IMPROVED IOT ENERGY METER APPLICABLE IN SMART BUILDINGS

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Abstract

This paper represents an improved solution of the IoT energy meter described in [1]. Besides to greater measurement accuracy and measurement resolution, the improved solution has the additional ability to measure frequency and power factor with respect to [1]. All of quoted advantages have been achieved by replacement the PZEM004 multifunctional energy meter module with a new compact PZEM-016 module as well as by innovation the digital dashboard interface of the Blynk cloud server. So, real time monitoring of important local electrical network parameters was extended to the real time monitoring of ambient parameters as temperature, relative air humidity, and atmospheric pressure.

The proposed new solution offers the possibility of collecting data relating to the electrical quantities and the ambient physical parameters in the real time.

Keywords: IoT, active energy, power factor, smart building, cloud server, WiFi, BME280.

INTRODUCTION

A modern concept of increasing the efficiency of electrical energy consumption in residential units, based on IoT (Internet of Things), was described in the article [1]. It is shown that when the consumer is aware of the consumption, he then strives to save energy, which is the interest of both the user and the manufacturer/distributor. The IoT system designed for these purposes [1], [2], [7] uses sensors and built-in systems for electricity consumption monitoring and control.

This paper represents one improvement of the solution described in article [1]. Increased accuracy and resolution of measurements, a greater number of monitored and controlled electrical parameters of the network, as well as monitoring of ambient living and working conditions are significant improvements of the proposed solution compared to [1].

SYSTEM COMPONENTS

Proposed system is designed to create the qualitatively better user friendly interface for interacting with real world devices. The information from the device to the user and commands from the user to the device is carried out in following steps:

- Collecting data of the electronic device and transmitting it over the Internet to the cloud server using NodeMCU WiFi module [6].
- Storing of data into the cloud server to maintain the record of data.
- Representing the transmitted data using the cloud server's interface.
- Controlling the appliances from same interface.

The complete system consists of two key subsystems: system hardware and Blynk cloud server [3]. On the other hand, the system hardware contains three key units: NodeMCU WiFi development platform [5], BME280 module [6] and newest PZEM-016 AC power/energy meter module [4] with data read through RS485 interface.

NodeMCU [5] is one of the many open source IoT platforms, based on the well-known ESP8266EX WiFi SoC (System on Chip), the product of Espressif Systems [5], Figure 1. This platform integrates 32-bit microcontroller (MCU) *Tensilica's L106 Diamond* with low power consumption and maximum clock frequency of 160MHz, WiFi interface with hardware TCP/IP stack and more serial communication interfaces.

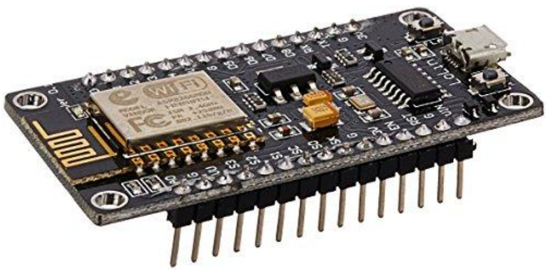

***Fig. 1.** The NodeMCU IoT development platform*

The ESP8266EX SoC can hosts an application, when "boots up" from the fast external flash memory. SoC 's integrated fast cache is then of direct help to increase system performance and optimize system memory [6]. The ESP8266EX SoC contains integrated 50kB SRAM (Static Random-Access Memory) and ROM (Read-Only Memory) units as well as a memory controller. The 17 GPIO lines of SoC can be used as an interface with external sensors and other devices.

BME280 module [6] is well known Bosch's combined digital humidity, pressure and temperature sensor, Figure 2. The BME280 achieves high performance in all applications requiring temperature, humidity and pressure measurement.

***Fig. 2.** Combined digital sensor module - BME280*

The humidity sensor provides an extremely fast response time for fast applications and high overall accuracy over a wide temperature range.

The sensor provides both SPI and I²C interfaces and can be supplied using 1.71 to 3.6V for the sensor supply V_{DD} and 1.2 to 3.6V for the interface supply V_{DDIO}. Measurements can be triggered by the host or performed in regular intervals. When the sensor is disabled, current consumption drops to 0.1 μA. BME280 can be operated in three power modes: sleep mode, normal mode and forced mode.

PZEM-016 AC power/energy meter module is mainly used for measuring AC voltage, current, active power, frequency, power factor and active energy [4]. Except the power factor, all of electrical quantities are measured with measurement accuracy of 0.5%. Measurement accuracy of power factor is some less and amounts 1%. Also, except the greater measurement accuracy, this module differs to the PZEM004 module because it hold differential, opto-isolated RS485 serial communication interface. Figure 3 shows the enclosure of PZEM-016 module intended to be connected with a split current transformer as a current sensor.

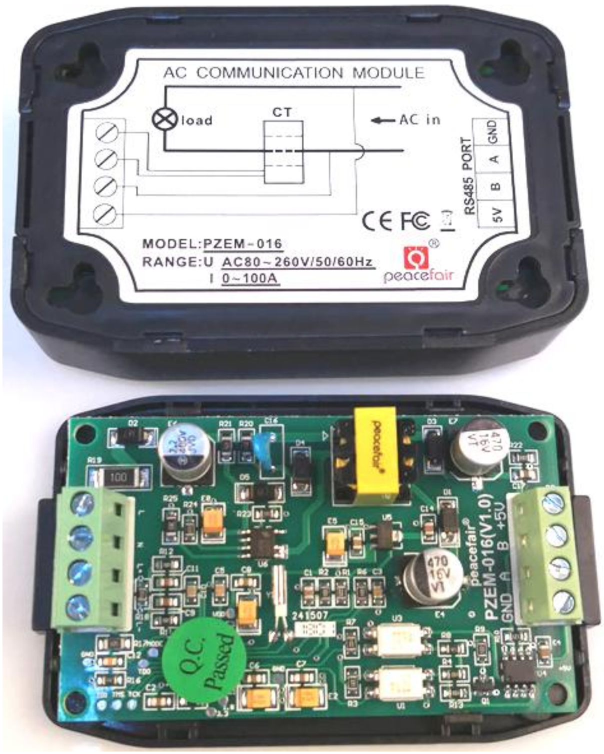

***Fig. 3.** PZEM-016 single phase modbus energy meter*

Two ports, one for communication and second one for AC power supply are available on the opposite sides of the module. AC voltage provides 5V DC voltage to RS485 communication circuit and external circuits. To connect the module with a microcontroller operating at 3.3V it is necessary use the MAX485 transceiver as interface. Because of voltages incompatibility, insignificantly modification of transceiver interface was needed by adding a Schotky diode on the receiver output (RO) pin of MAX485. Figure 4 shows complete system hardware.

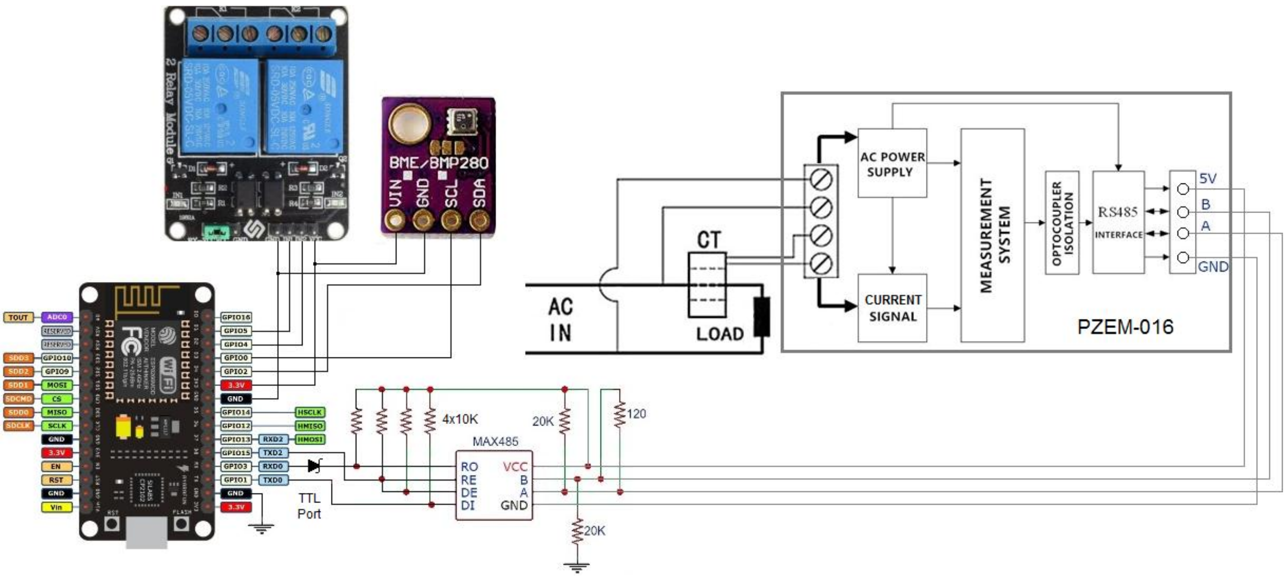

Fig. 4. System hardware of the improved IoT energy meter

BLYNK CLOUD SERVER - DIGITAL DASHBOARD

Blynk was designed for develop IoT applications that can control remote hardware via the Internet [3]. Showing data from sensors, data storage, visualization and many other features are enabled by Blynk applications that support more than 400 hardware development systems as NodeMCU. There are three main components of the Blynk platform:

- Blynk application that allows creation of user-oriented graphical interface using different, ready-made graphic objects (widgets).
- Blynk server, responsible for communicating mobile device and hardware. It can even be installed on a PC or Raspberry Pi system, and thus create a private, local cloud server.

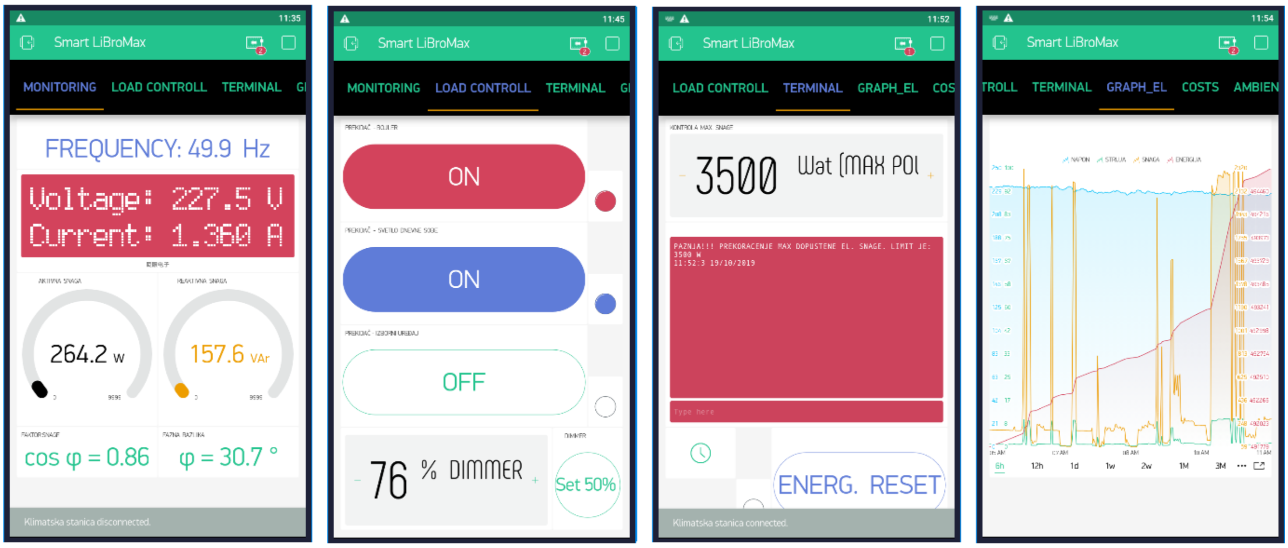

Fig. 5. First part of digital dashboard of improved IoT energy meter on the Blynk cloud server

- Blynk libraries available for the most popular hardware development systems that allow communication with the server and the processing of incoming and outgoing commands.

The Blynk application should be installed on iOS or Android platforms such as a smart phone or tablet. Upon installation, the user creates a new account for keeping and accessing the project from multiple devices and from anywhere.

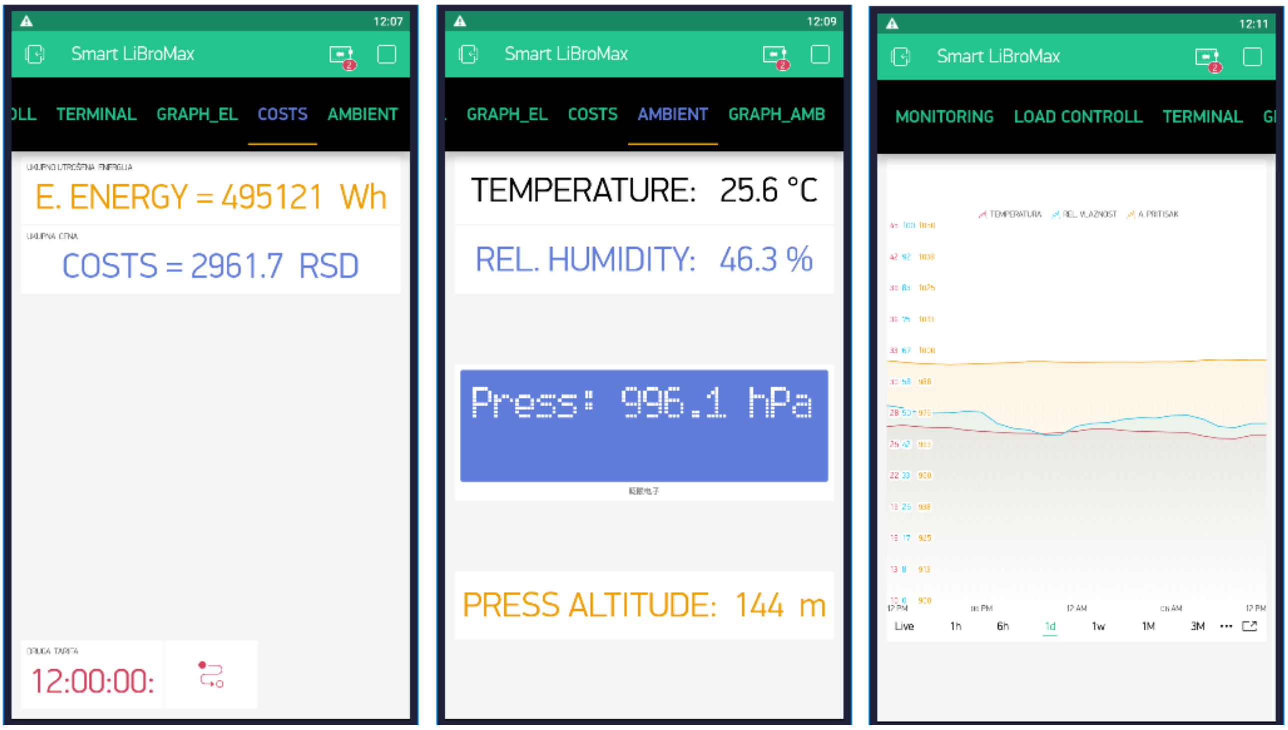

Fig. 6. *Second part of digital dashboard of improved IoT energy meter on the Blynk cloud server*

At the same time, the account also represents a security measure for the protection of user projects.

Arduino IDE, dedicated Blynk libraries for ESP8266 as well modbus library were used for NodeMCU platform programming.

The digital dashboard where we built a graphic interface for our project is shown in Figures 5 and 6.

As can be seen in Figure 5, all of above mentioned electrical quantities are reported in real time on the tab '**Monitoring**'. The exception is the reactive power obtained by computation.

The tab '**Load Control**' gives possibility of energy consumption control by turn-on or off individual loads.

The '**Terminal**' tab serves to set the limit of the active power. In case of exceeding the limit power, the user receives an audible and textual warning about the date and time of the overrun, as well as the current limit power. The message text remains permanently written in the terminal window, see Figure 5.

'**Graph_El**' tab depicts the waveforms of voltage, current, active power and energy consumption in the long time of monitoring. The discrete values of the waveforms of electrical quantities are stored on the Blynk cloud server and can be downloaded to the user's email as CSV files.

Figure 6 represents a continuation of the digital dashboard with additional three tabs. '**Costs**' tab contains information of consumed energy and the total price of consumption including higher and lower tariff.

'**Ambient**' tab presents the real ambient conditions of residential space like temperature, humidity, atmospheric pressure and pressure altitude in the real time, while the '**Graph_Amb**' collects and plots the waveforms of the first three physical quantities.

The application created on a mobile device provides a constant insight into the actual values of electrical and ambient physical quantities of importance for the electricity and comfort in a residential or business facility. The negligible self-consumption of the improved system does not have a significant impact on increasing the cost of managing and using the system.

CONCLUSION

The main goals of the proposed improved IoT energy meter were increase the number of electrical quantities to monitoring, increase the measurement accuracy and the monitoring expansion to the living and working conditions in residential or business spaces. By appropriate choice of the system components these goals were reached.

Proposed system is intended to be installed in single phase network environments. It was installed and tested in a residential unit. Thanks to it, the monthly electricity consumption was reduced and the stay comfort was increased.

The installation of the system requires only minor modifications of the electrical infrastructure on the installation panel with fuses or outside, due to the interruption of consumer circuits controlled by relay switches.

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