



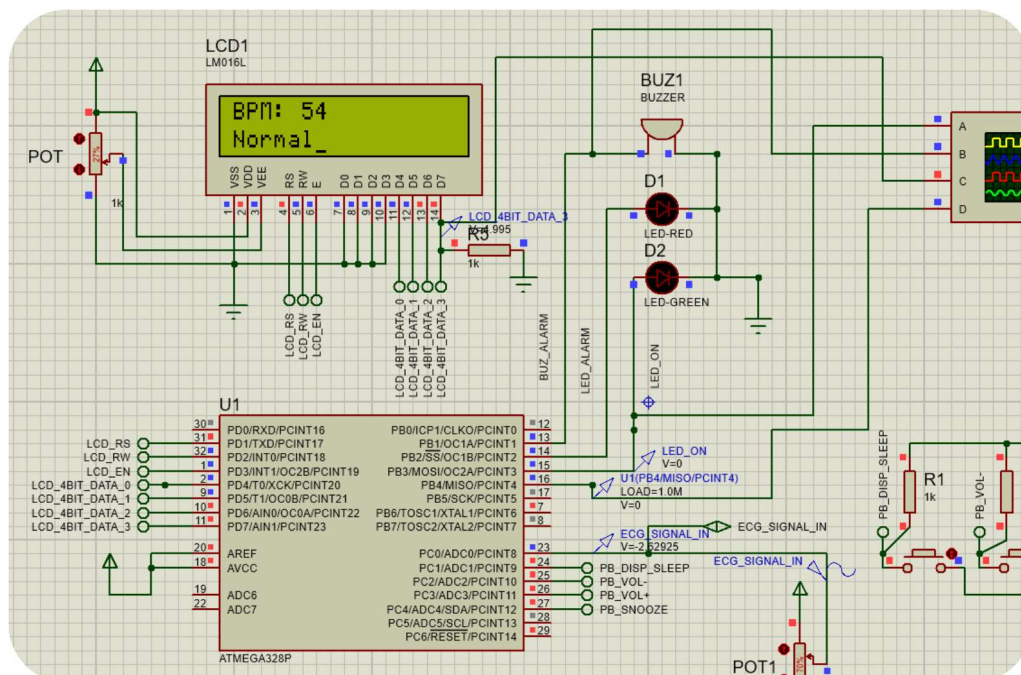
# ICU Heartrate Monitor

## SBEN430: Final Project

### Advanced Topics in Embedded Systems

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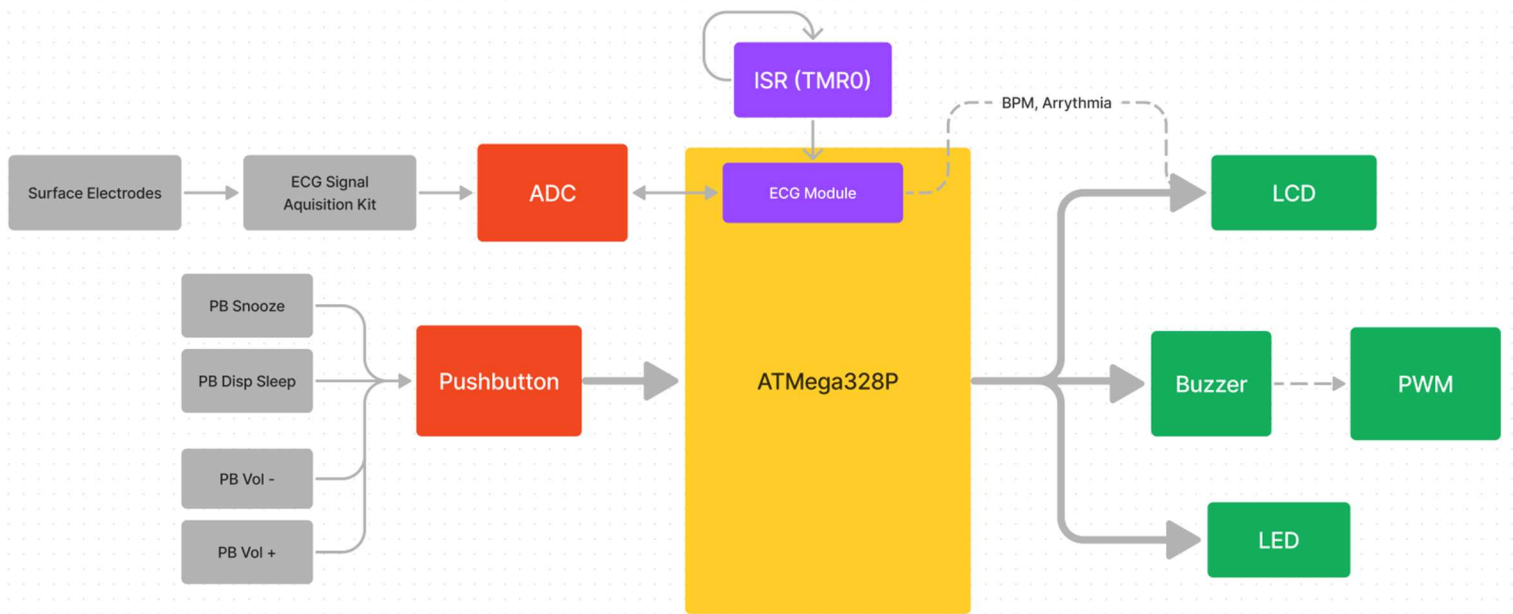


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## System Design

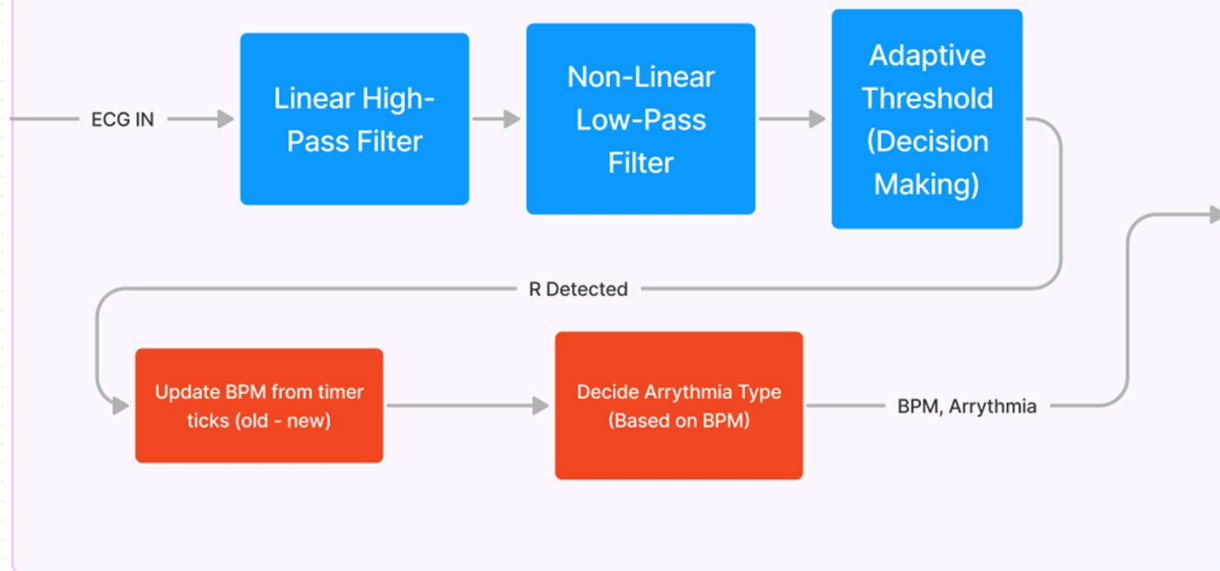
### Block Diagram



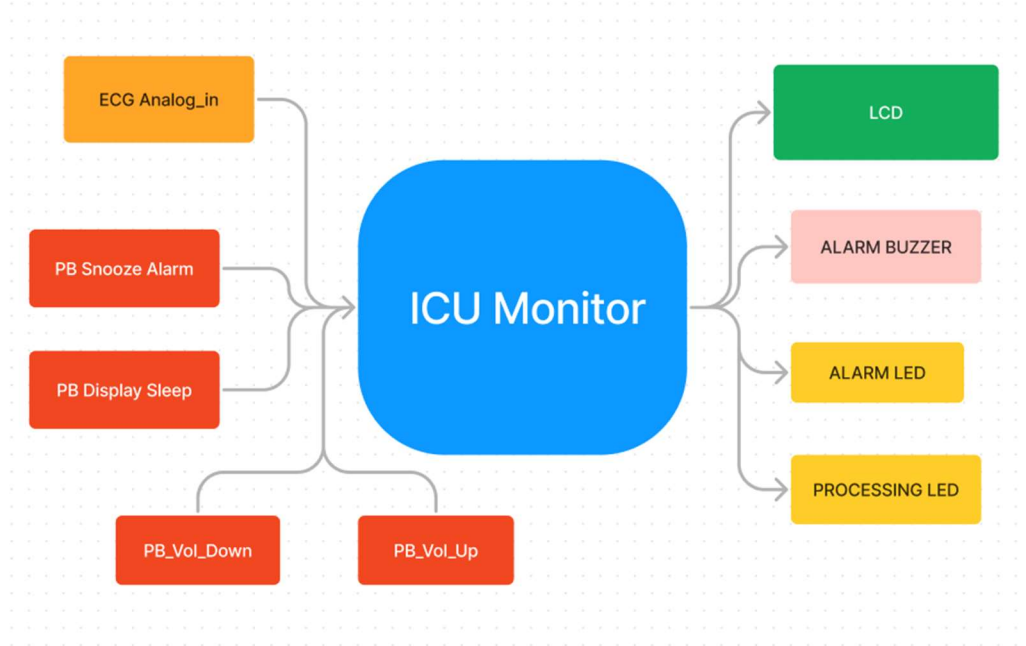
### ECG Module Detailed Design

#### Signal Processing Pipeline

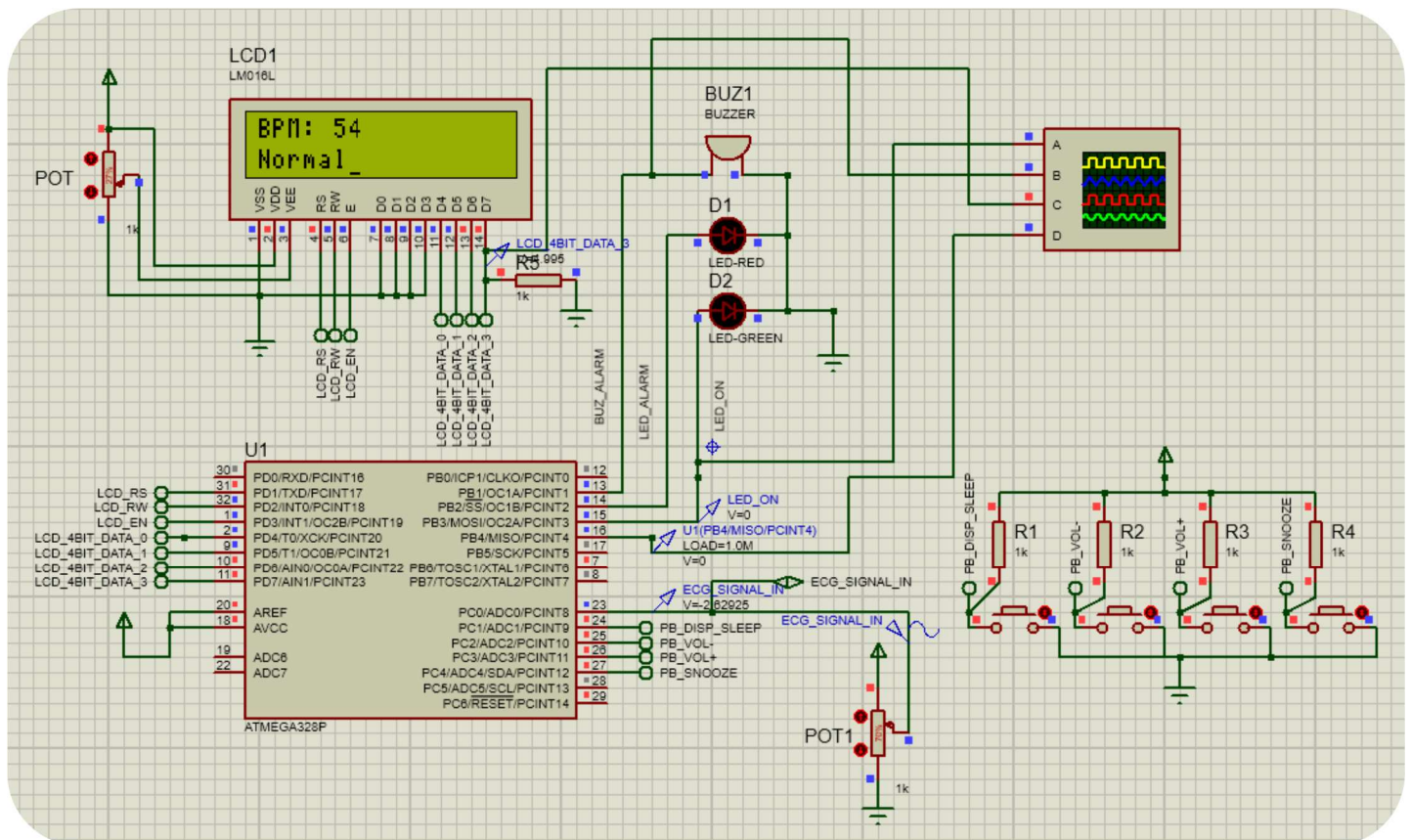
HC Chen, SW Chen, "A Moving Average based Filtering System with its Application to Real-time QRS Detection", Computers in Cardiology, 2003.



## Context Diagram



## Circuit Diagram

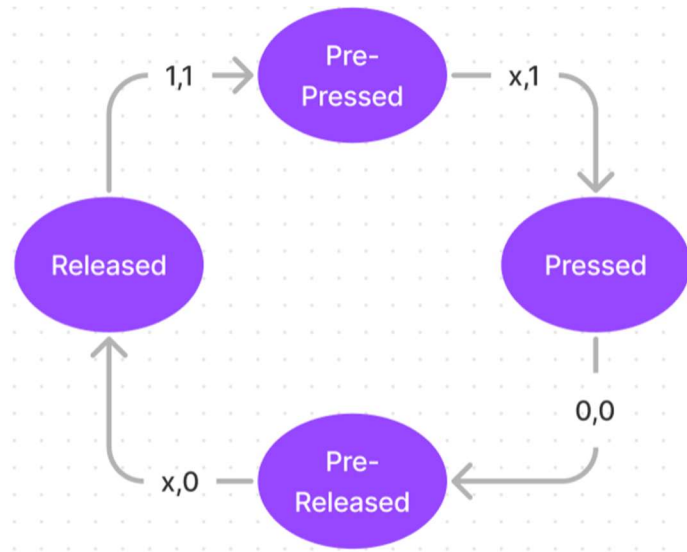


# Unit Testing Report

## Pushbutton Module

PB\_Update ()

State Diagram



State Transition Table

|        |                   | Events (Pin Samples) |     |     |     |
|--------|-------------------|----------------------|-----|-----|-----|
|        |                   | x,1                  | 0,0 | x,0 | 1,1 |
| States | S1: Pre- Pressed  | S2                   | --  | --  | --  |
|        | S2: Pressed       | --                   | S3  | --  | --  |
|        | S3: Pre- Released | --                   | --  | S4  | --  |
|        | S4: Released      | --                   | --  | --  | S1  |

### o - Switch Coverage

This also achieves full round trip coverage

| o-Switch  |
|-----------|
| S1 (1, 1) |
| S2 (x,0)  |
| S3 (0,0)  |
| S4 (x,1)  |

### Invalid Transition Test

S1 (1,1) S2(0,0) S3 (1,0) S4(1,1)

**PB\_Init (tPB pb, tPB\_State), PB\_GetState(tPB pb), PB\_SetState(tPB pb, tPB\_State)**

**Equivalence Partitioning**

| Test Case | tPB           | tPB_State      |
|-----------|---------------|----------------|
| 1         | PB_VOL_PLUS   | PB_RELEASED    |
| 2         | PB_VOL_MINUS  | PB_PRE_PRESSED |
| 3         | PB_SNOOZE     | PB_PRESSED     |
| 4         | PB_DISP_SLEEP | PB_PRE_PRESSED |
| 5         | PB_DISP_SLEEP | 4              |
| 6         | 4             | PB_RELEASED    |
| 7         | PB_SNOOZE     | -1             |
| 8         | -1            | PB_PRE_PRESSED |

**PB\_GetClicks (tPB pb), PB\_ResetClicks (tPB pb)**

**Equivalence Partitioning**

| Test Case | tPB pb        | Clicks |
|-----------|---------------|--------|
| 1         | PB_VOL_PLUS   | 1      |
| 2         | PB_VOL_MINUS  | 0      |
| 3         | PB_SNOOZE     | 255    |
| 4         | PB_DISP_SLEEP | 200    |
| 5         | 4             | 200    |
| 6         | PB_DISP_SLEEP | -1     |

## LED Module

**LED\_Init(tLED, tLED\_State), LED\_SetState(tLED, tLED\_State),**

**LED\_GetState(tLED, tLED\_State), LED\_On(tLED, tLED\_State),**

**LED\_Off(tLED, tLED\_State), LED\_Toggle(tLED, tLED\_State)**

**Equivalence Partitioning**

| Test Case | tLED           | tLED_State |
|-----------|----------------|------------|
| 1         | LED_ALARM      | LED_ON     |
| 2         | LED_PROCESSING | LED_OFF    |
| 3         | LED_ALARM      | 2          |
| 4         | 2              | LED_ON     |
| 5         | LED_PROCESSING | -1         |
| 6         | -1             | LED_OFF    |

# Timing Analysis Table

## Low Priority (While Loop)

| Task              | BCET    | WCET     |
|-------------------|---------|----------|
| LCD_UpdateDisplay | 1.40 ms | 10.15 ms |

## ISR Loop

| ISR Task         | BCET      | WCET     | Period of Task | Tick no. (tick = 1ms) |
|------------------|-----------|----------|----------------|-----------------------|
| ECG_Update       | 145.17 us | 308.2 us | 4ms            | 1 <sup>st</sup>       |
| PB_Update        | 11.5 us   | 11.78 us | 4ms            | 2 <sup>nd</sup>       |
| BUZ_Update       | 1.46 us   | 2.11 us  | 4ms            | 2 <sup>nd</sup>       |
| ECG_Update_Alarm | 3.91 us   | 4.03 us  | 4ms            | 3 <sup>rd</sup>       |

