Simulation of Microwave Oven

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Duration: 06 Jan, 2025 - 28 Feb, 2025
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Embedded Systems intern at EMERTXE

Overview

This internship at Emertxe focused on learning and implementing Embedded Systems concepts using PIC microcontrollers.

The main objective of this project was to simulate the functioning of a microwave oven using the PICSimLab simulation environment.

Key features of the simulation include:

- Implementing state machine logic to control the microwave operations (Idle, Cooking, Paused, and Stopped states)
- Using input peripherals like buttons for Start, Stop, and Pause
- Displaying the timer and status on a virtual display panel
- Controlling the turntable motor for realistic simulation of cooking operations
- This project helped in gaining hands-on experience in C programming, microcontroller interfacing, and system-level design.

Goals of Internship

- Gain in-depth knowledge of C programming, focusing on embedded systems applications.
- Understand the fundamentals of embedded systems and their role in automation.
- Learn to interface and integrate various peripherals with microcontrollers.
- Develop a simulation of a microwave oven using state machine logic and real-time control.
- Enhance problem-solving skills by implementing system-level designs in a virtual environment.
- Acquire hands-on experience with MPLAB X IDE, PICSimLab, and Embedded C programming.

This internship provided a strong foundation in embedded systems development and prepared me for advanced projects in automation and IoT.

Learning Journey
(1) C Programming

- C programming served as the foundation for developing embedded applications.
- Learned the basics of C language, including data types, operators, and control structures.
- Gained proficiency in writing functions to modularize code and enhance reusability.
- Focused on logic building for state machine implementation and real-time control.
- Explored the use of pointers and memory management for efficient data handling.
- Developed debugging skills using MPLAB X IDE to troubleshoot and optimize code.

This phase helped in mastering the essential programming skills required for embedded systems.

Learning Journey
(2) Embedded Systems

- Introduced to the world of embedded systems and their significance in automation.
- Understood the architecture of microcontrollers and their role as the brain of embedded devices.
- Learned about the interaction between hardware and software in embedded systems.
- Explored the applications of embedded systems in real-world scenarios like home appliances, automotive, and industrial automation.
- Emphasized the importance of resource constraints and real-time operation in embedded design.

This knowledge laid the groundwork for effectively designing and implementing the microwave oven simulation.

Learning Journey
(3) Peripherals Overview

- Explored and implemented various peripherals essential for the microwave oven simulation:
  - **CLCD (Character LCD):** Used for displaying the timer, status messages, and operational modes of the microwave oven. It enhanced user interaction and provided real-time feedback.
  - **Timer:** Utilized to manage cooking duration and countdown functionality. It also synchronized state transitions, ensuring accurate timing for cooking, pausing, and stopping.
  - **Matrix Key Pad:** Enabled user input for setting the cooking time and selecting operational modes. It allowed a flexible and intuitive interface for user interaction.
  - **Switches and Buttons:** Configured as input peripherals for essential controls such as Start, Stop, and Pause functionalities. They provided direct control over the microwave's operation.
  - **Interrupts:** Implemented to handle asynchronous events, ensuring prompt response to user inputs. It also enhanced system reliability and reduced latency in state transitions.

This phase helped in mastering peripheral integration, real-time control, and efficient input-output handling.

Project Requirements

- To simulate the microwave oven, the following hardware and software requirements were identified:
- **Hardware Requirements:**
  - PIC Microcontroller (Simulated using PICSimLab)
  - Peripherals: CLCD, Timer, Matrix Key Pad, Switches, and Buttons
  - Virtual Environment for simulating user interactions and outputs
- **Software Requirements:**
  - **MPLAB X IDE:** For code development, debugging, and simulation.
  - **PICSimLab:** To simulate the microcontroller and peripherals, ensuring accurate emulation of real-world behavior.
  - **Embedded C Programming:** For developing the state machine logic and implementing peripheral interfaces.

These requirements provided a comprehensive platform for designing, testing, and validating the microwave oven simulation.

Design Overview

- **Block Diagram Overview:**
  - **Input Modules:** Matrix Key Pad, Switches, and Buttons for user controls (Start, Stop, Pause, and Time Settings).
  - **Processing Unit:** PIC Microcontroller executing state machine logic and managing peripherals.
  - **Output Modules:** CLCD for displaying time and status, and simulated motor for turntable movement.
- **State Machine Logic:**
  - Implemented states: Idle, Cooking, Paused, and Stopped.
  - Controlled by user inputs and timer events.
- **Interrupt Handling:** Ensures quick response to inputs, enhancing system reliability.

Simulation environment in PICSimLab

Board & Components Info

- **Simulation Environment:**
  - **PICSimLab** was used as the simulation platform to emulate the PIC microcontroller and connected peripherals.
  - It provided a virtual environment for testing the state machine logic and user interactions.
- **Microcontroller Board:**
  - Simulated PIC Microcontroller for processing inputs and controlling outputs.
  - Configured with multiple input-output ports to interface peripherals.
- **Peripherals Used:**
  - **CLCD:** Displaying timer, status messages, and operational modes.
  - **Matrix Key Pad:** Input for setting time and selecting functions.
  - **Switches and Buttons:** Controls for Start, Stop, and Pause functionalities.
  - **Timer Module:** Managing countdown and state transitions.
  - **Interrupts:** Handling real-time user inputs without delays.
- **Development Tools:**
  - **MPLAB X IDE** for coding, compiling, and debugging.
  - **PICSimLab** for peripheral simulation and behavior validation.

Development Process
(1) Learning & Coding in C

- Focused on mastering C programming for embedded applications.
- Learned data types, control structures, functions, and pointers.
- Built foundational logic for state machines and real-time operations.
- Practiced coding and debugging using MPLAB X IDE.

Development Process

(2) Understanding Embedded Systems

- Gained knowledge about microcontroller architecture and interfacing.
- Studied how hardware and software interact in embedded systems.
- Explored real-time constraints and efficient resource management.
- Understood the significance of interrupts and I/O handling.

Development Process
(3) Integrating Peripherals

- Interfaced CLCD for displaying time and status messages.
- Configured Matrix Key Pad for time settings and function selection.
- Implemented Buttons and Switches for Start, Stop, and Pause controls.
- Managed timing and synchronization using Timer and Interrupts.
- Ensured smooth communication between peripherals and the microcontroller.

Development Process

(3) Implementing the Simulation

- Developed a state machine model for microwave operations (Idle, Cooking, Paused, Stopped).
- Integrated all peripherals to simulate real-time functionality.
- Used PICSimLab to test and validate user interactions and state transitions.
- Debugged and optimized the code for reliable performance.
- Achieved accurate simulation of microwave functionalities, including countdown, start, pause, and stop operations.

Implementation Details

- **State Machine Logic:**
  - Designed using four main states:
    - **Idle:** Waiting for user input.
    - **Cooking:** Countdown in progress, turntable motor running.
    - **Paused:** Timer stops, motor halts, waiting for Resume or Stop input.
    - **Stopped:** Cooking ends or manually stopped, timer resets.
- **Input Mechanism:**
  - **Buttons:** Start, Stop, and Pause for user interaction and state transitions.
  - **Matrix Key Pad:** For setting cooking time and selecting modes.
- **Output Mechanism:**
  - **CLCD Display:** Shows the timer, operational status, and mode.
  - **Motor Control:** Simulates turntable movement during cooking state.
- **Interrupt Handling:** Ensures real-time response to user inputs.

Project Demo

Simulation Process

Conclusion

- **Key Learnings:**
  - Gained proficiency in C programming and state machine implementation.
  - Understood embedded systems architecture and real-time constraints.
  - Acquired skills in peripheral interfacing and interrupt handling.
  - Learned to simulate complex systems using PICSimLab.
- **Challenges Faced:**
  - Debugging state transitions and synchronizing peripherals.
  - Handling asynchronous inputs with interrupt-driven programming.
  - Ensuring accurate timing and consistent user interactions.
- **Project Outcomes:**
  - Successfully simulated the microwave oven with all essential functionalities.
  - Achieved realistic user interface and operational accuracy.

THANK YOU

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