SOLAR IRRADINACE METER

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Abstract - Renewable energy sources are proven to be reliable and accepted as the best alternative for fulfilling our increasing energy needs. Solar photovoltaic energy is the emerging and enticing clean technologies with zero carbon emission in today's world. To harness the solar power generation, it is indeed necessary to pay serious attention to its maintenance as well as application. The IoT based solar energy monitoring system is proposed to collect and analyze the solar energy parameters to predict the performance for ensuring stable power generation. The main advantage of the system is to determine optimal performance for better maintenance of solar PV (photovoltaic). The prime target of PV monitoring system is to offer a cost-effective solution, which incessantly displays remote energy yields and its performance either on the computer or through smart phones. The proposed system is tested with a rotating solar module to monitor voltage, current, and sunlight status. Also, the Wireless monitoring system maximizes the operational reliability of a PV system with minimum system cost.

Key Words: Renewable energy, Solar Power Generation, Solar.

1.INTRODUCTION

Electricity is the most essential needs in the lives of everyone in this modern world. The energy consumption graph is rising from day to day, while energy resources are diminishing in parallel. For the generation of electricity, many numbers of sources are used to balance the lack of electricity. There are two prime sources to generate electricity: one is the conventional sources of energy and the other one is non-conventional sources of energy. Several carriers of the energy like nuclear fuels and fossil fuels too are utilized, yet they are not the renewable resources and these are said to be the non-conventional resources. In its broadest sense, solar power source plays a vital role in achieving the sustainable power source. Sun's rays serve as a significant source for the electricity generation by converting it into electric power and this application is conventional, which is known as the Solar Thermal Energy. Despite the fact that different sustainable sources, for example, wind, tides, geothermal, rain, etc., are available solar power has enormous benefits. In comparison to other resources that have geographical limitations, solar photovoltaic among all renewable energy sources, the availability of solar energy across the country proves to be the most beneficial and it will also have minimal effect on the environment. The solar energy that the earth receives is, 430 quintillion Joules per hour, which is all that could possibly be needed to supply power to the entire world for a year. However, the issue here is, it is difficult to use this amount of energy effectively. Now-a-days the solar panels are installed everywhere but they are not monitored, by doing this, we don't know the amount that they produce and also the solar panels work at its most extreme effectiveness for an hour or for 2 hours, however, by using IoT, the monitoring and control of the solar panel will solve these problems. For ideal power yield, solar power plants should be monitored. This assists in retrieving effective output of power from the power plants while monitoring for defective panels, connections and the dust collected on the panels, bringing down the output and other such issues affecting the solar performance. A solar power monitoring framework monitors the parameters of the panel, such as solar irradiance, displayed over a i2c Display , Now, the solar panel uses LDR to detect sunlight, with the goal that it can get positioned where it gets most extreme sunlight, because of this solar panel can work at its greatest productivity the entire day. The system also uses BH1750 to sense solar irradiance. [1]

2. COMPONENTS USED:

1. ESP32 Microcontroller

Figure 1: ESP32 Microcontroller [2]

ESP32 is a series of low-cost, low-power system on a chip microcontroller with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series employs either a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations, Xtensa LX7 dual-core microprocessor or a single-core RISC-V microprocessor and includes built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power-management modules. ESP32 is created and developed by Espressif Systems a Shanghai-based Chinese company, and is manufactured by TSMC using their 40 nm process. It is a successor to the ESP826 microcontroller. [2]

2. I2C LCD Module

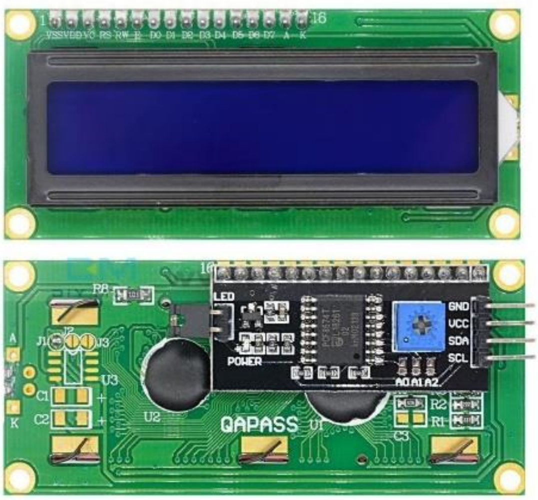

Figure 2: I2C LCD Module [3]

This is a 16x2 LCD display screen with I2C interface. It is able to display 16x2 characters on 2 lines, white characters on blue background. Usually, LCD display projects will run out of pin resources easily. Hence I2C LCD is used as it requires less number of pins. [3]

3. Sunlight (LDR) Sensor

Figure 3: LDR Sensor [4]

An LDR is a component that has a (variable) resistance that changes with the light intensity that falls upon it. This allows them to be used in light sensing circuits. ... They can be described by a variety of names from light dependent resistor, LDR, photoresistor, or even photo cell, photocell or photoconductor. [4]

4. TP4056 Module

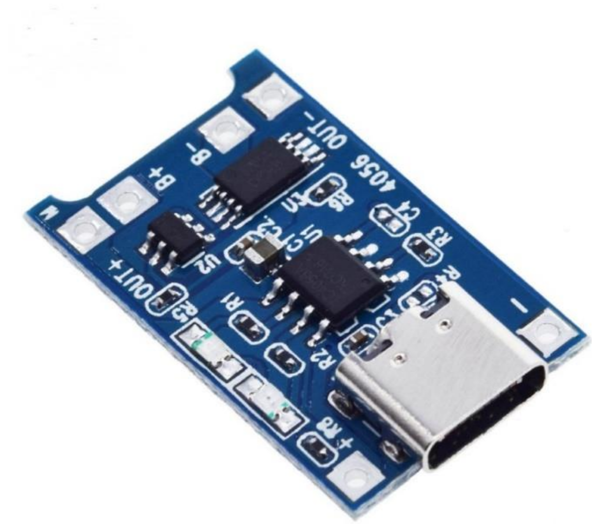

Figure 4: TP4056 Module [5]

TP4056 Battery Charging Module is one of the most used module for charging single cell Li-ion Batteries. It provides for different connections for battery and output. The TP4056 Battery Charging Module is a Constant Current/Constant Voltage charger. This module charges the battery using 4.2V and 1A current. The module stops the charging when the charging current drops below 1/10th (100mA in case of the module) of programmed current. [5]

TP4056 Features:

- Lithium-ion battery charging and discharging module which supports a constant current – constant voltage charging mechanism.
- Full charge voltage of 4.2 V.
- Over-discharge protection feature which prevents the battery from being discharged below 2.4V by cutting off output power until the battery is recharged above 3V.
- The 5V input voltage is applied through micro USB or solder pads IN+ and IN-.
- The charging current is 1A and it is adjustable. You can change it by connecting a resistor of 1kΩ at IN- pad.
- It can protect the battery from overcharging.
- Soft start protection is provided to limit the inrush currents.
- It can protect the battery from over currents and short circuits by cutting off the output from the battery. This happens in a case when the discharge rate becomes greater than 3A.
- It does not have reverse polarity protection.

5.Servo Motors

Figure 5: Servo motor [2]

It is tiny and lightweight with high output power. This servo can rotate approximately 180 degrees (90 in each direction), and works just like the standard kinds but smaller. You can use any servo code, hardware or library to control these servos. It comes with 3 horns (arms) and hardware. [2]

Specification

- ☐ Operating voltage: 4.8 V (~5V)
- ☐ Operating speed: 0.1 s/60 degree
- ☐ Stall torque: 1.8 kgf·cm
- ☐ Dead band width: 10 µs
- ☐ Temperature range: 0 ºC – 55 ºC

6. Zero PCB (Perf Board)

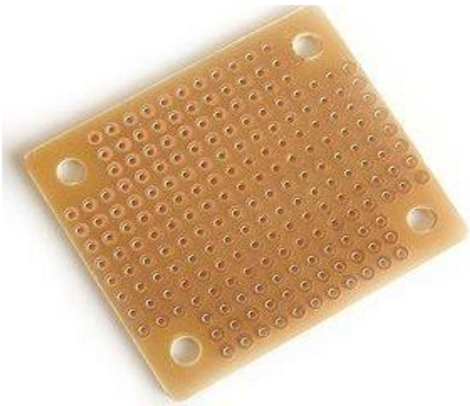

Figure 6: Zero PCB [2]

Perfboard or Zero PCB is a material for prototyping electronic circuits (also called DOT PCB). It is a thin, rigid sheet with holes pre-drilled at standard intervals across a grid, usually a square grid of 0.1 inches (2.54 mm) spacing. These holes are ringed by round or square copper pads, though bare boards are also available. Inexpensive perfboard may have pads on only one side of the board, while better quality perfboard can have pads on both sides (plate-through holes). Since each pad is electrically isolated, the builder makes all connections with either wire wrap or miniature point to point wiring techniques. Discrete components are soldered to the prototype board such as resistors, capacitors, and integrated circuits. [2]

7. Female Burg Strips

Figure 7: Female Burg Strips [2]

The *female connector* is generally a receptacle that receives and holds the male *connector*. [2]

8. Jumper Wires

Figure 8 : Jumper Wires [2]

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed. [2]

9. Connecting Wires

Figure 9: Connecting Wires [2]

Since stranded wire is more flexible than solid core wire of equal size, it can be used when the wire needs to move around frequently. [2]

10.Male Header:

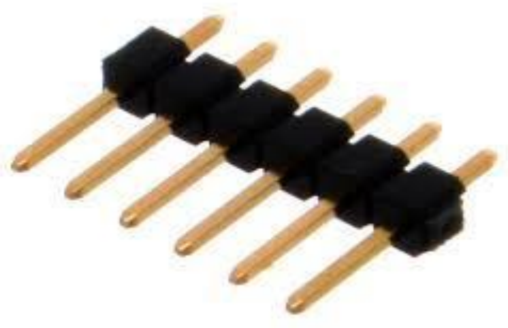

Figure 10: Male Header [2]

Male pin headers are often associated with ribbon cable connectors. When used alone, they can be recipients of jumpers, which have spacings of 2.54 mm (0.1 in) and 2.00 mm (0.079 in). The spacing distance between pins (measured from center to center) is often known as pitch. [2]

11. 18650 Rechargeable Battery

Figure 11: 18650 Rechargeable Battery [6]

An 18650 battery is a type of lithium-ion rechargeable battery. The numbers "18650" refer to the battery's dimensions: it is 18mm in diameter and 65mm in length. 18650 batteries are commonly used in electronic devices such as laptops and flashlights, as well as in electric vehicles and other high-power applications. They are known for their high energy density, long lifespan, and relatively low self-discharge rate. [6]

Basic Specifications and Features

- Voltage: The nominal voltage for a fully charged 18650 is around 3.7V.
- Capacity: Ranges between 1800mAh to 3500mAh, although advancements in technology are pushing these limits further.
- Chemistry: Various chemical compositions exist, including LiCoO2 (LCO), LiFePO4 (LFP), LiMn2O4 (LMO), and LiNiMnCoO2 (NMC).

12. Solar Panel

Figure 12: Solar Panel [7]

Solar panels are those devices which are used to absorb the sun's rays and convert them into electricity or heat. A solar panel is actually a collection of solar (or photovoltaic) cells, which can be used to generate electricity through photovoltaic effect. [7]

13. BH1750 Sensor

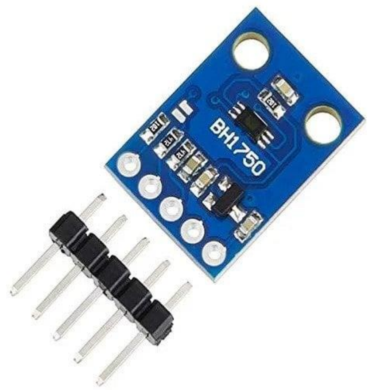

Figure 13: BH1750 Sensor [2]

This is a Light Intensity Detection Module based on the BH1750 chip. BH1750FVI is a digital Ambient Light Sensor IC for the I2C bus interface. This IC is the most suitable to receive the ambient light data for adjusting LCD and Keypad backlight power of the Mobile phone. It is possible to detect wide range at High resolution. [2]

3. BLOCK DIAGRAM OF SOLAR IRRADIANCE METER

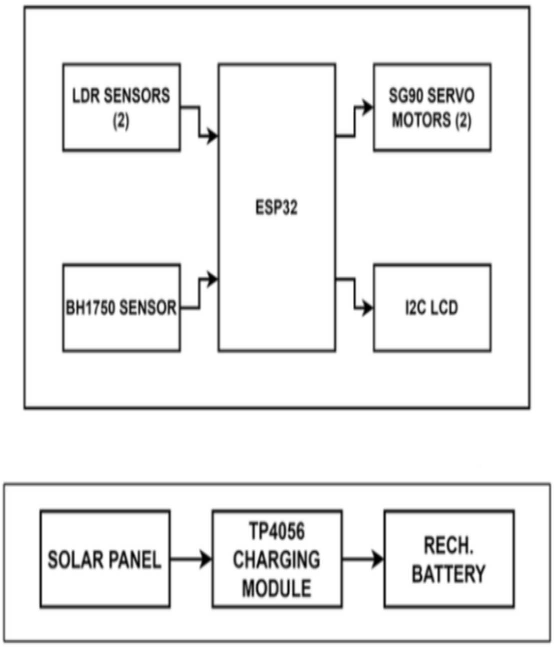

Figure 14: Block Diagram of Solar Irradiance Meter

The microcontroller used is stm32 which requires supply voltage of 5v and has analog and digital pins. The stm32 receives a digital signal from BH1750 sensor which is a digital Ambient Light Sensor IC for I2C bus interface. This IC is the most suitable to obtain the ambient light data for adjusting LCD and Keypad backlight power of Mobile phone. It is possible to detect wide range at High resolution. The unit for the quantity of light flowing from a source in any one second the luminous power, or luminous flux. The readings are then saved in the SD card which is a breakout board used for SD card processes such as reading and writing with a microcontroller. SD card can be directly inserted into the board, but to use microSD cards, you need to use an adapter. The current luminance will be displayed on the lcd. ESP32 is a series of low-cost, low-power system on a chip microcontroller with integrated Wi-Fi and dual-mode Bluetooth which is used for communication between servo motor and LDR sensors. It facilitates connection with and control of external devices and sensors. The TP4056 is a complete constant current or constant voltage linear charger for single cell lithium-ion batteries which will help in moving the solar panel servo motors in dual axis mode.

4. CIRCUIT DIAGRAM OF SOLAR IRRADIANCE METER

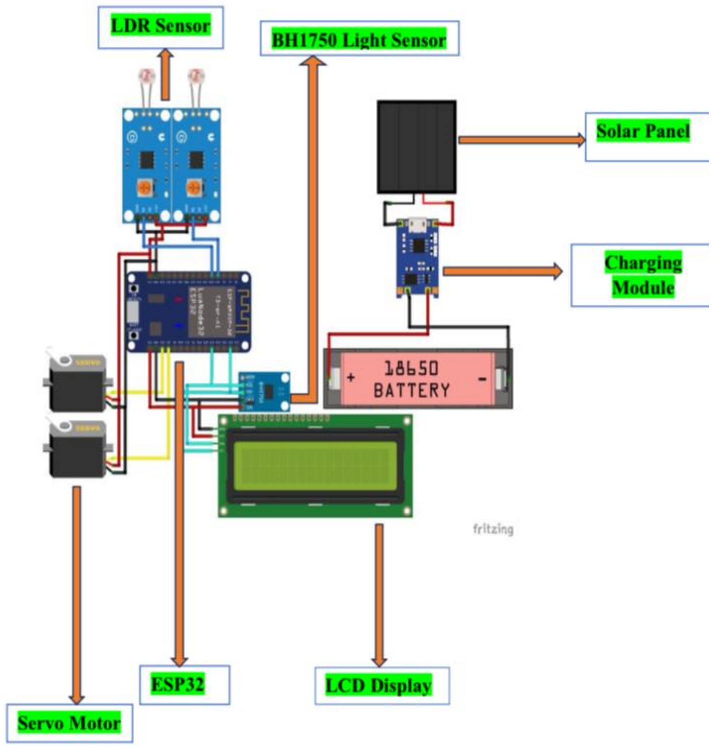

Figure 15: Circuit Diagram of Solar Irradiance Meter

1. The system uses ESP32 Microcontroller.
2. An I2C LCD is used to display data of solar irradiance measured through BH1750 Sensor.
3. RTC is used to get real time stamp and SD Card Module is used to store data.
4. 4 LDR Sensor is used for monitoring and tracking sunlight based on which the solar panels adjust themselves.
5. Solar panel adjust themselves with the help of two SG90 Servo Motors.
6. TP4056 along with 1 Li Ion Cells are used in the setup.

5. SOFTWARE USED:

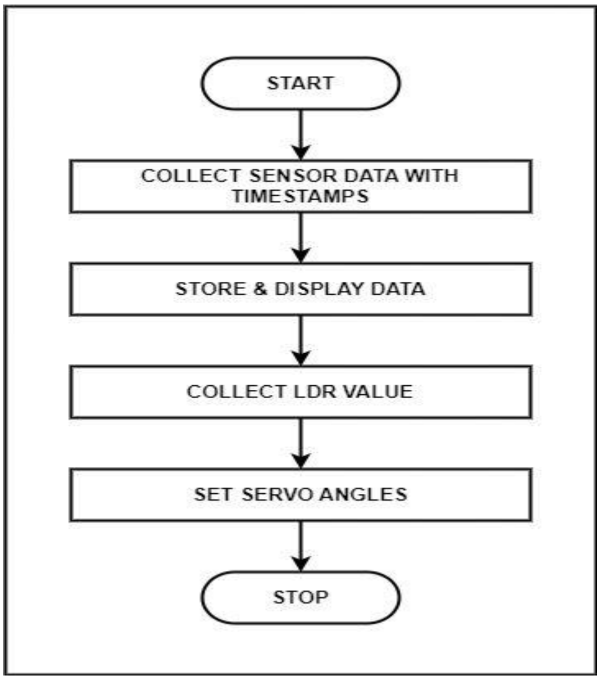

Figure 16: Flowchart

Code:

```
#include <ESP32Servo.h>

#define ldr1 35
#define ldr2 32
#define ldr3 33
#define ldr4 25
#define X_AXIS_PIN 18
#define Y_AXIS_PIN 19

Servo servoX;
Servo servoY;

void setup() {
  pinMode(ldr1, INPUT);
  pinMode(ldr2, INPUT);
  pinMode(ldr3, INPUT);
  pinMode(ldr4, INPUT);
  Serial.begin(9600);
  servoX.setPeriodHertz(50);
  servoX.attach(X_AXIS_PIN, 500, 2400);
  servoY.setPeriodHertz(50);
  servoY.attach(Y_AXIS_PIN, 500, 2400);
}

void loop() {
  int ldrval = 0;

  // Read LDR values
  int ldr1_val = analogRead(ldr1);
  int ldr2_val = analogRead(ldr2);
  int ldr3_val = analogRead(ldr3);
  int ldr4_val = analogRead(ldr4);

  // Print LDR readings
  Serial.print("LDR1: "); Serial.println(ldr1_val);
  Serial.print("LDR2: "); Serial.println(ldr2_val);
  Serial.print("LDR3: "); Serial.println(ldr3_val);
  Serial.print("LDR4: "); Serial.println(ldr4_val);
  Serial.println("---");

  // Compare LDR values to determine position
  if (ldr1_val > ldr2_val && ldr1_val > ldr3_val && ldr1_val > ldr4_val) {
    // Position servo for LDR1
    ldrval = 1;
    servoX.write(45);
    servoY.write(180);
    delay(2000);
  }
  else if (ldr2_val > ldr1_val && ldr2_val > ldr3_val && ldr2_val > ldr4_val) {
    // Position servo for LDR2
    ldrval = 3;
    servoX.write(45);
    servoY.write(120);
    delay(2000);
  }
  else if (ldr3_val > ldr1_val && ldr3_val > ldr2_val && ldr3_val > ldr4_val) {
    // Position servo for LDR3
    ldrval = 2;
    servoX.write(30);
    servoY.write(120);
    delay(2000);
  }
  else if (ldr4_val > ldr1_val && ldr4_val > ldr2_val && ldr4_val > ldr3_val) {
    // Position servo for LDR4
    ldrval = 4;
    servoX.write(30);
    servoY.write(180);
    delay(2000);
  }
}
```

4. CONCLUSION

A solar energy monitoring system is developed using a low-cost smart microcontroller. The I2C LCD shows the measured solar parameter in real-time. The monitored parameters show the optimized result that matches approximately with Electrical ratings of solar module tested under Standard Test Condition (STC). The proposed work helps to predict the performance of the Solar PV module through remote access. This can be extended for a large-scale solar plant to take preventive action by regularly monitoring the performance of the solar plant. It will be highly useful for the industrial and commercial application.

5. REFERENCES

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