ATmega328P & NodeMCU-ESP8266 Based Real-Time Power Monitoring Device

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Abstract: ***In our daily life we humans have upgraded in such a way that we have became slaves of electricity. Electricity is one of the fundamental necessities of human beings, which is commonly used for domestic, industrial and agricultural purposes. Without the use of electricity we will become immobile. Keeping that in mind we are making this project on a measuring device which will measure all the possible electric parameters of any appliance and send the particular data on a cloud through a Wi-Fi Module which eventually makes it an IOT based system. Through this system we are able get a visual representation of the data which makes it easier to detect any kind of problem in the appliance. We are using PZEM-004T as our main measuring unit of our system and NodeMCU-ESP8266 as our IOT unit of our system.***

Keywords: Wi-Fi Module, IOT, PZEM-004T, NodeMCU-ESP8266

1. Introduction

In our domestic life the meter we used was single phase induction type energy meter[7]. It had an analog dial to calculate the unit but it had a huge drawback of mechanical hacking using a magnet on the back of the meter dial. In order to overcome this drawback the provider companies came up with digital meters where it was impossible to hack by the consumers. But the thing is that the meters provided by the providers cannot measure the parameters other than unit. So we have come up with a system which can give all the possible parameters of an electrical system including the power factor and unit. Our system can measure voltage, current, power, energy, power factor and unit. One can always use a voltmeter to calculate voltage, ammeter to calculate current and watt meter to calculate power but one can never measure all of these parameters with a single device. With our compact system one can do all the above calculations with ease. Our system can measure the parameters of a single appliance at a time which is not possible for a domestic purpose digital meter which can only provide the calculations for all the appliances working together.

In the conventional unit measurement systems the readings that are shown is on the screen of the device but in our measuring system we have tried to upload all the parameters to a cloud using a Wi-Fi module[1]. Basically we have used ThingSpeak website as our main upload platform where all the values represented in a graph[16]. In our domestic life the meter we used was single phase induction type energy meter. It had an analog dial to calculate the unit but it had a huge drawback of mechanical hacking using a magnet on the back of the meter dial. In order to overcome this drawback the provider companies came up with digital meters where it was impossible to hack by the consumers. But the thing is that the meters provided by the providers cannot measure the parameters other than unit[15]. So we have come up with a system which can give all the possible parameters of an electrical system including the power factor and unit. Our system can measure voltage, current, power, energy, power factor and unit. One can always use a voltmeter to calculate voltage, ammeter to calculate current and watt meter to calculate power but one can never measure all of these parameters with a single device. With our compact system one can do all the above calculations with ease. Our system can measure the parameters of a single appliance at a time which is not possible for a domestic purpose digital meter which can only provide the calculations for all the appliances working together.

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2. Hardware Required

2.1 PZEM-004T

In this project PZEM-004T is the main measuring unit.The main part of the PZEM-004T module is the SD3004 chip from the SDIC Microelectronics Co., Ltd. In addition, the board having the EEPROM from Atmel(now microchip) 24C02C which is a 2K bit Serial Electrically Erasable PROM with a voltage range of 4.5V to 5.5V with More than 1 Million Erase/Write Cycles and 200+ Years Data Retention. Two optocouplers PC817, providing galvanic isolation of the serial interface.

Working Voltage	80 ~ 260VAC
Supply Voltage	5VDC
Current	0 – 100 A

Rated Power	22kW
Operating Frequency	45-65Hz
Measurement Accuracy	1.0 grade

2.2 NodeMCU

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua-cjson and SPIFFS.

Power Input	4.5V ~ 9V (10VMAX), USB Powered
Current	70mA (200mA)
Transfer Rate	110-460800bps
Digital I/O	9 (D0-D8)
Analog I/O	1(A0)
Working Temperature	-40°C ~ +125°C
Drive Type	Dual high power H-bridge
Flash Size	4MByte
CPU	ESP8266(LX106)
Operating System	XTOS

2.3 Arduino UNO

Arduino is an open-source hardware and software company, project and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control both physically and digitally[12].

Arduino board designs use a variety of microprocessors and controllers. The boards are equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards or breadboards (*shields*) and other circuits.

Microcontroller	ATMEGA 328
Operating Voltage	5V DC
Input Voltage	7-12V(RECOMMND.)
Input Voltage	6-20V(LIMITS)
Digital I/O	14(6 PIN PWM)
Analog I/O	6
Current Per I/O Pin	40mA
Current For 3.3V Pin	50mA
Flash Memory	32KB
SRAM	2KB
EEPROM	1KB
Clock Speed	16MHz

2.4 Load

In our project we are using two kind of light sources one of which is a CFL Lamp and the other is an Incandescent Bulb in order to get different output values.

CFL (compact fluorescent lamp)

Incandescent lamp

3. Block Diagram

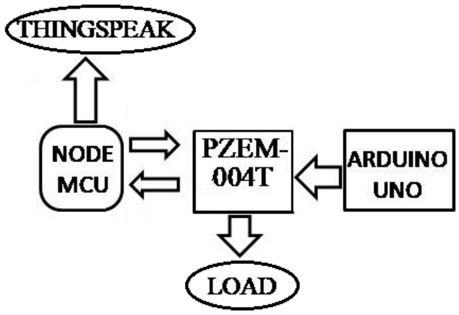

Figure 1: Block Diagram of the System

4. Website Required

We are using ThingSpeak Website as cloud. ThingSpeak is an IoT analytics platform service that allows you to aggregate, visualize and analyze live data streams in the cloud. ThingSpeak provides instant visualizations of data posted by your devices to ThingSpeak[3]. With the ability to execute MATLAB code in ThingSpeak you can perform online analysis and processing of the data as it comes in. ThingSpeak is often used for prototyping and proof of concept IoT systems that require analytics.

5. Methodology

First we are providing power to the Arduino Board using a power bank. We are also giving power to the NodeMCU from the same power bank through a different data cable. The PZEM module we are using is a very sophisticated module which does not work if the supply voltage is anything other than 5 Volt so we are using the Arduino board to provide a constant 5 Volt supply.

We are giving supply to the load which in our case is a light source from a normal 230 volt AC supply through a C. T. of the PZEM module.

When the system starts, the NodeMCU tries to connect to the mentioned Wi-Fi network. If it gets successfully connected to the Wi-Fi, it sends a request to the PZEM to provide it with the required data. The PZEM accepts the request and replies it with the data and in this way the communication is done.

After getting the values from the PZEM, the NodeMCU uploads the data in a platform which in our case is ThingSpeak website.

6. Working Flowchart

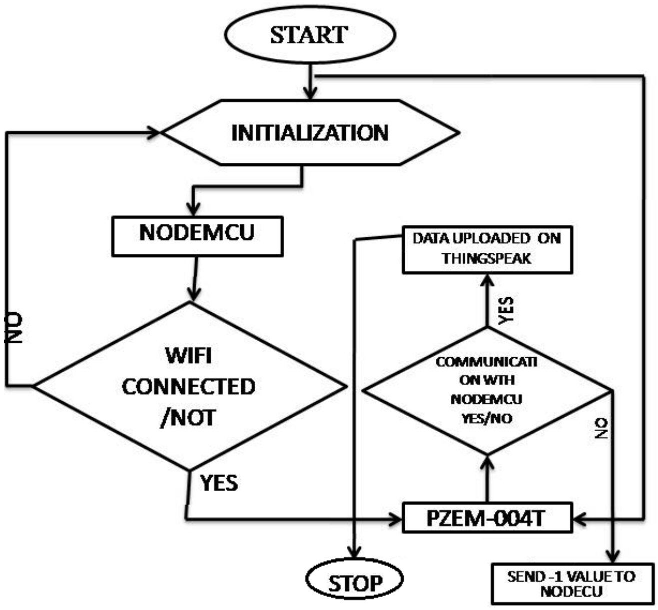

Figure 2: Flow Chart

7. Circuit Diagram

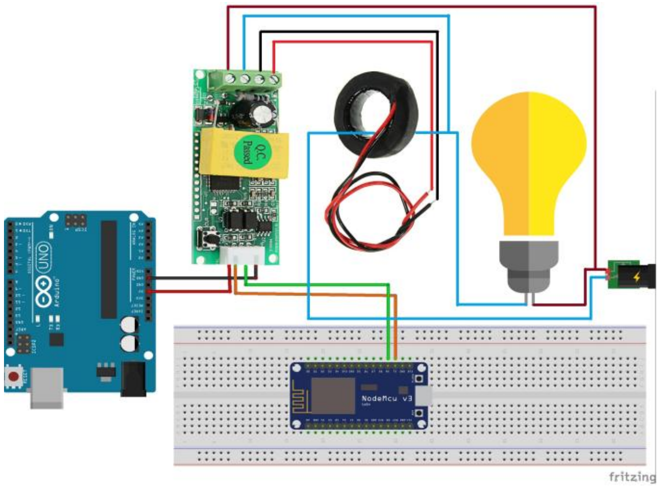

Figure 3: Circuit Diagram

8. Calculation

PZEM Module calculates the voltage, power and current on its own.

VOLTAGE = V
CURRENT = I
POWER = P
TIME = T [In Millisecond]
P = VICOSΦ
POWER FACTOR Calculation:
PF = POWER/(VOLTAGE*CURRENT)

$$PF = \frac{VICOS\Phi}{V\ I}$$

UNIT Calculation:
UNIT=POWER*TIME/(1000*3600000) KWHr

$$UNIT = \frac{PT}{1000 * 3600000}$$

9. Result

L1 (CFL) Observation Table:

Trial	Voltage (V)	Current (A)	Power (W)	Power Factor
1	236.4	0.06	14	0.98
2	233	0.07	16	0.98
3	232.8	0.07	15	0.92
4	240	0.07	15	0.89

L2 (Incandescent Lamp) Observation Table:

Trial	Voltage (V)	Current (A)	Power (W)	Power Factor
1	232.3	0.11	24	0.93
2	234.7	0.11	25	0.96
3	245.5	0.11	27	0.99
4	232.7	0.11	25	0.97

10. Graphs

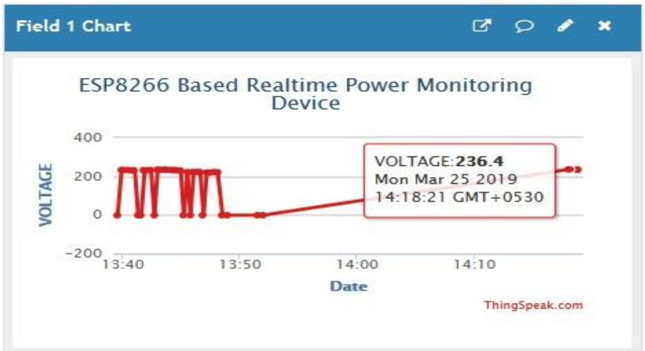

Figure 4.1: CFL Voltage

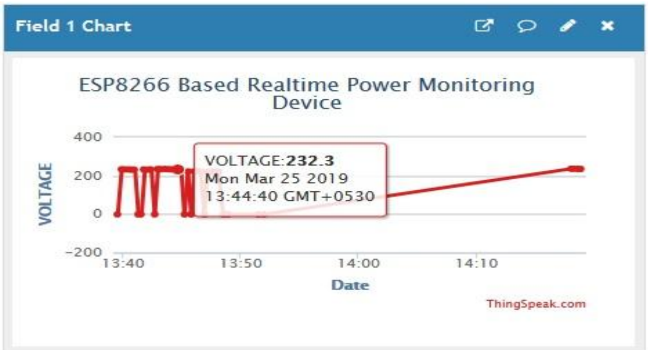

Figure 4.2: Incandescent Lamp Voltage

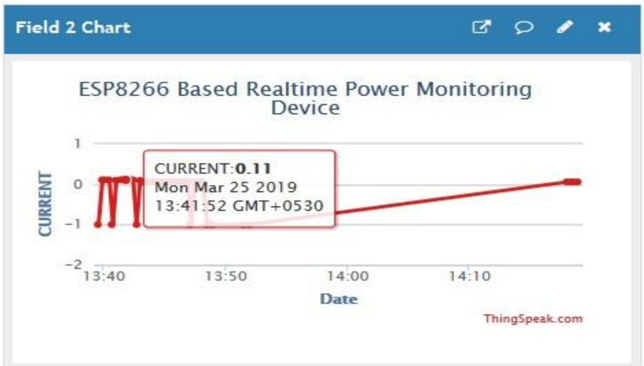

Figure 4.3: Incandescent Lamp Current

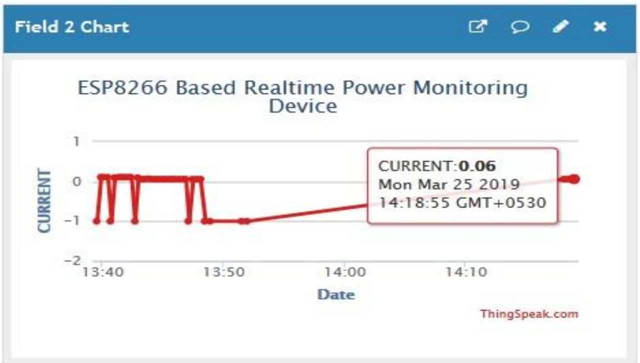

Figure 4.4: CFL Current

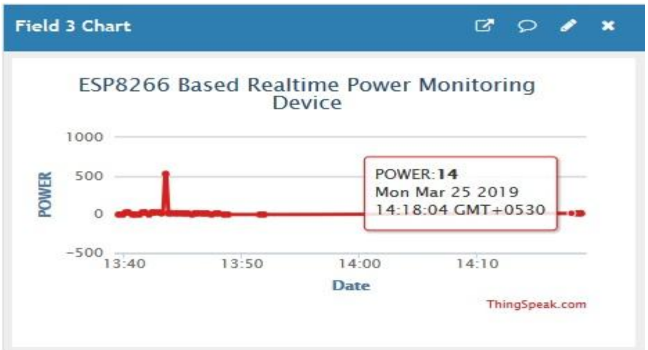

Figure 4.5: CFL Power

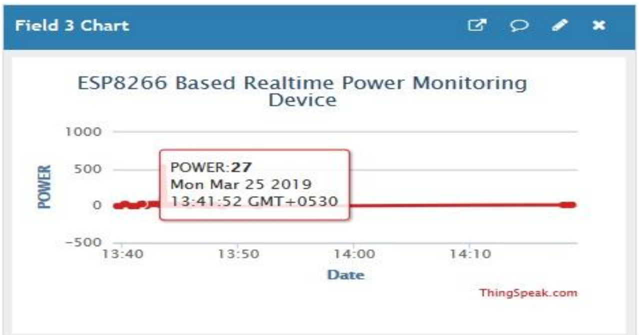

Figure 4.6: Incandescent Lamp Power

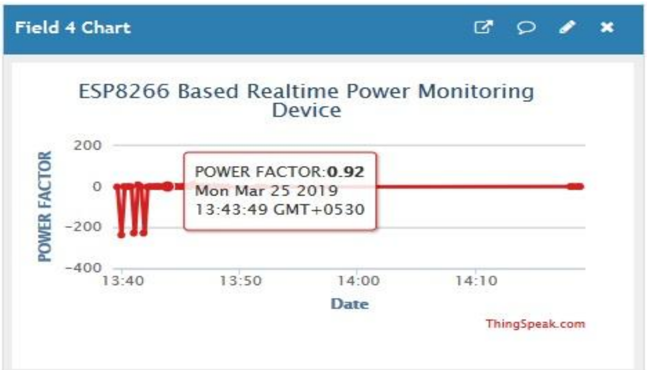

Figure 4.7: CFL Power Factor

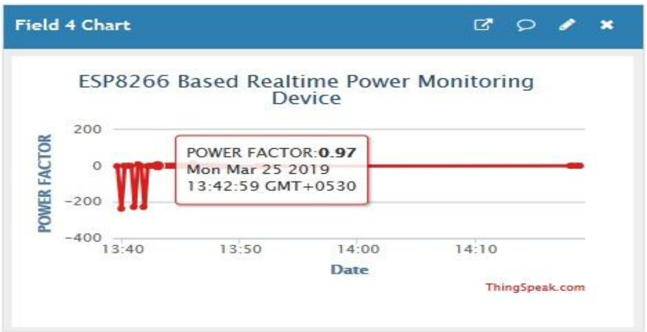

Figure 4.8: Incandescent Lamp Power Factor

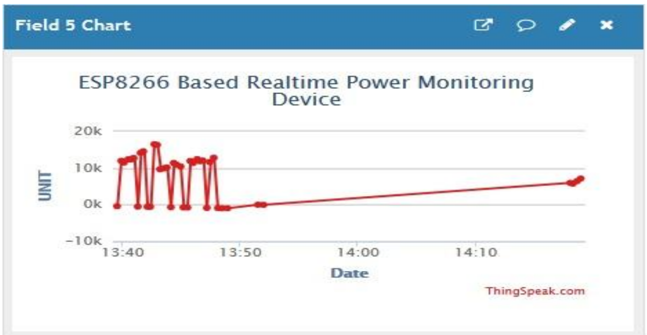

Figure 4.9: Unit Consumed

11. Drawbacks

The NodeMCU should be always connected to the mentioned Wi-Fi and a continuous uninterrupted internet connection is required to get accurate reading on the ThingSpeak platform.

If we connect the PZEM Module with more than one appliance then it will only send the data of the appliance of higher rating and the lower rating data will be suppressed. While calculating the unit, if we keep it in Kilo Watt Hour format then it becomes impossible for the NodeMCU to calculate the unit as it comes in more than two decimal places so we have to keep the unit in Watt Millisecond format.

We can get value from Kilo Watt Hour format if we can keep the system ON for an hour or more.

12. Conclusion

By completing this project we are able to successfully calculate the voltage, current, power and unit. The PZEM Module can calculate all the parameters by itself. For this no extra programming is required. Moreover it also calculates the RMS values rather than the instantaneous values.

At first while taking readings from PZEM the values were not showing instead of which it was giving -1 as output but we solved this problem after checking the connections multiple times. The NodeMCU makes it easy to transfer the received data of PZEM to an IOT Based platform which in our case is ThingSpeak. It is website which has free access to all and it is very easy to set up the required settings in ThingSpeak.

13. Future Scopes

- As of now we are sending the data to a website but in future we can upgrade it in such a way that we will be able to send it to any application which is more convenient to use.
- In future we can upgrade it so that if there is any abnormal readings then it can send a warning message through internet connection
- We can further add a GSM Module through which we can send warning message through SMS even if there occurs any kind of interference with the internet connectivity.
- We are trying to make it a market product which will be able to provide the data regardless of being offline or online.

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