An Approach to Energy Economy In Household Environment Using Smart System(SSFEE)

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Summary
The smart systems have been developed with the sole aim of economizing the use of energy and to make prudent use of energy resources.. People in general have their preferences and their behavior largely impact energy consumption. Lacking on the part of the consumers make a viable case for third party energy management system to control and monitor residential energy consumption patterns. Consequently, consumer behaviors and activities considered as a key indicators and have been long used to control and monitor the various kinds of home appliances such as televisions, heating systems, energy lightings, and air conditioning equipment's. However, taken in account of user activities and energy consumption behaviors some basic question need to be answered such as how much energy is lost, what are the activities, what financial losses has been occurred due to behavioral changes. Sometime energy consumer don't manage the home based energy effectively resulting in financial and energy losses at the same time. To cope up with these losses, we have developed a novel approach to energy economy using smart system with the theme of energy saving based on Smart Android Application and Ardunio Microcontroller System. The smart system efficiently and effectively manage the energy consumption through remote monitoring and also sent alerts to consumer regarding status of various appliances in the absence of consumer.

Key words:
Android Application, ardunio microcontroller, GSM module, ACS 712.

1. 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, 2, 3, 4, 5]. 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. The result was un-necessary wastage of electricity and damaged home appliances due to overheating and malfunctioning of the system. Especially when the consumers are far away from home and that devices remained functioning. 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 provides the power consumption details of every individual home appliance [6, 7,8]. In this proposed system we have developed a system based on GSM technology along with android based application and ardunio 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[9,10,11]. Furthermore, the system has mobile based GUI to control the different home appliances such as Bulb, Fan, TV, Ac, etc. The mobile based android application has list of the command buttons for consumer to select the option to control the home appliances and monitor the electricity consumption remotely. The rest of the paper has been organized in sections. Section II providing research background about Smart system. Section III elaborates on essence of the research problem, section IV discusses the system's 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 explains the result analysis while last section present the conclusion.

2. Research Background

The aim behind the designing of the smart system is to remotely monitor and control of home appliances using of various smart application (android application, GSM communication) without physically visitation of the remote sides. Moreover, the users should be able to check electric power loads, kinds of appliances being running at home/office/industry and can switch ON/OFF time and power consumption patterns of individual home appliance through GSM communication and android based mobile phone application.

- The system allows the residential consumers to monitor and control the home appliances via their mobile phone set by sending commands in the form of SMS messages and receiving the appliances status as well.
- The consumer can get the total power consumption patterns of all home appliances by

Manuscript received March 5, 2019
Manuscript revised March 20, 2019

using the android based application.
- Consumer can control and monitor his/her power consumption level on daily basis remotely.

Many smart systems has 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 [12, 13, 14] and some other researcher preferred ZigBee technology [9, 10]. Before invention of smart technologies, the home automation task were indistinct, difficult and complicated. However, in recent era, many residential and commercial consumers used home automation technologies across the world [15, 16, 17]. 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.

3. Problem with The Existing Systems

The design of the proposed prototype system is cost effective as compared to other existing systems due to low cost and user friendly interface [18, 19, 20]. Most of the existing systems are proprietary based and do not have the provision for commercial usage. Moreover, the systems are exorbitant in terms of hardware, and have complex interfaces. During the course of our research, we have found systems which have been used to control the home appliance by using wired and wireless technologies. However, the wireless technologies provides limited coverage such as Bluetooth has 20 meters, Wi-Fi has 100 meters, and ZigBee has 1000 meters in range. To avoid the coverage limitations we have proposed a smart system to monitor and control the energy losses remotely. The SSFEE (Smart System for Energy Economy) system has been developed with GSM technology along with android based application and ardunio microcontroller. The smart system has successfully demonstrated its ability to monitor and control the domestic wastage of energy at homes and also provided an easy interface to control the home appliance remotely.

4. Architecture of Smart System for Energy Economy(SSFEE)

The proposed system has various components to meet the requirements of home automation. The required components comprises ardunio 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. The status of the home appliances can be checked using android application. The status of devices has been shown by the LCD of the system as in Fig: 1.

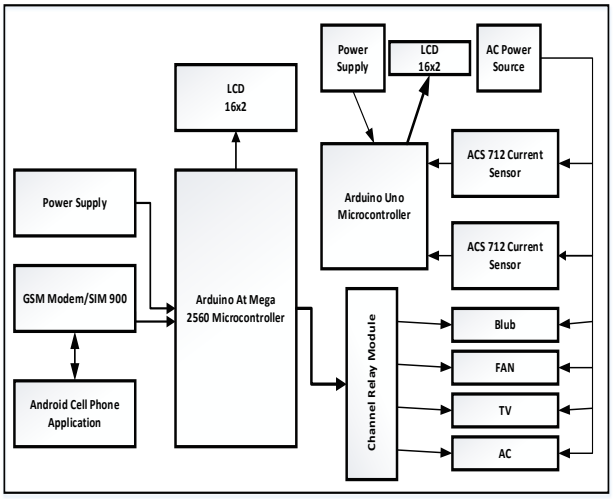

Fig. 1 Architecture of SSFEE System

5. Working Mechanism the System

The flowchart in fig.2 depicts the working mechanism and inter connectivity of components of proposed system.

- 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.

5.1 Operational Mechanism

The figure 2 and 3 shows the basic algorithmic operational mechanism of hardware and software components of smart system. In addition, both components start communication via GSM communication modems. The software module is based on smart android application which is installed on user smart phone. The smart android application needs

valid subscriber identification module for executing the various activities generate by user and hardware component of smart system. On the other side, hardware component combines different devices and designed primarily to measure the energy consumption of appliances connected to the communication module. Moreover, the hardware module receives various commands from the software module and execute the activities.

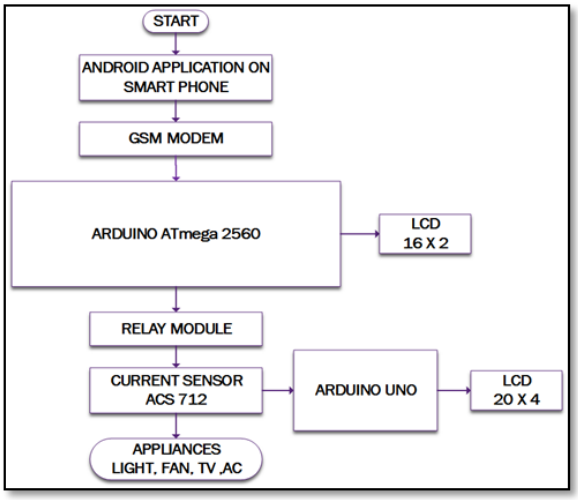

Fig. 2 Working Mechanism of the system

The software component of the system transmits control commands through GSM communication module. On the other side, GSM receiver receives the command and decode it and re-send it to the microcontroller which performs the required actions accordingly. Initially four home appliances namely (Electric Bulbs, Fan, Ac, and TV). Were chosen to test the functionality of the prototype smart system.

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

5.2 Interfacing of Android Application and GSM Modem

The user have to follow some basic routine steps while interacting with smart android application as shown in figure 3 such as

- Open the android application with a valid subscriber's identification module.
- Register the home appliances on android application control list
- Start to turn-on the appliances according to requirements

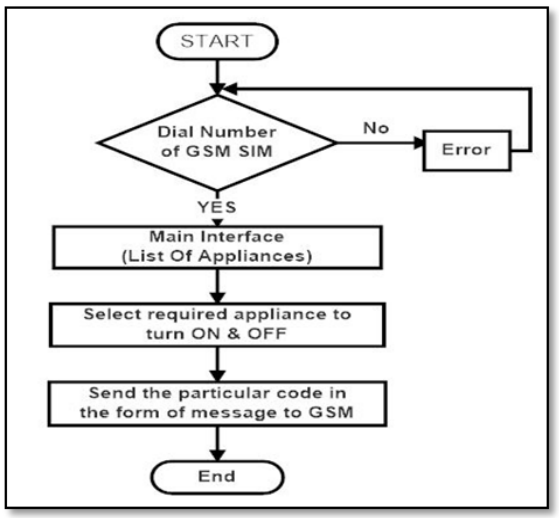

Fig. 3 Interfacing of Android Application and GSM modem

5.3 Interfacing of GSM and Ardunio Microcontroller

Once the initial steps of interfacing between android application and GSM communication module are done, the next step would be the interfacing between GSM and Microcontroller as shown in figure 4.

- When a control message or code is sent from the user terminal, the GSM communication module would simply receive the code and transmit that code to RX terminal of the Microcontroller.
- The next steps would be the authentication of the cell number.
- When the system finds a valid registered number the controller execute the code and send signals to command box to perform the required actions.

6. Hardware Module of SSFEE

The SSFEE prototype system module is the combination of hardware and software components. Each component is supposed to perform the specific function regarding domestic energy management smartly. Hardware component of SSFEE consists of various components such as ardunio 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 figure 5.

- Ardunio Microcontroller: Ardunio 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 performs switch-on and switch-off activities according to pass codes from the microcontroller.

Fig. 5 Hardware Component of SSFEE System

7. Software Module of SSFEE

The software component consist of android based application development depicts in figure 6. By using the android studio an android application has been developed and interface with hardware component of APMCSH. The software component has various components to control the energy consumption such as

- Android Based Power Monitoring System: This component is design to only monitor the energy consumption and receive energy consumption units 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 have 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.

Fig. 6 Screen Shots of Android Application for SSFEE

8. 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 SSFEE system was connected through five different home appliances such as TV, FAN, IRON, Electric Blubs and AC. when users wants 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 figure 7.

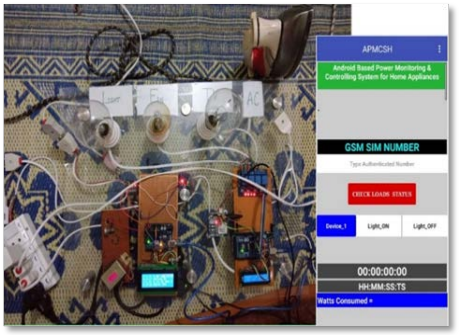

Fig. 7 System Testing and Result Analysis

8.1 Active Power Load of AC (Air-Condition)

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 8 shows the active power load of AC on hardware module.

Fig. 8 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 contain various interactive intent buttons for different activities.

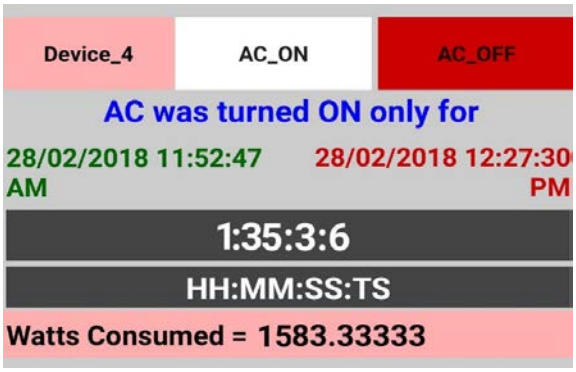

Fig. 9 Active Power Load Reading on Smart Android Application

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.

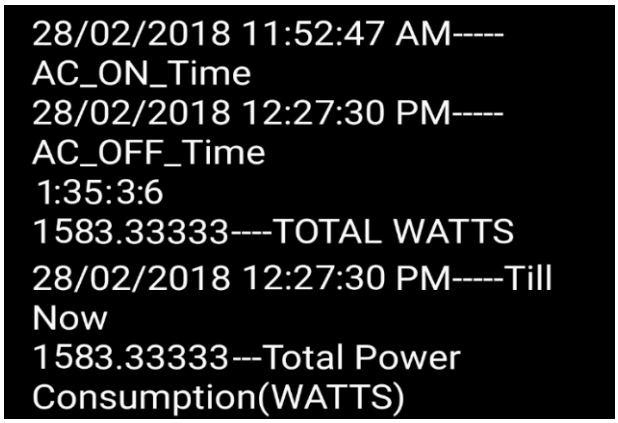

Fig. 10 Active Power Load Track Record of AC (Air-Condition)

8.2 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 SSFEE. Similarly same patterns is shown by smart android application.

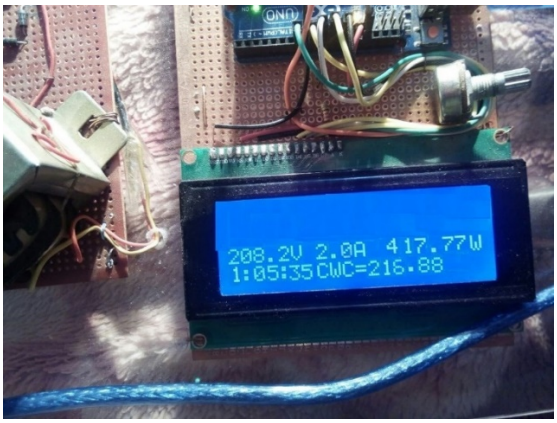

Fig. 11 Active Power Load of TV (Television) Smart Hardware Module

The figure 12 demonstrate the active power consumption patterns of home appliance (TV) by smart android application. It also shows the current time, date, home appliance name and energy consumption patterns.

Fig. 12 Active Power Load of TV (Television) Smart Android application

Figure 13 shows the track record of every single home appliance.

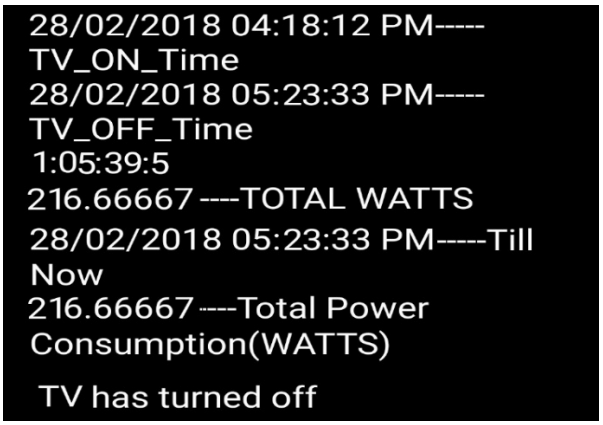

Fig. 13 Active Power Load Track Record (Television) Smart Android application

9. Graphical Result Analysis

The figure 14 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.

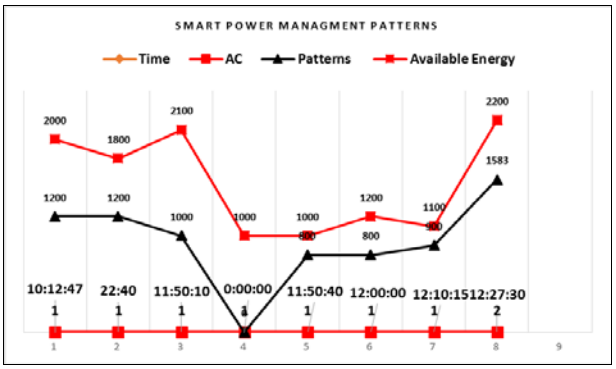

Fig. 14 Energy Consumption Patterns of Single Home Appliance (AC)

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.

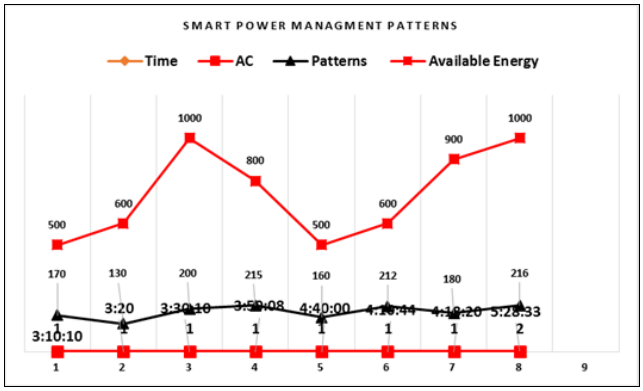

Fig. 15 Energy Consumption Patterns of Single Home Appliance (Television)

10. Conclusion

Efficient energy management has become critical in the current era due to increased usage of information and communication technological tools. The ICT smart solutions performed key roll to manage the energy losses by seamless and reliable communication mechanism. Distributive, cloud and smart computing technologies have recently received considerable attention as an encouraging methods for delivering smart services by using the ICT applications. The smart ICT solutions provided potential and significant smart solutions to overcome the energy losses at remote sides. This paper has also elaborated a new concept of smart system which performed the energy management remotely by using ICT tools. The purpose of

smart system was to save the unnecessary wastage of residential and commercial energy consumption. It is a smart approach towards the ultimate goal of energy economy where by implementation of the smart system, the energy consumer can monitor and control the energy consumption remotely thereby improving the financial viability of the system Moreover, it provides real time interface facility to user to interact with smart system. In addition, the system has been installed in different places. The performance is evaluated by assigning varying power loads and by controlling the home appliances functions remotely. During the testing phase, the hardware component of system sent different energy consumption patterns to it associated software components efficiently. The software component positively received the energy consumption patterns on its smart android application. Furthermore, the software component provides an interactive interface to user to control the enlisted home appliance and their energy consumption patterns.

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