Solaris Industria - Sensor Based Smart Solar Energy Meter

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***Abstract* - This paper aims at proposing a sensor-based solar energy meter, automatic in nature, which will measure the four parameters of solar energy using Arduino as a receiver and transmit it to the IoT panel to displaying the information about the energy parameter to the website or server using Arduino Wi-Fi Shield as sender. Solaris Industria is a Latin name of solar energy. Four parameters are voltage, current, power, and energy. The voltage will be measured using the voltage divider because the voltage generated by the solar panel is large for the Arduino as a receiver. The current will measured using the current sensor module that can sense the current generated by the solar panel. Power and Energy will be measured using the calculation process using parameters voltage, current, and time. By sharing the information about the solar energy parameter on the application, then there is no need for manually reading of meter. Here, I propose a sensor-based solar energy meter, which can detect the four parameters of solar energy meter and share the information on the IoT panel. An IoT based device will be integrated with a sensor-based solar energy meter to read the usage of electricity and uploaded on the IoT panel (server or website). This sensor-based energy meter is further useful for electricity regional/sub-regional office as well as personal use. In this project each customer is differentiated using address or ID, these IDs are used for identification by the consumers and as well as by officers to monitor the reading and payment details. The consumers/users can also track their usage from anywhere using the user login ID on the IoT panel.**

***Keywords*— Solaris Industria, Solar Energy, Sensors, Arduino, IoT**

1. INTRODUCTION

As technology is advancing, the cost of renewable energy equipments is decreasing which has resulted in a massive increase in Solaris Industria (solar energy) system installations. As well as, rising fossil fuel and burning fuel such as coal, global warming, and severe weather conditions have compelled many nations to look for alternative sources to reduce reliance on fossil-based fuels. Solar energy is one of the foremost renewable sources that is currently being used worldwide to contribute to meeting the elevating demands of electric power. Solar power is a conversion of sunlight into electricity, sunlight was collect either directly by using photovoltaics or indirectly using concentrated solar energy.

Solaris Industria (solar energy) was initially used as a power source for small and medium-size applications from the calculator powered by a single solar cell to remote homes powered by an off-grid rooftop Solaris Industria (solar energy) system. Solaris Industria (solar energy) is becoming inexpensive, low-carbon technology to harness renewable energy from the sun.

Internet of things or IoT is an elevator in the world of electronics. The notion is to connect all sensors and devices on a common network i.e. internet through wired or wireless methods so that the user or customers can approach the data and control the devices from anywhere where in the world with an internet connection.

This paper aims at proposing a sensor-based solar energy meter, automatic in nature, which will make the official as well as personal solar meter monitoring easy. Here, we are measuring for parameters of solar energy. The four parameters of solar energy using Arduino as a receiver and transmit it to the ThingSpeak, as it is the open IoT platform with MATLAB analytics the panel to displaying the information about the energy parameter on the website using Arduino Wi-Fi Shield as data sender. Solaris Industria is a Latin name of solar energy. Four parameters are voltage, current, power, and energy. Power and Energy will be measured through the calculation process using parameters voltage, current, and time.

2. BLOCK DIAGRAM

Figure 1. shown the block diagram of the research. In this block diagram circuit, it consists of two main parts: the voltage divider, the Current sensor, the Arduino Uno and Arduino Wi-Fi Shield. The power generated from the solar panel is 18V approximately which is dangerous for Arduino UNO, as the output voltage from it should be less than 5V. So, we designed the voltage divider in such a way that the output voltage from it should be less than 5V. Second, the current sensor for detecting the current produced by a solar panel. In this project, the main controller is used are the Arduino Uno and Arduino Wi-Fi shield. The power supply for this controller is 5V. Then, the Arduino Uno must have sending code for it to function as a data receiver for solar panel and data sender for Wi-Fi Shield. Lastly, the separate coding is done for the Arduino Wi-Fi Shield to work, as a data receiver for Arduino UNO and data sender to dedicated IoT panel or website or server. This sends data to the IoT panel (ThingSpeak) or any selected website or server is to display the various output values of solar energy meter.

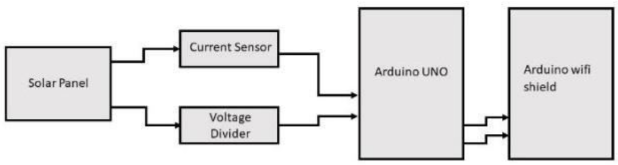

Fig. 1. The block diagram of research

3. Specific Components Used

This part are discusses the main components that used on this research.

- Solar panel (10 watt – 18 volt)
- Arduino UNO
- Arduino wifi shield esp8266
- ACS 712 current sensor
- Resistors (10k ,330ohm)
- IoT Panel (ThingSpeak)

3.1 Solar Cell

In this research, the panel solar is polycrystalline type is be used with 18V, 10W as a source. The required size of the panel for this proposed system is 145mm X 145mm as shown in Figure 2.

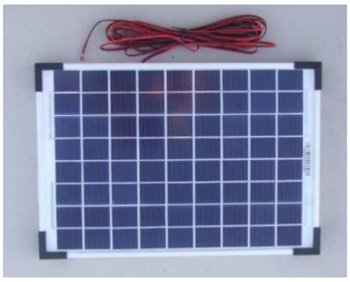

Fig. 2. The Solar Panel Polycrystalline Type

3.2. Arduino Board

In this proposed Solaris Industria (Solar Energy) meter system, the Arduino board acts as the main controller, which processes the incoming data from various sensors (like current, temperature, etc.). This board is selected because it reduces the requirement of various components like constant DC voltage regulator, burner hardware and does not require separate software to convert the code into a hex file and burn it in the microprocessor. All work is done by Arduino IDE and is burnt in the Arduino board via a USB cord. Arduino Uno is a microcontroller board based on ATmega328P processor. It can be coded as required using Arduino IDE in C/C++ language and uploaded directly to the board. This board has a vast use of applications in the field of embedded electronics. This is the area where it is decided whether the input values received by various sensors are within defined value as per the logic code given to the Arduino board. It processes the received data from various sensors and sends them to the Arduino WI-Fi shield.

Fig. 3. Arduino UNO

3.3. Arduino wifi shield

In this **Solaris Industria (Solar Energy) meter** system, it works as a sender of data to dedicated IoT panel, website, or server.
The Arduino WI-Fi shield is designed and developed as per the demand of esp8266, pins are compatible with Arduino UNO/Mega2560 DevBorad.

Special features are:

1. Serial data is transported to the WiFi device transparently, and vice versa. The Arduino program does not need any external source for configuration.
2. The webServer is developed to configure WiFi parameters and serial port parameters.

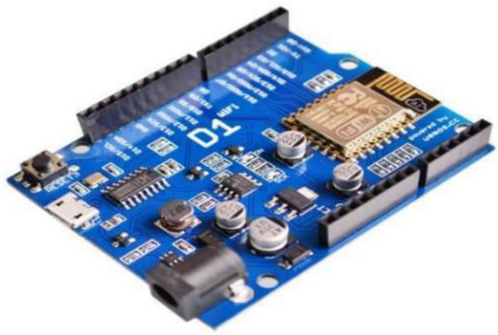

Fig. 4. Arduino wifi shield esp8266

3.4. ACS 712 Current Sensor

The ACS712 sensor is the current sensor used to reads the current value and convert it into a relevant voltage value.
The sensor can measure both positive and negative currents (*range* -5A…5A), and **power supply is 5V** for the sensor to be in operating mode and the middle sensing voltage is **2.5V when no current**.

Current is sensed using Hall Effect Current Sensor. Hall Effect is the generation of potential differences due to a current-carrying conductor in a perpendicular magnetic field. Hall Effect current sensors work on this principle.

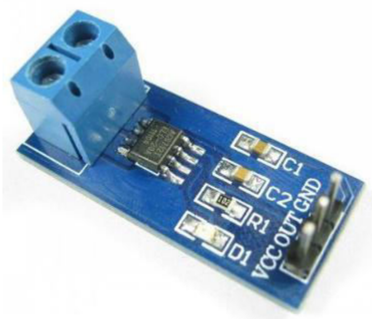

Fig. 5. ACS 712 Current Sensor

3.5. IOT Panel (ThingSpeak)

ThingSpeak is an open-source Internet of Things (IoT) application and API to store and retrieve data from things using the HTTP protocol over the Internet or via a Local Area Network.

ThingSpeak allows the creation of sensor logging applications, location tracking applications, and a social network of things with status updates.

ThingSpeak was originally launched by ioBridge in 2010 as a service in support of IoT applications.

ThingSpeak has integrated support from the numerical computing software MATLAB from MathWorks. allowing ThingSpeak users to analyze and visualize uploaded data using Matlab without requiring the purchase of a Matlab license from Mathworks.

4. PROCEDURE

It contains two programs receiving and sending. The receiving code will be codded in Arduino UNO, which will collect data from solar panels, and the Sending code will be codded in Arduino wi-fi shield esp8266, which will further send data to ThinkSpeak IoT panel website.

Step 1: Power and Energy

Power :
Power is product of voltage (volt) and current (Amp)
Power = Voltage * Current (P=VxI)
Unit of power is Watt or KW

Energy:
Energy is product of power (watt) and time (Hour)
Energy = Power * Time (E= Pxt)
Unit of Energy is Watt Hour or Kilowatt Hour (kWh)

From the above formula it is clear that to measure Energy we need three parameters

1. **Voltage**
2. **Current**
3. **Time**

Step 2: Voltage Measurement

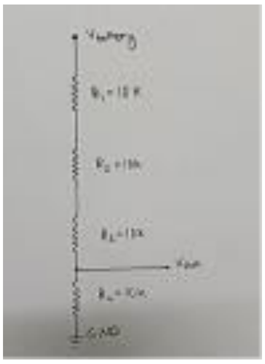

Fig. 6. Voltage Divider Circuit Diagram

Voltage is measured by the help of a voltage divider circuit. As the ARDUINO analog pin input voltage is restricted to 5V I designed the voltage divider in such a way that the output voltage from it should be less than 5V. Solar panel is rated 18v, 0.576Ah. So I have to step down this 18v to a voltage lower than 5V. Used R1=10k, R2 =10K, R3 =10K and R4 =10K. The value of R1, R2, R3 and R4 can be lower one but the problem is that when resistance is low higher current flow through it as a result large amount of power (P = I^2R) dissipated in the form of heat. So different resistance value can be chosen but care should be taken to minimize the power loss across the resistance.

Voltage Calibration:
When solar panel is fully voltage (18v) we will get a Vout=3.25v.

Step 3: Current Measurement

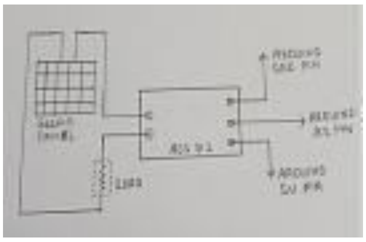

Fig. 7. Use of Current Sensor Diagram

For current measurement I used a Hall Effect current sensor ACS 712 (20 A).There are different current range ACS712 sensor available in the market, so choose according to your requirement. In bread board diagram I have shown LED as a load but the actual load is different.

Working Principle of Hall Effect:

The Hall Effect is the production of a voltage difference (the Hall voltage) across an electrical conductor, transverse to an electric current in the conductor and a magnetic field perpendicular to the current.

From Data Sheet
1. ACS 712 measure positive and negative 20Amps, corresponding to the analog output 100mV/A
2. No test current through the output voltage is VCC / 2 =5v/2=2.5V

Step 4: Time Measurement

For the measurement of time there is no need of any external sensor or hardware, as ARDUINO itself has inbuilt timer. The millis() function returns the no of milliseconds since the Arduino board began running the current program.

Arduino Code:

long milisec = millis(); // calculate time in milliseconds long time=milisec/1000; // convert milliseconds to seconds

Step 5: How ARDUINO Calculate Power and Energy

voltage = 5.0 * voltage1 / 1024;
voltage = voltage * 4.0; //to get full
voltage val = (5.0 * amps1) / 1024.0;
actualval = val - 2.5; // offset voltage is 2.5v
amps = actualval * 6.6; // 100mv/A from data
sheet totamps = totamps + amps; // total amps
avgamps = totamps / time; // average amps amphr
= (avgamps * time) / 3600; // amphour watt =
voltage * amps; // power=voltage*current energy =
(watt * time) / 3600; //energy in watt hour

By sharing the information about the solar energy parameter on the application, then there is no need for manually reading of meter. This sensor-based solar energy meter is further useful for electricity regional/sub-regional office as well as personal use. In this project each user is identified through a unique address or ID, these IDs are used by the consumer and as well as by officers to monitor the reading and payment details. The user can also monitor their usage from anywhere using the user login (ID). For future advancement, we can measure more parameters of solar energy by integrating sensors as per requirement. As we can add a temperature sensor for temperature measurement and density sensor for density measurement so on.

5. PROPOSED MODEL

Figure 8 & 9 shows the prototype of Solaris Industria - Sensor Based Smart Solar Energy Meter. The foremost position of the solar panel to provide the best output was the sun position with the highest output voltage value which is 14.75V at time 11.00 am have been recorded.

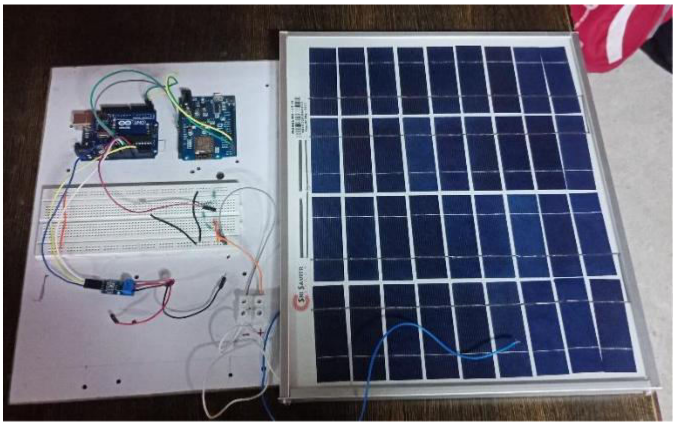

Fig. 8. Top View of Model

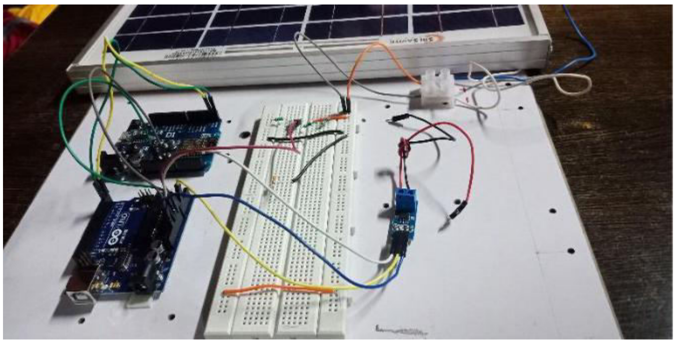

Fig. 9. Side View of Model

6. RESULT AND ANALYSIS

This section discusses the results based on the runtime data recoded from ThingSpeak IoT panel.

The foremost position of the solar panel to provide the best output was the sun position with the highest output voltage value which is 14.75V at time 11.00 am have been recorded.

Fig. 10. IOT panel show readings of solar energy parameter

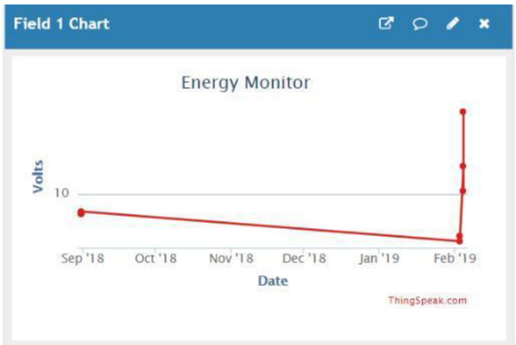

Fig. 11. Reading of Voltage (V)

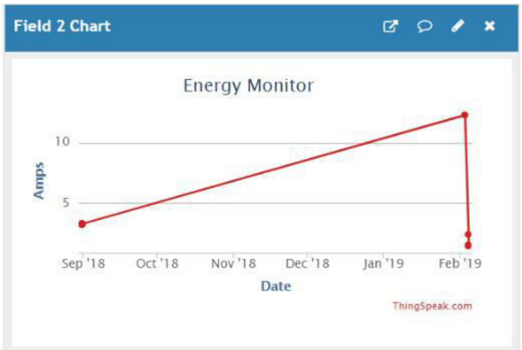

Fig. 12. Reading of Current (A)

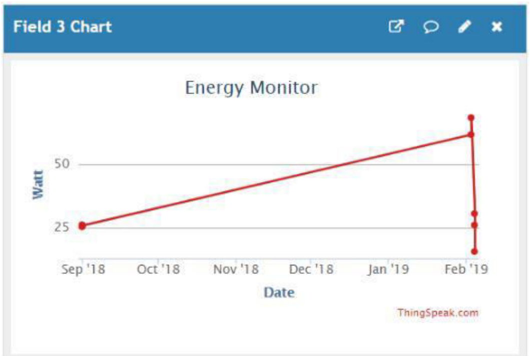

Fig. 13. Reading of Power (P)

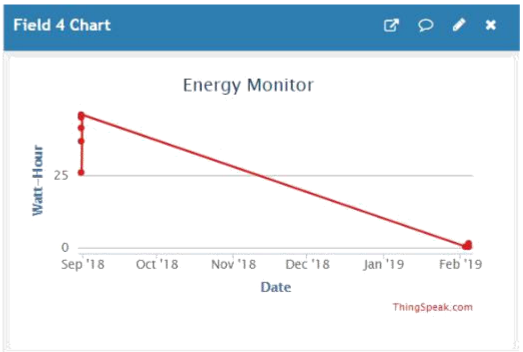

Fig. 14. Reading of Energy (E)

7. CONCLUSIONS

Here, we establish a Solaris Industria - Sensor Based Smart Solar Energy Meter. This project achieves all of the objectives are: to measure solar panel parameters such as the voltage, current, power, and energy. For the voltage parameter we use the voltage divider method to reduce the maximum output value of the solar panel to the voltage value suitable for the Arduino of power supply, for the current parameter was by using the current sensor module, for the power parameter was by the product of voltage and current (P=VxI) to Arduino UNO, for energy parameter was the product of power and time (E=Pxt) and lastly, all parameters are monitored on ThingSpeak IoT platform. Next, to find the best position and time for solar power effectively energize the electricity. The data from the measurement part shows that the best position of the solar panel effectively energize was the sunrise position with the highest voltage value which is 14.75V at time 11.00 am have been recorded. Lastly, we developed a portable device for measuring the sensor based Solaris Industria (solar energy) meter which we achieved by developing the light in weight of the device and the neat arrangement of the electrical component on the board as shown in the proposed model part. There is more to be done to achieve a more polished functionality of this project which will convert this prototype into a fully furnished product.

8. ACKNOWLEDGMENT

I would like my highly respected and esteemed guide Mr. Amit Sharma EN Department PSIT- Kanpur, for their valuable guidance, encouragement and help for completing this work. In last my genuine thanks to Dr. Anshuman Tyagi HOD (Electrical & Electronics Engineering) for his kind assistance. This work is funded by the Electrical and Electronics Department, Pranveer Singh Institute of Technology, Kanpur, India.

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