Real-Time Power Monitoring (Cloud) and Control (Two-way, Manual and web application) using IoT

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Abstract.

Presently most equipment and machinery in the digital era run on electricity, where energy is a need for modern living with its demand expanding day by day. Electricity has a critical part in all lives and our civilization cannot run without it. Food, cooling, heating, payment transactions, the stock market and the internet runs on electricity only. The power firms generate energy based on historical data on power usage, thus making energy monitoring very crucial. Power is always generated with reserve capacity by the power producing firms. Electricity demand fluctuates based on the time of day and season. Most significantly, storing large amounts of power is an impractical approach and the current solution is ineffective. This research proposes an energy monitoring and two-way (manual and Smart IoT) control system to reduce power wastage. The power supply partial diagnosis system is a novel technique (Optocoupler isolation module) utilized here; without any indication like light or camera, the web user may see the main and utility power supply status, as well as the utility status using the current sensor.

1. INTRODUCTION

Internet of Things (IoT) provides a facility to other technologies and small devices that connect each other and exchange data over internet or other communication networks. In this paper energy tracking and two-way controlling is discussed with the help of IoT concept real-time power monitoring and controlling is achieved. If end user has an internet and browser facility, then he can deploy this service anywhere, as it is hosted in cloud-based web host. The deployed system gives a real-time data to user controlling feature. User also has a lot to know if the power supply is available in supply lines. This proposed system enables simple design and implementation with minimum cost.

Current energy-demanding challenges such as inefficient energy management, squandered power assets and excessive power fees must be addressed in order to fulfil the growing demand for clean, cheap, and sustainable electricity. Currently, energy generation is totally dependent on the near-real-time power demands of electric loads. In this case, keeping reserve strength resources operational all the time to create and provide extra power to meet erratic surges in energy needs is a wasteful and unsustainable strategy. Electric power intake prediction skills are necessary to limit the quantity of energy squandered by having backup sources operational at all times. The electrical strength intake can be forecasted for the near future using prediction skills, allowing the specified amount of energy to be generated.

The production of electricity is responsible for 42.5% of global CO_2 emissions.

Coal-fired power plants are responsible for 73% of this, generating 950 grams of CO_2 every kilowatt-hour of energy generated vs 350 grams for fuel-fired power plants. Even after accounting for the eventual requirement to decommission ageing facilities, CO_2 emissions from nuclear power stations are only 6 grams. In comparison, coal-fired power plants release 950 grams every kilowatt-hour of electricity generated.

In this project, the IoT device acquires load in ampere current utility from the ACS712 sensor. Knowing the minimal ampere, the load consumed, the status of the utility will be known. The current practice to know the load in ON/OFF or power is available in main line to a person needed to operate the switch ON/OFF in same location. Due to advancement in technology, web interface is developed to know or check whether the power is available in the main line using optocoupler module and load is switched ON/OFF using ACS712 Sensor, and also control utility power ON/OFF using double pole optocoupler Relay.

2. RELATED WORK

In later days guided efforts are needed, for monitoring and controlling the energy utility load. Now the modern-day advanced technology enables to lessen manual efforts. For example, to switch on/off utility load, some person is needed to manually monitor the application in identical region. Somehow controlling and monitoring is done on huge appliances in industries with smart sensor and controllers. Industrial sensor and controller are of greater cost and it additionally needs non-stop maintenance. Most of energy wastage occurs in small domestic appliances and small-scale industries. Some researchers and developers provided solution using concept of IoT, actual viewing real-time and varying parameters of electricity on their consumer interface.

Based on IoT, energy monitoring and utility energy consumption discussed in this paper focuses on simplest optocoupler relay and current sensor, which is low-cost, as well as a cloud-hosted database to track energy usage. It can indicate the voltage levels at which various electric gadgets and appliances work. It includes an IoT cloud interface that works with any tool that has an internet or browser capability. Also, it can be used in both domestic and industrial settings.

The created model shows real-time energy consumption by load, and a real-time load log is kept in a cloud hosted web interface. It also offers the capacity to track daily predicted consumption to a cloud hosted database and send load relay-switch on/off instructions to the control unit via an integrated IoT cloud interface.

3. PROPOSED WORK AND IMPLEMENTATION DESGIN

3.1. Block diagram

In this block diagram, we can see the architecture of the suggested paradigm.

The ARDUINO R3, cloud-hosted database, optocoupler relay module, utility load, IoT interface, two-way manual switch, ESP8266 Wi-Fi Shield, ACS712 current sensor and optocoupler relay switch module are the components.

The following is the role of components in this device.

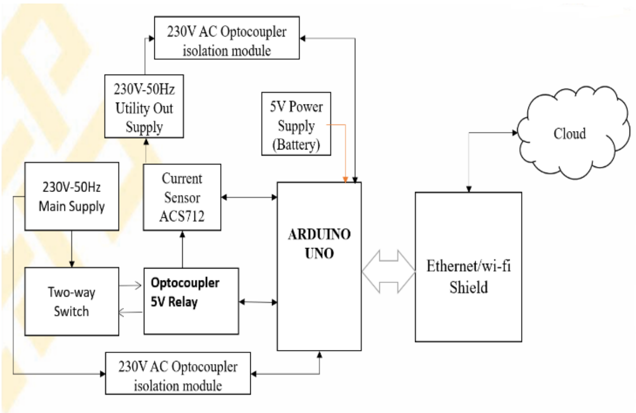

Fig. 1. Block diagram of Real-Time power monitoring with two-way control

Arduino UNO R3 is main control circuit board, which runs on 5V power supply and a small sized battery power bank is used. 230V AC Optocoupler isolation module is used to check the presence of power supply in main line and utility line. ESP8266 Wi-Fi Shield is used to establish wireless communication between Arduino UNO R3 and internet which connects through Wi-Fi AP with ISP connection.

In industrial, commercial, and communications applications, the ACS712 sensor provides solutions for AC or DC current detection. It is used for sensing AC current here. Optocoupler relay and two-way switch used to change a power state in utility supply line.

1) Arduino UNO R3: It is an IoT developed open-source board, with ESP8266 Wi-Fi Shield piggybacked for wireless internet access. It fetches an analogue signal from ACS712 sensor and receives a digital input from 220V AC optocoupler isolation module. It controls relay on/off, performs calculations and finds the utility average consuming ampere per second. It sends data to cloud hosted database for further analysis.

2) Database and web hosting in the cloud: The hosted database and web pages, provide a high-speed connection and high availability. Due to high availability user can get access to this service any time and from anywhere. It is used to store a utility log details in each and every action and it gives the user interface to access stored utility log data and control the utility.

3) Optocoupler Relay Module: This module, also known as an interface board, is made up of 4 sets of binary actuators. It serves as a 5V electrically operated switch known as a relay. Each relay in this module is used to address one load that runs on AC supply with a maximum voltage of 240 volts. It uses the Arduino board to carry out switching commands on loads received over the internet.

4) 230V AC optocoupler isolation module: It is used to find a 230V AC supply existence in power supply lines.

3.2. Hardware Design

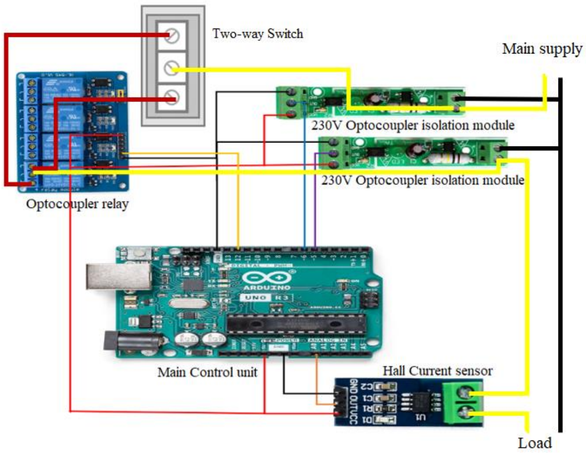

Fig. 2. Hardware design

In Arduino UNO R3 we have 14 Digital I/O pins, and 6 Analog input pins. Digital Pin 12 is used to control Optocoupler relay, and Digital Pin 5 and 6 gets status of power in utility and main line. Analog input pin A0 is used to acquire a value from AC712 sensor.

ACS712 Current sensor

The ACS712 provides cost-effective and precise AC or DC current sensing solutions for industrial, commercial, and communications applications.

For the client, the gadget bundle will be straightforward to use.

Common applications include motor control, load monitoring and management, switched-mode power supply and excess current fault avoidance.

The gadget is made up of a linear Hall sensor circuit and an accurate and low-offset copper conduction channel near the die's surface.

The magnetic field formed by the applied current flowing via this copper conduction line is used by the integrated Hall IC to calculate a proportional voltage. The magnetic signal is kept close to the Hall transducer, which improves the accuracy of the device. The precision-configured chopper-stabilized BiCMOS Hall IC has a low offset.

3.3. Working Principle

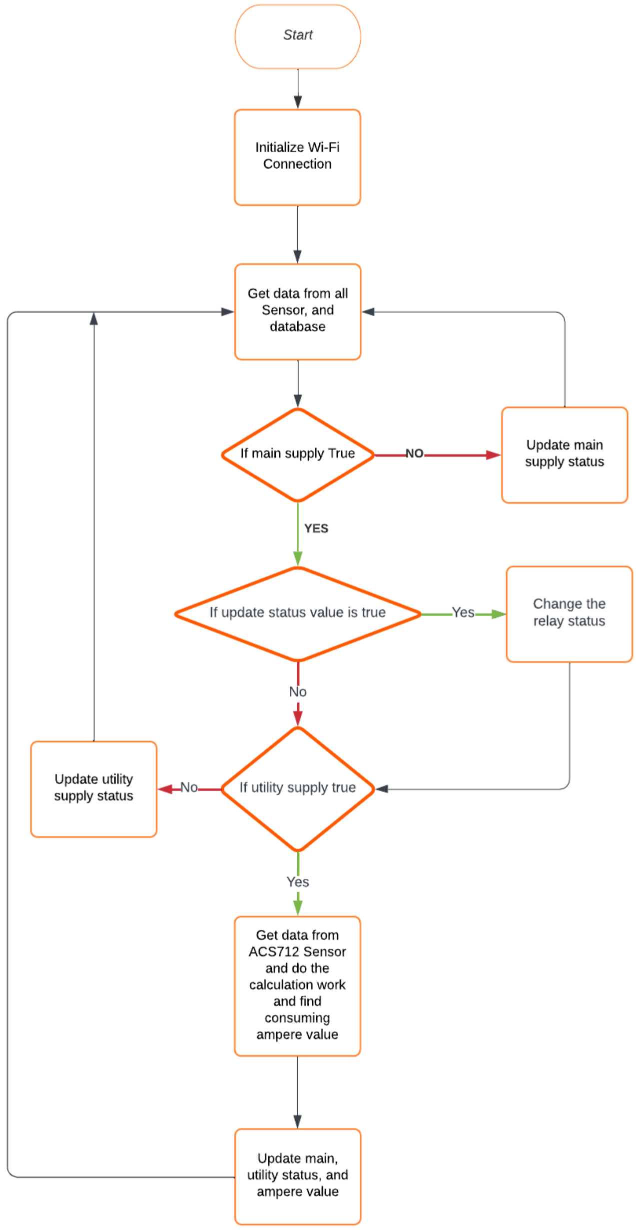

Fig. 3. Flow chart (main control unit)

If the Wi-Fi connection is successful, the Arduino gets data from all of the sensors, checks the main supply status, then the utility line status and only if the utility status value is true,

it fetches an ACS712 sensor output signal to perform the necessary calculations in determining the utility average consuming current value in ampere.
It also gets data from the database and checks the utility supply line status. It changes the relay state to normally open or normally close, if it contains update instructions for the relay.
The calculated value and sensor values are stored in database for monitoring this program procedure in a continuous loop. The stored utility log data will be used for feature report analysis, and it helps user to know energy usage.

The database procedure for utility consumed power in unit (watt) is described in steps. First it will check completed meter record, data start and end time. Then it will calculate duration of utility used and its amperage. Using available data the need to find an ampere used in a minute is arrived at.

Convert Amp hour to Watt hour (Ah to Wh)

Here's the equation: Formula is (Ah)*(V) = (Wh)

3.4. System Implementation

ESP8266 Wi-Fi shield is piggybacked with Arduino base board. With the connecting wire, relay module is connected to two-way switch and relay 5V VCC and GND connected to Arduino base board. 220V Optocoupler isolation module is connected to main supply line, another one is connected to utility supply line and 5V VCC and GND connected from Arduino. ACS712 current sensor is connected in serial to utility power line, 5V VCC and GND is connected from Arduino. Output of ACS712 sensor is connected to A0 analogue pin in Arduino board. For testing 60W bulb is connected to utility output power line.

Fig. 4. System prototype

3.5. Communication Flow

Control Unit:

Here Arduino UNO R3 works as a main control unit, with ESP8266 Wi-Fi shield enabling an Arduino board to connect to the internet using the IEEE 802.11 wireless standard (Wi-Fi). So ESP8266 is attached with the Arduino UNO R3 main Circuit Board. This ESP8266 Wi-Fi Shield establishes an internet connection between Cloud host through Wi-Fi AP. The control unit has sensors and relays to make communication between utility and Control Unit.

Cloud Host:

Cloud host contains Database host and Web host. Database host stores data which is received from Control unit and client program. Web host is an interface and communication bridge between control unit and user interface. Web host have a collection program code to make a communication with control unit and it stores data.

Client Device:

Client Device could be any device with internet and browser facility, like Personal Computer, Tablet and Smart Mobile. Client device retrieves a web page from web hosted in cloud for user and makes a communication through ISP to Cloud host.

4. RESULT AND REPORT

Fig. 5. Web user interface

This web page allows the user to operate the utility and displays the status of the main, utility power supplies and control unit, as well as the utility consumption current in amps.

Fig. 6. Clamp meter

Test case was also tested with a clamp meter. Clamp meter result and control unit test case result were same in web page shown.

This report page gives a flexible search date wise. User need to enter start and end date to get duration report. It shows utility start datetime, end datetime, duration, utility used power in watts and total power consumed between users given duration.

START DATE: 08 / 04 / 2022 END DATE: 25 / 04 / 2022 Search

SEARCH RESULT OF GIVEN DATE 2022-04-08 between 2022-04-25

Connected successfully

On Date	OFF Date	Used in Minute	Power Used in Watt
2022-04-09 09:27:39	2022-04-09 09:28:44	1	0.32
2022-04-12 14:54:40	2022-04-12 14:57:02	2	0.72
2022-04-21 21:02:14	2022-04-21 21:04:13	1	0.28
2022-04-21 21:07:41	2022-04-21 21:33:56	26	9.36
2022-04-21 21:57:15	2022-04-21 21:59:02	1	0
2022-04-21 22:01:06	2022-04-21 22:03:50	2	0
2022-04-21 22:05:57	2022-04-21 22:07:52	1	0
2022-04-21 22:24:37	2022-04-21 22:27:05	2	2.08
2022-04-21 22:30:07	2022-04-21 22:31:49	1	1.04
2022-04-21 22:36:58	2022-04-21 22:45:02	8	8.32
2022-04-23 23:11:55	2022-04-23 23:15:58	4	4.32
		Total Consumed Approximately* in Watt	26.440000385046005

Fig. 7. Report page

5. CONCLUSION

This article discusses the use of IoT devices for energy, utility monitoring, and control. The consumer can monitor the power consumption 24/7 in 365 days and also control the power utilization either locally or over the internet, thereby reducing the wastage of power, thus cutting down the electricity bill. The continuous power monitoring log provides a customized day-wise statistic report on utility performance.

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