**S3 Timer System for CLIC3 Board (MSP430F5308)**

**Project Overview**

This embedded system measures the ON-time of switch S3, displays it on seven-segment displays, compares it against a user-defined threshold, and provides visual feedback through LEDs and LCD display.

**System Architecture**

**Hardware Components**

* **Microcontroller**: MSP430F5308
* **Input**: Switch S3 (P1.3) with interrupt capability
* **Outputs**:
  + LED D0 (PJ.0) - Threshold alarm indicator
  + LED D7 (P3.7) - S3 status indicator
  + Seven-segment displays DIS1 & DIS2 (P2 for data, P4.0-P4.1 for enables)
  + 16x2 LCD Display (P2 for data, P4 for control)
* **Input**: 4x3 Matrix Keypad (P5)

**Timer Configuration**

1. **Timer A0** (TA0)
   * Purpose: Elapsed time measurement
   * Clock: ACLK (32.768 kHz)
   * Period: 100ms
   * Mode: Up mode with CCR0 interrupt
   * Function: Counts 10 ticks to measure 1 second
2. **Timer A1** (TA1)
   * Purpose: LED blinking for threshold alarm
   * Clock: ACLK (32.768 kHz)
   * Period: 500ms (2 Hz blinking rate)
   * Mode: Continuous up mode

**Interrupt Sources**

1. **Port 1 Interrupt** - S3 switch detection (rising/falling edge)
2. **Timer A0 CCR0** - 100ms time tick
3. **Timer A1 CCR0** - LED blink control

**Software Architecture**

**State Machine**

IDLE → THRESHOLD\_ENTRY → TIMING → STOPPED → IDLE

* **STATE\_IDLE (0)**: System waiting for S3 press
* **STATE\_THRESHOLD (1)**: User entering threshold value
* **STATE\_TIMING (2)**: Actively measuring S3 ON time
* **STATE\_STOPPED (3)**: S3 released, displaying final time

**Memory Map**

timer\_ticks: 2 bytes ; 100ms tick counter

elapsed\_secs: 1 byte ; Elapsed time (0-99 seconds)

threshold: 1 byte ; User-defined threshold

s3\_state: 1 byte ; Current S3 state

debounce\_cnt: 1 byte ; Debounce counter

blink\_state: 1 byte ; LED blink enable

display\_buffer: 2 bytes ; Seven-segment buffer

**Build Instructions**

**Prerequisites**

* IAR Embedded Workbench for MSP430
* MSP430F5308 header files
* CLIC3 board connected via USB/JTAG

**Assembly Process**

1. Create new project in IAR:
2. File → New → Workspace
3. Project → Create New Project → MSP430 → asm → OK
4. Configure project settings:
   * Device: MSP430F5308
   * Debugger: FET Debugger
   * Output format: Intel Hex
5. Add source files:
   * main.s43 (main timer system)
   * keypad.s43 (keypad module)
   * Link with MSP430F5308 libraries
6. Build project:
7. Project → Build All (F7)
8. Program device:
9. Project → Download and Debug (Ctrl+D)

**Pin Assignments**

| **Component** | **Pin** | **Port** | **Function** |
| --- | --- | --- | --- |
| S3 Switch | P1.3 | Port 1 | Input with interrupt |
| LED D0 | PJ.0 | Port J | Threshold alarm |
| LED D7 | P3.7 | Port 3 | S3 status |
| 7-Seg Data | P2.0-P2.7 | Port 2 | Segment patterns |
| DIS1 Enable | P4.0 | Port 4 | Units digit |
| DIS2 Enable | P4.1 | Port 4 | Tens digit |
| LCD Data | P2.0-P2.7 | Port 2 | 4-bit mode |
| LCD RS | P4.2 | Port 4 | Register select |
| LCD EN | P4.3 | Port 4 | Enable |
| Keypad Rows | P5.0-P5.3 | Port 5 | Output scan |
| Keypad Cols | P5.4-P5.6 | Port 5 | Input read |

**Operation Instructions**

**Initial Setup**

1. Power on the CLIC3 board
2. LCD displays "Enter Thresh:"
3. Use keypad to enter 2-digit threshold (00-99 seconds)
4. Press '#' to confirm
5. System displays "Ready"

**Normal Operation**

1. **Press S3**:
   * D7 LED turns ON
   * Timer starts
   * Seven-segment displays show elapsed time
2. **Release S3**:
   * D7 LED turns OFF
   * Timer stops
   * LCD shows final elapsed time
3. **Threshold Exceeded**:
   * D0 LED blinks at 2Hz
   * LCD displays "EXCEEDED!"

**Keypad Layout**

[1] [2] [3]

[4] [5] [6]

[7] [8] [9]

[\*] [0] [#]

* Numbers: Enter threshold digits
* '#': Confirm entry

**Sustainability Features**

**1. Low Power Modes**

* **LPM0** used during idle periods
* SMCLK remains active for timers
* CPU wakes only on interrupts

**2. Interrupt-Driven Design**

* No polling loops
* CPU sleeps between events
* Minimal active CPU time

**3. Peripheral Management**

* Unused modules disabled
* Display multiplexing reduces power
* LEDs use minimal duty cycle

**Energy Savings Estimation**

* **Idle Current**: ~50µA (LPM0 with ACLK)
* **Active Current**: ~300µA (during updates)
* **Duty Cycle**: <5% active time
* **Estimated Savings**: >80% vs polling design

**Debouncing Implementation**

**Hardware Debouncing**

* Pull-up resistors on switch inputs
* RC filtering on PCB (if available)

**Software Debouncing**

* 20ms delay after edge detection
* State verification after delay
* Edge direction tracking

**Testing Procedure**

**Unit Tests**

1. **Timer Accuracy**: Verify 1-second precision
2. **Display Test**: Check all segments 0-9
3. **Keypad Test**: Verify all keys respond
4. **LED Test**: Verify D0 blink and D7 status

**Integration Tests**

1. **Short Press**: Press S3 for 2-3 seconds
2. **Long Press**: Press S3 for >10 seconds
3. **Threshold Test**: Set threshold to 5s, test with 3s and 7s presses
4. **Overflow Test**: Hold S3 for >99 seconds
5. **Rapid Press**: Multiple quick presses

**Edge Cases**

* Power-on with S3 pressed
* Threshold = 0
* Threshold = 99
* Multiple simultaneous key presses
* S3 bounce simulation

**Troubleshooting**

| **Issue** | **Possible Cause** | **Solution** |
| --- | --- | --- |
| No display | Power/clock issue | Check ACLK crystal |
| Wrong time | Timer config | Verify CCR0 value |
| No S3 response | Interrupt disabled | Check P1IE register |
| LCD garbled | Timing issue | Increase delays |
| Keypad not working | Wrong port config | Verify P5 direction |

**Code Metrics**

* **Total Lines**: ~800
* **Code Size**: ~2KB
* **RAM Usage**: ~20 bytes
* **Interrupt Latency**: <10µs

**Future Enhancements**

1. EEPROM storage of threshold
2. Multiple timer channels
3. USB data logging
4. Averaging of multiple measurements
5. Configurable time units (ms/s/min)

**References**

* MSP430F5308 User Guide (SLAU208)
* MSP430 Assembly Language Tools (SLAU131)
* CLIC3 Board Schematic
* IAR Embedded Workbench Documentation