University of Washington Tacoma

System Design Document

TimeSync: A Multifunctional Digital Clock Using TM4C123GH6PM Microcontroller

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Contents

1 Introduction

This document serves as the design documentation for the TimeSync project, detailing the specifications, architecture, and implementation strategies. It aims to provide a comprehensive guide for understanding the project's structure and rationale.

2 Project Overview

TimeSync is a multifunctional digital clock project built on the TM4C123GH6PM microcontroller platform. It targets tech enthusiasts and educational purposes, demonstrating embedded system design's intricacies. The project encapsulates timekeeping, ambient temperature measurement, and alarm functionalities, all interfaced with a modern OLED display.

3 Design Goals

The project's primary objectives include:

- Precise timekeeping with minimal drift
- User-friendly interface with an OLED display
- Accurate ambient temperature readings
- Customizable alarm settings with audio output
- Low power consumption leveraging hibernation features
- Scalability for future enhancements such as additional sensors or connectivity modules

4 System Architecture

The system architecture of the TimeSync project is built around the TM4C123GH6PM microcontroller, which orchestrates the interaction between the input/output peripherals, communication interfaces, and power management. Below is a block diagram illustrating the main components and their interactions.

As shown in Figure 2, the microcontroller connects to the OLED display via I2C, to the temperature sensor via ADC, and to the MP3 module via UART. User input is captured through GPIO interfaced push buttons, and the system is powered by a regulated power supply that ensures efficient energy management.

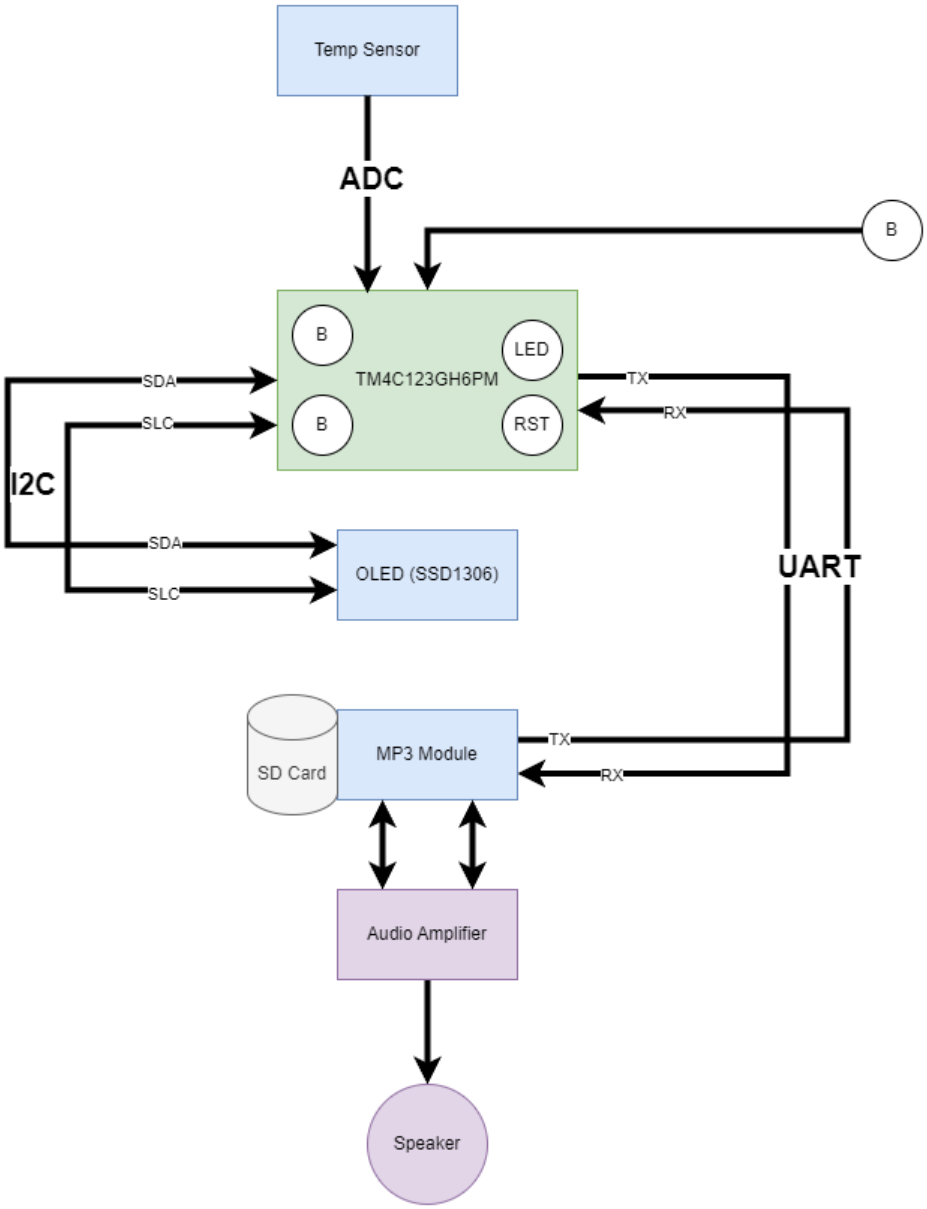

Figure 1: Represents the system architecture block diagram of the TimeSync project.

5 Components and Modules

5.1 Microcontroller

- The TM4C123GH6PM Microcontroller acts as the central processing unit.
- It manages timing, sensor data, user input, and communication with the MP3 module.
- Features such as GPIO, ADC, I2C, UART, and timers are pivotal for project operations.

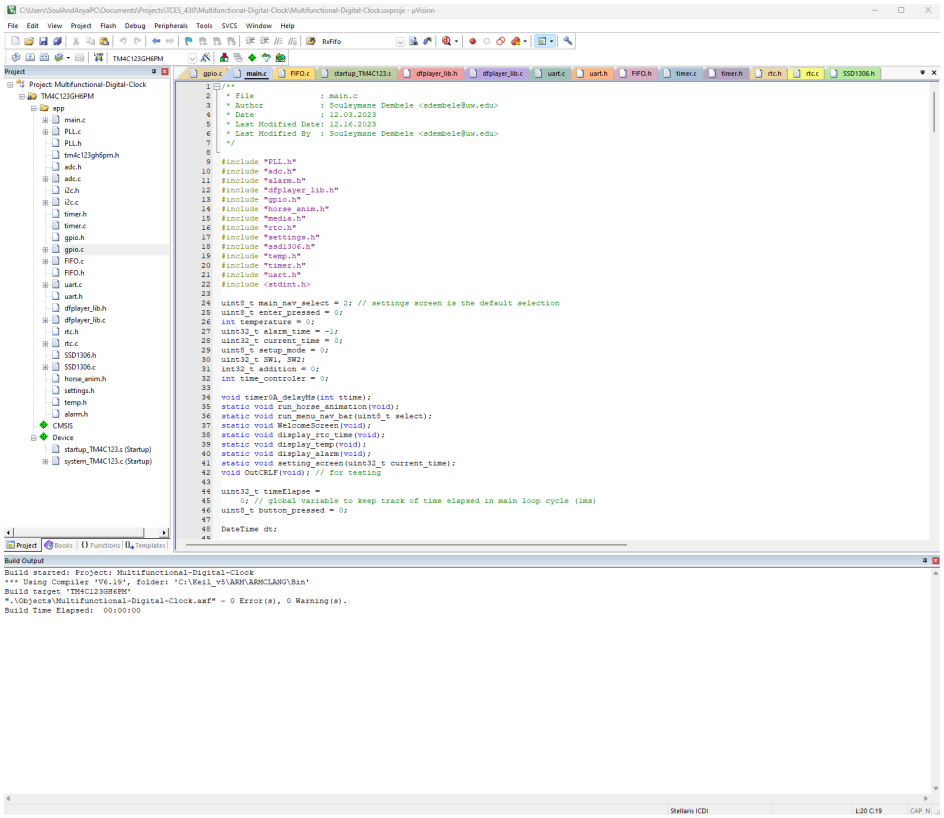

Figure 2: Represents the project view.

5.2 Display

- Utilizes an OLED display interfaced via I2C protocol.
- Provides a resolution sufficient for clear time and temperature display.

5.3 Temperature Sensor

- Employs a TMP36GT9Z sensor known for its linear temperature output.
- Interfaced with the MCU's ADC for temperature data acquisition.

5.4 Alarm and MP3 Module

- Includes an MP3 module interfaced through UART, providing audio feedback for alarms.

6 User Interface

The UI boasts a minimalistic design with a focus on ease of use. It includes a main menu, time, and temperature display, alongside a settings menu for alarm configuration. Three

push buttons allow users to navigate menus, set time/alarms, and silence alarms.

7 Software Design

7.1 Firmware

- Developed in the C programming language with direct register access for bare-metal programming of the TM4C123GH6PM microcontroller and compiled using Keil uVision.
- The firmware architecture is based on a low-level event-driven design, with interrupts directly managed through register configurations.
- Implements FIFO buffers using custom data structures, with direct manipulation of pointers and memory addresses to handle the data efficiently at a register level.

7.2 Algorithms

- A precise timekeeping algorithm implemented with direct writes to timer registers, ensuring accurate time increments and accounting for system clock variations.
- ADC values from the temperature sensor are converted to temperature readings using a direct register read and calculation method, avoiding the overhead of higher-level abstraction libraries.
- The FIFO implementation for UART communication ensures a continuous flow of data to and from the MP3 module, with manual handling of buffer pointers and register flags for data readiness and buffer full conditions.

8 Hardware Design

The hardware comprises the Tiva LaunchPad, off-the-shelf sensor, and display modules, with custom wiring and potential for a custom PCB in future iterations.

9 Testing Strategy

Testing encompassed manual functional tests, and full-system integration tests, ensuring robustness and reliability.

10 Future Enhancements

Future improvements could include Wi-Fi connectivity for network time synchronization, additional environmental sensors, and a mobile app for clock configuration.

11 Appendix and References

References would include the datasheets for the TM4C123GH6PM MCU, TMP36GT9Z sensor, are located under docs in source code.