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DESIGN AND IMPLEMENTATION OF PHOTOVOLTAIC MONITORING ENERGY SYSTEM BASED ON TELECOMMUNICATION POWER BASE STATION APPLICATION

B.Z.S. Azzawi [1,2]   I.A.R. Al Saddaee [1,3]   M.E. Yigit [1]   M. Ari [1]

1. Department of Electrical and Electronics Engineering, Graduate School of Natural and Applied Sciences, Cankiri Karatekin University Cankiri, Turkey
eng.bassamalazawi@gmail.com, ahdoba33@gmail.com, eyigit@karatekin.edu.tr, mari@karatekin.edu.tr
2. Electromechanical Engineering Department, University of Technology, Baghdad, Iraq
3. Department of Electrical Power and Machines Engineering, College of Engineering, University of Diyala, Diyala, Iraq

Abstract- Every year, global energy consumption increases quickly. But the majority of energy production still involves using fossil fuels like coal and natural gas. In particular for remote areas, the goal of this work is to develop a reliable system to monitor the effectiveness of solar energy generation used to power communication towers. This paper offers details on a particular kind of solar energy system that can be utilized to power communication towers. Identification and programming of the electrical components needed to build an instrument circuit for this electrical system. Software for the system has been created and is currently in use. The development and testing of a full GPS remote monitoring system are now complete. By combining the monitoring system with the embedded GSM system, this work proposes an online monitoring solution for grid PV installations. Variables like PV output and grid inverter output are tracked to assess the efficiency and stability of the system. In addition to the capabilities for observing the inverter input and sending the outcomes for observation online. A specific application for smartphones has been developed to enable remote monitoring of the same data on the cloud in addition to uploading data to the cloud via GSM. Google's MIT App Inventor 2, a wonderful tool for learning mobile development, especially if you don't have a programming background, was used to construct the smartphone app. The drag-and-drop capability is simple to use, well thought out, and effective as a teaching tool.

Keywords: AC Sensors, SIM 900A GSM Module, Arduino UNO, IoT, ThingSpeak, PZEM-004T.

1. INTRODUCTION

At many Telecommunication cell sites, the management of AC power and battery levels continues to be problematic. The management of mobile base station cell sites by Nigeria's telecom companies is incompetent, and the owners of the telecom networks continue to lose money [1]. At each cell location, no number of one-person activities will yield the desired results. Human beings (Site Operators) are fallible and shouldn't be encouraged to work in situations where they might make mistakes. They were involved in the majority of site failures in the records as a result of slow response times, inadequate diesel tank fueling, a failure to detect tank leaks, etc.

The world's mobile phone towers now have solar panels installed on top of them, enabling the nation to transition to using fewer fossil fuels without incurring significant costs. Solar energy technology is developing. However, the best time for solar energy to create is during the day. To assure the availability of services, this requires energy storage in the form of batteries. By connecting to the internet and other services, telecom towers enable people to conduct business remotely [2], [3]. To be employed for a variety of tasks, the towers' power source must be dependable. The towers' solar panels will keep them powered even if the national grid fails, which will be an issue if it does so frequently [4].

The potential for sudden voltage dips and subsequent cutoffs, which happen without the end-user being aware of it, is a major issue for telecom tower operators. As a result, the output is reduced and essential electrical equipment, such as tower services, becomes inoperable. It is critical to understand that battery hydrogen gas is hazardous to the environment and human health [5] [6]. Therefore, features that can endanger public health and safety, such as variations in AC and DC voltage, must be watched for and eliminated. Two of the main causes of voltage variations that have been discovered are insufficient battery data visualization and the large number of devices that rely on batteries. Since they are unaware of the anticipated battery low voltage, they are unable to act quickly. Thanks to the Internet of Things, many businesses and individuals may now access data remotely (IoT). IoT is essential for remotely acquiring, monitoring, and analyzing information and responding appropriately [7].

The alterations in voltage and current pose a serious problem for telecommunication towers. These oscillations frequently result from poor management and a lack of a system for checking the DC and AC voltage levels. The current study [8] offers a battery voltage-level monitoring system for communication towers. In the suggested approach, the installed battery's voltage, current, AC voltage, and current sensors are accessible in real-time via a mobile app dashboard. An Arduino Uno microcontroller board is used to monitor and assess the data gathered from the sensors. GSM is a tracking and data-storage module that runs on the cloud. The recommended method enables continuous real-time monitoring of battery consumption and inverter output power while allowing for the remote retrieval of battery and inverter information. The new voltage-level monitoring system has been intended to eliminate the hazard posed by batteries in towers. Therefore, to lessen the dangers associated with voltage fluctuation, telecommunication tower engineers might utilize the suggested battery voltage level monitoring system [9]. Instead of using manual employees to control the process, technology would be more successful and effective. The major focus of this study is on the efficient Internet of Things (IoT) technology implementation strategy [10].

The data is immediately accessible and the system is simple to utilize. Utilizing this technical innovation, research has been done in several domains to evaluate, analyze, monitor, and calculate data for real-time sensing [11]. Monitoring batteries mounted in towers were frequently excluded from the analysis since they were only used to monitor specific geographic areas. A variety of monitoring tools have been used to track changes in battery voltage [12]. To maximize the usage of batteries as a cost-effective and sustainable source of energy, battery features that voltage variations may threaten have been identified. An Arduino microcontroller is used to monitor the battery's charge condition and anticipates how many more years of useful life it has as an illustration of a more modern technique. According to the research project's findings, battery health, charge status, discharge rate, and the battery's remaining useful life may all be evaluated in real-time [13], [14].

2. SYSTEM REQUIREMENTS

In order to transfer data over great distances at the most reasonable rate and for the longest battery life, this study focuses on the design and implementation of a modern system for monitoring the power activity of solar systems for communication towers. This system will use a GSM communication technique. Overcharging and discharging lithium-ion batteries can cause damage. High temperatures, gas leaks, fire, or explosion are possible outcomes of this kind. To prevent such violence, battery management, and control systems will be developed by monitoring the voltage, and current of battery and inverter.

The most important primary electronic components and software that will be used in the final circuit design to monitor the electrical power system in communication base stations will be covered in this section. The primary diagram for the suggested system is shown in Figure 1.

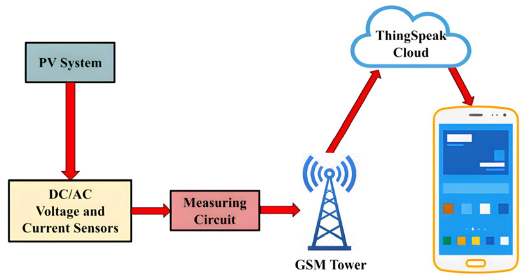


Figure 1. The proposed system's block diagram caption

2.1. Hardware Requirements

In this section, all the special electronic parts that are used in this paper will be discussed.

2.1.1. Microcontroller Unit

An core is found on the Arduino Uno microcontroller board in Figure 2. It has a reset button, an ICSP header, a power connector, a USB port, and a resonator operating at 16 MHzIncluded are 16 MHz resonators, USB connections, a power jack, an ICSP header, a reset button, 20 digital input/output pins, six PWM outputs, and six analog inputs [15].

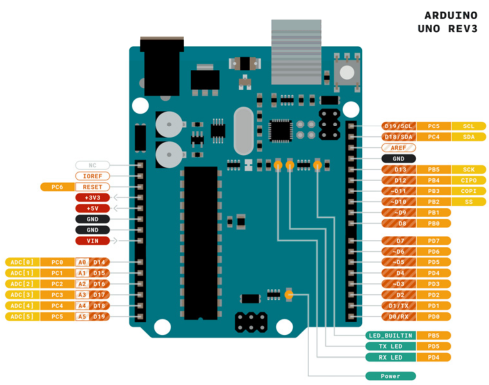


Figure 2. The Microcontroller unit (Arduino UNO REV3) [15]

2.1.2. DC Voltage Sensor Unit

This voltage sensor module, which is affordable and highly reliable, employs the same voltage division strategy Figure 3. The voltage sensor module can track voltages up to 25Vdc and has a resistance accuracy of 1 percent. The resistance of R1 is 30 kΩ, while the resistance of R2 is 7.5 kΩ [16].

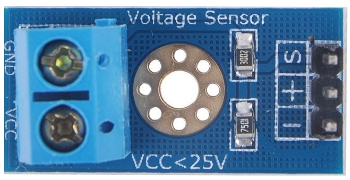


Figure 3. DC voltage sensor unit [16]

2.1.3. DC Current Sensor Unit

The ACS712 Current Sensor Module in Figure 4 is a typical current sensor for Arduino. It makes advantage of the hall-effect phenomenon, which is the generation of voltage by current flow inside a region of the magnetic field. Because the voltage generated by the hall effect is exactly proportional to the applied current, it is possible to determine the applied current from the measured voltage. The sensor can detect current flow in either direction. The sensor won't be harmed by a reverse current, but it will yield less voltage. The Arduino Analog input can only read positive integer values, as we are all aware. The zero point for measurements in two directions should be 2.5V, or half of the overall voltage range (0 to 5V). If the supply voltage of the sensor is 5V, then this is accurate [17].

Figure 4. DC current sensor unit [17]

2.1.4. AC Voltage, Current, and Power Sensor Unit

Applications that measure power usage are a choice for the Peacefair PZEM-004T Multi-function AC Power Monitor. Electrical quantities including voltage, current, power, and energy may all be measured using it. A perfect circuit for measuring AC voltage, current, and power (RMS) is shown in Figure 5. (single-phase). Using the code library, the device may simply connect with Arduino and other gadgets. A power supply (or the AC source you're monitoring) must be used to power the circular sensor and attach it to the circuit board. By passi the wire through the spherical sensor, you can gauge voltage, current, and power. A TTL to USB converter cable is included in the package to enable rapid connection to a computer or microcontroller [18].

Figure 5. The PZEM-004T [18]

2.1.5. SIM900 GSM Module

The SIM900 GSM/GPRS shield in Figure 6 is made to completely encircle the SIM900 chip with all necessary components for communication with Arduino as well as a few more goodies to make use of the chip's special features. Whether you want to make a covert call to turn on the irrigation system in your garden The SIM900 GSM/GPRS shield is a fantastic place to start with IoT if you want to remotely monitor what is occurring in the home [19].

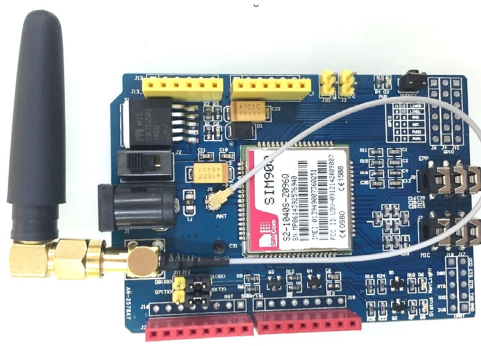


Figure 6. SIM900 GSM/GPRS shield [19]

2.1.6. 20×04 I2C LCD Unit

This is an Arduino-compatible 20×04 LCD module with a fast I2C interface Figure 7. It can display two lines of 20×04 characters with a white background and blue characters. The LCD will typically run out of Arduino pins. Six digital pins and two power pins are needed for an LCD. Making a robot project will be challenging due to the Arduino UNO and LCD [20].

Figure 7. LCD (20×04) units [20]

2.1.7. DC Power Supply Unit

The module in Figure 8 has a substantially easier life because of its options for 3.3 Volt and 5 Volt power supplies. You can now use a computer, a portable power supply, or a 12 Volt DC converter to power your circuit. The addition of this module should have a substantial positive impact on your electronic toolbox. On the left, are two power supply ports, a DC port, and a USB port [21].

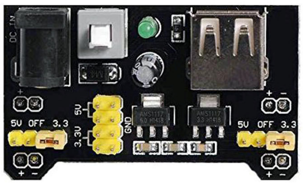


Figure 8. DC power supply unit [21]

2.2. Software Requirements

In this part of the paper, all open-source software that has been used will be presented.

2.2.1. Arduino IDE

Arduino is a platform for creating electrical projects that is open-source and cost-free. Your computer's IDE (Integrated Development Environment) application is used to generate and upload computer code to the physical board. A hardware-programmable circuit board, often known as a microcontroller, makes up the Arduino platform Figure 9 [22].

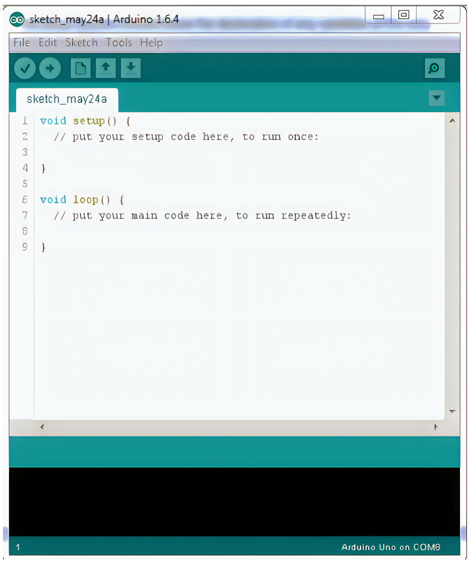


Figure 9. Arduino IDE Platform [22]

2.2.2. ThingSpeak Cloud

We can gather, evaluate, and analyze real-time data streams online with the aid of the IoT analytics service ThingSpeakTM. ThingSpeak immediately visualizes data that is transmitted by your devices to it. You may run MATLAB® code in ThingSpeak to do online analysis and analyze data as it is being received. ThingSpeak is frequently used for system development and proof-of-concept for IoT systems that need analytics Figure 10 [23].

Figure 10. The main website window of ThingSpeak cloud [23]

2.2.3. MIT APP Inventor 2

Anyone can design fully functional apps for Utilizing MIT App Inventor, a user-friendly visual programming environment, on smartphones and tablets. Beginners using MIT App Inventor may release their first simple app in around 30 minutes.

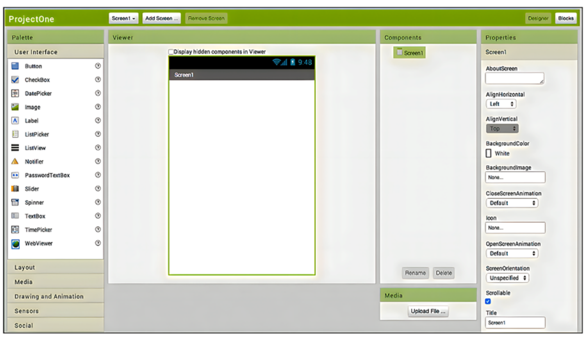


Figure 10. MIT App Inventor 2 Platform [24]

Additionally, our blocks-based solution accelerates compared to conventional programming environments, the creation of intricate, significant apps. By enabling everyone, especially young people, to create software instead of just utilizing it, the MIT App Inventor initiative aims to democratize software development Figure 11 [24].

3. FINAL HARDWARE SETUP

After the microcontroller and the sensors were described in detail in the previous section, which covered all the electrical components used in our project, these parts were gathered to build and implement the project's final system. This system's main goal is to gauge the PV system's DC/AC voltage and current for use in communication tower applications. Figures 12 and 13 show the final circuit. The block architecture of the whole monitoring system is shown in Figure 12, and the schematic diagram is shown in Figure 13.

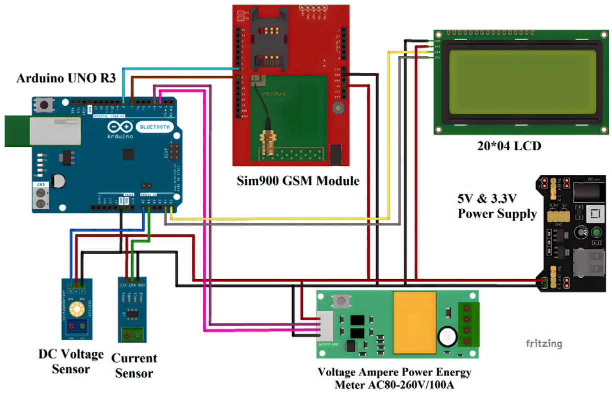


Figure 11. The block architecture of the whole monitoring system

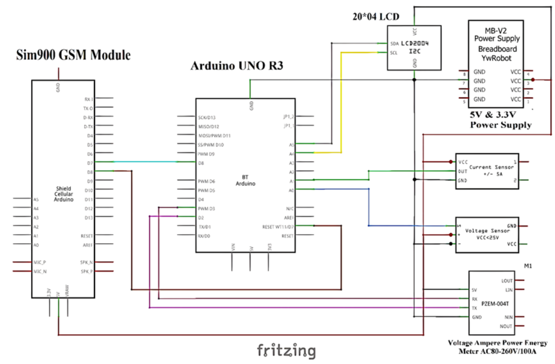


Figure 12. The schematic diagram of the whole monitoring system

These diagrams (block and schematic) were created using the excellent free software Fritzing. It makes it possible for anybody to learn from, collaborate with, and prototype their electrical ideas to produce a schematic and afterward a component that can be attached to wire diagrams with a highly professional look. Even better, you may produce your PCB design files yourself [25]. SparkFun uses Fritzing to show how to connect our boards to other gear in our seminars, hook-up guides, and wherever else we need to. Figure14 depicts the monitoring circuit's hardware design.

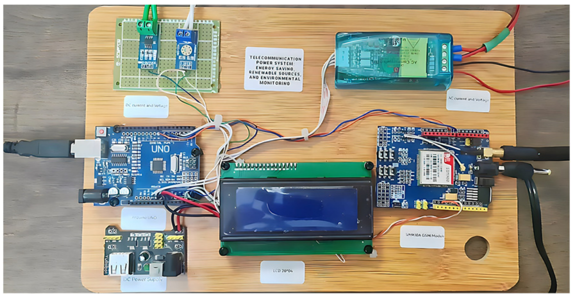


Figure 14. The Hardware monitoring system

4. RESULTS AND DISCUSSION

Three programs make up the entire system: the first is for measuring and sending circuits, the second is for cloud monitoring with ThingSpeak, and the third is for the smartphone application program. The measurement circuit's flowchart may be seen in Figure 15.

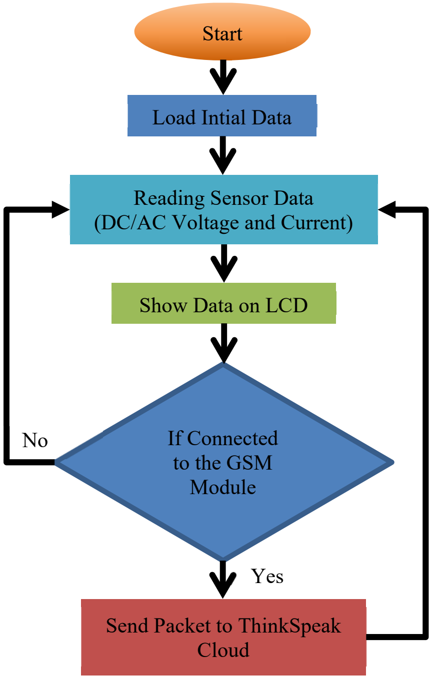


Figure 13. The measurement and transmitter circuit's flowchart

The flowchart illustrates how the Arduino UNO collects information from sensors (AC/DC voltage and current), measure it, and displays it on the LCD. Next, verify that the GPS is operational before beginning to upload data to the cloud.

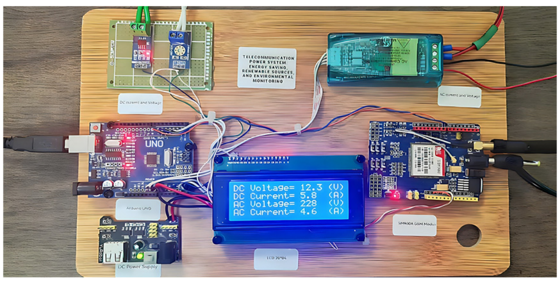


Figure 16. The Hardware monitoring circuit with results

The measurement circuit for the system testing is shown in Figure 16 after being linked to the single-phase photovoltaic inverter (2K12V)'s battery and the load.

The Pearson correlation coefficient will be used to verify the readings that were measured in the proposed device. The Pearson correlation coefficient, often known as Pearson's statistical test, assesses how strongly different variables are related to one another. The Pearson correlation coefficient indicates the strength of a linear relationship between two variables. The Pearson correlation coefficient is seen in Equation (1).

$$\Gamma = \frac{\sum_i \left(Xi - \bar{X}\right)\left(yi - \bar{y}\right)}{\sqrt{\sum_i \left(Xi - \bar{X}\right)^2}\sqrt{\sum_i \left(yi - \bar{y}\right)^2}} \quad (1)$$

where, Γ is correlation coefficient, X_i values of the X - variable in a sample, $\bar{X}$ mean of the values of the $\bar{X}$ variable, Y_i values of the $\bar{y}$ variable in a sample and $\bar{y}$ mean of the values of the $\bar{y}$ variable.

Table 1 presents some values of the system results for calculation the of Pearson's correlation coefficient and a comparison between the results of propped system with one of the instruments on the market. The criteria for DC voltage rate are presented in Equations (2) and (3) presents the criteria for DC current rate, Equation (4) presents the criteria for AC voltage rate and the criteria for AC current rate are presented in Equation (5).

Table 1. System Results for calculation Pearson's correlation coefficient

No.	$Vdc1$	$Vdc2$	$Idc1$	$Idc2$	$Vac1$	$Vac2$	$Iac1$	$Iac2$
1	12.3	12.35	5.8	5.75	228	227.5	4.6	4.72
2	12.4	12.42	5.2	5.1	221	220.3	4.2	4.25
3	12.3	12.35	4.9	4.82	219	219.5	3.9	4.23
4	12.3	12.35	4.9	4.2	218	218.8	4	4.4
5	12	12.18	5.5	5.41	222	223.2	4.2	4.4
6	12.4	12.35	5.4	5.35	218	218.6	3.9	4.05
7	12.2	12.18	5.6	5.52	224	223.1	4.5	4.55
8	12.5	12.45	4.9	4.83	224	222.4	4.5	4.58
9	12.4	12.44	5.2	5.08	222	222.6	4.4	4.56
10	12.3	12.15	4.6	4.51	218	219.6	4.2	4.35

$$\Gamma_{Vdc} = \frac{\sum_i \left(V_{dc1i} - M\left(V_{dc1}\right)\right)\left(V_{dc2i} - M\left(V_{dc2}\right)\right)}{\sqrt{\sum_i \left(V_{dc1i} - M\left(V_{dc1}\right)\right)^2}\sqrt{\sum_i \left(V_{dc2i} - M\left(V_{dc2}\right)\right)^2}} \quad (2)$$

$$\Gamma_{Idc} = \frac{\sum_i \left(I_{dc1i} - M\left(I_{dc1}\right)\right)\left(I_{dc2i} - M\left(I_{dc2}\right)\right)}{\sqrt{\sum_i \left(I_{dc1i} - M\left(I_{dc1}\right)\right)^2}\sqrt{\sum_i \left(I_{dc2i} - M\left(I_{dc2}\right)\right)^2}} \quad (3)$$

$$\Gamma_{Vac} = \frac{\sum_i \left(V_{ac1i} - M\left(V_{ac1}\right)\right)\left(V_{ac2i} - M\left(V_{ac2}\right)\right)}{\sqrt{\sum_i \left(V_{ac1i} - M\left(V_{ac1}\right)\right)^2}\sqrt{\sum_i \left(V_{ac2i} - M\left(V_{ac2}\right)\right)^2}} \quad (4)$$

$$\Gamma_{Iac} = \frac{\sum_i \left(I_{ac1i} - M\left(I_{ac1}\right)\right)\left(I_{ac2i} - M\left(I_{ac2}\right)\right)}{\sqrt{\sum_i \left(I_{ac1i} - M\left(I_{ac1}\right)\right)^2}\sqrt{\sum_i \left(I_{ac2i} - M\left(I_{ac2}\right)\right)^2}} \quad (5)$$

Then, the final results after the calculation:
The DC voltage Pearson's coefficient Γ_{Vdc}=0.773
The DC current Pearson's coefficient Γ_{Idc}=0.92
The AC voltage Pearson's coefficient Γ_{Vac}=0.821
The AC current Pearson's coefficient Γ_{Iac}=0.899

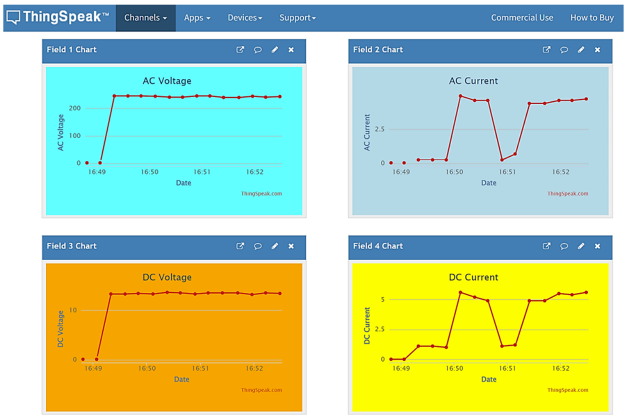


Figure 17. Thingspead pages with system Results (AC/DC Voltage and Current)

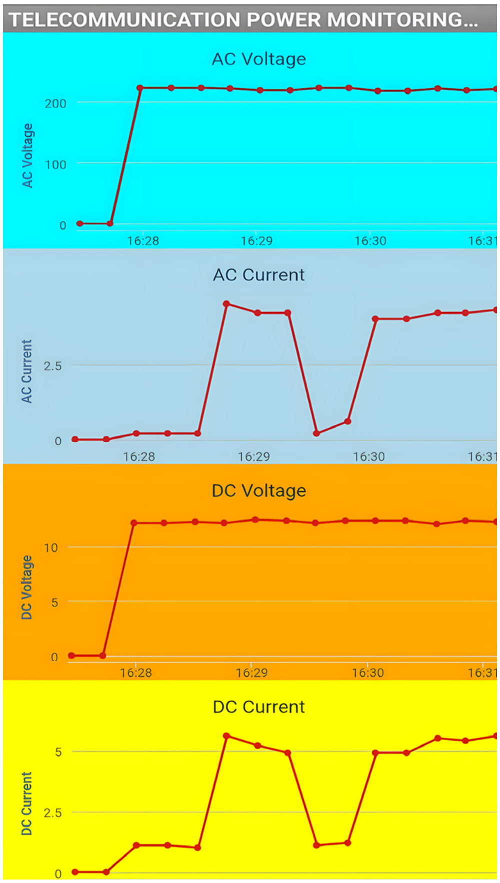


Figure 18. Main windows of smartphone app. for system results (AC/DC Voltage and Current)

For IoT system proof of concept and prototypes that require analytics, ThingSpeak is widely utilized. With the help of the cloud-based IoT analytics platform ThingSpeak, the photovoltaic system's status was evaluated, real-time data streams were visualized, and the findings are shown in Figure 17. ThingSpeak displays data that the devices communicate to it in real-time. The same results will be shown on smartphones using a special app created for this purpose when all the data and results have been posted on the ThingSpeak website Figure 18.

5. CONCLUSIONS AND FUTURE OF WORKS

This work provides an open-source, very low-power, low-cost, and efficient data-logging and monitoring system for an off-grid PV energy system. Through the use of this data logger, all necessary PV system parameters are stored in the cloud. In this work, a unique GSM circuit-based monitoring system is designed, developed, and put into use. The GSM communication system uses little power and can transfer data over great distances.

The majority of the monitors are situated exactly where the system is. Nevertheless, this research created the blueprint for remote battery and inverter condition monitoring for communication tower photovoltaic applications. The efficiency of communication networks and the battlefield's direction are directly impacted by the management of the condition and performance of batteries and inverters, which are crucial to contemporary industrial production. The system's architecture is focused on tracking key PV system properties including AC/DC voltage and current.

The advantages of using a GSM monitoring circuit include the ability to remotely monitor and control devices, as well as the ability to send and receive text messages and make phone calls. GSM networks also have wide coverage and are widely available. The disadvantages of using a GSM monitoring circuit include the possibility of network outages or poor signal strength, as well as the potential for security vulnerabilities if the system is not properly configured. Additionally, GSM monitoring circuit systems may have higher costs associated with them due to the need for a SIM card and ongoing service fees.

For future work, the authors advise researchers to,
1. Adding more sensors to making it capable of monitoring system temperatures
2. Appling a new technique by swapping out the GSM module for a LoRa module for remote monitoring systems.

REFERENCES

[1] A. Petraglia, A. Spagnuolo, C. Vetromile, A. D'Onofrio, C. Lubritto, "Heat Flows and Energetic Behavior of a Telecommunication Radio Base Station", Energy, Vol. 89, pp. 75-83, 2015.
[2] S. Bera, S. Misra, A.S. Vasilakos, "SoftwareDefined Networking for Internet of Things: A Survey, "IEEE Internet of Things Journal, Vol. 4, No. 6, pp. 1994-2008, 2017.
[3] H. Shehab, R.F. Chisab, M.J. Mnati, Q.A. Al Jarwany, "Design a New Smart Monitoring Micro-Grid Photovoltaic System Network Based on Mobile Technology", IEEE International Conference on Advance of Sustainable Engineering and its Application (ICASEA), pp. 37-42, 2021.
[4] R. Fantacci, T. Pecorella, R. Viti, C. Carlini, "A Network Architecture Solution for Efficient IOT WSN Backhauling: Challenges and Opportunities", IEEE Wireless Communications, Vol. 21, No. 4, pp. 113-119, 2014.
[5] M.J. Mnati, A. Van den Bossche, R. Chisab, "A Smart Voltage and Current Monitoring System for Three Phase

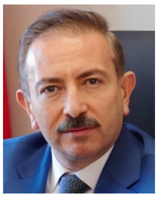
Inverters Using an Android Smartphone Application", Sensors, Vol. 17, No. 4, p. 872, 2017.
[6] A. Zanella, N. Bui, A. Castellani, L. Vangelista, M. Zorzi, "Internet of Things for Smart Cities", IEEE Internet of Things Journal, Vol. 1, No. 1, pp. 22-32, February 2018.
[7] M.J.M. Al-Rubaye, A. Hasan, D. Bozalakov, A. Van den Bossche, "Smart Monitoring and Controlling of Three Phase Photovoltaic Inverter System Using Lora Technology", The Sixth European Conference on Renewable Energy Systems (ECRES2018), pp. 1-7, 2018.
[8] M. Zile, "Design of Power Transformers Using Heuristic Algorithms", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 38, Vol. 11, No. 1, pp. 42-47, March 2019.
[9] S. Ciccia, G. Giordanengo, G. Vecchi, "Energy Efficiency in IoT Networks: Integration of Reconfigurable Antennas in Ultra-Low-Power Radio Platforms Based on System-on-Chip", IEEE Internet Things J., Vol. 6, No. 4, pp. 6800-6810, August 2019.
[10] M. Topal, I. Iskender, N. Genc, "Sensorless Speed Control of a BLDC Motor Using Improved Sliding Mode Observer Technique", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 38, Vol. 11, No. 1, pp. 1-9, March 2019.
[11] L. Chen, N. Zhao, Y. Chen, F.R. Yu, G. Wei, "Over-The-air Computation for IoT Networks: Computing Multiple Functions with Antenna Arrays", IEEE Internet of Things Journal (Early Access), pp. 1-12, June 2018.
[12] E. Naderi, H. Shayeghi, "Sustainable Energy Scheduling of Grid-Connected Microgrid using Monte Carlo Estimation and Considering Main Grid Penetration Level", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 42, Vol. 12, No. 1, pp. 10-19, March 2020.
[13] J. Torregoza, I.Y. Kong, W.J. Hwang, "Wireless Sensor Network Renewable Energy Source Life Estimation", The 8th International Conference one-Health Networking, Applications and Services, pp. 13-18, 2006.
[14] N. Talib, K. Hafeez, M.J. Mnati, S.A. Khan, "Design and Implementation of New Battery Monitoring System for Photovoltaic Application", The 4th Global Power, Energy and Communication Conference (GPECOM), pp. 1-7, 2022.
[15] Arduino UNO 3, https://store.arduino.cc/products/arduino-uno-rev3.
[16] EKT, "Arduino Voltage Sensor Module", pp. 2-3, 2015.
[17] F. Integrated, H.L. Current, S. Ic, "ACS712", pp. 1-15, 2020.
[18] The PZEM-004T, www.piddlerintheroot.com.
[19] Sim900 GSM Module, https://randomnerdtutorials.com/sim900-gsm-gprs-shield-arduino/.
[20] Vishay, "LCD-020N004B Vishay 20×4 Character LCD Standard Value Unit Electrical Characteristics Item Symbol Condition LCD-012N004B", Vishay, Vol. 4, p. 3, 2019, www.vishay.com.
[21] H. Technology, "Breadboard Power Supply Module", www.Components101.Com, pp. 1-3, 2020. https://components101.com/modules/5v-mb102-breadboard-power-supply-module.
[22] IDE, www.arduino.cc/en/softwarez.
[23] Thingspeak, https://thingspeak.com/.
[24] MIT APP Inventor 2, https://appinventor.mit.edu.
[25] Fritzing is Available online: https://fritzing.org.

BIOGRAPHIES

Name: **Bassam**
Middle Name: **Zayer Salman**
Surname: **Azzawi**
Birthday: 19.08.1978
Birth Place: Diyala, Iraq
Bachelor: Electromechanical Engineering Department, University of Technology, Baghdad, Iraq, 2002,
Master: Student, Department of Electrical and Electronics Engineering, Faculty of Engineering, Cankiri Karatekin University, Cankiri, Turkey, Since 2020
Research Interests: PV, Power System, IoT

Name: **Inam**
Middle Name: **Abbas Razooqi**
Surname: **Alsaddaee**
Birthday: 27.02.1983
Birth Place: Diyala, Iraq
Bachelor: Department of Electrical Power and Machines Engineering, College of Engineering, University of Diyala, Baqubah, Iraq, 2005
Master: Student, Department of Electrical and Electronics Engineering, Faculty of Engineering, Cankiri Karatekin University, Cankiri, Turkey, Since 2020
Research Interests: PV, Power Systems, IoT, Power Electronics

First Name: **Mahmud Esad**
Surname: **Yigit**
Birthday: 14.06.1989
Birth Place: Cankiri, Turkey
Bachelor: Electronics and Communication Engineering, Faculty of Electrical and Electronics Engineering, Yildiz Technical University, Istanbul, Turkey, 2011
Master: Telecommunication Engineering, Graduate School, Istanbul Technical University, Istanbul, Turkey, 2014
Doctorate: Student, Telecommunication Engineering, Graduate School, Istanbul Technical University, Istanbul, Turkey, Since 2014
The Last Scientific Position: Research Assistant, Faculty of Engineering, Cankiri Karatekin University, Cankiri, Turkey, Since 2020
Research Interests: Electromagnetics, Microwave Systems, Antennas, Optimization, Communications
Scientific Publications: 16 Paper, 1 Thesis
Scientific Memberships: IEEE Student Member



Name: **Murat**
Surname: **Ari**
Birthday: 22.05.1969
Birth Place: Cankiri, Turkey
Bachelor: Electrical and Electronics Engineering, Faculty of Engineering of Gaziantep, Middle East Technical University, Ankara, Turkey, 1992
Master: Electrical and Electronics Engineering, Institute of Science, Gazi University, Ankara, Turkey, 1999
Doctorate: Electronic Computer Education, Institute of Science, Gazi University, Ankara, Turkey, 2004
The Last Scientific Position: Prof., Faculty of Engineering, Cankiri Karatekin University, Cankiri, Turkey, Since 2017
Research Interests: Electrics, Electronics, Embedded Systems, Communications, Optoelectronics
Scientific Publications: 76 Papers, 1 Patent, 5 Projects, 3 Theses
Scientific Memberships: IJTPE Journal Scientific Board, Sub Area Editor of Gazi Journal of Science, 5 National Academic Memberships