v. 4, n. 3, 2024

Journal of
Engineering
Research

DEVELOPMENT OF A TELEMETRY SYSTEM BASED ON THE INTERNET OF THINGS, FOR THE MONITORING OF BASIC SERVICES IN A RESIDENTIAL INSTALLATION

MC Fredy Alberto Hernández Aguirre
Research Professor assigned to the Department of Graduate Studies and Research at ``Tecnológico Nacional de México``, campus: `` Instituto Tecnológico de Hermosillo``, Sonora, Mexico
ORC ID: 0000-0001-9208-5299

MC José Manuel Chávez
Research Professor assigned to the Department of Graduate Studies and Research at the Tecnológico Nacional de México, campus: `` Instituto Tecnológico de Hermosillo``, Sonora, Mexico
ORC ID: 0000-0001-9708-5925

MC Daniel Fernando Espejel Blanco
Research Professor assigned to the Department of Graduate Studies and Research at the Tecnológico Nacional de México, campus: ``Instituto Tecnológico de Hermosillo``, Sonora, Mexico
ORC ID:0000-0002-9692-013X

Journal of Engineering Research ISSN 2764-1317 DOI https://doi.org/10.22533/at.ed.317432415018

MC Héctor Martín Córdova Córdova
Full-Time Professor assigned to the Department of Electrical and Electronic Engineering at ``Tecnológico Nacional de México``, campus: ``Instituto Tecnológico de Hermosillo``, Sonora, mexico

Abstract: The objective of this article is to present the work and results of the research carried out for the development of a mobile application, designed so that the user can know the consumption of basic services (kWh, water and LP gas) in the home. The proposed architecture is based on the design of electronic circuits for signal conditioning in the sensors and the development of digital control algorithms for measuring parameters and their local and remote monitoring through the Internet. The proposed measurement prototype directly impacts the efficient use of basic services in residential facilities, since the user can detect, through the mobile application, the improper use of these resources, analyzing the consumption values shown on their Smartphone, generating preventive and corrective actions for its best use.
Keywords: Services, Mobile application, sensors, microcontroller

INTRODUCTION

Production in industries and domestic chores in homes require the use of various energy sources, among which the need for the rational use of electrical energy and water and LP gas supply services stands out. Next, various solution proposals are analyzed for the monitoring and control of various parameters related to the efficient use of electrical energy.

Valdiosera proposes in his thesis the design of a smart meter with bidirectional communication for the consumption of electrical energy. The first remote automatic meter systems appeared in the 1980s, and allowed one-way communication to be established from a group of meters to a central point (A. Valdiosera, 2013). W. Lim proposes a wireless telemetry system, using an Arduino® module to collect different parameters such as soil temperature and humidity for monitoring an agricultural field (W. Lim et al, 2014). RF

Eggea proposes the use of a mobile application for Android to visualize the data obtained from solar generated energy and electrical consumption in a residential installation (RF Eggea et al, 2016). J. López Hurtado, in his article "Interactive electronic electricity consumption meter for residential use", presents the design and implementation of an interactive electronic meter for residential use, which allows monitoring of electrical energy consumption in real time, such that the end user has sufficient information to make decisions that promote the rational use of electrical energy (J. López Hurtado, 2016). S. Idrovo and others, present in their thesis work "Design and implementation of an electronic energy meter for a home, with orientation to the prevention of consumption and energy savings", the design and implementation of an electronic meter for a home, with in order to monitor electricity consumption through a website and by mobile phone messages (S. Idrovo et al, 2016).

The objective of this article is to present the results obtained from the research carried out for the development of a mobile application, designed so that the user can know the consumption of basic services (kWh, water and LP gas) in the home, with the purpose of managing the efficient use of these resources, impacting the care of the environment and reducing tariff bills.

METHOD DESCRIPTION

PROBLEM STATEMENT AND SOLUTION PROPOSAL

Basic services in homes, electricity, water and LP gas, are essential for household chores and being able to survive in society, however, the misuse and abuse of them, as well as the infrastructures used for their production and distribution, They make rates more expensive year after year, strongly impacting the purchasing power of users. In current times, sustainable development and care for the environment imply greater responsibility on users for the efficient use of basic services at home, as a fundamental part of citizen activities that help reduce the effects of global warming and climate change. climate change. It is necessary for the end user to become an active agent capable of making decisions that allow them to consciously rationalize the consumption of basic services. Knowing and recording the consumption of these services periodically and in real time helps to detect critical factors such as water or gas leaks, improper use of electrical equipment, among other bad practices that generate high costs in the corresponding rates. The proposed solution to the problem raised consists mainly of the development of a telemetry system based on Internet of Things technologies (MLR Chandra et al, 2018) for the measurement and monitoring of energy consumption (kWh) and supply. of basic services, water and LP gas, in a residential installation. The proposed hardware is an electronic prototype with signal conditioning circuits to measure voltage and alternating current, water consumption and presence of LP gas in a residential installation. The sensors used with their respective conditioning circuits allow the necessary measurements to be made to calculate energy consumption (kWh), the amount of water consumed and the presence of LP gas. These data generated by the consumption of basic services can be viewed by the user through a mobile application in real time, allowing them to make decisions related to the misuse of facilities, maintenance and the costs generated.

Figure 1 shows the block diagram of the proposed solution for the basic services telemetry system (kWh, water and LP gas) in a residential installation: sensors, central processing unit, data communication, database and mobile application.

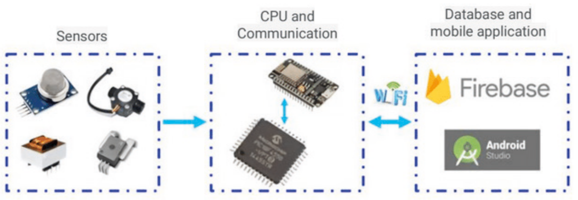


Figure 1. Block diagram of the telemetry system for basic services.

SENSORS USED FOR MEASURING BASIC SERVICES: KWH, WATER AND LP GAS

The main characteristics of the sensors used are described below:

To measure the presence of LP gas, the MQ2 sensor, figure 2(a), was used, installed directly in the LP gas supply line, with a supply voltage of +5 VDC. The output analog voltage is linearly proportional to the PPM of LP gas circulating in the air.

To measure the water flow, the YF-S201B flow sensor was used, figure 2(b), installed directly in the water service supply line, with a supply voltage of +5VDC, it has a Hall effect sensor to generate a train of TTL pulses with frequency directly proportional to the water flow.

(a) (b)

Figure 2. Sensors: a) Analog sensor for the presence of LP gas, b) Digital sensor for water flow.

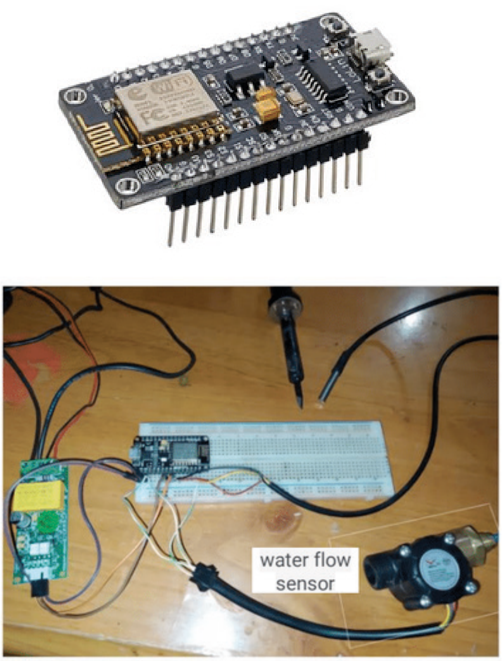
The PZEM-004T-100A module is a multifunction sensor that allows measuring the RMS voltage (Root Mean Square), RMS current, instantaneous active power and the energy supplied to a load connected to a single-phase line (kWh), figure 3. It has optocoupled outputs, overload alarm, value storage when power is disconnected, and serial communication. (Mikroelectron, 2020).

Figure 3. PZEM-004T-100A sensor, to measure energy consumption (kWh).

DATA ACQUISITION AND COMMUNICATION

The water, gas and energy consumption (kWh) sensors are connected to the NodeMCU microcontroller, a development board based on the ESP8266 integrated circuit, which has an integrated chip for WiFi connection, this allows the use of different communication protocols, figure 4(a). The ESP8266 module is an integrated circuit designed by Espressif Systems, with the intention of meeting the growing demand in the market for solutions developed for low-cost projects related to the Internet of Things (IoT). This chip offers a complete and programmable Wi-Fi (Wireless Fidelity) networking solution, which can be used to interconnect mobile applications and to share these network functions with other platforms, it has GPIO (General Purpose Input/Output) pins for connection of sensors, and has storage capacity. The NodeMCU development board has an integrated chip that provides a WiFi connection, this allows the use of different communication protocols, however, for the development of this prototype the Websockets communication protocol was used. This facilitates the development of the application layer, through the programming of a graphical interface for a mobile application made in Android Studio.

The NodeMCU module can work with the Arduino programming interface and its variety of libraries, this allows the development of algorithms to collect data from the different sensors. After this stage, the microcontroller makes the connection to the Firebase database and that is where the information from the sensors is loaded. The mobile application is connected to this database, making it possible to view it in graphic form. Once the algorithm is uploaded to the microcontroller through the USB port, it begins reading and sending the recorded measurements (kWh, water flow, LP gas pressure) to Firebase, Figure 4(b).



(a) (b)

Figure 4. Data acquisition and communication: a) ESP8266 NodeMCU module, b) Circuit for measurement tests and data communication.

IoT NETWORK ARCHITECTURE

Figure 5 shows the block diagram of the three layers for the IoT architecture used for the design of the telemetry system: the perception layer is composed of the sensors, the network layer consists of a digital platform to interpret the data digitized and centralize them on an Internet server, and the application layer is a graphical interface developed for the Android operating system.

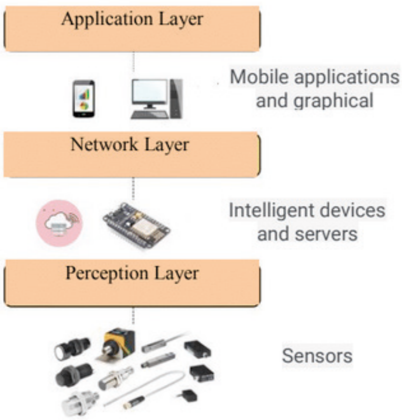


Figure 5. Block diagram of the three-layer IoT architecture.

DATABASE AND MOBILE APPLICATION

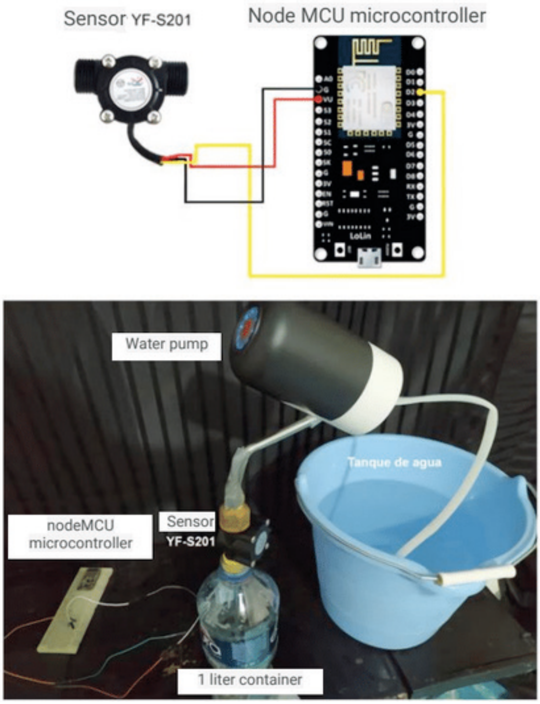
The wireless communications module is based on the ESP8266 platform with moduleIntegrated WiFi, using the Internet to deliver information to the mobile device. Subsequently, the ESP8266 module connects to the Firebase® database, which is used to load and manage the corresponding data in the tables. To process the data, programming algorithms are used within the Android application. This is required since the data sent by the sensors must be processed to calculate the corresponding values of kWh, flow rate and gas pressure. For the graphical interface, an application was created in the Android mobile operating system. This application is directly connected to the same database that is used to save the measurements made by the microcontroller on the sensors. Thanks to this, the parameters to be measured are They update in real time, every time the microcontroller uploads data to the database, the mobile application automatically updates it. The Android Studio development environment facilitates the adaptation of different types of mobile devices, allowing programming to focus on data communication algorithms and their visualization in a general and functional manner. Android Studio® is a free integrated development environment that can be used by anyone to design mobile applications. The only requirement for this software is to have Java® installed. The Firebase® real-time database allows you to create applications with a secure connection, from the client side to the data transport, and can support Android devices, Web applications and more. All the information stored in this database is in JSON (JavaScript Object Notation) format, and any change is reflected immediately as a synchronization is carried out on all connected platforms.

FINAL COMMENTS

SUMMARY OF RESULTS

The results obtained demonstrate that it is possible to design a low-cost monitoring system to record the consumption of basic services in a residential facility through a mobile application, which allows the user to view this information in real time so that they can make decisions at the same time. regard.

Figure 6(a) shows the connection diagram of the water flow sensor (YF-S201B) to a digital input of the NodeMCU module. Any digital input can be used since the ESP8266 microcontroller allows it to be configured to work with interruptions. external, and this way count the digital pulses to measure the water flow (450 pulses per liter). Figure 6(b) shows the plant used for calibration and testing, the sensor is coupled to the pump used to generate a constant flow of water.



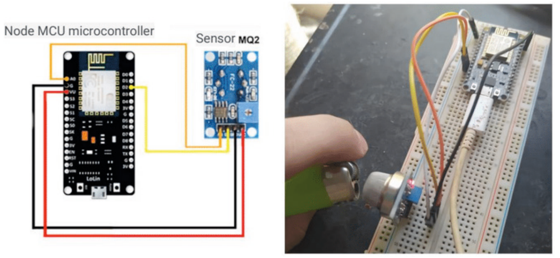
(a) (b)

Figure 6. Connection diagram for testing and calibration with the water sensor.

To determine the presence of LP gas, an MQ2 sensor was used, an electrochemical sensor that has an internal resistance that varies when exposed to certain gases. This module has an analog output and a digital output, which internally works with a comparator, and with the help of a potentiometer the threshold can be calibrated to interpret the digital output as the presence or absence of gas.

Figure 7(a) shows the connection diagram of the MQ2 sensor to an analog input pin and a digital input pin of the NodeMCU module, and figure 7(b) shows the circuit for calibration and testing. with LP gas.

Journal of Engineering Research ISSN 2764-1317 DOI https://doi.org/10.22533/at.ed.317432415018



(a) (b)

Figure 7. Connection diagram for testing and calibration with the LP gas sensor.

To view the data (measurements made by the sensors), a mobile application developed with Android Studio is used, with a login screen, a screen for measuring consumption parameters and a third screen for measuring electrical energy (kWh), with measurements added in the latest update of the prototype with a photovoltaic system interconnected to the grid: temperature, lighting and data from the photovoltaic panel. Figure 8 shows the screens developed for the mobile application. When you press the login button on the main screen, the application displays a screen to enter the user's credentials, the application validates the credentials with the Firebase database, if the data is correct it appears the screen for viewing the data, shown in figure 8.

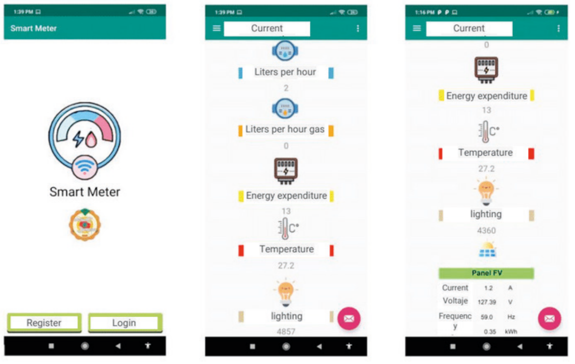


Figure 8. Screens of the mobile application designed to display data from the telemetry system.

CONCLUSIONS

The proposed prototype for measuring the consumption of basic services in a residential facility is an economical and functional option for the user to have access to information through the mobile application on their Smartphone, allowing them to make decisions related to these services. The results obtained from the tests carried out, the validation of the conditioning circuits and the firmware developed, allow us to establish that it is possible to develop a telemetry system for basic services in residential installations. The tests and experiments carried out were sufficient to validate the digital platform developed with the NodeMCU module. This module provides a wide range of tools for developing graphical interfaces, and the Android operating system is a completely free platform with a variety of functions for developing various applications.

RECOMMENDATIONS

It is important to continue with the research related to the parameters that are being displayed, this with the purpose of improving the format of the screens developed for the application, continue adding more measurement parameters, and above all work on the part related to the interconnected photovoltaic system to the network, which is also an important part for the efficient use of energy and renewable resources.

REFERENCES

A. Valdiosera, "Diseño de medidor inteligente e implementación de sistema de comunicación bidireccional," p. 365, 2013.

J. López, J. Arias, E. Quintero, "Interactive electronic energy meter for residential use", Prospect, Vol 14, N° 1, 61-72, 2016.

"Mikroelectron" (2020). [Internet]. Disponible en https://mikroelectron.com/Product/PZEM-004T-100A-AC-Power-Monitor-Module-TTL

M. L. R. Chandra, B. V. Kumar, and B. Sureshbabu, "IoT enabled home with smart security," 2017 Int. Conf. Energy, Commun. Data Anal. Soft Comput. ICECDS 2017, pp. 1193–1197, 2018.

R. F. Eggea, M. Ferreira, A. R. Aoki, and R. J. Riella, "Energy management including photovoltaic panel and energy storage for Smart Grids through mobile application," *2015 IEEE PES Innov. Smart Grid Technol. Lat. Am. ISGT LATAM 2015*, pp. 177–181, 2016, doi: 10.1109/ISGT-LA.2015.7381149.

S. Idrovo, D. Israel, V. Orellana, and D. Fernando, *"Diseño E Implementación De Un Medidor De Energía Electrónico Para Vivienda, Con Orientación a La Prevención De Consumo Y Ahorro Energético."* (2016)

W. Lim, H. K. Torres, and C. M. Oppus, "An agricultural telemetry system implemented using an Arduino-Android interface," 2014 Int. Conf. Humanoid, Nanotechnology, Inf. Technol. Commun. Control. Environ. Manag. HNICEM 2014 - 7th HNICEM 2014 Jt. with 6th Int. Symp. Comput. Intell. Intell., no. November, 2014.