iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VI **Month of publication:** June 2021

DOI: https://doi.org/10.22214/ijraset.2021.35968

Electronic Control System for Steer by Wire

Eeshan Ranade[1], Nickles Marisusai[2], Harsh Oza[3], Suchit Pradeep[4], Salman Shaikh[5], Sumit Dubal[6]
[1, 2, 3, 4, 5]*UG Student, School of Automobile Engineering, Symbiosis Skills and Professional University, Pune, Maharashtra,*
[6]*Assistant Professor, School of Automobile Engineering, Symbiosis Skills and Professional University, Pune, Maharashtra*

Abstract: Automobile industry's focus is on efficiency, safety and performance has resulted in the rapid introduction of electronics in vehicle safety systems and engine management. Mechanical and Hydraulic systems are now gradually being replaced by electronic controllers to achieve the objectives of optimizing power consumption, improving driver convenience, and maximizing driver safety resulting in an overall improved performance and experience. Vehicle steering systems have transitioned from mechanical to hydraulic power to an electric power assisted steering system and now to the state of the art, Steer by Wire (SbW) system. Traditional mechanical systems included a steering wheel, column, gear, rack and pinion and did not support any power steering. The next generation hydraulic systems were more stable, safer and required comparatively lesser effort. Electric or DC motors drove the Electric Power System addressing the drawbacks of the hydraulic systems especially those related to environment and acoustics with the added advantage of a compact structure and power-on-demand engine performance. By-wire steering technologies was originally introduced in the Concord aircraft in 1970s. The SbW is a steering system with no steering column. The mechanical interface between the steering wheel and the wheels is replaced with by-wire electrical connection/electronic actuators. SbW system has significant advantages in terms of driving safety due to the availability of the steering command in electronic form and the removal of the steering shaft, cruising comfort with driving manoeuvring due to no space constraint and favourable to the environment with the non-usage of hydraulic oils.
Keywords: Steer by Wire (SbW), DC motors, Driving manoeuvring, Hydraulic power-assisted system (HPS), Electro-hydraulic power-assisted steering (EHPS)

I. INTRODUCTION

Vehicle steering system has a development history started from pure mechanical generation upgraded with, hydraulic power-assisted system (HPS), electro-hydraulic power-assisted steering (EHPS), electric power-assisted steering (EPS), and finally progresses towards Steer-By-Wire system.

Traditional steering systems mainly consisted of steering wheel, column, gear, rack and pinion. This system was completely based on the commands given by the driver which was then transferred to the vehicle tyres so as to follow the desired path. The invention of HPS system is recognized as a great advancement introduced in 1951 by Chrysler Imperial. It needs less driver's effort and achieves faster response supported with more stability and safety compared to its predecessor. HPS was subsequently upgraded to EHPS system mainly because of considerable costs required for its design, assembling and maintenance. EHPS utilizes an electrical pump responsible for circulating hydraulic oil as an alternative of a pulley constantly connected to the combustion crank resulting in less fuel consumption.

Contrary to HPS, it can also work with the engine off. In 1996 an advancement to the EHPS was then introduced which was EPS using an electrical motor with compact structure and power-on-demand performance. The EPS system solved all the environmental and acoustic issues reported for EHPS due to the use of hydraulic oil. Fault-tolerant EPS system is being explored through industrial research and patents. Such improvements are broadened to develop Steer-By-Wire as the next generation of steering system. The first steer by wire technology was first implemented in the aviation industry, NASA's Digital fly-by-wire aircraft in 1972. The advantages of applying electronic technology are very evident: improved performance, safety and reliability with reduced manufacturing costs. On the other hand, the world's first automotive SbW system was unveiled in 2013 in the Infiniti Q50.

Some of the advantages of the steer by wire system are:

A. Improvement in passive and active safety systems
B. Reduced modifications for left/right hand drive vehicles.
C. Increasing scope for various steering functions such as autonomous vehicles, variable steering feeling, etc.
D. Better handling capabilities
E. SbW technique facilitates application of advanced systems such as corner modules and four-wheel steering.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

II. DESIGN STRUCTURE

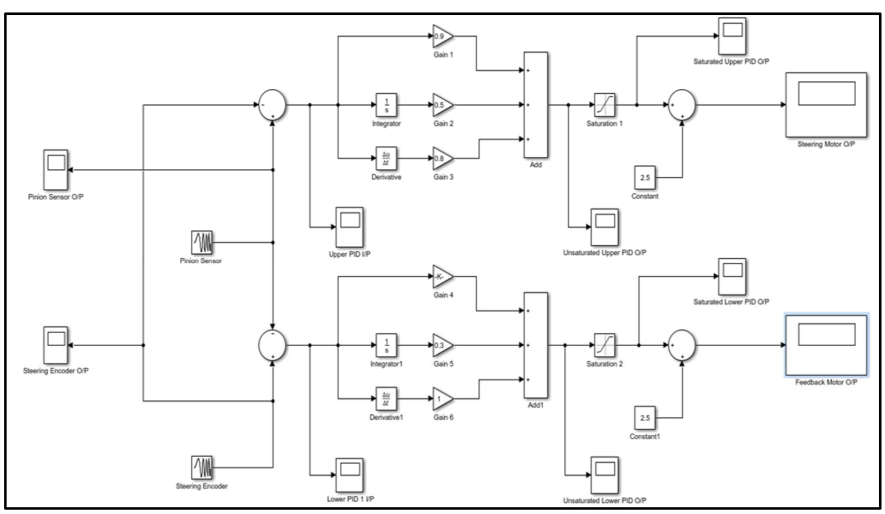
In a steer by wire system the process starts with the rotational measurement of the steering rod which is connected to the steering wheel, and on the rotation of steering wheel the steering rod is rotated and the rotation of steering rod is successfully measured by a position measuring system, which generally consists of a resolver and encoder, The same input is provided to the controller which further assists the motor individually. In this paper the major focus is on the approach of the stabilize the output signal of the motor with the help of PID controller. A feedback control system is part of a closed-loop system like a PID controller. To produce an error signal, this method uses a fixed point to evaluate the feedback variable. It adjusts the device performance based on this. This method will be repeated until the error reaches zero, at which point the feedback variable's value will be equal to a fixed point. When compared to the ON/OFF style controller, this controller produces excellent performance. Only two requirements are available to operate the device in an ON/OFF style controller. It will turn on until the process value falls below the fixed point. Similarly, if the value exceeds a predetermined threshold, it will turn off. In this type of controller, the output is not constant, and it swings around a lot near the fixed point. In comparison to the ON/OFF style controller, this controller is more stable and reliable.

A. Tuning Methods

Before the PID controller can start operating, it must be fine-tuned to match the dynamics of the mechanism to be operated. Designers use default values for P, I, and D terms, but these values don't always produce the desired results, resulting in uncertainty and slow control. To tune PID controllers, various tuning methods have been developed, and the operator must pay close attention to select the best values of proportional, integral, and derivative gains. In this model the PID controller was given a set of trial data which was considered as an input to the controller which could be stabilized and further transferred to rotate the motor.

B. Simulink Modelling

Although the control system can be implemented in hardware, it is much easier to do so in software. Due to ability of simulating dynamic system MATLAB was used to create the complete model. The model consists of the PID block. This PID controller in Simulink environment using simple gain block for proportional controller and integrator block is combined with gain block. Similarly, a differentiator block is used which is again combined with gain to make D- controller. Furthermore, the output of each block is combined together using addition operator which will be given to saturation block. A saturation block is included because, the voltage in the range -2.5v to 2.5 v, the saturation block will limit the voltage between set upper limit and lower limit. When the voltage is at 2.5 v Dc motor will be at rest as it operates between 0-5v. To provide solution to this there one constant voltage block added in the Simulink model after saturation block so it will provide additional 2.5 volts in order to operate the motor actuator. Input to this control system is from two sensors, one which is mounted at the actuator motor shaft and one is mounted on the steering shaft along with the feedback motor. The sensor output is analogous in nature and it will give the angular position of shaft. To convert this in voltage will use data acquisition hardware and toolbox in the Simulink to provide real time data to the controller. Output of the controller is given to the motor in order to control it based on the user input, along with this we can see the output waveform on the scope using Simulink environment.



Simulink Model of Steer by wire control

III. CONTROL SYSTEM WAVEFORMS

The above model can be divided into two loops upper control loop and lower control loop. The upper loop is responsible for controlling the steering motor, which will ultimately make the pinion to move in order to get desired steering angle and the lower loop is responsible for controlling the feedback motor, which will operate the feedback motor in the opposite direction of steering motor so driver can feel the feedback in terms of harder steering feel. Initially a chirp input is given to both the loops where the upper loop was excited by initial frequency of 1Hz for a duration of 4 seconds with the frequency at target time was set to 8.4Hz. Similarly, to the lower loop, the initial frequency was set to 0.2Hz for a duration of 2 seconds with the frequency at the target time was set to 3.8Hz.

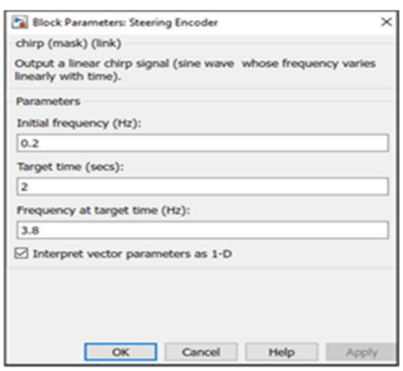
This signal will be given to the motor driver where the H Bridge will take care of respective direction control for feedback and steering actuator motor.

A. Simulation Setup

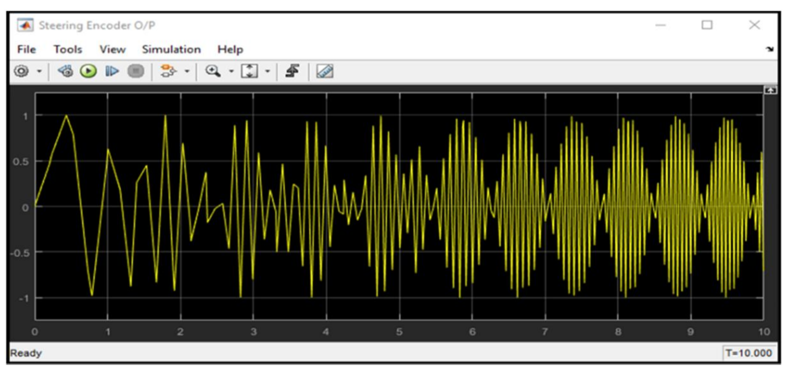
Simulation setup consists of the following:

1) *Steering Sensor:* A chirp input is generated which represents the variable voltage in case of driver interaction through movement of steering wheel.
2) *Pinion Sensor:* A chirp input is generated depending upon the pinion position, the target time is greater than that of steering sensor as well as voltage is different.
3) *Input To The Upper Control Loop:* The steering sensor output is subtracted from pinion sensor output using operator junction and then serves as an input for the PID controller.
4) *Input To The Lower Control Loop:* The pinion sensor output is subtracted from steering sensor output using operator junction and then serves as an input to PID controller.
5) *Upper PID:* This controller is responsible for steering motor control. The PID constants are set such that we get the error free output signal using trial and error method in reference to output characteristics.
6) *Lower PID:* This controller is responsible for feedback motor control. The PID constants for this controller are also set using trial and error method by observing the output in the scope.

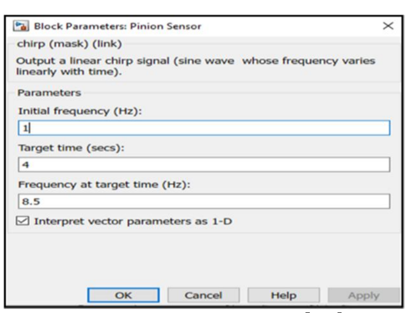
B. Input Waveforms



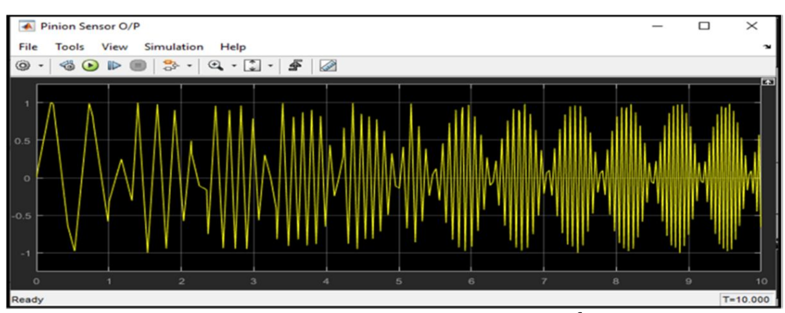
Steering Encoder Block Parameter



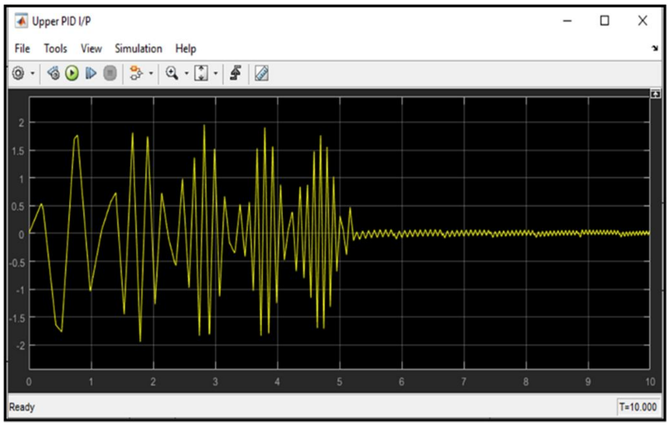
Steering Encoder Waveform



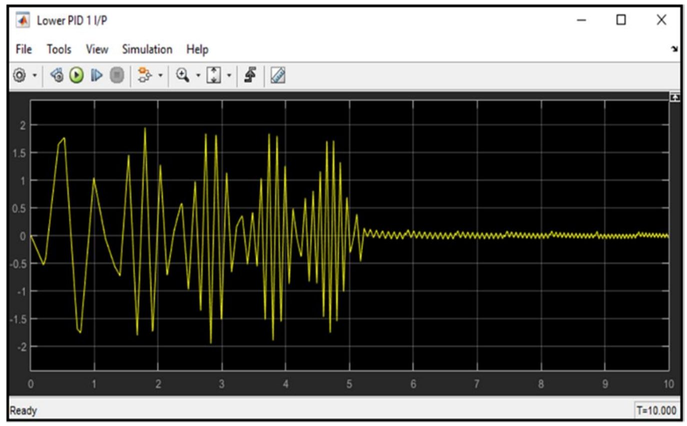
Pinion Sensor Block Parameter



Pinion Sensor Waveform



Upper PID Input



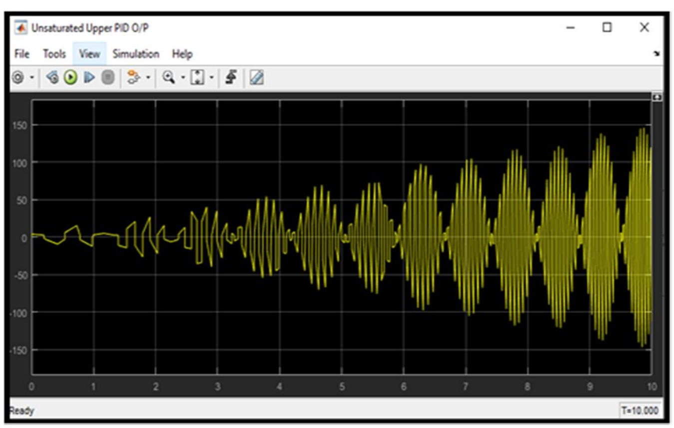
Lower PID Input

TABLE I
PID CONSTANT VALUES

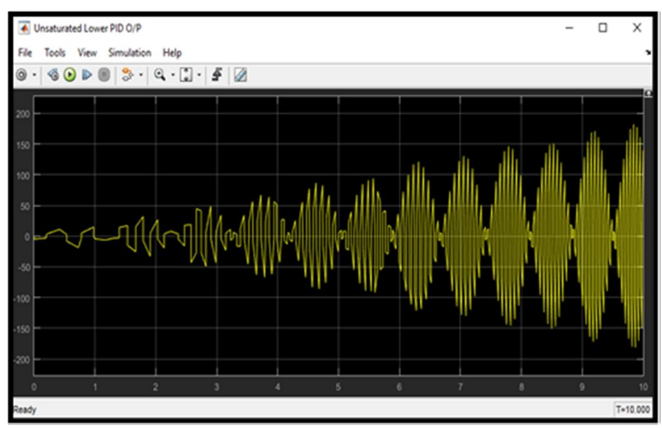
	Steering Motor	Feedback Motor
K_p	0.9	0.65
K_i	0.5	0.3
K_d	0.8	1

C. Output Characteristics

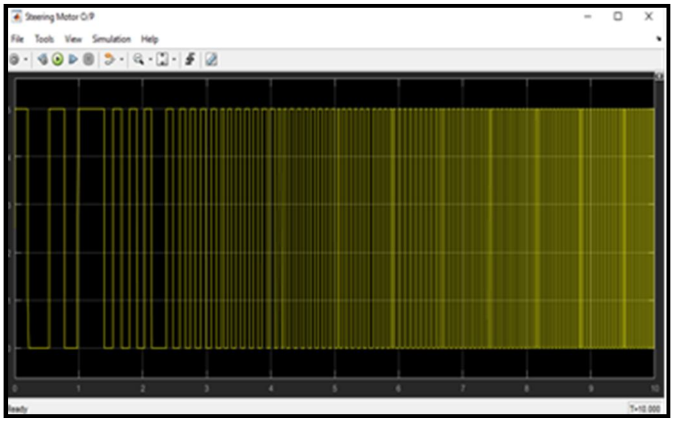
The above model can be divided into two loops upper control loop and lower control loop. The upper loop is responsible for controlling the steering motor, which will ultimately make the pinion to move in order to get desired steering angle and the lower loop is responsible for controlling the feedback motor, which will operate the feedback motor in the opposite direction of steering motor so driver can feel the feedback in terms of harder steering feel. Initially a chirp input is given to both the loops where the upper loop was excited by initial frequency of 1Hz for a duration of 4 seconds with the frequency at target time was set to 8.4Hz. Similarly, to the lower loop, the initial frequency was set to 0.2Hz for a duration of 2 seconds with the frequency at the target time was set to 3.8Hz. This signal will be given to the motor driver where the H Bridge will take care of respective direction control for feedback and steering actuator motor.



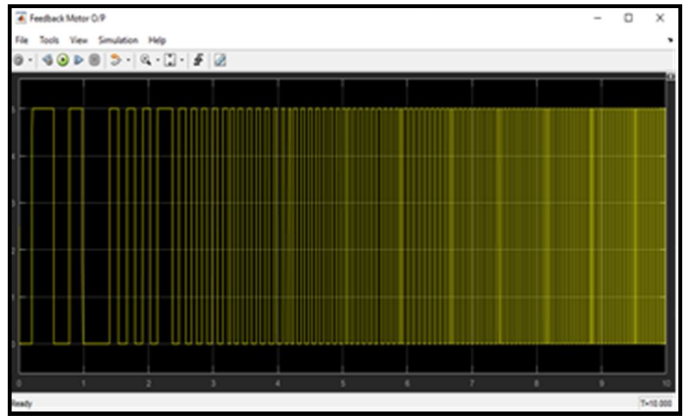
Unsaturated Upper PID output



Unsaturated Lower PID output



Output waveform to steering motor



Output waveform to feedback motor

IV. HARDWARE AND DATA ACQUISITION

A. Hardware Implementation

The biggest different in the simulation MATLAB model and the real-life model is the parameter. It is not necessary that the value considered in simulation is exactly the same what we get in real time situation and hence there is always a difference in the real and simulated model. The biggest problem in this was the validation of the system as due to the unavailability, the system was tested on the training set of values.

B. Data Acquisition

This was the most necessary step for a model to come into picture as collection of real time data was a must for a stable system. Collection of data of the components was limited. The main task was to perform the data acquisition on the board and feed the system with the values as per the real time situation. But due to the unavailability of the sensor and analog input the real time value could not be acquired.

V. CONCLUSION

A stable output signal was obtained after simulating the complete model and this output can be can be given to output circuitry to drive the steering motor. The DC motor which we consider works in the range 0-5v DC, here the waveform is square wave, it has range between 0v DC and 5v DC and continues until further control signal from PID is received. Therefore, we can interpret that the motor can be operated using this square waveform which is generated based on the user input. This waveform can be used for PWM control.

The present model can be implemented on hardware system. Using microprocessors, sensors, programmable motors the virtual system can be implemented practically. Currently the model is virtual which may be finer for theoretical calculation but then cannot be reliable hundred percent in practical world. Thus, working on practical model and working on the real-world calculations, improvement can be made in the current model. While implementing the model practically on the vehicle, programmable motors can be fixed in the steering system for all the four wheels separately such that the vehicle can rotate 360 degrees at its place thus making zero degrees turn.

REFERENCES

[1] Reza Kazemi." A Comprehensive model for developing of Steer-By-Wire System" , International Journal of Mechanical and Mechatronics Engineering

[2] Tankut Acarman t Keith A. Redmill t," A Robust Controller Design for Drive by Wire Hydraulic Power Steering System ", Proceedings of the American Control Conference, Department of Electrical Engineering The Ohio State University.

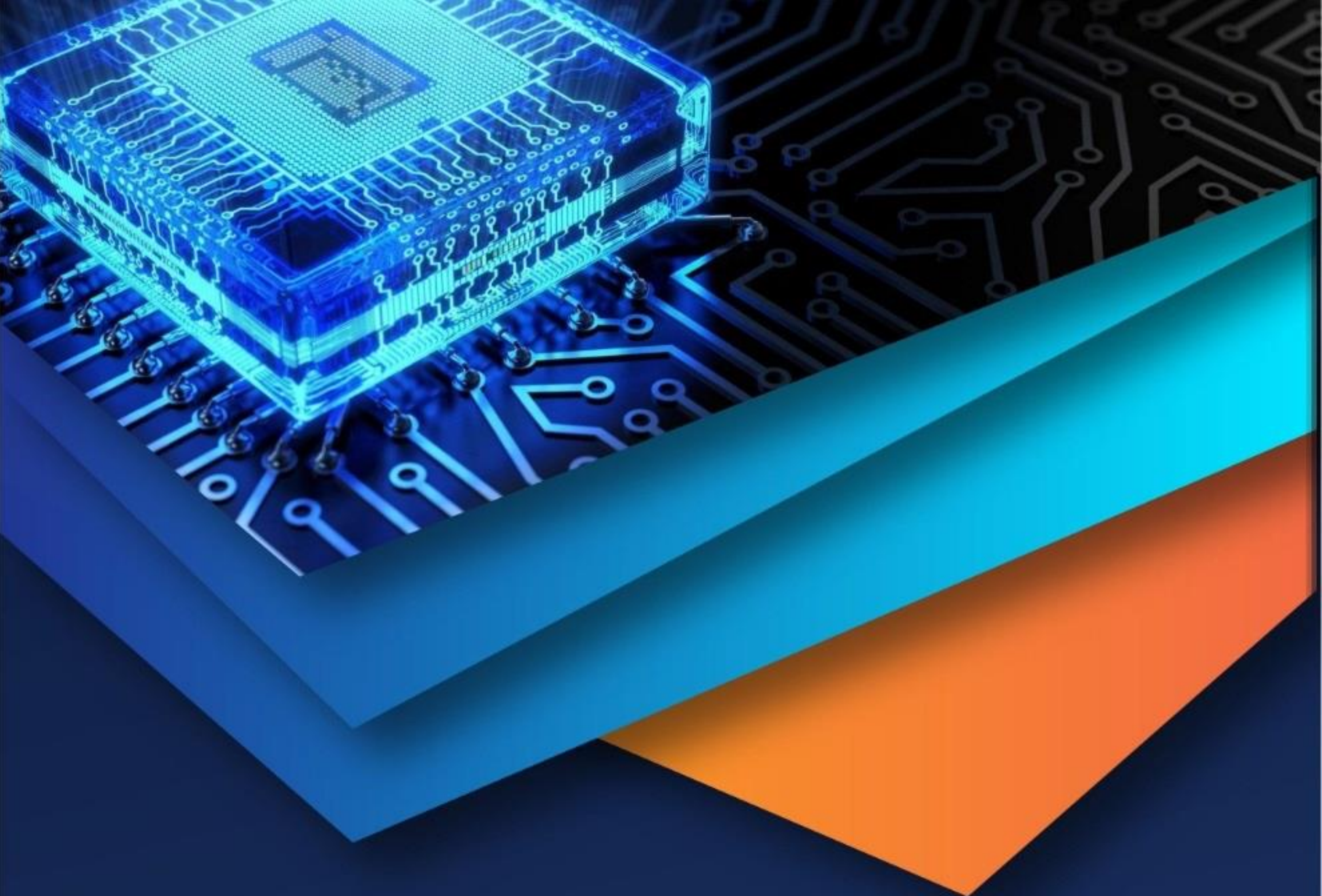
[3] Sanket Amberkar, Mark Kushion ,"Diagnostic Development for an Electric Power Steering System", Delphi Automotive Systems : Steering and Suspension Technology Symposium 2000,.

[4] Shinichiro Horiuchi An Analytical Approach to the Prediction of Handling Qualities of Vehicles With Advanced Steering Control System Using Multi-Input Driver Model , Department of Mechanical Engineering, College of Science and Technology.

[5] Yung-Hsiang Judy Hsu and J. Christian Gerdes , "STABILIZATION OF A STEER-BY-WIRE VEHICLE AT THE LIMITS OF HANDLING USING FEEDBACK LINEARIZATION", 2005 ASME International Mechanical Engineering Congress and Exposition.

[6] Arvind Goyal and Ayushi Thakur ," An Overview of Drive by Wire Technology for Automobiles", 2019 International Conference on Automation, Computational and Technology Management (ICACTM).

[7] C.V. Babu, Govindarao Potnuru, Santarao Korada, K. Murali Krishna," Design of Accurate Steering Gear Mechanism ", Department of Mechanical Engineering, GMRIT
[8] Li Qiang, He Ren," Modelling and Simulation Study of the Steer by Wire System Using Bond Graph ",IEEE journal, School of Automobile and Traffic Engineering, Jiangsu University.
[9] Sayed Abolfazl Mortazavizadeh, Ahmad Ghaderi," Recent Developments in the Vehicle Steer-by-Wire System", IEEE TRANSACTIONS ON TRANSPORTATION ELECTRIFICATION.
[10] Manuele Bertoluzzo, Giuseppe Buja," An Approach to Steer-by-Wire System Design ",IEEE Xplore, Department of Electrical Engineering University Padova



doi crossref

10.22214/IJRASET

INDEX COPERNICUS

45.98

ISRA JIF

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

ISI

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY