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ABSTRACT

ENERGY MANAGEMENT SYSTEM FOR SMART HOME

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Smart Home Energy Management system (SHEMS) monitors and controls the loads existing in a residential home and manages the available energy effectively. It plays a significant role in smart grid environment and helps in regulating the wastage of energy at residential homes. It provides a homeowner the ability to automatically perform smart load switching based on generation power and home owner preference and load priorities. In the thesis, energy consumption and energy management problems have been studied and new approaches have been proposed. In order to achieve the objectives of the thesis, the embedded system consisting of microcontroller, sensors, actuators, network and display devices have been designed and realized. In addition to embedded hardware design, embedded software and webserver for remote access and control are designed and implemented. Our energy management system for smart house proposed for energy saving has 3 different modes for load management. These are economic, auto, and manual modes. The system allows remote control of power tools using the Internet protocol via the Web server according to the set power. Thus, it provides energy savings and decreases the electricity bill. In order to solve the second problem discussed in the thesis, the required electrical appliances are powered up with control algorithm in the proposed system at the time when the electrical network is not over loaded. The performance and effectiveness of the proposed system according to different load and scenarios have been evaluated. As evaluation criteria's; availability to monitor home appliance status, energy management and ease of use of household appliances by the user, manageability by the control center, support of multi-power sources and communication technologies have been used. Test results showed that the system was designed and implemented successfully.

Keyword: Home automation, energy mangement, microcontrolle, sensors and actuators, webserver and remote control.

ÖZET

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Akıllı Ev Enerji Yönetim sistemi (SHEMS), bir konutta var olan yükleri izler ve kontrol eder ve mevcut enerjiyi etkin bir şekilde yönetir. Akıllı şebeke ortamında önemli bir rol oynar ve konutlarda enerji israfını düzenlemede yardımcı olur. Konut sahibine, üretim gücüne ve konut sahibi tercihine ve yük önceliklerini temel alarak akıllı yük AÇMA / KAPATMA anahtarlamayı otomatik olarak yapma yeteneği sağlar. Tezde enerji tüketimi ve enerji yönetimi problemleri çalışılmış ve bunlara yönelik yeni yaklaşımlar önerilmiştir. Tezin hedeflerine ulaşabilmek için mikro denetleyiciden, algılayıcılardan, eyleyicilerden, internet donanımından ve görüntüleme aygıtından oluşan gömülü sistemin tasarımı yapılmış ve gerçekleştirilmiştir. Gömülü donanım tasarımın yanı sıra gömülü yazılım ve uzaktan erişim ve kontrol için internet yazılımları da tasarlanıp gerçekleştirilmiştir. Enerji tasarrufu için teklif edilen akıllı ev için enerji yönetim sistemimiz yük yönetimi için 3 farklı konuma sahiptir. Bunlar ekonomik, oto ve manuel konumlarıdır. Sistem belirlenen güç değerine göre Web sunucusu üzerinden İnternet protokolü kullanarak uzaktan elektrikli aletlere kumanda edilmesine imkân vermektedir. Böylelikle enerji tasarrufu sağlayıp elektrik faturasının azalmasını sağlamaktadır. Tezde ele alınan ikinci problemin çözümüne yönelik ise önerilen sistemdeki kontrol algoritması ile elektrik şebekesinde yükün yoğun olduğu saatler yerine yükün az olduğu saatlerde ihtiyaç duyulan elektriksel aletler çalıştırılmaktadır. Önerilen sistemin farklı yük ve senaryolara göre performansı ve etkinliği değerlendirilmiştir. Değerlendirme kriterleri olarak; ev aletinin durumunu izlemek için kullanılabilirlik, enerji yönetimi ve ev aletlerinin kullanıcı tarafından kolay kullanımı, kontrol merkezi tarafından yönetilebilirlik, çoklu güç kaynaklarının desteklenmesi ve iletişim teknolojileri gibi kriterler kullanılmıştır. Test sonuçları, sistemin başarıyla tasarlandığını ve uygulandığını göstermiştir.

Anahtar kelimeler: Ev otomasyonu, Enerji yönetimi, mikro denetleyici, algılayıcılar, eyleyiciler, web sunucusu ve uzaktan kumanda.

To My Parents

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LIST OF ABBREVIATIONS

AC	Alternative Current
ADC	Analogue to Digital Convertor
AMI	Automatic Meter Infrastructure
AUTO	Automatic
CSS	Cascading Style Sheet
DC	Direct Current
DDNS	Dynamic Domain Name System
DHCP	Dynamic Host Control Protocol
DR	Demand Response
DSM	Demand Side Management
ECO	Economy
EEPROM	Electrical Erasable Random Only Memory
GND	Ground
GSM	Global System for Mobile
GUI	Graphical User Interface
HEC	Home Energy Controller
HMI	Human Machine Interface
HTML	Hypertext Markup Language
HVCA	Heating and Ventilation Air Conditioning
IC	Integrate Circuit
IP	Internet Protocol

IoT	Internet of Thing
KWH	Kilo Watt per Hour
LAN	Local Area Network
LCD	Liquid Crystal Display
MAC	Media Access Control
OMC	Operation Maintenance Center
PC	Personal Computer
PIC	Peripheral Interface Controller
PLC	Power Line Communication
RAM	Random Access Memory
RF	Radio Frequency
SHEMS	Smart Home Energy Management System
TCP	Transfer Control Protocol
UDP	User Datagram Protocol
VPN	Virtual Privet Network
W	Watt
WAN	Wide Area Network
WiFi	Wireless Fidelity
WPAN	Wireless Personal Area Network

CHAPTER 1

INTRODUCTION

Energy, in all its shapes, is a valuable source for mankind. Saving electrical energy and seeking methods of consuming are significant manners were concentrated, for a time ago, upon scientists. The electrical energy problem is that the energy generation rate cannot be saved with the energy demand rate. The electrical energy problem is the main concern factor of this work, so the electrical energy is mentioned for energy in this thesis.

Today, consuming energy efficiency is getting more difficult because of the quick progress in the electronics world. There are various new devices and inventions. Recently, in high rates they, for maintenance consume energy as well as development, involve a lot of factories and laboratories. Also, persons use much energy than they need and that results are in a giant wastage of energy and in an endless rise in the costs of energy resources [1].

In spite of discovery clean, non-exhausted energies, and environment-friendly, it is mandatory to progress proper management technologies and energy-saving, so as to effectively slow down the energy consumption and decrease the severe changes of environment. Especially in electricity domain, energy usage has been exceeded its normal range for controlling and efficiently use electricity in developed countries. Smart grid has been implemented, which using advanced metering infrastructure, for applying demand-response mechanism in order to control it over the consumption of electricity in the industrial domain and residential and local energy production in the case of renewable energy existence like wind turbine and PV panels.

Smart grid applies smart meter to aware customers by changing electricity price based on real time, but also, this is not efficient and effective way to reduce energy consumption, the solution is a smart home to efficient control, the

household appliances via a home energy controller depending on the received signal via smart meter and an appropriate management from the control center. Today, electric energy used in dwellings in developing countries to overcome the grid stability an important attention has to be paid to Demand response (DR) mechanism, which focus on manage of customer loads to reduce or optimize the energy consumption of dwellings; otherwise, additional power plants have to be built. It has a harmful effect on social impact, environmental and economic for example global warming due to CO2 emission etc. It allows occupants in residential segment fall their electricity consumes over a given time period or shifting it to another time period in response to utility signals and customer's liking.

Electrical energy movements from the power generating station to costumers that may be used for industrial, agricultural, government building and normal house through transmission and distribution network were suffering much energy wastage. The power loss in the load side directly mirrors the power loss in the distribution and transmission of the network. Therefore, it is to be observed that effective consumption of electrical energy was not only aids in saving the fuel reserves, but also directly effect to minimize pollution in the environment [2].

Demand response scheme execution requires full duplex communication between customers and the utility company, so by using AMI customers, it can alert the periodically energy price via smart meter and permission power consumption in real time. Smart meters are vital units in smart grid in the existence of energy management system. Inside Smart Home, the Home Energy Controller (HEC) is the central and main part between Smart Grid and physical devices or home appliances. To avoid influencing customers from controlling and monitoring the loads and making a wise decision for managing home appliances, a (SHEM) is designed and implemented in this thesis that all appliances connected to it. The key functions of thesis were reducing demand of electricity and cutting the energy cost compare to tradition energy meter. Eliminates the labor of meter data collection, in generation side and in consumer side, they provide comfortability through easily real-time monitoring of home appliances and control it via flexible, user-friendly by using GUI and drop bill and minimizes human efforts.

1.1 Overview

Over the last decade, energy management has been an extended topic across the whole world. Despite of upgrading the electricity traditional grid to the smart grid, for efficient use and saving of energy and connecting householders to demand response via smart home energy management that has smart meter and control appliance devices, but household appliances always finding it difficult to manage and handle their energy consumption.

A main concern with the house is energy usage. Many persons' surprised, where does the greater amount of the power I utilize go? They receive bills that are non-predictable and ask why it has modified such a great amount from the most recent month? He was doubting, how we find which appliances consume more energy and which the most efficient are? It happened to us too, metering, power usage of singular appliance. With online data, we might distinguish which appliances consume most load, and which one in my home attractions the minimum power. When the toaster and coffee maker were missing to turn off, they could remotely display working status and easily switch off/on, and how can be setting temperature room at comfortable degree before we reach to home also switch on water heater and switch off if forgot to switch off. Additionally , controlling the power source mode because in IRAQ government , it is unable to provide electrical energy 24 hours for consumers specially at summer and winter; therefore, many houses have two or three electrical power sources ;therefore, we use three modes to control the power supply for a house, the first mode is public power source (national power source), the second is private or local generator for small zone inside city that has a few and a limit current ; therefore, it can use only for lighting and refrigerating which has needed a small amount of energy and most priorities.

From the mentioned methods, applying renewable energy is considered as a good choice taking into account the point of opinion that does not threaten life. All of these solutions are a goal of shifting up the energy generation rate. This thesis does not search with this approach, it deals with the approach of reducing the energy demand rate and levelling its curve during the hours of the day that is the hope for consumers and provide also due to enhance living ethics obtain comfortability for control and monitoring appliance and mange it.

1.2 Aim of The Work

In order to shift down the energy demand rate and reach efficient energy management, scattering the awareness of the energy problem is the taken approach. This approach is not based only on understanding energy consumption, promote consumer for utilizing recent technology devices that consume less energy with high efficiency.

The developed system needs few budgets with high ability to automatically perform load switching according to plants capacity, the SHEMS user can do preference and indicates the priorities of appliances. The consumer is able to remotely switch on & off appliance by using the internet that comfortable and efficient for the consumer.

Increasing the awareness among consumers at real time used to reduce pay for the amount of consumed energy, and also by introducing various techniques can provide better energy management and comfort. One of these techniques is the introduction of SHEMS into the electricity systems. To fully understand the effect of the introduction of (SHEMS), traditional energy metering systems are described primarily.

The scope of this thesis is limited to low-power, low-bandwidth home area networks and smart home applications with constrained IoT devices. We typically study low-power and describe wire and wireless communication technologies.

1.3 Energy Management for Smart Home

1.3.1 What is a Home Energy Management System

One of the significant parts of the electricity demand is energy consumption in housing sector. In this framework, a good forecast of energy demand in the housing sector is significant because electrical energy wasted in residential presently account for a big amount of the overall energy demand cause spend a big amount of total budget [3].

Home automation is a technique to control and monitor devices of your home from remote places by means of a computer or smartphone. Home security through automation is monitoring your house using sensor networks, which alerts you every time sensor reads. Home automation not only aids you control the appliances of home, but also helps save energy, too. It helps sensing appliances on standby and turns them off when not in use and thus keeps energy. Securing home has never been much simpler

as it is today with automation user can remotely look after their home and the home itself warns them in case of emergency.

SHEMS is an important part of the smart grid and has many benefits such as:

- Minimize the electricity bill.
- Reduction of demand in peak hours.
- Meeting the demand side desires.

For decreasing the peak demand of households, SHEMS is considered one goal for this purpose as well as to keep in our mind that in the identical, the priority as well as the time of the customer. It has to be noticed that to regulate the consuming energy of the smart devices, SHEMS that based on communication, after receiving a signal from the energy service provider, can allow for the households. Two of vitality utilization tops amid the day: early in the day, somewhere in the range of 8 and 10 AM, and in the night, somewhere in the range of 6 and 10 PM [4].

Prediction of an energy for appliances in homes has an abundant impact on the effectiveness of a home energy management system. This system is skilled to regulate the best energy task strategy and a good negotiation between a power plant and the energy consumption or users.

1.3.2 Energy Usage in Residences

Home appliances are the main and the biggest source for consuming electrical energy, that was used for lighting facilities, water heater, kitchen devices as well as HVAC, among them, the consumed energy ratio for HVAC over 56% of the over-all housing electricity consumption. Even inferior, a great amount of energy is not fully useful by occupants and energy waste occurs in all day along. The author in [5] listed a reason that runs for energy loss in a house, as follows:

1) Endlessly working of an HVAC in the empty rooms of houses.
2) Overcooling and hotness to compensate for the temperature adjustment due to a centralized thermostat.
3) The potential energy drop occurs due to appliances in a switch off or standby mode Inevitably, the wrong applications of home appliances along with the lack of a smart energy infrastructure donates to waste or needless energy consumption in the popularity of residences [6].

4) A greater number of lights in a small area of the house without a respect light lux standard for specific rooms or are such as office need 500 lux but installed more than 1000 lux.

1.4 Traditional Energy Metering Systems

The electricity cost and pollution minimization are two globes growing problem today. Also, many countries suffering from another crisis for providing demand of electrical power. The main one is a damaged distribution network and irregular feeding. Iraq faces a lot of technical and financial problem in an electrical distribution system, irregular consumption, high cost of measurement because the present metering in Iraq is electromechanical energy meter and power theft, additional government could not serve 24 hours' electrical power, which is a key factor for increasing load on the power network during supply and also suffers a real problem of revenue assembly. One of the prime causes is the traditional billing system which is inexact numerous times, costly, slow, and not reliable [6].

A serious action need for overcoming the problems is by changing traditional energy metering to efficient system for correct readings and this cuts the cost of measurements is swapping the conventional electromechanical meters to a new advanced electronic meter to get better and provide precision in meter reading and prevent electrical theft .Also, the main step on the way to smart grid, in recent years, the progresses in power meter was appear to afford opportunities in executing energy efficient metering skills that are more accurate and error free. There are many methods for electrical power measuring at home are Card prepaid meter, IC manual meter, wire-line and wireless meter reading system [7].

1.4.1 Manual Meter Reading

It is from the past method and it is strong less because; for each household there is its private meter, employers which taking readings of metrics manually for each houses ; therefore, high charge of measurements, because it needs a lot of number of staff that need collecting money house by house, low precision of evaluations, and hard to monitor measurements that these devices vulnerable to abuses and the other main disadvantage is has more wastage of power due to irregular way (electrical theft). This technique is still used in some countries such as Iraq so far. Being unable to

support a multi-tariff scheme in order to resolve the crisis of peak demand of electrical energy. Essentially, the peak demand occurs when the electrical energy demanded by users touches an extreme peak value, such that service power plant is not capable to afford the sufficient amount of energy to consumers during that time period [5].

A good approach to resolve this matter is to discover a technique to make the users switch on their appliances at different time periods such that the energy consumption profile is virtually flat. If the value of energy consumed is high at peak demand intervals, and little at comfortable demand times, then it will contribute in levelling the energy consumption profile because the consumers will run only their mostly needed appliances during peak demand times [5].

To put more light on the peak demand matter in Iraq, the energy feeding profile of the day (22/7/2012) in Iraq is shown in Figure 1.1.

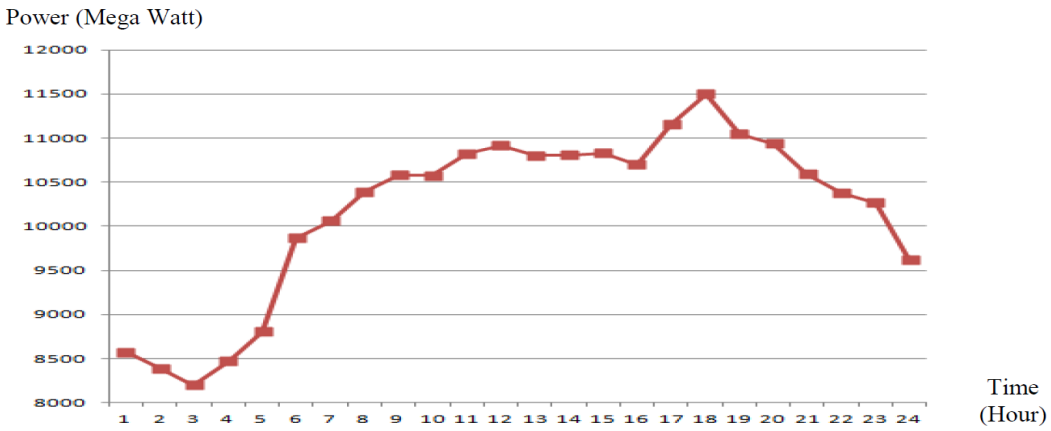


Figure 1.1 Energy consumption profile for (22/7/2012) in Iraq [9]

The peak demand period at the evening time (18:00) and there is a stress-free demand at morning time (03:00). The goal of utilizing the multi-tariff system is for distributing the energy demand away from the peak demand time periods by manipulating the stress-free demand time periods in other words, the appliances need more energy like boiler and factory running shift to that hour of relaxing demand.

It would be declared that the spreading of the peak demand periods and the relaxed demand time periods over the hours of the day might vary according to the season of the year, type of the region and happening of special events etc.

1.4.2 IC Card Prepaid Meter

It is prepaid technique, it means pay-before use energy; therefore, it does not require employers to read energy meter house by house or collect recharge manually. It has resolved some problem of manual meter reading such as fewer metering fee, but some snags happen in the real process such as simply damaged due to its direct contact with users, has not real-time watching and fails to prevent energy theft, damage, and also the fault of an energy measure.

The problem with this metering technique in online has been fixed, so all measurements are able to be checked and controlled in online. Also, this kind of meters can be linked to the station over telephone lines, power line network, ADSL etc. Therefore, it has a low metering fee. But it has snags of long creation period, great installation price and preservation price, development of the system compatibility with another network and easily upgrade [5].

1.4.3 Wireless Meter Reading System

This is the technology used metering data, read and processed automatically by using the measurement device through wireless communication and network technology. In this meter compose all issues of online estimation, checking and controlling have been settled. Compared with the conventional meter reading, it is not only successfully guarding human resources, and furthermore save the wiring fee and supports the supervision to discovery a problem in time and take suitable events to deal with. Also, it has simple and slight cost for installation, easy to upgrade process, and more protected compare other ways [4-8].

1.5 Work Objectives

The main objective of this work is to propose and implement the SHEMS that can perform multiple functions that are required for solving energy problem, reducing it and providing a comfortable technique for home.

The project goals to offer a clear picture of a home's present load, and through this data, offering a calculation of power consumption, and it is displaying which appliances switch on/off by study of a current facts and finally provided such information to a user to optimize and reduce their power usage.

1.6 Literature Survey

There are many works that demonstrate a comprehensive review of the internet of things and smart home applications. This topic is quite general among the researchers because of its actuality.

In 2008, Suhail Najim proposed an Internet Protocol (IP) founded monitoring and control system for power generation stations in IRAQ. The planned system is considered as a SCADA system. It is mostly concerned about monitoring and managing the power plants from a control center. The project provided a good study on improving the communication data-rate by using optical fibers in its place of coaxial cables used at this time; however, it is pointed out that the optical fibers suffer from installation price and maintenance difficulty [9].

In 2012, Gill, et al., Designed and presented of a Smart Power monitoring device. The system contains two main parts the center and the power meter. The task of the meter is to send the current and voltage signal to the center via wireless module ZigBee/Xbee. The center has constructed on a PC which accept signals from meter via ZigBee/Xbee module, here is a GUI designed by the C# program to display electrical parameters of the meters [10].

In 2011, Gang Xiong etal. Simulated a smart energy based on the scheduling system for efficiently managing energy demand. The offered simulation, distributed home appliances into two groups, online apparatuses and schedulable equipment, where the work of the second group can be delayed and operates after the demand peak time periods. Mathematical analyses display that the taken approach gave promising results, where the peak demand issue was decreased by a great extent when exploiting the comfortable demand time periods, and it was recommended to operate only the frequently required appliances at peak demand time periods [11]

In 2011, Mei Sung Kang etal. Executed a smart monitoring and managing power system using ZigBee. It contained a control network within the house to monitor and control different appliances. It controlled the home appliances based on their energy consumption and the accessible supplied energy. When the supplied energy was near a threshold limit, then only the appliances with high priority were premised to operate. The system contained an LCD to display various information to the

consumers, such as the quantity of available energy, an RTC IC to save path of time and support multi-tariff system if desired [12].

In 2013 Qinran Hu, Fangxing Li. Proposed and constructed hardware design of SHEMS with the presentations of communication, detecting technology, machine learning algorithm, with the offered project, users can simply reach an online, price-responsive manage approach for home loads such as an electric water heater, dishwasher, washing machine HVAC, electrical vehicle and dryer. Also, consumers could load serving entities to facilitate the load control at the supplier side. Further, helping consumers to reduce total payments for electricity without or with little consumer participation. Finally, experimental goals are presented according to a real SHEMS model to validate the hardware system [13].

In 2014 Adriana, A. And Dani, A.W., Outlined and made Smart Home System by using WLAN arrange in light of Arduino microcontroller. There is framework that might screen as well as cautions, room temperature, administration lights and different family of unit apparatuses. It was shown by the results in tests of the framework that observing capacities as well as legitimate control could be prpared from a device associated with a system that backings HTML5 [14].

In 2015, Datta, N., Masud, T., Arefin, R., Rimon, A.A., Rahman, M.S. and Pathik, B.B., Designed electrical circuit by then, a person has the ability to switch on/off the electrical appliances i.e. can lock/unlock windows, fans, door set through sending SMS to build android application for a number, that is specific phone, connected to the microcontroller. They were use android application for send order over SMS. The module of GSM can receive SMS as well as it can send codes of specific hexadecimal to a microcontroller. Afterwards, the code will be read by the microcontroller and the signals will be sent, for performing actions, to relays respecting to the determined logic. Smart guarding and effectual, that can be done by this system, are for reducing the consuming energy for living place as well for user's office [15].

In 2015, Bhubaneswar, S., Satish, B. And Mahalaksmi, Explained the hardware realization of the Home Energy consumption control (HECC) system for treatment the appliances which assistances in real consumption of the energy existing and

reduce of the electricity budget and energy depletion. The HECCs to do load control is to study the power consumption facts and it offers a homeowner the capability to automatically execute smart load switching based on home owner favorite [2].

In 2015, Amit Kumar Dwivedi, Yogendra Narayan, Shimi S.L, proposed and actualized of remote-control framework for mechanization of home apparatuses and energy administration utilizing advanced mobile phone. In this framework microcontroller remotely controls the apparatuses by means of GSM module whenever and wherever gave cell arrange scope. Client could screen the power utilization and power charge on its advanced mobile phone whenever and wherever gave GSM scope. A separated equipment module was intended for Power Factor estimation. Voltage is detected by voltage and Instantaneous current is detected by SCT-013 current sensor [3].

1.7 Thesis Structure

A brief review of the contents of this thesis is given as follows:

Chapter 1: discussed the significance of developing proper energy-saving and management technologies; especially, in the electrical domain and to minimize reduce the peak demand, an overview of the energy crisis is given, and the describe an energy metering system and the used nowadays are covered in detail.

Chapter 2: It mentions the theoretical background of the components of smart grids and their characteristics are described in detail. The advantages and disadvantages are labelled as well as several communication technologies. WIFI is covered in detail since it is chosen to be used communication technology in this work.

Chapter 3: presenting the detailed of the done work; the hardware, the software design and the execution of the proposed smart home energy system are described in detail.

Chapter 4: This chapter discusses the results obtained by implementing the proposed system and their discussions are covered.

Chapter 5: concluding the project, summarizing the developed system and future.

CHAPTER 2

THEORETICAL BACKGROUND

In this chapter, it describes the smart grid and their functions. This chapter also covers their requirements before implementation, advantages, and disadvantages. Also, this chapter defines power meter and types also, contains detailed descriptions about smart home and components. In addition, also describes communication infrastructure, Wi-Fi and brief descriptions of networks.

2.1 Smart Grid

A new and fresh idea were called for the concept of the Smart Grid and at the same time, in the late 1990s, this term was known. The example of the primary applied large-scale was, in the early 2000s, established. On older infrastructure and old ideas, a lot of electrical power systems were relied on that, so because of that, this grid was not, for the challenges of the 21st century, performed accurately. The implementation of the first Smart Grid, was accredited by Italy as well as by the company, that known for the country's largest energy, in 2000, like Enel S.p.A. The company, from that time till these days, has mounted, through the country, over 30 million smart meters [16].

Creating a Smart Grid in 2003 was started in the US. It is estimated for connecting the network and a total number of 200,000 equipment's online as well as additional 300,000 were found. Boulder as well as Colorado followed Austin. A lot of countries like the US were affected as well as they early take vital steps for the implementation of the Smart Grid, to bi-directional systems, moved from one-way systems [16].

For applying computer technology, the Smart Grid was considered to be a smart power network for optimizing production, consumption of electricity as well as distribution for promoting the demand as well as the supply between consumers and suppliers of electricity.

To store network status, it is an optimal amount of information. To conserve the equilibrium among power consumption, production flow as well as distribution, smart Grids help for this purpose. The new power system can challenge the concept of a smart grid. Smart Grid includes and composed of sensors, control, communications as well as it has the ability for improving the general functionality of the power system [17]. To enhance maintenance, operations, and planning using new technologies, the purpose of smart grid initiatives was to have a better management of energy costs as well as consumption.

2.1.1 Component of Smart Grid

The objective of applying smart grids is to enable consumers to demonstrate their will to become lively members of the energy market. This is reached by giving them the opportunity to mark superior selections about the energy management plans, which is mostly performed by increasing their awareness [18].

Smart grids also offer suitable energy metering and they contribute to collecting bills from consumers in a more resourceful method [19].

The targeted aim is trying to resolve the peak demand where power generation unit's requirement designed to meet peak demand rather than average demand. The personnel, at utility networks, are continually seeking ways for achieving this objective; including, providing, implementing multi-tariff billing, flexible billing dates, energy demand forecasting, and also enabling remote control connection and disconnection [20].

2.1.1.1 Control Center

The character of the billing center is to assemble energy consumed from each smart meter for the determination of preparing them for billing. Smart grids help the billing center to apply technologies that simplify the billing process compared to that in traditional utility grids. Smart Cart is one of the technologies that was used to simplify the billing process in smart grids, where smart cards had reached an acceptable as compact tools for security, transaction, and identification. It can be used as a credit bank card, which permits it to be used in different submissions. One of the most common applications was used in spending the smart card to purchase

energy. Consumers could purchase energy from any energy dealer whenever and wherever they need, and at a price founded on their previous consumption pattern, which assistance in growing their awareness to an abundant extent [21].

In order to execute these operations, they are planned that the smart grid contains a control center, a billing center or a number of billing centers that collect bills for the amount of consumed energy, a number of smart energy meters, and a communication infrastructure. In this way, to calculate the amount of spending energy as well as interleaving samples of voltage, they are currently being taken. For the current value, the simultaneous voltage was interpolated, while, in the following sequence, the interleaving sample measurements are attained [17].

2.1.1.2 Smart Energy Meter

The smart energy meter is a progressive electrical energy meter that measures the amount of consuming energy of a building, also providing extra specifications while compared to a traditional energy meter. It can read different data, such as current, voltage, frequency, quantity of consuming energy and the price of that energy. The design of a smart energy meter depends on the requests of providers, as well as consumers [17]. Smart grids comparing to traditional utility grids has several advantages that it obtains from some functions that are implemented by smart energy meters, these functions exclude:

1. Calculating the amount of consuming energy with an advanced precision more than the traditional energy meter. Exact measurement of energy consumption is precision compared to the traditional energy meters typically because of the consumption of a processing unit within the design of smart energy meters [23]. There are various methods for calculating the amount of consuming energy in smart energy meters, the voltage interpolation method and the method of using an electrical energy measurement IC are taken under consideration. The voltage interpolation is graphically illustrated in Figure 2.1.

- Voltage sample (V_1) is measured, at instant t_1.
-Current sample (I) is measured, at instant t_2.
- Second voltage sample (V_2) is measured, at time t_3.

- As the mathematical average, the voltage at t_2 is calculated and they are among the samples of the two voltage at t_1 and t_3 as follows:

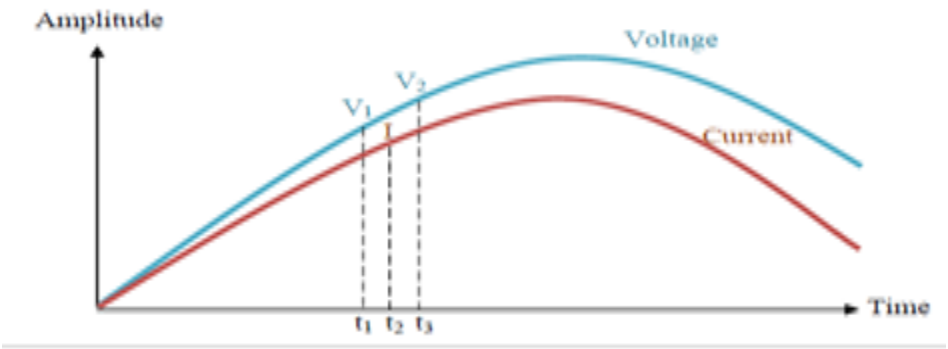


Figure 2.1 Voltage interpolation method for calculating energy

$$V_a = \frac{V_1 + V_2}{2} \tag{2.1}$$

Instantaneous power (P_i) value is calculated by multiplying the instantaneous current value at t_2 the by resultant average voltage (V_a) value.

$$P_i = v_a * I \tag{2.2}$$

Then the quantity of consuming energy (E_C) is calculated by multiplying the sampling period (T_S) by the instantaneous power value.

$$E_c = P_i * T_S \tag{2.3}$$

The sampling period is defined as the static time difference between adjacent energy samples readings. To the number of taken energy samples, the accuracy is related to each period of the power line, less than 1% [23] the percentage of this error, when per period of the power line, a number of eight samples will be the results.

Another method for calculating the amount of consuming energy is by using an electrical energy measurement IC, such as the ADE7755 or ACS712, that outputs a number of pulses with a frequency proportional to the consumed energy, that using to our project.

2. To support multi-tariff arrangement, the multi-tariff system concept can make the energy fee more than demand time periods at peak as well as less at periods of the stress-free demand time. They can strengthen the users to only turn on the required equipment's in the peak time that cost much money, and during a low fee period, to turn on most of appliances for obtaining low bills [17].

3. To Inform the users that spends much energy consumption, it can be clear that meters of smart energy can be, with several technologies, be enhanced such as short message service through mobile communication systems as well as alarm signals. In addition, (GSM) transceivers can facilitate and grow the awareness of the consumers but by house appliances overlapped a pre-specified boundary, the amount of consuming energy will be earlier regularly by consumers [24].

4. Supervisory building devices, where to manage devices, the smart energy meters was planned by, at pre-specified times, turning them on or off. In addition, they are earlier agreed by the users. In falling energy consumption, this can help a lot as well as by exploiting the periods of the relaxed demand time [25].

This function takes advantage of the appearance that building devices can be separated into two types, they are real-time devices that must be turned on whenever wanted such that they consume energy as preferred, and schedulable devices that can be switched on at a later time and still not disturb the relaxation level of the users. The fact that many devices proposal some degree of flexibility regarding when they are operated creates an excessive opportunity for energy conservation [26].

And also, a counter of operation of building appliances was found in smart energy meters according to the peak demand time as well as the importance of the operation of these appliances. To switch on/off the devices, the smart energy meter can be planned with least priority during receiving a message and the available energy can be limited for the restricted amount. The load-shedding manner was the feature where, by the consumers, the series of priority load-shedding is organized, according to the equipment's priority of operation.

5. Increasing the recognition of electricity theft to explain the negative outcome of the theft on utility grids [27].

2.1.2 Advantages of Smart Grid

Additional functions that are executed by the components of smart grids compared to those of traditional utility grids, there are other advantages obtaining from applying smart grids, these advantages consist of:

1. Having support for bidirectional energy movement, while smart energy meters have the capability to control which energy supply to connect to the building, and that's not the situation for traditional energy meters.
2. Amount of exhausted toxic gases was reduced in the atmosphere, where electrical power generation accounts about 25% of the world's CO2 emissions, which is a main reason for global warming, while it was affecting unhealthy for the mankind and the environment [18].
3. Decrease bills, energy losses, and advanced relaxation level for both the employees at utility grids and users.

2.1.3 Disadvantages of Smart Grid

Smart grids do not improve only advantages to the energy market, but they also execute a quantity of disadvantages as well, that include:

1. The smart energy meters did not send only their own data to the control center, but in some communication technologies, they also forward the information of neighboring meters. Thus, a hacker might try to use that data unlawfully, so the smart energy meter is considered as a spy that discloses special data in the point of view of consumers [28].

2. For execute the communication infrastructure depending on the used communication technology, an antenna was used to transmit and receive data, that are side effects to human lives. It might also interfere with the radio frequency (RF) of some equipment's and wireless communication system such as police radios and baby monitors [28].

3. It is found that the performance of the involved IC's within the smart energy meter in about designs will be able to affected by alternates in temperatures to a great extent [29].

2.1.4 Demand Response

Involving users in doing this controlling or shifting energy usage are not significantly reducing energy usage. Most customers use static prices of electricity, which explicitly characterizes the regular cost of electricity generation. Such a careless offer them with no sense as to how electricity production varies with stipulate and time no choices for customers to alter their habits in electricity consumption in reply to demand response signal. Shifting energy consumption from peak hours to off hours for smoothing or dropping peak demand will go a long way towards offering efficiency in the power network.

U.S. Department of Energy represented demand response as: "tariff or program well-known to prompt alterations in electricity use by customers in response to alterations in the fee of electric energy, according to time, or to give reason payments designed to use minor electricity consumption at times of peak market prices or while grid reliability is jeopardized". The capabilities of "changes in electricity use by customers" in the above description are the initiatives of demand response. It comes from that certain kinds of machines with operational flexibility may choose as a candidate for DR. For instance, some appliances (e.g. Clothes washer or dish washer) offer flexibility in the action time, therefore their operational time can be late to off hours [30].

Higher electricity fees within peak hours, denote the use of the additional generation unit and transmission assets to match the demand, can reveal minor energy consumptions marks in the utilization of fewer generation and transmission assets and lower electricity invention costs, and as a consequence lower electricity price. Moreover, the emergency demand decrease at the time of system contingencies can help operators handle the grid mitigate the possibility of blackouts and more efficiently. Due to the lack of possibility of keeping the electricity to match the supply, demand and the probability of significantly changing the grid situations in real time require the grid arrangement in several years for providing a reliable equilibrium of demand and energy sources, as well as asset availability. Grid operators can holder The demand via demand response mechanism by shedding or shifting loads, in lieu of increasing the generation capacity. [31]. Two types of DR programs: DR programs is the first motivate [32], where the home devices are

remotely moving to off state by apply with a short warning when the top is delivered in whenever interval. The second kind is Price-based DR programs where the electric energy supplier motivates the consumer to control their appliances at home in an effective mode for charge saving, reduce of electricity consumption [33]. Due to development in communication and computing skills, smart homes play a very vital role in decreasing energy consumption in houses. [34].

Furthermore, 10-30% electricity can be kept by scheduling of home uses by DSM approach, while smart grid is coupled with the smart homes [35], According to [36] to cut a load in peak hours different dynamic pricing systems are proposed for consumer motivation. Dynamic pricing structures consist of Time of Use (ToU), Real Time Pricing (RTP), Critical Peak Pricing (CPP), Critical Peak Rebate (CPR) and inclined Block Rate (IBR). However, when customers move the power utilization from top hours to off-crest hours, PAR goes to impractical. Several researchers offered different methods to resolve this problem. The fundamental focal point of works was to decrease the power cost, comfortably for control appliance and reduce electrical usage in peak demand and communicate real time with smart grid to reduce or increase power.

2.2 Historical Development of Smart Homes & Buildings

For many years, this idea for smart homes was presented to let persons to control, over intelligent controller, the HVAC, lights, gate as well as a lot of households. It was so hard to be established, namely the smart homes as well as buildings, before early 20th Century due to the limitation of electronic, electric, communication, computer and control techniques. Beside with the commonality of electrical appliances like, wash machine, TV in addition to HVAC in the time by 1920s-1960s, to have a solid physical basis, the creation of smart homes has been begun. Following that, for home appliance the, first communication protocol, through power line was X10, that it was established in 1975, purpose to invention to help persons simply manage their household appliances. The house appliances can be controlled and monitored using the 22-bit lengthy data package transmitted through the power line. Since 1980, the acknowledgment of working home devices through the varying interface on the PC is seen as the fundamental of smart home. Late 1990s, with the skipping up of ICT, the wireless communication, telecommunication, and Internet

technique were capable of integrated into the smart home systems in succession [35-40]. A number of wireless communication protocols for household devices such as LON Works, Cebu's, WLAN (IEEE 802.11), radio frequency and Bluetooth, were developed during the last ten years in 20th century. However, the costs of microcontroller, PC and correspondence parts were costly to be utilized in smart home framework in the most recent decade, which confines the presentation of the smart home framework into run of the mill individuals' life. In advance frame the 21st Century, as a result of the snappy improvement of ICT and drop in cost of related electronic parts, the smart home and smart home related products, for example, programmed lighting frameworks, remote power socket, and thermal controllers, wound up moderate for ordinary clients [40-42].

Also, in 2008, the idea of the smart grid was put by the previous USA president Obama as well as, in the house a self-monitoring, cost-effective and environmentally-friendly power network, goaled for this purpose with renewable energy techniques as well as the help of modern IT by creating smart grid to become analytically good-looking for both academic as well as industry. In Iraq the idea and application of smart home in the beginning steps. It is cost remarking that the modern smart home is labelled as the terminal link between smart grid and customers since the smart grid was planned. Therefore, it will not only regard as a home automation system, but also as a control of other distributed energy resources such as renewable energy revenues. With the addition of smart measurement, manage and IT techniques and other progressive, the smart home will be capable to support the renewable energy systems and achieving end user's adjustable tariffs and other power facilities from the smart grid standpoint, agreeing to the predicting of smart home market by market expert companies, the market size of smart home products containing smart measuring, sensors and other components will touch $44 Billion in 2016. A great number of leading companies, such as Microsoft, Google, Apple Cisco and GE, have in progress to launch and develop their products of smart home in demand to occupy the & building market & smart home [43-45]

2.3 Definition of Home Load

The load description is necessary to recognize potential control solutions, as by using a good recognition of energy loads, the system acquires more context

awareness. It is not obligatory that all the electrical loads are known by the smart control, but the more data the system has, the better it can react. The definition of loads can be reached through two-way communication between the sensors and the controller in housing. Really the definition of load explains the intelligent modeling as a knowledge base. The load definition contains classification of equipment's. A possible load sorting is given in Table 2.1 [46].

- Permanent loads: denotes to the electric power consumed by that equipment's that are constantly switched on in a full day like refrigerator. These loads can also call non-manageable loads because they cannot be controlled for the sake of the other factors.

- Priority loads: some loads have the priority to be switched on when they are necessary for their normal running for example dryer, iron, and lighting etc.

- Shift able loads: There are some electricity loads that consumers do not want to supply immediately and can be shifted to periods with lower electricity price and less demanding. Shift able loads can be further sub-categorized into loads Time and Power-Shift able [47].

- Time-Shift able loads: These loads, such as the dishwasher and washing machine can shift the power consumption time to a favorite working period.

- Power-Shift able loads: The Power-Shift able appliances can also have called interruptible loads, such as the plug-in electric vehicle and water boiler and (PEV) chargers, these loads can be switched off or on numerous time a day, conditional on management program.

- Standby loads: Denotes to the electric power consumed by electrical and electronic appliances when they are in a standby mode or switched off.

This happens only when some equipment's asked for to be "turned off" on the electronic interface, however in another state from turning off at the attachment. Backup control utilization means 4-15% of collective power custom in many homes [46]. A basic application is to turn off loads in backup in one of occupants at home for some time depending upon the controlling program.

Table 2.1 Definition of load for smart home [46]

Type	Definition	Appliance Include	Control
Priority	Normal loads that must be provided when it is required for their typical running.	Lighting, communication devices, dryer, oven, iron, office-equipment, ventilation, cooling devices, etc.	No control
Shiftable	Loads that are able to shifted in time.	Washing machine, dishwasher, storage heater and water heater, pumps, etc.	Move the load starting to a best moment for the energy system.
Permanent	Equipment's that are always switched on.	A/C, Fridge, freezer.	No control (green devices or specific solutions).
Standby	Appliances that have utilization in backup mode and stay in reserve when individuals are gone.	oven, cooker, white goods, office devices, entertainment (TV, DVD, etc.).	Open/close electrical supply depending on occupancy (or in sleeping periods).

2.4 Communication Technology Used for Smart Home and Building

Home automation is becoming more common due to the more growths in hardware which have minimized the improved capabilities and cost. The monitoring and control system are the cornerstone of smart home and buildings because it to enable take charge for controlling and communication the home appliances, renewable energy system and other devices inside the home.

There are a number of unlike systems existing in the market right now, which it uses a different communication technology for monitoring and control appliances for smart home. In this section, will present the two main communication techniques that used for creating monitoring and control scheme of smart building and home, that it is wireless and wired communication system.

2.4.1 Wireless

WPAN systems are proposed selections for setting up the screen and control arrange in homes and structures due to their economical, simple to-introduce and basically to-look after highlights. The system size and information stream transmission speed of most WPAN procedures completely fulfill the requests of individual buildings. Today there are various WPAN strategies existing in the market for savvy homes/structures, which are point by point in the accompanying table with their principle displayed Table 2.2.

2.4.1.1 Z-Wave

It can be a "wireless communication standard" that was authorized to the clients by Zensys Ltd, and, it was intended to meet the monitoring of remote observing and overseeing highlights for home devices in private or little business places. Contrasted with the IEEE 802.11 standard based WPAN, the Z-Wave can just transmit up to 100kbps inside its involved recurrence run, which is genuinely little. Also, a most extreme of 232 hubs can be controlled in a Z-Wave organize and the greatest correspondence removes in point-to-point for an open region is about 30 meters. In this way, the savvy building arrangements created by Z-Wave ought not to cover high information bundles and numerous devices [47-49].

2.4.1.2 ZigBee

It is a wireless communication utilized for development WPAN dependent on the standard IEEE 802.15. Appreciations to the simply automatic networking features and low power consumption, ZigBee has been generally implemented in home automation for controlling and monitoring purpose. Also, in ZigBee, the range of the nodes, can be between 10-100 meters. Also, in ZigBee, the communication distance of the nodes, is between 10-100 meters, and by implementation as well as a suitable design, it was enhanced like "the mesh network topology". It can be clear that the mesh network topology has the ability to transmit, through any separate routers, the data within the ZigBee network. The network of ZigBee can be large (support up to 65536 nodes) to fulfil the requirements of buildings or home with a huge number of equipment's. As unlike frequency channel necessary by altering countries, the

ZigBee network operate in 3 classes of frequency: 2.4 GHz, 915MHZ, 868 MHz which, to the various maximum data transmission rate, match and it is 250 Kbps.

Table 2.2 Wireless technology kinds used to smart home[48]

Features	ZigBee	Z-Wave	WIFI	Bluetooth
Standard	IEEE802.15.4	Zensys	IEEE802.15.1	IEEE802.15.1
Frequency(Hz)	915M/2.4G	900	2.4/5G	2.4-2.485G
Distance (m)	Up to 100	100	Up to 92	30-100
Data Rate(bits/s)	Up to 250kbps	Up to 100kbps	Up to 96.3M in 2.4GHz	Up to 24Mbps
Number of Network	64,000	232	255	7
Power Consumption	Approx.1mW	< 1mW	>20mW	>2mW

2.4.1.3 Bluetooth

The information rate of Bluetooth might, in the early period, achieve 3Mbps yet now up to 24Mbps. Due to the growths in data rate and power consumption, the technique of the Bluetooth can be applied for many techniques as well as even for the mobile system, in contrast, in these days, there are the and health systems, safety as well as the entertainment. The Bluetooth was presented by the researchers to build, during the early 21st century, solutions for smart home. Due to the quite high price, minor capacity of networking devices and communication distance is short, recently the technique of the Bluetooth is, with Z-Wave, ZigBee, hard to be competed. [50].

2.4.2 Wired

The wireless technology cannot fulfill all the desires of home automation by the stability, many factors like the communication distance, especially for the commercial buildings or large houses with having a large number of network-connected appliances, wireless techniques are difficult to hold many devices because

a number of sub-networks should be implemented. In order to manage the sub-network and handle the fairly great data packages, the wired communication technology is significantly noticed because of its reliable and higher bandwidth, we define some kinds of this technology:

2.4.2.1 Ethernet

It is used for local area network (LAN) and it is considered a common communication technology. With the Ethernet link, for example, (UTP and STP) and Fiber optic links, the PCs and some of the devices that having Ethernet card is having the ability, in the LAN, to speak to one another reach to, Mbps speed, (10,100 and 1000). In the smart home and building arrangements, the Ethernet is seen as the data 'motorway' to convey/collect the information bundles from/to the sub-systems. A growing number of office appliances and the devices of home entertainment, media console, printer as well as scanner include equipped Ethernet specifications. They have the ability for connecting, solutions without additional charge, the Ethernet-based smart home/build.

2.4.2.2 PLC

The PLC technique is suggested for the customers who only need simple features of home automation with fairly cheap solution, The PLC operate with 50 Hz AC control line as the information carrier to transmit the information inside the 5-500 kHz. Since the entire world uses the AC control links in the building and houses, there is no need for advancement or making correspondence, organize aside from some handsets on AC electrical cables for the PLC task. To define a PLC, arrange in homes and structures, there is a measure of systems administration innovations and related systems administration machines economically existing in the market now, for example, Home Plug, INSTEON, X10, IEEE1901, and PRIME.

2.4.2.3 BACnet

BACnet based on communication network can control and display the situations of devices (such as HVAC, lighting, entrance guard and in the building) intensively. It was at first planned for HVAC control and has turned into the main convention in the concentrated HVAC framework. With developing interest of controlling different

devices in the building, also BACnet has been effectively connected in an incredible number of structures. Devices in the PIC family come with many types of development tools, are easy to find, remain relatively cheap, and have good documentation [51].

2.4.2.4 X10

As a worldwide general point convention and an accepted open standard for Power Line correspondence, X-10 [32] is helpful to all parts of home robotization including house observation and security, indoor lighting control, home device control, house meter gets to, etc. It misuses the flow family unit electrical wiring to transmit advanced information between X-10 permitted devices by encoding information onto a 120 KHz control transporter through the zero intersection (a period when the electrical flow streams in an invert bearing and along these lines the unidentified clamor decreases to the slight dimension) of the 60 or 50 Hz Alternating Current (AC) control wave, in which case one piece is transmitted at each purpose of zero intersection.

2.5 Wi-Fi

Wi-Fi IEEE is the 802.11 standard protocol for the Wireless Local Area Network (WLAN), it is the flexible data communication system applied as an alternative or an extension to for, a wired LAN within a house, campus by using electromagnetic waves. WLAN receive and transmit data above the air for reduce wire networks, installation cost and time saving, WLANs combine data connectivity with client mobility and enable portable LANs over easy configuration [52].

The common of future wireless LAN development is estimated in corporate enterprise, the institutions that are educational, conference rooms, public areas as well as office spaces, for WLANs, are likely venues. The Institute of Electronics Engineers (IEEE) as well as Electrical institute will, in 1997 as the standard, rectified the original 802.11 specification. After a brief description of WLAN, we describe the type of WLAN and specification of it [53].

2.5.1 WiFi Kinds

According to a presented time and speed, Wi-Fi technology is able to be classified into IEEE802.11a, IEEE 802.11b, IEEE 802.11g, and IEEE802. 11n.IEEE802.11g and IEEE802.11b are more popular types. The first wireless network standard and commonly used to compare to others standards Wi-Fi standard is IEEE802.11b. Its peak bandwidth is 11Mbps, it can be adjusted to 5.5Mbps, 2Mbps and 1Mbps While the signal is not strength or there are interferences. The auto conditioning of bandwidth efficiently guarantees the reliability and stability of the network.

IEEE 802.11b less throughput than IEEE 802.11a. It runs in the 5GHz frequency band and it has a good ability for anti-interference while it cannot be friendly or compatible with IEEE 802.11b and IEEE802.11g [53-55].

IEEE 802.11a coverage area is small (only about 30m indoor) compared to 2.4 GHz band because having more frequency band. The comparison of Wi-Fi technology standard is shown in Table 2.3.

2.5.2 WIFI Features

The features and advantages are mostly reproduced in the following characteristics [57-58]:

(1) Broadcast distance. The radius of 802.11nstandard is up to about 1000m.
(2) Transmission speed, the speed can extent 600Mbps, which meets the personal and social needs.
(3) Compatibility with other services. In above the second layer of Wi-Fi technology are fully reliable with the Ethernet.
(4) Advantageous to form the system. Clients or devices with the WLAN system connector can be normally to enter the system. Consequently, it is truly appropriate for home automation.
(5) The transmission power of IEEE802.11 is about 60-70mW.

2.5.3 Channelization

It is known that wireless can suffer more from one reason to another and it can be a phenomenon take place in the time, in close proximity, the two wireless systems has

the ability for, in accidental manners, receiving or hearing in each other's transmissions. Like a crowded room, it is hard to distinguish a person or we can say the talker that can be much less than it was said. The same happens when several wireless systems are, at the same time, all trying to connect. In the 2.4 GHz band, several clients were there that share a section, that are very small, of the unlicensed band and as a result, it can be interference as well as noise abound. The standard channel width for 802.11b is 22 MHz, as a result, this band the existing channel that can be just 11 channels. Channels do overlap with each other except three channels are 1, 6 and 11, it related to the channel spacing, it means that the center frequency of the channel and the 11 MHz of the band that is used on either side crosses over the adjacent channels

Table 2.3 WiFi 802.11 types [52]

Standard	**Frequency Band(GHz)**	**B.W(MHz)**	**Modulation**	**Channel Arch.**	**Data Rate (Mbps)**	**Range**	**P(mw)**
802.11	2.4	20	BPSK to 256 QAM	DSSS, FHSS	2	20 m	100
b	2.4	21	BPSK to 256 QAM	DSSS	11	35 m	100
a	5	22	BPSK to 256 QAM	OFDM	54	35 m	100
g	2.4	23	BPSK to 256 QAM	DSSS,FHSS	54	70 m	100
n	2.4 & 5	24 & 40	BPSK to 256 QAM	OFDM	600	70 m	100
ac	5	20,40,80 &160	BPSK to 256 QAM	SC, OFDM	6930	35 m	160
ad	60	2160	BPSK to 256 QAM	SC, OFDM	3760	10 m	10
af	0.054-0.790	6,7,8	BPSK to 256 QAM	SC, OFDM	26700	>1 km	100
ah	0.900	1, 2, 4, 8, & 16	BPSK to 256 QAM	SC, OFDM	40	1 km	100

.For example, channel 1 on 802.11b stretches up to overlap with channel 5,4,3, and 2. channels 1, 6 and 11 are the only no-overlapping available channel. Any other cause your devices to interfere with themselves.

In Figure 2.2, on 11, 6 and 1, the canals centered are impossible to touch or even to overlap. At the same time, they are difficult for making interference, in contrast, the channel 2 as well as 1 clearly can overlap, thereby producing poor performance. In some cases, the interference reasons the failure for two devices to connect with each other. 802.11a offers additional capacity because working in standard 20 MHz channel mode, all channels are operating without over-lapping, because of the more band available, there is a higher acceptance by vendors and more flexibility with 802.11a. Using the standard 20 MHz channels, the non-overlapping channels which available will be 11 ones.

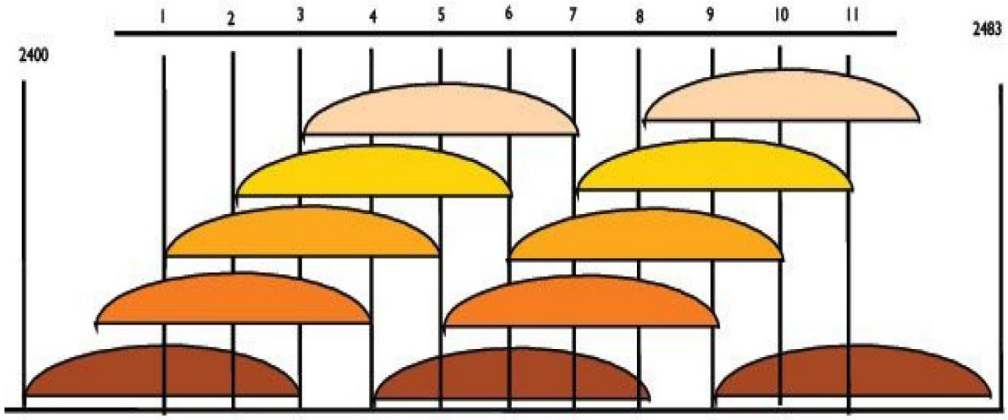


Figure 2.2 WiFi 2.4GHz channels

The usable turbo, that are 5, can be concurrent with 2 channels of usable standard on the other hand, to use turbo channels will be 40 MHz . In turbo mode, by utilizing 802.11a, it will decrease the available channels to be half, so the reason is that every turbo channel will, in its place of the standard 20 MHz, be 40 MHz .

2.5.4 WiFi Security

It is not just a button that we can push it as well as go away to feel comfortable as well as safe. Rather than, the accurate secure that the system has, for a layered methodology, the more layers that it has. In addition, it was stressed that one layer of

that security can be a charge in addition, on maintain as well as performance capability, the price was paid. Many layers, the more try is for a potential hacker to catch in and the more effort is for a user to maintain. There are many ways, it was discussed, to layers of secure wireless network as well as a result, they will be easily applied as follow:

- Encryption – WPA, WEP and WPA2 are some types of encryption protocol that supported in Router operation system for encrypting the transmission data.
- MAC Filtering – Governing access at the MAC layer. It so difficult to the station to associate; therefore, it will be so difficult to reach the network.
- Proprietary Protocols – selecting NV2 or Nstreme is a method to control access to the network. The hacker will have to use Router operation system to gain access and statistically, these benefits progress our odds of a resisting attack [59].
- To hide SSID – Simple method, in spite of its effectiveness in saving the network of the wireless, for many unexperienced clients, away from it, in contrast, the real hackers might not slowly run.

2.5.5 WIFI Application

Wi-Fi innovation was conceived toward the finish of the last century; it has advanced for over ten years. It was first application for indoor situating in 2000 [57]. With the advancement of cell phones with Wi-Fi, its area innovation is slowly stretched out from the indoor to the outside. In 2009, Nobuo Kawaguchi in Nagoya University presented Wi-Fi-based situating innovation into subway information frameworks. He likewise presented the examines and uses of inside and outside Wi-Fi area innovation. So far, Wi-Fi location technology has extendedly applied in the medical system. The medical doctor is able to quickly get the patient's facts and checking patients in real time by Wi-Fi network. Today Wi-Fi technology is integrated into most digital products, as the idea of a smart home is recommended, a variety of products, such as televisions, DVD players, digital sound box, projectors, electrical switch, smart plug also have adopted Wi-Fi technology. These appliances can be associated with the serves like microcontroller or computers via Wi-Fi network so as to realize digital and wireless of the whole home. [60-61]

2.5.6 Bridged Versus Routed Access Points and Stations

After definition hardware definition of WIFI, types and specifications in this section, we described the configuration kinds for WIFI.

For wireless devices, two main methods of operation were here; routed and bridged, it can be clear that the configuration of wireless components is likely the same, but there are differences that need to be understood and clarified.

2.5.6.1 Routed

It contains several interfaces, as a result wire or wireless. In a routed wired, no layer 2 to connect among the interfaces in addition to, the denotation for traffic to permit among the interfaces, the device needs to follow routing instructions to control packet flow. Entirely packets must track the firewall rules, routing rules, and numerous queue guidelines.

2.5.6.2 Bridged

It is included multiple interface, and all of them, that are physical, are together, into a logical interface named bridge, combined. The physical devices are interconnected through a bridge interface in layer two, such that any packets received one interface permit easily out the other interface on the bridge while has not bridge firewall. In the configuration of an Ethernet interface joined to a wireless interface. Bridges are a suitable configuration, easy to produce a network, but it is not scalable and rapidly expands itself, could not linking together two bridged devices, either directly or through a switch. [56].

2.5.6.3 Point to Multipoint

Point-to-Multipoint wireless bridge approach can combine an amount of LAN or clients into unique such as a number of appliances in a smart home. This technology usually proceeds a network as the central station. The other remote node receives signals from the central station. Helpful to recover the weaker of wireless signals and Point-to-Point wireless bridge typical contains of a pair of wireless bridge and a couple of outside aerial. Directional antenna is more stable for wireless system and two wireless antennae can be seen each other (line of sight).

2.6 TCP/IP

It is a suite of communication protocols applied to interconnect network nodes (router, switch ,pc, server ,…) on the private or public networks such as internet or can be used as a communications protocol in a private network .A protocol is an agreed-upon set of proceedings and guidelines, such as two nodes track the same set of rules and the same protocols they can make a connection easily and exchange information. Common protocols of our suite are TCP and IP.

TCP divides a file or message into packets that are transmitted through the internet and then collected when they reach their destination. IP is responsible for the address of each packet so it is directed to the right destination. TCP/IP was presently advance, while the OSI standard was accessed in 1984. The TCP/IP show isn't actually the indistinguishable as OSI demonstrate. TCP/IP is a four layered standard, however OSI is a seven-layered standard. TCP/IP has four main layers: application layer, transport, Internet layer and network access layer [62-63].

2.7 VPN

Virtual Private Network tunnels (VPN) are a technique of crossing various networks in a way to permit two network nodes to interconnect with one to another if they were on the identical local area network. It can be explained like that, we will a very congested room noisy people and two persons on reverse corners of the room that want to talk with each other. By extending a pipeline from side to side the room and each one talking into or heeding to the end of the pipe, noisy room is the public Internet, the traffic transceiver the same path as other traffic through the Internet, but would be encrypted and encapsulated that is shown in Figure 2.6, this is named a VPN tunnel.

When the packet receives in destination at the far-end of the tunnel, it is unencrypted. The common use of VPN’s is for remote hosts to dial in an office network, or using smart home, thereby permitting the remote device to touch home appliance such as light, air condition, water heater, etc., One more use of VPN tunnels is to join two networks over the public Internet. A company may have two or more branches in the world and by using VPN tunnels, they can connect completely branches together [64].

2.8 DDNS

It is a method by which the server's name in the Domain Name System (DNS) is automatically refreshed or updated with the custom domain name and the ever-altering IP addresses. When use the dynamic IP the DNS method is helpful, while the IP address is mapped to a domain that variations common, but in a case of static IP address DDNS is not necessary. In general static IP address for big enterprises, but a dynamic IP address is achieved to homes or small business users.

2.9 Conclusion

In a word, this chapter talks about the advantages as well as disadvantages, concepts, structure, definitions of the Smart Grids. They talked about Smart Homes and their challenges that has a relation for that field. It can be clear that the techniques of the Communication, for home automation, used They discussed the applications that aforementioned previously. Finally, some terms of the network, relating for the implementation of smart home was clarified.

In this chapter, concluding by saying that to implement the smart home, various efforts were made for this purpose as well as by applying various methods for smart home for reduce costs, for implementing energy management, in addition to maximize life efficiency. Anyway, lacking access to the Internet as well as lacking some infrastructures everywhere might be because of the problems that limit the spread of this technology, a new solution to these problems were proposed in the next chapter.

CHAPTER 3

METHODOLOGY

In this chapter, the planned hardware design and implementation of the smart home metering system are defined in detail. The system contains SHEMS and monitoring, control center. SHEMS and the control center consist of interconnected units, where the designed units are given with their practical implementation.

Also in this chapter, the proposed software proposal and implementation of the energy management of the smart home system is described in detail, where both of the SHEMS operations and the control center processes are described in detail and presented in flowcharts.

3.1 Hardware Design and Implementation

The developed SHEMS is a system that measures and calculates the quantity of used energy by the buildings, according to the time of consumption, the mode of operation prepares it for billing, displays related information to consumers for increasing the awareness, and switch on/off the power of the buildings when required.

3.1.1 Smart Home Energy Management System Design and Implementation

The proposed model of energy control and management for the smart home system is organized using low-cost hardware so as to make it affordable for tier 2 as well as tier 3 people too. It involves various sensors like the temperature sensor and humidity sensor, current sensor it also includes a load and display to notify people nearby in case of emergency. The planned system is controlled by ATMEGA328P microcontroller. The purpose of using this microcontroller is to make the system inexpensive and reasonable. The microcontroller accumulates data from the sensors and makes a decision accordingly and if it detects any interruption in the sensors or

any suspicious data it directs immediate notification to the homeowner. If the temperature rises above a certain level or the water temperature go high, it notifies the owner and automatically turns off a device.

Hardware system contains sensors, the microcontroller (ATMEGA328P), Ethernet shield, the display unit (LCD), router and also include a relay for output control and indication lamps, as is shown in Figure 3.1.

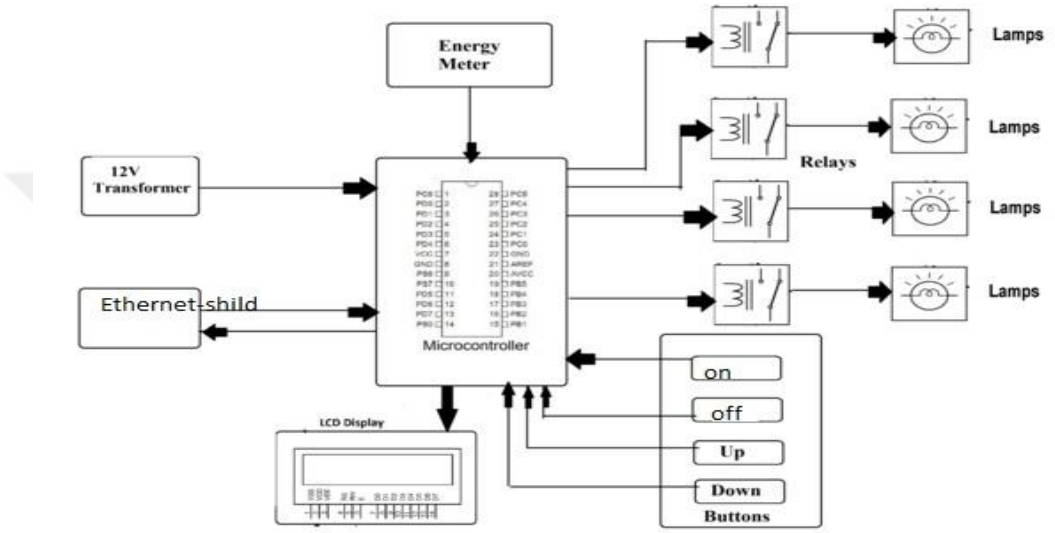


Figure 3.1 SHEMS architecture

The analogue inputs such as outputs of the current sensor, voltage sensor, air temperature, and water temperature sensors are connected to the analogue pins of the microcontroller, as these sensors will give some numeric values according to which the decision will be taken by the microcontroller, and the digital output of the sensor is linked to the digital input of microcontroller such as switch or push buttons. The sensor will be installed inside the room to measure air temperature and the temperature sensors inside a water tank. Sensors will monitor continuously the temperature if the reading exceeds the defined limit it will notify a user and switch off equipment's as is shown in Figure 3.2.

The analog sensor such as current sensor and voltage sensor is used to measure the consuming energy for house notify online energy consumption and announce homeowner about price usage and monthly consumption. Also, the project contains

six digital inputs that called buttons that used to turn on and turn off the lamps manually via a relay. In addition, it has five lamps that represent five digital outputs, control via push button manually or via operation mode automatically, and finally in the next sections we clarify the equipment's or devices that used to implement hardware design.

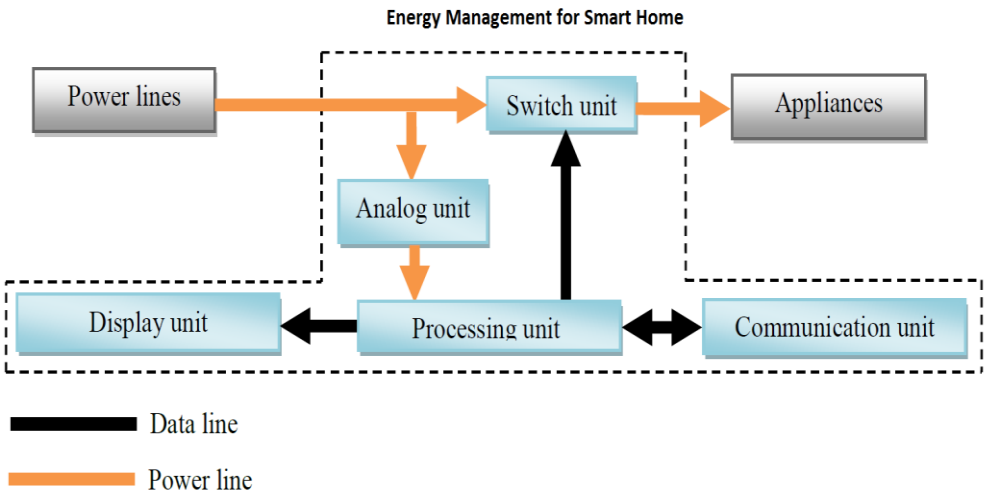


Figure 3.2 Input/ output detail

3.1.2 Arduino MEGA2560

The processing unit is the brain of the SHEMS in the project. Microcontrollers can be circuits of electricity which programmed to perform an enormous range of tasks. As timers, they were programmed or for controlling a manufacturing line. Such as alarm systems, phones and even computer control systems most electronic devices were used as well as indeed, nearly any device of them. A lot of them "microcontrollers" are available. The proper microcontrollers can be found in the Arduino range of programmable microcontrollers.

The Arduino Mega 2560 is a microcontroller board built on the ATmega 2560 as it shown in Figure3.3. It has 54 digital output and input pins, which 14 pins can be used as PWM outputs, a number of analog input are16 inputs, 4 UARTs (hardware serial ports), a USB connection, crystal oscillator frequency is at 16 MHz, a power jack, and a reset button. It contains all required to support the microcontroller; simply connect it to a computer through USB cable and supply power by AC-to-DC adapter

or DC battery. Specification of Arduino Mega2560 Microcontroller as it shown in Table 3.1.

Table 3.1 Arduino mega2560 specification

Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 14 provide PWM output)
Analog Input Pins	16 DC Current per I/O Pin 40 mA
Clock Speed	16 MHz
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB

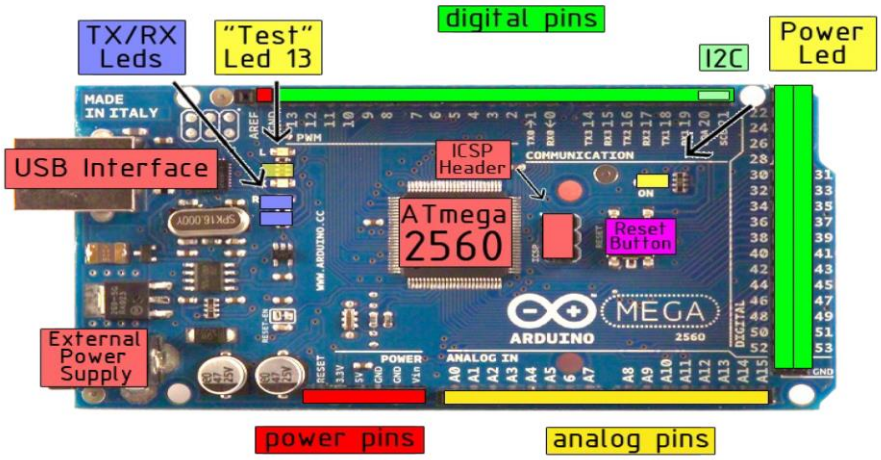


Figure 3.3 ARDUINO MEGA2560

3.1.3 The Sensors

A sensor is a device that faculties and answers to some kind of contribution from the physical condition. The particular input may be heat, pressure, moisture, light, motion, or other environmental phenomena, the output signal of the sensor that is converted to readable display or changed electronically through a network for reading for further processing as it shown in Figure.3.4.

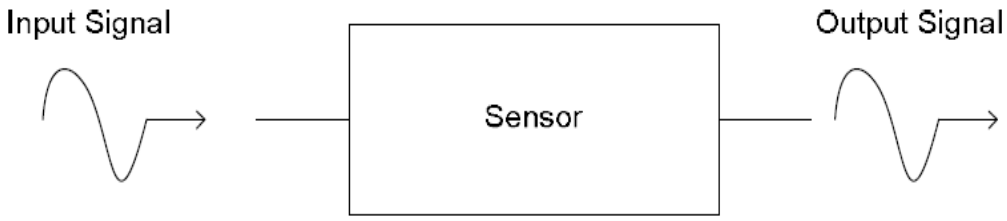


Figure 3.4 Sensor definition

An active element of a sensor is named a transducer. A device which adapts one form of energy to another [65].

While input is a physical amount, and output is electrical → Sensor.

But when the input is electrical and output a physical amount → Actuator.

Normally utilize typical kinds of sensors in a few electronic and electrical applications, which are named temperature, synthetic, weight, position, drive, vicinity, nearness, car, speed, sound, warm, stream, optical, attractive, electric, warm, fiber-optic sensors, simple and computerized sensors.

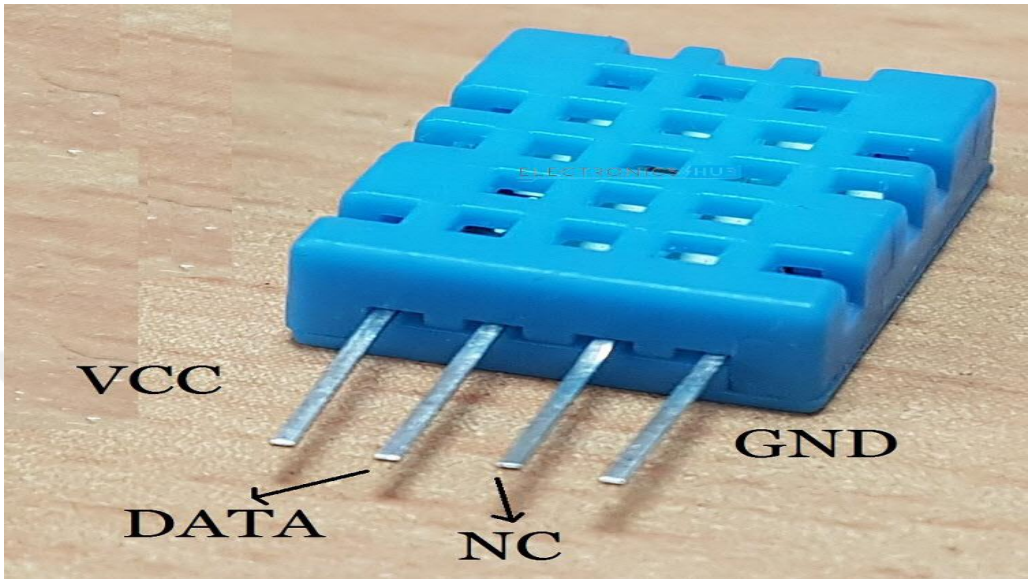
This non-discrete output signal created by the analog sensors is relative to the measured. There are various kinds of analog sensors are as follows: current transformer (CT), voltage transformer (VT), light sensors, sound sensors, pressure sensors, temperature sensors, and so on.

In digital sensors, the signal estimated is specifically changed over into advanced signal yield inside the digital sensor itself, and this advanced signal is transmitted through link carefully. There are individual kinds of digital sensors that beat drawbacks of simple sensors and example of digital sensor like digital temperature sensor, humidity sensor, inductive and capacitive proximity sensor and so on [66].

3.1.3.1 DHT 11

The DHT11 is a properly simple use and low-cost digital humidity and temperature sensor. It was used as capacitive thermostat and humidity sensor for metering the close air, and output was a digital signal on the data pin (no analog input pins required, every one second sends only one date or we can say sampling rate is 1 Hz. And finally it has a private single wire protocol, which needs precise timing and it

has a singular library for describing DTH 11 [66].There are temperature integer data, fractional temperature, humidity integer data, humidity decimal data, data and bit parity bit all in 8-bit form. It has four pins, GND, VCC, Data pin and NC Pin. A pull-up resistor from 5K to 10K Ohms is vital to save the data line as it is shown in Figure



3.5.

Figure 3.5 DHT 11 pin layout

3.1.4 Measurement Block for SHEMS

The power source reaches the house appliances through the smart energy meter first as shown in the block diagram in Figure 3.6.

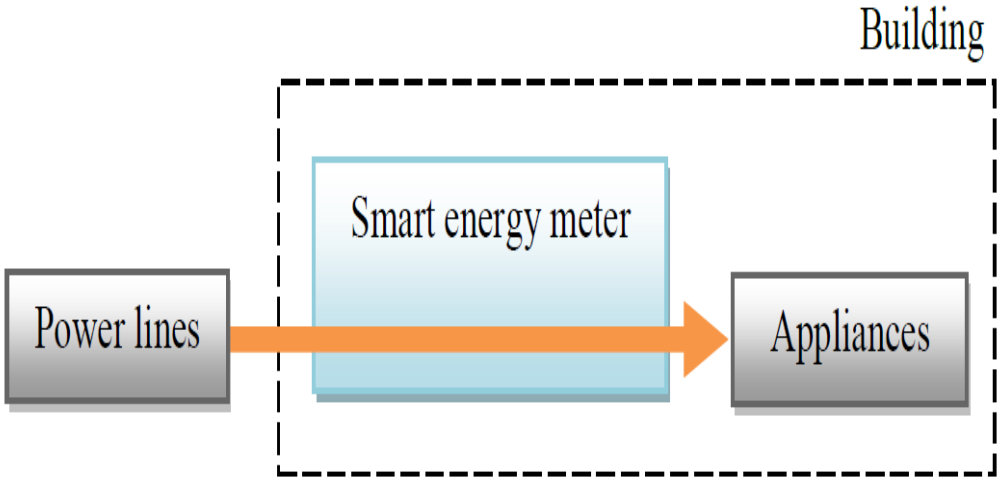


Figure 3.6 Block diagram of power connection

The metering unit is responsible for computing the quantity of power consumption of appliances connected to the main distribution and forwarding it to the processing unit for the necessary computation to be done with it. The microcontroller uses the voltage and current sensor to measure average active power consumption after converting the voltage to the value that it can connect to microcontroller analog pins in another word not more than (5) volts.

The Analog Devices ACS712 sensor was chosen because of its good performance and easy to connect an analog pin of a microcontroller as shown in Figure 3.7.

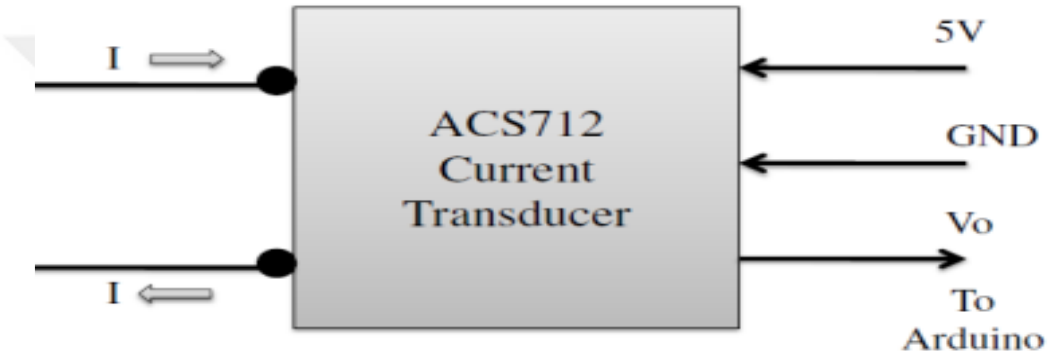


Figure 3.7 ACS 712 pin layout

For energy measurement in a house, ACS712 provides precise solutions, economical for AC or DC and simple implementation by the customer. Usual uses include current measurement for a house, load detection and management, motor control, overcurrent fault protection, and switched-mode power supplies. It can be seen that an exact, low-balance, that device was having as well as, with a copper conduction way, the direct Hall sensor circuit. It was located near the surface of the bite. By that copper conduction, connected current moving will be running as well as way yields an attractive field. It, by the incorporated Hall IC, was discovered. inside a corresponding voltage, it was altered. The device output is having a positive slope (>VIOUT (Q)) when we add, over the primary copper conduction path, current flow (from pins 1 and 2 to pins 3 and 4), which, for current sensing, was utilized. The internal resistance of this conductive path typically is 1.2 mΩ and low power loss providing. The terminals of the conductive terminal are electrically separated from the sensor (pins 5 through 8). This enables the ACS712 current sensor to be utilized in applications requiring electrical separation without the utilization of opto-isolators

or other expensive disconnection systems [67]. For calculating the amount of consumed energy, the microcontroller measures two parameters,

Instantaneous voltage and instantaneous current for the instantaneous voltage measurement, first the voltage is converted from its -312 to 312 volts peak to peak value to a -12 to 12 volts peak to peak value, this is performing by step down transformer.

To convert high voltage to low, need to step down converter or transformer. The supply voltage 230V AC power is transformed into 12V AC (12V RMS, peak value around 17V), therefore, 17V AC power need be converted into 17vdc because, the analog pin of microcontroller measure and permit equal or less than 5V DC then it can be minimized to the 5V DC. AC voltage can be converted into DC by rectifier or bridge circuit. There are various kinds of rectifiers, for example, half-wave rectifier, full-wave rectifier and extension rectifier. The extension rectifier is usually utilized for changing over AC to DC [68].

The four diodes are connected to gather such the shape of a bridge. The diode is an uncontrolled rectifier which will direct just forward bias and won't lead amid the inverted bias. The diode called forward bias If the diode cathode voltage less anode voltage, during a positive half cycle, during negative half cycle diodes D1 and D3 will

Conduct while diodes D2 and D4 will conduct. In this way AC can convert to DC; the achieved voltage is not a pure DC as it contains of ripple. So it is called pulsating DC power, drop voltage through to the diodes is (2*0.7V) 1.4V; then peak voltage reduced to 15V (17-1.4) approximately as it is shown in Figure.3.8.

The pulsating DC voltage can be smoothed or filtered by using a capacitor filter or an inductor filter or a resistor-capacitor-coupled filter for smoothing the ripples. When the input increase from zero to max value the capacitor does store energy and while the supply voltage decreases from peak to zero the capacitor start discharging, this process continuously occurs and cause to remove ripple and achieve pure DC voltage. The capacitor is an energy keeping component. In the circuit, the capacitor stores energy from zero to a peak value, the input will be increased, on the other hand, from the peak value to zero, the supply voltage will be decreased, in this case a

capacitor might discharge. It will make the pulsating DC into pure DC namely that discharging as well as the charging of the capacitor. In the end, the voltage will be low via a voltage divider to less than 5 DC voltage.

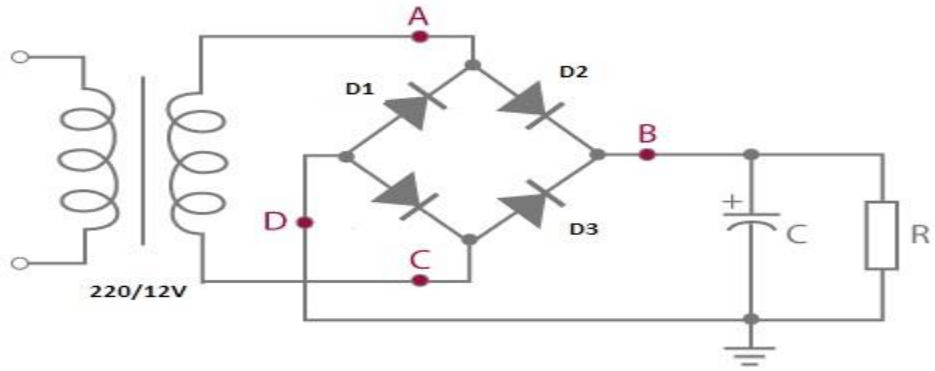


Figure 3.8 AC to dc converter

It was clear in the internal design of the used microcontroller that ADC blocks were implemented. Because of the instantaneous current measurement as well as the instantaneous voltage measurement were, in direct manner, fed to the microcontroller analog input as a result, it can simplify the design.

3.1.5 The Relay Shield

Relay subdivided into two sections: inputs and outputs as appeared in Figure 3.9. The information area has a coil which yields a field when a little voltage from an electronic circuit is connected to it. This voltage is identified as the working voltage. Usually working voltages like 6V, 9V, 12V, and 24V. There are three contacts: normally open, normally closed and common.

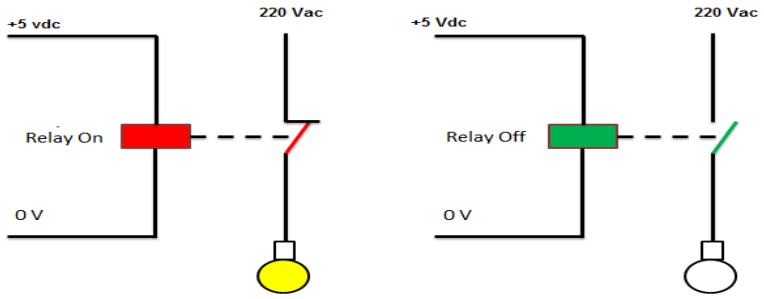


Figure 3.9 Relay and light connection

Relay output maximum contact is 250ACV 10A or DC30V 10A. A standard interface can be directly associated with microcontrollers. Driven red shading status

pointer lights are helpful for the protected utilize. In this project, we use to control smart home equipment's such as interior lamps, TV, refrigerators, HVAC, water heater (L1, L2, L3, ----) other such as dishwasher, cloth washer a so on [69].

3.1.6 Liquid Crystal Display

A 16x2 LCD unit shows 16 characters for each line and it has two such line and each character is shown in 5x7 pixel network. It has two registers, in particular, charge, and data. It is clear that to the LCD, the charge enrolls can store the given call guidelines. First, a Command can be considered, to LCD, a direction given by completing a predefined error. For instance, setting the cursor position, controlling the presentation, to instate it as well as the registering information can store the information to be shown on the LCD.

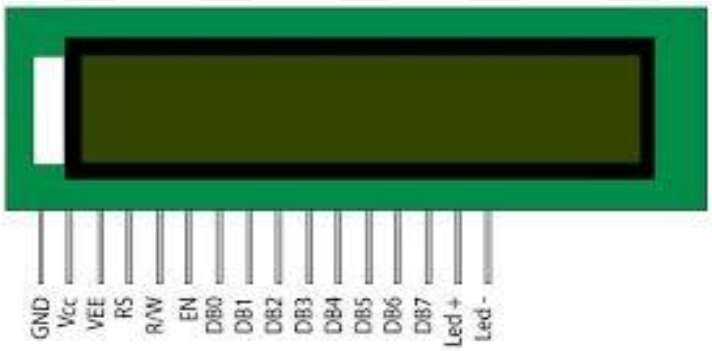


Figure 3.10 LCD pin definition

3.1.7 Gateway Block

The gateway is a device that arranges the communication between the home appliances and the web server hosting the home management system application via the microcontroller. The gateway consists of an Ethernet Shield and a router. Figure 3.11 depicts how all the earlier mentioned components are connected together inside the gateway. In this framework microcontroller remotely controls the apparatuses through web protocol (IP) module whenever and wherever gave web gets to. This framework is extremely helpful for the assurance of intensity utilization of devices or energy and estimation of power charge as indicated by control utilization, a client can screen the power utilization and power charge on its advanced cell whenever and wherever furnished with web get to the track after hardware uses to give above point:

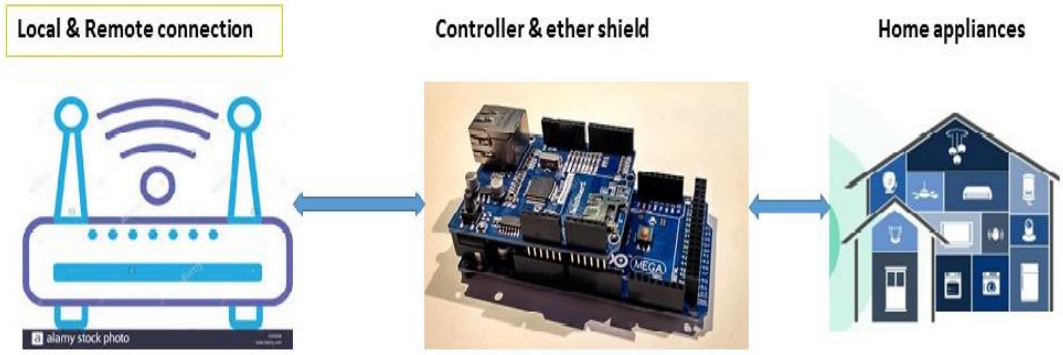


Figure 3.11. SHEMS gateway block

3.1.7.1 Ethernet Shield

The Arduino Ethernet Shield represented in Figure 3.12 licenses an Arduino board to interface with the web, it depends on the W5100 Ethernet chip, The W5100 gives a system (IP) stack equipped for both UDP and TCP. It supports up to four continuous attachment associations. Apply the Ethernet library to constitute depicts which connect to the web using the shield. The most current modification of the shield includes a miniaturized scale SD card space, which has the capacity to be utilized to store documents for serving over the system. The shield gives a standard RJ45 Ethernet jack, this keeps the pin format intact and enables another shield to be stacked to finish everything. It is utilized to interface the portal to the server [70].

3.1.7.2 Router Board (RB 751)

For forwarding packets between different network, need to advice is called a router. It implements the traffic directing functions of a network or the Internet. Until reach destination data packet is normally forwarded from router to another router over the networks that constitute. The largest router brand such as the CISCO, Juniper, and MikroTik communicate the various ISPs or may be used in big enterprise networks.

Small router more often than not give the availability to ordinary home and office systems. The best familiar kind of routers a small office, routers that simply pass packets between the home computers and the Internet [71].

In this thesis, we use router to execute the movement coordinating capacities on the network. In our project we used small router board MikroTik (RB 751) that can apply as a switch or WLAN and router, therefore we can access the home appliance locally by using protocols like dynamic host control protocol (DHCP) via smartphone or laptop through WLAN and we can access remotely by using virtual private network (VPN) and (DDNS) dynamic domain name system. It has five Ethernet ports10/100Mbps, one USB 2.0 port, and a high power WIFI and we depicted a few highlights of it in Table 3.2.

Figure 3.12 Ethernet shield

3.2 Software Design and Implementation

The design sections cover the proposed smart grid and SHEMS in a flowchart and its description, while the implementation section covers the created Graphical User Interface and its explanation.

Also accordingly, at first, the requirements and software tools utility in the proposed system are described and finally this section was closed by description of gateway configuration.

Table 3.2 RB751 specification [70]

Features	RB751G-2HnD
CPU	Atheros AR9344 600MHz CPU
Memory	128M
Ethernet	5-Ethernet 10/100/1000 Mb Ethernet port
LEDS	Power,5-Ethernet,WIFI activity
Supply Voltage	8-30 VDC
OSI	MickroTick Router OS
Operation Temp.	-20 C----+50
Antenna	2x2 MIMO , max Gain 2.5 dBi
Rx Sensitivity	-96 dBm
TX power	23-30 dBm
Modulations	OFDM: BPSK,16WAM.64QAM DSSS:DPSK,DQPSK

3.2.1 Control Center Design

This section described the design of proposed Control Center algorithms with a flowchart for Smart Grid, its description, and also covers the Development Software for control enter and the requirements software tools used in the proposed system are presented.

3.2.1.1 Development Algorithm for Control Center

The functions of the applied control and monitoring center are getting the amount of spent energy, creating a table of data for all home, calculating the bills based on the time of consumption, inspection if the bills are paid or not, informing the smart energy meters of the current time to support multi-tariff, and sending the commands of turning off or on the buildings while requiring.

For describing the flowchart shown in Figure 3.13, at first the OMC center goes into the initialization routine, in which the bidirectional correspondence module parameters are instated, where the OMC center is set at the final point of delivery for smarter energy meters to send their data of RMS voltage, RMS current and consumed energy.

Second, the OMC center waits for the buildings to join the network.

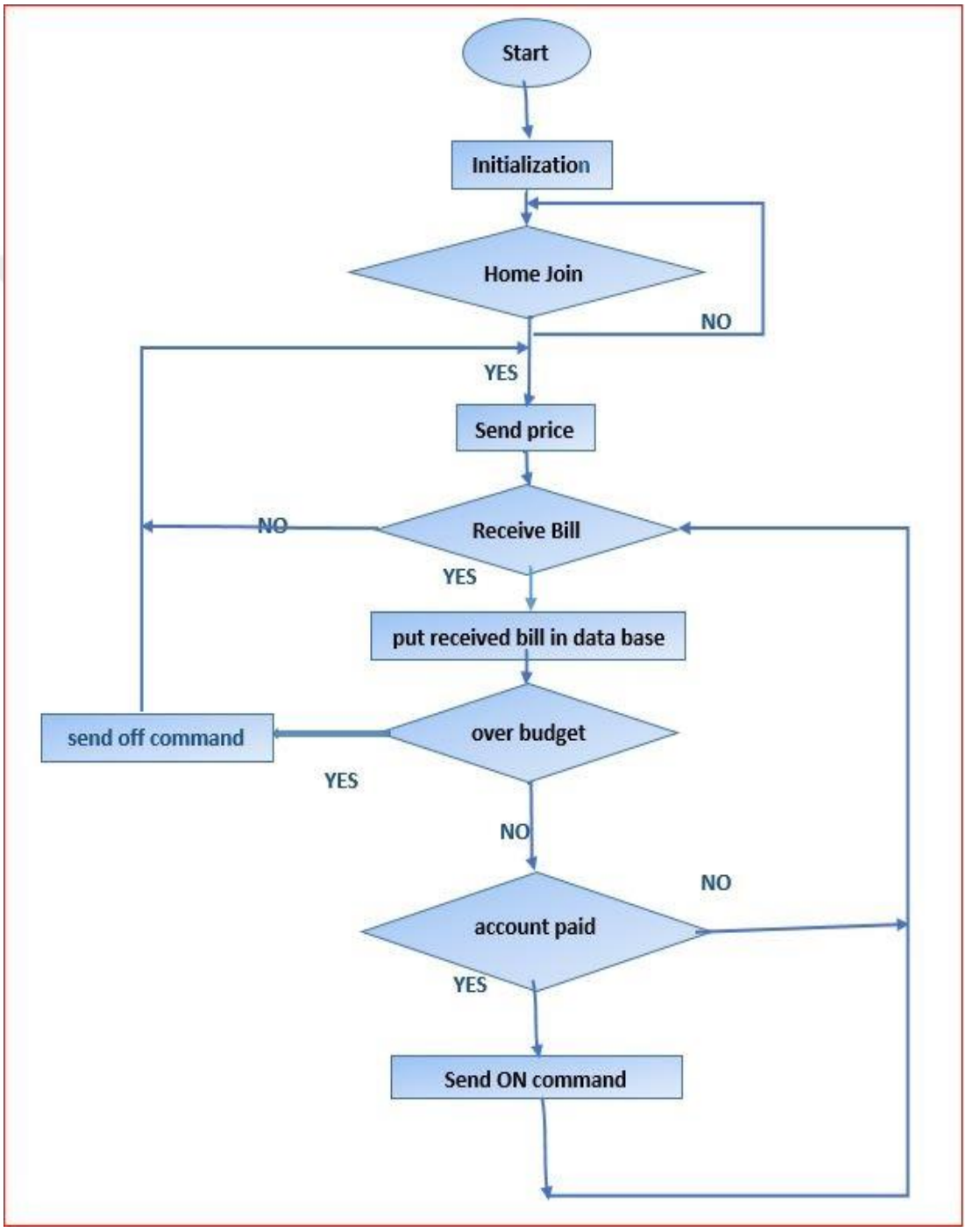


Figure 3.13 Proposed flow chart for control center

Third, the billing OMC waits for the data of the houses to be sent from the agreeing smart energy meters, where it receives this information at a specific time period one time per minutes.

Fourth, the OMC center was linked to the database table that saves. Fifth, the OMC center checks the bills of the buildings, where it has the ability to send an order to disconnect the smart energy meter from the power network at any time.

Fifth, the OMC center checks the bills of the buildings, where it has the ability to send an order to disconnect the smart energy meter from the power network at any time. Any fault in the happens between the OMC center and the SHEMS is unacknowledged and transmit again.

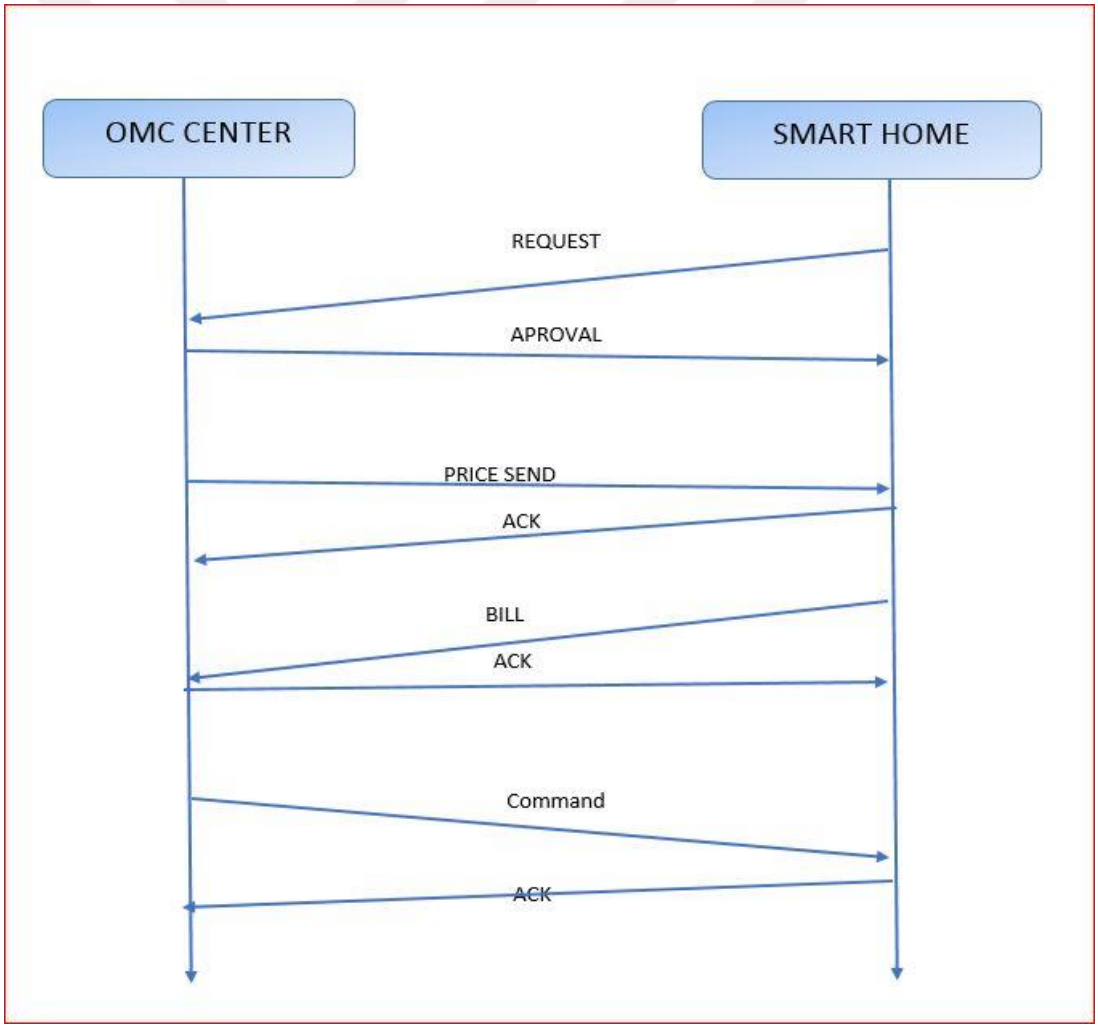


Figure 3.14 Communication between control center and SHEMS

3.2.1.2 Development Software for Grid Side

For implementing the software of the billing center, the programming Microsoft visual studio C# is used. It is used to make a GUI for the OMC center and linked to the database table of Microsoft office access to simplify the operation and controlling of billing and status of the houses, which is shown in Figure 3.15. As for the OMC center box on the left was related to power generation and permission Watt", a second text box shows the number of connected smart energy meters to the network, and finally text box was a limit power to each customer. energy range for each customer. The first text box on the top "power generation, but the right table box was specializing for a customer:

- The first column information about consumer.
- The second column text box "rms voltage (V) display the real time value of the RMS voltage.
- The third column box "rms current (A) display the consumed current.
- The fourth text box " energy (power & KWH) display the consumed energy.
- The fifth text box "Price at latest energy ($/kWH) shows the price.
- The sixth text box "Total charge " stores the total budget of the consumer, which decreases according to use energy.
- The indicates status, whether the building of the consumer is currently off (off line) or on (online).

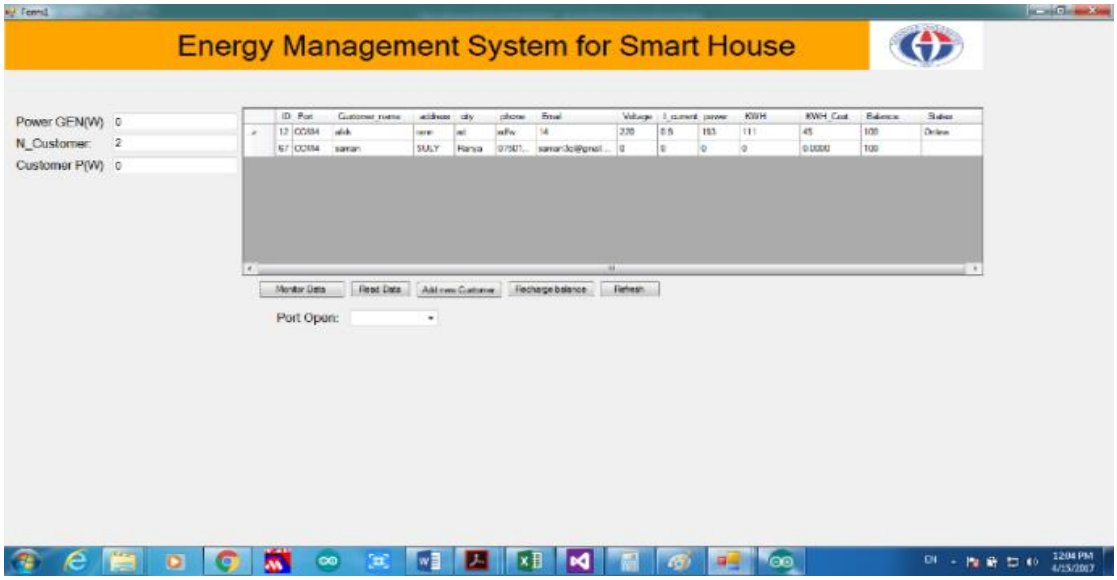


Figure 3.15 Control center GUI

It should be mentioned that if the charge of a consumer became negative, then an automatic (offline) command is sent, and when the payment is made and the budget is positive again, then an automatic (online) command is sent. We could be login to program via permission user account as shown in Figure 3.16.

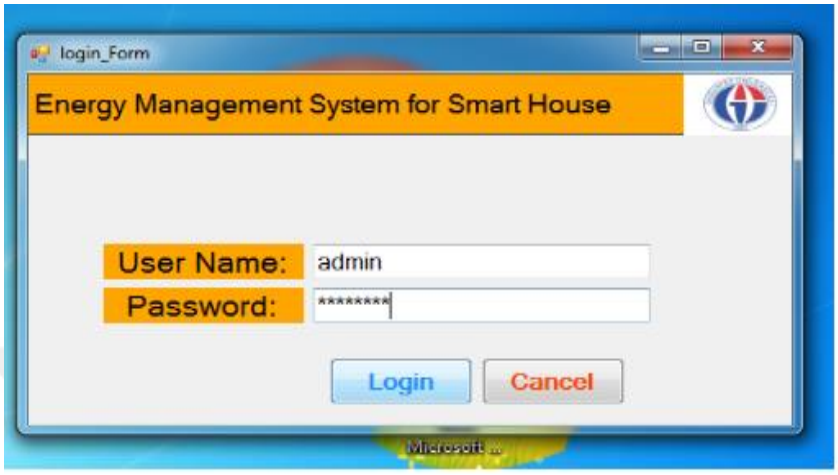


Figure 3.16 Login form

3.2.2 SHEMS Design

This section covers the design of proposed SHEMS algorithms with a flowchart, its description, and also covers the Development Software for SHEMS and the requirements software tools used in the proposed system are presented.

3.2.2.1 Control Algorithm for SHEMS

The control algorithm for SHEM framework utilized at customer section it has presented in the Figure 3.17, three loads as a test for home is considered for normal clarification and homeowner can set them in Eco, auto, and manual mode by using the switch. On the off chance that mode the control algorithm for SHEM framework utilized at the customer section controller. On the off chance that mode selector change is associated with a 5V terminal, it is considered as an AUTO method of operation and in the event that it is associated with GND, it is dealt with as a manual method of operation. The loads are denoted as L1, L2, to L6 where L6 has high need and L1 has the slightest need or low priorities.

At first, the mode is checked and, in the event, that it is an AUTO, control utilization limit value PL (permit load) is developed over a wireless medium (X-Bee and WIFI)

or through a wired medium on the receiver side at the start all loads are turned off. At that point, I, V is detected, the power utilization value P is metered and compared with PPL. In the event that P is not as much as PPL value, every appliance stays in ON condition, the program restarts on to the initial mode check new offer from OMC. Off chance that P is more prominent than PL, the slightest need stack L1is switch off and after V, I are detected and P is determined. As prior, P is compared to PL and off chance that it is more significant, L6 to L1 is turned off. Else, it will go to start to check new information or new power limit. Essentially, again P is determined and L1 is additionally switched off if P is more prominent than PL, the same process repeated until p less than PL and from lowest priority appliances turn off to high priority appliances.

If the mode is manual through GUI we can change appliance condition or by 6 push button switch subject upon the switch high(5V)/low (GND) position. Estimations of V, I, P and PL are shown on the LCD associated with the collector controller.

What's more, about ECO mode three loads (L4–L6) turn on that represented high priority and low power consumption appliances in a home like internal light, refrigerator, and TV others can't control loads.

3.2.2.2 Development Software for SHEMS

The executed project as it shown in Figure 3.18 was developed which is able to be attacked by everyone. Besides, the requirement of our project, either software and hardware is simple. So that it is easily available for people in all phases and stages. Various home automation innovation frameworks are available, among this home automation-based web is unique. For actualizing our framework online web language required. Then the language used to develop in web languages like HTML or CSS. A smart home is taken in our consideration. Power supply operation mode varies according to the time. For this, manual control mode the devices in his room are needed to operate manually via IP address. Or can be using the auto mode that operates according to permission power limit, in our system this labor is gone. A database in view of his routine is set up, time goes through which whether a device would be on or off can be resolved by means of approval control. If hardware preparation is able to reach of a specific period within this period, then devices

switch on, if below limits within this mode planning is not sensed, then devices switch off.

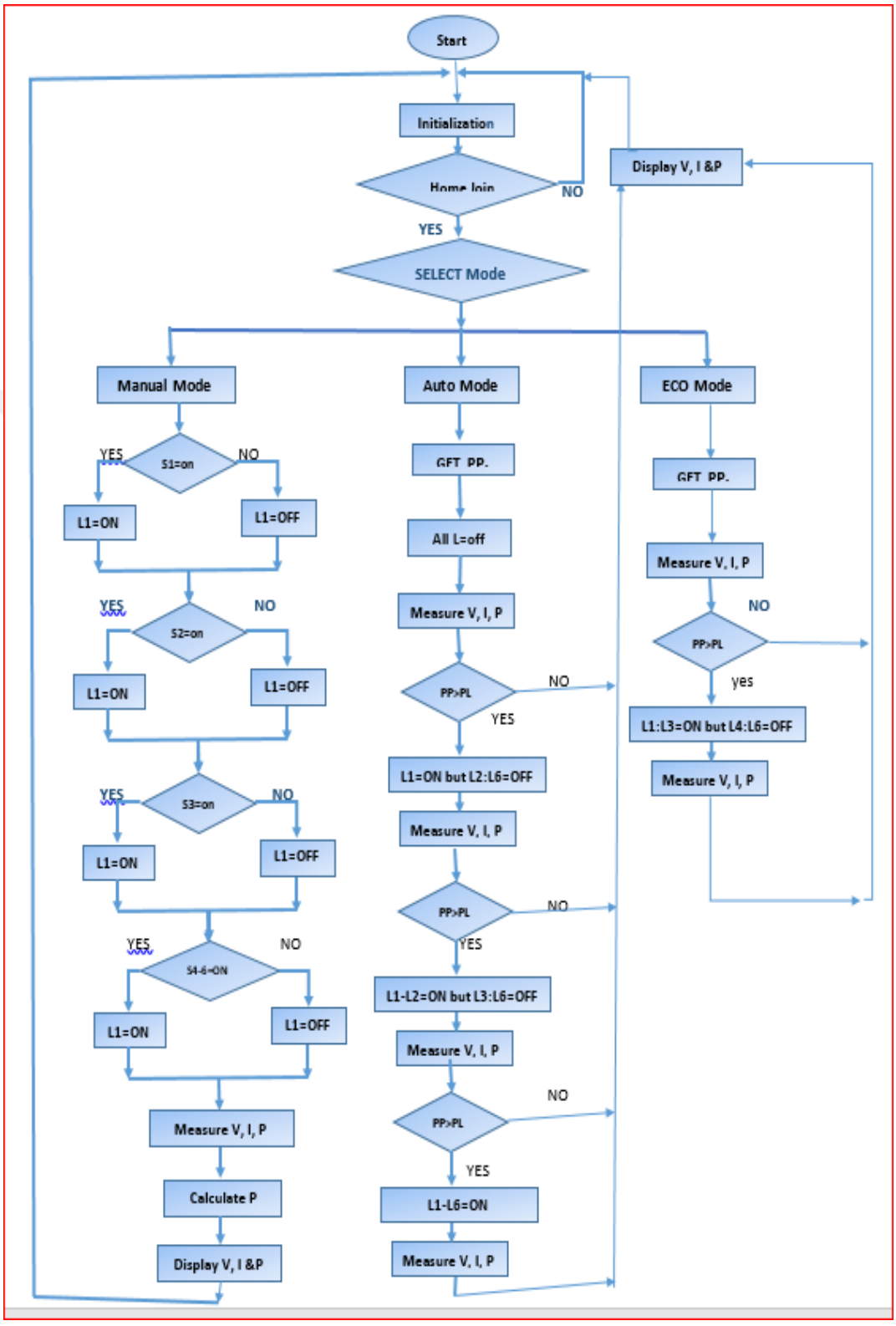


Figure 3. 17 SHEMS algorithm

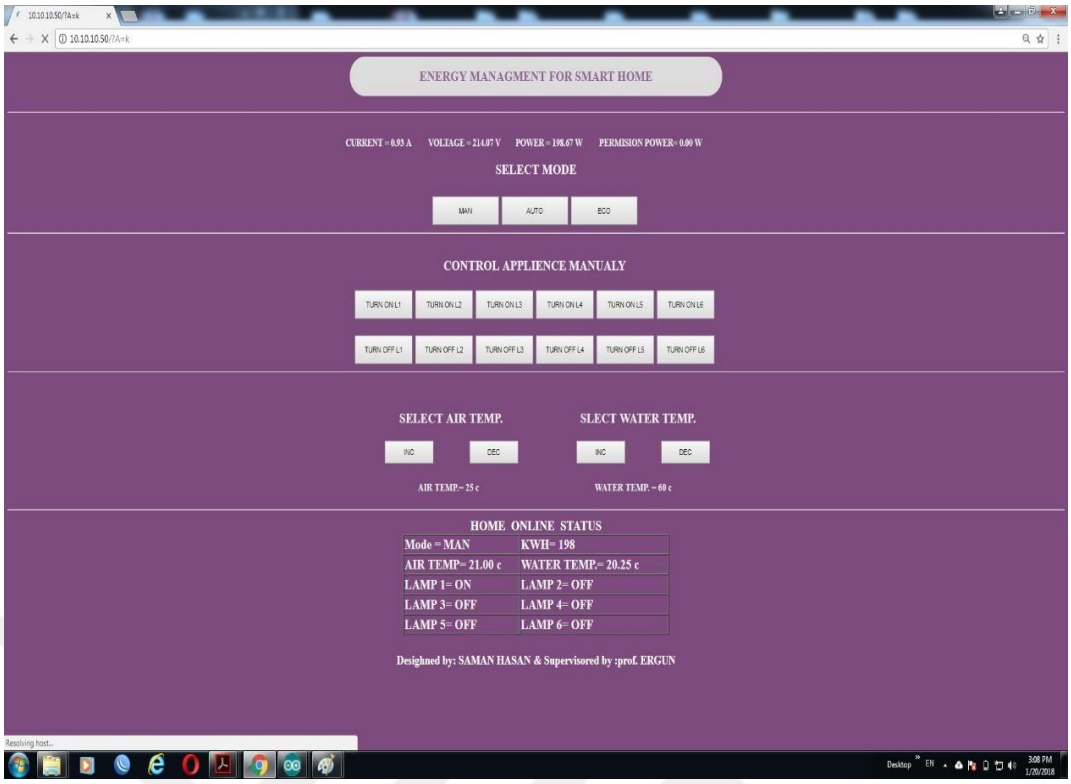


Figure 3. 18 GUI of SHEMS

3.2.2.2.1 HTML

Hypertext Markup Language is not programming language, it's a markup language. It is used for web page development, the most famous parameter used in HTML are named (Attribute), (Element), (Tag), element the most focused parameter and it has some exact layer. Whatever we see on the site page that may be the passage content, other than all the cover and enhancement are comprised of the page components.

- <p>-used to open paragraph tag.
- Element Content- paragraph words
- </P>-used to close the tag. [10]

The head, title and body element are the essential elements in HTML.

The first step to write HTML language is start by put (<>) sign like <html>, <html> Element...</html>. And for project name display over the web then we must to write, such as, <html> Project </html>.

<head> element suppose the header of the page and it is one of the document head that gives by of the document.

The survey components of the site page are worked in body component. There is been an appearing of tag is up to base and left to right. There are three parameters of tag:

i) opening tag

ii) contents

iii) closing tag [10].

Body tag holds all element of web page. We need to put the tables, list, forms and paragraphing body element. Another web design page language is CSS, for make nice and good our created page will do it by CSS. By varying the code, is able to redesign our webpage again. Selector's been the heart of CSS. In our proposed approach we have used web page HTML editor as shown in Figure 3.19, through this page we could easily convert shapes, text or buttons to C language and after that insert to microcontroller code software and through a browser can easily display the shapes or test action of buttons.

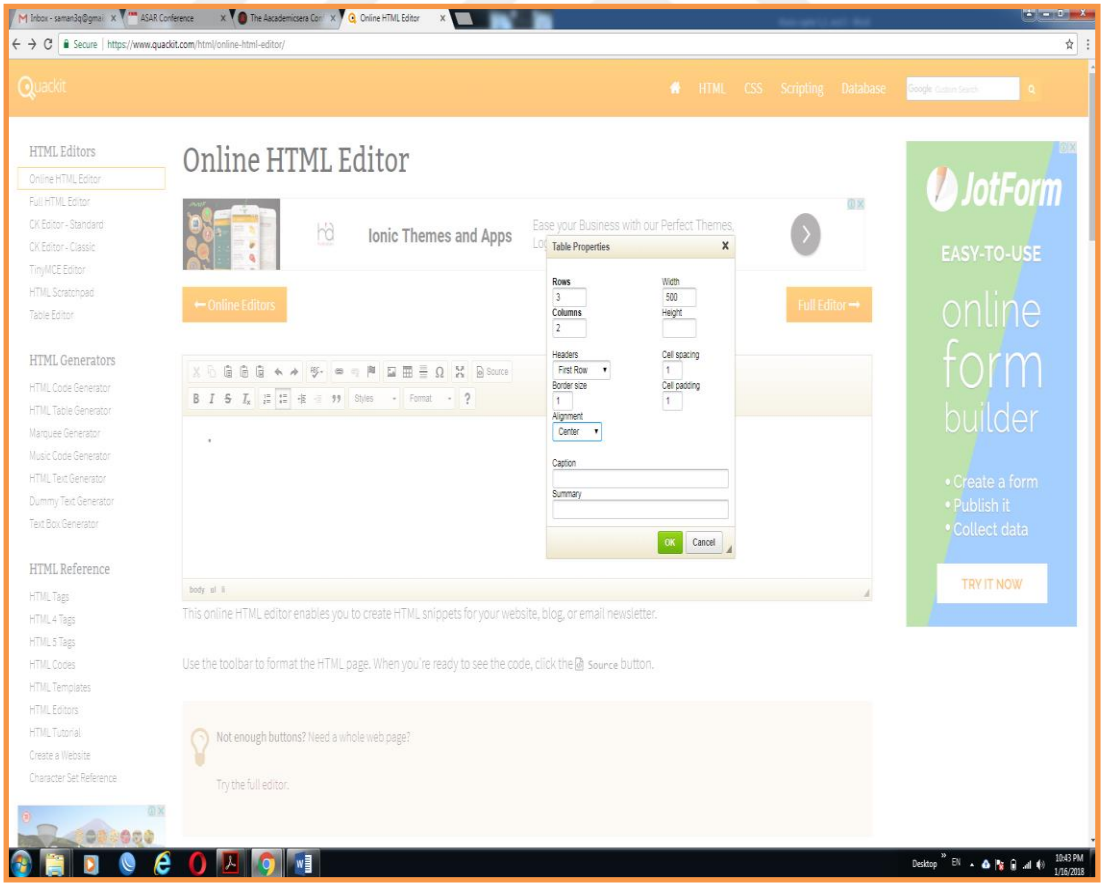


Figure 3. 19 HTML online editor

3.2.2.3 Gateway Block and Configuration

One of the main needs is that a SHEMS requirements to be able to do is to manage home appliances over wireless communications. Using WIFI technology and devices that `support it can respond to these needs and meet the requirements of the above. In our proposed approach we used MikroTik Router. It was one of the most popular routers, using in-network cause to stable, smooth and easy because it has many networking services. Many ISP Company or enterprise office is using MikroTik router. So, the system administrators who are not using MikroTik router yet, it is mainly famous for cheap prices as well as bandwidth control service and packet filtering functionalities also having a graphical user interface (GUI) helps to manage MikroTik router so easily software named winbox.

According to the above advantages we use MikroTik router type RB751.User or consumer of SHEMS can easily connect to a server (microcontroller) by using private IP address, after indicating the same class of private address for the server, but configure such as static IP address, and through public networks such as the internet or public IP the user outside of the local network can check home appliances and control it.

After describing the router work in SHEMS then we define shortly the configuration procedure of it as follows:

- Login to router and identify the router name such as SHEMS.
- Enable WIFI, identify and active encryption password.
- Create a security profile by MAC filtering.
- Bridging all LAN ports and wireless except WAN port.
- Define WAN IP according to ISP servers.
- Install DHCP on the bridge by using private IP except server IP must be static.
- Gateway configuration.
- DNS configuration.
- Firewall configuration and NAT masquerade.
- Configure system security.

3.3 Conclusion

In this chapter, the SHEMS was proposed and its skills described. The developed project includes energy management and for smart home and OMC, after describing and define equipment's used to proposed projects and clarify the projects by a flowchart, also describe software that used to programming our project.

In the next chapter, the proposed system will be explained how it has been implemented in practice. Also, the results that include results for two conditions, its performance and effectiveness will be discussed.

CHAPTER 4

IMPLEMENTATION OF PROPOSED METHODOLOGY AND RESULTS

In this chapter, the information is given how the proposed system has been implemented and tested in practice, based on the Chapter III content. So, primarily the detail of the implementation of the development system and interconnection of it are described.

In addition, described the implementation of the development system for the several modes; Manual, ECO and Auto, and then describe the effect of modes to reduce energy wastage for smart home then the results are presented.

A prototype system for energy management for smart home which includes a developed smart home and developed software on PC to apply management scheme using GUI interfaces has built. These results include the ones of the proposed hardware implementation and the ones of the proposed software implementation. Experimental results based on the whole system are included as well with corresponding analysis.

4.1 Implementation of Proposed Approach of SHEMS

Home automation as the term designates is the automation of home using the network, inputs like temperature sensor and outputs devices like buzzers and relays for getting control on the appliances and lights in the house in order to reduce energy consumption and enhance comfortability in home.

By implementing this approach, we were capable to discover a diversity of different engineering challenges, counting hardware design, Wi-Fi, TCP/IP protocols, software programing, web server logic design, and other aspects. This approach delivered great visions to the experiments of hardware and software engineering. After definition the hardware components of energy management for smart home.

In chapter three, we achieved the next point of the task which is the final physical implementation and connection. This operation goes through multiple steps.

For calculating an amount of consumed energy for house, the microcontroller measures two parameters, instantaneous voltage and instantaneous current. For the instantaneous voltage measurement, first the voltage is attenuated from its -312 to 312 volts peak to peak value to a 0 to 5 volts peak to peak value, this is performed by the voltage transformer and rectifier.

AC line voltage 220V convert to 12V through voltage transformer and rectified using bridge rectifier, the second covers reduction of voltage 12V to 5V by using resistive voltage divider (R1/R2) ensures the voltage output was connecting to analogue pin A15 on microcontroller as shown in Figure 4.1.

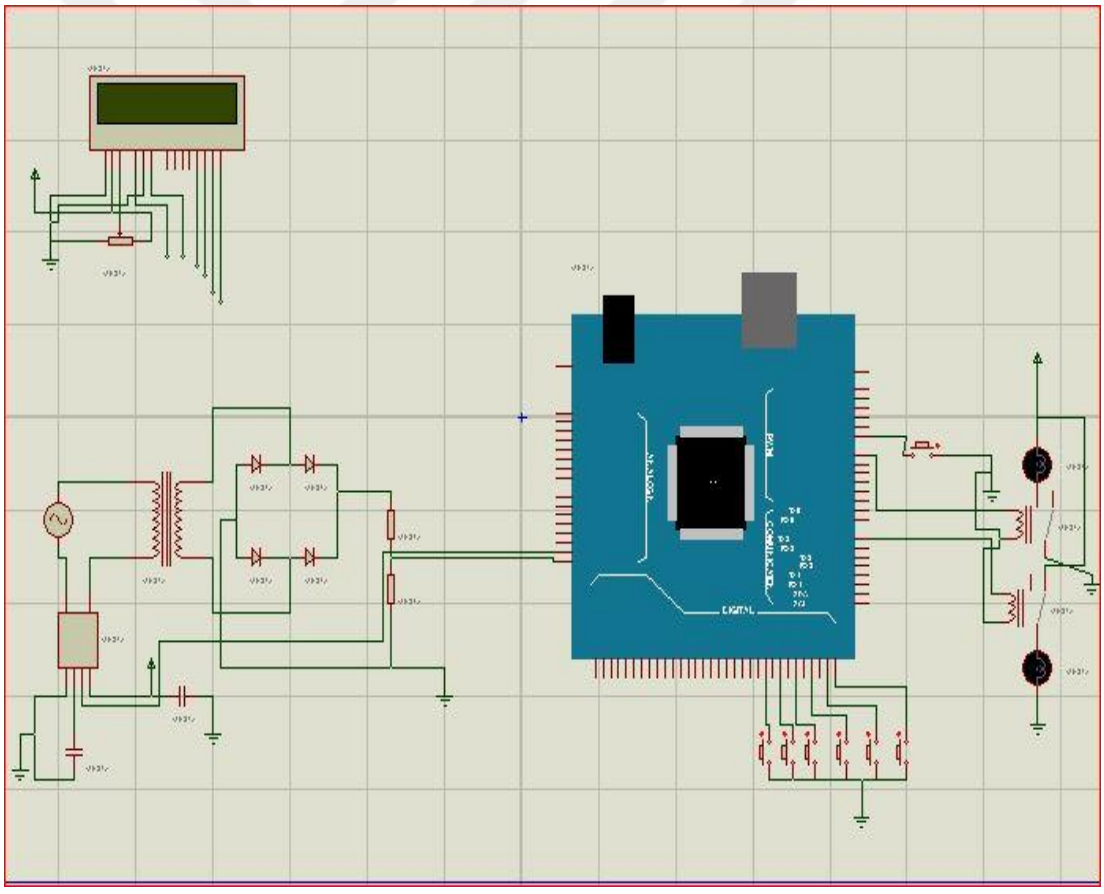


Figure 4.1 Development project layout

For measure the instantaneous current has many ways, like current transformer and IC, in this approach the current sensor (ACS712) was used. The output of current

sensor (ACS 712) is voltage, and it was direct proportional to consumed current. In additional it was connected to the analogue pin (A14) on microcontroller and the value varying between (0 to 5) voltage, the maximum read value is 30 ampere and minimum was 0 ampere.

To keep a track of temperature reading for room we need to accurate enough device like DHT 11, that it has 4 pins, we only need 3 connections to the sensor, since one of the pin is not used. The connection is: Ground, Voltage, and Signal which can be connected to any digital pin 20 on our microcontroller. The outputs of the temperature sensor are linked to the analog input as these sensors give some numeric values according to which the decision will be taken by the microcontroller, it monitors continuously the temperature if the reading exceeds the defined limit it notifies home owner and turn on or switch off air condition unit. The limit of temperature is adjusting via web server or application program, for human comfort in proceed mental store temperature is one of the greatest important part which has be controlled. Especially the temperature needed for human comfort in departmental keep between 21°C to 24°C, for example 24 C if the air temperature more or equal than this value the AC is switch of and if less than it switches on.

After description analogue inputs in above, now we are describing the digital input like pushbuttons or switches connect to circuit when press it cause to switch on light or switch off also it uses to change the operation modes manually (AUTO, ECO & MANUAL). In manual mode it uses to switch on and turn on light or equipment's (AC, WATER HEATER, lights,) that’s are connected to microcontroller input pull up (22,23,25,27,29, 31) and pin (8) is used to change the power source modes via local place as shown in Figure 4.2.

To display voltage, current and temperature and operation modes (Manual, Eco and Auto) need to LCD. In this project we have used LCD 2X16, it means two rows and sixteen columns to display characters and numbers. It has been connected to microcontroller via digital output pins (2,3,4,5,) for getting data from controller to display, pin AO in microcontroller connect to pin E (Enable) and sends data to data pins when a high to low pulse is given, and selector register (R/S) connect to pin A1, Selects command register when low; and data register when high. And 5 volt connect to pin VDD and ground to pin VEE as shown in Figure 4.1.

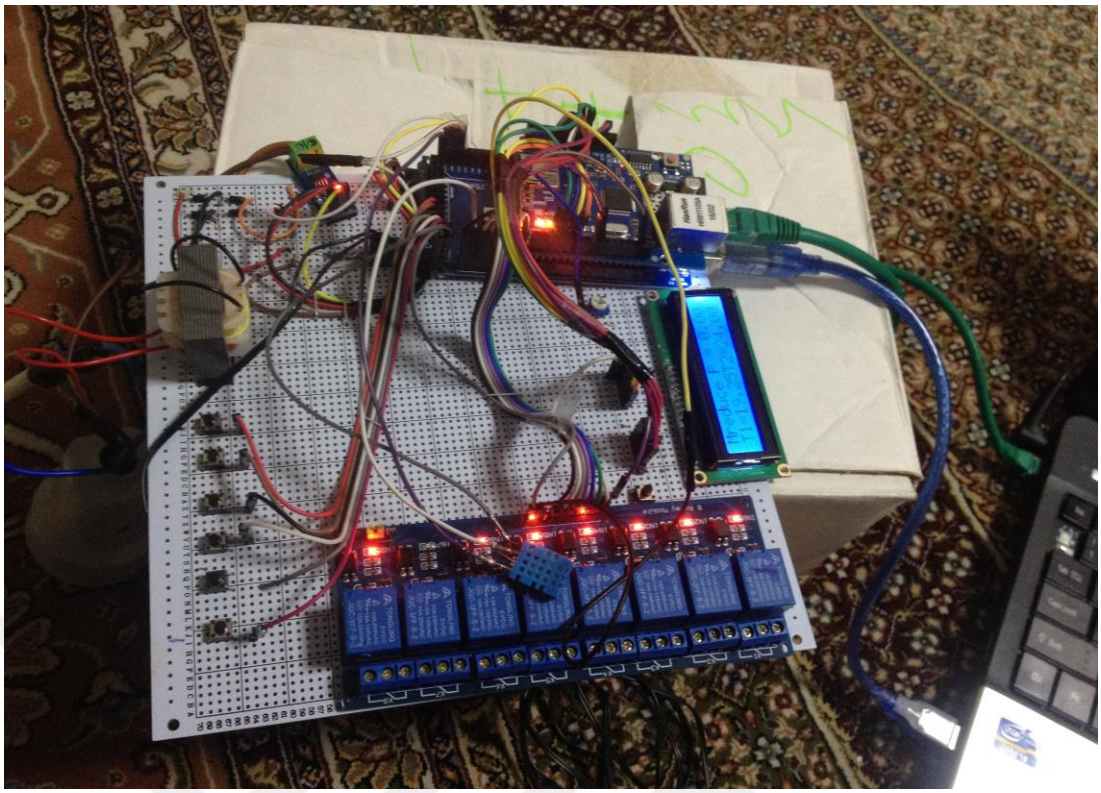


Figure 4.2 Digital ınput/output and project construction

The home appliances (AC, water heater, lamps, cloth washer, and dishwasher, …., etc.) controlled by the microcontroller through relay module. The relay modules have 8 pins that energized by 5 voltages and each relay was controlled through digital output of the microcontroller, the module connects to pin (14,15,16,21,18,19). In this approach, the five indication lamps used to represent home appliances. The switching on and switch of the lamps depending upon the decision making of the operation mode, the permission power value, and push buttons.

4.2 Proposed Approach for Network

Arduino MEGA 2560 is connected to local LAN or internet by Ethernet shield through Ethernet straight cable, shield is built on the Ethernet chip Wiznet W5100 as it shown in Figure 4.3. It is provided IP stack and both UDP and TCP. It can offer support to 4 simultaneous socket contacts. RJ 45 connector is needed to enable Ethernet.

Ethernet module supports full duplex and half duplex. The W5100 has internal memory 16 Kbytes for buffering TX/RX. Besides, it supports the serial peripheral

interface. In our work, controlling devices from an online GUI through web arrange is fundamental. For this, it is required to manage a system server.

The Ethernet shield is connected to RB751 to one of the Ethernet ports through Ethernet cable, the internet protocol of them must be the same class and the same network, in our thesis, we have configured IP 10.10.10.50, subnet mask 255.255.255.0 and gateway of the network was 10.10.10.1.

We could monitor and control home appliance via wire or wireless local area network medium. This makes the utilizations of this very constrained. To take our information and place it into an internet browser that can be gotten to any place we have to get a static and dynamic IP.

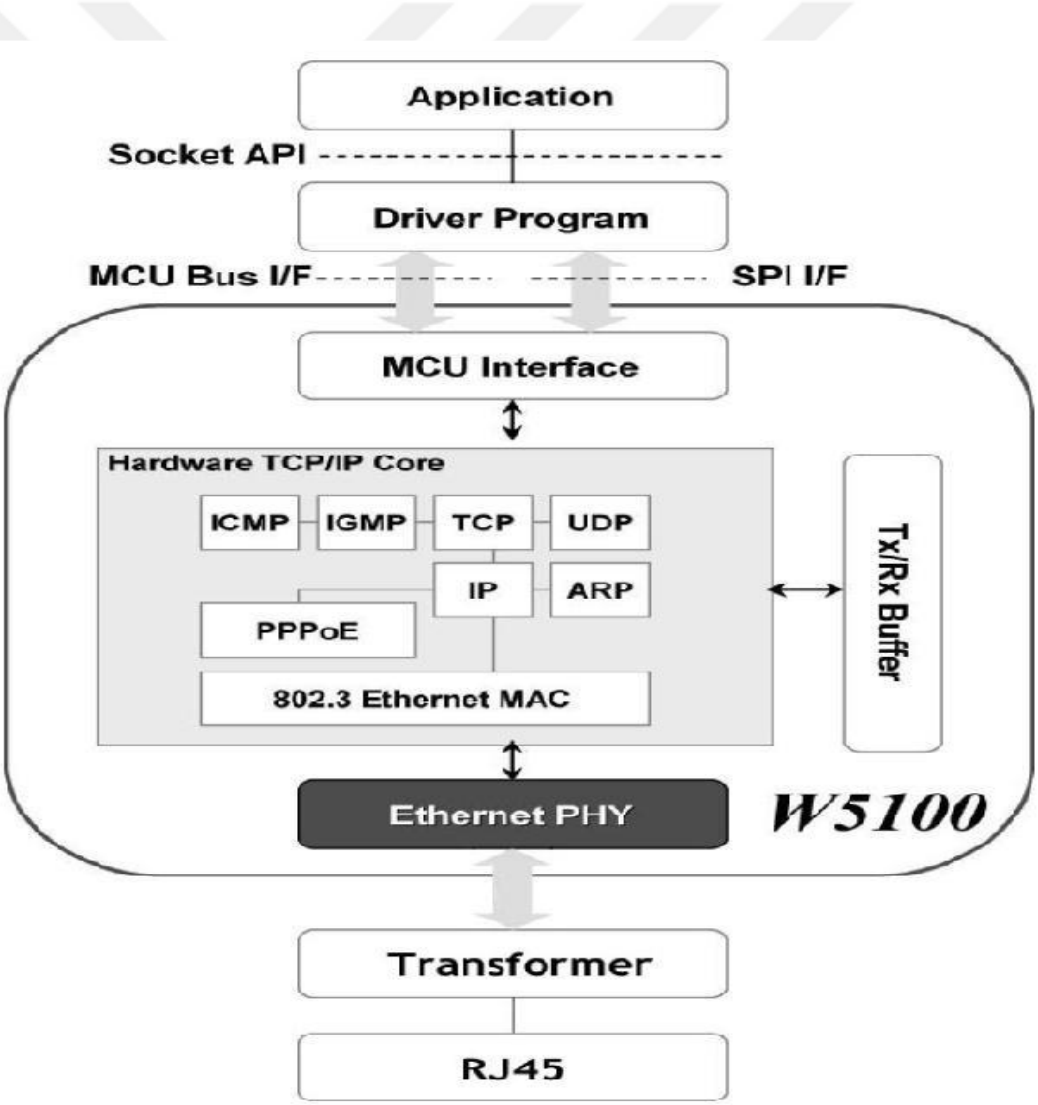


Figure 4.3 W5100 block diagram

4.2.1 User Access to SHEMS

After described in detail the components need for our development system in chapter three and more explained hardware connection in chapter four sections 4.2, in this section we will show how to SHEMS server available to users.

User can access to the SHEMS through a computer or user devices like tablets or smartphones equipped with iOS or Android to send command, display environment and light status information such as air, water temperatures and lights as it shown in Figure.4.4. The windows user can be accessed from locally by receiving WIFI access point that has in the same class or remotely and has the following options and functionalities to GUI interface by inserting home server IP: 10.10.10.50.

- Track the present loads of appliance.
- Manage the home appliances.
- Inform the user about the electricity price over the time.
- Schedule the activity of the appliances based on the energy cost.
- Adjusting the temperature room and switch on before reach to home.
- Change the power supply operation modes like (MANUAL, AUTO & ECO).
- Could be applied for safety and security issue for home by using special sensors.

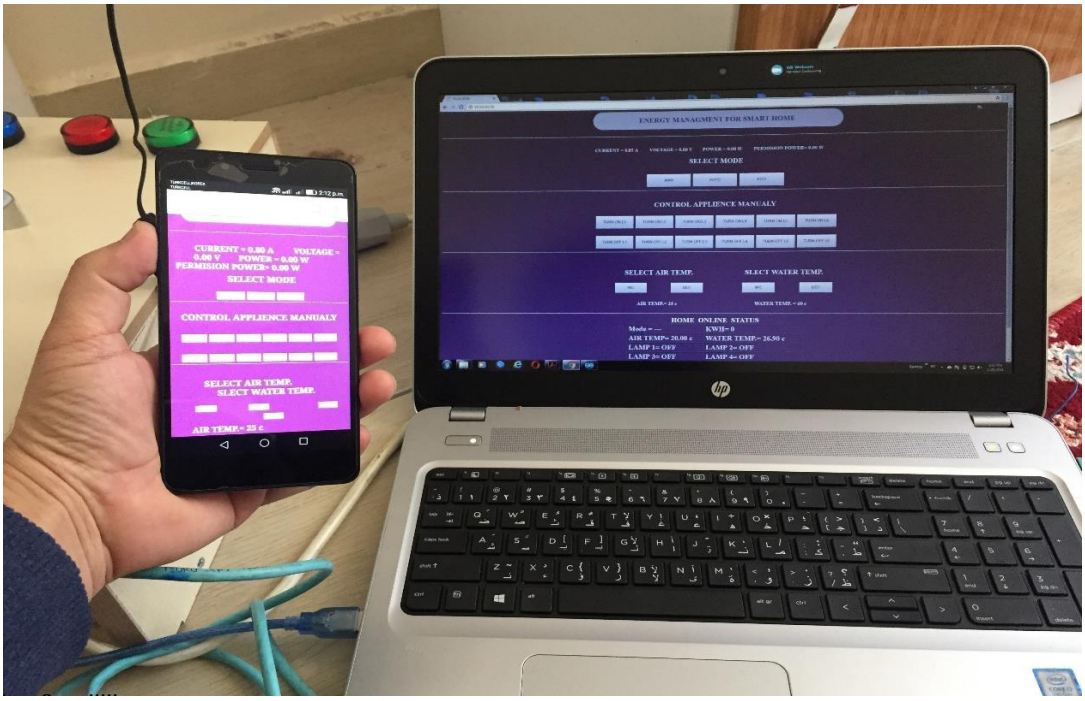


Figure 4.4 Client access to SHEMS

4.3 Experimental and Results

The setup for SHEMS framework has been crated. The framework has been experimented for Manual, ECO, Auto modes with respect various permit power. It can be seen from the outcomes that for varieties in power load values. The framework is reacting estimably and the appliances are exchanging effectively. According to the estimation of energy constraint got, the devices are switching and the power utilization is constantly kept up lower the estimation of permit load value. The proposed approach has been realized for described modes.

4.3.1 Experimented Approach for First Scenario

At first, the user must be access to server through WIFI or LAN cable, and after that enter the server IP:10.10.10.50, then the SHEMS server is available. After access to SHEMS server, indicate the permission power on 350W in the first scenario. SHEMS user can change operation modes according to minimize cost and his or her requirements and total result of this case shown in Table 4.1.

4.3.1.1 AUTO Mode

After a user access to SHEMS server, at first must be setting our system to auto mode. The smart energy meter measure load power and sends the data to microcontroller through two analog pins ,if range is less than permit limit, it was send signal to turn on first appliance (L6) that it is high priority that can be used to internal light ,refrigerator or TV, after 2 second the algorithm is executed also server check the power consumed through smart meter if less limit, it is turned on the second appliance(L5) that it is less priority than (L6) and most priority than (L4) ,it can connect external light ,TV, air cooler or any appliance that it has low energy consumption high need for house as it shown in Figure 4.5.

And ,for next time measured load power were less than set power value ; therefore ,the (L4) is switched on, the procedure is continued until all appliances are switched on or (L6) to (L1) were turned on, but must be consumed power less than permit power, in other words ,between 10W to 350W.The system is stable and all appliance are turn on until the microcontroller receive new order from user or control center form smart grid side.

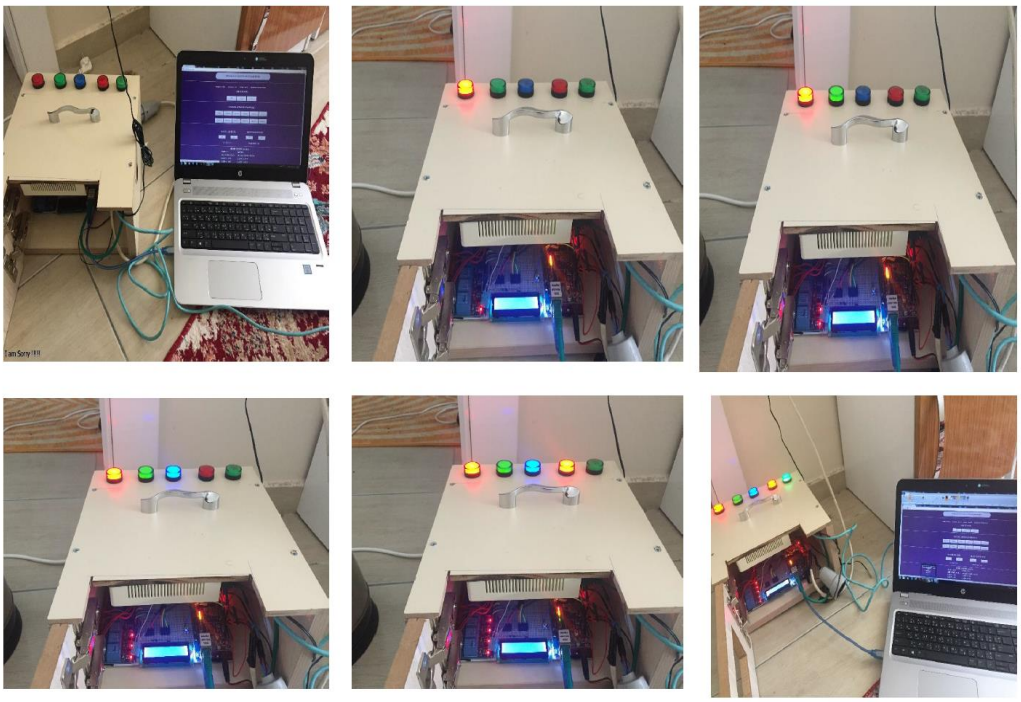


Figure 4.5 Auto mode for first scenario

4.3.1.2 Manual Mode

Operation mode must be in manual mode. The user, capable to switch off or on any desire an appliance without regard, priority of appliances, and also it can work all appliances turned on or turned off as it shown in Figure.4.6, but the control center of smart grid side enables to control consumed energy through command order that sends to microcontroller through access media.

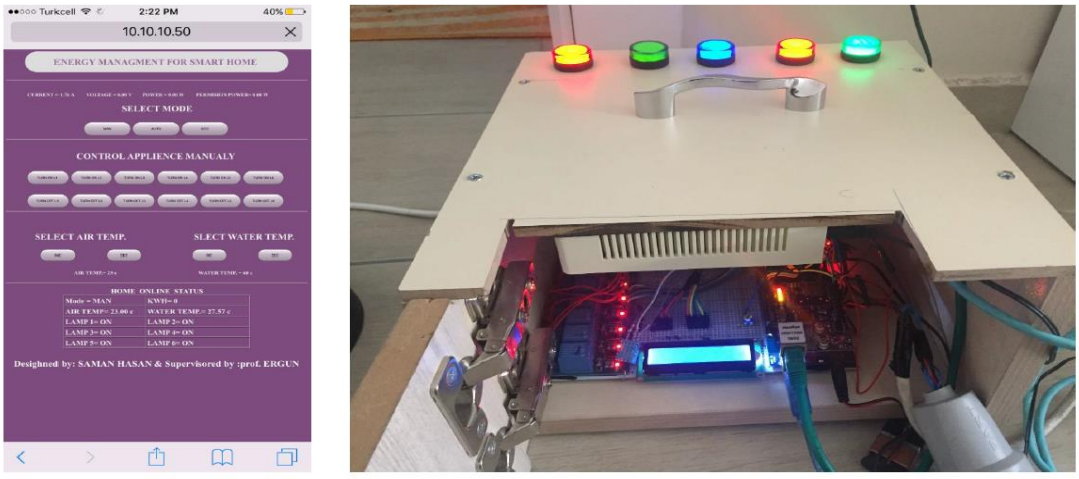


Figure 4.6 Manual mode for first scenario

4.3.1.3 ECO Mode

If we change mode to ECO, the microcontroller turns on only three high priority loads (L6, L5and L4), the total consumption power only 155.3. It can be used for operating internal, external lights and refrigerator, and also this algorithm is useful for standby power with power limit like a generator and it was comforting to a user while outside of a home and the system can be modified for more or less than three appliance loads as it displays in Figure 4.7.

Additionally, a consumer could be observing air and water heater temperature online and set to the desired values, while the operated mode was manual or auto mode only.

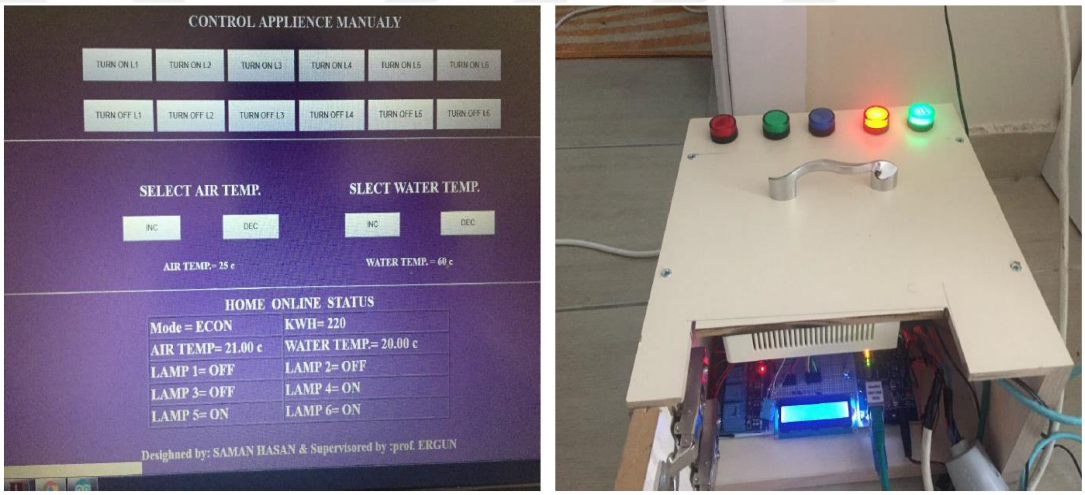


Figure 4.7 ECO mode for first scenario

4.3.2 Experimented Approach for Second Scenario

The home owner can access to the SHEMS server the same way that it described in early previous section. After access to the server, we reduce permit power load to 150w.

4.3.2.1 AUTO Mode

In the second scenario, we were decreasing the limit, power to 150 watts and the result was changed as it shown in Table 4.2. At first setting, our system is auto mode. The smart energy meter measures load power and sends the data to microcontroller through two analog pins ,if range is less than set value, it is sent signal to turn on first

appliance (L6), after 2 second the algorithm is executed also server check the power consumed if less limit, it is turned on the second appliance(L5) ,but for next time measured load is more than limit, therefore, the system stable on only to high priority loads switch on until receiving a new data (PL) and the used energy only 120W that it consumed by two high priority appliance as it shown in Figure 4.8. It is helpful to decrease demand in one hand, reduce bills for consumers and provide comfortability in other hand, there are the main goals of the project.

Table 4.1 Power measurement results for first scenario

No.	Items	Status(M)	Auto	ECO
1	PLL	350	350	350
2	L1	on	On	Off
3	L2	on	On	Off
4	L3	on	On	Off
5	L4	on	On	On
6	L5	on	On	On
7	L6	on	On	On
8	V(volt)	215	215	215
9	I(amp)	1.6	1.6	0.84
10	P(watt)	296	296	155.3

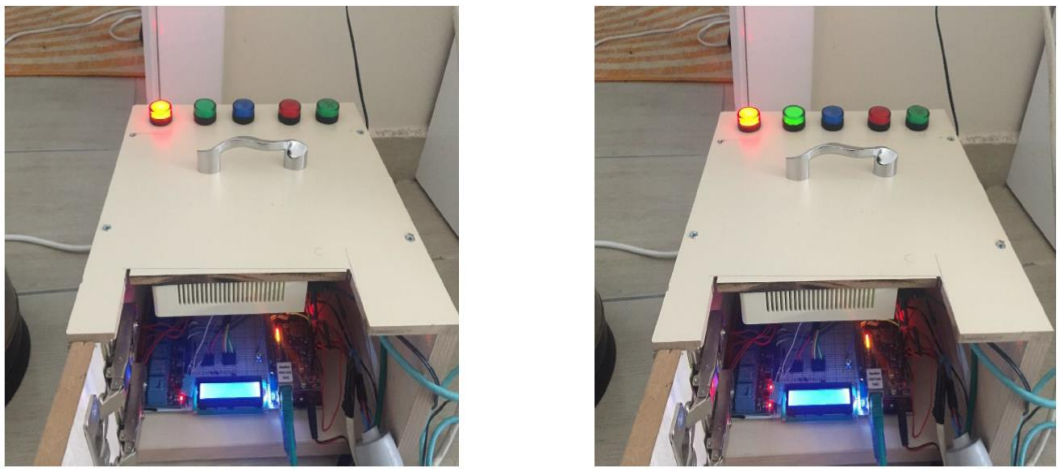


Figure 4.8 Auto mode for second scenario

4.3.2.2 Manual Mode

In manual mode, all appliances can be turned on or turned off, and then consumed energy range between 0 to 292W. Also, the user has an option which load is turned on or turned off, for any desire an appliance, in another meaning have not regard priorities as it is shown in Figure 4.7. But the control center of smart grid side can control consumed energy through command order that it send to microcontroller through access media.

4.3.2.3 ECO Mode

After performing experiment on our design in Auto and Manual modes, in case of permit power equal to 150W, finally we change setting mode to Eco, three appliances are the turn on and limit range is 155.3W as it shown in Table 4.2, the same result obtained that was experimented to on case of 350w permit power, but when change appliances type consumed energy increase or decrease according two appliances energy requirements.

Additionally, a consumer could be observing air and water heater temperature online and set to the desired values, while the operated mode was manual or auto mode only.

Table 4.2 Power measurement results for second scenario

No.	Item	Status(M)	Auto	ECO
1	PLL	150	150	150
2	L1	On	Off	Off
3	L2	On	Off	Off
4	L3	On	Off	Off
5	L4	On	Off	On
6	L5	On	On	On
7	L6	On	On	On
8	V(volt)	214.5	215	214.5
9	I(amp)	1.6	0.65	0.84
10	P(watt)	296	120	155.3

4.4 Experimented the Developed SHEMS with Connected to Control Center

The same experiment of the earlier section has been applied to the SHEMS, but this time the proposed supervision scheme has been run which has connected to the COM ports on the PC to communicate with the SHEMS. The control center successfully received the codes and power consumption with its identifier from the SHEMS. The responded signals from the control center were accepted by the SHEMS. The control center received the real time power consumption of SHEMS and separated its identifier, then added to the total consumption and stored in a special table with total electric bill with full description of users see Figure 3.16.

The control center has information about maximum demand and it can reduce the consumption energy of SHEMS when total consumption reaches peak demand and sends the permit consumption load to consumers until decrease demand after that it can send another permit load that is fill all the requirements of all SHEMS.

In additional the control center has data about budget of all SHEMS that it can share for users via E-mail, and then it capable to sending off command to SHEMS when bill account is vanishing.

4.5 Energy Cost Saving

The key motivation for a customer to accept any demand response program is the potential savings that customer could make on his/her electricity bill, thus decreasing the peak load. Dynamic pricing is very essential in any demand response program, and that is influencing consumers to change their consumption behavior in response to the price. In this study operation modes were used as the main factor to manage power consumption in housing using SHEMS. According to Table 4.1 and Table 4.2, we can see the effect of developmental system to reduce energy consumption by using a user-friendly interface without any manpower and hard work.

In Table 4.1 in the previous section, at first glance, we observe the auto mode in general. Developed system can limit consumed load for house, but in first scenario, has not good effect to demand response for smart grid side, and reduce bill for end user side. Also, for manual mode has the same, in addition if we leave a house and miss to turn off appliances, he can easily turn on/off the lights in the room via his

smart phone or PC. But when change mode to ECO, the system reduces the consumed energy of smart home, the total cost saving ratio is 47% compared to manual mode.

In Table 4.2 in the previous section, first we were describing the auto mode in our developed system. developed system can limit consumed load for house with the good effect to demand response for smart grid side and reduce bill for end user side and total cost saving ratio compare to manual is 60%. But when change mode to ECO, the system reduces the consumed energy of smart home, the total cost saving ratio is 47%.

Therefore, a consumer is being able to fall the energy bill -at least- by one third with the usage of a SHEMS. In Table 4 and table 5, The house "with" or "without" a model can be compared easily. %47, %60 cost reduction can be achieved by the optimization model in the given order.

4.6 Comparing the Proposed System with a recently Developed Approach

In this section, the ability of developed method is compared to recently presented approaches. To show the performance and efficiency of proposed approaches and compare it with other approaches, the following criteria have been used:

- Availability to monitor home appliance status.
- Ability to energy management home appliances by user.
- Manageability by control center.
- Support multi power supply.
- Communication technologies.

The following points shows the available specification in the proposed approach and some recently proposed approaches [2-3,10-15], and comparison results can be shortened as follows.

1) Related to online home monitoring, the features can be:

    a) Display status of lights and power sockets.
    b) Display air temperature and water temperature.
    c) The operation modes (Manual, Auto and ECO).

d) Display energy consumption of home.

The most approaches have not fully implemented the online monitoring through GUI interface except our approach and [2,3,13,14,15].

2) Energy measurement and control it available for our approach. that can be described as following points:

   a) Appliances control for home.
   b) Adjusting air and water temperature.
   c) Reduce energy consumption through modes.

Recently the developed approaches did not have all ability except approaches [2,3,15], [11-13] it has the most ability.

3) Related to centralization and manage home energy through control center. Our developed approach and others like [9-11] have this property.

4) Developed approach can support multi power supply, another approaches haven't support it, except approach [2].

5) As mentioned in chapter two, many communication technologies available for home automation either wire or wireless such as {Bluetooth, GSM, ZigBee, WIFI, BACNet, X10, etc.}. In our developed system, we used WIFI system that could be locally access to homes server or it could connect to internet to provide remote access to it. Also some developed approaches used WIFI like [14].

6) Implementation cost: Since all the approach argued here have used similar equipment's and sensors for execution of the home automation, they all have the same cost in manageability, safety, and security components.

In summary, the developed approach has been implemented. The main purpose was to execute, a dependable, few cost and good performance smart home that could make multiple jobs such as energy management, appliance control and monitoring locally or remotely, reduce consumer bill and reduce peak demand. The result of implementation and studying the proposed system can be appropriate option to be used in energy management for smart home industry.

CHAPTER 5

CONCLUSION AND FUTURE WORK

The design and implemented of the SHEMS based on extremely has less power consumption, high efficiency. And also high level of integration with low price, has been successfully implemented for 220 volts and 8 ampere value.

Therefore, a reliable energy management system has been designed and implemented based on ATMEGA2560 microcontroller. With the designed SHEMS; energy measurement ACS712 to measure active power, lamp indicator, load switching, manual operation, automatic operation, LCD display of the desired data, and a WIFI router board to provide bidirectional communication with the SHEMS server based on point to point structure are possible.

By using the designed system, the demand of electricity was reduced and cuts the energy cost compare to tradition energy meter. Additionally, our system eliminates the labor of meter data collection and provides remote detection of energy theft and meter fault.

The prototype system was flexible, user-friendly by using GUI, available for all levels and providing comfortability. Consumer can easily real-time monitoring of home appliance status like air, and water temperature and can view its consumption profile. A user can control home appliances like lights, refrigerator, air cooler, television, etc. according to our priority that user-defined previously locally by using private IP through Wi-Fi medium or remotely through internet by using public IP.

Also, we can conclude that the required purposes of the home automation system have been actualized and implemented. The system architecture and design were discussed, and prototype presents the basic level of home appliance control and remote monitoring has been executed. Finally, the proposed system is enhanced from the flexibility and scalability also effectively minimizes human efforts, energy can be saved for a distribute and reduce bills for a consumer.

5.1 Future Work

There are a few increases and adjustments that can be considered to enhance the execution of the actualized framework. Some of these are given as follows:

I. Control center unit based on a microcontroller with point to point communication by using WIFI.

II. The designed smart energy meter is implemented in testing conditions where the connected load draws only 8 Amps. It is suggested to modify the design in order to increase this value to a more realistic value.

III. It is recommended to use a type of display in the SHEMS that can show graphical content. HMI, GLCD and other graphical displays to make available the consumers information in a more convenient way. These displays could also offer the more ability to control the building appliances as well.

IV. Including the ability to pay the bills at the consumer nodes by using credit cards is a feature that facilitates the billing process and reduces billing irregularities.

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