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Smart Home Automation System

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ABSTRACT: This paper presents a low cost, flexible and scalable Smart Home Automation System based on Arduino Technology and Wi-Fi connection, in addition to apply specific techniques for reduction of power consumption and load management. The system will be accessible anywhere, anytime for controlling and monitoring. This study relies on Arduino Technology and Node-MCU boards, the electrical appliances are connected to a cloud database that communicates with the user by an android application connected to the internet. A prototype for a specific house has been built, the proposed system is able to control all home electrical units and appliances like: lighting, sockets, HVAC units, fire, gas and intruder siren systems, in addition to monitor the real time power consumption, the house PV system generation and the current room's temperature and humidity. Furthermore, the system is able to reduce power consumption using predefined algorithms.

Keywords: Smart Home, Arduino Mega 2560, wireless sensor network, Android, Node-MCU microcontroller, Home Automation.

1. INTRODUCTION

Smart home automation systems (SHAS) are new trend has been started beside all new technological innovation we have today, this trend started when smart appliances became more popular, nowadays we have smartphone, smart tablets, smart cars, smart washing machines and the list goes on. Most of smart appliances became "smart" when you connect them to the internet, to give access and control power over their settings and configurations and give more technical and useful information about the process they do, from this point of view Smart home automation became a thing.

Internet of things (IoT) can be simply described as providing internet connection to hardware devices, circuits or any form of electrical appliances in order to control them from remote devices such as smartphones, which indeed adds the ability to form unique communication and features between these appliances. [1]. Smart home automation system opens the door for safer life, increasing comfort and more control over house energy and consumption which all leads to energy saving and load control [2]. This study is an application of Smart home automation system (SHAS) concept in which we apply Arduino technology to give the control over the whole system, in order to obtain a law cost, flexible, scalable, user friendly and power economical system.

In [3] a full smart home system design presented, the main purpose of this design is to find a solid way to communicate three main elements in the proposed system:

- A website server (User interface to communicate with the system).
- A personal computer as a Server.
- Arduino hardware.

The methodology used in this system depends on a website user interface so the user could interact with the system by sending commands to the server (personal computer), then the server do the processing needed for that command and then send the actuator status to the Arduino hardware. On the other hand, Arduino hardware collects sensors data and sends it back to the server, then the server do the processing needed for these data and decide the best implementation of system's actuators, and send information about the process to the user by website page [4]. The main disadvantage of such system is the dependency on physical PC for the server which limits the flexibility of the system and increases the cost.

In [5], the author presented a concept design of Home Automation system based on internet website, the study aims to control electrical home units using a website accessible from anywhere worldwide, this website connected to a personal computer mounted in the house as a system server, this pc will be connected to a hardware controller from one side using USB or LAN connection, and from the other side the controller will be connected with all electrical equipment's and units, the author provided a full detailed control design and algorithms, but It lakes from any electrical designs like PCB (printed circuit board) or even simulation diagrams or schemes.

In [7],the authors proposed a security protection and monitoring home system using Arduino and NodeMCU boards, the main idea of this approach is to connect multiple PIR sensors, fire sensors, temp and humidity sensor and other switches and sensors to an Arduino board to process received sensors signals then send the processed data to nodeMCU board connected to blink server which is connected to mobile application, the user will be able to monitor several home parameters and control some lights and door look’s solenoid, also the user would receive an email if any house intruder detected by the system.

In [8], a full working industrial smart warehouse system was proposed that relied on Arduino mega 2560 board for software processing, actuators control and sensors data acquiring and ESP8266 modules for Wi-Fi connection. The proposed system has two modes online and offline mode, if the system has an internet connection then it could be monitored and controlled from anywhere using a smartphone application, if not then a control panel inside the warehouse will do the job, the system able to monitor several environmental parameter and has movement detection system which automatically activate some electrical appliances like lights, fans and gates, also it has fire/smoke alarm system. The authors assured that the system was robust, reliable, easy to use and efficient using just an Arduino board.

In [9], the author built a simple yet effective system for a PLC controlled room plant using Arduino board, the main idea here is to extend the current system setup to a wireless approach in which the Arduino board collects the main room plant’s parameters and send it wirelessly to an android device then store them in an SQL database, the results were very effective, reliable and most important with a very low additional cost, this study showed that a low-cost micro controller such as Arduino uno could replace high-end and high-cost PLC system with a very reasonable price.

In [10], a full Smart home electrical monitoring system proposed using Arduino boards, the system relied mainly on ZMPT101T voltage transformer and ACS716 current sensor, the system achieved was 96.7% accurate in comparison with fluke digital multimeter, the most interesting result that the system is able to reduce the instantaneous house power (electrical consumption) by 10% during peak hours which highly satisfying using such low-cost system, worth to be mentioned that the system work with predefined algorithms that reads users activity and power consumption and manages all connected electrical load in a such manner that reduces the house consumption smartly and wisely without affecting the user activities.

The author of [13] introduced a smart home activity prediction system called Sequence Prediction via Enhanced Episode Discovery (SPEED), this prediction system guarantees a prediction accuracy of 88.3% which is very accurate compared to other prediction systems like LeZi, IPAM and others, the main idea of this algorithm that it depends on common home activities patterns and scenarios, the main advantage of applying such systems to smart home systems (SHS) is improving the SHS efficiency and usability.

In [15] the author used ZigBee wireless network for modeling and analysis for the smart home, where the process on his study is divided for three main types : coordinator, router and terminal node. The author used petri-nets and PIP-2 to the analysis of the system where he have studied the workflow system framework. The petri-nets aims to achieve high security and reliability system data transfer that simulate the resource flow situation in the smart home system, using resource place and transition sequence of Petri Net model to analyze the accessibility of model and verify the non-deadlock and security and other property of the smart home system.

In [16] the author used raspberry-pi micro-controller board for monitoring temperature and humanity using Bluetooth and GSM modules. The study contains many modules which are: Raspberry Pi, EnOcean control protocol transceiver module, Internet access module, data storage module. Each sensor is connected to the smart home controller which is connected to the Wi-Fi where the Wi-Fi sends the data to the server and the server sends the data to the PC. The author used java programming languages to program the user interface on the web The study main disadvantage of the system that it have one purpose only which is measuring the humidity and temperature. The study is not cast effective also where it need PC connected to it to monitor the data and save it.

In [18] the author designed low cast smart home system where it is controlled using web server. In this study Arduino nano is used as the main controller for the system. The user can control devices such as lights and Fans speed using relay module, where the status of the devices is monitored on LCD (2*8) screen and on the web server. The main disadvantage of this study that it cannot control many devices where the Arduino nano doesn’t have too much input and output pins, the system also cannot be controlled outside the house where it’s connected to the web server using ESP8266 Wi-Fi chip.

In [19] the author used Arduino as the main controller for the system and used the Node-MCU module to connect to the internet using HTTP requests from the android phone where the system can be controlled from anywhere in the world. The system communication is based on HTTP communication using API requests where it has four main commands (put, get, post, delete). The app was programed using java language. The problem with this study that it cannot be installed in the house easily where the author have tested the system on breadboard and the main disadvantage for the system that the user don’t take any feedback from the system for the status of the devices.

In [20] the author used ESP8266 Wi-Fi module based smart home, where its used as the main controller for the system . The ESP8266 acts as web server with port address of 80 characters. In this study the author used a password and user name in the application to verify the appliances and secure their data where only the authorized person can enter and control the home from the smart phone app. The problem with the Node-MCU ESP8226 module that it doesn't have too much input and output ports which means that it cannot control many devices.

2. SYSTEM STRUCTURE AND DESIGN

Our smart home approach was designed to achieve 3 main objectives

- Low-cost system.
- Flexibility.
- Efficiency.

And to achieve these objectives the system was divided into three main circuits (Master, Indoor-slave and Outdoor-slave), each circuit has its own PCB design, electrical components and software and all work separately so the working of any doesn't affect others. Figure 1 illustrates the main system layout.

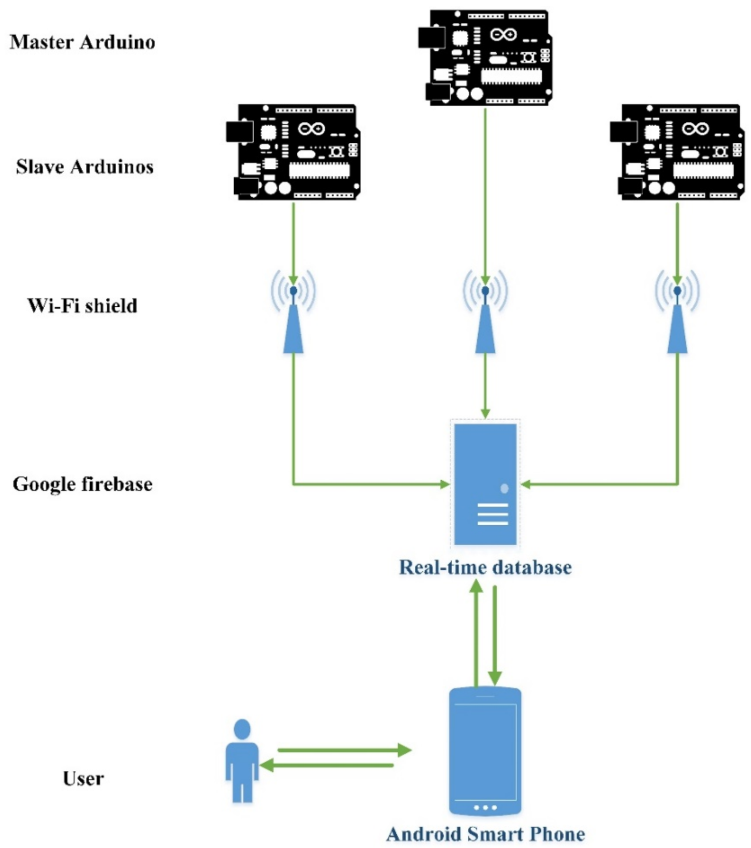

Figure 1. System layout.

2.1. Hardware design

As mentioned before the system contains 3 main circuits, each circuit has 2 Microcontrollers, actuators, sensors and electrical power elements.

- Microcontrollers: the circuit relies on 2 microcontrollers, Arduino mega 2560 microcontroller which process all user commands and activates the circuit's actuators as desired and process all received sensors signals and send it to the NodeMCU microcontroller is responsible for sending and receiving data from/to a cloud database and Arduino microcontroller.

- Electrical components:

A. Relay (10A/16A)
B. DC power supply
C. Buck converters (LM2596 DC-DC buck converter step-down).
D. Multi buffer IC (ULN2004a).
E. Gas/Fire sensor (MQ).
F. PIR sensor.
G. Humidity and temperature sensor (DH11).
H. Light sensor (LDR).
İ. Current sensor (ACS712).
J. Voltage transformer (ZMPT101B).
K. Real time clock (RTC).
L. 4 channel logic level converters.

- PCB boards: Each circuit has two PCB boards, shield board which contains NodeMCU microcontroller and RTC (real time clock) ship, and logic level shifter, the main board contains the power supply, Arduino microcontroller, and all circuit actuators and sensors.

2.1.1. Master Circuit

Figure 4 illustrates master circuit layout.

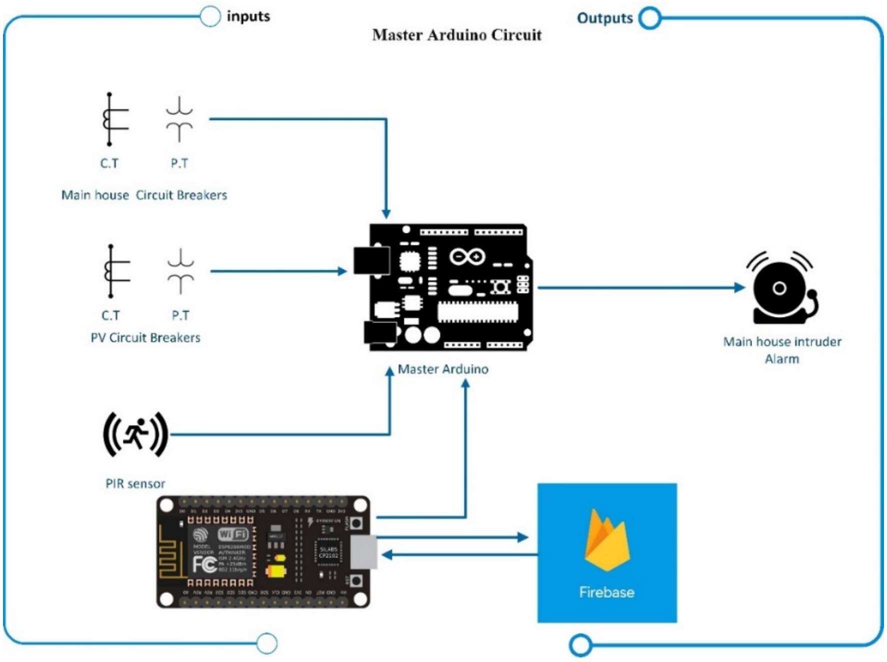

Figure 2. Master circuit layout.

- Microcontrollers:
  - 1x Arduino Mega 2560.
  - 1X NodeMCU (ver.3).
- Electrical Components:
  - 1 x Alarm relay (10A).

  - 1 x Buck converter.
  - 1 x power supply.
  - 4 x ACS712 current sensor.
  - 2 x ZMP101b voltage transformer.
  - 1 x RTC.
  - 8 x LED and resistors.
- PCB boards: Shield (figure 5 a-b) and main PCB boards (figure 6 a-b).

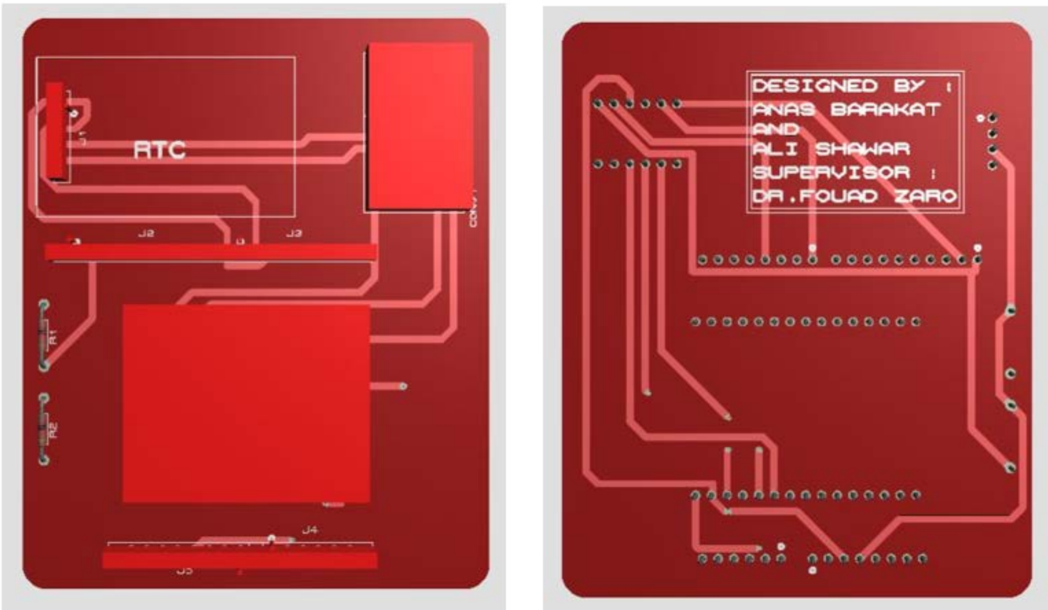

Figure 3. a-b front & back views of shield board.

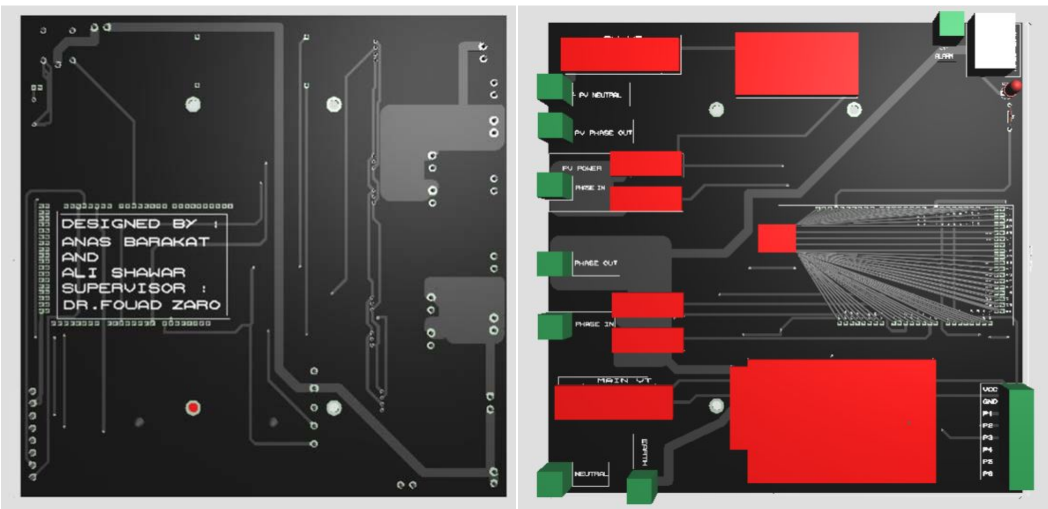

Figure 4. a-b front & back views main master board.

2.1.2. Indoor-slave

Figure 7 illustrates master circuit layout.

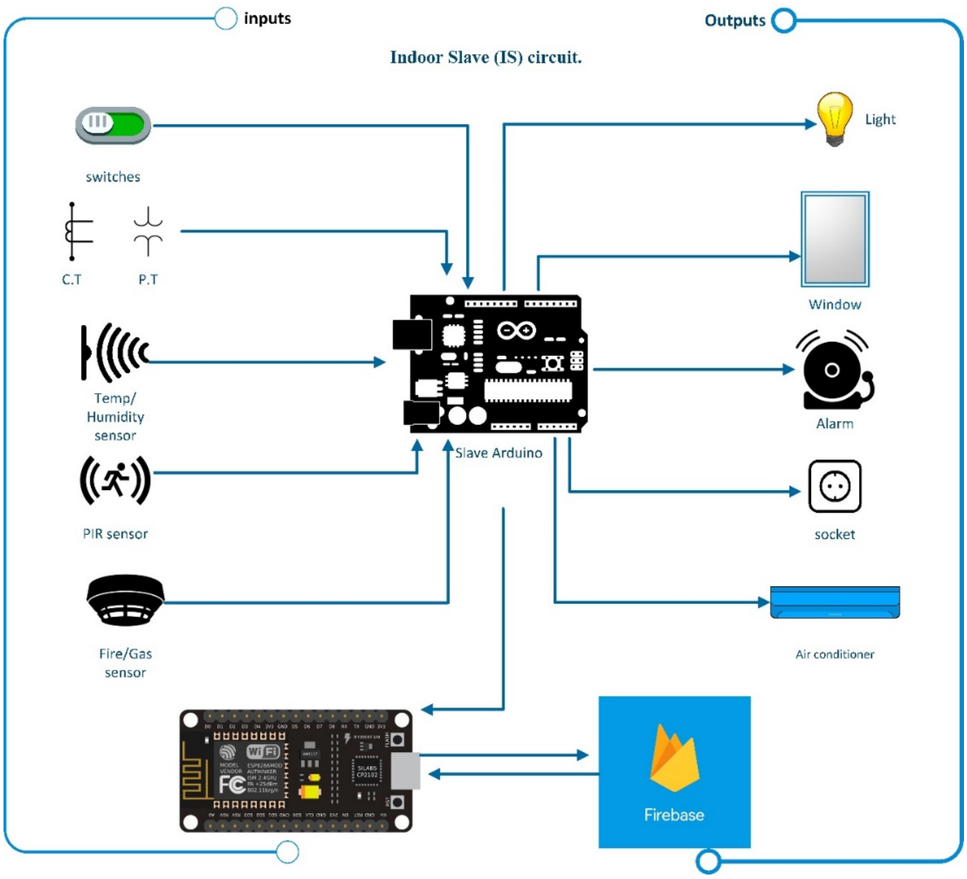

Figure 5. Indoor-slave circuit layout.

- Microcontrollers:
  - 1x Arduino Mega 2560.
  - 1X NodeMCU (ver.3).
- Electrical Components:
  - 6 x relay (10A).
  - 14 x relay (16A).
  - 3 x Buffer IC.
  - 3 x Buck converter.
  - 1 x power supply.
  - 2 x ACS712 current sensor.
  - 1 x ZMP101b voltage transformer.
  - 1 x RTC
  - 1 x LDR, 1x MQ2 & 1 x DH11.
  - 55 x LED and resistors.
- PCB boards: Shield and main PCB boards (figure 8 a-b).

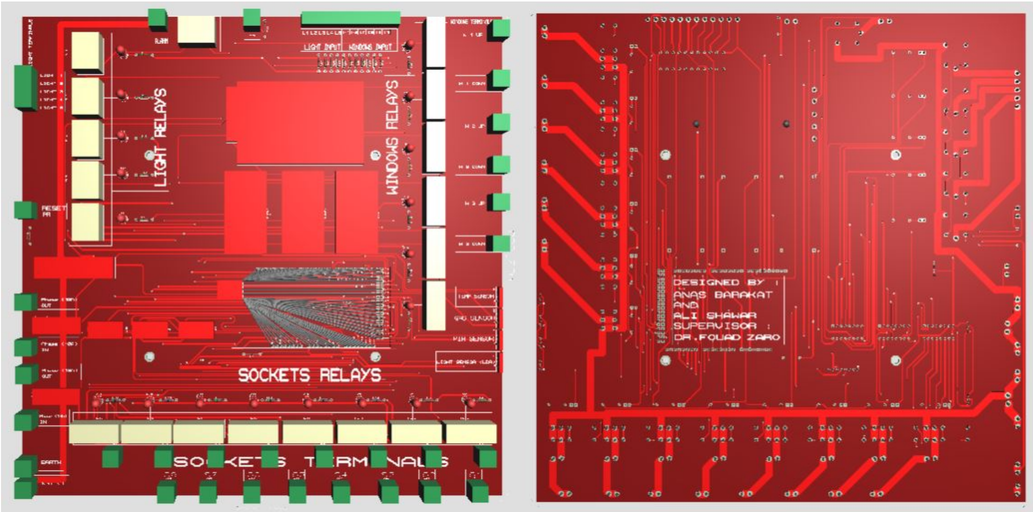

Figure 6. a-b front & back views Indoor-slave main board layout.

- Outdoor-slave

Figure 9 illustrates master circuit layout.

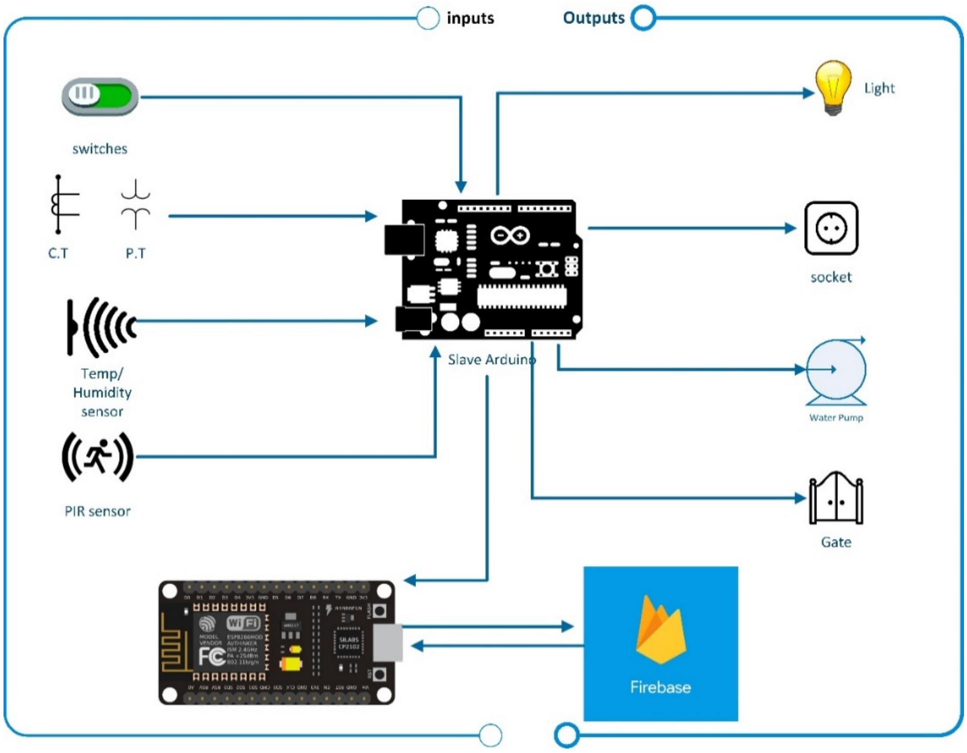

Figure 7. Indoor-slave circuit layout.

- Microcontrollers:
  - 1x Arduino Mega 2560.
  - 1X NodeMCU (ver.3).
- Electrical Components:
  - 11 x relay (10A).
  - 10 x relay (16A).
  - 3 x Buffer IC.
  - 3 x Buck converter.
  - 1 x power supply.
  - 2 x ACS712 current sensor.

- 1 x ZMP101b voltage transformer.
- 1 x RTC.
- 1 x LDR, 1x MQ2 & 1 x DH11.
- 55 x LED and resistors.

- PCB boards: Shield and main PCB boards (figure 8 a-b).

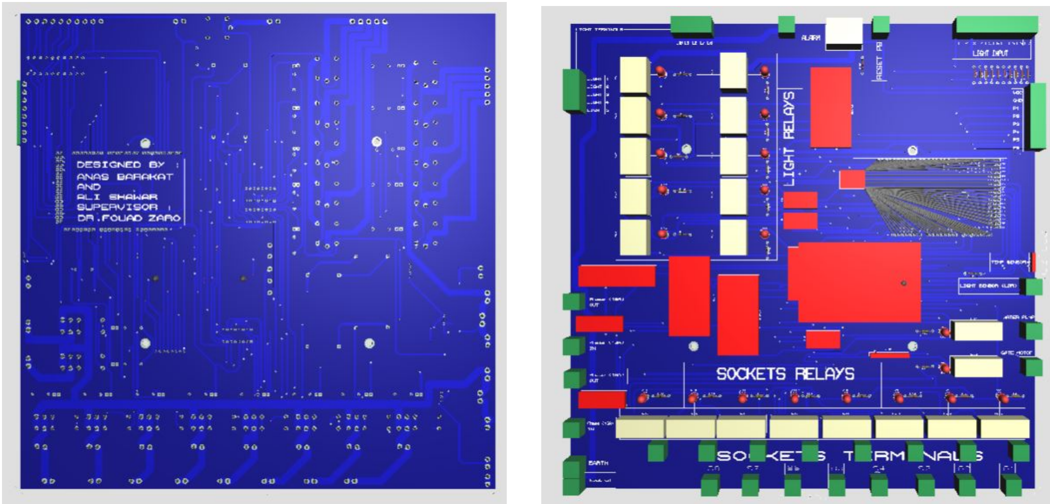

Figure 8. a-b front & back views Indoor-slave main board layout.

2.2. Software design

In this section we are listing all software programs (Tables 1&2) used in designing our system's hardware and software and the main flowcharts of each circuit describing the main processes and techniques used in the system.

Table 1. programming languages used.

Programming Language	Use
Arduino IDE software based on C/C++	Arduino programming
Http Commands + AT commands	Google firebase real-time database
android SDK based on Java	android Application programming

Table 2. software programs used.

Program	Use
Proteus version 8.1	Design Main Electrical Circuits PCB schemes
AutoCAD 2016	Design Case Study House
Shapr3D (based on CAD Software)	Design Wall mounted covers for PCB boards
Microsoft Visio 2016	Design study Diagrams and Flowcharts

Figures 11-14 show the flowcharts for the system's main circuit boards and the android application. Master circuit will act as a monitor device for both house electrical consumption and PV system production and includes an intruder siren system capable to detect movement for different 14 PIR distributed all over the house sensors.

The master circuit equipped with Hall Effect current sensor will be described later in this report and with V.Ts for both

- Main house circuit breaker.
- Main PV system circuit breaker.

The board read both RMS value for both voltage and current, and then calculate the power by 10 sec refresh rate, and calculate the consumption/production energy for recent day, month and send them to the database, in which all the data stored in specific variable, then these data read by the android application and presented in statistics page.

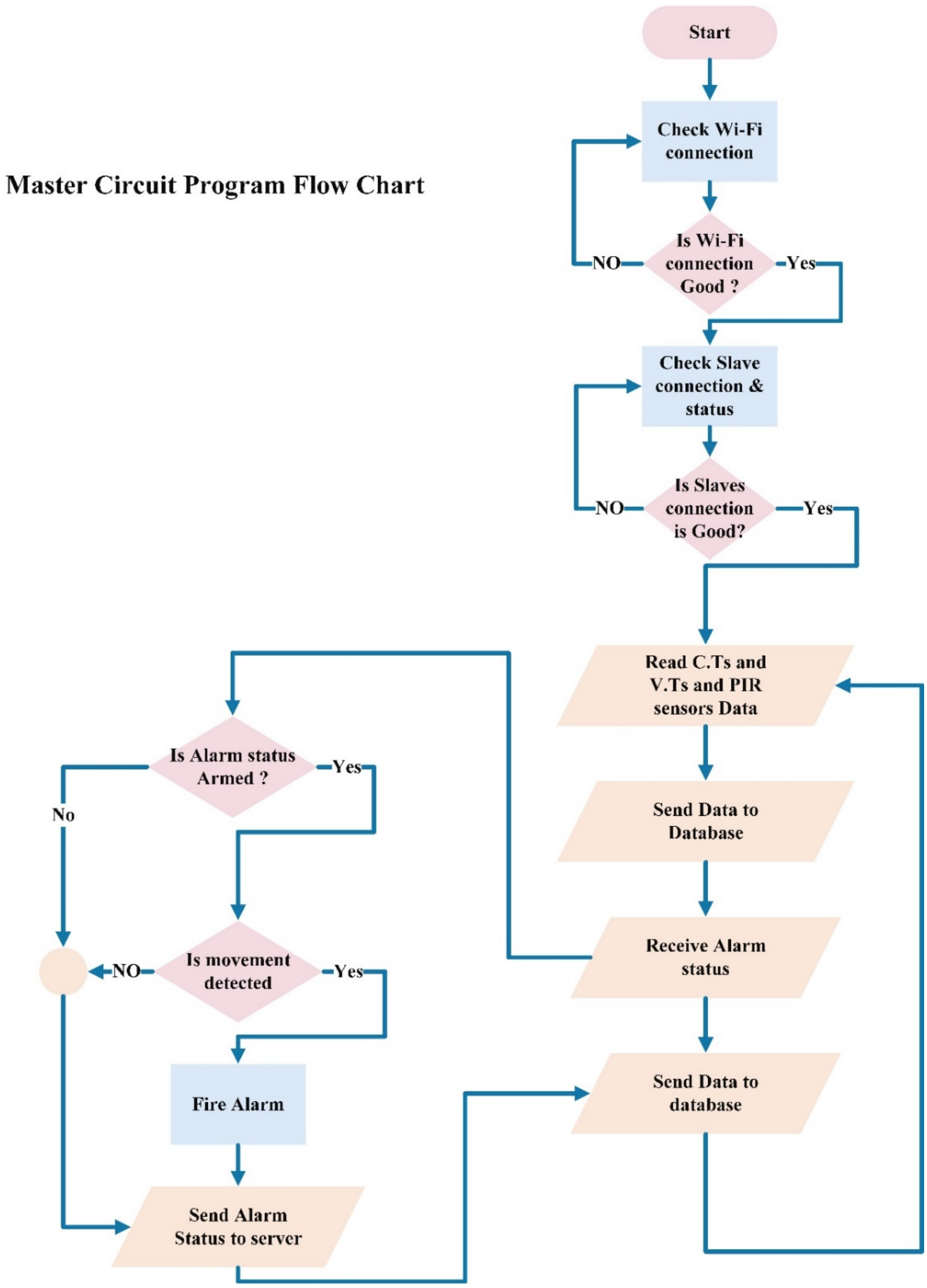

Figure 9. Master flowchart.

In Figure 11, we illustrate the main software algorithm for the master circuit board in the system:

- When the master board start working for the first time, it checks the internet connection as programmed before by the end user.
- After the board receives a robust and stable internet connection it checks the slave's boards connection to make sure that each part of the house is connected and properly working.
- Then the board starts reading each C.T and V.T values to detect the real R.M.S value for the voltage and the current of both the main circuit breaker of the house and the main breaker of the connected PV system (if available).
- Then based on previous readings the board calculates the consumed and produced (power and energy) of the house, then the board send the data to the server and store them inside its own memory in case of any internet connection problems.
- in parallel to previous process the board checks the alarm status from the database (Armed or Not armed), if the system is armed the board checks each PIR value to detect any human movement, if any is detected, then the intruder alarm system will be fired, and the board will send a notification to the database to be send to the user smartphone.
- Furthermore, master circuit calculate 15 minute KW demand and send it to a public or private (as desired) online google sheet, for electrical distribution calculation, this data is very useful for users consumption reading and building distribution transformer loading curves, transformer diversified demand curves, load duration curve and accurate diversity factor table for electrical utility database, so distribution transformer capacity and expansion calculations will be much more accurate for the government or at least for the local electrical supplier.

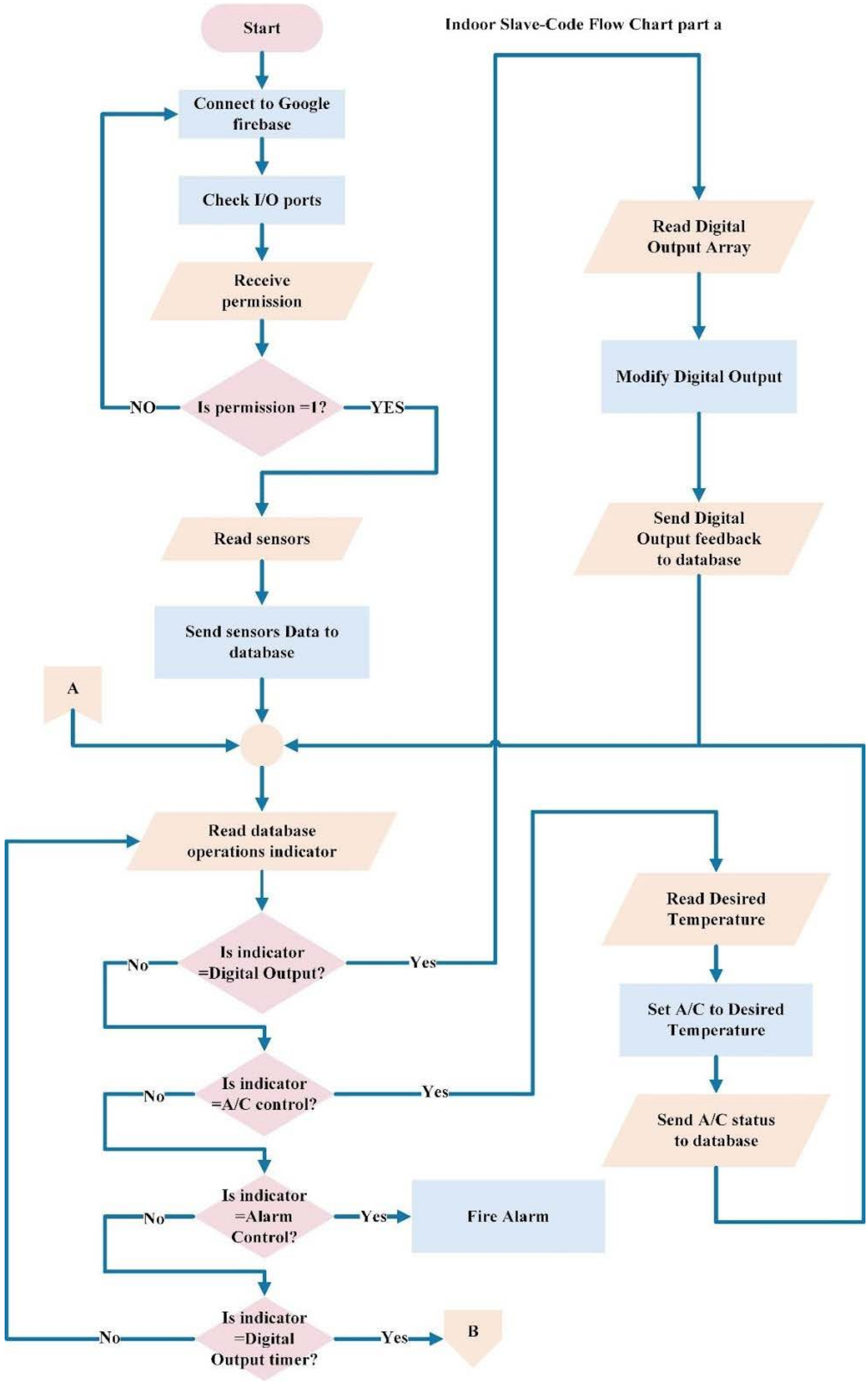

Figure 12. Indoor Slave software Flowchart A.

In Figure 12, we illustrate the main software algorithm for the indoor slave circuit board in the system:

- The circuit initiates the connection with the database using Wi-Fi internet connection, then checks ports status like relays, sensor and actuators, if everything is as expected, the circuit waits the permission to be given by the database to connect.
- After the connection to the Database, the circuit starts reading all sensors data (like: Temperature, humidity, V.T, C.T, PIR, LDR, Gas sensor etc.) and send sensor readings to the database.
- After that the circuit reads consumer commands stored in the database as a serial of characters and numbers (like: daa077664512L99999999w99999999xdab2000220099999999999999999xdac220020009999999999999999xdad2000220099999999c000x).
- Now each character in the sample above is an indicator, and the serial of numbers are decimals indicates the binary value of each inputs and an encryption for the alarm system and timers for each electrical appliance.
- For HVAC units, the system can read the desired temperature and then decode the temperature to the desired frequency, and then send it to previously programmed IR LED, to turn the HVAC unit on directly to the desired temperature and mode.
- Also the system is programmed with some predefined safety scenarios like if the system detects any toxic gases it automatically open the windows and if any fire is detected the system will activate Fire-Siren system and reach the user by the smartphone application.

Note: for HVAC units, the system is flexible so we can program it to any IR frequency, by other words we could program any IR remote with the system.

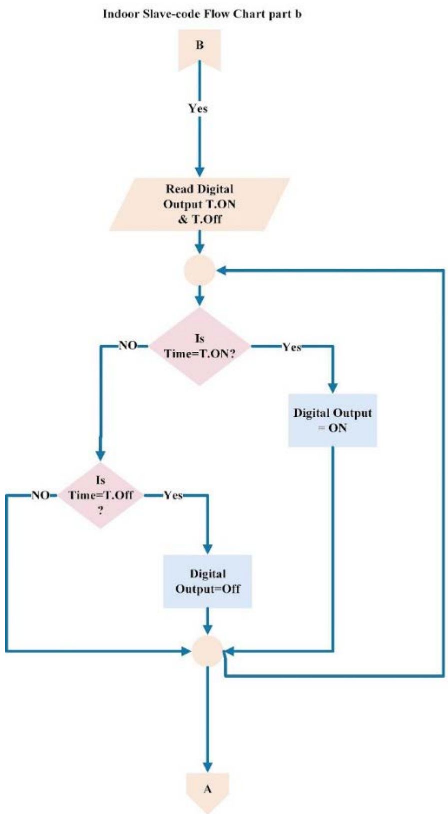

Figure 13. Indoor Slave software Flowchart b.

In Figure 13, we illustrate the timer algorithm for the indoor slave circuit board:

In this system, the user is able to define a timer for turning on or off any electrical appliance, for example: The user is able to set a timer to turn the kitchen lights off at 12:00 am, and turn all house's lights on and windows to open on at 7:00 am. Those timers stored in the database as serial of characters and numbers, when the circuit receives these serial it program itself to turn on/off or open/close any electrical appliance as desired.

The main user will communicate with the system using an android application loaded on android smartphone, the application have access specific predefined database for the system, the user will have database link and authentication key, Then the smart app send the authentication key and database link to Google firebase to check access if it's OK then the real-time database let the app control the master and slaves circuits by sending commands and receive information from the system see Figure 14 for android application flowchart.

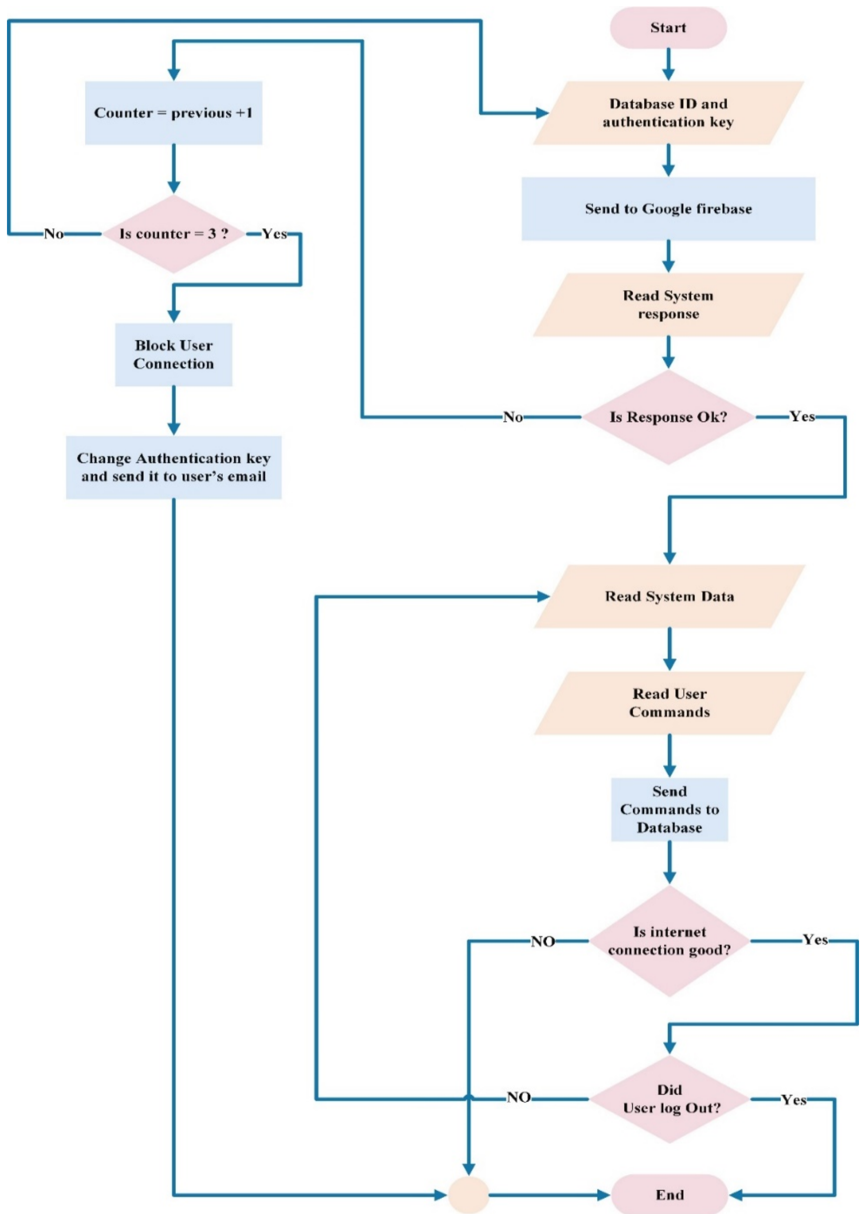

Figure 14. Android app flowchart.

3. IMPLEMENTATION.

In this section we describe the main techniques and how we implemented our system connection, control, electrical consumption measurement and PCB design and calculations.

3.1.System Connection

In this approach we relied on Wi-Fi technology where each circuit of the three has a shield board with NodeMCU controller, the NodeMCU controller provided with Wi-Fi ship that give the microcontroller an internet access which in turn connects the microcontroller to the cloud database (Google firebase).
The system's cloud database has specific name and authentication key, when the NodeMCU connects to Google firebase, google server checks the name and authentication key and gives the NodeMCU access to the system database. Now the microcontroller continually reads cloud's variables and send feedbacks about sensors and devices data and information.

The NodeMCU microcontroller communicates with Arduino microcontroller through I2C communication, this communication provides reliable and robust communication between different manufacturer boards, although it's much simpler than alternative communication types for microcontrollers but yet it's the most used serial communication in microcontroller industry.

3.2.Control

When the user activates an electrical device through the android app, the application generates a series of characters contains an encrypted information about the devices status including the new command then the app sends the data to a specific variable stored in the cloud database, as mentioned before the microcontroller continually read cloud's variables and when a new data is detected the NodeMCU microcontroller send the data to the Arduino Mega 2560 which in turn decrypts the data and activates the desired changes.

In this system the user will be able to control the following:

- Light units.
- Electrical outlets.
- Electrical windows.
- HVAC units the control includes desired temperate and mode (heating or cooling).
- Electrical Gate.
- Electrical water pump.
- And any loads operates with current under 16A.

The user will be able to turn on/off the devices, set desired daily turn on/off time and generate custom buttons able to activate or deactivate any devices as a predefined sequence of activities like (Leave Home button) that automatically deactivate all non-critical devices and close the gate with single button press, typically as any user would do when he leaves his home.
For HVAC unit control, we relied on IR technology, in which we program the system with the AC's remote control IR frequencies for each temperature (18-30) C^0 and mode (heating or cooling).

Also the system will present many electrical and environmental parameters:

- Humidity

- Temperature
- Toxic Gas & fire status.
- House power consumption (watt).
- House monthly consumption (kWh).
- House daily consumption (kWh).
- PV system generation power (Watt).
- PV system monthly generation energy (kWh).
- PV system daily generation energy (kWh).
- PV status. (Normal, need cleaning or need maintenance).

PV status is a technique in which the system will compare the generated energy and peak power of the system daily and compare it with NASA database of the solar hours of system's location and determine whether the system generates the expected energy or not.

3.3. Power and Energy Calculations.

In this section we're illustrating our technique in calculating voltage and current RMS values. For voltage measuring we're using ZMPT101B voltage transformer, that converts voltage from AC range to DC sinusoidal wave form with 2.5v reference value, in order to calculate the RMS value we take 40 samples each cycle (i.e. one sample each 500 micro seconds), then we calculate the RMS value for the measured cycle using the following equation.

$$\mathrm{Vrms/cycle} = \sqrt{\frac{\sum_{1}^{40} \mathrm{Vsample}^2}{40}} \qquad (3.3.1)$$

And for higher accuracy we take the average RMS value for 12 cycle, this process refreshed each 10 seconds, this calculation process used for both current and voltage and for current measuring we're using ACS712 Hall Effect IC.

Each 10 seconds we calculate the apparent power and add it to energy variables to calculate energy.

$$\mathrm{S\ (VA)} = \mathrm{Vrms} * \mathrm{Irms} \qquad (3.3.2)$$

To calculate the average power we need to calculate PF (power factor), and to do so we measure the time difference b/t voltage zero crossing sample and current zero crossing sample, as we have 20 sample per cycle

$$1 \text{ x Cycle} = 20\text{ms for 50 hz frequency}$$

And

$$1 \text{ x Cycle} = 360 \text{ degree}$$

For 20 samples per cycle we have

$$1 \text{ x sample} = 1\text{ms} = 18 \text{ degree.}$$

Now we calculate the number of samples b/t voltage zero crossing sample and current zero crossing sample

$$\mathrm{V_0\ sample\ \#} - \mathrm{I_0\ sample\ \#} = \mathrm{N}. \qquad (3.3.3)$$

Now for power factor angle

$$\theta = 18 * \mathrm{N} \qquad (3.3.4)$$

$$\mathrm{PF} = \mathrm{Cos}(\theta) \tag{3.3.5}$$

Average power

$$\mathrm{P_{avg}} = \mathrm{S} * \mathrm{PF} \tag{3.3.6}$$

$$\text{Energy variable (Watt Hour)} = \text{prevoius value (watt Hour)} + \mathrm{P_{avg}}(\text{watt}) * \left(\frac{10}{3600}\right) \tag{3.3.7}$$

3.4. PCB design and calculation

All PCB boards designed using Proteus software ver. 8.1.

For trace's width calculations we have 2 types of traces:

- Signal trace that represent all signals from-into Arduino boards.
- Power traces that represent phase traces, 16 Amp phase for power circuits and 10 Amp phase for lighting circuits.

3.4.1. Traces widths

- For signal trace width we chose 1.2 mm width which is s standard in PCB design.
- For 10 Amp trace we chose 3.75 mm width.
- For 16 Amp trace we chose 4.5 mm width.

3.4.2. Calculations

First, the Area is calculated:

Area [mils^2] = (Current [Amps]/ (k*(Temp_Rise [deg. C])^b))^(1/c) (3.4.2.1)

Then, the Width is calculated:

Width [mils] = Area [mils^2]/ (Thickness [oz]*1.378[mils/oz]) (3.4.2.2)

For IPC-2221 external layers: k = 0.048, b = 0.44, c = 0.725

- For 16A traces:

Area $=\left(\frac{16}{0.048*50^{0.44}}\right)^{1/0.725}$ = 281.01(mils^2)

Width $=\frac{281.01}{1*1.378}$ = 204(mils)

204 mils =5.18/2=2.56 mm

Average Ambient Temp. =50 C^o Temp. Rise = 20 C^o.

- For 10A traces:

Area $=\left(\frac{10}{0.048*50^{0.44}}\right)^{1/0.725}$ = 146.95(mils^2)

Width $=\frac{146.95}{1*1.378}$ = 107(mils)

107 mils =2.71 /2=1.355mm

Average Ambient Temp. =50 C° Temp. Rise = 20 C°.

4. DISCUSSION

This paper demonstrates that a low cost, flexible and scalable smart home automation system based on Arduino technology and Wi-Fi connection has been designed, implemented and established, each PCB circuit had been printed and tested thermally and it could withstand without any external cooling in environment with ambient temperature up to 45 C^0 .

Furthermore, this specific system has been implemented on a small room unit and tested for more than 6 months, all circuits worked perfectly fine, with command success rate of 99%, and the speed of processing the command was on average 1.5 second, and the average time for receiving the feedback of the processed command takes on average 2.7 seconds.

In comparison with other smart home systems our system will cost quarter the cost of other systems such as (ABB, Siemens, Belkin), these systems use master unit to control all the devices where each device has independent circuit that control and connect it to the master unit, this method will increase the price a lot where the total number of the circuits used is large.

5. CONCLUSION

The proposed system consists of many sub-systems that controlled by Arduino and Node-MCU microcontroller as a main controlling system, in addition, to apply specific techniques for the reduction of power consumption and load management. All equipment connected to a cloud database that communicates with the user by an android application connected to the internet. The system is accessible anywhere, anytime for controlling and monitoring issues. The performance of the communication system works well, although it is highly dependent on the internet provider.

A prototype for a specific house has been built, the proposed system is able to control all home electrical units and appliances like lighting, sockets, HVAC units, fire, gas and intruder siren systems perfectly, in addition, to monitor the real-time power consumption, the house PV system generation and the current room's temperature and humidity. Furthermore, the system is able to reduce power consumption using predefined algorithms.

The proposed architecture of SHAS increases the safety protection to the user; the system uses a low voltage activating switches rather than the conventional electrical switches. Moreover, implementing Wi-Fi connection in master and slave control boards that allows the system installs in a simpler way. Furthermore, any Smartphone based on Android and support Wi-Fi can be used to access, monitor and control the devices at home. Future works will focus on controlling the application of home devices by voice commands.

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APPENDIX

List of Symbols and Abbreviations

SHAS	Smart Home Automation System.
IoT	Internet of Things
PC	Personal Computer
HVAC	Heating Ventilating Air Conditioning units
UPS	Uninterruptable Power Supply
I/O	Inputs/Outputs
USB	Universal Serial Bus
LAN	Local Access Network
PCB	Printed Circuit Board
I2C	Inter-Integrated Circuit
IP	Internet Protocol
C.T	Current Transformer
P.T	Potential Transformer
IS	Indoor Slave
OS	Outdoor slave
LDR	Light Dependent Resistor
PIR	Passive Infrared Sensor
Kbps	kilobytes per second
SCL	Serial Clock Line
SDA	Serial Data Addressing
ID	Identification
SRAM	Static Random Access Memory
EEPROM	Electrically Erasable Programmable Read-Only Memory
LED	Light Emitting Diode
DC	Direct Current
IR	Infra-Red
RH	Relative Humidity
CAD	Computer-aided drafting
IDE	Integrated Development Environment
Http	Hypertext Transfer Protocol
SDK	Software Development Kit
3D/2D	3 Dimensions/ 2 Dimensions.