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LOW COST IOT BASED WEATHER MONITORING SYSTEM FOR SOLAR PLANTS USING RASPBERRY PI

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Abstract:

The paper would deal in explaining the concepts employed to build a low cost weather monitoring system. Weather parameters like temperature, humidity, solar irradiation and wind speed along with current and voltage values of the plant are sensed which could be helpful in evaluating the performance of the solar plant. Costly and sophisticated sensors are replaced by simple and cost effective sensor in innovative ways. The interfacing module used is raspberry pi micro-computer which helps to push the data into the internet. The data is then read through a mobile app developed to display the values.

1. Introduction:

In the growing twenty-first century, concern over the green energy has tremendously increased. This in turn has brought a great ray of hopes for the non-conventional form of energy.Amongst the non-conventional forms, the solar energy tops the other forms as the most reliable source of the future. It is calculated that the normal solar plants can convert 15 % of the sunlight into electricity while the more experimentalsetup like concentrating solar panel can convert up to 40% of sunlight into electricity.

Coordinating the existing advanced techniques with data analytics can provide much better results. This brings the requirement of weather parameters storing data loggers. The weather stations are built with complex and rigid sensors increasing the cost with a guaranteed performance. With the introduction of internet, data transfer has been made to the simplest forms. The introduction of IoT is blissful in performing cloud based automation and data transfer much easier than before.

2. Problem Statement:

Weather monitoring system being very hand for better performance of the solar plants has the issue of higher cost. The hard drive based data logging facility requires a separate computer setup for its operation and many a times, the data stored cannot be manipulated in a useful mean.

These two problems are the primary concerns when you consider a weather monitoring system and we have come up with cost effective innovative solution to provide the layman's weather monitoring system.

3. Measurement Transducers:

The weather monitoring system is built using the following sensors. The temperature and the humidity values are measured using the DHT22 sensor. It can operate between -40˚C to 80˚C with accuracy of ±2˚C. The solar irradiation is measured using the simple photo resistor and the wind speed is measured using an indigenous innovative concept with a simple Infrared Sensor without a hardware counter. The cost of the setup is reduced to one-tenth by applying the basic concepts to derive out the solutions.

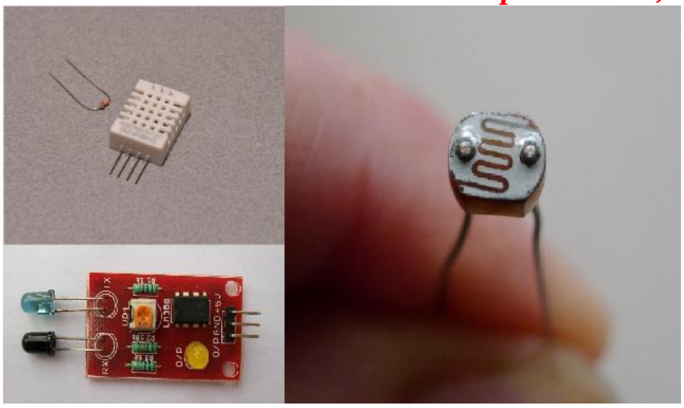

Figure 1: Sensors used for weather monitoring system

The above fig.1 shows the sensors that are been employed in the weather monitoring system (in clockwise 1. DHT22 – Temperature & Humidity sensor, 2. Photo-resistor to measure the solar irradiance and the IR Sensor to measure the wind of the speed). Along with these two sensors, current and voltage sensor are employed to study the overall performance of the solar plant.

DHT-22 Temperature & Humidity Sensor:

The DHT-22 is a 4 pin compact temperature and humidity sensor by Adafruit with a prebuilt DHT library for Arduino and Raspberry Pi. [1]The Analog sensor has resolution of two decimal points and accuracy of ±0.5˚C. [1]The DHT22 sensor can work under extreme temperatures between -40˚C to 80˚C. Fig 2 shows the DHT sensor's pin out.

Figure 2: DHT 22 Temperature & Humidity Sensor

Light Dependant Resistor:

[2] A resisitor which varies its resistance based on the light intensity is used as the substitute for the conventional pyranometer which helps in measuring the sun's irradiation. The LDR, the resistance reduces with increase in light internsity. Having the common source as sun, both these devices work on different principle and has got a different response. The response of the two devices is closely analyzed and the performance is balanced making the Light Dependant Resistor to take up the role as a low cost pyranometer. Below table Tab1. is comparative study done on the response of LDR and Pyranometer.

S.No	LDR Value	Pyranometer Value
1.	666	843
2.	658	848
3.	655	852
4.	646	863

Table 1: Deriving the relationship between LDR and Pyranometer value

The values were measured during the noon to derive out the Maximum response deviation.

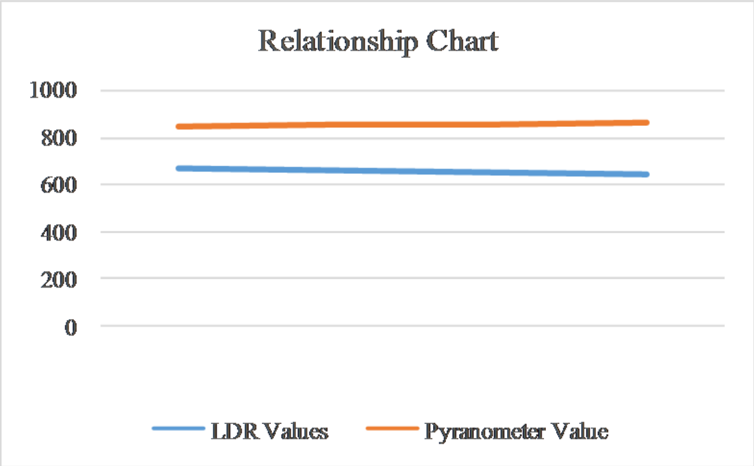

Figure 3: Relationship chart

The Fig 3. Relationship chart clearly depicted a linear response difference which is termed as "irradiation difference factor d **(IR)".** This implementation helps in setting up a very low cost pyranometer. The idea of implementing the Light Dependant Resistor has brought down the cost by 1000 times but with issues with accuracy. This can be overcome by using a photo transistor instead of Light Dependant Resistor, which is still cost effective.

IR Wind Speed Anemometer with Software Counter:

The Wind speed is considered as the integral part of the solar plant system. The heat transfer in the air due to sunlight can vary with the wind speed. The ingenious prototype of an anemometer using standalone Infrared sensor and software counter to measure the wind speed breaks the cost by 100 times. [3]The Arduino UNO has a crystal frequency of 16 MHz and is said to fetch data every 1 milliseconds. A cheap cup shaped anemometer model is built with tea cups and straws. The IR Sensor is placed at a particular distance from the centre point and it is programmed to count when it hits the obstacle and a separate counter for (total – high states). This would give number of low states. From this we can calculate the rotation per minute by the speed, distance, time formula.

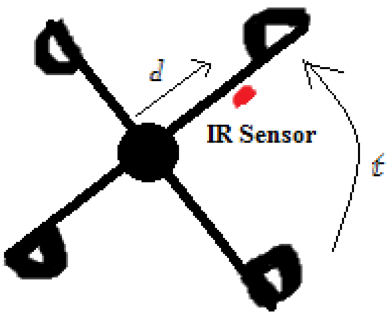

Figure 4: RPms Calculation

In the Fig 4. 'd' is the distance between the centre and IR sensor and the 't' is the time for one cup to complete one-fourth of the rotation. With these parameters, following algorithm is used to determine the RPms of the system with respect to wind.

```
longint op = digitalRead(c);
if(op == 1)      //if IR is blocked
  {
 h = high++;}      //high ++
else
 {
   l = low++;      //low ++
 }
//determining time
longinttim = ((h-l)/l);
//determining distance
float dis = ((3.14*9)/2);
R = dis/tim; // RPms(Distance/Time)
```

Series of comparison is done to derive a relationship between the wind speed and RPms and multiplied as the multiplication factor to make the system as alternate to the anemometer. With more than 85 % accuracy a low cost anemometer is built to measure the wind speed. The accuracy level is quite enough to understand the effect of wind speed on the solar plant.

3. Hardware Raspberry Pi:

A 40 pin powerful micro-computer Raspberry Pi is used as the control unit. [4]The processor is clocked to function at 2.7 MHz with vast 1GB RAM. The Pi B+ model with 4 USB ports helps to connect the Arduino and Wi-Fi dongle on it.

The programming in raspberry pi is done in Python, being simpler and user friendly platform to perform internet of things operations. The Raspbian Wheezy, Linux based OS being good for beginner is used as the Operating System.

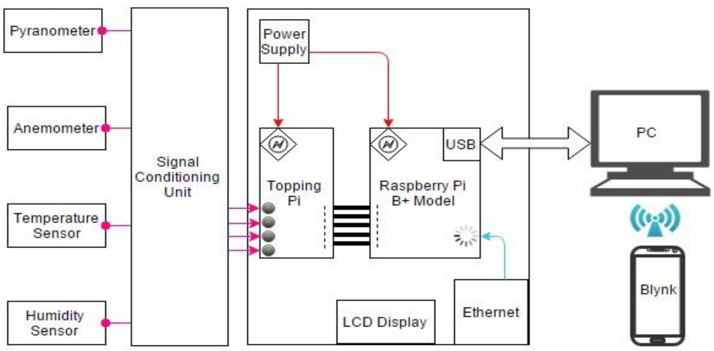

Figure 5: Functional Block Diagram

The Fig 5 is the functional block diagram of this low cost weather monitoring system. We receive the inputs of the ingenious sensors designed through the Arduino which in turn is connected to the USB port of the raspberry pi and data's are received serially.

Programming the sensor is done in the Arduino IDE and on commanding to run, the data is serially read on the Raspberry pi. The serially read data is displayed in the IP of the raspberry pi connected to the network (for eg.192.168.1.xx). The web server page script is written in the HTML language.

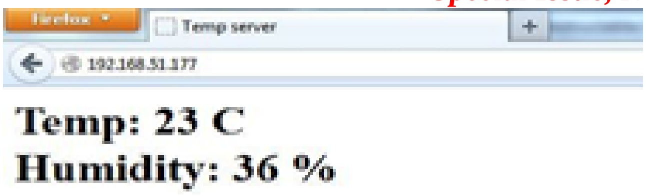

Figure 6: Webserver

The webserver allows the user to get live updates of the sensor parameters helping the Weather Monitoring System. Fig6 depicts the webserver with the sensor data's of temperature and humidity. The data in these webservers is pushed into the Android app so that the data can be fetched from various parts of the world.

4. Conclusion:

The weather monitoring system built is meant to be cost effective and economical even for small solar plants. The cost of the plant is brought down by 100 times considering theconventional plant to cost around 5 Lakhs whereas the solar weather monitoring system that built is just 11 thousand rupees. These solar monitoring system can be installed even in small level solar plants so that they can plan and harness to the best.

5. References:

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4. Raspberry Pi - https://www.raspberrypi.org/documentation/hardware/raspberrypi/README.md