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An Android Based Smart System to Control and Monitor Home Appliances Using Arduino Microcontroller

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Abstract: Profiling the usage of electric power home appliances within home can be used as a scheme for defining resident's activities of daily living. Due to advancement in technology, our daily based activities in homes and offices becoming smarter. The android and microcontroller based smart applications play a massive role in this regard. In this paper a smart system has been designed and implement to control and monitor power consumption patterns of various home appliance remotely. The smart system provide a user friendly android based interface to control the home appliance according to their requirements and moreover, monitor the power consumption patterns of different residents. This smart system bring together both technology such as android based application and wireless 3G technologies making it cost effective and more efficient system to control the power consumption patterns.

Keywords: Android Application, Arduino microcontroller, GSM module, ACS 712.

I. INTRODUCTION

Energy consumption is a major issue in the modern world. Inefficient electric power control and monitor techniques being used by residents, businesses communities and institutions are the main cause of electric power shortfall [1]. In Pakistan the electric power companies and consumers do not have an automated electric power monitoring and controlling system to manage the electricity at various levels. It's often happen that the consumers forget to switch off home appliances while leaving the home. The result was un-necessary wastage of electricity and damaged of home appliances due to overheating. Especially when the consumers are for away from the home and remained that some devices were on, it may be difficult for consumers to come back and switched off the appliances. Some researcher designed prototype systems based on different technologies such as GSM, ZigBee, Bluetooth, and cloud computing to control and monitor the appliances but these systems were not providing the power consumption details of every individual home appliance [3, 4]. In this proposed system we have develop a system based on GSM technology along with android based application and Arduino microcontroller. The prototype smart system monitor and control the domestic wastage of energy at homes and also provide an easy interface to switch on/off the home appliance remotely [5,6]. Furthermore, the system has mobile based GUI to control the different home appliances such as Bulb, Fan, TV, Ac, etc. The further paper is organized as section II provides research background about Smart system, section III indicates the research problem, section IV discuss the system architecture, and section V includes working mechanism as well as flow chart. Section VI and VII provides hardware module and software module respectively. Section VIII and IX explain the result analysis while last section i.e. section X presents the conclusion of the work.

II. LITRATURE REVIEW

Many smart systems have been developed by different experts which has provision to control and monitor the home appliances and protect the privacy of consumers. Some researcher has implement the smart system based on Bluetooth technology for home automation [7, 8] and some other researcher preferred ZigBee technology [9, 10]. Before invention of smart technologies, the home automation task was indistinct, difficult and complicated. However, in recent era, many residential and commercial consumers used home automation technologies across the world [11]. An overview of smart homes and different security issues were also presented in research [12]. The authors also summarized different security studies and there some relevant solutions. Researchers in [13] surveyed the use of the IoT and big data in smart homes and the technologies necessary to permit them in smart homes, they also presented their applications and services. In [14,15], the authors discussed the advantages and applications of using the IoT in smart homes. Research in [16], the challenges, obstacles and benefits of implementation of Smart homes is discussed. However, the existing technologies has some courage limitations due to limited coverage. In this research paper, we proposed the GSM technology along with android application to monitor and control the home appliance power consumption remotely. The developed system allows multiple consumers to monitor and control their home appliance remotely by using android application irrespective of their locations where they are. The design prototype system is cost effective as compare to other existing system due to low cost devices and user friendly interface. The maximum existing system are proprietary based and do not have provision for commercial usage. Moreover, the systems are expansive in

terms of hardware cost, difficult maintains and complex interfaces. In Pakistan, the consumers do not have an efficient smart system to control and monitor the home appliance however, the proposed system helps to supervised and regulated the home appliances. The Collection, disposing off, recycling of garbage in proper and sophisticated manners is the need of modern era. So in Paper [17], the authors proposed the development of Microcontroller based smart city infrastructure for garbage management system using Microsoft Azure cloud resources to tackle these issues.

To avoid traffic jams and maintain the smooth traffic the authors in [18] proposed a smart electronic toll collection system along with the vehicle record management system. The vehicle record management system will help to reduce the crime rate up to some extent.

In [19], the authors proposed five new pre-screening analysis methods that use interval energy consumption data to better characterize building energy use for the residential consumers who want energy savings from the use of Home Automations Devices before they are installed.

In [20] SHES aims to reduce the users' electricity bill while maintaining the stability of the power system and improving the user's comfort level by reducing the device's standby time

III. PROBLEMS WITH THE EXISTING SYSTEM

During the literature review, we have found various systems which were used to control the home appliance by using different wired and wireless technologies. However, the wireless technologies provide limited coverage such as Bluetooth has 20 meters, Wi-Fi has 100 meters, and ZigBee has 1000 meters or range. To avoid the coverage limitations, we proposed system to monitor and control the electricity losses remotely.

The APMCSH system will be developed which will be consist with GSM technology along with android based application and Arduino microcontroller. This will monitor and control the domestic wastage of electricity at homes and also provide an easy interface to switch on/off the home appliance remotely.

IV. SYSTEM ARCHITECTURE OF APMCSH SYSTEM

The proposed design system depicted in **Error! Reference source not found.** has various components to meet the requirements of home automation. The required components are as follow, Arduino AT mega 2560 microcontroller, Android based application, GSM communication module, ACS 712 current sensors, four channel relay circuit, power supply and different home appliances. After composition of the proposed system, the system works properly and perform the power consumption, measurements accordingly.

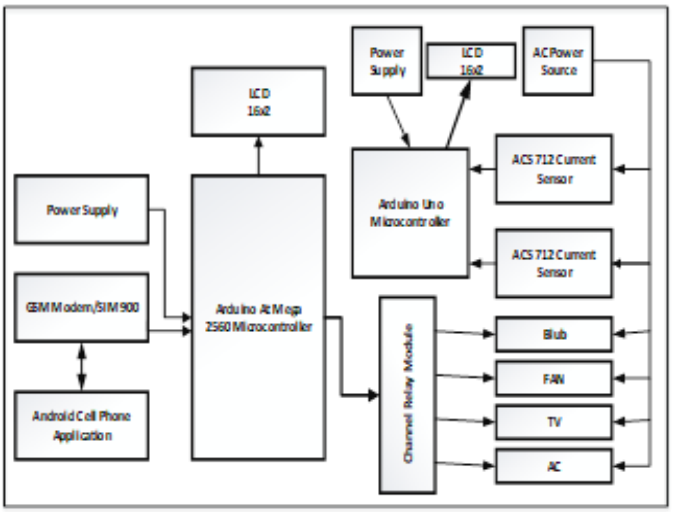

Figure 1. System Architecture of APMCSH System

The status of the home appliance can be check using android application and also turn ON & OFF the devices. The background process of android application is just like a text messaging. Just press the on button for any appliance on android application, the application will send command as a text message to the GSM module which is already interface with microcontroller. The microcontroller read the text from the command and switches the relays according to received command. The status of devices will be shown by the LCD of the system. The pros of design system are that any consumer can turn ON & OFF any device through timer setting process of android application.

V. WORKING MECHANISM OF THE SYSTEM

The following figure 2 depicted flowchart shows the working mechanism of proposed system. How the components of system are interconnected to each other to perform the required actions.

- The GSM modem is connected with the microcontroller by serial communication port.
- The android application on the smart phone is interacting with GSM modem by sending command (message) for controlling the home appliances.
- Android application also shows all devices power consumption pattern.
- With the help of android application any consumer can set timer for turn ON & OFF home appliances on need biases
- With the help of GSM consumer can be able to control the home appliances from any remote location.

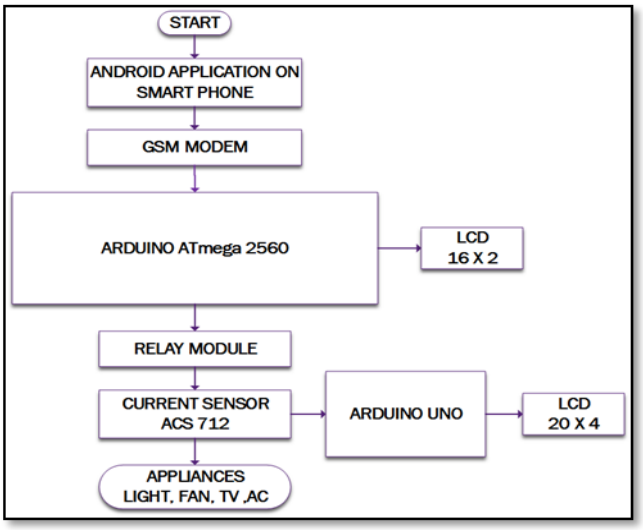

Figure 1. Working Mechanism of the System

A. *Controller Marker Sleeve*

In Figure 1 basic flow chart of system is given, when the embedded systems started working, a message is printed on LCD that the system is ready to use. It uses certain relays for successful communication and control of the power load of appliances. The touch screen smart phone handles the application using the GUI and developed android application automatically generates SMS messages based on the user commands and sends it to the GSM modem attached to the Arduino microcontroller. This allows user to control the select the particular home appliances. Furthermore, through the GUI (Graphical User Interface) android application helps to controlled home appliance remotely such as electric bulb, fan, TV, AC etc. The smart android application also provide list of all home appliance and control blocks for each home appliance. The control blocks provides interactive buttons to ON and OFF the appliances according to the requirement. The software component of the system transmitted control commands through GSM communication module. At the other side, GSM receiver receive the command and decode it and sent to the microcontroller. The microcontroller performed the required actions accordingly. Initially, four home appliances has been choose to test the functionality of design prototype smart system such as (Electric Bulbs, Fan, Ac, and TV).

- (#light on$ and #light off$)
- (#fan on$ and #fan off$)
- (#ac on$ and #ac off$)
- (#tv on$ and #tv off$)

B. *Interfacing of Android Application and GSM Modem*

When the user starts to use the smart android application. The user have been go through from some basic routine steps as shown in **Error! Reference source not found.** such as

- Open the android application with a registered and valid cell number
- Initially, registered the home appliances on android application control list
- Start to turn-on the appliances according to requirements

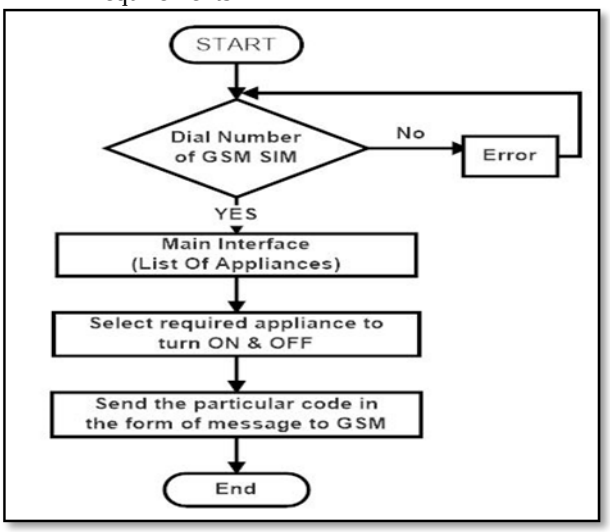

Figure 3. Interfacing of Android Application and GSM Modem

C. *Interfacing of GSM and Arduino Microcontroller*

Once user done the initial steps of interfacing between android application and GSM communication module. The next step was interfacing between GSM and Microcontroller as shown in **Error! Reference source not found.**.

- When a control message or code has been send from the user terminal. Then GSM communication module received the code and transmit that code to RX terminal of the Microcontroller.
- The next steps were authenticated the cell number, is it a legitimate or registered cell number
- When the system found a valid registered number then controller execute the code and sent signals to command box to perform the required actions.

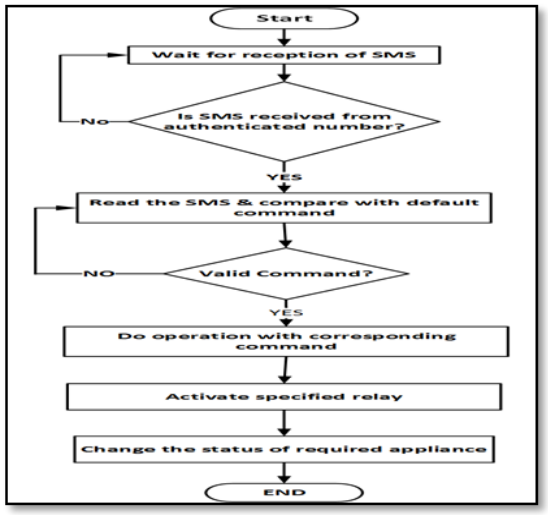

Figure 4. Interfacing of GSM and Arduino Microcontroller

VI. WORKING MECHANISM OF THE SYSTEM

The APMCSH prototype system module is the combination of hardware and software components. Each component supposed to perform the specific function regarding domestic energy management smartly. Hardware component of APMCSH is consist of various components such as Arduino microcontroller, ACS 712, AC, DC power convertor, android cell phone, Serial port communication, current sensor (ACS712), Liquid crystal display (LCD), 4-Channel relay module as shown by **Error! Reference source not found.**.

- Arduino Microcontroller: Arduino microcontroller has been used to connect the all components of home appliances. The microcontroller controlled the all activities inside smart electric panel. It has an open source hardware and software environment to extend the existing function of smart electric panel.
- ACS 712: ACS 712 current sensor was used to measure the electrical power measurements. The sensor is capable to measure the AC and DC electric power.
- GSM Module: GSM communication module is component of hardware and software module which provide serial ports for bi-directional communication.
- 4-Channel Relay Module: The relay module performed switch-on and switch-off activities according to pass codes from the microcontroller.

Figure 5. Hardware Component of APMCSH System

VII. SOFTWARE AND HARFDWARE MODULE OF SYSTEM

The figure 5 and 6 depicts the hardware and software components of proposed system. The hardware component consist of Adriano based microcontroller, LCD, real time clock, electric bulbs, GSM module and ACS 712 sensors. The hardware module of the proposed smart system has been used to measure the power consumption patterns of every connected home appliance, calculate the power reading and sent it to its cross pounding software component. Furthermore, the hardware component switched off electric power supply to specific home appliance as command by software component.

While the figure 6 shows software component and associated components to control the energy consumption such as

- Android based power monitoring system: This component is design to only monitor the energy consumption patterns and received power consumption reading via GSM communication module.
- Subscriber Identification Module Number: This component authenticated the valid subscriber identification module number. When user try to access the android application through unregistered cell number then this component intimate or sends an alerts to concern data center.
- Total Power Consumption: The total power consumption module was use to keep the record of total energy consumption used by consumer. The component shows energy consumption in watts.
- Appliances Timer: Appliances timer is another component of software module where the appliance has been set for specific time in case of absence of user in their homes. Once the timer is then the home appliance are turn-on and turn-off according to the timer line.

Figure 2. Android Application for APMCSH System

VIII. System Testing and Results Analysis

The testing phase includes hardware and software module participations. The user supposed to install the android application on their cell phone. Once application has been installed then user needs to register their valid cell number. After that, the android application shows the registered home appliances which will be control by the user requirements. Moreover, users can be able to control the home appliances by using the interactive button such as, (Light-ON), (Light-OFF), (Fan-ON), (Fan-OFF), (TV-ON), (TV-OFF), (AC-ON), (AC-OFF) buttons.

Initially, the smart system was connected through five different home appliances such as TV, FAN, IRON, Electric Blubs and AC. when users want to switch ON/OFF the electric bulbs. Then he/she press the ON/OFF button and then application sends the "ON/OFF" code to microcontroller. The microcontroller decode the signal and sent it to relay module to perform the specific action as shown in **Error! Reference source not found.**.

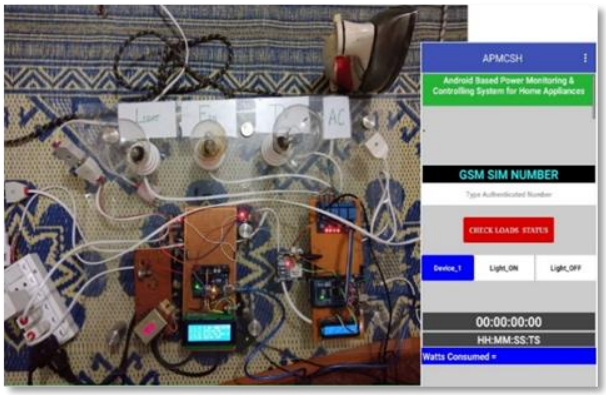

Figure 7. System Testing and Result Analysis

A. Active Power Load of AC (Air-Condition)

The Figure 8 shows hardware component of proposed smart system while the LCD shows the power consumption patterns of single home appliance such as AC.

Figure 3. Active Power Load Reading on Smart Hardware Module

The Figure 9 shows the active load of AC (air-condition) on smart android application. The android smart application contains various interactive intent buttons for different activities. When user want to switch ON the all registered home appliance, he /she just press the interactive ON buttons by smart android application. In-Addition, if user want to switch ON the single home appliance then he/she need to click on interactive button of particular devices such as Figure 9 shows the active power load of AC on hardware module.

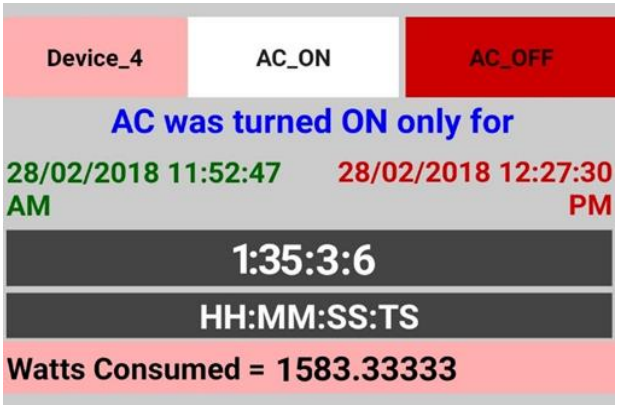

Figure 4. Active Power Load Reading on Smart Android Application

Figure 10 shows the track record of individual home appliances. Furthermore, smart android application shows the time, date, energy consumption time as well as time intervals. Android application. It also shows the current time, date, home appliance name and energy consumption patterns.

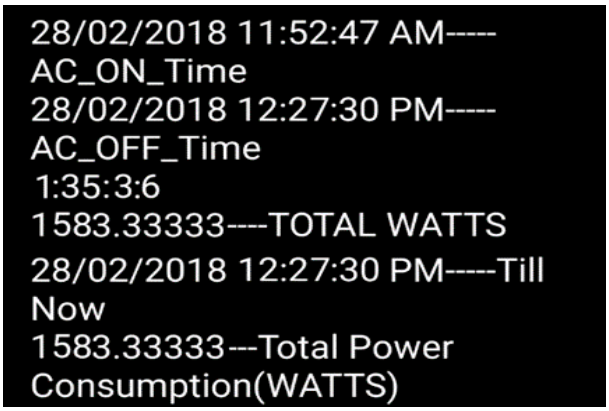

Figure 5. Active Power Load Track Record of AC (Air-Condition)

B. Active Power Load of TV (Television)

Figure 11 depict the active power load management of TV remotely. The LCD shows the active power consumption pattern of television by the hardware module of APMCSH. Similarly, same patterns are shown by smart android application. The Figure 12 demonstrate the active power consumption patterns of home appliance (TV) by smart

Figure 6. Active Power Load of TV (Television) Smart Hardware Module

The figure 12 depicts android based software application where it shows the power reading options, controlled buttons, and devices. This interface also shows the power consumption pattern of consumer such as 216.66667 watts.

Figure 7. Active Power Load of TV (Television) on Smart Android application

Figure 13 shows the track record of every single home appliance such as TV. The android based smart application has managed the track record of various other home appliance as well.

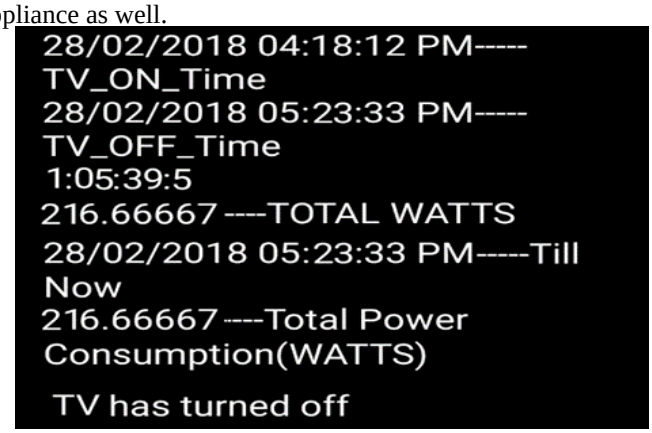

Figure 8. Active Power Load Track Record (Television) Smart Android application

IX. GRAPHICAL RESULT ANALYSIS

The **Error! Reference source not found.** demonstrate the graphical representation of energy consumption patterns of single home appliance (Air-Condition) on different times. Red color shows the number of home appliance and total available energy power while black and yellow colors indicates the power consumption patterns and time respectively. The below graph result shows the only one home appliance result such as (AC) power consumption behavior of consumer, time variations (peak /normal time) and on/off state of device.

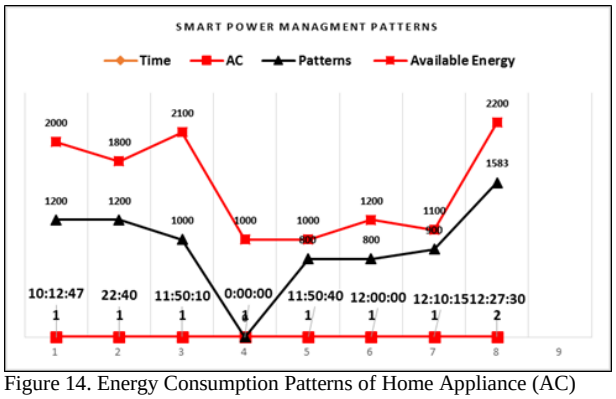

Figure 14. Energy Consumption Patterns of Home Appliance (AC)

The Figure 15 depicts energy consumption patterns of single home appliance (Television) on different times. Red color shows the number of home appliance and total available energy power while black and yellow colors indicates the power consumption patterns and time respectively. The result depicts power consumption behavior of consumer, time variations (peak /normal time) and on/off state of device. The power consumption pattern of home appliance can be monitor and control remotely via using the android based application. The application has two modes such as by default (In this mode the power consumption patterns has been controlled by application) and manual mode (where consumer can control the power patters by requirements via application control button).

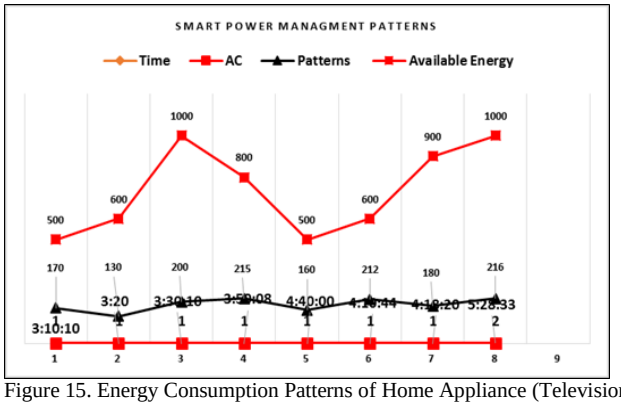

Figure 15. Energy Consumption Patterns of Home Appliance (Television)

X. CONCLUSION

In digitalization era, the trend is moving towards too smart world for instance, smart cities, smart homes etc. now a days the home automation systems take place in contrast to the manual controlled appliance. With the rapid increase of electric power consumers at various levels such as domestic, commercial and industrial.it is necessary to automate the energy power consumption patterns in sophisticated manner to save the unnecessary wastage of electricity. Pakistan, is country where the home appliance automations trend is new and most adopted trend as compared to manual because home automation include the ability to monitor and control lighting, heating, appliances, and security. Connecting, automating, and centralizing control of these things appliances added safety, convenience, and energy savings.

The objective of this project is to designed and develop smart system to control and monitor the power consumption patterns smartly. On the other side, the smart system also provide an android based application to consumer where he/she can control the home appliance according to requirements.

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