Embedded Systems
(CCE407)

Secure Access Control System

using 8051 microcontroller

Report

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1. Project Overview:

This project presents a **dual-microcontroller home system** that demonstrates how different subsystems can operate independently while still maintaining seamless communication via a **serial communication protocol—specifically, I²C (Inter-Integrated Circuit)**.

The system is architected around two 8051-based microcontrollers, each responsible for a distinct function within the home environment:

- **Microcontroller 1** is dedicated to **external access control**, using a 4-digit keypad for password entry, an LCD for user interaction, and sensors for presence detection. It also includes security alerts via a buzzer and status indication through LEDs. Once the password is verified, it initiates communication with the second microcontroller.
- **Microcontroller 2** manages the **internal features** of the home, such as lighting modes and air conditioning. It uses push buttons for control and provides real-time updates on another LCD.

The key innovation of this project lies in the use of **I²C communication to synchronize these two microcontrollers**. I²C allows for simple yet robust **serial communication** using only two lines (SDA and SCL), making it ideal for embedded systems where pin efficiency and communication integrity are critical. In this project, a signal ('S') sent over I²C from Microcontroller 1 acts as a trigger to enable functionalities in Microcontroller 2.

2. I²C Communication in Our Home System:

2.1 Purpose of I²C in the Project

In our home system, we use **two separate microcontrollers**:

- **Microcontroller 1** handles **security and access** using a password.
- **Microcontroller 2** controls **AC and lighting** inside the home.

These two microcontrollers need a way to talk to each other. For this, we used a simple **I²C communication** setup. This allows Microcontroller 1 to tell Microcontroller 2 when someone has entered the correct password, so it can start the control functions.

2.2 How I²C is Set Up

- We used **two wires** for this connection:
  - **SDA (Data)** connected to **P0.6 on both MCUs.**
  - **SCL (Clock)** connected to **P0.7 on both MCUs.**
  - **Pull-up Resistors (10kΩ)** are connected to both SDA and SCL lines to maintain high idle levels.

We implemented the I²C protocol using software (also called "*bit-banging*"), because the 8051 microcontrollers don't have built-in I²C hardware.

2.3 I²C Master (Microcontroller 1)

After someone enters the correct password:

1. The LCD displays "*Open*" then "*Close*".
2. The microcontroller sends the character 'S' over I²C.
3. This 'S' tells Microcontroller 2 to activate mode.
4. The I²C functions used are:
   - *I2C_start ()* – Starts the transmission.
   - *I2C_write('S')* – Sends the character 'S'.
   - *I2C_stop ()* – Ends the transmission.

This is a **very simple use of I²C**, just to send a one-byte message.

2.4 I²C Slave (Microcontroller 2)

Microcontroller 2 keeps checking the I²C lines in a loop:

1. It watches SDA and SCL.
2. If **both go LOW**, it means Microcontroller 1 has started sending data.
3. It understands this as a trigger and:
    - Turns on the home screen on the LCD.
    - Enables the AC and lighting buttons.

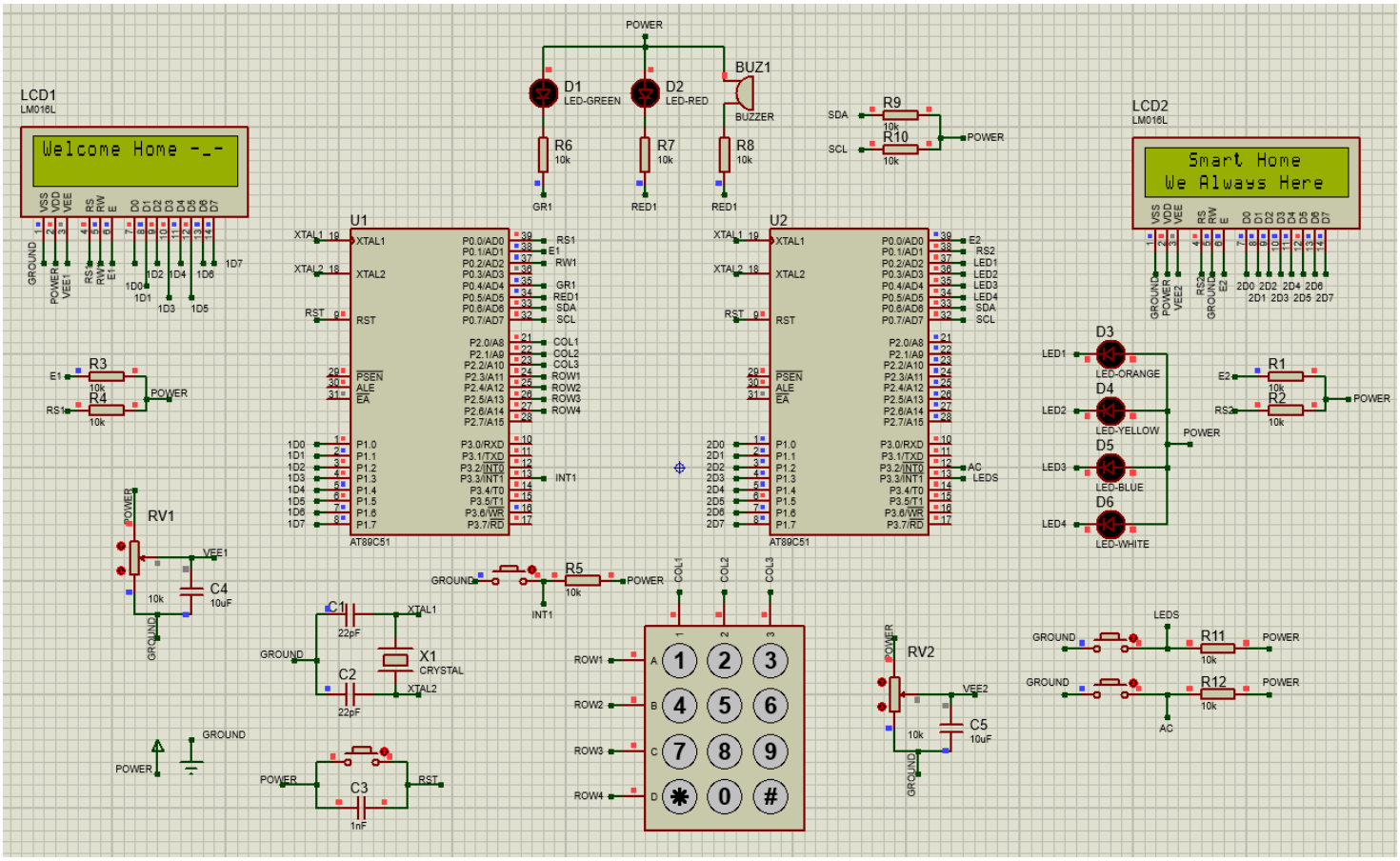
The function used here is:

- *I2C_Slave_Check ()* – Detects if data is coming and activates mode.

2.5 Why I²C is a Good Fit

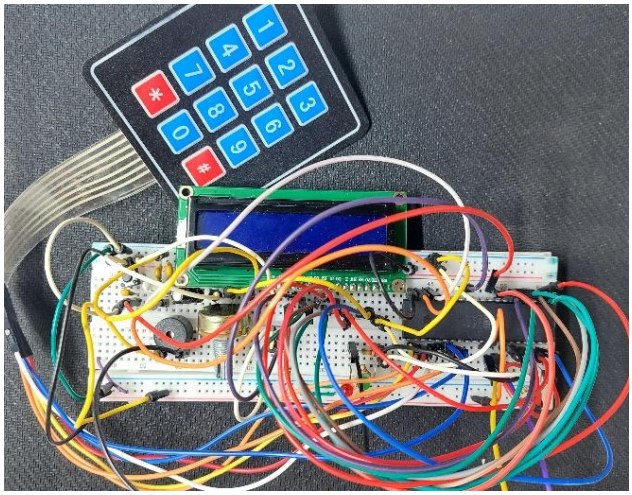
- **Only 2 wires** needed between the microcontrollers.
- Easy to implement in software.
- Allows for **simple, fast, and reliable communication**.
- Can be extended later to send more commands or data if needed.

3. Simulation Circuit Diagram:

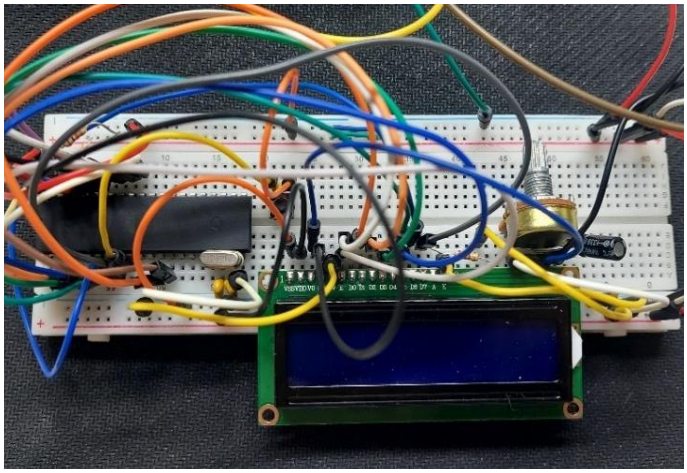


4. Circuit on real life:

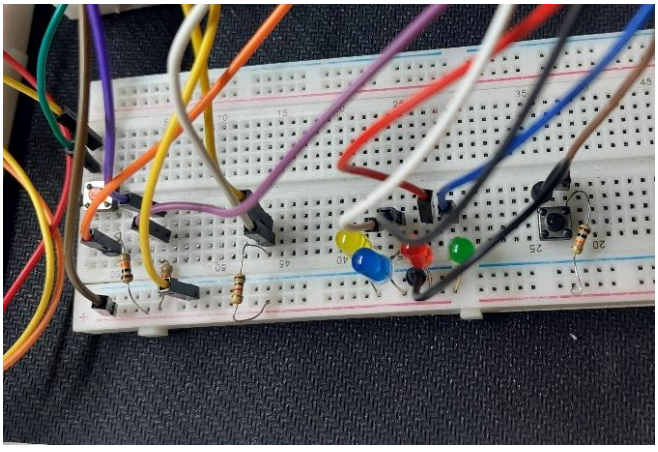
First Microcontroller Breadboard



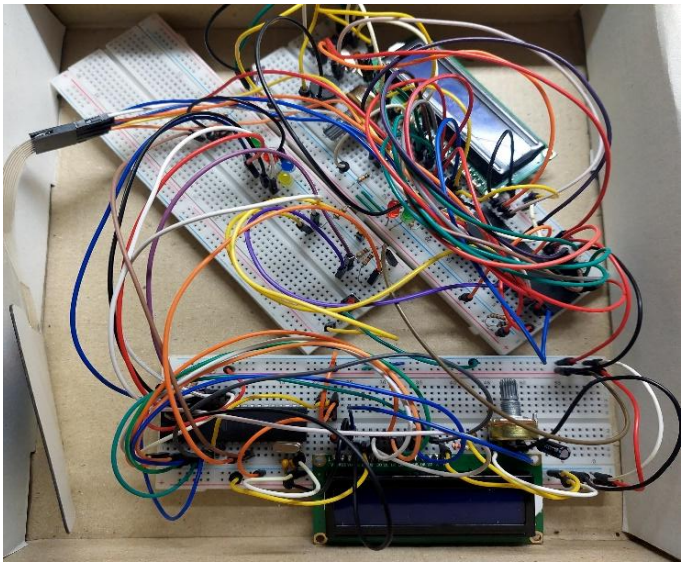
Second Microcontroller Breadboard



Serial Communication Breadboard



The Whole Project Connected



5. Algorithm:

- **Door Unit**

This unit handles password entry, verification, and access indication through LEDs and buzzer, and communication with the Inside Unit via I²C.

1. Initialize system peripherals: LCD, keypad, LEDs, and buzzer.
2. Display "***Welcome Home***" message on the LCD.
3. Wait for the user to enter a 4-digit password via the keypad.
4. Store the entered digits into memory.
5. Compare the entered password with the predefined correct password.
6. If the password is correct:
   - Turn ON the green LED. Display "***Open***" on the LCD. Wait for a short delay.
   - Display "***Close***" on the LCD.
   - **Send a message via I²C** to the Inside Home Unit to notify that access is granted.
   - This triggers the **screen change on the Inside Unit** from **"*Home - We're Always Here*"** to **"*AC State: / LEDs State:*"**.
7. If the password is incorrect:
   - Turn ON the red LED (and buzzer since connected in parallel).
   - Display "**Wrong Pass**" on the LCD.
   - Decrement the internal failed attempts counter.
   - If three consecutive incorrect attempts occur:
     - Display **"Intruder Alert"** on the LCD.
     - **Disable password entry** until reset.
     - Enter **alert mode**:
       - Start alternating **red and green LEDs** (blinking one ON while the other is OFF).
       - The **buzzer remains ON** (in parallel with red LED).
       - Continue this **LED blinking pattern** until the **reset button** is pressed.
     - Once the reset button is pressed:
       - Stop blinking.
       - Turn OFF both LEDs and buzzer.
       - Return to step 2 (await new input).

- **Inside Home Unit**

This unit handles control of room lighting and fan simulation through button inputs and responds to I²C messages from the Door Unit.

1. Initialize system components: LCD, buttons, and room simulation LEDs (White, Blue, Yellow, Orange).
2. Display **"*Home - We're Always Here*"** on the LCD.
3. Continuously check for **I²C message** from the Door Unit.
   If I²C message is received ('*S*'):
   - Change LCD display to **"*AC State: / LEDs State:*"**.
   - Enable user input for lighting and AC control.
4. Continuously monitor the button states:
   - If **Light button** is pressed:
     - Toggle White, Blue, Yellow LEDs.
     - Update LCD to show **"*LEDs State: M1*"** or **"*LEDs State: M2*"** or **"*LEDs State: M5*"** or **"*LEDs State: M4*"**.
   - If **AC button** is pressed:
     - Update LCD to show **"*AC State: ON*"** or **"*AC State: OFF*"**.
5. To reset:
   - A **reset button** to turn OFF devices and return to default display.
6.

6. Code Implementation:

➢ Microcontroller 1: Door Unit

This unit handles secure password entry, feedback via LEDs and buzzer, and communicates door status to the Inside Unit through I²C.

- **Main code**

```
#include <reg51.h>
#include "lcd.h"
#include "keypad.h"
#include "leds.h"
#include "delay.h"
#include "password.h"
#include "function.h"
#include "i2c.h"
#include "button.h"

unsigned char correct_pass_flag = 0;
unsigned char reEnter_pass_flag = 0;

void main() {
    unsigned char i;
    static bit welcome_shown = 0;

    LCD_init();
    I2C_init();
    LED_setRed(LED_OFF);
    LED_setGreen(LED_OFF);

    while (1) {
        if (Button_readStart() == BUTTON_PRESSED) {
            welcome_shown = 0;

            LCD_clear();
            LCD_writeText("Enter Password:");
            LCD_setCursor(1, 0);
            Password_inputFromUser();
            Password_checkCorrect();

            if (correct_pass_flag == 0) {
                LED_setGreen(LED_ON);
                LED_setRed(LED_OFF);
                num_ofCorrect_Password = 3;

                Password_successAction();
                I2C_start();
                I2C_write('S');
                I2C_stop();
                delay_ms(300);
            } else {
                num_ofCorrect_Password--;
                LED_setRed(LED_ON);
                LED_setGreen(LED_OFF);

                while (num_ofCorrect_Password != 0) {
                    LCD_clear();
                    LCD_writeText("WRONG PASS");
                    delay_ms(300);

                    LCD_clear();
                    LCD_writeText("Attempts Left:");
                    LCD_writeChar(num_ofCorrect_Password + '0');
                    delay_ms(300);

                    LCD_clear();
                    LCD_writeText("Enter Password:");
                    LCD_setCursor(1, 0);
                    Password_inputFromUser();
                    Password_checkCorrect();

                    if (correct_pass_flag == 1) {
                        num_ofCorrect_Password--;
                        if (num_ofCorrect_Password == 1) {
                            LED_setRed(LED_ON);
                        }
                        delay_ms(100);
                    } else if (correct_pass_flag == 0) {
                        reEnter_pass_flag = 1;
                        num_ofCorrect_Password = 3;
                        break;
                    }
                }
            }
```

```
            if (reEnter_pass_flag == 1) {
                reEnter_pass_flag = 0;
                LED_setGreen(LED_ON);
                LED_setRed(LED_OFF);

                Password_successAction();
                I2C_start();
                I2C_write('S');
                I2C_stop();
                delay_ms(300);
            }

            if (num_ofCorrect_Password == 0) {
                LCD_clear();
                LCD_writeText("ACCESS DENIED");
                LCD_setCursor(1, 0);
                LCD_writeText("INTRUDER ALERT!");
                delay_ms(1000);


                for (i = 0; i < 6; i++) {
                    if (i % 2 == 0) {
                        LED_setRed(LED_ON);
                        LED_setGreen(LED_OFF);
                    } else {
                        LED_setRed(LED_OFF);
                        LED_setGreen(LED_ON);
                    }
                    delay_ms(300);
                }

                while (1); // System locked; manual reset needed
            }
        } else if (!welcome_shown) {
            LCD_clear();
            LCD_writeText("Welcome Home -_-");
            welcome_shown = 1;
        }
    }
}
```

- **Function code**

```
#ifndef FUNCTION_H
#define FUNCTION_H

// Function Prototypes
void Password_inputFromUser(void);
void Password_checkCorrect(void);

#endif /* FUNCTION_H */
```

```
#include "function.h"
#include "lcd.h"
#include "keypad.h"
#include "delay.h"
#include "password.h"

extern unsigned char correct_pass_flag;

void Password_inputFromUser(void) {
    unsigned char i = 0, key;
    for (i = 0; i < 4; i++) entered_pass[i] = 0;

    i = 0;
    while (1) {
        key = Keypad_getKey();
        if (key == '#') break;

        if (key >= '0' && key <= '9' && i < 4) {
            entered_pass[i] = key;
            LCD_writeChar(entered_pass[i]);
            i++;
        } else if (key == '*' && i > 0) {
            i--;
            entered_pass[i] = 0;
            LCD_setCursor(1, i);
            LCD_writeChar(' ');
            LCD_setCursor(1, i);
        }

        delay_ms(50);
    }

    while (Keypad_getKey() != '#');
}

void Password_checkCorrect(void) {
    unsigned char i;
    correct_pass_flag = 0;
    for (i = 0; i < 4; i++) {
        if (entered_pass[i] != saved_pass[i])
            correct_pass_flag = 1;
    }
}
```

- **Password code**

```h
#ifndef PASSWORD_H
#define PASSWORD_H

// Global Variables (extern)
extern unsigned char saved_pass[5];
extern unsigned char entered_pass[5];
extern unsigned char num_ofCorrect_Password;

// Function Prototypes
void Password_successAction(void);

#endif /* PASSWORD H */
```

```c
#include "password.h"
#include "lcd.h"
#include "leds.h"
#include "delay.h"

// Define real memory for globals
unsigned char saved_pass[5] = {'1', '2', '3', '4', '\0'};
unsigned char entered_pass[5];
unsigned char num_ofCorrect_Password = 3;

void Password_successAction(void) {
    LCD_clear();
    LCD_writeText("Open");
    delay_ms(1000);

    LCD_clear();
    LCD_writeText("Close");
    delay_ms(500);

    LED_setGreen(LED_OFF);
    LCD_clear();
}
```

- **I²C code**

```h
#ifndef I2C_H
#define I2C_H

#include <reg51.h>

sbit SDA = P0^6;
sbit SCL = P0^7;


void I2C_init(void);
void I2C_start(void);
void I2C_stop(void);
void I2C_write(unsigned char byte);
bit I2C_WaitAck(void);


#endif
```

```c
#include "i2c.h"
#include "delay.h"

void I2C_init(void) {
    SDA = 1;
    SCL = 1;
}

void I2C_Start(void) {
    SDA = 1; SCL = 1;
    delay_ms(1);
    SDA = 0;
    delay_ms(1);
    SCL = 0;
}

void I2C_Stop(void) {
    SCL = 0; SDA = 0;
    delay_ms(1);
    SCL = 1;
    SDA = 1;
    delay_ms(1);
}

bit I2C_WaitAck(void) {
    SDA = 1;
    SCL = 1;
    delay_ms(1);
    if (SDA) {
        SCL = 0;
        return 0;
    }
    SCL = 0;
```

```
    return 1;
}
void I2C_Write(unsigned char dat) {
    unsigned char i;
    for (i = 0; i < 8; i++) {
        SDA = (dat & 0x80);
        SCL = 1;
        delay_ms(1);
        SCL = 0;
        dat <<= 1;
    }
    I2C_WaitAck();
}
```

- **Button code**

```
#ifndef BUTTON_H
#define BUTTON_H

#include <reg51.h>

// Define START button pin properly
sbit START_BUTTON_PIN = P3^3;

// Button states
#define BUTTON_PRESSED   1
#define BUTTON_RELEASED  0

// Function Prototype
unsigned char Button_readStart(void);

#endif
```

```
#include "button.h"
#include "delay.h"

unsigned char Button_readStart(void) {
    if (START_BUTTON_PIN == 0) {
        delay_ms(20);
        if (START_BUTTON_PIN == 0) {
            while (START_BUTTON_PIN == 0);
            return BUTTON_PRESSED;
        }
    }
    return BUTTON_RELEASED;
```

- **LEDs code**

```
#ifndef LEDS_H
#define LEDS_H

#include <reg51.h>

// LED Pin Definitions
sbit LED_RED = P0^5;
sbit LED_GREEN = P0^4;

// LED States
#define LED_ON   0
#define LED_OFF  1

// Function Prototypes
void LED_setRed(unsigned char state);
void LED_setGreen(unsigned char state);

#endif /* LEDS_H */
```

```
#include "leds.h"

void LED_setRed(unsigned char state) {
    LED_RED = state;
}

void LED_setGreen(unsigned char state) {
    LED_GREEN = state;
}
```

- **Delay code**

```
#ifndef DELAY_H
#define DELAY_H

void delay_ms(unsigned int ms);

#endif
```

```
#include "delay.h"
#include <reg51.h>

void delay_ms(unsigned int ms) {
    unsigned int i, j;
    for (i = 0; i < ms; i++)
        for (j = 0; j < 1275; j++);
}
```

- **LCD code**

```c
#ifndef LCD_H
#define LCD_H

#include <reg51.h>
#include "delay.h"

// LCD Control Pins using sbit
sbit LCD_RS = P0^0;
sbit LCD_E  = P0^1;
sbit LCD_RW = P0^2;

// LCD Data Port
#define LCD_DATA_PORT P1

// LCD Command Constants
#define LCD_CLEAR_COMMAND               0x01
#define LCD_GO_TO_HOME                  0x02
#define LCD_TWO_LINES_EIGHT_BITS_MODE   0x38
#define LCD_CURSOR_OFF                  0x0C
#define LCD_CURSOR_ON                   0x0E
#define LCD_SET_CURSOR_LOCATION         0x80

// Function Prototypes
void LCD_init(void);
void LCD_sendCommand(unsigned char command);
void LCD_writeChar(unsigned char character);
void LCD_writeText(const char *text);
void LCD_clear(void);
void LCD_setCursor(unsigned char row, unsigned char col);

#endif /* LCD_H */
```

```c
#include <reg51.h>
#include "delay.h"
#include "lcd.h"

void LCD_init(void) {
    LCD_RS = 0;
    LCD_E = 0;
    LCD_RW = 0;
    delay_ms(20);
    LCD_DATA_PORT = 0x00;

    LCD_sendCommand(LCD_TWO_LINES_EIGHT_BITS_MODE);
    LCD_sendCommand(LCD_CURSOR_OFF);
    LCD_sendCommand(LCD_CLEAR_COMMAND);
}

void LCD_sendCommand(unsigned char command) {
    LCD_RS = 0;     // Command mode
    LCD_RW = 0;     // Write mode
    delay_ms(1);
    LCD_E = 1;
    delay_ms(1);
    LCD_DATA_PORT = command;
    delay_ms(1);
    LCD_E = 0;
    delay_ms(1);
}

void LCD_writeChar(unsigned char character) {
    LCD_RS = 1;     // Data mode
    LCD_RW = 0;     // Write mode
    delay_ms(1);
    LCD_E = 1;
    delay_ms(1);
    LCD_DATA_PORT = character;
    delay_ms(1);
    LCD_E = 0;
    delay_ms(1);
}

void LCD_writeText(const char *text) {
    while (*text) {
        LCD_writeChar(*text++);
    }
}

void LCD_clear(void) {
    LCD_sendCommand(LCD_CLEAR_COMMAND);
}

void LCD_setCursor(unsigned char row, unsigned char col) {
    unsigned char memory_address;

    switch (row) {
        case 0: memory_address = col; break;
        case 1: memory_address = col + 0x40; break;
        default: memory_address = col; break;
    }
    LCD_sendCommand(memory_address | LCD_SET_CURSOR_LOCATION);
}
```

- **Keypad code**

```c
#ifndef KEYPAD_H
#define KEYPAD_H

#include <reg51.h>
#include "lcd.h"
#include "delay.h"

/* Define keypad configuration */
#define KEYPAD_NUM_COLS 3
#define KEYPAD_NUM_ROWS 4

/* Define ports for rows and columns */
#define KEYPAD_PORT P2

/* Button states */
#define KEYPAD_BUTTON_PRESSED  0
#define KEYPAD_BUTTON_RELEASED 1
```

```
/* Define pin mappings for rows */
sbit KEYPAD_ROW1 = KEYPAD_PORT^3;
sbit KEYPAD_ROW2 = KEYPAD_PORT^4;
sbit KEYPAD_ROW3 = KEYPAD_PORT^5;
sbit KEYPAD_ROW4 = KEYPAD_PORT^6;

/* Define pin mappings for columns */
sbit KEYPAD_COL1 = KEYPAD_PORT^0;
sbit KEYPAD_COL2 = KEYPAD_PORT^1;
sbit KEYPAD_COL3 = KEYPAD_PORT^2;

/* Function prototype */
unsigned char Keypad_getKey(void);

#endif /* KEYPAD_H */
```

```
#include "keypad.h"

/* Function to get the pressed key */
unsigned char Keypad_getKey(void) {
    while (1) {
        // Set all columns high
        KEYPAD_COL1 = 1;
        KEYPAD_COL2 = 1;
        KEYPAD_COL3 = 1;

        delay_ms(50);

        // Activate each row and scan columns
        KEYPAD_ROW1 = 0; KEYPAD_ROW2 = 1; KEYPAD_ROW3 = 1; KEYPAD_ROW4 = 1;
        if (KEYPAD_COL1 == 0) { delay_ms(50); while (KEYPAD_COL1 == 0); return '1'; }
        if (KEYPAD_COL2 == 0) { delay_ms(50); while (KEYPAD_COL2 == 0); return '2'; }
        if (KEYPAD_COL3 == 0) { delay_ms(50); while (KEYPAD_COL3 == 0); return '3'; }

        KEYPAD_ROW1 = 1; KEYPAD_ROW2 = 0; KEYPAD_ROW3 = 1; KEYPAD_ROW4 = 1;
        if (KEYPAD_COL1 == 0) { delay_ms(50); while (KEYPAD_COL1 == 0); return '4'; }
        if (KEYPAD_COL2 == 0) { delay_ms(50); while (KEYPAD_COL2 == 0); return '5'; }
        if (KEYPAD_COL3 == 0) { delay_ms(50); while (KEYPAD_COL3 == 0); return '6'; }

        KEYPAD_ROW1 = 1; KEYPAD_ROW2 = 1; KEYPAD_ROW3 = 0; KEYPAD_ROW4 = 1;
        if (KEYPAD_COL1 == 0) { delay_ms(50); while (KEYPAD_COL1 == 0); return '7'; }
        if (KEYPAD_COL2 == 0) { delay_ms(50); while (KEYPAD_COL2 == 0); return '8'; }
        if (KEYPAD_COL3 == 0) { delay_ms(50); while (KEYPAD_COL3 == 0); return '9'; }

        KEYPAD_ROW1 = 1; KEYPAD_ROW2 = 1; KEYPAD_ROW3 = 1; KEYPAD_ROW4 = 0;
        if (KEYPAD_COL1 == 0) { delay_ms(50); while (KEYPAD_COL1 == 0); return '*'; }
        if (KEYPAD_COL2 == 0) { delay_ms(50); while (KEYPAD_COL2 == 0); return '0'; }
        if (KEYPAD_COL3 == 0) { delay_ms(50); while (KEYPAD_COL3 == 0); return '#'; }
    }
}
```

➢ Microcontroller 2: Inside Home Unit

- **Main code**

```
#include <reg51.h>
#include "lcd.h"
#include "delay.h"
#include "button.h"
#include "leds.h"
#include "i2c_slave.h"

// Global variables
unsigned char AC_button_count = 0;
unsigned char Light_button_count = 0;
bit smart_mode = 0;

// Function prototypes
void LCD_showSmartFeatures(void);
void LCD_showHomeScreen(void);

void main(void) {
    LCD_init();
    I2C_Slave_Init();

    LED_setWhite(LED_OFF);
    LED_setBlue(LED_OFF);
    LED_setYellow(LED_OFF);
    LED_setOrange(LED_OFF);

    LCD_showHomeScreen();

    while (1) {
        I2C_Slave_Check();  // Check for I2C 'S'

        if (smart_mode) {
            // AC Button Handling
            if (Button_isACPressed() == BUTTON_PRESSED) {
                AC_button_count++;
                if (AC_button_count == 1) {
                    LCD_moveCursor(0, 10);
                    LCD_displayString("ON ");
                } else if (AC_button_count == 2) {
                    AC_button_count = 0;
                    LCD_moveCursor(0, 10);
                      LCD_displayString("OFF");
                  }
              }
```

```
            // Light Button Handling
            if (Button_isLightPressed() == BUTTON_PRESSE
                Light_button_count++;
                if (Light_button_count == 1) {
                    LCD_moveCursor(1, 14);
                    LCD_displayString("M1");
                    LED_setOrange(LED_ON);
                    LED_setYellow(LED_OFF);
                    LED_setBlue(LED_OFF);
                    LED_setWhite(LED_OFF);
                } else if (Light_button_count == 2) {
                    LCD_moveCursor(1, 14);
                    LCD_displayString("M2");
                    LED_setOrange(LED_ON);
                    LED_setYellow(LED_ON);
                    LED_setBlue(LED_OFF);
                    LED_setWhite(LED_OFF);
                } else if (Light_button_count == 3) {
                    LCD_moveCursor(1, 14);
                    LCD_displayString("M3");
                    LED_setOrange(LED_ON);
                    LED_setYellow(LED_ON);
                    LED_setBlue(LED_ON);
                    LED_setWhite(LED_OFF);
                } else if (Light_button_count == 4) {
                    LCD_moveCursor(1, 14);
                    LCD_displayString("M4");
                    LED_setOrange(LED_ON);
                    LED_setYellow(LED_ON);
                    LED_setBlue(LED_ON);
                    LED_setWhite(LED_ON);
                } else if (Light_button_count == 5) {
                    Light_button_count = 0;
                    LCD_moveCursor(1, 13);
                    LCD_displayString("OFF");
                    LED_setOrange(LED_OFF);
                   LED_setYellow(LED_OFF);
                   LED_setBlue(LED_OFF);
                   LED_setWhite(LED_OFF);
                }
            }
        }
    }
}

void LCD_showSmartFeatures(void) {
    LCD_clearScreen();
    LCD_moveCursor(0, 0);
    LCD_displayString("AC Status:   ");
    LCD_moveCursor(1, 0);
    LCD_displayString("Light Status:");
}

void LCD_showHomeScreen(void) {
    LCD_clearScreen();
    LCD_displayString("   Smart Home   ");
    LCD_moveCursor(1, 0);
    LCD_displayString(" We Always Here ");
}
```

- **LCD code**

```
#ifndef LCD_H
#define LCD_H

#include <reg51.h>
#include "delay.h"

// LCD Control Pins
sbit LCD_RS = P0^1;
sbit LCD_En = P0^0;

// LCD Data Port
#define LCD_DATA_PORT P1

// LCD Command Constants
#define LCD_CLEAR_COMMAND               0x01
#define LCD_GO_TO_HOME                  0x02
#define LCD_TWO_LINES_EIGHT_BITS_MODE   0x38
#define LCD_CURSOR_OFF                  0x0C
#define LCD_CURSOR_ON                   0x0E
#define LCD_SET_CURSOR_LOCATION         0x80

// LCD Function Prototypes
void LCD_init(void);
void LCD_sendCommand(unsigned char command);
void LCD_displayCharacter(unsigned char my_data);
void LCD_displayString(const char *Str);
void LCD_clearScreen(void);
void LCD_moveCursor(unsigned char row, unsigned char col);

#endif /* LCD_H */
```

```
#include <reg51.h>
#include "delay.h"
#include "lcd.h"

void LCD_init(void) {
    LCD_RS = 0;
    LCD_E = 0;
    LCD_RW = 0;
    delay_ms(20);
    LCD_DATA_PORT = 0x00;

```

```
    LCD_sendCommand(LCD_TWO_LINES_EIGHT_BITS_MODE);
    LCD_sendCommand(LCD_CURSOR_OFF);
    LCD_sendCommand(LCD_CLEAR_COMMAND);
}

void LCD_sendCommand(unsigned char command) {
    LCD_RS = 0;      // Command mode
    LCD_RW = 0;      // Write mode
    delay_ms(1);
    LCD_E = 1;
    delay_ms(1);
    LCD_DATA_PORT = command;
    delay_ms(1);
    LCD_E = 0;
    delay_ms(1);
}

void LCD_writeChar(unsigned char character) {
    LCD_RS = 1;      // Data mode
    LCD_RW = 0;      // Write mode
    delay_ms(1);
    LCD_E = 1;
    delay_ms(1);
    LCD_DATA_PORT = character;
    delay_ms(1);
    LCD_E = 0;
    delay_ms(1);
}

void LCD_writeText(const char *text) {
    while (*text) {
        LCD_writeChar(*text++);
    }
}

void LCD_clear(void) {
    LCD_sendCommand(LCD_CLEAR_COMMAND);
}

void LCD_setCursor(unsigned char row, unsigned char col) {
    unsigned char memory_address;

    switch (row) {
        case 0: memory_address = col; break;
        case 1: memory_address = col + 0x40; break;
        default: memory_address = col; break;
    }
    LCD_sendCommand(memory_address | LCD_SET_CURSOR_LOCATION);
}
```

- **LEDS code**

```
#ifndef LEDS_H
#define LEDS_H

#include <reg51.h>

// LED Pin Definitions
sbit LED_WHITE  = P0^5;
sbit LED_BLUE   = P0^4;
sbit LED_YELLOW = P0^3;
sbit LED_ORANGE = P0^2;

// LED States
#define LED_ON   0
#define LED_OFF  1

// Function Prototypes
void LED_setWhite(unsigned char status);
void LED_setBlue(unsigned char status);
void LED_setYellow(unsigned char status);
void LED_setOrange(unsigned char status);

#endif /* LEDS_H */
```

```
#include "leds.h"

void LED_setWhite(unsigned char status) {
    LED_WHITE = status;
}

void LED_setBlue(unsigned char status) {
    LED_BLUE = status;
}

void LED_setYellow(unsigned char status) {
    LED_YELLOW = status;
}

void LED_setOrange(unsigned char status) {
    LED_ORANGE = status;
}
```

- **BUTTON code**

```c
#include "button.h"
#include "delay.h"

unsigned char Button_isACPressed(void) {
    if (AC_button == BUTTON_PRESSED) {
        delay_ms(20);  // debounce delay
        if (AC_button == BUTTON_PRESSED) {
            while (AC_button == BUTTON_PRESSED); //
            return BUTTON_PRESSED;
        }
    }
    return BUTTON_RELEASED;
}

unsigned char Button_isLightPressed(void) {
    if (Light_button == BUTTON_PRESSED) {
        delay_ms(20);  // debounce delay
        if (Light_button == BUTTON_PRESSED) {
            while (Light_button == BUTTON_PRESSED);
            return BUTTON_PRESSED;
        }
    }
    return BUTTON_RELEASED;
}
```

```c
#ifndef BUTTON_H
#define BUTTON_H

#include <reg51.h>

// Define Button Pins
sbit AC_button = P3^2;
sbit Light_button = P3^3;

// Define Button States
#define BUTTON_PRESSED  0
#define BUTTON_RELEASED 1

// Function Prototypes
unsigned char Button_isACPressed(void);
unsigned char Button_isLightPressed(void);

#endif /* BUTTON_H */
```

- **I²C code**

```c
#ifndef I2C_SLAVE_H
#define I2C_SLAVE_H

void I2C_Slave_Init(void);
void I2C_Slave_Check(void);

#endif /* I2C_SLAVE_H */
```

```c
#include <reg51.h>
#include "i2c_slave.h"

sbit SDA = P0^6;
sbit SCL = P0^7;

extern bit smart_mode;
void LCD_showSmartFeatures(void);

void I2C_Slave_Init(void) {
    SDA = 1;
    SCL = 1;
}

void I2C_Slave_Check(void) {
    if (!SCL && !SDA) {
        smart_mode = 1;
        LCD_showSmartFeatures();
    }
}
```