# Mid Term Report

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**Project: Smart Throttle Control**

**# Summary:**

The project began with core control system concepts such as system types, poles and zeros, DC gain, Laplace transforms, and frequency-domain analysis using Bode plots through both manual methods and MATLAB.

We then focused on system response analysis, especially step responses, by modeling different plants and evaluating performance using rise time, settling time, overshoot, steady-state error, and damping characteristics.

Next, we studied PID controllers, examining the role of P, I, and D gains, implementing PID models in MATLAB, tuning controllers for required performance, and addressing practical issues like windup, anti-windup, and noise filtering.

Finally, advanced topics such as compensator selection, feedforward control, and introductory MIMO systems were explored.

## Challenges Faced

- Visualizing how mathematical models connect to real hardware.
- Understanding why PID tuning alone is often insufficient.
- Grasping sampling time effects and real-world nonidealities (noise, delay, friction).
- Shifting mindset from equations to system architecture.

## My Contribution to the Project

- Studied core control theory concepts which are not familiar to me till now and their application to smart throttle systems.
- Analyzed digital control workflow and hardware integration.
- Worked on understanding system structuring, block diagrams, and control architecture.
- Contributed to discussions on controller strategy, feedback design, and implementation planning.

# Project Implementation Plan

Pump Throttle Control for Water Management

## Objective:

The goal is to design a smart pump throttle control system that automatically regulates pump speed or valve position to maintain a desired flow rate or pressure. The system should ensure stable operation, reject disturbances, and include basic safety mechanisms.

## System Architecture:

The system follows a closed-loop digital control structure:

Reference input —-----→ Controller —-------→ Actuator/Driver —--------→ Pump & water system —----------→ Sensor —-------→ Feedback —-------→ Controller

Sensors measure flow or pressure and send signals to a microcontroller through an ADC(analog to digital convertor). The controller computes the error and generates a control signal, which drives the pump or valve using PWM(pulse width modulation). Continuous feedback ensures accuracy and disturbance rejection.

## Key System Modules:

- Plant: Pump and water pipeline network
- Sensors: Flow and/or pressure sensors

- Controller: Microcontroller-based digital controller
- Actuator: Motor driver or electronic valve
- Safety Layer: Over-pressure protection, dry-run detection, saturation limits

## Control Strategy

The primary controller will be a PID-based feedback controller to ensure stability and reference tracking. A feedforward path can be added to improve response to known demand changes. If needed, lead or lag compensators can be introduced to enhance transient response or steady-state accuracy.