ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

# AUTONOMOUS HOME ENERGY MONITORING AND MANAGEMENT SYSTEM

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## ABSTRACT

Home Energy Management System(HEMS) needs to consider both energy consumption and generation simultaneously to minimize the energy cost. Our project proposes a smart HEMS architecture that considers both energy consumption and generation simultaneously.Energy consumption is helpful for management and increasing efficiency of energy.A developed system is presented that uses a photovoltaic module to efficiently charge a super capacitor, which in turn provides energy to a microcontroller-based autonomous sensing platform. The embedded software on the node is structured around a framework in which equal precedent is given to each aspect of the sensor node through the inclusion of distinct software stacks for energy management and sensor processing. This promotes structured and modular design, allowing for efficient code reuse and encourages the standardization of interchangeable protocols.

**KEYWORDS**: wireless automatic sensor (EAS), home energy management system (HEMS), graphical user interface (GUI)

## INTRODUCTION

There is a suitable way to find out the monitoring and management of energy consumption in our day today life. In the current system their we adopt energy from a single source, grid. But the deficiency of energy in the Grid is an important problem facing our society. For that purpose we can adopt multiple sources such as solar panel, grid, battery etc. By using multiple sources we can easily reduce the consumption from the grid. The advantage of reducing energy consumption in Grid will helps to reduce the rate of load shedding. It is as much important to select appropriate energy sources in appropriate time else, there is not much importance to use multiple sources. For the selection of sources in each and every time should need a controller to manage the sources automatically. The selection of sources is based on the availability of sources and the load.

For example in we can use solar panel as the main source in day time because in day time we could get max efficiency from solar panel and can use grid as lower priority. But in evening section the output from solar tense to zero and the load across grid should be high. In that case we can adopt for battery as the main source. If we want to use a high load device in day time and the source, solar panel, can’t drive the load in that time then the controller switches the sources to appropriate one. By this method the consumers get maximum output in each and every time for which load is to be used. Energy autonomous systems using energy harvesting are particularly attractive when long-term remote deployment is needed or wherever a natural long-term energy source is available (such as forexample temperature or vibrations) for continuous replenishing of the energy consumed by thesystem. Such inexhaustible energy supply is a significant advantage over battery supply or mainspowering. Extended lifetime and autonomy are also particularly advantageous in systems with limited accessibility, such as medical implants and infrastructure-integrated micro-sensors.

This project is also providing an extra option such that it can send message the detail of energy consumption to the billing section through the GSM module. By using this technology, it is very simple to adopt the online billing technology. And there is an extra option such that the consumers can notice the usage information in displaying section and data is transfered to the display section through the zigbee module.This transfered data is displayed in the pc using Graphical User Interphase (GUI). It is a software developed in computer with the help of ‘virtual basicGUI displays the energy consumption details in the computer window

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***Autonomous energy management and monitoring system***

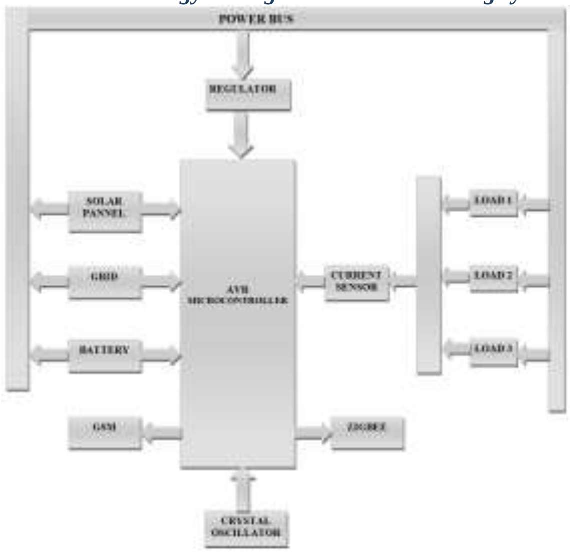


***Figure 1.1. Block diagram***

The figure shows the block diagram of autonomous energy management and monitoring system. This system architecture has the capability to control and monitor various renewable energy sources and power consumption. The primary energy sources used with this system are solar, battery and power system. It is likewise connected with GUI, to display timing and energy consumption details, and GSM module, to interact with power provider. The interaction between the system and GUI (graphical user interface) is achieved by using Zigbee protocol transmitters. This system is also equipped with an intelligent current sensing system to detect loads. The heart of this system is an AVR architecture based microcontroller, which controls and coordinates all the operation of this system. The HEMS (home energy management system) architecture and optimization algorithm used with this system, efficiently manage the renewable energy and storage to reduce a building's electric bill. To alternate between different renewable energy sources a controlling device is required, it is accomplished by using AVR microcontroller and relays. The primary energy sources that are employed in these projects are solar panels, battery and electric grid. The switching process among different renewable energy sources are controlled by applying a HEMS optimization algorithm.

The principal parameters of this algorithm are

1. Cost of electricity from external grid
2. Time
3. Power availability from solar panels
4. Power availability from battery

AVR microcontroller is used for controlling all the operation of this system, which receives inputs from various sensors, process the data according to the program stored in its flash program memory and controls various output devices connected to it. The AVR is a modified Harvard architecture 8-bit RISC single chip microcontroller which was developed by Atmel in 1996. The AVR was one of the first microcontroller families to use on-chip flash memory for program storage. The Atmega series AVR microcontroller is employed in this system. These microcontrollers can be operated on 1 MHz to 6 MHz of clock frequency. Here we use 16 MHz crystal oscillator clock the microcontroller. The programming of AVR microcontroller is done in embedded C by using Atmel Studio software.

This system architecture supports the online monitoring of connected load and power consumption. To achieve communication between power provider and a GSM modem attached to this system and is utilized for broadcasting messages to power provider through GSM network. The GSM modem is interfaced to AVR microcontroller through the inbuilt UART communication module. The GSM modem is controlled by using AT commands, the microcontroller sends various AT command instruction to GSM modem to send messages. The communication between the master section and the slave section is achieved by using a Zigbee protocol based wireless transceiver module. Zigbee is a specification for a suite of high-level communication protocols used to create personal area networks built from small, low-power digital radios. Zigbee is based on an IEEE 802.15 standard and has a defined rate of 250 Kbit/s, best suited for intermittent data transmissions from a sensor or input device

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## GREEN ENERGY

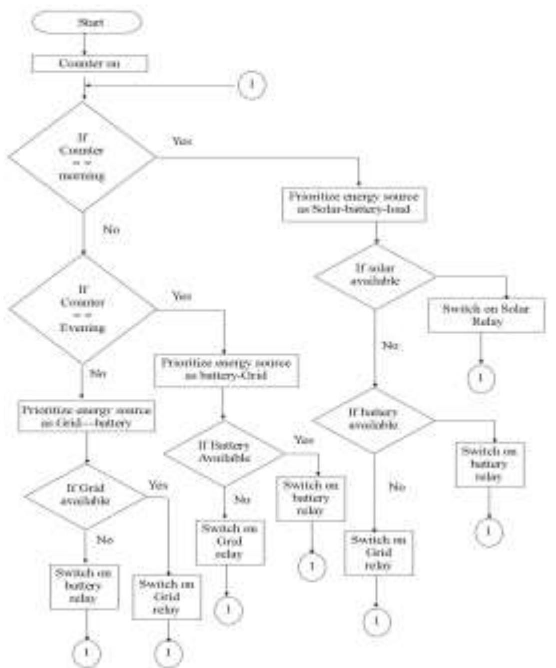


*Figure 1.2. green energy flow chart*

Energy management is the process of monitoring, controlling, and conserving energy in a building or organization

Energy harvesting done by three methods, from

- Solar panel
- Grid
- Battery storage

On usage energy consumption is selected using controller, by referring the previously stored data. Regulator is using for providing 5V regulated voltage for microcontroller.Energy management involves the following steps:Metering your energy consumption and collecting the data.Finding opportunities to save energy, and estimating how much energy each opportunity could save. Typically analyze meter data to find and quantify routine energy waste, and you might also investigate the energy savings that you could make by replacing equipment (e.g. lighting) or by upgrading your building's insulation.Taking action to target the opportunities to save energy.Typically you'd start with the best opportunities first. Tracking your progress by analyzing your meter data to see how well your energy-saving efforts have worked.Crystal oscillator providing clock frequency.

Current sensors calculates the current entering to the loads. By the way we can see the power consumption of each load. It can display on the receiving section. GSM module is use in this system for sending the unit of power consumption to KSEB.

## GREEN ENERGY SWITCHING

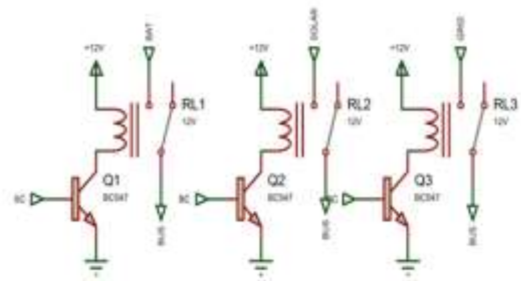


*Figure 1.3 Energy source switching relay*

The green energy switching mechanism consists of a relay attached to each power source which is connected to the microcontroller. The relay switching mechanism consists of a npn transistor and a relay connected to the n region on tht teransistor. Tht basec is connected to the microcontroller. The micro cobntroller interpretys the the power source and selects the optimum power source for the consumer. The npn transistor consists of a0.7V saturation voltage. The micri controller gives this signal to the relay attached to the selected source and this opens the source the building.

## GSM MODEM

The GSM modem is a specialized type of modem which accepts a SIM card operates on a subscriber's mobile number over a network, just like a cellular phone. It is a cell phone without display. Modem sim300 is a triband GSM/GPRS engine that works on EGSM900MHz, DCS1800MHz and PCS1900MHz frequencies. GSM Modem is RS232-logic level compatible, i.e., it takes-3v to -15v as logic high and +3v to +15 as logic low.MAX232 is used to convert TTL into RS232 logic level converter used between the microcontroller and the GSM board. The signal at pin 17 of the microcontroller is sent to the GSM modem through pin 11 of max232.this signal is received at pin2 (RX) of the GSM modem. The GSM modem transmits the signal from pin3 (TX) to the microcontroller through MAX232, which is received at pin 18 of PIC16F877A

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**Features of GSM**

- Single supply voltage 3.2v-4.5v
- Typical power consumption in SLEEP Mode: 2.5mA.
- SIM300 tri-band GSM/GPRS engine that works on frequencies 900/1800/1900 MHz
- Two serial interfaces
- SMS storage: SIM card
- Supported SIM Card :1.8V,3V
- Controlling is done by AT command

***Figure 1.4 GSM Module***

## ZIGBEE


***Figure 1.5: ZigBee***

ZigBee is a specification for a suite of high-level communication protocols used to create personal area networks built from small, low-power digital radios. ZigBee is based on an IEEE 802.15 standard Though its low power consumption limits transmission distances to 10–100 meters, depending on power output and environmental characteristics, ZigBee devices can transmit data over long distances by passing data through mesh of intermediate devices to reach more distant ones. ZigBee is typically used in low data rate applications that require long battery life and secure networking (ZigBee networks are secured by 128 bit keys. ZigBee has a defined rate of 250 kbit/s, best suited for intermittent data transmissions from a sensor or input device. Applications include wireless light switches, electrical meters with in-home-displays, traffic management systems, and other consumer and industrial equipment that requires short-range low-rate wireless data transfer. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs such as blootooth or wi fi

ZigBee is a low-cost, low-power, wireless mesh net work standard targeted at wide development of long battery life devices in wireless control and monitoring applications. Zigbee devices have low latency, which further reduces average current. ZigBee chips are typically integrated with radios and with microcontrollers that have between 60-256 KB flash memory. ZigBee operates in the industrial, scientific and medical radio bands: 2.4 GHz in most jurisdictions worldwide; 784 MHz in China, 868 MHz in Europe and 915 MHz in the USA and Australia. Data rates vary from 20 kbit/s (868 MHz band) to 250 kbit/s (2.4 GHz band).

The ZigBee network layer natively supports both star and tree networks, and generic mesh networking. Every network must have one coordinator device, tasked with its creation, the control of its parameters and basic maintenance. Within star networks, the coordinator must be the central node. Both trees and meshes allow the use of ZigBee router to extend communication at the network level.

The ZigBee Smart Energy V2.0 specifications define an ip based protocol to monitor, control, inform and automate the delivery and use of energy and water. It is an enhancement of the ZigBee Smart Energy version 1 specification adding services for PEV charging, installation, configuration and firmware download, prepay services, user information and messaging, load control, demand respons and common information and application profile interfaces for wired and wireless networks. It is being developed by partners including:

- HomeGrid Forum responsible for marketing and certifying ITU-T technology and products

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- HOME plug Powerline Alliance
- International Society of Automotive Engineers SAE inter national
- IPSO Alliance
- SunSpec Alliance
- Wi fi allians

The radio design used by ZigBee has been carefully optimized for low cost in large scale production. It has few analog stages and uses digital circuit wherever possible. Though the radios themselves are inexpensive, the ZigBee Qualification Process involves a full validation of the requirements of the physical layer. All radios derived from the same validated semiconductor mask set would enjoy the same RF characteristics. An uncertified physical layer that malfunctions could cripple the battery lifespan of other devices on a ZigBee network. ZigBee radios have very tight constraints on power and bandwidth. Thus, radios are tested with guidance given by Clause 6 of the Standard. Most vendors plan to integrate the radio and microcontroller onto a single chipgetting smaller device

This standard specifies operation in the unlicensed 2.4 GHZ (worldwide), 915 MHZ (Americas and Australia) and 868 MHz (Europe) . Sixteen channels are allocated in the 2.4 GHZband, with each channel requiring 5 MHZof bandwidth. The radios use DSSS coding, which is managed by the digital stream into the modulator. BPSK is used in the 868 and 915 MHz bands, and OQPSK that transmits two bits per symbol is used in the 2.4 GHz band.

The raw, over-the-air data rate is 250 kbit/s per channels in the 2.4 GHz band, 40 kbit/s per channel in the 915 MHz band, and 20 kbit/s in the 868 MHz band. The actual data throughput will be less than the maximum specified bit rate due to the packet overhead and processing delays. For indoor applications at 2.4 GHz transmission distance may be 10–20 m, depending on the construction materials, the number of walls to be penetrated and the output power permitted in that geographical location. Outdoors with , range may be up to 1500 m depending on power output and environmental characteristic]. The output power of the radios is generally 0-20 dbm (1-100 mW). ZigBee uses 128-bit keys to implement its security mechanisms. A key can be associated either to a network, being usable by both ZigBee layers and the MAC sublayer, or to a link, acquired through pre-installation, agreement or transport. Establishment of link keys is based on a master key which controls link key correspondence. Ultimately, at least the initial master key must be obtained through a secure medium (transport or pre-installation), as the security of the whole network depends on it. Link and master keys are only visible to the application layer. Different services use different variations of the link key in order to avoid leaks and security risks.

## CHALLENGES OF EAS AND APPLICATIONS

Making a forecast on the applications of Energy Autonomous Systems is very difficult, even in the near future, due to the overwhelming amount of variables that are involved. However, a very rough estimate could be done considering trends of electronic systems. Figure 7 shows a possible trend of the energy required by electronic systems in the next years. Given an application, we could consider the system composed of three parts: digital signal processing, A/D conversion and transmission. The application is composed of a blend of these subsystems, following different energy scaling trends: digital according Gene’s law, analog on a slower trend and transmission depending on path link and data rate. According to the specific application and on the subsystem which is prevailing, asymptotic trend lines are shifted one respect to the others in the plot. Obviously, the trend comes to flat in the far end, due to fundamental limits (thermodynamic or minimum transmission energy required, whichever comes first).

## CONCLUSIONS

This paper has highlighted wireless autonomous sensing as an attractive technology that, due to its economic benefits, is likely to continue to receive considerableinterest. A variety of low-power autonomous sensing platforms are now commercially available and, due to recent advances in energy harvesting technology, it is becoming viable to replace the on-board battery with sucha source. A system has been developed which uses a 0.5F supercapacitor as its sole energy store. The supercapacitor is efficiently charged via a photovoltaic module illuminated by fluorescent lighting in a regular office building. The embedded software in the developed system was structured using a “unified framework”, which specifies and structures the communications, energy management and sensor processing interfaces on the node. This promotes a structured and modular design, and hence allows for efficient code reuse and

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encourages the standardization of interchangeable protocols.

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