

GSM Based Power Plant Temperature Remote Monitoring and Control System with Real Time Data Acquisition

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Abstract

This paper presents a GSM based Power Plant Temperature Remote Monitoring and Control System with Real Time Data Acquisition. Power Plants used in the Industries are powered ON steady to carry various loads twenty-four hours each day. This requires real time remote monitoring of the system's parameters to avoid system breakdown or malfunctions. Research pointed out that one of the main challenges of a power generating plant is accurate failure prediction. This has been a serious challenge and to tackle this challenge, a system that will monitor, acquires data and control power generating plant remotely in case of any serious change in the plant's parameters to avoid failure or malfunctioning via GSM is proposed. The system is divided into hardware and software. The hardware part includes a temperature transducer (LM35) which takes raw measurement and generates analog signals to an Analog to Digital Converter (ADC), the digitized output of an ADC goes into a programmable micro-controller, and the micro-controller is programmed to communicate the data to a GSM module through RS-232 serial communication protocol. The software part used agile method of Software development life cycle and the program written using C-language with (PHP/HTML) for web page development. The system is tested and the results shows that the GSM module transmits measured parameters to the web-based platform and also sends processed values as an SMS to the power plant operator's GSM accordingly. The system also backs up the parameters to the SD card integrated in the system for future use and further predictions. A real time graph of temperature against time is plotted to showcase the system performance and guide to the power plant operator on the power plant health.

Keywords: Remote Monitoring System, Real-time Data Acquisition, GSM, HTTP, HTML, PHP, SQL, Database.

1.0 Introduction

In years past, remote monitoring, data acquisition and control finds its applications in many industries such as Power plants, Factories, Homes, network operation centers, Airports, smart grids, Spacecraft, Pipeline, train control, structural health monitoring, patient monitoring, Desktop/Server monitoring etc. Remote monitoring equipment helps to schedule maintenance to reduce failure rate. Discovery had shown that maintenance make up to 15-40% of the total product cost (Wireman, 1994). With remote monitoring, certain plants' operating factors are measured, saved, and processed for purposes of control. In previous years, manned operators took these measurements manually; hence, the reliability of accurate records is compromised because of fatigue or ineptitude of the operators. Sometimes, operators required within the plants vicinity could be outrageous, leading to excessive overhead cost. Considering UNIPORT power plants in Abuja Campus, with operating temperatures of 0-80 Degree Centigrade ($^{\circ}\text{C}$), any attempt for the plants to exceed this temperature limit result to Engine shut down. Consequently, a total collapse of the engine would require a complete overhauling of the plant. Reasons for temperature hikes could be due to Shortage of oil in the Engine or Overload. However, monitoring the temperature remotely, real-time and applying necessary control would mitigate if not completely eliminate the above shortcomings.

The relevance of remote monitoring cannot be over-emphasized. The traditional method of data communication through cable has various limitations, which include; complexity of network, cost of installation, limited coverage, cost of maintenance, human dependent coupled with human errors in taking measurement. However, the scheme of remote monitoring mechanism is to obtain real-time measurement, make measurement possible in areas inaccessible to humans, eliminate errors during measurement, reduces labor cost and shutdown of the users' system remotely. For an organization of any size to remain viable in today's market, a strong and efficient network is vital. Entrepreneurs and Managers are always in search of new solutions in making their businesses as competitive as possible. So, in the current economic challenges where business owners are facing limited resources and shortage of qualified and suitable man power especially in Information and Technology (IT) management, remote monitoring presents an effective solution to achieving the desired results and as well reduces costly down time.

2.0 Researched Related Works

(Malik et al., 2009) in their project brought to limelight "SMS based infrastructure for controlling of home appliances". This was done remotely through personal computer and GSM modem, which allow the capability of

sending and receiving SMS. Also, (Subhani, et al 2013) in their project, “Implementation of GSM Based Heart Rate and Temperature monitoring system”, introduced a device that monitors and controls the temperature and heart beat rate. The temperature readings and heart beat rate however read on the GSM device and further sends the data to the hospital where the doctors can read and give required administration or preliminary precautions as this helps to break distant proximity barriers. Furthermore, (Bulli et al 2015) in their project, GSM based Agriculture Monitoring and Controlling System, proposed a framework, checking data on a farm or rural environment by using wireless sensing element network (WSN) innovation. The following ecological parameters were measured: temperature, luminance, humidity, pH, CO₂, with the aid of Keil Micro Vision, the data is ascertained and viewed on the GSM device of the farmer who observes it and takes the necessary precautions or actions. However, there seem to be some sustained gaps in their designs because the devices utilize only the SIM network means of transmitting information and may not be reliable alone, especially where there are poor mobile network services. Alternately, this article bridges these gaps because the proposed device explores more options on information and data transmission thereby ensuring more reliability and alternative means of collecting data, which include liquid crystal display (LCD), web page database; and SMS to the plant operator who then carries out the appropriate operation. The device has the ability to initiate a control to shut down the plant if temperature exceeds pre-set value. There is also a backup of data in an external device (SD card) in the event of network failure.

3.0 System Design

The System’s design consists of hardware and software. The hardware section comprises of five modules that make up the entire system: the power supply unit, the microcontroller unit, the SD Card unit, the GSM communication unit and the LCD Display unit as shown in Figure 1.

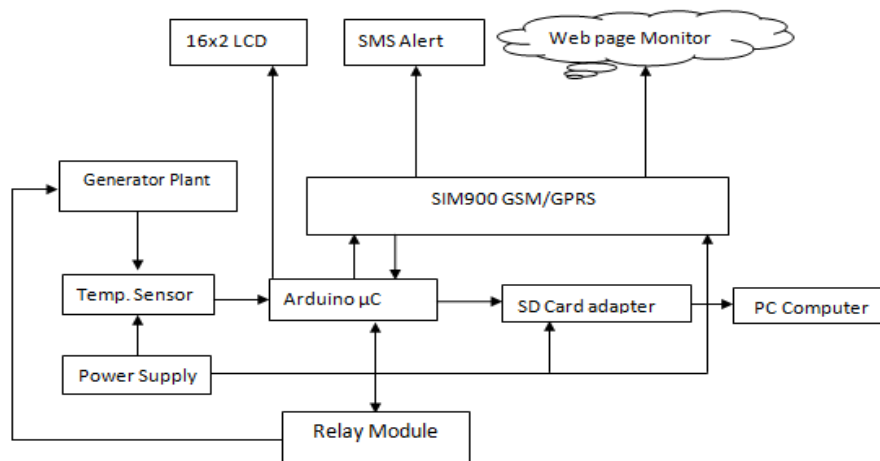


Figure 1: The System block diagram

3.1 System Modules Implementation

The brain of the system is the Arduino Uno microcontroller that controls the entire system. Different modules were carefully designed and implemented based on system specifications shown in figure 2. Components were assembled on a bread board (figure 3) before finally transferred to Vero board for final testing.

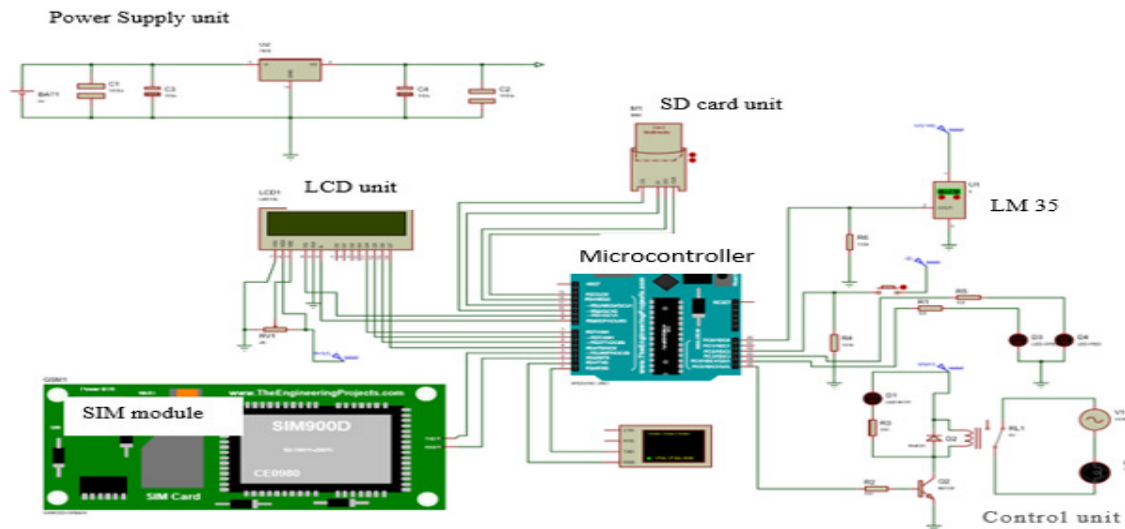


Figure 2: The system circuit diagram

A. Power Supply Unit

A 9-volt battery is used and its output passed through a voltage regulator, 7805 that keeps the terminal voltage of the dc supply constant at an output of 5V. The 5V is used to powers all the circuit for normal operation. The 7805 regulator can deliver up to 1.5 A as throughput current.

B. Liquid Crystal Display (LCD)

A 16x2 LCD is used in the design which can show 16 characters per line and two (2) of such lines exist. Each character displays in 5x7-pixel matrix. The LCD displays real time temperature value captured during system operation hours. It also detects and displays the status of the SD card when inserted for backup data storage.

C. Temperature Sensor LM35

The LM35 is a precision integrated-circuit temperature-sensing element. Its output voltage is linearly proportional to the Celsius temperature. It has benefit over linear temperature sensing elements calibrated in °K, as there is no need for unnecessary mathematical computations to convert from its output to obtain centigrade reading. It offers exactness of $\pm 1/4^{\circ}\text{C}$ at room temperature and $\pm 3/4^{\circ}\text{C}$, over a full -55 to $+150^{\circ}\text{C}$ temperature range. The output varies linearly with temperature and issues an output of 10milli volts per degree centigrade. LM35 senses temperature and sends analog output to the ADC for further processing.

D. The Microcontroller Unit

This unit is responsible for driving the entire system. It is the brain that controls every other peripheral that is interfaced to it. The Arduinos Uno microcontroller was selected for this project because, though small and portable in size, it is complete and breadboard-friendly board based on the ATmega328 AVR microcontroller. The microcontroller controls the GSM engine by sending AT Command via its serial interface. It also receives measured temperature data from LM35 and issues control commands to the relay modules for proper action and control.

E. SIM900 Module

The SIM900 GSM module receives and echoes AT commands back to Arduinos microcontroller via its USART Rx and Tx pins respectively. Meanwhile, the Hardware defined serial on Pin0 and Pin1 of the Arduinos microcontroller is used to mimic computer to Arduinos communication using the Arduinos serial monitor. This communication is made possible via the USB to serial converter embedded in the Arduinos board. Since a computer program defined serial is used in this project, Pin2 on the Arduinos board is used as the serial transmit pin (Tx pin) and Pin3 as the serial receive pin (Rx pin). SIM900 GSM module is also responsible for transmitting data to wireless devices.

F. Relay module

This control section is activated to shuts down the plant as soon as temperature exceeds pre-set limit. It consists of an electromechanical relay and an NPN transistor BD139, which has a gain of approximately 98 to achieve an amplified current of 100mA (from datasheet) suitable to energize the relay.

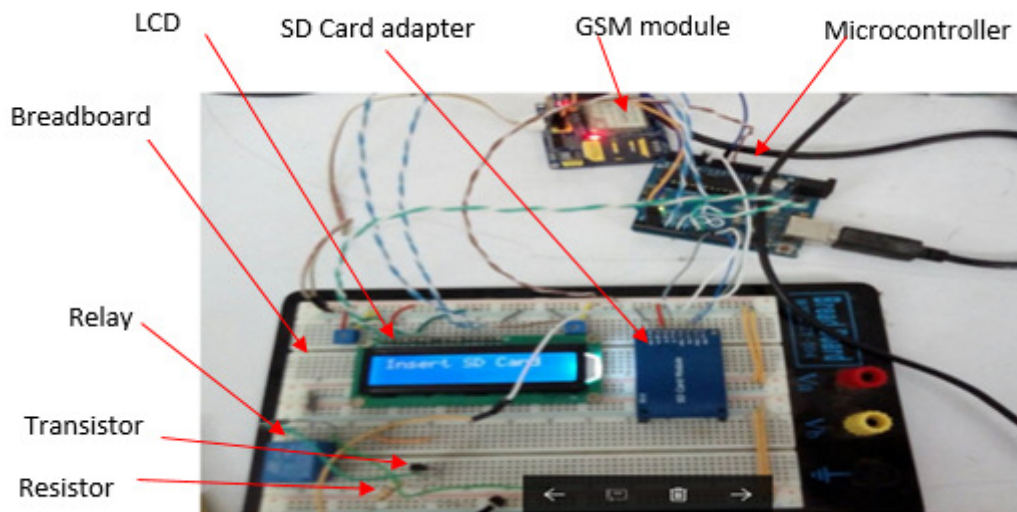


Figure 3: Breadboard implementation of the system

3.2 System Software Design

The system program is developed using the algorithm flow chart (figure 4) and a web-page script written to stores and queries data from the database for further processing. The algorithm flow chart to send temperature data to the web page is shown in figure 5. Different programming languages PHP, HTML, JavaScript and SQL were used for web and database design, while C and C++ were used for Arduinos microcontroller programming. In figure 4, as soon as the system is switched ON, the timer initializes, the microcontroller reads analog temperature value from the temperature sensor (LM35), converts it to temperature in degree Celsius, and sends to the web page. It also compares the measured temperature with the set point value (80°C), if the temperature is equal to or greater than set point value, a critical temperature alert is sent via SMS to a mobile phone to alert the operator. As far as the temperature remains below the set point value, if the timer is below 10 minutes, the micro controller continues data acquisition from the temperature sensor, but, if the timer is equal to or greater than 10 minutes, data is logged into SD card until the STOP button is pressed before the system returns to idle mode. Figure 5 illustrates web page algorithm flow chart. When temperature data is sent to the web page, it is acquired through http and sent to the database. When the database is queried successfully, data is processed and either displayed current data on the web page, displayed logged data on the displayed page or export a downloadable data format to an excel file. But if query is unsuccessful, no result is processed and no display of temperature data.

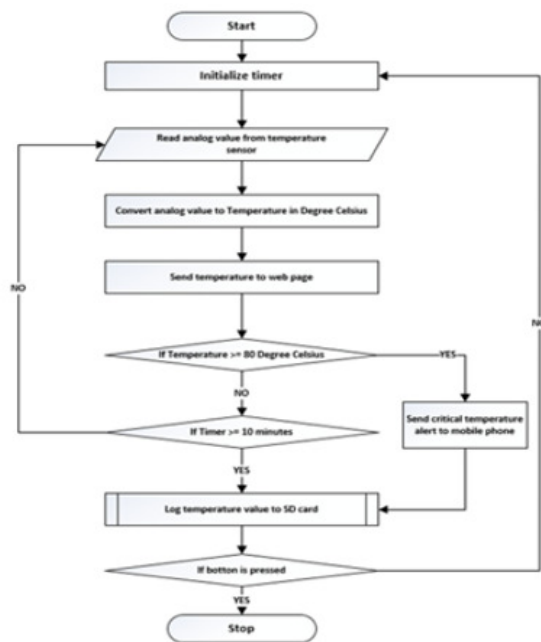


Figure 4: Microcontroller control algorithm diagram

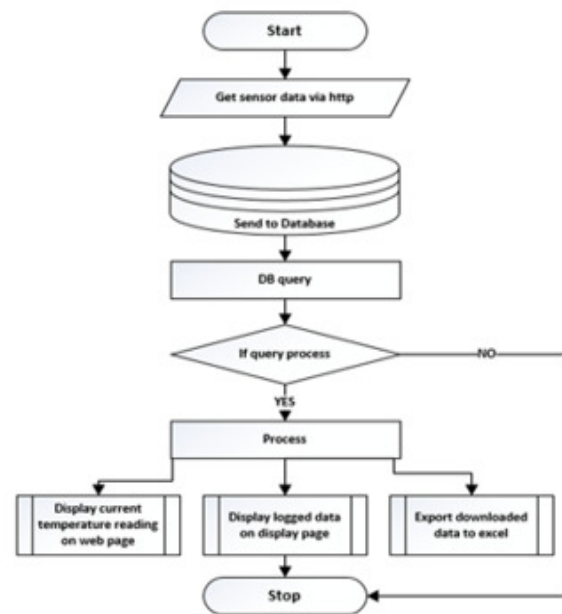


Figure 5: Web page algorithm flow chart

4.0 System Result

Simulation was carried out in Proteus 8.1 Integrated development Environment to see the visibility of the proposed system before carrying it on bread board. The relay is connected to the load in the normally close position to keep the plant running when the device is in idle state. This is ensured by keeping Pin A5 of the Arduinos microcontroller low unless in a critical temperature condition where the pin is triggered to the high state. LM35 has two buttons; increments (+) and decrements (-) that is used to vary the temperature for the sole purpose of analysis. The Arduinos microcontroller acquires the Temperature values using the Temperature sensing element connected to Pin A0, the analog output of this Temperature is converted to its voltage equivalent and then to the actual Temperature value in degree Celsius. This Temperature value is sent to display on the LCD and transmitted to the web page using the Arduinos Serial communication (USART) to SIM900 and then to the web Uniform Resource Locator (URL). The microcontroller monitors and logs the plant temperature to the SD card every ten minutes for backup storage for the purpose of offline data retrieval, and sends an SMS alert to the operator and finally shuts down the plant after five minutes by triggering the relay connected to Pin A5 of the microcontroller. Simulation result obtained (figure 6) indicates that when the temperature of the plant is 77.15 °C, the Arduinos sends data to LCD and to virtual terminal showing an indication of data logged to SD card and web page.

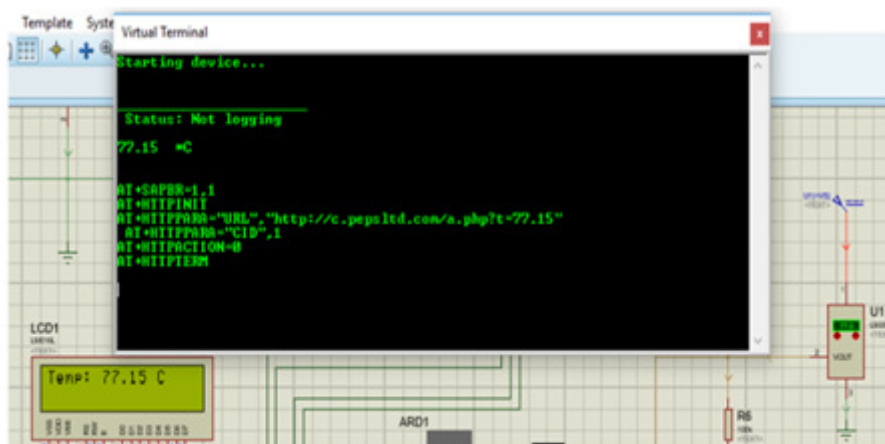


Figure 6: Temperature at 77.15°C sent to web page and SD card

Also, when the temperature of the plant reaches or exceeds the set temperature of 80°C, an SMS is sent to a mobile line (figure7) and after few minutes, the system shuts down the plant and returns to idle mode, LED1 comes ON indicating plant has shut down, while LED3 returns to ON position indicating infrastructure in idle

mode. LED2 indicates system in logging mode. LED1, LED2 and LED3 are shown in figure 8.

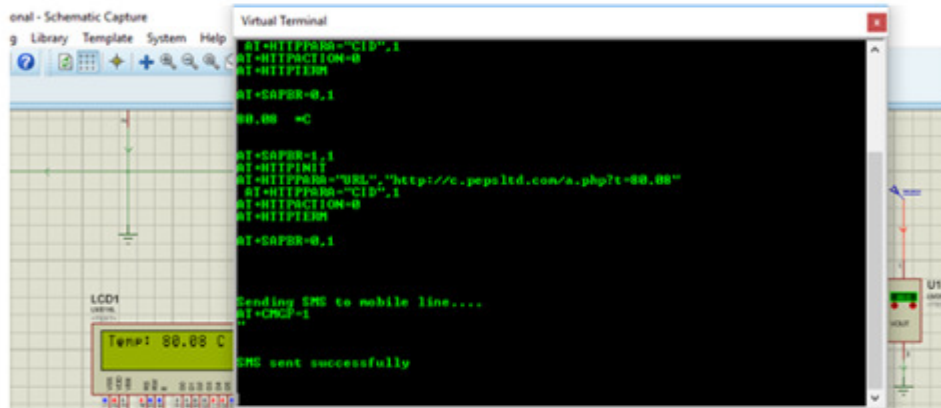


Figure 7: Temperature at 80.08°C sent to web page and SD card

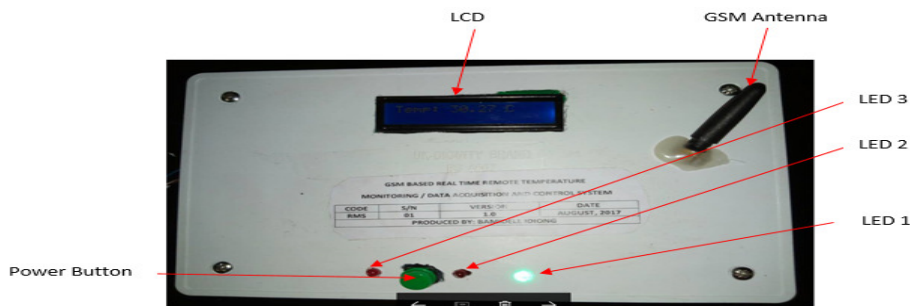


Figure 8: Implemented System prototype

4.2 Web Page Data Results

After carrying out various simulations, the entire circuitry was transferred from the bread board and soldered unto a Vero board. The device was then powered up; as the temperature sensor senses the plant's temperature, the SIM module transmits real time data to the database and also displayed real time temperature profile on the web page as shown in figure 9.

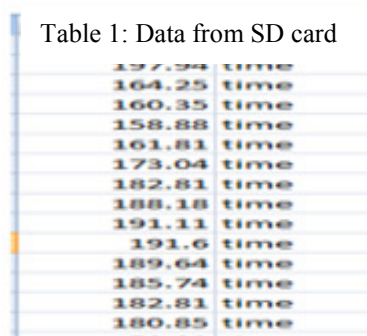


Figure 9: Captured Real Time Temperature profile

4.3 Data from SD Card

During data logging, data was also logged into an SD card to serve as a backup in the event of network failure. The data obtained were purely temperature values (table 1) without indicating the time of data acquisition. This is the challenge in the work which could be overcome by introducing a real time clock (RTC) for time stamping.

Table 1: Data from SD card



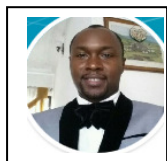
157.74	time
164.25	time
160.35	time
158.88	time
161.81	time
173.04	time
182.81	time
188.18	time
191.11	time
191.6	time
189.64	time
185.74	time
182.81	time
180.85	time

5.0 Conclusion

This article presented a research work carried out on the development of a GSM based real time remote temperature monitoring and control system for power plant. A prototype and simulations were developed to buttress the operability of the proposed system. The system was designed, simulated and developed. The platform deployed offers real time data acquisition, with data logged into an SD card. An SMS is sent to the operator as a means of alerting when the temperature exceeds set point before shutting down the plant. The approach applied in executing this work offers redundancy in temperature measurement; the GSM/GPRS approach gives wide area coverage, high data transmission speed and offers less cost. SD data serves as a backup for data recovery in the event of network failure. However, the data obtained from SD card was purely temperature values without indicating the time of data acquisition. This is the challenge in the system's design, which can be overcome by introducing a real time clock (RTC) for time stamping.

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Bamidele Idiong was born on 10th November, at Surulere in Lagos State, Nigeria. He obtained a Higher National Diploma in Instrumentation and Control Engineering from Petroleum Training Institute, Effurun, Delta State and emerged as the best graduating student in 2004 academic session. After his National Service in 2006, he joined Schlumberger, an Oil Servicing Company same year. In the course of his service in the industry, he received technological trainings in major cities in the world including Houston Texas, Fuchinobe in Japan, Scotland, Paris and United Arab Emirates. Due to his zeal in academic pursuits, he quits from his job and moved to the United Kingdom where he obtained a Bachelor degree in Electrical and Electronics Engineering from the University of Sunderland in 2012, with a first class honor of 4.0/4.0 CGPA and became a member of Institute of Electrical and Electronics Engineering (IEEE) same year. He later rejoined Schlumberger International and worked as a Production and Centre for Reliability and Efficiency (CRE) Supervisor for Angola, Ghana, Ivory Coast and Remotes. In early 2016, he took a short break from service to pursue a Masters Degree Program in Electronics and Telecommunication Engineering in the University of Port Harcourt, Rivers State, Nigeria. In April, 2017 he rejoined Schlumberger Nigeria as a Technology Life Cycle Management (TLM) Supervisor till date. His research interest is Automation and Embedded Systems. He is married with two children (Jason and Jemimah).



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