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Development of ESP 32 Based Weather Monitoring System For Photovoltaic Yield Chariterisation In Delta State, Nigeria.

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ABSTRACT: *The yield from a given photovoltaic power system is always a function of varying atmospheric condition at the site of installation which may be different from the standard operating conditions stated by the manufacturer thus requiring the need to characterise the extent to which prevailing atmospheric conditions affect photovoltaic yield. Therefore, this research work is aimed at developing an ESP 32 basedweather monitoring system for the characterization of the yields of photovoltaic panel in the Delta State of Nigeria.*
To achieve this aim,design and fabrication of solar atmospheric monitoring system to measure temperature, humidity, light intensity of the atmosphere and voltage produce from solar panel was carried out. The system incorporate a DTH 11 sensor to measure the temperature and humidity of the environment and an LDR sensor for the light intensity measurement, the system also incorporated a voltage sensor for measuring the solar panel open circuit voltage. The output of the sensors are connected to an ESP 32 chip microcontroller board for processing based on the written C program. The sensed or measured environmental factor is then displayed on a LCD screen and also transmitted to the Thingspeak database hosted online at regular intervals
The developed Atmospheric monitoring system worked satisfactorily in monitoring and recording the varying atmospheric parameters as it affects the photovoltaic yield.
KEYWORDS*: Photovoltaic, Yield, Light intensity, Humidity, Temperature, sensors*

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I. INTRODUCTION

The energy from the sun are reliably converted into electricity using the PV modules and has aided the continuous supply of electrical power for various economic activities (Esan et al 2018). The intensity of solar radiation reaching the Earth's surface varies dramatically as a function of changing atmospheric conditions as well as the changing position of the Sun through the day (Chiemeka 2009). Accurate data of global solar radiation are necessary at various steps of the design, simulation, and performance evaluation of any project involving solar energy (Bengir et al 2019). There are several weather monitoring system used for the acquisition and monitoring of weather conditions for applications in several fields. Many previous design of weather monitoring systems incorporated PIC, ATMEL or Arduino microcontrollers as enunciated below. Ejodamen et al 2018 designed and developed an Arduino-Based Weather Monitoring System, TheArduino as an open-source platform enables easy development of electronics projects. The work comprised of a physical Programmable Circuit Board (PCB) and a software component (which is an Integrated Development Environment (IDE) that works in all known operating systems. The system developedwas mainly a weather monitoring system that only monitor temperature and humidity variables obtained from a DHT11 sensor. Pandikumar et al, 2013 in the article "Architecture of GSM based WSN for Greenhouse Monitoring System in Ambient Intelligence Environment" employed the GSM technologies which has been a rapidly developing wireless technology in the recent years. In the research work, The GSM based WSN was developed as an alternative to the old wired greenhouse network which made the measurement system expensive and vulnerable. Moreover, the cabled measurement points are difficult to relocate once they are installed. In the work sensors are used to sense climate parameters and transmit data through wireless communication. It was also a GSM-SMS based reporting system. Hamouda et al, 2018 designed a wireless system to monitor weather conditions as a useful tool to impact the human life daily. In the work, a wireless system was used to monitor the current environmental conditions such as humidity, temperature, wind direction, rainfall levels instantaneously store the collected data and compare data with the past gathered data to predict the future changes in the weather conditions. The work served as a pilot system for studying the escalating adverse effects of changes in weather conditions as it affects sustainable healthy and hygienic environment. The system was developed using Adruino DUE as the heart of the system and a GSM-module (SIM900A) as a wireless counterpart and other supportive sensors. KirankumarG.Sutar, 2015 describes a weather monitoring system which enables the monitoring of weather parameters like Temperature, Humidity and Light intensity. Sensor modules which included temperature, humidity and light sensors were used.The system developed incorporated a ZigBee wireless module. The measured weather parameters were Temperature, Humidity and Light intensity. The developed system was cost effective, compact and portable as opposed to the fixed weather station as Weather monitoring holds great importance and have uses in several areas ranging from keeping track of agricultural field weather conditions to industrial conditions monitoring. Weather monitoring plays an important role in human life, so the collection of information about weather changes is very important. Majharul ,2019 conducted a research that involves the deployment of internet of things in weather monitoring, In this research, a foundation is set for an efficient solution for tracking the weather conditions of a specific location and making the information available anywhere in the world. The technological advances behind this is Internet of Things (IoT), which is an efficient and effective solution for linking the things to the web and to connect the entire world of things in a network. The system included an alert section whose functions was to track and monitor environmental parameters such as temperature, relative humidity, light intensity, pressure and quantity of rainfall with sensors and whenever the output values of these parameters exceed a selected threshold limit for each, an e-mail, an SMS alerts the appliance owner to take the required steps. In 2012, Shachi andMor presented the principles of the measurement system for solar radiation, and implemented the concept of Web based data logging concept. In the work, photocurrent produced by Silicon PN junction is used as a solar radiation transducer, to make it more viable commercially available solar panels was used as transducers. It was shown that by using a silicon solar cell as sensor, a low cost solar radiometer could be constructed. The photocurrent produced by solar cell was electronically measured and stored by a web based data acquisition and monitoring system. Measurement using real solar cell array gave a good measure of the actual producible energy by solar arrays. Portable instrument was used in remote sites and substitutes the solar monitor and integrator, the result obtained indicated that by the use of simple sensors, the same measurements results can be obtained as using more expensive measurement systems like the pyrometer.Further more, Roneel V. Sharan 2014 presented a practical development of a Remote Automatic Atmospheric Station with a PCbased Data Logger. Several Parameters, air temperature, relative humidity, dew point, wind speed, and rainfall were measured and transmitted wirelessly to a PC for logging and display by means of a graphical user interface. His work indicated potentials applications for atmospheric data monitoring especially for renewable energy projects which require atmospheric data measurements at remote locations. However recent designs of IOT based system now incorporate the ESP 32. ESP32 became one of the most common MCU due to its versatile functions, it integrates a rich set of peripherals, ranging from capacitive touch sensors, Hall sensors, SD card interface, Ethernet, high-speed SPI, and UART. This MCU is commonly found in his module version ESP32-WROOM. The current designed weather monitoring system incorporates the ESP 32 due to these advantages it has over other generation of microcontrollers which will normally require the use of an add-on Ethernet shield. The ESP32 has Wi-Fi capabilities onboard. This makes the Esp32 more suitable for IoT projects.

II. MATERIALS AND METHODS

2.1 Materials

The materials and modules deployed in the realization of this research are as outline in the following sections. The Table 3.1 shows the list of components used in the research work

Table 3.1: List of Components used for the design

S/N	Part Type	Description
1	ESP 32	Having wi-Fi capability
2	DHT 11 Sensor	Humidity and Temperature Sensor
3	LDR	Light intensity sensor
4	Voltage sensor	Senses input voltage
5	LCD screen	Display system
6	Jumpers	Connections
7	Resistor	Limiting current
8	Mono solar panel	50 watts, 12Volts

2.1.1 ESP 32 Board

The ESP32 board is a family of low cost and low powered chip microcontroller designed with wifi capabilities. The ESP32-wroom with 38-pins board presented in Figure 1 was used for this work.

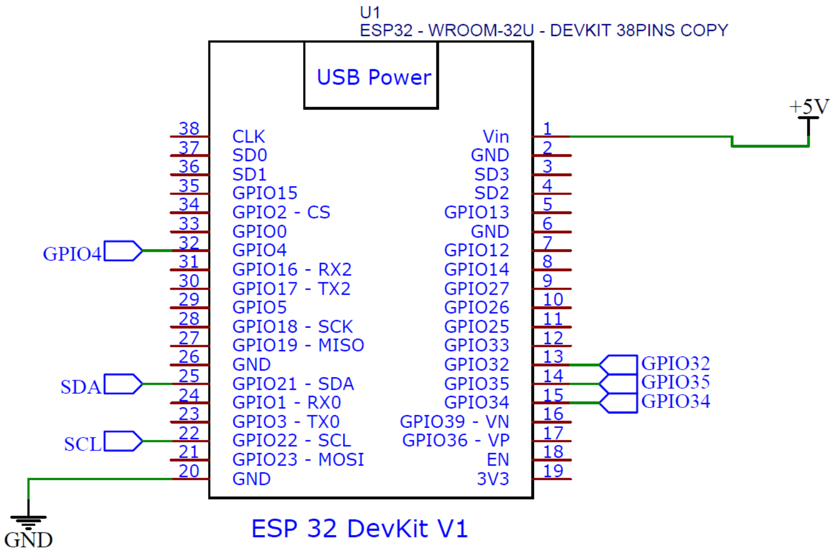

Figure 1: ESP 32 microcontroller circuit pin layouts and connections

2.1.2 Voltage sensor

Figure 2 shows the voltage sensor employed for this design, the Vcc and GND, labelled at the 2-pin screw terminals are connected to the positive and negative terminal of the solar panel.

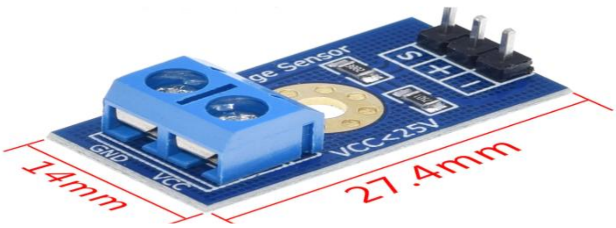

Figure 2: Voltage sensor

2.1.3 DHT 11 Sensor

DHT is an acronym representing digital humidity and temperature. The DHT11 sensor is from a family of DHT sensor used to measure humidity and temperature, it is a low-cost sensor. The DHT sensor consist of a capacitive humidity sensing element and an NTC thermistor for sensing temperature (NTC means negative temperature coefficient). Operating voltage of the sensor is between 3-5V with max current of 2.5mA max. Temperature range is between 0-50^{o}C with ±2^{o}C error margin. Humidity range is between 20-80% with ±5% error margin. Figure 3 shows the picture of a DHT sensor used for this work.

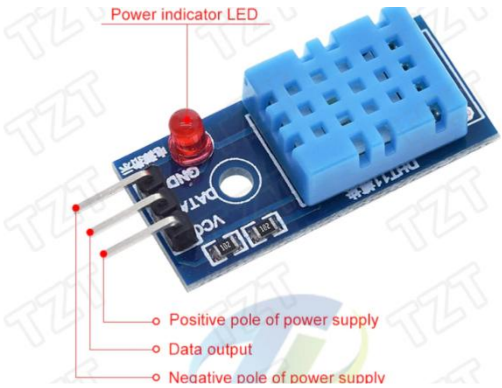

Figure 3: DHT11 sensor

2.1.4 Light intensity sensor.

Light dependent resistor (LDR) also called photo resistor, photoconductor or photocell is a type of resistor whose resistance increase or decreases depending on the magnitude of light rays falling on its surface. In this work, LDR was employed to measure the intensity of sun light and units were presented in lux. Figure 4 present the LDR used for this work.

Figure 4:LDR connection points

2.1.5 OLED display

The OLED display was incorporated in the design to aid visualization and also for update purpose. The parameter programmed for display on the OLED monitor are the light intensity (sunlight), temperature, humidity and the voltage. The OLED is 0.96 square inch in size with a resolution of 128 by 64 pixel. The OLED screen used in this work is as presented in Figure 5.

Figure 5: 0.96" OLED display

2.1.6 Solar Panel

Monocrystalline solar panel was employed for this research. It is known from literature that monocrystalline solar panel is more efficient compared to Polycrystalline. Figure 6 shows the panel used for this project. The solar panel is rated at 50W, it's a 12V solar panel with normal operating temperature of 25^{o}C.

Figure 6: Monocrystalline 12V, 50W solar panel.

2.1.7 Buck converter

The ESP32 module has a maximum operating voltage of +5V, same applies to DHT and voltage sensors . The device cannot be connected directly to the solar panel rated at 12Vdc to avoid burn out, the buck converter module was incorporated to step down the 12Vdc to 5Vdc. The XL7015 DC-DC step-down module was acquired for this task, it is highly efficient, with high-voltage step-down DC- DC converter. The board size, has a dimension of 16mm by 44mm. picture of the buck converter module is presented in Figure 7

Figure 8: 7W Bulk converter.

The ArduinoIDE was employed in programming the ESP32 microcontroller, using the C++ programming language. The OLED display was programmed to display the values of the sensors. Figure 9 shows theprogramme flowchart for designed monitoring system.

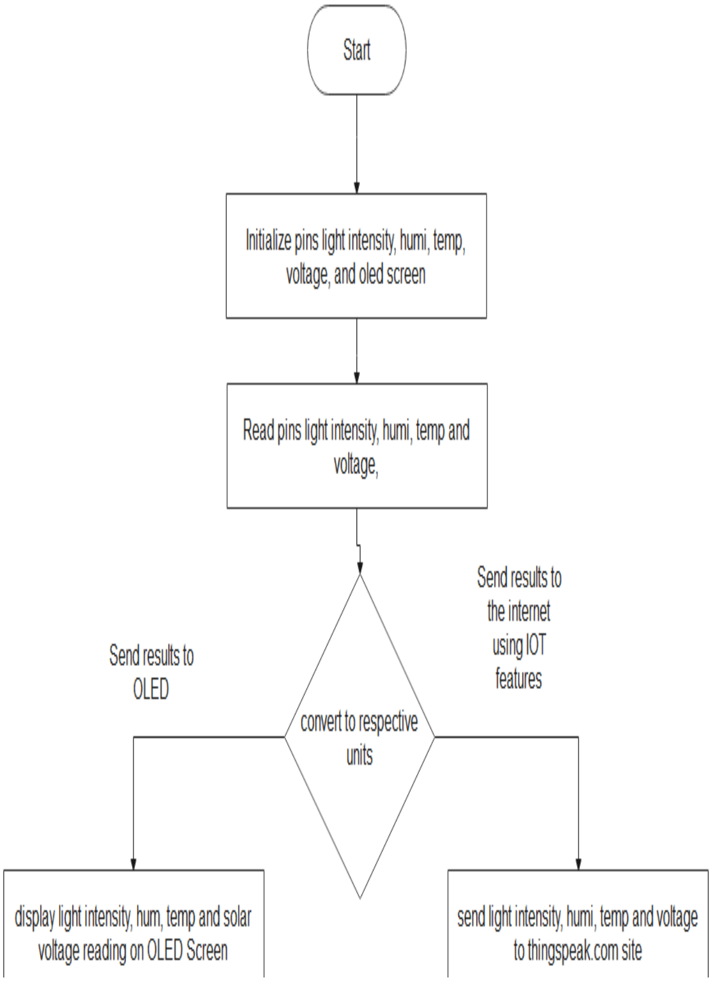

Figure 9: Program flowchart of operation

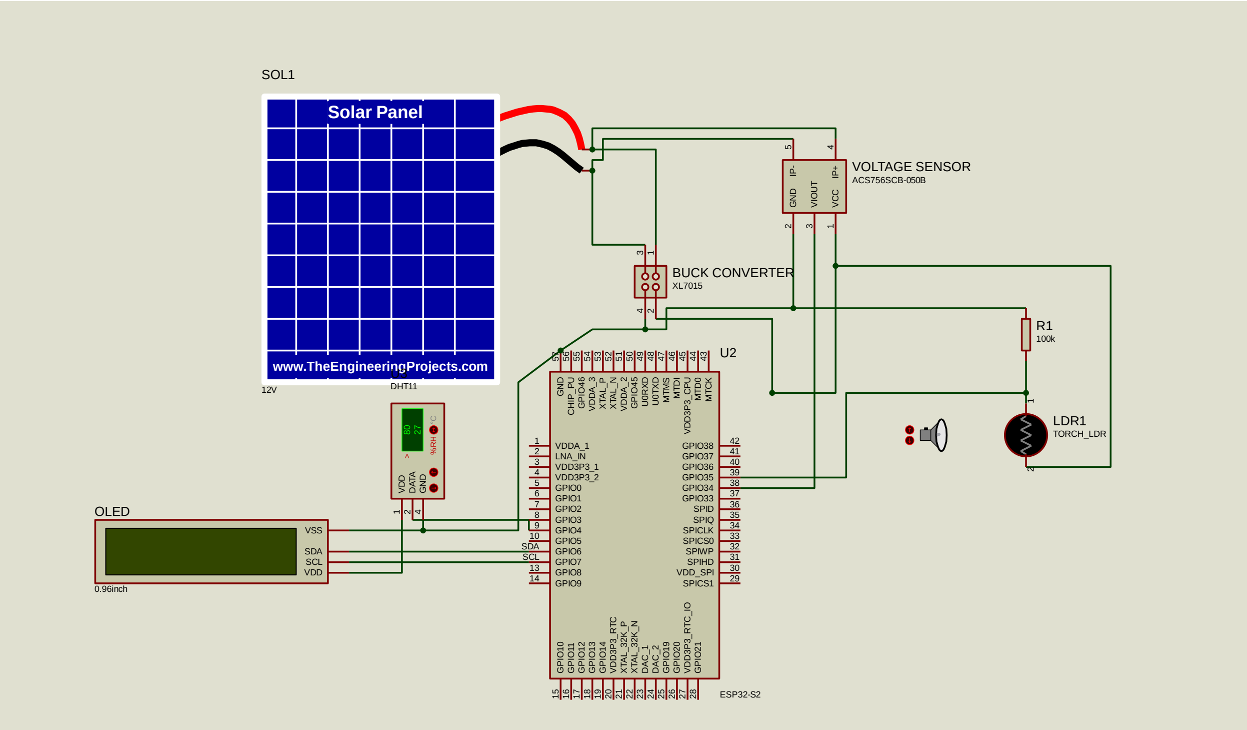

Figure 10:Circuit diagram of ESP 32 based weather monitoring system

The Figure 11 shows the picture of the constructed ESP 32 based weather monitoring system. It uses jumper cables to connect to the monitoring sensors

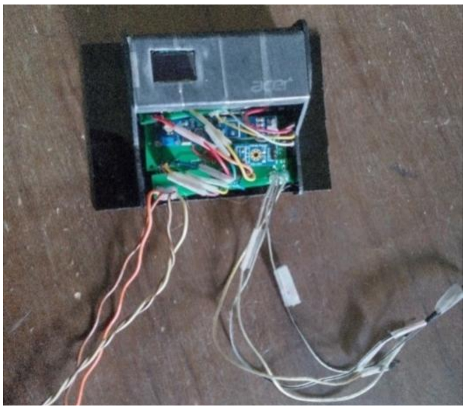

Figure 11:ConstructedESP 32 based weather monitoring system

2.2 Methods

The experiment to utilize the designed monitoring system is set up in an area where there is no shading of the panel by connecting wires from the panel and sensors to the indoor monitoring device. Daily cleaning of the panel is done to eliminate influence of dust on the surface of the panel. To effectively acquire data from the monitoring system, IOT based technique using thingspeak.com as website for logging the atmospheric information was employed. An account was first created on thingspeak.com (subset of MATLAB), then a new channel to host transmitted result was created.

III. RESULTS AND DISCUSSION

Presented in Figure 12 is the time series plot of solar panel output voltage (volts) for a given solar intensity (Klux), humidity (%), and temperature (^{0}C) monitored and recorded using the designed and constructedESP 32 based weather monitoring system. The data collected were logged on to thingspeak.com website for the months of January to December 2021.

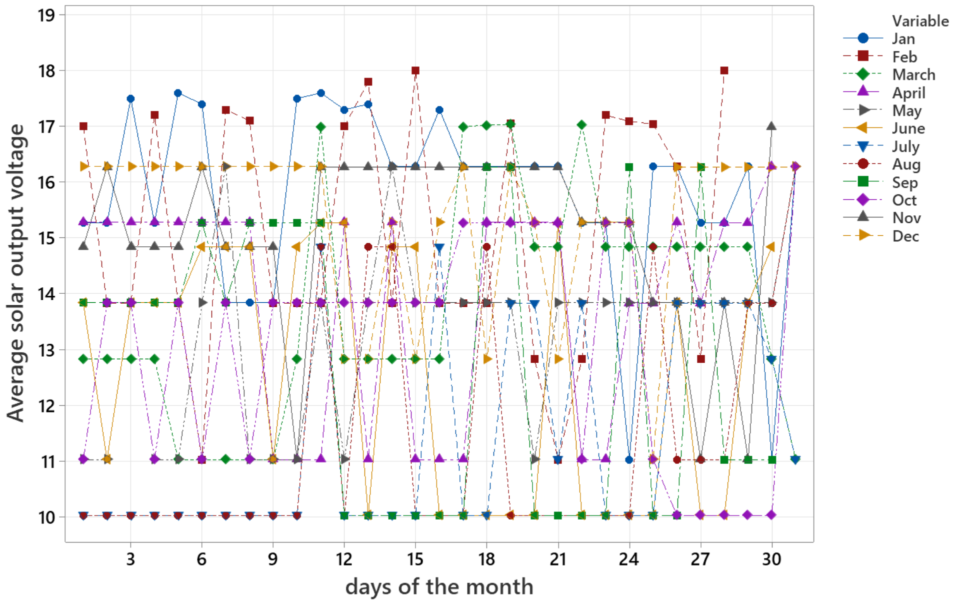

Figure 12:Collected data using the ESP based weather monitoring system

IV. CONCLUSIONS

The paper demonstrates the development and Implementation of photovoltaic yield Monitoring System used for studying the effect of weather conditions on the yield of a photovoltaic panel in the tropical region of Delta State, Nigeria. In place of conventional weather stations which lack sensors for measuring the effect of environmental parameters of interest on photovoltaic yield, the work incorporated simple electronic sensors for the development of the photovoltaic monitoring systems. The deigned photovoltaic monitoring system successfully monitored and measured the level of solar irradiance, temperature and humidity as it affects the output yield of a photovoltaic panels.

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