IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Volume 7, PP 01-04

Devices Used For Measuring Solar Radiation – A Review

Vishrut Shenoy[1], Priyanka Tripathi[3], Abhishek Mahadik[3], Puja Nalawade[4], Aditya Mahajan[5]
[1]*(Electrical Engineering, Atharva College Of Engineering, India)*
[2]*(Electrical Engineering, Atharva College Of Engineering, India)*
[3]*(Electrical Engineering, Atharva College Of Engineering, India)*
[4]*(Electrical Engineering, Atharva College Of Engineering, India)*
[5]*(Electrical Engineering, Atharva College Of Engineering, India)*

Abstract: *Different instruments, satellite data and simulation softwares are available for measuring solar irradiation intensities but efficiency and accuracy of all devices are different. This paper represents detailed comparison of various measuring instruments based on efficiency, cost effectiveness, availability, accuracy, compactness and reliability .Importing solar radiation measurement instruments is very costly from economic and maintenance point of view for developing countries so it is preferred to construct devices from locally available equipments.*

Keywords –*Photodiode, Pyranometer, Pyrheliometer , Solar Radiation, Thermopile*

I. Introduction

Measurement of solar radiation per unit of surface (W/m^2) is called irradiance. The efficient utilization of solar energy for system design and selection of components for agricultural, industrial, telecommunication and household applications require knowledge of actual solar irradiation reaching earth's surface at the locations of interest.

A basic analog pyranometer requires no power to operate and contains thermopile sensor beneath a glass dome. The thermopile absorbs all the solar radiation which it encounters and generates a small proportional output voltage. Pyranometers are basically used on or near solar panels to have optimum panel positioning. Pyrheliometers are like pyranometers, but are designed to measure only direct beam solar irradiance. They are occasionally used in identical applications like in solar tracking systems to ensure that the system is consistently aimed towards the sun. The device is usually mounted directly on the tracking system so it is always measuring direct beam sunlight. Sunlight enters pyrheliometers via lens, which projects sunlight onto a thermocouple in the device. Most pyrheliometers can convert a thermopile's small voltage output into watts per square meter and either output or record this data. Quantum sensors are basically special devices which measure the quantity of photosynthetically active radiation or portion of visible spectrum which can be used by photosynthetic organisms. Specifically quantum sensors measure photosynthetic photon flux density of sunlight. This measurement is useful in choosing farmland locations, maintaining greenhouses, in oceanography to calculate boundaries of an ocean's sunlight zone[2].This paper represents reliability and cost effectiveness of different instruments used for measuring solar irradiation.

II. Classification, Construction And Working

Meteorologists and climatologists use various types of sensors depending upon the type of solar radiation they intend to measure. Pyranometer, Pyrheliometer, sunshine recorder and quantum sensors are used to measure solar irradiation intensity.

Thermopile pyranometers: A thermopile pyranometer is a sensor based on thermopiles designed to measure the broadband of the solar radiation flux density. A thermopile pyranometer measures 300 to 2800 nm with a large flat spectral sensitivity. Irradiation is calculated from the differential measure between temperature of black sectors exposed to sun and temperature of white sectors not exposed to the sun or in the shades. In all thermopile technology, irradiation is proportional to the difference between temperature of the sun exposed area and the temperature of shadow area.

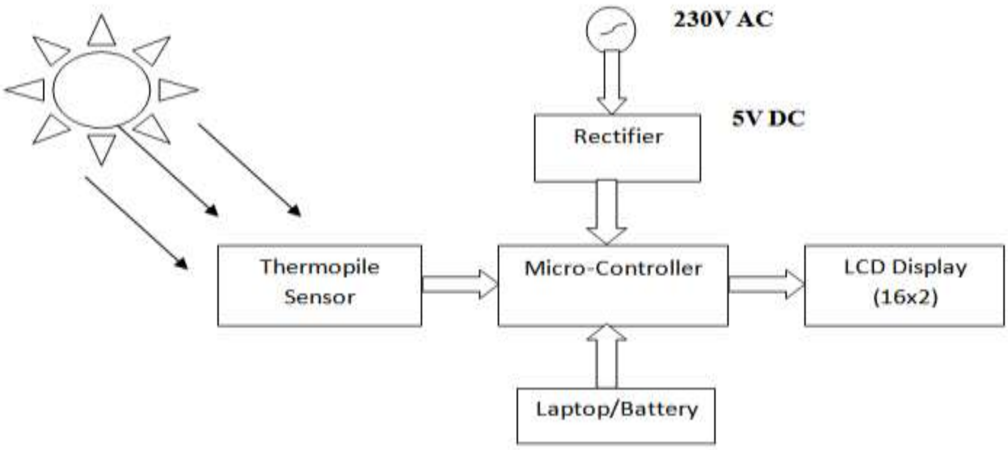

Fig 2.1 Block Diagram of Thermopile Pyranometer

Photodiode-based pyranometer: It is also known as silicon pyranometer. A photodiode-based pyranometer can detect the portion of solar spectrum between 400 nm and 900 nm with highest performance detecting between 350 nm and 1100 nm. The photodiode converts solar spectrum frequencies into current at high speed based on photoelectric effect.

Photovoltaic pyranometer: It is a derivation of the photodiode pyranometer. The main part of the sensor is made of a photovoltaic cell working in near short-circuit condition. The generated current is directly proportional to the solar radiation incident on the cell in a range between 350 nm and 1150 nm.

Photodiode based pyranometers require less maintenance and are less costly compared to thermopile based pyranometers[4].

Specifications	Thermopile Pyranometer	Photodiode Pyranometer	Photovoltaic Pyranometer
1. Main Component used	Thermocouple	Photodiode	PV Cell
2. Sensitivity Range	300nm to 2800nm	400nm to 900nm	350nm to 1150nm
3. Cost	Expensive	Reliable	Moderate
4. Accuracy	Highest	Moderate	High

Fig 2.2 Comparison between Pyranometers

III. Methodology

The best way to make pyranometer is using a silicon photodiode which is chosen for its local availability and high sensitivity. This silicon photodiode is a solid state device that converts light energy to electric current. When radiation at a specific energy level that is capable of ionizing the atoms is incident on P-N junction photodiode, an electrical current arises from continuous movement of excess electrons and holes. Electric current produced by photodiode is directly proportional to the amount of global solar radiation reaching its surface. The sensor is covered with a transparent plastic material to save the sensor from dirt. The developed pyranometer generates an electrical signal proportional to the irradiance received [5].

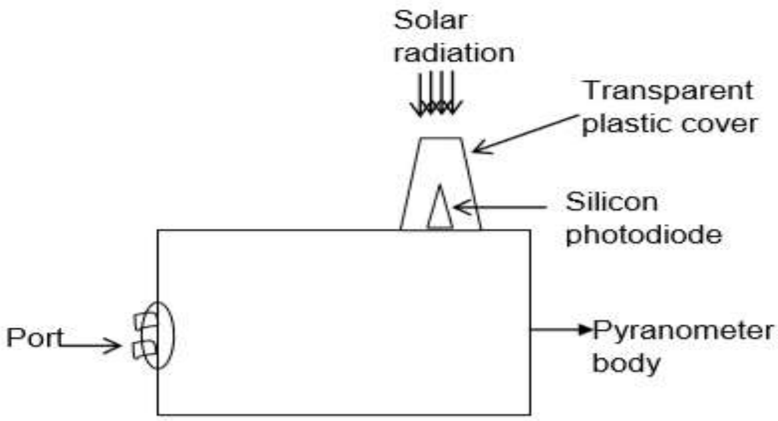

Fig 3.1 Block diagram of Photodiode Pyranometer

3.1 Components:
1. Sensor
2. Microcontroller
3. 3.LCD Display(16X2)
4. 4.PCB material
5. 5.Arcylic material and Dome Shaped Plastic material(Covering Sensor)
6. 6.Connecting wires
7. 7.Power bank(5V)
8. 8.Laptop
9. 9.Adaptor

3.2 Software:
1. Arduino IDE

3.3 Coding:
```
#include <Wire.h>//sensor library
#include <LiquidCrystal_I2C.h>  //LCD library
#define BH1750_Addr 0x23 //Sensor address
byte buff[2]; // buffer for digital data storage
float Radiation;
LiquidCrystal_I2C lcd(0x27, 16, 2); //LCD configuration
void setup()
{
Wire.begin(); //sensor initialization
lcd.begin(16,2); //LCD initialization
lcd.backlight();
}
void loop()
{
uint16_tval = 0;
BH1750_Init(BH1750_Addr); //function call for sensor initialization
delay(200); // in millisecond
if(BH1750_Read(BH1750_Addr) == 2) // intensity in lux
{
val = ((buff[0]<<8) | (buff[1]))/1.2;
}
Radiation = (val * 0.04726); // 0.04726 = (max watt per meter sq / max raw )
lcd.setCursor(0,0); //1st column and 1st row
lcd.print("Radiation:"); // print on lcd
lcd.setCursor(0,1); //1st column and 2st row
lcd.print(Radiation); // print reading
lcd.print(" W/m^2"); //print unit
}
```

```
int BH1750_Init(int address)
{
Wire.beginTransmission(address);
Wire.write(0x10); // 1 1ux resolution 120ms
Wire.endTransmission();
}
int BH1750_Read(intaddr)
{
intidx = 0;
Wire.beginTransmission(addr);
Wire.requestFrom(addr, 2); //request data from sensor
while(Wire.available()) //if data available
{
buff[idx] = Wire.read();
idx++;
}
Wire.endTransmission();
return idx;
}
```

IV. Conclusion

So we can conclude that photodiode based pyranometer is most suitable device which can be used to measure solar radiation for developing countries. It is very easy to make solar radiation measurement device by using photodiode sensor and microcontroller as main components as maintenance cost is low and overall cost of making device is also low, hence best sensor to make solar radiation measuring device is photodiode considering all parameters like cost,reliability, availability and efficiency.

References

[1] S.Nwankwo, M. N Nnabuchi and J.E Ekpe, Construction and characterization of a pyranometer using locally available materials forglobal solar radiation measurement,Asian Transactions on Basic and Applied Sciences 2 (04).

[2] Solar Radiation Instruments Information, IEEE GlobalSpec. Olivia, Difference between Pyranometer and Pyrheliometer.

[3] R. D. Parmar, Solar radiation and Pyranometer : a review, Journal of information, knowledge and research in electrical engineering.

[4] Wilfred I Okonkwo,Design, construction and evaluation of a pyranometer for solar radiation measurement.