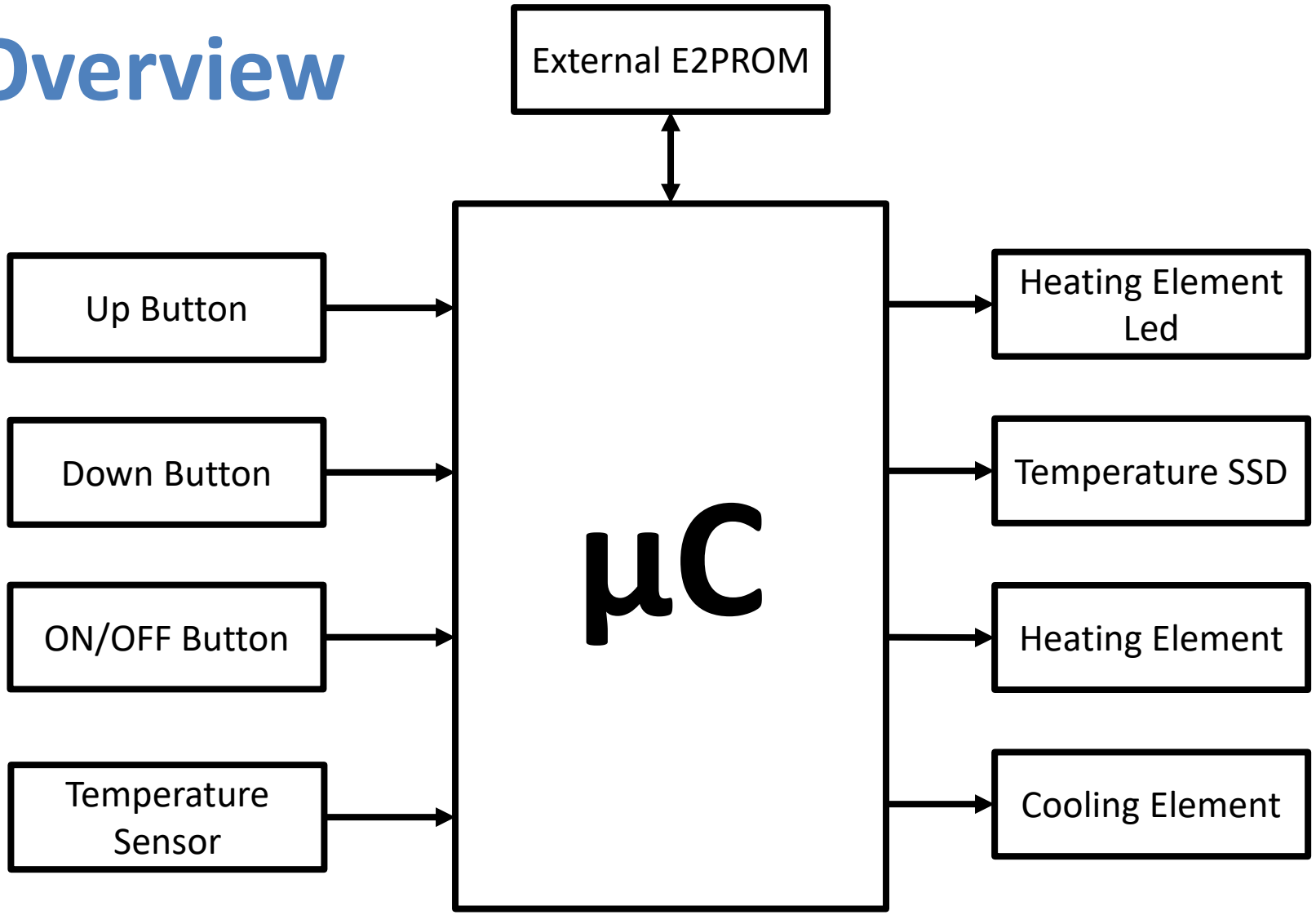
Case Study: Electric Water Heater

Timeline

- **Before July 19**
- **July 24 – full day**
- **July 26 – Oct 26**

Overview


External E2PROM
Up Button
Down Button
ON/OFF Button
Temperature Sensor
µC
Heating Element Led
Temperature SSD
Heating Element
Cooling Element

Specifications – Temperature Setting

1. The “Up” or “Down” buttons are used to change the required water temperature (set temperature)
2. The first “Up” or “Down” button press, enters the temperature setting mode
3. After entering temperature setting mode, a single “Up” button press increase the set temperature by 5 degrees
4. After entering temperature setting mode, a single “Down” button press decrease the set temperature by 5 degrees
5. The minimum possible set temperature is 35 degrees
6. The maximum possible set temperature is 75 degrees
7. The “External E2PROM” should save the set temperature once set
8. If the electric water heater is turned OFF then ON, the stored set temperature should be retrieved from the “External E2PROM”
9. The initial set temperature is 60 degrees

Specifications – ON/OFF Behavior

1. If power is connected to the heater, the electric water heater is in OFF state
2. If the “ON/OFF” button is released and the electric water heater is in OFF state, the electric water heater goes to ON state
3. If the “ON/OFF” button is released and the electric water heater is in ON state, the electric water heater goes to OFF state
4. In the OFF state, all display should be turned OFF

Specifications – Temperature Sensing

1. The temperature sensor measures the water temperature
2. The water temperature should increase, if the “Heating Element” is ON
3. The water temperature should decrease, if the “Cooling Element” is ON
4. Temperature should be sensed once every 100 ms
5. The decision to turn ON or OFF either the “Heating Element” or the “Cooling Element” based on the average of the last 10 temperature readings

Specifications – Heating/Cooling Elements

1. The “Heating Element” should be turned ON, if the current water temperature is less than the set temperature by 5 degrees
2. The “Cooling Element” should be turned OFF, if the current water temperature is less than the set temperature by 5 degrees
3. The “Heating Element” should be turned OFF, if the current water temperature is greater than the set temperature by 5 degrees
4. The “Cooling Element” should be turned ON, if the current water temperature is less than the set temperature by 5 degrees

Specifications – Seven Segments

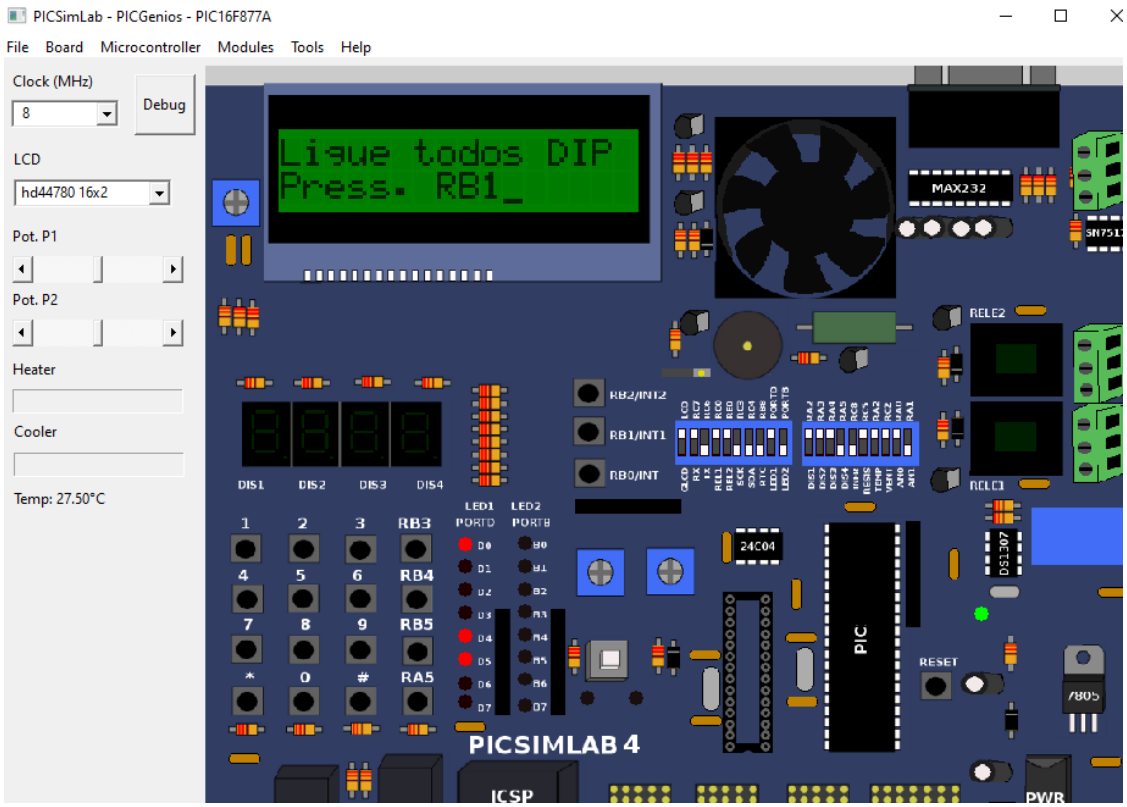
1. 2 seven segment by default show the current water temperature or the set temperature
2. By default, the 2 seven segment display are show the current water temperature
3. If the electric water heater is in the temperature setting mode, the 2 seven segment displays should blink every 1 second and show the set temperature
4. In the temperature setting mode, every change in the set temperature should be reflected on the 2 seven segment displays
5. The 2 seven segment display should exit the temperature setting mode, if the “UP” and “Down” buttons are not pressed for 5 seconds

Specifications – Heating Element Led

1. If the “Heating Element” is ON, the “Heating Element Led” should blink every 1 second
2. If the “Cooling Element” is OB, the “Heating Element Led” should be ON

Hardware

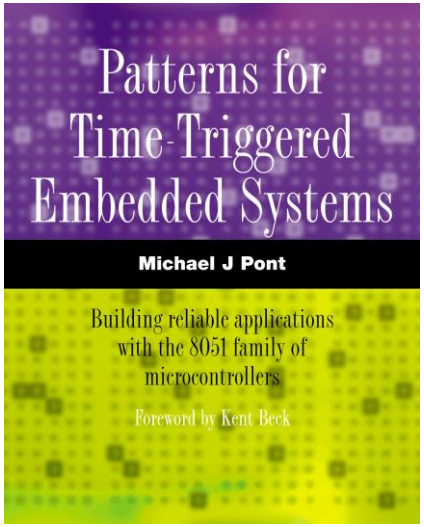
- Use PICSimLab v0.8
- Board: PIC Genios with pic16f877a
- Use peripherals from the board
  - Heating Element ➔ Heater
  - Cooling Element ➔ Fan
  - External E2PROM ➔ I2C E2PROM
  - Map other elements as you wish
- Use any compiler you want

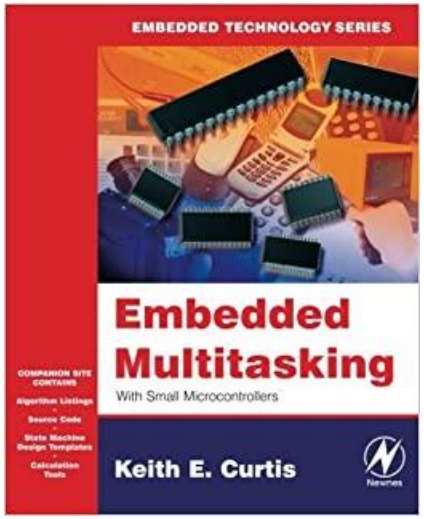


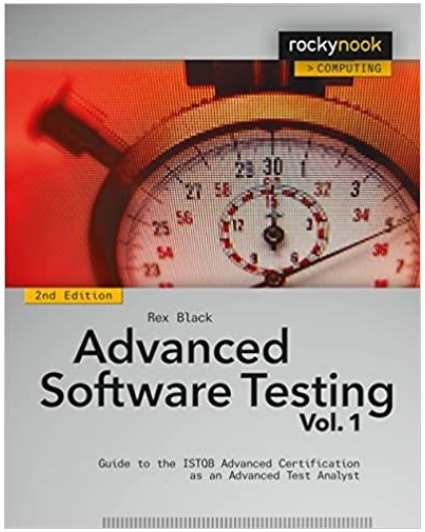
Deliverables

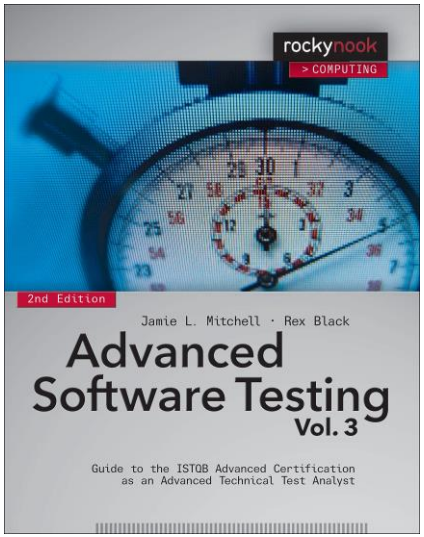
- Your CV
- Project folder that has source code and executables
- Project Documentation (power point explaining design)
  - Check the slides with “Example in the title” for a minimal example
- Delivery is through Internship form only (https://forms.gle/yoUg7bgdZy82QjSNA)

Suggested Readings

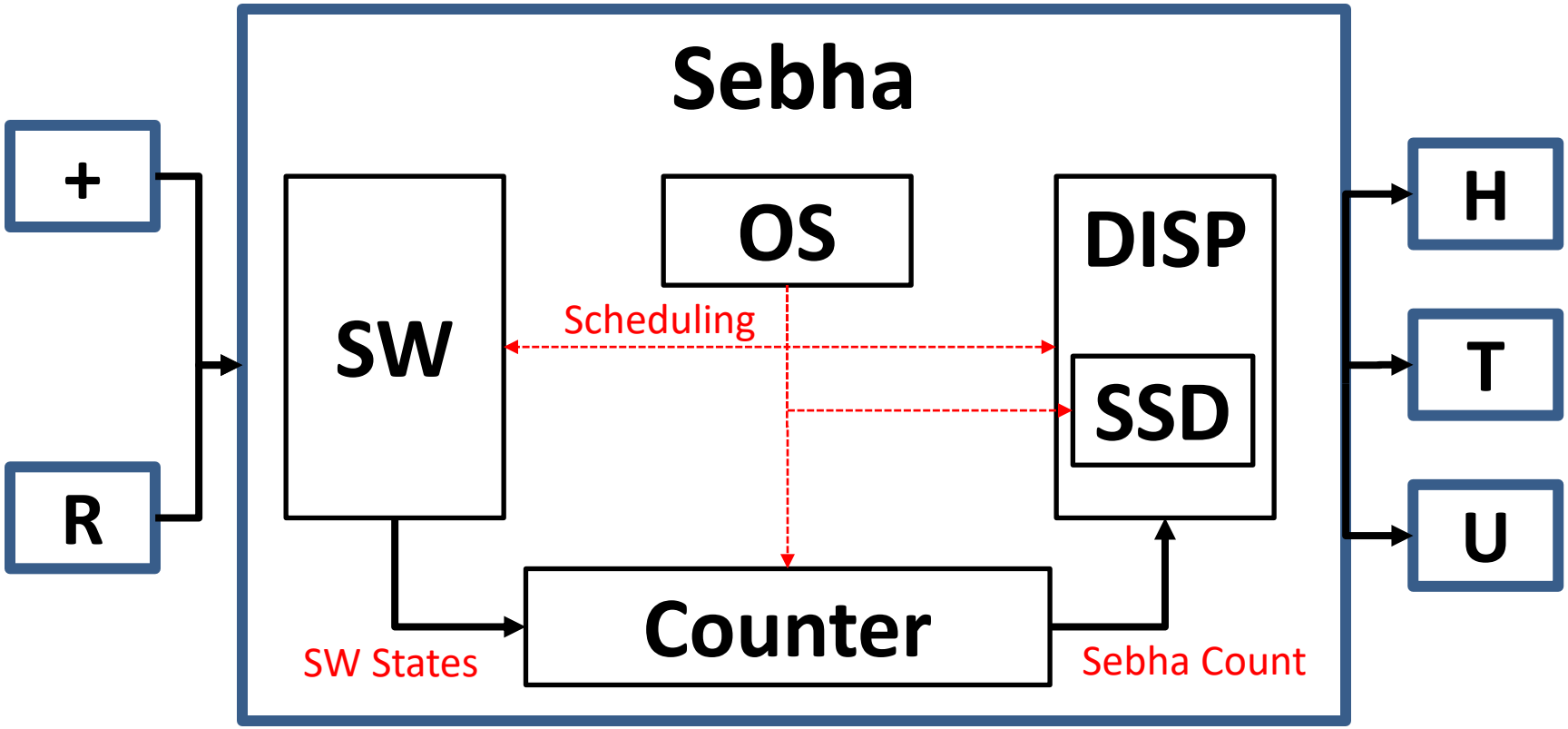








Example Sebha: Static Architecture



Exmple Sebha: Detailed Design

- SW
  - SW_Init
  - SW_Update
  - SW_GetState
- OS
  - OS_Init
  - OS_update
  - OS_Sleep
- CTR
  - CTR_Init
  - CTR_Update
  - CTR_GetCount
- DISP
  - DISP_Init
  - DISP_Update
- SSD
  - SSD_Init
  - SSD_Update
  - SSD_SetSymbol
  - SSD_GetSymbol
  - SSD_SetState
  - SSD_GetState

Example Sebha: Timing Analysis

Task	Actions	BCET (ms)	WCET(ms)	Period of Action (ms)	Period of task (ms)
SW	Update samples Update SW state	~0 ~0	~0 ~0	20 20	20
CTR	Update CTR	~0	~0	20	20
DISP	Update display	~0	~0	20	20
SSD	Update SSD	~0	~0	5	5
				Tick (ms)	5
				Major Cycle (ms)	20

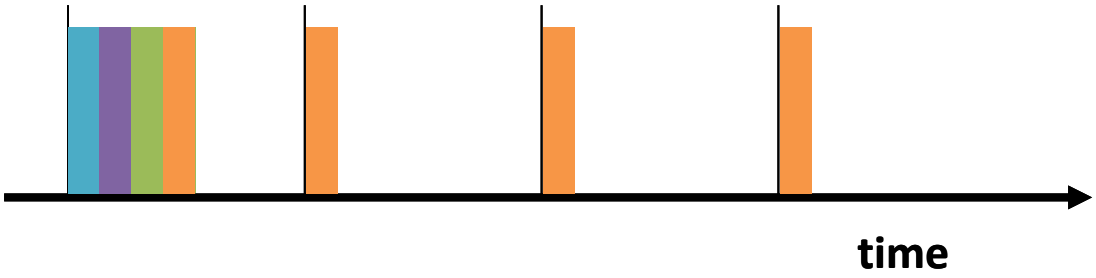
Example Sebha: Schedulability Check

SSD Task @ 5 ms

Counter Task @ 20 ms

SW Task @ 20 ms

DISP Task @ 20 ms



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