ASSIGNMENT COVERSHEET

UTS: ENGINEERING & INFORMATION TECHNOLOGY

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NAME OF TUTOR	TUTORIAL GROUP	DUE DATE
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ASSESSMENT ITEM NUMBER & TITLE
48550 Lab 1 PV panel measurement

☒ I confirm that I have read, understood and followed the guidelines for assignment submission and presentation on page 2 of this cover sheet.
☒ I confirm that I have read, understood and followed the advice in the Subject Outline about assessment requirements.
☒ I understand that if this assignment is submitted after the due date it may incur a penalty for lateness unless I have previously had an extension of time approved and have attached the written confirmation of this extension.

Declaration of originality: The work contained in this assignment, other than that specifically attributed to another source, is that of the author(s) and has not been previously submitted for assessment. I understand that, should this declaration be found to be false, disciplinary action could be taken and penalties imposed in accordance with University policy and rules. In the statement below, I have indicated the extent to which I have collaborated with others, whom I have named.

Statement of collaboration:

Signature of student(s) ______________________ **Date:** 11 Aug 2019

✂- -

ASSIGNMENT RECEIPT

To be completed by the student if a receipt is required

SUBJECT NUMBER & NAME	NAME OF TUTOR

SIGNATURE OF TUTOR	RECEIVED DATE

PV Measurement

48550 Renewable Energy Systems - Lab 1

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August 11, 2019

UTS
UNIVERSITY OF TECHNOLOGY SYDNEY

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1 Purpose

- To become familiar with the non-linear electrical properties of solar PV generation.
- To investigate the effects of solar radiation and shading levels, along with the tilt angle of a solar panel on the electrical characteristics of solar cells.
- To determine the optimal conditions for operating a PV panel in a circuit with a known load and understand the maximum power point tracking (MPPT) principle.
- To collect measurement data for construction of a PV array for the individual assignment.

2 Lab Questions

2.1 Q1

Briefly explain the mechanism of solar PV generation with the aid of diagram(s).

Solar photovoltaic (PV) electricity generation works by using multiple semiconductor devices (PV cells) that convert light into electrical energy. Usually these PV cells are arranged in arrays to increase electrical output.

An example is of PV cell construction is a wafer of p-type silicon with a thin layer of n-type silicon on one side. The p-type and n-type material acts as the positive and negative terminal of the cell respectively. When light hits the PV cell, photons of light provide energy to the electrons to promote them from the valence band into the conduction band, leaving behind a positive electron "hole". At this point, the electrons are now free to flow through the crystal structure and conduct electricity. This process is illustrated in fig. 1, (Zhu, Dorrell & Lu 2019).

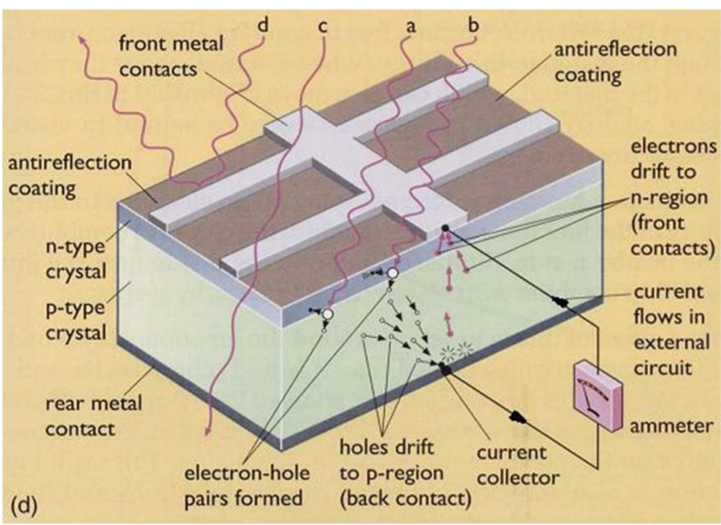

Figure 1: PV Cell Structure (Zhu, Dorrell & Lu 2019, p. 88)

2.2 Q2

Explain the three test conditions and show the results in both table format and graphical plots.

We took measurements on two separate days, one with overcast conditions and one with full sun. For both days, we took measurements at the same time of day and location with the solar panel in the same orientation. The tilt angle of the PV panel was changed to provide multiple sets of data.

1. Overcast Day
   - Solar panel with 0 degrees of tilt.
   - Solar panel with 40 degrees of tilt.
   - Solar panel with 90 degrees of tilt.
   - Solar Panel with 0 degrees of tilt with 3 PV cells covered.
2. Clear Sunny Day
   - Solar panel with 0 degrees of tilt.
   - Solar panel with 40 degrees of tilt.

The results from these test cases can be seen in section 3.1.

2.3 Q3

Locate on the graphs the estimated maximum power points (MPPs). Comment on any variation of the MPPs and the implication of loading impedance values for the PV panel to maintain at MPPs under all solar intensity conditions.

The maximum power point is marked for one of the data sets in fig. 5 and a similar peak can be seen in each of the data sets which represents the MPP for those conditions.

From fig. 5 it can be seen that the MPP is much larger for higher insolation values (measured in lux). This is due to the fact that there is a much larger current flow occurring with greater insolation.

Figure 6 illustrates the implications of loading impedance on the MPP for different insolation. For our higher insolation measurements (>38400 Lux), the MPP occurs at impedances of around 50Ω. However, for lower insolation measurements (<8380 Lux), the MPP occurs at impedances of around 250Ω. This illustrates that in order to maintain the MPP, the load impedance needs to be reduced for greater insolation.

3 Experimental Measurements

To begin taking measurements of the current and voltage produced by the PV panel, the equipment, consisting of the PV panel, a current meter, voltage meter and resistance box, were set up as shown in fig. 2

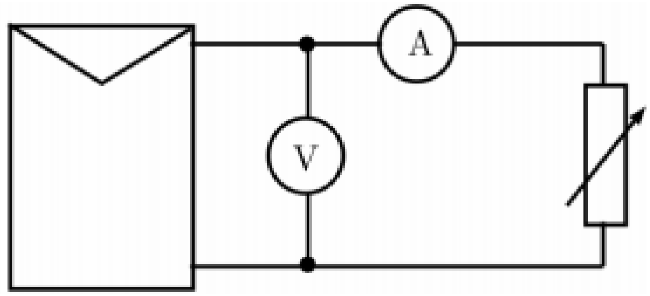

Figure 2: Circuit diagram of experiment

The insolation of the PV panel was taken for each angle setup by placing the light meter on top of the PV panel before measurements were taken as shown in fig. 3.

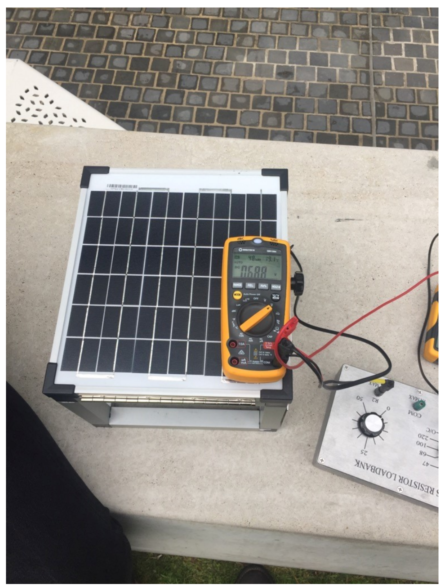

Figure 3: Measurement of panel insolation

The voltage and current produced by the PV panel was then measured at three different levels of insolation and at a number of resistances, provided by the resistance box, in order to find the maximum power point (MPP) for the panel.

3.1 Results

3.1.1 Graphs

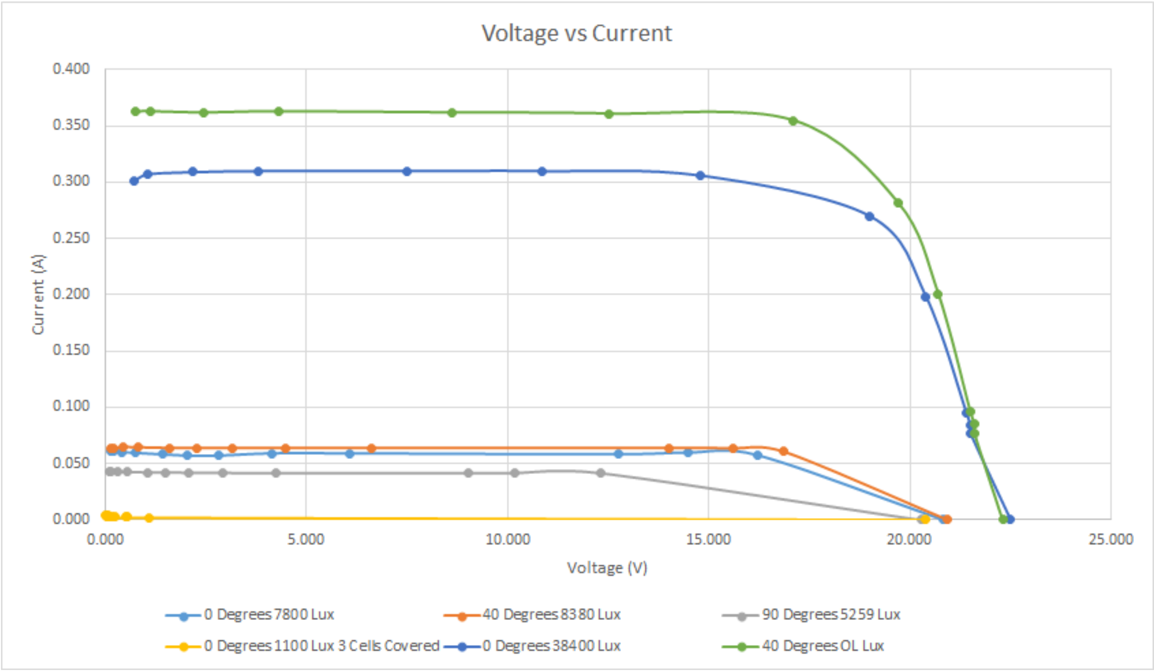

Figure 4: Voltage vs Current

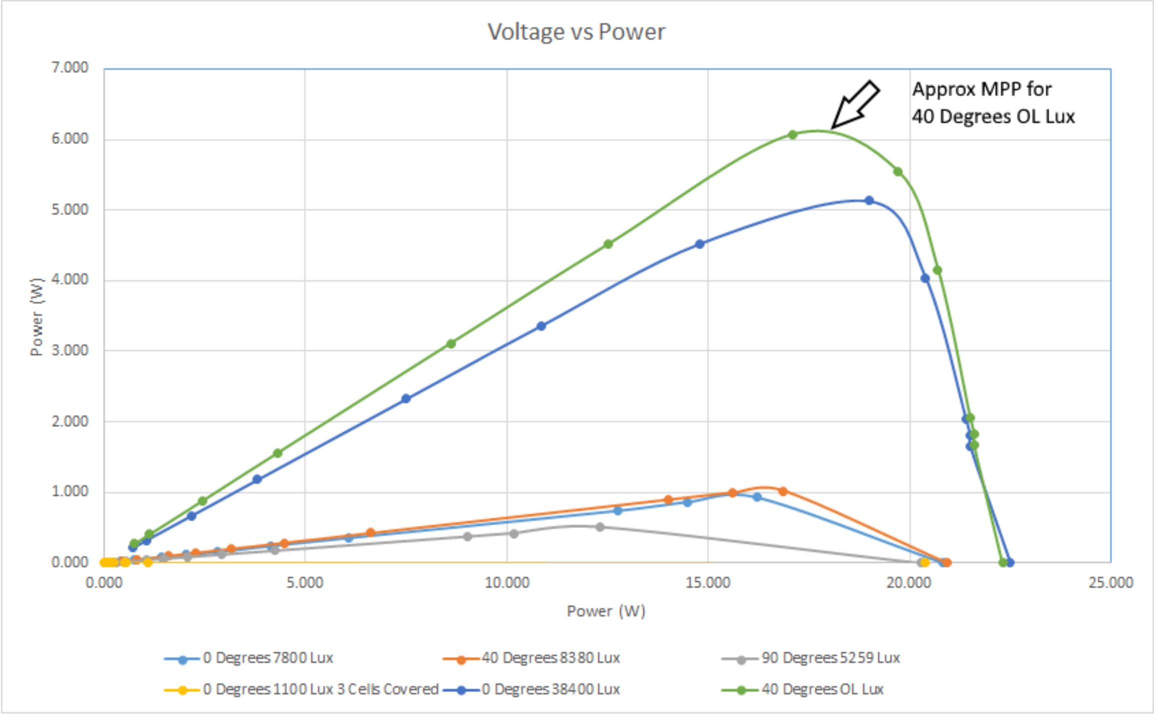

Figure 5: Voltage vs Power

Figure 6: Resistance vs Power

3.1.2 Tables

Table 1: 0 Degrees, 7800 Lux

R1 (Ohms)	R2 (Ohms)	Total (Ohms)	Current (A)	Voltage (V)	Power (W)
0.00	0.00	0.00	0.06	0.14	0.01
1.00	0.00	1.00	0.06	0.20	0.01
4.70	0.00	4.70	0.06	0.43	0.03
10.00	0.00	10.00	0.06	0.74	0.04
22.00	0.00	22.00	0.06	1.43	0.08
33.00	0.00	33.00	0.06	2.03	0.12
47.00	0.00	47.00	0.06	2.83	0.16
68.00	0.00	68.00	0.06	4.15	0.24
100.00	0.00	100.00	0.06	6.08	0.36
220.00	0.00	220.00	0.06	12.75	0.74
220.00	25.00	245.00	0.06	14.50	0.87
220.00	50.00	270.00	0.06	16.20	0.93
O/C			0.00	20.83	0.00

Table 2: 40 Degrees, 8380 Lux

R1 (Ohms)	R2 (Ohms)	Total (Ohms)	Current (A)	Voltage (V)	Power (W)
0.000	0.000	0.000	0.064	0.150	0.010
1.000	0.000	1.000	0.064	0.217	0.014
4.700	0.000	4.700	0.065	0.456	0.030
10.000	0.000	10.000	0.065	0.808	0.052
22.000	0.000	22.000	0.064	1.585	0.101
33.000	0.000	33.000	0.064	2.265	0.145
47.000	0.000	47.000	0.064	3.150	0.202
68.000	0.000	68.000	0.064	4.470	0.286
100.000	0.000	100.000	0.064	6.600	0.422
220.000	0.000	220.000	0.064	14.000	0.893
220.000	25.000	245.000	0.064	15.600	0.992
220.000	50.000	270.000	0.061	16.850	1.021
O/C			0.000	20.930	0.000

Table 3: 90 Degrees, 5259 Lux

R1 (Ohms)	R2 (Ohms)	Total (Ohms)	Current (A)	Voltage (V)	Power (W)
0.000	0.000	0.000	0.042	0.100	0.004
1.000	0.000	1.000	0.043	0.150	0.006
4.700	0.000	4.700	0.042	0.300	0.013
10.000	0.000	10.000	0.042	0.540	0.023
22.000	0.000	22.000	0.042	1.050	0.044
33.000	0.000	33.000	0.042	1.497	0.063
47.000	0.000	47.000	0.042	2.070	0.087
68.000	0.000	68.000	0.042	2.930	0.122
100.000	0.000	100.000	0.041	4.250	0.176
220.000	0.000	220.000	0.041	9.040	0.374
220.000	25.000	245.000	0.042	10.170	0.422
220.000	50.000	270.000	0.041	12.300	0.509
O/C			0.000	20.280	0.000

Table 4: 0 Degrees, 1100 Lux, 3 Cells Covered

R1 (Ohms)	R2 (Ohms)	Total (Ohms)	Current (A)	Voltage (V)	Power (W)
0.000	0.000	0.000	0.004	0.020	0.000
1.000	0.000	1.000	0.004	0.010	0.000
4.700	0.000	4.700	0.004	0.080	0.000
10.000	0.000	10.000	0.002	0.040	0.000
22.000	0.000	22.000	0.002	0.060	0.000
33.000	0.000	33.000	0.002	0.080	0.000
47.000	0.000	47.000	0.002	0.120	0.000
68.000	0.000	68.000	0.002	0.170	0.000
100.000	0.000	100.000	0.002	0.240	0.001
220.000	0.000	220.000	0.002	0.500	0.001
220.000	25.000	245.000	0.002	0.540	0.001
220.000	50.000	270.000	0.002	1.100	0.002
O/C			0.000	20.400	0.000

Table 5: 0 Degrees, 38400 Lux

R1 (Ohms)	R2 (Ohms)	Total (Ohms)	Current (A)	Voltage (V)	Power (W)
0.000	0.000	0.000	0.301	0.700	0.210
1.000	0.000	1.000	0.307	1.050	0.322
4.700	0.000	4.700	0.309	2.160	0.667
10.000	0.000	10.000	0.310	3.800	1.178
22.000	0.000	22.000	0.310	7.500	2.325
33.000	0.000	33.000	0.310	10.850	3.364
47.000	0.000	47.000	0.306	14.800	4.529
68.000	0.000	68.000	0.270	19.000	5.130
100.000	0.000	100.000	0.198	20.400	4.039
220.000	0.000	220.000	0.095	21.400	2.033
220.000	25.000	245.000	0.084	21.500	1.806
220.000	50.000	270.000	0.077	21.500	1.656
O/C			0.000	22.500	0.000

Table 6: 40 Degees, Out of Range Lux

R1 (Ohms)	R2 (Ohms)	Total (Ohms)	Current (A)	Voltage (V)	Power (W)
0.000	0.000	0.000	0.363	0.760	0.276
1.000	0.000	1.000	0.363	1.120	0.407
4.700	0.000	4.700	0.362	2.430	0.880
10.000	0.000	10.000	0.363	4.300	1.561
22.000	0.000	22.000	0.362	8.600	3.113
33.000	0.000	33.000	0.361	12.500	4.513
47.000	0.000	47.000	0.355	17.100	6.071
68.000	0.000	68.000	0.282	19.700	5.555
100.000	0.000	100.000	0.201	20.700	4.161
220.000	0.000	220.000	0.096	21.500	2.064
220.000	25.000	245.000	0.085	21.600	1.836
220.000	50.000	270.000	0.077	21.600	1.663
O/C			0.000	22.300	0.000

4 References

Zhu, J.G., Dorrell, D., Lu, D. 2019, 'Renewable Energy Systems 48550, Course Notes', rev 07/2019.