Short Research Article

APPLICATION OF INTERNET OF THINGS (IoT) IN NIGERIAN POWER GRID MANAGEMENT

Abstract

The importance Internet of Things (IoT) in managing the Nigeria 330kV power grid cannot be overemphasized. The nation's power sector has been deviled with problems ranging from low voltages to total system collapse. There have been efforts to reverse the negative trends. One of the efforts was the development of robust modern technologies to monitor and control the systems in real time. Another challenge of note is the lack of visibility with the grid controller, which can be compared to driving a car with blurred windscreen. The existing SCADA system has lower coverage and parades about 22% visibilities to control operators. Internet of things (IoT) is machine to machine connection via the internet for the purpose of controlling, monitoring and exchanging information. A lot can be achieved via IoT like controlling remote actuators, sensing of remote device's parameters such as temperature, position, voltage, current, and power. It helps controllers at the master stations or control centers to make informed decisions for better grid stability. The paper explains the design and implementation of the IOT based solution to the problems. It describes its components and deployment in twenty-nine power stations in Nigeria. The paper discloses that the application of the homegrown solution has brought visibility and stability to the Nigerian power grid network.

Keywords: Controller, Grid Monitoring, IoT, Power, SCADA,

1. Introduction

Today, the Nigerian electricity grid is faced with enormous challenges, one of which is lack of visibility to grid monitoring by operators. According to reports from task team for network automation system, the existing SCADA system on the National grid has 56.3% coverage out of which only 22.3% is visible to the National Control Centre (NCC) [1]. Grid monitoring without a clear view of field parameters is challenging which oftentimes has led to instability and system collapse. The cost of running the grid in this manner is very high [2]. The need for a remedy is apparent, hence the design and deployment of Internet of Things (IoT) technologies as a stop-gap solution for real-time grid operation, this will give the grid operators a field view of grid parameters; power flow direction, real power, reactive power, current and voltage on the dashboard at the National Control Centre (NCC). IoT refers to the occurrence of interactions between the physical and digital world through the usage of sensors and actuating devices [3]. In other words, indicate devices that work by connecting them to the internet. It involves sending and acting on data they obtained from their surroundings using embedded sensors, processors and communication hardware [4].The term was initially coined in the early 2000s. and formally recognize in 2005 by the international telecommunication union (ITU) [5]. ITU defines IoT as smarts objects that are connected to the internet and communicate to each other with minimal or no human intervention"[5].Advancement in information technology, particularly the introduction of 5G, has increased the use of IoT by many industries to sense and control devices. Of special interest in this paper is how it is applied in the power industry for grid monitoring and control. IoT has several advantages over conventional means of monitoring in terms of cost of implementation, design simplicity, footprint, speed and abstraction. In this paper, Application of Internet of Things (IoT) in Nigerian Grid Management has been carried out at National Control Centre (NCC) and the result of the implementation has been illustrated. The IoT devices were installed at twenty-nine remote stations not captured by the existing Supervisory Control and Data Acquisition (SCADA) system. The Dashboard and Server were installed at National Control Centre (NCC), Oshogbo. This paper is structured as follows: Section 2 describes the methodology; section 5 illustrates the results and section 6 concludes the paper.

2. Methodology

To achieve the task of managing the grid with IoT, computer aided system engineering was deployed. Hardware and software development were applied. JLCPCB online web application was used for the printed circuit board (PCB) design while espressif microcontroller hardware board was engaged for the field controllers, C++ programming language was employed to write the controller firmware, Html, JavaScript and CSS technology were used for the dashboard display design and Nigerian Mobile Network Operator routers were deployed as internet sources for the field devices.

3. Explanations on System's Components

3.1 The controller

The system controller comprises a wireless module card, communication protocol card, power supply unit, reset unit and status LED indicator (fig.1). It is designed for the real time monitoring of power parameters of the electric circuit. It collects power parameters (Current, Voltage, Active Power and Reactive Power) and sends them to the server for real time monitoring. The unit also interfacesthe Power Meter with the server.

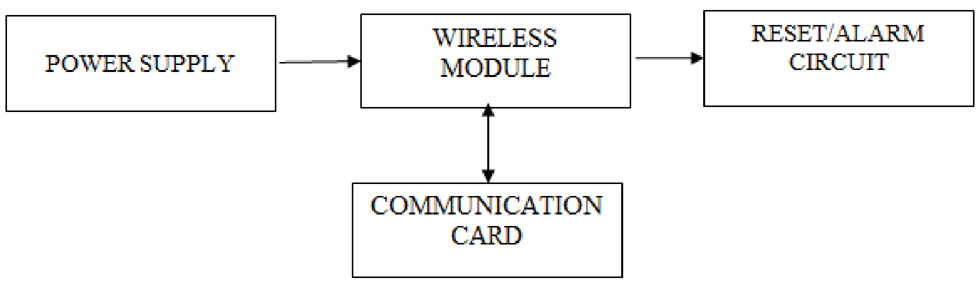

Fig. 1: System's block diagram

3.2 Wireless module

ESP8266 (fig. 2) (also called ESP8266 Wireless Transceiver) is a cost-effective, easy-to-operate, compact-sized & low powered WiFi module, designed by Espressif Systems, supports both TCP/IP and Serial Protocol [6]. It's normally used in IOT cloud based embedded projects and is

Fig. 2: A Wireless module

considered the most widely used WIFI module because of its low cost and small size. It runs at an operating voltage of 3V and can handle maximum voltage of around 3.6 V, so an external logic level converter is required if you are using 5V supply [6]. ESP8266 Wi-Fi module can easily be interfaced with microcontrollers board (Arduino UNO) [7] Serial Port. It is a major development in terms of wireless communication with little circuitry. and contains onboard regulator that helps in providing 3.3V consistent power to the board

3.3 Communication card

The communication card used in the controller is RS485 card (fig.3). RS485 to TTL Module (supporting EIA-485 standard) is for long range, high data rate error prone differential communication. Digital

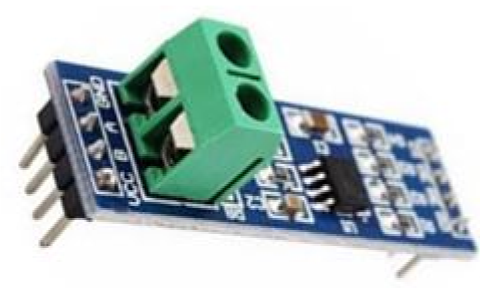

Fig. 3: A Communication card

communication networks implementing the EIA-485 standard can be used effectively over long distances and in electrically noisy environments. It has long distance error if wired communication is used due to losses and the communication cable used. Also, it can transmit high data. It is cost Effective [8].

3.4 The printed circuit board design

JLCPCB online web application is a popular printed circuit board design application [9]. When the design was concluded online, it was submitted to the JLCPCB factory in China for mass production of the PCB (fig.4). The production and shipping to Nigeria usually take about two weeks.

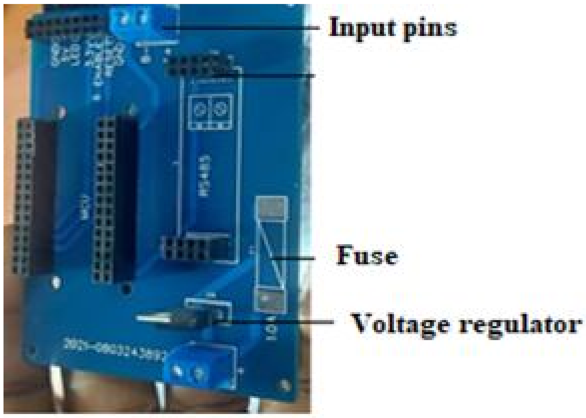

Fig. 4: A PCB showing pins

3.5 The hardware development

Various components of the controller were assembled and placed in a plastic casing to make up the hardware part. In the same vein, power quality meters were installed at designated power stations to read out the amount of power quantities (Active and Reactive) in the system, the information obtained were transmitted to the server through a Nigeria mobile communication link [10].

4. Deployment Summary

To enhance reliable system operations in every power station where the IoT was deployed the following steps were carried out:

Fig. 5: An assembled IoT controller module

The power station's single line diagram SLD were analyzed in order to understand the station's arrangement.

(a) Locating the control panel and determination of where the meter and controller will be installed.

(b) Study of the control panel diagram to locate where termination will be done.

(c) Marking, Cutting and Filling of the portion of the control panel where the Meter is to be installed.

(d) Termination of CT and VT for the Meter.

(e) Termination and connection of the power supply to both the Power Meter and the Controller

(f) Mounting of the controller (fig. 5) and the Internet Modem

(g) Termination and Connection of communication link at both the Meter and the Controller

(h) Application of Outage on the line which the Meter is to be Installed On

(i) Connection of the Meter is completed and checked for Errors

(j) The Meter is Configured

(k) Configuration of the Micro-Controller Chip

(l) Readings from the newly Installed Meter were compared with the Line Meter

(m) Transmitting of the readings to the server

5 Results and Observation

The project was initially installed at the Oke- Aro transmission station in Lagos Nigeria. Table 1 shows the reading on the live 330kV taken from the developed IoT monitoring system. The reading was found accurate. Tests were carried out to establish good working condition of the system. The success led to the installation of the device in other 29 stations spread in the country.

Table 1. Reading obtained from the monitoring system.

Parameters	Units	Values
Active Power	MW	138.87
Reactive Power	MVAR	30.39
Voltage	kV	311.18
Current	A	262.71A

The application of Internet of Things to the Nigerian Grid Network resulted to increased visibility from 22.3% to 47.2%

6. Conclusion

In other to eliminate the stress involved in running the grid system blindly, there is the need for more IOT based Grid Monitoring System to be deployed in the entire grid network to serve as backup to the conventional SCADA system. This is typically a monitoring system whose function is to extract field readings and upload them. It is unique and locally made to save enormous cost at uncompromised efficiency and standard. The IoT based Grid Monitoring System is needed in every Substation because of the following advantages: The controller is reliable, durable and affordable. Its ability to provide immediate live readings. It is recommended that further work be done on the design to bring down the cost to negligible value.

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