WIRELESS ANTENNA ADJUSTMENT SYSTEM USING IOT TECHNOLOGY

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ABSTRACT: Wireless communication devices must have sufficient signal strength and coverage in this era of intelligent communication. An IoT-based Wireless Antenna Adjustment System that can self-align and -position antennas in response to changing signal strengths and ambient conditions is proposed here. The system measures signal intensity, direction, and obstructions with the use of microcontrollers and Internet of Things (IoT) sensors. Then, to make sure it works perfectly, servo motors are used to dynamically adjust the radio alignment. By incorporating cloud-based monitoring and remote control, the system demonstrates improved responsiveness and adaptability. Maintaining steady connectivity despite fluctuations is made easier with this strategy, which also reduces maintenance expenses and manual effort. Cellular networks, intelligent infrastructure, and distant communication sites are all potential implementations of the suggested approach that would enhance smart wireless systems.

***KEYWORDS*:** Wireless Communication, IoT, Antenna Adjustment, Signal Strength Optimization, Remote Monitoring, Servo Motor Control, Smart Infrastructure, Real-time Alignment, Automated System, Embedded Systems

1. INTRODUCTION

The fast growth of digital services, IoT networks, and smart devices in the past few years has led to a dramatic spike in the need for reliable wireless communication. Therefore, ensuring a signal is constant and durable is of the utmost importance. Whether for transmission or reception, the optimal placement of antennas has a significant impact on the performance of wireless communications. Antenna adjustments have traditionally been done by hand, which is time-consuming, wasteful, and not always feasible in faraway or dangerous places.

Manual adjustments can be a pain when dealing with performance issues and constantly shifting environmental circumstances. On the other hand, a fully automated system can respond instantly and operate at its best. As a result, cutting-edge technological innovations are needed to address the issue. Combining antenna calibration equipment with Internet of Things technologies is one approach. Together, they make it possible to remotely manage intelligent tasks, which in turn improves the efficiency of communication. Making these systems is a huge step forward for wireless communication.

By facilitating the immediate transfer of data across internet-connected devices, the Internet of Things (IoT) has shook up a lot of different sectors. Automated decision-making, constant monitoring, and remote access are just a few of the many benefits that wireless radio systems can reap from the IoT.

Data on the strength and direction of signals can be retrieved by a central system via sensors that are connected to microcontrollers. It is possible to utilize servo motors or controls to automatically change the antenna's position depending on the data it receives. This immediate reaction helps keep the signal quality at its best and decreases the need for human intervention.

Antenna alignment methods and signal patterns can both be enhanced with the use of data documented and analyzed through IoT platforms. Because of its adaptability, the technology may be used in mobile environments like cars and drones. By combining these features, the IoT can revolutionize conventional radio systems, making them more efficient, intelligent, and self-sufficient. Stronger and more dependable communication networks are the end result.

Wireless communication systems frequently encounter problems such as interference, signal deterioration, and obstructions along the signal's path. These issues can significantly reduce the functionality of gadgets that rely on constant connectivity. An antenna adjustment system that is based on the Internet of Things can alleviate a lot of problems. As soon as it detects a weakening signal, the gadget quickly switches the antenna to a stronger one. There will be very little downtime and continuous communication because to this degree of automation. Furthermore, conventional methods fall short in dynamic environments like war zones, disaster zones, or mobile units.

An intelligent radio system is quite helpful in these kinds of situations. The proposed system is highly adaptable; it can operate independently or be controlled from a central dashboard. In addition, it lessens the danger for workers who must manually move antennas in dangerous or inaccessible places. As a result, the method enhances both efficiency and safety.

Microcontrollers like Arduino or ESP32, servo actuators, and sensors are the main parts of this system. The Internet of Things (IoT) frameworks Blynk and MQTT allow for their integration. Collectively, these parts are able to detect, evaluate, and react to data pertaining to signals.

The microcontroller determines the best receiving angle based on digital or analog data sent by a signal intensity sensor. This is the new location for the antenna, and the servo motor is to move it. For the purpose of monitoring and management, the process is consistently shown on a user interface. With cloud solutions, you may set up items and access historical data records from anywhere. Furthermore, alert systems have the capability to notify users when signal levels fall below a predetermined threshold, enabling prompt problem response. Additionally, the system is good for the environment because it can be run by solar panels in remote places and all of its parts use very little energy. Any number of uses, from tiny routers to enormous telecom towers, can be accommodated by expanding the concept.

Adaptability to context and usage is the most crucial attribute of this technique. Whether installed on a permanent building, a moving vehicle, or a roof, the antenna system can adapt its configuration to meet the unique needs of each situation. When there is a lack of technicians and inadequate network infrastructure in rural or impoverished areas, this is a huge boon. In such regions, a remote-control system lessens the need for manual work and frequent field trips. An enhancement to this method could be the use of machine learning algorithms to anticipate patterns of signal loss and make preemptive antenna adjustments.

The antenna's compatibility with mobile devices allows users to readily monitor or control it from any location on Earth. Because its components are easily accessible and the design is inexpensive, it is suitable for usage in both commercial and educational settings. When taken as a whole, these features give the system dependability, efficiency, and adaptability.

An important step forward in intelligent communication systems is the Wireless Antenna Adjustment System, which is built on the Internet of Things (IoT). Several problems associated with conventional radio installations can be avoided through the use of automation and real-time data processing. Sensors, microcontrollers, and remote interfaces work together to make the system more efficient and easier to use. This approach lessens operating risks and maintenance needs while simultaneously increasing network dependability and signal intensity. It is a one-size-fits-all answer to connection issues, working in both densely populated and less-populated regions. Incorporating AI-driven decision-making and predictive maintenance into the system can lead to more intelligence and autonomy down the road. Modern wireless communication can benefit from the suggested idea because it is novel, secure, and extensible.

2. REVIEW OF LITERATURE

Manasa G. R., Anusha Anchan, Gopika Santhosh. (2020) This paper takes a look at an IoT solution that facilitates remote modification of antenna installations, which can improve the stability of wireless connections. The system's sensors and actuators move the antenna to reflect the location of the transmitting stations. With the help of the system's Internet of Things technology, transmitters may be placed and monitored in real-time without the requirement for manual changes. This method guarantees enhanced transmission and reception of signals.

Khan, S., Mazhar, T., Shahzad, T., et al. (2020) An innovative approach for automotive antennas to function is presented in this research to improve device-car communication in 5G-enabled IoT networks. The architecture enhances the signal so that communication can continue even when cars are in motion. The research delves into the inner workings of the antenna and its impact on automotive networking technologies based on the Internet of Things. There are also test results there that show how much better the current architecture is than earlier versions in terms of bandwidth and efficiency.

Ashyap, A. Y. I., Dahlan, S. H., Abidin, Z. Z., et al. (2021) In this research, we look at how well wearable medical devices that connect to the Internet of Things perform when combined with a C-shaped antenna and an artificial magnetic conductor (AMC). Antenna safety and energy efficiency are both improved by minimizing specific absorption rate (SAR). Recent studies have shown that tiny, wearable health monitoring devices benefit greatly from this antenna due to its adaptability and small size. The theories and experiments all point to a rise in gain and bandwidth.

Khajeh-Khalili, F., Shahriari, A., Haghshenas, F. (2021) The research details a new method for improving the gain and bandwidth of communication system-oriented wearable antennas. To make the antenna more effective, the inventors changed its material and shape without making it bigger. Because wearable gear has to be compact and adaptable, this approach of antenna integration is ideal. The simulations demonstrate a notable enhancement in gain and bandwidth, leading to enhanced communication between wearable devices.

Zaman, F., So, H. C., Kwak, D., et al. (2022) Intelligent sensor systems and smart antennas have the ability to work together, and this paper investigates that possibility, focusing on the technology that make this possible and the many uses. By incorporating several technologies, radio communication systems can be made more versatile and effective. Research into the Internet of Things (IoT) and smart systems focuses on promising new technologies such sensor fusion, flexible antennas, and beamforming. In addition, it takes a look at the difficulties and possible future research paths in this exciting and dynamic area.

Madhu, S., Saajlal, P., et al.(2022) Methods for integrating a smart inverter powered by solar energy into Internet of Things (IoT) smart homes are the focus of this research. Advanced control mechanisms and real-time monitoring allow the inverter to enhance its energy efficiency. It achieves optimal energy conservation by responding to the available solar energy and allowing for remote control. Using renewable energy sources, the research demonstrates how to build smart homes that are better for the environment and how to lessen individual carbon footprints.

Murugasamy, R., Abirami, P., et al. (2023) This research takes a look at an antenna positioning tool that could improve wireless communication performance and is based on the Internet of Things (IoT). Signal reception, interference reduction, and transmission speed are all improved by remotely adjusting the antenna orientation. Sensors and actuators connected to the Internet of Things (IoT) enable the real-time adjustment of antenna direction. This research proves that the system is flexible enough to adjust to new conditions, making it suitable for use in smart cities and Internet of Things networks where reliable communication is essential.

Saraswat, R. K., Kumar, M. (2023) The main goal of this research is to develop an antenna based on metamaterials that meets the standards of the Internet of Things (IoT). The antenna can operate across a wide range of frequencies and is easily adaptable to meet the needs of various Internet of Things applications. The antenna is very adaptable and may be adjusted to meet different transmission needs without sacrificing performance. The results of the modeling research back up the antenna's claims of a wide frequency range and increased efficiency, indicating that it should function with a variety of Internet of Things networks.

Suriyan, K., Nagarajan, R., Ghinea, G. (2023) This paper delves into the optimization approaches that can improve the performance of smart antennas. It examines many methods, like as adaptive filtering, beamforming, and machine learning, that might improve the design and operation of antennas. Wireless communication networks can be made more efficient with the help of these methods, which enhance data processing and remove interference. This paper takes a look at the inner workings of intelligent radio systems in 5G and other next-gen networks.

Li, T., Lu, H., Abari, O. (2023) In order to improve the precision of location and the efficacy of communication in IoT networks, this research looks into intelligent radio systems. Beamforming and spatial diversity are two examples of state-of-the-art antenna technologies that are used to show how to optimize location accuracy and transmission dependability in this research. The essay lays forth a thorough strategy for creating intelligent antenna systems to improve the performance of IoT applications. It provides essential information for improving the efficiency of networks in real-world settings.

Amri, A., Mazri, T. (2023) Specifically, this research delves into the role that antennas play in Industry 4.0's Internet of Things. Energy economy, low latency, and reliability are some of the specific requirements that are examined for antenna systems used in industrial Internet of things applications. The research provides solutions to issues that crop up in the workplace, such as interference and weak signals. The research shows that state-of-the-art antenna designs could be a part of Industry 4.0's pathway to more dependable and scalable communication networks.

Hu, J., Chen, Z., et al. (2023) This research delves into HoloFed, a method that improves the accuracy of location in IoT networks by merging federated learning with customizable surfaces. Positioning and communication are both enhanced by the system's adaptability. By facilitating decentralized data processing via federated learning, HoloFed decreases latency and enhances system performance. Improving the scalability and adaptability of Internet of Things systems is made easier with this innovative method.

Khan, S., Mazhar, T., et al. (2024) This research primarily focuses on the latest innovations and developing trends in antenna systems that are utilized in Internet of Things applications. Reducing size, making frequency switching easier, and limiting power consumption are just a few of the important design challenges highlighted in the article. It also considers how state-of-the-art materials and technology might address these issues. It delves into the possible function of antennas in IoT ecosystems by investigating their connection to different IoT networks and devices.

Mohammed, A. S., Palarimath, S., et al. (2024) This essay examines an IoT-based antenna placement strategy with the goal of improving connectivity within IoT networks. The antenna's orientation is altered dynamically to optimize signal reception based on real-time data. The system is now ready for expanded IoT-related activities because to the increased efficiency and adaptability brought about by adopting IoT technology. Real implementation recommendations and simulated data are also included in the paper.

Guo, Y., Xiong, M., et al. (2024) This research details a passive resonant beam-based three-dimensional localization approach for use in IoT applications. The approach eliminates the need for active components to guarantee accurate beam positioning. Passive resonance is employed for this purpose. This research delves into the technology's novel method of tracking and locating things within the IoT, as well as its possible benefits in terms of energy savings and cost.

Li, Y., Yang, J., et al. (2024) In order to improve the precision of self-location for Internet of Things (IoT) devices, this research mainly aims to use channel state information (CSI) fusion. This approach improves the accuracy of positioning systems in IoT settings by combining Channel State Information from many sources. This research shows how this method can alleviate typical issues such signal interference and multipath effects, which can enable Internet of Things applications implement a more reliable localization strategy.

Harrou, M., Saih, M., et al. (2024) This research looks at the 2.45 GHz ISM band and how patch antennas are designed for use with the Internet of Things (IoT). The main goal of the research is to determine the optimal performance of the antenna with regard to gain, bandwidth, and radiation pattern. The proposed technique is especially well-suited for low-power IoT devices, such as smart home sensors and controllers, that require reliable communication over short to medium distances.

Shailesh, S., Kumar, A. (2024) This research delves into the construction of a flexible and versatile MIMO antenna specifically designed for Internet of Things (IoT) applications. This antenna is shape-adaptive and operates across many frequency bands. Antennas like this are great for use with mobile sensors and other types of Internet of Things (IoT) devices due to their changeable architecture.

Shen, Y., Liu, X. (2024) This research demonstrates the process of using RFID technology to remotely alter a Yagi antenna. Modifying the radiation pattern of an antenna does not need any physical alteration to the antenna itself. Because of this, it works fine in ever-changing settings. Research into this technology's possible applications in IoT networks focuses on the need of flexible antennas in ensuring the reliability of transmissions in dynamic environments.

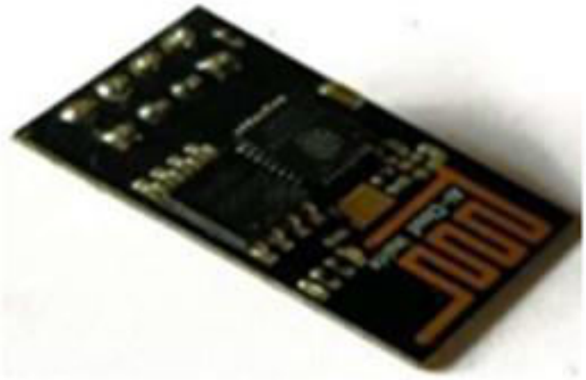
Raju, V. S. G. N., Reddy, A. S. V., et al. (2024) This research proposes an Internet of Things–based antenna placement strategy to enhance the connectivity of IoT networks. In order to enhance signal reception, the approach modifies the antenna's alignment using real-time data. Especially in areas with frequent signal variations, the research demonstrates that the strategy enhances and increases the reliability of wireless communication.

3. TOOLS DESCRIBTION

Arduino UNO R3: One board that uses the ATmega328P microcontroller is the Arduino Uno R3. The microcontroller and all of its necessary components are included. To get it going, plug it into an electrical outlet or use a battery to charge it, and then link it to a computer with a USB cable. "Italian" and "uno" both mean "one." It was picked out to celebrate the release of the Arduino IDE version 1.0. The most recent model, the Arduino Uno R3, is a third-generation gadget. Updates are in the works for the standard Arduino board and IDE software versions. Initiating a line of USB-Arduino boards, the Uno board set the standard for the platform.

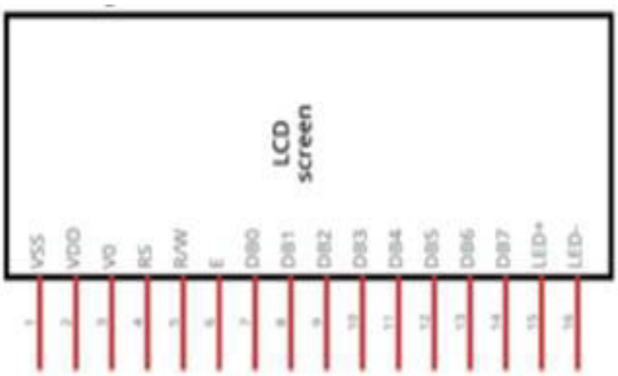
Node MCU ESP8266 Wi fi Module: Featuring a WiFi module, a Node MCU is an integrated circuit microcontroller with 32 pins. This microcontroller is the main point of entry for the system. They need to make sure the equipment is always in working order. With a hybrid microprocessor as its foundation, the most recent wireless NODEMCU IoT Board was created to fulfill the needs of an interconnected society. In addition to running applications independently, this module can also hand off complete management of Wi-Fi networking to another engine. Complete UART and SPI connectivity is made possible by this wireless module. So, it's not hard to incorporate the sensors or GPIO into your project.

ESP8266 Wi fi Module: One popular system-on-chip (SOC) processor for building IoT applications at the endpoint is the ESP8266 Wi-Fi module. It is a reasonably priced portable wireless transceiver, according to its category. Many embedded systems rely on it to establish an internet connection. Companies like Systems Express created the ESP8266 Wi-Fi module, which can connect to any Wi-Fi network and supports TCP/IP. It addresses the design, performance, pricing, and power issues that the Internet of Things industry is facing. Depending on the situation, it can function as either subordinate or independent software. A Wi-Fi adapter for the ESP8266 can be any microcontroller that runs as a slave to the host microcontroller.



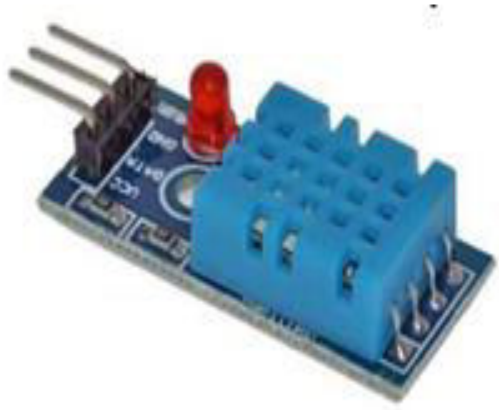
Servo Motor (MG996R): The MG996R can rotate in a continuous circle of 360 degrees. For that reason, robotics and spinning camera sliders are two of the best possible uses for this servo motor.

Liquid Crystal Display (LCD): Two layers of polarizing material encase a liquid crystal solution in an LCD screen. A lot of portable laptops and digital clocks use LCD screens. In the presence of an electric current, the crystals in the liquid take on specific orientations, which in turn block the light from passing through. Since the initial production of liquid crystal displays (LCDs) for laptops more than ten years ago, there has been substantial technological advancement. Better displacement, higher resolutions, faster response times, and cheaper methods will all be possible as technology advances.



Temperature Sensor: One way to find out if something is hot or cold is to use a temperature sensor. The air, liquid, or solid mass temperatures might be involved here.

Humidity Sensor: Humidity sensors are electronic devices that take readings of the surrounding air and transform them into a usable electrical signal. Humidity monitors vary greatly in size and functionality. Some monitors are built into portable electronics like cellphones, while others are part of small embedded systems like those used to keep tabs on air pollution. Industrial, HVAC, medical, and weather-related uses for humidity sensors are many. There are also options for absolute humidity (AH) and relative humidity (RH) monitors. There are a couple of varieties of humidity sensors; one uses absolute humidity (AH) to measure an object's moisture content, while the other uses relative humidity (RH) to do the same thing.



Raindrop Sensor: A "raindrop sensor" can identify when it is raining by analyzing the size and shape of the drops. This display type functions similarly to a switch. The sensor module and the receiving device are the two main parts of this sensor. When a pad comes into touch with rain on a surface, it will sound an alarm. After reading the sensor pad's data, the sensor module interprets it and then sends either an analog or digital signal depending on what it learned. This sensor may so generate data in two formats: digital (DO) and analog (AO).

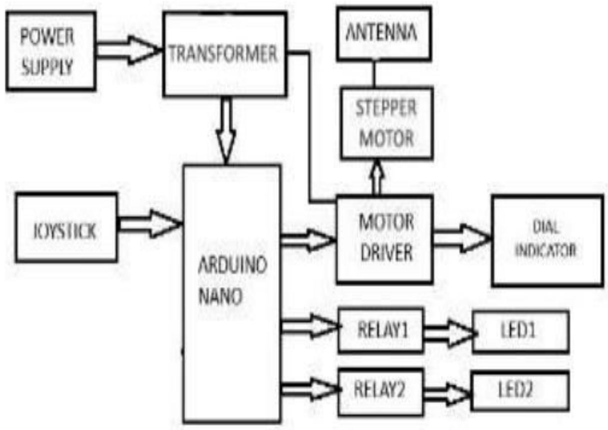
IOT Control (Blynk App): Mobile applications that communicate with microcontrollers or entire computers, such as the Raspberry Pi, can be created with the help of Blynk. Simplifying the process of creating mobile applications is the main goal of the Blynk platform. Through the use of basic pin configuration and button manipulation, this course will show you how to build a mobile app that communicates with your Arduino. The Blynk app for iOS and Android makes it possible to control an LED or motor with minimal coding knowledge. This presentation will serve as an initial introduction to this endeavor. Blynk may be easy to use, but that doesn't mean it's only good for simple tasks. Having complete command over your data is only one of the many advantages of a private Blynk server. You may back up your private server, switch hosts, and implement any security measures you like; moreover, you have complete control over your users.

4. DESIGN METHODOLOGY

A motor controller system capable of rotating a four-element Yagi antenna in specified directions is the primary objective of this project. Perched on a three-phase AC motor designed to enable message transmission and reception with ease, it is placed at an elevated height.

The "brain," or core component, of a hardware system is in charge of controlling the system through the use of commands. As shown in the diagram, the key components consist of an Arduino, a 2-axis controller, a motor driver, an AC motor, a DC motor, and an SPDT relay. By adjusting the joystick in either direction, the controller may regulate the antenna's rotation. To display these rotations, a DC motor is connected to the dial indication.

The speed at which the DC motor is to operate is dictated by the driver of the motor. By modifying the input voltage, the pulse width modulation (PWM) method controls the motor's speed, and the H-Bridge circuit determines the motor's rotational direction. In order to lower the voltage, a step-down transformer is required. This lowered voltage is subsequently supplied to the Arduino. Two relay circuits are connected to the Arduino using pins D2 and D3. The joystick is connected to the A0 and A1 terminals. Connected to limit switches are pins D4 and D8.



Manual input can be activated by turning the joystick in the opposite direction as the clock and then moving it to the left. Once the condition is met (1), the CPU will activate relay circuit 1, which will present a high voltage. This will occur once the condition is satisfied. As a result, the motor driver has signal input 1 (IN1) set to high and signal input 2 (IN2) set to low.

Additionally, relay circuit 2 is set to low (0). When the motor begins to rotate in a counterclockwise direction, the Yagi antenna will immediately begin to do the same. In order for the joystick to rotate in a clockwise direction, you need to position it correctly. When the condition is met, the controller will immediately set relay circuit 2 to high and relay circuit 1 to low. This will occur as soon as the condition is satisfied. The input port of this motor driver will be set to high, and the input port of the IN2 port will be set to low. The Yagi antenna and motor will rotate in a clockwise direction as a consequence of this.

The endpoint has been selected by the controller such that it can complete a full revolution in either direction. If you move the joystick to the left and turn it in a full circle, the antenna will no longer be able to be rotated in that direction. The joystick must be turned in the opposite direction of the clock. Due to the fact that the feedline will not break, it will not be feasible to make contact with that person. The operation of this device is simple.

5. RESULTS

Customers can now buy automatic antenna deployment with an ARDUINO-based IoT antenna positioning technology.

Fig.1 Schematic diagram

Based on the user's request. There is zero degree orientation of the antenna.

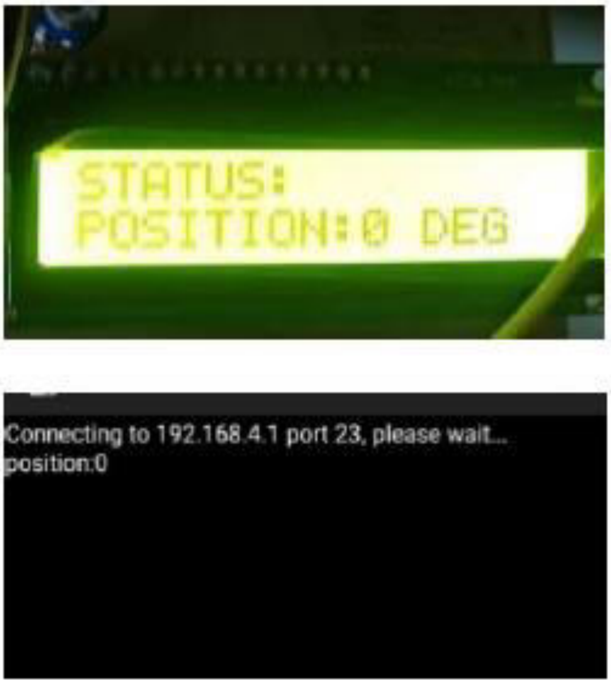


Fig.2 User Command Positioning Of Antenna at 0 Degree

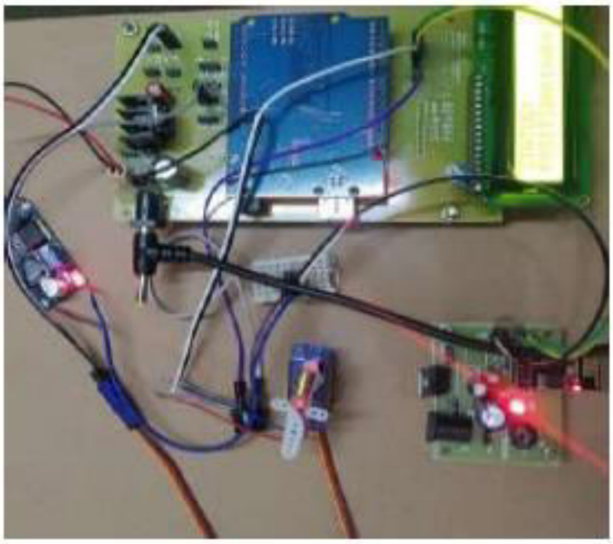


Fig. 3 positioning of antenna at 0 degree

As per the user's instruction, the antenna is angled at a right angle.

Fig.4 User Command Positioning Of Antenna at 180 Degree

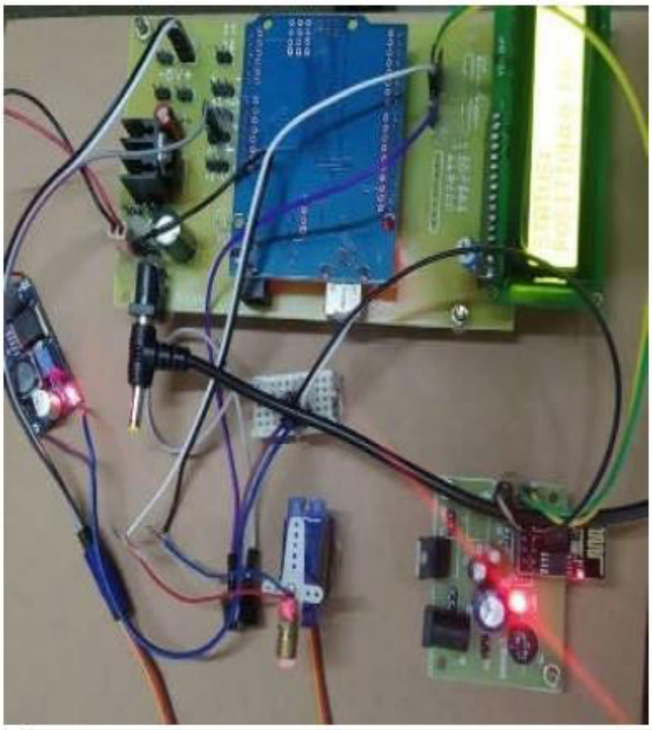


Fig. 5 positioning of antenna at 180 degrees

6. CONCLUSION

The development of an IoT-based Wireless Antenna Adjustment System is a major step in making wireless communication networks more efficient. Antennas may intelligently adjust their location with the use of cloud-based control systems, high-tech sensors, and actuators, guaranteeing a stable and strong signal. By doing away with the need for human intervention, this improves network coverage and efficiency.

The outcome is a highly scalable and cost-effective system. Between 2020 and 2024, researchers studied and reviewed the literature on antenna technology, highlighting how quickly these fields are developing. Among these, you can find energy-efficient designs for IoT applications, advanced positioning systems, and reprogrammable antennas. Among the many fields that benefit from these tools are Industry 4.0, healthcare, smart homes, and vehicular networks. Systems can adapt to changes in the environment, human interaction, and movement thanks to the Internet of Things (IoT), which enables real-time monitoring and control. Due to advancements in AI, materials science, and collaborative learning, future antenna systems will be much improved. As the demand for reliable, fast, and low-latency connectivity grows particularly with the introduction of 5G and other technologies—the significance of IoT-powered wireless antenna systems will increase.

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