DEBRE BERHAN UNIVERSITY

THESIS REPORT

ON

DESIGN AND DEVELOPMENT OF AUTOMATIC VEHICLE OVERLOAD CONTROL SYSTEM

Submitted in the partial fulfillment of the requirements for the Award
Of
MASTER OF SCIENCE
IN
MOTOR VEHICEL ENGINEERING
BY

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USN: PGR/068/11

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DECLARATION

I, **GEZAHEGN TIBEBU**, student of fourth semester Mechanical Engineering ,in motor vehicle engineering ,college of engineering ,Debre Berhan university, declare that the project entitled **"design and development of automatic vehicle overload control system "** has been carried out by me and submitted in partial fulfillment of the course requirements for the award of degree in **Master of science** in **motor vehicle engineering** of **debre berhan university, Debre Berhan** , during the academic year **2019-2020**. The matter embodied in this report has not been submitted to any other university or institution for the award of any other degree.

Place: Debre Berhan
Date:

GEZAHEGN TIBEBU
(USN: PGR/068/11)

APPROVAL SHEET

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Acknowledgement

First of all thanks be to lord Jesus Christ for all that he has done for me here and praise be to his mother St. Mary and my guardian angel St. Uriel and all saints

I would like to express my deepest gratitude to my advisor **Dr. ANAND. S. N** (PHD) for his insight and encouragement that has led to the completion of this thesis. His guidance helped me in all the time of research and writing of this thesis. I am also thankful to my teacher Dr. B. dayal (PHD) for his valuable suggestion and continuous support.

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My gratitude also goes to my friends **andinet mekonen, kalab ameneshwa,yonas taye,dagmawi tadesee** . Thank you so much

List of figures

Nomenclature

WIM ------------------------------ weight in motion

CAN--------------------------------controller area network

GPS---------------------------------global positioning system

LCD----------------------------------Liquid crystal display

BOT---------------------------------build operate and transfer

A/D--------------------------------- alternating current to direct current

GSM--------------------------------- global system for mobile communication

PIR----------------------------------- passive infrared ray

ADC ---------------------------------analog to digital converter

SMS--------------------------------- short message service

MS-----------------------------------multiple sensor

B-------------------------------------bridge

DSP--------------------------------digital signal processing

IC------------------------------------integrated circuit

CPU----------------------------------central processing unit

$\rho \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots . resistiviity$

X--------------------------------------deflection

A -------------------------------------area

L1 ------------------------------------ Length of span or overall length of the spring,

l --------------------------------------- The ineffective length of the spring,

nF -------------------------------------Number of full length leaves,

nG ------------------------------------ Number of graduated leaves, and

n --------------------------------------Total number of leaves = nF + nG.

t ---------------------------------------Thickness of leaves, b --Width of plate, and

L --------------------------- ------------Length of plate or distance of the load W from the cantilever end

σ_f … … … … … … … … … … … … … … ….Stress

W---------------------------------------weight

E--young's modules

F---force

V-- Voltage

Vs. --------------------------------------voltage supply

R---resistance

Abstract

Traffic accidents are on increase in Ethiopia and it has resulted into unattainable crisis on economic, social also political aspects. From many causes of these phenomena, overloading of the vehicle takes the lion allotment. Effects of the overloading of the vehicle encompasses human life will be in drastic danger, unimaginable injuries to the passengers and individual and government economic crisis. Besides service life of the vehicle will decrease and tires are more prone to wear, steering control becomes more difficult and vehicles take longer to react to braking, decrease safety and driving comfort of the vehicle.

Firmly this bad practice has been seen in passenger and commercial vehicles. This research work focuses on commercial vehicles specifically on truck vehicles, because data shows that more percentage of overloading lay towards heavy vehicles.

This research work presents the overloading control and warning system by using load sensor which detects the weight of the vehicle. In case the weight is exceeding from the prescribed load, the audio and light warning system will activate to warn the driver. Further, the overload command is sent to the fuel system to shutoff the engine. Thus, the vehicle is not allowed to move unless the load comes under prescribed limits. The over load warning will give the tremendous advantage towards safety and reduce the loss of human life and economic crisis.

Finding the deflection of the leaf spring then by using potentiometer converting the deflection value into voltage in ten iteration is conducted. The voltage gab was examine and the first gab is normal load the second gab was warning and the last gab is fuel shutoff stage. Modeling the system in the MATLAB was conducted by setting the governing equation here the result show that the output is linear because the governing equation is linear so it implies the system is effective. In the MATLAB modeling load versus deflection and deflection versus voltage shows how the system is work and the result shows it is linear result. Finally by using protous software show how the system work.

Chapter one

Introduction

Controlling the overloading vehicle system start in 19th century which is Traditional weight limit enforcement procedures are static weighing. This was the only method approved by the legal metrology up until the mid-1990s.Weighbridges, and wheel and axle scales, are used to measure gross vehicle weight and wheel or axle loads. If axle scales are used, the gross vehicle weight is obtained by summing the individual axle loads. If wheel scales are used, an axle load is obtained by summing the wheel loads of the same axle. [3]

In United States of America new technology which is weight in motion (WIM) was invent. They were developed and implemented in the mid-1950s until the late 1970s. There is a sensor in the pavement of the road and detect while the vehicle goes and processing the data and giving the output measuring in the computer. By inventing and changing different types of strip sensor still now this WIM system used in many country.

In the beginning of 20th century up to now many technology was developed so it was try to control the overload by establishing the warning system in the vehicle it self .these research also try to control the vehicle overload by giving the warning and cut off the fuel.

Overloaded trucks pose serious threats to road transport operations, with increased risks for road users, deterioration of road safety, severe impacts on the durability of infrastructure (pavements and bridges), and on fair competition between transport modes and operators besides in vehicle itself [5] .

Conveniently determining the weight of a cargo load on a commercial vehicle has been a problem since horse drawn wagons delivered goods from producer to user. As time has passed, the carriers have become motorized and substantially larger in size, and their load carrying capacity has increased concomitantly.

The cost of delivering a load for commercial purposes is assessed to the customer according to the weight of the load and the distance it must travel. Since a truck cargo may consist of a plurality of individual sub-loads for many customers, a single load for a single customer, or a combination therefor, every sub-load and total load must be weighed and recorded for billing purposes. [3]

For any business, maximizing efficiency is key reducing operating costs and improving profit margins. When transporting goods, the temptation to overload a vehicle in a bid to maximize to pay load and reduce fuel cost can be a costly mistake. [2]

overloading of a commercial draft vehicle causes stress on vital components of the vehicle, such as drive trains, brakes, springs, tires, and the like, which are beyond the design tolerances of these parts. As a result, overloading of a vehicle may seriously shorten the working life span of the vehicle and result in higher replacement costs to the vehicle operator. An overload commercial vehicle may also comprise a threat to the public safety when operated on the highways, due to its reduced ability to brake from high speeds or to negotiate corners and the like.

Furthermore, overloaded commercial vehicles are a significant factor in the deterioration of existing high ways. Whenever paved roads are constructed, they are designed for specific maximum tolerances in pounds per square inch of load applied to the roadway surface per vehicle tire. When these designs parameters are exceeded by an overloaded vehicle, deterioration of the roadway is accelerated markedly. Even with highway check stations and special equipment carried by high way patrol officers, only a small percentage of over loaded vehicles is detected and cited. Controlling overloading reduces accident, save the pavement life, Decrease operating cost to maintain infrastructure of road and bridges, Malpractices arising out of the overloading. [3]

Vehicle overloading control is a challenging task from its planning to operation and management because it has to be addressed a number of issues of the different disciplines such as legal provisions, electronic system, computer system, mechanical system, traffic signaling system, facility management, human resource management, financing, operation of weighbridges, and maintenance management.[2]

An overloaded truck is more likely to be involved in an accident, and have more severe consequences, than a legally loaded truck. The heavier the vehicle, the higher its kinetic energy, resulting in greater impact forces and damage to other vehicles or to the infrastructure in the event of a crash. However, the absolute weight is not an issue in itself and heavy loads can safely be carried by trucks designed for that purpose, such as the so-called “high capacity vehicles”. However, when the current load exceeds the maximum permitted limit of a truck, several adverse consequences may occur:

- ❖ **Truck instability**: an overloaded vehicle is less stable because of the increased height at the center of gravity and more inertia of the vehicle bodies (e.g. trailer or semi-trailer.). Because the on-board stability tools (anti-rollover system,) may be overstrained, the risk of rollover, lane departure or knife-jacking is increased as shown in figure 1.

Fig. 1 overload truck accident {source : LowSpeedWIMusing load cellwheel scales in a concrete platform (Châlon s/Saône,France).}

- ❖ **Braking default**: the braking system of any truck is designed for the maximum allowable weight indicated on the vehicle documents. The breaking capacity depends on the brakes themselves, but also on the tire and suspension performances designed for the maximum allowable weight of the truck. Any weight in excess reduces the braking capacity of a truck, and may even damage the braking system.
- ❖ **Loss of motivate and maneuverability**: an overloaded vehicle becomes under-powered; this results in lower speeds on up-hill slopes as well as the risk of congestion, inefficient engine braking and over speeding on down-hill slopes. Overtaking also takes longer, and thus incurs additional risks for the other road users.

• Overloads can induce tire overheat, with a higher risk of tire blow-outs.

• When flammable goods are transported, overloads increase both the risk and severity of a fire, due to accident or loss of control of a truck.

- **Damage to the infrastructure**

Overloaded trucks present a threat to road safety, but also to infrastructure, as they increase pavement wear, cracking and rutting, and thus can contribute to premature pavement failure Heavy trucks also contribute to bridge fatigue damage. When trucks are overloaded their aggressiveness may be significantly increased. Extreme bridge loading cases are also governed by very heavy trucks, either carrying abnormal loads. [1](E.g. cranes) or illegal overloads. Some weak (old) bridges with reduced capacity may be severely damaged, or even destroyed, by overloaded trucks.

In January 1986, during a very cold period (−15 °C), a log truck skidded on an icy section of road entering the suspended bridge on the Loire river in France, hitting the parapet and cable anchorage on the bridge deck. The shock resulted in the collapse of the bridge following the failure of a cable anchorage with low-resilience steel at the top of a pylon (Fig. 2). [5]

Fig. 2 bridge damage by overload vehicle

{Source: Bridge collapse in Sully-sur-Loire (January 1986) due to a truck accident}

1.1 Problem statement

Overloading the vehicles is one of the major cause of traffic accidents. Now a days these bad and dangerous practice losses the human life and individual as well as countries affluence. Although these practice increase rapidly time to time because of many reason it is unable to control efficiently.

The vehicle will be less stable, difficult to steer and take longer to stop. Vehicles react differently when the maximum weights which they are designed to carry are exceeded. Overloaded vehicles can cause the tire to overheat and wear rapidly which increases the chance of premature, dangerous and expensive failure or blow-outs. The driver's control and operating space in the overloaded vehicle is diminished, escalating the chances for an accident. The overloaded vehicle cannot accelerate as normal – making it difficult to overtake At night, the headlights of an overloaded vehicle will tilt up, blinding oncoming drivers to possible debris or obstructions on the roadway Brakes have to work harder due to 'the riding of brakes' and because the vehicle is heavier due to overloading. Brakes overheat and lose their effectiveness to stop the car.

The existing systems that used to control the overload of the vehicle have a vital problems, basically the effectiveness problem that means the way of controlling the overload is only warning not stop the vehicle. Besides some of the system work in pavement of the road and vehicle will weighing under the circumstance of the station. This controlling method have drawbacks like require human power,

Staff is needed to select and intercept trucks in the traffic flow, to perform the weighing operation on the static control area, and to fine the violators and apply other penalties as needed. And It is difficult to safely perform checks on heavily trafficked highways and motorways. With high traffic volume, and the increase on roads of heavy vehicles, static weighing becomes ineffective and acts as a limited deterrent. Require long time required for static weighing, when several trucks are selected for checking. The other thing is not efficient.

Goals

To enhance the safety system of the vehicle by controlling the overload of the vehicle

1.2 Objectives

Main objective

To design and development of vehicle automatic overload control system

Specific objective

- To identify various alternatives design for vehicle automatic overload control system
- To Design and development of warning system for automatic vehicle overload control system (ISUZU NPR400)
- To Design and development of fuel cut-off system for an automatic vehicle overload control system

1.3 Scope

The scope of this research work is design and modeling the overload control system in commercial vehicles.

Deliverable

- To finish the thesis
- To complete the literatures
- To model the system analysis

Assumption

- The required data will be getting
- The materials will be available
- The high speed and performance computers will get for software analysis.

1.4 Significance

This research concern about preventing the vehicle from overloading .This method is secure and feasible and it gives effective controlling system of the vehicle for overloading. Thus it will safeguard the human life and economic crises.

The implication of this research is to encounter the vehicle stability, to save the components of the vehicles via reducing the chance of failure due to overloading. In addition to this it will prevent the vehicle from unexpected and unnecessary catastrophic failure. Besides that the main problem which is the fatigue of government officials specifically traffic police will decreases.

The social and economic crises of the countries also decrease. The road and bridges also kept in working condition for a long period of life without damaged and cracked. It increase the driver comfort besides the goods will deliver safely to the society in fact it can eliminate both social and economic crises. These system generally significant to decrease individual and country economic, social life of a human.

1.5 Limitation

- getting the working vehicle so that design system to be implemented
- Adopting the microcontroller and load cell in to my country

1.6 Organization of the thesis

This research paper is organized in to four chapters.

The first part is introduction part and it present the introduction part, and it present the problem statement, objectives, scope, significance, limitation of the research.

The second part is literature review and it is concerned with a survey of related literatures.

The third part is material and method, in this section arctecture of the system concept design, design of the system will be deeply analyzed.

Finally, the last part is result and discussion in this section the results will briefly discuses and final conclusion, recommendation and future work is conduct. Last but not the least references is mention.

Chapter two

Literature review

In the history of vehicle world, off the beginning overloading the vehicle was a headache. In fact many stakeholders try to stop these bad practice in many ways such that by teaching the society but they can't stop the phenomena the crises due to overloading the vehicle increase time to time in many aspects. To handle this bad practice engineers start developing technologies so, these literature review section try to identifying those researches and projects within their gaps.

Controlling the vehicle overloading methods start in 19th century by announcing static weighing which is traditional enforcement practices. This was the only method approved by the legal metrology up until the mid-1990s. Weighbridges, and wheel and axle scales, are used to measure gross vehicle weight and wheel or axle loads. If axle scales are used, the gross vehicle weight is obtained by summing the individual axle loads. If wheel scales are used, an axle load is obtained by summing the wheel loads of the same axle. [5]

There are three types of static weighing devices:

• **The fixed systems**, which are permanently mounted in the pavement, generally in concrete frames or platforms. This is the case for all weighbridges and some wheel and axle scales.

• **Semi-portable systems**, which use permanent grooves and road installations (electricity supply, connection to the weight recorder, etc.), but with portable scales which are installed only during the weighing operations.

• **Portable systems,** using either wheel or axle scales which are laid on the pavement surface (e.g. on a parking lot or any weighing area), and complemented with leveling plates or ramps, in order to get all the weighed wheels at the same level and in the same plane.

Due to the limitation of static weighing which was traditional potential weighing in motion (WIM) system were introduced in the United States in the mid-1950s. Since then, many developments and progresses have taken place, while various sensors and techniques have been introduced and implemented.

The concept of WIM is using wheel or axle scales, mainly equipped with load cells – the most accurate technology – and installed in concrete or strong asphalt platforms of at least 30 to 40 m in length. The software of the data acquisition and processing system is designed to analyze the signal of the load cells, taking into account the speed, and to accurately calculate the wheel or axle loads. Such systems are installed either outside the traffic lanes, on weighing areas, or in toll gates or any other controlled area.

Fig. 3 weight in motion (WIM) overload vehicle detection system
{*Source:Low Speed WIM using load cellwheel scales in a concrete platform (Châlon s/Saône, France).}*

It is a fully automated weighing system and can record all vehicles — whatever their speed, number of axles, or time of the day . No additional infrastructure is required, and it can be installed on good pavements and it is a reasonable cost system.

Both the above systems work in asphalt pavement road due to that the limitation is over tan the benefit in terms of accuracy so in many countries many scholars try to establish another system in different window as they see which are listed below

Study on vehicle mounted overloading control system for vehicle

By using the sensor circuit, sensor control circuit and interference circuit with microcontroller to control the overload in passenger vehicle the software of the control was designed in assembly language. Based on the actual number of passenger starting of the vehicle was controlled by the control of the amount of fuel injection.

In this paper automatic control system based on microcontroller for overloading passenger vehicle was designed. The system software was designed in assembly language. Its function is to determine whether a passenger was on the bus or off the bus according to the sequence of low signals received from the sensors of. When the passenger number in accumulator was more than rated number, the engine was controlled to stop fuel injection, so that the engine cannot start.[17]

Intelligent load distribution system

The present invention relates to a system for optimizing load distribution on a tractor/trailer or other vehicle. A computer or other evaluation unit reads the information from at least one load Sensor, measuring the load and its distribution. The computer then evaluates the information with a database compiling information on optimizing load distribution for vehicle performance as well as for compliance with State and federal law.

The invention comprises a vehicle information System that optimizes vehicle performance and load distribution. A first position Sensor generates a first position signal based on an actual location of a first vehicle component. A load Sensor generates a first load Signal based on a first vehicle load. The evaluation unit of the vehicle information system communicates with both sensors and evaluates signals from these sensors. Based on these signals, the evaluation unit provides data on how to relocate the tractor axle for optimal vehicle performance and load distribution. The vehicle information system may provide its instruction to a vehicle driver based on a determination of the vehicle's center of gravity as calculated from data from the first position sensor and the first load sensor.

The inventive information system senses the actual location of the tractor axle. A load distribution is determined electronically across the vehicle. The evaluation unit then determines an alternative location for the axle based on the Sensed actual location of the axle and the load distribution across the vehicle. An alternative location of the axle is then displayed on a general user interface. Based on this information, a vehicle driver may adjust the location of the axle or adjust the load distribution.

An evaluation unit receives information from the Sensors as well as from a memory unit Storing vehicle optimization data and a general user interface that receives input from the vehicle driver. Based on the information received from these Sources, the evaluation unit may generate a vehicle optimization instruction relating to the optimal distance between the vehicle axle and the kingpin. The vehicle driver may then adjust the axle to this optimal distance.

In this way, the inventive information system provides a vehicle driver with the opportunity not only to determine his current load distribution but to adjust components of the vehicle as well as load within the vehicle to optimize the vehicle for performance as well as to comply with State and federal load limit requirements.[14]

Truck Overloading Monitoring System Based on Beidou Vehicle Network System

Overload detection truck freight terminal installed in the vehicle cab; suspension load detection CAN nodes installed on freight vehicle leaf spring suspension; the owner of the terminal owners own place. Suspension load detection CAN node weight information collection, speed and other information transmitted via the CAN bus terminal to detect overloading of goods vehicles, truck overload detection after a four-node data collection terminal, truck load information obtained through the arithmetic processing by Compass - GPS module obtaining vehicle position information, and load, speed, truck terminal position information through the LCD display module display while load, speed, location information sent to the vehicle via CAN bus compatible terminal Beidou compatible by the terminal is connected to a remote monitoring platform , load, speed, position information is sent via trucks overload detection terminal module to the owners - GPS Compass terminal can also be connected to a remote monitoring platform. Should overloading, speeding, overloaded trucks detection terminal through sound and light alarm warning to the driver module, synchronization information is uploaded to a remote monitoring platform and terminal owners.

Compass vehicle networking based on real-time monitoring system overloaded trucks, vehicle dynamic load measurement information compatible with Beidou vehicle terminal network overloading of goods vehicles to achieve real-time monitoring, can solve the truck overloading, speeding and other issues, and by the six-axis gyroscope measurements and ground vehicles the angled measuring the weight allowed to solve the problem when the truck downhill; measured with trucks during each vibration cycle time to solve the problem are not allowed to truck operation [23].

Axle load control system and wheel base adjustment system

According to a first aspect of the invention, a first object of the invention is to provide a load control system of the type mentioned in the introduction, by which system an undesired overload of an axle of a truck can be avoided. This problem is solved by the invention providing an axle load control system for a load-carrying truck having a front axle and two or more rear axles, the system comprising: a wheel suspension system with a suspension control processor; load sensor means arranged at each of said axles for detecting one or more load indication parameters, said load sensor means providing said parameters to said Suspension control processor which translates the parameters into actual axle load values for the individual axles. The invention is especially characterized in that the control processor is arranged to compare said actual axle load values with a predefined maximum allowable axle load value for each axle, and to control—or indicate to a driver the need to control—the wheel Suspension system so as to effect an individual adjustment of the Suspension characteristics for each axle in Such a way that excess axle load on an overloaded axle is transferred to one or more of the remaining axles, thereby adjusting the theoretical wheelbase of the truck.

In one embodiment, the control processor is arranged to control the wheel Suspension system so as to effect an individual adjustment of the Suspension characteristics for the rear axles in Such a way that excess axle load on the front axle is transferred to one or more of the rear axles. In an advantageous embodiment, the control processor is arranged to continuously compare said actual axle load values with said predefined maximum allowable axle load value for each axle, and to automatically continuously control the wheel Suspension system in the described man

In an alternative embodiment of the invention, the control processor is arranged to continuously compare said actual axle load values with said predefined maximum allowable axle load value for each axle, and to a driver indicate the need to control the wheel Suspension system in the described manner, said indication being communicated to the driver via a driver interface means provided with manual control means for effecting said individual adjustment of the Suspension characteristics for each axle in predefined discrete steps. [10]

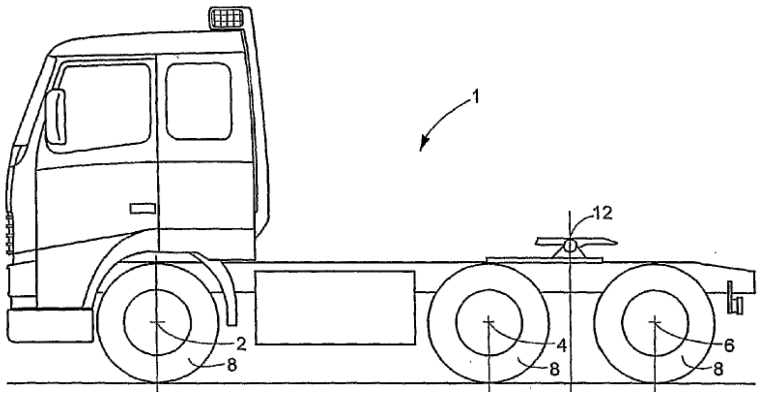


Fig. 4 overload vehicle control by using axle load control

{source: united states patent application publication.lnc}

Vehicle load warning system

The present invention provides a load warning system that overcomes drawbacks experienced in the prior art and that provides additional benefits. Under one aspect of the invention, a load warning system is provided for use with a vehicle. The vehicle has a load-support portion adapted to receive a load thereon. A first portion of the vehicle, such as a frame, is coupled to the load-support portion. A second portion of the vehicle. Such as an axle or Suspension system, is movable relative to the first portion upon application of the load onto the load-support portion. The load warning system has an engagement portion mountable to and movable with the one of the first portion or second portion of the vehicle as a unit.

A load indicator is mountable to the other one of the first portion or second portion of the vehicle. The load indicator is configured to be spaced apart from the engagement portion and to be in a first position when the load on the load-support portion is less than maximum load. The load indicator is also configured to engage the engagement portion and move to a second position when the load on the load-support portion is greater than a maximum load. The load indicator provides a signal upon being moved to the second position. A warning indicator is coupled to the load indicator to receive the signal and to provide an overload warning to a user upon receiving the signal.

Under another aspect of the invention, a load warning system has an engagement portion movable with a Vehicle's frame or a vehicle-support portion. A load indicator is coupled to the other one of the vehicle-support portion or the frame. The load indicator is spaced apart from the engagement portion when in a first position. The load indicator is configured to move to a second position and engage the engagement portion when the load applied to the load-Support portion exceeds a first maximum load. The load indicator is also configured to move to the second position and engage the engagement portion when the load applied to the load. [12]

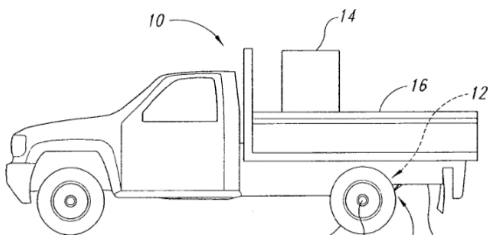


Fig. 5 control the overload vehicle by warning system

{Source: united States patent puplication.inc}

Vehicle overload sensor

The general purpose of the present invention, which will be described subsequently in greater detail, is to provide a new apparatus and method which has many of the advantages of the weight Sensors mentioned heretofore and many novel features that result in a new system which is not anticipated, rendered obvious, Suggested, or even implied by any of the prior art weight Sensors, either alone or in any combination thereof. To attain this, the present invention generally comprises a truck bed for supporting a load thereon. The truck bed includes a plurality of tab members coupled to an underside thereof and depending therefrom. An axle associated with the truck bed is also included for allowing the coupling of wheels thereto. a plurality of shock absorbers are provided having a first linear portion pivotally coupled at a first end thereof to one of the tab members and a Second linear portion pivotally coupled at a first end thereof to the axle. A Second end of the Second linear portion is slid ably situated within a second end of the first linear portion for precluding movement of the axle from being transferred to the truck bed, as is conventional in the art of Shock absorbers. Further provided is a linear potentiometer having a first linear portion pivotally coupled at a first end thereof to one of the tab members. The linear potentiometer further has a Second linear portion pivotally coupled at a first end thereof to the axle. A second end of the first linear portion is slid ably situated within a Second end of the Second linear portion for changing a resistance thereof as a function of a weight situated on the truck bed.[15]

Vehicle load monitoring system

These invention generally comprises a system mounted on a vehicle for determining the load carried by that vehicle. The device overcomes the problems normally associated with determining the weight of a vehicle load, the present invention further lends great assistance to law enforcement agencies in determining compliance with vehicle load regulations through the inclusion of a standard weights and measures identification and seal which prevents tampering with the system once it is installed on a vehicle. The system for monitoring the load carried by a vehicle includes a plurality of load cells, each extending between the load bed and the unsprung portion of the vehicle suspension. Each load cell includes a hydraulic cylinder which generates a hydraulic force corresponding to the load applied thereto. A pressure transducer is connected to each hydraulic cylinder, and the outputs of all the transducers are summed and fed to an auto zeroing system. The output of this system is connected to an A/D converter, and then to a visual display. The A/D converter output is also fed to a digital comparator which is connected to a switch set to an overload level. If the load exceeds the input, an overload alarm is sounded and the display flashes.[3]

Design of vehicle overload detection system based on geophone

In this research work, based on the geophone sensor and algorithm, a new type of vehicle overload detection system is established, which make it possible to detect the overloaded vehicle and transfer the relevant data to the background after the vibration signal is obtained. Then further processing can be done. The system has advantages of small size, high sensitivity, and it can adapt to different test environments. Relevant system tests showed that overloaded vehicles can be accurately detected by this system, which has a very good practical prospect. In this paper, vibration sensor is used to collect vibration data, according to the varied sizes of vibration data to detect overload. Raspberry pi is used as the core of data collection equipment. A signal conditioning circuit board is designed independently to filter and amplify original vibration signals, and convert analog signals to digital signals. The embedded nodes are connected by wireless network. Classic model is used to classify the data and determine the vehicle status.[19]

Weight overload warning system

The present invention generally relates to a measurement methods and systems. More particularly, the present invention relates to systems and methods for measuring the weight of a vehicle and its load using the Tire Pressure Monitoring System and the Auto-Leveling Technology already installed on many vehicles.

The present invention provides advantages and alternatives over the prior art by providing a means of determining if a vehicle is overloaded without the need for the installation and expense of additional hardware. According to a further aspect of the present invention, there is presented a method of determining a vehicle weight overload condition using the existing tire pressure monitoring system and the existing auto leveling system of a vehicle comprising: using said auto leveling system to determine the weight of the vehicle; and using said tire pressure monitoring system to determine an overload condition of the vehicle.

According to yet another aspect of the present invention there is presented a method of determining vehicle weight overload utilizing the vehicle's existing tire pressure monitoring system and existing load leveling Suspension system [24]

Controlling Vehicle Overloading in build operate and transfer (BOT) Projects

Commercial Vehicle overloading on highways a menace; a bane to the exchequer having the onus of maintaining the road infrastructure - it not only increases his expenses but, is also one of the major causes of road accidents. And, over 50 % of the commercial vehicles plying on our National/ State Highways are overloaded. Although there are legal axle load limit and gross vehicle weight limit of the vehicles plying on roads, they are violated wickedly by the transporters. The damage by over-loaded vehicles to pavements is exponential. It is believed that the damage caused to a pavement by an axle load twice the standard axle is 16 times the damage incurred by the latter.
There are standard legal axle load limit and gross vehicle weight limit but neither are followed by transporters no reinforced stringently by the enforcement authority. Overloading vehicles reduce

the design pavement life. Controlling overloading not only prevents premature failure of the pavement but, also brings in monetary benefit to the Concessionaire.

This research presents the benefits in term of toll revenue for controlling overloading in a Build Operate and Transfer (BOT) Project with a real case study. From the case study, it is found that maximum revenue has been achieved by allowing vehicle to ply on the road carrying maximum permitted legal load. Other than the beneficial aspects indicated above, controlling overloading reduces accidents, increases speed of vehicles, requires lesser pavement maintenance costs and operating cost. In the end, plausible ways of controlling overloading with strict enforcement are highlighted. This paper, through detailed analysis, brings out the whole gamut of implications of overloading and some suggestions to check this overloading or generate additional revenue by penalizing overloading operators for compensating towards accelerated damage caused to pavement. This paper also presents financial benefits for controlling overloading for a BOT Project based on axle survey data collected on a project.[21]

Designing Of Overload Monitoring System in Public Transportation Based On Microcontroller in Ethiopia

The GSM/PIR based monitoring and controlling passenger system is a system that makes use of PIR infrared radiation motion analyzer which counts passengers who get in and out of the public buses. GSM is used as communication link between different modules. These modules include bus station module, in bus module and bus stop module. Bus station module contains GSM modem interfaced to the microcontroller and receives bus information from in bus module. The bus starts to transmit the number of peoples to the bus station and bus stop terminal while crossing the road.

Bus stop module after receiving buses data through GSM engine displays it on LCD installed at each bus stop. GSM based overload monitoring system will provide effective real time vehicle monitoring, mapping and reporting this information value and adds by improving the level of service provided. The system has an on-board module which resides in the vehicle to be tracked and a base station that monitors data from the various vehicles. This system uses ARDUINO Uno microcontroller. The inbuilt analog to digital converter (ADC) receives analogue data from sensors and converts it to digital data and passes it to the microcontroller. The sensors continuously send data from the distant site. This system is interfaced with a GSM modem. This system senses the conditions continuously and a message is sent to bus station. Using this system, the operator can monitor the signals from anywhere. Whenever a short message service (SMS) is sent to the GSM modem, the GSM modem receives the data and sends to microcontroller. After receiving the signal from the microcontroller it processes the data and sends the read data to GSM modem. The GSM modem sends the updated data to bus station. So in this manner this project try to control the overload [18]

Weigh-in-motion for direct enforcement of overloaded commercial vehicles

A major step of this project consists to assess the response and performance of the WIM sensors available on the market, in the laboratory, and on site, under controlled test conditions. This should allow to improve the algorithms used for the sensor signal processing, and to select suitable signals to meet the required accuracy and tolerances for direct enforcement. The required tolerances are ±5% for the gross vehicle weight, and ±10% for axle loads. None of the existing WIM system matches this accuracy for 100% of the vehicles. Therefore the objective is to set up some sorting criteria and algorithms, eliminating the weighing outside these tolerances.

The project is divided into 5 parts, to characterize WIM sensor response under controlled environment and loading conditions and to develop fiber optic WIM sensors, to assess the capability of multiple sensor (MS-) and bridge (B-) WIM systems to meet the requirements, to carry long term road tests and to develop type approval procedures for direct enforcement. This paper presents results gathered on the accelerated pavement testing facility within WIM sensors. Some results of B-WIM systems are also reported. Perspectives are given how to achieve a WIM system type approval procedure for direct enforcement.[4]

Fig.6 overload control by using weight in motion system (WIM) in road

{*source:Transportation Research Procedia.lnc*}

The Design of Bus Overload Control System

The overload of buses happens now and then, especially on holidays when millions of people are hurrying home, making some drivers gain greater benefit by overloading. Though the relevant departments have prohibited it again and again, it still exists, causing lots of traffic accidents. In addition, at the present time it is rather time-consuming for the conductor to check the number of passengers, so it is very urgent to design a bus overload control system to automatically detect and work out the number of passengers in the bus. The system is composed of three parts, the detection module, single-chip module and control module.

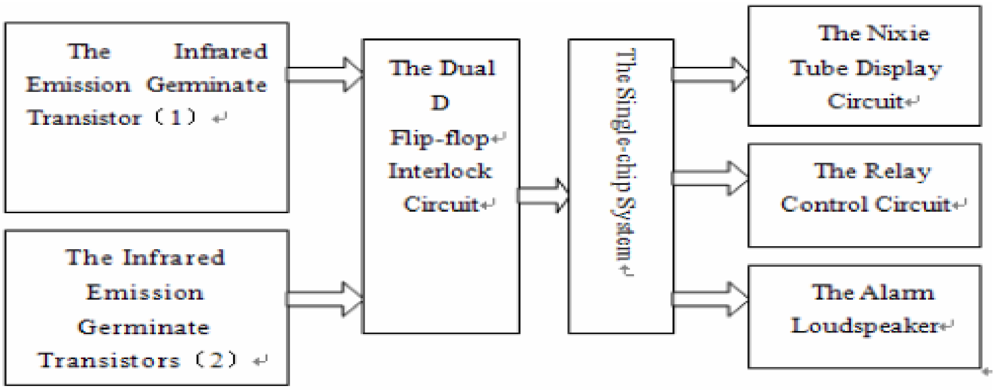


Fig. 7 system framework of bus overload control system

Two groups of infrared emission and reception transistors are responsible for counting the passengers and sending the collected information to single-chip system, i.e., the central processing unit which can add or subtract the number of the passengers and put it into Binary-Coded Decimal displayed through Led tube and compare the number of passengers to the full load, determining whether it is overloaded or not at the same time. If not overloaded, it keeps supervising, but if overload, the alarm speaker will work. If still overloaded after several minutes, the bus engine will be locked by the relay control circuit and work again only if the extra passengers are all off.[13]

Design of Overload Vehicle Monitoring and Response System based on DSP

This research proposes a compact structural health monitoring system project about overload vehicles based on DSP and uses rain-flow counting method to estimate fatigue life of roads and bridges. Besides, the miniaturization and effectiveness of the system will also make it easy to manufacture and save the cost of structural health monitoring.

The designed system is divided into sensor arrays, the charge amplifier module, the DSP processing unit, the alarm system for overload and the estimate for damage of the roads and bridges. When the vehicle goes through the sensor arrays, the sensor arrays get pressure signals. Then the signals are pre-processed by the charge amplifier. DSP processing unit will receive the amplified signals, convert analog variables into digital ones so that they are compatible with the back-end digital circuit for further processing and estimate whether it is an overload signal or not. The system will also restrict certain vehicles that are overweight, including taking image and sending the alarm for vehicles in violations, and transferring the collected pressure data to remote data center for further structure health monitoring analysis by rain-flow counting method.

DSP chip is highly optimized for general use, with the advantages of accurate calculation, strong anti-interference ability etc. Achieving digital processing and control with DSP chip has become the development trend of the future. So there are many semiconductor manufacturers in the development of high-performance DSP.series processors from Company have high signal processing and control functions, with prospects in the field of digital control. [22]

Figure.8 DSP chip *{source:www.DSP chip.com}*

An Intelligent Freight Corridor Overload Control System

In this research work demonstrating that an efficiently designed overload control system that utilizes modern information and communication technologies can simultaneously achieve the objectives of improved accuracy of control and increased logistics efficiency. The expected operational impact of the system is assessed by quantifying the effect of fewer static scale visits on a typical cargo vehicle traveling on a typical trade corridor.

The use of freight corridor implies the pre-registering of vehicles; while it will initially limit the percentage of participating vehicles it supports the concept of voluntary self-regulation where participating vehicles that enables automated in-traffic compliance checking enjoys specific benefits over nonregistered vehicles that require manual static compliance checking. In the case of a vehicle that is recognized by the system the prior history of that vehicle is extracted from the system and used as part of automated real-time decision making.[6]

Vehicle weight identification system for spatiotemporal load distribution on bridges based on non-contact machine vision technology and deep learning algorithms

This study proposes an automatic non-contact methodology to distinguish vehicle loads on bridges based on deep learning algorithms and machine vision technology. Vehicle information is obtained in the monitoring video recorded by a roadside traffic surveillance camera. The automatic identification method consists of four modules: the vehicle weight prediction module, the vehicle type's classification module, the vehicle object detection module

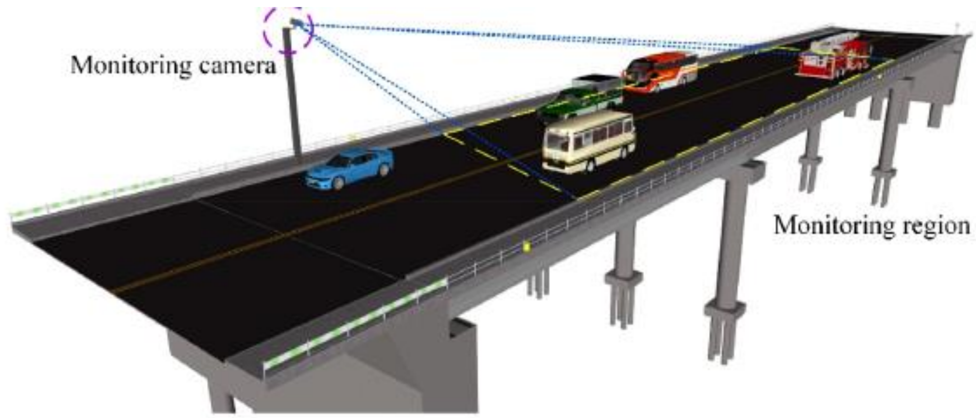


Fig.9 Vehicle weight identification system

{Source: www.elsevier.com/locate/measurement}

Machine vision technology provides a direct way to monitor vehicle loads on a whole bridge deck, and the technology has been generally adopted as a novel way to identify vehicle load information on bridges

This research proposes a non-contact vehicle identification methodology to distinguish a vehicle from its load based on machine vision technology and deep learning algorithms. The vehicle information (i.e., type, weight, position, and motion trajectory, etc.) is conveniently obtained from a roadside monitoring surveillance camera, while the axle-weight distribution interval for nine classified vehicle types is obtained from the statistical information of vehicles from which the relationship between a unique vehicle type and the corresponding weight information is established.[24]

To sum up in these literature review section different research's, journals, papers was assessed .in order to find the gabs those literatures categorized in three groups as per their work.

- The first category is obviously the traditional way of controlling the overloading which is static weighing system.
- The second category is weighing in motion system (WIM) which is weighing the vehicle in motion most scholars do these system in different way on the asphalt.

- The third category is controlling the overload by establishing different system in in the vehicle itself by using new technology such as camera detecting system, sensors and processors giving warning to the derivers.

So in all categories it was try to control the overloading these bad practice but they are not effective and efficient.

Category one gaps:

- It requires staff and time to perform static weighing. Staff is needed to select and intercept trucks in the traffic flow, to perform the weighing operation on the static control area, and to fine the violators and apply other penalties as needed.
- It is difficult to safely perform checks on heavily trafficked highways and motorways. With high traffic volume, and the increase on roads of heavy vehicles, static weighing becomes ineffective and acts as a limited deterrent.
- Because of the long time required for static weighing, when several trucks are selected for checking, the weighing area becomes saturated and thus other overloaded trucks are able to by-pass the check point.
- Moreover, static weighing implies delays of 10 to 30 min (sometimes more), which penalizes truck operators, including the majority of them who comply with the regulations.

Category two gaps:

The main gap is the *accuracy*, which depends highly on the road surface evenness and pavement characteristics – as well as truck suspension performances –because of the dynamic interaction between road and trucks.

In addition, as road sensors are exposed to whole traffic loads and are mounted on the pavement surface, they may have a limited lifetime if the pavement failed. A difficult issue is the calibration and accuracy assessment of WIM systems. These system is not effective and efficient.

Category three gaps:

In these category different system is established in the vehicle itself by using sensors, controllers and other systems in the vehicle to warn the driver to stop overloading the vehicle but the main problem is effectiveness ,which drivers ignore the warning and their life's in to crises besides the government stockholders can't control due to many reasons.

- Due to the gaps mentioned above overloading the vehicle is still the headache. So these research will try to full fill those gaps and giving effective and efficient controlling method to stop these bad practice and saving the life of humans and animals and countries economic and social crises.

Chapter three

Material and method

3.1 System arctecture

As shown in fig 10. The system consist of Arduino system which is used to control the sensor and actuators. Here sensor give the input voltage to the Arduino then it will examine the voltage then give the command as per the voltage. If the voltage is low no warning will done and become medium it gives command to the buzzer and light to warn and if the load is become over the voltage becomes high so the Arduino system give command to the shut off solenoid to stop the fuel the engine. Unable to run unless the load is removed.

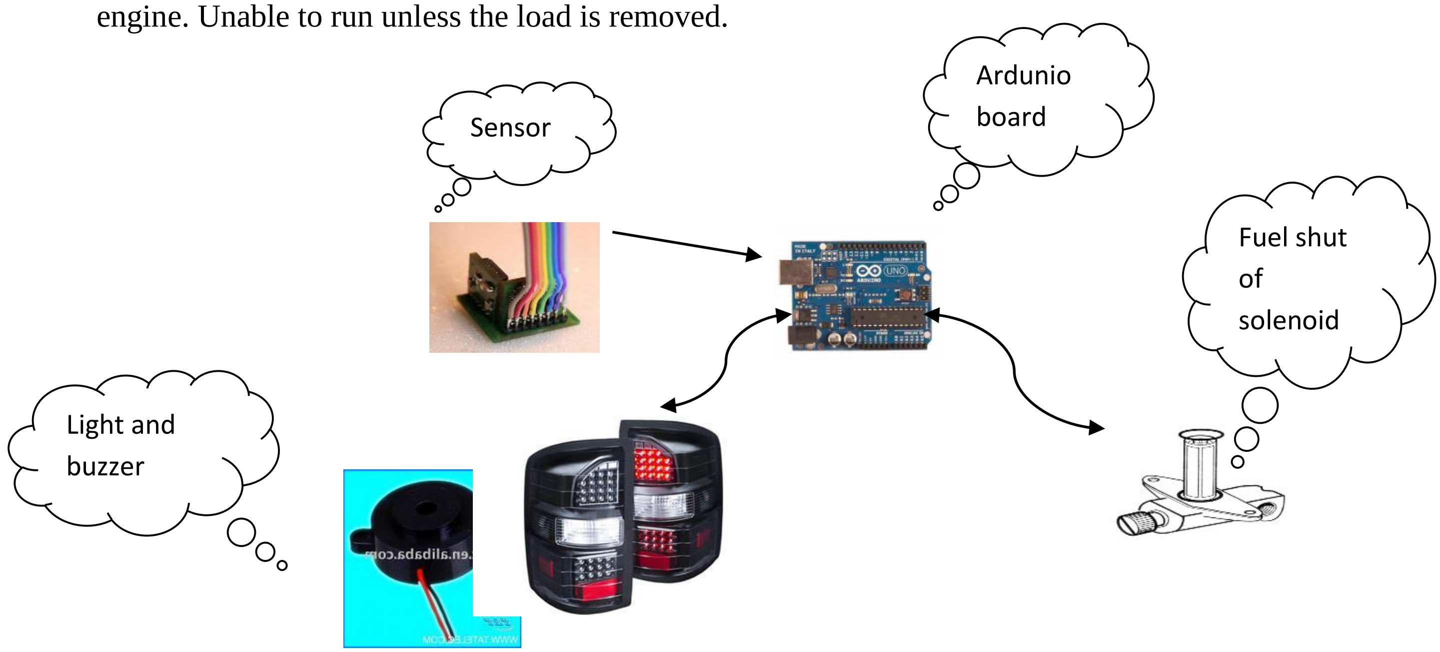


Fig. 10 system arcticture of overload vehicle control system

3.2 Composition and working principle of the system

In order to control overloading of the vehicle, an automatic control system based on Arduino system for overloading commercial vehicle was designed in this paper. The system hardware is mainly composed of the sensor circuit, sensor working control circuit, fuel injection control circuit and other components. Sensor circuit mainly consists of processing circuit. The sensor working control circuit is used to control the sensors by deflection of the spring .The front-end detection system has sensors mounted on both sides of the spring The system started in time when the load is over the limit load sensor detect and give the measurement

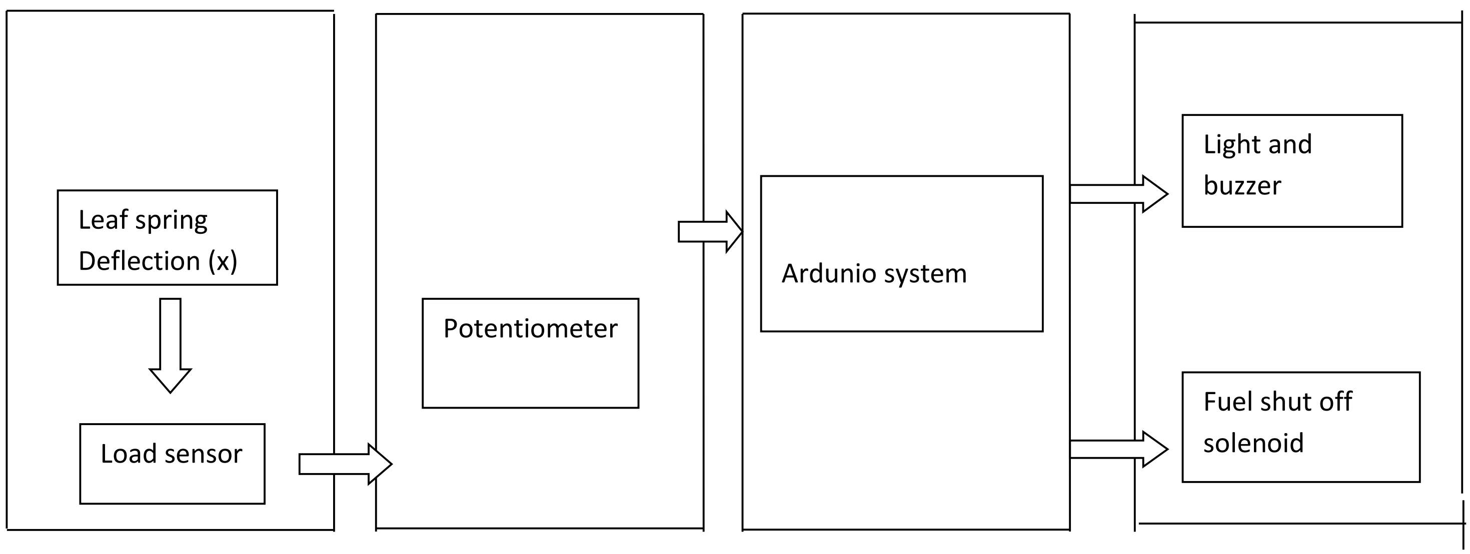


Fig. 11 block diagram of the control system

Working principle of cut –off solenoid

The fuel cut-off solenoid valve opens and closes the fuel passage leading to the suction port. The current, which flows into the solenoid, is cut off, allowing the valve to retract downward by the spring. As the valve closes the suction port, the fuel supply to the cylinder will stop, causing the engine to stop.

The stop solenoid is usually located at the entrance to the fuel injection pump or in the fuel line before the fuel injection pump. At a state of rest, the solenoid will have no power and need to be energized to allow the engine to run.

A typical solenoid valve works by creating a magnetic field after receiving an electric current, which prompts the valve to open or close. In an engine with a diesel fuel shut-off solenoid, the solenoid is connected to the main electrical system of the machine. It receives an electrical current from the battery, which prompts the solenoid valve to open, allowing diesel fuel to run from the gas tank to the engine.

When working properly, a shut-off solenoid transports diesel fuel from the fuel line to the solenoid though an inlet pipe. At the entrance of this inlet pipe is a rubber stopper held in place by a metallic spring attached to the back of it and a metal bar running perpendicular from the stopper to a metal pin located near the solenoid coil. When the solenoid valve creates a magnetic field as a result of an electric current, it causes the pin to retreat, pulling the stopper from the inlet pipe. With the stopper removed, fuel is free to run from the fuel line to the engine. What differentiates a diesel fuel shut-off solenoid from a regular solenoid, however, is its ability to receive and interpret signals from the main electrical system.

The main electrical system of the vehicle monitors the temperature and mechanical fluctuations of the engine, and can therefore detect malfunctions and unusually high temperatures. When the electrical system detects that something went wrong with the machine, it interrupts the electrical current sent to the solenoid valve, prompting the spring to push the stopper back into the inlet pipe. When the valve closes, it prevents diesel fuel from reaching the engine, causing the engine to stop.

3.3 Concept design

1. Warning

When the load is over the nominal load the deflection will occur so sign is display in dashboard for the driver.

Fig 12. Warning system

Advantage:

- Simple construction
- low cost
- Available

Disadvantage:

- low efficient
- not secured

2. Controlling electrical system

Fig.13 control electrical system

When the vehicle is overloaded the load sensor will send command to electrical system of the vehicle specifically to electrical control unit (ECU) so the ignition system will off.

Merits	demerits
• Simple	* risks for the vehicle
• Low cost	* not effective

3. Controlling Fuel system by cutting fuel shut off solenoid

When the vehicle is over loaded the load cell in the suspension system will send the command to the controller then shut of solenoid then activated by get message from the controller and it will lock up in this time no fuel transfer unless the overload is removed.

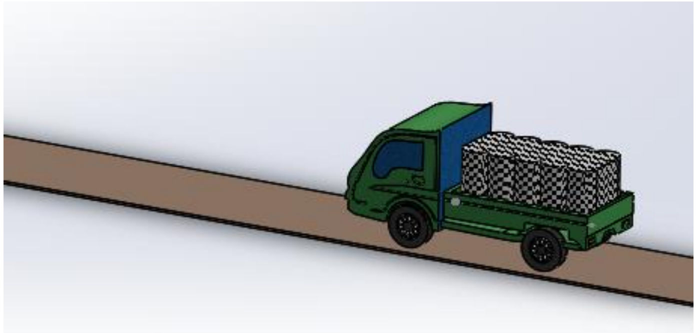


Fig. 14 shutoff fuel and stop vehicle

Merits demerits

- Good efficiency * somehow complex
- Good effective
- Good cost

3. Controlling the accelerating pedal

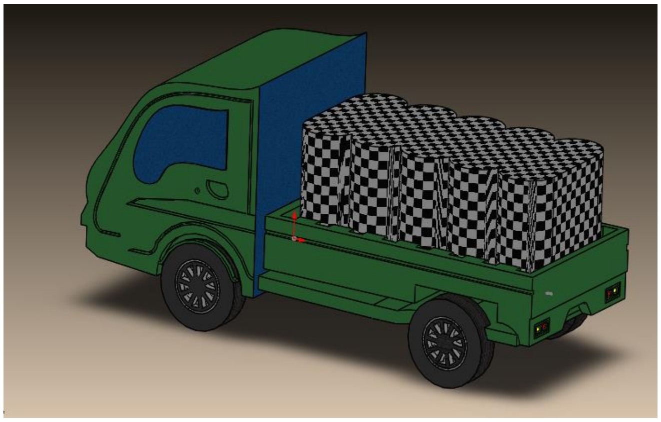


Fig. 15 control the accelerating pedal

When the vehicle is over loaded the load cell in the suspension system will send the command to the controller then gas pedal will locked by getting message from the controller and it will lock up in this time no fuel transfer unless the overload is removed

From the above alternatives as they have their own merits and demerits but the main thing is that the efficiency and the effectiveness of the system. Thus by comparing those alternatives controlling the overload in two steps is selected. In which by giving voltage gap in the first step by giving warning to the driver and sign to the traffic police by light and sound warning so the driver must unloaded or if the traffic polices are over their they can stop them other with if the load is become over the fuel will cutoff the vehicle will stop unless the load is nominal.

- **Description of design component**

1. **Sensor**

A **sensor** is a device, module, machine, or subsystem whose purpose is to detect events or changes in its environment and send the information to other electronics, frequently a computer processor.

- **Potentiometer**

A **potentiometer sensor** measures the distance or displacement of an object in a linear or rotary motion and converts it into an electrical signal.

Fig. 16 potentiometer

- **Load cell**

A **load cell** is a force transducer. It converts a force such as tension, compression, pressure, or torque into an electrical signal that can be measured and standardized. As the force applied to the **load cell** increases, the electrical signal changes proportionally.

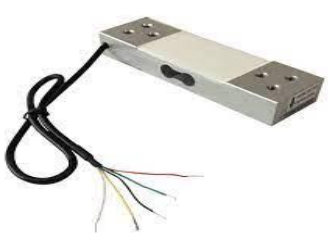


Fig. 17 load cell

- **Proximity sensor**

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal**.**

Fig. 18 proximity sensor

From the above alternative sensors by setting basic criteria potentiometer is used the basic criteria's are accuracy, efficiency, easy to use, effectiveness, cost, availability

2. **Processor**

A processor (CPU) is the logic circuitry that responds to and processes the basic instructions that drive a computer. The CPU is seen as the main and most crucial integrated circuitry (IC) chip in a computer, as it is responsible for interpreting most of computers commands.

- **Arduino**

  Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs.[1]

Fig. 19 Arduino board

- **LPC**

  LPC is a family of 32-bit microcontroller integrated circuits by NXP Semiconductors (formerly Philips Semiconductors)

Fig. 20 LPC board

- **Microchips**

A **microchip** is a radio-frequency identification transponder that carries a unique identification number, and is roughly the size of a grain of rice. When the **microchip** is scanned by a vet or shelter, it transmits the ID number. There's no battery, no power required, and no moving parts.

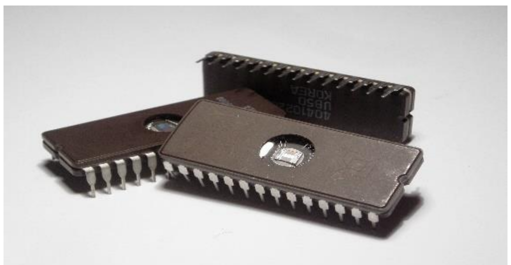


Fig. 21 microchips

From the above alternative processors by setting basic criteria Arduino processor is used the basic criteria's are accuracy, efficiency, easy to use, effectiveness, cost, availability

3. **Cables (wire)**

   The most typical type of wire used in most automotive **applications** is automotive cross-link wire and automotive primary wire. General Purpose High Temperature automotive wire is ideal for under-hood automotive wiring **applications** with hard-to-fit areas.

Fig. 22 cables

3.4 Design of a system

Since the sensor is placed on the leaf spring the deflection must calculate as per the weight so, the deflection of leaf spring is given by [11]

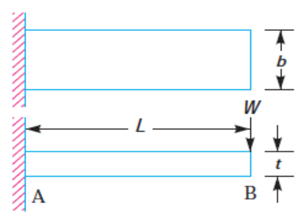
Input Data

Isuzu NQR 500 SWB truck [6]

- Maximum total Weight=72,000 Kg
- Leaf spring specification=semi-elliptical spring
- L_1=1000mm
- l=100mm
- n=9
- n_f=3
- n_g=6
- E=210MPa

Fig.23 Isuzu NQR 500 SWB truck

❖ The length of the leaf spring leaves may be obtained



Let $2L_1$ = Length of span or overall length of the spring,

l = the ineffective length of the spring,

n_F = Number of full length leaves,

n_G = Number of graduated leaves, and

n = Total number of leaves = $n_F + n_G$.

t = Thickness of leaves,

b = Width of plate, and

L = Length of plate or distance of the load W from the cantilever end.

❖ thickness of leaves(t)

$\frac{n*t}{b}$=3 ⟶ $\frac{n*t}{3}$=b ⟶ $\frac{9*t}{3}$=b b=3t ⟶

- ❖ Effective length of spring(L)

2L=2L$_1$-l ⟶ L=$\frac{1000*(2)-100}{2}$=950mm

Assume that the leaves are not initially stressed the maximum bending stress for fully length leaves (σ_f)

$\sigma_f = \frac{18wL}{bt^2(2n_g+3n_f)}$…………………………………………………………[9]

The material used for leaf springs is usually a plain carbon steel having 0.90 to 1.0% carbon. The leaves are heat treated after the forming process. The heat treatment of spring steel produces greater strength and therefore greater load capacity, greater range of deflection and better fatigue properties.

According to Indian standards, the recommended materials are :

For automobiles : 50 Cr 1, 50 Cr 1 V 23, and 55 Si 2 Mn 90 all used in hardened and tempered state. The yield strength for 55 Si 2 Mn 90 from table 1 is 1920Mpa and factor of safety 3

So The permissible stress (σ_f)=yield strength /factor = 1920/3=640Mpa

640Mpa=$\frac{18*720kN*950mm}{2(3t)t^2(2*6+3*3)}$ ⟶ t=30mm

b= 3t ⟶ 3*30= 90mm

- ❖ Deflection of the spring $(\Delta x) = \frac{12wL^3}{Ebt^3(2n_g+3n_f)}$ [7]

$\Delta x = \frac{12wL^3}{Ebt^3(2n_g+3n_f)}$……………………..[9]

By changing the values of mass check the deflection and convert it to voltage

- ✓ W_1=720kN

$\Delta x_1 = \frac{12*720KN*950^3}{210*40*90^3(2*6+3*3)2} \longrightarrow \Delta x_1 = 0.6913mm$

- ✓ W_2=1000kN

$\Delta x_2 = \frac{12*1000KN*950^3}{210*40*90^3(2*6+3*3)2} \longrightarrow \Delta x_2 = 1.7297mm$

- ✓ W_3=2000KN

$\Delta x_3 = \frac{12*2000KN*950^3}{210*40*90^3(2*6+3*3)2} \longrightarrow \Delta x_3 = 2.342mm$

- ✓ W_4=3000KN

$\Delta x_4 = \frac{12*3000KN*950^3}{210*40*90^3(2*6+3*3)2} \longrightarrow \Delta x_4 = 3.543mm$

- ✓ W_5=4000KN

$\Delta x_5 = \frac{12*4000KN*950^3}{210*40*90^3(2*6+3*3)2} \longrightarrow \Delta x_5 = 4.342mm$

- ✓ W_6=5000KN

$\Delta x_6 = \frac{12*5000KN*950^3}{210*40*90^3(2*6+3*3)2} \longrightarrow \Delta x_6 = 5.043mm$

- ✓ W_7=6000KN

$\Delta x_7 = \frac{12*6000KN*950^3}{210*40*90^3(2*6+3*3)2} \longrightarrow \Delta x_7 = 6.045mm$

- ✓ W_8=7000KN

$\Delta x_8 = \frac{12*7000KN*950^3}{210*40*90^3(2*6+3*3)2} \longrightarrow \Delta x_8 = 6.981mm$

- ✓ W_9=7500KN

$$\Delta x_9 = \frac{12*7500KN*450^3}{2000*40*13^3(2*6+3*3)2} \longrightarrow \Delta x_9=7.213mm$$

- ✓ W_{10}=8000KN

$$\Delta x_{10} = \frac{12*8000KN*450^3}{2000*40*13^3(2*6+3*3)2} \longrightarrow \Delta x_{10}=7.6806mm$$

3.4.1 Conversion of deflection (Δx) to voltage (V)

In order to give the input to the Arduino system the deflection in mm must be convert to voltage such that the Arduino will give the command to the indication light as well as the fuel system as per the load.to convert the deflection to voltage potentiometer is used.

A potentiometer is a manually adjustable variable resistor with 3 terminals. Two terminals are connected to both ends of a resistive element, and the third terminal connects to a sliding contact, called a wiper, moving over the resistive element.

The position of the wiper determines the output voltage of the potentiometer. The potentiometer essentially functions as a variable voltage divider. The resistive element can be seen as two resistors in series (potentiometer resistance), where the wiper position determines the resistance ratio of the first resistor to the second resistor.

A potentiometer is also commonly known as a pot meter or pot. The most common form of pot meter is the single turn rotary pot meter. This type of pot is often used in audio volume control (logarithmic taper) as well as many other applications. Deferent materials are used to construct potentiometers, including carbon composition, cermet, wire wound, and conductive plastic or metal lm.

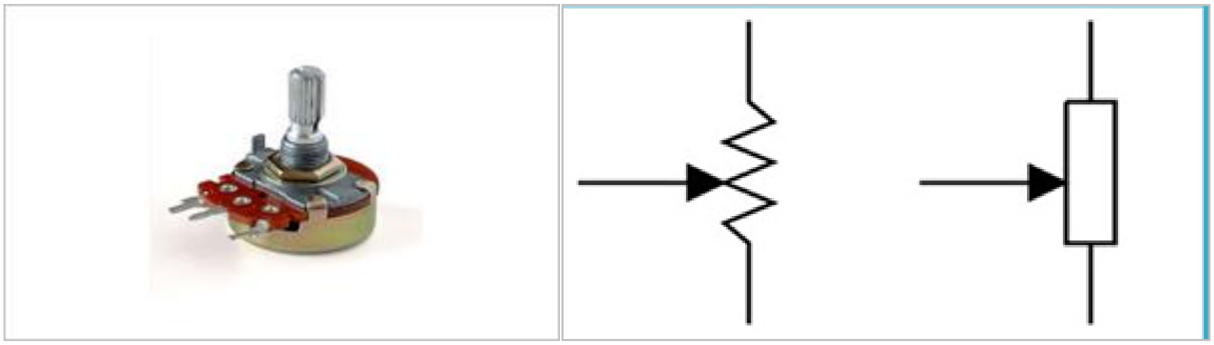


Fig. 24 Potentiometer

{Source: www.potentiometer.com}

Working Principle

The potentiometer can be used as a voltage divider to obtain a manually adjustable output voltage at the slider (wiper) from a fixed input voltage applied across the two ends of the potentiometer. The potentiometer can be used as a voltage divider to obtain a manually adjustable output voltage at the slider (wiper) from a fixed input voltage applied across the two ends of the potentiometer.

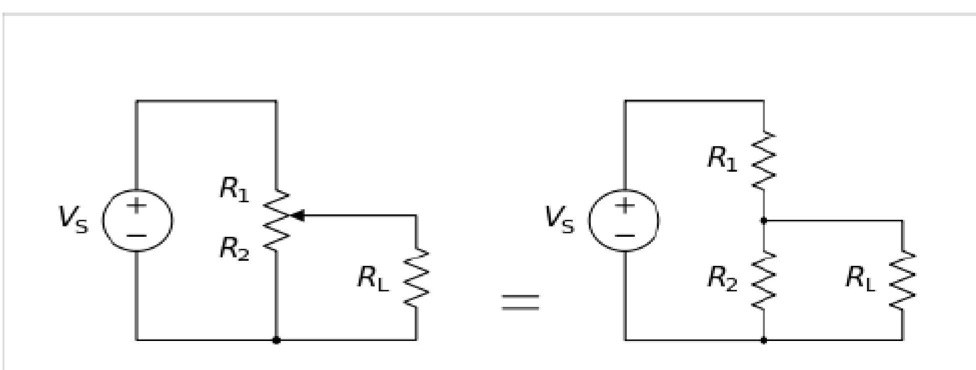


Fig.25 The working principle of potentiometer

From the above analysis the change in deflection in the leaf spring is related with the corresponding loaded mass on the truck. The change in deflection which is related with the weight is perpendicular to the surface as shown in fig.7 these deflection as leaf spring can be sensed with electrical sensor load sensor.

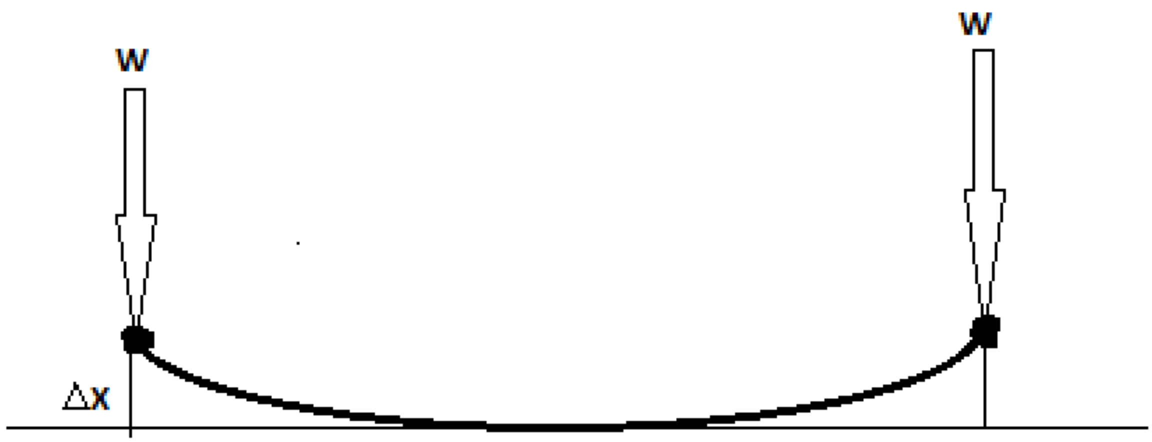


Fig.26 deflection in leaf spring

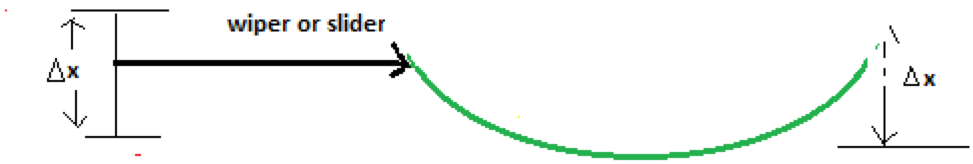
The basis of potentiometer is that resistance of the material depend on length of the material. The relationship can be state by

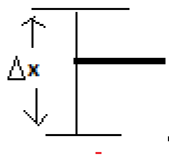
$R = \frac{\rho x}{A}$ Where $\rho = resistiviity$

X=deflection

A =area

The deflection of leaf spring will cause the wiper position to displace, these deflection of the leaf spring will result in two different resistance along the wire.

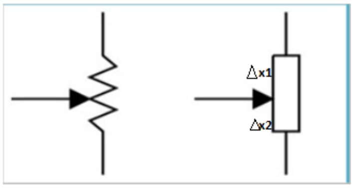




Take typical potentiometer length is 10 mm.

- $\Delta x = 0.6913 - - - - - - - - - \Delta x_1$= 0.6913mm and Δx_2=9.31mm
- $\Delta x = 1.7297 - - - - - - - - - \Delta x_1$=1.7297mm and Δx_2=8.2703mm
- $\Delta x = 2.3421 - - - - - - - - - \Delta x_1$=2.342mm and Δx_2=7.6579mm
- $\Delta x = 3.543 - - - - - - - - - \Delta x_1$=3.543mm and Δx_2=6.457mm
- $\Delta x = 4.543 - - - - - - - - - \Delta x_1$=4.543mm and Δx_2=5.457mm
- $\Delta x = 5.043 - - - - - - - - - \Delta x_1$=5.043mm and Δx_2=4.957mm
- $\Delta x = 6.045 - - - - - - - - - \Delta x_1$=6.045mm and Δx_2=3.955mm
- $\Delta x = 6.981 - - - - - - - - - \Delta x_1$=6.981 mm and Δx_2=3.019mm
- $\Delta x = 7.213 - - - - - - - - - \Delta x_1$=7.213mm and Δx_2=2.787mm
- $\Delta x = 7.681 - - - - - - - - - \Delta x_1$=7.681mm and Δx_2=2.319 mm

With the above deflection (Δx) values we can calculate the resistance of each segment or the deflections.



$$\Delta x_1 + \Delta x_2 = 10 \text{ mm}$$

The resistance of each segment

$R_1 = \frac{\rho \Delta x_1}{A}$ And $R_2 = \frac{\rho \Delta x_2}{A}$

Since the segment materials are the same the values of A and ρ are constant.

In order to find the voltage drop on each segment we will use ohms law.

$V = IR \longrightarrow I = \frac{V}{R}$

There is two resistor in series according to design. By using ohms law find the voltage drop on each segment that is resistor.

When resistor combined in series

$$R_t = R_1 + R_2 + \ldots\ldots R_n$$

To find the total current we have

$I_t = \frac{V_S}{R_t}$ So, $I_t = \frac{V_S}{R_1 + R_2}$ ………………………………1

The voltage drop on R_2 (segment two) as follows

$V_{out} = I_t * R_2$ ……………………………………2

Equating equation 1 & 2

$V_{out} = \frac{V_S * R_2}{R_1 + R_2}$

For every deflection on the leaf spring we can find the corresponding resistance and eventually the voltage

$V_{out}=(\frac{R_2}{R_1+R_2})V_S$ where Vs=5v

Resistance values

- **$\Delta x = 0.6913$ −−−−−−−− Δx_1= 0.6913mm and Δx_2=9.31mm**

✓ $R_1 = \frac{\rho \Delta x_1}{A} \longrightarrow R_1 = \frac{\rho * 0.6913}{A} \longrightarrow R_1=2.9279$

✓ $R_2 = \frac{\rho \Delta x_2}{A} \longrightarrow R_2 = \frac{\rho * 9.31}{A} \longrightarrow R_2=7.0721$

✓ $V_{out}=(\frac{R_2}{R_1+R_2})V_S \quad V_{out}=\left(\frac{7.0721}{2.9279+7.0721}\right) * 5 = 0.6654V$

- **$\Delta x = 1.7297$ −−−−−−−− Δx_1=1.7297mm and Δx_2=8.2703mm**

- $R_1 = \frac{\rho \Delta x_1}{A} \longrightarrow R_1 = \frac{\rho * 1.729}{A} \longrightarrow R_1=2.4787$
- $R_2 = \frac{\rho \Delta x_2}{A} \longrightarrow R_2 = \frac{\rho * 8.2703}{A} \quad R_2=7.5213$
- $V_{out}=(\frac{R_2}{R_1+R_2})V_S \longrightarrow V_{out}=\left(\frac{7.5213}{2.4787+7.5213}\right) * 5 = 1.03V$

- **$\Delta x = 2.3421$ −−−−−−−− Δx_1=2.342mm and Δx_2=7.6579mm**

✓ $R_1 = \frac{\rho \Delta x_1}{A} \longrightarrow R_1 = \frac{\rho * 2.3346}{A} \longrightarrow R_1=2.3346$

✓ $R_2 = \frac{\rho \Delta x_2}{A} \longrightarrow R_2 = \frac{\rho * 7.6654}{A} \longrightarrow R_2=7.6654$

✓ $V_{out}=(\frac{R_2}{R_1+R_2})V_S \longrightarrow V_{out}=\left(\frac{7.6654}{2.3346+7.6654}\right) * 5 = 1.865V$

- **$\Delta x = 3.543$ −−−−−−−− Δx_1=3.543mm and Δx_2=6.457mm**

- $R_1 = \frac{\rho \Delta x_1}{A} \longrightarrow R_1 = \frac{\rho * 3.543}{A} \longrightarrow R_1=1.9648$
- $R_2 = \frac{\rho \Delta x_2}{A} \longrightarrow R_2 = \frac{\rho * 6.457}{A} \longrightarrow R_2=8.0357$
- $V_{out}=(\frac{R_2}{R_1+R_2})V_S \longrightarrow V_{out}=\left(\frac{8.0357}{2.3346+8.0357}\right) * 5 = 1.9567V$

- $\Delta x = 4.543$ -------- Δx_1=**4.543mm and** Δx_2=**5.457mm**
- $R_1 = \frac{\rho \Delta x_1}{A}$ ⟶ $R_1 = \frac{\rho * 4.543}{A}$ ⟶ R_1=1.7171
- $R_2 = \frac{\rho \Delta x_2}{A}$ ⟶ $R_2 = \frac{\rho * 5.457}{A}$ ⟶ R_2=8.2829
- $V_{out}=(\frac{R_2}{R_1 + R_2})V_S$ ⟶ $V_{out}=\left(\frac{8.2829}{1.7171+8.2829}\right) * 5$ =2.012V

- $\Delta x = 5.043$ -------- Δx_1=**5.043mm and** Δx_2=**4.957mm**
- $R_1 = \frac{\rho \Delta x_1}{A}$ ⟶ $R_1 = \frac{\rho * 5.043}{A}$ ⟶ R_1=1.4698
- $R_2 = \frac{\rho \Delta x_2}{A}$ ⟶ $R_2 = \frac{\rho * 4.957}{A}$ ⟶ R_2=8.5302
- $V_{out}=(\frac{R_2}{R_1 + R_2})V_S$ ⟶ $V_{out}=\left(\frac{8.5302}{1.4698+8.5302}\right) * 5$ =2.456V

- $\Delta x = 6.045$ -------- Δx_1=**6.045mm and** Δx_2=**3.955mm**
- $R_1 = \frac{\rho \Delta x_1}{A}$ ⟶ $R_1 = \frac{\rho * 6.045}{A}$ ⟶ R_1=1.3462
- $R_2 = \frac{\rho \Delta x_2}{A}$ ⟶ $R_2 = \frac{\rho * 3.955}{A}$ ⟶ R_2=8.6538
- $V_{out}=(\frac{R_2}{R_1 + R_2})V_S$ ⟶ $V_{out}=\left(\frac{8.6538}{1.3462+8.6538}\right) * 5$ =2.678V

- **$\Delta x = 6.981$ − − − − − − − − −Δx_1=6.981 mm and Δx_2=3.019mm**

- $R_1 = \frac{\rho \Delta x_1}{A}$ ⟶ $R_1 = \frac{\rho * 6.981}{A}$ ⟶ R_1=1.0990
- $R_2 = \frac{\rho \Delta x_2}{A}$ ⟶ $R_2 = \frac{\rho * 3.019}{A}$ ⟶ R_2=8.9010
- $V_{out}=(\frac{R_2}{R_1+R_2})V_S$ ⟶ $V_{out}=\left(\frac{8.9010}{1.0990+8.9010}\right) * 5$ =3.325V

- **$\Delta x = 7.213$ − − − − − − − − −Δx_1=7.213mm and Δx_2=2.787mm**

- $R_1 = \frac{\rho \Delta x_1}{A}$ ⟶ $R_1 = \frac{\rho * 7.213}{A}$ ⟶ R_1=0.8517
- $R_2 = \frac{\rho \Delta x_2}{A}$ ⟶ $R_2 = \frac{\rho * 2.787}{A}$ ⟶ R_2=9.1483
- $V_{out}=(\frac{R_2}{R_1+R_2})V_S$ ⟶ $V_{out}=\left(\frac{9.1483}{0.8517+9.1483}\right) * 5$ =3.67415V

- **$\Delta x = 7.681$ − − − − − − − − −Δx_1=7.681mm and Δx_2=2.319 mm**

- $R_1 = \frac{\rho \Delta x_1}{A}$ ⟶ $R_1 = \frac{\rho * 7.681}{A}$ ⟶ R_1=0.6044
- $R_2 = \frac{\rho \Delta x_2}{A}$ ⟶ $R_2 = \frac{\rho * 2.319}{A}$ ⟶ R_2=9.3956
- $V_{out}=(\frac{R_2}{R_1+R_2})V_S$ ⟶ $V_{out}=\left(\frac{9.3956}{0.6044+9.3956}\right) * 5$ =4.0124V

3.4.2 Design of the system by using MATLAB software

- Setting the load as a variable and finding the deflection

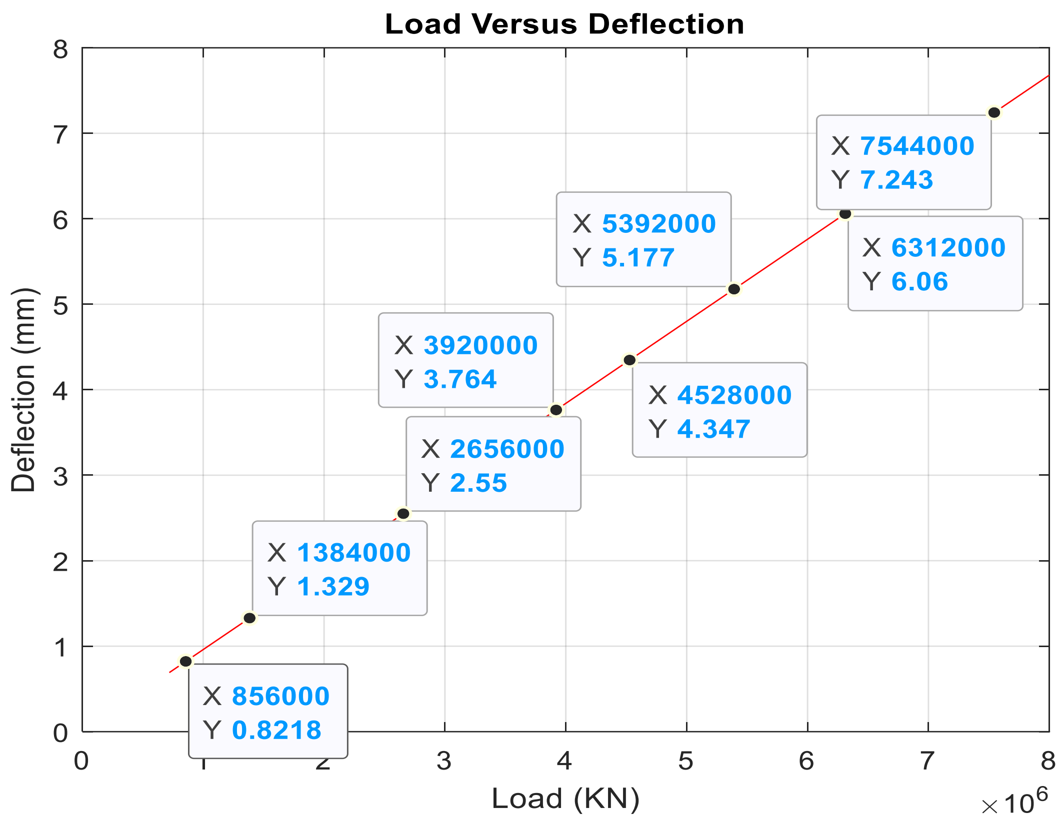


Fig. 27 load versus deflection graph

As we can see from figure 27 the load versus deflection graph when the load is increase the deflection increase spontaneously. Since the governing equation is linear the result became linear so setting gabs in deflection will encounter the response.

Getting the deflection of leaf spring then finding the voltage is the next task, in order to activate the system. So

- Setting the deflection as variable and finding the voltage

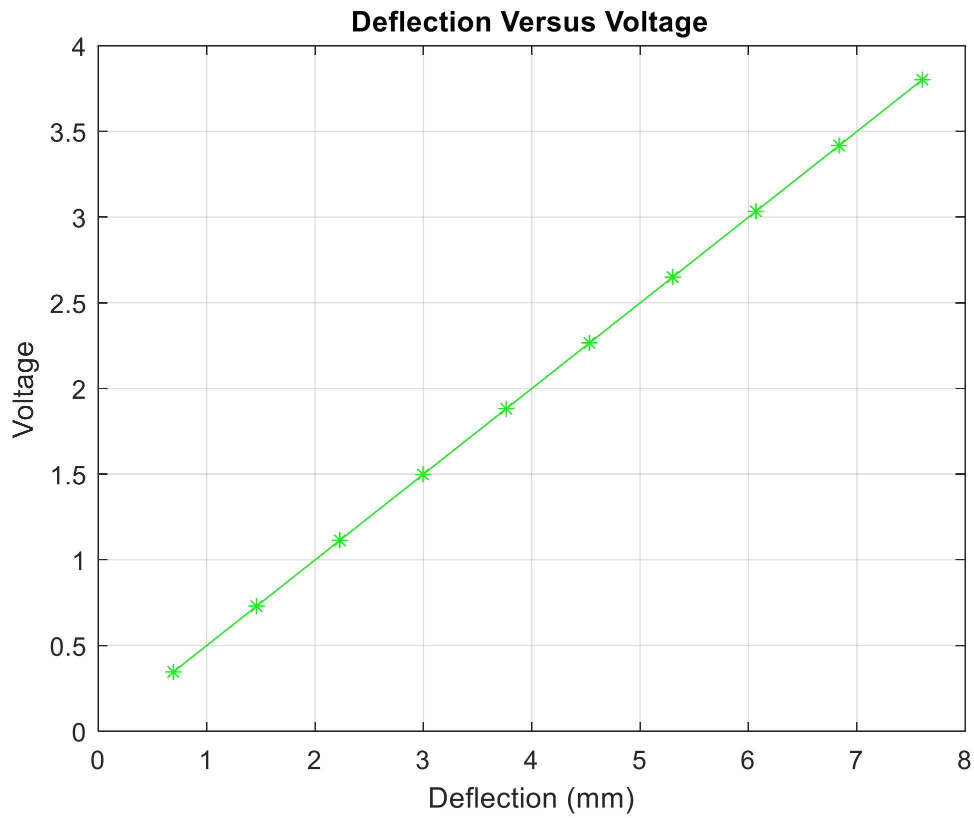


Fig. 28 deflection versus voltage graph

Here as we can see from graph 28

From deflection 0-3mm the voltage gap is 0-2v this is normal load, from 4-6mm the voltage gab is 2-3 this is warning area the light and buzzer will activate finally from deflection 6-8mm the voltage gab is 3-4v here depending on the situation the fuel will stop unless the overload is removed.

3.4.3 Design of the system by using protous software

Using the range of potentiometer that convert the deflection value to the voltage taken as an input to the Arduino board and within these values according to the range give the command to the buzzer and light so as to increase the weight the voltage will increase and the Arduino give the command to shutoff solenoid to stop the vehicle.

the limit switch protect the load sensor in which if the person remove the load sensor the limit switch will open and can't close again like the meter of electricity power which is available in our house. The supply voltage is come from the battery of the vehicle.

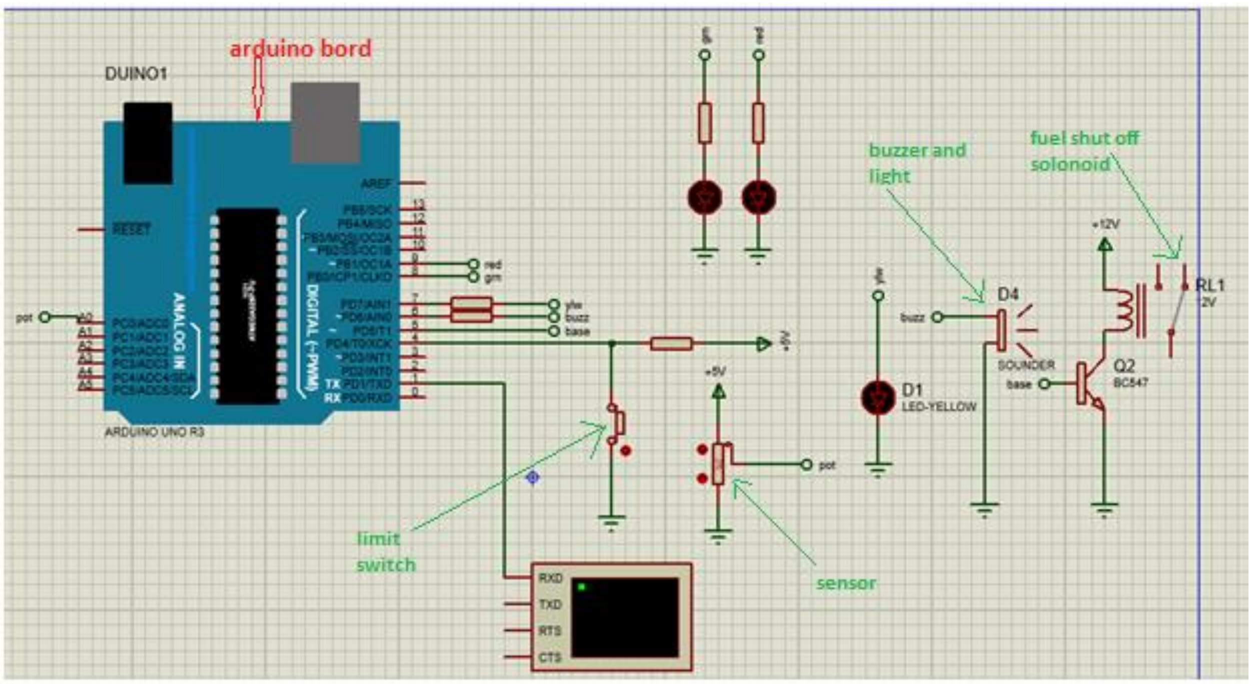


Fig. 29 arctecture of the system by using protous software

3.5 Vehicle Direction Stability control system

The directional stability of a vehicle refers to its ability to stabilize its direction of motion against disturbances. A vehicle is considered to be directionally stable if, following a disturbance, it returns to a steady-state regime within a finite time. A directionally unstable vehicle diverges more and more from the original path, even after the disturbance is removed.

- **Neutral stability**

If a side force is acting on the CG, and an equal steady state slip angles are produced due to side force on the front and rear tyres, the vehicle moves on a new straight line at an angle in proportion to the generated slip angle. This motion is free of yaw velocity and hence known as neutral steer.

A car is called 'neutral' when the front and rear tires will lose traction at the same time. This is desirable because while the vehicle may slide towards the outside of the turn, it maintains the effective steering angle set by the driver. This makes it 'safer' to drive near the limit condition of traction because the outcome of breaking traction is more predictable.

- **Over steering**

Over steer is what occurs when a car turns (steers) by more than the amount commanded by the driver. If the rear tires break traction first. The front tires will continue to accelerate the front of the vehicle laterally, tracing a circle. The rear tires will have a tendency to continue along the tangent of that circle, but cannot because of their attachment to the front of the car, which still has traction. The result is that the rear tires will swing outwards relative to the front of the vehicle. This turns the vehicle towards the inside of the curve. If the steering angle is not changed (i.e. the steering wheel stays in the same position), then the front wheels will trace out a smaller and smaller circle while the rear wheels continue to swing around the front of the car

- **Under steering**

Understeer is what occurs when a car steers less than the amount commanded by the driver. Understeer can typically be understood as a condition where, while cornering, the front tires begin to slip first. Since the front tires are slipping and the rear tires have grip, the vehicle will turn less than if all tires had grip. Since the amount of turning is less than it would be if all tires had traction, this is known as under-steering.

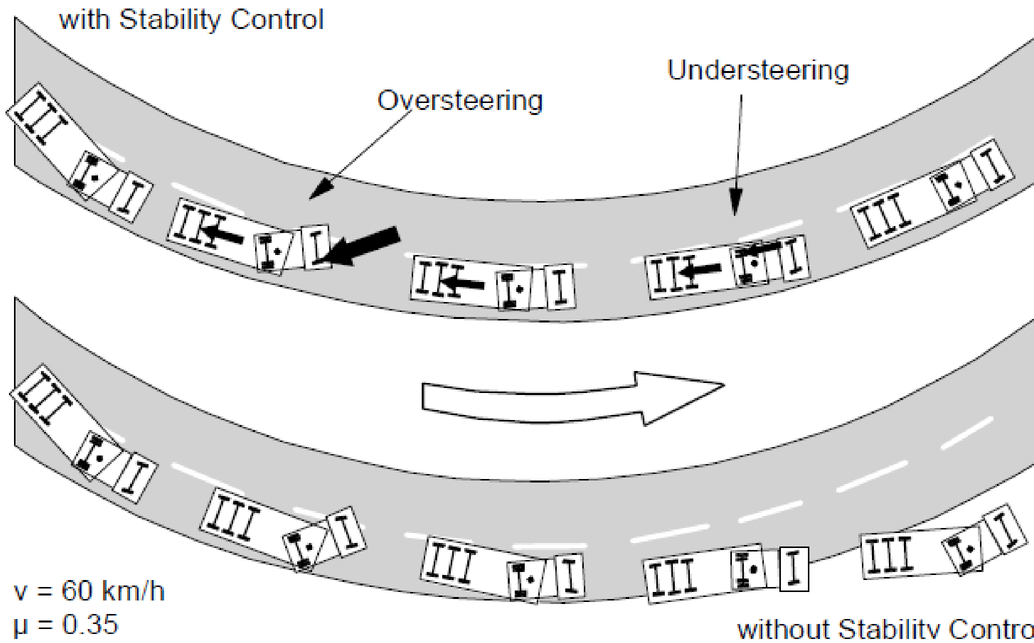


Figure 30 Brake Application for Directional Control

From many reason for over steering and under steering ,Overload is one of the major causes.so, integrating these overload control system with electronic stability control (ESC) which is an electronically controlled braking system, to allow automatic activation of the brakes and a high speed data link (CAN) to the engine control system. Commercial vehicle stability control is further enhanced with brake pressure control on trailers by an electro-pneumatic. Trailer control valve or with EBS on trailers in combination with roll-over protection.

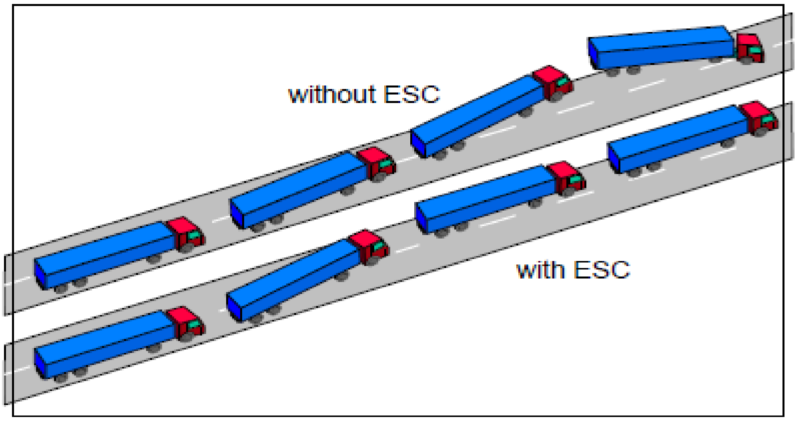


Figure 31. Simulation of a lane change with and without ESC

{*Source: Society of Automotive Engineers.inc*}

3.6 safety of the system

One of the main issue for these system is how to secure the system? Basically the unsafe condition is the installation of the sensor that is what will be done if the sensor is removed or the driver uninstall it here for security limit switch is install together with the sensor that means if the remove the sensor the limit switch will open since once open can't close again so the traffics can check it. Can easily monitor the overloaded vehicle and punish the driver who uninstalled when renewed the vehicle per year.

Fig 30. Limit switch

{Source: www.limit switch.com}

Chapter four

4.1 Result and discussion

Total weight (KN)	Deflection (Δx) in mm	Voltage (V)	action
720	0.651	0.6654	Normal load
856	0.8218	1.03	Normal load
1384	1.329	1.865	Normal load
2656	2.55	1.9567	Normal load
3920	3.764	2.013	**Overload warning**
4528	4.347	2.456	**Overload warning**
5392	5.177	2.678	**Overload warning**
6312	6.06	3.325	Cut off fuel supply
7544	7.243	3.67	Cut off fuel supply
8000	7.63	4.013	Cut off fuel supply

To Begin with from table above the result show that within the voltage gab trying to activate the system as per command. Designing the leaf spring was the first task to get the deflection value so using Isuzu NPR 400 manual specification getting the deflection values by varying the loads.

Here the result shows that the deflection is minimum and by using potentiometer changing the values of deflection to voltage was conducted. Here the total supply voltage is 5V that is from the source of the vehicle battery. As the result show the voltage

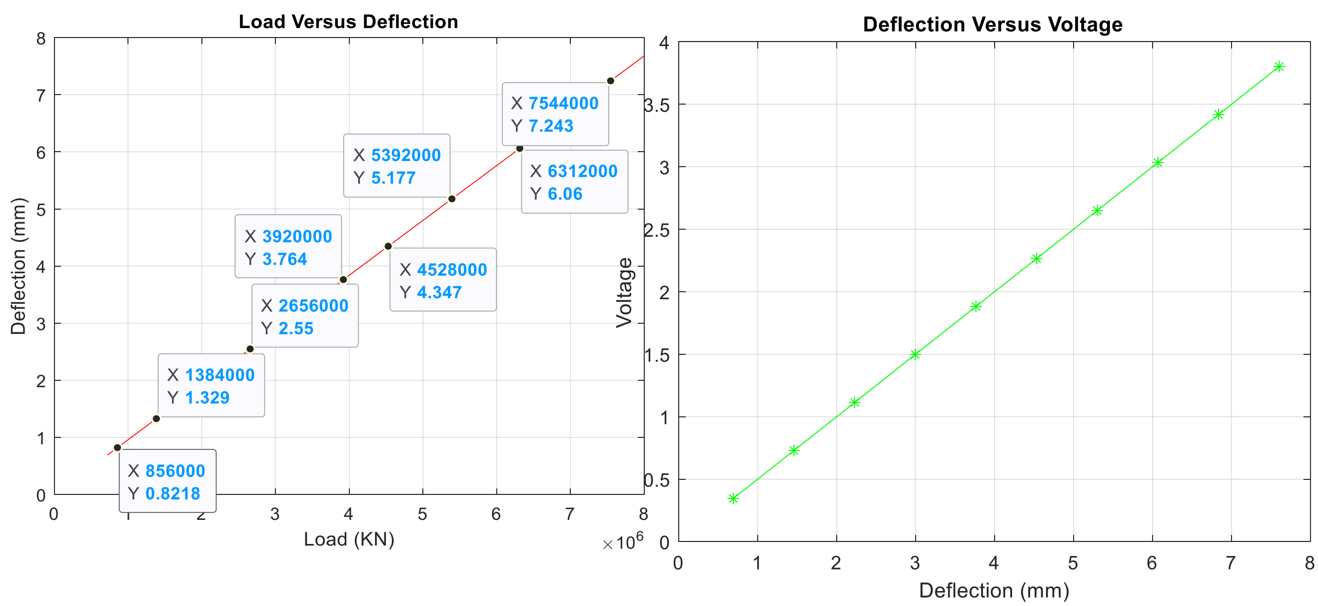
Is not above the supply voltage. This show that not much power is consumption from the vehicle battery.

From load 720KN-2656 KN it is permissible load the voltage gap is from 0-2V in these voltage gab the driver can drive it normal.

From load 3920KN to 5392KN warning stage that means the light and the buzzer (audio) warning will activate when it reach the voltage gap between 2V to 3Vit warn to the driver to stop and eliminate overloaded .

Finally from load 6312KN to 8000KN the shut off solenoid will activate in the range of 3V to 5Vand it will closed so no fuel will transmit hence the vehicle will stop unless the overload is removed.

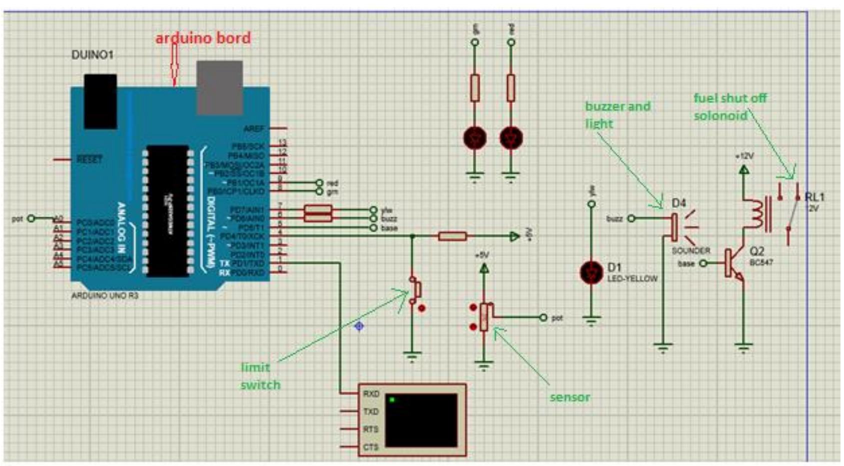
Further more finding the governing equation was the next task to do simulation in MATLAB software. As the governing equation is linear the result is linear that means the system is good to apply in the vehicle.



From the MATLAB analysis the result is linear because the governing equation is linear, primarily using load sensor ,load versus deflection analysis was done next by using potentiometer converting the deflection value to voltage the deflection versus voltage analysis is conducted. Besides, the protous software show the system how to work.

Finally by using Proteus software try to show how the system work . here as shown in the Board the ardino board monitor to the system primely the load cell will detect the deflection and give to the ardunio board as input then the ardunio board examine the deflection via the load. So give the command as per the voltage gab.

As shown in the figure the light and the buzzer sysyetm activate from the ardunio command then if the load is exceed the fuel will stop when the ardunio sent the command to the cut off solenoid to stop fuel transmission.



In conclusion design manually the system then by doing the MATLAB simulation the showing and analyzing the system in Proteus software is done in this research work.

4.2 conclusion

In this paper, based on the potentiometer load sensor detecting the load and giving the warning by sound and light finally by cutoff the fuel and stop the vehicle, a new type of vehicle overload detection system is established, which make it possible to detect the overloaded vehicle and transfer the relevant data to the Arduino processor after the deflection of the leaf spring signal is obtained.

Then further processing can be done. The system has advantages of small size, high sensitivity, and it can adapt to different test environments. Relevant system tests showed that overloaded vehicles can be accurately detected by this system, which has a very good practical prospect.

These research basically used the MATLAB software in order to model the system, finding the deflection of the spring and convert to the voltage by potentiometer besides protous software is used to show how the system work.

In these system by voltage gab warn the driver by light and sound to reduce the overload if not the voltage will increase as per the load increase the full will stop any place. The challenge in these system was how to secure the system so limit switch is installed so the transport minister must check in every time.

4.3 Recommendation

The responsibility to protect these system lay on all the stockholders mainly the transport minister it should have protecting these system to decrease the traffic accidents which are caused by the overload of the vehicle. Besides the automotive engineers must collaborate with software and electrical engineers to implement the system in the ground. Last but not the least in order to save our life and huge damage of resource which is caused by the traffic accidents one way which is overload all peoples must protect the system.

4.4 Future work

Although the system is established for one type of car based on the design of each vehicle passenger and commercial vehicle designing and installing these system is the future work in order to decrease the accidents and damages of the resources due to overload.

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Appendices

1. physical properties of materials commonly used for leaf spring

Material	*Condition*	*Ultimate tensile strength (MPa)*	*Tensile yield strength (MPa)*	*Brinell hardness number*
50 Cr 1	Hardened	1680 – 2200	1540 – 1750	461 – 601
50 Cr 1 V 23	and	1900 – 2200	1680 – 1890	534 – 601
55 Si 2 Mn 90	tempered	1820 – 2060	1680 – 1920	534 – 601