HELIO.EYE

DESIGN MANUAL

AUTOMATED SUNTRACKING MODULE

Contents

INTRODUCTION

Project Overview

The Dual Axis Rotation Solar Panel with IoT Integration is an innovative project designed to enhance the efficiency of solar panels by enabling dual-axis rotation. This means that the solar panels can automatically adjust their position both horizontally and vertically throughout the day to maximize exposure to sunlight. The project incorporates an ESP32 microcontroller, motors, sensors, and IoT connectivity to create a sophisticated solar tracking system.

Key Features

- **Dual-Axis Rotation:** The solar panel system can rotate both horizontally and vertically, ensuring optimal sunlight exposure for increased energy production.
- **ESP32 Microcontroller:** The project is powered by the ESP32 microcontroller, providing a robust and versatile platform for controlling the rotation mechanism and communicating with the IoT Core.
- **IoT Integration:** The inclusion of IoT capabilities allows for remote monitoring and control, enabling users to track power generation and adjust settings from anywhere with an internet connection.
- **Local Website Configuration:** A user-friendly local website is provided for easy and intuitive configuration of the solar panel system, making it accessible to users without extensive technical knowledge.

Intended Audience

This manual is intended for DIY enthusiasts, hobbyists, and individuals interested in renewable energy solutions. It is suitable for those with a basic understanding of electronics and programming. The project is designed to be scalable and adaptable, making it accessible to both beginners and experienced makers looking to explore solar tracking systems with IoT integration.

Safety Considerations

- **Electrical Safety:** When assembling and wiring the components, ensure that power is disconnected. Follow proper electrical safety practices to avoid electric shock or damage to components.
- **Mechanical Safety:** Exercise caution during the mechanical assembly process to prevent injuries. Be mindful of moving parts, and handle tools and equipment with care.

- **Environmental Considerations:** Install the solar panel system in a safe and suitable location. Consider environmental factors such as wind, rain, and extreme temperatures when planning the installation.
- **IoT Security:** Implement secure practices when configuring IoT connectivity to prevent unauthorized access. Use strong passwords and follow best practices for securing IoT devices connected to the internet.

By adhering to these safety considerations, users can ensure a safe and successful implementation of the Dual Axis Rotation Solar Panel project.

HARDWARE REQUIREMENTS

ESP32 Microcontroller

The central processing unit driving the Dual Axis Rotation Solar Panel system is the ESP32 microcontroller. This versatile microcontroller is responsible for precisely controlling the movements of the solar panel, ensuring optimal alignment with the sun. Additionally, it facilitates seamless communication with the local configuration website and IoT Core for remote monitoring and control.

Motors and Actuators

Enable the dual-axis rotation of the solar panel, 9g servo motors are employed. These motors provide precise control over both the horizontal and vertical movement of the solar panel, allowing it to dynamically follow the sun's position. The lightweight and compact design of the 9g servo motors makes them well-suited for this solar tracking application.

Sensors

Four Light Dependent Resistor (LDR) sensors are strategically placed on each side of the solar panel to track the shadow cast by the panel. These sensors detect variations in light intensity caused by the sun's movement, allowing the system to dynamically adjust the solar panel's orientation for optimal sunlight exposure. The LDR sensors play a crucial role in enhancing the efficiency of the solar panel's power generation by ensuring it is always positioned to capture maximum sunlight.

Power Supply

To ensure uninterrupted operation, a high-capacity 9600mAh battery powers the system. This battery serves as a reliable energy source, enabling the solar panel to generate power even during periods of low sunlight. Additionally, a 5V supply converter regulates the voltage, powering various components and ensuring stable performance.

Additional Components

- **INA219:** Serving as a current sensor, the INA219 measures the power generated by the solar panel system. This data is crucial for monitoring energy efficiency and optimizing the system's power output.
- **Wiring and Connectors:** Various wiring and connectors are essential for the secure electrical connections between the microcontroller, motors, sensors, and power supply components. Reliable connections are vital for the efficient functioning of the entire system.
- **Mounting Hardware:** Necessary hardware, including brackets, screws, and other mechanical components, is required for assembling and mounting the solar panel system securely.

By incorporating these hardware components, the Dual Axis Rotation Solar Panel system effectively tracks the sun's movement by monitoring the shadow cast by the solar panel, optimizing its position for maximum sunlight exposure, and generating power efficiently.

SOFTWARE REQUIREMENTS

ESP32 Firmware

The ESP32 microcontroller is programmed using the Arduino framework and the ESP32 board libraries. This firmware is responsible for managing the dual-axis rotation of the solar panel based on the input from the LDR sensors. The firmware also includes the necessary logic to communicate with the AWS IoT Core and handle real-time data transmission to and from the local configuration website. The code ensures precise control of the servo motors, efficient energy management, and seamless integration with IoT services.

IoT Core Configuration

AWS IoT Core is utilized for securely transmitting data from the solar panel system to the cloud. The ESP32 firmware is configured to use the AWS IoT SDK to establish a secure connection with the AWS IoT Core. This configuration involves setting up an IoT Thing, generating the necessary security certificates and keys, and integrating them into the firmware. The AWS IoT Core serves as the central hub for managing and monitoring the solar panel system remotely.

Local Website Configuration

A local configuration website is hosted on the ESP32, allowing users to easily configure and monitor the solar panel system. The website is created using HTML, CSS, and JavaScript, providing an intuitive user interface for adjusting tracking parameters and viewing real-time data. The ESP32 serves as a web server, and the website communicates with the microcontroller using WebSocket for real-time updates. Users can access this website from any device connected to the same local network.

Communication Protocols

- **WebSocket:** The local configuration website communicates with the ESP32 using WebSocket for real-time data updates. This bidirectional communication ensures that users receive instant feedback on changes made through the web interface.
- **MQTT (Message Queuing Telemetry Transport):** The ESP32 communicates with the AWS IoT Core using the MQTT protocol. This lightweight and efficient protocol enable secure and reliable data transmission between the solar panel system and the cloud. MQTT ensures the delivery of messages related to power generation, system status, and any configuration changes made remotely.

By combining these software components, the Dual Axis Rotation Solar Panel system seamlessly integrates local configuration capabilities with AWS IoT services, providing users with real-time data and control over the solar tracking system. The ESP32 firmware, AWS IoT Core, local configuration website, and communication protocols work in harmony to optimize system performance and user experience.

Assembly and Installation

Mechanical Assembly

Tools and Components Needed:

- Solar Panel
- Servo Motors (9g)
- LDR Sensors
- Mounting Brackets
- Screws and Nuts
- Tools (Screwdriver, Wrench)

Steps:

1. Position the solar panel in a location with maximum sunlight exposure.
2. Attach the servo motors to the solar panel using mounting brackets.
3. Ensure the servo motors are securely fastened to allow for smooth rotation.
4. Place the LDR sensors on each side of the solar panel, securing them with brackets.
5. Orient the LDR sensors to face outward to detect the shadow cast by the solar panel.
6. Connect the servo motors to the ESP32 microcontroller using appropriate cables.

Electrical Wiring

Tools and Components Needed:

- ESP32 Microcontroller
- Wiring and Connectors
- INA219
- 9600mAh Battery
- 5V Supply Converter

Steps:

1. Connect the servo motors to the designated pins on the ESP32 microcontroller.
2. Wire the LDR sensors to the analog input pins on the ESP32.
3. Connect the INA219 current sensor to monitor power generation.
4. Connect the 9600mAh battery to the power input of the 5V supply converter.

5. Connect the 5V supply converter to the ESP32 and other components

Sensor Calibration

Steps:

1. Power up the system and access the local configuration website.
2. Use the website to calibrate the LDR sensors by adjusting sensitivity.
3. Monitor real-time data to ensure accurate detection of the solar panel's shadow.
4. Fine-tune sensor positions if necessary for optimal tracking performance.

Powering Up the System

Steps:

1. Confirm all electrical connections are secure.
2. Turn on the 5V supply converter to power up the ESP32 and other components.
3. Monitor the servo motors for smooth operation as the solar panel initializes.
4. Access the local configuration website to ensure the system is online.
5. Verify power generation data on both the local website and AWS IoT Core.

By following these assembly and installation steps, you can set up your Dual Axis Rotation Solar Panel system efficiently. Ensure all connections are secure, and carefully calibrate sensors for optimal tracking performance. The power-up process should be monitored to confirm smooth operation and successful power generation.

CONFIGURATION

Connecting to the Local Website

Steps:

1. Ensure the Dual Axis Rotation Solar Panel system is powered up.
2. Connect your device (computer, smartphone, etc.) to the AP MODE local network at the ESP32.
3. Open a web browser and enter the IP address assigned to the ESP32 in the address bar.
4. Access the local configuration website.
5. If prompted, enter any required credentials.
6. Give WIFI network credentials for connect to internet

IoT Core Registration

Steps:

1. Access the AWS IoT Core console.
2. Create a new Thing to represent your Dual Axis Rotation Solar Panel.
3. Generate security certificates and keys for the Thing.
4. Download the generated certificates and keys.
5. Integrate the certificates and keys into the ESP32 firmware.
6. Configure the ESP32 firmware to connect to the AWS IoT Core using MQTT.

Calibrating Rotation Angles

Steps:

1. Access the local configuration website.
2. Navigate to the calibration section.
3. Use the calibration interface to calibrate the light sensors
4. Save the calibration settings for precise solar tracking.

By following these configuration steps, you can customize the operation of your Dual Axis Rotation Solar Panel system. Connecting to the local website allows for real-time monitoring and adjustments, while IoT Core registration enables remote management and monitoring capabilities. Calibrating rotation angles and setting up tracking parameters ensure accurate and efficient solar tracking based on your specific requirements.

OPERATION

Manual Mode

1. Activate the AP MODE by powering up the system.
2. Connect to the ESP32's Wi-Fi network using a device.
3. Access the local configuration website to set Wi-Fi credentials.
4. Switch to WIFI MODE after configuring Wi-Fi.
5. In WIFI MODE, manually control the solar panel using the local website.
6. Use the interface to adjust rotation angles and track the sun in real-time.
7. Save any manual adjustments made during this mode.

Automatic Tracking Mode

Steps:

1. Ensure the system is in WIFI MODE.
2. The solar panel will automatically track the sun based on LDR sensor data.
3. Real-time adjustments are made to optimize sunlight exposure.
4. Monitor power generation data on the local website and AWS IoT Core.
5. The system continuously adapts to changing sunlight conditions for optimal efficiency.

Monitoring Power Generation

Steps:

1. Access the local configuration website or AWS IoT Core console.
2. Navigate to the power generation section.
3. View real-time and historical data on power generated by the solar panel.
4. Monitor performance metrics to assess system efficiency.
5. Use this data for analysis and optimization of the solar tracking system.

Troubleshooting Tips

Common Issues and Solutions:

1. **Connection Issues:**
   - Ensure Wi-Fi credentials are correctly configured.
   - Verify AP MODE to set up Wi-Fi if necessary.
2. **Mechanical Issues:**
   - Check for obstructions that may hinder solar panel movement.
   - Inspect servo motors for proper functioning and secure connections.
3. **Sensor Calibration Issues:**
   - Access CALIBRATE MODE to fine-tune LDR sensor calibration.
   - Adjust sensitivity and response time for accurate shadow detection.
4. **Communication Problems:**
   - Check MQTT and WebSocket connections to AWS IoT Core.
   - Ensure proper integration of security certificates and keys.
5. **Power Supply Issues:**
   - Verify the battery charge and replace if necessary.
   - Monitor the 5V supply converter for stable voltage output.
6. **Software Bugs:**
   - Update firmware if new versions are available.
   - Review code for any reported bugs or issues.
7. **IoT Core Issues:**

- Check AWS IoT Core for any reported errors.
- Verify the status of Thing registration and connectivity.

REFERENCES

All the details, code and html files are can be found at,

e19-3yp-automated-sun-tracking-solar-pv-power-plant-monitoring/code/Arduino_code/sketch_jan2a at main · cepdnaclk/e19-3yp-automated-sun-tracking-solar-pv-power-plant-monitoring (github.com)