e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Volume 10, Issue 10, October 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 7.282

9940 572 462 6381 907 438 ijareeie@gmail.com www.ijareeie.com

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 10, October 2021 ||

DOI:10.15662/IJAREEIE.2021.1010002 |

Performance Evaluation of Algae Effect on Insolation of Solar Module

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ABSTRACT: Performance evaluation of algae effect on insolation of solar module has been studied.The materials used for this study are; a 250 watts Monocrystalline solar module (control), a 250 watts Monocrystalline solar module (surface covered with algae), a digital multimeter, and a timing device. The experiment was carried out at university of Port Harcourt and at the premises of school of basic studies having longitude 7.0498^0 E and latitude 4.8156^0 N. The solar module was inclined at 15^0 to the ground level facing the sun. It was observed that at some instance output power was gained, and at other instance, output power was lost. When the maximum power generated by the control module was 64.8W, the corresponding value for algae module was 61.18W. The power loss is thus 4.67%. When the maximum power generated by the control module was 454.14W, the corresponding value for algae module was 276.47 W and the power loss was 39.12%. Cumulatively, the total output power loss daily ranges from 12.62% to 39.29% and the average daily output power loss can be as low as 12%. The study, hence, shows that the presence of algae on the surface of the solar module does not necessarily indicate huge loss in output voltage. When deposited or grown Algae is greenish on the solar module surface, there is gain in output power. When deposited or grown algae becomes dry, the solar module experiences power loss. The deposited algae particles have low, significant effect on the output power of the solar module.

KEYWORDS : Insolation, Algae, Solar Module, Output Voltage, Power Loss.

I. INTRODUCTION

The need for energy consumption by man is tremendously increasing globally. This yearnings continually arouse as a result of modern life style as regards transportation, communication, manufacturing or production and so on. All these lead to an increase in energy necessary for all those modern systems. Electrical energy is the most popular form of energy. It is either required in the usable thermal form (heating applications), in mechanical form (electrical motor applications in Industries), for lighting purposes (illumination systems), or for transportation systems. The common electrical energy sources areHydro-electric, Wind power, Thermal, Solar Photo voltaic cells andFuel cells.

Solar energy is generated when sunlight is used to produce electrical energy. Photovoltaic modules use solar cells which convert solar radiation into direct electricity voltage. The solar radiation impinges the solar cells and the electrons are knocked out of the cell, this electron-hole mobility produces the electricity. The direct current from solar cells can further be converted to alternating current needed in homes to power appliances such as laptops, phones, refrigerator, lamp, light bulbs, air-conditioner, electric fan and so on.

The solar modules that are installed outdoor space for maximum reception of solar radiations from sunlight are confronted with environmental impacts. After exposure for a long time, the glass surface of the panel may be covered or coated with particles such as dust, dirt, droppings from birds, leaves, soot and algae.

Shobokshy and Hussein (1993) showed that the reduction in PV module conversion efficiency were 10%, 16% and 20% respectively for 12.5 g/m^2, 25 g/m^2 and 37.5 g/m^2 dust deposition on its surface.

An experiment was conducted to investigate the impact of wind speed and dust accumulation on the PV cell performance. The results showed that Wind speed affects the PV cell performance largely since the output reduction is greater in high winds than in low winds. At the same time, the wind affects the sedimentological structure of the dust coating on the cell, resulting in a higher transmittance (of light) for coatings created during high winds. The experiment investigated the effect of aeolian dust deposition on photovoltaic solar cells (Goosen and Van Kerschaerer, 1999).

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 10, October 2021 ||

DOI:10.15662/IJAREEIE.2021.1010002 |

In the Eastern Province of Saudi Arabia, the effect of dust accumulation on the output of PV modules was conducted. After six months of exposure to the environment, it was observed that power decreased by as much as 50% as experienced by the solar modules. In the study, it was found that due to sand dust deposition on PV panel surface, the reduction in short circuit current (I_{sc}) and maximum power output (P_{MAX}) are respectively 40% and 34% (Hasan and Ghoneim., 2005).

Elimir (2006) discussed the effect of dust on the transparent cover of solar collectors. The reduction in glass normal transmittance depends strongly on the dust deposition density in conjunction with plate tilt angle, as well as on the orientation of the surface with respect to the dominant wind direction.
Mani and Pillai (2010) reported that dust is the lesser acknowledged factor that significantly influences the performance of the PV installations.

Kaldellis and Kokala (2010) studied the influence of dust in the aggravated environment of the Greek capital, Athens, and considered that the dust effects are site-specific.
Kaldellis and Fragos (2011), conducted an experimental study to compare the energy performance of two identical pairs of PV panels; the first being clean and the second being artificially polluted with ash, i.e. a by-product of incomplete hydrocarbons' combustion mainly originating from thermal power stations and vehicular exhausts.

An analysis on the dust effect on the performance of PV systems in Athens was conducted. The studies were done using three different pollutants, red soil, limestone and carbonaceous fly-ash particles. It was found that there was a 6% reduction on PV performance with carbonaceous fly-ash, 10% with limestone and 19% with red soil (Kaldellis and Kapsali, 2011).

Jiang et al. (2011) investigated the impact of airborne dust deposition on the performance of PV module inside the laboratory under the controlled conditions in a test chamber. Dust was uniformly distributed on the panel surface with the help of a fan. It was concluded that efficiency of PV module reduced to 26 % as mass of dust increased to 22 g/m^2.
Mekhilef et al, (2012) have correlated between thickness of dust collected on PV module and difference in efficiencies in composite climate. They inferred that there is a significant reduction in PV module output, near 10–20%, when heavy layers of dust are accumulated. They also reported that a small amount of dust on solar PV module covers has a negligible effect on the sunlight transmission to the silicon PV module.

Hussein (2013) have investigated the experimental effect of three types of dust pollutants (red soil, ash and sand) on the performance of PV panels (mono-c, multi-c and a-Si technologies investigated). The authors claimed that ash have the highest effect in comparison with other pollutants. Also, it is found that a-Si is performing better than mono-c and multi-c in dusty environment.

Rajput and Sudhakar (2013) investigated experimentally the effect of deposited dust particles on PV modules and provided a concept on electrical performances. The study concentrated on parameters such as radiation availability, efficient operating strategies, design and sizing of these systems. It was concluded that dust significantly reduces the efficiency of solar PV module.

Darwish (2013) research inferred that the mean of the daily energy loss along a year caused by dust deposited on PV module surface is around 4.4%. In long periods without rain, daily energy losses can be higher than 20%. Dust particles differ in phase, sort, chemical and physical properties depending on many environmental conditions. Air, humidity and temperature in addition to wind speed play a significant role in defining isolated dust and how it will collect on the PV cell.
Kumar et al, (2013) determined the impact of dust on the performance of PV modules by conducting experiment on 96 cm^2 photovoltaic panels with maximum power of 302mW. It was found that the decrease of energy conversion efficiency was 10%, 16% and 20% with increasing of the dust density 0.1g, 0.2g, 0.3g respectively.
Kazem et al, (2014) conducted an experiment to determine the effect of dust physical properties on photovoltaic module in northern Oman, 64% of the dust particles size ranged from 2 to 63 µm in diameter. There is no significant loss of energy productivity due to the traceability of a little surface of dust (less than 1 g/m^2) on the photovoltaic unit. The daily loss in PV efficiency didn't exceed 0.05%. However, after 3 month exposure to outdoor conditions, the efficiency reduced by 30-35%.

Sulaiman (2014) studied the influence of dirt accumulation on performance of PV modules and analyzed the effects of particles on solar module performance. The study reported that external resistance could reduce PV performance by up to 85%. This study also concluded that water droplet from rain would not affect significantly the performance of PV modules.

Said and Walwil (2014) carried out fundamental studies on dust fouling effects on PV module glass cover. It was found that the spectral transmittance reduction was around 35% and the overall transmittance was around 20%. It was also observed that the dust particles accumulated were generally spherical in shape.
Another study conducted to determine the effect of pollution and cleaning on photovoltaic performance by Chaichan et al, (2015) showed that the exposure, even within a short period, to air pollutants deteriorated the PV yield. The polluted and dusty PV panel lost 12%, while the naturally cleaned cell (by rain) lost about 8% compared to the clean panel. The use of sodium surfactant or alcohols preserves high rates of the PV panels' performance.

Emmanuel and Tamuno-omie (2018), conducted an experiment using two panels of 10W capacity, mounted on a stand. The two PV systems are of polycrystalline type. One has carbon particles (grinded charcoal) as black soot debris on the panel while the other has none. They inclined both panel at an optimal angle of 15^{o} facing the northern hemisphere. From their experiment, they came up with the conclusion that “the highest voltage is produced when the panel is not covered by layer of black soot”. They observed that the voltage and power for the panel with black soot is low compared to the panel without soot.
The effect of shadow on output performance of solar module in a series-parallel solar cell array was studied. Measurements of the degradation of the power curve with time, current-voltage characteristics as function of total and partial shade were made on 250W monocrystalline silicon solar modules. The results show that the power loss for partially shaded solar modules ranges between 12%-40% when compared with the fully illuminated solar module. So, the power loss for partially shaded solar module can be as high as approximately 40%. For totally shaded module, the power loss ranges between 33% -80% when compared with the fully illuminated solar module. So, the power loss for totally shaded solar module can be as high as 80%. (Amusan and Otokunefor, 2019).

The effects of solid dirt accumulation on the solar panel’s surface was investigated and quantified. Typically, a total daily power output for control solar module was 1758.487W while the corresponding value for dirty (mixture of algae, sand, dust and moist air) solar module was found to be 1286.813W at the instance of time and same insolation. The study shows that the solid dirt affects the output power of the solar module and consequently reduces the efficiency of the solar module (Amusan and Igwe, 2020).

The growth of algae on the surface of solar module is commonly noticeable overtime. The presence of algae on the surface of the solar panel thus necessitates this study.
Microalgae are one of the most effective sources of renewable energy production and can grow at high rates. They grow in fresh water, sea water, waste water, non-arable lands, and can be grown almost everywhere. They can complete their growth cycle in few days by photosynthesis process that converts sun energy into chemical energy. They have higher photon conversion efficiency of about 3-8% (Ellatif, 2018).

This paper, thus reports the output performance of solar module coated with algaeat the specific geographical location. As the algae grown on the surface of the solar module, the algaeabsorbs and converts solar radiations into chemical energy and retains the energy.It is of interest to know the benefits of the retained radiations or energy on the output yield of solar module.

II. MATERIALS AND METHODS

The materials employed in this study are:

- **Two 250W monocrystalline solar modules** of the same dimensions and specifications. The panels without algae is the “control” while the panel with algae is the “algae”. Figure 1 (a) and (b) present the panels respectively.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 7.282|

|| Volume 10, Issue 10, October 2021 ||

DOI:10.15662/IJAREEIE.2021.1010002 |

Figure 1(a): control

Figure 1(b): algae

The specifications of the employed solar panels are:

i.	Model type	HU250
ii.	Typical Power	$(\pm 15\%) 250W$
iii.	Current at Typical power	8.35amps
iv.	Voltage at Typical power	30.1Volts
v.	Short Circuit Current (I_{sc})	8.93A
vi.	Short Circuit Voltage (V_{OC})	36.5Volts
vii.	Insulation	≥100mv
viii.	Wind bearing	≥120km/h
ix.	Voltage standoff	AC2000V DC3000V
x.	System voltage	1000V
xi.	Impact Resistance	225g Steel ball

- **Two digital multi-meters**

The specifications of the employed multi-meter (Figure 2) are:

i.	Model number	DT9205A (auto power off)
ii.	AC Voltage	200m - 750V
iii.	AC Current	2m - 20A
iv.	DC Voltage	200m - 1000V
v.	DC Current	2m - 20A
vi.	Resistance	200Ω - 200MΩ

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Figure 2: Employed digital multi-meter.

- **Life algae**(Figure 3)

Figure 3: Pictorial display of algae on a surface.

- **Stop watch timer** used to measure the amount of time elapses between its activation and deactivation.

The experimentwas carried out at the frontage of Basic Study unit of University of Port Harcourt, Rivers state, Nigeria with Latitude 4.9069^0N and Longitude 6.9170^0E.Figure 4shows the materials and the experimental set up.

Figure 4: In-Situ experimental set up.

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The following procedures were adopted while taking measurement:

i. The solar panels were inclined at an angle of 15^0C on ground mount to get an optimum output (Amusan, et al, 2012).
ii. Open circuit voltage, $V_{dc}$of the panels (control and algae) was recorded.
iii. Short circuit current, I_{dc} of the panels (control and algae) were recorded.
iv. The output power is calculated from the (ii) and (iii) above using equation (1)..
v. Readings were taken between the hours of 9am to 5pm at an interval of 15minutes daily.
vi. The *I-V* characteristics of the control and algae panels were plotted.
vii. The output voltage against time of the day for both control and algae panels were plotted.
viii. The output power against time of the day for both control and algae panels were plotted.
ix. The percentage voltage loss and power loss due to algae were determined using equations (2) and (3) respectively.

$$P_{dc} = I_{sc} \; x \; V_{oc} \quad (1)$$

I_{sc}= short circuit current
V_{oc}= open circuit voltage

Percentage loss in output voltage, V_L is:

$$V_L = \frac{V_a - V_b}{V_a} \; x \; 100 \quad (2)$$

Where:

V_a= voltage output without algae
V_b= voltage output with algae

The percentage loss in output power, P_L is :

$$P_L = \frac{P_a - P_b}{P_a} \quad (3)$$

Where:
P_a= power output without algae
P_b= power output with algae

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III. RESULTS AND DISCUSSIONS

The typical measured values obtained during the period of the experiment are shown in Tables 1 and 2.

Table 1: Measured Value for Day 1:

Time of day (mins)	I_{sc} for Control panel (amperes)	V_{oc} for control panel (volts)	Average Power p_{dc} for control panel (watts)	I_{sc} for algae panel (amperes)	V_{oc} for algae panel (volts)	Average Power p_{dc} for algae panel (watts)	Weather Conditions
10:00am	0	0	0	0	0	0	Rainfall
10:15am	0	0	0	0	0	0	Rainfall
10:30am	3.42	35.2	120.38	2.65	35.4	93.81	Low sunlight
10:45am	3.00	34.3	102.9	2.83	34.8	98.48	Cloudy
11:00am	0.22	34.5	7.59	0.99	34.2	33.86	Cloudy
11:15am	1.39	34.6	48.09	1.57	34.8	54.64	Cloudy
11:30am	2.58	34.8	89.78	1.98	34.9	69.10	Cloudy
11:45am	1.87	34.3	64.14	1.40	34.2	47.88	Cloudy
12:00pm	3.12	35.0	109.20	2.34	34.9	81.67	Cloudy
12:15pm	2.16	34.6	74.73	1.76	34.6	61.01	Low sunlight
12:30pm	3.02	35.3	106.61	2.76	34.8	96.05	Low sunlight
12:45pm	5.68	35.1	199.37	5.19	35.0	181.65	Sun
1:00pm	7.59	34.6	262.61	5.91	34.8	205.67	Sun
1:15pm	4.41	34.6	152.59	2.15	34.1	73.315	Low sunlight
1:30pm	0.93	32.5	30.22	0.60	32.4	19.44	Cloudy
1:45pm	3.39	34.9	118.31	3.70	35.1	129.87	Low sunlight
2:00pm	0	0	0	0	0	0	Rainfall
2:15pm	0	0	0	0	0	0	Rainfall
2:30pm	0	0	0	0	0	0	Rainfall
2:45pm	0	0	0	0	0	0	Rainfall
3:00pm	0	0	0	0	0	0	Rainfall
3:15pm	0	0	0	0	0	0	Rainfall
3:30pm	0	0	0	0	0	0	Rainfall
3:45pm	9.25	35.4	327.45	5.01	35.7	178.86	Sunny
4:00pm	9.68	35.8	346.54	7.21	36.2	261.00	Sunny
4:15pm	3.10	33.8	104.78	2.47	33.6	82.99	Low sunlight
4:30pm	2.55	33.6	85.68	1.69	33.9	57.29	Cloudy
4:45pm	0.07	26.7	1.87	0.18	27.6	5.01	Cloudy
5:00pm	0	0	0	0	0	0	Rainfall
5:15pm	0	0	0	0	0	0	Rainfall
5:30pm	0	0	0	0	0	0	Rainfall
5:45pm	0	0	0	0	0	0	Rainfall
6:00pm	0	0	0	0	0	0	Rainfall

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Figures 5 and 6 show respectively the I-V curve for the control module and algae module for the measured values of short-circuit current I_{SC} and open-circuit voltage V_{OC} for day 1. In Figure 5, the maximum values of I_{SC} and V_{OC} for the control module are 9.68A and 35.8V respectively. In figure 6, the maximum values of I_{SC} and V_{OC} for the algae module are 7.21A and 36.2V respectively. The trendlinesin both figures show direct proportionality between short circuit current, I_{SC} and open circuit voltage, V_{OC}.

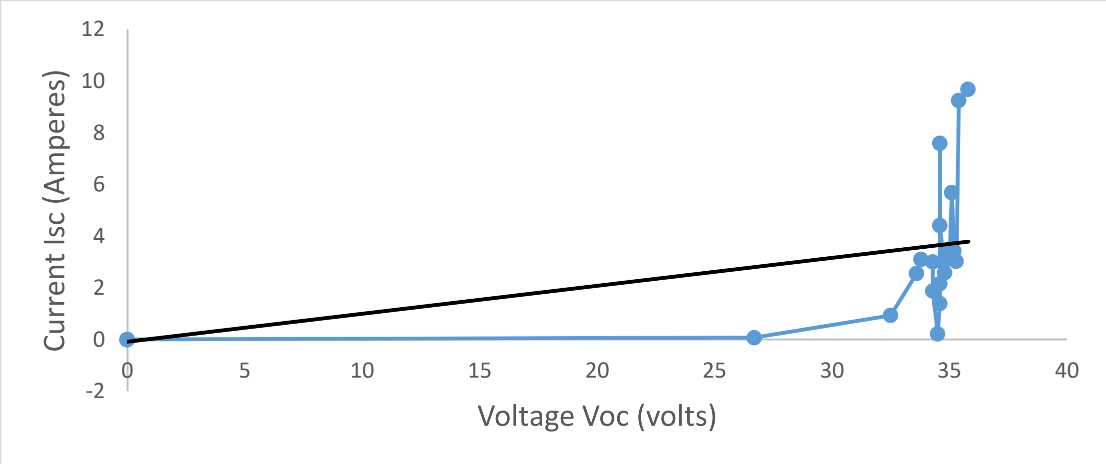

Figure 5: I-V curve for control panel Day 1

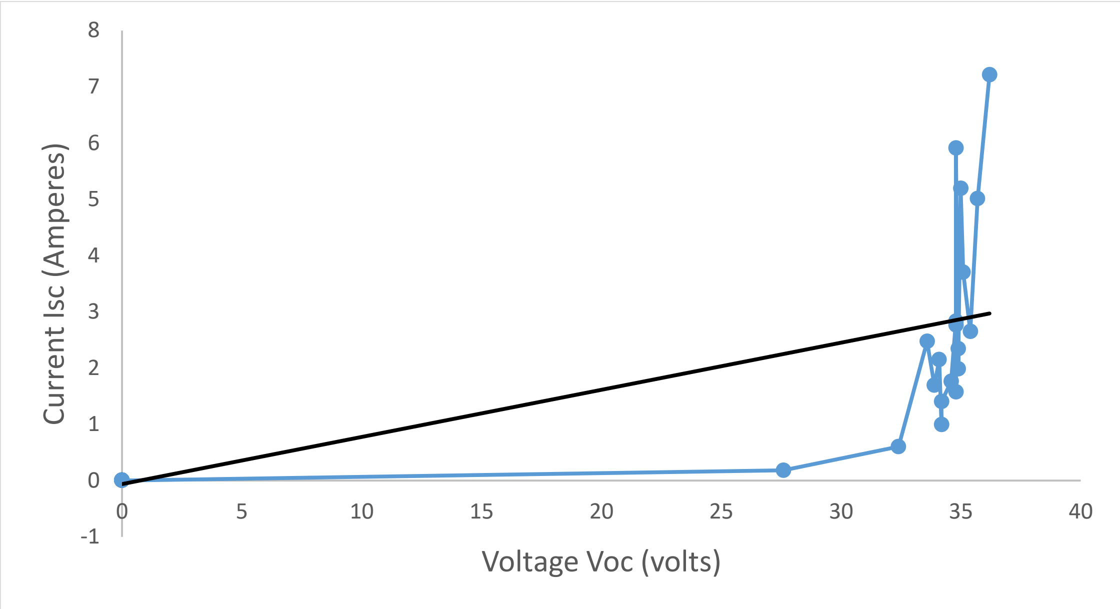

Figure 6: I-V curve for algae panel Day 1

Figure 7 shows a plot of the open-circuit voltage, V_{OC} for both control module and algae module against time of the day. The maximum open-circuit voltage, V_{OC} produced by control module was 35.8V at 4:00pm whereas that of the algae panel was 36.2V at same time.Hence, the percentage (%) loss in output voltage at 4:00pm for both control and algae modules can be calculated as:

$$\%\ Loss\ \ in\ Output\ Voltage\ =\ \frac{Max.\,V_{OC}\ \ for\ Control\ -\ Max.\,V_{OC}\ \ for\ A\lg ae}{Max.\,V_{OC}\ \ \ for\ control}\ \ x\ 100\%$$

$$\%\ Loss\ in\ \ Output\ \ Voltage\ =\ \frac{35.8-\ 36.2}{35.8}\ \ x\,100\%\ \ =\ -1.12\%$$

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Solar module with fresh, greenish Algae gained voltage output of 1.12% rather than losing voltage. Probably, the Algae was able to retain the solar radiation for onward transmission.

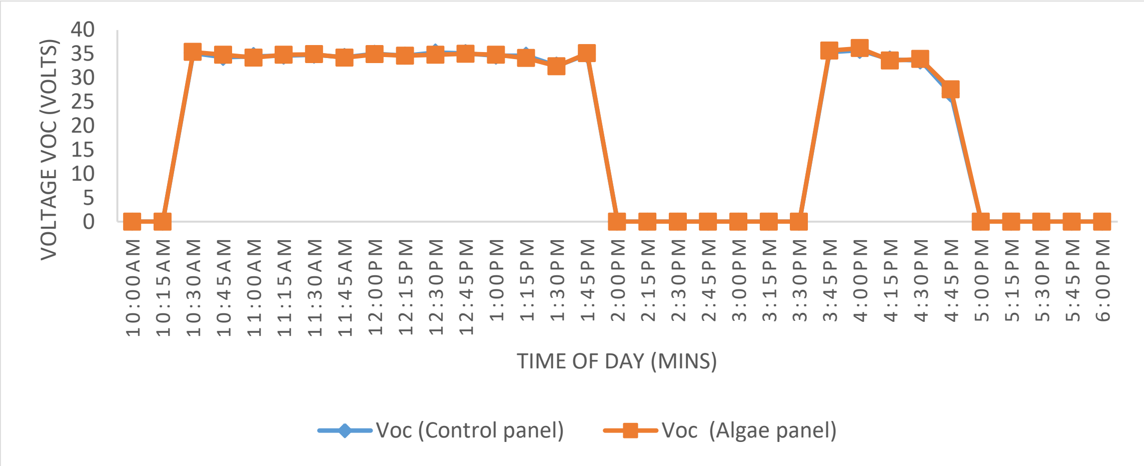

Figure 7: V_{OC} (control and algae in volts) against Time of Day for Day1 (mins).

Figure 8 shows a plot for the Average power P_{dc} (watts) against Time of day (mins) for both the control and algae module. The maximum power generated by the control module was 346.54W at 4:00pm while the corresponding value for the algae module was 261.00W at the same time.

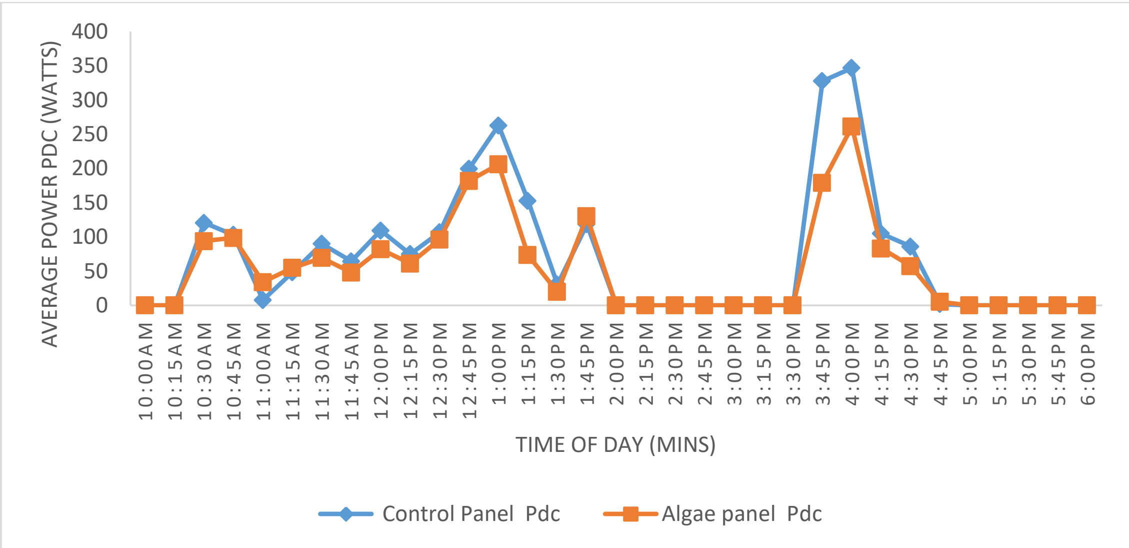

Figure 8: Average Power P_{dc} (watts) for control and algae panels against Time of day (mins) for Day 1

Therefore, the percentage (%) power loss at this time can be calculated as:

$$\% \; Power \;\; Loss \; = \frac{346.54 - 261.00}{346.54} \; x \; 100\% \; = \; 24.68\%$$

Also, the maximum power produced by the control module was 48.09W at 11:15am and the corresponding maximum power for the algae module was 54.64W at the same time. Thus,

$$\% \;\; Power \;\; Loss = \frac{48.09 - 54.64}{48.09} \; x \;\; 100\% \; = \; -13.62\%$$

It was observed that power was lost at some instances and output power was gained at other instances. This indicates that presence of algae on solar module surface has low significant effect on the output power. The power loss due to dry algae on the surface of solar module can be compensated for at another instance when the algae is greenish.

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Table 2: Measured Value for Day 6

Time of day (mins)	I_{sc} for Control panel (amperes)	V_{oc} for control panel (volts)	Average Power p_{dc} for control panel (watts)	I_{sc} for algae panel (amperes)	V_{oc} for algae panel (volts)	Average Power p_{dc} for algae panel (watts)	Weather Conditions
8:00am	0	0	0	0	0	0	Fair
8:15am	3.53	34.6	122.14	2.43	34.4	83.59	Fair
8:30am	6.80	35.3	240.04	3.53	34.6	115.22	Fair
8:45am	5.72	34.9	199.63	4.95	33.3	164.84	Fair
9:00am	6.15	35.6	218.94	4.70	34.4	161.68	Sunshine
9:15am	7.57	35.7	270.249	5.42	35.7	193.49	Sunshine
9:30am	8.62	36.4	313.768	6.82	35.2	240.06	Fair
9:45am	4.42	34.4	152.048	4.03	33.9	136.62	Fair
10:00am	5.70	35.2	200.64	4.24	35.8	151.79	Fair
10:15am	5.08	34.3	174.244	6.23	34.9	217.43	Fair
10:30am	5.95	36.1	214.80	3.49	34.3	119.71	Fair
10:45am	10.07	37.0	372.59	7.26	36.0	261.36	Sunshine
11:00am	11.69	35.01	409.26	9.81	35.7	350.22	Sunshine
11:15am	12.85	34.5	443.33	10.34	32.8	339.15	Sunshine
11:30am	11.82	33.5	395.97	9.39	34.6	324.89	Sunshine
11:45am	11.35	35.0	397.25	9.90	35.0	346.5	Sunshine
12:00pm	12.05	35.2	424.16	9.88	34.9	344.81	Sunshine
12:15pm	9.59	34.2	327.98	8.06	34.3	276.46	Sunshine
12:30pm	9.09	34.6	315.51	7.39	34.5	254.95	Sunshine
12:45pm	6.24	34.6	215.90	5.12	34.4	176.13	Fair
1:00pm	4.85	33.4	161.99	2.86	33.1	94.67	Fair
1:15pm	2.40	33.7	80.88	1.99	33.0	65.67	Fair
1:30pm	0	0	0	0	0	0	Fair
1:45pm	0	0	0	0	0	0	Fair
2:00pm	3.53	35.4	124.96	5.23	35.4	185.14	Cloudy
2:15pm	5.57	34.5	192.16	2.21	34.1	75.36	Cloudy
2:30pm	4.25	34.2	145.35	3.27	34.4	112.49	Cloudy
2:45pm	2.89	33.3	96.24	1.14	32.7	37.28	Cloudy
3:00pm	2.18	34.2	74.56	1.72	33.4	57.45	Cloudy
3:15pm	2.67	34.8	92.92	1.19	34.2	41.01	Cloudy
3:30pm	2.59	35.2	91.17	1.30	34.9	45.37	Cloudy
3:45pm	2.93	37.6	110.17	2.06	36.9	76.01	Cloudy
4:00pm	3.28	36.3	119.06	1.93	35.2	67.94	Cloudy
4:15pm	2.27	34.2	77.63	1.04	34.1	35.46	Cloudy
4:30pm	2.34	33.8	79.09	1.17	33.7	39.43	Fair
4:45pm	2.38	34.8	82.82	1.42	34.5	48.99	Fair
5:00pm	2.11	33.0	69.63	0.83	32.5	26.97	Fair
5:15pm	1.51	31.5	47.56	0.73	31.2	22.78	Fair
5:30pm	1.47	30.6	44.98	0.70	32.1	22.47	Fair

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Figures 9 and 10 show respectively the I-V curve for the control module and algae module for the measured values of short-circuit current I_{SC} and open-circuit voltage V_{OC} for day 6. The trendlines show direct proportionality between short circuit current, I_{SC} and open circuit voltage, V_{OC}

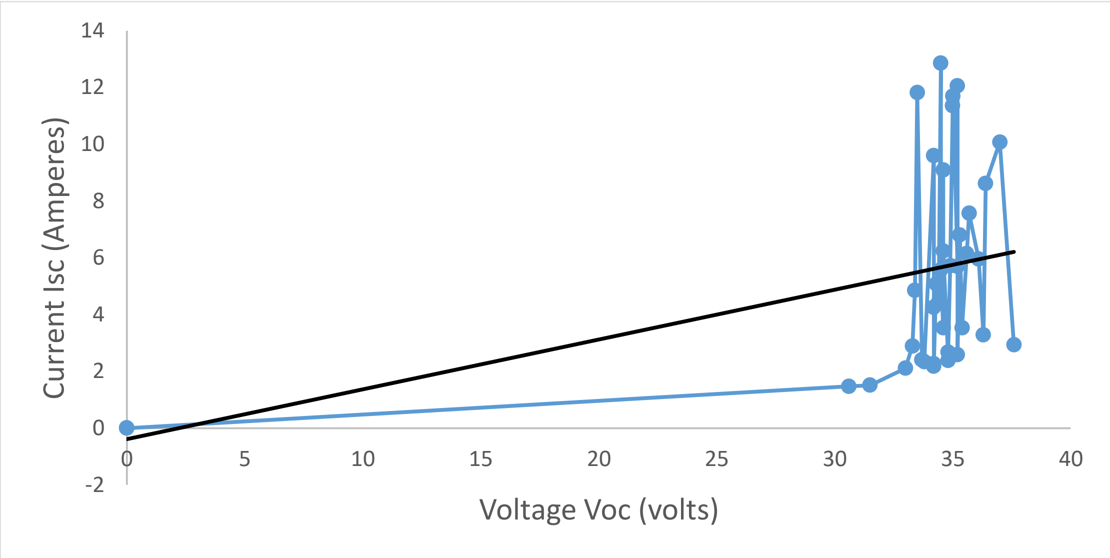

Figure 9: I-V curve for control panel Day 6

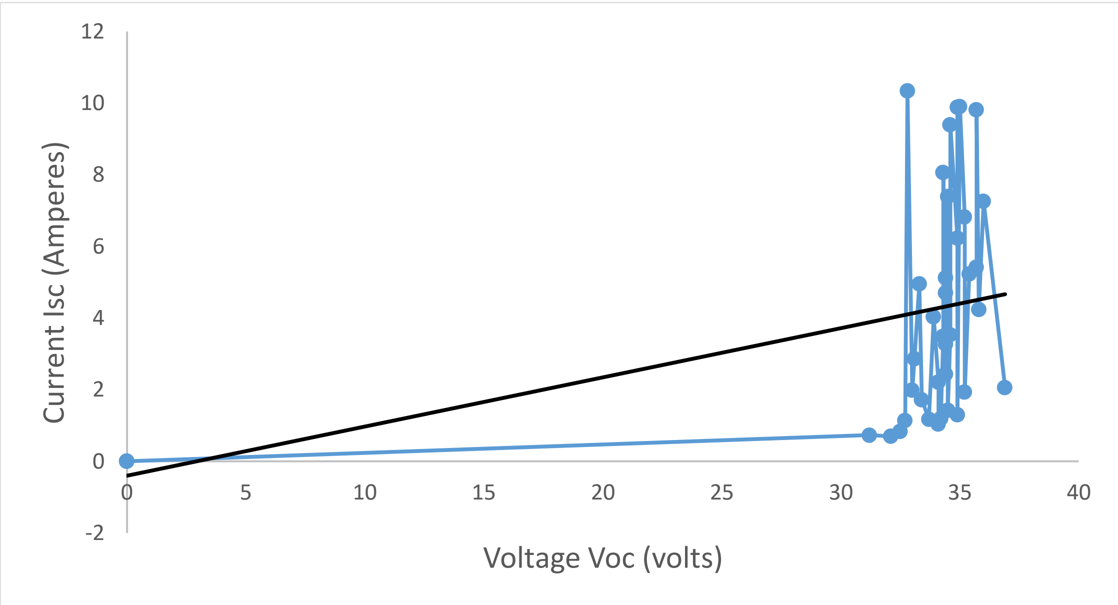

Figure 10: I-V curve for algae panel Day 6

Figure 11 shows a plot of the open-circuit voltage V_{OC} for both control module and algae module against time of the day. The maximum open-circuit voltage, V_{OC} produced by control module was 37.0V at 10:45am while that of the algae panel was 36.9V at 3:45pm.Hence, the percentage (%) loss in output voltage for both control and algae modules is 0.27% . The loss in output voltage of 0.27% for solar module with Algae is very low compared with the control module.

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|| Volume 10, Issue 10, October 2021 ||

DOI:10.15662/IJAREEIE.2021.1010002 |

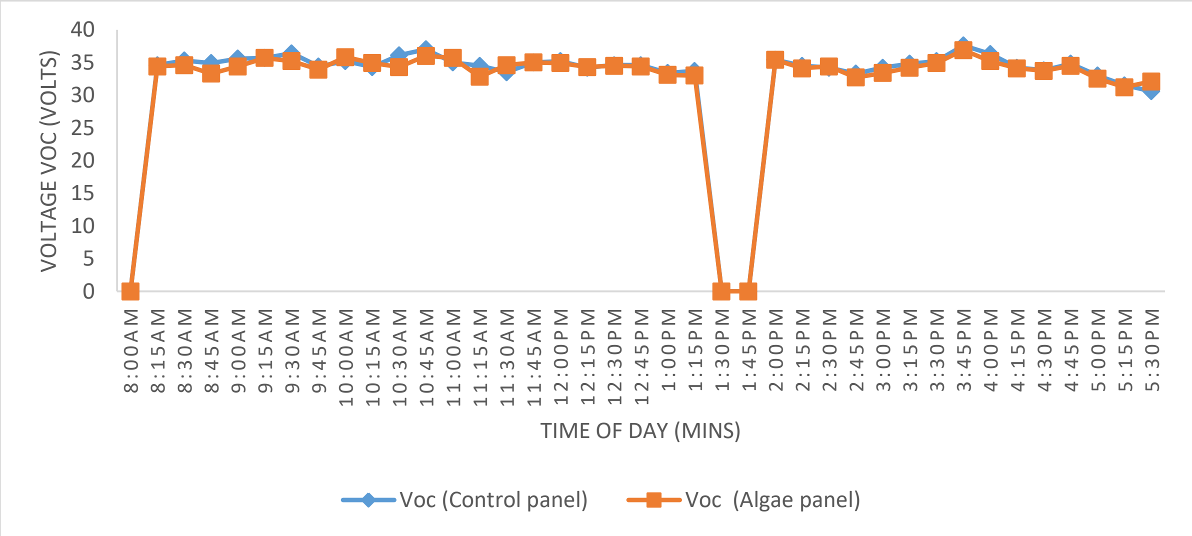

Figure 11: V_{OC} (control and algae in volts) against Time of Day for Day 6.

Figure 12 shows a plot for the Average power P_{dc} (watts) against Time of day (mins) for both the control and algae module. The maximum power generated by the control module was 282.05W at 10:00am while the corresponding value for the algae module was 115.94W at the same time.

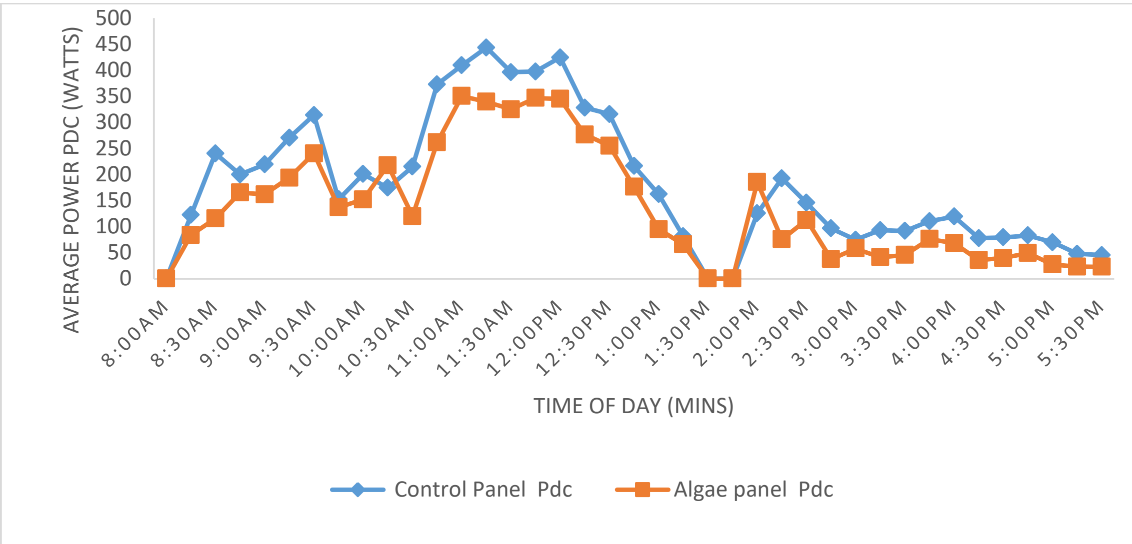

Figure 12: Average Power P_{dc} (watts) for control and algae panels against Time of day (mins) for Day 6

Therefore, the percentage (%) power loss at this time is calculated as:

$$\% \ Power \ Loss = \frac{443.33 - 350.22}{443.33} \ x \ 100\% = 21.00\%$$

Also, the maximum power produced by the control module was 424.16W at 12:00pm and the corresponding maximum power for the algae module was 344.81W at the same time. Thus,

$$\% \ Power \ Loss = \frac{424.16 - 344.81}{424.16} \ x \ 100\% = 18.71\%$$

Table 3summarizes the total average power output obtained during the period of measurements for the control and algae modules. It shows that the accumulation of algae on the solar module can probably reduce the average power output. The daily output power loss can be as low as 12%.

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Table 3: Summary of total average power output power for the control and algae modules for the days of measurement.

Days	Daily Average Power Output for Control Module	Daily Average Power Output for Algae Module	% Power Loss
1.	2352.84	1831.60	22.15
2.	575.75	434.92	24.46
3.	2049.80	1428.33	30.32
4.	5168.25	4516.21	12.62
5.	2367.38	1437.52	39.28
6.	7099.62	5313.39	25.16
7.	3948.07	2784.23	29.48

At the instant of measurement, the range of output power loss can be from 4.67% to 48.02%. Cumulatively, the total output power loss daily ranges from 12.62% to 39.28%. The variations in percentage (%) loss of average output power is mainly because of the variation in short-circuit current I_{SC} and open-circuit voltage V_{OC} produced by both the control and the algae module. Sometimes, output power is gained by the solar module covered with algae depending on the ability of the Algae to retain solar radiation. At another instance, the solar module experienced power loss. The daily output power loss can be as low as 12%. So, the loss in output power due to Algae is significantly low when compared with the clean solar module.

IV. CONCLUSION

The output performance and efficiency of solar modules was studied. The materials used were two monocrystalline solar panels, and two multimeters. The Output performance of modules with the presence of algae on one module and the absence of algae on the other was analyzed and evaluated at a time interval of 15 minutes under varying weather conditions. From the I-V graph of both the control and the algae modules, the trendline shows direct proportionality between short circuit current, Isc and open circuit voltage, Voc. For instance, the maximum voltage measured from the control module for day 2 is 34.0V and the maximum voltage measured from the algae module on same day is 33.8V. On day 7, the maximum voltage measured from the control module is 35.9V and the corresponding voltage for the algae module is 35.5V. Thus, the percentage (%) output voltage loss for day 2 is 0.59% while the percentage (%) output voltage loss for day 7 is 1.11%.

Also, it was observed that deposited algae particles have low, significant effect on the output power of the solar module. The maximum power produced by the control module was 424.16W at 12:00pm and the corresponding maximum power for the algae module was 344.81W at the same time. Thus, the percent power loss is 18.71%.Cumulatively, the total output power loss daily ranges from 12.62% to 39.28%. Hence, the daily output power loss can be as low as 12%.

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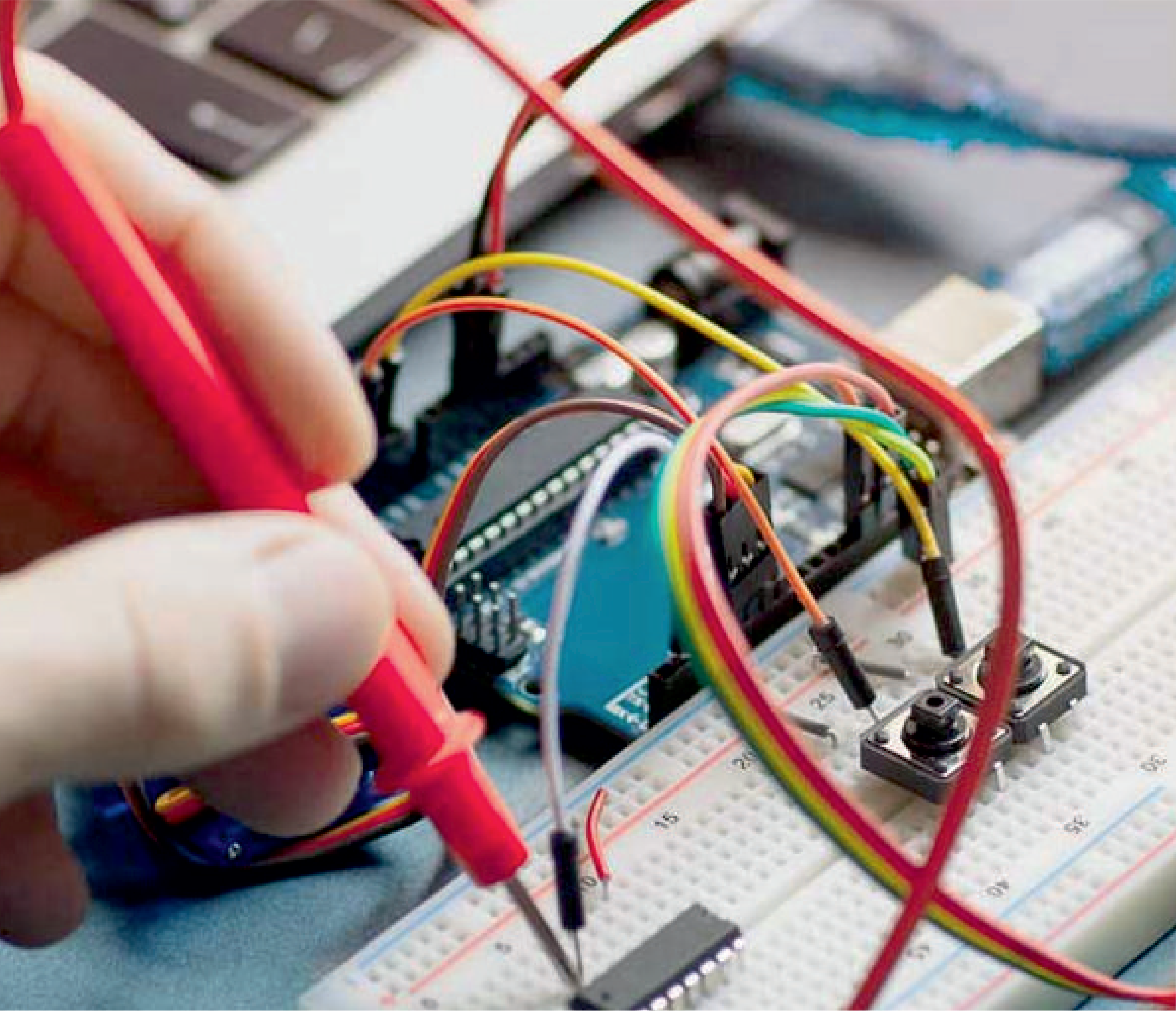

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