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PID CONTROLLER DESIGN FOR ELECTRIC TROLLY

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***Abstract* :- PID (proportional-integral-derivative) controllers in Electric trolleys. Electric trolleys, which are widely used in industrial and urban transportation settings, require precise control systems to ensure efficient and safe operation. PID controllers are favored for their simplicity and effectiveness in regulating variables such as speed and position .the survey explores various aspects of PID controller design and implementation, including the development of control algorithms, hardware integration with microcontrollers and sensors, and different methods for tuning methods such as Ziegler- nichols are compared with modern optimization techniques like genetic algorithms and particle swarm optimization. the performance of PID controlled electric trolleys is analyzed through both simulation studies and real-world experiments, highlighting key metrics such as stability, response time, and accuracy. Comparative studies between PID controllers and other control strategies such as fuzzy logic and model predictive control, are also reviewed. key challenges in the implementation of PID controllers, including handling system nonlinearities and uncertainties, are discussed alongside potential solutions such as adaptive and self-tuning PID controllers. The report concludes with a summary of findings, emphasizing the effectiveness of PID controllers in electric trolley applications, and provides recommendations future research directions to address existing challenges for improved performance and sustainability.**

Keywords—PID Controller, PID Controllers Electric Trolly, Electric Vehicles

I. INTRODUCTION

A. Need

The advancement of electric vehicles has significantly impacted various sectors, including public. transportation,logistics, and personal mobility. Among these innovations, electric trolleys have emerged as a promising solution for efficient and environmentally friendly urban optimizing the performance of electric trolley is the implementation of sophisticated control systems that ensure stability.one such control system is the proportional-integral- derivative controller a PID controller is a widely used feedback control loop mechanism in industrial control system it continuously calculates an error value as the difference between a desired set point and a measured process variable and applies a correction based on proportional, integral, and derivative terms. This type of controller is particularly valued for its simplicity, robustness, and effectiveness in a wide range of applications. The primary objective of this report is to explore the applications of PID controllers in the context will provide an overview of the fundaments principles of PID control, discuss the specific challenges and requirement of electric trolley systems, and present a detailed analysis of the implementation and performance of PID controllers in this domain . Background and motivation the electrification of transportation systems is crucial step towards reducing greenhouse gas emissions and achieving sustainable urban mobility. Electric trolleys which operate on fixed tracks advantages over traditional several combustion engine vehicles, including lower emissions, reduced noise pollution, and improved energy efficiency. However, the performance and reliability of electric trolleys heavily depend on the effectiveness of their control systems .overview of PID controllers . PID controllers are integral to modern control systems due to their straightward design and reliable performance.

II. LITERATURE REVIEW

PID controllers in electric trolleys involves examining various research papers, articles, and studies that explore the design, implementation, and performance of PID controllers in this context. The goal is to understand the current state of knowledge,identify key challenges, and highlight areas for future research. Below is a structured approach to conducting a literature survey on this topic. design and implementation of PID controllers algorithm development studies that focus on the mathematical formulation and computational aspects of PID controllers. Hardware implementation research on integrating PID controllers with microcontrollers, sensors, and actuators in electric trolleys. Performance analysis simulation studies use of simulation tools to model and analyze the performance of PID controlled trolleys. Experimental validation real world experiments to validate the effectiveness of PID controllers in various operational scenarios. Comparative studies studies comparing PID controllers with other control strategies like fuzzy logic, adaptive control, and model predictive control.

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OVERVIEW

Properties of PID controller::-

- precision
- flexibility
- Ease of implentation
- Noise sensitivity
- Dynamic range
- sability

Features of PID controller:

- directional pads
- multiple buttons
- anolog sticks
- motion detection
- touch screens
- plethora

III. COSTRUCTION AND WORKING

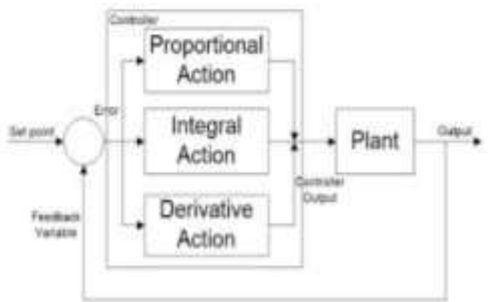

fig.1 Block Diagram of PID controller

A. Explanation of Blocks in fig.1.

- The Block diagram of the PID Controller shows it working in a closed-loop action. In such a close loop controller, the efficiency of our work is outstanding. In the case of an open loop system, the system runs for a specific time and doesn't focus on the desired results.
- For example, when we turn on a dryer, it runs over a period, and it is set and turned off after that time, irrespective of whether the clothes are dry. When a Closed-loop dryer is seen, a sensor is set to check whether moisture is present in the clothes. If there is any moisture left, the dryer will not stop working. When the clothes are completely dried out, the dryer will stop and provide output (dry clothes)
- PID Controller combines three basic terms, i.e. Proportional, Integral and derivatives. So, there are three modes of the device. Let's check them out one by one..
- As shown in the block diagram for the PID Controller, The Proportional (P) value is the value of the error, usually known as a steady-state error. When this value is large, the output will be large, and the system will behave abnormally. So, a P Controller doesn't fulfil our needs alone.
- propotional control provides an immediate action to the control.error.an example of an error may be slippage into bearing issues.feedback control is back adequate to assist the error control but is not . It entirely a solution be itself.the error will be in a constant state and therefore correction. is limited. Calibrating a PID controller is usually complecated. Automatically as part of an autocalibration technique. Critical performance parameters.
- This Controller is not used alone as well. The integral Controller keeps the steady state error to zero, but there is always a constant error at higher speeds. The derivative Controller keeps this constant error in check and keeps the output value to set value, neglecting any kind of constant error
- A closed-loop system like a PID controller includes a feedback control system. This system evaluates the feedback variable using a fixed point to generate an error signal. Based on that, it alters the system output. This procedure will continue till the error reaches Zero otherwise the value of the feedback variable becomes equivalent to a fixed point.
- This controller provides good results as compared with the ON/OFF type controller. In the ON/OFF type controller, simply two conditions are obtainable to manage the system. Once the process value is lower than the fixed point, then it will turn ON. Similarly, it will turn OFF once the value is higher than a fixed value. The output is not stable in this kind of controller and it will swing frequently in the region of the fixed point. However, this controller is more steady & accurate as compared to the ON/OFF type controller.
- With the use of a low cost simple ON-OFF controller, only two control states are possible, like fully ON or fully OFF. It is used for a limited control application where these two control states are enough for the control objective
- However oscillating nature of this control limits its usage and hence it is being replaced by PID controllers.

B. Construction & Working of PID controller:

In This kind of PID controller will merge proportional control through integral & derivative control to automatically assist the unit to compensate modifications within the system. These modifications, integral & derivative are expressed in time-based units.

These controllers are also referred through their reciprocals, RATE & RESET correspondingly. The terms of PID must be adjusted separately otherwise tuned to a specific system with the trial as well as error A feedback signal from the process plant is compared with a set point or reference signal u(t) and the corresponding error signal e(t) is fed to the PID algorithm. According to the proportional, integral, and derivative control calculations in the algorithm, the controller produces a combined response or controlled output which is applied to plant control devices.

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C. MATLAB Simulation

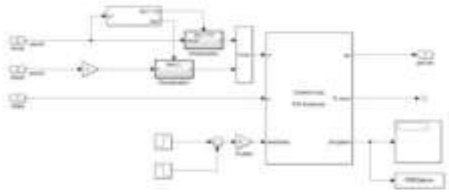

Fig.2.Simulation Model of MATLAB

In this MATLAB Simulation, the model an electric vehicle with a PID controller transfer function using GA and the Model- Redused order DRA algorithm steps in section 4 are. Followed for the inplemention of the DRA algorithm.

D. Simulation Results

1) Continuous time step response G(S)

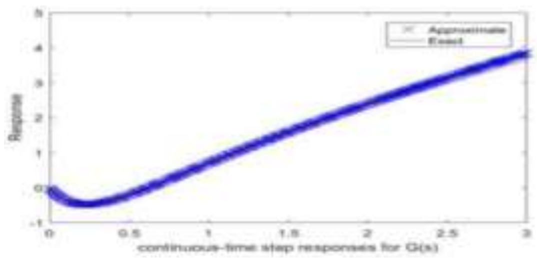

Fig.3.continuous time step response G(s)

To find approximate a continuous-time impulse response in discrete time, and its output must be scaled by the sampling period Ts to achieve the true unit-pulse response and comparison between the unit-pulse responses produced by the DRA approximate method and MATLAB's exact method.

Fig shows the step response closed loop vehicle control system with GA based PID controller. The most common parameters for comparison and to know the stability of the system are the percentage overshoot (%OS), peak time (Tp), settling time (Ts), rise time (Tr) and the percent steady state error (%Error). Table 2 summarizes all the responses specification values

2) The step response of the closed loop EV control system Using PID controller

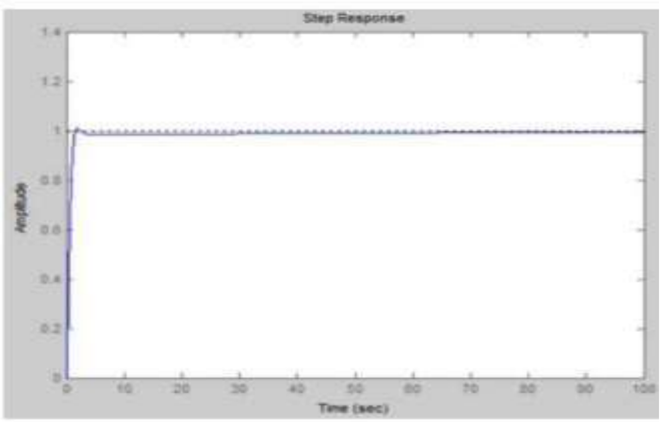

Fig.4.the step response o the closed loop EV control system using PID controller

The investigation using Root locus for analysis of transient & stability behavior yields that EV system is stable and with good dynamic performance. The most common parameters for comparison and to know the stability of the system are the percentage overshoot (%OS), peak time (Tp), settling time (Ts), rise time (Tr) and the percent steady state error (%Error)

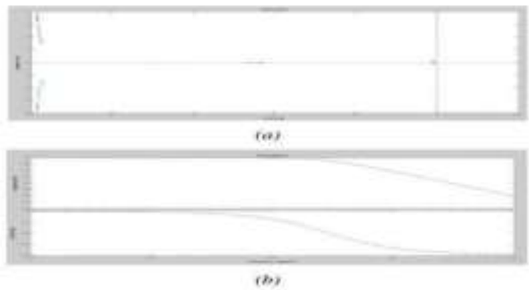

Fig.5.(a)&(b) Time & Frequency Response

For any real-time process, the mathematical model can be classified into three categories namely stable systems; unstable systems; and systems with dead time. The stable system model (20) from [16] is considered as the mathematical model for electric vehicle. The equation is given as, G(s) = 0.913242 / 1.3s^2+1.215s+0.913242.

IV. BENIFINTS OF PID CONTROLLER

1. Adaptability: PID controllers can adapt to changes in the system dynamics or operating conditions through proper tuning of the controller gains.

2. Ease of Implementation:Simple to design and implement using standard algorithms

3. Robustness: Can handle a wide variety of system dynamics and disturbances. Reduced Oscillations: Proper tuning can reduce oscillations and overshoot.

4. Flexibility: can be tuned to prioritize response speed, accuracy, or stability.

RESULT AND CONCLUSION

PID controllers offer a versatile solution for controlling wide range of systems by adjusting the proportional, integral, a nd derivative terms. They provide stability, responsiveness, and accuracy in various applications, making them a fundamental tool in control engineering. However, selecting appropriate tuning parameters and understanding system dynamics are crucial for optimal performance. The PID controller demonstrated its effectiveness in enhancing the electric trolley's efficiency, stability, and safety.

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