ORIGINAL RESEARCH

SAMRIDDHI Volume 12, Special Issue 2, 2020 Print ISSN: 2229-7111 Online ISSN: 2454–5767

Smart Energy Monitoring using ARM Cortex

Apurva Borghare[1*], Arati Bhosale[1], Shital Kardile[1], Nikhil Sardar[2]

[1]Student, MIT Academy of Engineering, Pune-412105, Maharashtra, India

[2]Assistant Professor, MIT Academy of Engineering, Pune-412105, Maharashtra, India

Abstract

Nowadays, the demand for electricity increases due to an abrupt increase in population. In the existing system, the physical energy meter reading is taken, which is inefficient and is an outdated concept. This will require a large number of laborers. The person comes from the electricity board to the consumer's house for taking the readings from the energy meter and then, has to calculate the amount of energy consumption. This process is time-consuming and is a waste of manpower and will cause a lot of errors. A solution is, to implement a smart energy meter that will monitor energy consumption in terms of unit cost on an hourly and daily basis, to reduce human errors, physical labor,s and to improve the efficiency of the system. The proposed system will solve all the problems which are in existing energy meters. The proposed work calculates the energy consumption and sends the data to the consumer's mobile via the global system for mobile communication (GSM) module, and the Bluetooth module HC-05 will also give them information on Android application, only when the Bluetooth is in the range of 100 meters from the smart meter. Both of these modules are connected to the ARM Cortex Board (AT91SAM3X8E). It has low power consumption and lower cost. The smart energy meter will also have a display unit that will show the real-time running data and consumed unit. When there is no supply from Maharashtra State Electricity Board (MSEB), then the smart meter will automatically switch to the inverter or battery backup through the relay. The proposed system is user friendly and has better efficiency than the existing energy meter.

Keywords: ARM (AT91SAM3X8E), Bluetooth module HC-05, Current sensor ACS712, GSM SIM 900A, Relay board, Smart meter.

SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology (2020); DOI: 10.18090/samriddhi.v12iS2.3

Introduction

Electricity plays an essential role in the day to day life. The energy crisis has become a very big problem due to rapid growth and development in our society. A system should be made in order to analyze the power consumption in terms of unit and cost.[1] An existing energy metering system is very much time consuming and require labors for billing. The values given by the existing meter are not accurate and the person from the power department has to visit the consumer house to note down the data and that will cause errors.[2] In order to reduce these errors, the solution is a smart energy meter. The proposed system consists of ARM Cortex (AT91SAM3X8E) and GSM module 900A, which will send the SMS of energy consumption in terms of unit and cost to the consumer mobile on an hourly and daily basis.[3] This will reduce human efforts and will not cause any error. It also consists of Bluetooth module HC-05, which will give the information about energy consumption and unit cost on an android application when it will in the range of 100 meters from the smart meter.[4] The proposed system is designed in such a way that, if the supply is cut off from the MSEB, then the smart meter will switch to the inverter through the relay board.

Corresponding Author: Apurva Borghare, Student, MIT Academy of Engineering, Pune-412105, Maharashtra, India, e-mail: aaborghare@mitaoe.ac.in

How to cite this article: Borghare, A., Bhosale, A., Kardile, S. & Sardar, N. (2020). Smart Energy Monitoring using ARM Cortex. *SAMRIDDHI : A Journal of Physical Sciences, Engineering and Technology,* 12(SI-2), 11-15.

Source of support: Nil

Conflict of interest: None

Literature Survey

As of now, many people are using the internet of things (IoT) gateway for creating architectural design and its execution for a smart home with wired or wireless structure. Saikat Saha *et. al.* have implemented a wireless system for limiting water temperature through the internet protocol/ transmission control protocol having the minimum cost of hardware. But to use such a system is very much necessary to install special software which makes little inconvenience as the system comprises of a number of sensors and it is also too complex.[3] The wire-based system faces few difficulties, like the use of the communication channels between the devices and the background system. This naturally enhances

the maintenance cost, as well as, building the cost of the network. However, it definitely reduces the cost of the home automation system.

Win Hlaing *et. al.* have come up with a home gateway for ZigBee and an ethernet network, which is known as a green system for monitoring air pollutants. But it is seen that this ethernet system is not supporting the various function of a traditional access point. This system is useful for exchanging, sensing, or finding the data and commands between two devices through the internet along with a combination of personal wireless local area network and home automation system.[4]

The system which we have proposed if compared with the system under use, then our system definitely has a minimum maintenance cost, as well as, execution cost. The hardware cost is also minimized, and it also helps the concept of the internet of things by using energy meter with Bluetooth module (HC-05) and GSM at a lower cost. The HC-05 module is used which is wirelessly connected to the meter and GSM module to update the customer on an hourly and daily basis with the help of messaging ARM cortex controller is used because it has better performance as compared to other processors. It also consists of low power consumption and has a low cost. It is very easy to handle for the development of an effective application. It has a memory protection unit and the operating frequency of ARM cortex (AT91SAM3X8E) is 84 MHz. It consists of the Thumb 2 instruction set and Nested Vector Interrupt Controller. In the proposed system ARM cortex is used for controlling the functionality of the system and the relay board is for switching in case of MSEB supply is off.[5] This system can read the data from an electric meter automatically in real-time. This data is displayed on the LCD connected to the smart energy meter. The data is updated and the user can view the consumption of energy usage thereby and ultimately the cost of power usage is also minimized substantially.

Proposed System

The existing system is time-consuming and requires a large number of workers for a billing process. The person from the electricity department has to come and check the meter reading to calculate the bill. This process is a little bit lengthy and will also cause an error. The proposed work makes the system error-free and it is a cost-efficient and time-saving process. This system overcomes all the problems which are in the existing energy meters. The system has low power consumption and lower cost. The proposed system will monitor the energy consumption on an hourly and daily basis to reduce the errors and to improve the efficiency of the system. The system calculates the energy consumption in terms of unit and cost and will send the SMS to the consumer via GSM module 900A.[6] The bill amount will send to the consumer every month through SMS. The Bluetooth module HC-05 will also give the information through the mobile application when it will in the range of 100 meters from the system. In case the supply is off by the MSEB, then the proposed system will switch the supply to the inverter or battery backup through the relay board. The proposed system is user friendly and easily understandable by the consumer. Figure 1 shows the functional block diagram of the proposed system.

The main blocks of the functional unit are discussed hereafter.

Current Sensor

In electronic devices, if the current increases above its requirement lead to overload and can damage the device. So, the current measurement is necessary for the proper working of devices. For measuring the current, we require a current sensor. ACS712 current sensor is used to measure and calculate the current in the system. The precise measurement for both alternating current (AC) and direct current (DC) signals is given by the sensor. The module can be measured up to 30A current. The sensor is interfaced with the ARM controller to provide the information which is given by the AC input supply. Then this analog information is converted into digital by analog to digital converter (ADC), which is inbuilt in the ARM Cortex controller.[7] This digital data then processed by the controller and calculates the consumed energy in terms of unit and cost. This unit and cost send to the consumer mobile via the GSM module and bluetooth module.

GSM Module

The GSM module is a chip or a circuit that will be used for communication between a mobile device and a GSM system. In the proposed system the SIM 900A is used for communication between the smart meter and consumers mobile. It has a single power supply from 3.4 to 4.5V. The communication between consumers' mobile and the smart meter is done by using AT commands. This GSM module is interfaced with the ARM Cortex controller, and it will be programmed in such a way that it calculates the energy consumption in terms of unit and cost. This information will send to the consumer's mobile by the ATtention (AT) commands which are used in programming.[8]

Bluetooth Module

The bluetooth module HC-05 is used for wireless communication between the mobile and the smart meter. The HC-05 module can also be used for two-way wireless

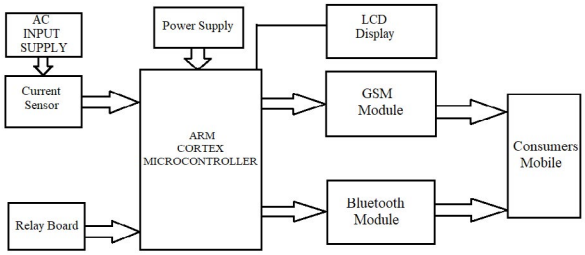

Figure 1: Functional block diagram of smart meter

communication. This module communicates at 9600 baud rate with the help of the Universal Synchronous Asynchronous Receiver Transmitter (USART).[9] Typically, the operating voltage of HC-05 module is 5V and the operating current is 30mA. This bluetooth module is also used to provide information on energy consumption to the consumer. It shows the information in the Android application when it will be in the range of 100 meters from the proposed system. It is used to get time to time update of energy consumption in terms of unit and cost.

Relay Board

In the proposed system, a single-channel 5V relay module is used for switching the device. This relay board requires a 5V DC supply. It is interfaced with the ARM Cortex controller to switch the supply from MSEB to inverter or battery backup if required.

Liquid-Crystal Display (LCD)

The LCD is 16 characters by 2 lines display. It can be interfaced with any of the controllers easily. This LCD has an 8-bit parallel interface. It can use all the 8 bits or 4 bits and 3 control lines. This LCD is interfaced with the controller and will show real-time energy consumption.

System Implementation

In the proposed work ARM controller is the main hub of the system. It controls all the functionality of the system. As shown in Figure 2, the ARM controller (AT91SAM3X8E) is connected with the current sensor, relay board, Bluetooth module, GSM module, and an LCD display.

The proposed system is divided into three parts, i.e., input, processing, and output. In the input part, it consists of current sensor ACS712, which senses the current coming from the MSEB supply. The output of the current sensor is in analog form. The analog output of the current sensor is connected with the ARM Cortex board. This analog data received from the current sensor is then converted into digital data by ADC, which is already inbuilt in the ARM Cortex controller. The controller will calculate the energy consumption and send it to the output devices which are interfaced with the ARM Cortex controller. It also consists of the relay board, which is used for switching purposes when there is no supply from MSEB. This relay board will switch the supply from MSEB to inverter or battery backup when required (Dias B.L., 2020).

The processing part of the system is the ARM Cortex controller, in which the output modules are been interfaced with the controller. The programming of the controller is done in such a way that the analog data is given by the current sensor is converted into digital data and calculates the unit cost and gives information on energy consumption on a daily and hourly basis as per the consumer's requirement.

The output part of the system consists of the GSM module, Bluetooth module, and LCD. These three modules are interfaced with the ARM controller. The GSM module SIM 900A gives information about energy consumption in terms of unit and cost by sending SMS to the consumer. The SMS are sent to the consumer registered mobile number by the AT commands, which are used in the programming of the ARM controller. The Bluetooth module HC-05 is also used for wireless communication in the proposed work. It is similar to the GSM module, but the difference is that it gives information on the android application when the consumer mobile is in the range of 100 meters from the system. The real-time update of the energy consumption is given by the LCD which is attached to the smart meter. It shows real-time information about the energy consumed by the consumer. The proposed system consists of an ARM controller and other modules like GSM module, bluetooth module, and relay module. These modules interfaced with the ARM controller by programming. The flowchart of the program is given in Figure 3.

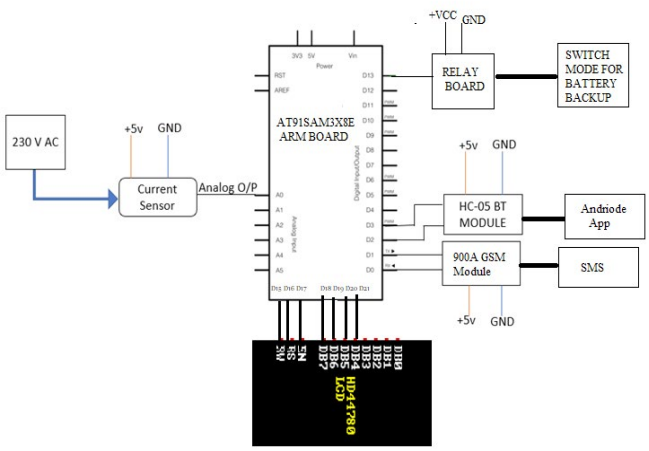

Figure 2: Circuit diagram

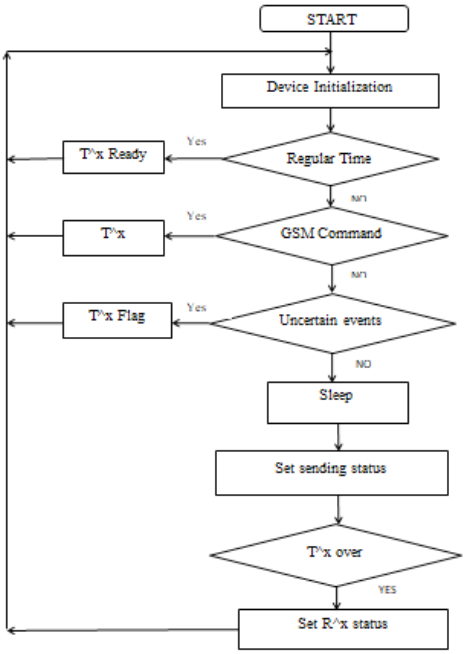

Figure 3: Flow chart

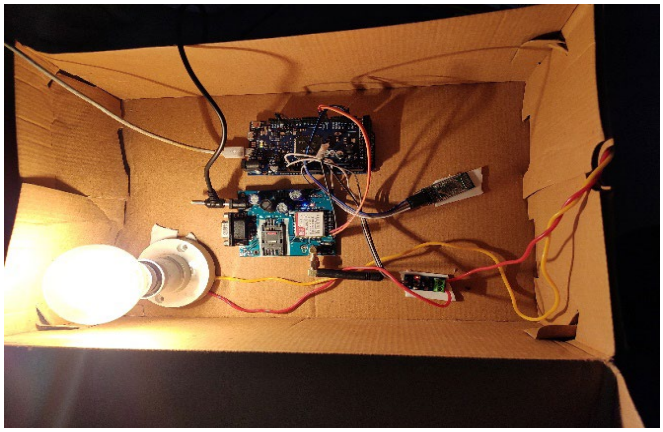

Figure 4: Practical output

Figure 5: GSM output

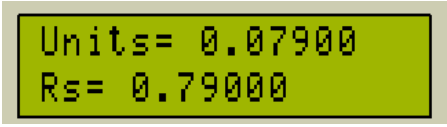

Figure 6: LCD output

The electric meter shows the amount of electricity used by the consumer. So, if a 100-Watt bulb kept on for 10 hours will consume:

The controller consists of 10-bit ADC so, the resolution is given as,

ADC resolution = 2^{10} = 1,024

The analog input voltage is 5V and the output of the sensor is,

Sensor output = 5V in 20 Amp

It means that the ADC maximum the level is at 1,024 and it is equal to the 20 Amp.

10-bit ADC (1,024) = 20 Amp

1 Amp = 51.2 ADC value as per linear equation

Watt = voltage × current

100 × 10 = 1,000 Watt-hour

1 kilowatt-hour (KWH) = 1-unit (on the meter)

1-unit = Rs. 8 (unit price for states and cities are different, and it is also variable)

Unit cost (bill) = unit × unit price

Results

By interfacing, all the components with the ARM controller and by debugging will get the required outcome. As in the existing system, energy consumption is done only on a monthly basis. But in the proposed system, the information about energy consumption in terms of unit and cost will be done for an hourly and daily basis. It also provides information on real-time consumption on the LCD, which is connected with the smart meter. It also provides the facility of switching the supply of smart meter from MSEB to the inverter or battery backup. The following Figures 4 to 6 show the practical output and accurate results of the system. The hardware implementation of the smart energy meter is shown in Figure 4. The ARM Cortex controller is interfaced with the GSM module, Bluetooth module, current sensor, and relay circuit. The bulb is connected as a load to the circuit. The current sensor will sense the current and transfers the analog signal to the Cortex controller, and the required output will get generated by the smart meter. Figure 5 shows the output of the GSM module. The SMS is sent to the consumer's registered mobile number having the information of per day energy consumption with unit and cost. Figure 6 shows the output of the LCD, which is connected to the smart meter. This LCD will show real-time energy consumption in terms of unit and cost. It gives time to time information about the energy that is consumed by the consumer. This system is user friendly and is easy to operate.

Future Scope

The ARM-based smart energy meter is programmed to perform the objectives with the help of the GSM module. The proposed system overcomes all the disadvantages in the existing energy meter. This system saves time and reduces the error occurred due to physical reading is taken by the labors. It is user friendly and also reduces human efforts. All the details of energy consumption are sent to the consumer's registered mobile number through the GSM module and on the Android application by Bluetooth module. This improves the efficiency of the system.

- The developed device can have some immediate future advancement possible:
- Wi-Fi module can be used to upload the information of energy consumption on a webpage, which will increase the efficiency of the system and will overcome the problem of the bill being misplaced.
- 3G-4G GSM modem can be used in the future because these modems can carry information with more speed than other GSM modems.
- It can also be used for theft detection and over usage of electricity.

References

[1] Prathik, M., Anitha, K., & Anitha, V. (2018). Smart Energy Meter Surveillance Using IoT.International Conference on Power, Energy, Control and Transmission Systems (ICPECTS).

[2] Bibek, K.B., Shiv, N.Y., Shivam, K., & Sadhan, G. (2018). IOT Based Smart Energy Meter for Efficient Energy Utilization in Smart Grid, IEEE.
[3] Saikat, S., Swagata, M., Anindya, S., & Purkait, P. (2018). Design and Implementation of IoT Based Smart Energy Meter.Proceedings of 2018 IEEE Applied Signal Processing Conference (ASPCON).
[4] Win, H., Somchai, T., Varunyou, N., Natthanan, T., Tanayoot S., & Chaiyod, P. (2017). Implementation of WiFi-Based Single Phase Smart Meter for Internet of Things (IoT). 5th International Electrical Engineering Congress, Pattaya.
[5] Carmine, L., Pietro, M., & Giacomo, I. (2011). ARM Based Energy Management System using Smart Meter and Web Server. IEEE International Instrumentation and Measurement Technology Conference.
[6] Xiong, Y., & Luo, W. (2018). The Smart Home System Based on ARM Platform. International Conference on Smart Grid and Electrical Automation (ICSGEA).
[7] Danielly, A., Simion, G.B.M., Ricardo, A.L.R., Petar, S., & Joel, J.P.C.R. A Flexible IoT Energy Monitoring Solution. Brazilian National Council for Research and Development (CNPq).
[8] Dias, B. L. (2020). Big Data in Public Health: Real-Time Epidemiology Using Mobility and Environmental Data to Predict Outbreaks. International Journal of Cell Science and Biotechnology, 9(01), 05-10.
[9] Jai, K.M., Shreya, G., & Vinay, A.T. (2018). An IoT Based Smart Energy Management System. 4th International Conference on Computing Communication and Automation (ICCCA).
[10] Samson, J., Joy, R., Fredrick, K., Wesley, W., Sathiya, M., & Samuel, S. (2019). Smart Energy Monitoring Using RaspberryPi. Proceedings of the Third International Conference on Computing Methodologies and Communication (ICCMC).