

# Temperature Control System Using PID Controller in MATLAB/Simulink

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**Abstract:** *Temperature control plays a major role in industrial automation, manufacturing systems, heating plants, HVAC units, boilers, and incubators. This paper presents the design and simulation of a temperature control system using a PID controller in MATLAB/Simulink. A first-order thermal model is considered and tuned PID gains are applied to improve transient response. The controller reduces overshoot, minimizes steady-state error, and improves system stability. MATLAB simulation results demonstrate that PID control provides accurate and reliable temperature regulation.*

**Keywords:** PID Controller, Temperature Control, MATLAB, Simulink, Thermal Process, Process Control

## I. INTRODUCTION

Temperature is one of the most important variables in process industries. Accurate temperature regulation is necessary to maintain product quality, ensure operator safety, and reduce power consumption.

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MATLAB/Simulink is widely used for designing and testing PID based controllers before practical implementation.

## II. NEED OF PID CONTROL

Heating systems usually show slow response and delay. Disturbances such as environmental temperature changes, load variation, and airflow affect system performance.

PID control continuously changes heater power according to error between desired and measured temperature.

### Benefits of PID control:

- Fast response
- Lower overshoot
- Reduced steady-state error
- Better disturbance rejection
- Stable operation

## III. SYSTEM MODELLING

A thermal process is represented as:

$$G(s) = K / \tau s + 1 \quad (1)$$

Where:

- K = Gain
- $\tau$  = Time constant

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Assume:

$$G(s) = 5 / 10s + 1 \quad (2)$$

#### IV. PID CONTROLLER DESIGN

The PID controller equation is:

$$u(t) = K_p e(t) + K_i \int e(t) dt + K_d \frac{de(t)}{dt} \quad (3)$$

Where:

- $K_p$  = Proportional Gain
- $K_i$  = Integral Gain
- $K_d$  = Derivative Gain

Used values:

- $K_p = 4$
- $K_i = 1.5$
- $K_d = 2$

#### V. MATLAB PROGRAM

```
num = 5;
den = [10 1];
plant = tf(num,den); C = pid(4,1.5,2);
sys = feedback(C*plant,1); step(sys,100);
```

Figure 1: MATLAB Code for PID Temperature Control

#### VI. RESULTS AND OUTPUT GRAPHS

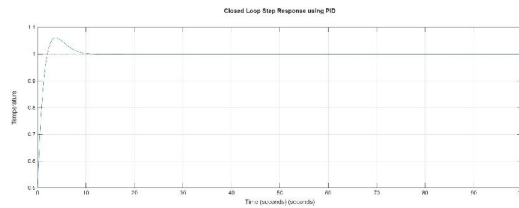


Figure 2: Closed Loop Step Response  
Open Loop vs PID Controlled System

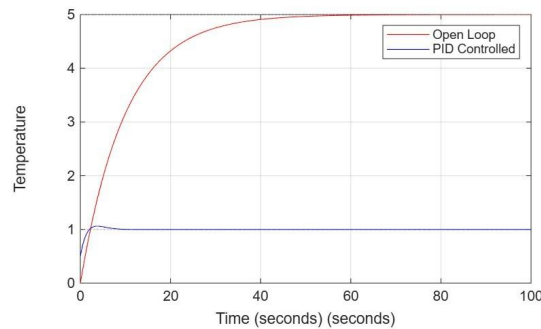


Figure 3: Open Loop vs PID Controlled Response



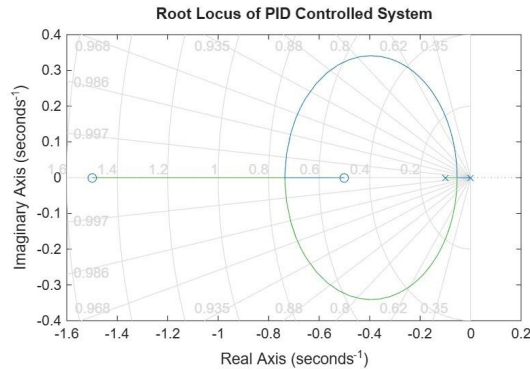


Figure 4: Root Locus of Controlled System

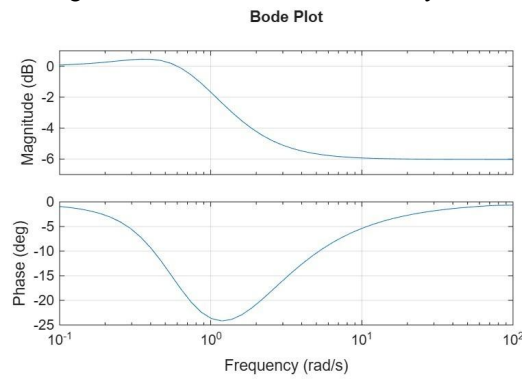


Figure 5: Bode Plot

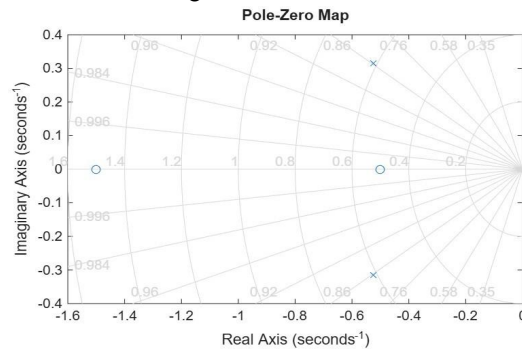


Figure 6: Pole-Zero Map

The obtained results show that the PID controller improves response speed and reduces oscillation.

## VII. PERFORMANCE ANALYSIS

Table 1: System Comparison

| Parameter     | Without PID | With PID  |
|---------------|-------------|-----------|
| Rise Time     | High        | Low       |
| Overshoot     | Large       | Small     |
| Settling Time | Slow        | Fast      |
| Error         | Present     | Near Zero |
| Stability     | Low         | High      |



### VIII. ADVANTAGES

Advantages of PID temperature control include:

- Accurate temperature control
- Fast response
- Easy tuning
- Low cost implementation
- Reliable operation
- Better energy efficiency
- Industrial acceptance
- Easy digital implementation

### IX. APPLICATIONS

Used in:

- Industrial furnaces
- Boilers
- Incubators
- HVAC systems
- Ovens
- Food processing
- Plastic molding
- Water heaters

### X. LIMITATIONS

Some limitations are:

- Difficult tuning for nonlinear systems
- Derivative sensitive to noise
- Delay systems need advanced tuning

### XI. FUTURE SCOPE

Future developments include:

- Fuzzy PID Controller
- Adaptive PID
- IoT Monitoring
- PLC Implementation
- Arduino Hardware Model
- AI Based Tuning

### XII. CONCLUSION

A temperature control system using PID controller was designed and simulated in MATLAB/Simulink. The controller reduced overshoot, improved settling time, and minimized steady-state error. Because of its simple structure and reliable operation, PID control remains an important solution for industrial thermal systems.

### REFERENCES

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