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Dr. M. S. Sheshgiri Campus, Belagavi

Department of Electronics and Communication Engineering

Automotive Electronics

23EECC305

Project Report

on

Cruise Control

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CERTIFICATE

This is to certify that project entitled “Cruise Control System using Matlab” is a bonafide work carried out by the student team of Bhakti Betagiri 02FE21BEC019, Bhuvan Budavi 02FE21BEC021, Komal Melavanki 02FE21BEC042, Praveen Magdum 02FE21BEC064”. The project report has been approved as it satisfies the requirements with respect to the Course project work prescribed by the university curriculum for B.E. (VI Semester) in Department of Electronics and Communication Engineering of KLE Technological University Dr. M. S. Sheshgiri CET Belagavi campus for the academic year2023-2024.

Prof. Vinayak Dalavi	**Dr. Dattaprasad A Torse**	**Dr. S. F. Patil**
Guide	**Head of Department**	**Principal**

ACKNOWLEDGMENT

I Acknowledge my guide I extend my sincere appreciation to those who have contributed to the successful completion of this course project. Their expertise, guidance, and support have been instrumental throughout the entire process. I would like to express my deepest gratitude to, our mentor Prof. Vinayak Dalvi, your technical acumen and insightful feedback have greatly enriched the content of this report. I would also like to acknowledge the collective efforts of the entire project team, including Bhakti Betagiri, Bhuvan Budavi, Komal Melavanki, Praveen Magdum for their collaboration and hard work has been pivotal in achieving our goals. This project stands as a testament to the collaborative spirit and dedication of each individual involved. Thank you for your commitment to excellence.

-The project team

ABSTRACT

This project explores the design and implementation of a cruise control system using MATLAB, Simulink. Cruise control systems are critical in modern vehicles for maintaining a constant speed without the driver’s continuous input on the accelerator. The primary objective of this study is to model, simulate, and analyze the performance of a cruise control system through MATLAB Simulink, a physical modeling tool that enables simulation of multi-domain physical systems. The project begins with the development of a dynamic model of a vehicle, capturing the essential components such as the engine, transmission, and vehicle dynamics. A PID (Proportional-Integral-Derivative) controller is then designed to regulate the throttle position, ensuring the vehicle maintains the desired set speed. The controller’s parameters are tuned using MATLAB’s control design tools to achieve optimal performance in terms of stability, responsiveness, and disturbance rejection. Simulations are conducted under various scenarios to evaluate the system’s performance, Including changes in desired speed, road slope variations, and external disturbances like wind resistance. The results demonstrate the efficacy of the designed cruise control system in maintaining a steady speed with minimal deviation, showcasing the robustness and adaptability of the PID controller within the Simulink environment. The study concludes with a discussion on the advantages of using MATLAB Simulink for modeling and simulation of automotive systems, highlighting its ability to integrate physical components seamlessly and its effectiveness in control system design and analysis. This work lays a foundation for further research and development in advanced vehicle control system, paving the way for more sophisticated driver assistance technologies.

Keywords: Cruise control, MATLAB Simulink, PID controller, vehicle dynamics, control system design, simulation, automotive systems.

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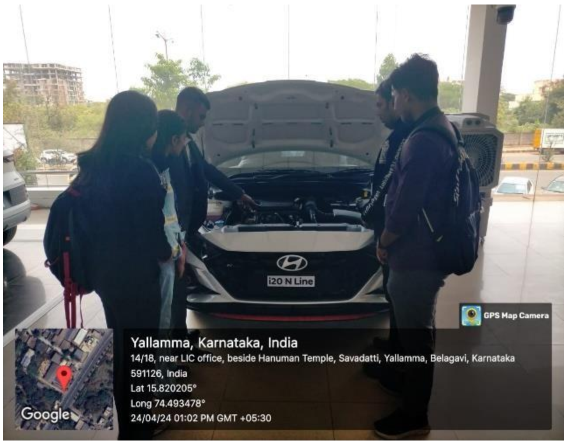
SURVEY REPORT:

1. Field Visit



- During the visit to the Hyundai i20 showroom in Belgaum, we engaged with the dealership staff to gather insights into the technical aspects and functionalities of the Hyundai i20, particularly emphasizing the Turbo Engine, HD Display, and Cruise Controller. The information gathered provides valuable insights into the technological advancements and challenges faced in these key areas.

1. **Turbo Engine:**
   - The dealership highlighted the turbocharged engine as a prominent feature of the Hyundai i20, enhancing performance and fuel efficiency.
   - We learned about the working principle of the turbo engine, which involves utilizing exhaust gases to spin a turbine, thereby compressing air and delivering more oxygen to the engine for improved combustion.
   - Challenges mentioned include ensuring optimal performance under varying driving conditions and maintaining reliability and durability of turbocharger components.

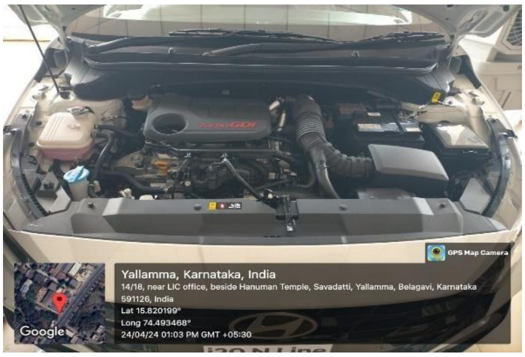


Figure 1: Turbo engine

2. **HD Display:**

- The Hyundai i20 features a high-definition (HD) display integrated into the dashboard, providing a modern and intuitive interface for multimedia, navigation, and vehicle settings.
- We inquired about the display technology and its resolution, brightness, and touch sensitivity, which contribute to user experience and visibility under different lighting conditions.
- Challenges discussed revolved around ensuring seamless integration with vehicle systems, minimizing glare and reflections, and addressing potential issues related to software updates and compatibility.

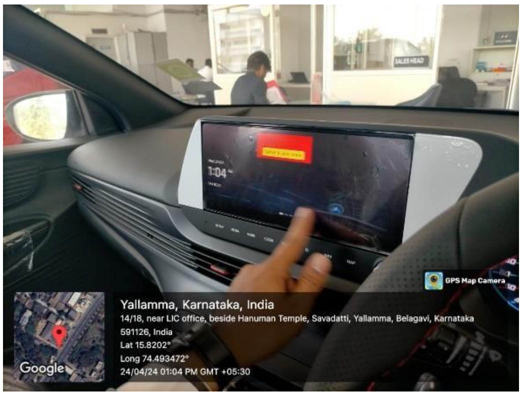


Figure 2: HD display

3. **Cruise Controller:**

- The dealership explained the functionality of the cruise controller, allowing drivers to maintain a set speed without constant throttle input, enhancing comfort and reducing fatigue during long journeys.
- We explored the cruise control system's features, such as adaptive cruise control (if available), which adjusts speed based on traffic conditions.

Figure 3: Cruise control

Problems Identified :

Based on the information gathered during the visit to the Hyundai i20 showroom in Belgaum, the following problems or challenges were identified:

1. **Turbo Engine:**

- One of the challenges noted was ensuring consistent performance of the turbo engine under varying driving conditions, including acceleration, deceleration, and load changes.

2. **HD Display:**

- Ensuring seamless integration of the HD display with vehicle systems, including multimedia, navigation, and connectivity features, was highlighted as a potential challenge.

3. **Cruise Controller:**

- Optimizing the performance of adaptive cruise control, particularly in congested traffic or hilly terrains, emerged as a challenge to enhance driver comfort and safety.
- Ensuring seamless integration with advanced driver-assistance systems (ADAS), such as collision avoidance and lane-keeping assistance, was identified as a key consideration to maximize the effectiveness of cruise control features.

Introduction:

- The Hyundai i20 stands as a testament to Hyundai's commitment to innovation, blending style, performance, and cutting-edge technology to redefine the driving experience. Boasting a sleek design and a host of advanced features, the i20 exemplifies Hyundai's pursuit of excellence in the compact car segment.
- Hyundai i20 is more than just a car , it's a statement of sophistication and innovation. With a turbocharged engine delivering exhilarating performance, an HD display offering immersive connectivity and entertainment, and a cruise controller enhancing comfort and convenience, the i20 sets new standards in the compact car segment. Whether navigating city streets or exploring the open road, the Hyundai i20 promises a driving experience that is as thrilling as it is refined.

Figure 4: Hyundai i20

Functional Architecture of Cruise Controller :

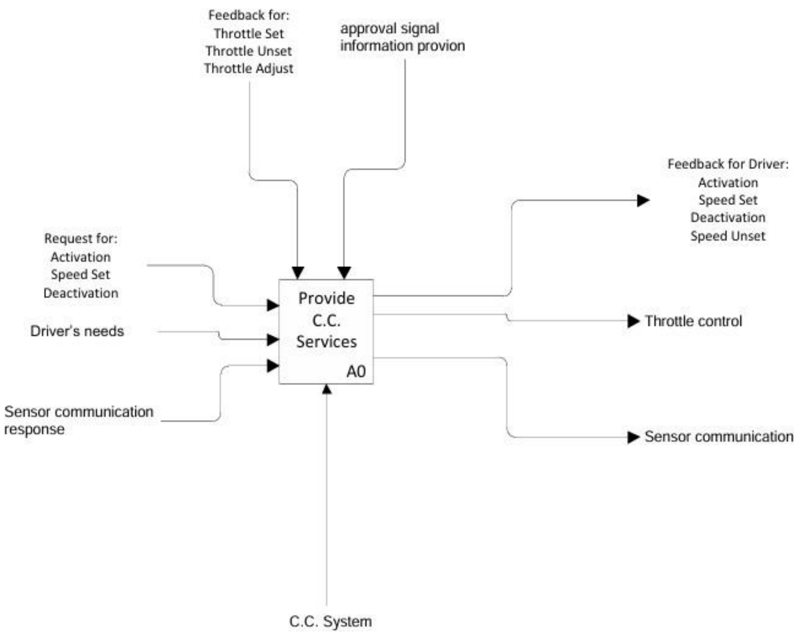


Figure 5: Functional Architecture of Cruise Controller

Functional Architecture Diagram of Cruise Controller :

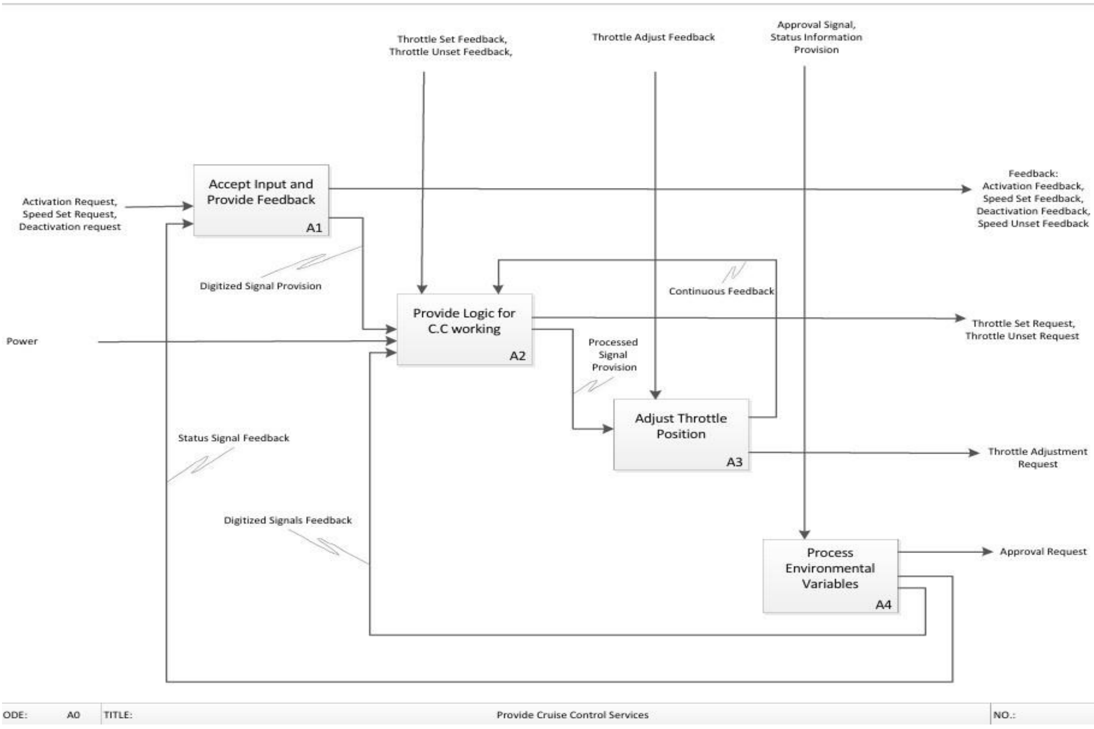


Figure 6: Functional Architecture of Cruise Controller

Objectives:

1. The primary objective of visiting the Hyundai i20 showroom is to conduct research and gain familiarity with the features, specifications, and technologies offered by the Hyundai i20 model.
2. Evaluation of Customer Experience
3. Identification of Potential Challenges and Opportunities.

Outcomes of survey :

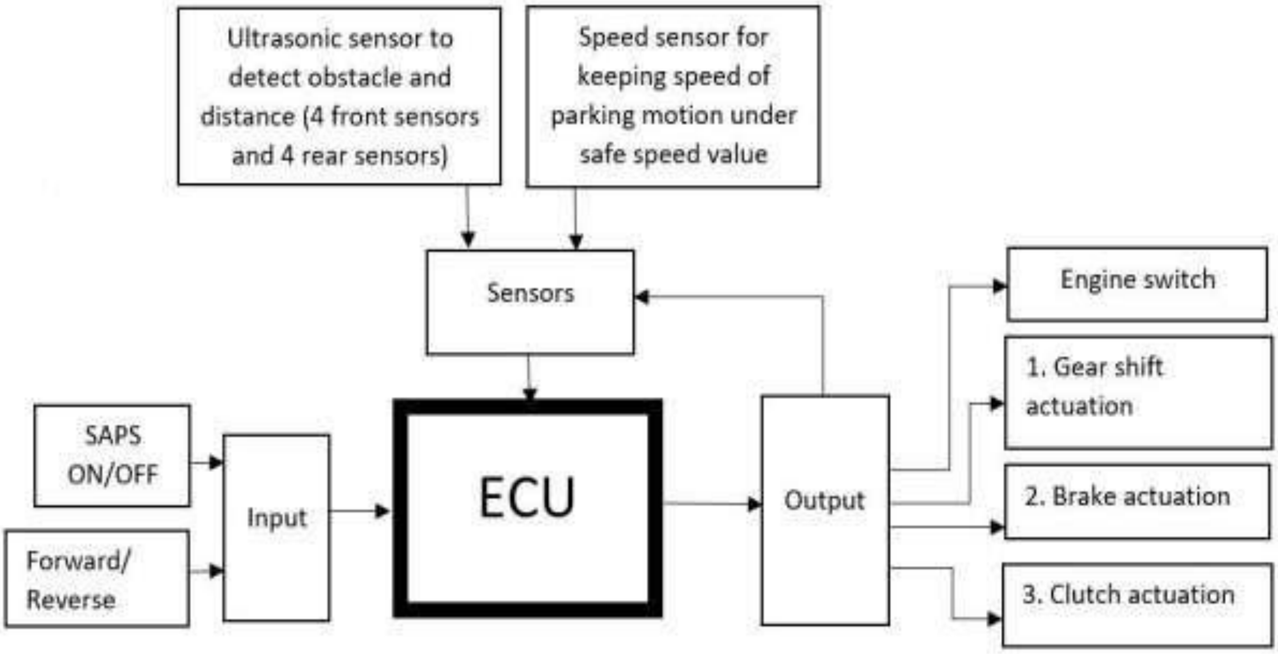
1. Enhanced Understanding of Hyundai i20 Features.
2. Identification of Customer Preferences and Concerns.
3. By comparing the features and functionalities of the Hyundai i20 with competing models in the market, the survey has provided insights into the competitive landscape.
4. Opportunities for Product Development and Innovation.
5. Enhanced Customer Engagement and Satisfaction.

Conclusion:

The field visit to the Hyundai i20 showroom provided valuable insights into the technical aspects and functionalities of the vehicle, particularly focusing on the Turbo Engine, HD Display, and Cruise Controller. The information gathered will contribute to a comprehensive understanding of Hyundai i20's features and technologies, aiding in decision-making and future research and development efforts.

E\E System Architecture

- What is Single ECU Architecture?



` A single Electronic Control Unit (ECU) is the workhorse behind simpler cruise control systems. Imagine it as a self-contained brain for the entire operation. This ECU receives information from various car sensors, like the ones tracking wheel and engine speed, as well as driver inputs through the cruise control buttons. Based on this data, the ECU calculates the necessary adjustments to maintain the desired cruising speed. It then sends control signals, typically to the engine control module, to electronically adjust the throttle position or interact with the engine management system. While this single ECU approach offers a simpler and potentially more reliable design, it's limited in functionality. It lacks the processing power for advanced features like adaptive cruise control, making it more suitable for older vehicles or those with basic cruise control systems.

- How Does it work in general?

Inputs:

- **Sensors:** The single ECU gathers data from various sensors that measure different aspects of the system it controls. These sensors can be:
    - **Analog sensors:** Provide a continuous electrical signal corresponding to the measured quantity (e.g., voltage signal from a temperature sensor).
    - **Digital sensors:** Transmit on/off or high/low signals (e.g., button press detected by a seat belt sensor).
- **User Inputs:** The ECU might also receive control signals from user interfaces like buttons or switches (e.g., cruise control activation).

Processing:

- The ECU's internal processor unit (CPU) takes the received sensor data and user inputs.
- Based on pre-programmed logic or control algorithms stored in its memory, the ECU interprets this data and determines the necessary actions.

Outputs:

- **Actuators:** The ECU sends control signals to actuators, which are devices that physically influence the system. Examples include:
    - **Solenoids:** Valves controlled by electromagnets (e.g., controlling fuel flow in an engine).
    - **Electric motors:** Used to adjust components like throttle position or air conditioning vents.

Benefits:

- **Simplicity:** Single ECUs offer a cost-effective and straightforward design for controlling basic functionalities.
- **Reliability:** Fewer components translate to potentially less prone to failures compared to more complex systems.

- How Does it best suits our Project?

- **Reduced Complexity:** Matlab thrives on clear and concise code. A single ECU translates to a less intricate model, requiring you to manage just one set of inputs, control logic, and outputs within your Matlab script. This simplifies development, debugging, and overall understanding of the system's behavior.

- **Focus on Control Algorithms:** By using a single ECU, you can concentrate on the heart of the cruise control system – the control algorithms. Your Matlab script will become the playground for implementing the logic that maintains a desired speed. This includes:
  - **Reading sensor data:** Simulate sensor readings (like vehicle speed) within your Matlab script or by integrating data from your Simulink model.
  - **Control logic design:** Develop control algorithms that calculate the necessary throttle adjustments based on the difference between the desired and actual speed. This might involve proportional-integral (PI) control techniques commonly used in cruise control systems.
  - **Sending control signals:** Output these calculated throttle adjustments from your Matlab script back to the Simulink model, effectively controlling the simulated engine power.
- **Learning Platform:** A single ECU setup shines as a learning tool for students or those new to cruise control design. It offers a manageable environment to grasp the fundamental principles of the system without the complexities of communication protocols and multiple interacting ECUs. You can focus on the core concepts of sensor feedback, control logic implementation, and how these elements work together to maintain a constant speed.

Limitations to Consider:

- **Basic Functionality:** Remember, a single ECU represents a basic cruise control system. Your Matlab simulation won't be able to handle advanced features like Adaptive Cruise Control (ACC) that require constant monitoring of surrounding traffic. Additionally, integrating with other driver-assistance systems won't be possible with this setup.

Conclusion:

A single ECU approach in a Matlab project offers a valuable starting point for understanding the core concepts of cruise control system design and control algorithms. It provides a manageable environment for learning and experimentation without the complexities of a distributed ECU architecture. By focusing on the control logic within your Matlab script, you can gain valuable insights into how feedback, calculations, and control signals work together to maintain a constant speed in a simulated environment. Once you've mastered the basics, you can explore more complex scenarios and eventually move on to distributed ECU architectures for simulating more advanced driver-assistance systems.

Course Project Report

1.Introduction

Cruise control systems are integral to modern vehicles, providing comfort and efficiency by maintaining a consistent speed without continuous driver input on the accelerator. This automation reduces driver fatigue, enhances fuel efficiency, and promotes safer driving. The system operates by adjusting the throttle to maintain the desired speed, compensating for road conditions, vehicle load, and other factors. This project focuses on modeling and simulating a basic cruise control system using MATLAB Simulink, which enables the simulation of multi-domain physical systems.

The objectives include developing a dynamic vehicle model with essential components, designing a PID controller to regulate the throttle, and simulating the system under various conditions to assess performance and robustness. We begin by constructing a detailed vehicle dynamics model in Simulink, representing the engine, transmission, and other critical components. The PID controller is then designed and tuned using MATLAB's control design tools to achieve optimal performance in terms of responsiveness, stability, and disturbance rejection.

Simulations under various scenarios, such as changes in desired speed, road slope variations, and external disturbances, demonstrate the system's effectiveness in maintaining a steady speed with minimal deviation. The results highlight the robustness and adaptability of the PID controller within the Simulink environment. This study underscores the advantages of using MATLAB Simulink for automotive systems modeling and simulation, showcasing its seamless integration of physical components and effectiveness in control system design and analysis. The findings provide a foundation for further research and development in advanced vehicle control systems, paving the way for sophisticated driver assistance technologies.

2.Problem statement

The development of effective cruise control systems is crucial for enhancing driving comfort, safety, and fuel efficiency. Traditional systems often struggle to maintain a steady speed under varying conditions such as road slopes, vehicle loads, and external disturbances. The challenge is to design a robust cruise control system that can accurately handle these dynamic conditions. This project aims to address this challenge by using MATLAB Simulink to model and simulate a cruise control system. The key objectives are to develop a dynamic vehicle model, design a PID controller to regulate the throttle position, and evaluate system performance through simulations under various conditions to ensure robustness and adaptability. The goal is to demonstrate MATLAB Simulink's capability in creating an effective cruise control system and lay the groundwork for future advancements in automotive control technologies.

3.Objectives

The primary objectives of this project are:

- Develop a Dynamic Vehicle Model: Create a comprehensive model of the vehicle dynamics using MATLAB Simulink, including key components such as the engine, transmission, and other factors that influence the vehicle's speed and behavior.

- Design a PID Controller: Implement and tune a Proportional-Integral-Derivative (PID) controller to regulate the vehicle's throttle position, ensuring it can maintain a consistent speed as specified by the driver.

- Simulate and Analyze Performance: Conduct simulations under various driving scenarios, such as changes in desired speed, road slope variations, and external disturbances like wind resistance, to evaluate the performance, stability, and robustness of the cruise control system.

- Optimize System Response: Fine-tune the controller parameters to achieve optimal system response characterized by minimal speed deviation, quick adjustment to set speed, and effective disturbance rejection.

- Demonstrate MATLAB Simulink Capabilities: Showcase the effectiveness of MATLAB Simulink in integrating physical modeling with control system design, highlighting its utility in developing advanced automotive control systems.

- Provide a Foundation for Future Research: Establish a groundwork for further advancements in vehicle control technologies, including adaptive cruise control and other driver assistance systems, by leveraging the insights and results obtained from this project.

- Enhance Fuel Efficiency: Demonstrate how a well-designed cruise control system can contribute to improved fuel efficiency by maintaining optimal speed and reducing unnecessary acceleration and deceleration.

- Improve Driver Safety and Comfort: Ensure that the designed cruise control system can enhance driver comfort by reducing fatigue and maintaining consistent speeds, while also contributing to safety by adhering to speed limits and responding to road conditions effectively.

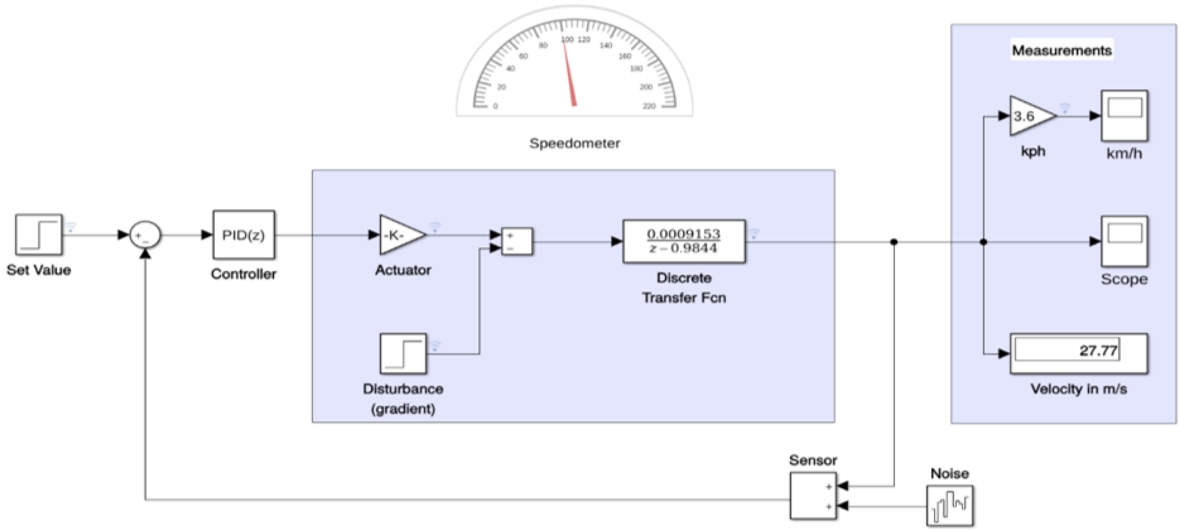
- Integration with Vehicle Systems: Explore the integration of the cruise control system with other vehicle systems, such as braking and steering, to provide a more comprehensive approach to vehicle automation.

- User Interface and Control: Design a user-friendly interface for drivers to easily set and adjust the desired speed, and to engage or disengage the cruise control system as needed.
- Real-World Applicability: Validate the simulation results with potential real-world scenarios to ensure the cruise control system's practicality and effectiveness in actual driving conditions.

- Cost-Effectiveness: Analyze the cost implications of implementing the cruise control system in vehicles, ensuring that the design is not only effective but also economically viable for production and use in consumer vehicles.

- Environmental Impact: Assess the environmental benefits of using an efficient cruise control system, such as reduced emissions due to smoother driving patterns and better fuel management.

4.Working



- Set Value:
  This block represents the desired speed for the vehicle. It's the reference input to the system, typically a step input to indicate a sudden change in desired speed.

- Summation Block:
  This block calculates the error by subtracting the actual speed from the set value. The error is then fed to the PID controller.

- PID Controller:
  This block is configured as a PID controller. It processes the error signal to generate a control signal aimed at minimizing the error over time. The PID controller consists of Proportional (P), Integral (I), and Derivative (D) components, which help in reducing the error by adjusting the control input to the system dynamically.

- Actuator:
  This block represents the actuator dynamics. The gain block preceding it adjusts the control signal appropriately before it's applied to the system.

- Disturbance (Terrain):
  This block simulates external disturbances, such as changes in terrain, affecting the vehicle's speed. It adds these disturbances to the control signal.

- Plant (Transfer Function):
  This block represents the dynamic model of the vehicle. The transfer function given is 1/(1084s + 17), indicating the relationship between the control input (throttle position) and the vehicle speed.

- Measurements:
  This subsystem measures the vehicle's speed in different units. The speed is calculated in meters per second (m/s) and then converted to kilometers per hour (km/h) using a gain block (multiplication by 3.6).

- Speedometer:
  This visual component displays the vehicle's speed in real-time in km/h, providing a user-friendly interface to observe the speed.

- Noise:
  This block adds noise to the measured speed to simulate realistic sensor readings, accounting for inaccuracies and fluctuations in the speed measurement.

5.Working of the Cruise Control System:

- Setting Desired Speed:
  The user sets a desired speed (Set Value).

- Error Calculation:
  The system calculates the error by comparing the actual speed with the desired speed.

- PID Control:
  The PID controller processes the error to determine the appropriate control action (throttle adjustment) to minimize the error.

- Actuation:
  The control signal is adjusted by the actuator and any external disturbances are accounted for.

- Vehicle Dynamics:
  The adjusted control signal is applied to the vehicle model (Plant), resulting in a change in vehicle speed.

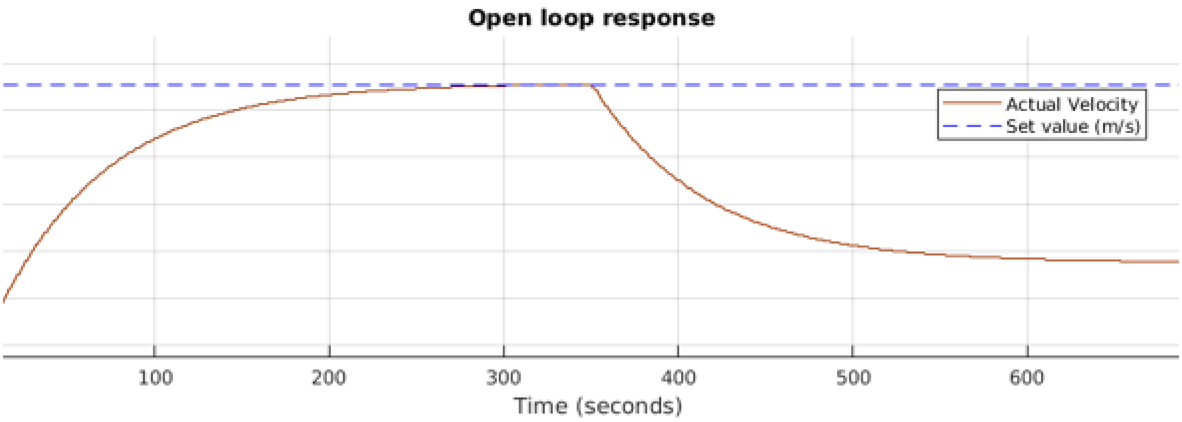
- Speed Measurement:
  The actual speed of the vehicle is measured, converted to different units, and displayed on the speedometer.

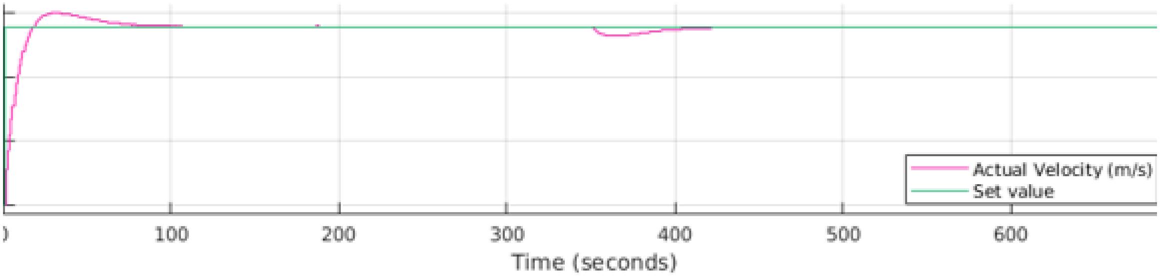
- Feedback Loop:
  The measured speed is fed back to the summation block to continuously update the error.

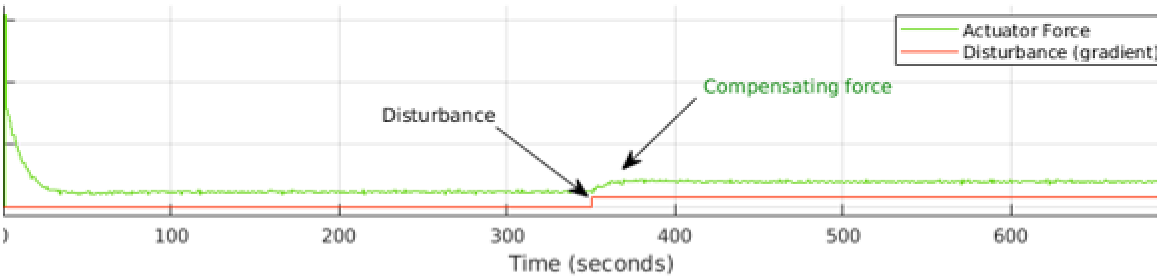
6.Results and Discussion:

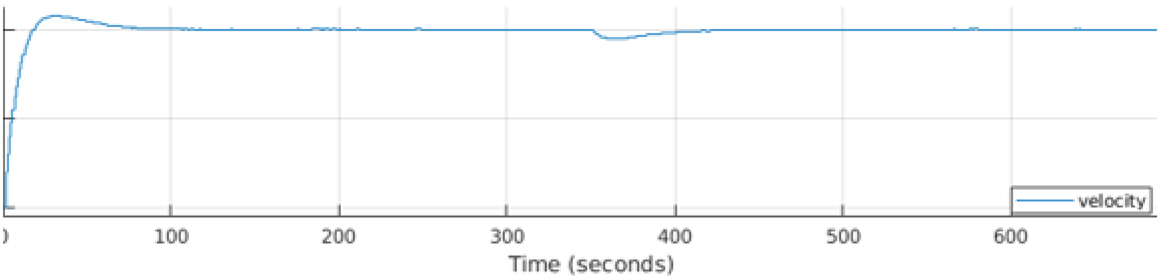
By comparing these waveforms, We can clearly see the advantage of using a closed-loop control system for maintaining the desired speed accurately and quickly, which is essential in applications like cruise control in vehicles.

The waveform demonstrates the resilience and accuracy of a closed-loop control system in maintaining the desired speed even when external disturbances are introduced. The controller effectively mitigates the impact of disturbances, ensuring the system's performance remains within acceptable limits.




Actual Velocity (m/s)
Set value
100
200
300
400
500
600
Time (seconds)


Actuator Force
Disturbance (gradient)
Compensating force
Disturbance
100
200
300
400
500
600
Time (seconds)


velocity
100
200
300
400
500
600
Time (seconds)

7.Cruise Control Applications:

Cruise control systems have become an integral feature in modern vehicles, providing various applications that enhance driving comfort, safety, and efficiency. Here are some key applications of cruise control:

- Highway Driving: Cruise control is especially useful on highways where constant speeds are maintained over long distances. It reduces driver fatigue by allowing them to relax their foot from the accelerator pedal.

- Fuel Efficiency: Maintaining a consistent speed helps in optimizing fuel consumption. Cruise control systems can contribute to better fuel economy by avoiding unnecessary acceleration and deceleration.

- Speed Limit Adherence: Drivers can set the cruise control to adhere to speed limits, reducing the risk of speeding violations and associated penalties.

- Long-Distance Travel: On long trips, cruise control enhances driving comfort and reduces stress, allowing drivers to focus more on steering and road conditions rather than maintaining speed.

- Traffic Flow Management: Adaptive cruise control systems can adjust the vehicle's speed based on traffic conditions, maintaining a safe following distance from the vehicle ahead. This helps in smooth traffic flow and reduces congestion.

- Driver Assistance Systems: Integrated with advanced driver-assistance systems (ADAS), cruise control can work with features like lane-keeping assist, collision avoidance, and automatic braking, enhancing overall vehicle safety.

- Commercial and Fleet Vehicles: In commercial transportation and fleet management, cruise control can help in maintaining consistent speeds, improving fuel efficiency, and reducing wear and tear on vehicles, leading to cost savings.

- Electric Vehicles (EVs): Cruise control is particularly beneficial in electric vehicles by optimizing energy usage and extending the driving range

- Autonomous Vehicles: As a foundational technology for autonomous driving, cruise control systems are being developed into more sophisticated forms, such as adaptive and predictive cruise control, contributing to the advancement of self-driving car technologies.

- Comfort in Varied Terrain: Advanced cruise control systems can adjust speed based on road gradients and curves, providing a smoother driving experience in varied terrains.

- In summary, cruise control systems enhance driving comfort, safety, and efficiency across various driving scenarios. They play a crucial role in modern automotive technologies and are essential for the future of autonomous and semi-autonomous vehicles.

8.Conclusion:

In conclusion, this project has successfully demonstrated the design, implementation, and analysis of a cruise control system using MATLAB Simulink. By developing a dynamic vehicle model and designing a PID controller, we have shown how the system can effectively maintain a constant speed under varying conditions. Through extensive simulations, we have evaluated the system's performance, highlighting its stability, responsiveness, and robustness in the face of disturbances.

The results obtained underscore the effectiveness of the cruise control system in maintaining a steady speed with minimal deviation, showcasing the capabilities of MATLAB Simulink in integrating physical modeling with control system design. Additionally, the project has provided valuable insights into the advantages of using such simulation tools for automotive systems, emphasizing their role in advancing vehicle control technologies.

Looking ahead, the findings of this project lay a solid foundation for further research and development in advanced vehicle control systems. By leveraging the insights gained, future efforts can focus on enhancing the system's adaptability, integrating with other vehicle systems, and addressing real-world challenges to further improve driving comfort, safety, and efficiency.

In summary, this project contributes to the growing body of knowledge in automotive engineering and paves the way for the continued evolution of cruise control and driver assistance technologies.

9.Future Scope:

The successful implementation of the cruise control system using MATLAB Simulink presents several avenues for future research and development. Integrating the system with Advanced Driver Assistance Systems (ADAS) can enhance overall vehicle safety by incorporating functionalities such as lane-keeping assistance and collision avoidance. Expanding the system to include Adaptive Cruise Control (ACC) features, adjusting vehicle speed based on distance to preceding vehicles, can further optimize traffic flow management. Investigating the environmental impact of the system and optimizing fuel efficiency align with sustainability goals in transportation. Integration of machine learning algorithms and artificial intelligence techniques can personalize the system to driver preferences and enhance adaptability to varying road conditions. Transitioning to real-time implementation and conducting extensive field testing is crucial for validating performance under diverse real-world conditions. Improving user interface design and ensuring regulatory compliance are essential for user acceptance and legal requirements. Exploring cost-effective solutions and scalability options can make cruise control systems accessible across different vehicle makes and models. Education and outreach efforts can raise awareness about cruise control benefits and safety considerations among drivers and policymakers. Pursuing these future research directions will advance cruise control technology, contributing to safer, more efficient, and sustainable transportation solutions.

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