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Solar Efficiency Improvement Using MQTT Protocol

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Abstract: The goal of this thesis was to develop a laboratory prototype of a solar tracking system, which is able to enhance the performance of the photovoltaic modules in a solar energy system. The operating principle of the device is to keep the photovoltaic modules constantly aligned with the sunbeams, which maximizes the exposure of solar panel to the Sun's radiation. The proposed prototype is based on a dual-axis solar tracker controlled with Arduino Uno which is an open-source prototyping platform based on easy-to-use hardware and software.

1.INTRODUCTION

The International Telecommunication Union (ITU) has defined the IOT as a global infrastructure for the information society that enables the provision of advanced services by connecting (physical and virtual) things, based on existing and evolving interoperable information and communication technologies

This project presents an open hardware/software test bench for solar tracker. The proposed prototype is based on a dual-axis solar tracker controlled with Arduino Uno which is an open-source prototyping platform based on easy-to-use hardware and software. The solar tracker can be controlled automatically with the help of Light Dependent Resistor (LDR) sensors or manually using a potentiometer. Moreover, this test bench provides virtual instrumentation based on Excel in which its solar tracker data can be recorded and presented. The hardware used has been chosen to be inexpensive, compact and versatile. The proposed test bench is designed to help students develop their understanding of control theory and their application**.**

It is based on a solar tracker that can rotate automatically to track the sun with the help of four LDR sensors and two servomotors (SM1 and SM2), or manually using a potentiometer. To switch between the two modes (automatic and manual), a push-button is used. Another push-button is used to link either the SM1(up-down servomotor) or SM2 (left-right servomotor) to the potentiometer to control their movement. Moreover, a computer is used as a virtual instrument to visualize the mode and current. Arduino Uno board is utilized to implement all software requirements of the system.

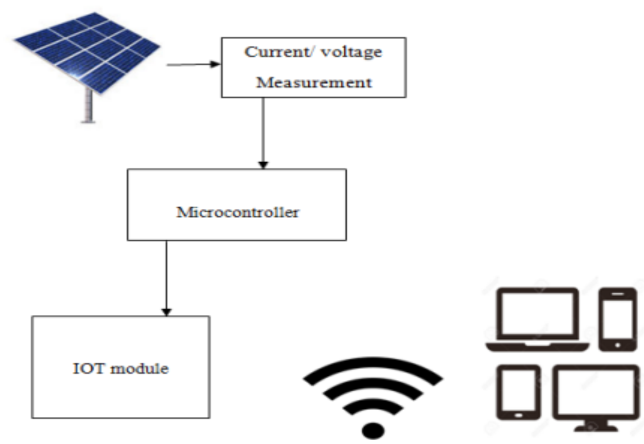

Fig 1: System Architecture
[Courtesy – republication.com]

2. Need of Recommendation Systems

Solar trackers have become important components of solar photovoltaic (PV) installations. Their ability to track the changing position of the sun in the sky can dramatically boost the energy gains of PV systems, by as much as 25 to 35 percent in some cases according to Energy Sage.

Since debuting on the commercial market in the early 2010s, tracker technology has rapidly evolved to work across many different environments. A solar tracking system maximizes your solar system's electricity production by moving your panels to follow the sun throughout the day, which optimizes the angle at which your panels receive solar radiation.

3. Literature Review

Gallium arsenide crystals are grown especially for photovoltaic use, but silicon crystals are available in less expensive standard ingots, which are produced mainly for consumption in the microelectronics industry. Norway's Renewable Energy Corporation (REC) has confirmed that it will build a solar manufacturing plant in Singapore by 2010 -the largest in the world. This plant will be able to produce products that can generate up to 1.5 gigawatts (GW) of energy every year. That is enough to power several million households at any one time. Last year, the world as a whole produced products that could generate just 2 GW in total.it was implemented with a dc motor and a dc motor controller. The solar energy conversion unit consisted of an array of solar panels, a step-up chopper, a single-phase inverter, an ac mains power source and a microcontroller-based control unit.

Since the sun moves across the sky throughout the day, in order to receive the best angle of exposure to sunlight for collection energy. A tracking mechanism is often incorporated into the solar arrays to keep the array pointed towards the sun Proposed Architecture.

3.1. MQTT Protocol

Message Queuing Telemetry Transport (MQTT) is a lightweight application-layer messaging protocol based on the publish/subscribe (pub/sub) model. Remember HTTP is based on request-response model which is one of the reasons why it does not fulfil the needs of IOT applications. In the pub/sub model, multiple clients (sensors) can connect to a central server called a broker and subscribe to topics that they are interested in. Clients can also publish messages to specific topics of their interest through the broker. The broker is a common interface for sensor devices to connect to and exchange data. Another important point to note about MQTT is that it utilizes TCP connection on the transport layer for connections between sensors and broker which makes the communication reliable.

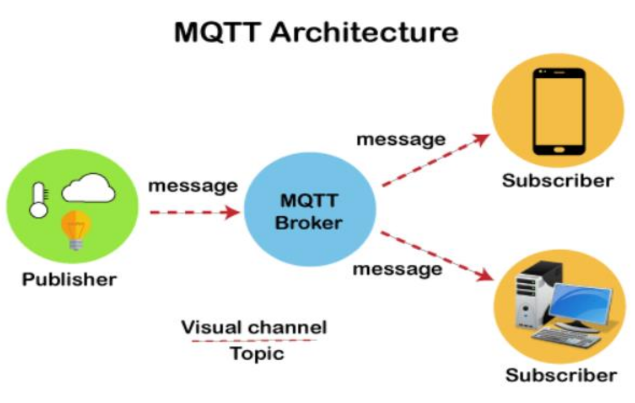

Figure 2: MQTT Architecture
[Courtesy – Javatpoint]

Messages in MQTT are always published on topics, which basically represents the destination address for that message. A client may subscribe as well as publish to multiple topics. Every client subscribed to a topic receives all the messages published to that topic. As a standard practice, topics should follow a hierarchy using a slash (/) as a separator. This allows for logical grouping/arrangement for a network of sensors. For example, a topic "kitchen/oven/temperature" clearly conveys the hierarchy of temperature sensor of oven in the kitchen. An IOT sensor network in a modern kitchen may have multiple devices each of which having multiple sensors. Hence, topics follow this hierarchical arrangement for easy understanding and logical arrangement of sensor variables.

3.2. Why MQTT?

MQTT is considered a lightweight protocol because all its messages have a small code footprint. Each message consists of a fixed header -- 2 bytes -- an optional variable header, a message payload that is limited to 256 megabytes (MB) of information and a quality of service (QoS) level.
Because the MQTT protocol aims to be a protocol for resource-constrained and IoT devices, SSL/TLS might not always be an option and, in some cases, might not be desired. On such occasions, authentication is presented as a cleartext username and password, which are sent by the client to the server.

3.3. mydevices cayenne?

The Cayenne MQTT API is used to connect any device that you have with the Cayenne Cloud. After connecting your device, you can send data from your device to the Cayenne dashboard and display it using widgets. You may also receive commands from Cayenne, allowing remote control and automation of your devices. myDevices Cayenne allows you to quickly design, prototype, and visualize IoT solutions. You can use Cayenne as a tool to visualize real-time and historical data, sent over The Things Network.
The MQTT is the API for sending information to the Cayenne cloud, or devices controlled by Cayenne. The messaging agent in this connection is the cloud, it manages the different clients (sensors and actuators) that send and receive the data. To use MQTT with Cayenne, we need to use the Cayenne libraries.

For example, to establish the connection between Cayenne cloud and Arduino Mega equipped with the Ethernet module, we call the Cayenne MQTT Ethernet library where we declare our authentication information.

Widgets can be re-arranged on your dashboard by drag and dropping them anywhere. To move a widget, place your mouse or finger at top middle area of widget. Then tap and move the widget where you want it on your dashboard.

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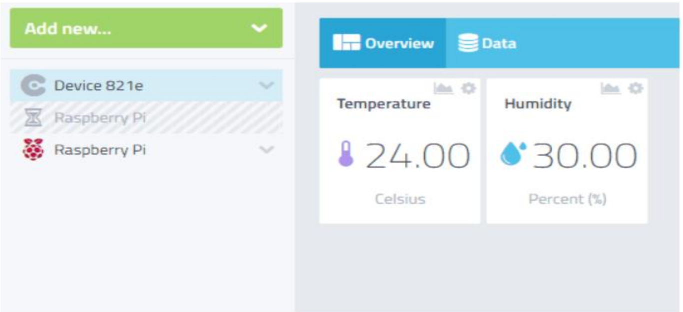

Figure 3: mydevices cayenne dashboard

The data fetched from temperatures sensor get displayed on mydevices cayenne dashboard. As shown in Fig No-3.

For Arduino, the Cayenne MQTT library can be installed from the IDE's Library Manager. To program our Cayenne IOT platform-based IOT application, we will take advantage of the predefined functions.

3.4. Mechanical Design

As shown in Fig. 2, It is composed of the PV panel, the left-right and up-down servomotors, and four LDR sensors. For the horizontal axis, a bearing is fixed in parallel with the up-down servomotor for better flexibility. The solar tracker is designed to have two degrees of freedom, from east to west by the left-right servomotor and from south to north by the up-down servomotor. The LDR sensors are placed in the four corners of the PV panel and are put in dark tubes with a small hole on the top to detect the illumination of the sun. These dark tubes are also considered a concentrator of radiation and are used to increase the solar tracker robustness.

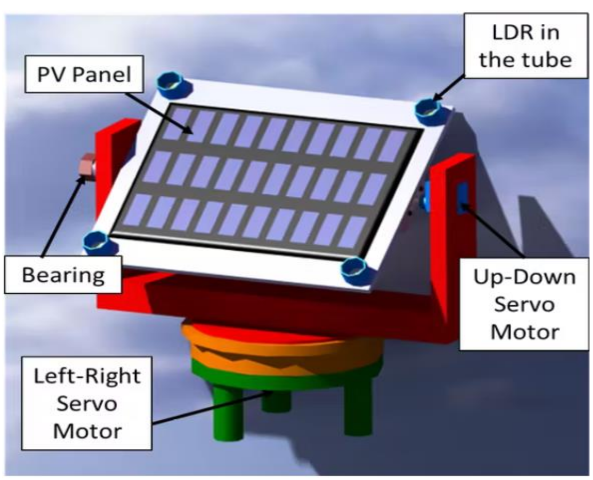

Figure 4: Solar panel alignment
[Courtesy – arduino.cc]

3.5. Hardware System

Fig. 3 presents the electronic circuit of the proposed testbench. For automatic mode, the microcontroller converts the analogs values of LDR sensors (pins A0 to A3) into digitals. Then it controls two servomotors (up-down and left-right) using two Pulse-Width Modulation (PWM) signals (pins 5and 6) to track the sun. The rotation movements occur in two axes, in azimuth from east to west according to the daily sun's path and in elevation from south to north according to the seasonal sun's path. For manual mode, a potentiometer (pin A4) is used to control the movement of the two servo motors, a push-button (pin 11) is deployed to connect the potentiometer either to up-down servomotor or left-right servomotor. Besides, another pushbutton (pin 12) is used to switch between the two modes. Furthermore, the PV voltage is measured through the analog pin A5 of the Arduino, then the PV current is calculated since the resistor of the load is already known. Next, the PV current, voltage and power versus time.

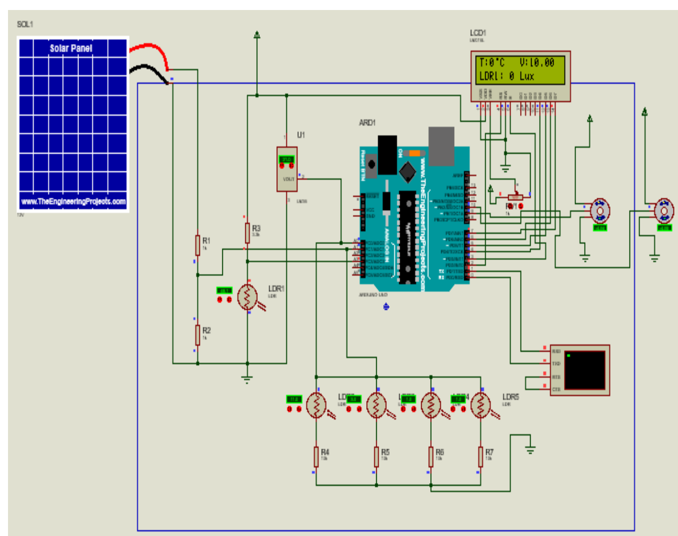

Figure 5: System Simulation

The LDR sensor circuitry is designed as a voltage divider circuit. The variation in the light intensity is proportional to the variation of the divider output voltage. The top of the potential divider is 5 V, the ground is at 0 V, and the output of the voltage divider is connected to an analog input (A0 for instance) of the microcontroller. Subsequently, the Analog to Digital Converter (ADC) of the microcontroller converts the analog value read by A0 into a digital value between 0 and 1023 because the ADC is coded in 10 bits, and according to this value, it is possible to know the level of light. The value of resistors used in voltage dividers is 330 Ω.

Two 180 degrees servomotors are used. A servomotor (MG996R) to control the solar tracker according to the vertical axis, which is the left-right servomotor. And a micro servo motor (SG90) to control the solar tracker according to the horizontal axis, which is the up-down servomotor.
The advantage of the servomotor is that we can control its stop, run, the direction of rotation and speed using a single low current wire.

4. Advantage

- Easy assembly and maintenance
- Inexpensive.
- There are many different kinds of solar trackers, such as single-axis and dual-axis trackers, all of which can be the perfect fit for a unique jobsite.
- Advancements in technology and reliability in electronics and mechanics have drastically reduced long-term maintenance concerns for tracking systems.

5. Future Scope

The goals of this project were a purposely kept within what was believed to be attainable within the allotted timeline. As such, many advance improvements can be made up of initial design of solar tracker. It is felt this design represents a functioning scale model which could be replicated for a much larger scale. following recommendation are provided as ideas for future expansion for this project.

- For large scale project we can use wood and other locally available materials instead of Mild steel and thus reduce the cost further.
- A spring of appropriate stiffness could be designed to avoid sudden jerks.
- Provisions for safety of solar panels from rain.
- More accuracy can be achieved by providing measures against wind vibrations.

6. Result

In this Dual Axis Solar Tracker, when source light falls on the panel, the panel adjusts its position according to maximum intensity of light falling perpendicular to it. The objective of the project is completed. This was achieved through using light sensors that are able to detect the amount of sunlight that reaches the solar panel. The values obtained by the LDRs are compared and if there is any significant difference, there is actuation of the panel using a servo motor to the point where it is almost perpendicular to the rays of the sun.

The objective of the project is completed. This was achieved through using light sensors that are able to detect the amount of sunlight that reaches the solar panel.

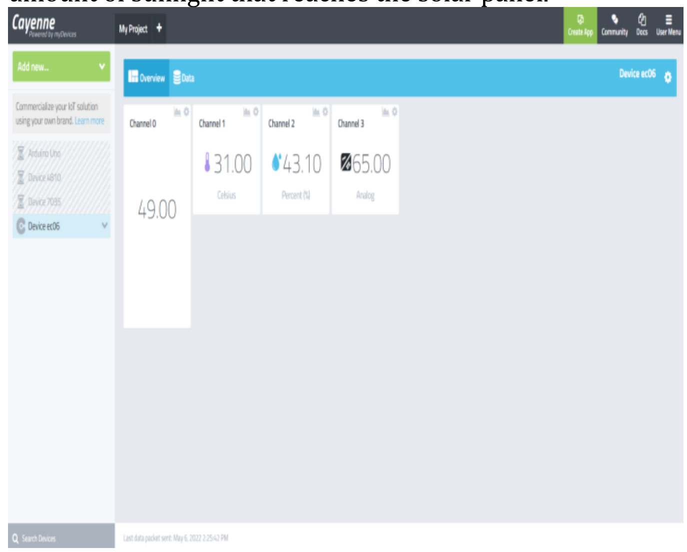

Figure 6: Software Result

The final stage was the driving circuitry that consisted mainly of the servo motor. The servo motor had enough torque to drive the panel. Servo motors are noise free and are affordable, making them the best choice for the project.

Once the connection with the solar tracker system is established, sensor data can be visualized on their associated widgets, the tracking mode (automatic or manual) can be selected from the switch button, as well as controlling servomotors' angles through their widgets.

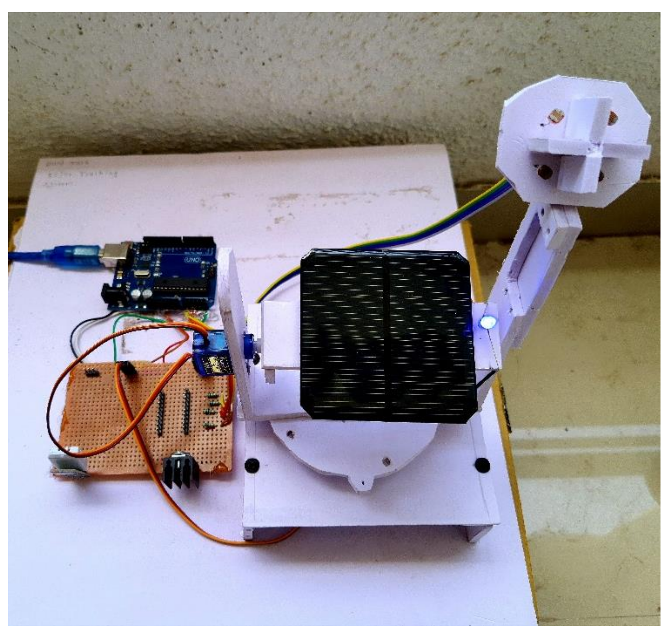

Figure 7: Hardware Result

7. Conclusion

This study presents an overview on the advancements in the work of the solar tracking systems in the world and it emphasizes on the performance analysis of dual axis solar tracking systems equipped with different designs and techniques which have been evolved in recent years.
Advances in the algorithms of sun tracking systems have enabled the development of many solar thermal and photovoltaic systems for a diverse variety of applications in recent years. Compared to their traditional fixed-position counterparts, solar systems which track the changes in the sun's trajectory over the course of the day collect a far greater amount of solar energy, and therefore generate a significantly higher output power. Overall, the results presented in this review confirm the applicability of sun tracking system for a diverse range of high-performance solar-based applications. Dual axis solar tracking systems generally prove to be more efficient than single axis and fixed counterparts.

In this chapter, a smart prototype has been designed to monitor and control a dual-axis solar tracker system using a simple and efficient IoT solution. The prototype has been tested experimentally. Test results demonstrate that the developed IoT-based solar tracker provides users with a simple monitoring application, in which users can easily and in real-time monitor electrical and environmental parameters of the solar tracker system for further processing and management.

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REFERENCES

[1] Concept: What is solar panel? http://www.knowledgerush.com/kr/encyclopdia/Solar_panels/

[2] 1st Solar Panel- http://inventors.about.com/od/sstartinventions/a/solar_cell.html.

[3] Solar plant to be set up by 2010 in Singapore: http://www.wildsingapore.com/news/20070910/0710271.htm#st

[4] Solar Tracker Mount Types" http://en.wikipedia.org/wiki/Solar_tracker.

[5] Arduino Solar Tracker- https://create.arduino.cc/projecthub/336271/arduino-solar-tracker-41ef82.

[6] George Bakos.c. 2013. "Design and construction of a two-axis Sun tracking system for parabolic trough collector (PTC) efficiency improvement." Solar energy materials and solar cells 3:2-7.

[7] Based Solar Tracker System https://www.researchgate.net/publication/351114059_Internet_of_Things-Based_Solar_Tracker_System.

[8] Aboubakr_Elhammoumi/internet-of-things-iot-based-solar-tracker.