Low Cost IoT System for Solar Panel Power Monitoring

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ABSTRACT: In this work, we will present a low-cost system to monitor energy production from a solar panel. Based on simple devices, this solution made it possible to measure the current, voltage, power, and visualize them through an available and free IoT application called Node-Red. The project can be qualified having plenty of essential purposes : to be used in education field, research and even production monitoring in a photovoltaic system.

Keywords: NodeMCU, IoT, Low Cost, Monitoring, Node-red, Solar Panel.

1. INTRODUCTION

The Internet of Things (IoT) is related, to the exchange of data between devices on an available network infrastructure. By 2020, the expected outcome is 50 billion devices connected [1]-[3].

IoT projects cover many areas and more specifically the remote monitoring of production and energy consumption of equipment. This category is necessary because we tend to take measures to reduce energy consumption and preserve the environment.

A great deal of work has been done to create monitoring applications. In [4], the remote measurement and controlling of domestic devices over the Internet was designed. Health Monitoring and Management, was discussed as well in [5]. Other applications have been realized, in [6] a Smart Home Automation Technique was presented, It is based on the use of Raspberry Pi using IoT as a module that can overcome the problem of consumption and also the high price of a computer.

By focusing on the monitoring of renewable energy, other works exist in the literature. An successful development of an innovative system for a solar photovoltaic energy conditioning unit was described, it was based on the use of network GPRS (Global Positioning Radio Service), embedded system gateway and other components such as Arduino Uno R3 [7]. The chosen solution is interesting; however, it seems to be expensive. Another solution was also proposed for the monitoring and the control of photovoltaic panels [8], GPRS was integrated as a means of communication, and a hard solution was based on a PIC18F46K22 microcontroller. A control system was also designed in [9] using a smart IoT gateway to create a connection between an industrial case and the cloud. The aim of the work was to provide a solution to visualize in real-time the parameters of an existing wind energy system.

With regard to solar energy management, a consistent work has been presented in [10], it is based mainly on artificial intelligence as well as a hard solution containing a microcontroller, a network radio, relays for reconnecting or bypassing panels, and sensors.

In the majority of research, we find different monitoring configurations; the difference exists in both hard and soft terms. In the first aspect, some authors have tried to develop adapted cards with the necessary communication devices. Others have deployed existing platforms such as Arduino Uno R3. As for the second aspect, there are solutions based on the development of customized applications, whether on a computer or a mobile phone, or the use of existing applications that can communicate with the equipment under control and that are free or not.

In this present work, we will propose a new architecture. The components are qualified as the cheapest in the market. Indeed, we will use Wifi as a communication solution and the monitoring application we have chosen Nod Red as a powerful and free tool to build applications of the Internet of Things (IoT). The whole system will be combined with a current, voltage and power sensor to monitor production from a solar panel.

In short, the proposed solution will have various advantages, namely its low cost, which will make it accessible to anyone wishing to monitor production remotely; the second advantage is the ease of implementation, the flexibility of the solution. And it is an effective way to monitor solar panels generally installed in inaccessible locations.

This paper consists of three sections: In section 2, the proposed architecture is introduced. Component specifications are given in section 3. Sections 4 and 5 will be devoted to present the obtained results, and estimated price of the solution. Section 6 discusses the conclusion.

2. PROPOSED ARCHITECTURE

This paper proposes a real time and low cost monitoring system for solar panel using NodeMCU which is connected to Node-Red. This system can help to measure PV system's productions: voltage, current and power.

The following figure shows an overview of the proposed system architecture.

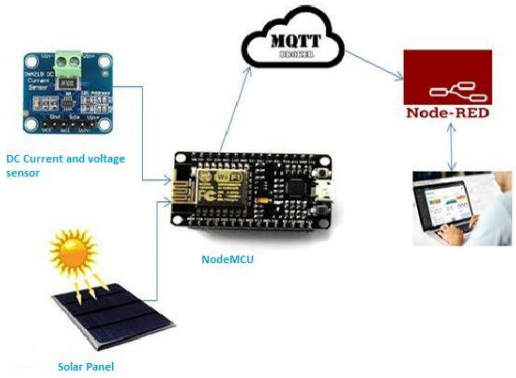

Fig. 1: System architecture

2.1 Components required: Hardware

1) ESP8266 based Wifi module NodeMCU,
2) INA219.

2.2 Components required: Software

1) Node-Red,
2) IDE,
3) MQTT.

3. COMPONENT SPECIFICATIONS

3.1 NodeMCU

NodeMCU is an open source IoT platform, it is a wifi SOC (System On a Chip) produced by Espressif Systems. It is based ESP8266 -12E WiFi module. It is a highly integrated chip designed to provide full internet connectivity in a small package.

Fig. 2 : ESP8266 NodeMCU development kit

3.2 INA219

The INA219 is a power and current shunt controller with an I²C or SMBUS compatible interface. The instrument monitors both the shunt voltage drop and the bus supply voltage, with programmable conversion times and filtering. A programmable calibration value, combined with an internal multiplier, allows a direct reading of the current in amperes.

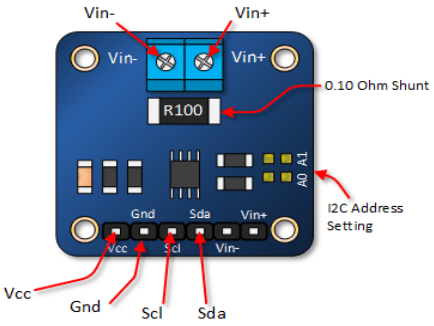

Fig. 3: INA219

3.3 Node-Red:

Node-RED is a flow-based development tool for visual programming that IBM originally developed for wiring hardware devices, APIs and online services as part of the Internet of Things [11].
Node-RED offers a web browser-based flow editor, which can be used to set up JavaScript functions. Application elements can be backed up or shared for further use. The runtime is built on Node.js. The flows created in Node-RED are recorded using JSON.

3.4 ARDUINO IDE:

Arduino software is an open source and free development environment (IDE), which can be downloaded from the official Arduino website [12]. It allows program edition (sketches) and its compilation, so it can be uploaded into the Arduino's memory and finally be able to communicate with the Arduino card through the terminal.

3.5 MQTT :

MQTT is a simple messaging protocol, designed for constrained devices with low-bandwidth. So, it's the perfect solution for Internet of Things applications. MQTT allows sending commands to control outputs, read and publish data from sensor nodes.
Therefore, it makes it simple to establish a communication between multiple devices.

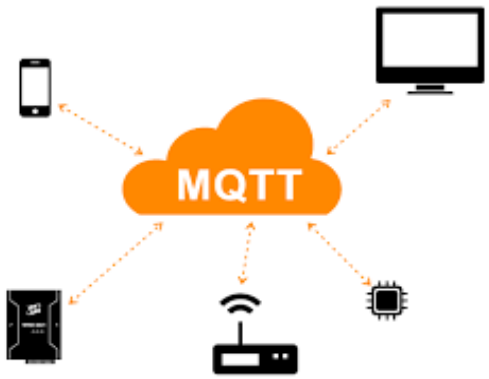

Fig. 4: MQTT connectivity

4. OBTAINED RESULTS

The microcontroller of NodeMCU gets the voltage, and current, and power output from the sensor. Once the NodeMCU is connected with MQTT via the Wi-Fi, we launch Node-Red and use the MQTT to receive the output values from the NodeMCU. To visualise the result, Node-Red dashboard must be launched. As we can see, the data measured by the sensor is transmitted to Node-Red in real time, any device connected to the same Wi-Fi, can visualise the results by using the same dashboard's address but he must have access to it by logging in with the user name and the password. The characteristics of the PV panel Figure 6 (current, voltage, power) can be presented graphically or by using a gauge. Two multimeters have been used to compare both the result and the sensor's result, one to measure the voltage and the other to measure the current. The power is obtained, by multiplying the values stated and obtained above. The Table 1 shows the results and the comparison between the values of Node-Red. Both the results are close to each other, there is a tiny error, due to the sensor's characteristics.

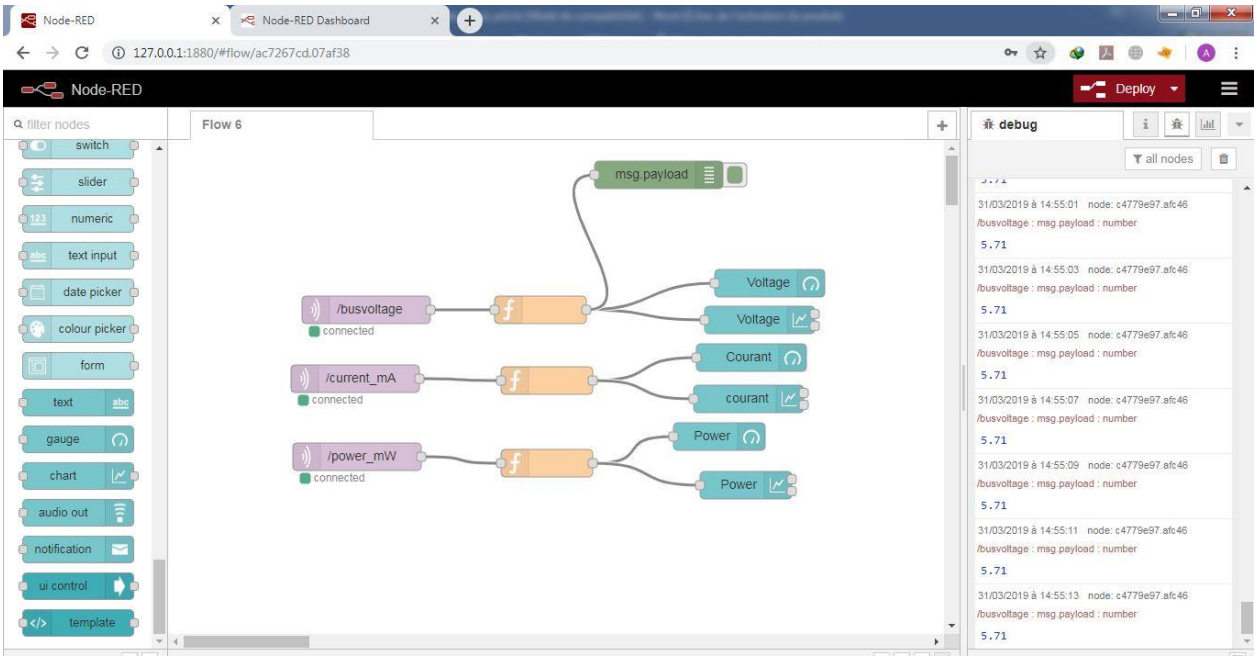

Fig. 5: Node-Red Flows

The obtained results are given in figure 6. .

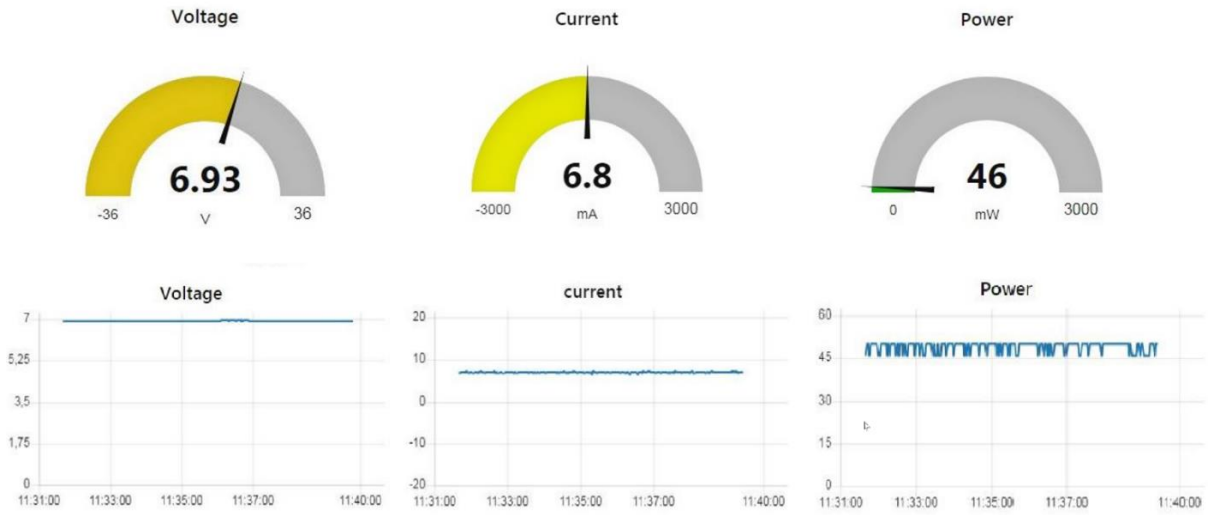

Fig. 6: Sensor data's Dashboard and graphs

Table 1: Data measurement and comparison

Multimeters			Proposed architecture		
Current (mA)	**Voltage (V)**	**Power (mW)**	**Current (mA)**	**Voltage (V)**	**Power (mW)**
6,82	6,85	46,77	6,9	6,92	50
6,86	6,83	46,9	6,9	6,93	48
6,87	6,83	46,92	6,8	6,93	46
6,82	6,86	46,79	7,1	6,92	50
6,83	6,87	46,97	7,1	6,9	49
6,84	6,87	47	7	6,94	50
6,84	6,87	47,01	6,9	6,9	47

5. PROPOSED ARCHITECTURE PRICE

Table 2 gives an idea about the cost of performing the process using the stated architecture.

Table 2: Price of the proposed instrumentation system

NodeMCU	$2,38 (ww.aliexpress.com)
INA 219	$4.67 (www.amazon.com)
Node-Red	Free
Total	**$7,05**

6. CONCLUSION

The proposed architecture provides Low Cost IoT System for Solar Panel Power Monitoring. A suitable association between software and hardware has been implemented to finally design an efficient and real-time measurement system. This solution can also be extended or applied in other applications, especially in research or for education purposes.

References

[1] Swan, M. (2012). Sensor mania! the internet of things, wearable computing, objective metrics, and the quantified self 2.0. Journal of Sensor and Actuator networks, 1(3), 217-253.

[2] Ratasuk, R., Vejlgaard, B., Mangalvedhe, N., & Ghosh, A. (2016, April). NB-IoT system for M2M communication. In 2016 IEEE wireless communications and networking conference (pp. 1-5). IEEE.

[3] Ansari, A. N., Sedky, M., Sharma, N., & Tyagi, A. (2015, January). An Internet of things approach for motion detection using Raspberry Pi. In Proceedings of 2015 International Conference on Intelligent Computing and Internet of Things (pp. 131-134). IEEE.

[4] Kelly, S. D. T., Suryadevara, N. K., & Mukhopadhyay, S. C. (2013). Towards the implementation of IoT for environmental condition monitoring in homes. IEEE sensors journal, 13(10), 3846-3853.

[5] Hassanalieragh, M., Page, A., Soyata, T., Sharma, G., Aktas, M., Mateos, G., ... & Andreescu, S. (2015, June). Health monitoring and management using Internet-of-Things (IoT) sensing with cloud-based processing: Opportunities and challenges. In 2015 IEEE International Conference on Services Computing (pp. 285-292). IEEE.

[6] Patchava, V., Kandala, H. B., & Babu, P. R. (2015, December). A smart home automation technique with raspberry pi using iot. In 2015 International Conference on Smart Sensors and Systems (IC-SSS) (pp. 1-4). IEEE.

[7] Shrihariprasath, B., & Rathinasabapathy, V. (2016, February). A smart IoT system for monitoring solar PV power conditioning unit. In 2016 World Conference on Futuristic Trends in Research and Innovation for Social Welfare (Startup Conclave) (pp. 1-5). IEEE.

[8] Adhya, S., Saha, D., Das, A., Jana, J., & Saha, H. (2016, January). An IoT based smart solar photovoltaic remote monitoring and control unit. In 2016 2nd international conference on control, instrumentation, energy & communication (CIEC) (pp. 432-436). IEEE.

[9] Salhaoui, M., Arioua, M., Guerrero-González, A., & García-Cascales, M. S. (2018, June). An IoT Control System for Wind Power Generators. In International Conference on Information Processing and Management of Uncertainty in Knowledge-Based Systems (pp. 469-479). Springer, Cham.

[10] Spanias, A. S. (2017, August). Solar energy management as an Internet of Things (IoT) application. In 2017 8th International Conference on Information, Intelligence, Systems & Applications (IISA) (pp. 1-4). IEEE.

[11] https://iotbyhvm.ooo

[12] www.arduino.cc