Arduino Based Remote Controlling for Home: Power Saving, Security and Protection

Dr. Subhi R. M. Zeebaree, Hajar M. Yasin

Abstract- The open-source hardware development platform Arduino has been growing in recent years. Nowadays, the Arduino platform became one of the important parts in remotely control and monitor of electrical devices (Home power saving) at home, office or company. Arduino platform has good specifications, cheap, easy to use and wide varieties of shields have been emerged with many different purposes such as; Ethernet and GSM support.
This paper produces a proposed Arduino-microcontroller based system to remotely controls and monitors electrical devices and sensors as power saving and security/protection operations. With the help of the GSM network, a mobile can be used to control devices/sensors and getting alerts on robbery and burglary. This system provides decreasing of the power consumption and intrusion/alarm detections around the restricted premises.
The proposed system consists of two sides; the Arduino Microcontroller (AM-side) and the Mobile Phone (MP-side). The MP-side acts as a recipient to get responses from the AM-side as well as a controller for sending commands. While AM-side, is responsible for reading/producing data-signals/control-signals from/to the devices/sensors. The Arduino Mega 2560 is used in this system as a microcontroller. The SIM900 GPRS/GSM module was used to communicate between the microcontroller unit and the mobile phone unit. The system could be installed at any place and could be controlled by any mobile phone supporting the SMS service. The system consists of four sensors, which are used as Fire detector, gas leak detector and motion detector.

Index Terms— Arduino Microcontroller, GSM, Home Automation, Power Saving, Sensor Monitoring, Device Controlling, SMS, Mobile Phone.

1 Introduction

To be capable of utilizing the technology available currently, there will be a need to design a product using this technology that will be beneficial to the lives of others. This action is considered as a huge contribution to the community [1].

Power system quality affected by the energy saving issues, which in turn effect on the global environment. The technology used for smart home (i.e. promising area) can be considered as the important tools that deal with the demands of appliances power consumption. Hence producing various benefits such as security, safety and consequently good comfort, safety and security [2, 3].

In 2013, R. Piyare [4], Android based smart phone used with the home monitoring and control system. This system depended an embedded micro-web server, with IP connectivity for accessing and controlling devices and appliances remotely. In 2013 R. Ramlee [5], a system is proposed to has accessing from a smart phone or a laptop host to one sensor and home lights. This is done via design a Home Automation System (HAS) based on Peripheral Interface Controller (PIC) microcontroller and wireless Bluetooth technology.

In April 2013, A. Shrivastava [6], proposed a home-security system that manages GSM module and a sensor based on 8051 microcontroller for communication between the microcontroller and user (cell phone). In 2013, J. Bangali [7], depended on wireless sensor network to present the design and implementation of a smart home system. In April 2014, M. Nikose [8], proposed a system deals with remote control system of smart appliances based on Zigbee wireless sensor network. A review on a home and industrial automation was produced as a final conclusion.

2 Background Theory

Microcontroller is the term that describes the "embedded controller". Also, it describes the single-chip computer, which consists of two sub-terms. "Micro" suggests that the device is small, and "controller" means that the device might be used to control objects, processes, or events. Another term to describe a microcontroller is "embedded controller" [9]. Arduino is a simple sophisticated device. This device considered as an open source electronics platform based on flexible hardware and software which is based on Atmel's ATmega microcontrollers. Windows, Macintosh and Linux operating systems support Arduino software which is based on C programming language and can be expanded through C++ libraries [10].

When choosing a device for the implementation of any project, there necessary things have to be considered. There must be a processor, "a kilobyte of Random Access Memory (RAM) for holding data, a few kilobytes of Erasable Programmable Read-Only Memory (EPROM) or Flash memory for holding programs, and it has a suitable number of I/O pins". The cross-platform application IDE written in Java derived from the IDE for the "Processing programming language and the Wiring projects" [11, 12].

One of the microcontroller board based on the ATmega2560 is the Arduino Mega 2560. It has 54 digital input/output pins, 4 Universal Asynchronous Receiver/Transmitter (UARTs), 16 analog inputs, 8 KB of SRAM, a 16 MHz crystal oscillator, 4 KB of EEPROM, 256 KB of flash memory, a USB connection, In Circuit Serial

Programming (ICSP) header, a power jack and a reset button. It contains everything needed to support the microcontroller. "Simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila" [13]. Fig. 1, shows the main components of Arduino Mega2560.

The Arduino Mega 2560 was chosen for this system because of its abundance of digital inputs and outputs and its operating characteristics.

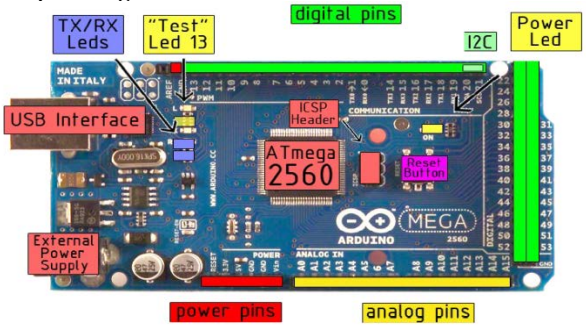


Fig.1. Arduino Mega 2560

3 Structure And Algorithms Of The Proposed System

The proposed system consists of two sides: first side concerned with the direct operations done on the building (i.e. Home automation) which are done with the designed-kit of Arduino Microcontroller (AM), while the other side represents the remote controlling done by a Mobile-Phone (MP). These two sides communicate with each other via GSM module.

Adding to the connected electrical devices and sensors, AM-side has a Control Board (CB) which consists of seven main parts, these parts and the sensors are illustrated in Fig. 2, which are: GLCD 128x64, Arduino Mega2560, Four Relays Shield, DHT22 Sensor, GAS Sensor, PIR Sensor, RTC module, Voltage regulator 7805 (provide +5V [1500 mA]), SD card module, Flame Sensor and GSM Module.

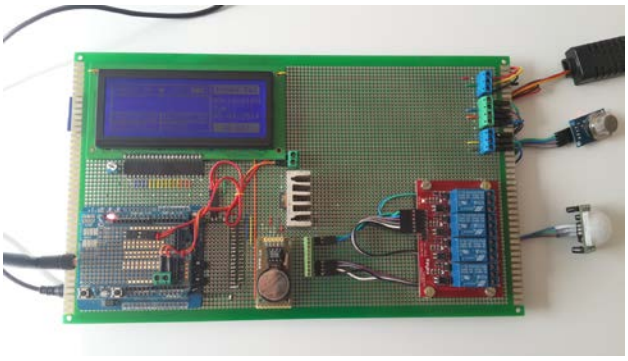


Fig.2. Control board design

The MP-side consists of one mobile-phone device, regardless of any constraints on the device features. The programming of the AM-part is done by a PC (here is a Laptop computer) and saved into Arduino-Flash-Memory (AFM). This program can be updated at any time very simply by the user (designer) using this PC. Fig. 3, represents the block structure of the proposed system. While MP-side concerned with a mobile-phone-device.

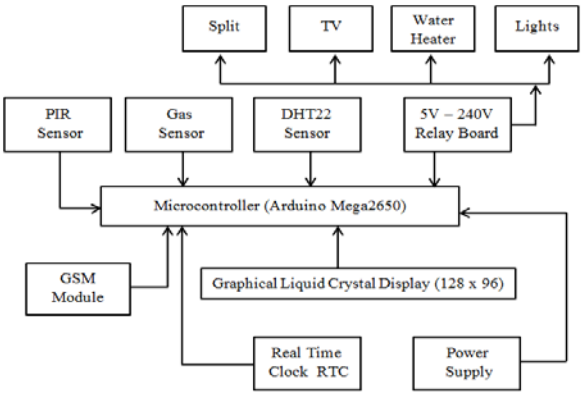


Fig.3. Hardware architecture and implementation

Fig. 4, illustrates the mechanism of the system in terms of sending SMS from the MP-side to the AM-side for controlling and monitoring electrical appliances, as well as receiving alert messages from the device.

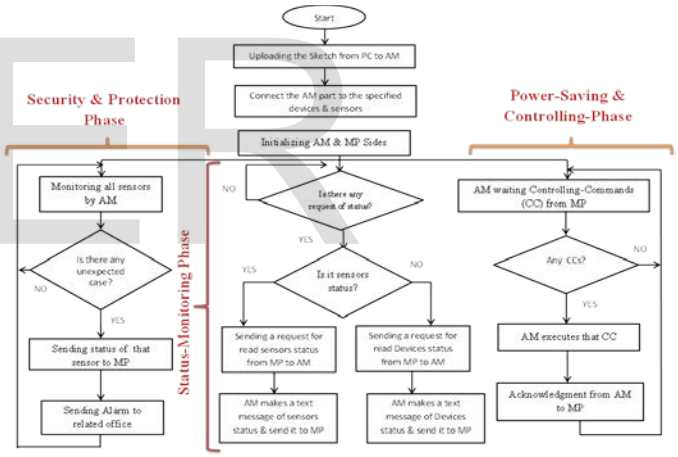


Fig.4. General block-structure of the proposed system

3.1 AM-Side

After connecting the AM-side to a (9 DC volt) power supply, it will start operating. As shown in Fig. 5, the first stage of AM-side starts with Initialization-stage. The saved-sketch is loaded via Boot-Loader (8 KB) within the flash-memory. Hence, an OFF-signal will be passed to each connected device (i.e. at starting there is no any device will operate), and an ON-signal passed to each connected sensor (i.e. all sensors must operate from starting). In parallel, the GSM module will operate with starting of AM-side. GSM module works as a mobile-phone adding to that, it has the ability of converting the data (signals) to appropriate text-massages and vice versa. The main job of GSM is making a connection between both of AM and MP sides, this is done by sending and receiving the required messages between two sides.

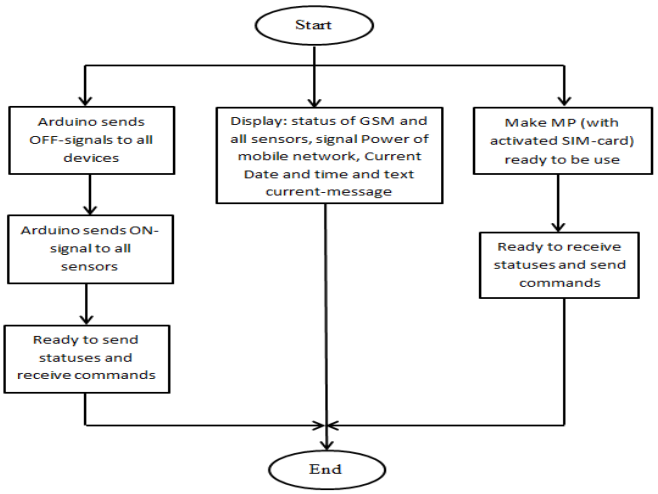


Fig.5. Initialization stage

3.2 Security and Protection Phase

This system contains four sensors, DHT22 is the temperature and humidity detector, Passive Infrared (PIR) sensor is the motion detector, Fire sensor is the flame wavelength detector and Gas sensor for gas leak detection. The detection signals of the sensors will be converted to suitable data continually and sent to the Arduino-Microcontroller. Then, these data are compared with critical values customized by the programmer. When getting any unexpected values of (Temperature, Humidity, and gas level) or (motion-detection and Fire-Flame) occurred at any time, these situations will be translated to suitable messages and sent to the MP-side. Fig. 6, represents the flowchart of security and protection phase.

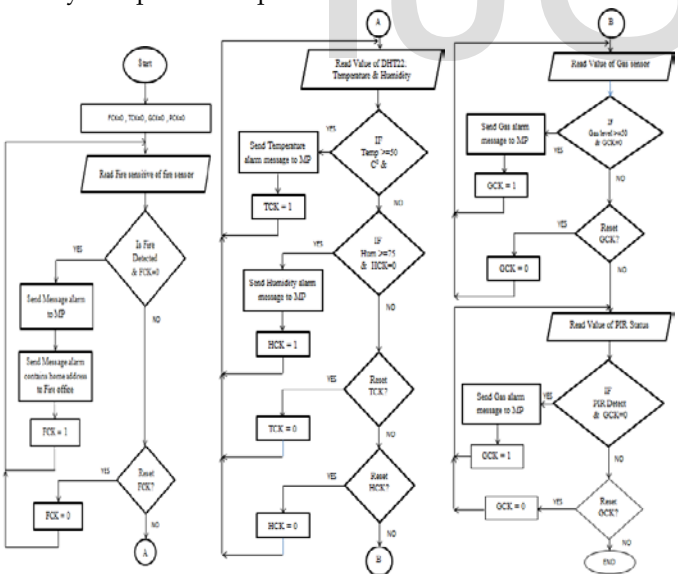


Fig.6. Flowchart of security and protection phase

3.3 Power Saving Phase (Controlling and Monitoring)

There are many electrical devices in the home that their statuses are unknown (ON or OFF), which can be left ON inadvertently or by mistake. When a device has been left at ON status for a long time, it will be necessary to turn it to OFF status. So, there is a need to control the electrical devices remotely to prevent the risk of any accidents, as well as to decrease the use of electricity (saving the power). The electrical devices such as; TV, air-conditioner, electric shower and lights can be controlled remotely using the GPRS/GSM module (using the SMS) in this system.

All home appliances (devices) use a 220V AC, while Arduino-kit can provide only a 5V DC. Therefore, relays must be used between the Arduino-kit and the appliances, which operate by supplying 5V DC and work as a switch for 220V AC by getting a trigger from an Arduino-kit.
The relay can be controlled by the I/O pins of the Arduino-kit which in turn controls the appliances.

In this system MP-side is used to control and monitor home appliances via SMS sending. When an MP has sent text messages to AM-side for switching devices On/Off, the digital pin on Arduino-kit that connects to IN pin on the relay will become high/low and send 0V/5V to relay. And when its send text message to known the status of the device, AM-side will send text messages about the status of pin that connected to relay is high/low.

3.4 RTC, GLCD And SD Card Module

The other components that used in this system put on CB are: Real Time Clock (RTC) Module, Graphic Liquid Cristal Display (GLCD), and SD card Module.

RTC DS1302 is used to display the current time and date and determines and displays the arrival time and date of the text messages (and the text itself) that sent from MP-site to AM-site and vice versa, on GLCD. Then saves them in an SD card with the related information such as: receiving/sending time, date, content of SMS and the sender phone number. GLCD 128x64 is very important to be used in this system for displaying: real time, date, values of all sensors and received SMS. In additional, phone network signal strength displays on GLCD to help the user to locate the system in a correct place within the home.

3.5 MP-Side

MP is used to send SMSs to AM-side for controlling and monitoring all devices and sensors that used in this system. There is no need to any special features or any special applications for the MP to be used as a part of this system. Any mobile phone supporting the messaging application is suitable for the system regardless of its type. The mobile phone can be used as a controller from anywhere in the world if the GSM network is available regardless of the used mobile network.

4 Implementation Results And Discussion

The implementation results obtained by this Paper can be categorized into two main parts: power saving category and security/protection category.

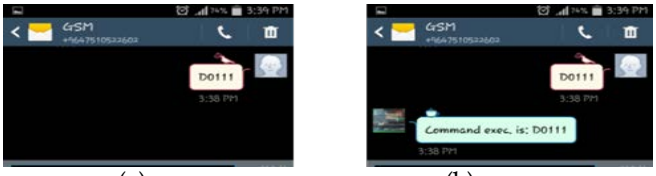
4.1 Power Saving Implementation Results

To get economic electrical power consumption, the electrical devices operation controlled remotely. The

microcontroller unit responds to the commands that sent by the MP according to the necessity of the application.

4.1.1 Device Controlling

To illustrate the mechanism of electrical devices controlling, a certain command such as "D0111" will be depended. This command means that; the devices (1, 2 and 3) from the right wanted to be ON and device NO. 4 to be OFF. The command will be sent from MP-side to AM-side. Fig. 7, shows a screenshot for sending SMS "D0111" as a command from MP-side to AM-side for controlling devices. This command received at the AM-side and displayed with the sender phone number on GLCD directly as shown in Fig. 8. Then it will be decoded and executed by Arduino-kit.



(a) (b)

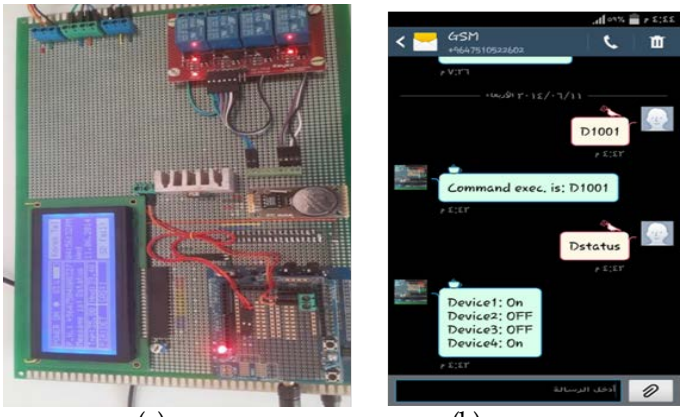
Fig.7. sending devices controlling command: (a) MP-side after sends a control command. (b) MP-side after receiving response of controlling command from AM-side.

Fig.8. display the command and MP number on GLCD

4.1.2 Devices Monitoring

In this system, the homeowner can monitor the electrical devices that connected to AM-side at any time in terms of which device is ON or OFF. This achieved by sending an SMS via MP-side to AM-side for inquiring about the status of devices and the later returns a report about them.

Fig. 9.a, shows the relay status (devices status) that connected to electrical devices, which devices (1 and 4) are ON and others are OFF. While, Fig. 9.b, shows a screenshot for sending SMS "Dstatus" as a command from MP-side to AM-side for inquiring about devices status (sending commands and receiving status).



(a) (b)

Fig.9. sending/receiving the monitoring command (Dstatus): (a) Electrical devices status. (b) Screenshot of MP-side for sending monitoring commands and receiving response.

4.1.3 Determined Results

Figs. 10 to 12, are charts for representation the power saving results when implementing the system using electrical devices. The charts illustrate power consuming of four devices for the durations (one day, one Month and one year). These results considered for full periods, so partial periods can be obtained to get partial power saving. The partial periods illustrated in Figs. 11 and 12, assuming the values of 16 Hrs./Day are depended for other figures.

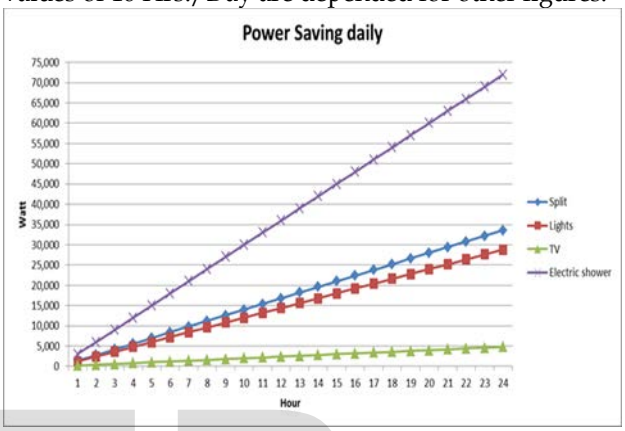


Fig.10. Daily power saving of 4 electrical devices

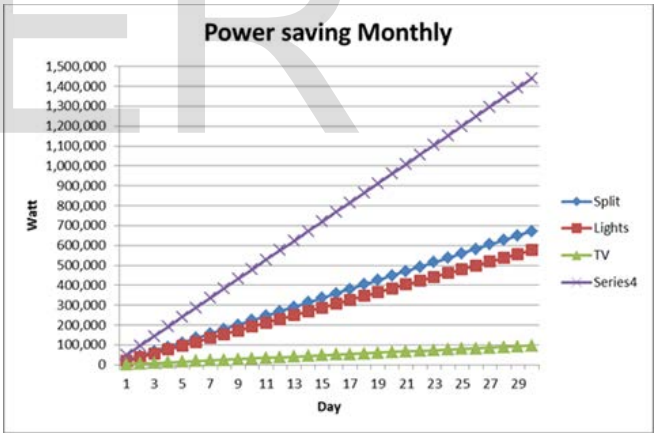


Fig.11. monthly power saving of 4 electrical devices at rate 16 Hrs./day.

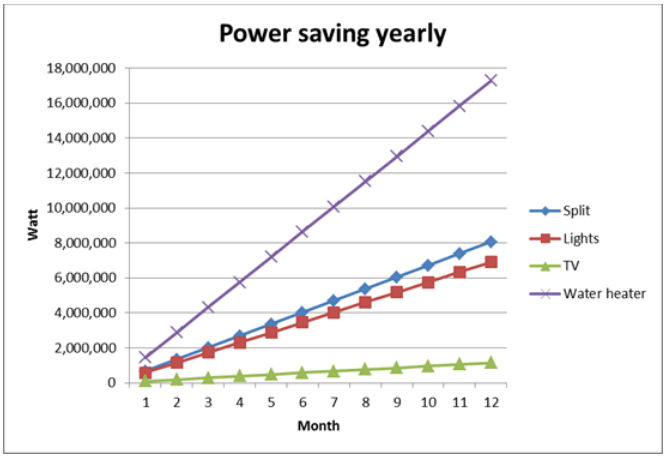
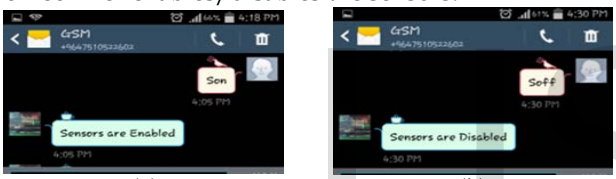


Fig.12. yearly power saving from 4 electrical devices at rates 16 Hrs./day and 30 days/month.

their values by sending limited SMS at any time. And he can control them by turning all sensors ON/OFF states by sending "Son"/"Soff" SMSs respectively.

4.2.1 Sensors Controlling

Fig. 13, shows the screenshot of mobile phone when the homeowner enables/disables the sensors.



(a) (b)

Fig.13. Implementing command to sensors controlling: (a) Implementing command to enable sensor and receive acknowledgement. (b) Implementing command to disable sensor and receive acknowledgement.

4.2.2 Sensors Monitoring

Fig. 14, shows a screenshot of mobile phone for sending related inquires-command about the values of the sensors.

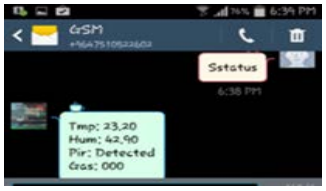
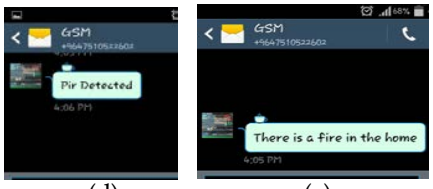


Fig.14. Implementing command to get values of sensors

4.2.3 Getting Alarm Message

When all sensors become ON, AM-side can send alarm SMS to MP-side when the values of any sensor reach a critical point. Fig. 15, shows the screenshot of the mobile, when MP-side receives alarm messages from the AM-side.

(a) (b) (c)



(d) (e)

Fig.15. Receiving message alarm from AM-side: (a) Screenshot of MP-side at instance of receiving temperature alarm SMS. (b) Screenshot of MP-side at instance of receiving humidity alarm SMS. (c) Screenshot of MP-side at instance of receiving Gas alarm SMS. (d) Screenshot of MP-side at instance of receiving motion alarm SMS. (e) Screenshot of MP-side at instance of receiving Flame alarm SMS.

4.3 Message's Report

The commands that been sent from the MP-side related to control and monitoring of home appliances and sensors are stored in a text file called "History.txt" that is located in the SD card attached to the Arduino-kit. As well as, the response messages of executing these commands sent from AM-side to MP-side are also stored in the same file. Fig. 16, represents a print-screen of "History.txt" file, which describes the structure of the stored data.

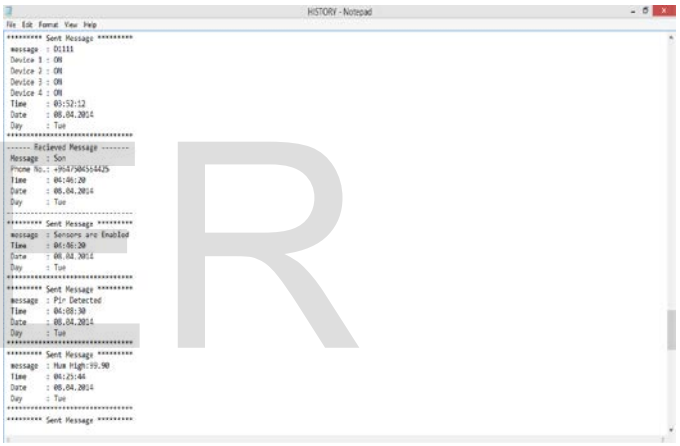


Fig.16. Print Screen of "History.txt" file

4.4 Results of Controlling and Monitoring from Outside of Iraq (Vancouver-Canada)

In order to have a full evaluation of the correct operation of the proposed system, we selected a person named (Khalil Safar) from Canada to register his phone number in our system and apply different operations (controlling and monitoring). The user is from Vancouver-Canada, where the system is located at Akre-Duhok-Kurdistan-Iraq.

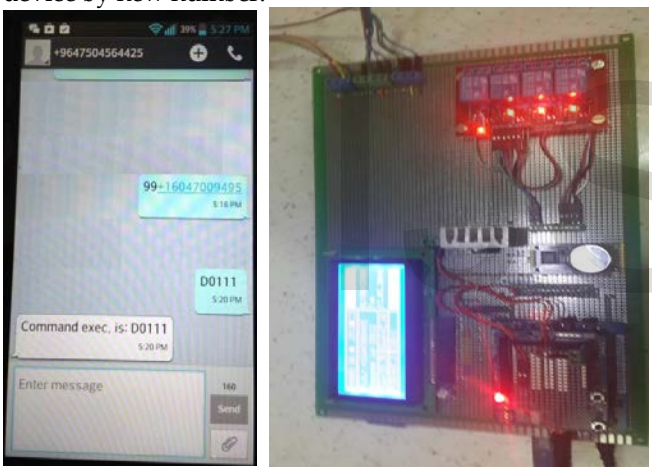
Firstly, he needs to change the registered phone number at the AM-side to his phone number.

Fig. 17.a, shows the picture taken from his mobile phone in Canada after the user sending an SMS. Fig. 17.b, represents a picture of GLCD in Iraq, which displays that SMS.

(a) (b)

Fig. 17: change the phone number. (a): picture of the MP-side when send SMS to change the phone number. (b) GLCD when received the message.

Now the user can control the devices by sending "D0111" SMS to turn the devices No. 1, 2 and 3 to ON and No. 4 to OFF. Fig. 18, illustrates the controlling of electrical device by new number.



(a) (b)

(c)

Fig. 18: applying control command D0111 by the new user: (a) picture of the MP-side in Canada when sending D0111 SMS. (b) Control board after executing the command. (c) GLCD when received the message.

Hence, the new user can apply all commands and inquiries of controlling and monitoring as he is in Iraq.

5 Conclusions

The most important points concluded from this work can be summarized as below:

1. An efficient system is proposed, designed and implemented that remotely controls and monitors home electrical devices and security/protection systems via microcontroller depending on the GSM network. This system used Arduino Mega2560 microcontroller and SIM900 GPRS/GSM Module.
2. The mobile phone did not need to have any special applications or hardware to be used in this system, and any mobile phone supporting the SMS service could be used in the system.
3. At normal situation, just one mobile phone number depended to send/receive command-messages in this system (i.e. homeowner's phone number). But, to add additional numbers (e.g. his wife's phone number), it can be done very easily by changing the related source code.
4. One of the most important concluded points, is that the homeowner can use this system (controlling and monitoring) from anywhere overall the world. This process can be done, by exchanging his phone number via sending an SMS contains the new phone number and depended secret code to the microcontroller.
5. The required size for this system programming is (41,680) bytes, which equals to (16%) of the total microcontroller storage space which is (258,048) bytes.
6. For experimental testing, this system used (34) digital pins and (2) analog pins while the total numbers of available pins in Arduino mega are (54) digital pins and (16) analog pins. Therefore, other (34) devices and sensors can be connected very easily to this system. Hence, the flexibility with the technical customization (i.e. adding/removing the connected devices/sensors) and the economy are the advantages of this design.

6 References

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