

# DESIGN OF A TEMPERATURE STABILIZATION HEATING CONTROL SYSTEM IN INDUSTRY

Duong Quỳnh Nhật<sup>1</sup>

<sup>1</sup>Thai Nguyen University of Technology, Thai Nguyen city, Viet Nam

## ABSTRACT

*This study presents the design and implementation of a heating control system to maintain stable temperature in industrial applications, specifically in poultry farming environments. The system utilizes a Mitsubishi Q03UDCPU PLC combined with temperature sensors, analog modules, and solid-state relays (SSR) for temperature measurement and control.*

*A PID control algorithm is applied to improve accuracy, minimize steady-state error, and enhance system response. The system model is identified using experimental methods, allowing appropriate controller parameters to be determined. Simulation and experimental results demonstrate that the system can maintain stable temperature, reduce energy consumption, and improve farming efficiency.*

*This research contributes to the application of automation technology in agriculture and suggests future development directions with IoT integration for remote monitoring and control.*

**Keywords:** Heating system, Temperature stabilization, PID controller, Mitsubishi Q03UDCPU PLC, Automatic control, Poultry farming, Solid-state relay (SSR).

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## 1. INTRODUCTION

In the context of rapid development in modern industry and agriculture, the application of automated control systems has become increasingly essential. In poultry farming, maintaining a stable environmental temperature plays a crucial role in the growth and development of livestock, especially during the brooding stage.

Traditional heating methods often consume high energy, lack precise control, and heavily depend on human experience. Therefore, designing an automatic, accurate, and efficient temperature control system is of significant importance.

This project, titled “Design of a Temperature Stabilization Heating Control System in Industry,” focuses on developing a control system based on PLC combined with a PID algorithm to maintain the desired temperature. The proposed system is designed to be flexible, easy to monitor, and scalable, making it suitable for modern farming applications.

The study includes analysis of technological requirements, equipment selection, system modeling, PID controller design, PLC programming, and performance evaluation through simulation and experimental results.

## 2. SUMMARY OF PLC AND EQUIPMENT SELECTION

### 2.1. PLC Controller

The system uses a **Mitsubishi Q03UDCPU PLC** as the main controller due to its high performance, reliability, and suitability for industrial control applications.

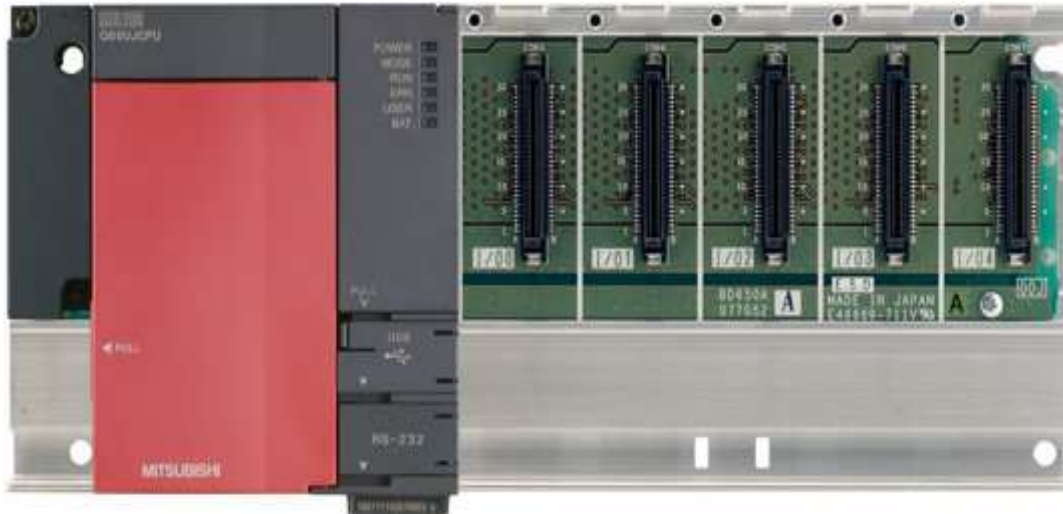


Fig. 1. Mitsubishi Q03UDCPU PLC

**2.2. Digital I/O Modules**

- QX40 module: digital input signals
- QY40P module: digital output control



Fig. 2. Digital I/O modules

**2.3. Analog I/O Modules**

- Q64AD: analog input (4–20 mA)

- **Q64DAN**: analog output control



*Fig. 3. Analog modules*

#### 2.4. Temperature Sensor

A **PT100 or thermocouple sensor** with a signal transmitter is used to ensure accurate temperature measurement.



*Fig. 4. Temperature sensor*

#### 2.5. Heating Element

The system uses an **electric heating element** for thermal generation.



*Fig. 5. Heating element*

### **2.6. Solid-State Relay (SSR)**

SSR is used for switching the heating load, offering high reliability and fast response.



*Fig. 6. SSR relay*

### **7. Protection and Power Supply**

- Circuit breaker for protection
- 24VAC power supply for control circuits

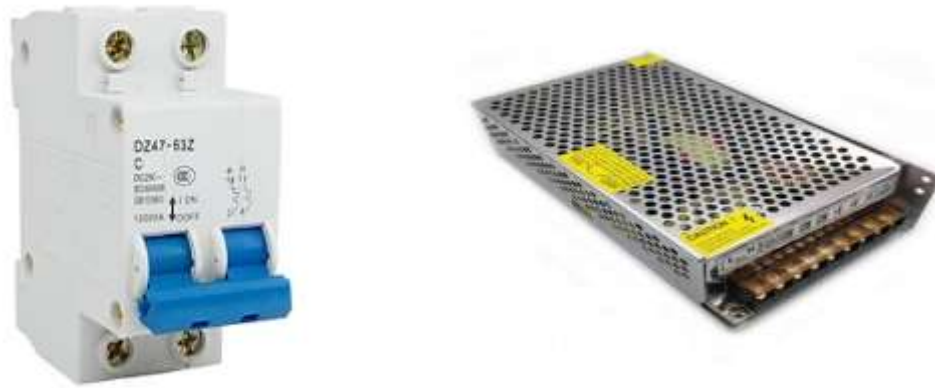
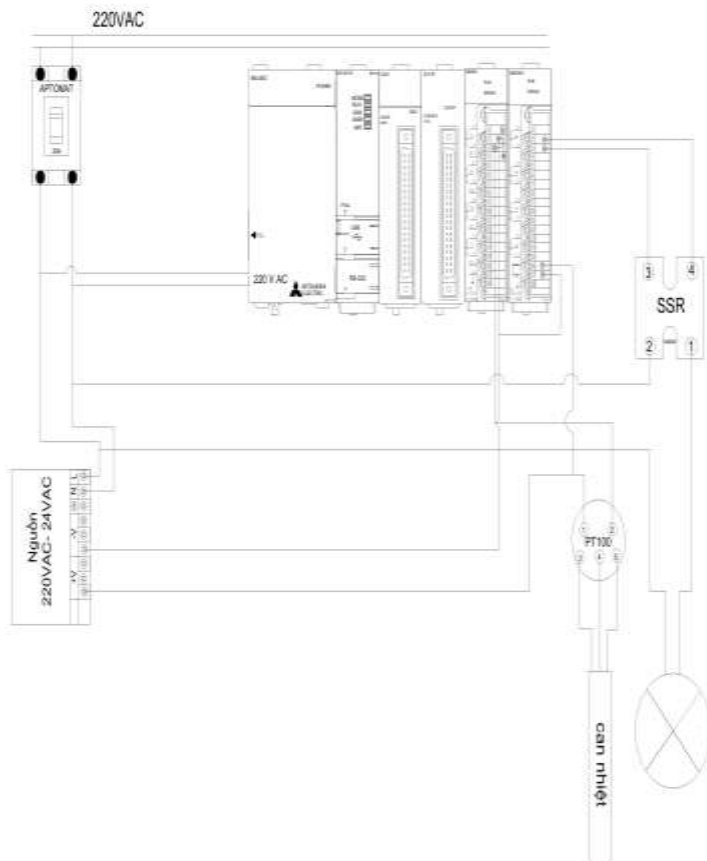


Fig. 7. Power and protection devices

### 8. Heating System Schematic Diagram

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### 3. MATHEMATICAL MODEL OF TEMPERATURE STABILIZATION SYSTEM

The temperature control system can be modeled as a thermal dynamic process with inertia and time delay. Based on experimental identification, the system is approximated by a **first-order plus dead-time (FOPDT)** model.

$$G(s) = \frac{K \cdot e^{-Ls}}{(Ts+1)}$$

Where:

- K is the system gain,
- T is the time constant (s),
- L is the dead time (s).

From the experimental data:

- $t_1 = 340s$ ,  $t_2 = 785s$ ,
- $K = 38.6$

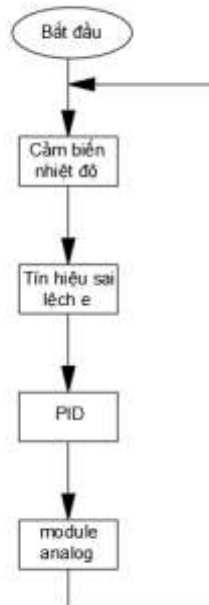
The parameters are determined as:

- $T = 1.5(t_2 - t_1) = 667.5s$
- $L = 1.5t_1 - t_2 = 117.5s$

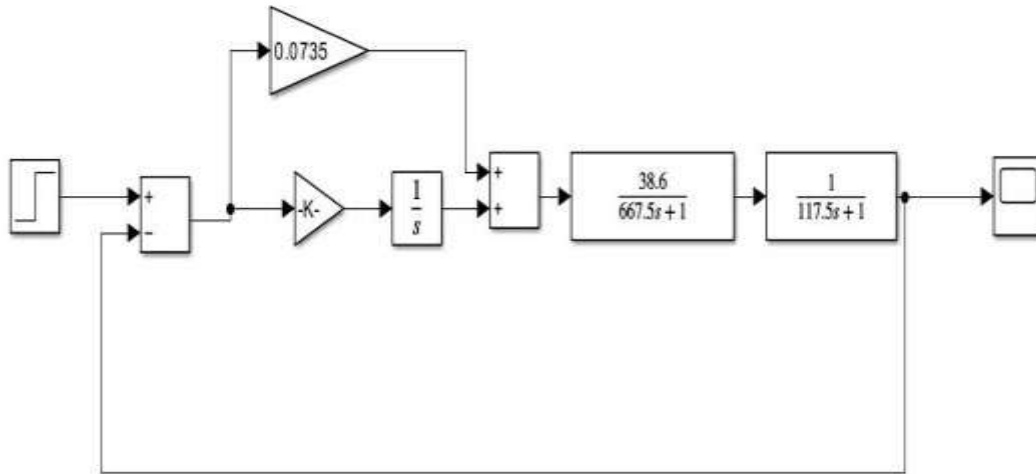
Thus, the transfer function of the system is:  $G(s) = \frac{38.6e^{-117.5s}}{(667.5s+1)}$

This model reflects the slow thermal response and delay characteristics of the heating system, which are typical in industrial temperature processes.

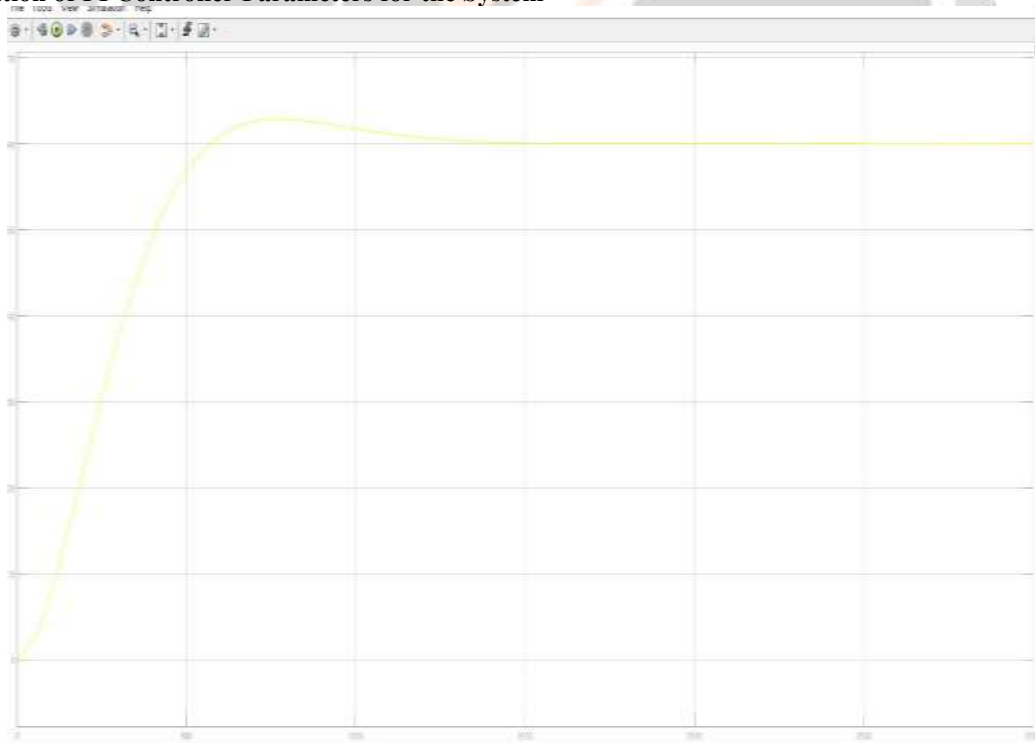
#### \* Control Algorithm Development



**\* System Output Response**

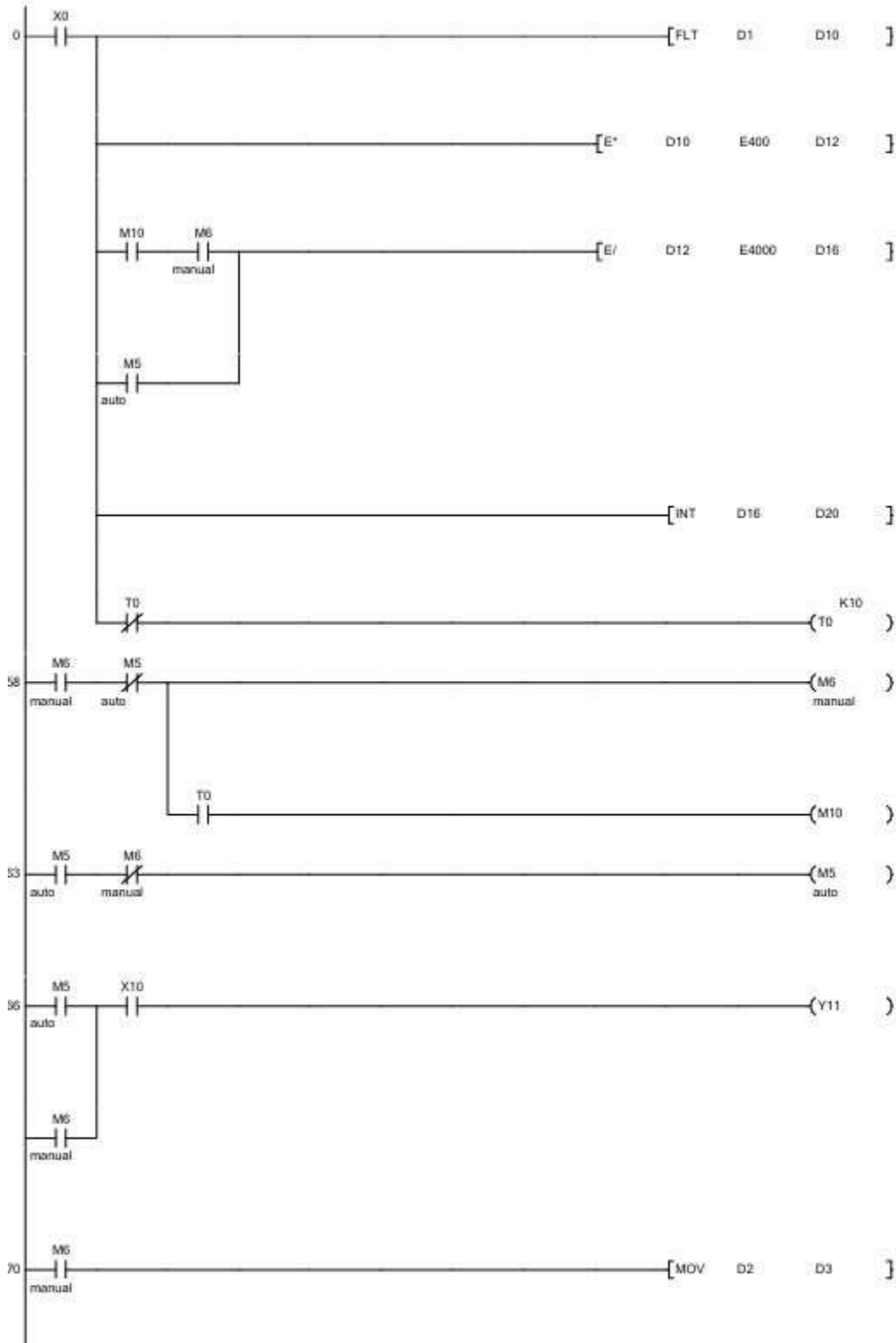


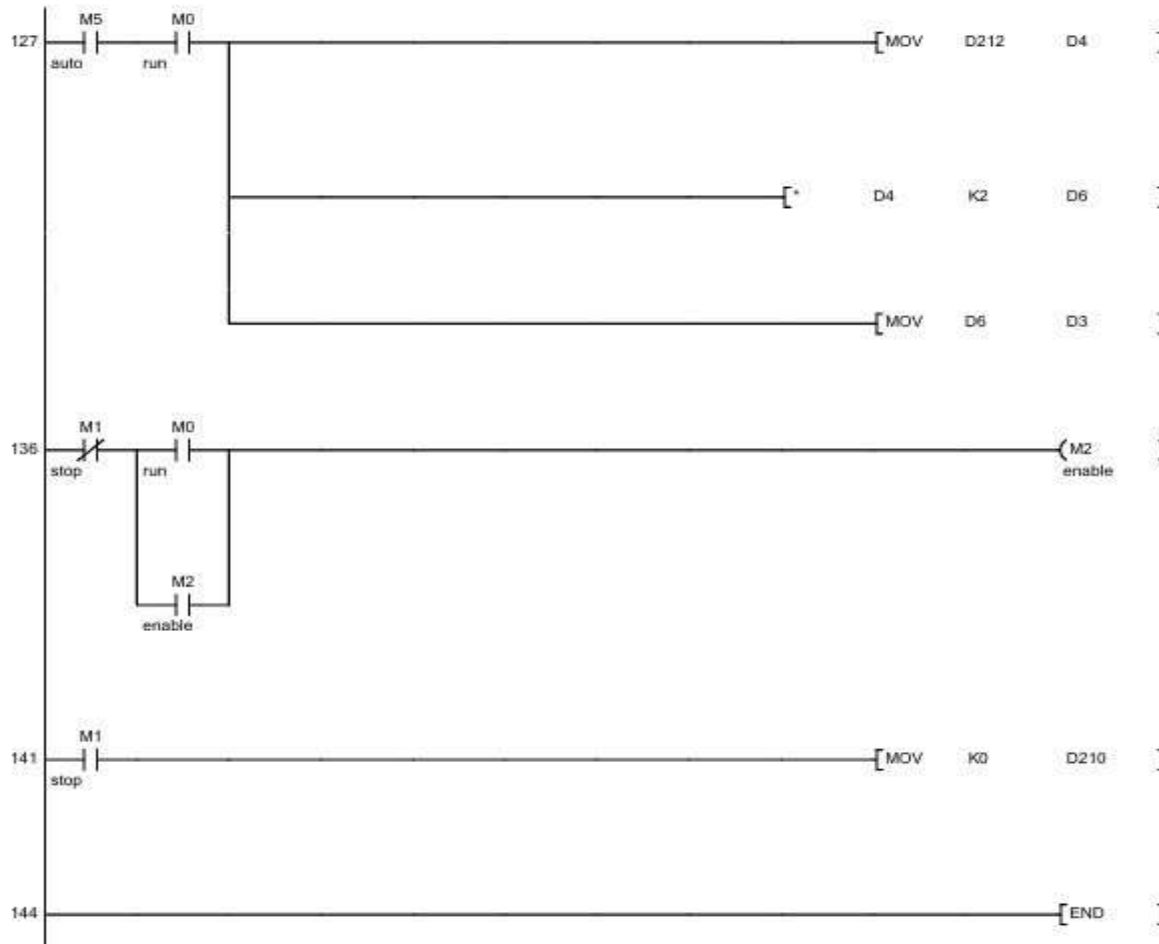
**\* Simulation of PI Controller Parameters for the System**



**4. SYSTEM PROGRAMMING**

The control program is as follows:





#### 4. CONCLUSION

The project titled “Design of a Temperature Stabilization Heating Control System in Industry” has been carried out to ensure optimal temperature conditions for poultry development, especially during the brooding stage of chicks. The system is designed based on the Mitsubishi Q03UDCPU PLC, utilizing a PID controller to achieve accurate temperature control through a solid-state relay (SSR) and temperature sensors.

The research and experimental results show that:

- The system is capable of maintaining a stable temperature within the required range, thereby optimizing the growth conditions for chicks.
- The use of a PID controller combined with a 4–20 mA analog signal enables flexible heating power regulation and reduces energy consumption compared to conventional on/off control methods.
- The solid-state relay (SSR) ensures reliable operation, eliminates electrical noise, and increases system lifespan compared to mechanical relays.
- The PLC-based control interface allows easy parameter setting and temperature monitoring, facilitating system operation for users.

#### System limitations:

- The inherent delay of the PID controller may affect performance if parameters are not properly tuned.
- A stable power supply is required for effective system operation.
- Remote control and IoT integration have not yet been implemented to enhance automation capabilities.

In conclusion, the heating control system has successfully achieved its objectives, contributing to improved farming efficiency, reduced operational costs, and providing an optimal environment for chick development. In the future, the system can be expanded with IoT technologies to enable remote monitoring and control.

**ACKNOWLEDGEMENT**

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