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Residence Energy Power Regulation by Employing Wireless Smart Socket and IoT

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***Abstract*— The non-renewable resources on green earth are being exhausted so, it is a duty of all human beings to save the energy which should be followed in our everyday life. The implementation of energy control on some appliances is an effective method to save energy at a residence, since it prevents users from consuming too much energy and by this the user can have a track on amount of energy consumed. Therefore, in this paper, an intelligent energy control scheme, named the Residence Energy Power Regulation by Employing Wireless Smart Socket and IoT (REPRESS) is proposed, which is implemented by designing a smart socket and Internet of Things technology to minimize energy consumption of home appliances without the use of sensors as they themselves consume energy and should have power supply connected to it always. The existing methods use sensors and has smart socket that should be connected to individual loads. The REPRESS contains single controller to keeps track on status of all connected loads. The REPRESS provides four control modes, including automatic control, user control, peak-time control, and energy-limit control. The former two can be implemented to control all loads in a house, while the latter two are implemented on certain loads, to achieve energy control.**.

***Index Terms*— Renasas, Peak time control, Automatic Control mode, User Control mode, Peak Time Control Mode, Energy Limit Control Mode.**

I. INTRODUCTION

Until recently, because of global warming [1] energy saving has been one of the criteria in developing smart electronic equipment. So designing smart home for energy conservation is necessary. The purpose of constructing smart home is to improve energy efficiency. In order to minimize the energy consumption, a residence control system with smart and automatic energy control policies is required. A smart-house designed using the Internet of Things (IoT) can save more energy, where IoT is a network system consisting of hardware and software that are connected to the network and this connects all entities to make the system controllable and provides services.

The REPRESS mainly implemented by using smart socket and IoT, to control all the loads at the residence. This makes in analyzing the various power consumptions and wastages that are done in a smart way. The REPRESS is also be made to control the state of the socket that is in standby based on the user requirement.

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II. LITERATURE SURVEY

There are different proposals of energy conservation at different place, Mohsenian-Rad et al. [2] has expressed a game based approach to minimize the energy consumption at residence. Different optimized schedule using storage devices is discussed [3], main intention is to save energy by optimization. The above quoted two techniques developed based on deterministic and/or meta-heuristic methods. But they did not consider the user convenience and comfort levels on the optimization process. Han and Lim [4] proposed home energy control using IEEE 802.15.4 and ZigBee to provide users with intelligent services to enrich their lives. Previous control systems used information from various sensors, such as temperature sensor, distance sensor, position under, passive infrared sensor, and ambient light sensor to obtain various lifestyles.

III. THE REPRESS ARCHITECTURE

A.SYSTEM OVERVIEW

In the REPRESS, sensors are not used as they would consume some energy so, the data of appliances energy consumption is uploaded to cloud server (IoT) by the smart socket. The home appliances that are in the standby state and not in use can be made automatically off by giving commands to the smart socket through the server or electronic circuitry. The Fig. 1 shows the system architecture of the REPRESS, in which the smart socket includes controller along with other necessary components like relay, voltage divider, Current Transformer, etc., The microcontroller controls all the four modes by making use of necessary data and controls the various load as per the condition set.

LOADS selected to demonstrate the various modes are:

1. Peak time mode -Geyser
2. Automatic mode -Bulb
3. User control mode -Table fan
4. Energy Limit mode -Bulb

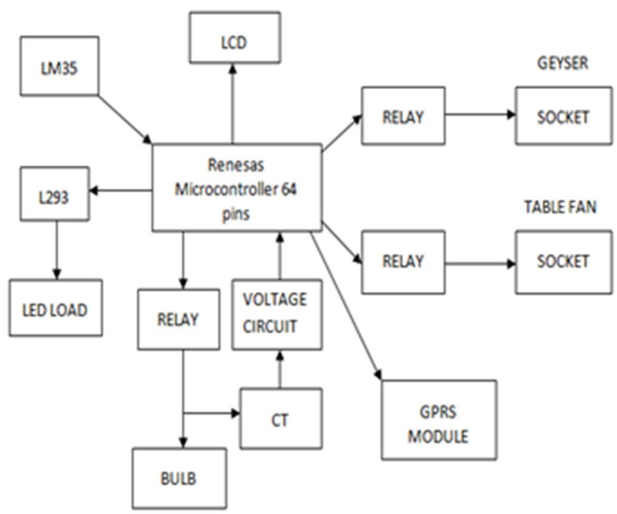


Figure 1: System architecture of REPRESS

B. COMPONENTS REQUIRED:

HARDWARE COMPONENTS:The hardware of the system includes Renesas microcontroller (RL78), single channel relays, plug sockets, bulb socket, LED, L293 driver circuit, LM35 temperature sensor, LCD, current transformer, GSM module and voltage divider circuit.

Renesas microcontroller (RL78): The RL78R5F100LE microcontroller is chosen for this application since it is IoT friendly and works on ultra-low power consumption technology.

Single channel relays: Relay can control any appliance using the magnetic circuit present in it. A single-channel relay can basically control 1 appliance. It needs 12v power supply. The current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts.
L293 driver circuit: The L293 is an integrated circuit driver that can be used for simultaneous, bidirectional control of two small devices and we connect LED at the output of the driver circuit. The L293 is limited to 600 mA, but in reality can only handle much small currents.
LM35 temperature sensor: It is the temperature sensor which gives the digital data of temperature to the microcontroller
LCD: The LCD (**JHD162A)** is used, which can display 32 characters simultaneously.
Current transformer: The transformer steps down the voltage and this are given to the controller through voltage divider which is necessary in determining various conditions.
Voltage divider circuit: The AC voltage cannot be given directly to microcontroller as it works only in DC so it is converted to DC voltage by this circuit.
GSM module: GSM module is used to establish communication between a computer and a GSM system. Global System for Mobile communication (GSM) is an architecture used for mobile communication in most of the countries.
SOFTWARE: The program is written using the cube suite+, which is the software to write programs for Renesas microcontroller. The written code is flashed to the controller using the Renesas flash programmer.

C. THE CONTROL MODES:

The REPRESS has following four modes of control and they are automatic control mode (AC), user control mode (UC), peak-time control mode (PTC) and energy-limit control mode (ELC). In the PTC mode, the REPRESS controls the state of the load to be in on/off state based on user set time duration. When the total energy consumption of certain load crosses the pre-defined energy limit then that corresponding load is turned off and this is ELC but, the sockets which are having low priority will be changed to off state in order to minimize the peak power consumption. The AC and UC modes are applied to control individual smart sockets following automatic control policy and user defined control policy, respectively. The REPRESS in its UC mode gives an interface option to users so, that they can turn the various loads to on/off state. The various modes are as explained:
AUTOMATIC CONTROL MODE(AC): In this control mode the controller turns on/off the particular sockets for particular defined time periods and based on total energy consumption of a particular load. If the energy consumption exceeds the defined limit, then it will turn off those devices and when there is overload in the loads the smart socket will turn off the low priority devices and keeps high priority devices in on state itself.
USER CONTROL MODE(UC): In this control mode users can control each loads based on their requirements, no matter whether the REPRESS is in AC or UC mode. User can turn on/turn off the socket that is in idle state or not necessary and even when the energy consumption of a particular appliance is more.
*PEAK-TIME CONTROL MODE(PTC):*In this control mode user assigns peak-time periods for certain appliances and a socket's. In the PTC mode the smart socket controls the on/off state of the loads that are set with the defined peak time. When the total energy consumption of all the loads crosses the defined peak-time energy limit then the lower priority sockets will be turned off.
ENERGY-LIMIT CONTROL MODE (ELC): In this control mode user sets an energy limit. When the energy consumption of the appliance crosses the limit that is assigned to the load then the controller is given with a control signal to turn off the corresponding socket and if the socket is in UC mode then a warning message is given to user to turn it off.

IV. AMAZON CLOUD SERVER

Amazon cloud server is a bundled remote computing service that provides cloud computing infrastructure over the Internet with storage, bandwidth and customized support for application programming interfaces. Amazon cloud server provides a unique IP address to every user so that they can control any operation through the internet. Cloud server is the on-demand delivery of compute power, database storage, applications, and other IT resources through a cloud services platform via the internet with pay-as-you-go pricing. The various devices can be accessed and can be controlled by the on/off option as shown in the Fig. 2.

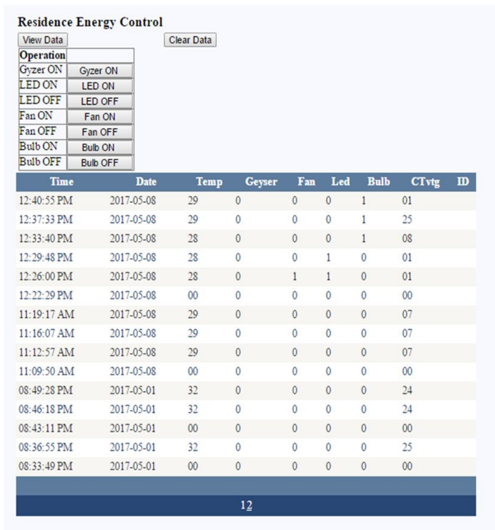
V. EXPERIMENTAL RESULTS AND DISCUSSIONS

A. Implementation

The hardware implementation of the said project is shown in Fig.3and the various modes of operation are as mentioned below.

*User contol mode:*Fan is considered as the load and whenever fan is not in use, user can turn off the fan through server i.e user can control the operation of fan from anywhere required so it is also called as user control mode.

*Automatic control mode***:** We consider overloading concept and the loads used are bulb and geyser. When geyser is on and 40W bulb is turned on then bulb glows but instead if we use 60W bulb then geyser is given the priority and hence geyser is maintained on whereas bulb turns off automatically after few seconds. If a 100W bulb is inserted in the socket it doesn’t even turn on due to its high power consumption.



Time	Date	Temp	Geyser	Fan	Led	Bulb	CTvtg	ID
12:40:55 PM	2017-05-08	29	0	0	0	1	01	
12:37:33 PM	2017-05-08	29	0	0	0	1	25	
12:33:40 PM	2017-05-08	28	0	0	0	1	08	
12:29:48 PM	2017-05-08	28	0	0	1	0	01	
12:26:00 PM	2017-05-08	28	0	1	1	0	01	
12:22:29 PM	2017-05-08	00	0	0	0	0	00	
11:19:17 AM	2017-05-08	29	0	0	0	0	07	
11:16:07 AM	2017-05-08	29	0	0	0	0	07	
11:12:57 AM	2017-05-08	29	0	0	0	0	07	
11:09:50 AM	2017-05-08	00	0	0	0	0	00	
08:49:28 PM	2017-05-01	32	0	0	0	0	24	
08:46:18 PM	2017-05-01	32	0	0	0	0	24	
08:43:11 PM	2017-05-01	00	0	0	0	0	00	
08:36:55 PM	2017-05-01	32	0	0	0	0	25	
08:33:49 PM	2017-05-01	00	0	0	0	0	00	

Figure 2: Controlling various equipment through server

Peak time control mode: In this type of mode, if we consider a geyser we make it to turn on for 20 seconds if it’s maintained at 30 degree Celsius which is measured using a temperature sensor, in the same way it’s made to remain on for 10 seconds if its temperature is 40 degree Celsius. By operating this in this way it’s a peak time control mode.

*Energylimit controlmode***:** In this mode user sets a certain energy limit for certain duration, quota depending on user. This energy limit mode calculates the amount of energy required by an appliance and sets its quota for one day or the time specified by user. When the energy consumption exceeds the quota reserved for the socket then this mode automatically turns off that socket or intimates the user with a warning message on the LCD. We use 60W bulb to demonstrate this mode.

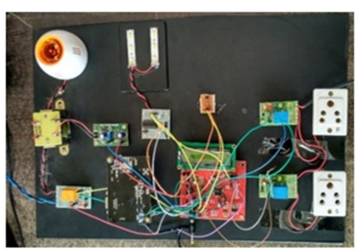


Figure 3: Implemented circuit

B. Experimental results3

The experimental results and observations are tabulated in the Table 1.

TABLE I: RESULTS

SL. NO.	LOAD	MODE		WORKING
1	LED / FAN	USER CONTROL		Based on the requirement of user they are turned on/off.
2	GEYSER	PEAK TIME CONTROL		The geyser will run only for a certain period of time based on the surrounding temperature. If temperature is room temperature then the geyser runs for 20secs.
3	BULB	40W	AUTOMATIC CONTROL	If geyser is on along with 40w bulb both will remain on. .
		60W	AUTOMATIC CONTROL	When a 60W bulb is connected the bulb will turn off and geyser will continue to be on as the geyser has high priority than the bulb and will, enter into PTC mode.
		100W	AUTOMATIC CONTROL	If geyser is on and if the 100w bulb is energized, then the bulb will be in off state and will not turn on. This is Overload concept.
4	60W BULB	ENERGY LIMIT CONTROL		Initially the bulb load will be set with a certain Energy limit and if it crosses the limit then, user is informed regarding the status on the LCD display to turn it off.

VI. CONCLUSION AND FUTURE STUDIES

A simple IoT structure which integrates Smart Socket, Controller and Internet is proposed with main intention is to have smart controls and monitor energy consumption various loads at a residence and thereby, achieving the goals of saving then energy. The control on the energy consumption is by using IoT and microcontroller which itself is the backend of the smart socket or main parts of the smart socket. The REPRESS defines the four control modes to control the on/off state of the various loads connected to the socket. The main proposed feature of REPRESS is, it contains no sensors in monitoring the various equipments connected to the smart socket and hence, can be implemented to outdated appliances, i.e., those that do not have any facility for LAN connections. In the further developments, the reliability and behavior models [2], [3] would be designed to the REPRESS, so that the users respectively, can come to know its reliability and behaviors' before using it. Besides, a simple user interface and personalized learning model will also be developed so that the REPRESS can reduce the energy consumption more intelligently. Furthermore, security is an important aspect on designing any system so, the REPRESS has to be protected in these aspects, e.g., the control commands has to be encrypted while sending it to the smart sockets [4], [5] this helps in avoiding false on/off of the equipments by hackers. These constitute the future studies.

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