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IoT BASED ENERGY MONITORING AND MANAGEMENT SYSTEM FOR SMART HOME USING RENEWABLE ENERGY RESOURCES

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Abstract: *The proposed work is based on to monitor the energy consumption and energy management through Internet of Things (IoT). Electricity is one of the key factors in human life to survive on the earth. Most of our work requires electricity so it's important to save electricity. Without electricity life will be like heart without heartbeats. Energy saving is one of the main challenge in our day to day life. Energy saving can be done only when the energy consumed by the load is monitored. Once the load is monitored, suitable control methods can be adopted to operate the load in the optimized way to save energy. Even though there are lot of technologies and solutions available to effectively monitor, control and save energy consumption of load in a house or an industry, the Internet of Things technology is proposed to monitor, control and minimize energy consumption of load. The proposal is to design and develop an Internet of Things based Energy Management System in which the data is collected from smart energy meter using GPRS network and displayed on web page. The proposed system is suitable for data collection and control the load in the Internet of Things environment*.

1. INTRODUCTION

You can use smart mobile apps or connect products to a wireless gateway to communicate with them to start you home automation journey. In plug and play segment you can start with Wi-Fi smart plugs. A smart plug converts an ordinary power outlet into a smart one without any installation hustle. You can automate a device or power outlet one at a time and start building your automation network around it. Execute tasks like turn on and off a device or set rules to operate the device automatically from your Smartphone. You can find Smart Plugs available in the market at a very affordable price, so beginners and enthusiasts can enter in to home automation segment and experiment with smart plugs. There are overwhelming number of service providers from start-up companies to home security companies to tech innovators, these companies can design and install a custom system to suits your home.

Professional installation can come especially in handy for those who need to retrofit older homes and can't use a standard plug-and-play setup. Major home automation systems works around a gateway, or hub. The hubs act as a central command post to communicate between the controller and the controlled i.e., computer or mobile device used for control and monitoring.

Stand-alone hubs are readily available in the market, you can select a hub based on range of products you are using and the tasks you are aiming to execute Home automation systems will usually have their own hub, and products are built around the hub so configuration and installation will be simple and can be done by yourself or a technician will be provided to you. A home automation system consists of a device which communicates to a gateway or a hub. The number of devices required in your home depends on the degree of control you wish to have in your home.

In light of the increasing cost of electricity and the Global Warming campaigns to reduce general electricity usage, there is a growing interest in analyzing power consumption in households. By analyzing the electricity usage of each individual appliance separately, more accurate conclusions can be drawn on their efficiency and need for replacement. Furthermore this can also determine whether an appliance is drawing unusually high amounts of power when turned off and whether it should rather be unplugged. In this way electricity consumption and cost can be reduced. Most conventional prepaid power meters currently installed in households only display the total real time usage of its power and the amount of electricity available.

2. LITERATURE REVIEW

Tsirmpas [1] proposed a new method for profile generation in an IoT environment: An application in ambient assisted living. The current paper serves well in providing a great deal of detail about how components of the IoT might collect data to be processed into contextual information by implementing the proposed methodology of profile generation. Gomes [2] described an FPGA-based edge device for the Internet of Things. The system proposed an FPGA-based edge device for IoT which uses System-on-Chip (SOC) FPGA technology to offload important features of the

communication stack to dedicated hardware, aiming to increase system performance.

Jeya Padmini & Kashwan et.al.,[3] explained an effective power utilization and conservation in smart homes using IoT. A technique based on IoT, for recognizing human activity through image processing is proposed in the paper. Energy management is done based on real time approach in which a machine to machine communication takes place. Jinsoo Han [4] proposed a SMART home energy management system using zigbee and PLC. The server displays the web page which gives the information of the homes power consumption and generation. It is then compare with the previous data which optimize the cost and use of electricity.

Jose G. de Matos [5] explained a system to control the state of charge of the battery bank reducing the voltage on its terminals by controlling the generated power by the energy sources. Shiu Kumar [6] described a SMART home using android application. This paper presents a stand-alone system and low cost, which is based on the Android app communicate with the micro-web server provides more than the switching functionalities.

Mohanty, Panda & Pattnaik et.al., [7] discussed Implementation of a Web of Things based Smart Grid to remotely monitor and control Renewable Energy Sources. The integration of Web of Things with existing power grid architecture will provide us numerous opportunities for improvements in our energy saving techniques. Huiyong, Jingyang, & Min et.al., [8] described a "Building a smart home system with wireless sensor network and service robot." The author elaborated examined the integration of WSN with service robot for smart home monitoring system.

Minh-Thanh [9] discussed a "Towards Residential Smart Grid: A Practical Design of Wireless Sensor Network and Mini-Web Server Based Low Cost Home Energy Monitoring System" the 2013 International Conference on Advanced Technologies(ICAT) for Communications The paper presents a practical design of wireless sensor network based energy monitoring smart home system.

3. BLOCK DIAGRAM

Proposed project is having two main sections in (Fig: 1). First section is the electric meter region which continuously monitors the energy consumption.

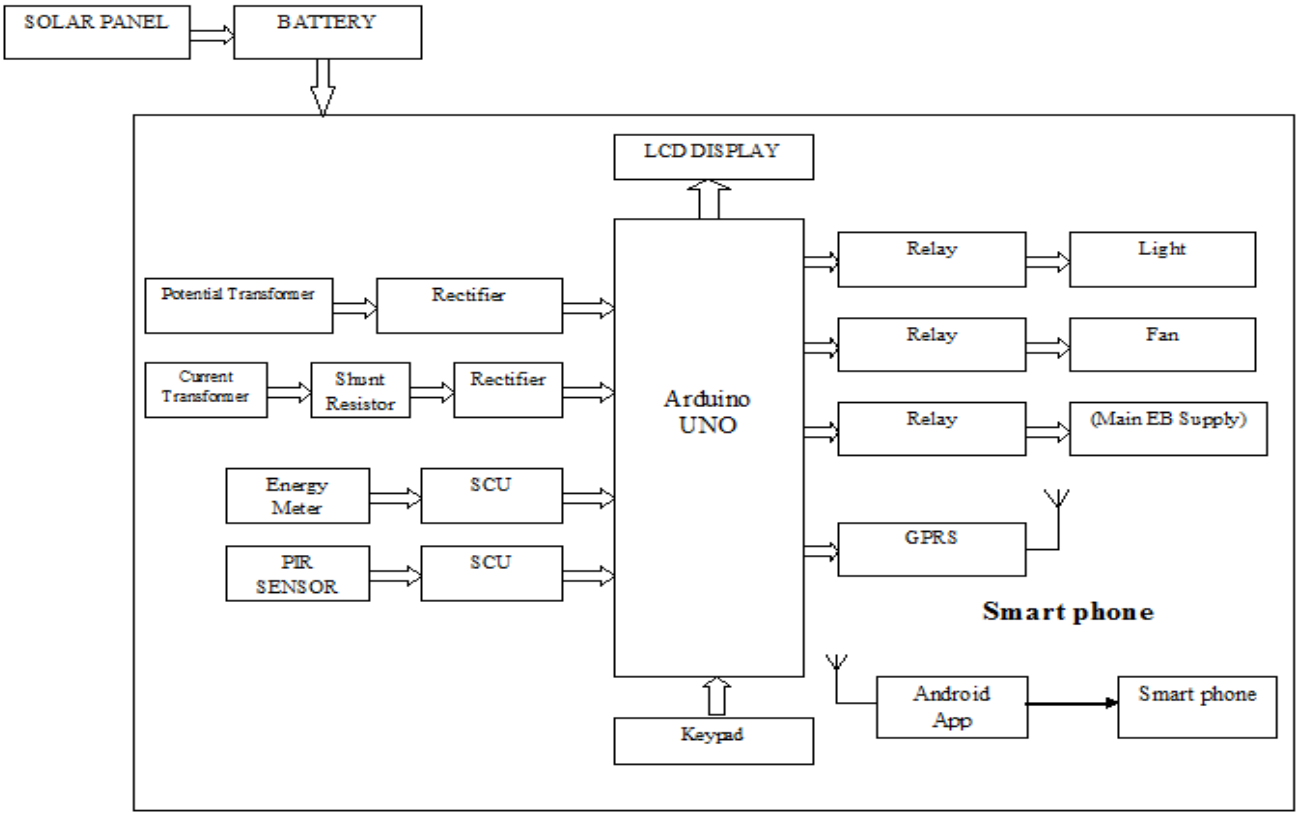


Fig: 1 Proposed Block Diagram

The second part of the project consists of a set of relays controlled by commands which are provided by making suitable changes in the web page. The system follows a separate operation for each of the components that are attached to the relay. As we have explained in the previous section, the core of our project is an Arduino Uno board. Power is supplied to the Arduino board and the computer. The electric meter, signal conditioning unit, rectifier, driver circuit, LCD display are attached to the corresponding pins of the controller. A computer or smart phone can be used as a user interface to control the components of home automation system.

3.1 ARDUINO UNO

Arduino/Genuino Uno is a microcontroller board based on the A Tmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 Analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button.

Fig: 2 Arduino Uno Microcontroller

"Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. . It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started (Fig: 2) you can tinker with your UNO without worrying too much about doing something wrong, worst case scenario you can replace the chip for a few dollars and start over again.

3.2 LCD DISPLAY

A liquid crystal display (LCD) is a thin, flat electronic visual display (Fig: 3) that uses the light modulating properties of liquid crystals (LCs). LCs do not emit light directly

Fig: 3 Liquid Crystal Display (LCD)

They are used in a wide range of applications including: computer monitors, television, instrument panels, aircraft cockpit displays, signage etc. They are common in consumer devices such as video players, gaming devices, clocks, watches, calculators, and telephones. LCDs have displaced cathode ray tube (CRT) displays in most applications.

3.3 ENERGY METER

An electric meter or energy meter is a device that measures the amount of electrical energy consumed by a residence, business, or an electrically powered device. Electric meters are typically calibrated in billing units, the most common one being the kilowatt hour. A periodic reading of electric meters establishes billing cycles and energy used during a cycle (Fig: 4).

Fig: 4 Electronic Meter

Panel-mounted solid state electricity meter, connected to a 2 MVA electricity substation. Remote current and voltage sensors can be read and programmed remotely by modem and locally by infra-red. The circle with two dots is the infra-red port.

3.4 POTENTIAL TRANSFORMER

This circuit (Fig: 5) is designed to monitor the supply voltage. The supply voltage that has to monitor is step down by the potential transformer. Usually we are using the 0-6v potential transformer.

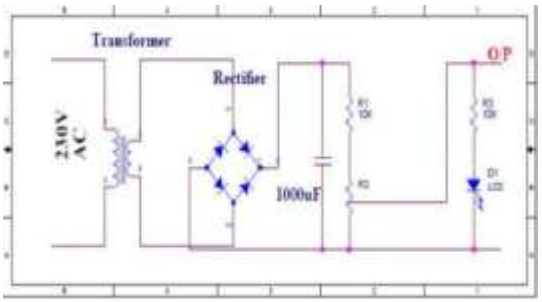


Fig: 5 Potential Transformer

The step down voltage is rectified by the bridge rectifier. Then bridge rectifier to convert ac voltage to dc voltage. Then the output of the rectified voltage is adjusted to 0-5v with the help of variable resistor R2. Then given to ripples are filtered by the C1 capacitor. After the filtration the corresponding DC voltage is given to control unit.

3.5 CURRENT TRANSFORMER

Current transformers (Fig: 6) used in metering equipment for three-phase 400 ampere electricity supply. Current transformers are often constructed by passing a single primary turn (either an insulated cable or an uninsulated bus bar) through a well-insulated tropical core wrapped with many turns of wire. The CT is typically described by its current ratio from primary to secondary. For example, a 4000:5 CT would provide an output current of 5 amperes when the primary was passing 4000 amperes.

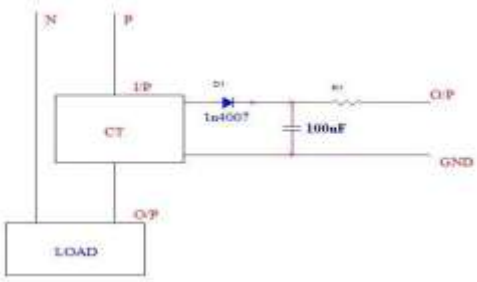


Fig: 6 Current Transformer

The secondary winding can be single ratio or have several tap points to provide a range of ratios. Care must be taken that the secondary winding is not disconnected from its load while current flows in the primary, as this will produce a dangerously high voltage across the open secondary and may permanently affect the accuracy of the transformer.

3.6 SIGNAL CONDITIONING UNIT

The signal conditioning unit accepts input signals from the analog sensors and gives a conditioned output of 0-5V DC corresponding to the entire range of each parameter. This unit also accepts the digital sensor inputs and gives outputs in 10 bit binary with a positive logic level of +5V. The calibration voltages (0, 2.5 and 5V) and the health bits are also generated in this unit. Microcontrollers are widely used for control in power electronics. A signal conditioning unit which provides necessary interface between a high power grid inverter and a low voltage controller unit.

3.7 RELAY

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example a low voltage battery circuit can use a relay to switch a 230V AC mains circuit. There is no electrical connection inside the relay between the two circuits; the link is magnetic and mechanical.

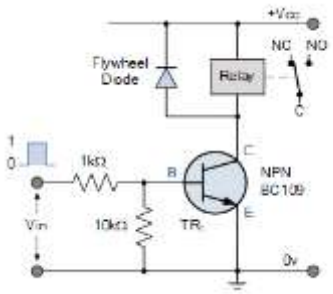


Fig: 7 Relay

Relays are usually SPDT or DPDT but they can have many more sets of switch contacts (Fig: 7) for example relays with 4 sets of changeover contacts are readily available. Most relays are designed for PCB mounting but you can solder wires directly to the pins providing you take care to avoid melting the plastic case of the relay.

3.8 PIR SENSOR

PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range.

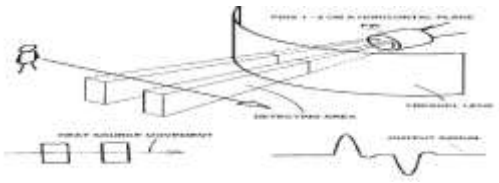


Fig: 8 PIR Sensor – Differential Change

They are small, inexpensive, low-power, easy to use and don't wear out. For that reason they are commonly found in appliances and gadgets used in homes or businesses. They are often referred to as PIR, "Passive Infrared", "Pyroelectric", or "IR motion" sensors**.** When a warm body like a human or animal passes by, it first intercepts one half of the PIR sensor, which causes a positive differential (Fig: 8) change between

the two halves. When the warm body leaves the sensing area, the reverse happens, whereby the sensor generates a negative differential change. These change pulses are what is detected.

3.9 BATTERY

An electrical **battery** is one or more electrochemical cells that convert stored chemical energy into electrical energy. Since the invention of the first battery (or "voltaic pile") in 1800 by Alessandro Volta, batteries (Fig: 9) have become a common power source for many household and industrial applications.

Fig: 9 Rechargeable Batteries

There are two types of batteries: primary batteries (disposable batteries), which are designed to be used once and discarded when they are exhausted, and secondary batteries (rechargeable batteries), which are designed to be recharged and used multiple times.

3.10 SOLAR PANEL

A solar panel (photovoltaic module or photovoltaic panel) is a packaged interconnected assembly of solar cells, also known as photovoltaic cells.

Fig: 10 Solar Panel

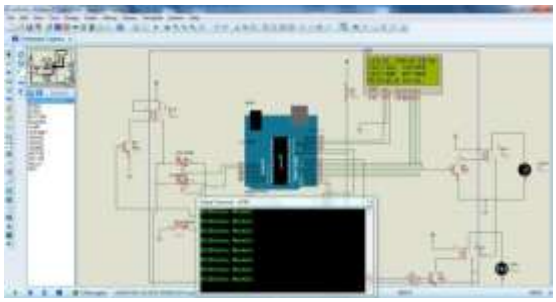
The solar panel is used as a component in a larger photovoltaic system to offer electricity for commercial and residential applications. Because a single solar panel can only produce a limited amount of power, many installations contain several panels (Fig: 10). This is known as a photovoltaic array. A photovoltaic installation typically includes an array of solar panels, an inverter, batteries and interconnection wiring.

4. RESULTS AND DISCUSSION

The result was obtained through two stages, one with simulation and another with real hardware implementation. In simulation, the work was done with Proteus Software. Then the next stage is hardware implementation and it was done with the combination of GPRS and smart home.

4.1 SIMULATION RESULT

Having concluded the design work of the circuitry, the first stage of testing was done by setting up of the circuit on a simulator (Proteus). The hex code was loaded to the microcontroller and the simulator is displayed. The design was put to test in a 3 bedroom flat apartment to monitor and control 4 electric fans with 2 A.C. systems, ten 60W bulbs including fluorescent tubes, television sets and water heater. Before installing our device, the overall energy consumed for the period of 24hrs with normal day to day activities was monitored and recorded (Fig: 11).



Fig; 11 Simulation output capture for load ON

After full installation of our device the energy consumed for the same period with normal day to day activities was also monitored and recorded (Fig: 12).

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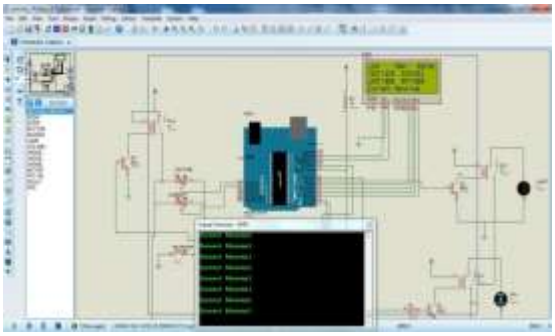

Fig: 12 Abnormal condition

In this work, a complete working model of an intelligent energy saving system has been implemented using an Arduino Uno microcontroller. The active intelligent energy-saving system is to help the common man in India to save cost as opposed to the exorbitant price of electricity consumption being charged by the distribution companies.

4.2 HARDWARE IMPLEMENTATION

The concept of Home Automation aims to bring the control of operating your every day home electrical appliances to the tip of your finger, thus giving user affordable lighting solutions, better energy conservation with optimum use of energy. The Internet of Things (or commonly referred to as IoT) based Home Automation system, as the name suggests aims to control all the devices of your smart home through internet protocols or cloud based computing.

The IoT based Home Automation system offer a lot of flexibility over the wired systems s it comes with various advantages like ease-of-use, ease-of-installation, avoid complexity of running through wires or loose electrical connections, easy fault detection and triggering and above and all it even offers easy mobility. Thus IoT based Home Automation system consist of a servers and sensors.

These servers are remote servers located on Internet which help you to manage and process the data without the need of personalised computers. The internet based servers can be configured to control and monitor multiple sensors installed at the desired location (Fig: 13). Let us understand in detail the working of different smart devices which together constitute the Home Automation system.

Fig: 13 Project Kit

The IoT based home automation consist of several smart devices for different applications of lighting, security, home entertainment etc. All these devices are integrated over a common network established by gateway and connected in a mesh network. This means that it gives users the flexibility to operate one sensor based followed by the action of the other Thus all the sensors within a common network can perform cross-talk via the main controller unit.

As shown in the figure (Fig: 14) some of the smart sensors in home automation acts as sensor hubs. These are basically the signal repeaters of signal bouncers which that are located in the midway between the hub installation location and the sensors that are at a distant location.

Fig: 14 Circuit connected with Solar Panel

Real-time monitoring and notifications is one of the key features of IoT based Home Automation systems. Since the hub is connected over the cloud network through the Internet, you can schedule various events as per your routine activities or daily schedules. After receiving such notification, the user can quickly turn on the IP based home security smart camera can check the status of your home even from remote location.

CONCLUSION

Smart Home and Energy Management is current trend with the development of IoT. Lot of work been reported in regards to controlling the appliances of home and also on monitoring the electrical parameters towards hazard. Also work reporting in controlling the appliance for energy consumption. So with all these work reported, we here have developed an better IoT system for Energy Management which takes the Humidity, Temperature and light intensity into consideration and accordingly interfaced with Arduino Microcontrollers for controlling the usage of appliance like speed of fan, light intensity rather than just switch on or off. Also the prototype system computes the current drawn from each appliance based on appliance usage and send to Android Smartphone where total power consumed of appliances computed against time. This information is computed all through the day and same uploaded in cloud server too. This ultimately achieves in energy consumption of every household resulting in Energy Management using IoT.

The system so developed is not fully complete as we have developed a prototype only for controlling two appliances i.e. fan and light. In future, we propose to extend the system for controlling appliances like Refrigerator, Air cooler, Television etc. The presence of human only will switch on the appliances. More amount of power can be saved based on the lesser usage of the appliances. There can be also a manual control over the appliances. We can implement algorithm that learns the change in the weather based on season and detect changes.

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