



## I-V Curve Measurement Test Report

<b>Client name:</b> XXXX XXXX	<b>Date:</b> yyyy-mm-dd
<b>Address:</b> Manama, Kingdom of Bahrain	

I-V curve measurement test provides the following information about the PV module:

- 1- Open circuit voltage ( $V_{oc}$ ) and short circuit current ( $I_{sc}$ ).
- 2- Maximum power ( $P_{max}$ ), current ( $I_{mpp}$ ) and voltage ( $V_{mpp}$ ) at  $P_{max}$  point.
- 3- Performance and fill factor.
- 4- It can be used to identify defects of PV module.

Tested modules are installed on UOB Renewable Energy Lab and connected to Precision Photovoltaic Measurement Systems (PVMS) that measure different characteristics of the PV module.

### General Information:

	Panel Model/Type	Qty	Remarks
1	Sample Module 300W Mono Crystalline	1	
	Total	1	

### Module No. 1

Module information	
<b>UOB Serial No.</b>	00000
<b>Test Date</b>	2019-05-02
<b>Manufacturer</b>	XXXX XXXX XXXX
<b>Manufacturer Serial No.</b>	-
<b>Model Number</b>	XXXXX
<b>Technology</b>	Mono Crystalline
<b>Maximum Power <math>P_{max}</math> (W)</b>	300
<b>Maximum Power Voltage <math>V_{mp}</math> (V)</b>	32.84
<b>Maximum Power Current <math>I_{mp}</math> (A)</b>	9.107
<b>Open Circuit Voltage <math>V_{oc}</math> (V)</b>	39.48
<b>Short Circuit Current <math>I_{sc}</math> (A)</b>	9.595
<b>No. of Cells / Cells dimensions</b>	60 cells / 156mm x 156mm each



I-V curve:

Below figure shows four measured I-V curves for different irradiance, followed by a table shows the corresponding parameters for each curve.

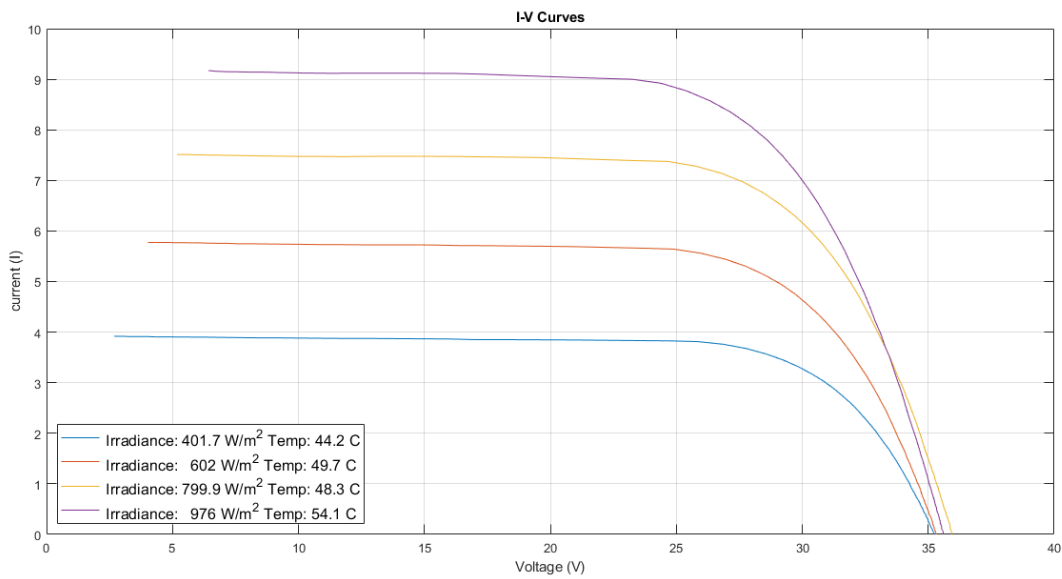


Figure 1: Current - Voltage characteristics at different Solar Irradiance

No.	Irradiance (W/m <sup>2</sup> )	Module Temp. (°C)	P <sub>max</sub> (W)	I <sub>mp</sub> (A)	V <sub>mp</sub> (V)	I <sub>sc</sub> (approx.) (A)	V <sub>oc</sub> (V)	Efficiency (%)	Fill Factor
1	401.7	44.2	102.092	3.677	27.765	3.925	35.236	17.406 %	0.738
2	602.0	49.7	147.193	5.305	27.746	5.783	35.314	16.745 %	0.721
3	799.9	48.3	192.673	6.964	27.667	7.520	35.942	16.496 %	0.713
4	976.0	54.1	226.746	8.343	27.178	9.180	35.589	15.911 %	0.694



Power and efficiency:

In addition to I-V curve test a real time measurement was taken for  $I_{mp}$ ,  $V_{mp}$ , module temp. and in-plane solar irradiance.

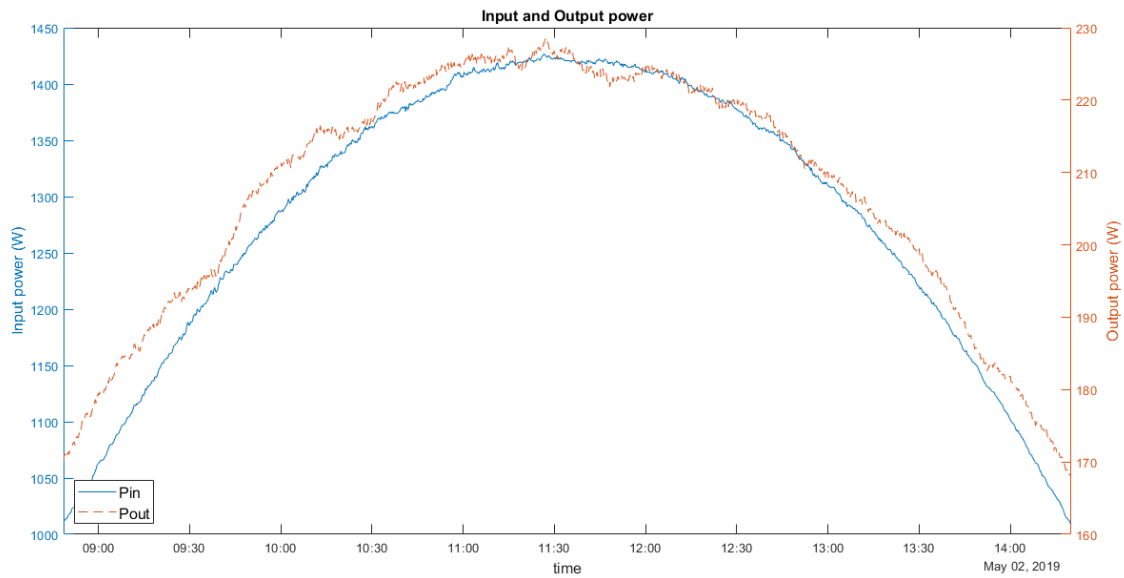


Figure 2: Tested Module's Input and Output Power versus time

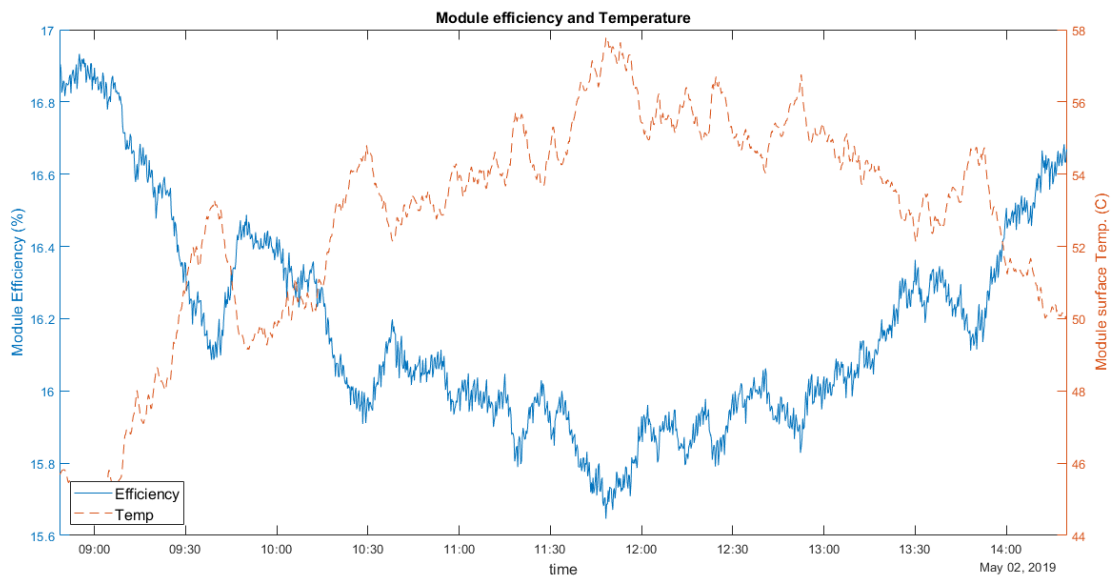


Figure 3: Tested Module's efficiency and surface temp. versus time



Figure 2 shows a comparison between the input power (solar irradiance multiplied by the area of all cells) and the maximum output power of the tested module. While figure 3 shows the module temperature and efficiency of the module based on measured Pin and Pout shown in figure 2.

The following table shows sample points from the previous curves:

No.	Time	Irradiance (W/m <sup>2</sup> )	Module Temp. (°C)	Pin (W)	Pout (W)	Imp(A)	Vmp (V)	Efficiency (%)
1	09:30	812.0	50.7	1185.650	193.850	6.967	27.824	16.350
2	10:00	881.0	49.8	1286.401	211.307	7.632	27.687	16.426
3	10:30	933.0	54.5	1362.329	217.733	7.954	27.374	15.982
4	11:00	963.0	54.0	1406.134	225.082	8.252	27.276	16.007
5	11:30	975.0	54.7	1423.656	226.663	8.450	26.824	15.921
6	12:00	966.0	55.4	1410.515	224.683	8.297	27.08	15.929
7	12:30	943.0	55.0	1376.931	220.197	8.108	27.158	15.992
8	13:00	897.0	55.2	1309.764	210.087	7.758	27.08	16.040
9	13:30	835.0	52.2	1219.234	199.502	7.262	27.472	16.363
10	14:00	754.5	51.3	1101.691	181.848	6.610	27.511	16.506

Energy and efficiency:

Figure 2 shows the input and output power of the module that were measured every 15 seconds for a period of 05 hours, 31 minutes and 45 seconds. From measured data, the input and output energy were found as follow:

Total Input energy = 7.098 Kwh

Total Output energy = 1.146 Kwh

Energy efficiency = 16.146 %



Maximum power temperature Coefficients:

To find the effect of module's temperature on its output power, the irradiance, module's temperature and output power were measured for many days. Then the linear least squares fit was calculated for the output power as a function of module's temperature for different irradiance as shown in below figure.

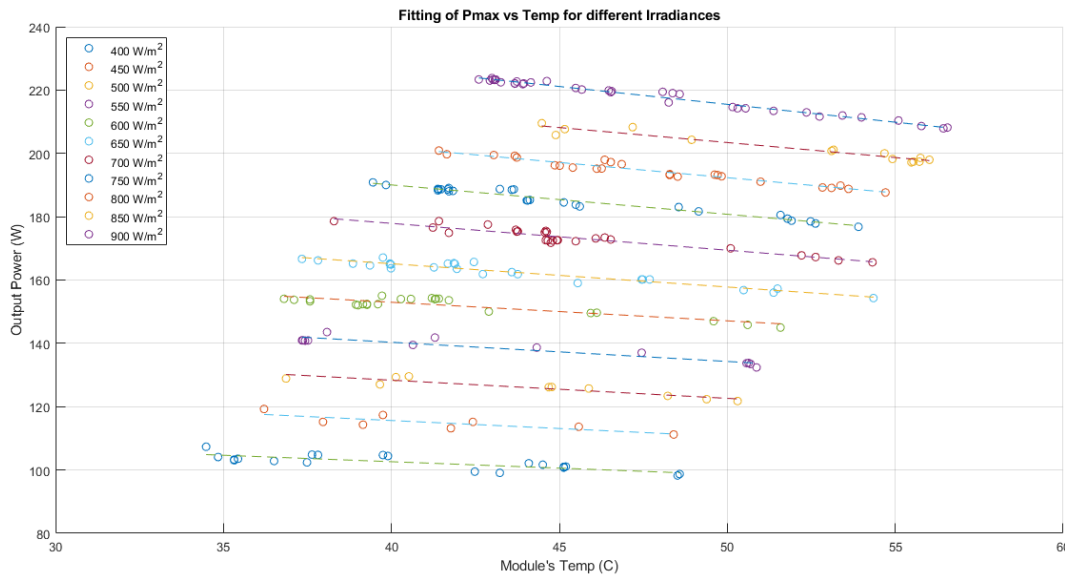


Figure 4: Pmax vs Module's temperature and linear fits for different irradiance

The temperature coefficients were found from the slopes of linear fits as follow:

No.	Irradiance (W/m <sup>2</sup> )	Temperature Coefficient (W/°C)
1	400	-0.4066
2	450	-0.5051
3	500	-0.5733
4	550	-0.6059
5	600	-0.5867
6	650	-0.7353
7	700	-0.8472
8	750	-0.9277
9	800	-0.9625
10	850	-0.9473
11	900	-1.1275



Also, from the data shown in the previous table the linear least squares for the temperature coefficient as a function of irradiance as shown below:

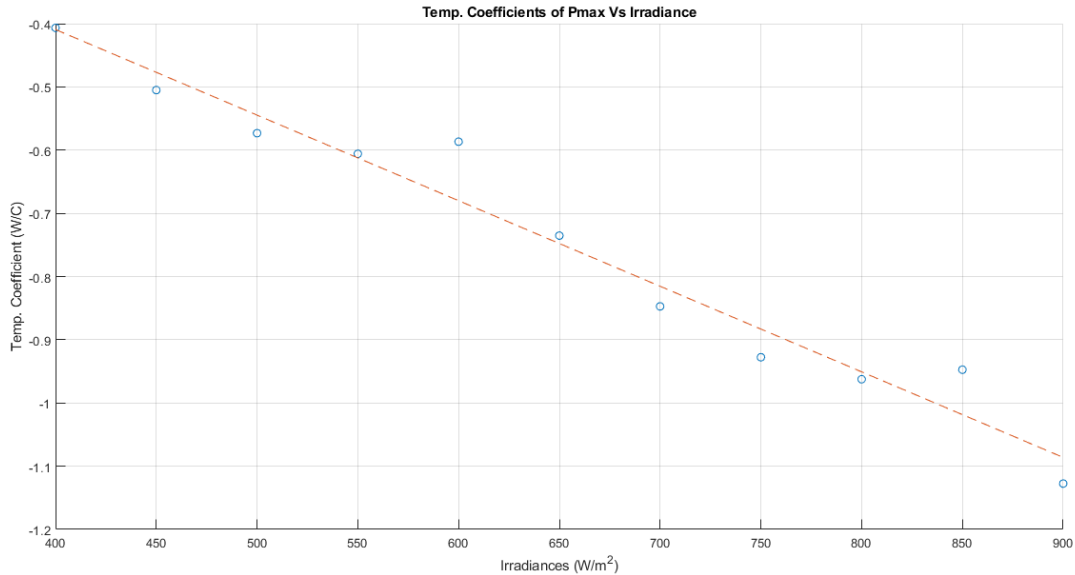


Figure 5: Linear fit for temp. coefficient vs irradiance

References:

- [1] IEC 62446-1: Photovoltaic (PV) systems - Requirements for testing, documentation and maintenance - Part 1: Grid connected systems - Documentation, commissioning tests and inspection.
- [2] IEC 61215-1:2016: Terrestrial photovoltaic (PV) modules - Design qualification and type approval - Part 1: Test requirements.

Created By: XXXX XXXXXX Signature: Date:	Stamp
Approved By: XXXX XXXXXX XXXX Signature: Date:	