



# Standard Embedded Diploma - Final Project

## **Project Title:**

Dual Microcontroller-Based Door Locker Security System Using Password Authentication

## **Objective:**

The objective of this project is to develop a secure and efficient smart door control system. It uses two microcontrollers, HMI\_ECU and Control\_ECU, which communicate via UART. The system implements password authentication, stores data in external EEPROM, and integrates additional components such as a PIR sensor, H-bridge motor control, and a buzzer for enhanced functionality.

## **Project Overview:**

This smart door control system is designed with two microcontrollers, one acting as the Human-Machine Interface (HMI\_ECU) and the other as the Control Unit (Control\_ECU). Users interact with the system using an LCD and keypad to enter passwords, which are verified and stored using external EEPROM. The door is controlled by an H-bridge circuit connected to a motor, and the system includes a PIR sensor for motion detection, a buzzer for alarms, and password-protected access to system options like door unlocking and password changing.

## **Features:**

1. **Password Protection:** Users can set and verify a password stored in external EEPROM.
2. **LCD and Keypad Interface:** Allows easy interaction for entering and managing passwords.
3. **UART Communication:** HMI\_ECU sends and receives data to and from Control\_ECU via UART.
4. **EEPROM Storage:** Passwords and system data are stored securely in an external EEPROM.
5. **Motorized Door Control:** The door is unlocked/locked using a motor driven by an H-bridge.
6. **Buzzer Alert:** The buzzer is activated for failed password attempts and system alerts.
7. **PIR Motion Sensor:** Detects motion to trigger door operations.
8. **Password Change Option:** Users can change the password after verification.
9. **Security Lock:** System locks for one minute if the password is entered incorrectly three times consecutively.

## Hardware Components:

- **HMI\_ECU Connections:**

1. **LCD (8-bit mode)**

- **RS** pin connected to **PC0**
- **E (Enable)** pin connected to **PC1**
- **Data Pins (D0-D7)** connected to **Port A** (PA0 to PA7)

2. **Keypad (4x4)**

- **Rows** connected to: **PB0, PB1, PB2, PB3**
- **Columns** connected to: **PB4, PB5 ,PB6 ,PB7**

3. **UART Communication**

- **TXD (Transmit Data)** pin connected to **RXD** of Control\_ECU.
- **RXD (Receive Data)** pin connected to **TXD** of Control\_ECU.

- **Control\_ECU Connections:**

1. **External EEPROM (I2C Communication)**

- **SCL** (Serial Clock Line) connected to **PC0**
- **SDA** (Serial Data Line) connected to **PC1**

2. **Buzzer**

- Connected to **PC7**

3. **H-bridge Motor Driver**

- **Input 1** connected to **PD6**
- **Input 2** connected to **PD7**
- **Enable1:** PB3/OC0

4. **Motor (for Door Control)**

- Connected to the H-bridge motor driver.

5. **PIR Motion Sensor**

- Connected to **PC2**

## Operation Steps

### Step1 – Create a System Password

- The LCD should display “Please Enter Password” like that:



- Enter a password consists of 5 numbers, Display \* in the screen for each number.



- Press **enter** button (choose any button in the keypad as enter button).
- Ask the user to re-enter the same password for confirmation by display this message “Please re-enter the same Pass”:



- Enter a password consists of 5 numbers, Display \* in the screen for each number.
- Press **enter** button (choose any button in the keypad as enter button).



- **HMI\_ECU** should send the two passwords to the **Control\_ECU** through the **UART**.
- If the two passwords are **matched** then the system has a password now and save it inside the **EEPROM** and go to **Step 2**.
- If the two passwords are **unmatched** then repeat **step 1** again.

### Step2 - Main Options

- The LCD will always display the main system option:

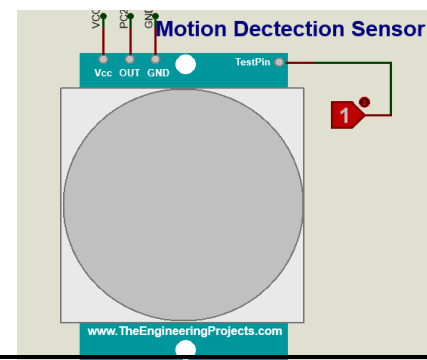
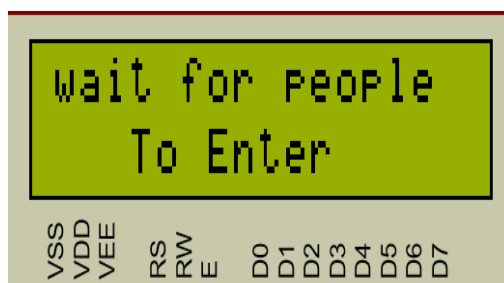


### Step3 - Open Door +

- The LCD should display "Please Enter Password" like that:



- Enter the password then press **enter** button (choose any button in the keypad as enter button).
- **HMI\_ECU** should send the Password to the **Control\_ECU** and it should compare it with the one saved in the **EEPROM**.
- if two passwords are **matched**:
  - **rotates** motor for 15-seconds **CW** and display a message on the screen "Door is Unlocking"
  - hold the motor as the PIR sensor Detected Their Motion and Display "Wait for people to Enter".



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- **rotates** motor for 15-seconds **A-CW** and display a message on the screen “Door is Locking” when the PIR is No longer Detect Motion

#### Step 4 - Change Password -

- The LCD should display “Please Enter Password” like that:



- Enter the password then press **enter** button (choose any button in the keypad as enter button).
- **HMI\_ECU** should send the Password to the **Control\_ECU** and it should compare it with the one saved in the **EEPROM**.
  - if two passwords are matched then repeat Step 1.

#### Step 5

- if the two passwords are **unmatched** at step 3 (+ : Open Door) or step 4 (- : Change Password)
- Ask the user one more time for the password.
- The LCD should display “Please Enter Password” like that:

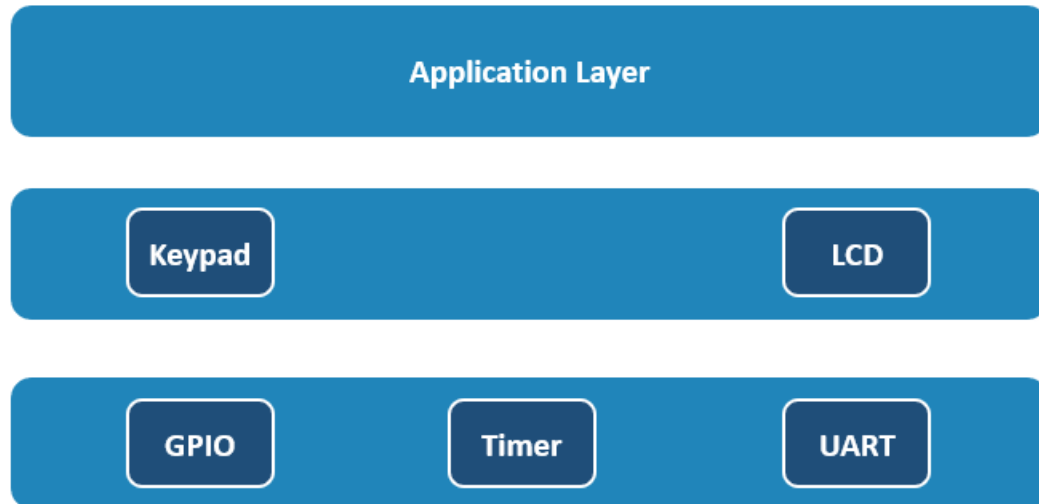


- Enter the password then press **enter** button (choose any button in the keypad as enter button).
- **HMI\_ECU** should send the password to the **Control\_ECU** and it should compare it with the one saved in the **EEPROM**.
- if two passwords are matched then open the door or change the password in steps 3 and 4.
- If the two passwords are **not matched** again then ask the user **one last time** for the password.

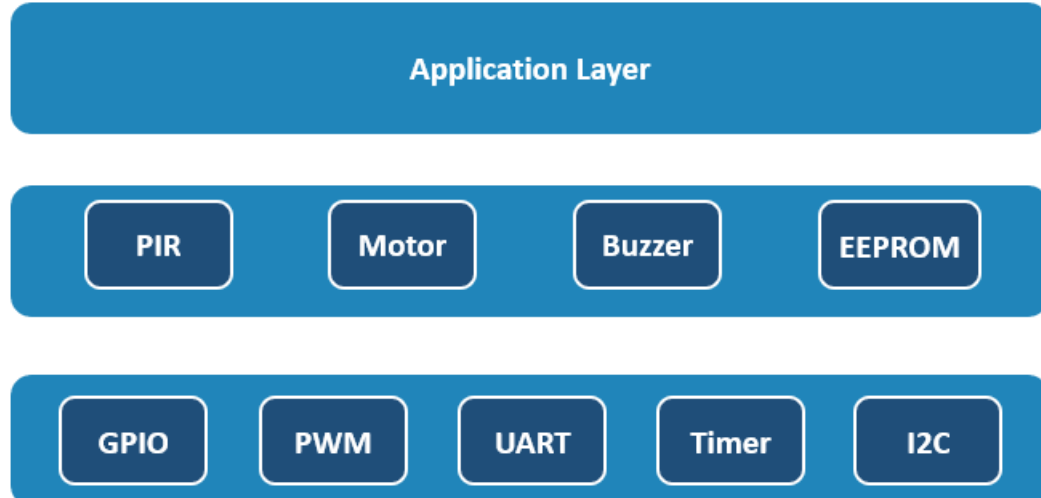
- if two passwords are matched then open the door or change the password in steps 3 and 4.
- If the two passwords are not matched for the third consecutive time, then:
  - Activate Buzzer for 1-minute.
  - Display error message on LCD for 1 minute.
  - System should be locked no inputs from Keypad will be accepted during this time period.
  - Go to Step 2 the main options again

## System Requirements:

1. **System Frequency:** 8 MHz
2. **Microcontroller:** ATmega32.
3. **The Project should be implemented using the below layered model architecture:**
  - a. **The HMI\_ECU**



- b. **The Control\_ECU**





## Drivers Requirements:

### GPIO Driver Requirements

- Use the Same GPIO driver implemented in the course.
- Same driver should be used in the two ECUs.

### UART Driver Requirements

- Use the Same UART driver implemented in the course.
- Same driver should be used in the two ECUs.
- You need to modify the **UART\_init** function implemented in the UART session to take a Pointer to the configuration structure with type **UART\_ConfigType**.
- The function declaration should be:

**void UART\_init(const UART\_ConfigType \* Config\_Ptr)**

- The **UART\_ConfigType** structure should be declared like that:

```
typedef struct {  
    UART_BitDataType bit_data;  
    UART_ParityType parity;  
    UART_StopBitType stop-bit;  
    UART_BaudRateType baud-rate;  
}UART_ConfigType;
```

Note: The **UART\_BitDateType** ,**UART\_ParityType** , **UART\_StopBitType** , and **UART\_BaudRateType** are types defined as uint8/uint16/uint32 or enum

### LCD Driver Requirements

- Use a 2x16 LCD.
- Use the Same LCD driver implemented in the course with 8-bits data mode.
- Connect the LCD control and data bus pins as mentioned in Hardware Component
- LCD should be connected to the HMI\_ECU.

### Keypad Driver Requirements

- Use a 4x4 Keypad.
- Connect the Keypad as mentioned in Hardware Component
- Keypad should be connected to the HMI\_ECU.

## I2C Driver Requirements

- Use the Same I2C driver implemented in the course.
- I2C driver will be used in the **CONTROL\_ECU** to communicate with the external EEPROM
- You need to modify the **TWI\_init** function implemented in the I2C session to take a pointer to the configuration structure with type **TWI\_ConfigType**.
- The function declaration should be:

**void TWI\_init(const TWI\_ConfigType \* Config\_Ptr)**

- The **TWI\_ConfigType** structure should be declared like that:

```
typedef struct {  
    TWI_AddressType address;  
    TWI_BaudRateType bit_rate;  
}TWI_ConfigType;
```

Note: The **TWI\_AddressType** and **TWI\_BaudRateType** are types defined as uint8/uint16/uint32 or enum.

## PWM Driver Requirements

The driver uses **Timer0** in **PWM mode** and operates as follows:

### PWM Function:

- **void PWM\_Timer0\_Start(uint8 duty\_cycle)**
  - Initializes Timer0 in PWM mode and sets the required duty cycle.
  - Prescaler:  $F_{CPU}/64$
  - Non-inverting mode
  - The function configures OCO as the output pin.
  - **Parameters:**
    - **duty\_cycle:** Percentage (0 to 100%) representing the PWM duty cycle

## Timer Driver Requirements

- Same driver should be used in the two ECUs.
- In the **HMI\_ECU** to count the displaying messages time on the LCD while opening/closing the door. In the **CONTROL\_ECU** to count the time for controlling the motor.
- Implement a full Timer driver for TIMER0, TIMER1, TIMER2 with the dynamic configuration technique.
- The Timer Driver should be designed using the Interrupts with the callback's technique.

- The Timer Driver should support both normal and compare modes and it should be configured through the configuration structure passed to its initialization function.
- The Timer Driver has **3 functions and Six ISR's** for Normal and Compare interrupts:
  - **void Timer\_init(const Timer\_ConfigType \* Config\_Ptr)**
    - Description: Function to initialize the Timer driver
    - Inputs: pointer to the configuration structure with type Timer\_ConfigType.
    - Return: None
  - **void Timer\_delInit(Timer\_ID\_Type timer\_type);**
    - Description: Function to disable the Timer via Timer\_ID.
    - Inputs: Timer\_ID
    - Return: None
  - **void Timer\_setCallBack(void(\*a\_ptr)(void), Timer\_ID\_Type a\_timer\_ID );**
    - Description: Function to set the Call Back function address to the required Timer.
    - Inputs: pointer to Call Back function and Timer Id you want to set The Callback to it.
    - Return: None
- The **Timer\_ConfigType** structure should be declared like that:

**typedef struct**

```
{
    uint16 timer_InitialValue;
    uint16 timer_compare_MatchValue;  /*it will be used in compare mode only*/
    Timer_ID_Type timer_ID;
    Timer_ClockType timer_clock;
    Timer_ModeType timer_mode;
}Timer_ConfigType;
```

Note: The **Timer\_ID\_Type**, **Timer\_ClockType** and **Timer\_ModeType** are types defined as uint8/uint16/uint32 or enum.

### Buzzer Driver Requirements

- Use the Same Buzzer driver implemented in the previous projects.
- The Buzzer should be Connected to the **Control\_ECU**.

### PIR Driver Requirements

- Use a PIR sensor to detect motion near the door. When the sensor detects movement, it will keep the door held open.
- PIR is connected to **CONTROL\_ECU**
- The PIR Driver contain Two functions as following
  - **void PIR\_init(void)**
    - Description: Function to initialize the PIR driver
    - Inputs: None
    - Return: None
  - **uint8 PIR\_getState(void);**
    - Description: Function to return PIR State
    - Inputs: None
    - Return: uint8

### DC\_Motor Driver Requirements

- Use the Same **DC\_Motor** driver implemented in the Smart Home Project.
- Motor should always run with the maximum speed using **Timer0 PWM**.
- Motor should be connected to the **CONTROL\_ECU**.
- Connect the Motor pins mentioned in Hardware Component

### EEPROM Driver Requirements

- Use the Same **external EEPROM** driver controller by the I2C.
- EEPROM should be connected to the **CONTROL\_ECU**

**Video Reference:**

<https://youtu.be/X5EwIRfGAAY>

**How to add PIR sensor library to proteus:**

<https://youtu.be/bhT90bM-Vdw>

**PIR sensor library download link:**

[https://www.mediafire.com/file/vjffcf868ea2fbi/PIR\\_Sensor\\_lib.zip/file](https://www.mediafire.com/file/vjffcf868ea2fbi/PIR_Sensor_lib.zip/file)

**Thank You  
Edges For Training Team**