IOT-IZED ENERGY MONITORING AND CONTROL

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Abstract - *The Energy Monitoring System (EMS) provides real-time home electrical energy usage in terms of current consumed by appliances and provides data to the occupants so to keep informed of the energy usage. The increasing number of industries and the advancement in technology has emphasized the need to monitor and maintain the efficient working of machinery. This research work aims at improving the quality of monitoring the energy requirement in various industries. In this paper, we discuss about the integration of energy monitoring technology in industries. This system is a basic dynamic database utility system which fetches all information from a centralized database. The application at the user end contains the visual model of the monitored energy and will also allow the user to control the system. The user application, machine and the cloud computing database connects directly with each other through Wi-Fi. This wireless application is user-friendly, improves efficiency and accuracy of machinery in the industries by saving time and reduces human errors. This system successfully overcomes the drawbacks in trivial methods of energy control and is less expensive as it requires a one-time investment for gadgets.*

Key Words: Energy Monitoring, Internet of Things (IoT), Cloud Computing, ACS712 HALL effect sensor, Raspberry Pi 3B.

1. INTRODUCTION

Monitoring, Managing and reducing energy consumption not only saves money but also helps in mitigating climate change and enhancing corporate reputation. The primary objective of energy monitoring is to achieve and maintain optimum energy procurement and utilization, throughout the organization which may help in minimizing energy costs and mitigating environmental effects. In fact, by monitoring consumed energy, energy management is widely acknowledged as the best solution for direct and immediate reduction of energy consumption. Importance of Energy Management Energy should be regarded as a business cost, like raw material or labour. Companies can achieve substantial reduction in energy bills by implementing simple housekeeping measures. This project provides IoT support by sending the data to cloud and hence these data can be remotely monitored.

Reduction and control of energy usage is vital for an organization as it:

• Reduces costs: Reducing cost is the most compelling reason for saving energy. Most organisations can save up to 20% on their fuel cost by managing their energy use;

• Reduces carbon emissions: Reducing energy consumption also reduces carbon emissions and adverse environmental effects. Reducing your organisation's carbon footprint helps build a 'green' image thereby generating good business opportunities; and

• Reduce risk: Reducing energy use helps reduce risk of energy price fluctuations and supply shortages.

1.1 Objective

The major objectives to be achieved in this project are as follows:

1. Provide a Real time energy monitoring system.

2. Provide a more efficient data processing platform – Amazon Web Services.

3. Provide an easily accessible end user platform for controlling actions- Android Application Platform.

4. Provide an efficient, cheap and easy to use system under the IoT system which can fulfil above objectives.

1.2 Concepts involved

The major concepts involved in the project are

Energy Monitoring: The task of energy monitoring is to measure the current across the loads and also calculate the power via measured current. This helps us to accumulate the data of the consumed energy of the various loads connected and helps in control the usage of various devices.

Internet of Things (IoT): The Internet of Things (IoT) is the network of physical devices, home appliances and other items embedded with electronics, software, sensors, and connectivity which enables these objects to connect and exchange data. The IoT allows objects to be sensed or controlled remotely across existing network infrastructure and resulting in improved efficiency, accuracy and economic benefit in addition to reduced human intervention.

The cloud server used in the project for implementation of IoT is ThingSpeak. ThingSpeak is an open source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP protocol over the Internet or via a Local Area Network. ThingSpeak enables the creation of sensor logging applications, location tracking applications, and a social network of things with status updates.

Cloud Computing: Cloud computing is an information technology (IT) paradigm that enables ubiquitous access to shared pools of configurable system resources and higher-level services that can be rapidly provisioned with minimal management effort, often over the Internet. Cloud computing relies on sharing of resources to achieve coherence and economies of scale, like a public utility. Party clouds enable organizations to focus on their core businesses instead of expending resources on computer infrastructure and maintenance. Advocates note that cloud computing allows companies to avoid or minimize up-front IT infrastructure costs. Proponents also claim that cloud computing allows enterprises to get their applications up and running faster, with improved manageability and less maintenance, and that it enables IT teams to more rapidly adjust resources to meet fluctuating and unpredictable demand. Cloud providers typically use a "pay-as-you-go" model, which can lead to unexpected operating expenses if administrators are not familiarized with cloud-pricing models.

2. Advantages and disadvantages

Advantages include User-friendly, improves efficiency, Accuracy for industries, Time Saving, Reduces human errors,

Low power consumption and cost efficient.

Disadvantages includes Less accuracy (error: 1 to 2%), Less precision (0.5 cm), Requires continuous Internet connectivity.

2.1 Literature Survey

Our project makes use of a ACS Current Sensor which gives the value of current coming through the AC live wire. The value is calibrated and brought down to a specific level which is then passed on to the microcontroller. From this value we can measure the power consumption. Bothe these values are sent to cloud and then to the app which will be provided to the user. Given below are the research papers and videos that we have referred for completion of our project.

An on-site microprocessor functioning as a multiple meter unit is coupled to all such consuming units and stores the temperature differential with appropriate processing to record the heat usage during a known time. The microprocessor meter can store the individual energy usage of many consuming units and can be remotely or locally interrogated for purposes of collecting of the necessary data when and as required for billing and the like with equitable allocation of costs among the units based on such individual energy usage.-Sharad M. Marathe et al., "Energy monitoring system", Patent Number: US 4306293 A.-(an individual energy usage monitoring, no controlling access to user, no real time monitoring).

A system and method for real time monitoring and control of energy consumption at a number of facilities to allow aggregate control over the power consumption. A central location receives information over a communications network, such as a wireless network, from nodes placed at facilities. The nodes communicate with devices within the facility that monitor power consumption, and control electrical devices within the facility.-Erik J. Bartone, Ernest L. Mendenhall, Jr., John H. McClutchy, Jr., Devang N. Patel et al., "System and method for monitoring and controlling energy usage's Patent Number: US 6633823 B2. -(Real time monitoring but requires electrical equipment at every station "node" and not easily accessible. Hard to understand at user end).

Systems that monitor and control energy distribution manage energy distribution or use for Energy Service Providers and end-users. A system includes a publicly or privately accessible distributed network, a network access device, and a management device. The network access device communicates with the management device through the distributed network to control loads at a remote location. The method of monitoring and controlling energy distribution receives data at an on-line Site, processes an application program that evaluates load and market supply data, and initiates power curtailment requests or power curtailment events..- Gerd W. Nierlich, James Ronan Heffernan et al., "System and method for monitoring and controlling energy distribution", Patent Number: US 6519509 B1.-(less efficient way to access the monitored energy can be improved with cloud computing services)

3. Architecture

The skeletal body of the project is as given in the figure below which consists of the 3 modules. Module 1 consists of Hardware part; Module 2 consists of AWS and Cloud Computing and the third Module covers the application part which will be handled by the user.

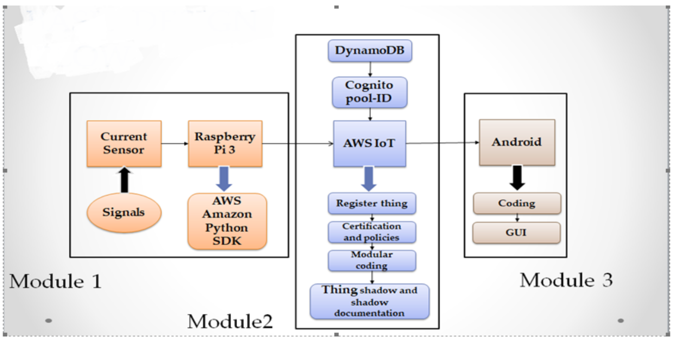

Fig -1: Block Diagram of Project.

3.1 Hardware requirements

3.1.1 ACS712 HALL effect sensor

The ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial and communications systems. The internal resistance of this conductive path is 1.2 mΩ typical, providing low power losses. The device consists of a precise, low-offset, linear Hall circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which the Hall IC converts into a proportional voltage. Device accuracy is optimized through the proximity of the magnetic signal to the Hall transducer.

Fig 3.2 ACS712 Current Sensor

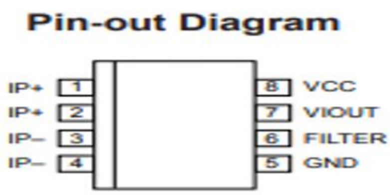

Fig -2: Current Sensor and Pin-out Diagram

3.1.2 Raspberry Pi 3B

The Raspberry pi is a general-purpose computer, with a (open source) Linux operating system. It is cheapest minicomputer that can be used in IoT system as the hardware interfacing component. Raspberry pi 3 model B consists of inbuilt Bluetooth and Wi-Fi. It is easily compatible with various cloud services as it works with python SDK.
Processor Broadcom BCM2387 chipset. 1.2GHz Quad-Core ARM Cortex-A53 802.11 b/g/n Wireless LAN and Bluetooth 4.1 (Bluetooth Classic and LE)

GPU: Dual Core VideoCore IV® Multimedia Co-Processor.
Memory: 1GB LPDDR2

Operating System: Boots from Micro SD card, running a version of the Linux operating system or Windows 10 IoT.
Video Output HDMI (rev 1.3 & 1.4 Composite RCA (PAL and NTSC)

Audio Output Audio Output 3.5mm jack, HDMI USB 4 x USB 2.0 Connector

GPIO Connector 40-pin as well as +3.3 V, +5 V and GND supply lines.

Ethernet 10/100 Base Ethernet socket

Fig -3: Raspberry Pi 3B Model

3.1.3 ATMega328P-PU

The high-performance Microchip 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1KB EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed. We boot loaded ATmega328 PU to work as an Arduino Uno board and mounted minimum necessary requirements to it such as crystal oscillator, capacitors and reset circuitry.

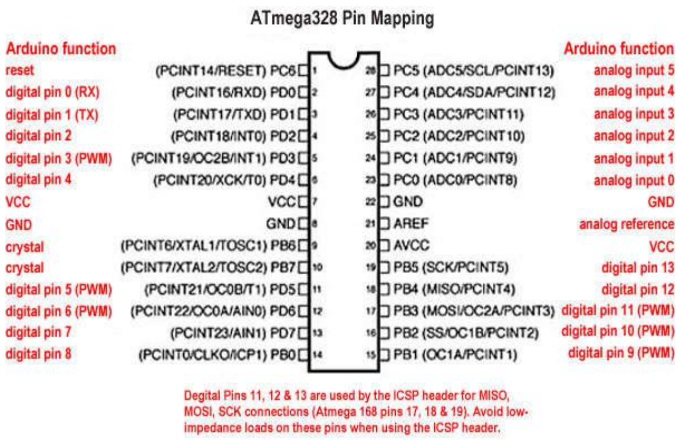

Fig -4: ATMega328P-PU

3.2 Software requirements

3.2.1 Amazon Web Services – AWS IoT Platform

AWS IoT (Amazon internet of things) is an Amazon Web Services platform that collects and analyzes data from internet-connected devices and sensors and connects that data to AWS cloud applications. Provides secure, bi-directional communication between Internet-connected THINGS and the AWS cloud. Enables to collect telemetry data from multiple devices. Store and analyze the data. Create applications that enable your users to control these devices. Amazon Web Services provides the following services at affordable price and easily scalable rate:

- Compute
- Storage and Content Delivery
- Database
- Analytics & Big Data
- Internet of Things
- Mobile Services
- Security & Identity
- Management & Monitoring.

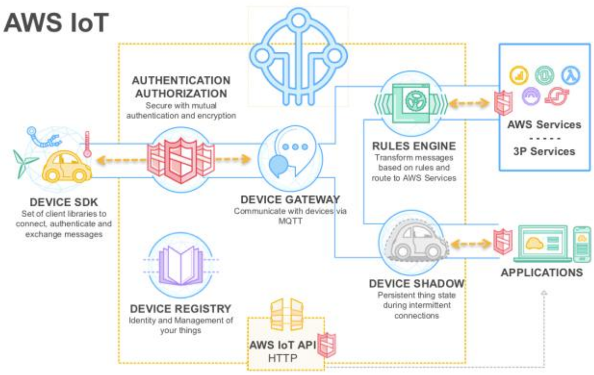

Fig -5: Architecture of AWS IoT

3.2.2 Amazon Web Services – AWS IoT Platform

PUTTY is a free and open source terminal emulator, serial console and network file transfer applications. Fig below shows the front panel of PUTTY.

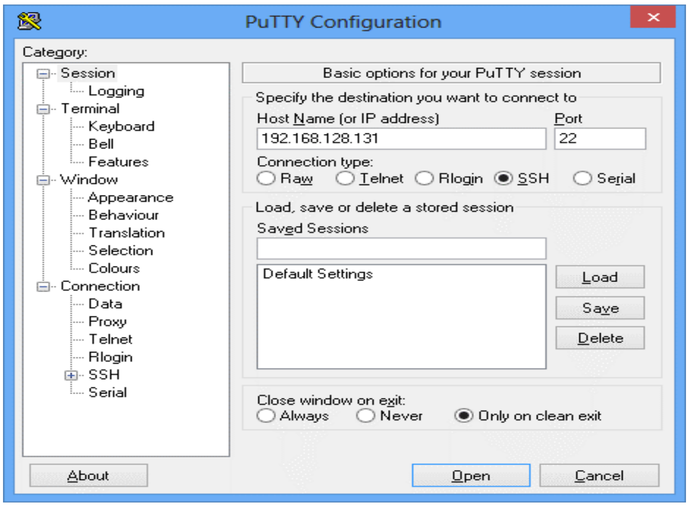

Fig -6: puTTY

3.2.3 Android Studio

Android application platform is most widely and most commonly used user end application platform, hence it is more familiar than any other platform. It is easily portable, compatible with numerous sources of uses and easy to use. Fig 6 below shows Android Studio and Fig. 7 shows the application made to monitor energy consumption.

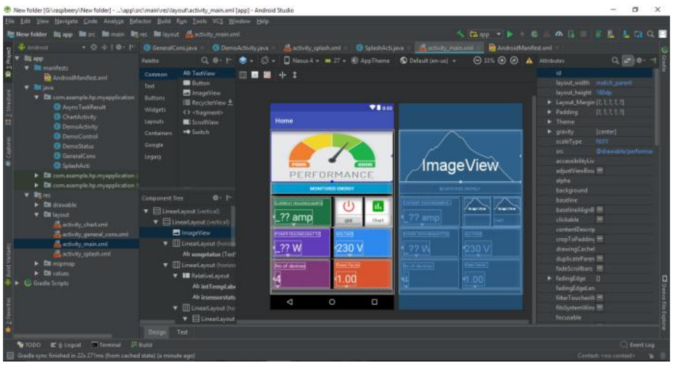

Fig -7: Android Studio Application Activity Tab

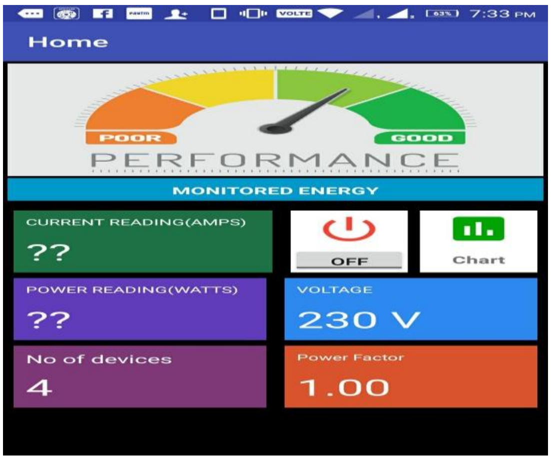

Fig -8: Android Application Interface

3.2.4 Arduino IDE

In our project we used Arduino IDE to program the microcontroller. The first task was to boot load the ATMega328P-PU so that it could be programmed by Arduino IDE. Then we programmed the microcontroller to obtain the proper interfacing results with the ACS712 sensor which are then sent to Raspberry pi.

4. Working

The operation of the whole system can be seen through the block diagram. The figure shows the project block diagram. The supervisor uses the Android App which will provide all the information about the energy dissipation of the machine. The App will act as a catalyst making the procedure of controlling the functionality of the machine faster and easier. The supervisor based on the information obtained from the sensors can monitor every machine. Instantly the machine will be turned on and off according the supervisor's requirement. Raspberry Pi which has inbuilt Wi-Fi is used for communication between sensor on the machine and the application with the supervisor. In the application, the current status of the machines along with its energy details is displayed.
The system consists of three subsystems

1. AC Current Measurement Point
   - This system measures the actual current that is utilized by the connected device using a small sized minicomputer and a current sensor.
   - The system has internet connectivity and has development kit for cloud connectivity.

2. Database server and Processing.
   - The system accepts data serially and acts as a bridge between first and last system.
   - Processing the data as per requirement and keeping it secure for user is the main task here.

3. Accessing data on Android platform.
   - The related data of the connect device and the user is shown here. It needs internet connectivity.
   - It provides user interaction and gives details of units consumed by device on a simple and easily accessible interface.

Fig -9: Basic Design Flow

5. Results

Given below are the results obtained with current reading seen on Arduino, Raspberry PI, AWS cloud platform, Android Application and PLX-DAQ chart.

Fig -10: Readings obtained on Raspberry Pi terminal

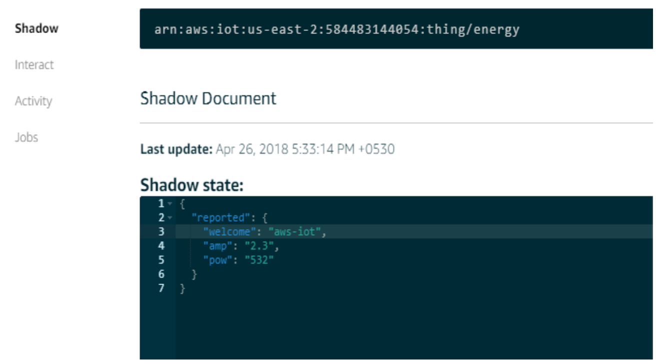

Fig -11: Current and Power reading received on AWS cloud platform

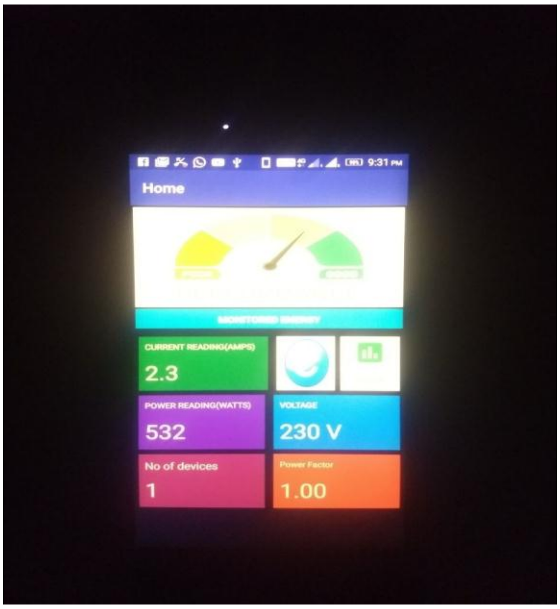

Fig -12: Output received on the actual Android application

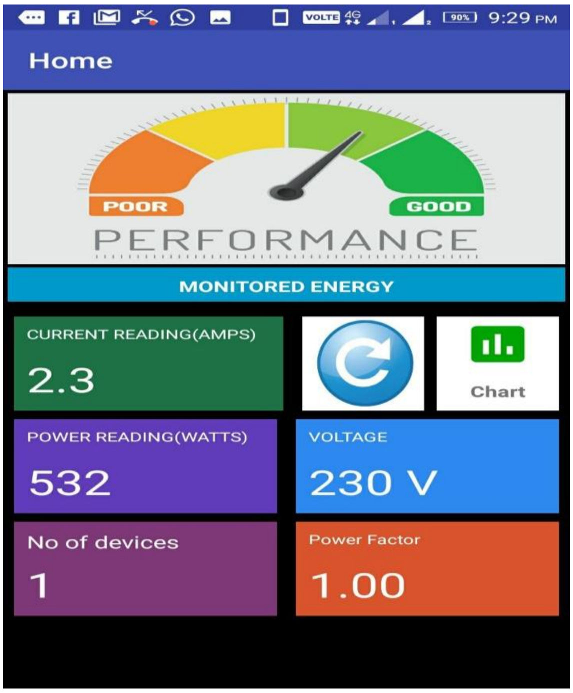

Fig -13: Screenshot of actual readings received on android application

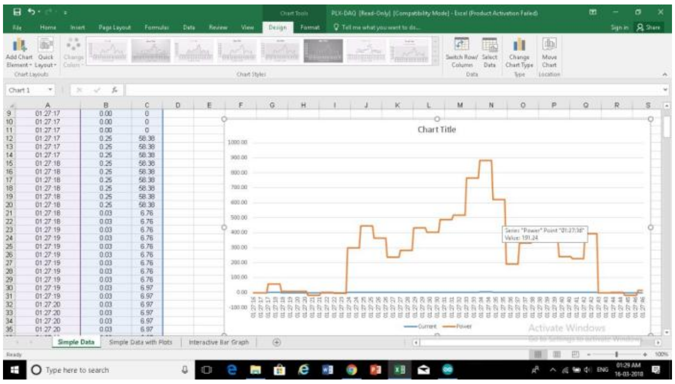

Fig -14: Obtained results shown on the PLX-DAQ chart

The orange line shows the power consumed by the load, I used a hair dryer as load and setting it on different mode gave different values for power. The blue line near the 0 value (of Y axis) signifies the current. Since the maximum current is near 3A, it does not show significant change in the chart. The readings on serially received data converted in excel sheet format is shown, they are the current readings obtained from connected devices.

6. Future scope

- In industries to improve efficiency of machines working together.
- To reduce human intervention and provide accessibility at places which is inaccessible to humans.
- Provide a real-time energy monitoring at android application platform and ability to control it over application.

Acknowledgment

We are feeling very humble in expressing my gratitude. It will be unfair to bind the precious help and support which we got from many people in few words. But words are the only media of expressing one's feelings and my feeling of gratitude is absolutely beyond these words. It would be my pride to take this opportunity to say the thanks.

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