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IoT-Based Energy Meter System with Remote Sensing Facility

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Abstract: With energy sources depleting at an alarming rate and insufficient monitoring and control of household and industrial energy consumption, optimized and efficient utilization of energy is of great importance today. To rectify these problems, establishments are interested in developing smart grids for power systems. Currently, no energy meter system has the feature of complete duplex communication. Hence, we propose an Energy Meter System which functions using Internet of Things (IoT) by calculating energy consumption, and stores data on a daily, monthly and yearly basis. The data is stored in Excel Sheet format from which various graphs and charts may be plotted for data visualization and easier tracking of data consumption.

Keywords: Energy Meter System; Energy Consumption; IoT

I. INTRODUCTION:

Population growth and development of new equipment led to a spike in energy consumption, and, consequently, damage to energy security and the environment. It would be beneficial for all if consumers could track their own consumption and organize their need efficiently. A smart energy meter may be added to the list of modern network technology gadgets, including features such as bidirectional communication and Wi-Fi equipment control. This is a step in the direction of development of smart power grids for an enhanced user experience, which would be more economical and efficient. Operators will use information about the provided energy quality to enhance energy supply, which in turn can be scheduled, monitored and managed-on-demand thanks to the design. The proposed device can integrate different communication interfaces into some monitoring software to facilitate multi-protocol connection.

Presently, the only feedback about consumption statistics given to the consumer is a monthly bill which shows the total power used, whereas it is desirable to track usage on a more detailed and immediate basis. Power providers are facing tremendous load due to the fast-rising consumption. Also, tampering of the meter system is easily done and must be prevented.
In this proposed system, energy used can be tracked in regular intervals and power can be managed accordingly. In case the customer fails to pay the bill on time, the host may autonomously turn off the power connectivity.

Internet of Things (IoT) is a network of physical devices ("things") which are embedded with sensors, software, electronics and network connection, enabling the collection and exchange data by the "things". IoT allows remote sensing and control of within the established network infrastructure. Physical world systems can be integrated with computer-based systems in this manner, and this directly results in greater accuracy, efficiency and economy. Here, "things" may refer to devices such as biochip transponders for farm animals, implants that monitor the heart, automobiles having built-in sensors, electric clams deep in water bodies, devices performing DNA analysis for pathogen monitoring, field-operation devices which provide assistance to fire-fighters in search-and-rescue operations, etc. These devices facilitate the collection and autonomous flow of data between devices.

II. Related Work:

Chandra et al [1] proposed Smart Energy Meter with use of IoT to help facilitate an energy profile for real-time smart home/building, user apps which bill, data accounts, and fault and theft detection. Wasteful routines and inefficient appliances can be eliminated. Utility companies will receive exact billing data along with a balance for demand-and-supply. With the IoT platform, smart meters can be easily implemented to support these and many other smart grid features.

Devadhanishini et al., [2] proposed Smart Power Monitoring Using IoT, stating that energy consumption is a challenge and is an issue of importance today. Automatic Electrical Energy meter is used in large electric energy distribution system. The Arduino WIFI and SMS have been integrated providing the Smart Power Monitoring system. It provides data for optimization and lowers power consumption. Motion sensor are also provided so as to automatically turn of power supply when there are no humans in the house.

Mohammed Hosseiu et al., [3] presented the paper "Design and implementation of smart meter using IoT", which discusses the rise of IoT within digital technology. The future energy grid needs to be implemented in a distributed topology that can dynamically absorb different energy sources. IoT can be utilized for various applications of the smart grid consisting power consumption, smart meter, electric power demand side management and various area of energy production. In this paper, the Smart Energy Metering (SEM) is explained as the main purpose of SEM is necessary for collecting information on energy consumption of household appliances and monitor the environmental parameters and provide the required services to home users.

Himanshu K Patel et al., [4] demonstrated Arduino based smart energy meter that removes human intervention in meter readings and bill generation thereby reducing the error that usually causes in India. The system consists the provision of sending an SMS to user for update on energy consumption along with final bill generation along with the freedom of reload via SMS. The disconnection of power supply on demand or due to pending dues was implemented using a relay. The system employs GSM for bidirectional communication.

Bibek Kanti Barman et al. [5], proposed a smart meter with use of IoT for efficiency in energy utilization, which would play a vital role in the power system. Proper monitoring and control of power consumed is prioritized in this smart grid. As dual communication is yet to be achieved, this smart energy meter aims for this. The smart energy meter controls and calculate the consumption of energy using. The Wi-Fi module, ESP 8266 12E, calculates energy consumption and sends this to the cloud from which one may view the data.

III. Proposed System:

A. Physical Structure of Proposed System:

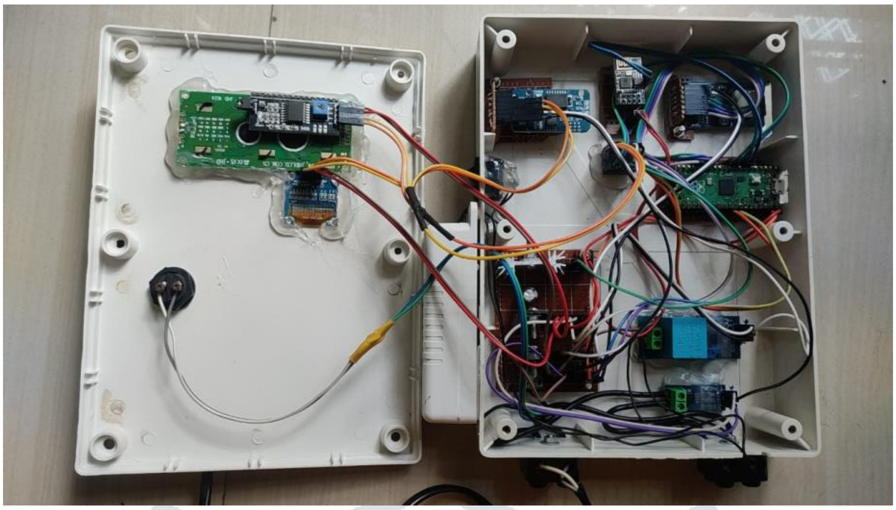

Fig 1: Interior of Device

Fig 2: Exterior of Device

B. Hardware components:

1) **Raspberry Pi Pico-** Raspberry Pi consists of a series of miniature single-board computers (SBCs), developed by the Raspberry Pi Foundation, United Kingdoms, in association with Broadcom. The Raspberry Pi project originally leaned towards the promotion of teaching basic computer science in schools and in developing countries. The original model became more popular than anticipated, selling outside its target market for uses such as robotics. It is widely used in many areas, such as for weather monitoring, because of its low cost, modularity, and open design. It is typically used by computer and electronic hobbyists, due to its adoption of HDMI and USB devices. After the release of the second

board type, the Raspberry Pi Foundation set up a new entity, named Raspberry Pi Trading, and installed Eben Upton as CEO, with the responsibility of developing technology. The Foundation was rededicated as an educational charity for promoting the teaching of basic computer science in schools and developing countries. A Raspberry Pi Pico is a low-cost microcontroller device the design of the Raspberry Pi Pico board provides module soldering directly to carrier boards. The all-new Raspberry Pi Pico is the latest addition to the Raspberry Pi family of microcontrollers. It is a new flexible microcontroller board that is built on silicone and is designed entirely by Raspberry Pi. Microcontrollers are tiny computers, but they tend to lack large volume storage and peripheral devices that you can plug in (for example, keyboards or monitors). A Raspberry Pi Pico has GPIO pins, much like a Raspberry Pi computer, which means it can be used to control and receive input from a variety of electronic devices.

Fig 3: Raspberry Pi Pico

2) **ESP 8266-** The ESP8266 ESP-01 is a Wi-Fi module which gives micro-controllers Wi-Fi access. Being a self-contained SOC (System-On-a-Chip), it doesn't require a micro controller for manipulation of inputs and outputs, as in case of an Arduino, as the ESP-01 acts as a small computer in itself. In some versions of ESP8266, there may be as much as 9 GPIOs (General Purpose Input Output). It can act as a microcontroller while also having internet access. Thus, the ESP8266 is very versatile and cost effective.

Fig 4: ESP 8266

3) **MicroSD Card Module-** The MicroSD Card Adapter is a Micro SD card reading module and is the SPI interface through which the file system driver can read and write files. Users can directly use the Arduino IDE comes with an SD card to complete the library card initialization and read-write. The module is a Micro SD card reader module and the SPI interface via the file system driver, micro controller system to complete the Micro SD card read and write files. Users can directly use the Arduino IDE comes with an SD card to complete the library card initialization and read-write 3.3V voltage regulator circuit: LDO regulator output is 3.3V level converter chip, Micro SD card supply. Level conversion circuit: Micro SD card into the direction of the signal is converted to 3.3V, MicroSD card interfaces to control the direction of the MISO signal is also converted into3.3V, general AVR micro controller system can read the signal. Micro SD card connector: a self: bomb deck, easy card insertion.

Positioning holes: 4 M2 screws positioning hole diameter is 2.2mm, the positioning of the module is easy to install.

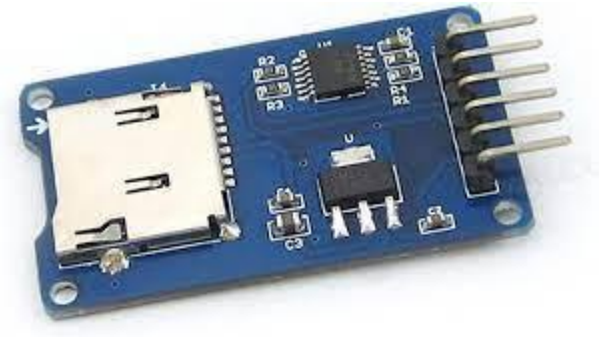

Fig 5: Micro SD Card Module

4) **DS3231 RTC Module-** DS3231 Module is Bread Board friendly and a very precise I²C real-time clock Module. It uses DS3231 RTC and AT24C32 EEPROM integrated with temperature-compensated crystal oscillator.AT24C32 consists of 32,768 bits of serial EEPROM present as 4096 words x 8 bits. A built-in comparator for monitoring the VCC status is also present for detection of power failures and automatic switching to the backup power supply. This gives us 32Kb of non-volatile memory and is easy to interface with Raspberry Pi, Arduino Boards and all other Microcontrollers.

Fig 6: DS3231 RTC Module

5) **12v Power Supply-** Input: 220 V; Output: 12 V; Output Current: 1 Amp;
This is a very basic form of SMPS which converts mains power to 12V DC to power all of the equipment. Each of these require either 3.3V or 5V. So, it may be stepped down to the required voltage using linear voltage regulator.

Fig 7: 12v Power Supply

6) **Voltage & Current Sensor-** ZMPTB101B has been used as the voltage sensor and ACS712 5A module as the current sensor. Both are popular for their accuracy and their relatively cheap price.

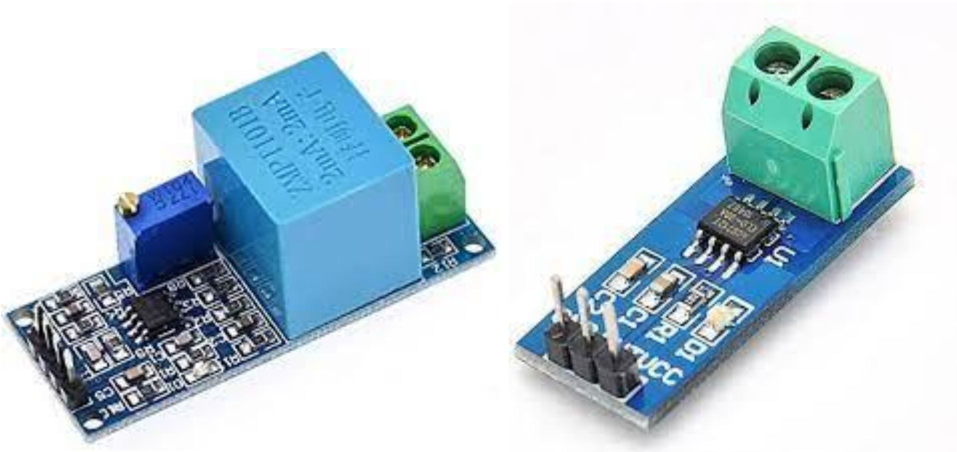

Fig 8 & 9: ZMPTB101B and ACS712 5A

C. Flowchart:

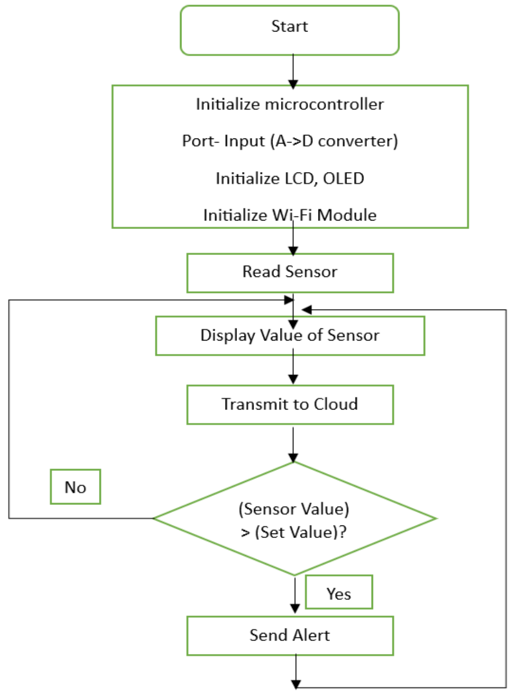

Fig 10: Working Principle of Device

I. EXPERIMENTAL RESULT:

The meter is connected to a test lamp, although any suitable appliance may be used for testing purpose, and the online website used to plot the data is observed in the "power-on" condition.

The data is analyzed on the cloud platforming, where plots are made in real time, in the form of a line plot in the following manner:

- Minute-Power graph: The plot consists of power in W/min vs time. Even small fluctuations of power can be easily found using this.
- Hour-Power graph: The plot consists of power in W/hour vs time. Small fluctuations of power are harder to detect but this is still useful for persistent fluctuations.
- Total Power graph: The plot consists of power in W/hour vs time over the total time period of operation. The slope is seen to be very gradual irrespective of power fluctuations. This is the type of data analysis done in most power stations today. Unless extreme power misuse occurs, no changes can be detected by these graphs.

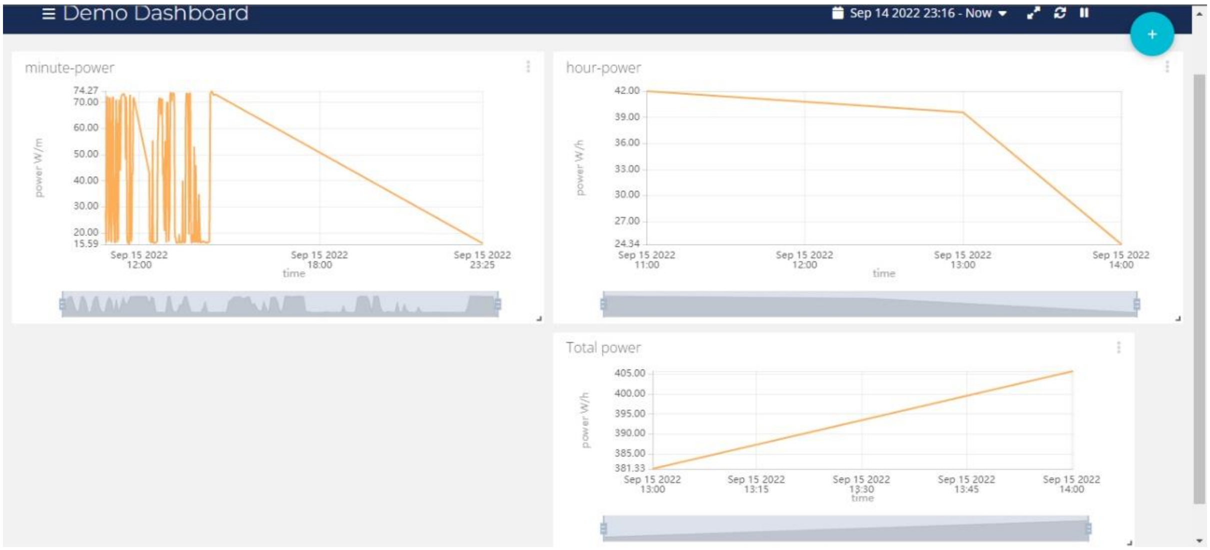

Fig 11: Statistics from Cloud Platform- minute-power graph (top left), hour power graph (top right), and total power graph (bottom right)

I. CONCLUSION AND FUTURE WORK:

The proposed Energy Meter can solve many global power-related issues. Easy storage of data and generation of charts and graphs from it facilitates analysis of consumption statistics. Fossil fuel is quickly depleting and power consumption must be lowered in all ways possible. Internet of Things (IoT) provides us with a modern solution for this. It serves as a communicates medium through control signal or identified data anywhere in the world. For these reasons, it is quickly gaining popularity in this field. With proper implementation, data may be exchanged between a centralized office and any remote location. Hence, the unnecessary hassle of humans having to collect meter readings physically may be eliminated.

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