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AWG SYSTEM FOR DRINKING WATER

M.Bhaskara Rao[1]
Assistant Professor
Department of Electrical & Electronics Engineering
ACE Engineering College
Ghatkesar, Telangana

M.Bharath Kumar[2]
Student
Department of Electrical & Electronics Engineering
ACE Engineering College
Ghatkesar, Telangana

S.G.Harsh[3]
Student
Department of Electrical & Electronics Engineering
ACE Engineering College
Ghatkesar, Telangana

SK.Sadik[4]
Student Department of Electrical & Electronics Engineering ACE Engineering College
Ghatkesar, Telangana

***Abstract*— This paper presents the development of a prototype Atmospheric Water Generator (AWG) designed to extract potable water from humid air using Thermo-Electric Coolers (TECs). Leveraging the Peltier effect, the system condenses water vapor into liquid by creating a temperature differential across TEC modules. The cold side induces condensation, while the hot side is cooled using heat sinks and DC fans for optimal performance. An LM35 temperature sensor monitors the cold side, with real-time data processed via an Arduino Uno and displayed on an LCD. IoT functionality is enabled through an ESP8266 Wi-Fi module, allowing remote temperature monitoring. Although limited in scale, the prototype validates the feasibility of atmospheric water generation, offering a potential solution for clean water access in arid and coastal regions. Future enhancements, including solar integration, could further improve its efficiency and sustainability.**

***Keywords*— Atmospheric Water Generator, Thermo- Electric Cooler, Peltier Effect, Water Condensation, Arduino Uno, LM35 Sensor, ESP8266 Wi-Fi, Humid Air, Heat Sink, Renewable Energy.**

I. INTRODUCTION

A. AWG OVERVIEW

Access to clean drinking water is one of the major challenges in many regions of the world, particularly in arid and coastal areas where freshwater resources are limited or non-existent. The development of innovative technologies to extract water from unconventional sources has become an urgent necessity. One such promising technology is the Atmospheric Water Generator (AWG), which generates water by condensing moisture from the surrounding air. This project, "AWG SYSTEM FOR DRINKING WATER", presents a prototype model of AWG utilizing Thermo-Electric Cooler (TEC) modules and integrating real-time temperature monitoring using the Internet of Things (IoT).

This document provides a detailed introduction to the design and functioning of the AWG system, including its major components such as Peltier coolers, temperature sensors, control units, cooling mechanisms, and wireless communication modules. The prototype aims to demonstrate the feasibility of generating water from air using compact, low-cost, and energy-efficient technologies. the cooling condensation principle is employed using TEC modules, which are solid-state devices operating on the Peltier Effect. These modules are capable of creating a significant temperature differential, with one side becoming cold enough to attract moisture from the air, which condenses into water droplets.

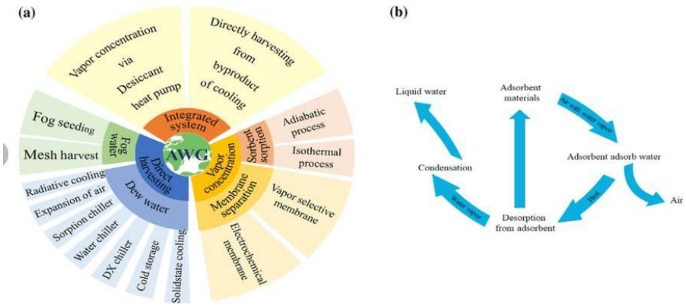

Fig.1.AWG cycle

B. SCOPE AND OBJECTIVES

The scope of this project encompasses the design, development, and testing of a compact prototype Atmospheric Water Generator (AWG) that utilizes Thermo-Electric Coolers (TECs) to extract drinkable water from humid air. While the prototype operates on a small scale, it aims to validate the concept for potential scaling in regions facing water scarcity. The project also considers integration with renewable energy sources like solar power for enhanced sustainability and off-grid deployment.The primary objective of this project is to design and develop a functional prototype of an Atmospheric Water Generator (AWG) that utilizes Thermo-Electric Coolers (TECs) to extract drinkable water from humid air. The system aims to demonstrate the feasibility of using the Peltier effect for water condensation by creating a temperature differential that allows moisture in the air to condense on the cold surface of the TECs. To monitor and maintain operational efficiency, an LM35 temperature sensor is used to measure the cold side temperature, with data processed by an Arduino Uno microcontroller. Additionally, the project incorporates an ESP8266 Wi-Fi module to enable real-time transmission of temperature data to a mobile device, facilitating remote monitoring through IoT integration. Another key objective is to evaluate the prototype's performance in different environmental conditions and establish its potential for use in water-scarce areas such as deserts and coastal regions. Furthermore, the project explores the possibility of integrating solar power to enhance the system's sustainability, making it suitable for deployment in off-grid and remote locations. Ultimately, the project seeks to validate the core working principle of atmospheric water generation and present it as a scalable solution to address global drinking water shortages.

II-ARCHITECTURE

The system architecture of the Atmospheric Water Generator (AWG) prototype is designed to extract drinkable water from humid air using a combination of thermal, electronic, and communication components. At the core of the system is the condensation unit, which consists of two Thermo-Electric Coolers (TECs), also known as Peltier modules. When a DC current is applied, these TECs create a temperature difference between their two sides. The cold side becomes significantly cooler than the ambient temperature, allowing moisture in the surrounding air to condense into water droplets. To maintain the efficiency of this process, the hot side of each TEC is equipped with a large heat sink and cooled using DC fans, ensuring that the temperature gradient remains effective for continuous condensation.To monitor and control the system, an Arduino Uno microcontroller serves as the central processing unit. An LM35 temperature sensor is attached to the cold side of the TEC to accurately measure its surface temperature. The Arduino processes this data and displays it on a 16x2 LCD screen, providing real-time temperature feedback to users. For remote monitoring and IoT functionality, the system incorporates an ESP8266 Wi-Fi module, which is connected to the Arduino through serial communication.

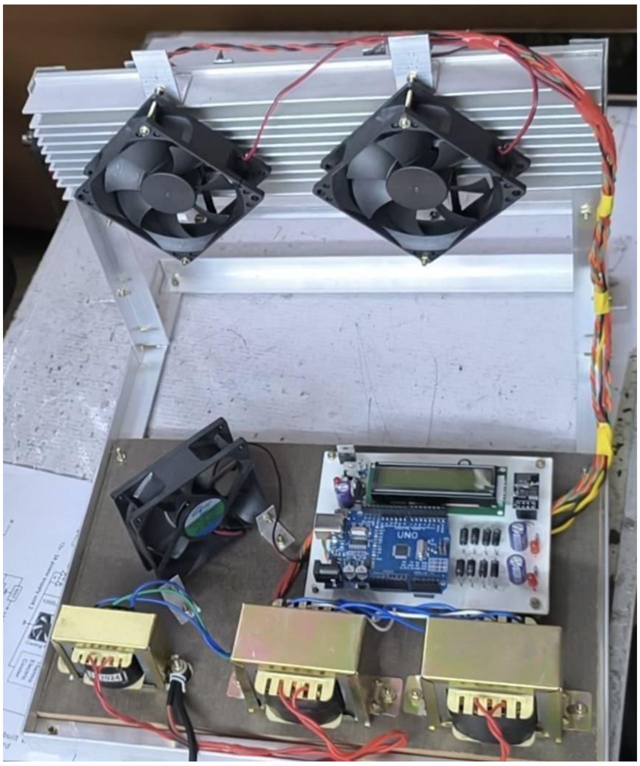

Fig.2.Architecture

III-HARDWARE IMPLEMENTATION

The hardware implementation of the Atmospheric Water Generator (AWG) prototype involves assembling and integrating multiple electronic and thermal components to condense atmospheric moisture into drinkable water. The core component of the condensation mechanism is the Thermo-Electric Cooler (TEC1-12706) module, which operates based on the Peltier effect. When a DC voltage is applied, it creates a temperature differential—cooling one side while heating the other. Two TEC modules are used in the prototype to increase the condensation surface area and improve overall water output efficiency.

A.CIRCUIT LAYOUT

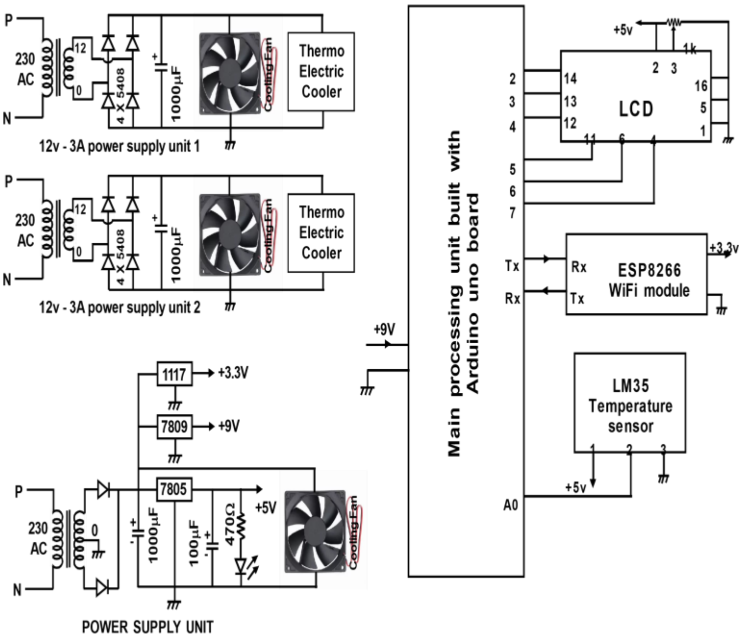

Fig.3. Circuit

To maintain the cooling performance of the TECs, aluminum heat sinks are firmly attached to the hot sides of the modules. These heat sinks are supported by 12V DC cooling fans, which actively dissipate the heat to the surrounding environment, preventing the hot side from overheating and ensuring a stable temperature gradient. The cold side, where condensation occurs, is exposed to humid air. As the surface temperature drops below the dew point, water vapor condenses into droplets, which can be collected using a metal plate or drip tray.Temperature monitoring is handled by an LM35 analog temperature sensor, which is fixed onto the cold side of one of the TEC modules. The sensor continuously reads the surface temperature and sends analog voltage signals to the Arduino Uno microcontroller. The Arduino processes this data and displays the real-time temperature on a 16x2 LCD module, providing an easy-to-read interface for users.

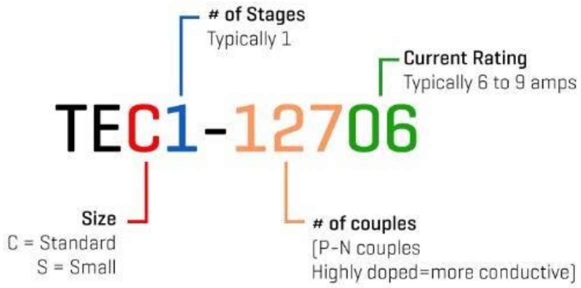

Fig .4.TEC structure

For remote monitoring and IoT integration, an ESP8266 Wi- Fi module is interfaced with the Arduino via UART (TX/RX) pins. The module connects to a Wi-Fi network and transmits the temperature data to a cloud server or a mobile device, allowing users to observe system performance from a distance. The entire setup is powered by a regulated 5A DC

power supply, which ensures stable operation of the high-current TEC modules and cooling fans. The Arduino and ESP8266 are powered either through a USB connection or a

separate 9V/12V adapter, ensuring logical separation and preventing voltage drops.The components are mounted on a wooden or acrylic base, with proper insulation and airflow management to ensure safety and efficiency. The system demonstrates effective condensation and monitoring in a

compact, low-cost setup.This hardware implementation validates the core working principle of atmospheric water generation and provides a strong foundation for future scaling and enhancements, such as solar power integration and automated humidity control. Thermoelectric coolers (TEC), also known as Peltier devices, are electronic components that generate a temperature differential across two sides when powered by direct current (DC). This unique property allows TEC modules to be used for both cooling and heating purposes. When current is applied, one side of the module absorbs heat and becomes cold, while the opposite side dissipates heat and becomes hot. This reversible function means TEC modules are versatile and can be used in various thermal management applications, including cooling down heat-sensitive components or warming specific items. Additionally, thermoelectric modules can operate as energy harvesters. When a temperature difference exists between the two sides of the module, a voltage is generated, thereby producing electricity. ESP8266EX delivers highly integrated Wi-Fi solution to meet users' continuous demands for efficient power usage, compact design and reliable performance in the Internet of Things industry. With the complete and self-contained Wi-Fi networking capabilities, ESP8266EX can perform either as a standalone application or as the slave to a host MCU. When ESP8266EX hosts the application, it promptly boots up from the flash. The integrated high speed cache helps to increase the system performance and optimize the system memory. Also, ESP8266EX can be applied to any microcontroller design as a Wi-Fi adaptor through SPI/SDIO or UART interfaces. ESP8266EX integrates antenna switches, RF balun, power amplifier, low noise receive amplifier, filters and power management modules. The compact design minimizes the PCB size and requires minimal external circuitries. Besides the Wi-Fi functionalities, ESP8266EX also integrates an enhanced version of Tensilica's L106 Diamond series 32-bit processor and on-chip SRAM. It can be interfaced with external sensors and other devices through the GPIOs. Software Development Kit (SDK) provides sample codes for various applications.

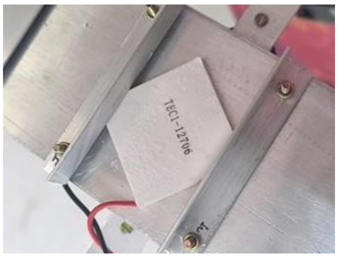

Fig.5.Wifi module Fig.6.TEC device

The ESP8266 Wi-Fi module enables wireless communication between the AWG system and external devices, allowing real-time monitoring of temperature data via IoT platforms. It connects to the Arduino through serial communication and transmits sensor readings over a local Wi-Fi network. The TEC1-12706 Thermo-Electric Cooler is the key component responsible for creating the temperature differential needed for condensation. When powered by a DC source, it cools one side below ambient temperature to condense water vapor while the opposite side is heated and cooled using a heat sink and fan for efficient operation.

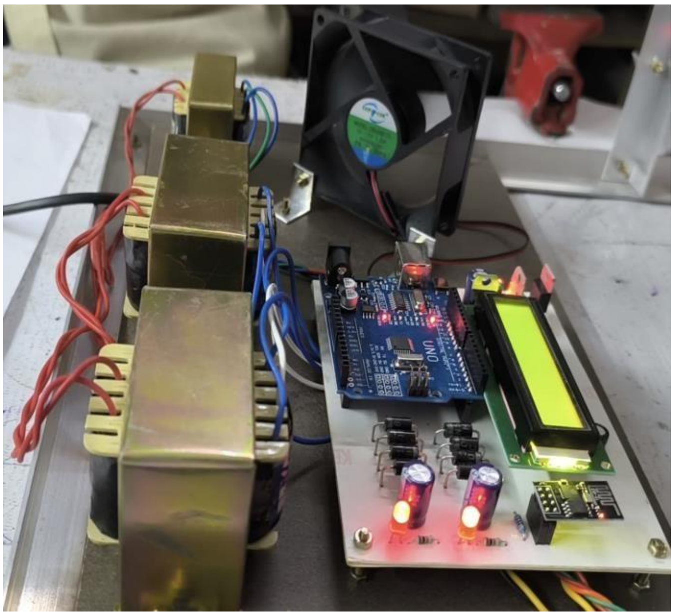

Fig.7.Hardware

TEMPERATURE MONITORING

Temperature monitoring in the AWG system is carried out using an LM35 temperature sensor, which is attached to the cold side of the TEC module. This sensor provides an analog voltage output directly proportional to the temperature in Celsius, allowing accurate measurement of the cooling surface. The data from the LM35 is fed into the Arduino Uno, which processes the signal and displays the real-time temperature on a 16x2 LCD screen.

ARDUINO

Arduino is an open-source electronics platform based on simple hardware and software. It consists of a programmable microcontroller board and an Integrated Development Environment (IDE) that allows users to write code, compile it, and upload it to the board. Arduino boards are used to build digital devices and interactive objects that can sense and control the physical world. The primary appeal of Arduino is its ease of use for beginners while still being flexible and powerful enough for advanced users to build complex embedded systems.

The Arduino platform simplifies the process of working with microcontrollers by removing the complexity of low-level programming and hardware integration. It allows developers, hobbyists, students, and engineers to focus more on designing their systems and writing the logic rather than spending excessive time dealing with circuit wiring or programming at the register level.

Fig.8.Arduino UNO

Arduino board specifications.

- Microcontroller: ATmega328.
- Operating Voltage: 5V.
- Input Voltage (recommended): 7-12V.
- Input Voltage (limits): 6-20V.
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 6.
- DC Current per I/O Pin: 40 mA.
- DC Current for 3.3V Pin: 50 mA.

IV-RESULT AND DISCUSSIONS

The prototype Atmospheric Water Generator (AWG) was successfully developed and tested under controlled environmental conditions with moderate humidity levels (50–70%) and ambient temperatures ranging from 28°C to 34°C. During operation, the TEC modules effectively reduced the cold-side surface temperature to as low as 8°C–12°C, as measured by the LM35 temperature sensor. This temperature drop was sufficient to cause visible condensation of water vapor from the surrounding air onto the cold surfaces of the TECs.

Water droplets began to form within 10–15 minutes of powering the system, confirming the feasibility of atmospheric moisture condensation using Peltier-based cooling. The condensed water was collected on a metallic surface and accumulated in a small tray placed below the cold side. On average, the prototype generated approximately 5–10 mL of water per hour, depending on humidity and ambient temperature conditions. Though the water output is modest, it successfully validates the system's working principle and proves its potential when scaled.

Temperature data captured by the LM35 sensor was consistently accurate and stable, and real-time monitoring was achieved through the ESP8266 Wi-Fi module, which transmitted the data to a mobile interface via a simple IoT.

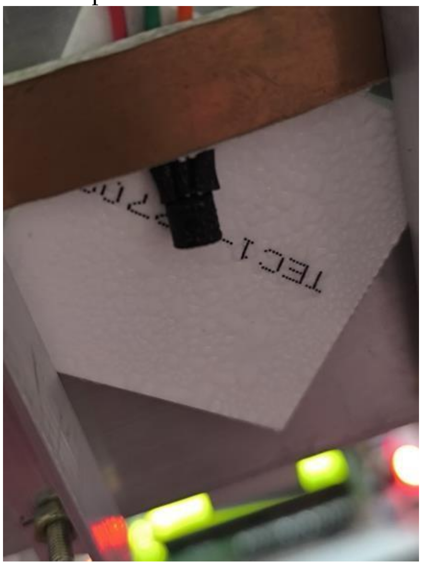

Fig.9.water droples on TEC

One of the key findings was that effective heat dissipation is critical to maintaining a high-temperature differential. Without proper cooling of the TEC's hot side, the system's efficiency drops significantly. Another observation was the dependency of water production on ambient humidity levels—higher humidity directly led to increased condensation rates. Additionally, power consumption was measured and found to be approximately 60–70 watts, indicating the need for a renewable energy solution like solar power for long-term, off-grid deployment.

ADVANTAGES

Produces Drinking Water from Air:
Extracts clean water from humid air, making it suitable for areas with water scarcity.
Useful in Remote and Arid Areas:
Ideal for deserts, coastal regions, or disaster zones where traditional water sources are unavailable.
No Need for Water Source:
Operates independently without needing a river, well, or reservoir.
Eco-Friendly Technology:
Does not involve chemical processes, reducing environmental impact.
Uses Thermo-Electric Coolers (TECs):
Solid-state, compact cooling devices with no moving parts—low maintenance.
Real-Time Monitoring via IoT:
Sends live temperature data to mobile devices for easy remote monitoring.

APPLICATIONS

1. Drinking Water in Arid Regions – Supplies potable water in deserts or drought-prone areas.
2. Military Field Operations – Provides water to troops in remote, water-scarce zones.
3. Disaster Relief Camps – Useful in emergency shelters after floods, earthquakes, or wars.
4. Coastal Areas – Extracts fresh water from humid sea air where groundwater is saline.
5. Off-grid Homes or Cabins – Supports self-sufficiency in locations without water pipelines.
6. Smart Agriculture – Supplies water to precision farms using humidity-based extraction.
7. IoT-based Water Monitoring – Sends temperature and performance data to cloud platforms.
8. Space-constrained Urban Setups – Can be installed on rooftops for home water harvesting.
9. Schools and Remote Institutions – Ensures clean drinking water in rural educational facilities.
10. Green Buildings – Integrates into sustainable architecture to minimize external water demand.
11. Remote Research Stations – Essential for scientists working in isolated environments.
12. Smart Cities – Can be scaled and integrated with smart infrastructure for water resilience.

CONCLUSION

This project successfully demonstrates a compact and functional prototype of an Atmospheric Water Generator (AWG) system enhanced with IoT capabilities. Using Thermo-Electric Cooler (TEC) modules, the system creates a temperature differential that cools the air below its dew point, leading to the condensation of water vapor into liquid water. This water, which originates from ambient air, is clean and can serve as a valuable drinking water source, especially in regions lacking fresh water.

The project further incorporates an LM35 temperature sensor to monitor the cold side of the TEC device. This sensor feeds data into an Arduino Uno microcontroller, which processes the analog input and displays the current temperature on an LCD. Additionally, the system employs an ESP8266 WiFi module, allowing real-time data transmission of temperature values to a remote mobile device or cloud platform. This provides remote monitoring, alerting users if the temperature conditions are not optimal for condensation.

Although this is a prototype model using two TEC modules, it proves the scientific principle and technical viability of harvesting water from air. The system demonstrates effective temperature monitoring, heat management using heat sinks and fans, and IoT-based communication—all essential for the operation and scaling of a larger AWG system.

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