



Article Title: IoT-Enabled Monitoring and Controlling System for Solar Panel/AC Power Electronic Billings

IoT-Enabled Monitoring and Controlling System for Solar Panel/AC Power Electronic Billings

A. Vadivelu¹, T. Navya Lakshmi², V. Mohan Raj³, P. Gowri Sankari⁴,
P. Pavan Kumar⁵, M. Poorna Chandra⁶

¹Associate Professor, Department of Electronics and Communication Engineering, Sri Venkatesa Perumal College of Engineering and Technology, Puttur, AP, India

^{2,3,4,5,6} UG Students, Department of Electronics and Communication Engineering, Sri Venkatesa Perumal College of Engineering and Technology, Puttur, AP, India

ABSTRACT

This paper proposes an IoT-based solution for efficient monitoring and control of solar panel and AC power consumption, aiming to optimize energy usage and reduce utility bills. Leveraging IoT technology, the system collects real-time data on power generation from solar panels and consumption by AC units, enabling users to gain insights into their energy usage patterns. Through remote access via mobile applications or web interfaces, users can monitor their power consumption, identify inefficiencies, and remotely control their devices. The system also supports automation features such as scheduling to optimize energy usage based on time-of-day pricing or user preferences. By integrating solar panels into the monitoring and control system, users can effectively utilize renewable energy and further reduce their dependency on traditional grid power. Overall, this IoT-based solution empowers users to make informed decisions regarding their energy consumption, contributing to cost savings and environmental sustainability.

Keywords: IoT, Solar Panel, AC Power, Energy Monitoring, Remote Control, Energy Conservation, Electricity Bill.

1. Introduction

In the present billing system, the distribution companies are unable to keep track of the changing maximum demand of consumers. The consumer is facing problems like receiving due bills for bills that have already been paid as well as poor reliability of electricity supply and quality even if bills are paid regularly. The remedy for all these problems is to keep track of the consumers load on a timely basis, which will help to assure accurate billing, track maximum demand and to detect threshold value. These are all the features to be taken into account for designing an efficient energy billing system.

India became the third largest producer of electricity in the world with 4.8% of the global share. Out of the total power generated renewable constituted 28.43% and Non-Renewable constituted 71.57%. However, due to the insufficient amount of fossil Indian is incurring huge



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losses. More than 300 million people have no access to electricity. As energy saved is energy generated hence one of the proposed measures. To save electricity is to provide the customers with a means to manage their electrical energy consumption.

The present project “IoT Based Smart Energy Meter” addresses the problems faced by both the consumers and the distribution companies. The paper mainly deals with smart energy meter, which utilizes the features of embedded systems i.e. combination of hardware and software in order to implement desired functionality. Also with the help of a Wi-Fi modem, the consumer can monitor his consumed reading and can set the threshold value through the webpage.

This system enables the electricity department to read the meter readings monthly without a person visiting each house. This can be achieved by the use of an Arduino unit that continuously monitors and records the energy meter reading in its permanent (non-volatile) memory location. This system continuously records the reading and the live meter reading can be displayed on the webpage to the consumer on request. This system also can be used to disconnect the power supply of the house when needed.

2. Objective

The main object of the project is to develop a smart energy meter, which not only measures the consumer’s power consumption in kWh but also enables and supports real consumption in rupees according to consumer tariffs. The proposed system has the provision of sending SMS alerts to the user at the end of every billing cycle. To make it an anti-theft and tamper-proof product without human intervention. The data acquired during monitoring will help us to take the necessary steps to save energy.

3. Existing System

The present system only provides feedback to the customer at the end of the month. Also, the meter readings are taken manually. Consumers can know the units consumed by seeing their electricity bill only. Also, huge manpower is required to take the readings. There is no protection for energy meter tampering. The consumers cannot monitor their everyday energy consumption or usage. The major drawback of this system is the management of power consumption is difficult.



3.1 Existing Block Diagram

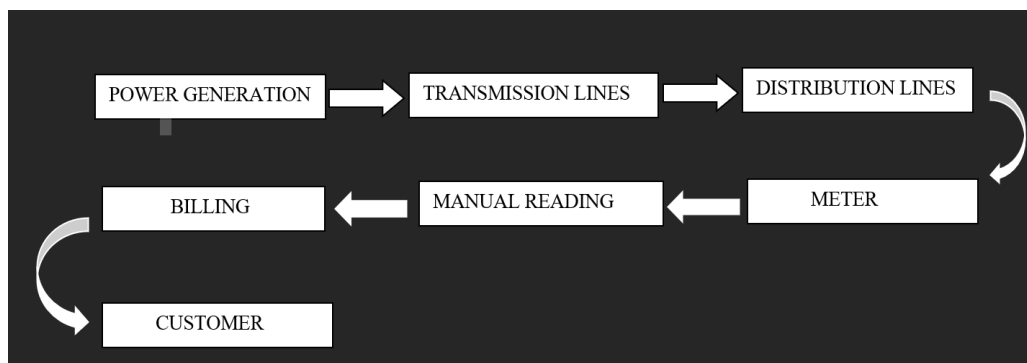


Figure 1: *Block-Diagram for Existing System*

Power Generation: Here, electricity is produced at power plants.

Transmission Lines: High voltage lines carry electricity over long distances.

Distribution Lines: These lines step down the voltage and distribute it to neighbourhoods.

Meter: This device measures the electricity used by a customer over a billing period.

Manual Reading & Billing: A meter reader physically visits the location to collect the meter reading, which is then used to calculate the bill.

Customer: The customer receives the bill at the end of the month and has no real-time information about their consumption.

4. Proposed System

The energy meter used here is a clamp energy meter. 230V AC mains is the input given to the transformer and AC mains are converted to low voltage. The energy meter measures the live current, voltage and power in terms of KW-h. The microcontroller reads these parameters and sends them to the cloud.

Node MCU is a Wi-Fi device that has a microcontroller in it. This connects the local router through IoT. The status of these parameters can be obtained through mobile or laptop. WIFI is used for data communication. WIFI is configured with Arduino.

The Data from the Energy meter is sent to Arduino and to the WIFI module and it reaches the user's mobile phone. In this system, the user can switch on/off the mains or home appliances from their Android smartphone app.

The WIFI module transmits and receives the data from the cloud and sends it to Arduino and the Arduino controls the relay to switch on and off the circuit of the home.



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4.1 Block Diagram

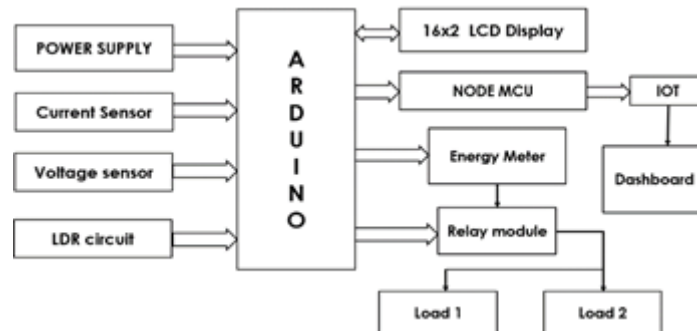


Figure 2: Block – Diagram for proposal system

5. System Description

The e-bill monitoring and controlling system is a comprehensive platform designed to facilitate the efficient handling of electronic bills for both individuals and organizations. The proposed system consists of various blocks for different methodologies that is discussed below.

5.1 ARDUINO UNO

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet).

It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16MHz, a USB connection, a power jack.



Figure 3: Arduino Uno

5.2 NODE MCU

Node MCU is a popular open-source development board based on the ESP8266 WiFi module. It integrates the ESP8266 chip with a USB interface and allows for easy programming using the Lua scripting language or the Arduino IDE. Node MCU is widely used for IoT projects due to its low cost, built-in WiFi capabilities, and compatibility with various sensors and actuators. It offers a convenient platform for prototyping and deploying IoT solutions, enabling connectivity to the internet for data exchange and remote control. With its compact size and versatile features,



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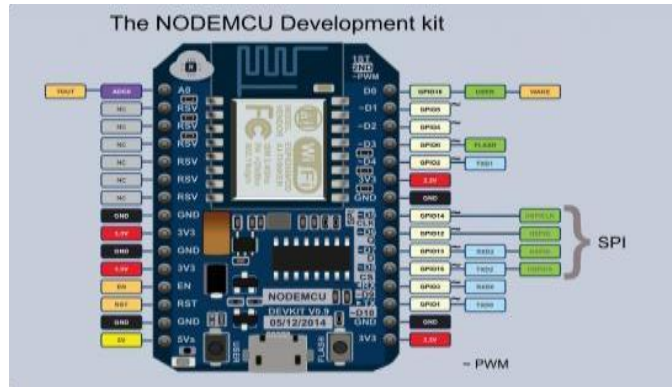


Fig 04: Node MCU

5.3 Light Dependent Resistor

An LDR, or Light Dependent Resistor, is a passive electronic component that varies its resistance based on the intensity of light it is exposed to. In low-light conditions, the resistance of an LDR increases, while in high-light conditions, it decreases. This property makes LDRs useful for applications such as automatic lighting control, dusk-to-dawn switches, and light intensity measurement.

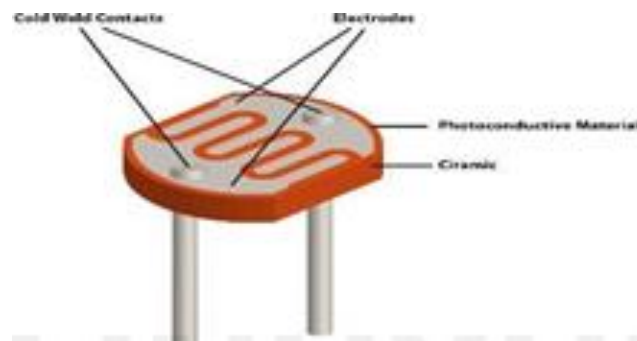


Figure 5: Light Dependent Resistor

5.4 LCD Display (16*2)

LCD is an abbreviation for liquid crystal display. It is one type of electronic display module that is utilized in many different circuits and gadgets, such as TV sets, computers, calculators, mobile phones, and so on. Seven segments and multi-segment light-emitting diodes are the major applications for these displays. The primary advantages of utilizing this module are its low cost, ease of programming, animations, and unrestricted character, special, and animation display options.



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Figure 6: LCD Display (16*2)

5.5 Relay Module

A relay module is an electrical switch that is controlled by an external signal. It consists of an electromagnet that, when energized, mechanically closes or opens one or more switch contacts. Relay modules are commonly used in electronic circuits to control high-power devices or circuits with low-power signals, such as those from microcontrollers or sensors. They provide electrical isolation between the control circuit and the load circuit, ensuring safety and preventing damage to sensitive components. Relay modules come in various configurations, including single-pole single-throw (SPST), single-pole double-throw (SPDT), and double-pole double-throw (DPDT), to accommodate different switching requirements.



Figure 7: Relay module

5.6 Voltage Sensor

Voltage sensor is a type of sensor that measures electrical voltage levels in a circuit. It detects the potential difference between two points in an electrical system and converts it into a proportional analogue or digital output signal. Voltage sensors are essential components in various applications, including power distribution systems, battery monitoring systems, and electronic devices. They come in different forms, such as resistive voltage dividers, capacitive voltage dividers, and integrated circuit voltage sensors. Voltage sensors play a crucial role in ensuring the safety and efficiency of electrical systems by providing accurate voltage measurements and facilitating control and monitoring processes.



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Figure 8: *Voltage sensor*

5.7 Energy Meter

An energy meter, also known as an electricity meter or watt-hour meter, is a device used to measure the amount of electrical energy consumed by a residence, business, or industrial facility. It typically measures energy consumption in kilowatt-hours (kWh) and is installed by utility companies to bill customers accurately for their electricity usage. Energy meters work by monitoring the flow of electrical current through a circuit over a specific period and multiplying it by the voltage to calculate energy consumption. Modern energy meters often feature digital displays for easy reading and may include additional functionalities such as remote monitoring and data logging. Energy meters are crucial for promoting energy efficiency and enabling effective energy management practices by providing users with insights into their electricity usage patterns.



Figure 9: *Energy Meter*

6. Software Implementation

6.1 Software Requirements

Arduino 1.0.6 software tools are used to program microcontrollers. The working of the software tool is explained below in detail.

6.2 Programming Microcontroller

A compiler for an abnormal state dialect decreases generation time. To program the Arduino UNO microcontroller the Arduino is utilized. The writing of computer programs is done entirely in the installed C dialect. Arduino is a suite of executable, open-source programming advancement devices for the microcontrollers facilitated on the Windows stage.

Arduino is a device for appears well and good and controls a greater amount of the physical



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world than your desktop PC. It's an open-source physical registering stage given a straightforward microcontroller board and an improvement domain for composing programming for the board.

One of the challenges of programming microcontrollers is the restricted measure of assets the developer needs to manage. In PC assets, for example, RAM and preparing speed are essentially boundless when contrasted with microcontrollers. Conversely, the code on microcontrollers ought to be as low on assets as could reasonably be expected **about Arduino Compiler**.

```

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#include <LiquidCrystal.h>
#include <SoftwareSerial.h>
#include <EEPROM.h>

LiquidCrystal lcd(4,5,6,7,8,9);
SoftwareSerial mySerial(3, 12); // RX, TX
int light1=10;
int light2=11;
int signal=2;
unsigned char payment=1,units=0, pulsecount=0,s;
int teapdelay,incoming;
//int pin = 2;
//int pin_irq = 0; //IRQ that matches to pin 2
unsigned int delaycount=0,l=0;
char usermobilenm[14]="+918800153809";
void clear_buffer(void);
void treading(void);
unsigned char teappulse=0xff;

void setup()
{
  // Open serial communications and wait for port to open:
  Serial.begin(57600);
  while (!Serial) {
    ; // wait for serial port to connect. Needed for Leonardo only
  }
  delay(10);
}

```

Figure 10: Code for System

7 Process And Execution

This system utilizes the Internet of Things (IoT) technology to provide real-time monitoring and control of your home's energy consumption, including both solar power generation and AC power usage. Here's a breakdown of the process and execution:

Data Collection

- Smart meter and solar monitoring unit continuously collect data on AC power usage and solar power generation.
- CTs and voltage sensors provide real-time information on current and voltage levels.

Data Transmission

- The IoT Gateway gathers data from all sensors and transmits it securely to the cloud platform through a wireless connection (e.g., Wi-Fi, cellular).



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Data Processing & Storage

- The cloud platform receives stores, and processes the collected data.
- It calculates various metrics like total energy consumption, solar energy generated, grid dependence and cost savings.

Visualization & Analysis

- The mobile app or web interface displays real-time and historical data in a user-friendly format.
- Users can see trends, identify peak usage periods, and compare solar generation against consumption.

Control (Optional)

- With some systems, users can remotely control specific appliances (e.g., smart plugs) through the mobile app based on real-time energy data.
- This allows for optimizing energy use and minimizing reliance on grid power

7.2 Execution

System Installation: Install the smart meter, solar monitoring, unit, CTs, and voltage sensors

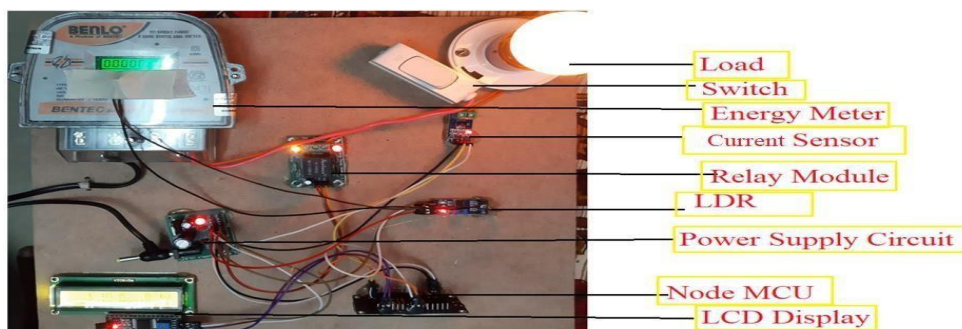


Figure 11: *Smart meter with solar monitoring unit*

8 Result and Analysis

The IoT-based solar panel/AC power bill monitoring and controlling system offers a comprehensive solution for optimizing energy usage and reducing electricity bills. By integrating sensors on solar panels and AC appliances, the system captures real-time data on energy generation and consumption.

This data is analyzed to make informed decisions on energy usage, such as adjusting appliance

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settings for maximum efficiency. With a user-friendly interface and cloud-based platform, users can monitor their energy consumption, access historical data, and implement energy-saving measures remotely.

Overall, this system represents a significant advancement in promoting sustainability and reducing costs through intelligent energy management.

DATE	AMOUNT_VALUE	UNITS_VALUE
05/29/2022 23:35	4.00	1.00
05/29/2022 23:30	4.00	1.00
05/29/2022 23:12	12.00	3.00
05/29/2022 22:41	116.00	29.00
05/29/2022 22:36	116.00	29.00
05/29/2022 22:31	120.00	30.00
05/29/2022 22:26	112.00	28.00

Figure 12: Data for Power Consumptions



Figure 13: Mail Notification from NodeMCU

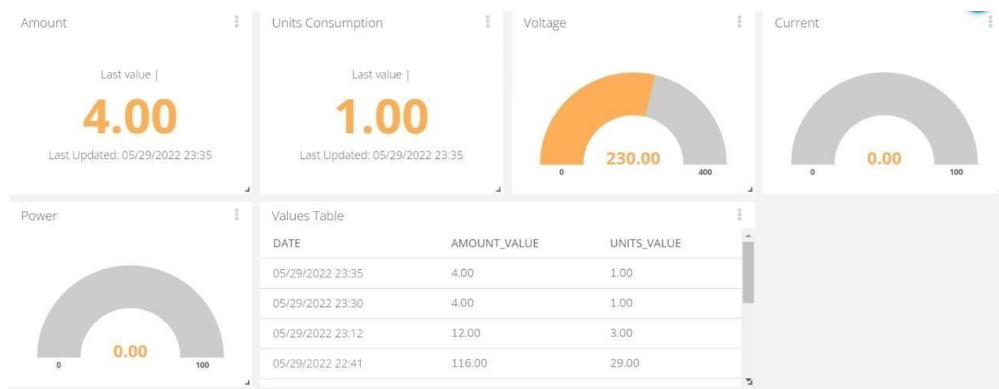


Figure 14: Web interface display through mobile/System

9. Conclusion

In conclusion, the IoT-based solar panel/AC power bill monitoring and controlling system presents a promising avenue for achieving greater efficiency and cost savings in energy



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management. By harnessing the power of IoT technology, this system enables real-time monitoring and intelligent control of energy usage, leveraging data insights to optimize performance. Its user-friendly interface and cloud-based platform empower users to make informed decisions about their energy consumption and take proactive steps towards sustainability. Furthermore, the integration of sensors on solar panels and AC appliances enhances accuracy and reliability in monitoring energy generation and consumption. As a result, this innovative solution not only helps reduce electricity bills but also contributes to a greener and more sustainable future by promoting efficient energy utilization.

Future Scope

The performance of the system can be further enhanced by connecting all the household appliances to the IoT. Online bill payment can also be implemented to make the system more user-friendly. We can further incorporate a system where the user will receive warning messages when he/she crosses the threshold of the electricity usage slab. In future, the proposed system can be extended to be used as prepaid energy meters. These meters can be recharged according to the user's need thus saving any additional cost in the billing.

The future scope will be on the PC side one server software is required for automatic data collection.

In this project, HTML knowledge is taken for demonstration purposes.

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