

Thermal Targets System - Project Proposal

by Ethan Reynolds

Submission date: 14-Nov-2025 10:49AM (UTC+0000)

Submission ID: 267639106

File name: 58325_Ethan_Reynolds_Thermal_Targets_System_-_Project_Proposal_689853_1100108274.docx
(31.93K)

Word count: 1882

Character count: 11075

Ethan Reynolds

2406303

BEng Electrical and Electronic Engineering

Independent Project (ACCA6020)

Project Proposal

Contents

Table Of Figures	3
1. Introduction	4
1.1 Problem Statement.....	4
1.2 Aim	4
1.3 Objectives	4
1.4 Expected Outcome.....	5
2. Background to the Project/Literature Review	6
3. Project Design	7
4. Resource/Planning	9
4.1 Project Timeline.....	9
References	10

Table Of Figures

Figure 1: Project Timeline Table.....9

1. Introduction

This project will explore the design and development of a thermal target system that is managed by a programmable logic controller (PLC). The system is based within the field of industrial automation, where PLCs are widely used to manage electrical and process control tasks. PLCs are valued for their reliability, flexible programming, and ability to integrate with both digital and analogue equipment [1]. Recent developments in control hardware and interfacing have made PLCs suitable for managing energy-based systems that require adjustable voltage or current output [2], [3].

Thermal target systems are commonly used in areas such as defence testing, calibration, and materials research, where a controlled and repeatable heat signature is required. Many existing systems rely on manual control or pre-set heating elements, which can make them slow to adjust and difficult to reproduce consistently. Research in PLC-based heating control has shown that closed-loop systems using feedback sensors and frequency-controlled outputs can achieve precise temperature regulation [2]. However, there has been limited investigation into open-loop control methods that use direct current modulation to generate heat without relying on dedicated temperature sensors.

The proposed project aims to fill this gap by creating an open-loop PLC-controlled thermal target that adjusts current levels through a 0–10 V analogue signal. Studies on PLC-based current and voltage regulation support the idea that stable, adjustable power output can be achieved safely through analogue interfacing [3]. This project will apply those concepts to a thermal target application, providing a simpler and more flexible approach to heat control that could later be adapted into closed-loop operation.

1.1 Problem Statement

Existing thermal target systems often depend on complex or sensor-based feedback methods, making them expensive and difficult to scale. There is a lack of simple, open-loop PLC systems designed specifically to control current for heat generation. This project addresses that gap by designing and implementing a PLC-based thermal control system that produces adjustable heat through controlled current induction.

1.2 Aim

To design and develop a PLC-controlled system capable of delivering adjustable, current-based thermal outputs in a controlled and scalable configuration.

1.3 Objectives

- To review and evaluate existing PLC based thermal control methods and identify suitable interfacing techniques.
- To design the hardware layout for a multi supply current control system with protection and interlocks.
- To create and test PLC logic for a 0–10 V analog control output.

- To construct and test a working prototype, evaluating its performance and safety.

1.4 [Expected Outcome](#)

The project will result in a working demonstrator of a PLC controlled thermal target system, along with schematics, simulations, test data and technical documentation that could support future development into a closed-loop system.

2. Background to the Project/Literature Review

Programmable logic controllers are widely used in industrial automation because they offer reliable control and can be programmed for a range of different applications. Over the years, their use has expanded from basic sequencing to more advanced tasks such as process regulation, analogue control and integration with power systems [1]. These developments have made PLCs suitable for use in heating and energy-based systems where accuracy and repeatability are important [4].

Most research found on PLC based heating focuses on closed-loop control, where temperature sensors feed back to the controller to keep a set temperature. This approach is common in manufacturing and industrial heating, as it allows very stable operation [5]. However, many of these systems rely on temperature sensors and resistive heaters, which can add cost and complexity. Very little work has been found that looks at using open-loop current control, where the heat output is set directly by the current rather than by feedback from a sensor. This makes the proposed project slightly different, as it focuses on producing a controllable thermal output using a simpler open-loop design.

There are also important safety and ethical points to consider. Supplying high current into a conductive target can be dangerous if not properly protected. The system therefore needs fuses, circuit breakers, and isolation to prevent electric shock or damage to equipment. Energy use and efficiency also need to be considered, as part of good engineering practice and sustainability standards [6].

The project is based on the basic I^2R heating principle, where the amount of heat produced depends on the square of the current and the resistance of the target. The design will also make use of standard control ideas such as open-loop versus closed-loop operation. Although PLCs are commonly used for temperature regulation, there are few examples where they are used to control current directly to generate a thermal effect. The literature therefore highlights a gap that this project will aim to address by showing how a PLC can be used in a new way to produce variable heat output through current control.

3. Project Design

The project will be designed to demonstrate the operation of a programmable logic controller as the main control unit for an open-loop thermal target system. The design will follow a structured engineering development process, beginning with conceptual modelling, circuit design, system simulation, and prototype evaluation. PLCs are well established in industrial automation because of their reliability, flexibility, and suitability for analogue signal processing [1], [2]. The project aims to show how a PLC can generate variable thermal output by adjusting current through analogue control rather than by using temperature feedback sensors.

At the conceptual stage, the system will be divided into three main subsystems: the control stage, the power delivery stage, and the thermal target. The control stage will consist of a PLC programmed to output a 0–10 V analogue signal corresponding to user-selected thermal levels, consistent with standard automation approaches for current regulation [3]. The power stage will use regulated power supplies connected in parallel, converting this control voltage into varying current levels. The thermal target will be a conductive element that dissipates electrical energy as heat, following the I^2R heating principle, which directly relates electrical current to heat generation [4]. This modular layout provides flexibility for future development, such as adding sensor feedback for closed-loop operation, while keeping the initial design simple and measurable [5].

The project development will combine simulation and experimental evaluation. Appropriate PLC programming and circuit-simulation software will be used to model the control logic and verify that the analogue output scales correctly with the selected input levels. Once validated, a laboratory prototype can be constructed using controlled power sources and test loads to observe heating behaviour. Data collected will include current and voltage measurements at different control levels, as well as surface temperature of the target where practical. These results will demonstrate the system's ability to produce predictable changes in heat output based on current variation. Similar open-loop PLC control and monitoring systems have been reported in industrial environments, confirming the feasibility of this approach for prototype-level development [7].

Where sufficient experimental data are obtained, results will be analysed using basic statistical methods such as average current response, rate of temperature rise, and standard deviation across test cycles. This analytical process will provide quantitative evidence of consistency and linearity between the PLC control voltage and resulting thermal output. Supervisory control frameworks for open-loop systems have shown that trend-based analysis can effectively measure performance repeatability without sensor feedback [8].

A structured risk management process will be applied throughout the project to identify and mitigate hazards. Key risks include electrical faults, overheating, and component damage. Mitigation strategies will include the use of fuses, isolation switches, and current-limiting features. All experimental work will follow institutional safety procedures, with risk assessments completed before live testing. Ethical considerations mainly concern safe working practices and the responsible use of electrical energy, ensuring compliance with sustainable engineering standards [6]. Environmental impact is expected to be low, but the project will still aim to reduce energy waste by limiting test durations and optimising circuit efficiency.

The overall design will demonstrate that a PLC can effectively control electrical current to achieve a range of thermal outputs in an open-loop system. By combining simulation, prototype testing, and structured risk management, the project will meet its objectives while providing a foundation for future improvements such as temperature feedback or automated calibration.

4. Resource/Planning

The project will be completed using standard laboratory facilities, including programmable logic controllers, regulated DC power supplies, wiring components, and resistive or conductive test loads. Measurement tools such as multimeters and oscilloscopes will be used to record voltage and current data during testing. Appropriate PLC programming, circuit-simulation, and data-analysis software will support design development and performance evaluation. Access to academic databases and digital libraries will provide supporting literature and technical standards relevant to control-system design and testing.

Key deliverables include a working open-loop prototype, circuit schematics, the PLC program with documentation, test data and analysis, and the final project report. An approved ethics form will also be submitted to confirm compliance with institutional safety and sustainability standards.

Project planning follows recognised engineering management frameworks [9]. Tasks will progress from research and design to development, testing, and final evaluation. Risks such as electrical faults or component failure will be mitigated using isolation, fuses, and current-limiting devices. Environmental impact will be minimised by reducing test durations and using efficient circuitry.

4.1 Project Timeline

<u>Month</u>	<u>Weeks</u>	<u>Activity / Milestone</u>
November 2025	1–3	Literature review and initial research
December 2025	4–7	System design, circuit modelling, and resource planning
January 2026	8–11	PLC programming and simulation development
February 2026	12–15	Prototype construction and initial bench testing
March 2026	16–19	Full testing and data collection
April 2026	20–23	Data analysis, evaluation, and report drafting
May 2026	24	Final documentation and submission

Figure 1: Project Timeline Table

References

- [1] M. A. Koondhar et al., "The Role of PLC in Automation, Industry, and Education Purpose: A Review," *Pakistan J. Eng. Technol. Sci.*, vol. 11, no. 2, pp. 22–31, 2023.
- [2] S. Abdallah and R. Abu-Mallouh, "Heating Systems with PLC and Frequency Control," *Energy Convers. Manag.*, vol. 49, no. 12, pp. 3356–3361, 2008.
- [3] P. K. Dey, M. S. Arefin, and M. S. Islam, "Design and Implementation of a PLC-Based Automatic Voltage and Current Control System," *Int. J. Electr. Comput. Eng.*, vol. 9, no. 6, pp. 4907–4916, 2019.
- [4] "A review on the applications of programmable logic controllers (PLCs)," *Renew. Sustain. Energy Rev.*, vol. 57, pp. 118–127, 2016.
- [5] F. Wei, "The PLC-based Industrial Temperature Control System: Design and Implementation," *MATEC Web Conf.*, vol. 129, p. 03031, 2017.
- [6] V. Sihvonen, "Role of Power-to-Heat and Thermal Energy Storage in Energy Systems: A Review," *Energy*, vol. 278, Art. 122622, 2024.
- [7] M. G. Ioannides, "Design and Implementation of PLC-Based Monitoring Control – An Open-loop Control System for Variable Speed Operation," 2004.
- [8] A. González-Marcos, J. Ordieres-Meré, V. Muñoz-Munilla, and F. Alba-Elías, "An Intelligent Supervision System for Open-loop Controlled Processes," *Int. J. Manuf. Technol. Manag.*, 2013.
- [9] Project Management Institute, *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*, 7th ed., Newtown Square, PA, USA: Project Management Institute, 2021.

Thermal Targets System - Project Proposal

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

87 /100

Good introduction to the project. Clear aim and objectives. Clear success criteria defined along with project deliverables. 18/20

Good, clear project background including links to literature. Excellent selection of reference material used.

18/20

Project design is clear and the methods listed are appropriate. Good description of how the data will be collected and analysed. 26/30

Gantt chart for the project is missing,
although a list of tasks and durations is provided.
Ethics form completed. 10/15

Excellent document presentation, spelling,
grammar, and
punctuation. Referencing is correct. 15/15

Total 87%

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10
