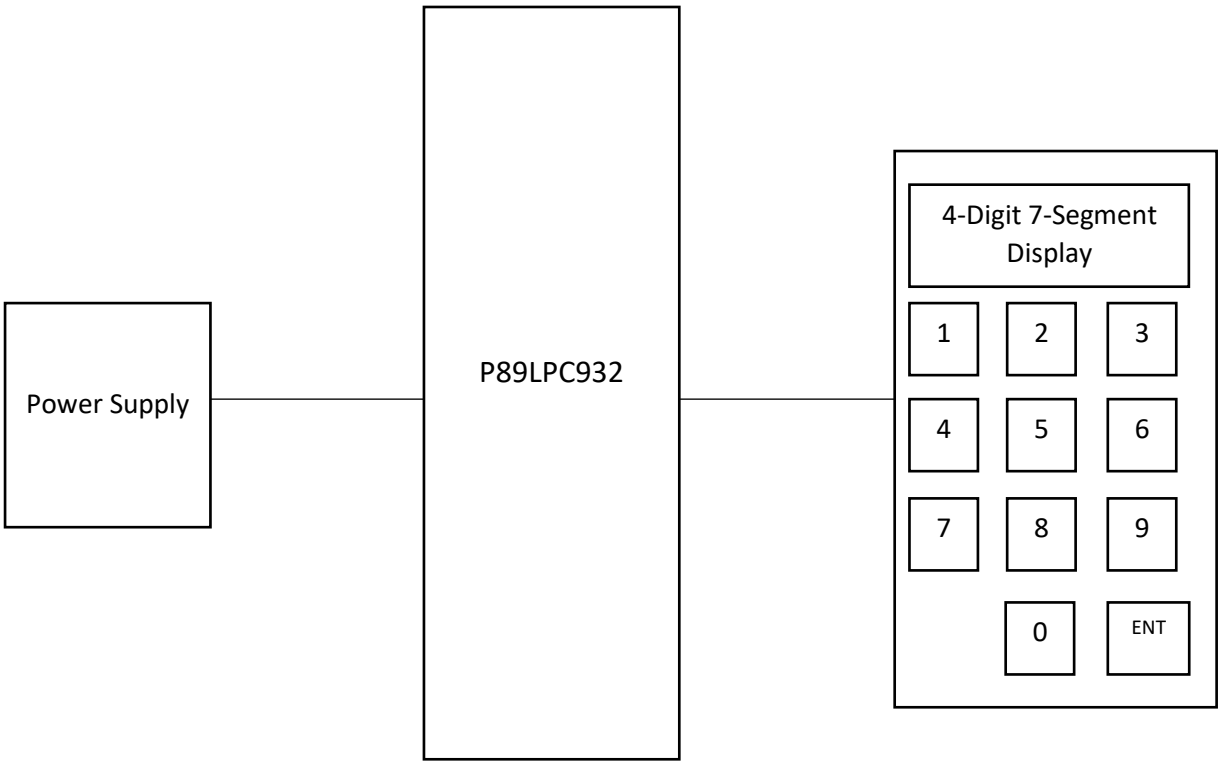
Microcontroller Design Project



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Chapter 1) Introduction:

1. Aim:

Design a password-based door lock system.

2. Introduction:

A micro-controller is a simple computer processor, which acts similar to a computer as it has some common features:

1) Contains CPU (Central Processing Unit)
2) Contains different types of Memory: RAM (Random Access Memory) and ROM (Read-Only Memory) but there are different types of ROM like EPROM (Erasable Programmable Read-Only Memory) and EEPROM (Electrically Erasable Programmable Read-Only Memory)
3) Contains I/O ports (Input / Output ports)

The difference between a micro-controller and a computer is that the micro-controller is only used for one task and the computer can do multiple tasks at the same time. Micro-controller when it's placed inside a product it becomes an embedded micro-controller, when the micro-controller is embedded inside a device; it is programmed to execute a task that the product should do. The micro-controller basically is placed at the centre of the system where it captures the input from the system and the output is controlled by the micro-controller which could be either analogue or digital and it is surrounded by passive circuit components like transistors, capacitors, inductors and resistors. Moreover, micro-controllers have a couple of advantages that make them more desirable:

1) Small and low cost
2) Requires low power

So having a micro-controller as small as possible helps where it can be used as a handheld device like handheld fuel gauges and handheld oscilloscope etc. Making a device that contains an embedded micro-controller as low cost as possible helps in increasing production.

3. Specification:

The aim is to design a password-based door lock system using an 80C51 8-bit microcontroller. So, the system has to be equipped with a keypad where the user can enter an 8-digit password code and a 4-digit numeric display. The keypad should commonly contain numbers from 0 to 9 and have a button that acts as an enter key. When the enter

button is pressed and the code entered is correct, then the relay should operate and activate the electrical lock.

The structure of the system consists of these components:

1) 80C51 8-bit microcontroller [P89LPC935FDH, 518]
2) 4-digit 7 segment LED display
3) Keypad
4) PSU (Power Supply Unit)
5) Relay

Figure 1 displays the block diagram of the system:

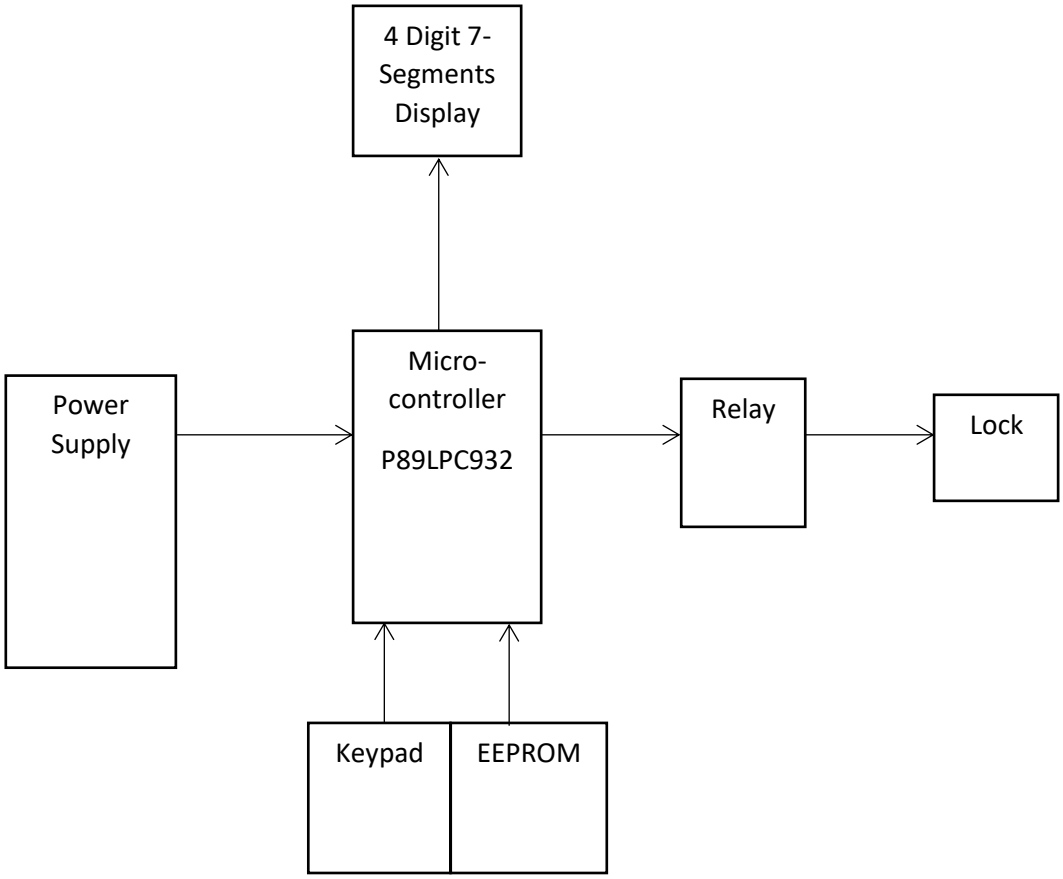

Figure 1: Block diagram of the password-based door lock system

Furthermore, at the beginning of the system, it has to display the message ‘SHUT’ and when the user enters the code it displays the last 4 digits entered; in addition to that if a key was not pressed then the system waits for 30 seconds and if there was no key pressed then it should go back and display ‘SHUT’. Meanwhile, when ‘ENT’ is pressed and the code is invalid, then it displays ‘SHUT’ or if the code is correct then it displays ‘OPEN’. If the user

attempted to enter the code three times, then it should display ‘BAR’ and the user will be prevented from entering any code for 2 minutes, after which it will be enabled again.

4. Requirements:

When the micro-controller is turned on, it should wait for the user to enter a valid code before the beginning of the program. So, the system should:

1) Remember the code during power failure
2) Have a backup power system that operates for 30 minutes during a power shortage
3) Powered by the mains
4) Doesn’t consume more than 75mW from mains
5) Withstand different environments within the UK
6) Simple for anyone to understand how it works
7) Interacts most efficiently and safely

Chapter 2) Hardware Design:

After looking into the specification and requirements for the project, a design for the system was finalized as shown in the next section.

1. Main Circuit Diagram:

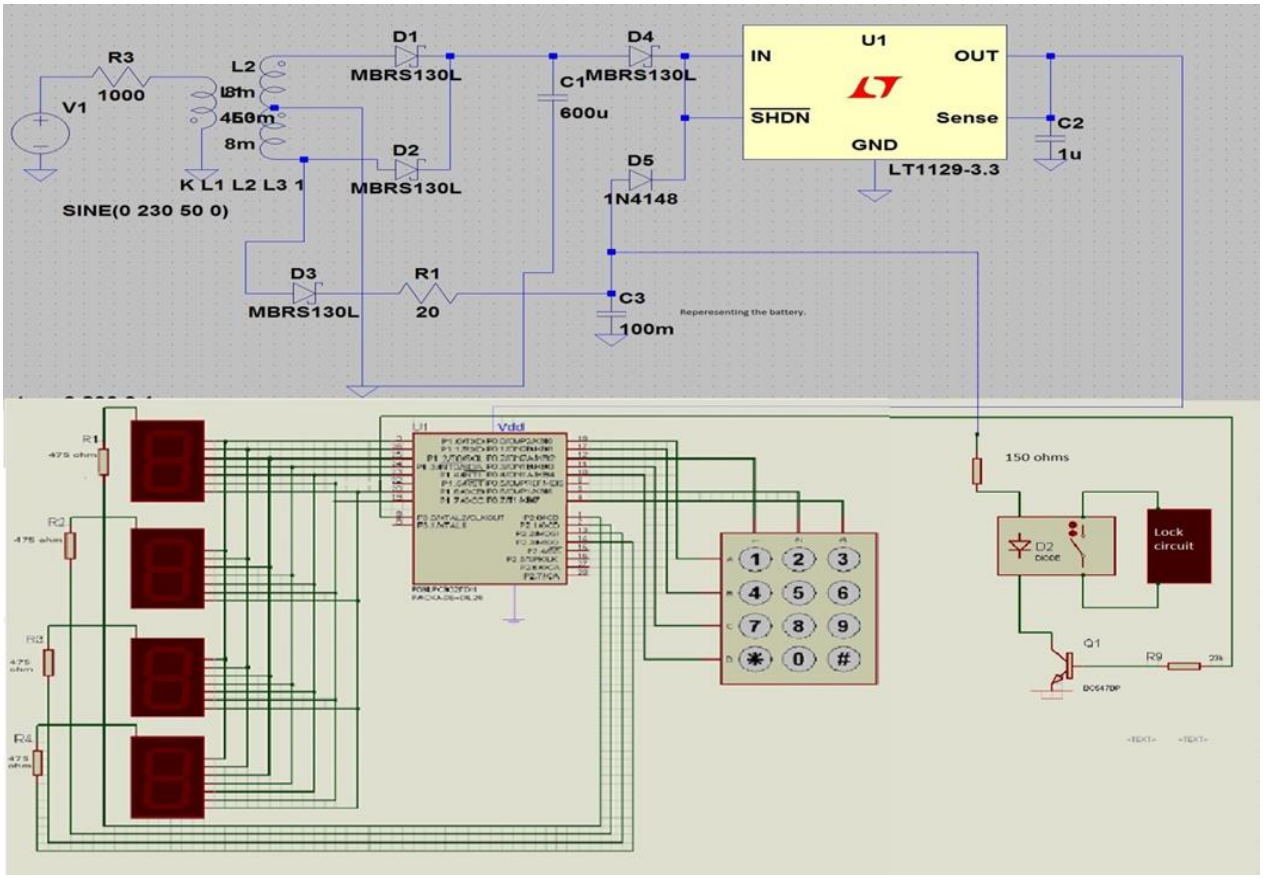

Figure 2: Diagram of the Main Circuit

2. Micro-Controller:

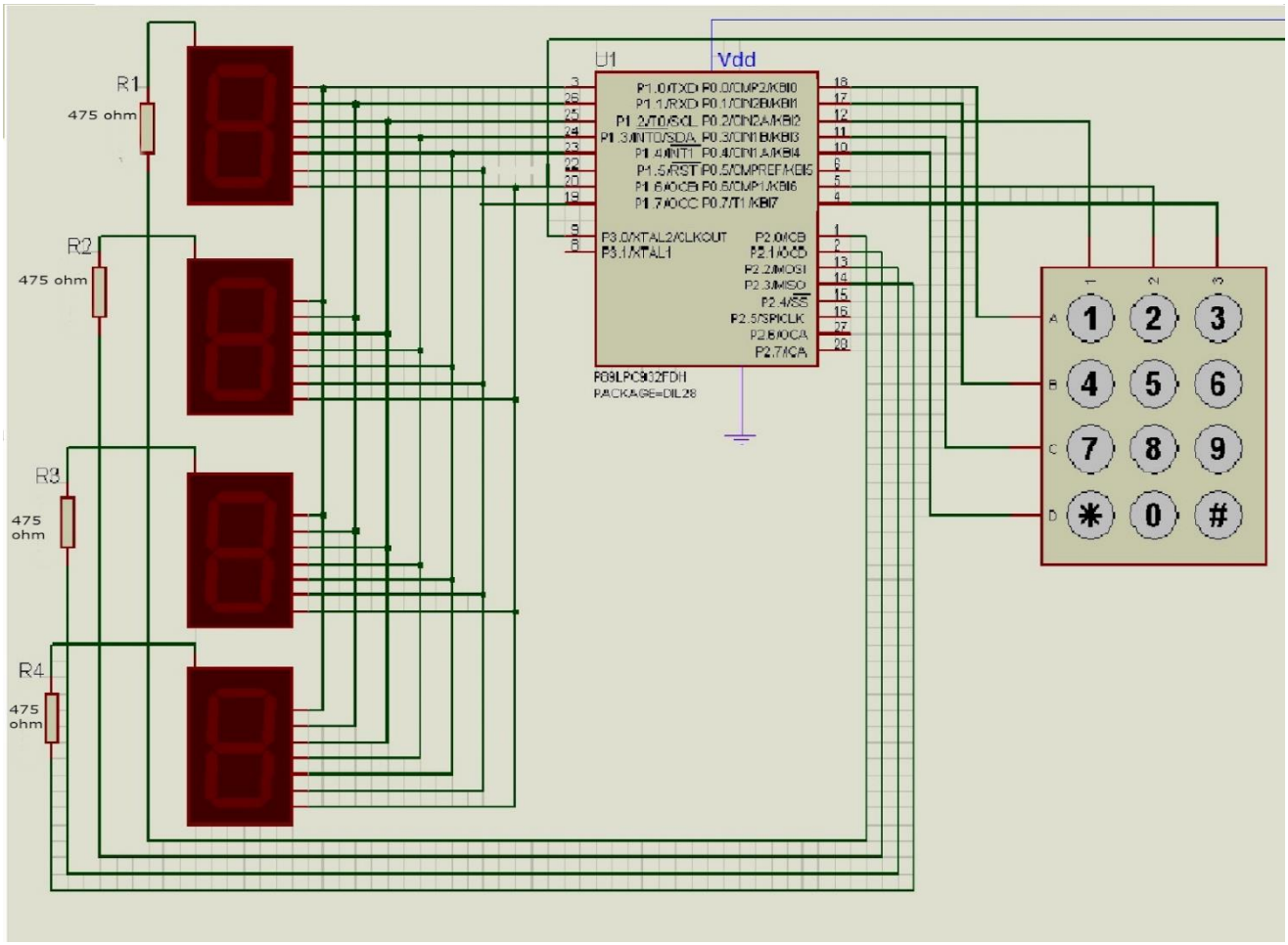

Figure 3: Diagram of micro-Controller with keypad

3. Circuit Diagram Explanation:

The main part of the circuit diagram (Figure 2 and Figure 3) mentioned above is the micro-controller P89LPC932. The keypad act as an input device and the connections in the keypad are connected in a matrix which helps in reducing the number of ports needed to be connected to the micro-controller. The keypad is connected to port 0 in the micro-controller, port 0's mode is a quasi bi-directional mode. The quasi bi-directional mode can be used both as an input or output without the need to reconfigure the port. This helps because when the output gives out a high, it's causing the pin to be weakly driven whereas with the help of an external device (which is the keypad) it pulls down the pin to low. Therefore, when the pin reads a low, it indicates that a button has been pressed. Therefore, the micro-controller cycles one of the outputs as high and reads the input. If one of them is low, then it shows that one of the buttons had been pressed. The micro-controller reads the 8-digit password through the keypad and compares it with the password that is stored in the on-chip data EEPROM of the micro-controller and if the password is correct, it displays 'OPEN' and it turns on the relay to unlock the door, but if the password is incorrect, it displays 'SHUT' and

it doesn't allow the user to enter the password for a certain amount of time. If this occurs twice, the display shows 'BAR' and a user can't enter the code for 2 minutes. The password is pre-programmed and stored in the EEPROM; this is the advantage of using EEPROM where the user can change the password. For the user to change the password, enter a valid password and press the '*' key to change the password. The LEDs are connected to the micro-controller and acts as the output device that displays the password and messages. Some calculations were done to find the resistor to be used,

$$V_{supply} = 3.5V, V_{in} = 3.5 - V_{pin} = 3.5 - 0.7 = 2.8V$$

$$V_{diode} = 1.85V, V_{resistor} = V_{in} - V_{diode} = 2.8 - 1.85 = 0.95V$$

$$I = 2mA, \therefore V = I(R) \Longrightarrow R = \frac{V}{I} = \frac{0.95}{(2E-3)} = 475\ \Omega$$

As shown in the diagram of the micro-controller the LEDs are the common cathode and connected back to the micro-controller due to the reason that the current coming is 2mA; so it's quite low that it cannot damage the micro-controller and could be sinking from the micro-controller to the ground. The current that passes through the LEDs is enough to show the characters in the display as the LEDs are super red; with 2mA it gives out 600 µcandela which is visible during the day. In the initial design, there was an idea of using the transistors to toggle between the LEDs, in the end, the transistors were disregarded as changing the LEDs could be done in the software. Therefore, this helps in reducing the cost of the product.

4. Components needed in Hardware Design:

Table 1: Prices and list of the components used in the hardware design

	Component	Quantity	Cost	Total Cost
Microcontroller	P89LPC935FDH,518	1	1.1400	£1.14
UI	Keypad	1	22.7400	£22.74
	4-digit 7 Segment Display	1	1.3000	£1.30
Resistors (ohms)	475Ω	4	0.0183	0.08
			Total:	£29.93

As shown on the table the keypad costs a lot as it is made of a high impact polymer and water/dust resistant material that operates from $-25^{o}C$ to $85^{o}C$ and has a lifetime duration of 4 million cycles (≈10+ years). The design is simple and the cost reasonable (total cost = £29.93). As the cost is economical then this helps in increasing the mass production of the product.

Chapter 3) Software Design:

1. Flowchart:

Here is the flowchart diagram of how the main system was setup:

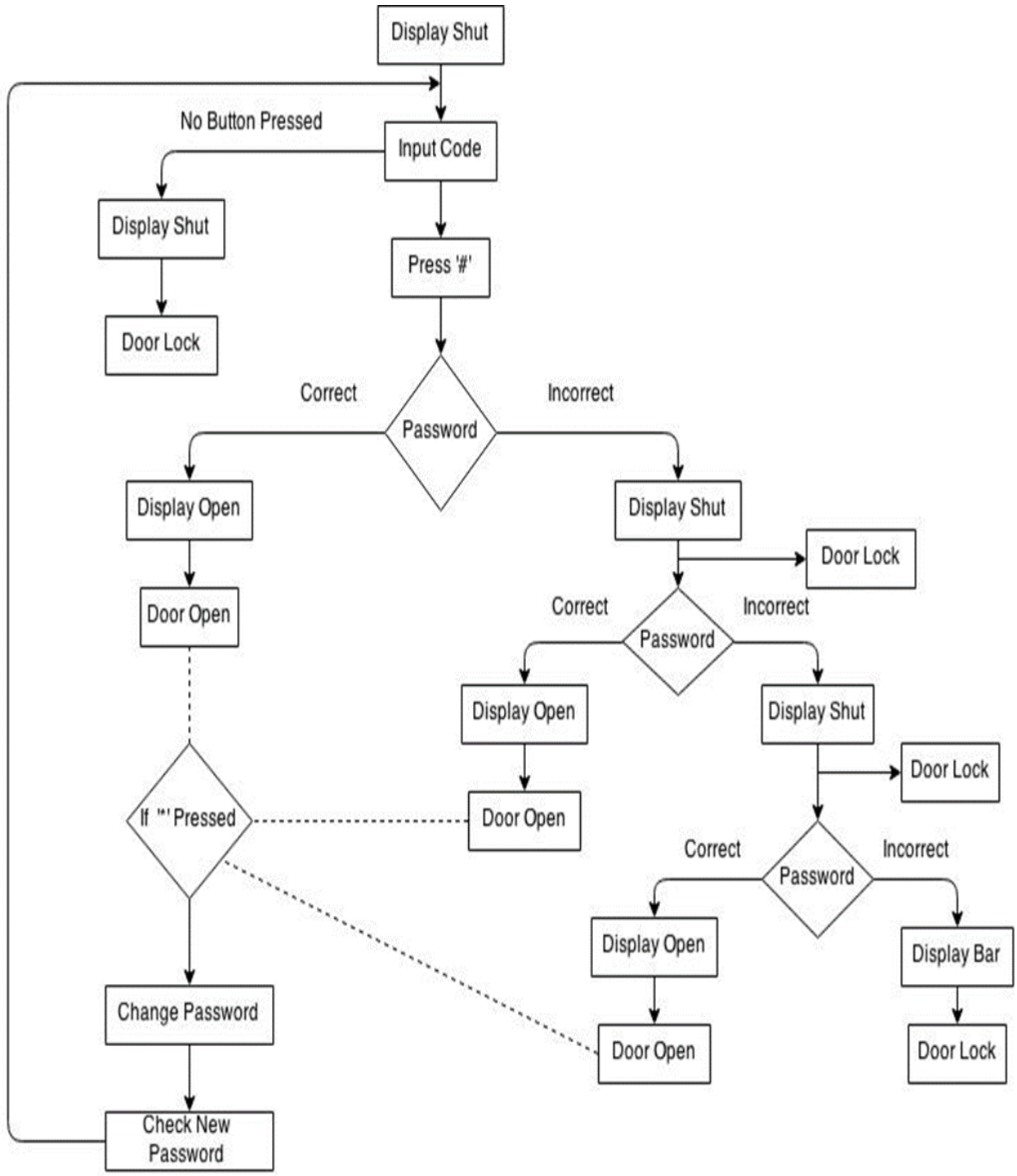

Figure 4: Flowchart diagram of the main system

2. Password design:

Here is the flowchart diagram of how the coding for password was setup:

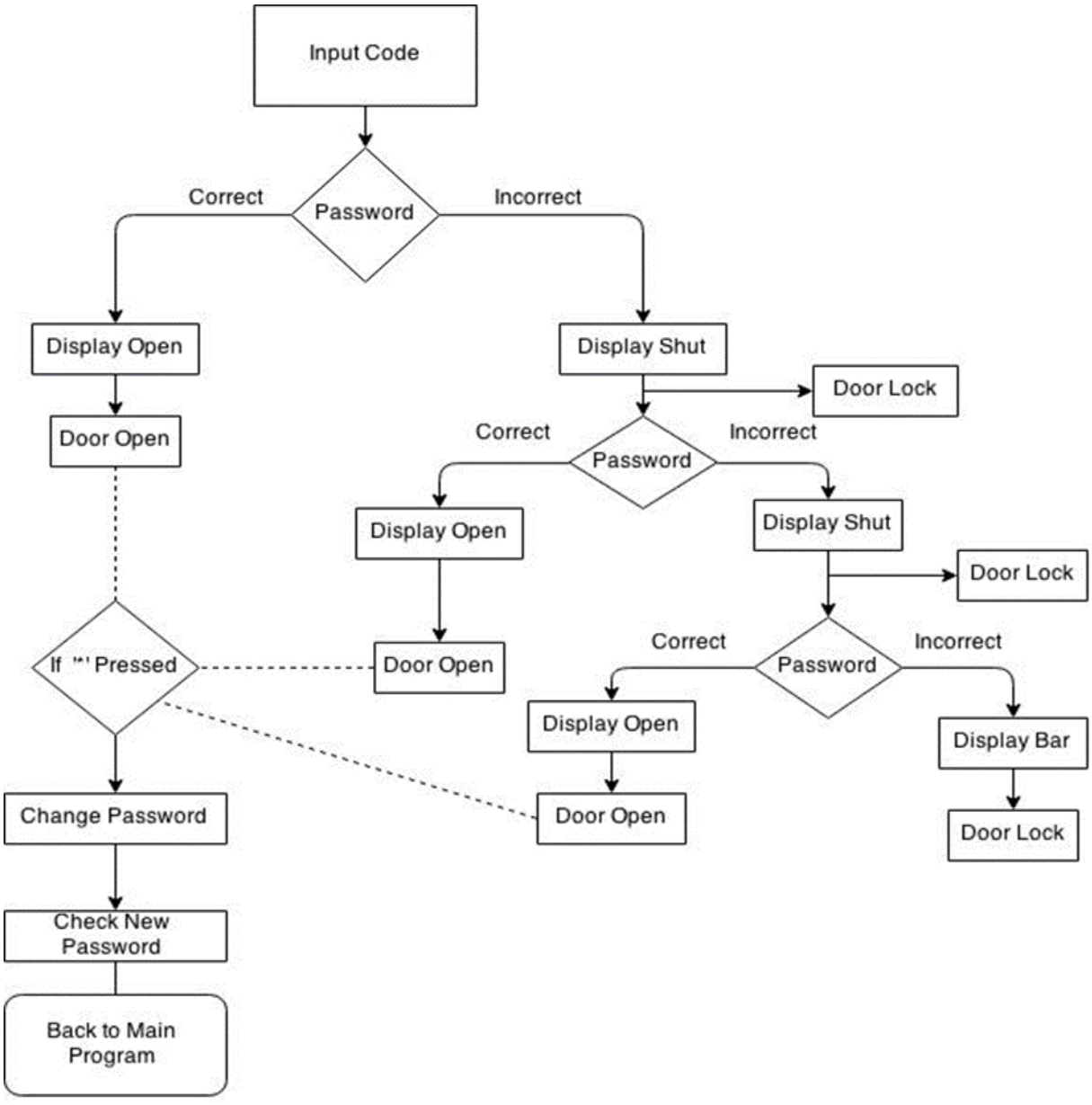

Figure 5: Diagram of the password design

Initially, the password design was done in a program called Dev-C++ to understand how the code will be checked and saved and from there the code can be amended as it's used in programming the design in Keil 3.

The coding in Dev-C++ with the result is displayed in Figure 6 and Keil 3 code is found in the repository.

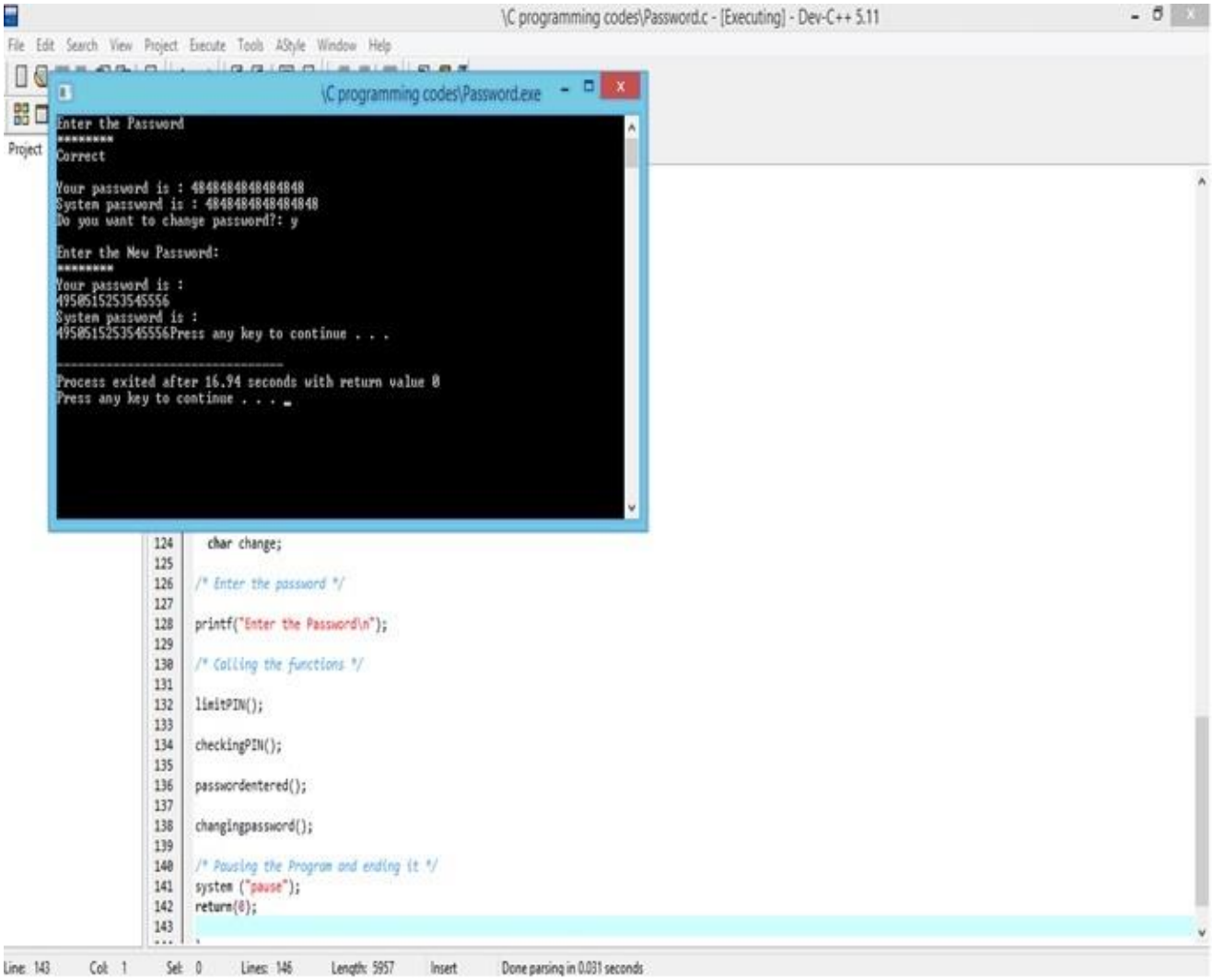

Figure 6: Coding diagram in Dev-C++

3. Coding Explanation:

As shown in the coding, in Dev-C++ was done to see how the password was checked and saved. The trial went as it was supposed to do as shown in Figure 6. In Keil 3, the coding done there was from Dev-C++ but amended as there were some additional coding that were added like interrupts, displaying messages, and converting bits into ASCII code to show the numbers and letters on screen and delays. Interrupts were used in the program so that if the user had entered the code and it was invalid then it interrupts the program for a given time. For example, if the user entered 3 incorrect passcode then the program will be interrupted for 2 minutes. After doing the coding, the program was tested and it worked but it had an issue with debouncing were when the user pressed a button once the number appeared on the display twice. Therefore, delays were added to try to eliminate the problem of debouncing.

Chapter 4) Conclusion:

At the end of the design, project testing was done in the micro-controller to check if it acts as group expected and it does, in addition to that the design met all the requirements as its power consumption is around 67mW. The overall price is reasonable and the chosen keypad was a bit expensive but it can handle different environments as it can be outdoors in the UK; a cheaper model of the keypad can be used for indoor use and with that, it can accommodate both indoor and outdoor uses. A minor problem was observed in the case when the password was saved in EEPROM. However, it was not investigated due to time limitations. For future projects, more time to find faults would be beneficial but overall, it was a pleasant experience.

Chapter 5) References:

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