Overall SUMMARY

Key Concepts

- Transfer functions are mathematical models in the Laplace (s) domain that relate system input and output.
- Effect of poles and zeroes on steady state behaviour of the system.
- Types of systems(TYPE 0,TYPE 1,etc).
- time performance measures like settling time,rise time.
- BODE magnitude and phase plots.
- Effect of Controllers like P,PI,PID on system performance.
- Control techniques beyond basic PID: lead and lag compensators, feedforward control, and basic MIMO control and how are these used to improve speed and accuracy.

Tools and Techniques:

1. Learned about matlab and its functions like
   - `tf`, `step`, `stepinfo`, `feedback`
   - `bode`, `lsim`

2.Sketching of BODE plots by hand.

3.Using Final value theorem to predict steady state behaviour.

4.Interpreting and predicting the plots before simulation to build intuition.

5.PID and PI controllers.

6.Lead and Lag compensators.

7.Feedforward and feedback controls to cancel the known disturbances.

8.MIMO control concepts:Understanding 2x2 MIMO transfer function matrix.

Major Challenges Faced:

1.Predicting system's response manually before using MATLAB's simulation.

2.Handling inputs that are not step inputs like ramp inputs,sinosoidal input,etc.

3.Understangdoing how does the pole and zero of the transfer function affect our system and how to do phase compensation wherever required.

4.Understanding fedforward vs feedback control and how are these useful.

5.Handling MIMO systems.

6.Handling MATLAB simulation for complex systems containing multiple controllers and plots.

7.Linking and understanding how these things exactly work in a physical control system.Rather how to apply this knowledge to a control system to make it better.

My Contribution to Project

1.Analyzed the plants by determining the system type, poles, and zeros.

2.Utilized analytical tools to forecast system behavior, such as formulas and the Final Value Theorem.

3.Manually created and analysed BODE plots.

4.Designed simple controllers to meet the system's requirements.

5.Linked the concepts and understanding to the real world control systems that is applied the theorotical knowledge to practically make control system better.

6.Performed comparative analysis between different controllers to understand the strengths and weaknesses.

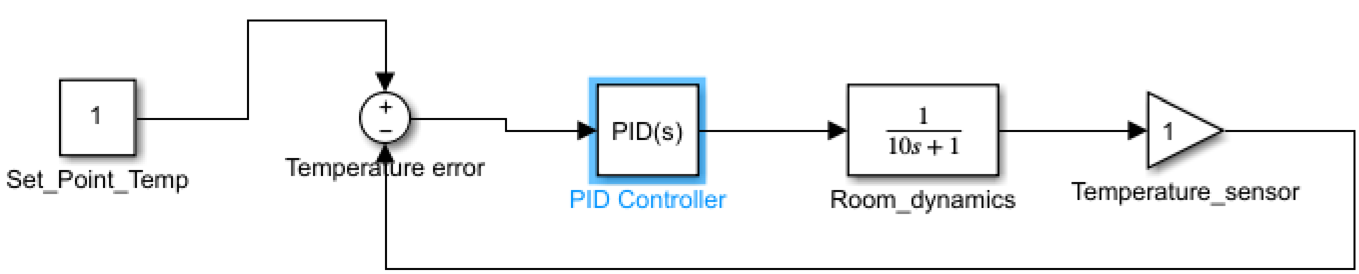
Implementation

Smart HVAC temperature control system

1.Key components:

- Sensors:Used to measure the current temperature.
- Setpoint:Temperature set by the user.
- Error calculation:Calculates difference between setpoint and room temperature.
- Controller:Makes the decisions,commands the actuator accordingly.
- Actuator:Performs actual operation given by the controller.
- Feedback Loop:Updated temperature is sensed.
- Safety and constraint mechanisms

2.System Flow:



The above block diagram represents a closed loop-feedback control system used to maintain the room temperature at a desired value.It uses PID controller.

- Setpoint temperature is the temperature which is actually set by the user.It is the reference value.
- Temperature error calculates the difference between the desired temperature and the actual temperature.
- Positive error implies room temperature is coolker than desired.
- Negative error implies room temperature is hotter than desired.
- PID controller is the brain of the system.
- Room dynamics represents:Combined dynamics of HVAC unit,Room Thermal behaviour,heat capacity of air and walls.
- Temperature sensor measures the actual temperature of the room.
- Measured temperature is sent through the feedback system and thus the temperature is updated.