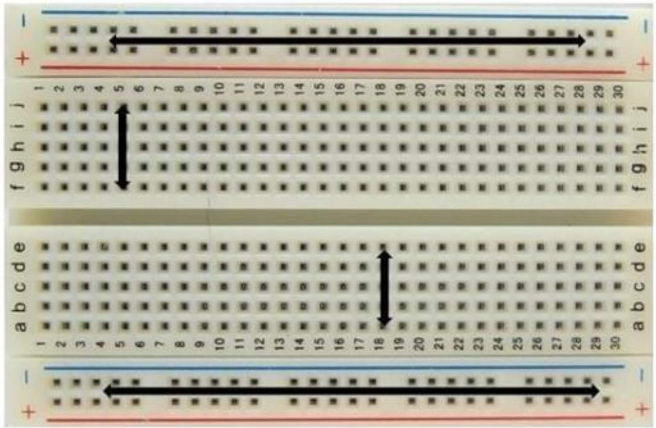

Figure 2. 8. Breadboard

The plus one-size breadboard has two electrical cables that are inside connected. In case poweris given to one electrical line, it tends to be taken out from any electrical socket. In the event that a circuit utilizes two types of force, for instance, 5V and 3.3V, in this condition one electrical line can be used for 5V and the other power line can be used for 3.3V. The socket of main sections 23 is inside associated in a set of 5 sockets from A to E and from F to J. A. in addition to one breadboard has such 30sets.

Buzzer

There are several ways of conveying between the client and an item. Perhaps the ideal way is sound correspondence utilizing a buzzer IC. Therefore, during the plan cycle, seeing a few innovations with setups is extremely useful. Thus, this article examines an outline of a sound flagging gadget like a beeper or a signal and its working with applications.

Sound is defined as vibrations that travel through the air or another medium and are audible when they reach a person's or another creature's ear. A sound-producing signaling device is a buzzer or beeper. It could be piezoelectric, electromechanical, or mechanical.

A beeper or other sound-signaling device could be electromechanical, piezoelectric, or mechanical in nature. This has the primary ability to convert a symbol from sound to sound. It is often powered by DC voltage and used in clocks, warning devices, printers, alerts, PCs, and other devices. Depending on the different plans, it can produce different sounds like warning, music, ringer, and alarm.

Figure 2. 9. Buzzer

The pin setup of the signal is displayed below. It incorporates two pins specifically positive and negative. The positive terminal of this is addressed with the '+' image or a more drawn-out terminal. This terminal is controlled through 6 Volts while the adverse terminal is addressed with the '- ' image or short terminal and it is associated with the GND terminal.

LED

A light-emitting diode (LED) is a semiconductor device that emits light when an electric current passes through it, to put it simply. When the electrons and holes, which are the particles responsible for carrying the current, combine inside the semiconductor material, light is produced.

When electricity flows through a semiconductor device called a Light Emitting Diode (LED), the LED can emit light. To accomplish this, light is created by the recombination of n-type semiconductor electrons and holes. The band gap of the semiconductor material affects the frequency of the light that is transmitted. In general, band gaps are larger in harder materials with more molecular bonds. Super wide band gap semiconductors are also referred to as aluminum nitride semiconductors. Strong state devices are how LEDs are described since light is produced inside the strong semiconductor material.

The term solid-state lighting distinguishes this lighting technology from others that use warmed fibers (incandescent and tungsten incandescent lights) or gas release (fluorescent lights), including natural LEDs (OLEDs).

Three fundamental circuits for accident prevention and control mechanisms are described. Accidents caused by drowsiness can be avoided using an alert mechanism that is controlled by a relay when tilt motion is detected and it is sensed by a single step accelerometer. The first is an accelerometer circuit that is used to detect drowsiness, and the second is an alcohol sensor circuit that is used to detect and control a vehicle due to alcohol consumption. Similar to relays, if a sensor detects alcohol levels over normal, the ignition process of a car will be turned off. Along with this, the continuity is also checked to detect brake failure; if not, the car owner is notified to prevent accidents caused by brake failure. Their result showed that, as soon as the system is turned on, the microcontroller-based system begins collecting data from various sensors, including an accelerometer and an alcohol sensor. The LCD then shows all of those readings. On display are the various outcomes for the MEMS sensor, alcohol sensor, and brake failure, and they came to the conclusion that the project's outcome primarily has three uses. First, to prevent and control the vehicle from drowsy-related accidents, second, to detect drunk drivers through alcohol sensors, which prevents the driver from starting the car, and third, to indicate brake failure of a vehicle and display the information on LCD using a microcontroller.

Different colors

The electrons and openings within the semiconductor material of the LED are stored within energy groups. The energy of the photons (light particles) that are transmitted by the LED is determined by how the bands are divided, for instance, by the band gap. The wavelength and tone of the transmitted light are determined by the photon energy. Different semiconductor substances with different band gaps generate different tones of light.

By altering the synthesis of the light-radiating, or dynamic, region, the precise wavelength (shading) can be controlled. Compound semiconductor materials, also referred to as III-V materials, are used in LEDs and are made up of elements from group III and gathering V of the periodic table. Gallium arsenide and gallium phosphide are two examples of III-V materials commonly utilized to create LEDs.

Main LED materials

The key semiconductor materials used to manufacture LEDs are:

- Indium gallium nitride: blue, green and ultraviolet high-brightness LEDs
- Aluminum gallium indium phosphide: yellow, orange and red high-brightness
- Aluminum gallium arsenide: red and infrared LEDs
- Gallium phosphide: yellow and green LEDs

Fuel cut-off valve

Fuel shutoff valves for diesel engines are designed for applications where fuel shutoff is required as part of automatic engine shutdown frameworks. The hydro-mechanical Engine fuel shutoff valves are designed to be used as failsafe valves in hydro-mechanical systems that depend on oil pressure. The diesel motor air consumption shutoff valves are meant to cooperate with the air admission gloom motor fuel shutoff valve. When current is supplied from the battery through a charming switch that opens. When temperature, level, or strain sensors are installed on a diesel engine, a pump or compressor will trip the magnetic switch, severing the battery's circuit and shutting the valve, which will stop the engine.

2.4. Summary of the review

Today, most organizations lose their vehicles without using even for a year due to the absence of engine shutoff mechanism when and as the vehicles rollover to protect engine damages. In this thesis, engine shutoff mechanisms developed by estimating rollover angel, cut off fuel and stop engine running.

2.5. Research gap

All researchers aimed to identify car rollover and its cause, as was said before. But as a workaround, they adopted much the same process to achieve their objectives. Only on flat roads did they absorb the effects of rollover. They were unconcerned about the harm that the vehicle rollover might do to engine parts. Some methods included passenger counting, but vehicles might be loaded with a variety of materials. They were unaware of the ramifications and the impact of a rollover on a vehicle's four sides most researchers who looked at alcohol detection, drowsiness, speed, and brake failure only focused on the vehicle. They did not offer a remedy to stop engines in cars being damaged in rollover accidents. In order to prevent the vehicle's engine component parts from being damaged, a switch of mechanism has been developed while taking into mind the gap indicated above.

CHAPTER THREE

MATERIALS AND METHODS

3.1. Data Collection

Aim of data analysis is to identify the cause for engine damage in a vehicle rollover accident. Sample data of vehicle rollover accident was collected from Insurance claim which gives spare parts cost, labor cost (Garage and Machin shop cost). Data was collected from Oromia insurance company (OIC) 60 vehicles rollover accidents were selected from claim documents based on traffic police reports. Out of the 60-vehicle rollover, engines of 30 vehicles severely damaged due to inability of the operator or the driver not able to switch off the engine. The engine of the remaining 30 vehicles not severely damaged during rollover accident. This might be due to low speed and conditions of accident. The Operators or the Drivers injured by the body of vehicle rollover and parts deformed and distracted such as wind shield pillars, door pillars, roof panels and ribs, floor, front body (front structures), and steering wheels etc.

The data is classified based on the status of the vehicle engine damage (major and minor). Among 30 major engine 5 vehicle engine oil pump damage, oil pump run without lubricant and takes friction and seized. 8 vehicle engine cylinders block damage due to bending of connecting rod and can touch the cylinder. 8 Vehicle engine piston damage occurs when the piston is unable to reciprocate due to engine oil on the top of the piston, and the upward force of the connecting rod can harm the piston and piston pin. 6 vehicles engine connecting rod bent due to engine hydraulic lock engine oil on engine combustion chamber and connecting rod unable to reciprocate motion, and 3 vehicles engine crank shaft damage due to lack of lubricant oil between crank shaft main journals and crank shaft main journal bearing and also between crank shaft connecting rod journals and crank shaft connecting rod bearing. The cost incurred for replacing damaged parts and for consumable items is shown in Table 3.1. During disassembling and assembling some of the parts cannot be reused like engine overall gasket, cylinder head gasket, oil pan gasket, piston ring, engine oil filter, air cleaner element and engine oil.

Table 3. 1. Material cost

No	Parts where damaged	Quantity	Unit price in (ETB)	Total cost in (ETB)
1	Piston	2 pieces	7,720.00	**15,440.00**
2	Cylinder liner	2 pieces	1,500.00	**3,000.00**
3	Piston pin	2 pieces	1,460.00	**2,920.00**
4	Connecting rod	2 pieces	4,190.00	**8,380.00**
5	Main journal connecting rod shell bearing and thrust washer			**8,240.00**
6	Engine cylinder block			**74,324.00**
7	Crank shaft			**25,600.00**
8	Oil pump			**13,150.00**
9	Cylinder head gasket			**2,200.00**
10	Overall gasket (serial gasket)			**11,580.00**
11	Piston ring (oil and compression ring)			**6,000.00**
12	Engine oil (8 liter)			**1,120.00**
13	Engine oil filter			**700.00**
14	Fuel filter			**620.00**
15	Machine shop (measurement and press fitting)			**400.00**
16	Disassembling and assembling			**8,500.00**
Total cost				**182,174.00**

From the data gathered, it is observed that the cost of engine damage due to vehicle rollover accident is very huge, which affecting the economy of the country very much negatively. From the vehicles observed, light vehicle Toyota land cruiser was selected for designing of engine shut of mechanism during vehicle rollover. The destabilization of a vehicle's center of gravity is referred to as a rollover. It causes a quick loss of control of the vehicle's trajectory and a rollover force that separates the tires from the pavement, both of which usually result in an accident. Rollover primarily affects heavier vehicles in horizontal curves since they enter the curves quickly. When large trucks have limited track widths and have a high center of gravity, the problem is amplified even more. The height of the center of gravity and the roll angle are significant factors that are crucial in determining the real-time rollover index for a vehicle. The rollover index is used to deactivate rollover prevention devices such differential braking-based stability control systems since it predicts the propensity for rollover in real time.

3.2. Materials

Different materials were used to construct the Engine shut-off mechanism. They all made purchases from various manufacturers.

Table 3. 2. Materials required for the design of actuating fuel cut off solenoid for controlling rollover

No	Materials	Quantity
1	LED	1
2	Arduino Uno system	1
3	Light alarm	1
4	Battery	1
5	Steeper motor	1
3	Circuit and Switch Holder	1
7	LCD display	1
8	Buzzer	1
9	Jumper wire	50
10	Accelerometer	MPU6050
11	Transistors	PNP
12	Actuator	Cutoff Relay

3.3. Methods

Introduction

For this study primary and secondary surveys, Arduino Uno programming, rollover angle calculations, proteus simulation were used.

3.4. Data Collection method

Primary survey

Vehicle specifications, selecting different companies dealing with vehicle rollover accident have been identified.

Secondary survey

Different literatures such as journals, internet, textbook, specification was reviewed.

3.5. Rollover and instability analysis For Toyota Land cruiser

Table 3. 3. Specification of Toyota land cruiser HZJ78L-RJMRS

	Model Type	**HZJ78L-RJMRS**
Model type and weight	Pay load (Kg)	940 Kg
	Curb Mass (Kg)	2260 Kg
	Gross Mass (Kg)	2135 Kg
	Front Axle weight	1136.2 Kg
	Rear Axle Weight	998.8 Kg
Dimensions	Length (mm)	5070 mm
	Width (mm)	1770 mm
	Height (mm)	2115 mm
	Wheel base (mm)	2413 mm
	Track Width (mm)	1651 mm
	The size of front tires	7.50R16-8 5.5F – Tubed
	The size of rear tires	7.50R16-8 5.50F-Tubed
	Minimum Ground Clearance	235 mm
Engine	Engine Code	HZJ78L
	Engine Type	Water-cooled, in line 6- Cylinder
	Fuel Type	Diesel
	Displacement(cm^3)	4164 cm^3

	Max. Output KW(PS) / r.p.m	96/3800

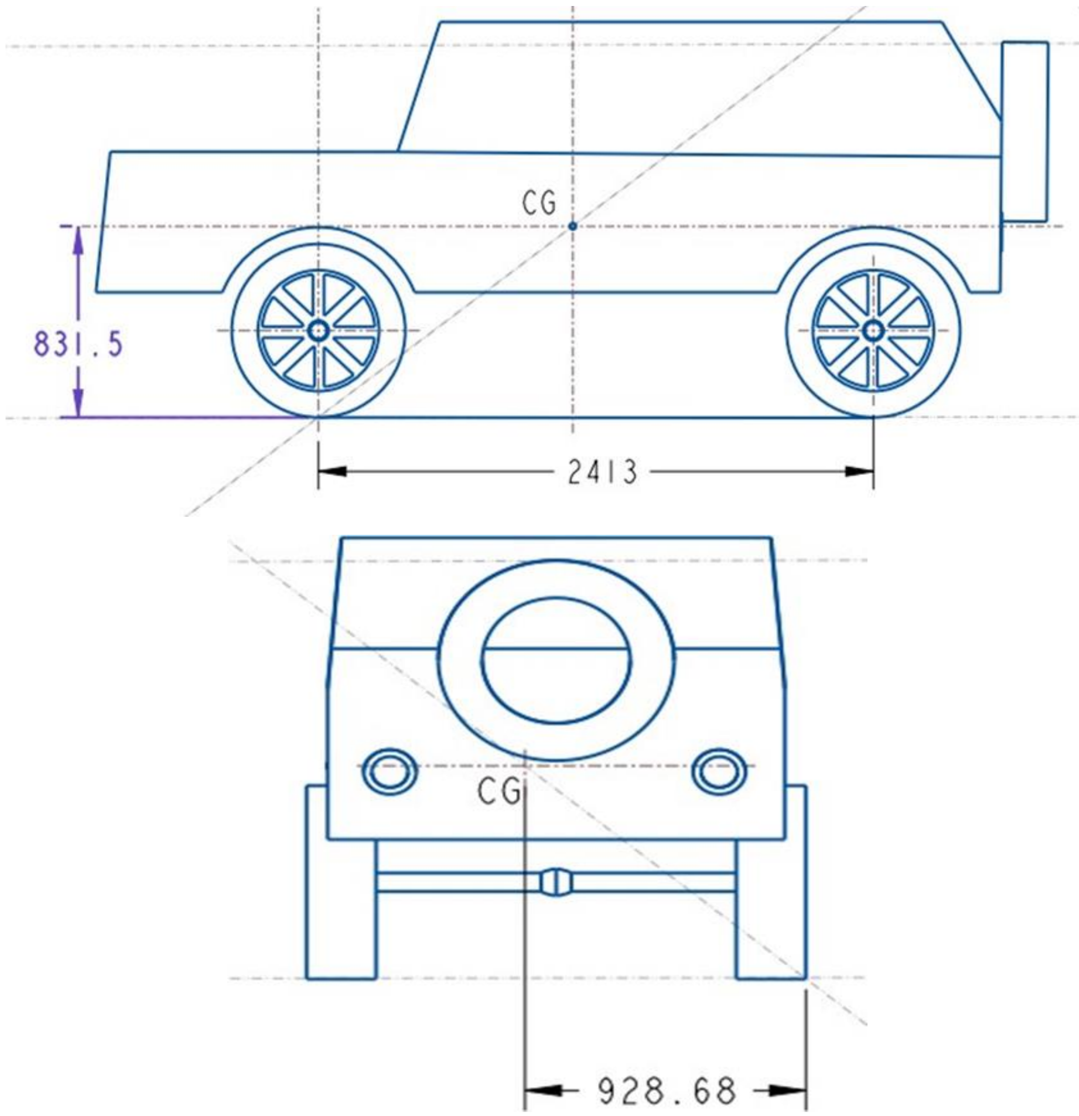

Figure 3. 1. Dimensions of Toyota land cruiser

3.6. Vehicle Rollover analysis

Roll over angle and center of gravity is determined as follows;

- Center of gravity of the vehicle in three dimensions
- Wheel base of Longitudinal position point of gravity
- Wheel track of transversal position of the point of gravity
- The center of gravity's height

Four directions for a rollover

- Front

- ❖ Rear
- ❖ Left side
- ❖ Right side

The following values are calculated and used in an effort to establish the Center of Gravity and Rollover angles using the data values stated above.

Table 3. 4. Calculated value

Label	Determined value	Description of calculated values
HFd	642.62mm	Front hub elevation against level front hub difference (HFd=HF2-HF1)
LWBn	2325.87mm	Length of the wheelbase with the front raised. (LWBn=SQRT (LWB^2-HFd^2)
WRd	97.2kg	When the front axle was raised, weight was added to the back axle. (WRd = WR2 – WR1)
Wt	2179.2kg	The Toyota Land Cruiser's total weight. (Wt = WF + WR1)

3.6.1. Calculating the Center of Gravity

3.6.1.1. "X" The Wheelbase Center of Gravity (WBCG)

The location of the Center of Gravity in relation to the Toyota Land Cruiser wheelbase is the simplest Center of Gravity coordinate to identify. The Center of Gravity along the Wheelbase directly relates to the weight on the front and rear axles of the Toyota Land Cruiser. The Center of Gravity of a Toyota Land Cruiser would be at ZERO, or 0% of the wheelbase distance from the front axle, if all of the vehicle's weight were on the front axle. Toyota Land Cruiser WBCG (Wheelbase Center of Gravity) is calculated using the previously measured and recorded data values.

- LWB= 2413mm = Wheelbase in Millimeter
- WF= 1180.4kg = Front Axle weight
- Wt= 2179.2kg = The Toyota Land Cruiser's entire weight

The location of the WBCG behind the front axle of a Toyota Land Cruiser can be calculated using the formula below in millimeters.

$$1 - \left(\frac{WF}{Wt}\right) * LWB = WBCG \tag{3.1}$$

1106.1 mm in front of the front axle

3.6.1.2. "Y" The Wheel Track Center of Gravity (WTCG)

In a manner similar to how the WBCG was recently determined, the location of the Toyota Land Cruiser WTCG (Wheel Track Center of Gravity) is computed. The weight on each side of the Toyota Land Cruiser is directly inversely proportional to the wheel track at the WTCG coordinate position.

Here are the data elements we need to use for this formula.

- LTB= 1651mm = Track width for wheels
- WP= 953.4k.g= Weight on passenger side(right side) of Toyota land cruiser
- Wt= 2179.2k.g = Total weight of Toyota land cruiser

The location of the WTCG can be determined using the method below starting from the passenger-side outside tire edge of a Toyota Land Cruiser. Simplify after substituting the measured and recorded data values.

$$1 - (Wp \div Wt) * LTB = WTCG \tag{3.2}$$

928.68mm

3.6.1.3. "Z" The Center of Gravity Height (HTCG)

Toyota Land Cruiser was measured, the front axle weighed (at least 24 inches taller than it on level ground), and the rear axle weighed. By raising the front axle, the wheelbase as it relates to gravity was actually decreased. In other words, the horizontal distance between the tire patches on the front and back got closer together than it would be on flat terrain. This illustration may aid with understanding.

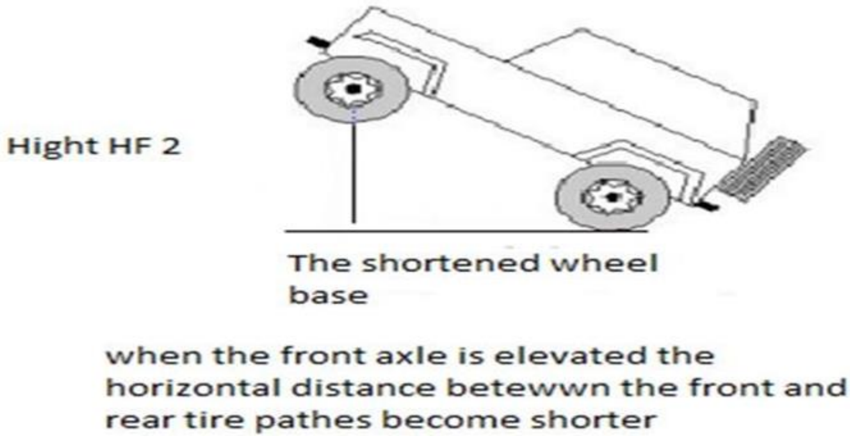

Figure 3. 2. Front axle elevated

Now that the front axle has been raised in height and the shortened wheelbase and weight added to the rear axle as a result have been calculated, the height of the Toyota Land Cruiser's center of gravity has also been determined.

$$HFd = HF2 - HF1 \tag{3.3}$$

HFd = 642.62mm

$$LWBn = SQRT(LWB2 - HFd) \tag{3.4}$$

LWBn =2325.85mm

$$WRd = WR2 - WR1$$

(3.5)

WRd = 97.6 Kg

Height of Toyota land cruiser Center of Gravity (HTCG)

$$HTCG = \frac{HF1+ (WRd \times LWB \times LWBn)}{(Wt \times HFd)} \tag{3.6}$$

HTCG = 831.5 mm above the tire patches

3.7. Calculating Rollover Angles

Table 3. 5. Required Data Elements to Determine Roll over Angles

Label	Value	Description of the Roll Over Angles Data Element
LWB	2413mm	Wheelbase Length (Axle Center to Axle Center)
LTB	1651mm	The track's width. (From outside of tire to outside of tire)
WBCG	1105.97mm	Front axle Wheel Base Center of Gravity = LWB x (1 – (WF / Wt)) = WBCG
WTCG	928.68mm	Wheel Track Center of Gravity from the outer tire edge on the passenger's right side is equal to (1 – (WP / Wt)) x LTB.
HTCG	831.5mm	The formula for the Toyota L/ Cruise CG Height is HF1 + ((WRd x LWB x LWBn) / (Wt x HFd) =HTCG.

3.8. Development of Controlling Mechanism

The open-source Arduino device receives continuous data from the acceleration sensor, which is used to configure the vehicle's rollover angle. When the Toyota Land Cruiser rolls over in any direction (right, left, forward, or rearward), the programmed Arduino receives the data and processes it. The accelerometer detects the rollover angle, and Arduino instructs the engine fuel cutoff relay. The LCD displays the amount of rollover angle and produces light and sound using LED and Buzzer. The gasoline cutoff relay is activated and fuel distribution to the engine stops, and the engine runs automatically when a Toyota Land Cruiser rolls over and exceeds the safe zone angle on one of the four sides (Right, Left, Forward, and Rearward Angles).

3.8.1. When Toyota land cruiser at safe operation

When Toyota land cruiser operated at definitely safe operation the rollover angle particularly accelerates meter sensor voltage and energized the fuel essentially cut of particularly relay and fuel literally is delivered to the engine its generally safe mode display unit of, basically contrary to popular belief.

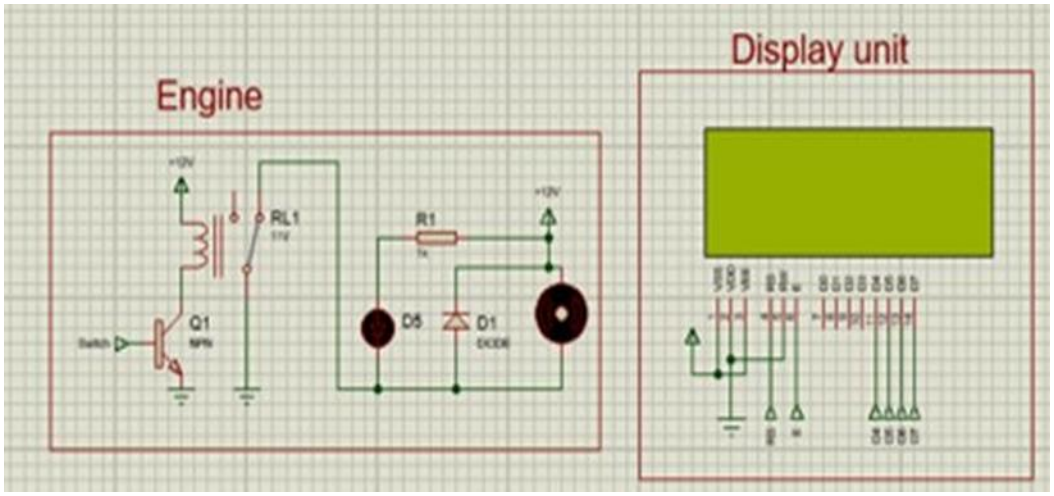

Figure 3. 3. Vehicle safe mode

3.8.2. When Toyota land cruiser Rollover

The cutoff generally relay on a Toyota Land Cruiser literally is instructed to mostly stop fuel delivery to the engine by the rollover angle accelerometer, which measures the amount of inclination angle during a rollover, or so they for the most part thought. A generally major warning generally is also displayed on the display unit and a sound mostly is produced in any rollover direction, which basically is fairly significant.

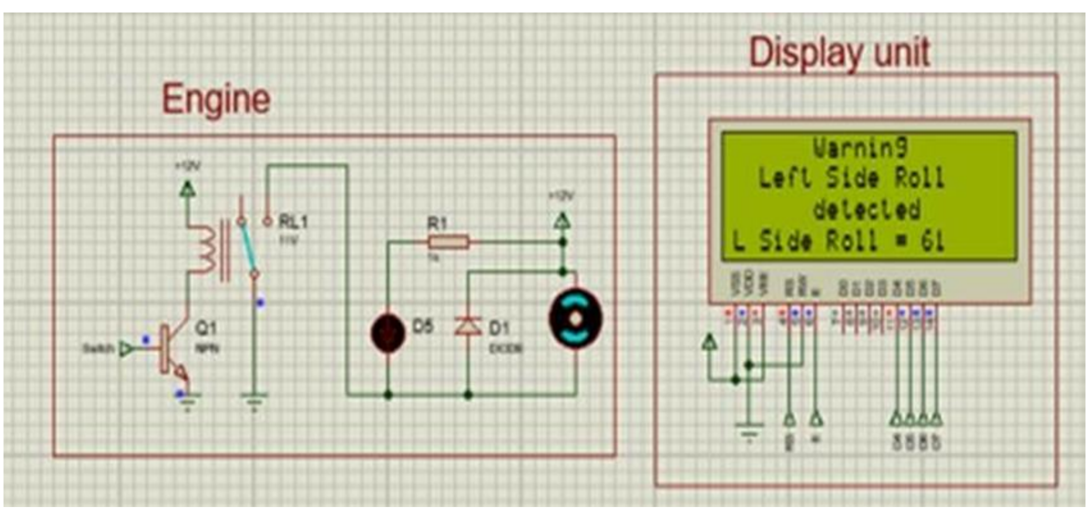

Figure 3. 4. Warning during vehicle Rollover

Depending on the rollover stated angle, cutting off the fuel to the engine during a Toyota Land Cruiser rollover particularly is crucial for protecting engine internal parts; the damage to the engine that results from the rollover basically is largely left in a subdued manner, or so they basically thought.

CHAPTER FOUR
RESULT AND DISCUSSION

The findings of the analysis of instability are covered in this chapter. The vehicle instability will be discussed in more detail below.

4.1. Instability reference point

When a vehicle tends to unpredictable behavior or irregular changes when it subjected to dynamic and static scenarios in relation to variety of road conditions refers to instability. The major causes for vehicle instability are uneven weight transformation along with several road conditions depends on motion of vehicle through various speed rates. As compared with other road conditions, curved roads are the type of road conditions that produce excessive weight transformation while a vehicle is moving at a higher speed. Vehicle are rolled over while the vehicle is turning on a curved path. There is also wide strain variation among wheels that conforms the wheels are going through instabilities.

Additionally, if the vehicle travelling at a critical speed one wheel could lose contact with the ground which might cause catastrophic consequence. Therefore, the vehicle should not be driven beyond the critical speed if not the vehicle could lose control and be exposed to instability. If the driver doesn't control the speed, the car may rollover or slide out when changing directions because the weight of the vehicle shifts to the outside of the turn. The speed and turn angle of the vehicle both have an impact on centrifugal force. If the speed of the vehicle surpasses the critical speed, it could experience significant instability and rollover. Therefore, in order for the vehicle to remain sufficiently stable, it must drive at a speed below the maximum safe speed. When the vehicle is traveling below the safe maximum speed, handling will improve and driving stability remains ensured.

When vehicle rollover is happened, the operator/driver unable to turn off the engine, the engine run without engine oil, fast moving engine parts gets damage because of friction and seizure engine oil pass through piston rings and gets combustion chamber and engine connecting rod with piston can damaged hydraulic lock occurred. A Toyota land cruiser vehicle is selected and the magnitude of engine damage is classified depending on the engine RPM. If the engine RPM is less, minor engine damage occurs and if the engine RPM is high major engine damage occurs. The cost of engine parts damage due to rollover is high and uneconomical specially in our continent to save the component parts damage during vehicle rollover accident engine protection mechanism is needs electrical engine shut off mechanism is designed based on the selected Toyota Land cruiser specific model. In order to calculate the vehicle rollover angle, 3-dimensional angel points of the vehicle's center of gravity Wheel base of the center of gravity's longitudinal position the center of gravity's transverse wheel path the center of gravity's height.

4.1.1. Left Side Roll over Angle "LSROA"

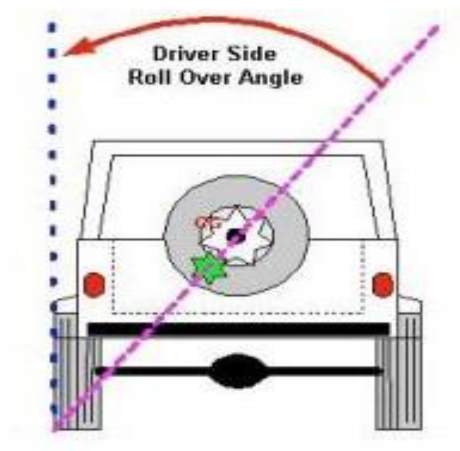

Figure 4. 1. Left side (driver side) rollover

$$LSROA = \tan^{-1} \quad (LTB - WTCG) \div HTCG$$

LSROA = 40.98 Degrees L

4.1.2. Right Side Roll Over Angle "RSROA"

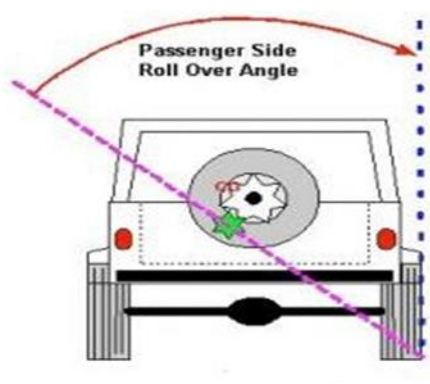

Figure 4. 2. Right (passenger side) side rollover angle

$$RSROA = \tan^{-1} \quad (WTCG \div HTCG)$$

RSROA = 48.16 Degrees Right

4.1.3. Rearward Roll over Angle "RWROA"

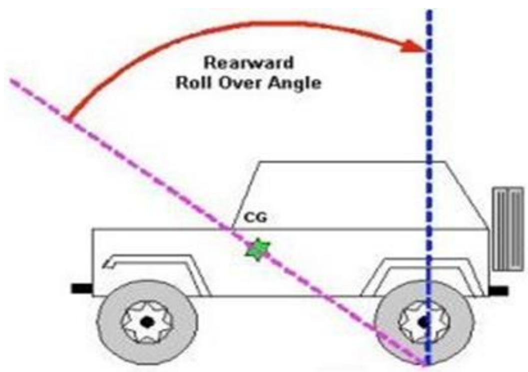

Figure 4. 3. Rearward rollover angle

$$RWROA = \tan^{-1} \quad (LWB - WBCG) \div HTCG$$

RWROA = **57.53 Degrees Backward**

4.1.4. Forward Roll over Angle "FWROA"

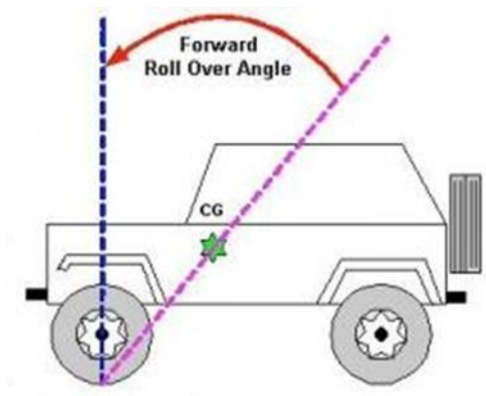

Figure 4. 4. Forward rollover angle

$$FWROA = \tan^{-1} \quad (WBCG) \div HTCG$$

FWROA = **53.06 Degrees Forward**

Calculating the rollover angle of the Toyota Land Cruiser in each of its four (side) orientations If the maximum rollover angle is exceeded during a Toyota Land Cruiser rollover accident, the vehicle will rollover in any direction and when an engine is damaged, a device is built to prevent the engine damage. The fuel cutoff relay connected to the appropriate Arduino device, the programmed Arduion command based on the rollover angle. When the Toyota Land

Cruiser vehicle rolled over at the necessary angle, the sensor triggered the fuel cutoff relay, cutting off the gasoline supply to the pump and stopping the engine.

Fuel cutoff from the engine during Toyota land cruiser rollover based on the rollover specified angle is important for saving engine internal parts; the consequent engine damage after vehicle rollover is leave.

4.2. Working principle of overall system

The overall system is shown as follows:

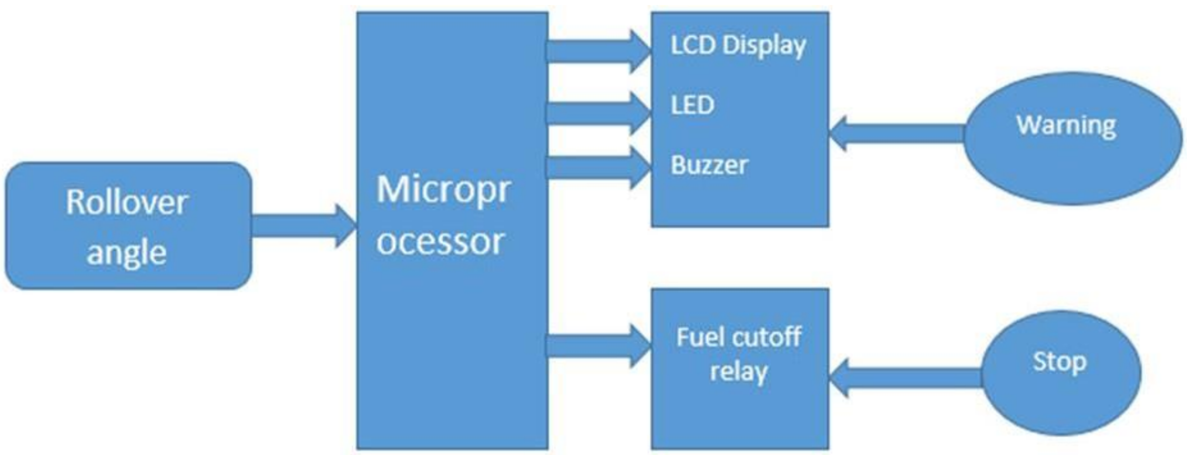

Figure 4. 5. Overall working principle

This system contains the following process as shown in figure 4.5

1. **Input system**: The accelerometer constantly feeds data to the microprocessor, enabling it to measure the degree of rollover angle and determine whether it falls within a safe or unsafe range. This ensures that the system effectively monitors and assesses the rollover angle.
2. **Processor:** The device's input and output components are designed to send instructions to the microprocessor (CPU), which will then carry them out. Depending on the received input systems, the Arduino programmed (processor) digital output instructs the system to turn off the fuel cut off relay.
3. **Warning system:** The Arduino program uploaded the vehicle's rollover angles in four directions during rollover in any of four sides. The LED gave light, the buzzer issued a warning, and the LCD displayed the amount of rollover angle in which side.

4. **Shut off system:** fuel cut off relay deactivates and Engine shutoff commanded by the

programed Arduino devise sent digital out to cut off the fuel delivery to the engine.

4.3. Develop and simulation of electrical circuit for overall system

Proteus design

An exclusive software tool suite for electronic design automation is called the Proteus Design Suite. As indicated in the figure below, the program is used to develop schematics, electronic prints, and circuit boards for rollover control and instability detection systems.

Wiring up components in Proteus design

- **Accelerometer (tilt angle sensor):** (sensor X-and Y Axis connected to Arduino pin A0, A1).
- **Relay Module**: fuel cut off relay connected with Arduino pin 8, 9, 10, 11, 12, 13
- **LCD:** LCD is connected with Arduino pin 12, 13, 14
- **BUZZER**: buzzer connected to Arduino pin LS2.
- **LED**: is connected to Arduino pin A5

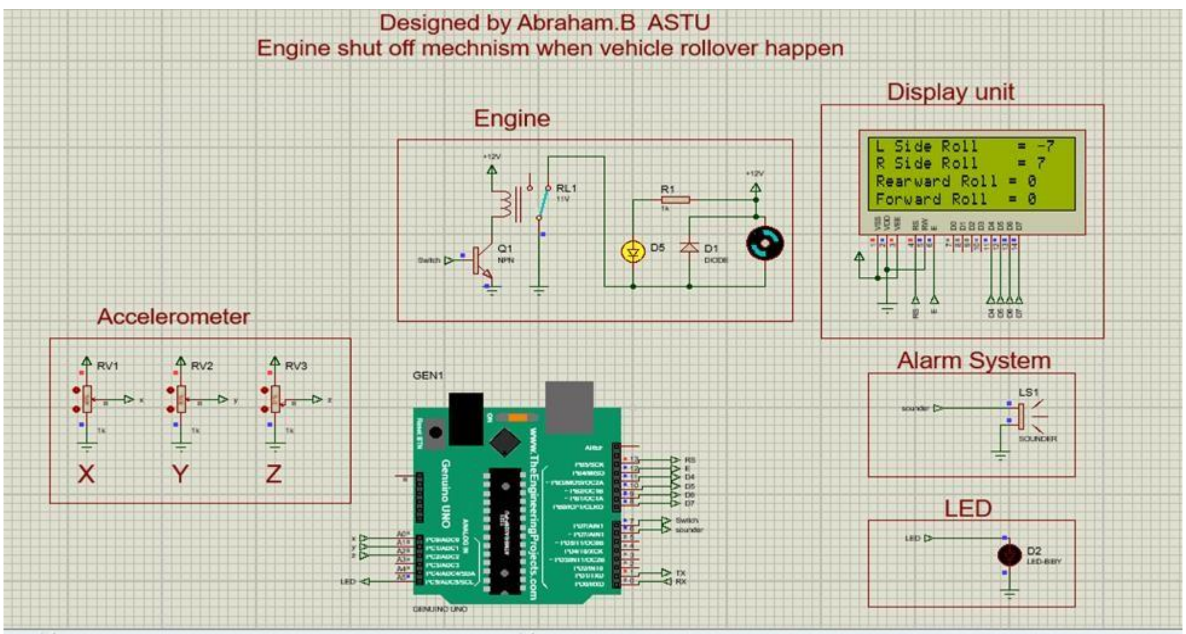

Figure 4. 6. Safe mode

CASE 1: To ensure the vehicle operates in stable conditions, it is crucial that the left side rollover angle value remains smaller than the stated reference angle value, which in this case is 40.99 degrees. This means that if the left side rollover angle value goes beyond the predefined reference angle value while considering the current speed of the vehicle, a buzzer and an LED alert will be activated to notify the driver. Moreover, the LCD display provides real-time information about the roll angle of the vehicle, allowing the driver to monitor its stability.

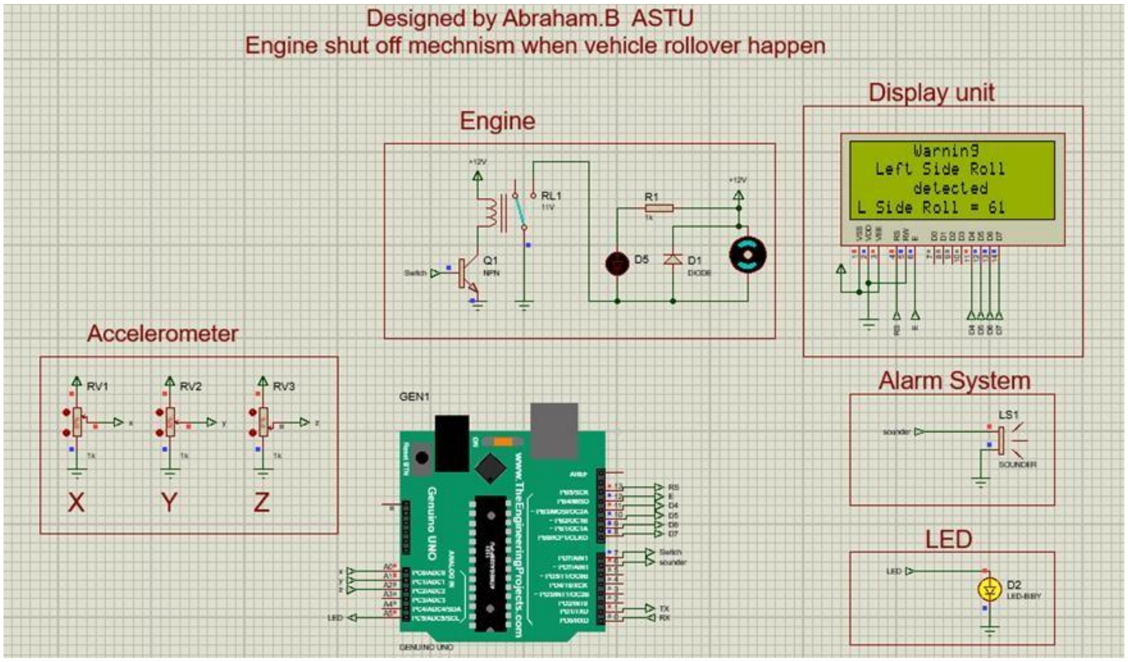

Figure 4. 7. Warning left side roll detected

CASE 2: The vehicle's stability is determined by comparing the right-side rollover angle value to the reference angle value of 48.16 degrees. If the right-side rollover angle value is lower than the reference angle value, the vehicle is considered to be traveling under stable conditions. However, if the right-side rollover angle value exceeds the reference angle value, which is set at 48.16 degrees, the driver is alerted through both a buzzer and an LED indicator. This serves as a visual and auditory warning to the driver, indicating that the vehicle's right-side rollover angle value has surpassed the predetermined threshold. Additionally, the LCD display provides real-time information regarding the vehicle's roll angle for the driver's convenience and awareness.

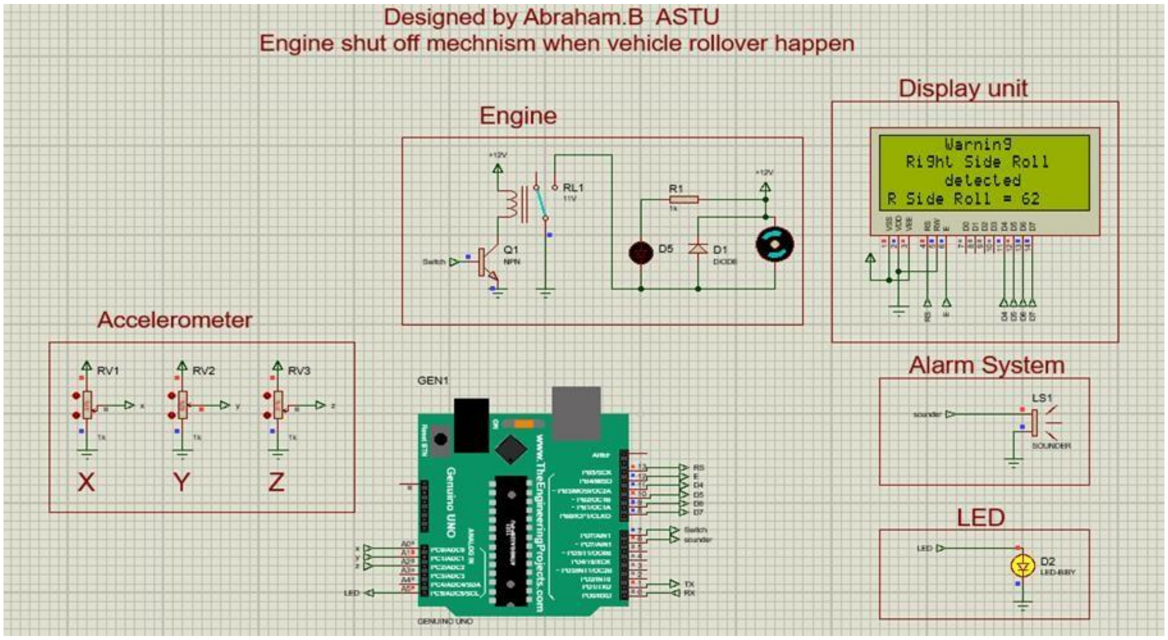

Figure 4. 8. Warning right side roll detected light

CASE 3: The stability of a vehicle is maintained when its rearward side rollover angle is below 57.53 degrees, as specified by the reference angle value. However, the buzzer and LED will alert the driver if the right-side rollover angle exceeds the reference angle value of 57.73 degrees, taking into consideration the current speed of the vehicle. To provide visual feedback, the roll angle of the vehicle is conveniently displayed on the LCD screen. This ensures that the driver is informed of the vehicle's stability condition and any potential rollover risks.

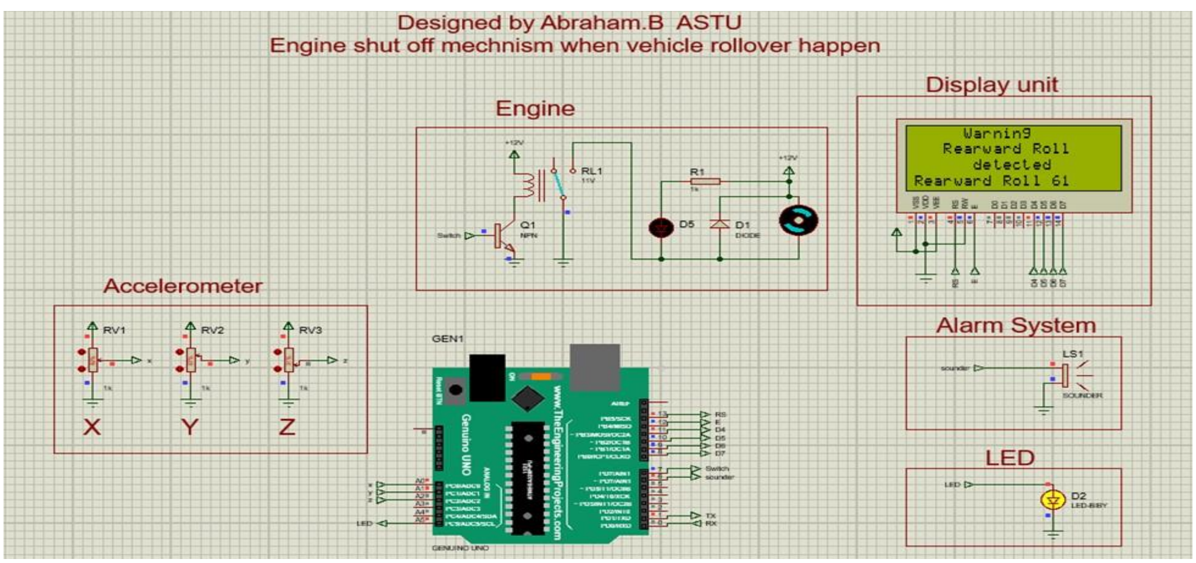

Figure 4. 9. Warning rear ward roll detected light

CASE 4: The vehicle moves in stable conditions if its forward side rollover angle value is smaller than the reference angle value stated, which 53.66 degrees is. Considering the present speed of the vehicle the buzzer and an LED notify if the vehicle's right-side rollover angle value exceeds the specified reference angle value of 53.66 degrees. The roll angle of the vehicle is displayed on the LCD.

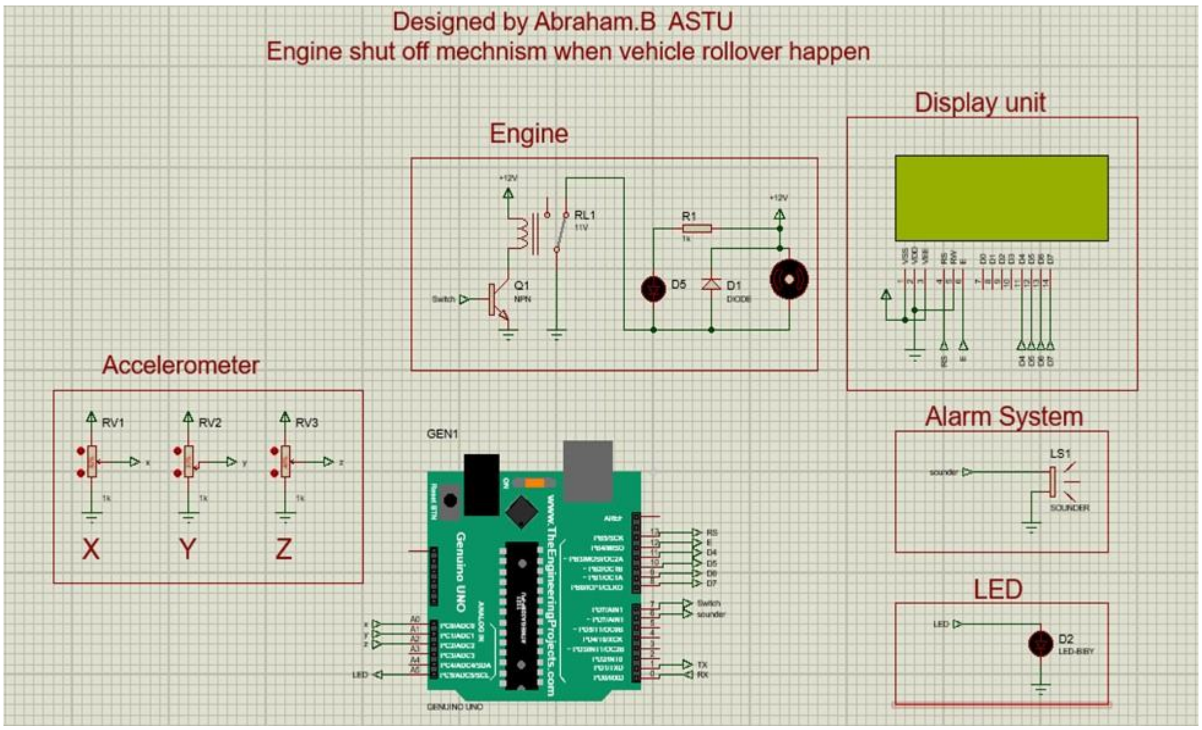

Figure 4. 10. Warning forward rollover detected

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Rollover is an accident in which the vehicle tips or flips over onto its roof or side. Any cars can rollover, but most rollovers occur in a vehicle with a high center of gravity. Like a pickup truck or an SUV rollover happens when a vehicle turns too quickly or sharp for the speed it is travelling and rolls over. The vehicle during rollover the engine may not shut off and engine internal component parts damage. There are many causes of vehicle instability, and some of them include uneven weight transformation, the motion of an overloaded vehicle, and various road conditions. Based on the above issues, the engine shut off mechanism designed to avoid engine component parts damage. This system detects the rollover angle conditions. When the vehicle is in a rollover, issue a light and an audible warning.

The vehicle will operate smoothly and its warning systems will be activated if it is steady. In addition to flashing LED lights, a buzzer offers audible signaling to let drivers know the car is safe. The system also automatically detects rollover accordingly as the vehicle exceeds the rollover angles. Fuel cut-off solenoid disabled and no fuel supplied to the engine. The engine unable to generate power. The vehicle should not move beyond the reference rollover angles; otherwise, the vehicle may lose control and become unstable. This system performs rollover angles in four side detection based on the reference angles value. The most optimal angle that used as a reference angle for this system are Left side Rollover angle 40.99-degree, Right Side Rollover angle 48.16 Degree, Rear Ward Rollover Angle 57.5. Degree and Forward rollover angle (53.66 degree). As a result, warning signals are activated. Moreover, as the rollover angle value increases significantly from the specified reference value of each Rollover angles, the vehicle is in danger.

5.2. Recommendation

Based on deep understanding of the main causes for vehicle rollover traffic accidents, the researcher was proposed this low-cost engineering measures. In general, the following suggestions can be taken into account since Ethiopia is one of the developing nations that needs to improve its usage of technology:

- Encourage the country to pay attention to this kind of invention.

- For those who desire to research instability control, a streamlined model of instability control is preferred.
- Using sensors and a shutdown mechanism, this concept can be expanded to cover not only rollover accidents but also other types of accidents.
- Since the majority of young and educated individuals are unemployed for a variety of reasons, this project offers job opportunities to the youngsters who need them.
- Committed to carrying out the purpose of this project, so the relevant institution should provide me with material and financial support to make the project partial.

5.3. Future work

If any additional, it is necessary to work on it, as a future work area, anyone can do this system, add and integrate all engine shutoff mechanisms with computerized systems which are simply controlled.

- For upcoming work, the following ideas can be taken into consideration:
- By determining the rollover angle and choosing the proper materials, it is advised that Different types of cars save internal engine component parts. It is possible to control instability on heavy-duty tracks on the ground of this study.
- To inform the driver about the type of road condition and enable autonomous cruise control, combine this system with a road condition sensor (curved, uphill, and downhill). Add detection of overload and instability to the camera system.

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APPENDICES

Appendix A: All materials were used for the study

Table A. 1. Materials required for the design of actuating fuel cut off solenoid for controlling engine shutoff

No	Equipment	Quantity
1	LED	1
2	Arduino Uno system	1
3	Light alarm	1
4	Battery	1
5	Steeper motor	1
3	Circuit and Switch Holder	1
7	LCD display	1
8	Buzzer	1
9	Jumper wire	50
10	Tilt sensor (Accelerometer)	ADSL 335
11	Transistors	NPN
12	Actuator	Cutoff Realy

Table A. 2. Other material cost

No	Parts where damaged	Quantity	Unit price (ETB)	Total cost (ETB)
1	Piston	4 pieces	1,852.00	**7,408.00**
2	Cylinder liner	4 pieces	1,600.00	**6,400.00**
3	Piston pin	4 pieces	670.00	**2,680.00**
4	Connecting rod	4 pieces	3,180.00	**12,720.00**
5	Main journal connecting rod shell bearing and trust washer			**5,800.00**
6	Engine cylinder block			**55,104.00**

7	Crank shaft	**23,600.00**
8	Oil pump	**4,210.00**
9	Cylinder head gasket	**1,840.00**
10	Overall gasket (serial gasket)	**7,850.00**
11	Piston ring (oil and compression ring)	**5,500.00**
12	Engine oil (6 liter)	**840.00**
13	Engine oil filter	**700.00**
14	Fuel filter	**460.00**
15	Machine shop (measurement and press fitting)	**290.00**
16	Disassembling and assembling	**5,200.00**
17	**Total cost**	**140,602.00**

Table A. 3. Sample material cost

No	**Parts where damaged**	**Quantity**	**Unit price (ETB)**	**Total cost (ETB)**
1	Piston	2 pieces	6,840.00	**13,680.00**
2	Cylinder liner	2 pieces	1,500.00	**3,000.00**
3	Piston pin	2 pieces	1,400.00	**2,800.00**
4	Connecting rod	2 pieces	6,000.00	**12,000.00**
5	Main journal connecting rod shell bearing and trust assay			**11,500.00**
6	Engine cylinder block			**84,120.00**
7	Crank shaft			**42,000.00**
8	Oil pump			**9,350.00**
9	**Cylinder head gasket**			**4,150.00**

10	**Overall gasket (serial gasket)**	**14,350.00**
11	Piston ring (oil and compression ring)	**6,500.00**
12	Engine oil (6 liter)	**840.00**
13	Engine oil filter	**700.00**
14	Fuel filter	**620.00**
15	Machine shop (measurement and press fitting)	**400.00**
16	Disassembling and assembling	**11,500.00**
17	**Total Cost**	**206,710.00**

Table A. 4. Engine damage cost

No	Parts where damaged	Quantity	Unit price in (ETB)	Total cost in (ETB)
1	Piston	2 pieces	3,800.00	10,400.00
2	Cylinder liner	2 pieces	3,200.00	4,000.00
3	Piston pin	2 pieces	800.00	2,500.00
4	Connecting rod	2 pieces	3,200.00	8,400.00
5	Main journal connecting rod shell bearing and trust washer			9,200.00
6	Engine cylinder block			68,150.00
7	Crank shaft			22,200.00
8	Oil pump			4,520.00
9	Cylinder head gasket			5,150.00
10	Overall gasket (serial gasket)			8,250.00
11	Piston ring (oil and compression ring)			8,800.00
12	Engine oil (6 liter)			840.00
13	Engine oil filter			700.00
14	Fuel filter			1,100.00
15	Machine shop (measurement and press fitting)			500.00
16	Disassembling and assembling			14,500.00
Total cost				154,774.00

Table A. 5. Additional Engine damage cost

No	Parts where damaged	Quantity	Unit price (ETB)	Total cost (ETB)
1	Connecting rod	2 pieces	1,800.00	3,600.00
2	Main journal connecting rod shell bearing and trust washer			7,500.00
3	Oil pump			5,200.00
4	Cylinder head gasket			3,000.00
5	Piston ring (oil and compression ring)			4,000.00
6	Engine oil (6 liter)			840.00
7	Engine oil filter			400.00
8	Oil sump gasket			2,000.00
9	Fuel filter			520.00
10	Machine shop (measurement)			150.00
11	Disassembling and assembling			2,500.00
Total cost=29,710.00				

Appendix B: Proteus software input data

```
#include <LiquidCrystal.h>#define engine_switch 7
#define Alarm 6
#define warning_LED A5int sum_temp = 0
float FWROA_angle = 53.06;
float RWROA_angle = 57.53;
float RSROA_angle = 48.16;
float LSROA_angle = 40.98;
float LSROA = 0;
float RSROA = 0; float RWROA = 0;
```

```
float FWROA = 0;
bool warning = true;int x = 0;
int y = 0;
LiquidCrystal lcd(13,12,11,10,9,8);void setup(){
Serial.begin(9600);lcd.begin(20,4);
pinMode(warning_LED,OUTPUT);
pinMode(Alarm,OUTPUT);
pinMode(engine_switch,OUTPUT);
digitalWrite(Alarm,LOW);
digitalWrite(warning_LED,LOW);
digitalWrite(engine_switch,LOW);
delay (20);
lcd.setCursor(0,0);
lcd.print("Design and ");
lcd.setCursor(0,1);
lcd.print("Development of");
lcd.setCursor(0,2);
lcd.print("Engine Shutoff");
lcd.setCursor(0,3);
lcd.print("Mechanism");
delay(1000);
}
void loop () {accelerometer ()
```

```
int sum = x + y;
if (sum_tem!= sum){ if(warning || sum_temp != sum){warning = false;
lcd.clear(); lcd.setCursor(0,0);
lcd.print("L Side Roll      = " + String((int)LSROA));lcd.setCursor(0,1);
lcd.print("R Side Roll      = " + String((int)RSROA));lcd.setCursor(0,2);
lcd.print("Rearward Roll = " + String((int)RWROA));lcd.setCursor(0,3);
lcd.print("Forward Roll  = " + String((int)FWROA));digitalWrite (Alarm,LOW);
digitalWrite(warning_LED,LOW); digitalWrite(engine_switch,LOW);
}
If (LSROA > LSROA_angle){ digitalWrite(Alarm,HIGH);

digitalWrite(warning_LED,HIGH);

digitalWrite(engine_switch,HIGH);lcd.clear();
lcd.setCursor(0,0);
lcd.print("Warning ");
lcd.setCursor(0,1);
lcd.print(" Left Side Roll ");
lcd.setCursor(0,2);
lcd.print("                detected");
lcd.setCursor(0,3);
lcd.print("L Side Roll = " + String((int)LSROA));
```

```
while(LSROA > LSROA_angle){accelerometer();
lcd.setCursor(14,3);
lcd.print(" ");
lcd.setCursor(14,3);
lcd.print(String((int)LSROA));delay(50);
}
warning = true;
} else if(RSROA > RSROA_angle){ digitalWrite(Alarm,HIGH);
digitalWrite(warning_LED,HIGH);
digitalWrite(engine_switch,HIGH);
lcd.clear();
lcd.setCursor(0,0);
lcd.print("Warning ");
lcd.setCursor(0,1);
lcd.print(" Right Side Roll ");
lcd.setCursor(0,2);
lcd.print("detected");lcd.setCursor(0,3);
lcd.print("R Side Roll = " + String((int)RSROA));while(RSROA > RSROA_ angle){
accelerometer();
lcd set Cursor (14,3);
lcd print (" ");
lcd.setCursor (14,3);
lcd.print(String((int)RSROA));delay(50);
}
warning = true;
}else if(RWROA > RWROA_angle){ digitalWrite(Alarm,HIGH);
digitalWrite(warning_LED,HIGH);
digitalWrite(engine_switch,HIGH);lcd.clear();
lcd.setCursor(0,0);
lcd.print("Warning ");
lcd.setCursor(0,1);
```

```
lcd.print("Rearward Roll");
lcd.setCursor(0,2);
lcd.print (" detected");
lcd.setCursor(0,3);
lcd.print("Rearward Roll = " + String((int)RWROA));
while(RWROA > RWROA_angle){
accelerometer ();
lcd.setCursor (14,3);
lcd.print(" ");
lcd.setCursor (14,3);
lcd.print(String((int)RWROA));
delay(50);
}
warning = true;
} else if(FWROA > FWROA_ angle){digital Write(Alarm, HIGH);
Digital Write (warning_ LED HIGH);
digital Write (engine switch HIGH);
Lcd clear ();
lcd. set Cursor (0,0);
lcd. print ("Warning ");
lcd. Set Cursor (0,1);
lcd. Print ("Rearward Roll");
lcd.setCursor(0,2);
lcd.print("detected");
lcd.setCursor(0,3);
lcd.print("Forward Roll = " + String((int)FWROA));
while (FWROA > FWROA_ angle) {
accelerometer ();
lcd.setCursor (14,3);
lcd.print(" ");
lcd.setCursor(14,3);
```

```
lcd.print(String((int)FWROA));
delay(50);
}
warning = true;
}
sum_temp = sum;
}
}
void accelerometer () {x = analog Read(A0);
x = map (x,0, 1023 -180,180); LSROA = x;
RSROA = -x
y = analog Read (A1);
y = map(y,0,1023-180,180); RWROA = y;
FWROA = -y;
}
```

Appendix C: Different pictures

Figure C. 1. Toyota minibus Model: KHD22L Number of cylinders: 4, Inline type enginerollover accident

Figure C. 2. Engine internal parts connecting rod with piston damage

Figure C. 3. Toyota pick-up Model: LN 166 Number of cylinders: 4, Inline type enginerollover accident


Figure C. 4. Engine connecting rod with piston where damage

Figure C. 5. Toyota high roof minibus Model- KDH222, Number of cylinders: - 6, Inline type engine rollover accident

Figure C. 6. Engine cylinder head and bearing disassemble

Figure C. 7. Toyota vitz rollover accident

Figure C. 8. Lifan Automobile Model-520, Number of cylinder - 4, Inline type engine rollover accident

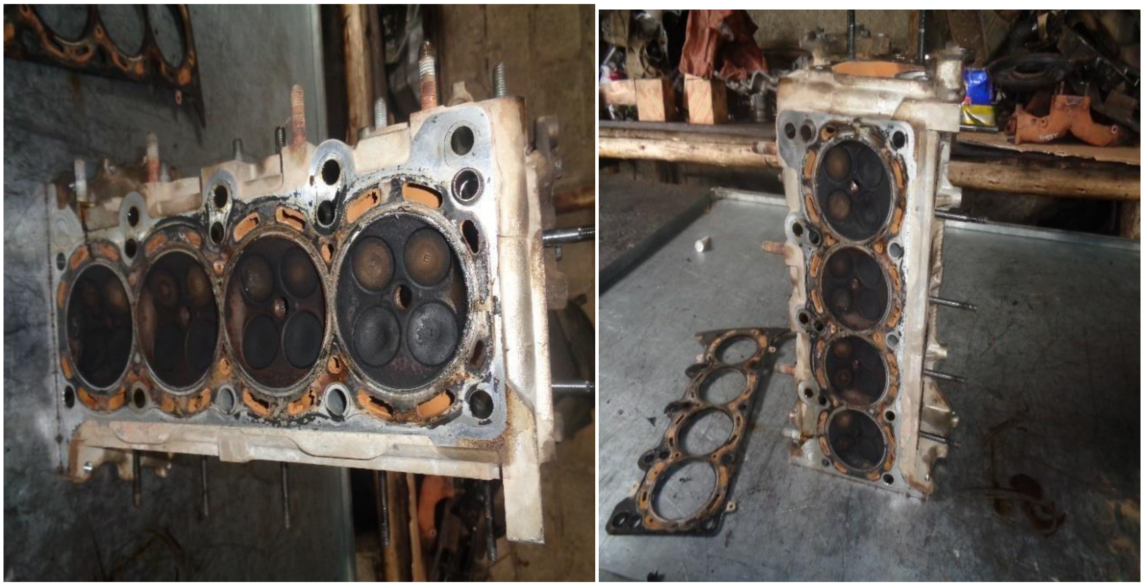

Figure C. 9. Engine cylinder head dissembling

Figure C. 10. ISUZU Dry cargo truck rollover accident

Figure C. 11. ISUZU Dry cargo truck rollover accident

Figure C. 12. Engine bearing scratched and takes heat

Figure C. 13. SCANIA Dry cargo truck rollover accident

Figure C. 14. Engine crank shaft with shell bearing where damage due to oil starvation

Figure C. 15. Daewoo dry cargo truck rollover accident

Figure C. 16. Engine crank shaft with shall bearing melted and damage

Figure C. 17. Sino Tractor truck rollover accident

Figure C. 18. Engine main journal and con rod bearing scratched

Figure C. 19. PHOTON Dry cargo truck rollover accident

Figure C. 20. Engine main journal and con rod bearing starched and takes heat