Design and Implementation of a Solder Reflow Oven Using PIC18F458 Microcontroller

M. Rayan Ur Rehman Khan*, Muhammad Abdullah†
Department of Electrical Engineering
Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Topi, Pakistan
Email: *2023281@giki.edu.pk, †2023324@giki.edu.pk

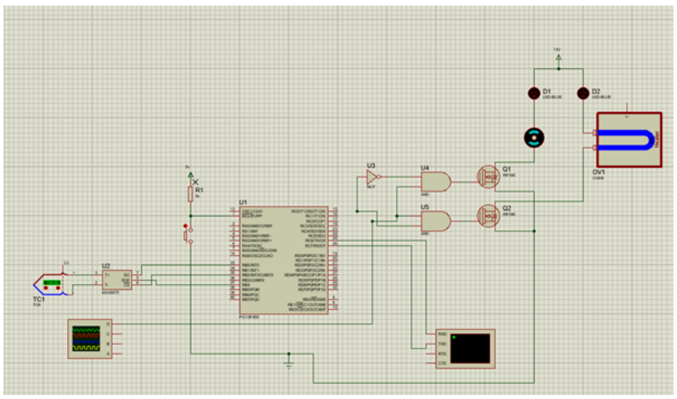

Fig. 1: simulation file for Solder Reflow Oven

***Abstract*—This report details the design and implementation of a solder reflow oven system that incorporates the MAX6675 temperature sensor and a thermocouple for precise temperature measurement. The system is managed by a PIC18F458 microcontroller, which adjusts temperature setpoints every five seconds through Timer0. Control logic adheres to a predefined temperature-time reflow profile to ensure optimal soldering conditions. A single PWM signal controls both the heating element and the cooling fan, with only one actuator active at a time. The PWM duty cycle is dynamically adjusted according to the measured temperature, ensuring accurate thermal control during the preheat, soak, reflow, and cooling stages. This cost-effective design offers dependable performance for small-scale reflow soldering applications.**

***Index Terms*—Reflow oven, MAX6675, thermocouple, PIC18F458, temperature control, PWM, embedded system.**

I. Introduction

Reflow soldering is a standard method for attaching surface-mounted components to PCBs. Commercial reflow ovens are expensive, motivating the development of cost-effective and accessible alternatives for hobbyists and educational purposes. This project presents the design of a solder reflow oven using a PIC18F458 microcontroller and a MAX6675 thermocouple sensor. The system follows a temperature-time reflow profile and uses a single PWM output to alternately control heating and cooling.

II. Problem Statement and Objectives

A. Problem Statement

The goal is to develop an embedded control system for a basic solder reflow oven. It should monitor and control the oven temperature using a standard temperature-time reflow profile to ensure optimal soldering.

B. Objectives

- Design a functional reflow oven control system using a PIC18F458 and MAX6675 thermocouple.
- Implement temperature monitoring and control using a predefined temperature-time reflow profile.
- Control heating and cooling with a single PWM signal.
- Transmit temperature data via UART and visualize it in real-time using Python.

III. Methodology

A. Temperature Sensing

A thermocouple interfaced with the MAX6675 sensor provides temperature readings via software-implemented SPI on the PIC18F458 microcontroller.

B. Setpoint Management

An array of 48 setpoints defines the four reflow stages: Preheat, Soak, Reflow, and Cooling. Timer0 triggers every 5 seconds to update the current setpoint.

C. PWM-Based Control

A proportional controller adjusts PWM duty cycle:

- If temperature $<$ setpoint: heater is activated.
- If temperature $>$ setpoint: fan is activated.

Only one actuator operates at any time.

D. Actuator Switching

IRF540N MOSFETs switch the heater and fan. Logic gates (AND, NOT) ensure mutual exclusivity of operation, preventing simultaneous activation.

E. Real-Time Monitoring

Data is transmitted via UART and plotted using a Python script with Matplotlib to observe system behavior and verify profile tracking.

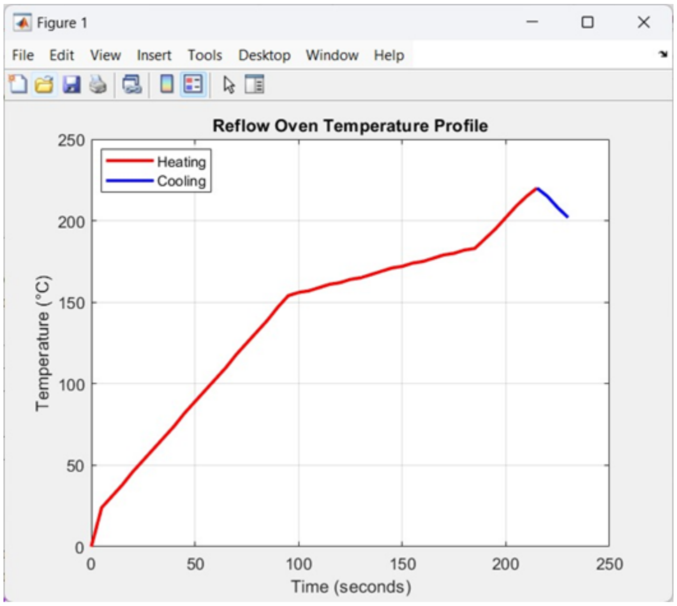

Fig. 2: Output

F. Interrupt-Driven Control

Timer0 interrupts drive the main control sequence:

1) Update setpoint.
2) Read temperature.
3) Calculate PWM duty.
4) Control actuator.
5) Transmit data.

IV. Simulation and Results

The system was simulated in Proteus and verified via:

- Accurate temperature readings from MAX6675.
- PWM output for heating and cooling.
- Logic gate control for safe actuator switching.
- UART transmission and real-time graphing via Python.

The system closely followed the temperature profile, transitioning smoothly through the four soldering stages.

V. Hardware Components

- **PIC18F458**: Core controller for logic and PWM generation.
- **MAX6675 + Thermocouple**: Digital temperature measurement.
- **IRF540N MOSFETs**: Power switches for fan and heater.
- **DC Heater & Fan**: Provide heating and cooling.
- **1N4007 Diodes**: Flyback protection.
- **Logic Gates**: Ensure only one actuator is active.
- **8 MHz Crystal**: Provides clock for MCU.
- **UART Interface**: Serial communication for real-time data.

VI. Discussion

The design effectively implements an embedded thermal control system using basic components. Logic gates provided safe operation, while PWM allowed smooth temperature transitions. UART-based monitoring enabled intuitive real-time observation of system behavior. The use of Timer0 interrupts facilitated synchronized, stage-wise control over the soldering process.

VII. Conclusion

A reliable and cost-effective solder reflow oven controller was developed using the PIC18F458 microcontroller, MAX6675 sensor, and PWM logic. The system demonstrated accurate temperature tracking, safe actuator switching, and real-time monitoring. This project reinforces key embedded systems concepts and has practical applications for educational and prototyping environments.

Acknowledgment

We sincerely thank Engr. Memoon Sajid and the Faculty of Electrical Engineering at GIK Institute for their invaluable support and mentorship throughout this project.

References

[1] M. H. Rashid, *Power Electronics: Circuits, Devices and Applications*, 4th ed., Pearson Education, 2013.

[2] Y. Zhang, L. Wang, and J. Chen, "Design and Implementation of an Automatic Solder Reflow Oven Using Embedded Control," *IEEE Trans. Ind. Electron.*, vol. 67, no. 9, pp. 7582–7590, Sep. 2020.

[3] A. K. Sharma and V. Patel, "Temperature Control in Reflow Ovens Using Thermocouple Feedback and PWM Techniques," *J. Control Syst. Eng.*, vol. 55, no. 4, pp. 291–298, Apr. 2022.

[4] T. H. Lee and R. S. Karthik, "Design Optimization of RC Filtering and Logic Control in Solder Reflow Systems," *Int. J. Electr. Electron. Eng.*, vol. 49, no. 3, pp. 225–231, Mar. 2023.