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IOT - ENABLED LOW-SLUNG POWER ATMOSPHERIC MONITORING SYSTEM

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ABSTRACT

This study presents a remote environmental monitoring system for smart agriculture, leveraging low-power Internet of Things (IoT) technology to achieve real-time monitoring of critical parameters such as temperature, humidity, and light intensity in crop environments. The system optimizes agricultural practices by utilizing IoT features like broad coverage, multiple connections, rapid data transmission, cost efficiency, low energy consumption, and robust architecture. By addressing these key needs, the system provides an efficient solution to enhance agricultural productivity while ensuring sustainable resource management. The system architecture integrates multiple components, including low-power environmental monitoring nodes, a LoRa (Long Range) gateway, and upper computer software for data visualization and analysis. The monitoring nodes, equipped with energy-efficient sensors, collect and relay data to the LoRa gateway, which ensures reliable long-distance communication. The upper computer software processes this data and provides farmers with actionable insights through an intuitive interface. This combination of hardware and software ensures seamless integration, enabling precise monitoring of environmental conditions critical for crop growth. A significant contribution of this research lies in developing and optimizing the LoRa protocol. This protocol is tailored to enhance communication range, stability, and energy efficiency, addressing the challenges of deploying monitoring systems in large agricultural fields with limited infrastructure. The optimized protocol ensures the system performs effectively in long-distance communication scenarios, maintaining low power consumption while delivering consistent data. These advancements make the system particularly suitable for rural and remote agricultural applications. The system's performance was rigorously tested, demonstrating exceptional reliability across metrics like communication distance, power efficiency, and operational stability. The results validate its potential to support sustainable agricultural practices by enabling data-driven decision-making. With its affordability, scalability, and energy efficiency, the system provides a powerful tool for modernizing agriculture and revitalizing rural communities. This innovation empowers farmers to optimize resources, reduce environmental impact, and enhance productivity, contributing significantly to the ongoing transformation of the agricultural sector.

INTRODUCTION

With the increasing global focus on environmental protection and energy conservation, the importance of environmental monitoring has grown significantly. Effective monitoring systems are vital for sustainable resource management, enabling timely detection of environmental changes and facilitating appropriate responses to ensure ecological balance. Advances in science and technology have played a pivotal role in enhancing the scope and efficiency of these systems. However, modern environmental monitoring faces critical challenges, including the need for broader coverage, the ability to operate in harsh natural conditions, and compliance with stringent power consumption and networking requirements. These factors pose new demands on the development and deployment of monitoring systems, necessitating innovative solutions to meet the complexities of contemporary environmental management. Low-power Internet of Things (IoT) technology has emerged as a transformative solution, addressing many of these challenges with its unique features. It offers wide coverage, supports multiple device connections, enables fast data transmission, minimizes energy consumption, and provides a cost-effective and robust architecture. These characteristics make low-power IoT technology particularly suitable for a wide range of applications, including agriculture, soil testing, air quality monitoring, and water quality assessment, where sustainable resource management is essential. In the realm of agriculture, environmental monitoring plays a critical role in understanding and managing the factors that influence crop growth. Key parameters such as temperature, humidity, and light intensity are essential for maintaining optimal conditions in the crop growth environment. However, traditional monitoring methods often involve manual measurements and localized systems that are resource-intensive and limited in scalability. To address these limitations, this research proposes the development of a remote environmental monitoring system based on low-power IoT technology, specifically tailored for smart agriculture. The system is designed to enable remote and real-time monitoring of critical environmental parameters within the coverage range of the equipment. It employs low-power sensor nodes that efficiently capture data while minimizing energy consumption and utilizes LoRa (Long Range) communication technology to transmit data across significant distances reliably. The system also integrates advanced software for data analysis and visualization, providing farmers with actionable insights to optimize agricultural practices. By leveraging these innovations, the proposed system offers a practical and scalable solution for improving resource utilization, enhancing crop productivity, and promoting sustainable farming practices. This study not only addresses the pressing challenges of agricultural monitoring but also contributes to the broader application of low-power IoT technology in environmental monitoring, supporting advancements in agricultural modernization and rural revitalization. Through its innovative approach, the research aims to transform traditional farming into a more efficient, environmentally conscious, and technologically advanced sector, aligning with global efforts toward sustainable development.

LITERATURE SURVEY

A) Zhou, G. Sun, Y. Luan, D. (2022) Research and Design of Smart Agriculture Based on NB IoT. Computer Knowledge and Technology, Volume 18 (21): 102-104

Smart agriculture, driven by the integration of the Narrowband Internet of Things (NB-IoT), is emerging as a transformative approach to addressing the challenges of modern farming. This study explores the design and implementation of a smart agricultural system that leverages the low-power, wide-area network capabilities of NB-IoT to monitor and optimize critical environmental parameters. By deploying intelligent sensors and centralized control systems, the proposed framework facilitates real-time data acquisition, analysis, and decision-making for various agricultural applications, such as crop monitoring, soil moisture regulation, and resource management. The research evaluates the system's performance in terms of energy efficiency, data reliability, and scalability, highlighting its potential to enhance productivity while minimizing operational costs. This work provides a foundation for implementing sustainable and efficient agricultural practices supported by advanced IoT technology. The increasing demand for sustainable agriculture has led to the rapid adoption of innovative technologies to enhance productivity and resource management. Among these technologies, NB-IoT has garnered significant attention due to its advantages in connectivity, low power consumption, and extended communication range, making it highly suitable for rural and remote agricultural environments. This paper presents a detailed analysis of a smart agricultural system based on NB-IoT technology, designed to address common challenges such as resource scarcity, climate variability, and inefficient monitoring practices. The system integrates IoT-enabled sensors, a centralized data processing platform, and user-friendly interfaces to provide real-time insights into crop and soil conditions. By automating data collection and analysis, it aims to empower farmers with actionable information for informed decision-making. The research emphasizes the role of NB-IoT in overcoming traditional limitations of agricultural systems, such as high energy demands and poor network coverage. Through experimental validation, the system demonstrates enhanced communication reliability, energy efficiency, and scalability, making it adaptable to various agricultural scenarios. This study not only contributes to the field of precision agriculture but also underscores the potential of NB-IoT to drive innovation in sustainable farming practices. By addressing the critical requirements of modern agriculture, the proposed framework lays the groundwork for developing advanced solutions that balance productivity with environmental stewardship.

B) Xie, W. (2021) Power consumption and coverage performance testing and analysis of typical NB IoT devices Mentor: Wu, Y. Nanjing University of Aeronautics and Astronautics. DOI: 10.27239/d.cnki.gnhhu.2021.000883 The paper by Xie, W. (2021) titled *"Power Consumption and Coverage Performance Testing and Analysis of Typical NB IoT Devices"* provides an in-depth exploration of the critical parameters of power efficiency and network coverage in Narrowband IoT (NB-IoT) devices. NB-IoT is a widely adopted low-power wide-area network (LPWAN) technology that has become integral to Internet of Things (IoT) solutions, especially in applications like smart agriculture, environmental monitoring, and remote sensing. The paper's primary focus is on empirical testing of power consumption and signal strength, two of the most vital aspects of NB-IoT deployment. Xie examines how varying factors such as device configuration, environmental conditions, and network settings affect the energy usage and coverage capabilities of NB-IoT devices. Xie discusses the importance of low-power, long-range connectivity technologies like NB-IoT, which enable IoT devices to function efficiently in remote or rural areas where other connectivity solutions may not be viable. The need for these technologies arises from the growing demand for reliable, cost-effective, and energy-efficient communication systems that can support the massive deployment of IoT sensors and devices. By analyzing the power consumption characteristics of NB-IoT devices, the paper identifies key factors that contribute to optimizing device longevity while maintaining the necessary coverage and connectivity. Xie's findings are particularly relevant for applications in remote agricultural systems, where long-term device deployment in harsh environments requires the devices to be energy-efficient and capable of maintaining strong signals over long distances.This study also compares the performance of different NB-IoT devices, providing benchmarks for the performance of these devices under real-world testing conditions. These benchmarks are critical for understanding the trade-offs between power usage and signal coverage, offering valuable insights for IoT network designers and engineers. The paper emphasizes the need for a balanced approach that optimizes both energy efficiency and coverage, particularly for large-scale deployments in remote regions. Overall, Xie's research provides critical insights into the challenges of deploying NB-IoT technology for large-scale IoT applications, highlighting the need for optimized device configurations to enhance performance while minimizing power consumption. These findings help to ensure that NB-IoT can continue to support applications in agriculture, environmental monitoring, and other fields that require long-range, energy-efficient connectivity.

C)Li, Z. Dong, W. Huang, S. (2021) Design of Agricultural Greenhouse Temperature and Humidity Monitoring System Based on DHT11. Industrial instruments and automation devices (01): 39-43.

The paper *"Design of Agricultural Greenhouse Temperature and Humidity Monitoring System Based on DHT11"* by Li, Z., Dong, W., and Huang, S. (2021), focuses on developing a reliable and cost-effective monitoring system for agricultural greenhouses. The system utilizes the DHT11 sensor, a widely used sensor for measuring temperature and humidity, which is known for its low cost and sufficient accuracy in agricultural applications. The monitoring system continuously collects real-time data on these parameters, providing greenhouse managers with crucial information to optimize the environment for plant growth. The design includes sensors, data acquisition modules, and a communication platform, ensuring efficient data transmission and processing. The authors discuss the growing importance of precision agriculture and the need for smart technologies that can ensure optimal growing conditions in greenhouses. Traditional monitoring methods, which often rely on manual data collection, are time-consuming and inefficient, especially for large-scale greenhouse operations. By integrating the DHT11 sensor into an

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automated monitoring system, this research addresses the challenge of providing continuous and real-time environmental data to farmers and greenhouse operators. The system's ability to monitor both temperature and humidity in real time allows for better regulation of environmental conditions, improving the quality of crops and reducing the risk of environmental stress on plants. Additionally, the paper outlines how such a system contributes to the broader trend of smart farming, where IoT devices play a key role in improving sustainability and resource management in agriculture. By combining automation with real-time monitoring, this system enhances decision-making, enabling greenhouse managers to make adjustments based on live data, which can ultimately increase crop yield and reduce resource wastage. The research reflects a significant step toward the integration of low-cost, scalable technology into greenhouse management, emphasizing the practical applications of simple sensors like DHT11 in precision farming. Through this system, the authors demonstrate the potential for affordable technology to support sustainable and efficient agricultural practices.

III.IMPLEMENTATION

BLOCK DIAGRAM

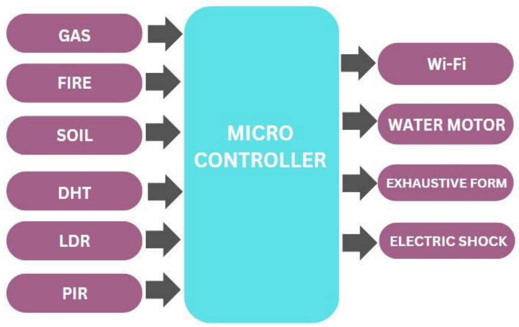

FIG: BLOCK DIAGRAM

DESCRIPTION

POWER SUPPLY

A **regulated power supply** transforms unregulated AC (Alternating Current) into a stable DC (Direct Current). It guarantees consistent output despite variations in input. A regulated DC power supply is also known as a linear power supply, it is an embedded circuit and consists of various blocks

- **Regulated Power Supply Definition**: A regulated power supply ensures a consistent DC output by converting fluctuating AC input.
- **Component Overview**: The primary components of a regulated power supply include a transformer, rectifier, filter, and regulator, each crucial for maintaining steady DC output.
- **Rectification Explained**: The process involves diodes converting AC to DC, typically using full wave rectification to enhance efficiency.
- **Filter Function**: Filters, such as capacitor and LC types, smooth the DC output to reduce ripple and provide a stable voltage.
- **Regulation Mechanism**: Regulators adjust and stabilize output voltage to protect against input changes or load variations, essential for reliable power supply

SENSORS

Sensors are used for sensing things and devices etc. A device that provides a usable output in response to a specified measurement. The sensor attains a physical parameter and converts it into a signal suitable for processing (e.g. electrical, mechanical, optical) the characteristics of any device or material to detect the presence of a particular physical quantity. The output of the sensor is a signal which is converted to a human-readable form like changes in characteristics, changes in resistance, capacitance, impedance, etc.

FLAME SENSOR

A sensor which is most sensitive to a normal light is known as a flame sensor. That's why this sensor module is used in flame alarms. This sensor detects flame otherwise wavelength within the range of 760 nm – 1100 nm from the light source. This sensor can be easily damaged to high temperature. So this sensor can be placed at a certain distance from the flame. The flame detection can be done from a 100cm distance and the detection angle will be 600. The output of this sensor is an analog signal or digital signal. These sensors are used in fire fighting robots like as a flame alarm.

What is a Flame Sensor?

A flame-sensor is one kind of detector which is mainly designed for detecting as well as responding to the occurrence of a fire or flame. The flame detection response can depend on its fitting. It includes an alarm system, a natural gas line, propane & a fire suppression system. This sensor is used in industrial boilers. The main function of this is to give authentication whether the boiler is properly working or not. The response of these sensors is faster as well as more accurate compare with a heat/smoke detector because of its mechanism while detecting the flame.

Working Principle

This sensor/detector can be built with an electronic circuit using a receiver like electromagnetic radiation. This sensor uses the infrared flame flash method, which allows the sensor to work through a coating of oil, dust, water vapor, otherwise ice.

Flame Sensor Module

The pin configuration of this sensor is shown below. It includes four pins which include the following. When this module works with a microcontroller unit then the pins are

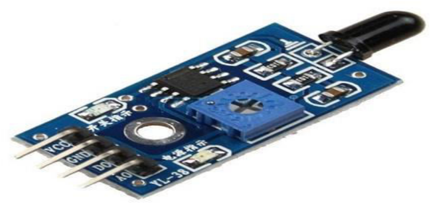

Fig flame-sensor

- Pin1 (VCC pin): Voltage supply rages from 3.3V to 5.3V
- Pin2 (GND): This is a ground pin
- Pin3 (AOUT): This is an analog output pin (MCU.IO)
- Pin4 (DOUT): This is a digital output pin (MCU.IO)

Light Dependent Resistor

The controlling of lights and home appliances is generally operated and maintained manually on several occasions. But the process of appliances controlling may cause wastage of power due to the carelessness of human beings or unusual circumstances. To overcome this problem we can use the light-dependent resistor circuit for controlling the loads based on the intensity of light. An LDR or a photoresistor is a device that is made up of high resistance semiconductor material. This article gives an overview of what is LDR or light-dependent resistor circuit and its working.

What is Light Dependent Resistor?

An electronic component like LDR or light-dependent resistor is responsive to light. Once light rays drop on it, then immediately the resistance will be changed. The resistance values of an LDR may change over several orders of magnitude. The resistance value will be dropped when the light level increases.

The resistance values of LDR in darkness are several megaohms whereas in bright light it will be dropped to hundred ohms. So due to this change in resistance, these resistors are extremely used in different applications. The LDR sensitivity also changes through the incident light's wavelength.

The designing of LDRs can be done by using semiconductor materials to allow their light-sensitive properties. The famous material used in this resistor is CdS (cadmium sulfide), even though the utilization of this material is currently restricted in European countries due to some environmental issues while using this material. Likewise, CdSe (cadmium selenide) is also restricted and additional materials that can be employed mainly include PbS (lead sulfide), InS (indium antimonide).

Even though for these resistors, a semiconductor material is used, because they are simply passive devices and they do not have a PN-junction. This detaches them from other LDRs such as phototransistors & photodiodes.

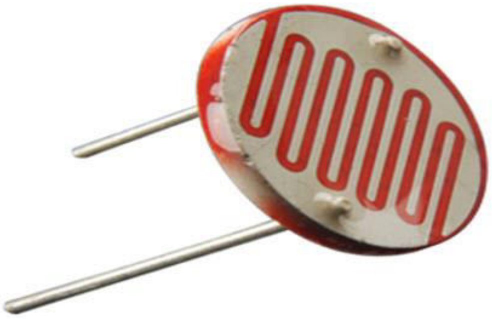

Fig :Light Dependent Resistor

Moisture Sensor Working and Applications

The moisture of the soil plays an essential role in the irrigation field as well as in gardens for plants. As nutrients in the soil provide the food to the plants for their growth. Supplying water to the plants is also essential to change the temperature of the plants. The temperature of the plant can be changed with water using the method like transpiration. And plant root systems are also developed better when rising within moist soil. Extreme soil moisture levels can guide to anaerobic situations that can encourage the plant's growth as well as soil pathogens. This article discusses an overview of the soil moisture sensor, working and it's applications.

What is a Soil Moisture Sensor?

The soil moisture sensor is one kind of sensor used to gauge the volumetric content of water within the soil. As the straight gravimetric dimension of soil moisture needs eliminating, drying, as well as sample weighting. These sensors measure the volumetric water content not directly with the help of some other rules of soil like dielectric constant, electrical resistance, otherwise interaction with neutrons, and replacement of the moisture content.

The relation among the calculated property as well as moisture of soil should be adjusted & may change based on ecological factors like temperature, type of soil, otherwise electric conductivity. The microwave emission which is reflected can be influenced by the moisture of soil as well as mainly used in agriculture and remote sensing within hydrology.

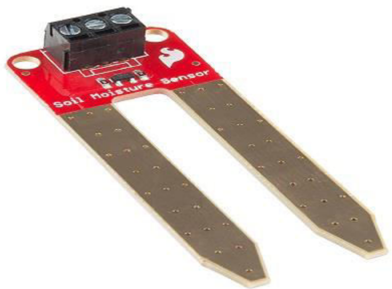

Fig :soil-moisture-sensor-device

These sensors normally used to check volumetric water content, and another group of sensors calculates a new property of moisture within soils named water potential. Generally, these sensors are named as soil water potential sensors which include gypsum blocks and tensiometer.

NODEMCU:

NodeMCU is an open source LUA based firmware developed for ESP8266 wifi chip. By exploring functionality with ESP8266 chip, NodeMCU firmware comes with ESP8266 Development board/kit i.e. NodeMCU Development board. Since NodeMCU is open source platform, their hardware design is open for edit/modify/build. NodeMCU Dev Kit/board consist of ESP8266 wifi enabled chip. The ESP8266 is a low-cost Wi-Fi chip developed by Espressif Systems with TCP/IP protocol. For more information about ESP8266, you can refer ESP8266 WiFi Module. There is Version2 (V2) available for NodeMCU Dev Kit i.e. NodeMCU Development Board v1.0 (Version2), which usually comes in black colored PCB.

NodeMCU Development Kit/Board consist of ESP8266 wifi chip. ESP8266 chip has GPIO pins, serial communication protocol, etc. features on it.

ESP8266 is a low-cost Wi-Fi chip developed by Espressif Systems with TCP/IP protocol. For more information about ESP8266, you can refer ESP8266 WiFi Module.

The features of ESP8266 are extracted on NodeMCU Development board. NodeMCU (LUA based firmware) with Development board/kit that consist of ESP8266 (wifi enabled chip) chip combines NodeMCU Development board which make it stand-alone device in IoT applications.

Let's see 1st version of NodeMCU Dev Kit and its pinout as shown in below images.

Fig: Node Mcu

CONCLUSION

This article introduces a remote environmental monitoring system based on low-power Internet of Things (IoT) technology, with a primary focus on smart agriculture applications. The system is designed to enable real-time remote monitoring of critical environmental parameters such as temperature, humidity, and light intensity, which are essential for understanding and optimizing crop growth conditions. By leveraging low-power sensors, the system effectively reduces energy consumption, which is a common challenge in long-term field monitoring applications. Additionally, the system utilizes LoRa (Long Range) communication technology, which is well-suited for remote locations due to its extended range and low power requirements. Coupled with solar power for energy supply, the system ensures sustainability by minimizing the need for frequent maintenance or battery replacements, thus enhancing its practical applicability in agriculture. This setup allows for continuous monitoring of crop environments without significantly increasing operational costs, making it a valuable tool for precision agriculture. However, the article also acknowledges certain limitations in the system that need to be addressed for broader deployment. One major issue is the communication distance, which can be affected by signal strength and environmental interference, potentially leading to reduced reliability and data transmission stability. Despite LoRa's advantages in long-range communication, physical obstructions, atmospheric conditions, and interference from other electronic devices can limit its performance, especially in challenging agricultural landscapes. Furthermore, power consumption remains a critical factor that could impact the long-term usability of the system. Although solar power helps mitigate some of these concerns, optimizing energy efficiency and extending the operational life of devices remain key challenges for future research. Finding innovative solutions to reduce power consumption without compromising the system's performance will be vital for scaling this technology in large-scale agricultural applications, especially in remote or off-grid areas. Future developments may include more advanced low-power sensor technologies, adaptive communication protocols, and energy-efficient data transmission techniques to ensure the system's continued effectiveness in diverse environments.

REFERENCES

[1] Zhang Ling, Chen Shaohua, Chen Yifan. Design of Agricultural Meteorological Stations Based on LORA Technology [J]. Information Technology and Informatization, 2021, (10): 141-144

[2] Zhou, G. Sun, Y. Luan, D. (2022) Research and Design of Smart Agriculture Based on NB IoT. Computer Knowledge and Technology, Volume 18 (21): 102-104

[3] Xie, W. (2021) Power consumption and coverage performance testing and analysis of typical NB IoT devices Mentor: Wu, Y. Nanjing University of Aeronautics and Astronautics. DOI:10.27239/d.cnki.gnhhu.2021.000883

[4] Li, Z. (2017) New Technologies and Applications of Narrowband Internet of Things (NB IoT). Communication World (23): 61-62.

[5] Li, Z. Dong, W. Huang, S. (2021) Design of Agricultural Greenhouse Temperature and Humidity Monitoring System Based on DHT11. Industrial instruments and automation devices (01): 39-43.

[6] Chen, J(2021) Design and Implementation of a Temperature and Humidity Acquisition System Based on LoRa Communication Technology. Mentor: Luan, J. Xinjiang Normal University. DOI: 10.27432/d.cnki.gxsfu.2021.000025

[7] Chen, Y P. Shi, Y. Yuan, M M, (2013) Design and implementation of multifunctional teaching robots. Laboratory research and exploration, 32(02): 84-87.

[8] Han, D. Wang, F. (2013) Research on the Application of DHT11 Digital Temperature and Humidity Sensor. Electronic Design Engineering 21 (13): 83-85+88.

[9] Yi, P. (2014) Design and Implementation of Indoor Environment Wireless Monitoring System Based on ARM and Zigbee Technology. Donghua University of Technology.

[10] Li, Y X. Zhang, H R. Xie, Y T. (2021) Design of Intelligent Farmland Irrigation System. Practical rural technology, (07):46-48.

[11] Sheng, G. (2021) Design of Litchi Intelligent Storage System Based on Environmental Perception. Journal of Foshan University of Science and Technology (Natural Science Edition), 39(01): 72-76. DOI:10.13797/j.cnki.jfosu.1008-0171.2021.0013.

[12] Mao Z, Liu G (2018) Meteorological Monitoring System Based on Lora Technology. Electronic Design Engineering, 26 (07): 113-118. DOI: 10.14022/j.cnki.dzsjgc.2018.07.026

[13] Zhang, L. Chen, S. Chen, Y. (2021) Design of Agricultural Meteorological Stations Based on LORA Technology. Information Technology and Informatization, (10): 141-144.

[14] Guo, Q. Wang, Y. (2022) Implementation of a LoRa-based greenhouse monitoring system cloud platform application. Agricultural Mechanization Research. 44 (06): 219-222. DOI: 10.13427/j.cnki. njyi. 2022-06.038