Energy Monitoring System for Agri and Aquatic Field

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ABSTRACT

With the advancement in technology and emergence of IoT, various devices systems have been evolved and designed to monitor the under-water conditions, these devices include: water quality monitoring system, fish-finder, Marine VHF Radio. The energy consumed by these devices should be monitored as a new problem is arising with the management of energy required to power these devices. The key challenge is in minimizing the energy that is consumed by these IoT systems due to increased power required by these sensors. These devices can be classified into two broad categories that are community monitoring, and personal sensing applications. Sometimes these devices are combined to form a complex system. Here, we are proposing a system using which we can monitor the energy consumption of a user remotely. Wireless communication models will be used in this system to get the energy consumption data remotely. The proposed system will replace the traditional meter reading method i.e., energy consumption can be monitored without a person visiting each house. Energy monitoring systems will also help user to understand energy consumption patterns and they can be notified of the different ways to maximize power saving.

The proposed system will consist of an energy metering module, Real Time Clock and Microcontroller. The data will store in database and it will display in website. Users can see the energy consumption on the website. It is the need to optimize energy consumption, and this can be done by analyzing energy consumption patterns.

Keywords: Energy Monitoring System, Energy Meter, Remote Energy Monitoring, Real Power, Power Factor, RTC

1. NTRODUCTION

An energy meter is also known as a kilowatt-hour meter, electricity meter, electric meter, or electrical meter. A gadget estimates how much power consumed by the client. It measures the power consumed by a user in a particular time interval. Companies in the electric power industry use energy meters installed in user's premises for monitoring and billing. Energy is measured in units that are in kilowatt-hours. They are normally perused once each charging period. In certain areas meters have transfers for request reaction load shedding during top load periods. 1 unit is equivalent to how much energy utilized by a heap of one kilowatt over a time of 60 minutes, or 36,00,000 joules. There are two types of energy meters:

i. Electronic meters,
ii. Electromagnetic meters.

The most common type of electricity meter is the electromagnetic watt-hour meter. It operates on the principle of electromagnetic induction by counting the revolutions of a non-magnetic but electrically conductive, metal disc which is made to rotate at a speed proportional to the power passing through the meter. The number usage is proportional to energy usage. Electronic meters display the

energy used on an LCD or LED display and some of these meters can record the readings and transmit it to remote places using ZigBee [11]. Electronic meters can record various parameters like instantaneous and maximum rate of usage demands, volt. power factor, and active power used.

Power factor is defined as the cosine of phase difference between voltage and current. If phase difference is positive, then the load acts as inductive load. When the phase difference is negative, then the load acts as capacitive.

Active Power, also termed as real power, it is the power that is consumed in an AC circuit.

The meter has a power supply, a metering motor, a processor and correspondence motor, and other extra modules like real time clock and Infrared communication ports.

Our goal is to create a sustainable world with IoT technology and expertise to reduce costs, increase efficiency and reduce environmental impact. Energy and electricity consumption is a constant concern for homes and business owners. As resources become scarce and electricity prices continue to rise, it is important to know how homes and businesses use energy and use it most efficiently. One way this is done is by installing an energy management system. This smart system model is used to calculate the household's energy consumption without changing the energy meters which is already installed at our houses. In earlier implementations, ADE7757IC have been used and data was being sent using GSM modem. Output pulses from the metering IC are counted using the default timer of PIC MCU. Also, formula that was being used is [9]

Energy = Average Power x Time = (Counter / Time) x Time

2. Requirement Analysis

Energy Monitoring system involves energy measuring IC along with that it includes a microcontroller for displaying the data on the screen. The system includes RTC (Real Time Clock) to get current time accurately.

A. Hardware Requirements

ESP32 is a progression of minimal expense, low-power frameworks on a chip microcontroller with coordinated Wi-Fi and double mode Bluetooth. The ESP32 series utilizes either a Tensilica Xtensa LX6 microchip in both double center and single-center varieties, a Xtensa LX7 double center chip, or a solitary center RISC-V chip and incorporates worked in radio wire switches, RF balun (transmission line transformer), power amplifier, low-noise receive amplifier, filters, and power-management modules. ESP32 is created and developed by Espressif Systems. For the project we will be using UART protocol to receive the data from energy metering IC, and I2C protocol is used for interfacing with RTC (Real Time Clock).

Energy meter module (HLW8032): The HLW8032 IC is intended for application of single phase and it uses CMOS manufacturing process. It measures line voltage and current, and calculates active power, apparent power, and power factor. It has low power consumption, high reliability, and strong adaptability to the environment. It works on UART Protocol, Rx pin is used to send the data, the data is sent in series of 24 bits.

Data format of HLW8032:

Baud rate:4800bps
Start bit + data bit (8bit) + even bit + stop bit
Every complete transmission of data by HLW8032 is 24bytes. The transmission of a group of data starts from register 1 (State REG) and ends at register 11 (Check Sum REG), involving altogether 11 registers and data of 24 bytes.
Transmission order of data: High 8bit - > middle 8bit - > low 8bit

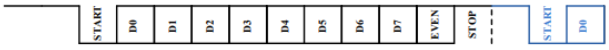

Fig 1: UART Data Frames

Let register be a 24byte array of hexadecimal data sent by the sensor

Calculation for Voltage:

$$\text{Voltage} = \frac{\text{Voltage Parameter REG}}{\text{Voltage REG}} * \text{Voltage Coefficient}$$

$$\text{Voltage Coefficient} = 1.88$$

$$\text{Voltage Parameter REG} = \text{register}[2:4]$$

$$\text{Voltage REG} = \text{register}[5:7]$$

Calculation for Current:

$$\text{Current} = \frac{\text{Current Parameter REG}}{\text{Current REG}} * \text{Current Coefficient}$$

$$\text{Current Coefficient} = 1$$

$$\text{Current Parameter REG} = \text{register}[8:10]$$

$$\text{Current REG} = \text{register}[11:13]$$

Calculation for Active Power:

$$\text{Active Power} = \frac{\text{Power Parameter REG}}{\text{Power REG}} * 1.88 * 1$$

Calculation for Power Factor:

$$\text{Power Factor} = \frac{\text{Active Power}}{\text{Apparent Power}}$$

Calculation for Apparent Power:

$$\text{Apparent Power} = \text{Voltage} * \text{Current}$$

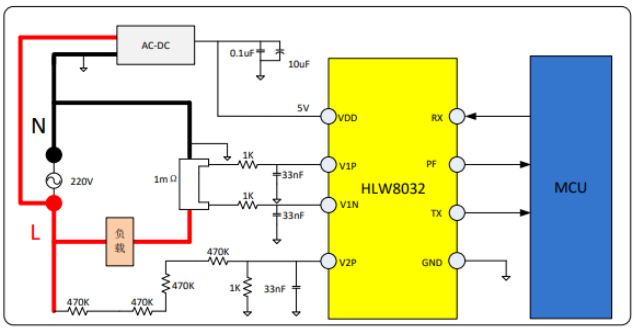

Fig 2: Schematic of HLW8032 module used in circuit

Real-time clock is an electronic device used to measure a time interval There are two types of RTC: Hardware-based RTC and Software Based RTC. Software-based RTCs are used in Embedded systems. Software-based RTC will be used in this project. DS1307 Real-time clock (RTC) counts seconds, minutes, hours, date of the month, month, day of the week, and year with leap-year compensation (valid up to 2100). It is 56-byte, battery-backed, nonvolatile RAM for data storage. It can identify power disappointment and automatically switch to battery supply. The benefits of using RTC are: it avoids time critical situations also it consumes very less power and is perfectly accurate. RTC uses a crystal oscillator with frequency of approximately 32.768 kHz,

which is like what is used in quartz clocks and watches. It operates as a slave device on a serial bus.

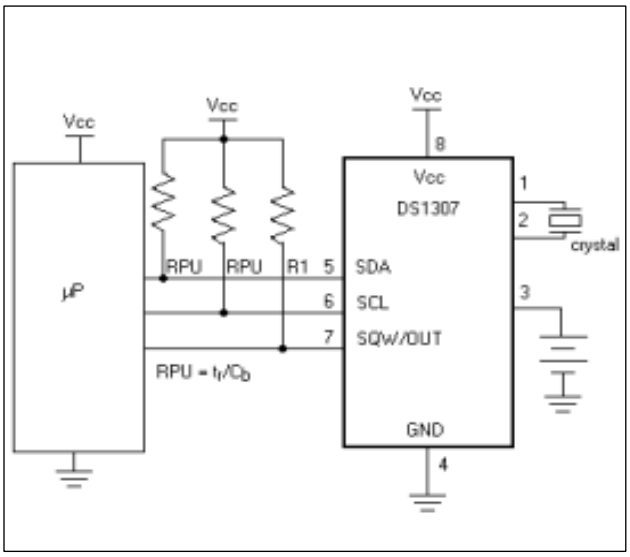

Fig 3: Schematic of RTC circuitry

B. Software Requirements

Arduino IDE is open-source software that is used to write code and upload it onto the board. Arduino IDE provides the provision to select the board and do programming according to the board. In this project, Arduino IDE was used to program ESP32 and interface ESP32 with HLW8032 and RTC. A few of the open-source libraries from ARDUINO IDE were used are:

i. Wi-Fi: Empowers network association utilizing the Wi-Fi Shield. With this library instantiate Servers, Clients and send/get hold of UDP packets via Wi-Fi. The shield can join both to open or encrypted networks (WEP, WPA). The IP address may be appointed statically or via DHCP. The library also can control DNS.

ii. WIFI Client: Makes a client that can associate with a predetermined web IP address and port as characterized in the client.

Along with the above libraries WebServer, WiFiHttpClient, Wire, RTClib, and HLW8032 were used. In the case of large users, the cloud will be used for storing a huge amount of data.

To store the obtained data from the sensor, a database was created using XAMPP. XAMPP is an open-source cross-stage web server arrangement bundle comprising essentially of the Apache HTTP Server, MariaDB database,
and interpreters. XAMPP provides a graphical interface for SQL (phpMyAdmin).
In XAMPP
X represents cross-platform (ideographic)
A represents Apache
M represents MariaDB
P represents PHP
P represents Perl
XAMPP server locally hosts our webpage on the internet.
The power consumption output from hardware is stored in the database. The stored data is retrieved by webpage using PHP. PHP is an abbreviation of Hypertext

Preprocessor. It is an interpreted language and is faster than other languages. PHP is a general-purpose scripting language that supports object-oriented programing for web development. It is used for developing web applications. PHP is basically used to connect webpage to sever.

Visual Studio Code editor is also known as VS code editor is used for developing the page that is for building and debugging web applications. It is used to write code for HTML, CSS, and PHP and execute it.

HTML and CSS are used for designing a webpage. HTML is a standard markup language for webpages. It is used for creating a skeleton webpage. It consists of a series of elements for displaying the content on the webpage. CSS is a markup language, which stands for Cascading Style Sheets, used for designing HTML tags. There are three kinds of CSS, Inline CSS, Internal/Embedded CSS, and External CSS. It is used to style the HTML elements. It is used for adding fonts, layouts, effects, background colors, and background images to the website.

phpMyAdmin is an open-source software tool which handles MYSQL administration over the web. It is a portable web application written in PHP, and is generally used for web hosting services. phpMyAdmin is a server tool to access the MYSQL database.

C. Communication Protocol

For transmitting data from sensor to ESP32 UART communication protocol is used. UART is abbreviation of Universal Asynchronous Receiver Transmitter Protocol. For serial communication UART is used. It can be applied to any receiver or transmitter, also synchronization of data signal is not a major concern as it is an asynchronous protocol. In short, using UART protocol does not need clock signal for serial data communication. Only two pins are required for communication that is TX and RX. TX of sensor is connected to RX of microcontroller. RX of sensor is connected to TX.

For sending the data from RTC to ESP32 I2C protocol is used. I2C is abbreviation of Inter-Integrated Circuit. It is point of interaction connection protocol for serial communication. It has two bi-directional open-drain lines for data communication, SDA and SCL. The exchange of data takes place through Serial Data (SDA) pin. The clock signal is carried through Serial Clock (SCL) pin. Transfer of each data bit on SDA line is synchronized by a high to low pulse of each clock on SCL line. It consists of two modes, master and slave mode. In this protocol the data is transmitted in the form of packets.

3. Circuit Diagram

HLW8032 energy meter module measures the power consumption. DS1307 RTC is used to get the current time accurately. RTC works on I2C communication protocol

and HLW8032 works on UART communication protocol.

a. Communication over I2C protocol takes place through 2 pins SDA and SCL. SDA is serial data line and SCL is serial clock
b. The VCC of RTC is connected to 3.3V of ESP32,
c. GND of RTC is connected to GND of ESP32,
d. SDA of RTC is connected to D21 of ESP32,
e. SCL of RTC is connected to D22 of ESP32.

Communication over UART protocol takes place through TX and Rx pins i.e.

transmission and reception. It is a full-duplex protocol.

a. Vin of HLW8032 is connected to VCC of ESP32 for powering up,
b. GND of HLW8032 is connected to GND of ESP32,
c. TX of HLW8032 is connected to RX2 of ESP32.

HLW8032 uses TX pin to send data to ESP32, it does not use RX for interfacing. We are using RX2 pin of ESP32 as RX0 is used for programming ESP32. And HLW8032 is powered using 3V3 pin as HLW8032 needs 3.3V power. Also, a jumper is placed at 5V and GND on HLW8032, do not remove it leave it as it is. HLW8032 has four input pins Load and Live you can connect it to load, the load that was used is 100W bulb. It was connected to AC power supply.

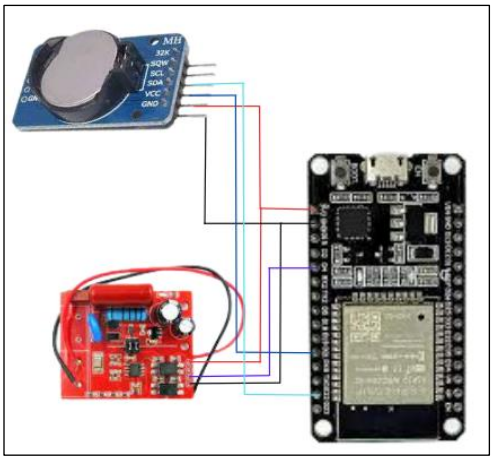

Fig 4: Circuit Diagram of Energy Monitoring System

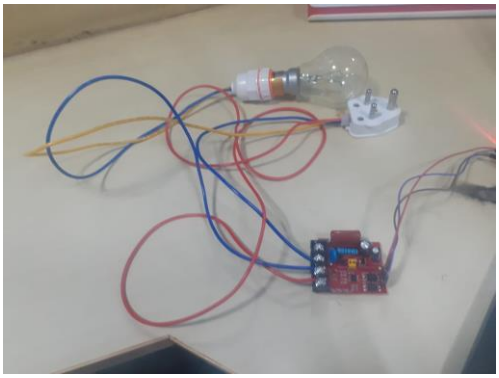

Fig 5: Energy Meter Circuit

4. Flow-Chart

The firmware programming is done in Arduino IDE. First install all the required libraries. Then, open new sketch and all the required libraries are included. Then the GPIOs of ESP32 are initialized. After initialization of GPIOs of ESP32, the name of Wi-Fi and its password will be mentioned. Through this Wi-Fi, the communication between the device and web page will take place. The device will check for voltage and current, if it is detected, apparent power, real power and power factor will be calculated. All the measured parameters will be displayed on web page (localhost).

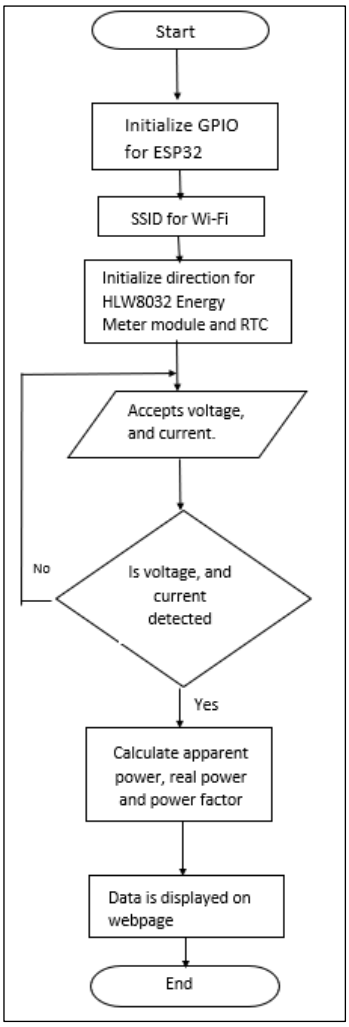

Fig 6: Flow chart of energy monitoring system

5. Advantages

A. Continuous Monitoring

Smart energy meters continuously monitor the energy consumption by the user any irregularity or any change in the pattern of consumption can be identified and concern actions can be taken.

B. Optimized Use of Power

The energy monitoring system will help users to know about the power consumption on regular basis, this will help the users understand their energy consumption pattern, and users can think on different ways to optimize it.

5.3 Accurate Billing

Since the data will be displayed on web page the errors caused

due to human and improper capturing of meter reading will be

reduced also the transparency between the customer and

electricity company will be increased.

6. Result and Discussion

The data is obtained from the sensor using Hercules Software, it is in HEX format, these series data bytes need to be converted into decimal format for a user to understand. For getting the data, few settings are required that is enable hex, set even parity bit, baud rate, data size, and handshake should be off.

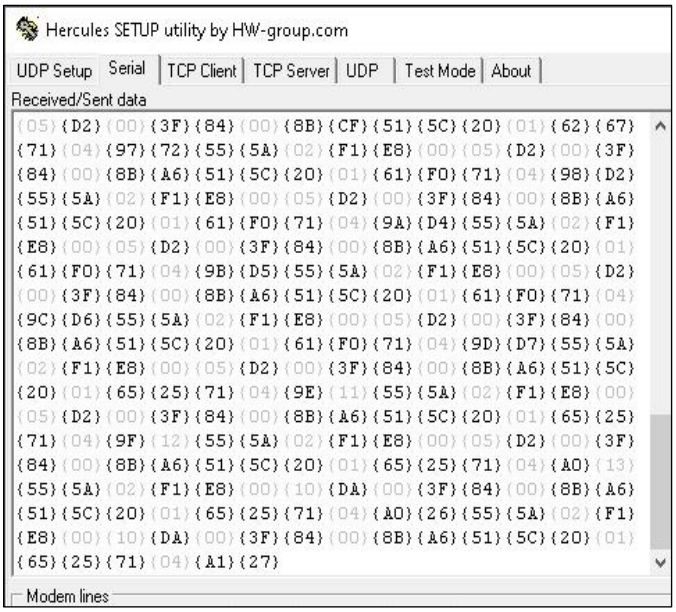

Fig 7: HEX data received

ESP32 is used for getting the data and converting it into a decimal format, the following output is displayed on Serial Monitor and Webpage.

Fig 8: Data on serial monitor

Verification of the received voltage was done by measuring the voltage at the input of sensor using a multimeter as shown in fig 7 and then comparing it with the data received on the webpage. The multimeter was first set for AC voltage and then the probes of multimeter were placed on the input terminals of the sensor. And it was noticed that values were much more precise and accurate.

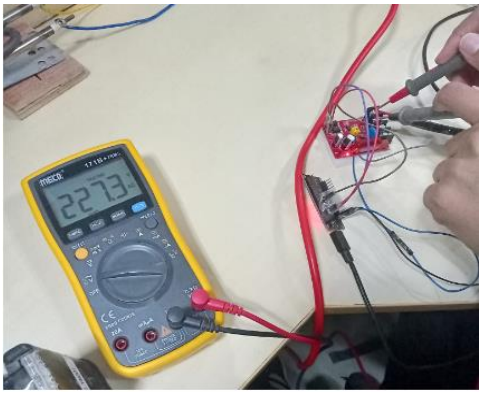

Fig 9: Voltage on multimeter

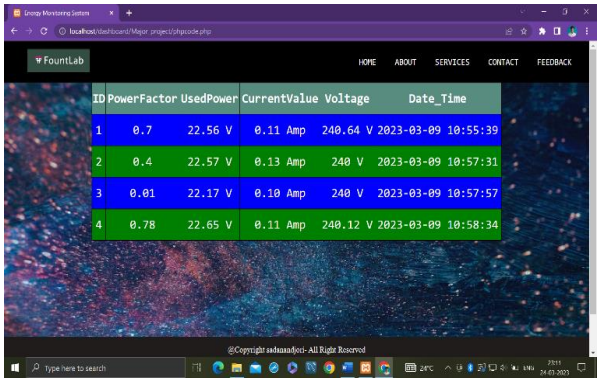

Fig 10: Output displayed on Webpage

7. Conclusion and Future Scope

The device calculates the consumed power and the measured data will display on the web page with time.

Energy monitoring system can be used for marine engineering and various under-water devices. By monitoring the energy usage for each device under-water, the scientists/ engineers can keep the track of devices that are not functioning efficiently or have been damaged. This will help in decreasing the wastage of power resources.

The system can be modified to notify the user for optimizing the use of power.

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