

Remote Environmental Monitoring of Atmospheric Water Generators Using Low-Cost Sensors and GSM Technology

Kinda Habib Mahmoud

Department Of Industrial Automation
Faculty Of Technical Engineering
Tartous University, Tartous, Syria

Abstract - This study presents the design and implementation of a low-cost, GSM-based monitoring system for Atmospheric Water Generators (AWGs) operating in remote or off-grid areas. The system continuously measures two critical environmental parameters—air temperature and relative humidity—using a DHT11 sensor. Data is recorded at hourly intervals and transmitted in real time to the user via Short Message Service (SMS), enabling performance tracking without the need for internet connectivity. A distinctive feature of the proposed design is its integrated location monitoring capability, which sends an instant SMS alert if the AWG is moved from its original position, enhancing operational security and theft prevention.

The monitoring unit consists of an Arduino Uno microcontroller, a GSM communication module (SIM900), and a solar-powered energy supply for autonomous operation. Field experiments were conducted over three months during the dry summer season, with measurements taken daily from 09:00 to 15:00. The system successfully transmitted over 250 consecutive data sets, accurately reflecting natural fluctuations in temperature and humidity. Results confirmed that the DHT11 sensor provided sufficient accuracy for environmental monitoring, while the GSM module ensured reliable communication even in low-coverage areas.

This work demonstrates the feasibility of integrating affordable sensors with GSM technology to create a robust monitoring solution for AWGs in harsh or inaccessible environments. The approach not only improves operational efficiency by enabling early detection of performance issues but also enhances system security through real-time geolocation tracking. The proposed system can be adapted for broader applications, including precision agriculture, environmental monitoring, and distributed infrastructure management in resource-limited regions.

Keywords - Atmospheric Water Generator, GSM Communication, Environmental Monitoring, Relative Humidity, Remote Monitoring

I. INTRODUCTION

Freshwater scarcity has emerged as one of the most pressing global challenges of our time. According to recent United Nations reports, over 2 billion people currently live in water-stressed regions, with projections indicating this number could rise to 3.5 billion by 2025 [1].

While the Earth's atmosphere contains approximately 12,900 km³ of water vapor – a volume comparable to all freshwater rivers combined – traditional methods of

atmospheric water extraction remain inefficient and geographically limited [2]. Atmospheric water generators (AWGs) represent a promising solution to this crisis, particularly for remote and arid regions where conventional water infrastructure is unavailable. However, the widespread deployment of AWG systems faces significant technical challenges, chief among them being the lack of reliable, real-time monitoring capabilities in off-grid environments.

Current AWG systems often operate without adequate performance tracking, leading to undetected efficiency losses and system failures. Field studies have shown that nearly 70% of AWG performance issues in remote locations go unnoticed for extended periods, resulting in substantial water production losses [5]. This monitoring gap becomes particularly critical in harsh environmental conditions where temperature and humidity fluctuations directly impact water extraction efficiency. Moreover, the security of these valuable systems in unattended locations remains a persistent concern, with equipment theft or displacement significantly compromising water access for vulnerable communities.

Similar challenges in AWG monitoring systems highlight the need for GSM-based solutions in water-scarce regions [4],[8],[12]. The importance of smart sensing for optimizing water harvesting in arid environments is also emphasized [5]. Additionally, a low-cost SMS-based monitoring system has been proposed to validate the feasibility of such technologies in remote environmental applications [6]. This research addresses these critical challenges through the development of an innovative GSM-based monitoring system specifically designed for atmospheric water generators. Our solution integrates low-cost DHT11 environmental sensors with robust mobile communication technology to provide real-time performance tracking and equipment security monitoring. The system measures key operational parameters including ambient temperature and relative humidity at regular intervals, transmitting this data via SMS to enable remote supervision in areas lacking internet connectivity. A distinctive feature of our design is its integrated location monitoring capability, which immediately alerts operators to any unauthorized movement of the AWG equipment.

By implementing this monitoring solution, we demonstrate how simple, cost-effective technology can significantly enhance the reliability and security of atmospheric water generation systems. Our approach not only improves operational efficiency through continuous performance

tracking [7],[8] and is supported by numerous case studies showing that real-time data analytics and remote monitoring substantially reduce maintenance costs and downtime in similar decentralized water systems, but also addresses the practical challenges of deploying and maintaining AWG systems in remote, off-grid locations. The development of such monitoring capabilities represents a crucial step toward making atmospheric water generation a more viable and sustainable solution for addressing global water scarcity, particularly in regions where traditional water infrastructure is impractical or impossible to implement. The remainder of this paper presents the technical design of our monitoring system, evaluates its performance under various environmental conditions, and discusses its implications for improving AWG reliability and accessibility in water-scarce regions. Through this work, we aim to contribute to the growing body of research on sustainable water solutions while providing practical, implementable technology that can make immediate improvements to water security in vulnerable communities.

II. PROPOSED SYSTEM DESIGN

A. Microcontroller (Arduino Uno):

An Arduino Uno board was used as the central controller due to its compact size, low power consumption, and affordability. It was interfaced with several modules[3],[4], as illustrated in Fig. 1, a DHT11 sensor for measuring temperature and relative humidity, and an LCD display for local visualization of environmental parameters.

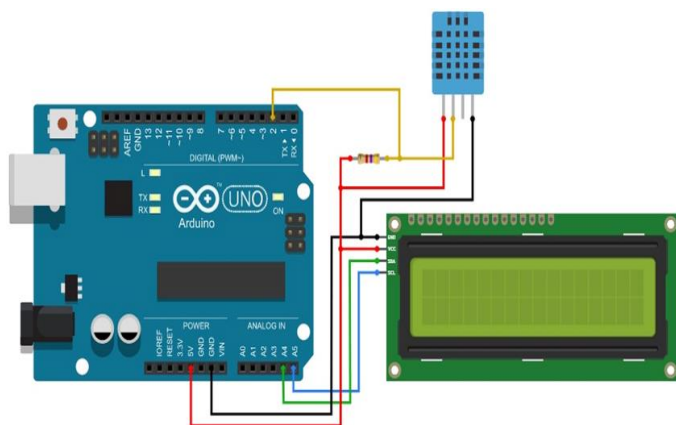


Fig. 1. Arduino Uno microcontroller connected to LCD display and DHT11 sensor [11].



Fig. 2. Temperature and humidity sensing module (DHT11)

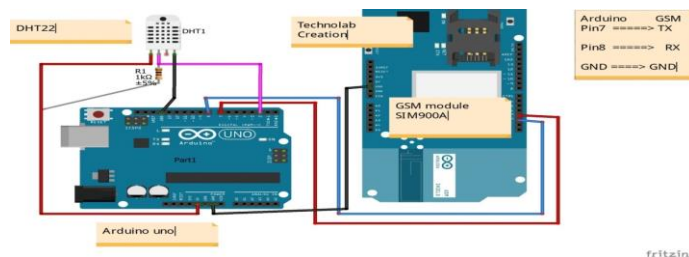


Fig. 3. SIM900 GSM communication module [12]

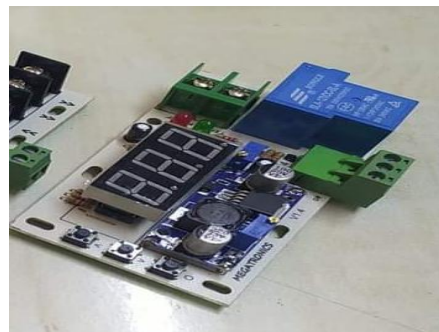


Fig. 4. Digital timer

B. Temperature and Humidity Sensor (DHT11)

The DHT11 sensor [11] measures air temperature within a range of -40°C to 120°C ($\pm 0.5^{\circ}\text{C}$ accuracy), and relative humidity from 0% to 100% [12]. These values are periodically read and processed by the microcontroller and then transmitted to the user via SMS as shown in Fig. 2.

C. GSM Communication Module (SIM900)

This module was selected for its compatibility with Arduino boards and its ability to transmit data via Short Message Service (SMS) and provide GPS-based location tracking as shown in Fig. 3 [12]. A 2G-compatible SIM card was used (from either Syriatel or MTN networks) [13].

D. Timing Control

A digital timer was used to restrict system operation to daytime hours only, specifically from 9:00 AM to 3:00 PM, in order to conserve energy and focus measurements on peak atmospheric activity, as shown in Fig. 4.

III. EXPERIMENTAL SETUP

The experimental tests were conducted on the rooftop of the Solar Energy Research Laboratory at the Faculty of Technical Engineering, Tartous University, during the summer season.

The measurements were conducted over a period of three consecutive months, specifically from 9:00 AM to 3:00 PM each day.

The system was programmed to send one SMS per day containing the GPS location of the device, if it remained stationary; Immediately send a text alert with the new location



Fig. 5. New location message



Fig. 6. Sample environmental data SMS

if the system was moved as shown in Fig. 5, Transmit an hourly SMS including both temperature and relative humidity values as shown in Fig. 6.

The outer physical enclosure of the system, which includes all integrated components and is designed for operation in remote environments, is shown in Fig. 7.

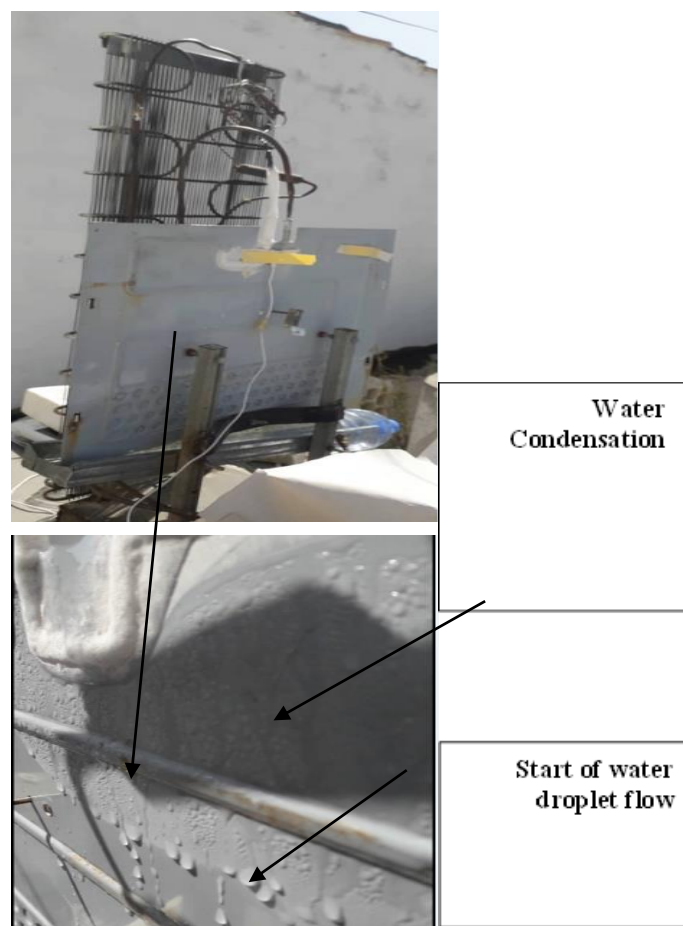


Fig. 7. External hardware structure of the monitoring system.

IV. RESULTS AND DISCUSSION

The implemented system demonstrated consistent performance in collecting and transmitting environmental data from the atmospheric water generation unit. During the experimental phase, 250 consecutive readings were conducted during daytime hours over several weeks.

As shown in Fig. 8, the system accurately captured variations in relative humidity across the 250 measurements, reflecting natural fluctuations in atmospheric moisture [9]. This highlights the sensor's sensitivity to surrounding environmental changes. Similarly, Fig. 9 illustrates changes in ambient temperature over the same measurement sequence, confirming the capability of the DHT11 sensor [10],[12], despite its simplicity, to provide sufficient accuracy for real-time environmental monitoring. One of the most

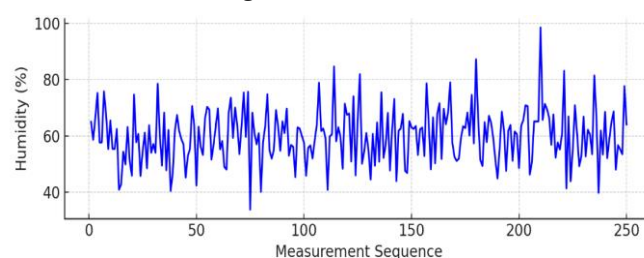


Fig. 8. Variation in relative humidity across 250 measurement

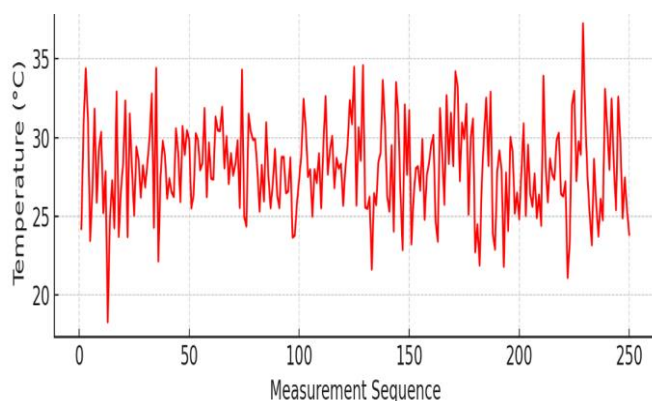


Fig. 9. Variation in relative temperature across 250

Measurements one of the notable features of the system is its GSM-based geolocation tracking. The device automatically sent SMS alerts when it was moved or relocated, providing instant information about its position. This feature enhanced the system's security and suitability for use in outdoor or unsupervised environments [12].

Additionally, the system successfully transmitted temperature and humidity readings on an hourly basis via SMS without requiring user intervention, confirming its reliability in autonomous monitoring scenarios [5],[11],[13]. These results validate the applicability of the system in remote locations where continuous human presence is not feasible. Furthermore, the low-cost and low-power components used make the system suitable for environmental tasks in resource-constrained conditions [10],[13].

V. CONCLUSION

This study addressed the challenge of monitoring environmental systems in remote or inaccessible areas by developing a GSM-based monitoring solution for an atmospheric water generator device. The system proved capable of accurately capturing temperature and humidity data and transmitting it in real time via SMS. Such functionality enhances the device's operational reliability and opens the door to broader applications in fields such as environmental monitoring, smart farming, and resource optimization. The results highlight the potential of integrating wireless communication technologies into autonomous systems to improve responsiveness and decision-making in isolated environments.

VI. ACKNOWLEDGMENT

The authors would like to express their gratitude to all those who supported them throughout the course of this research and provided the necessary facilities and assistance during the

experimental measurements. Their contributions, whether technical or logistical, were essential to the successful completion of this work.

VII. AUTHORS' DECLARATION

K.H.M. developed the system, conducted the experiments, collected and analyzed the environmental data, and wrote the manuscript. The author has reviewed and approved the final version of the paper.

VIII. REFERENCES

- [1] UNESCO. The United Nations World Water Development Report 2021: Valuing Water [Internet]. Paris: UNESCO; 2021 [cited 2022 Jun 14]. Available from: <https://unesdoc.unesco.org/ark:/48223/pf0000375724>
- [2] WWAP (United Nations World Water Assessment Programme). The United Nations World Water Development Report 2019: Leaving No One Behind [Internet]. Paris: UNESCO; 2019 [cited 2025 Jul 24]. Available from: <https://unesdoc.unesco.org/ark:/48223/pf0000367306>
- [3] Bayle J. C Programming for Arduino. Birmingham (UK): Packt Publishing; 2013. 512 p.
- [4] Margolis M, Jenson B, Weldin NR. Arduino Cookbook: Recipes to Begin, Expand, and Enhance Your Projects. 3rd ed. Sebastopol (CA): O'Reilly Media; 2020. 795 p.
- [5] Zrioual H, Toluwalase Adewale I, Bahaa Eddine C. Remote Environmental Monitoring System Using DHT11. International Journal of Innovative Science and Research Technology (IJISRT). 2024; 386-392. doi:10.38124/ijisrt/ijisrt24nov200
- [6] Wazwaz A, Amin K. Error Rate Control in Humidity and Temperature Sensors Using IoT and ThingSpeak. In: Proceedings of the 2020 International Conference on Intelligent Systems and Computer Vision (ISCV). ACM Digital Library; 2020. doi:10.1145/3418981.3418993
- [7] Narayana TL, Venkatesh C, Kiran A, et al. Advances in real time smart monitoring of environmental parameters using IoT and sensors. Heliyon. 2024;10(7):e28195. doi:10.1016/j.heliyon.2024.e28195
- [8] Kuchekar NK, Pagare RA. Embedded system for automatic irrigation using wireless sensor network and GSM. International Journal of Engineering Research & Technology (IJERT). 2013;2(4):1-4.
- [9] Nikkhah H, Azmi WMBW, Nikkhah A, et al. A comprehensive review on atmospheric water harvesting technologies: From thermodynamic concepts to mechanism and process development. J Water Process Eng. 2023;53:103728. doi:10.1016/j.jwpe.2023.103728
- [10] Al-Mashaqbeh MH, Al-Haija FM, Al-Zoubi SK. Development and applications of DHT11 humidity and temperature sensor in environmental monitoring. Sensors. 2023;23(13):5692. doi:10.3390/s23135692
- [11] Othman MF, Shazali K. Wireless sensor network applications: A study in environment monitoring system. Procedia Engineering. 2012;41:1204-1210. doi:10.1016/j.proeng.2012.07.302
- [12] Akanda NI, Hossain MA, Fahad MMI, Rahman MN, Khairunnahar. Cost-effective and user-friendly vehicle tracking system using GPS and GSM technology based on IoT. Indonesian Journal of Electrical Engineering and Computer Science. 2022;28(3):1826-1833. doi:10.11591/ijeecs.v28.i3.pp1826-1833
- [13] Gaggini F, Crespo RNF, Calò M, Gentile V, Macii A, Patti E. An Internet of Things Ecosystem for Atmospheric Water Generators. IEEE Access. 2025;13:77565-77581. doi:10.1109/ACCESS.2025.3562742.