Design of an Internet of Things (IoT) network system for Kitchen food waste management

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Summary
The applications of Information communication technology have brought change in human life. IOT has changed the life of human beings. Internet of Things (IoT) are measured as one of the enormous advantages for business. So, many types of organizations use IoT technology for various purposes not limited to business automation, business intelligence and marketing. IoT can play a great role in Kitchen industry. But these technologies are not widely used in the Kitchen industry. Food waste is becoming a big problem in many countries, Food waste has always been an issue in kitchens of all sizes. It is, however, seen a lot more in commercial kitchens where there are high volumes of food. Commercial kitchens have many stations that focus on different types of food, which means different ways of preparing food and ultimately should minimize food waste. This paper proposes an IoT based system customized for Kitchen suffering from wasting food during cooking it because of a large number of meals preparing at the same time so that the Chef can forget them on the Cooker during preparing another one. This paper purposes the design and implementation of an Internet of Things (IoT) sensor network technology for refining food waste supervision and management

Key words:
IoT, Smart Kitchen, Automated Cooker.

1. Introduction

Nowadays, Internet of Things (IoT) has a crucial role in all parts of our regular lives. It focuses on several different fields such as entertaining, homes, automobiles, healthcare, industrial applications, sports and many different things. The ubiquity of IoT facilities some ordinary activities, improves the way people interact with the surroundings, and enlarges our social communications with other people and objects.It is very challenging to create systems for the IoT for the following causes: (i) distributed computing complexity , (ii) the absence of common guidelines or outlines that handle low level communication and make it easy for high level implementation, (iii) several programming languages, and (iv) many protocols of communications. Developers are involved to handle the infrastructure and manage both hardware and software layers for all preserving functional and nonfunctional software requirements. The main idea of IoT refers to network technology that allows information transfer between sensor devices. Recently, advances in technology supports many features such as adaptability, real-time monitoring, and traceability [1].The applications of IoT can be observed in number of areas such as kitchen, agriculture, health, and so on. Generally these are prefixed by the word "smart", Ex. Smart Kitchen.

The use of IoT increases with the increased complexity in actuation, sensing, control and communications in extracting knowledge from huge amount of data. This will effect on the quality of different life styles currently [14].

IoT is leading us toward the concept of smart systems, such as smart homes where various electronic appliances are connected with each other with high-quality full-duplex channels for multimedia services. People are controlling their home appliances from remote location. Recently, researchers have done extensive efforts on the smart home technology [15]. Correspondingly, the clue of the smart home is also drawn-out toward the smart community where assistance to humanity is offered by aggregating home, service and community domains. For that system, where a large number of objects are connecting with each other through the internet, producing a huge amount of data, called big data.

IoT researchers suggested many new different applications, such as smart homes, e-health systems, wearable devices, etc. [16]–[18]. Kitchen is the unique place, called the main hub or the heart of the home. It is the place where one of the basic needs i.e. food is prepared. It is the common center of social activities of all the family members who share their feelings or emotions. It is equipped with all basic amenities. Smart Kitchen is a technologically advanced system that incorporates interactive services. It is a built in system which consists of a LCD, WSN, RFID reader and tags to provide all the necessary information regarding the menu, inventory of ingredients and diet control measures etc. Recently, Some IoT applications pay more attention on the food supply chain and food waste, but still food waste applications need more attentions. The original contribution in this paper the different technologies, and applications involved in IoT, in different fields and a special mention regarding its role in Smart Kitchen has been discussed. The crucial reasons behind focusing on food waste are the financial, social and environmental costs related with it. A lot of food wastes during industrial processing, distribution

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and consumption. As a result, nonprofit organizations and governments have urgently focuses on understanding and ending the food waste that leads to many discussions of the causes, effects and solutions of food waste [2].

Food waste is becoming a big problem in many countries, Food waste has always been an issue in kitchens of all sizes. It is, however, seen a lot more in commercial kitchens where there are high volumes of food. Commercial kitchens have many stations that focus on different types of food, which means different ways of preparing food and ultimately should minimize food waste. But that is not the case. Proper portion control is one of the most important steps to minimizing food waste. Commercial kitchens often have scales to measure out the correct portion amount before sending meals out of the kitchen, or they use smaller plates. With proper serving portions, less food will be wasted.

Investing in high-quality kitchen equipment can impact on kitchen waste reduction. Using specialized knives, such as those for filleting fish, will result in less wasted product. These small differences can have a huge impact over time. Most of Kitchen suffering from wasting food during cooking it because of a large number of meals preparing at the same time so that the Chef can forget them on the Cooker during preparing another one. This article presents the development, execution, and evaluation of a sensor-based Internet of Things (IoT) network technology for refining the supervision and administration of food waste in the "Basmatio" restaurant in the city of Cairo, Egypt. We proposed to design and construction of an embedded system in a kitchen cooker, this system allows the chef to choose between different timers for different meals and all timers can work in parallel which will save a lot of food losses and unnecessary employees it's interfaced with an Atmega 32 microcontroller programmed in C language.

The reminder of the article is structured as follows. We provide related work and background on IoT technology including a discussion of Role of IoT in Smart Kitchens. And discuss System architecture design in Section 2. System Development discussed in section 3, In Section 4, we discuss the system implementation, is given. Next, In Section 5 discusses the software development. In Section 6, we present the results of experiments. The article concludes with a summary of the main findings of this research and some possible future lines of research to be explored in Section 7.

2. Background and Related Works

Numerous studies have attempted to explain and discuss smart kitchens with various approaches and methods shown in table 1 the smart kitchen appliances and Functionality.

Shivaranjini S. Mogali [3] highlights the various aspects of IoT and its role in smart kitchen. The different technologies such as RFID, WSN, Cloud Computing, Networking Technology and Nanotechnology that support the IoT, and their applications in various fields i.e Smart home, Smart City, Smart Grid, Smart Health and Smart Farming, and she found, and how IoT is significant because it could open new avenues of research and learning. Of course it raises serious concern about privacy, security and data ownership. The different applications of IoT in Kitchen ranks the highest to compared with other domains. Perhaps it may be due to the hi-fi living style and advancement of the applied technology in every walk of life. Ultimately the smooth functioning of the devices and the knowledge for their operation are essential to achieve the expected results. Otherwise the traditional cookware can only save us.

Shirsath et al. [4] aimed to design and construction of an SMS based Gas Leakage Alert System to reduce the risks in Kitchen if there is leakage in gas cylinder using Internet of Thing, and thereby leads to a faster response time in the events of a leakage condition. Multiregional sensors has been designed, constructed and tested. The result, acquired from carried out examinations, displays that the system is capable of sending SMS alerts whenever there is gas concentration at the inputs of the gas sensors. For this they are using gas sensors, temperature sensors, weight sensors. Threshold values are set into the room, when it crosses that values it will send a notification to the user, about the leakage of a gas cylinder and leakage of a gas. Server can communicate with the user through android device. Through email and SMS server can sends a notification to the user which will display on the android devices. It can prevent the accident and hazards. It is a cost effective and time consuming solution.

Gaurav et al. [5] also focused on the gas leaking problem by designing a gas leaking monitoring system for kitchen and home safety.

This system identifies the leakage of the LPG and warnings the user about the leak by texting and the system will turn off the power supply as an emergency measure, while triggering the alarm.

What's more, this system is continuously monitors the level of the LPG present in the cylinder using load sensor via load sensor. And if the level touches under the threshold limit of gas then the cylinder must be replaced by the user and automatically books the cylinder using GSM Module. The device certifies safety and avoids suffocation and explosion due to gas leakage and software monitors all the functionality of software.

Lei et al. [6] established an automatic checkout and healthy diet catering system based on lOT technique. By using a Dishware system with RFID tag, the system able to mark the diet with IS014443A air protocol and bind it to the user. The system can save the labor costs for the catering company and reduce the user waiting time by the automatic checkout feature to enhance the quality of service. Due to the uniqueness of the RFID tag's identification, system able

to mark every dish the user select. The system able to collect the diet data by recognize the RFID tags, which embedded in dish ware, during customer checkout. This system uses the advantage of cluster, providing catering enterprises SaaS (Software as a Service) service. By using the diet data mining, the system can figure out the total spending of the consumers. What's more, the system can increase the efficiency of catering creativities by the feature of automatic checkout. So the system can reduce the unsalable food to increase the catering enterprises profit.

Saeed et al. (2016)[7] implemented an IoT based application for restaurant, which helps customers finding free parking lot and free table, ordering foods and paying bills from their mobile phone. On the other hand, the management can monitor the whole work properly. But they did not use the power of big data which can bring more attractive functions. This analysis proposes a conceptual model of IoT and big data based application for restaurant. Kitchen IoT sensors will be connected to the system, so managers get the real-time information about what is going on in the kitchen. When customers order food from the table using their mobile application, the order list will be shown to the kitchen in real-time. It will reduce the time of placing order. On the other hand, customer can know that approximately how much he or she has to wait for the ordered item [7].

Wang and Yue (2017)[10] proposed a food safety risks system for the food supply chain that support an intial notice framework. For Nychas et al. (2016)[11] have discovered the ability of using cloud computing and IoT through the food chain for food safety organization. Where in [12] Hong et al. developed smart garbage system (SGS) to apply the idea of "Pay as You Throw" efficiently and effectively in south Korea. A pilot study, for one year, had been applied in the Gangnam district, Seoul. From the experimental study, the SGS able to reduce about 33% and also able to save energy by 16%.

Grind2Energy, is an IoT system that is proposed in USA for discovering the wasteful habits and repairing equipment before it is broken by supporting disposal service providers. It is expected also to reduce the tipping fees related to traditional form of food waste disposal. It direct us to think about food waste collection bins to collect it when it reach to specific level rather than using a pre-scheduled collection times

There is lot of promotion surrounding the IoT. The main idea links daily use objects with the internet and each other allowing them to communicate in a new way to easy our life. Many companies are building projects into the field with internet connected kitchen appliances, clothing, home security systems.

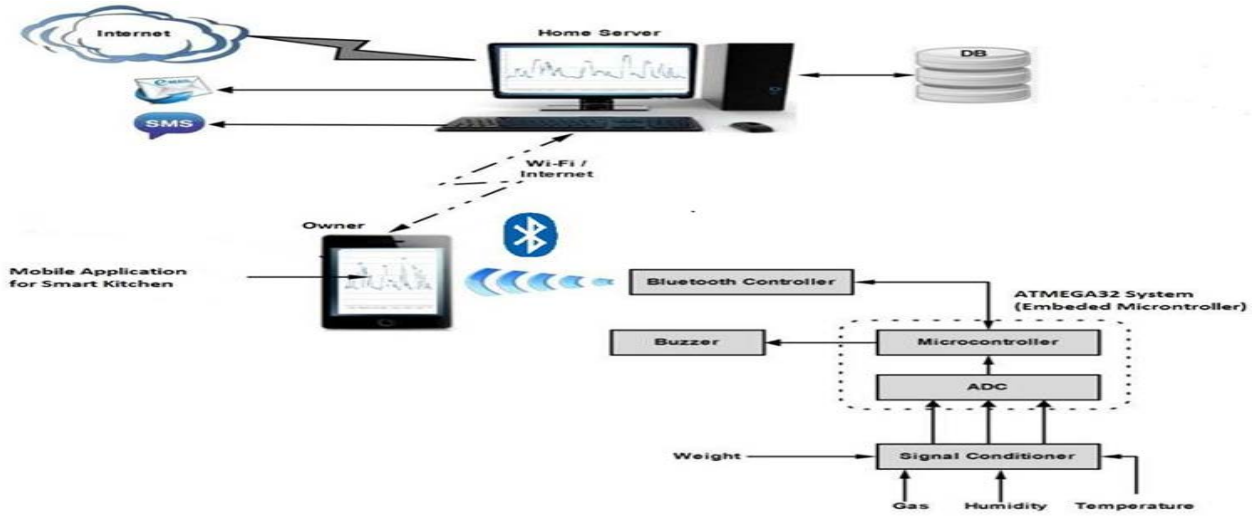
The implications of IoT in food industry are highly appreciate especially the ones that making improvements in food safety. The advancement in Wireless technology and cloud computing the IoT has the potential to make food safer from the farm to the consumers' dinner plate.The smart kitchen is installed with all computing system to exhibit smart behavior based on sensors, actuators and interactive devices that are built in or embedded within the household articles such as dinning set, refrigerators, cooking range, coffee machine, oven, sink and so on. The integral components of the computing system will sense and model contextual information and apply it for providing smart services for a chosen application. IoT based applications shown in table 1 are used for smart kitchen. It enables manager to get a clear insight of the foods and its ingredients. For example, IoT based application can help in monitoring the quality of oil. It can measure the amount of oil being used in food. If the quality of oil is poor or the amount of oil in a food is excessive it will make a notification. It can also monitor the food quality in refrigerators [3], [13]. Many other researchers who are recognized in literature on IoT applications such as [21], [22] and [23] studied the important of IoT application in our life.

Table 1 smart kitchen appliances and Functionality

smart kitchen appliances	Functionality
Pantelligent (atmel.com, 2015). [9]	The sensor communicates over Bluetooth (which is in its handle) with help of Smartphone which is associated with it. The process of cooking is communicated in a phased manner. This appliance is more suitable for the beginners in the cooking field.
Baidu Kuaisou venturebeat.com, 2015).	They offer the analyzed readings to the user. The chopsticks are able to detect oils containing unsanitary levels of contamination,(venturebeat.com, 2015).The further advancement is to measure the freshness of the oil, water and food and its pH level, temperature and caloric value.
Egg Minder (atmel.com, 2015)	It is a device which is developed by Quirky. It is wireless connected egg tray that helps in tracking the duration of each egg that it contains and how long it is there in the tray. When the tray is opened the smart device blinks an LED light next to the egg that's been in it the longest. Based on this, decision can be taken to crack the particular egg,
HAPIfork	It will monitor how many bites of food that one takes and at what rate, (atmel.com, 2015).If over stuffing of the mouth is made with more than one bite every 10 seconds the fork, warns by vibrating to slow down the intake. Further with help of USB data can be uploaded.
B4RM4N	This B4RM4N smart cocktail shaker is designed by the Magnified Self Crew. This is powered by an Atmel MCU and connected to Smartphone via Bluetooth. This allows the user to make a perfect cocktail drink every time, (atmel.com, 2015). To begin with the user connects the device to smart phones and then with the help of relevant mobile application the required proportions are added to the drink.
The Milkmaid,(venturebeat.com, 2015)	This is developed by Quirky. It helps to detect the spoilage of milk. The smart jug will give the signal to the users when the milk is going to spoil, and when to discard it,(venturebeat.com,2015)
SITUSITU (venturebeat.com, 2015).	Is a smart food guide which contains food nutrition scale capable of weighing food in calories and nutrients; it also weighs in grams and ounces, (venturebeat.com, 2015). With the help of this the user can have a précised calorie and nutrient diet as per the need.
Drop	A Drop is a smart kitchen scale it is designed to bake beautiful and delicious food without any experience. In this device the scale is connected to a custom iPad application via Bluetooth. The bakers can bake by referring to library of recipes,(atmel.com, 2015)
Mr. Coffee 10-Cup Smart Optimal Brew	Mr. Belkin has introduced number of smart products which have changed the scenario in the home automation. Out of them WiFi-enabled coffee maker is one. This is capable of preparing or brewing up to 10 cups coffee,(atmel.com, 2015) This is supper since it is simple to schedule, monitor, and modify the preparation of coffee from anywhere.
The Hug	The Hug offers a solution as how much of water has been consumed throughout the day and how much is needed, (venturebeat.com, 2015)It is installed with a combo sensor band and iOS app. The sensor band is wrapped around the water bottle and keeps tracking of water consumed.

Many of proposed researches focused only on the ideas of pertaining to system design of smart kitchen devices, and most studies focus on just one of smart kitchen appliances as shown in Table 1. The lack of rigorous methodology coupled with effective process implementation on the wasting food during cooking .Most of Kitchen suffering from wasting food during cooking it because of a large number of meals preparing at the same time so that the Chef can forget them on the Cooker during preparing another one. Consequently, this paper represents a respected contribution to the increasing researches on food waste management. Recently, food waste management become a hot topics that has gain a lot of focuses.

3. System architecture design



The main purpose of this system is to automize home appliances via IoT domain. As a result, a gas cylinder, that supported various types of sensors, has been used. Different variables of different sensors have been observed and the values will be considered regarding to the variation. For example, in case of the weight of the gas reached below the threshold value that measured by weight sensor, at the same time a message will be send to the user. Additionally, the measured value will be recorded in the database. Similarly all sensors work in the same manner.

4. Implementation

In the implementation process we walkthrough many steps, firstly we must specify the Hardware components of the system, and they are will be:

4.1 Input Unit

We have only one input in our device and it is the 4*4 Keypad and it`s role is to make the user choose the meal which he wants to put on the stove that he already choose, and to generate alarm sequence. The user press on the reset button to reset the stove and terminate the alarm sequence.

Fig. 2 The 4*4 Keypad

4.2 Output Unit

We used the LCD (LMO 016L 16*2 Alphanumeric) as an output device because it makes the user simply see what he chooses and the changes in the system conditions easily, it is also easy to program and uses less DIOS from my micro controller

Fig. 3 The LCD

4.3 Microcontroller Unit

This unit is divided into two parts, hardware part and software part. The hardware is essentially the microcontroller. Microcontroller is a single chip containing a microprocessor, memory (RAM & ROM), input/output ports, timers and serial ports and it is designed for embedded control applications. We know that the main use of microcontroller is the control of a machine or system using a fixed program stored in the ROM and this program does not change over the lifetime of the system [10]. We used ATmega32 microcontroller. ATmega32 is an 8-bit high performance microcontroller of Atmel's Mega AVR family. ATmega32 is based on enhanced RISC architecture with 131 powerful instructions. Most of the instructions execute in one machine cycle. ATmega32 can work on maximum frequency of 16MHZ.It contains 8-channel 10-bit A/D Converter and a JTAG interface for on-chip debugging. The device supports throughput of 16 MIPS at 16 MHz and operates between 4.5-5.5 volts.

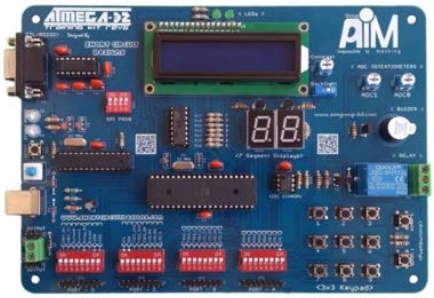


Fig. 4 AVR – Atmega 32 Micro controller kit

4.4 Alarm Unit

We also need buzzer and led as alarm indications for the user.

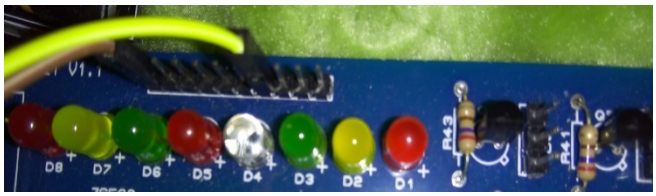


Fig. 5 The Led Indicator

4.5 Burning Tool

We used the USB asp as an AVR Burning Tool.

Fig. 6 USB ASP

5. Software Development

The software needed to run the control process of this system was developed using C language in the microC PRO for AVR. The program code was then written into the chip. Eclipse Neon 0.2 used to write code and burn it in the microcontroller.
We also need to specify Timers to calculate the time for the meals and give us indications when it`s done, Choose the DIO-S to connect the hardware components (LCD – Keypad – Led – Buzzer), and create the drivers for the microcontroller peripherals (Timers – DIO – ISR "Interrupt") and the devices that I used (LCD – Keypad).

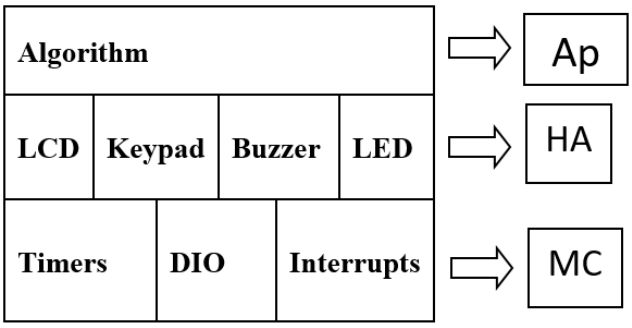


Fig. 7 Static Design

6. System Modules

The system was constructed in modules as designed and later put together on completion to simplify construction, testing and maintenance. After verifying that all the components are working as expected, we integrated them into a single system. The entire system circuit as shown in fig 8 was laid out carefully to minimize error and to ease troubleshooting.

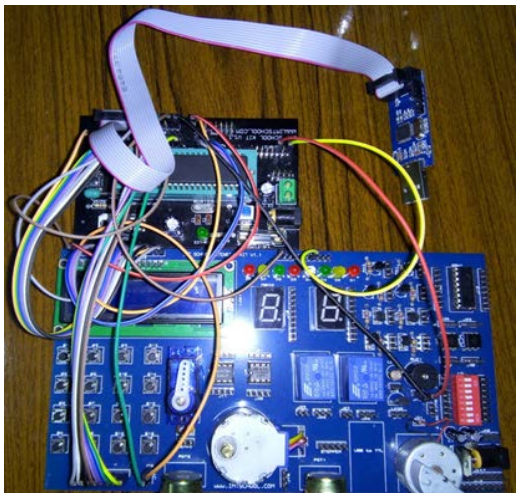


Fig. 8 The system construction

7. Results

At the first, the LCD will show the default screen (fig 9) which contains the cooker stoves numbers.

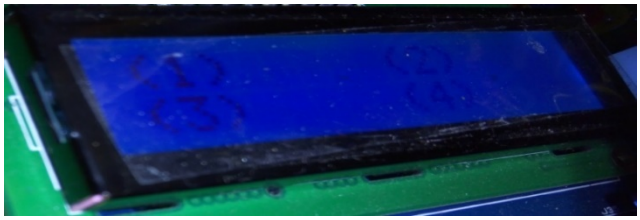


Fig. 9 The Default Screen

And then check which button has the user pressed, if it was stove 1 the button waits until he choose the meal. And the same for the other stoves buttons. When the user chooses the meal it appears on the screen the name of the meal next to the stove he chooses as shown in fig 10.

Fig. 10 The Screen after choosing the meal

The global flag of the meal turns to 1 and when the code goes to the ISR it will check the flag of the meal when it finds the flag equals to 1, it starts the timer logic for this meal. When the meal counter reaches the desired time as

shown in fig 11 , it starts the alarm sequence which is putting voltage on the pins which the buzzer and the led are connected to and they turned on. And put (*) next to the meal name on the screen to work as indication that this meal has already finished.

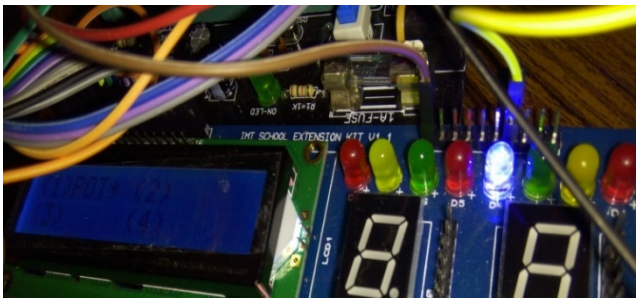


Fig. 11 The Screen and the Led after reaching the desired time

If the user pressed on the reset button of the stove. It deletes the meals name, and the (*) from the LCD and remove the voltage from the pins which the buzzer and the led connected to terminates the alarm sequence for this stove, and return to the default screen.

8. Conclusion

Due to the advances in technologies the attention to IoT market increasing rapidly. A lot attention has shifted to identify frameworks supporting the standard IoT suites of regulations and protocols. This research has focused on a subset of commercially available framework and platforms in order to develop industrial and consumer based IoT applications. The developed IoT embedded system has partially solved the cooking problems in “Basmatio” restaurants by allowing the chef to choose between different timers for different meals and the all timers can work in parallel. This system can solve many problems for restaurants and make the daily operations of restaurant faster, less time consuming, easier and more efficient with reduced cost. In the future work one of the modifications is to provide the system with heat sensor for safety if there is undesired fire from the stove. Make the configuration of the meal time generic product. And develop a counter using 7 segment to count how many time as he cooked a certain meal, to know which meal is preferred by his clients and the average of each meal`s ingredients consumption.

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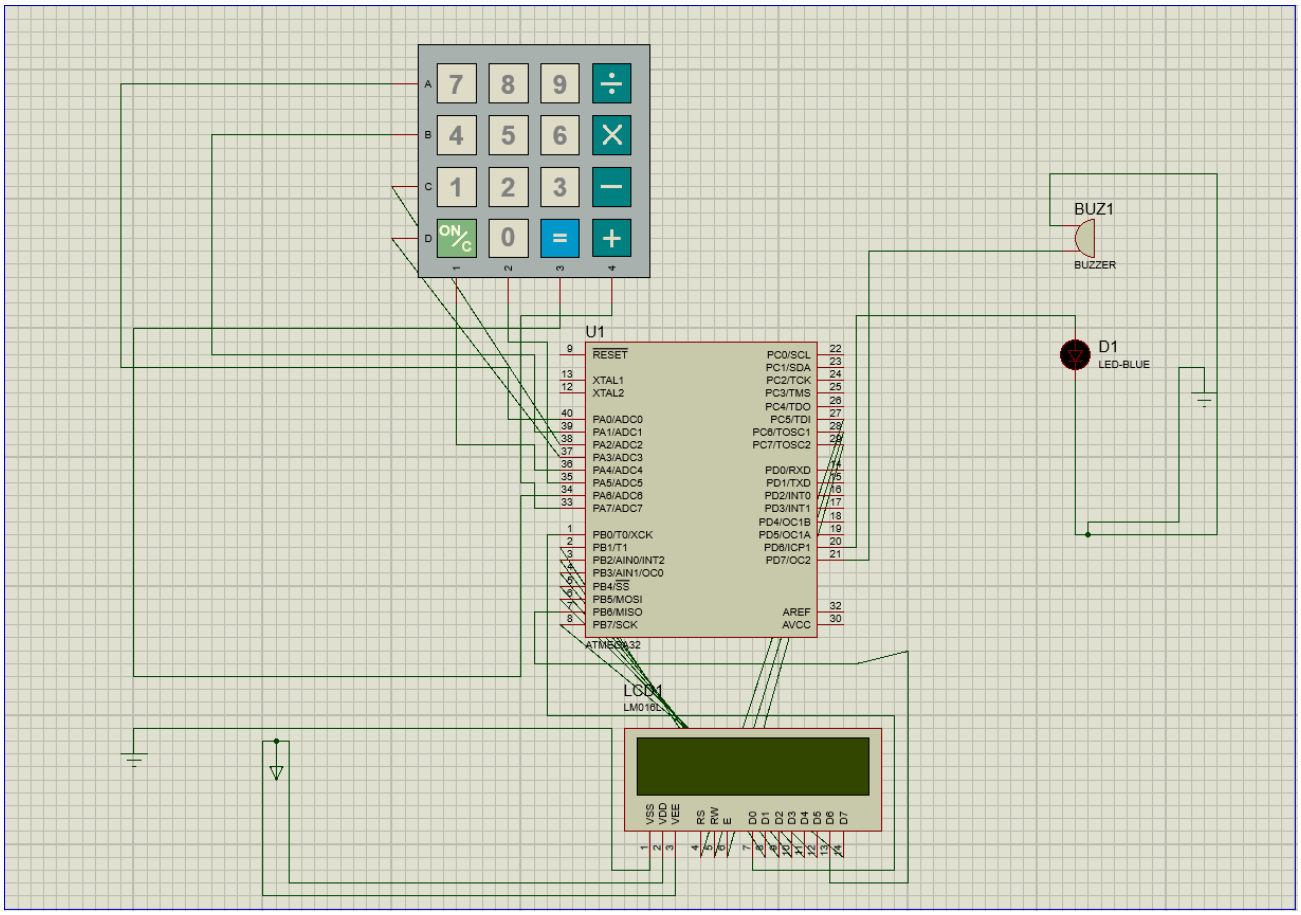

Fig. 12 The System Layout and the Circuit Diagram

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