A

PROJECT REPORT ON

ADAPTIVE HEADLIGHT SYSTEM IN AUTOMOBILES

BY

RAJRATNA . M . PATIL	B120310951
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IN FULLFILLMENT OF

BACHELOR OF ENGINEERING

[BE MECHANICAL]

DEGREE OF SAVITRIBAI PHULE PUNE UNIVERSITY

UNDER THE GUIDANCE OF

Prof. S.V GOASAVI

Year 2016-17

DEPARTMENT OF MECHANICAL ENGINEERING

PES's MODERN COLLEGE OF ENGINEERING PUNE-05

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CERTIFICATE

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Adaptive Headlight System For Automobiles

Has Been Successfully Completed By

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During the Academic Year 2016-17

Prof. Dr. Mrs. K. R. Joshi	**Prof S. Y. Bhosale**	**Prof. S. V. Gosavi**
Principal	HOD Mechanical	Project Guide

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INTERNAL EXAMINER EXTERNAL EXAMINER

Acknowledgement

This is to acknowledge all the people who have helped and guided us in the accomplishment of this project. The objectives defined by us have been successfully accomplished due to constant guidance and motivation provided by team.

We would like to express our deepest and sincere gratitude to our guide, Assistant Prof. S.V. Gosavi of the Department of Mechanical Engineering for his unflagging support and continuous encouragement throughout the project. Without his guidance and persistent help, this project would not have been possible.

We are graced by the presence of honorable Head of Department Prof. S.Y Bhosale, PES's Modern College Of Engineering, Pune for his sheer support and motivation. We also thank Project-In charge Prof. Shyam Darewar for his timely guidance regarding project coordination. We must acknowledge the faculty and staff of Mechanical Engineering for their support. It gives us great pleasure to acknowledge my colleagues for their help.

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ABSTRACT

The highest fatal traffic accident rate occurs on curved roads at night time. Night time driving with conventional headlamps is particularly unsafe. Only 25% of the driving is done at night but 55% of the driving accidents occur during this period. The existing conventional light systems do not provide illumination in the right direction on curve roads. Due to this constrain, a need to understand an alternative technology solution. The aim is to improve visibility for driver and so achieve a significant increase in safety and driving comfort. This calls for a flexible front light for automobiles to illuminate road ahead in the night at corner.

This project presents the hardware in the loop simulation of an Adaptive Headlight System for automobiles. The Adaptive Headlight System is an active safety system, where the head lamp orientation control system rotates the right and left low beam headlights independently and keeps the beam as parallel to the curved road as possible to provide better night time visibility. Different kinds of tests were done on critical parts of the system in order to determine its accuracy, its response time, and the system impact. Finally, the results acquired from these various tests will be discussed. Any findings and changes that should be made are discussed and may be useful for future development.

From the results, it is concluded that the headlamp swings in horizontal track by sensing steering angle and vertical by sensing the slope of the road. Accuracy, consistency and availability of the components were few considerations during the conceptualization stage.

CHAPTER 1
INTRODUCTION

The rate of accident are much and more at the night drive then at the day light, for avoiding the accidents these concepts are very useful for automobile. The reason as to focus on the subject of safety of car is related to the statics and to the expose the serious consequences of accident in 2014 out of 6,98,451 people from accident 4,882 people dead and remaining people were injured with a corresponding financial loss in India. Adaptive headlight system moves the headlights by turning the vehicle through the steering. This places light into the turning radius visibility at the cornering improved.

The present invention relates to headlights of an automobile, more particularly to a direction turning device for headlamps of the vehicle which enables to turn direction synchronously with the rotation of the steering and hence increasing the safety for driving at night or in the darkness. In the known technology of the prior art, a headlight of the vehicle has a fixed line of emission which is aligned with the front direction of the vehicle. Although the effects of "high beam" or "low beam" can be achieved by adjusting the angle of elevation of the headlamp, the direction of emission is not adjustable as to the left or right. When the road curves or turns, the corner on time when the vehicle turns, thereby creating a dead angle of illumination and such lack of visibility poses danger in driving at night or in darkness. Therefore, it is highly desirable to invent a device to solve this problem and such device is of high utility. An objective of the present invention is to provide a direction turning device for a headlight of the vehicle which renders to emission direction of a headlight of an automobile in synchronization with steering and thus increases the illuminated area upon change of direction of the automobile when the automobile makes turns.

The oldest headlamps were fueled by acetylene and oil and were introduced in the late 1880s. The first electric headlamps were introduced in 1898 on the Columbia Electric Car from the Electric Vehicle Company, and were not mandatory. The concept of swiveling headlamps is actually old one. An old innovation in lighting was to vertically tilt the beams high-beam-to-low-beam (dipped) switching dating back to 1917. More recently, automatic self-leveling has become an increasingly common requirement as the light sources have become more bright and glare has increased. Horizontal swiveling is important in the automotive industry. The current static headlamp provides illumination in tangent direction of the headlamp without any consideration towards the steering shaft angle and the distance between incoming vehicle and subject vehicle. The Adaptive Headlight System (AHS) controls the aiming direction and lighting distribution of the low beams according to the amount of turn applied to the steering wheel during cornering or turning. AHS therefore improves driver's visibility during night driving by automatically turning the headlamp in the direction of travel according to steering wheel angle.

The aim of this project is to build a cost effective "Adaptive headlight system" that will help achieve increases safety, comfortless and reliability. The new design and build should modify and fit into an existing fixed headlamp with a very close eye on cost and reliability. Use of existing headlamps will also allow the AHS to maintain the vehicle's conformity to existing vehicle aesthetics as well as government regulation.

The objectives is to achieve horizontal movement of the headlamp in related to angle of steering shaft, thereby focusing in the right direction and achieve vertical movement of the headlamp in accordance to the slope of driving terrain, thereby enhances driver's visibility. The current static headlamp provides illumination in tangent direction of the headlamp without any consideration towards the steering shaft angle. The driver is therefore subjected to insufficient illumination and unreliable or incomplete view of the road. It is therefore imperative to study new technology.

Adaptive headlight system (AHS) is an innovative technology and is being studied by researchers across the globe. The adaptive front lighting system (AHS) helps to improve visibility during night time driving.

The AHS controls the aiming direction and lighting distribution of the low beams according to the amount of turn applied to the steering wheel during cornering or turning. AFS therefore improves driver's visibility during night driving by automatically turning the headlamp in the direction of travel according to steering wheel angle.

When driving on the curve road, Adaptive headlight system (AHS) will change the lighting pattern to compensate for the curvature of the road to help enhance night visibility. Fig 1.1 shows car-1 without AHS and car-2 with AHS system. AHS therefore improves driver's visibility during night driving by automatically turning the headlamp in the direction of travel according to curve road.

Adaptive Headlight System (AHS) is the outcome of engineering efforts in developing the next generation lighting systems not only for drivers but also for all other road users. AHS is introduced in order to prevent a possible accident from happening by increasing the visibility at night. AHS automatically adjusts the light to match the direction of travel. That enables the driver to react more quickly because he/she will see the road ahead more clearly. AHS significantly enhances driving safety in the dark by dynamically adjusting the headlights according to the car’s current direction of travel to ensure optimum illumination of the road ahead and to give the driver much better visibility.

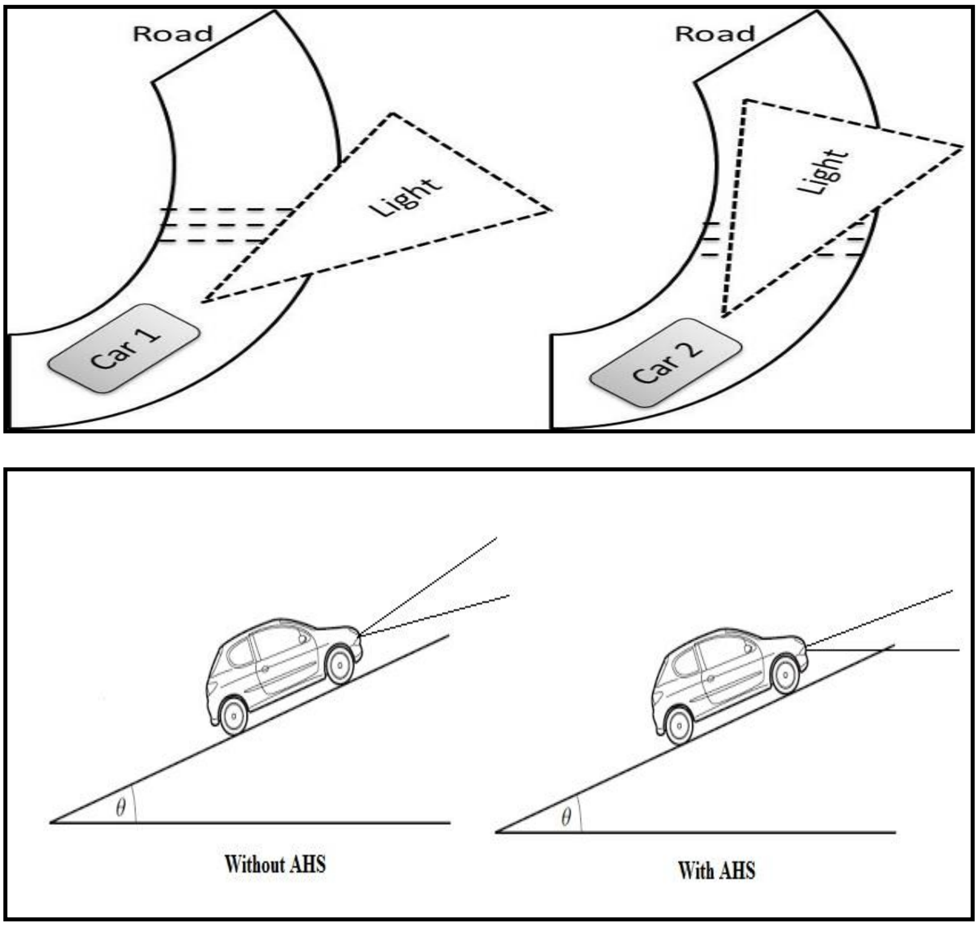


Fig 1.1 : Car without AHS system and car with AHS system

CHAPTER 2
LITERATURE REVIEW

In past different researchers presented their work on Steering wheel controlled mechanism. The important literature reviews are as follows:-

Meftah Hrairi and Anwar B. Abu Bakar, "Development of an Adaptive Headlamp Systems", International Conference on Computer and Communication Engineering (ICCCE 2010), 11-13 May 2010, Kuala Lumpur, Malaysia [1] aimed to design and build a prototype of Steerable headlights by adapting a conventional static headlamp with a very close eye on cost and reliability. Components that are easily available in the market and suitable for developing a steerable headlight system were tested. Different kinds of tests were done on critical parts of the system in order to determine its accuracy, its response time, and the system impact. Finally, the results acquired from these various tests are discussed.

Mangesh A. Jadhav, Tushar S.Borkar, Nilam B. Narote, Pratik D.More, Rajendra S. Chaudhari, "Design of Head Light Moving Mechanism With Steering ", International Journal of Modern Trends in Engineering and Research, e-ISSN No.:2349-9745, Date: 28-30 April, 2016 [2] aim to design and develop a “Steering Controlled Headlight Mechanism” which acts as directional headlights. This is done by connecting headlights and steering. When the steering wheel is rotated and rotary motion is converted to translatory motion through the rack and pinion mechanism. When the front wheels are steered, the headlights follows the same path and the light is focused on more divergent area. In the present project, it is planned to design “Steering Controlled Headlight Mechanism” and a live model unit is fabricated.

Rares Crisan, Olimpiu Tatar, Vistrian Maties, Dan Mandru, " Design of An Adaptive Headlights System For Automobiles " , Journal Mechanisms and Manipulators, Vol. 5 2006 [3] discussed the issues related to the safety of driving in night or fog conditions, the comparison between classical lights and adaptive systems, as well as one solution, developed at Technical University of Cluj-Napoca which deals with fully integrated solution for positioning of the spot lights which is used as didactical stand. They presented the principles for command and control of adaptive headlights, in two variants, one which serves as demonstrative approach commanded from P.C. via Lab View software and one as principle, for implementation with micro controller.

D. Kiran Varma, N.Laxmi, B.Anil Kumar, "Design and Fabrication of A Steering Controlled Headlights in Automobile" , International Journal & Magazine of Engineering, Technology, Management and Research, ISSN No: 2348-4845 [4] states that car safety is the avoidance of automobile accidents or the minimization of harmful effects of accidents, in particular as pertaining to human life and health. They developed a device - a headlight arrangement operable connected to the steering and front wheel assembly to maintain headlight members and the front wheels pointed in the same direction at all times. They computed design calculations to determine pitch circle diameter of pinion used in steering mechanism. They used rack and pinion steering system.

Shinde Ganesh R, Jadhav Tushar D, Varade Shubham A , Korde Goraksha K, Belkar S.B, "Adaptive Headlight System" ,International Journal of Informative & Futuristic Research ISSN (Online): 2347-1697, IJIFR/ V2/ E7/ 043 [5] designed and build a prototype of steerable headlights by adapting a conventional static headlamp. Components that are easily available in the market and suitable for developing a steerable headlight system were tested. Different kinds of tests were done on critical parts of the system in order to determine its accuracy, its response time, and the system impact. Finally, the results acquired from these various tests will be discussed. Any findings and changes that should be made are discussed and may be useful for future development.

Shirsat Shashikant, Mechkul M.A, "Adaptive Front Light System", IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834, p-ISSN: 2278-8735 (PP 05-09) [6] stated that night time driving with conventional headlamps is particularly dangerous: approximately 25% of the driving is done at night but 55% of the driving mishaps occur during this period. Adaptive front light system (AFS) helps get better driver’s visibility at night time hence achieving improve safety. The purpose of this paper is to design and build an AFS model. From the results, it is concluded that the headlamp swings in horizontal track by sensing steering angle and vertical by sensing distance between subject vehicle and next vehicle. Accuracy, consistency and availability of the components were few considerations during the conceptualization stage.

Renton Ma , "Automotive Adaptive Front-lighting System Reference Design", Texas Instrumentation-Reference design SPRUHP-3 July-2013 [7] states Adaptive

Front-lighting System (AFS) as one part of the active safety system of a middle-high end passenger car, providing an optimized vision to the driver during night time and other poor-sight conditions of the road by adapting the headlight angle and intensity, and judging the speed of the car, the steering wheel angle, the weather condition, and yaw and tilt rate of the car. To facilitate a user's development of such a system and to demonstrate the performance of TI's automotive MCU family, a reference design of AFS is developed. This paper describes the functions of the reference design, as well as the implementation. It states the guidelines for manipulating the demonstration of the reference design.

Chan ChikKee, "Design of Advanced HID headlamp system, Auto light beam level control and glaring prevention" , The Hong Kong Polytechnic University 2009 [8]. It states that adaptive front lighting system can be used is relation with distance of obstacle. Different distance will trigger different operations of AFS. Simulation of system by MATLAB has been done to examine different cases and conditions. The logic-input and output have been simulated through software.

M.Canry, S.Cherfan, P.Lecocg, J.M.Kelada, A.Kemeny presented the, "Application of Real Time Lighting Simulation for Intelligent Front Lighting Studies ", VALEO Lighting Systems Journal [9]. In this paper author introduce the adaptive headlight strategies which are used in Renault Automobile. They have used the real time lighting simulation. The driving simulator include driver cockpit, an image generator which provide realistic restitution of headlight distribution, a sound generator, realistic traffic and man machine interface. This system can be easily handled during switching in real time driving conditions. The system is called as Valeo Lighting system Branch which is developed by Renault Lighting Department which includes dynamically directing additional headlamp according to the behaviour vehicle, environment and road conditions. They have used the Halogen bulbs which provides 30% more light than other previous generation bulbs. Because of the clear lens and complex shape uses 80% light that was previously wasted on shields and bezels. They have used Xenon lightning which increasing the performance in the range: double flux and beam width, 40% reduction in use of electricity, day light colour rendering, 30% increased range. Renault Xenon headlamp has been installed in the Safranein early 1997. After studying this paper, we found that Author divide the light distribution in Motorway light, Adverse weather light, Town Light, Bending

Light. Several simulations have been developed by Renault Research Department since 1989.

2.1 Problem Statement

The major problem hindering safer and more comfortable driving is the driver and his/her limited reaction time in the presence of changing road conditions. An aim of development in active safety is to reduce the reaction time of the driver by improving visibility and thus achieve a significant increase in road safety and driving comfort. Alexander and Lunen Feld mentioned that driving an automobile primarily a visual task because vision contributes as much as 90% of the information needed to drive.

Good visibility contributes to driver confidence and enables more relaxed and safer driving. Moreover, statistics clearly show that the majority of accidents take place at night or in bad weather because of low visual conditions. Under such conditions, or in bad weather, drivers have difficulty in being able to see traffic control devices, lanes, other vehicles, pedestrians, animals, and other potential hazards. Studies show that visual perception, with which we absorb 90 percent of all relevant traffic information, is reduced to as little as four percent during foggy or rainy nights.

Furthermore, according to Germany's Federal Statistics Bureau, more than 40 percent of all automobile accidents resulting in death occur at night, despite the fact that there is up to 80 percent less traffic on the road than during the day. Reduced vision increases reaction time which can have fatal consequences.

Drivers rely on headlights in the dark and in bad weather for a clear view of the road and to illuminate possible hazards ahead. It is, therefore, of great importance to use available technology to contribute to road safety by improving the visual conditions provided by vehicle headlights. Appropriate solutions will be based on the mechatronic design concept and will incorporate components from heterogeneous fields such as lighting technology, mechanics, actuators, sensors, power electronics and system control.

2.2 Objectives

Adaptive Headlight System for Automobiles is a smart solution for safe and convenient night driving without the intense dazzling effect and aftermaths. Adaptive Headlight System for Automobiles needs no manual operation for switching headlight Left/Right and UP/Down when there is a turn at night.

When there is a turn, it automatically switches to the direction of turn and when the vehicle passes a slope other that horizontal plane, headlight moves in oppsite slope(Up/Down).

To design and implement “Adaptive Headlight System for Automobiles” the following steps can be used:

i. Achieve horizontal movement of the headlamp in accordance to steering shaft angle, thereby illuminating in the appropriate direction..

ii. Achieve vertical movement of the headlamp in accordance to the slope of driving terrain, thereby increase driver’s visibility.

iii.To investigate the lighting conventional system and mechanism in automobiles.

iv. To design and develop an Adaptive Lighting System to be implemented in automobiles.

2.3 Scope of the project

Adaptive headlights is an active safety feature designed to make driving at night or in low-light conditions safer by increasing visibility around curves and over hills.

When driving around a bend in the road, standard headlights continue to shine straight ahead, illuminating the side of the road and leaving the road ahead of you in the dark. Adaptive headlights, on the other hand, turn their beams according to your steering input so that the vehicle’s actual path is lit up.

Similarly, when a vehicle with standard headlights crests a hill, the headlight beams temporarily point upwards towards the sky. This makes it difficult for driver to see the road ahead and for oncoming motorists to see the driver approaching.

In contrast, adaptive headlights use a self-leveling system that points the light beam up or down, according to the position of the vehicle. Adaptive headlights can be implemented in two ways

i. Mechanical system

In this system two headlights are mounted, which are mechanically operated by a four bar kinematic chain mechanism.

The linkage is connected to stub axle from where it receives motion of the wheels. This motion is transmitted to headlights through four bar linkage. The headlights are connected to two opposite links of four bar linkage. Such linkage may also be referred as 'Ackerman Steering mechanism'.

ii. Mechatronic System

In order to manage system costs and complexity, a simple framework was laid out for the developed AHS.

It consists of three important components:- input sensors, a microcontroller as the brain of the system, and a motor for positioning the headlights.

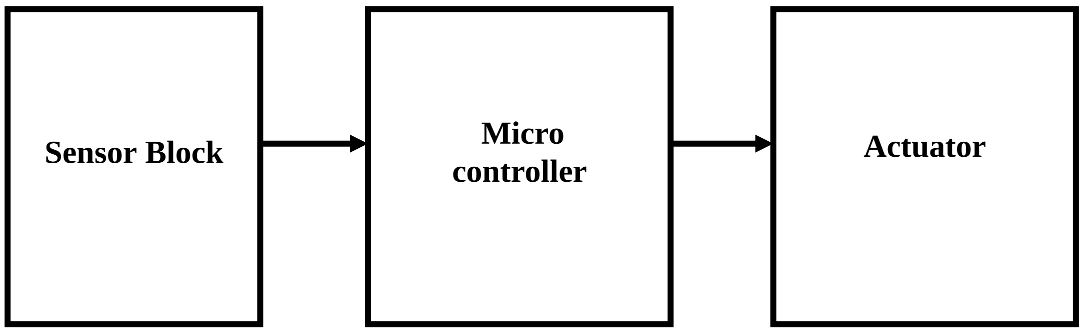


Fig 2.1: Basic Block Diagram

2.4 Methodology:

This study/project would be consisting of following chronological step of working:

i. Literature study

Firstly, we studied all the research papers and came with the concept of adaptive headlights. We formulated the basic idea of project based on literature survey we did.

ii. Project identification

We chose Maruti 800 steering to carry out this project as it was easily available, reliable and cost-effective.

iii. Design stage

We used PTC CREO software package version 2.0 to create all the parts required as per Maruti 800 specifications. These parts were then assembled to form an assembly.

iv. Electronic system drawing

Then we came up with the electronic system to be used -

a) Arduino board
b) Ultrasonic Sensor and Accelerometer Sensor
c) Servo Motors
d) Zero PCB

v.Material procurement

Material required was procured as per the following cost and sequence.

Table 2.1: Bill of Materials

Part Name	Quantity	Rate Per Piece	Amount
Main Frame	4 m	65	260
Plate (45 x 45 cm^2)	1	400	400
Servo Motor (5 kg-cm torque)	6	450	2700
Steering Column and Steering Wheel	1	1000	1000
Steering Rack	1	1000	1000
Ball-bearings	2	60	120
Laser-cuts	8	350	2800
Bending	20	30	600
Electronics	1	-	1214
Wheel (Caster)	2	350	700

2.5 Organization of Dissertation

Chapter 1 consists of basic Introduction on Project ideology. Chapter 2 consists Literature review of Project .Chapter 3 consists of Design of AHS. Chapter 4 consists of Manufacturing of AHS. Chapter 5 consists of Electronics of AHS. Chapter 6 consists of Results of AHS. Chapter 7 consists of Conclusion.

2.5.1 Features of the project

a) Horizontal swiveling (yawing of headlight)

Horizontal swiveling is used to turn the headlight in horizontal plane. It rotates in the direction proportionate to the wheel while taking turn.

b) Vertical swiveling (pitching of headlight)

Vertical swiveling is used to compensate the pitching of car, during driving through steep slope. It Helps To Focus The Light At The Required Path.

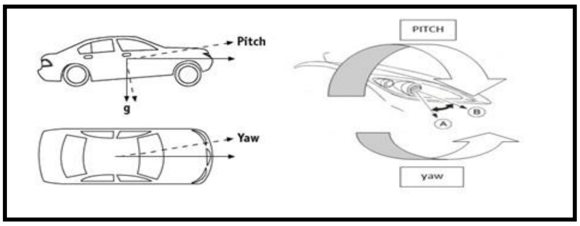


Fig 2.2 : Yawing and Pitching

2.5.2 Manufacturing Stages

We followed a specific manufacturing strategy. We used flow chart to plan our manufacturing stages prior to even designing stage.

Flowchart of Manufacturing Stages

Welding of main frame of the assembly

↓

Mounting of steering and rack and pinion by welding

↓

Laser cutting of Clamps, Yawing and Pitching frame and Bending

↓

Welding U- clamp to the Main- Frame and
Fabricating Wheel U-clamp to the Frame U-clamp

↓

Attaching Caster wheels to Wheel u-clamp and checking the motion

↓

Mounting the Yawing and Pitching frame along with Servo motor by Nut & Bolts

↓

Placing the Ultrasonic Sensor near on end of Headlight and joining the Rack and Pinion with Wheel U-clamp

↓

Arranging the Arduino board near the Ultrasonic sensor and completing its circuit with ADXL sensor, and motors

↓

Giving power source through Adapter and Testing it.

Gantt Chart

Activity Schedule	Project Status	JULY	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE
Project Identification	✓												
Project literature study	✓												
Field work	✓												
Project Report (Stage 1)	✓												
Project Presentation (Stage 1)	✓												
Design Modeling	✓												
Design Calculations	✓												
Material Procurement	✓												
Manufacturing Stage	✓												
Assembly	✓												
Trials and Troubleshooting	✓												
Testing	✓												
Conclusion	✓												
Report Preparation	✓												

2.5.3 Trials and troubleshooting

Number of trials were taken in order to test the synchronization of motors, ADXL and ultrasonic sensor. Readings were taken from these trials.

CHAPTER 3
DESIGN OF ADAPTIVE HEADLIGHT SYSTEM

Various mechanical components of adaptive headlight system were designed using PTC- CREO software package version 3.0 and reference geometry of standard car dimensions were used as a base for designing the setup of adaptive headlight system.

3.1 Components of Adaptive headlight system

Mechanical components of Adaptive headlight system are-

i. Main Frame
ii. Wheel U Clamp (2nos.) And Frame U Clamp (2 nos.)
iii. Pitching Frame And Yawing Frame

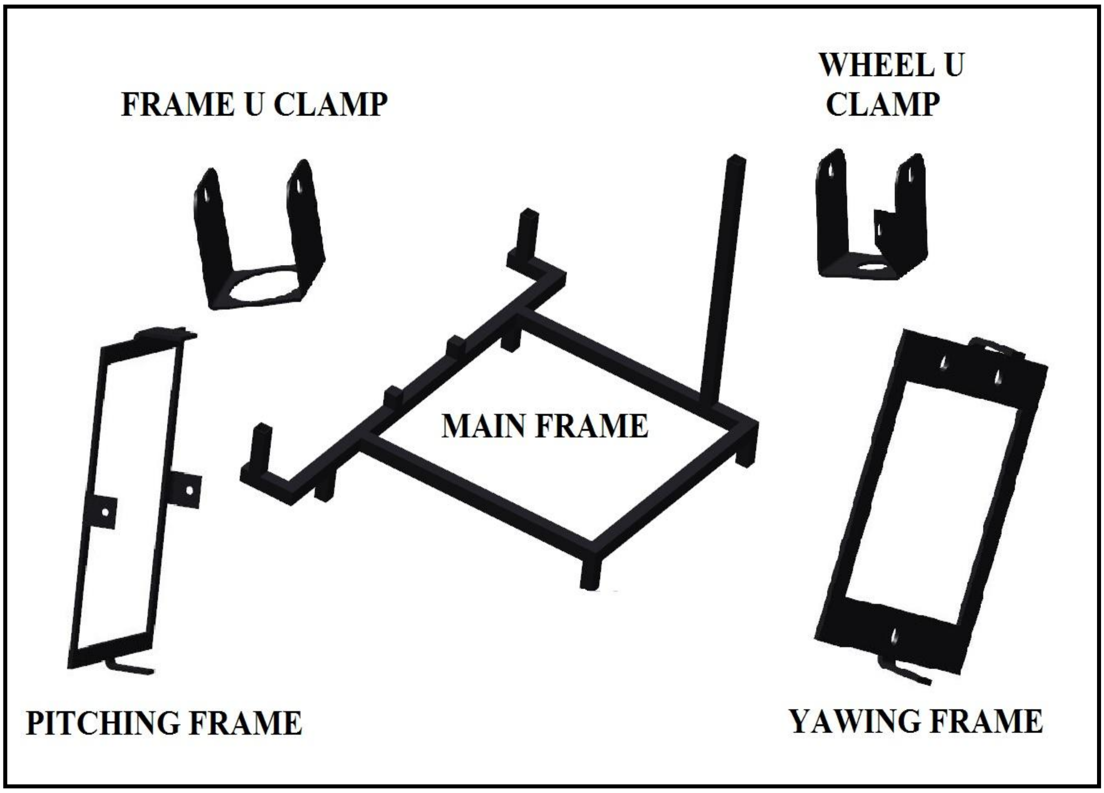


Fig: 3.1: Components of Adaptive headlight system

3.2 Designing of Parts

i. Main Frame

We used standard Maruti 800 car dimensions to design our mainframe which works as support for Steering column, Pitching and Yawing frames, electronic sensors. We segregated main frame into different mini-parts for better design for manufacturing ideology. We designed square pipes of 25 x 25 mm^2 cross-section step-by-step to create a 3D model of main frame using PTC -CREO 3.0 software package. Different mini-parts of Main Frame are given in table 3.1. The overall dimensions of main frame are shown in table 3.2 -

Table 3.1 : Mini-parts of Main-frame

Sr. No.	Mini-Part	Quantity
1	Main channel	1
2	Connector channel	2
3	End channel	1
4	Legs	4
5	Rack Support	2
6	Headlight holding channel	4

Table 3.2 : Main frame dimensions

Parts	Dimensions (mm)
Main Frame	900 x 600 x 525

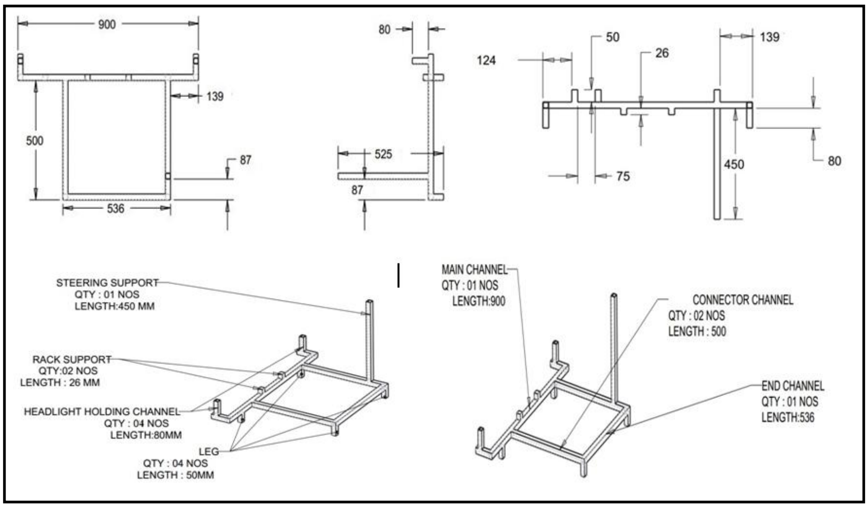


Fig: 3.2: Main-Frame Design

ii. Wheel U-Clamp And Frame U-Clamp

Wheel U-Clamp is a crucial part for assembling Caster wheel and its accurate mating with Frame U-Clamp and is essential for smooth steering motion. So dimensional accuracy for Wheel U-Clamp And Frame U-Clamp is a top priority. We used sheet metal work in PTC CREO 3.0 software package to precisely design stages for manufacturing these parts.

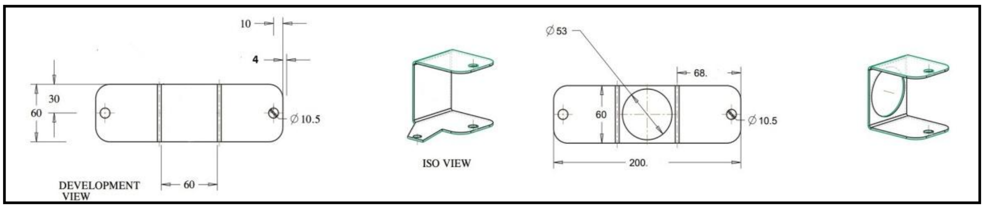


Fig: 3.3 : Design of Frame-U-Clamp and Wheel U-Clamp

We used very thin plates to generate a 3D model of Wheel U-Clamp and Frame U-Clamp. The overall dimensions of Wheel U-Clamp And Frame U-Clamp are shown in Table 3.3

Table 3.3 Wheel-u-clamp And Frame-u-clamp dimensions

Parts	Dimensions (mm)
Wheel U-Clamp	68 X 60 X 64
Frame U-Clamp	68 X 60 X 64

iii. Pitching Frame and Yawing Frame

Pitching Frame and Yawing Frame form the basis on which headlight moves parallel to road curvature. So accurate dimensions and precise matching dimensions for design for assembly ideology must be implemented.

Further manufacturing these parts is crucial for reliable pitching and yawing motion of headlights. So development view and Isometric view are essential for design for manufacturing ideology.

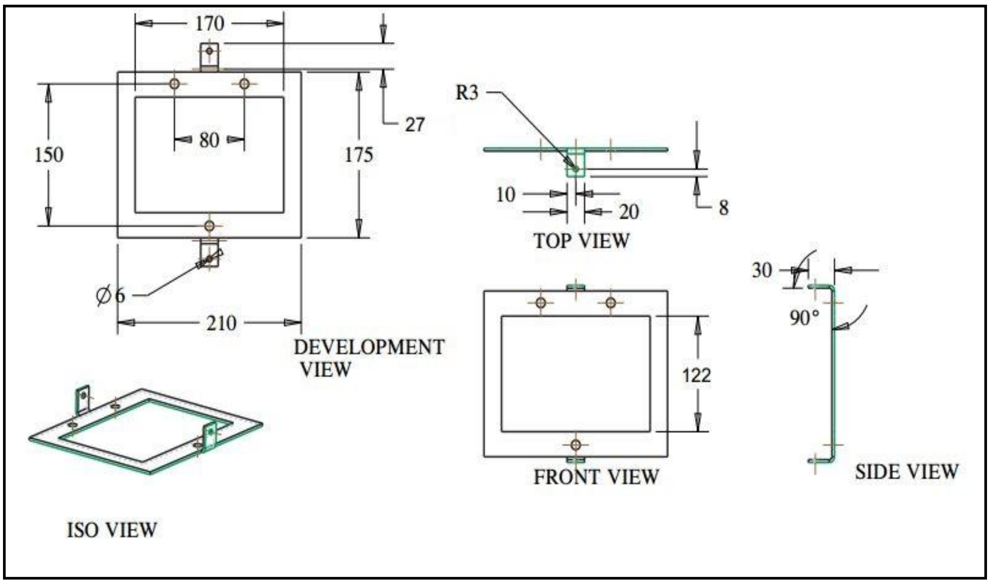


Fig 3.4: Design of Yawing Frame

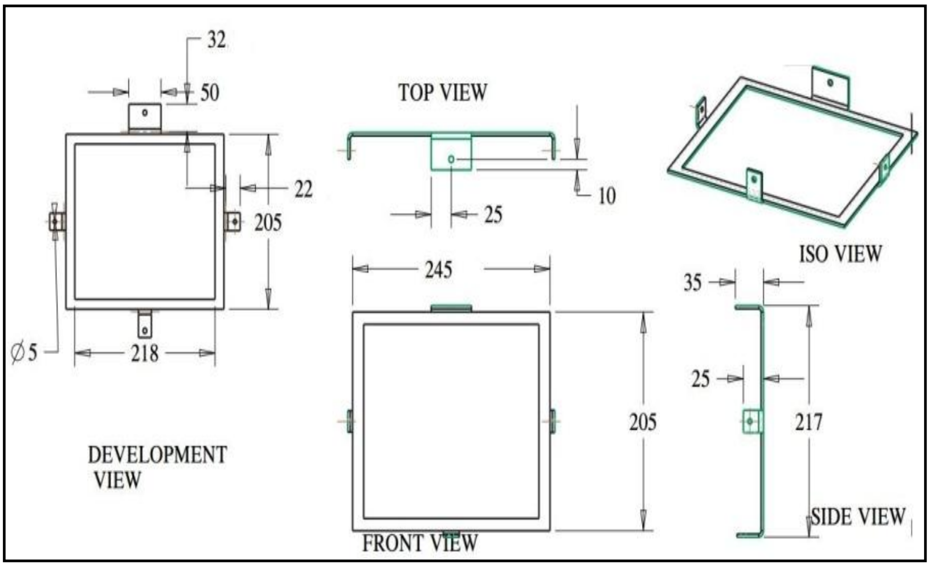


Fig 3.5: Design of Pitching Frame

Using thin section for better flexible movement and sheet metal process 3D model is generated using PTC CREO 3.0 software package. The overall dimensions of Pitching Frame and Yawing Frame are shown in table. 3.4.

Table 3.4 Pitching Frame and Yawing Frame dimensions

Parts	Dimensions (mm)
Pitching Frame	205 x 245 x 32
Yawing Frame	210 x 175 x 27

iv. Lock to Lock angle and Steering Ratio

The steering wheel has to rotate three complete revolutions to move the caster wheel from lock-to-lock position . Thus 3 x 360 = 1080^0 steering angle to move from lock-to-lock position. Thus 1.5 x 360 = 540^0 steering angle to move from Center to Right/ Left position. Center to Right/ Left caster wheel Angle is 45^0. Steering ratio is given by following equation-

$$\textbf{Steering Ratio} = \frac{\textbf{Angle moved by steering wheel(degrees)}}{\textbf{Angle moved by Caster wheel(degrees)}}$$

S.R = 540/45 = 12= approximate **12:1**

Center to Right/Left Steering angle –1.5 turns (540^0 of steering wheel motion)

Center to Right/ Left Caster wheel angle : $45^{\mathbf{0}}$

Lock to lock Caster wheel angle : 90^0

Lock to Lock Steering angle (Extreme Right to Extreme Left) - 3 turns (1080^0 of steering wheel motion)

Table 3.5: Specifications of rack and pinion assembly

Specifications	Dimensions
Number of teeth on rack	27
Number of teeth on pinion	18
Module	1.5 mm
Pressure angle	20^{0}
Rack length	127 mm

Here, we synchronized this lock to lock caster wheel angle with the horizontal swivelling angle in order to move the yawing frame in the same direction as that of caster wheel.

v. Motor Selection

Table 3.6: Comparison between Steeper Motor and Servo Motor

Parameter	Stepper Motor	Servo Motor
Drive circuit	Simple. The user can fabricate it.	Since the design is very complicated, it is not possible to fabricate your own driving circuit.
Out-of-step condition	Will not run if too heavy load is applied	Will rotate even if heavier load is applied
Control method	Open loop	Closed loop
Noise and vibration	Significant noise	Very little or no sound

Hence from the above table we conclude that servo motor is most suitable as it has to work with load while positioning the yawing frame and pitching frame as it is closed loop it helps in accurate position control.

Calculations :

Thickness of the plate = 0.2 cm

Density of the MS (Grade- ASTM A-36) = 7.85 g/cm^3

Area of Pitching Frame = (20.5 x 24.5) – (17.8 x 21.8) = 114.21 cm^2

Area of Yawing Frame= {[(21 x 17.5) – (17 x 13.5)] + (2 x 2.5 x 2.1) + (12 x 6.5)

Area of Yawing Frame = 226.5 cm^2

Total Area = Area of Pitching Frame + Area of Yawing Frame

Total Area = 114.21 + 226.5 = 340.71 cm^2

Total Volume = 340.71 * 0.2 = 68.142 cm^3

Mass = Density x Volume

Mass of Pitching and Yawing Frame= 7.85 x 68.142 = 511.065 gram

Total mass = Mass of Pitching and Yawing Frame + Mass of servo motor

Total mass = 511.065 + 55 = 566.065 grams = approx 566 gram

We have programmed for maximum tilt of 20^0

Therefore moment can be calculated = Force * Perpendicular distance

Moment = (566 x $\sin 20^0$) x (10.25) = 1984.22 gram-cm

Taking Factor of Safety = 1.5

Moment = 2976.344 gram-cm

Actual moment = 2.97 Kg-cm

Selecting motor such that Restoring Torque > Moment

Motor MG995 4.8 volt applies torque of 9.40 kg-cm

As 9.40 kg-cm > 2.97 kg-cm

Therefore we selected **Motor MG995** as it is best suited for our project.

3.3 Assembly of parts

To assemble different parts of adaptive headlight system we used a specific methodology and flow of mating part for ease of manufacturing. Step by step procedure for assembly of parts of adaptive headlight is given in following chart.

i. Frame Assembly

We completely constrained frame motion along all axis so that frame forms basis for mating for other parts. So frame is fixed and fully constrained.

ii. Wheel u clamp and frame u clamp assembly

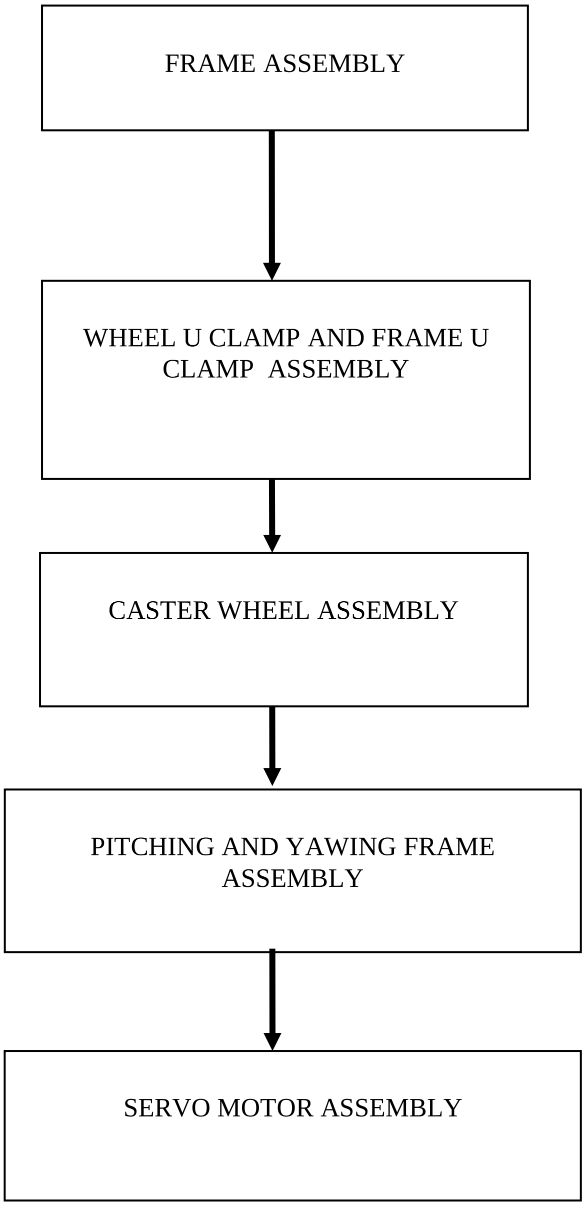
Mates are applied along axis of Main Frame and axis of Frame U Clamp. Mates are also applied on surface of Main Frame and surface of Frame U Clamp. To constrain rotational motion we constrained its angular motion along z-axis.

Mates are applied along axis of Frame U Clamp and axis of Wheel U Clamp. Mates are also applied on surface of Frame U Clamp and surface of Wheel U Clamp. Rotational motion is essential for turning of wheels so this motion is unconstrained.

iii. Caster Wheel Assembly

Mates are applied along axis of Wheel U Clamp and axis of Caster Wheel. Mates are also applied on surface of Wheel U Clamp and surface of Caster Wheel.

Assembly Flow Chart



iv. Pitching And Yawing Frame Assembly

Mates are applied along axis of Pitching frame and axis of Main Frame. Mates are also applied on surface of Main Frame and surface of Pitching frame .Mates are applied along axis of Pitching frame and axis of Yawing frame.

Mates are also applied on surface of Pitching frame and surface Yawing frame with appropriate clearance between them.

v. Servo Motor Assembly

Mates are applied along axis of Pitching frame and axis of Servo motors. Mates are also applied on surface of Servo motors and surface of Pitching frame.

Mates are applied along axis of Yawing frame and axis of Servo motors. Mates are also applied on surface of Yawing frame and surface Servo motors with appropriate clearance between them.

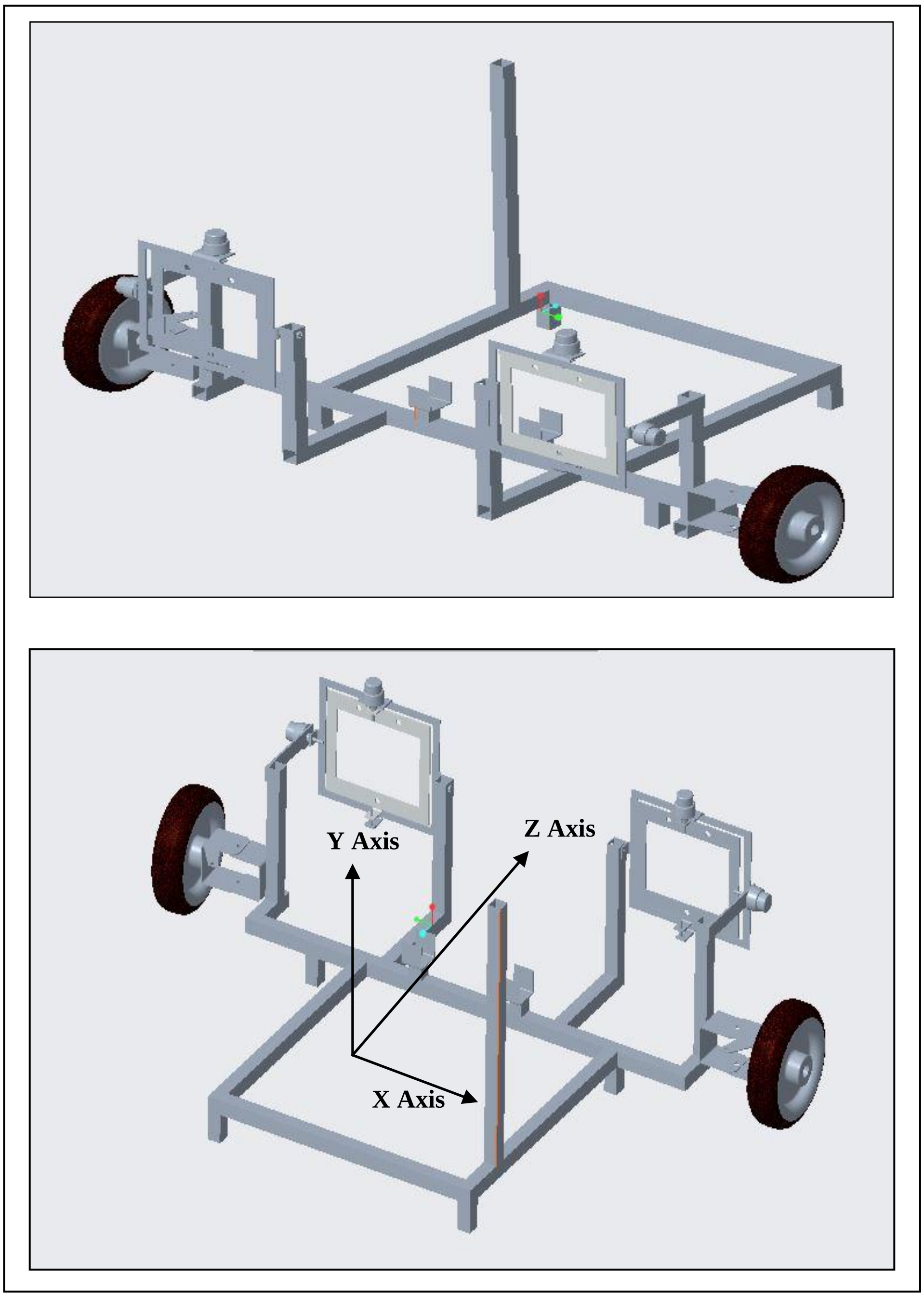


Fig 3.6 : Assembly of adaptive headlight system

CHAPTER 4

MANUFACTURING OF ADAPTIVE HEADLIGHT SYSTEM

First we manufactured basic main frame using MS Square Pipe. We then mounted the standard Maruti-800 steering column and rack on rack housing on main frame. To fit steering wheel, steering column we used ball bearings. Then we welded caster wheels on wheel-u-clamp.

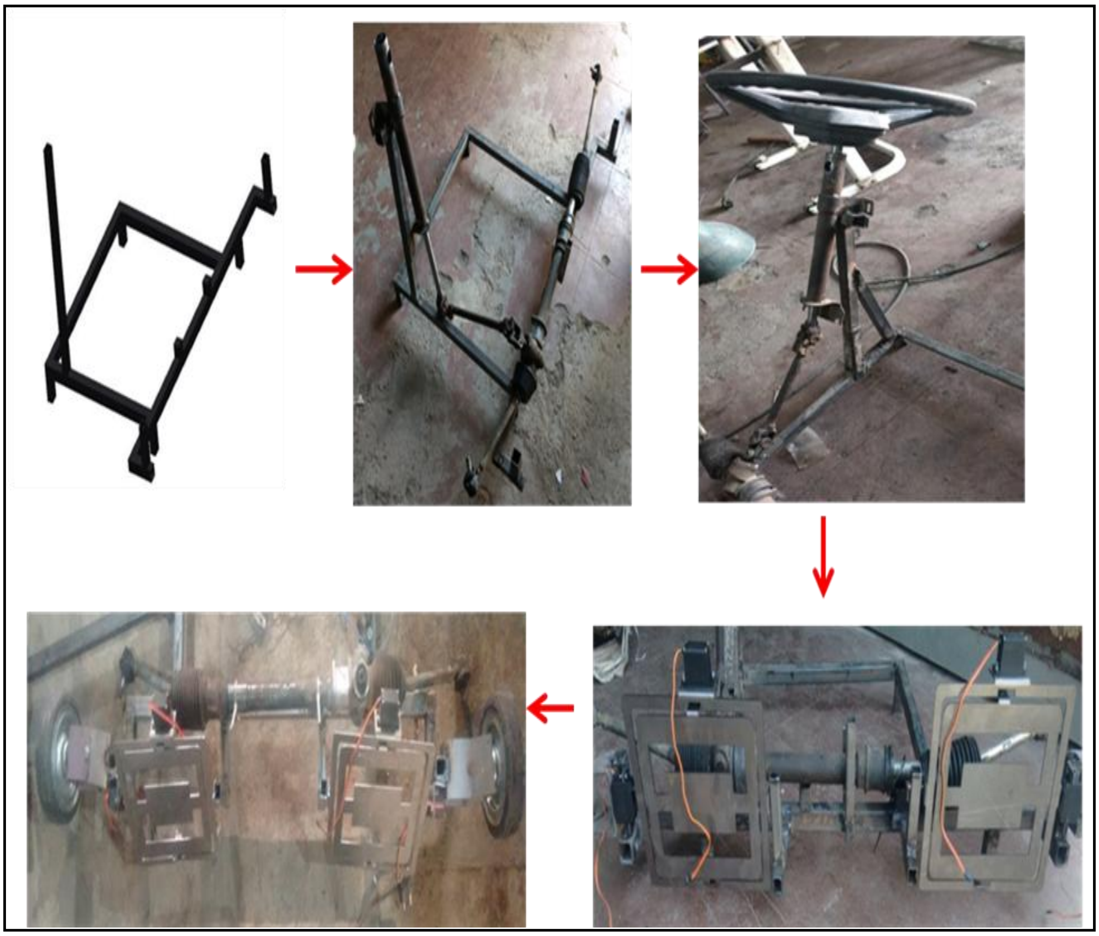


Fig: 4.1 Manufacturing Stages

i. **Main Frame manufacturing**

For manufacturing main frame we used was of square pipe of Mild Steel of $625mm^2$ cross-section. According to design data, we sorted different mini-parts of main-frame using Hack-saw. Then we step-by-step manufactured the main-frame using electric arc welding of 230 V.

Following is the manufacturing procedure that we followed to weld mini-parts of Main-frame. Material quantity knowledge is essential for economic manufacturing and precise fabrication of Main-frame.

Different mini-parts of Main Frame with Material Quantity are given as below.

Table 4.1: Main frame -Mini-Part Quantity

Mini-Part	Quantity	Length/Quantity (mm)	Length (mm)
Main channel	1	900	900
Connector channel	2	500	1000
End channel	1	536	536
Legs	4	50	200
Rack Support	2	26	52
Headlight holding channel	4	80	320
Total Quantity Estimate	14	2092	3008

Procedure for manufacturing Main-frame is given below-

Manufacturing Flow chart of Main Frame

SORTING MINI-PARTS USING HACK-SAW

MAIN CHANNEL-CONNECTOR CHANNEL-END CHANNEL WELDING.

LEGS WELDING

RACK SUPPORT WELDING

HEADLIGHT HOLDING CHANNEL WELDING

Table 4.2 : Manufacturing equipment of Main frame

Parts	Dimensions (mm)	Material (mm)	Manufacturing Equipment
Main Frame	900 x 600 x 525	Square pipe M.S 25 x 25	Hack-Saw Cutting; Electric Arc Welding (230 V)

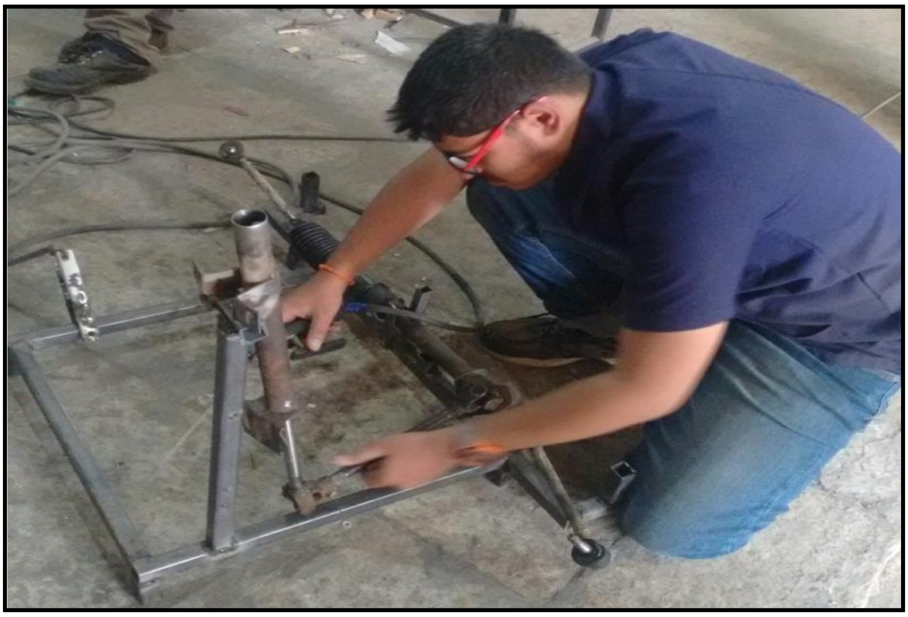


Fig 4.2 : Main-frame manufacturing

ii. Wheel U Clamp and Frame U Clamp with Caster Wheel

We assembled Wheel U Clamp and Frame U Clamp using M10 nuts and bolts. Then we welded caster wheel on wheel U-clamp.

Table 4.3: Manufacturing equipment of Wheel U Clamp and Frame U Clamp

Component	Dimensions (mm)	Material used	Manufacturing Process
Wheel -U-Clamp	68 x 60 x 60	M.S (Thick plate)	Laser-cutting; Bending; Drilling
Frame-U-Clamp	68 x 60 x 64	M.S (Thick plate)	Laser-cutting; Bending; Drilling

Table 4.4 : Specifications of nuts and bolts used for U-clamps.

Material	Stainless Steel
Diameter	10 mm
Length	80mm
Type	Hex bolt
Bolt size	M10

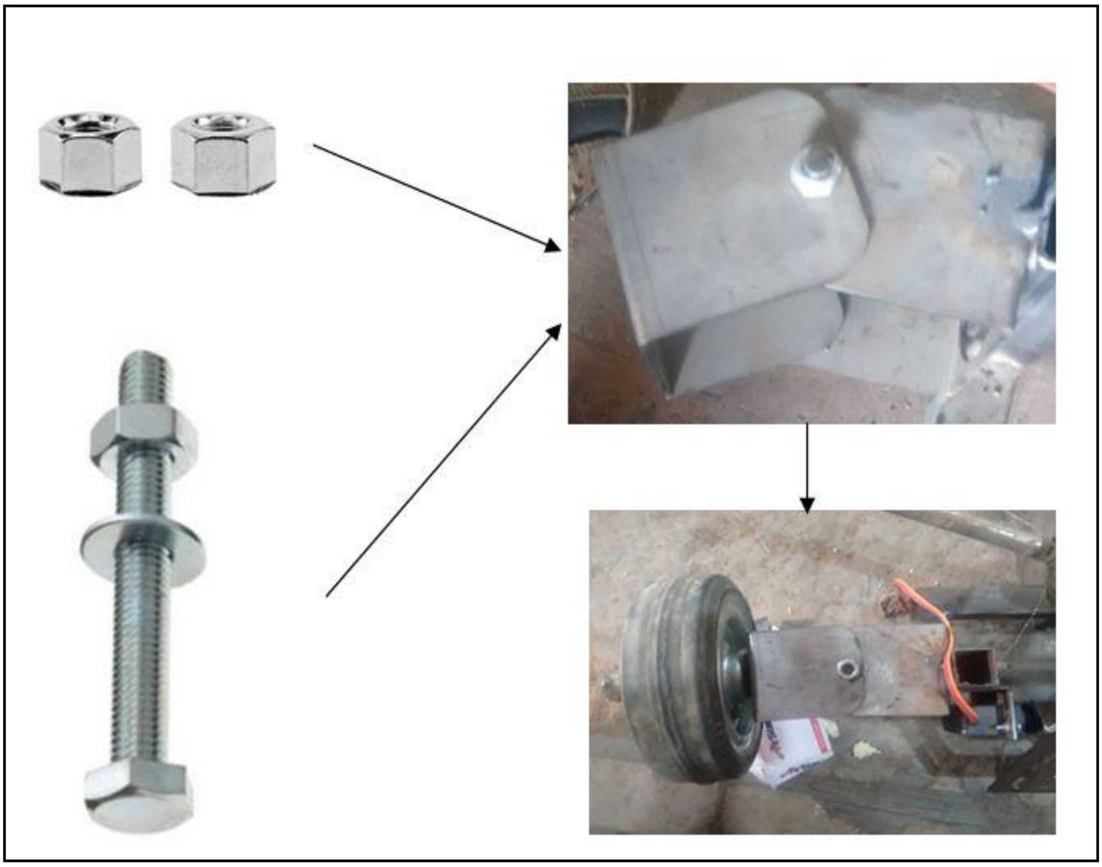


Fig 4.3: Clamping of Wheel U clamp and Frame U clamp by caster nut

iii. Steering Column, Rack & Pinion and Steering Wheel

We welded a hollow bar to fit the steering column and fitted the steering column using two ball bearings for smooth rotation of steering wheel. We supported Rack and Pinion mechanism on rack support.

ii. Servo Motor, Pitching Frame and Yawing Frame.

We fasten all servo motors to their respectable locations using nuts and bolts, couplers to Pitching and Yawing frame.

Fig 4.4: Steering column fitted with ball-bearings

Table 4.5: Manufacturing equipment of Pitching Frame and Yawing Frame.

Parts	Dimensions (mm)	Material	Manufacturing Equipments
Pitching Frame	245 x 205 x 50	MS (Thin Plate)	Laser-cutting; Bending; Drilling
Yawing Frame	210 x 175 x 27	MS (Thin Plate)	Laser-cutting; Bending; Drilling

Table 4.6: Servo Motor, Pitching Frame and Yawing Frame Quantity

Fabricating parts	Quantity/part	Total Quantity
Servo to Pitching frame	1	2
Servo to Yawing frame	1	2
Pitching frame to yawing frame	2	4
Total	**4**	**8**

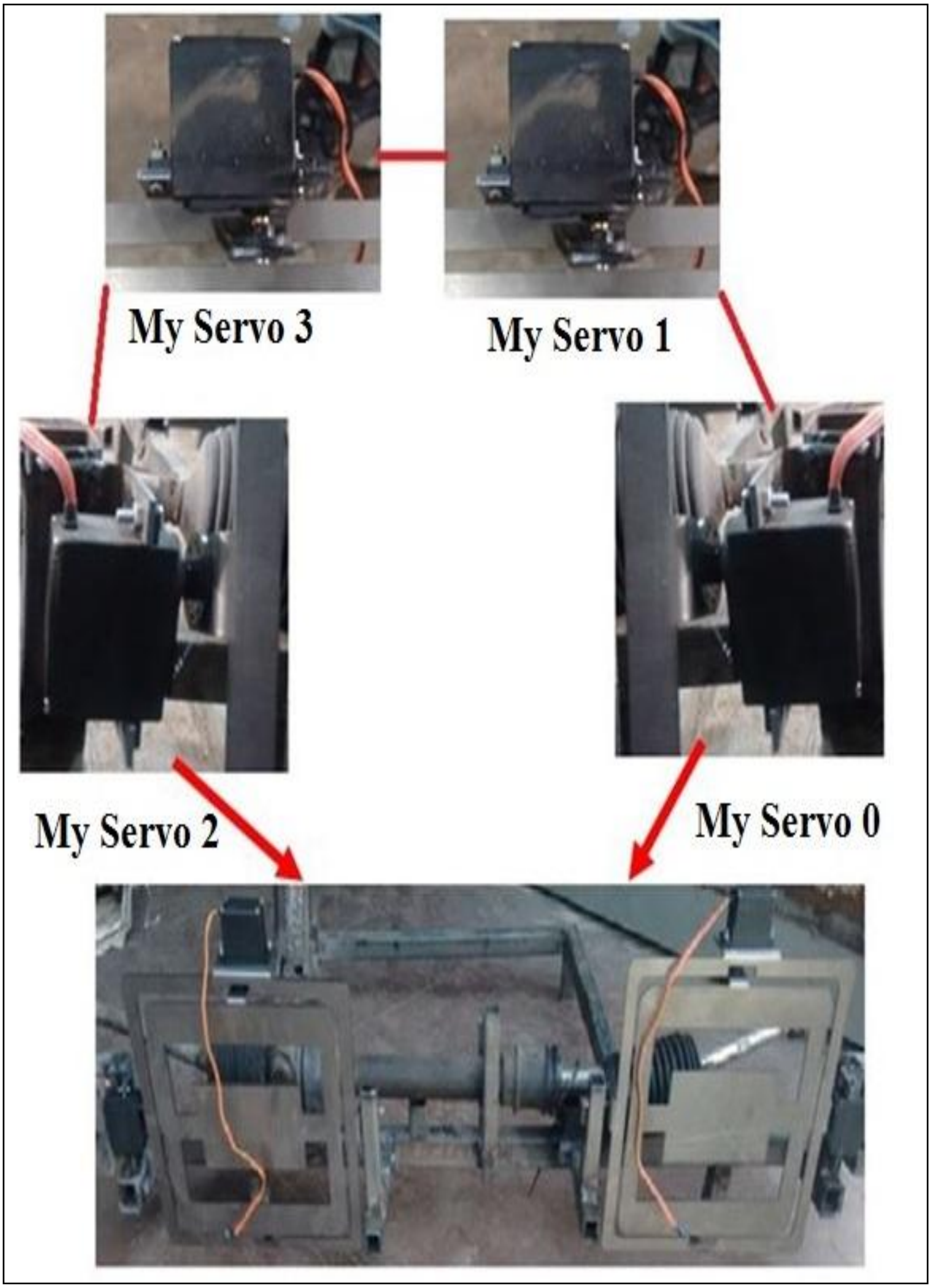


Fig. 4.5: Mounting Servo motor on Pitching and Yawing frame

CHAPTER 5

ELECTRONICS OF ADAPTIVE HEADLIGHT SYSTEM

5.1 Electronic Components

Electronic components of Adaptive headlight system are-

i. Servo motor – 5volt

ii. Ultrasonic sensor – HC-SR04

iii. Accelerometer sensor – ADXL-335

i. Servo Motor

A servo motor is a closed loop actuator. It uses position feedback to control its position and motion. It contains some type of encoder to record the position of the motor shaft, when the encoder gives the readings it compares with the required position given from controller in comparator. If the position does mot matches it generates error signal and motor (actuator) goes in required direction till the error signal goes on decreasing. As the shaft of the motor comes to the required position the error signal goes on decreasing.

Fig 5.1 : Servo motor MG995

Specification – stall torque = 9.4 kg-cm, volt = 4.8 V.

Yellow wire = Data signal / control line

Red wire = servo power +5 volt

Brown / Black wire =Ground wire

ii. Ultrasonic Sensor

An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back.

By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object.

$$\boldsymbol{Distance} = \frac{(\boldsymbol{speed\ of\ sound} \ * \boldsymbol{time\ taken})}{\mathbf{2}}$$

Pins designation -1) Power pin (+5V), 2) Trigger pin, 3) Echo pin, 4) Ground pin.

Fig 5.2: Ultrasonic Sensor- HC-SR04

iii. Accelerometer sensor

Accelerometers can be used in order to measure vehicle acceleration. They are also used to measure the vibration in vehicles, process control systems, machines, buildings and safety installations. They can also measure seismic activity, inclination and speed and machine vibration. An accelerometer behaves like a damped mass on a spring. In semiconductor devices, piezo resistive, piezoelectric and capacitive components are commonly used in order to convert the mechanical motion into an electrical signal.

Fig 5.3: Accelerometer sensor- ADXL335

5.2 Electronic construction

i. Arduino Uno

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input and output (I/O) pins that may be interfaced to computer. Zero PCB is also used which act as an external power source for 4 servo motors.

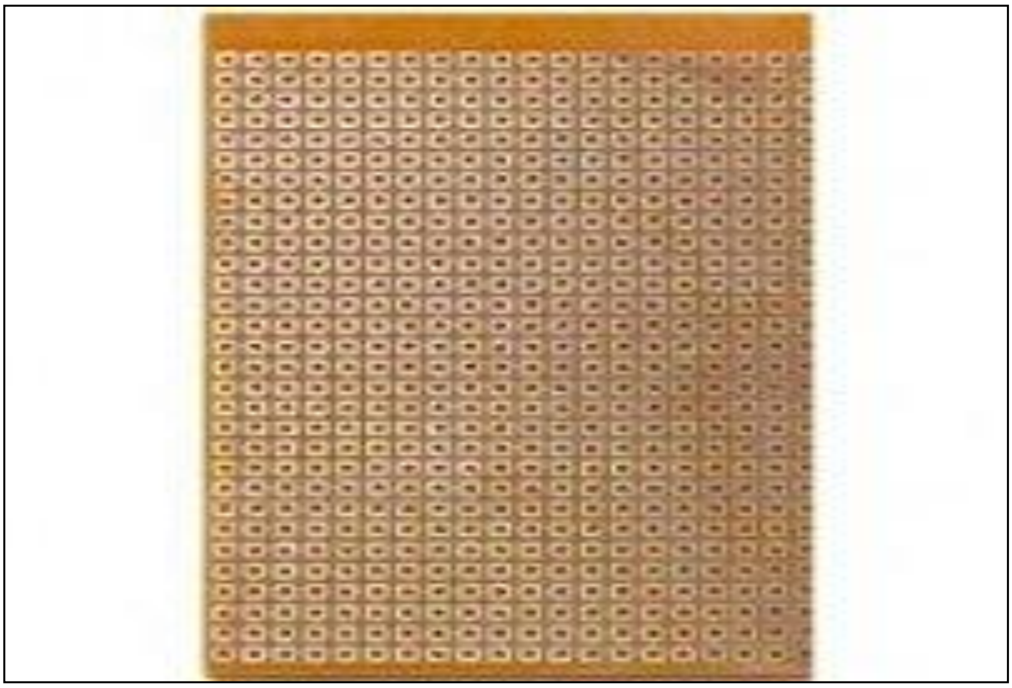


Fig 5.4: Zero PCB board

ii. Blocks Of Adaptive Headlight System

Construction Diagram of Adaptive Headlight System

Adaptive Headlight comprises of three blocks as-

a) Sensor Block

This block consist of two sensors ultrasonic sensor and accelerometer sensor. These sensors act as input to the controller (Arduino Uno). The ultrasonic sensor is used to sense the linear motion, we have used HC-SR04 ultrasonic sensor it works on 5V power supply .The accelerometer is used to sense the inclination or tilt of the vehicle in along Z-axis, we have used ADXL335 accelerometer sensor.

b) Controller Block

We have used Arduino Uno board for controlling the actuators and processing the data given by the two sensors. It works on 5volt power supply; it has 14 digital input output pins and 6 analog input pins.

c) Actuator Block

The plates on which headlight are mounted are actuated by servo motor shaft. We have used four servo motors to actuate the vertical and horizontal plates, each servo works on 5V power supply.

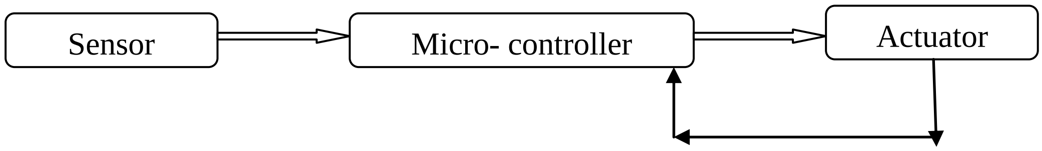


Fig 5.5: Block Diagram of Arduino

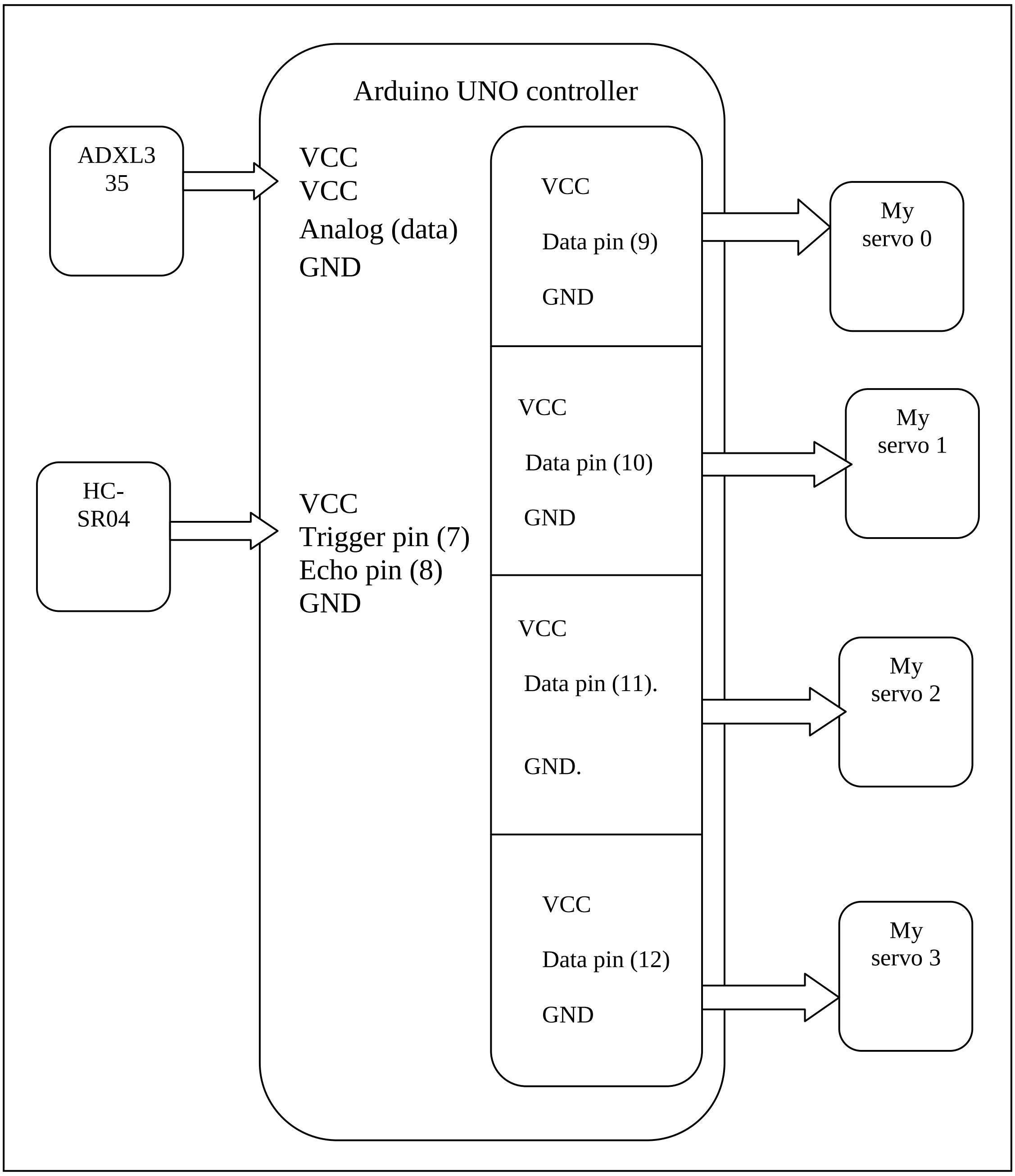


Fig 5.6: Circuit diagram of Adaptive Headlight System

5.3 Working of Electronic Circuit

In our project we have tried to control the motion of frame along X-axis and Z-axis. Yawing Frame is controlled along the X-axis by servo 1 and servo 3 motors. Pitching Frame is controlled along the Z-axis by servo and servo 2 motors

i) Horizontal Swivel control

In our project we have used ultrasonic sensor to sense the horizontal motion, thus the sensor is used for control of yawing frame. The ultrasonic sensor sends the ultrasonic pulse from the trigger pin and after colliding with the obstacle it falls on echo pin thus trigger pin act as input and echo pin act as output pin, the distance is calculated by formula as

$$\boldsymbol{Distance = \frac{(speed\ of\ sound\ *\ time\ taken)}{2}}$$

The ultrasonic sensor are connecting V_{cc} and ground by jumper wire to Arduino Uno board .The sensor continuously sends ultrasonic pulses with a interval of 15milliseconds, the trigger and echo pins are connected to Arduino Uno at 8 and 7 respectively the trigger pin sends the ultrasonic pulse and when it collides with an obstacle its reflected pulse falls on the echo pin than the distance is calculated by above formula and the respective distance is displayed on the serial monitor.

The actuators are Servo 1 and Servo 3 receives the data from the Arduino at 10 and 12 number pin respectively. As a result the motors rotate the yawing frame are rotated to the required positions

The set limits in program are –

a) Distance greater than 19 cm rotates the yawing frame to extreme right.

b) Distance between 23 and 19 cm give centered position of yawing frame.

c) Distance less than 27 cm rotates the yawing frame to extreme left.

Program details –

a) The motor is set at 100 degrees as centre position

b) Right turn movement is set as forward motion and left turn motion actuates the motor in reverse direction.

The yawing frame set at an angle of 45 to 50 degrees for inside lock angle of caster wheels and the set angle is 30 to 50 degrees for outside lock angle .We have kept 3 to 4 degrees tolerance because the positional accuracy of servo motor.

Fig 5.7: Yawing frame while taking right turn

Fig 5.8: Yawing frame while taking left turn

ii) Vertical Swiveling Control

In our project we have used capacitive type ADXL335 accelerometer to measure the inclination of the vehicle in XZ plane .It gives analog input to the arduino, the micro-controller analyses the data and gives the required signal to the servo motor. These servo motors are used to align the pitching frame with respect to that of the tilt .The main objective of this is to position the headlights in downwards direction when car is moving or climbing up the steep slope and to position the headlights upwards when car is moving down the steep slope thus the tilt is in upwards the servo motor should move the pitching frame down in equal and opposite direction and vice versa.

Servo and Servo 2 are used for actuating the pitching frame; the accelerometer senses the tilt in XZ plane with an interval of 15 milliseconds. Servo motors receive power from zero PCB external supply from 5volt and 2 Amp charger.

The set limits in program are –

a) If position greater than or equal to 370 position the pitching motor in upward position by 20 degrees.

b) If position between 350 and 370 position the pitching motor in centre position.

c) If position less than or equal to 350 position the pitching motor in downwards position by 20 degrees.

We have kept the tilt between 20 to 25 degrees tilt is normal and can be increased up to 28 degrees beyond that might lead to the possibility of toppling.

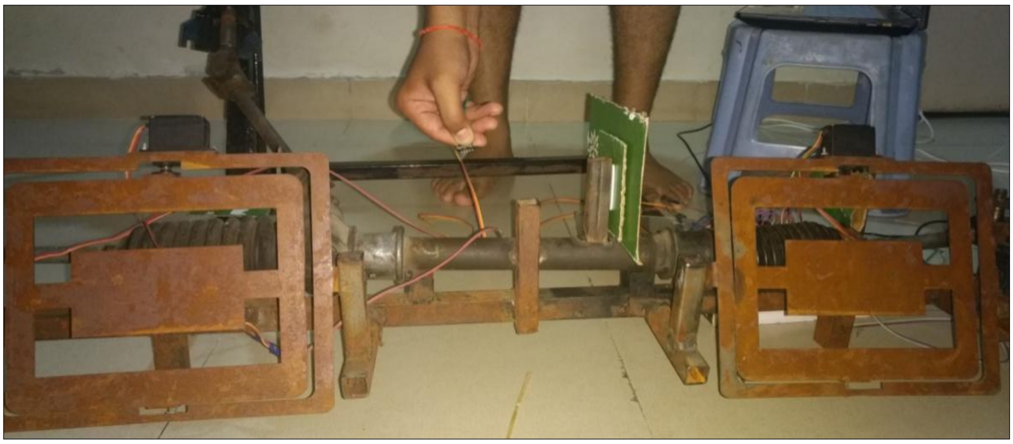


Fig 5.9: Pitching Frame moves up when ADXL moves down

Fig 5.10: Pitching Frame moves down when ADXL moves up

Fig 5.11: Center position

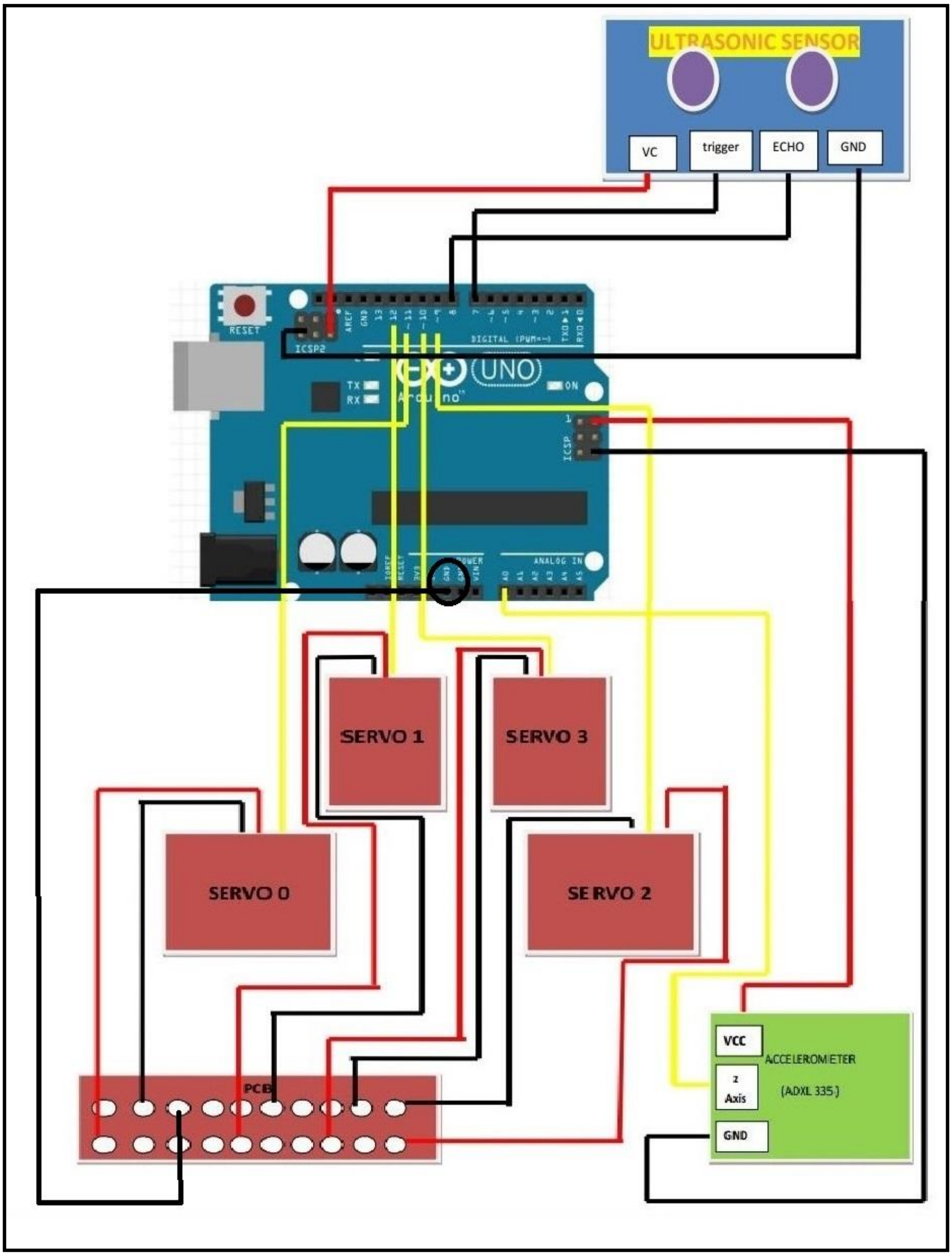


Fig 5.12 : Overall Circuit Daigram Of Adaptive Headlight System

Specifications:

Red Wire = Power supply

Yellow Wire = Data wire

Black Wire= Ground wire

5.4 Programming of Adaptive headlight system.

Arduino Uno has its own programming software. We have used Arduino Uno 1.8.2. for programming Accelerometer Sensor and Ultrasonic Sensor.

i. Defining variable and assigning pins.

First we defined variables needed for four servo motors. Then we assigned pins for each Servo motor, Ultrasonic sensor and Accelerometer sensor on Arduino Uno Board. We also defined the nature of trigger and echo pin on Ultrasonic sensor.


```
#include <Servo.h>

Servo myservo;
Servo myservo1;
Servo myservo2;
Servo myservo3;

const int y = A0;
int  triggerPin = 7;
 int  echoPin = 8;

int light_val, press_val, alch_val, adxl_y_val, duration, distance;

void setup()
{
  Serial.begin (9600);

   myservo.attach (9);
myservo1.attach (10);
myservo2.attach (11);
myservo3.attach(12);


  pinMode (triggerPin, OUTPUT);
  pinMode(echoPin, INPUT);
}
```

Fig 5.13: Arduino Program (Defining variable and assigning pins.)

ii. Reading inputs from sensors

Here we programmed the sensors to read inputs of changing variables and print them on Serial Monitor for constant reviewing and analyzing process.


```
void loop ( )
{
   digital Write (triggerPin, HIGH);
   delay Microseconds(10);
   digital Write(triggerPin, LOW);
   duration = pulseIn(echoPin, HIGH);
   distance = (duration / 2) / 29.1;
   delay(1000);
   Serial.print(distance);
   Serial.print("cm");
   Serial.println(" ");
   Sensor_Read();
   servo_run();
}

void Sensor_Read()
{
  adxl_y_val = analogRead(y);
  Serial.print("ADXL: ");
  Serial.print(adxl_y_val);
  Serial.print("\t");
  delay(1000);
}
```

Fig 5.14 : Arduino Program (Reading inputs from sensors.)

iii. Programming Accelerometer Sensor

Here we programmed 'Vertical Swiveling' or Pitching of Headlight frame. We defined different conditions for pitching motion of headlight and relative angular response for said conditions. We designed both motors for Center position with 90^0, Up position for servo 0 as 70^0 and for servo 2 as 110^0, Down position for servo 0 as 110^0 and for servo 2 as 70^0.

iv. Programming Ultrasonic Sensor

Here we programmed 'Horizontal Swiveling' or Yawing of Headlight frame. We defined different conditions for pitching motion of headlight and relative angular response for said conditions.

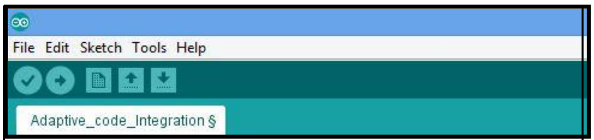
We designed both motors for Center position with 100^0, Right position for servo 1 as 150^0 and for servo 3 as 135^0, Left position for servo 1 as 65^0 and for servo 3 as 50^0.


```
void servo_run()
{
 if ((adxl_y_val > 320) &&
     (adxl_y_val < 370))
 {
  Serial.println("In centre motor");

  myservo.write(90);
  myservo2.write(90);
  delay(15);
 }
 else if (adxl_y_val >= 370)
 {
  Serial.println("In up motor");

  myservo.write(70);
  myservo2.write(110);
  delay(15);
 }
 else if (adxl_y_val <= 320)
 {
  Serial.println("In dowm motor");

  myservo.write(110);
  myservo2.write(70);
  delay(15);
 }
```




```
if ((distance < 23) && (distance > 19))
 {
  Serial.println("In center motor");

  myservo1.write(100);
  myservo3.write(100);
  delay(15);

 }
 else if (distance >= 23)
 {
  Serial.println("In right motor");

  myservo1.write(150);
  myservo3.write(135);
  delay(15);
 }
 else if (distance <= 19)
 {
  Serial.println("In left motor");

  myservo1.write(65);
  myservo3.write(50);
  delay(15);
 }
}
```

Fig 5.15 : Arduino Program (Accelerometer Sensor and Ultrasonic Sensor)

5.5 Troubleshooting

In our project we had kept the distance between the Yawing frame and the ultrasonic sensor very small as it emerged out as a design flaw which have been affecting in electronic working of the Adaptive Headlight System. Actual Problem Faced – As the distance between the path of the ultrasonic sensor and the yawing frame was small, thus when the distance sensed by the sensor exceeded the set limit servo motor would turn the yawing frame to right side. However the yawing frame would come in path of the ultrasonic sensor and it would sense immediately lesser distance. This distance would lie within the set limit for left turn. Therefore servo would rotate the yawing frame immediately to left side .Hence the yawing frame kept on fluctuating continuously when taking right turn.

Number of solutions that could be applied:

i. Increase the height of the ultrasonic sensor by moving the sensor along positive Y axis.

ii. In order to solve this problem we could move the ultrasonic sensor along negative Z axis Best optimum solution selected:

We selected the first solution of moving the sensor along positive Y axis as it would give more reliable and efficient results as it would also prove efficient during transportation.

Procedure:

We increased its height in Y axis by increasing its length by use of jumper wires and accurately positioning the sensor on rigid support in front of obstacle. Thus we tested the system and found accurate readings and the fluctuation while taking right turn were completely eliminated.

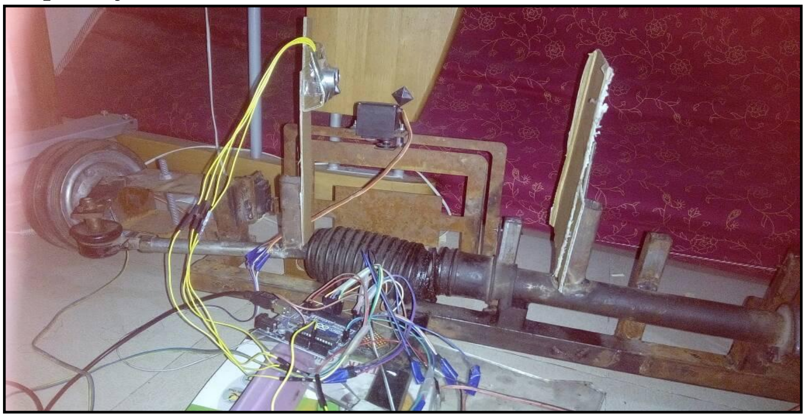


Fig 5.16 : Troubleshooting

CHAPTER 6
RESULTS

After performing number of trials, we came up with the experimental values which we are keeping as our readings. These readings are given as below:

i. Yawing frame angle

Table 6.1: Yawing frame angle (outside lock angle)

SR. NO.	Theoretical Value Of Outside Lock Angle In Degrees	Experiment Value Of Outside Lock Angle In Degrees	Accuracy Percentage
1	35	32	91.428%
2	35	34	
3	35	31	

Table 6.2: Yawing frame angle (Inside lock angle)

SR. NO.	Theoretical Value Of Inside Lock Angle In Degrees	Experiment Value Of Inside Lock Angle In Degrees	Accuracy Percentage
1	45	44	97.77%
2	45	45	
3	45	43	

ii. Pitching frame angle

Table 6.3: Pitching frame angle

SR. NO.	Actual Value In Degrees	Experiment Value In Degrees	Accuracy
1	20	18	88.33%
2	20	16	
3	20	19	

CHAPTER 7
CONCLUSION

Considering functionality, adaptability, accuracy of adaptive headlight system-

i. Objective of headlight motion according to vehicle dynamics (Pitching and Yawing of headlight) is achieved by mechanical and electronic coupling of Arduino UNO, ultrasonic sensor, accelerometer (ADXL 335).

ii. The level of accuracy is optimized using several experimental tests for user comfort and convenience.

iii. It is concluded that with Adaptive headlight system, the number of night accidents will reduce reasonably and that the reaction time or response time of the system in range of milliseconds (15 to 30).

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