A new multi-function smart electricity measurement device

Um novo dispositivo multifuncional de medição de eletricidade inteligente

Un nuevo dispositivo inteligente multifunció para medir la electricidad

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Saad Khadar
Doctor in Electrical Engineering
Institution: Applied Automation and Industrial Diagnostics Laboratory (LAADI), Department of Electrical Engineering, University of Djelfa
Address: Djelfa, Algeria
E-mail: saad.khadar@univ-djelfa.dz

Rabhi Nadjoua
Bachelor's in Electrical Engineering
Institution: Department of Electrical Engineering, University of Djelfa
Address: Djelfa, Algeria
E-mail: nadjouanana111@gmail.com

Missaoui Isra Oumaima
Bachelor's in Electrical Engineering
Institution: Department of Electrical Engineering, University of Djelfa
Address: Djelfa, Algeria
E-mail: isramissaa@gmail.com

Aggoun Hanane Aya
Bachelor's in Electrical Engineering
Institution: Department of Electrical Engineering, University of Djelfa
Address: Djelfa, Algeria
E-mail: aya.aghanane@gmail.com

ABSTRACT

Algeria's national gas and power provider is called Sonelgaz. It is in charge of producing, distributing, and transmitting power throughout the nation. Sonelgaz has encountered several difficulties in effectively supplying electricity to consumers and keeping track of their usage over the years. One of the primary problems is that client consumption is not accurately metered. Algeria has a large number of old power meters that don't give precise readings of the real electrical usage. Customers receive inaccurate bills as a result of this. It also makes it more challenging for Sonelgaz to monitor usage trends and detect power thieves. Poor
metering infrastructure has led to disputes between Sonelgaz and customers over excess bills. In recent years, the idea of a smart power meter has become increasingly popular all around the world. Traditionally, readings must be taken in the meter reading room. As a result, tracking and keeping tabs on your electricity usage is a time-consuming and annoying chore. Furthermore, a lot of us worry about our large electricity bills at the end of the month, therefore, we have to periodically check the energy meter. However, what if we could track how much electricity we consume from anywhere in the world? In this paper, we will develop a new multi-function smart electricity measurement device using an ESP32 microcontroller and the mobile Blynk app. The smart electricity measurement device displays the voltage, current, power factor, and power consumption in real time. In addition, it displays the cost of electricity in dollars and the total energy consumed in kWh, saving you both time and money. The consumer's electricity will be remotely off if the bills are not paid.

**Keywords:** Smart Electricity Measurement Device. ESP32 Microcontroller. Blynk Application. Sonelgaz. 7-Inch HMI LCD Display.

**RESUMO**
O fornecedor nacional de gás e energia da Argélia chama-se Sonelgaz. É responsável pela produção, distribuição e transmissão de energia em todo o país. A Sonelgaz tem encontrado diversas dificuldades no fornecimento eficaz de electricidade aos consumidores e no acompanhamento da sua utilização ao longo dos anos. Um dos principais problemas é que o consumo do cliente não é medido com precisão. A Argélia tem um grande número de medidores de energia antigos que não fornecem leituras precisas do consumo elétrico real. Os clientes recebem faturas imprecisas como resultado disso. Também torna mais difícil para a Sonelgaz monitorizar tendências de utilização e detectar ladrões de energia. A má infra-estrutura de medição levou a disputas entre a Sonelgaz e os clientes sobre facturas em excesso. Nos últimos anos, a ideia de um medidor de energia inteligente tornou-se cada vez mais popular em todo o mundo. Tradicionalmente, as leituras devem ser feitas na sala de leitura dos mediadores. Como resultado, rastrear e controlar o uso de electricidade é uma tarefa demorada e irritante. Além disso, muitos de nós nos preocupamos com nossas grandes contas de luz no final do mês, por isso temos que verificar periodicamente o medidor de energia. No entanto, e se pudéssemos controlar quanta eletricidade consumimos em qualquer lugar do mundo? Neste artigo, desenvolveremos um dispositivo inteligente multifuncional de medição de eletricidade usando um microcontrolador ESP32 e o aplicativo móvel Blynk. O dispositivo inteligente de medição de eletricidade exibe a tensão, corrente, fator de potência e consumo de energia em tempo real. Além disso, exibe o custo da energia elétrica em dólares e o total de energia consumida em kWh, economizando tempo e dinheiro. A energia elétrica do consumidor será desligada remotamente caso as contas não sejam pagas.

RESUMEN
El proveedor nacional de gas y electricidad de Argelia se llama Sonelgaz. Se encarga de producir, distribuir y transmitir electricidad por todo el país. A lo largo de los años, Sonelgaz se ha encontrado con varias dificultades para suministrar electricidad a los consumidores de forma eficaz y llevar un control de su consumo. Uno de los principales problemas es que el consumo de los clientes no se mide con precisión. Argelia tiene un gran número de contadores antiguos que no dan lecturas precisas del consumo eléctrico real. Por ello, los clientes reciben facturas inexactas. También dificulta a Sonelgaz el seguimiento de las tendencias de consumo y la detección de ladrones de electricidad. La deficiente infraestructura de medición ha provocado disputas entre Sonelgaz y los clientes por facturas excesivas. En los últimos años, la idea de un contador inteligente se ha hecho cada vez más popular en todo el mundo. Tradicionalmente, las lecturas deben realizarse en la sala de lectura de contadores. Como resultado, el seguimiento y control del consumo de electricidad es una tarea larga y molesta. Además, muchos de nosotros nos preocupamos por las elevadas facturas de electricidad a final de mes, por lo que tenemos que comprobar periódicamente el contador de energía. Pero, ¿y si pudiéramos saber cuánta electricidad consumimos desde cualquier lugar del mundo? En este artículo, desarrollaremos un nuevo dispositivo inteligente multifunción de medición de la electricidad utilizando un microcontrolador ESP32 y la aplicación móvil Blynk. El dispositivo inteligente de medición de electricidad muestra el voltaje, la corriente, el factor de potencia y el consumo de energía en tiempo real. Además, muestra el coste de la electricidad en dólares y la energía total consumida en kWh, lo que permite ahorrar tiempo y dinero. La electricidad del consumidor se cortará a distancia si no se pagan las facturas.


1 INTRODUCTION

Electricity meters are instruments used by residential, commercial, and industrial clients to track how much electricity they use [1-5]. For many years, common or standard electricity power meters have been used to track how much power is used in homes and businesses. Utility companies and consumers can both benefit from the crucial information these meters provide [2]. Conventional electric meters usually count the kilowatt-hours (kWh) of electricity that flow through them over time by means of electronic registers or rotating discs. Electric current travels through the meter as it enters a house or building from the power wires. The kWh used is then recorded by the meter either digitally or electromechanically. A utility worker viewing the meter by hand can periodically...
read the cumulative recorded use. The electric provider then uses the measured kWh to create customer bills according to predetermined rate schedules [3].

Over the past few decades, electricity power meters have undergone a great evolution from simple analog meters to today’s smart digital meters. Electricity power meters’ ability to precisely monitor and record energy consumption has evolved along with technology [6]. These meters enable services like remote meter reading and power outage alerts by allowing two-way communication between the meter and the utility. Customers can also view stored energy usage data to learn more about their consumption patterns. Fundamentally, smart electric meters compute power consumption in kilowatt-hours and continually measure voltage and current flow using microprocessors and solid-state devices. Both historical data and real-time readings are available on an LCD or LED display [7].

As a result, we are developing multi-function smart electricity measurement device today that use HMI displays and ESP32 microcontrollers. Through a smartphone app, customers may examine real-time data and remotely control the system via the Blynk platform. The parameters of the energy meter are also visible on the 7-inch HMI LCD Display. The presented work is structured in seven section, Section 2 is concerned with explaining the principle of the proposed device. Section 3 gives the circuit description. Then, the Section 4 contains the hardware setup, and the section 5 comprises a Blynk dashboard setup of the proposed system. Section 6 presents the testing electricity measurement device. Finally, some conclusions are drawn in Section 7.

In light of the above, the main objectives of suggested smart electricity measurement device can be summarized as follows:

- enables the user to keep track of electricity costs by estimating the cost of electricity utilized based on a predetermined cost per kWh;
- makes use of an HMI LCD display to show the cost, power factor, energy consumption, AC current, voltage, and power;
- utilizes a Blynk server to show the cost, power factor, energy consumption, AC current, voltage, and power;
- remote power disconnection in the event of delayed payment of due invoices;
• the ESP32's EEPROM will store the data from the electricity measurement device and retrieve the energy usage (measured in kWh) in the event of a power consumption, guaranteeing the data's permanence.

2 WORKING EXPLANATION

Smart electricity measurement devices are an advanced digital technology that record consumption in intervals throughout the day and communicate that data to the utility for monitoring. Smart electricity measurement devices, in contrast to traditional meters, have the ability to remotely and automatically use wireless technologies and communication networks to communicate hourly or half-hourly consumption readings to the central system. This allows customers and utilities to track power consumption in near real-time. The actual image for the proposed multi-function smart electricity measurement device is shown in Figure 1.

Figure 1. A multi-function smart electricity measurement device

A multi-function smart electricity measurement device

In order to create a multi-function smart electricity measurement device using the ESP32 board and the Blynk application [8], we need to choose the current sensor and the voltage sensor. By measuring the current and voltage, we can determine the energy consumption and total power consumed. SCT-013 is the greatest current sensor on the market right now [9]. The SCT-013 Non-Invasive
AC Current Sensor has an operating temperature range of -25 °C to +70 °C and can measure AC current up to 100 amperes. Meanwhile, the ZMPT101B module is the greatest voltage sensor. When using a voltage transformer to detect the voltage precisely, the ZMPT101B sensor works well [10]. The modules have an operating temperature range of 40ºC to +70ºC and can measure voltage within 250V AC voltage, as shown in Figure 2.

![Figure 2. ZMPT101B voltage sensor module and SCT-013-030 current sensor module](source: Saad, Ahmed e Salama (2014)).

All of the necessary characteristics for a multi-function smart electricity measurement device can be measured with the current and voltage sensors. The SCT-013 sensor and ZMPT101B sensor will be interfaced with the ESP32 Wi-Fi board. The data will be sent to the Blynk App and shown on a dashboard that is viewable from anywhere in the world. The ESP32's EEPROM will store the energy device data in the event of a power failure, guaranteeing ongoing readings.

3 CIRCUIT DESCRIPTION

The circuit diagram for the multi-function smart electricity measurement device using ESP32 board is shown in Figure 3. The Fritzing software was used to develop the design. A 220V AC power supply is connected to the input terminal of the electricity measurement device. The output of the relay module is connected to its output terminal. Every electrical load is connected to the relay as well. You can attach anything to the load in this task, including fans, lights, heaters, and other items you use around the house.
The Rx and Tx pins of HMI LCD Display are directly connected to the Tx and Rx pins of ESP32 board respectively. The Vin and GND of the ESP32 board are linked to the VCC and GND pins of the ZMPT101B sensor and the SCT-013 sensor. The D35 of the ESP32 board is linked to the ZMPT101B voltage sensor's output analog pin. Similarly, the D34 of the ESP32 board is linked to the output analog pin of the SCT-013 current sensor. To finish the circuit, two 10K resistors, one 100-ohm resistor, and a 10uF capacitor are needed as well. D23 on the ESP32 board can be used to control the 5V 1-channel relay. A 5V power source is necessary for the HMI LCD display. That means you can utilize an external 5V DC power supply, such as the DC power adapter.

4 HARDWARE SETUP

For this Hardware setup of smart electricity measurement device, we need following materials: ESP32 Wi-Fi board, 7-inch HMI LCD display, ZMPT101B AC voltage sensor module, SCT-013-030 AC Current sensor module, 1-Channel relay module, 5-volt DC power supply, 2-Resistor 10K Ω, Resistor 100 Ω, Capacitor 10uF, Capacitor 100uF, and PCB Board, as shown in Figure 4.
Caution! You are working with a high electrical supply right now! It is expected that you possess fundamental electrical knowledge and are aware of what you are doing. If you're new to electrical work, you could require advice from more seasoned individuals. Always keep safety and precaution in mind.

The hardware parts and their purposes are broken down as follows:

- **AC Source (110/250V)**: the main source of alternating voltage that supplies the loads and is observed by the energy measurement devices' voltage and current sensors;

- **DC Power Supply (5V)**: This draws power from a regular DC power supply to power the ESP32 Wi-Fi board and HMI display;

- **AC Voltage and Current Sensors**: For the accurate determination of electrical characteristics, these sensors are essential. To determine power and energy consumption, the ZMPT101B sensor and SCT-013 sensor measure the electrical voltage and current of the loads;

- **ESP32 Microcontroller Board**: This is the power meter's central processing unit, which manages the collection of data from sensors, processes it, and connects to other platforms such as the Blynk app to visualize and control the data;

- **HMI display**: Local viewing of electrical characteristics like voltage, current, power, power factor, energy consumption, and electricity cost is done on a 7-inch HMI LCD display manufactured by DWIN Technology;
• relay module: using the Blynk app or the HMI display, users can remotely control the relay, which serves as a switch for the main power line;

• loads: these are the electrical devices (lights, heaters, motors, etc.) that the system monitors and controls in terms of energy consumption;

• additional items: we need two resistors of 10KΩ and a single resistor of 100 Ω connected along with a 10uF Capacitor for protection.

5 BLYNK DASHBOARD SETUP

Blynk is an online user platform that offers a web interface for displaying data. By displaying data on an online dashboard, it enables remote monitoring and control of the power meter. There are numerous Widget boxes in the application that may accommodate a large amount of measuring data. The ability to store data on the Blynk server for the purpose of tracking down or downloading historical records is one of the benefits of utilizing Blynk.

Figure 5. Blynk Dashboard

Source: Saad, Ahmed e Salama (2014).

To monitor the electricity measurement device data from ESP32 microcontroller, we must configure the Blynk Dashboard. Here, the data from the energy measurement gadget will be shown on the mobile application. For the regulation of current, voltage, electrical power, power factor, energy consumption, cost, and load, virtual pins must be created.

1. create a new template after downloading and installing the Blynk application from the Google Play Store;
2. assign the name such as ‘Smart electricity measurement device’, Hardware and Connection Type;

3. now go the Datstreams Section, drag or add 7 widgets Gauge. The 7 widgets are here to display the values of electrical characteristics. As can be seen in Table 1, every parameter is tested using a distinct virtual pin (V0 to V6);

<table>
<thead>
<tr>
<th>Name</th>
<th>Pin</th>
<th>Data type</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>voltage</td>
<td>V0</td>
<td>Double</td>
<td>V</td>
</tr>
<tr>
<td>current</td>
<td>V1</td>
<td>Double</td>
<td>A</td>
</tr>
<tr>
<td>electrical power</td>
<td>V2</td>
<td>Double</td>
<td>W</td>
</tr>
<tr>
<td>power factor</td>
<td>V3</td>
<td>Double</td>
<td></td>
</tr>
<tr>
<td>energy consumption</td>
<td>V4</td>
<td>Double</td>
<td>kWh</td>
</tr>
<tr>
<td>cost</td>
<td>V5</td>
<td>Double</td>
<td></td>
</tr>
<tr>
<td>Load control</td>
<td>V6</td>
<td>Integer</td>
<td></td>
</tr>
</tbody>
</table>

Source: Authors.

4. to view all of the presented values, select the Gauge widgets. Choose the Switch for the Load Control section, as shown in Figure 6. Assign virtual pins to each and every gadget as well;

At last, the Web Dashboard has this appearance and is prepared to accept data from the ESP32 microcontroller board, which is a multi-function smart electricity measurement device.
6 TESTING ELECTRICITY MEASUREMENT DEVICE

Now that we are well-versed in the hardware aspect. The code has been uploaded and the device is prepared for testing. The ESP32 microcontroller board requires some time for initialization and calibration before it can begin reading data from sensors. After establishing a connection with the Wi-Fi network, it will begin displaying the value. Start the Serial Plotter after the code has been uploaded to see the results. Adjust the potentiometer until the sensor produces a proper sine wave if one is not visible on the Serial Plotter, as shown in Figure 7. When the sensor produces a proper sine wave, it has been calibrated correctly.

Figure 7. Voltage measured by ZMPT101B sensor

The ESP32 microcontroller board will attempt to establish a Wi-Fi network with the provided password and SSID. The current and voltage characteristics should be nearly zero when there is no load connected or when the load is turned off. The LCD display will now show the voltage and current values, power consumption, and total kWh units when the load is attached. Now, we must view the data on the Blynk Dashboard in order to remotely monitor the smart electricity measurement device data. Thus, to view the real-time data, navigate to the Blynk Dashboard.
Similarly, you can concurrently view the data on Serial Monitor.

On the other side, the EEPROM retains the cost and power values even when the device is not in use. To ensure that measurements are ongoing and not lost, the power consumption value and estimated cost are added to the preceding value.

7 CONCLUSIONS

The development of a multi-function smart electricity measurement device using Blynk app will bring about a revolution in the measurement and monitoring
of power consumption in Algeria's national gas and power. On the other hand, we believe that the results obtained can help society in many ways as:

- time and money are saved by doing away with manual meter readings using the smart electricity measurement device-based solution;
- accurate measurements of voltage, current, power, and total energy spent can be achieved by using the best current and voltage sensors;
- the Blynk dashboard allows access to the data from anywhere;
- this work benefits both the consumer and the company. It can help consumers monitor bills and manage their electrical data consumption.

The study's limitations include reliance mainly on the Internet, which may not be generalized to all population areas. Future work should focus on a new method that does not rely on electricity and another method that detects electricity theft.
REFERENCES


