KAUNAS UNIVERSITY OF TECHNOLOGY

MECHANICAL ENGINEERING AND DESIGN FACULTY

Development of assisting system for differently abled persons to drive electric car

Master's Degree Final Project

Mechatronics (621H730001)

Supervisor

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Project made by

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KAUNAS, 2017

KAUNAS UNIVERSITY OF TECHNOLOGY

FACULTY OF MECHANICAL ENGINEERING AND DESIGN

Jagadeesh Ramakrishna Sridar

Final Degree Project

DEVELOPMENT OF ASSISTING SYSTEM FOR DIFFERENTLY ABLED PERSONS TO DRIVE ELECTRIC CAR

Mechatronics (621H730001)

DECLARATION OF ACADEMIC INTEGRITY

08 June 2017

Kaunas

I confirm that the final project of mine, **Jagadeesh Ramakrishna Sridar**, on the subject "Development of assisting system for differently abled persons to drive electric car" is written completely by myself; all the provided data and research results are correct and have been obtained honestly. None of the parts of this thesis have been plagiarized from any printed, Internet-based or otherwise recorded sources. All direct and indirect quotations from external resources are indicated in the list of references. No monetary funds (unless required by law) have been paid to anyone for any contribution to this thesis.

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Approved:

Head of Production engineering Department

(*Signature, date*)

Kazimieras Juzėnas
(*Name, Surname*)

MASTER STUDIES FINAL PROJECT TASK ASSIGNMENT
Study programme MECHATRONICS

The final project of Master studies to gain the master qualification degree, is research or applied type project, for completion and defence of which 30 credits are assigned. The final project of the student must demonstrate the deepened and enlarged knowledge acquired in the main studies, also gained skills to formulate and solve an actual problem having limited and (or) contradictory information, independently conduct scientific or applied analysis and properly interpret data. By completing and defending the final project Master studies student must demonstrate the creativity, ability to apply fundamental knowledge, understanding of social and commercial environment, Legal Acts and financial possibilities, show the information search skills, ability to carry out the qualified analysis, use numerical methods, applied software, common information technologies and correct language, ability to formulate proper conclusions.

1. Title of the Project.

Development of assisting system for differently abled persons to drive electric car.
Sistemos padedančios neįgalių žmonių elektrinio automobilio valdymui kūrimas.

Approved by the Dean Order No.V25-11-7, 3 May 2017

2. Aim of the project.

Aim of the project is to develop the assisting system for differently abled persons to drive car.

3. Structure of the project.

- To design walking assistance system and design driving assist assistance system and analyse it.
- To design a control system of walking and driving assistance system.
- To find cost estimation of walking and driving assistance system

4. Requirements and conditions

- Designing a innovative knuckle to support steering assistance system and transfer joystick signals to throttle control module for acceleration assisting system
- Comparing stress results on pedals for conventional and joystick braking assistance system
- Manufacture the product more economically

5. This task assignment is an integral part of the final project

6. Project submission deadline: 2017 June 1.
Given to the student

Task Assignment received

(*Name, Surname of the Student*) (*Signature, date*)

Supervisor

(*Position, Name, Surname*) (*Signature, date*)

Jagadeesh Ramakrishna Sridar. Development of Assisting System for Differently Abled Persons to Drive Electric Car. *Master's* Final Project / supervisor Assoc. Prof Dr. Rūta Rimašauskienė; Faculty of Mechanical Engineering and Design, Kaunas University of Technology.

Research field and area: Production Engineering, Technological Sciences.

Keywords: *Driving assist, joystick control, walking assist, car*

Kaunas, 2017. 51 pages.

SUMMARY

The master thesis work involves the design of driving assist and walking assist in the electric car, differently abled people suffer for their transportation and this project focuses on those people to use the car. It created higher possibility and confidence on them to drive the vehicle with the joystick. The joystick is fixed in the power seats to control the vehicle direction and speed.

The joystick controls need lesser energy to operate. It is more sensitive for steering and accelerating the vehicle. Here we are using the electric car. So, they can enjoy the power full initial torque of the vehicle. The steering is purely electrically controlled through the joystick.

Safety systems are also introduced. Here safety systems are viewed in different perspectives. The walking assist is also designed for them to walk nearby distance after traveling the car.

Jagadeesh Ramakrishna Sridar. *Sistemos padedančios neįgalių žmonių elektrinio automobilio valdymui kūrimas*. Magistro baigiamasis projektas / Vadavas doc. dr. .Rūta Rimašauskienė Mechanikos inžinerijos ir dizaino fakultetas, Kauno technologijos universitetas.

Tyrimų sritis: Gamybos inžineriją, Technologijos mokslai.

Raktiniai žodžiai: *pagalbinis vairavimo mechanizmas, valdymo rankenos kontrolė, pagalbinis vaikščiojimo mechanizmas*.

Kaunas, 2017 m. 51 p.

SANTRAUKA

Magistro darbe pateikiamas vairavimo ir vaikščiojimo pagalbinio mechanizmo, naudojamo elektriniame automobilyje, projektas. Žmonės, turintys įvairių neįgalumų, susiduria su transporto sunkumais, todėl pagrindinis šio projekto dėmesys ir skiriamas tokių žmonių naudojimuisi automobiliais. Automobilio vairavimas valdymo rankenos pagalba suteikia jiems daugiau galimybių ir pasitikėjimo. Valdymo rankena pritvirtinama prie sėdynės, kurioje yra elektrinis reguliavimo atvedimas. Taip valdoma transporto priemonės kryptis ir greitis.

Valdymo rankenos kontrolei reikia mažiau energijos. Ji jautresnė automobilio vairavimo ir greičio didinimo atžvilgiu. Čia mes naudojame elektrinį automobilį, todėl galime pasimėgauti pilno galingumo pradiniu sukimo momentu. Vairavimas visiškai kontroliuojamas per elektrinę valdymo rankeną.

Be to, pristatomos ir saugos sistemos. Jos peržvelgiamos iš skirtingų perspektyvų. Vaikščiojimo pagalbinis mechanizmas sukurtas, kad žmonėms būtų lengviau nueiti nedidelį atstumą, išlipus iš automobilio

ACKNOWLEDGEMENTS

I am thankful to my supervisor, Assoc Prof. Dr. Rūta Rimašauskienė for guiding me and for helping me with fulfilling and completing my task in this research project. The support from my supervisor on designing helped for carrying it out successfully.

I would like to take opportunity to thank Assoc Prof. Dr. Jolanta Baskutienė for giving me the opportunity to work in innovative task and time which helped me to a great extent.

Conveying my hearty thanks to colleagues who were a huge source of encouragement in terms of gathering information and helping for finishing the work together on time. I sincerely thank my family members and friends, for their continuous support and limitless encouragement throughout this project work.

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INTRODUCTION

Travelling is the activity, which is loved by all. Not only humans but even animals love to travel. To travel, we use the different mode of transport. Travelling will help to gain knowledge of different geography, people etc. it also gives wide knowledge for the people who is regular to this activity. For so many decades we have been inventing the machines that could help us travel and we were continuously keen on developing those, The driverless car is also invented, but did we think about the differently abled people. It will be the boon for them once they travelled in a lifetime, but it is sure that we have the capability to create the environment in which travelling of disabled people will be more common. It’s hard to see them in many places. I would wish there will be more intellectual people among them who can contribute the world more.

The scientists have discovered the robot that could help them walk in this decade. Comparatively the step taken to develop in this field should be even faster. I would like to expose them to the world with normal regular activities, which other people could do. We can also view this in the different perspective, if we believe the joystick that could drive a car, then definitely the differently abled people will be smart enough to drive it. Let us see the ways through it. In this project, I am going to create a possibility of elderly and differently abled persons to drive cars.

Aim and task of the project

The aim of the project is to develop the assisting system for differently abled persons to drive the electric car.

Tasks

- To design walking assistance system.
- To design driving assistance system and analyse it.
- To design a control system for walking and driving assistance system.
- To calculate cost estimation of walking and driving assistance system.

1. LITERATURE REVIEW

The joystick will help differently abled persons to hold control, for speed, along with the control of the direction of car with just a hand movement, and thus expands the effective percentage of their mobility. This literature survey has acquired documentation on differently abled drivers possibility of controlling their simple control modules(Joystick). International rules and required regulations of the car are not well explained when improving in such control systems as joystick power control in the car. The aim in this documentation is to describe the concerned situation of moving a car with least effort and to test the control system and where improvements could be made [1].

Design

A joystick is working as a socket-ball mechanism with 2 DOF, front, rear and left–right. The joystick original position can be obtained through springs and control to the driver in a conventional equipped car(steering and pedals) will be reduced. The joystick controls on turning the wheels, speed control and stopping ability with the help of hydraulic or electronic position feedback servo units.

Risks

By surveying the design of joystick control and pedals for accelerating, directing and to halt from the differently abled person perspective, it is manageable to find the risk and technical issues with cars operated by joysticks.

Control system

Controlling the joystick should be more efficient than the conventional control system. To find a time-delay depend on amplitude and frequency is introduced in the mechanism. The brake is operated by the angle position of the joystick and throughout the transfer function is obtaining a non-linear results.

Joystick versus conventional driving controls

Joystick control vehicles for differently abled drivers are found rarely. Since a joystick differs the primary controls. joystick control will show surprising critical issues concerning primary control mechanisms and drive-by-wire concepts.A integration of directing and motion control in a lever as shown in Fig. 1. While surveying joystick-controlled cars designed for differenetly abled, interference between direction control along with speed and hardship in-accurate response for direction and motion control

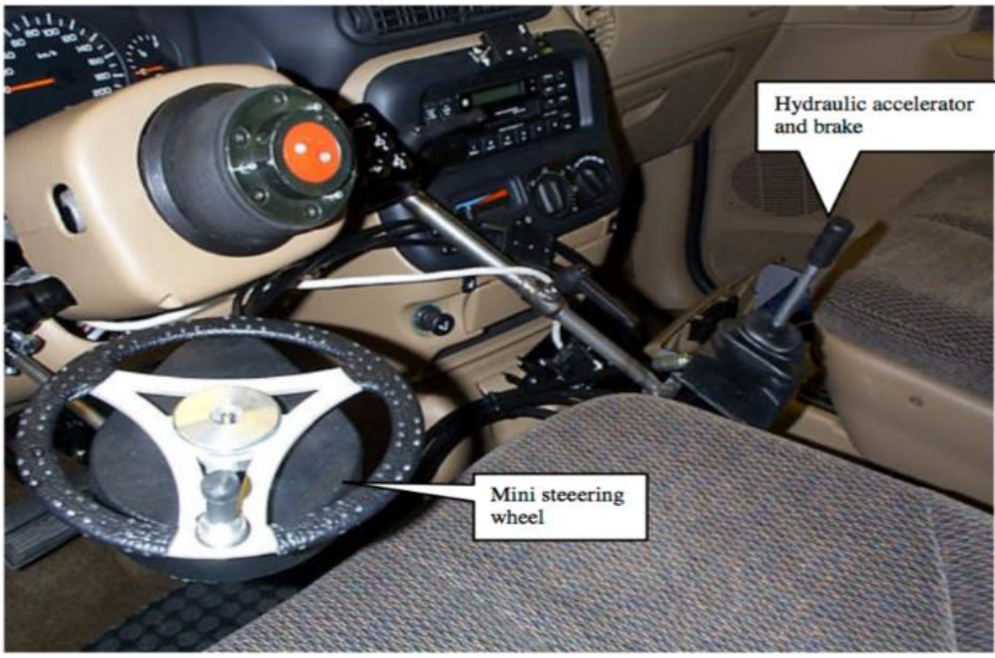

Fig. 1 Joystick controlled car

Background of joystick controlled car

The capacity of mechanical/hydraulic components to the preliminary controls of the car can be achieved through electronics. The electronic components show flexibility of replacement and design, A joystick controlled could have been a reality for drivers with disabilities over a decade Automotive generals are aware of extreme risks and functioning disabilities with these control system. A joystick could affect the handling and is therefore considered adaptation alternative would be in scarsing percentage.

Joystick design and control characteristics

The speed and directing is joystick controlled. This joystick controlled car users might suffer from weakness and motion of the hand, and that reason the joystick is simply designed and mainly focuses on control by finger movements. The joystick movement is to that of the steering wheel is fractional movement. There are precision/range and precision problem and could be fixed by unique programming of speed downscaling and directing commands. The system limitations result in acceptable time lags to control. It could not be efficient for sensitive steering requirements, Hence no faster response between moving components and controlling system [2].

1.1 Data analysis of differently abled person’s transportation

This segment contains a study of the differently abled persons. It is isolated into three segments.

1) Differently abled person Information on travel outside the home.

2) Nearby and Long-Distance Personal Travel.

3) Individual Motor Vehicle Ownership and Use. Local Travel and Mode Choice.

People use transportation for travelling and the modes depend upon the distance. About sixty-two percent of people with paralyzed who are fifteen years or older, and about eighty-six percent of the normal people who are 16 years or older, drive vehicles in the month prior to the interview for local travel to work, doctor, medical, and for shopping.

Seventy-seven percent of those with differently abled and eighty- two percent of the normal people rode in a personal vehicle as a passenger for local travel. Forty-seven percent of differently abled walked for local travel during the month prior to the interview, compared to fifty-eight percent of nondisabled persons. A higher percentage of differently respondents, thirty-three percent, rode bicycles or other pedal cycles compared to eighteen percent of disabled persons [3].

1.2 Considerations to discontinue driving

People would decide to quit operating a vehicle under some circumstances. Approximately one-third of both differently-abled and normal drivers would consider to quit driving if any of the followings occurs:

- they feel they are not efficient to operate a motor vehicle safely,
- their eyesight,
- they experience on another physical inability.

A dominating percentage of normal drivers than differently-abled drivers indicate they would quit driving when they reach a certain age. Around ten percent of normal people compared to seven percent of differently abled had some other mental limitation.

2. RESEARCH METHODOLOGY

The walking assistance system helps the user to reach the car and the driving assistance system will help the user to control the car as shown in Fig. 2. The driving assistance system will control the direction, speed, and braking. Steering the vehicle is done using the horizontal axis of the potentiometer or joystick.

Fig. 2 Walking assistance system to reach the car and driving assistance system to control the car

Voltage value according to the movement of the joystick controls the position of the servo motor. Servo is positioned upon the value of the voltage given by the joystick is manipulated by the microcontroller. For braking, linear compact actuator is designed in the brake pedal to complete the action. For acceleration, the signals are directly sent to the throttle control module

2.1 Walking assistance system

Walking assistance system motivates the person to walk very easily with the effort of the motor. It is fixed in the hip of the user. The model of the system is shown in Fig. 3. The wiper motor is used as a source of energy for walking. This method is very cheap and provides the greater assistance for the person to walk. It induces each step using skotch yolk mechanism.

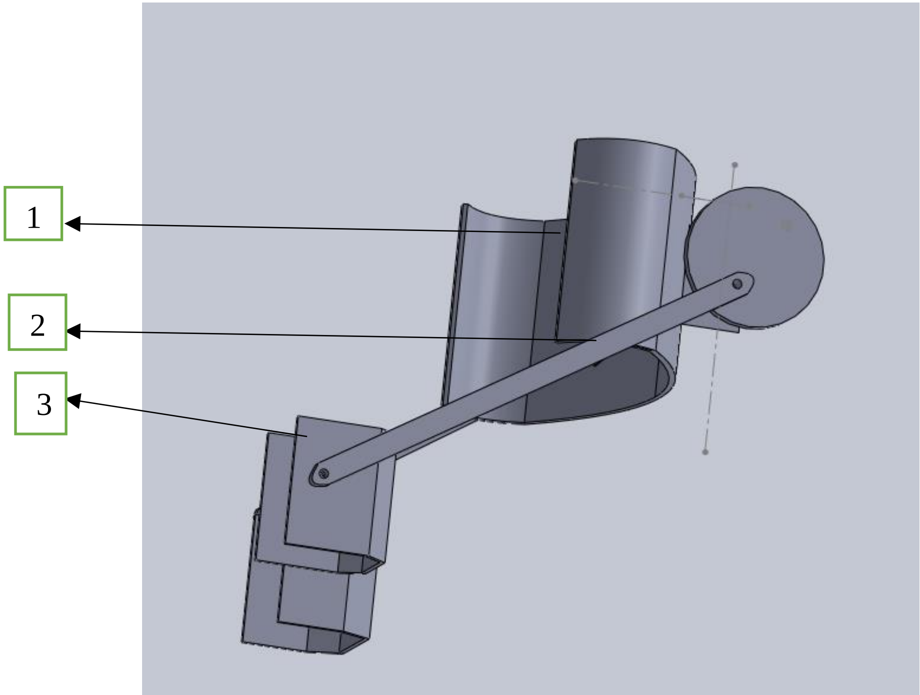

Fig. 3 Walking assistance 3D model; 1- Hip clamp; 2- Aluminum plate; 3- Thigh clamp

Thigh Clamp

This clamp pushes the thigh forward through skotch yoke mechanism using aluminum links and disc. The thigh clamp is fixed with the help of the simple wrap. All the components are wrapped with gap in the hip belt, thigh clamp leg clamp. The hip belt is wrapped.

Hip clamp

This hip clamp is designed for waist size 34cm. This hip clamp helps the aged people to hold the walking machine setup. This supports well at the hip and makes comfortable. This leg clamp helps the leg to move freely in front and backward direction with 2 degrees of freedom using aluminum links.

Hip belt

A conventional hip is used. The portion of the hip clamp is cut and the belt is inserted in the hip clamp and it is fixed promptly. The belt connection gap in hip clamp.

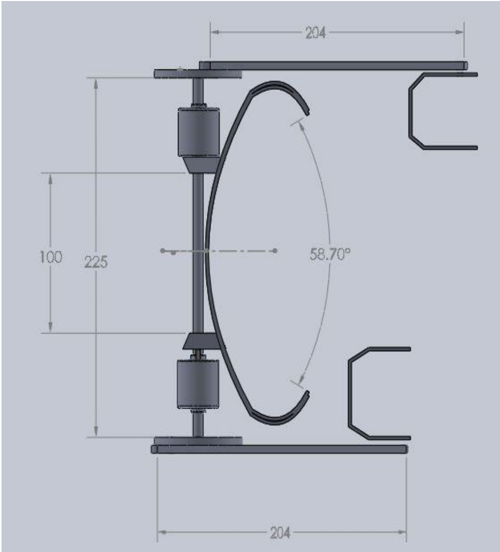

Fig. 4 Dimensions of walking assistance system

This supports well at the hip and makes comfortable such that all leg clamp helps the leg to move freely in front and backward direction with 2 degrees of freedom using aluminum links. The model is shown in Fig. 4.

Shaft

The shaft ends are squared of different dimensions to clamp the disc and that rotational motion is transferred to skotch yoke disc

Fig. 5 Assembled model of walking assistance system

Bearing

The bearing along with aluminum slot is welded with the hip clamp which makes to rotate shaft and rest of the welded components is held stationary.

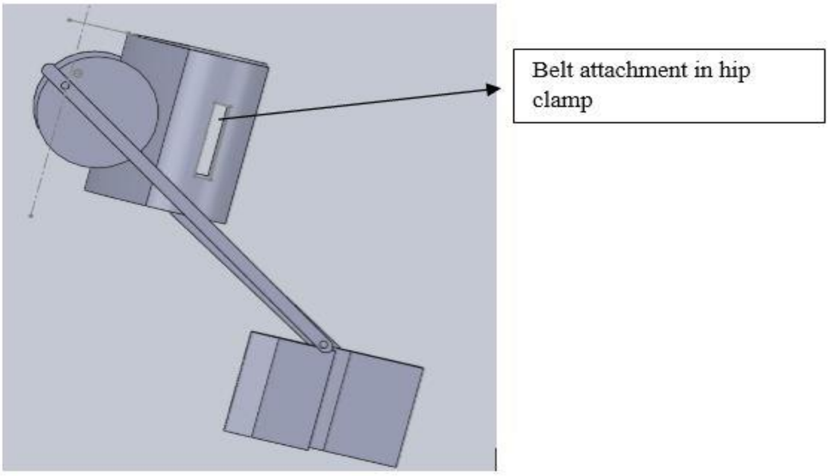

Fig. 6 Hip attachment

Aluminum disk

Here the disk rotational motion is converted into translational motion to aluminum plates. The disc of dimension 150mm diameter is used here. The stud is placed in 70mm from the center. The studs is connected with the aluminum connector. The rotation source is wiper motor.

Stud

The studs are used to connect aluminum plate and also helps to connect Aluminium links with hip clamp, thigh clamp and leg clamp. The components are fixed as shown in assembled model.

Connector

The connector is connected from the Aluminium disc to the thigh clamp. This connecter engages the translational moment from the disc.

Wiper motor

The conventional wiper motor is uses here and a compact 12 v battery is fixed the hip belt. And connected with the switch.

Working of walking assistance system

When the battery is switched on, the wiper motor runs. The gears are meshed parallel and the driven gear transfer the rotational motion to the aluminium shaft. The aluminum shaft welded with disc also rotates. The scotch yolk mechanism is defined with the disk and connector. The connector moves to and fro, which leads to action of walking.

Calculation for force on legs by wiper motor

Given (wiper motor) N=80 rpm

V = 12v

I = 7amps

P = V*I equation (1)

P = 12*7 =84watts

1watts =0.00134102209hp (1hp=746watts)

84watts = 0.1126hp

$$HP = \frac{2\pi NT}{33000} \quad \text{equation (2)}$$

$$T = HP * \frac{33000}{2\pi \text{n}} \quad \text{equation(3)}$$

T= (0.1126*33000)/(2*3.14*80)

T=10.03Nm

Motion of leg per rotation = skotch nut Diameter * angle of thigh clamp = 13.9mm in left leg in forward direction. When the forward motion takes place, it automatically creates the distance of 13.9mm in right leg. The control system and cost estimation is discussed in the later part of the report. But we are focusing on designing robots using mechanism without any sensor boards at low cost. The walking machine that were done is little weight with 2 degrees of freedom. We are doing research to reduce weight and also to increase degrees of freedom.

Advantages and disadvantages of the walking assistance system

Economical; Easy to manufacture; Simple components are used in this system, which makes it very easy to repair. The disadvantages are, walking posture is not very flexible; cannot be used for long distance.

2.2 Driving assistance system

The block diagram of the driving assist is shown in Fig. 7. The components used are Joystick, Microcontroller, steering motor, rack and pinion, knuckle, brake pedal motor, the linear actuator.

The system consists of three assistance system.

- Steering assistance system
- Braking assistance system
- Acceleration assistance system

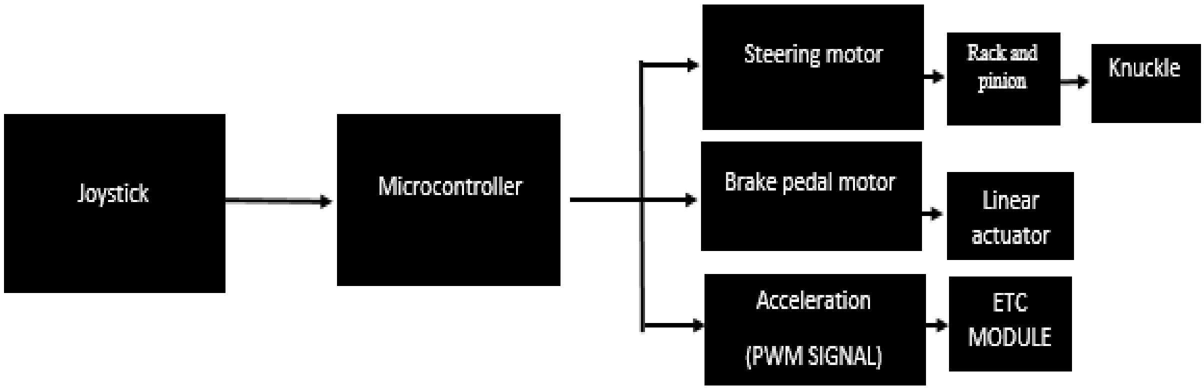

Fig. 7 Block diagram of driving assistance system

All the three system works parallel with the single microcontroller and the signals are continuously sent through the communication bus systems in the controller. All the systems work simultaneously and precisely. The results prove that this could be the promising system that could work efficiently.

2.2.1 Steering assistance system

The steering assistance system helps the driver to direct the vehicle in the desired direction. The horizontal axis of the joystick with the varying voltage helps the steering motor to rotate in the desired direction. The microcontroller precisely manipulates the change in position of the joystick. The helical rack and pinion system is used here.

Fig. 8 explains the working procedure of steering system. This assistance system is connected with the steering knuckle along with the conventional steering system. The knuckle is designed with innovative arms to support the joystick steering system. This steering assistance system is designed to a compact hatchback.

Fig. 8 Functional block diagram of steering system

The joystick is placed near the arm rest. Control of accelerating, steering, and braking are controlled through the joystick. 3d modelling of joystick is shown in Fig. 9.

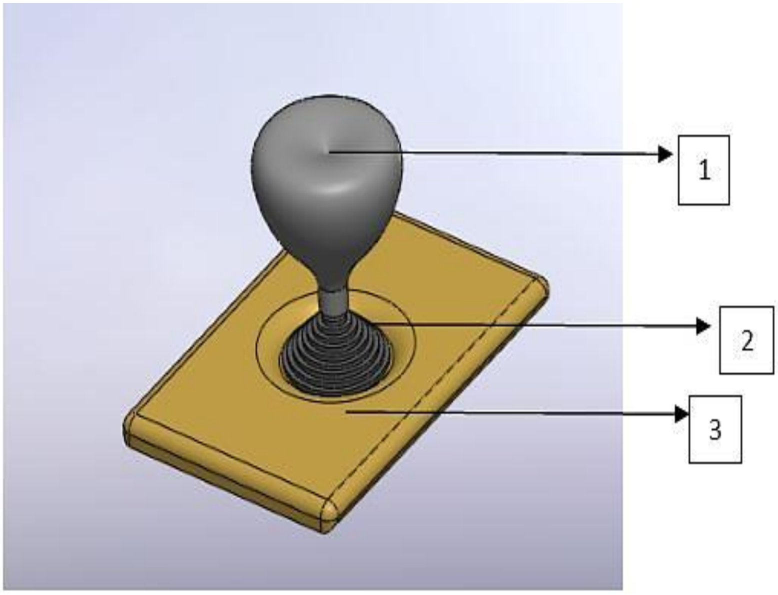

Fig. 9 3D Joystick model: 1- Joystick knob; 2- Rubber Joint; 3- Plastic support

The joystick can be used for control of speeding and direct the electric vehicle. The joystick knob is connected directly to the plastic plate with the rubber joint. This is the compact joystick with the of 10 mm. This is joytick dimensions are assumptions to fit to all people. So we have designed for 10mm dia and 10mm2 plate and a rubber joint.

Microcontroller

PIC controller is used in this system. It is very compact and it fits in comfortably with system. It varies from 8, 16, 32 bit controller, with a simple architecture and can be reprogrammed very easily with flash memory. In this driving assistance system, the program will vary upon the segment of the car, here we programmed this controller for compact hatchback. Architecture of PIC16F877A is shown in Fig. 10.

The voltage divider is the basic input of this driving assistance system. The varying voltages for corresponding 0 to 255 (voltage limits in Proteus programming). The corresponding voltage from 0 to 5 is matched with the software. The varying voltage is manipulated and the outputs are given out. The outputs obtained here are pulse width modulation and a signal to dc motor controller. The program is attached in the appendix

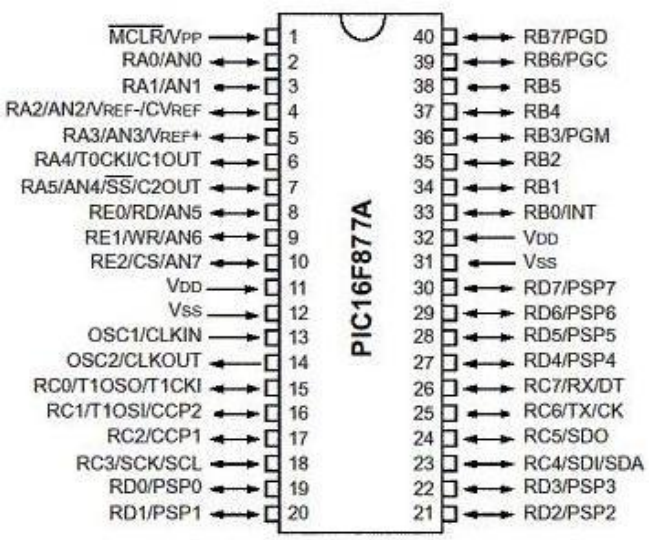

Fig. 10 PIC Controller

The specification of the controller are follows Program Memory Type: Flash; Program Memory (KB): 14; CPU Speed (MIPS): 5; RAM Bytes: 368; Data EEPROM (bytes): 256; Digital Communication Peripherals: 1-UART, 1-SPI, 1-I2C1-MSSP (SPI/I2C), Capture/Compare/PWM Peripherals, 2 Input Capture, 2 CCP; Timers: 2 x 8-bit, 1 x 16-bit; ADC: 8ch 10-bit; Temperature Range (C): -40 to 85; Operating Voltage Range (V): 2 to 5.5; Pin Count: 40.

Design of steering mechanism

The connected rack and pinion help to direct the electric car. As normal the pinion is constantly considered as the steering apparatus. For a rotational movement of the pinion, there is a straight movement of the rack. Therefore because of revolution of the helical gear, the rack interprets bringing about the use of power over the knuckle arm to steer.

Calculations for designing steering mechanism

In order to turn the vehicle, the steering mechanism is required. Nowadays most of the four-wheelers are having steering mechanism based on Ackerman principle. To design steering mechanism based on Ackerman principle, one method is to use rack and pinion with tie rods. In the present work, a new mathematical model is used to design steering geometry considering different geometry parameters. This mathematical model includes three equations. By solving this three equations we can get different steering geometry parameters by fixing some variables according to restriction and considering optimum steering geometry with respect to steering effort and ackerman. This model can be used for Ackerman and Anti-Ackerman steering geometry. During turning if I-centers of all wheels meets at a point as shown in *Fig. 14*, then the vehicle will take a turn about that point which results in a pure rolling of the vehicle. In Fig. 11 are showing the parameters in

Ackerman steering. The condition is called the Ackerman condition as shown in equation 1 and this principle is known as Ackerman-principle and the calculations are shown below.

$$cot\delta o - cot\delta i = \frac{b}{l} \quad \textbf{(1)}$$

Where,

• δo = outer wheel angle

• δi = inner wheel angle

• W = Track-width of the vehicle

• B = distance between left and right kingpin centerline

• L = wheel-base of the vehicle

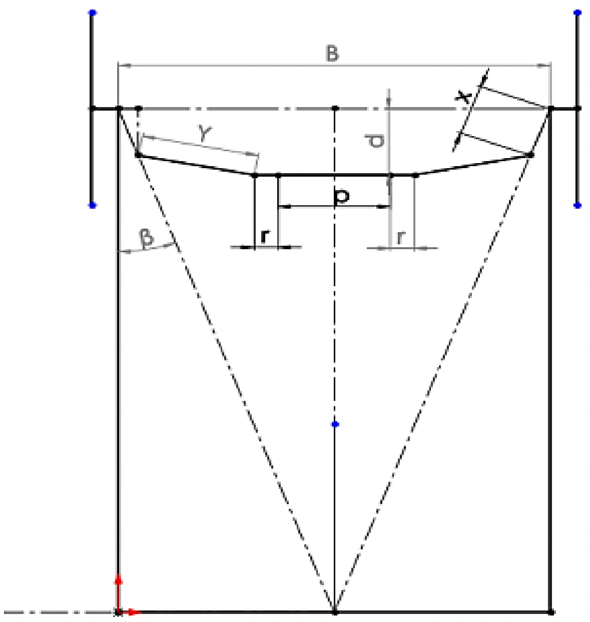

Fig. 11 Ackerman steering parameters

Where,

x= steering arm length;

y= tie-rod length (in top view);

p= rack casing length;

p+2r= rack ball joint center to center length;

q= travel of rack; d= distance between front axis and rack center axis;

β= Ackerman angle.

With the parameters, we have to obtain the equations for three conditions. The three conditions are for toe zero, Inner wheel and outer wheel condition [5].

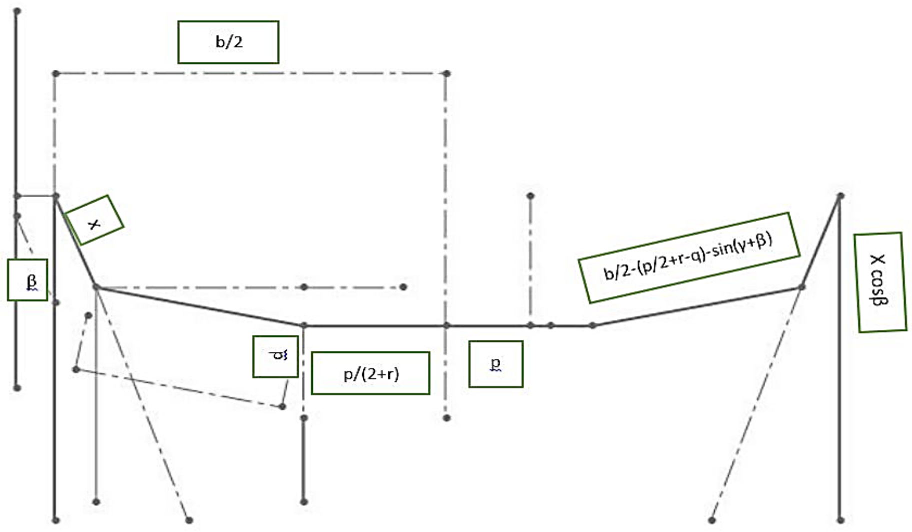

Fig. 12 Toe zero condition [5]

For toe zero condition $y^2 = [\frac{B-(p+2r)}{2} - x\sin\beta]^2 + [d - \cos\beta]^2$ [5] (2)

Inner wheel geometry $y^2 = [\frac{B}{2} - \left(\frac{p}{2} + r - q\right) - x\sin(\delta i + \beta)]^2 + [d - x\cos(\delta i + \beta]^2$ (3)

Outer wheel geometry $y^2 = [\frac{B}{2} - \left(\frac{p}{2} + r + q\right) + x\sin(\delta o - \beta)]^2 + [d - x\cos(\delta o - \beta]^2$ (4)

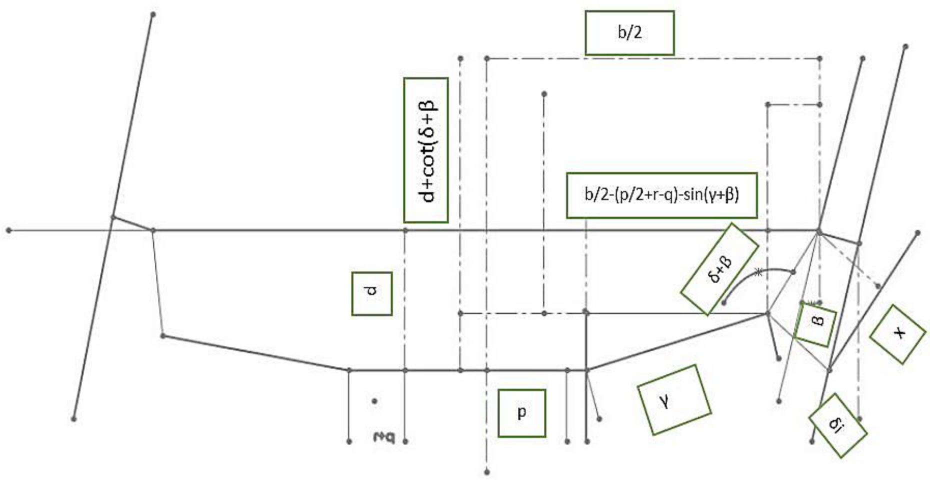

Fig. 13 Inner wheel geometry [5]

By solving all the three equations, the following results are obtained

1. Wheel-base L = 1.6 m

2. Track-width W = 1.3 m

3. B = 1.137 m

4. β = 20.457 deg

5. For Tata Nano rack p = 0.30 m and r = 0.07 m

X = 0.08 m is the design of steering arm in wheel hub assembly. When inner wheel angle δi = 40 deg and therefore as per. Ackerman principle δo = 27.296 deg.

Solving the equations 2, 3&4, we will obtain equation 5, 6&7. Results of this equations will give the required parameters such as rack distance.

$$y^2 = [0.4 - 0.38x]^2 + [d - x]^2 \quad (5)$$

$$y^2 = [(0.4 + q) - 0.9x]^2 + [d - 0.5x]^2 \quad (6)$$

$$y^2 = [0.4 - q + 0.09x]^2 + [d - x]^2 \quad (7)$$

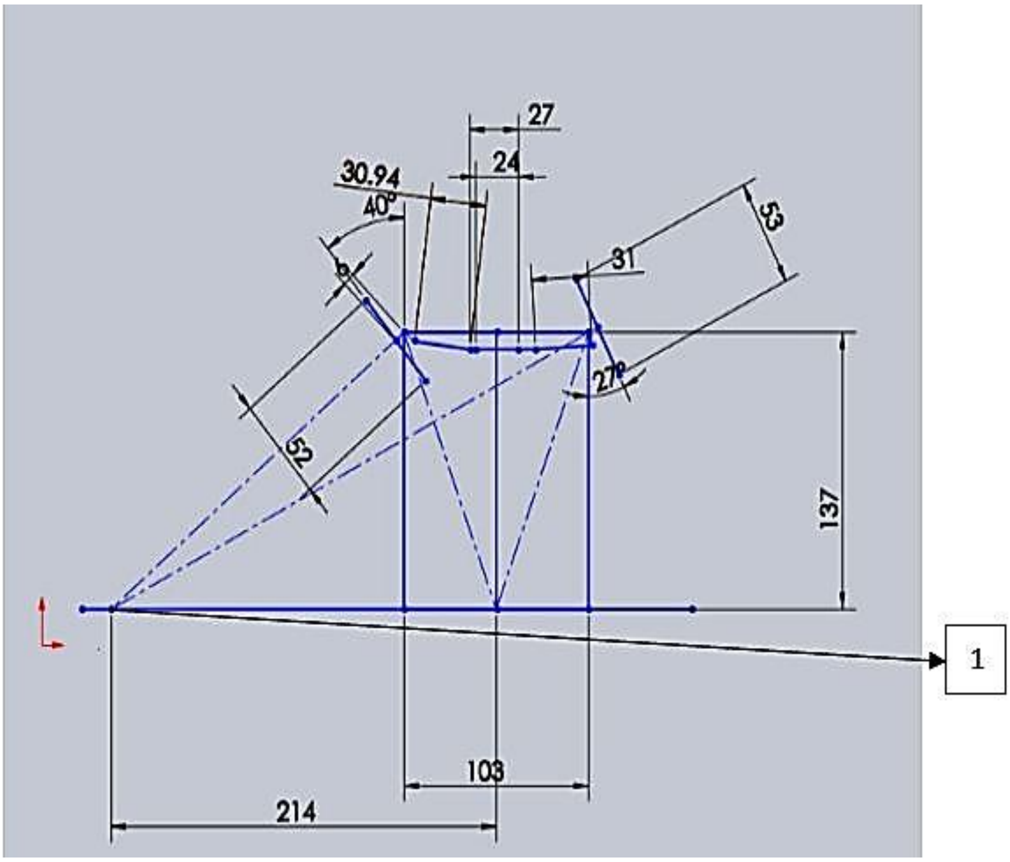

Fig. 14 Ackerman dimensions for steering 1. i point (turning center for all wheels)

With the corresponding values of the obtained equations to get tie rod length (y) and distance of steering from the center axis Travel of rack,

When inner wheel angle is 40 deg.

Y = 0.4 m

d = 0.1 m

q = 0.04

δi = 40 deg (Inner wheel angle).

Now the module for helical gear and rack is selected and designed in the solid works software. The specifications for helical gear and rack systems norms are studied. With the calculations and conclusion from the ackerman steering calculation, modules for gears are selected.

Table 2.1 Helical gear and rack calculations for rack travel per revolution

No.	Item	Symbol	Formula	Example	
				Pinion	Rack
1	Transverse module	mt	Set Value	6	
2	Transverse pressure angle	αt		20 deg	
3	Reference cylinder helix angle	β		10 deg 57’49”	
4	No of teeth & . helical hand	z		13	28
5	Transverse profile shift coefficient	xt		0	–
6	Pitch line height	H		–	27.5
7	Mounting distance	a	$\frac{zm_t}{2} + H + x_t m_t$	80	
8	Reference diameter	d	zmt	78.0	–
9	Base diameter	db	d cos αt	73.5	
10	Addendum	ha	mt (1 + Xt)	3	3
11	Tooth depth	h	2.25mt	13.5	
12	Tip diameter	da	d + 2ha	84	–

With selected module 6, the helical rack and pinion is designed and helix angles are indicated in the table 2.1. The solid work model is shown in Fig. 15.

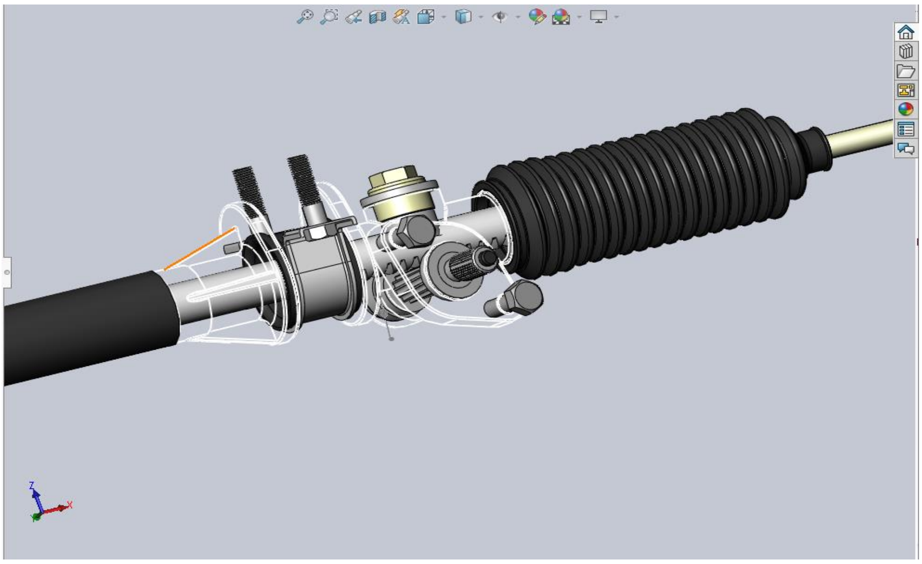

Fig. 15 Helical rack and gear

Rack and pinion calculation

Length of the rack as per calculation is = 400 mm

For pinion, Travel of rack per revolution of helical gear

$$l = m_t \pi z \quad = 6 * \pi * 13 = 245\text{mm}$$

As per Ackermann solution two revolutions will make the required rack travel for

Steering knuckle, Torque required in the steering knuckle

$$T = w * u * \sqrt{\left(\frac{(b^2)}{8} + E^2\right)}$$

W = weight of the vehicle on that side = 200 kg

U = friction co-efficient = 0.7

B = Width of the tire = 0.215mm

E = King pin offset = 0.0753mm

T = 30 inch lbs. => 4 NM

With the F.O.S = 16 NM

F = 1.5g

D = 970mm

This knuckle is designed to carry out the perpendicular load of 650 kg weight When de-acceleration pressure acting on it would be M = F * d = 150000 N mm (rounded value).

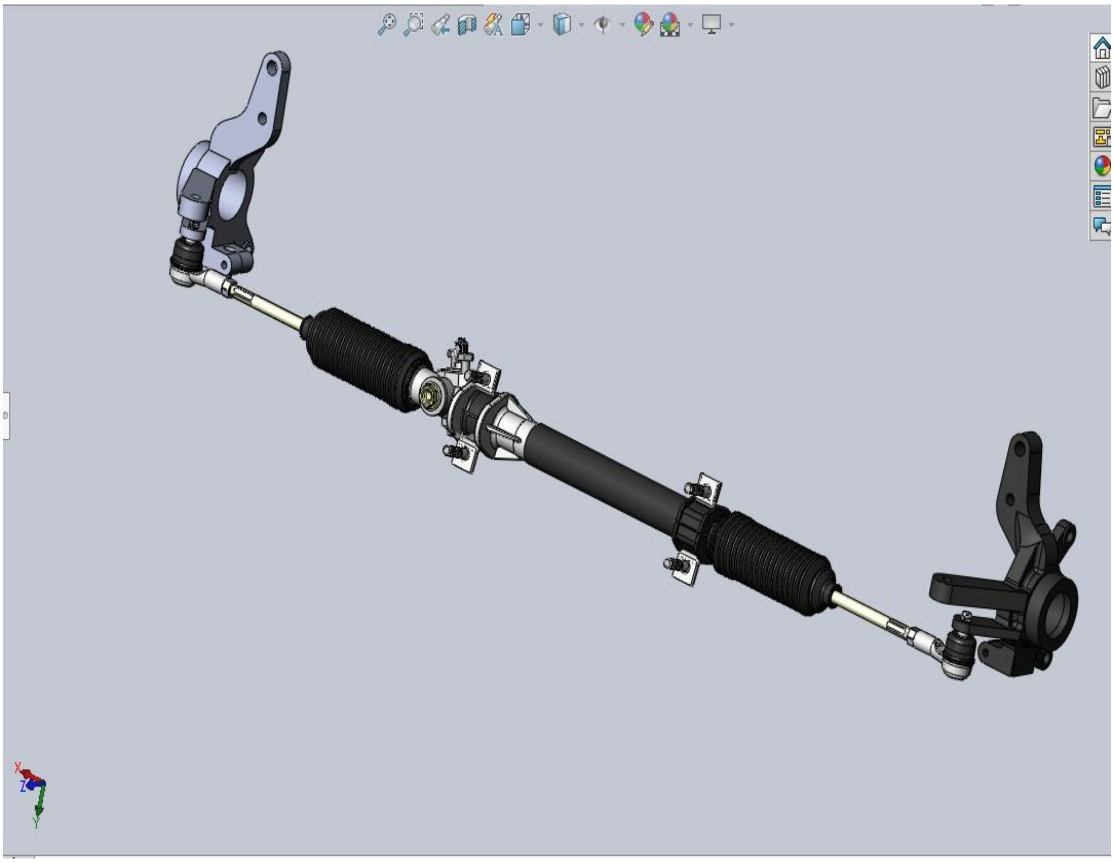

Fig. 16 Solid works model of steering system

With the calculated dimensions, the solid works model is created as shown in Fig. 16. The Rack and pinion are calculated and designed with module 6 as shown in Table 2.1. The conventional helical rack and gear system is used. We will discuss about the steering knuckle in the later section. This knuckle is designed to support the joystick control system. The 3d model of steering drawing is created as shown in Fig. 16.

Steering knuckle

This casting product will combine and act as a main source for connecting the lower-arm, suspension and disc pad allowing the wheel to turn towards the contact pitch on roads. Here an extra steering arm is designed along with the existing arm to make steering control through our joystick, which allows the wheels to turn. On cars with conventional suspension systems, the heavy bearings are fixed inside the knuckle. It should be quite strong to withstand the weight of the vehicle and to allow it to steer in the desired direction [6].

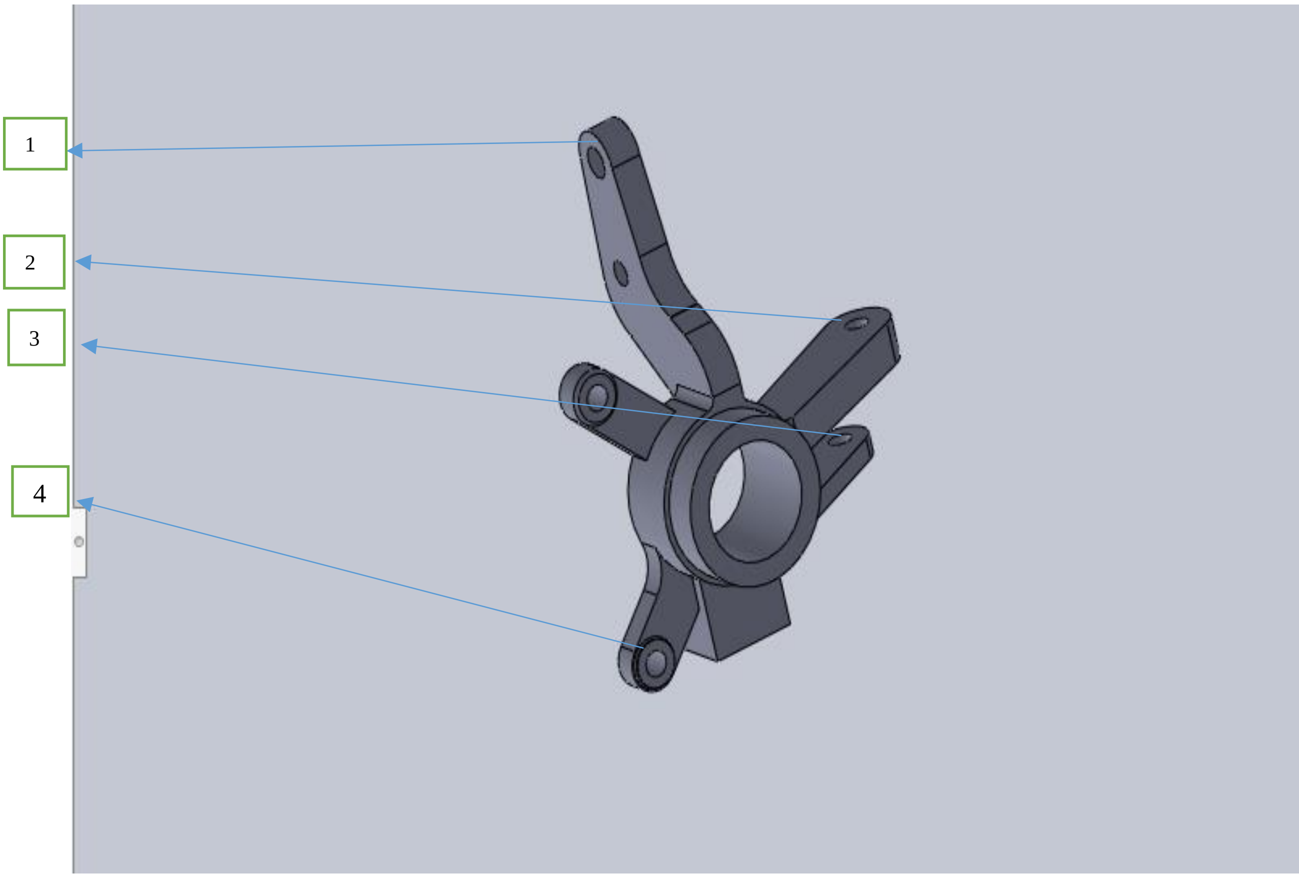

Fig. 17 Steering Knuckle; 1-Suspension mount; 2-Steering arm; 3-Disk brake pad mount 4. Extra arm.

The steering knuckle is the end joint which provides directional assistance as per the inputs of the steering wheel. The steering knuckle is a part of the wheel hub which is finally bolted to the wheels. Hence, the final directional changes are attained by the movement given to the steering knuckle.

The analysis subjected to the steering knuckle are

Total weight = 650 kg with F.O.S 4

Force acting on knuckle = 150000 N mm (quarter car analysis)

Shape optimization [7] is could be done in the material platform to reduce deformation, but defining a material which is not deforming under the sudden impact of force should be studied. It is utilized to produce material format ideas though shape streamlining refines and enhances the topology inside the idea. Fit as a fiddle improvement, the external limit of the structure is altered to take care of the deforming issue. Here extra knuckle arm is designed for joystick controlled steering.

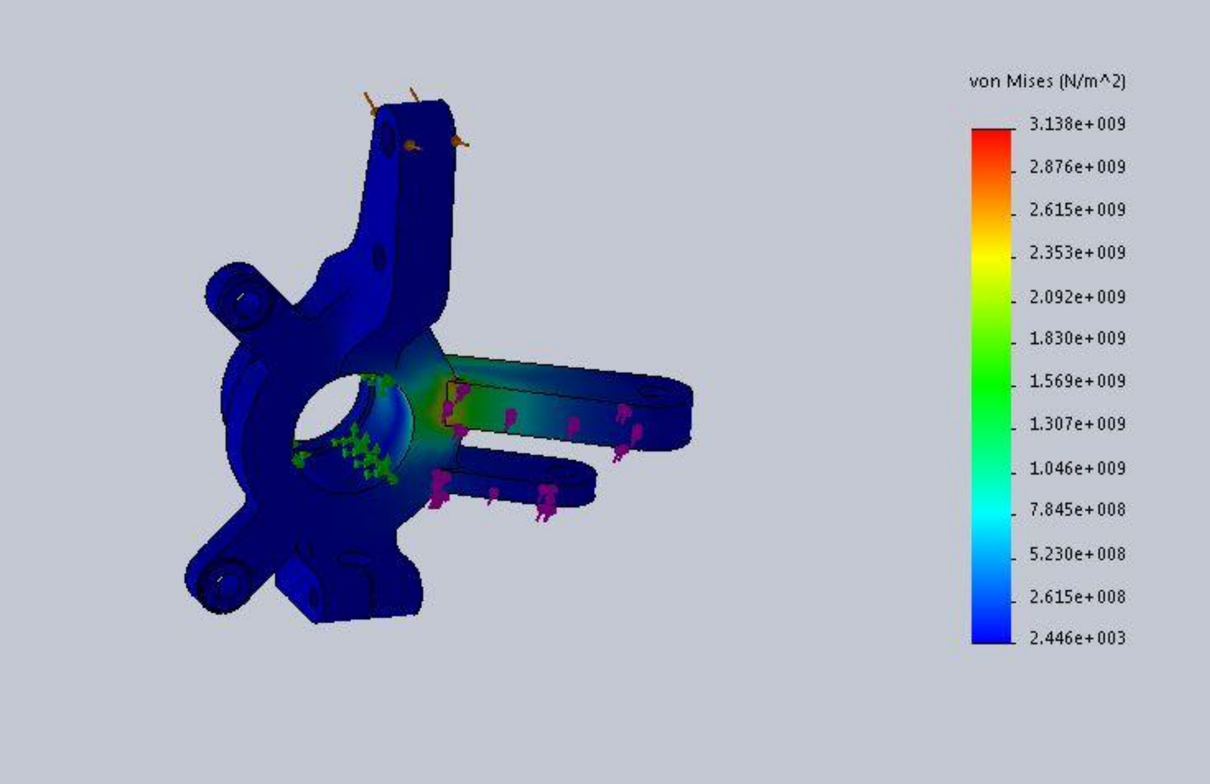

Fig. 18 Stress result of steering knuckle

Stress and deformation of knuckle analyzed when different forces such as braking force, load transfer during acceleration and braking etc. are applied. The result shows the steering knuckle will withstand both conventional steering system and joystick steering system shown in Fig. 18.

Static analysis of knuckle deformed: 0.140 mm;

Stress on arm: 64Mpa.

Electric power steering motor

The steering motor is mounted and connected to the helical rack system to support the steering mechanism. The motor should be compact and should provide required torque to steer the vehicle. This motor fulfills the requirement of the driving assistance system. The specifications of the motor are mentioned below. The motor varies for different segments of cars. Here a simple steering motor for a compact hatchback is assumed.

Specifications of steering motor

Specification: Rated voltage: 10V DC, Rated power: 525W, Rated speed: 1250rpm, Rated torque: 4.0N x m, Rated current: 98A, Line resistance: 0.022Ω, Torque constant: 0.041N x m/A, Rated duty: S2/3 minutes, Rotation direction: two-direction rotating, Insulation grade: F level, Protection grade (IP grade): IP66, Noise level: <65dB [8].

Fig. 19 Steering Motor

Withstanding voltage (against ground) : >1000V, Pole number: 8 poles, Wire connection mode: Y-type, Storage environment: -40 to 125°C, Operating temperature: -40 to 150°C, Service voltage: 9 to 16V DC, Wire-leading specification type: car wire AWG10 [8].

Simulating the DC motor

The simulation is done using the Simulink as shown in Fig. 20 and it has efficient torque and speed characteristics in relative to the control of the joystick. The initial torque is very high. The motor is proved to be well suited for our project.

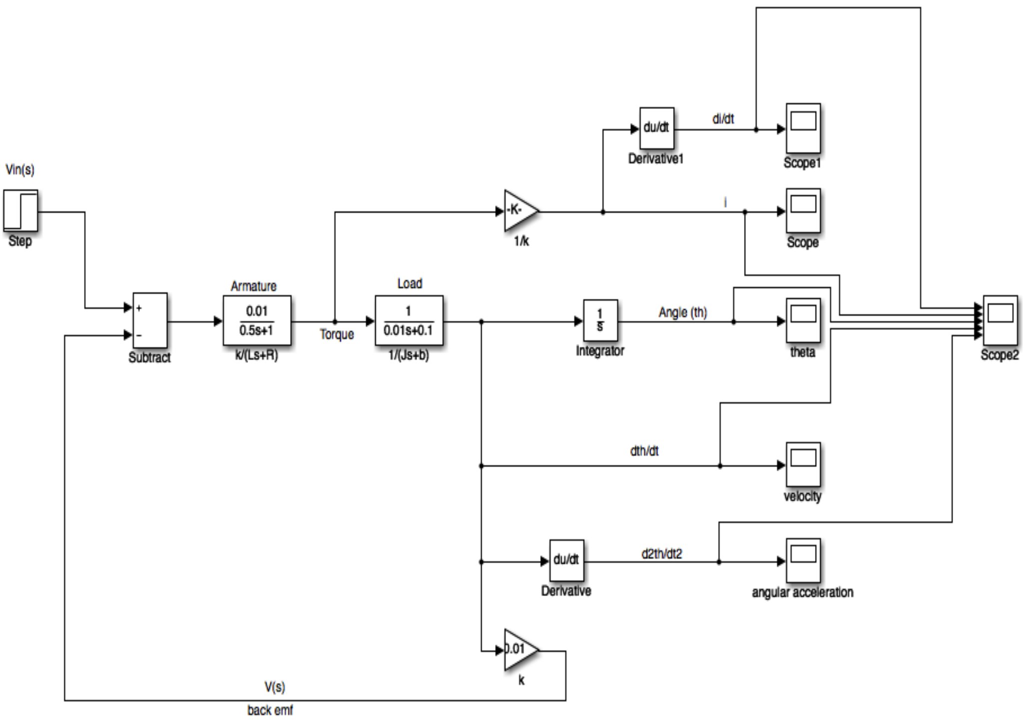

Fig. 20 Simulink model of dc motor

We have studied transfer function of the dc motor to analyze the characteristics of the dc motor. The input signal from the potentiometer is not analyzed here

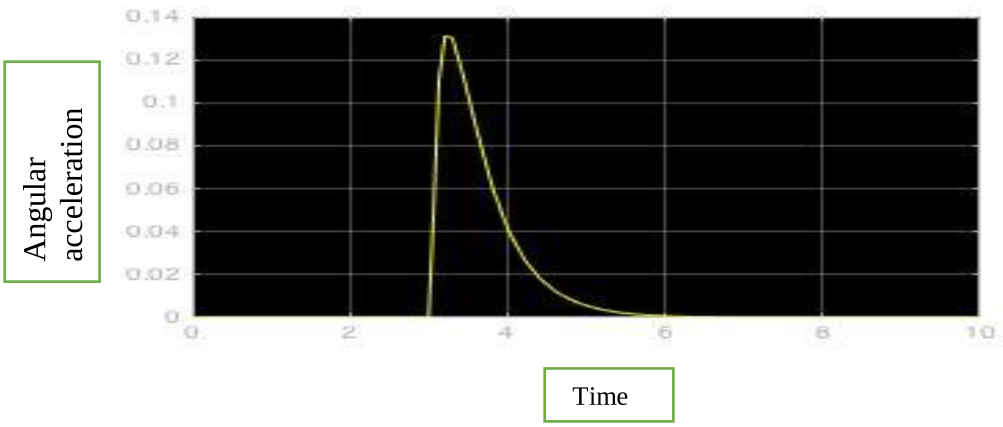

Fig. 21 Angular acceleration vs time

Since transfer function is the output model to input model. Here angular acceleration result is taken from the scope as shown in Fig. 21

2.2.2 Braking assistance system

The braking assistance system helps to decelerate the vehicle with the simple motion of the joystick in the negative y direction of the joystick. Fig. 22 explains the working structure. This axis position is programmed to de-accelerate depend upon the position of the joystick. The simple linear actuator is used to complete the action of braking. The actuator gets powered from the motor and provides the linear action on the pedal. The motor is controlled precisely through the microcontroller.

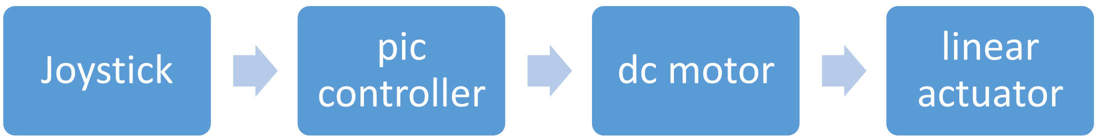

Fig. 22 Functional block diagram of braking system

The compact linear actuator designed to hit the pedal on the control of joystick. The actuator acts linearly upon the position of the joystick. The variable voltage precisely actuates the pedal. The linear actuator consists of a gear which controls the linear actuation of the pedal. Braking is powered by the simple servo motor. The motor is programmed to the maximum of two rotations. Which gives the efficient braking as well as life to the compact linear actuator is shown below.

Motor Type:	Coreless
Bearing Type:	Dual Ball Bearing
Speed (6.0V/7.4V):	0.15 / 0.12
Torque oz./in. (6.0V/7.4V):	333 / 403
Torque kg./cm. (6.0V/7.4V):	24.0 / 29.0
Size in Inches:	1.57 x 0.78 x 1.45
Size in Millimeters:	39.88 x 19.81 x 36.83
Weight oz.:	2.30
Weight g.:	65.20

Fig. 23 Braking assistance motor specification

We use HS-7954SH in this project. The specifications as shown in Fig. 23 it assists the braking with the required amount of braking force. It could be considered as the cheapest high voltage, high torque and coreless servo on the market. It has added of benefit of our high-voltage coreless motor.

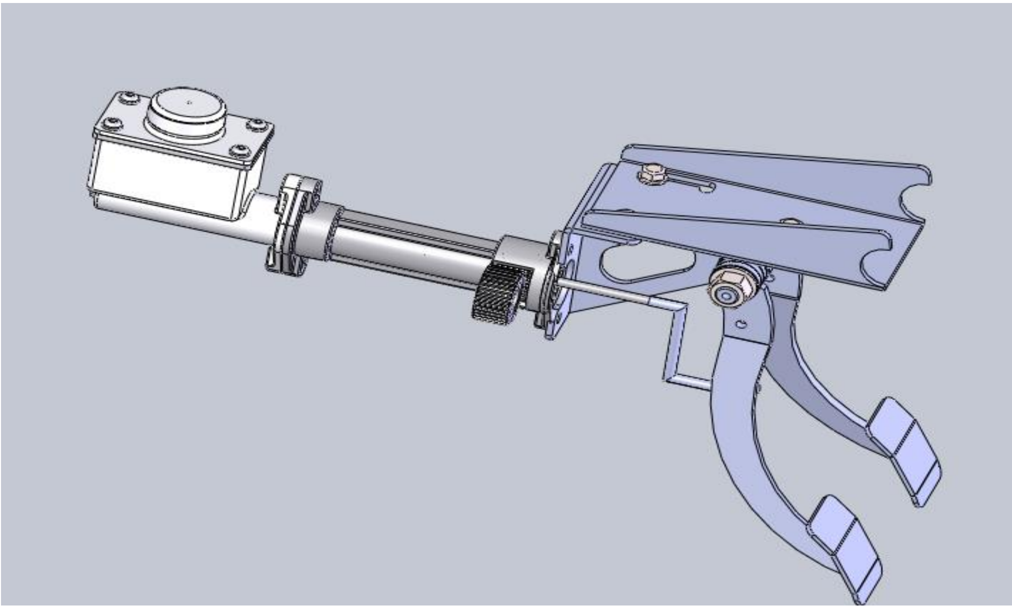

Fig. 24 Model of braking assistance system

The linear brake actuation system is designed with the solid works and shown in Fig. 24. The actuation system is placed behind the pedal with the connector to make contact with the pedal. The actuator forces the pedal to press against it and completes the braking action. The actuator design is shown in Fig. 25. The actuator consists of a head screw which is fixed in the spiral design. The rotation of the spiral design makes the linear action of the head screw. The head screw is connected with the connector which forces the pedal. This could be the simple mechanism, which is compact and provide the required force to press the pedal.

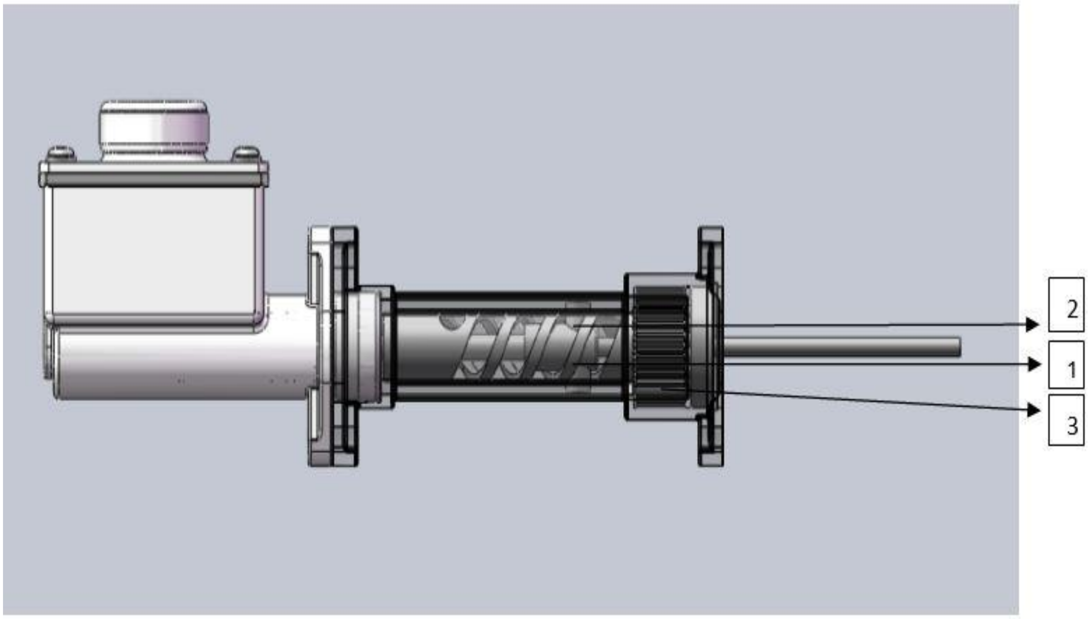

Fig. 25 Linear brake actuation system. 1-Barrel 2-Head 3-Driven gear.

A survey was done to get the values of pressure applied to the brake pedal of an automobile. The conclusion of the survey is that, 5th percentile people apply a maximum brake pedal force of about 400N, it is concluded that this value could be taken in analysis for knowing stress in the designed component. With the result, it is clear that there is no possibility of mechanical failure under this loading constrains. The analysis is made with following factors as shown in Fig. 26. The stress is given load in the barrel with the pressure of head. The thickness of 0.5mm is given in the barrel shaft. In analysis, it should replace the braking work done by the driver.

The pressure at the head screw = 400N (maximum)

The pedal motion for one revolution = 6 cm

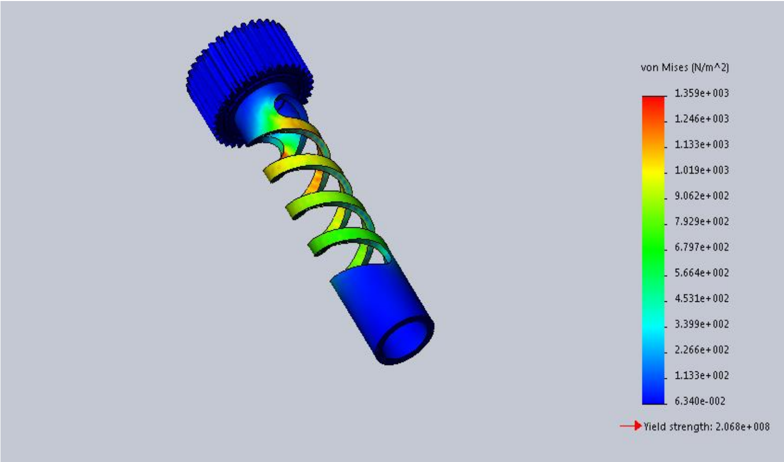

Fig. 26 Barrel stress analysis

The analysis is made with the calculated and applied forces on barrel for linear motion on barrel. The analysis study when the driver hits the brake pedal and the analysis of linear actuator motion against the pedal is also proved to be the same action of pressing the pedal through the study.

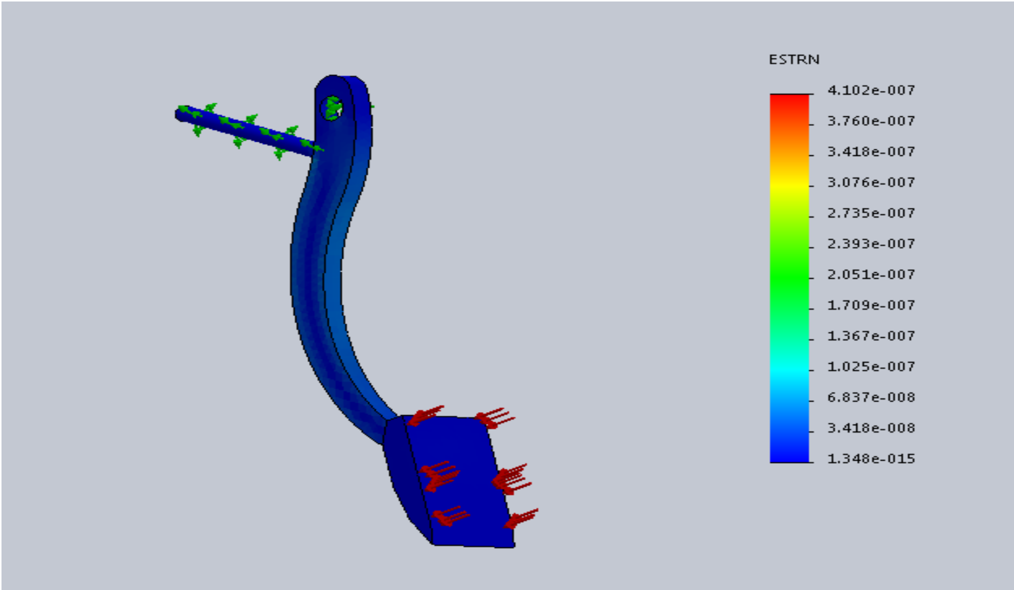

Fig. 27 Stress analysis on pedals

The above Fig. 27 result shows the stress result of 400 N on conventional braking method on the braking pedal. We will compare the result of conventional braking method and joystick controlled braking method. The obtained result would replace the braking action without any user action and could be completed through the actuation system. It could not be concluded as advantage or disadvantage, only with the practical results it could prove brake pedal life, but the working of actuator and results in the analysis seems to be promising for doing braking action without the failure.

(a) (b)

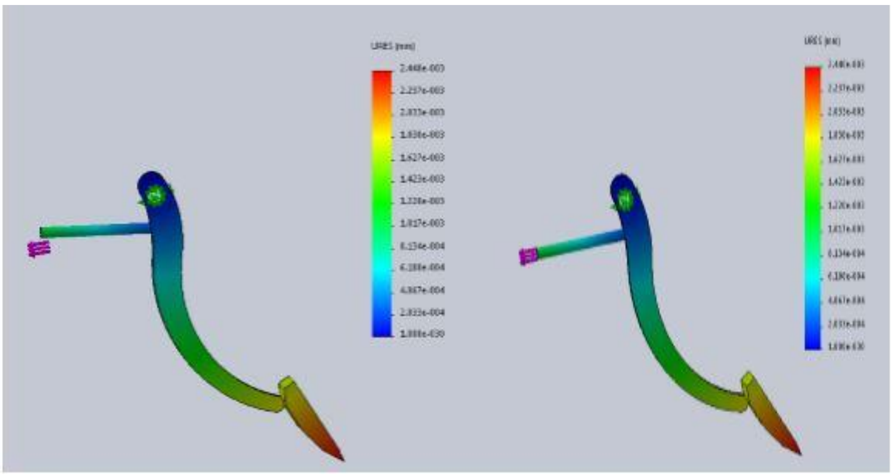

Fig. 28 Pedal stress analysis deformed (a) and un-deformed (b).

Here in Fig. 28, we can see from the result that the linear actuation system, on applying 400 N will provide the action of the braking.

2.2.3 Acceleration assistance system

The electronic throttle control is the rising trend in automotive technology. This system is not an innovative, as it is introduced in Bavarian motor works on their higher end series 2 decades ago. This concept now used in almost all the segments of the automotive industry. Always a mechanical linkage is fixed with the throttle pedal, which open ups the throttle body to supply more air in order to increase the speed of the vehicles. Now, this electronic throttle control replaced the mechanical linkages with sensors. This system can be called as 'Fly-by-Wire' as shown in Fig. 29. Electronic throttle control is far way better than the conventional throttle cable. With the help of electronic throttle control, the efficiency of the engine and mileage can be increased per liter of gasoline. The mechanical throttle systems only control the mass airflow intake, but this electronic throttle can be connected with the engine control module and get all the required information's like temperature of the engine, rpm of the engine, mass air flow rate and fuel injection rate. PWM signals are obtained from PIC and sent to the control module.

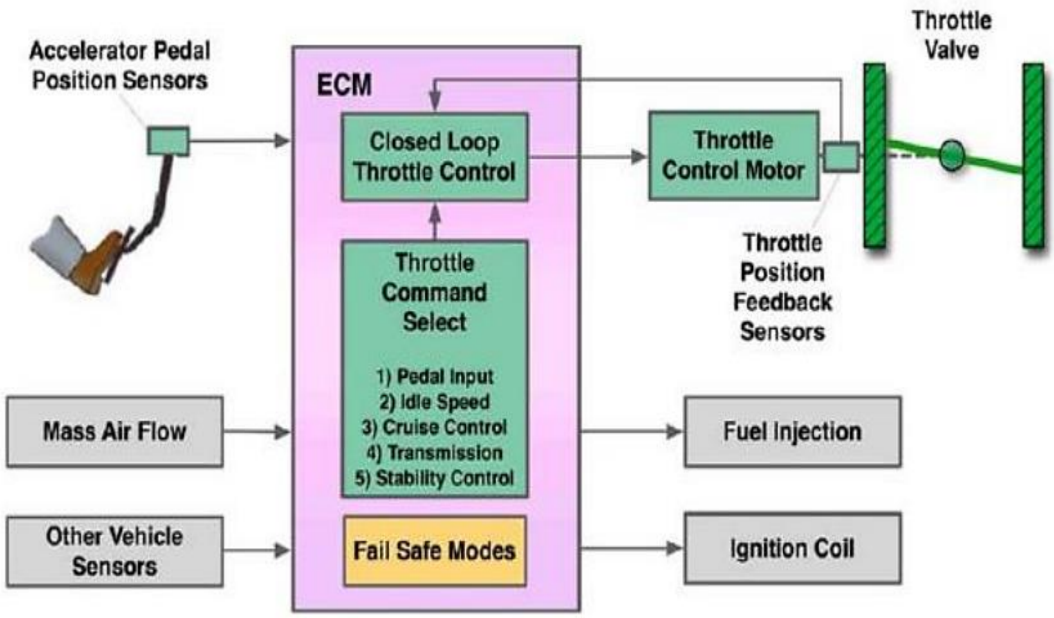

Fig. 29 Throttle control module [18]

Conditions for acceleration in driving assistance system

The main motto of the project is to design for differently abled persons to the drive car. When approaching for acceleration. Each vehicle is integrated with Autosar software, but it is hard to design this system for each vehicle. It cost too much to buy this software and installation will be technically takes a long time. So an acceleration sensor is added with one more connection for the PIC controller module. When the joystick is used, the relative signal of the voltage from the joystick is manipulated for the pulse width module signal.

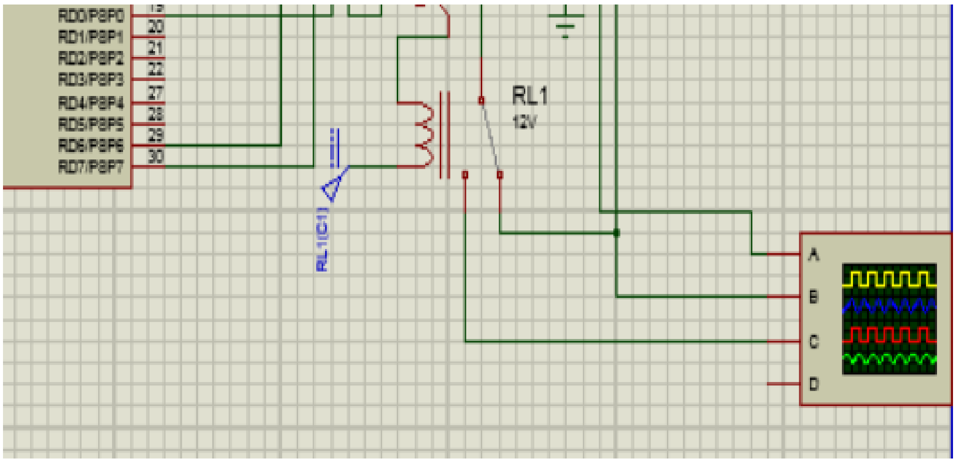

Fig. 30 PWM signals for acceleration

This signal is given as square waveforms through the pic controller as shown in Fig. 30. The wave forms signals are connected to the electronic throttle control module. This module infers the signals and adjusts the throttle body. The relay is used during the joystick operation to disable torque sensor. When the torque sensor is disabled. It enables joystick controlled motor for steering. This will help for easy installation for any kind of cars with electronic throttle control. Mostly most of the today’s car are enabled with electronic throttle control.

3. WALKING AND DRIVING ASSISTANCE CONTROL SYSTEM

The control system for walking assistance and driving assistance system is explained in this section. We have used Proteus software for the working simulation of both assistance system. The walking assistance system consists of a simple motor to control it in both forward and backward motion.

3.1 Flowchart of walking assistance system

The simple flowchart gives the detailed version of working procedure of the walking assistance system shown in Fig. 31. The system will check whether the motor is switched on or off. In the case of there will be no change in the system. Suppose, the motor is switched on, the motor transmits the power to the pinion through the gear fixed in it

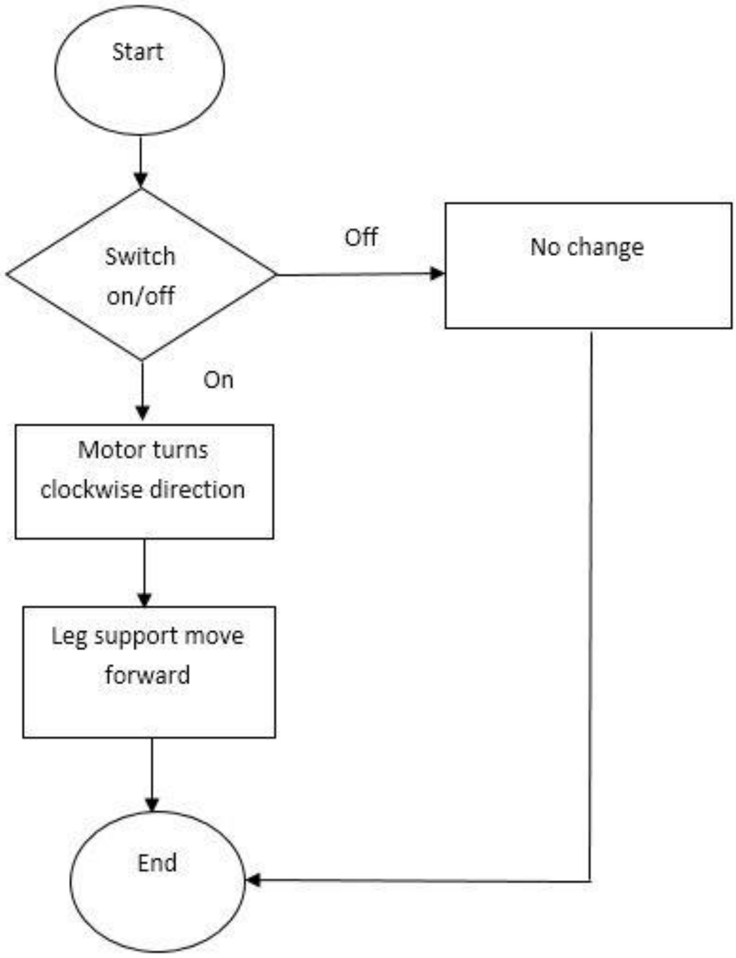

Fig. 31 Flowchart of walking assistance system

The pinion is connected to the shaft. Both the shaft are connected with the disc. The disc is based on skotch yolk mechanism. The mechanism is connected the both end thighs and legs of the user. Here electrical energy is directly converted into mechanical energy, which means the mechanism will lift the legs and initiates the walking motion with the help of the motor through the connector.

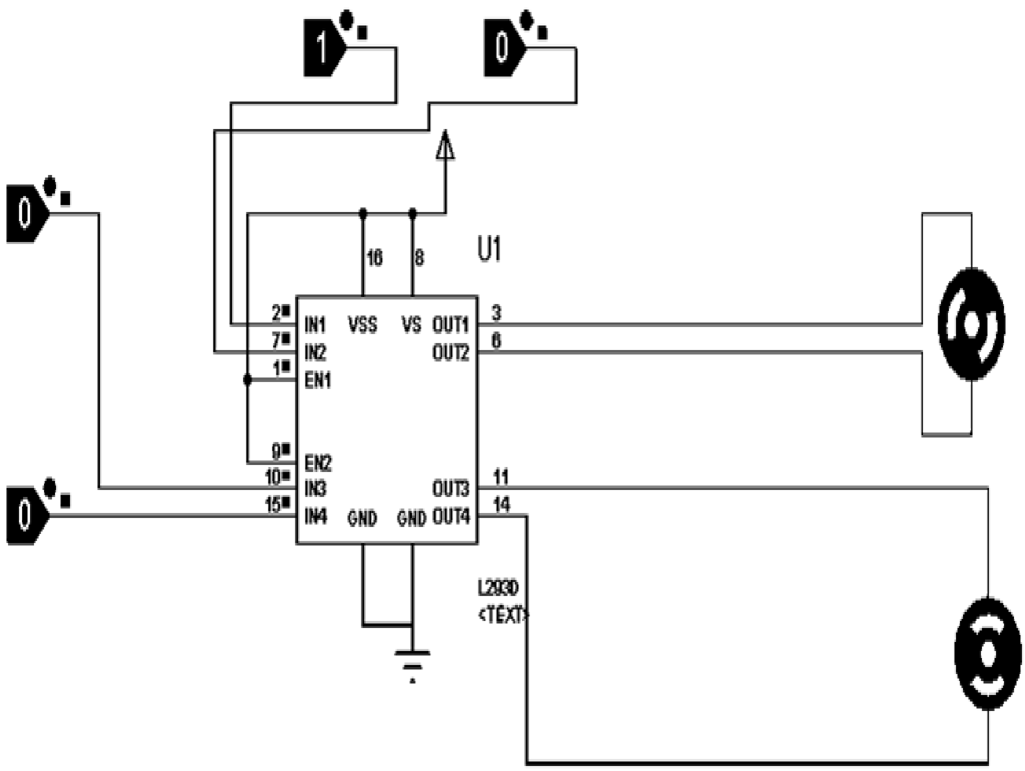

Fig. 32 Control system of walking assistance system

The Fig. 32 is shown above. The simple circuit represents the working of the wiper motor, which enables the person to lift the leg. The circuit connections are made using proteus software. The control system is designed in such a way that it will help the person to move forward and backward direction. The working model proves to be compromising to assist elderly person to walk easily without much effort. The program is attached in the appendix.

3.2 Flow chart of driving assistance system

The flowchart describes the working model of the driving assistance system and shown in fig 33. The joystick is connected to the car battery and the microcontroller is powered with the battery, which controls all the functions of the joystick. When the ignition is on, and the user selects to use the joystick control system. He has to turn the relay on.

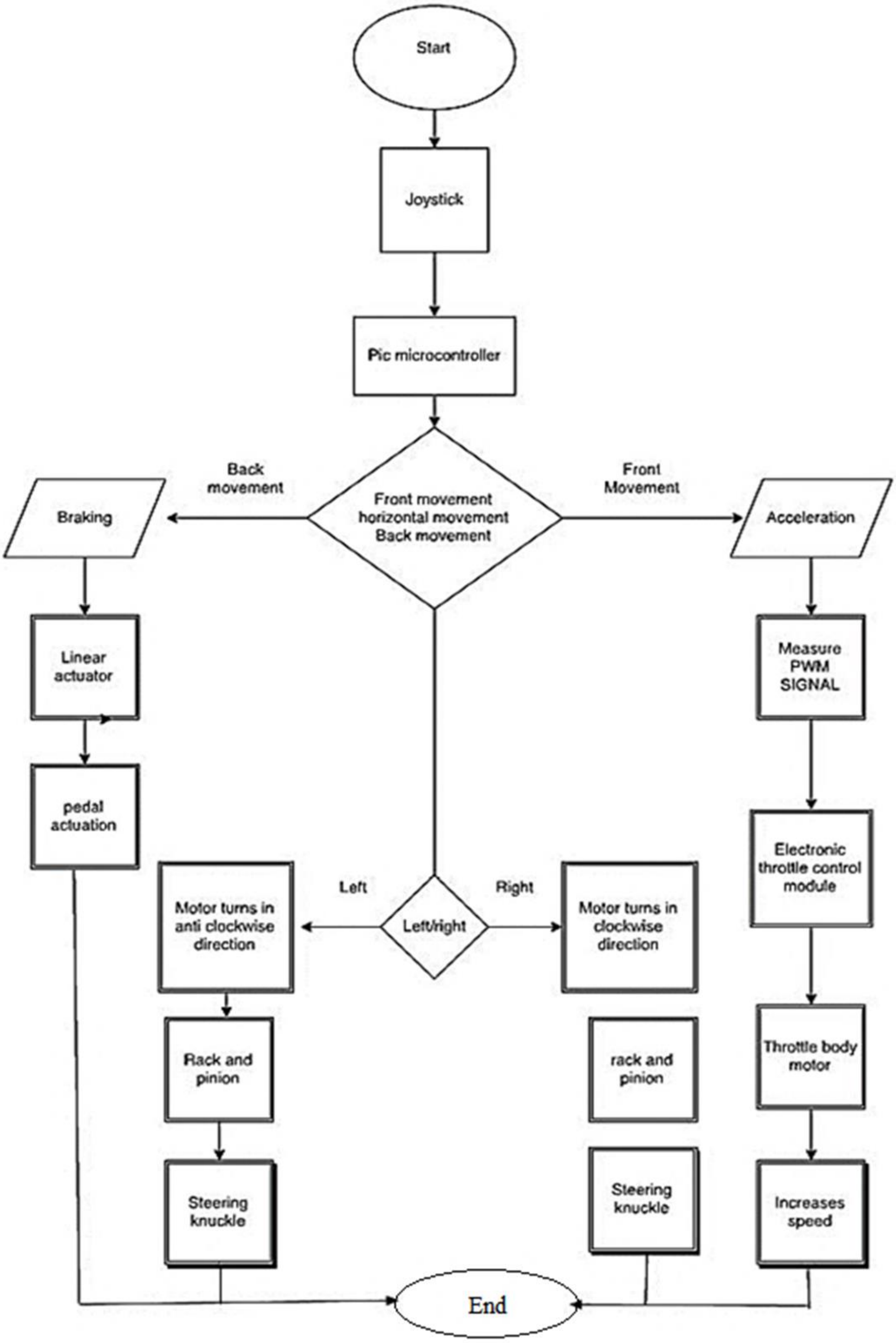

Fig. 33 Flow chart of driving assistance system

The diagram below shows the schematic circuit diagram of driving assistance system. Here the voltage divider is placed on the left side of the circuit. It is connected to the input pins 16 and 17 for steering and braking in microcontroller as shown in Fig. 34.

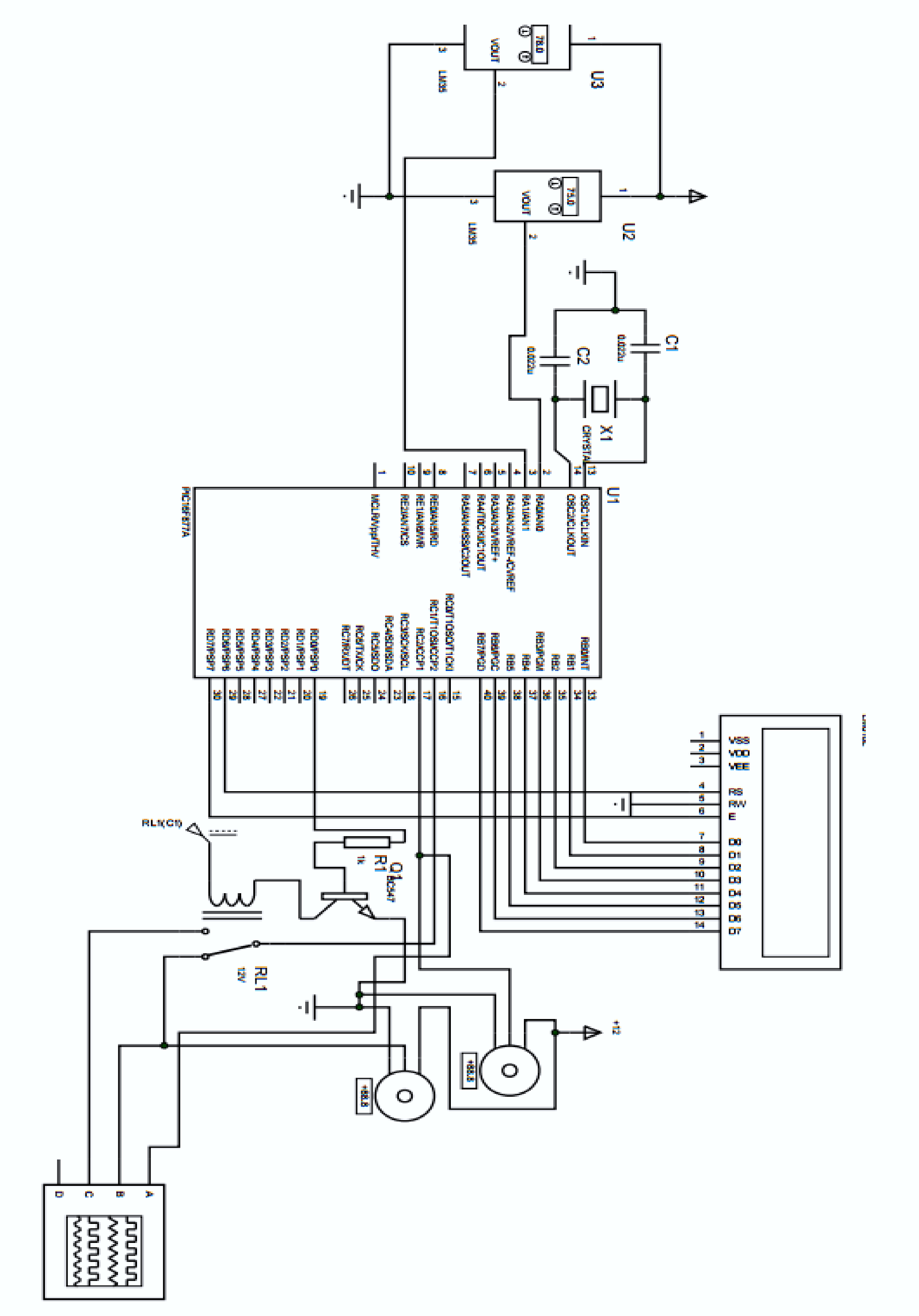

Fig. 34 Schematic circuit diagram of driving assistance system

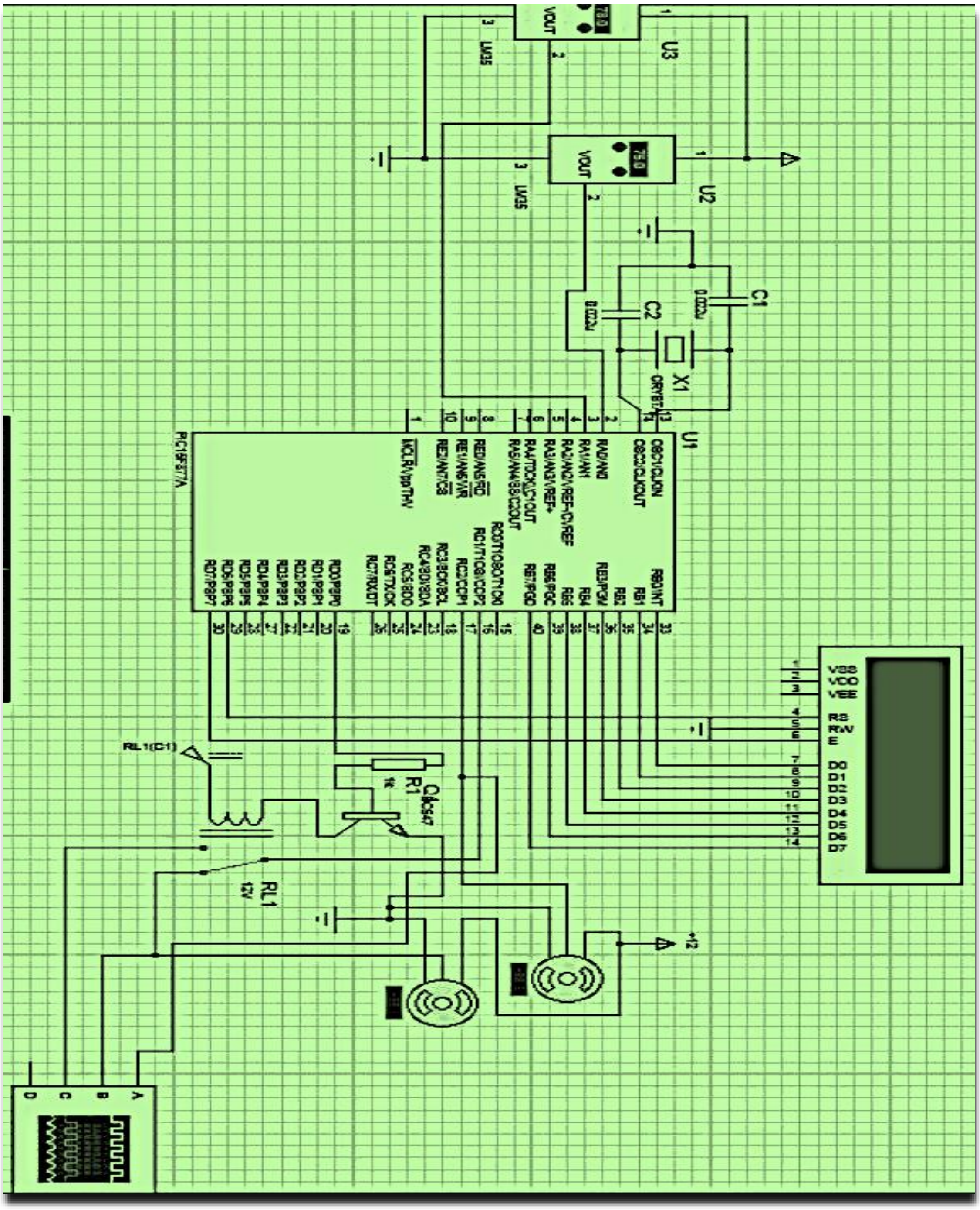

Fig. 35 Simulation of driving assistance system in Proteus software

The PWM signals are obtained from the pin 19 and the joystick input are given in 2, 3, 13&14. For accelerating the vehicle, the microcontroller gives out the pulse width module analog signal to the electronic throttle control module. The module gets the input of the square wave and opens the throttle body upon the movement of the joystick. The connection of driving assistance system is connected successfully and the simulation is positive as shown in Fig. 35. The program script is attached in the appendix.

4. COST ESTIMATION

The walking assistance proves to be every cheap and economical to manufacture it. The components and working cost of the walking assist have been listed below in Table 4.1.

Table 4.1 Economical cost

Components and working methods	**Cost in euros**
Wiper motor	5
Battery	7
Aluminum rods	8
Aluminum plates	7
Aluminum sheet metal	2
Sheet metal bending	1
Mild steel rod	4
Gears cutting	2
Machining charge	15
Labor charge	15
Aluminum welding	4
Nuts ,bolts , grub screw	2
Waist belt	7
Miscellaneous	13
TOTAL	90

The table above includes the total cost of the waking assist. Since it is made separately, the cost seems to be little higher. In case of high production, the cost would be reduced into half of it. The cost management should be studied further to reduce the cost. This system should be improved more economically, ergonomically and to reduce cost.

4.1 Driving assistance system costing

The costing system of steering knuckle is obtained through the solid works. The knuckle is innovative product and it’s one of the solutions to control steering mechanism through the joystick control system. The costing sheet below explains the cost from material till the product.

Table 4.1 Driving system cost estimation

Driving assistance system components	cost in EUROS
Tata Nano steering arm and assembly	80
Linear actuator	30
PIC micro controller	3
Wiring	2
Joystick	4
Knuckle	15
Other expenses	10
Total cost	143

The cost describes that the whole system cost only in 143 euros. This system is the cost for compact cars with standard dimensions of track width and length. It could be installed in any cars but the costing will be approximately equal to this estimated cost. In case of very high manufacturing goods. The costing will be very economical when it is manufactured in huge plants

5. CONCLUSION

1. Walking assistance system is designed, fabricated for hip size 34cm and it assisted comfortably for walking . Each rotation of disk will assist to move 13.9cm.
2. Driving assistance system is designed and analysed for compact sedan cars with pulse width modulation signal for acceleration, maximum braking of 400 Newton is tested in linear actuator and steering force with F.O.S 4 is analysed in knuckle and results were successful without mechanical failure.
3. The control system for walking and driving assistance system is programmed and simulated using Proteus software and results for Pulse Width Modulation for acceleration and electronic signals are obtained.
4. Cost estimated for walking assistance system is 90 euros and driving assisting system is 143 euros, Which proves to be more economical to install in a compact hatchback segment.

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APPENDIX

```
#include<pic.h>
#include<htc.h>
#define _XTAL_FREQ 20000000
__CONFIG(FOSC_HS &WDTE_OFF &  PWRTE_ON & CP_OFF & BOREN_ON & LVP_OFF
& CPD_OFF);
void delay();
void delay1();
void delay4(int);
void lcd_data(unsigned char);
void lcd_com(unsigned char);
void comn_data(unsigned char,unsigned char*);
void lcd_init();
void adc1();
void adc2();
void val(unsigned int);
void vall(unsigned int);
#define lcd PORTB
#define rs RD6
#define en RD7
#define in1 RD0
#define input2 RD1
#define input3 RD2
#define m1 RD4
#define m2 RD5
int flag2,flag1,flag3;
unsigned int a,b,d1,d2,d3,d4,d,a1,b1,d11,d21,d31,d41;

void msdelay(unsigned int time)  // Function for creating delay in milliseconds.
{
   unsigned i,j ;
   for(i=0;i<time;i++)
   for(j=0;j<12;j++);
}
```

```
void main()
{
PORTB=0X00;
TRISB=0X00;
PORTD=0X00;
TRISD=0X00;
PORTC=0X00;
TRISC=0X80;
PORTA=0X00;
TRISA=0XFF;
CCP1CON=0x0c;zdv
CCPR1L=0;
CCPR1H=0x00;
CCP2CON=0x0c;
CCPR2L=0;
CCPR2H=0x00;
INTCON=0xc0;
T2CON=0x06;
PR2=0xff;
TMR2=0x00;
//TMR1L=0x00;
//TMR1H=0x00;
//T1CON=0x03;
lcd_init();
while(1)
{
adc1();
adc2();
a1=(a/2);
b1=(b/2);
if(a<155)
{
CCPR1L=a1;
}
else
```

```
{
CCPR1L=-a1;
}
if(b<155)
{
in1=1;
CCPR2L=b1;
}
else
{
in1=0;
msdelay(500);
CCPR2L=-b1;
}
/*in1=1;
msdelay(b1/16);
in1=0;
msdelay(b1/16);
in1=1;
msdelay(b1/16);
in1=0;
msdelay(b1/16);
in1=1;
msdelay(b1/16);
in1=0;
msdelay(b1/16);
in1=1;
msdelay(b1/16);
in1=0;
msdelay(b1/16);
in1=1;
msdelay(b1/16);
in1=0;*/
PR2=0xff;
}
```

```
}
void adc1()
{
comn_data(0x80,"GAS  ");
ADRESH=0X00;
ADRESL=0X00;
ADCON0=0X81;
ADCON1=0X80;
delay();
ADCON0=0X85;
while(ADCON0==0X85);
a=((ADRESH<<8)+ADRESL);
val(a);
}
void adc2()
{
comn_data(0x86,"CH4");
ADRESH=0X00;
ADRESL=0X00;
ADCON0=0X89;
ADCON1=0X80;
ADCON0=0X8d;
while(ADCON0==0X8d);
b=((ADRESH<<8)+ADRESL);
vall(b);
}
void lcd_init()
{
lcd_com(0x38);
lcd_com(0x0c);
lcd_com(0x06);
lcd_com(0x80);
lcd_com(0x01);
}
void val(unsigned int re)
```

```
{
lcd_com(0xC0);
d1=(re/1000);
d2=((re-d1*1000)/100);
d3=((re-(d1*1000+d2*100))/10);
d4=(re-(d1*1000+d2*100+d3*10));
lcd_data(d1+0x30);
lcd_data(d2+0x30);
lcd_data(d3+0x30);
lcd_data(d4+0x30);
}
void vall(unsigned int ree)
{
d11=(ree/1000);
d21=((ree-d11*1000)/100);
d31=((ree-(d11*1000+d21*100))/10);
d41=(ree-(d11*1000+d21*100+d31*10));
//lcd_data(d11+0x30);
lcd_com(0xc6);
lcd_data(d21+0x30);
lcd_data(d31+0x30);
lcd_data(d41+0x30);
}

void lcd_com(unsigned char com)
{
lcd=com;
rs=0;
en=1;
delay();
en=0;
delay();
}
void lcd_data(unsigned char dat)
{
```

```
lcd=dat;
rs=1;
en=1;
delay();
en=0;
delay();
}
void comn_data(unsigned char com,unsigned char *dat)
{
lcd_com(com);
while(*dat)
{
lcd_data(*dat++);
}
}
void delay()
{
unsigned char i;
for(i=0;i<255;i++);
}
void delay1()
{
unsigned int i,j;
for(i=0;i<65535;i++);
}
void delay4(int z)
{
unsigned int i,j;
for(i=0;i<z;i++)
{
for(j=0;j<65535;j++);
}
}
```