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"Solar panel parameters monitoring using ESP WROOM 32 and Blynk"

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Abstract - One of the challenges of unsatisfactory performance of solar powered equipment in Nigeria is the importation of substandard solar panels which in turns give rise to improper rating of the solar panels. Some of the equipment manufacturers are known for labeling the solar panels with arbitrary ratings in other to sell and make profit. Since the solar powered equipment depends on the Sun for its energy,there is need to monitor and measure the solar panel parameters like voltage, current, light intensity and temperature. This is necessary to confirm if the solar panel is performing to expectation and giving good readings. This work aims at developing a Solar Energy Measurement System that will aid in the measurement and monitoring of solar panel parameters like voltage, current, light intensity and temperature. The design work is divided into two main parts, hardware and software sections. The hardware involves the development of major units like the power.

Key Words: ***Solar Energy, Measurement, Monitoring, Light intensity,Voltage***

1. INTRODUCTION

The use of solar power system as alternative source of power supply has continued to be advocated and embraced all over the world because of its ease of deployment and low orno maintenance [1]. However the highinstallation cost is still scaring a lot of people who would have wished to have theirfacilities powered by solar [2]. In most developing countries like Nigeria the story is becoming a sour experience because most ofthe installations don't perform as intended. Key factors that have been identified forSupply unit, the control unit and the sensor units of the entire project by using solid state electronic components, integrated circuits and microcontroller. The software design involves the development of a program using C programming language to enable the arduino microcontroller to function and perform as desired. The basic inputs to the system are the sensor units. They sense the required variable that is to be measured and the measured values are then displayed. The results obtained from the display unit are then compared with the manufacturer's values that are found on the solar panel. It is observed that there are slight differences between the measured and the manufacturer's values, but still within a tolerable range (less than 5%) Non-performance of solar installationinclude wrong sizing, poor workmanship and lack of appropriate maintenance culture [3]. Also, there have been growing concernson the challenges of unsatisfactory

Performance of solar powered equipment in Nigeria which has been linked to importation of sub-standards solar panels to the market. Most of these solar panels arenot rated properly. Some manufacturerslabel the solar panels with arbitrary ratingsin other to sell and make profit as seen in figure 1. This work is therefore necessary so as to assist both those system as well as consumers to confirm the manufacturer's specification claim on the imported solar panels in Nigeria. The Solar Energy Measurement System is a system designed to measure the rating of the solar panel by monitoring the Solar Panel Parameters - voltage, current, temperature and light intensity.

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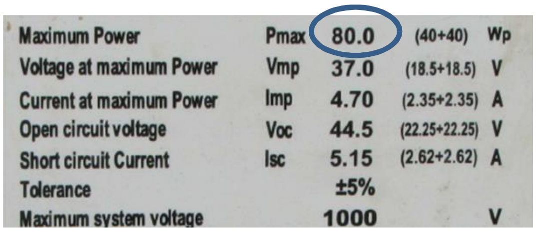
2. LITERATURE REVIEW:

There have been attempts to address this challenge before now as seen in literature. Three articles were critically reviewed . These authors measured solar cell parameters like voltage, current, temperatureand light intensity with the aid of sensors so as to measure energy of the solar panel(s). They all used the PIC16F8 series microcontroller. The data gotten from the sensors (i.e. the measured values of the voltage, current, temperature and light intensity) are then displayed on an LCD which is interfaced to the microcontroller. The uniqueness of this work is that a different microcontroller was used which is the Arduino Uno R3 which was programmed using C programminglanguage.

MATERIALS AND METHOD:

In the development of the measurement system, two design stages were involved - Software design and Hardware design.(LDR) sensor, the voltage by voltage dividerprinciple, current by current sensing circuit and temperature by temperature sensor.



Maximum Power	Pmax	80.0	(40+40)	Wp
Voltage at maximum Power	Vmp	37.0	(18.5+18.5)	V
Current at maximum Power	Imp	4.70	(2.35+2.35)	A
Open circuit voltage	Voc	44.5	(22.25+22.25)	V
Short circuit Current	Isc	5.15	(2.62+2.62)	A
Tolerance		±5%		
Maximum system voltage		1000		V

Solar panel name plate

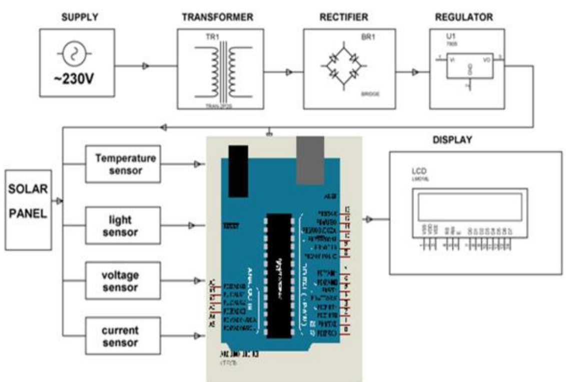


Figure 2: block diagram of the measurement

The power supply consists of a step down transformer 230/12V, which steps down the voltage to 12V AC. This is converted to DC using a bridge rectifier. The ripples are removed using a capacitive filter and it is then regulated to +5V using a voltageregulator 7805 which is required for the operation of microcontroller and other circuits.

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The Software:

This stage involved the programming of the microcontroller which is the Arduino Uno R3. The programming language used for the microcontroller is C programming Language.

The Hardware:

This stage is divided into following sub- units:

- The Power Supply Unit
- The Sensor Units
- The Control Unit
- The Display Unit

The Power Supply Unit:

This unit is made up of the following components: the 240/12V step–downtransformer, bridge rectifier, 1000-µF capacitor, Voltag regulator (LM7805).These components were used to produce a DC voltage from AC mains. The transformer changes the mains voltage to a lower level suited to our requirements; and the rectifier removes the negative part of the alternating signal giving an output which only has positive voltages which is filtered by the capacitor and regulated.

The Sensor Units:

The sensor units are made up of four sensor sub-units- Voltage Sensing, Current Sensing, Light Sensing, and Temperature Sensing

Voltage Sensing Sub-unit

This unit is made up of the following components: 1kΩ fixed value resistor and100 ohm resistor. The two components above were used to form a voltage divider network, which was used to scale the output voltage of the solar panel down to between 0-5v since Arduino does not accept voltages greater than 5. The voltage divider's output voltage of the solar panel down to between 0-5v since Arduino does not accept voltages greater than 5. The voltage divider's output is connected to channel 0 of Arduino's analog-to-digital converter module. As the voltage of the solar panel varies with respectto light intensity, the output of the voltage divider also varies between 0 and 5v.Analogue to Digital Converter (ADC) converts this analog signal to digital form. Arduino eventually displays the voltage on LCD after processing.

Current Sensing Sub-unit:

This unit is made up of a 10 ohms resistor which is connected in series with the load to measure the current flowing through the load. The voltage drop across the 10 ohms resistor was used to calculate the flowing current using ohms law.

$I = R$ _

Where R = 10 ohms and

$V = V_1 - V_2$ but $V_2 = 0$, since it is on the low side (ground)

V_1 = output voltage of the solar panel, measured with ADC, hence $V = V_1 - 0 = V_1$ $I = V_1/10$ = the current flowing through the load which is in series with the 10 ohms resistor. Arduino processes the sensor's output and displays the current value on LCD.

Light Sensing Sub-unit:

This unit is made up of the following components: 33kΩ fixed value resistor and LDR. The 33k resistor and the Light Dependent Resistor (LDR) were used to form voltage divider network. LDR is the light sensor which its resistance is inversely proportional to light intensity. The output of this voltage divider is connected to channel2 of Arduino's ADC.

This voltage is related to light intensity by the formula below:

Where,

Analog LDR Voltage = output of the voltagedivider

R_f = 33kΩ (fixed value resistor)

LUX = unit of luminosity (= measure oflight intensity)

Program to measure light intensity from the varying output of the voltage divider. The light intensity value is eventually displayed on LCD.

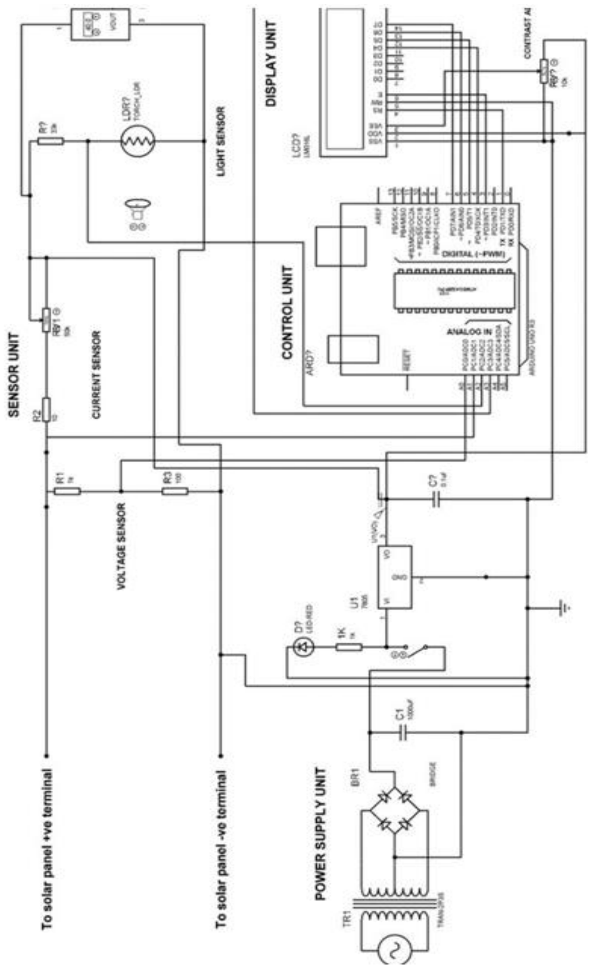
Temperature Sensing Sub-Unit:

This unit is made up of LM 35 temperature sensor. It is a linear sensor with sensitivity of 10mV per degree Celsius. Its voltage output is directly proportional to temperature.The two parameters are related by the formula:

$T = 100 \times V_{out}$ Where T = temperature in degree Celsius and V_{out} = voltage in volts

Display Unit

This unit is made up of a 16 x 2 Liquid Crystal Display (LCD). It has 16 columns and 2 rows; hence, it can accommodate upto 32 characters. The microcontroller is interfaced to the LCD. It is on the LCD that the values of voltage, current, light intensityand temperature are displayed. A 10k ohm potentiometer is used for the adjustment of the contrast. The complete circuit digram of system measurement.



PRACTICAL IMPLEMENTATION:

Microcontroller *Coding and testing-* TheArduino Uno R3 microcontroller was programmed to carry out its functions as outlined in previous sections. C programming language was employed in thecoding of the Microcontroller. The compiler used for debugging was the Arduino compiler. The microcontroller code was tested using a software simulation package - proteus 8 professional. The code was loaded on the Arduino Uno R3 with the use of the Arduino Compiler and simulated the activities of the pins, ran some tests and monitored its activities as shown in the proteus simulation environment of figure 4.

Figure 4: proteus simulation showing thetesting of the microcontroller.

EXPERIMENTALRESULTS:

The designed system was tested with twohigh quality solar panels which were verified to be properly rated to determine thepercentage error before other ten different solar panels which are selected from the solar panels available in the Nigeria market and the values from the designed system were recorded and compared with the manufacturer’s rated parameters. This is done to check effectiveness of the designed Figure 5 shows the snap shot of the packaged work with a solar panel which is being measured.

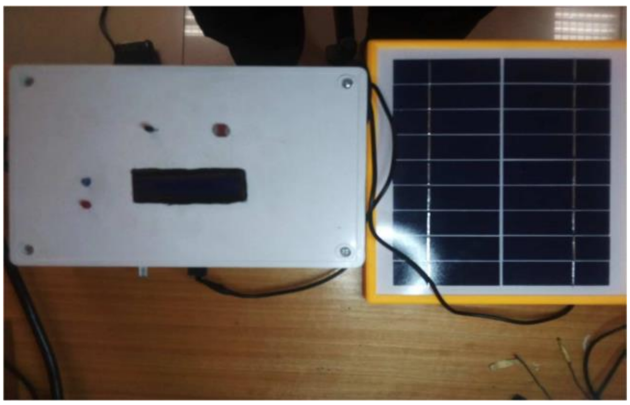


Figure 5: snap shot of the finished work.

System. The results are as shown in Tables 1and 2. The Test was carried out at 25 C, 2300W/m^2 insolation average between 11noon to 2pm GMT.

Parameters	Solar Panel A		Solar Panel B	
	Manufacturers specification	Measuredvalues	Manufacturers specification	Measured values
Voltage	9V (10.8 V at maximum)	8.67V	17.5V (21.6V at maximum)	21.07 V
Current	550mA (630mA at maximum)	556.01mA	2.26A (2.56A at maximum)	1.85 A
Power	5W	4.82W	40 W	38.96W
% error	3.6		2.6	

Table 2: reading gotten from selected solar panel

Solar panel ID	Measured value			Specified values		
	V(V)	I(A)	P(W)	V(V)	I(A)	P(W)
1	5.0	0.1	0.6	6	0.16	1
2	8.6	0.26	2.22	8.85	0.28	2.5
3	18.8	4.26	80	20	6.0	120
4	16.0	1.77	28.6	16.9	1.84	30
5	61.8	0.94	60	37	4.7	80
6	21.3	4.45	94.7	21.7	4.61	100
7	17.0	3.69	62	17.6	7.39	130
8	33.8	.29	145	36.4	5.43	200
9	35.3	5.52	195	36.7	7.63	300
10	29.7	6.03	175	30.7	8.13	250

CONCLUSION:

Solar Energy measurement and monitoring system was designed and implemented.Tests were carried out on the designed system and the results obtained demonstrated the proper functionality of the Solar Energy Measurement System. The system therefore serves the purpose of confirming solar panel parameters byplugging it to the solar panel at the locally that there are slight differences between the measured and the manufacturer's values, but still within a tolerable range (less than 5%). It is recommended, for future work, that thesystem be made with higher precisionsensors and also be made to have the abilityto store data gotten from the measurementsso as to ensure proper monitoring andevaluation. Also the system can be made touse a DC supply from a battery and acharging circuit can be added so as the battery can be charged, this would make thesystem more portable. The implementation of the project costs Thirty Thousand NairaOnly (N30, 000) which is about $85 dollars.

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