EE 351
Section AE

Lab Report 2

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Part 1: AC/AC Converter as Light Dimmer

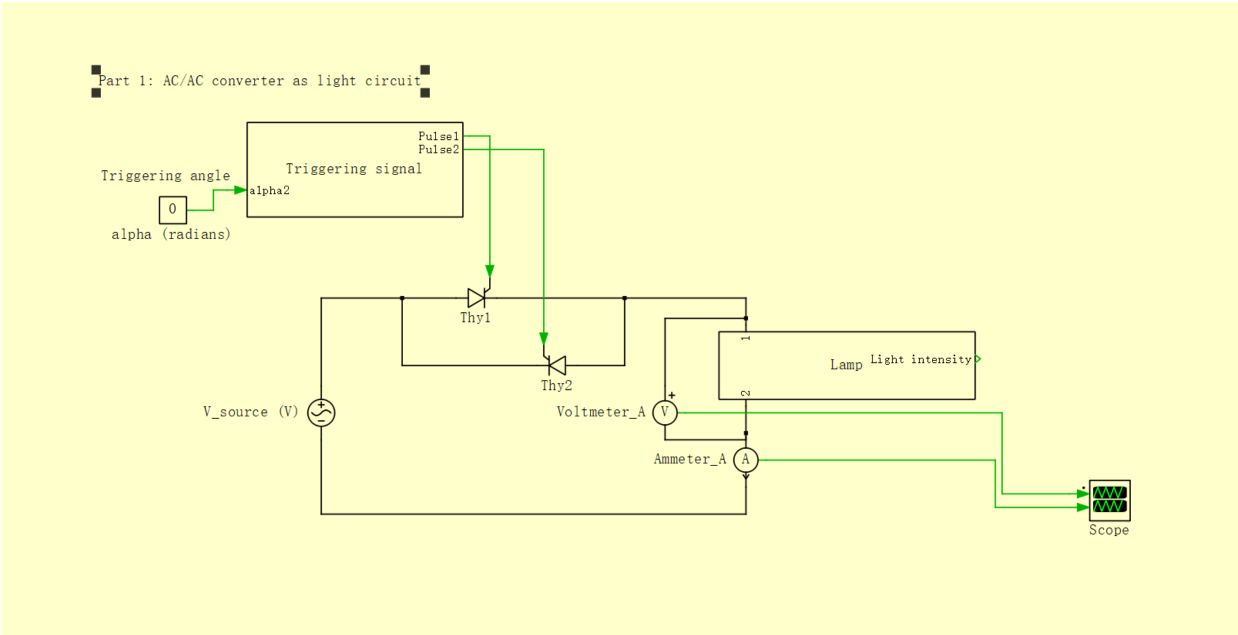

Fig. 1. AC/AC Converter as Light Dimmer Schematics

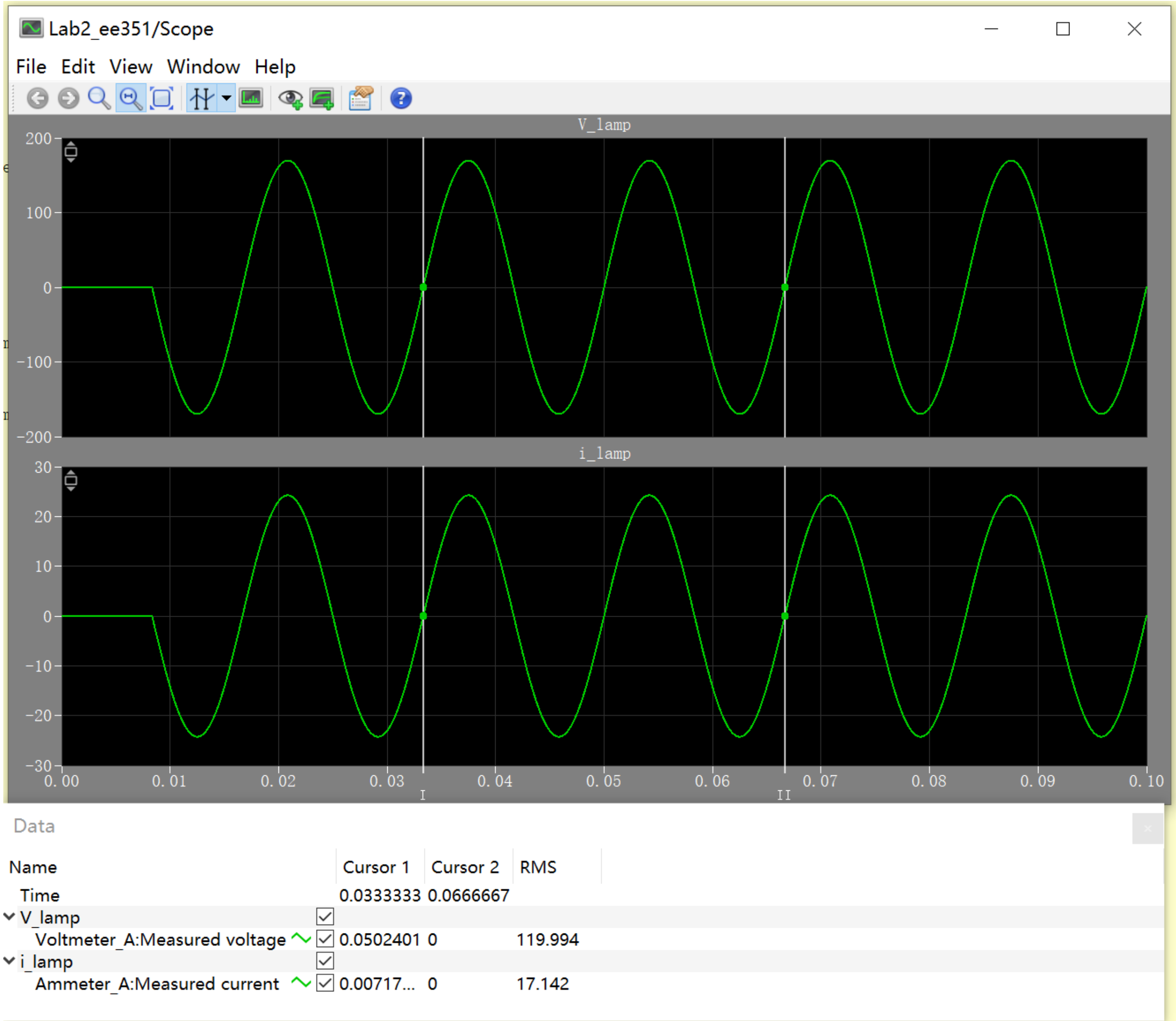

Fig. 2. Current and voltage waveforms for firing angle 0 degree

Fig. 3. Current and voltage waveforms for firing angle 45 degree

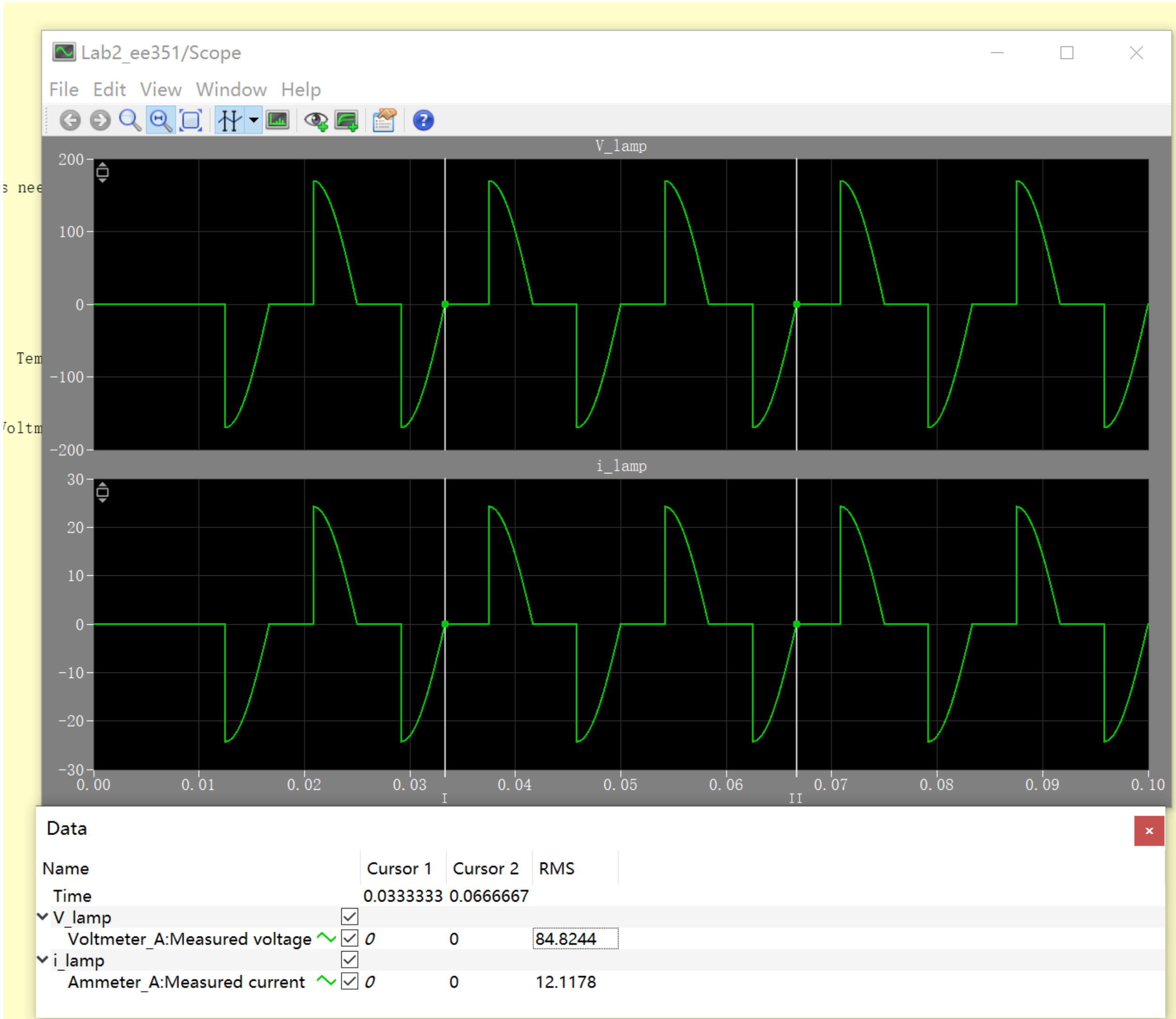

Fig. 4. Current and voltage waveforms for firing angle 90 degree

Comment: The measured RMS voltages are 119.994V, 114.405V, and 84.8244V for 0º, 45º, and 90º as indicated in Fig. 2 ~ Fig. 4.

Based on the equation for Vrms:

$$V_{rms} = \frac{V_{\max}}{\sqrt{2}} \sqrt{\left[1 - \frac{\alpha}{\pi} + \frac{\sin(2\alpha)}{2\pi}\right]}$$

The computed RMS voltages are:

$$V_{rms} = \frac{V_{max}}{\sqrt{2}} \sqrt{1 - \frac{0}{\pi} + \frac{sin(0)}{2\pi}} = 120 \text{ V}$$

$$V_{rms} = \frac{V_{max}}{\sqrt{2}}\sqrt{1 - \frac{0.7854}{\pi} + \frac{sin(90)}{2\pi}} = 114.4 \text{ V}$$

$$V_{rms} = \frac{V_{max}}{\sqrt{2}}\sqrt{1 - \frac{1.5708}{\pi} + \frac{sin(180)}{2\pi}} = 84.85 \text{ V}$$

We can see that the measured RMS voltage is the same as the computed RMS voltage.

Part 2: Solar Panel

Step A: Varying firing angle

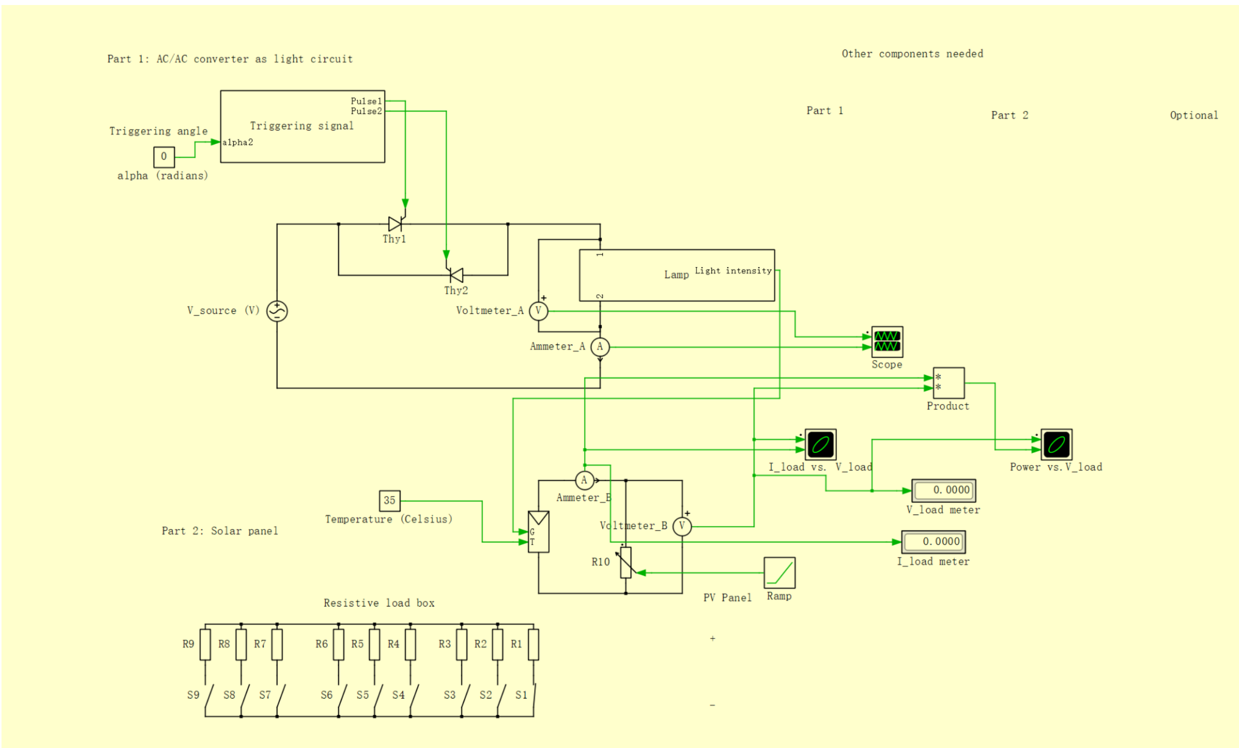

Fig. 5. PartII StepA Schematic

Foe Firing Angle 0°:

Step 3.

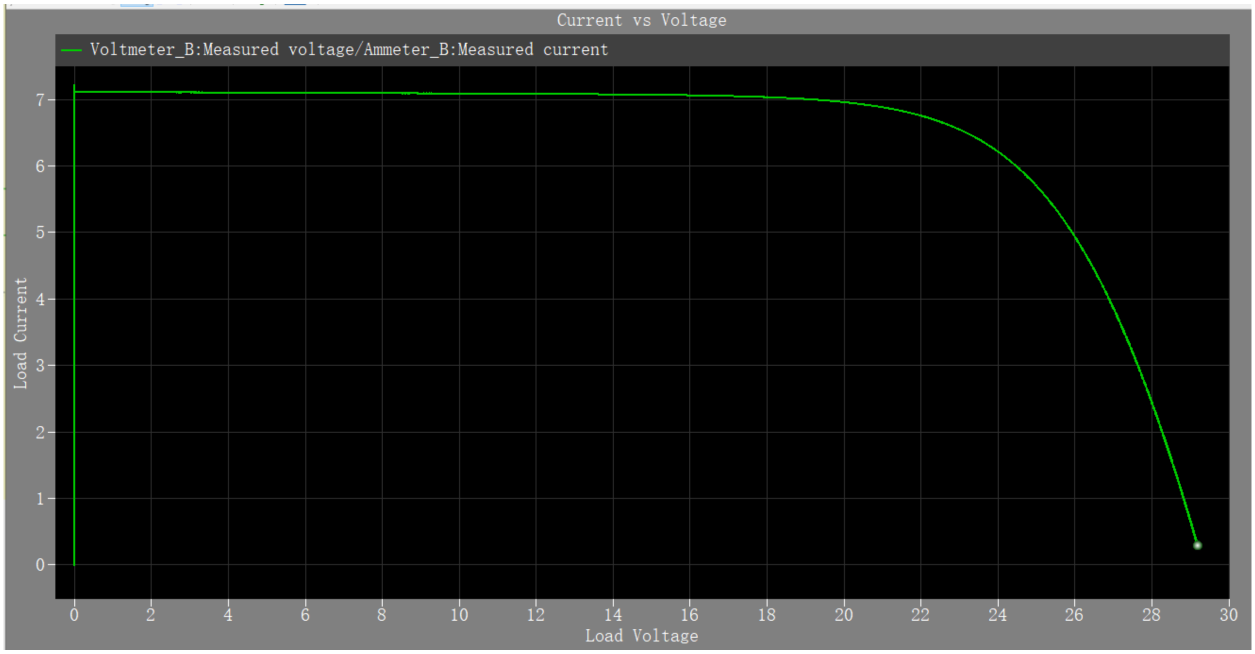

Fig.6. Current vs. Voltage(firing angle 0°)

Comment: We can see as load voltage getting bigger and bigger, load current decays very slowly at first and begin decaying rapidly after load voltage rises to above about 20V

Step 4.

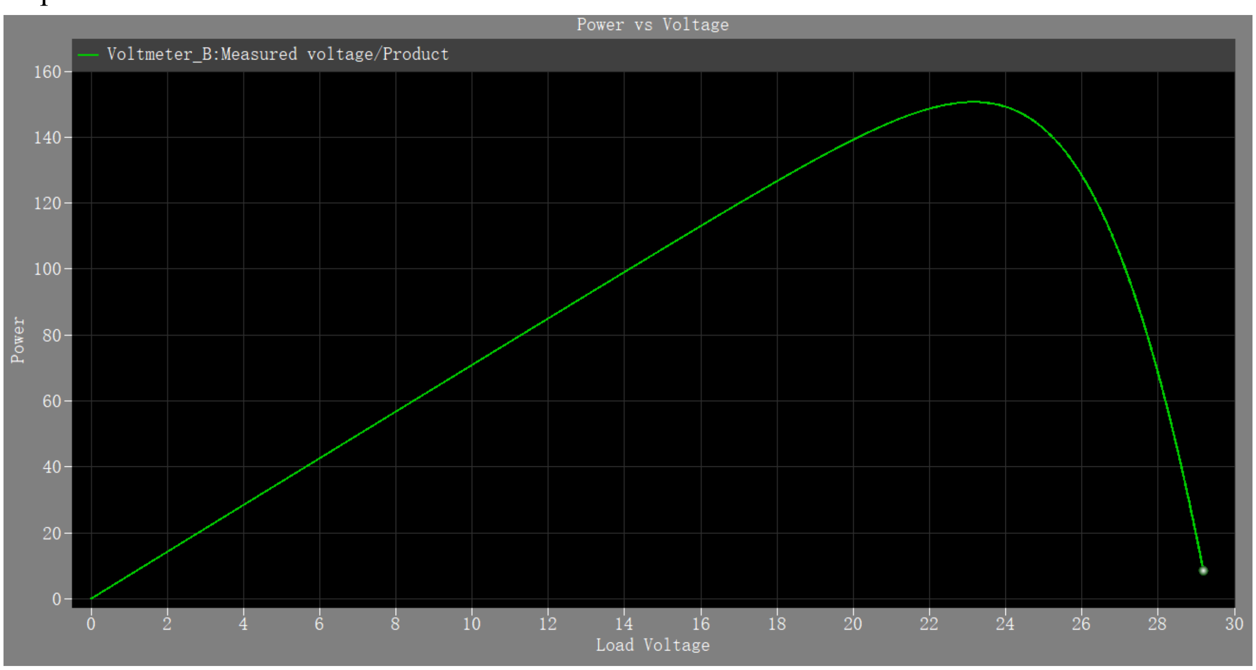

Fig.7. Power vs. Voltage(firing angle 0°)

Comment: Power increases linearly as load voltage increases, but after power reaches its maximum at about 23.2V, it then decays rapidly.

Step 5.

Open circuit voltage: V =29.3494V

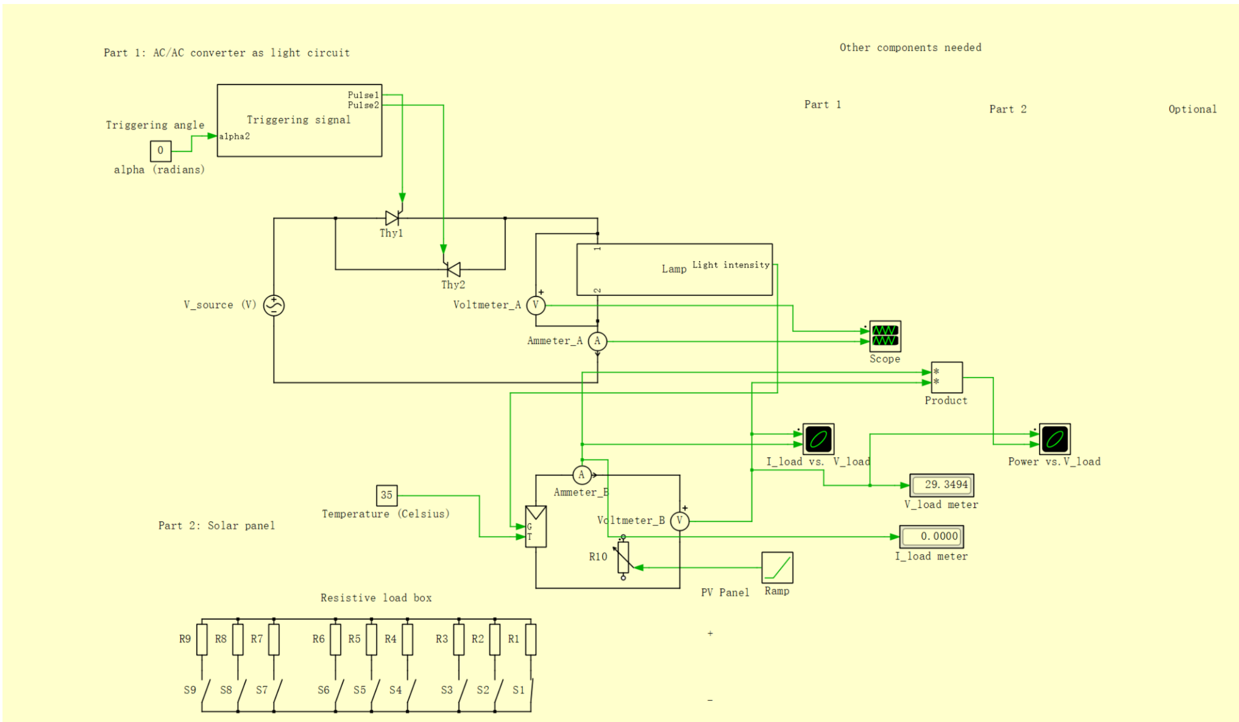

Fig.8. Open circuit voltage(firing angle 0°)

Short circuit current: I = 7.1166A

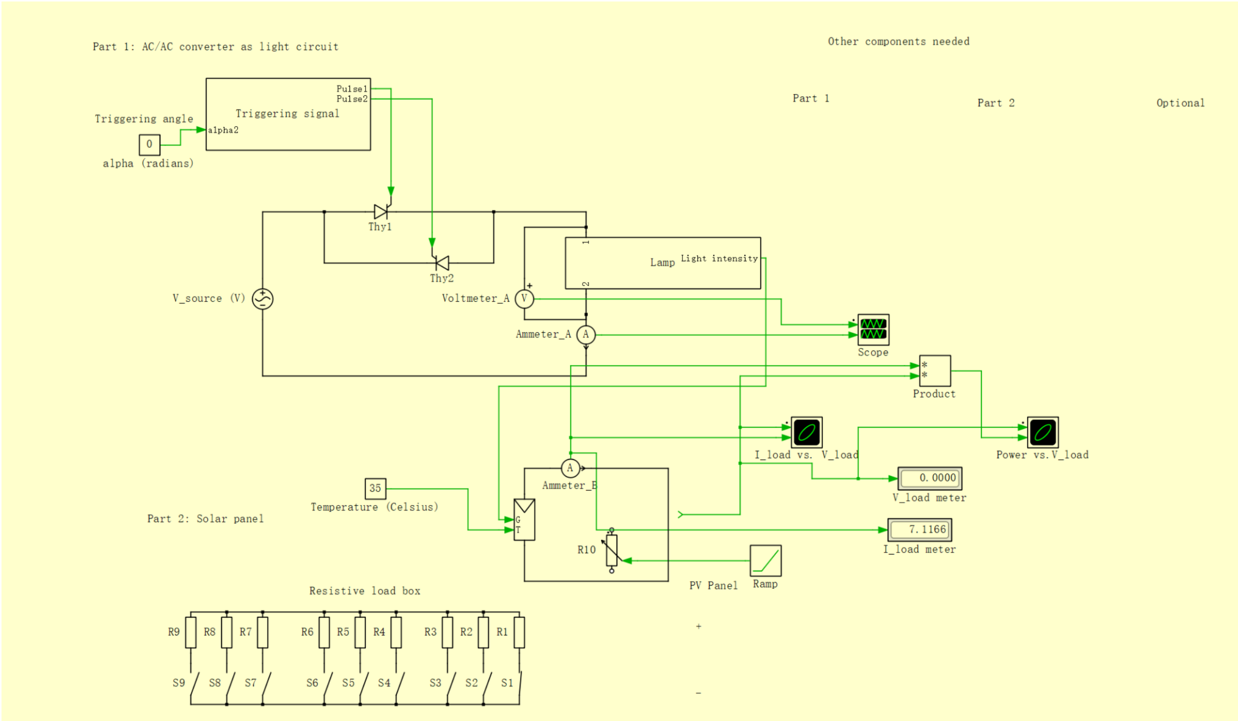

Fig.9. Short circuit current(firing angle 0°)

Maximum power

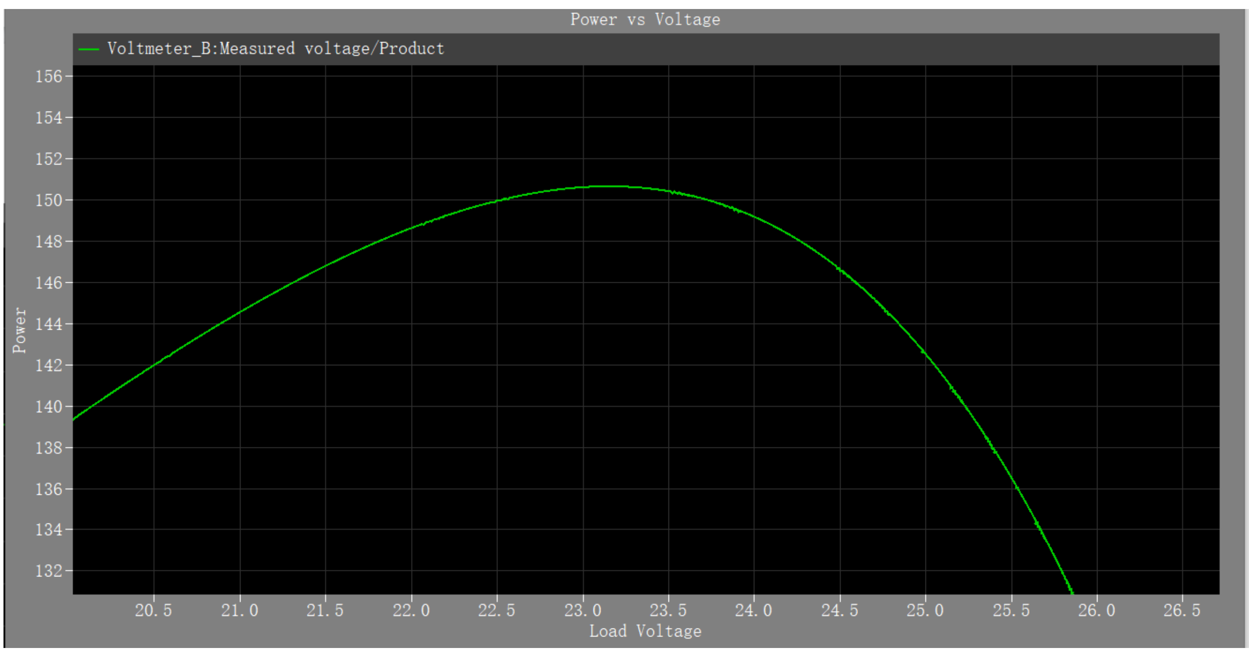

Fig.10. Max Power(firing angle 0°)

Pmax = 150.5W

Voltage at max power: 23.2V (as shown in above)

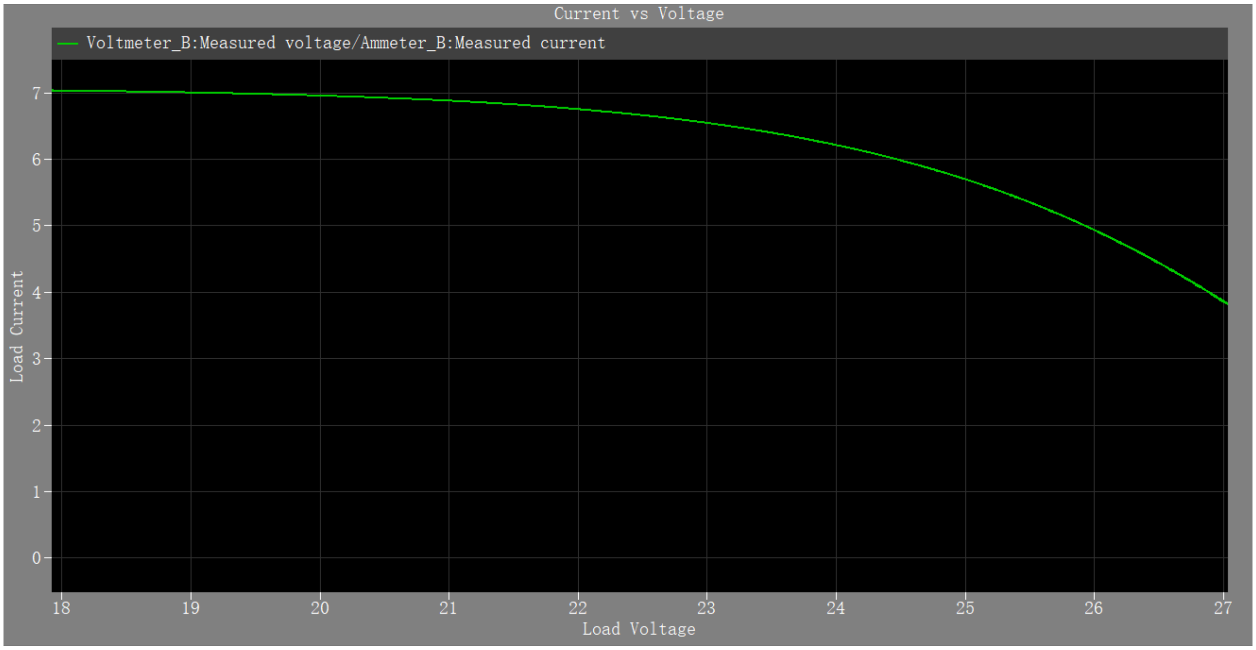

Fig.11. Current vs. Voltage(firing angle 0°)

Current at max power: use the Voltage at max power, we can find the current at max power corresponding to this voltage in the current vs voltage plot, we get I = 6.5A
Resistance of load at maximum power: R = V/I = 23.2/6.5 = 3.57 ohm

For Firing Angle 45°:

Step 3.

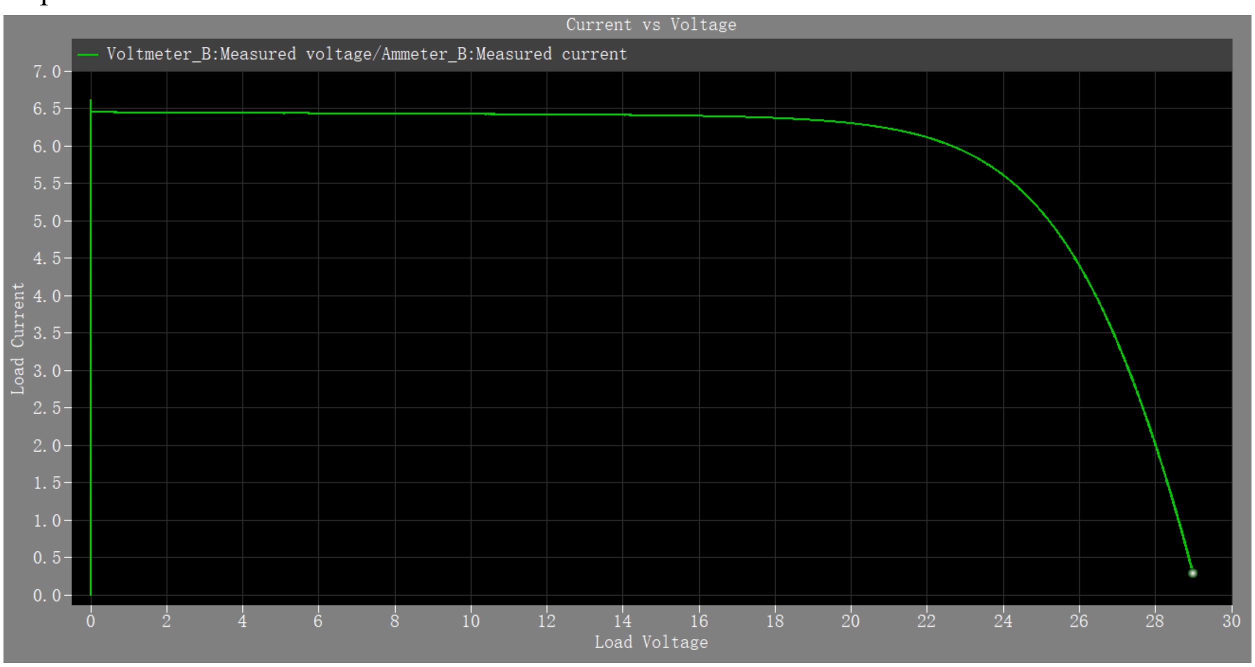

Fig.12. Current vs. Voltage(firing angle 45°)

Comment: We can see as load voltage getting bigger and bigger, load current decays very slowly at first and begin decaying rapidly after load voltage rises to above about 18V

Step 4.

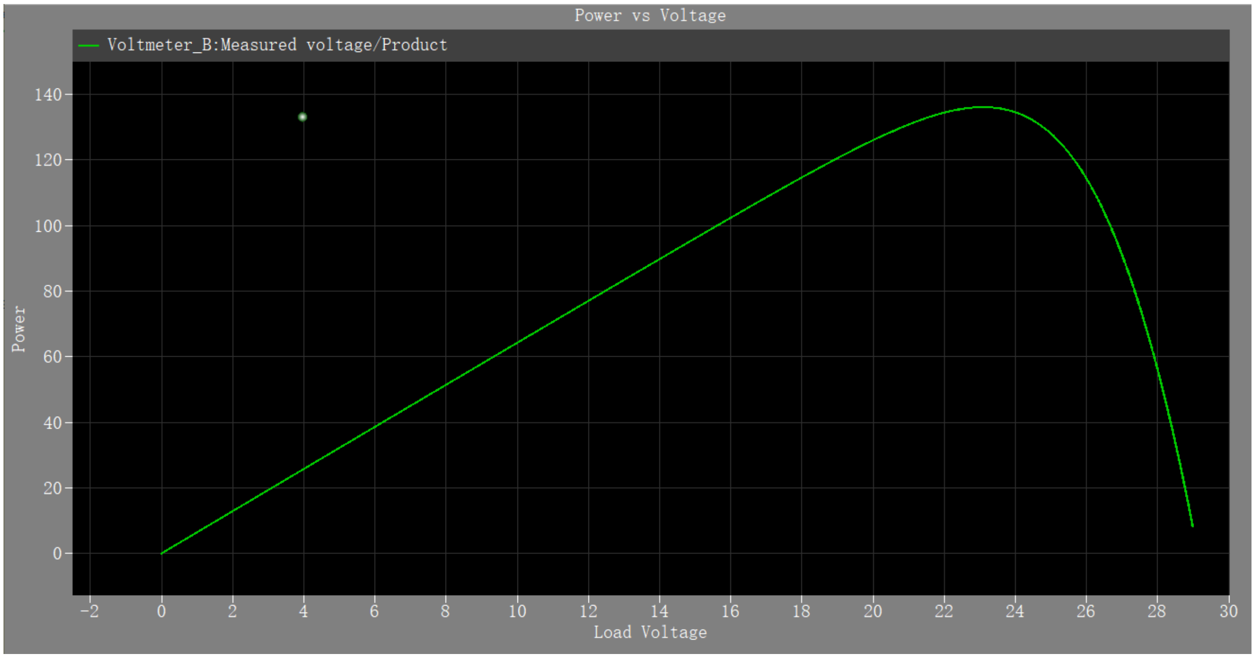

Fig.13.Power vs. Voltage(firing angle 45°)

Comment: Power increases linearly as load voltage increases, but after power reaches its maximum at about 23.2V, it then decays rapidly.

Step 5.

Open circuit voltage: V = 29.1704V

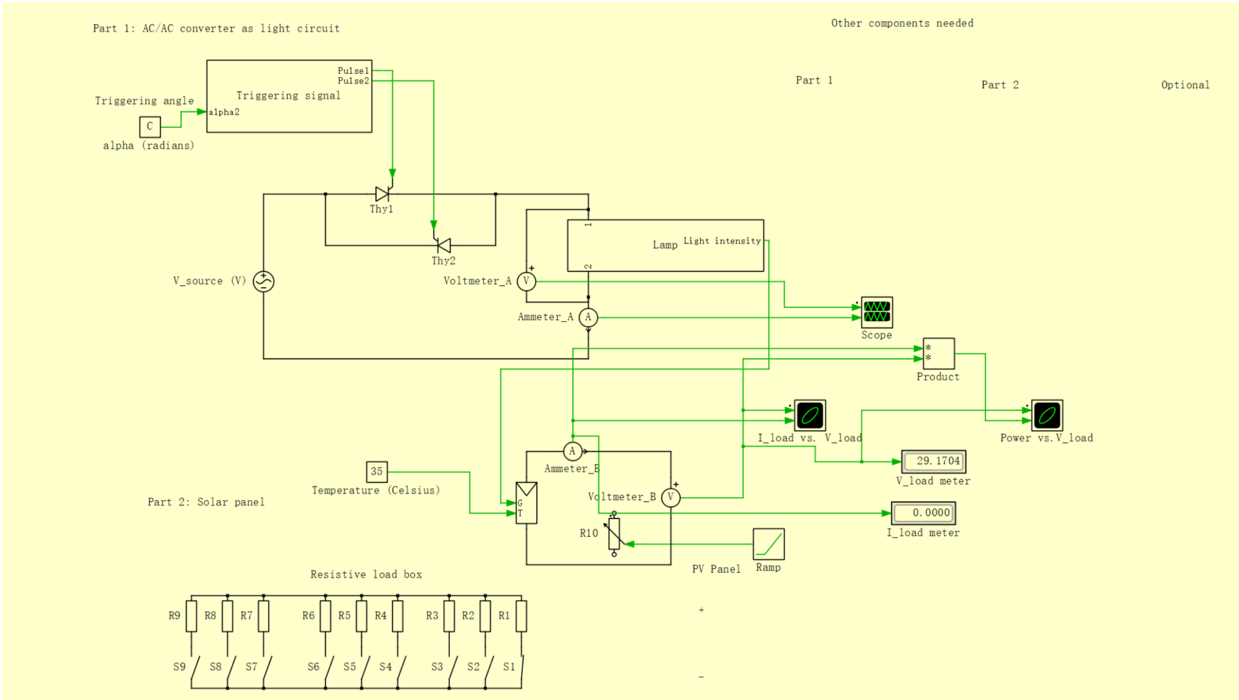

Fig.14. Open circuit voltage(firing angle 45°)

Short circuit current: I = 6.4093A

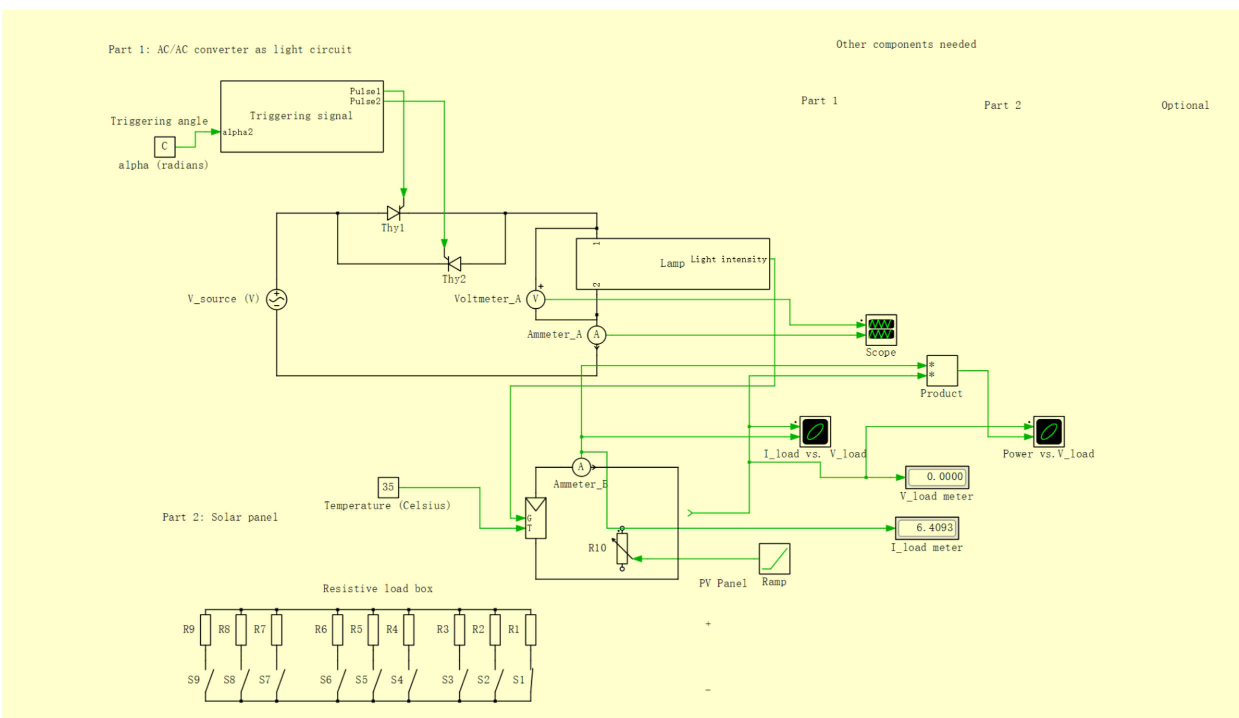

Fig.15. Short circuit current(firing angle 45°)

Maximum power:

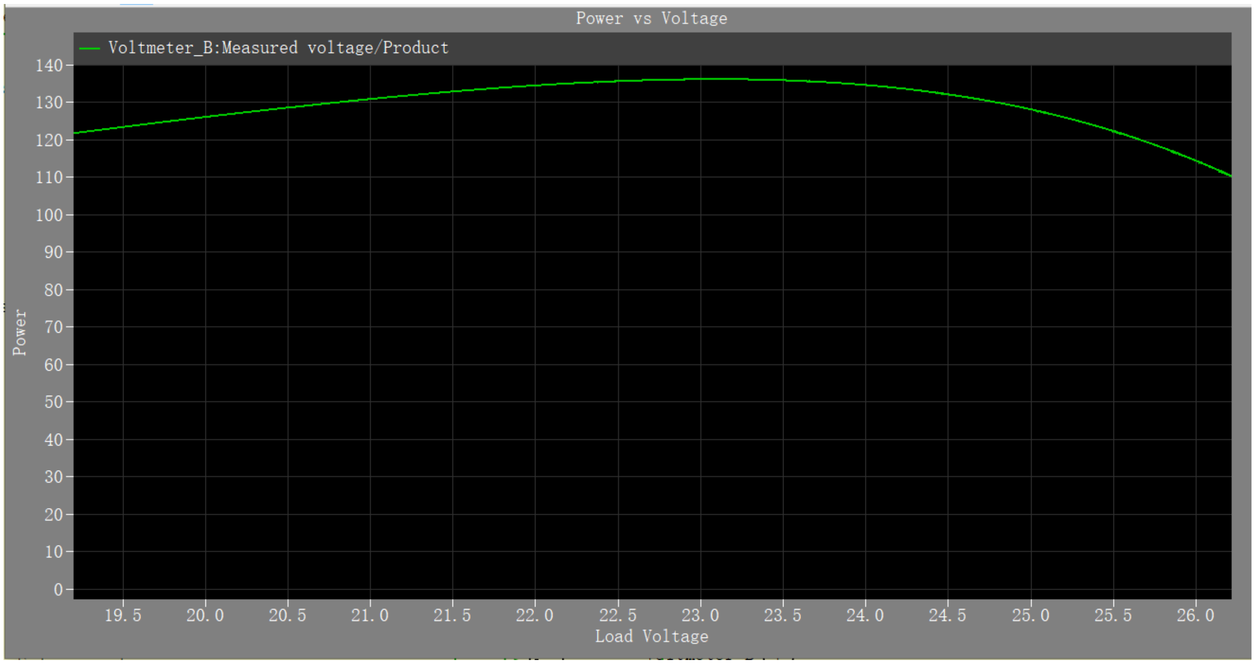

Fig.16. Max Power(firing angle 45°)

Pmax = 136W

Voltage at max power: V = 23.2V

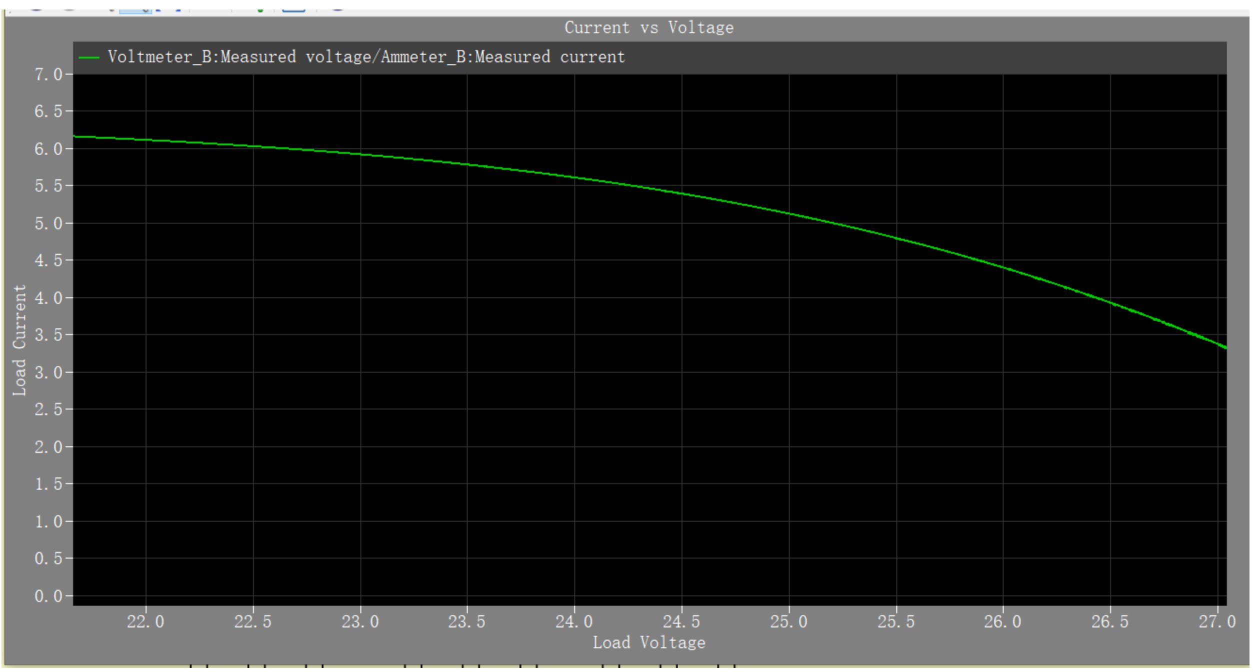

Fig.17. Current vs. Voltage(firing angle 45°)

Current at max power: I = 5.9A
Resistance of load at maximum power: R = V / I = 23.2 / 5.9 = 3.93 ohm

For Firing Angle 90°:

Step 3.

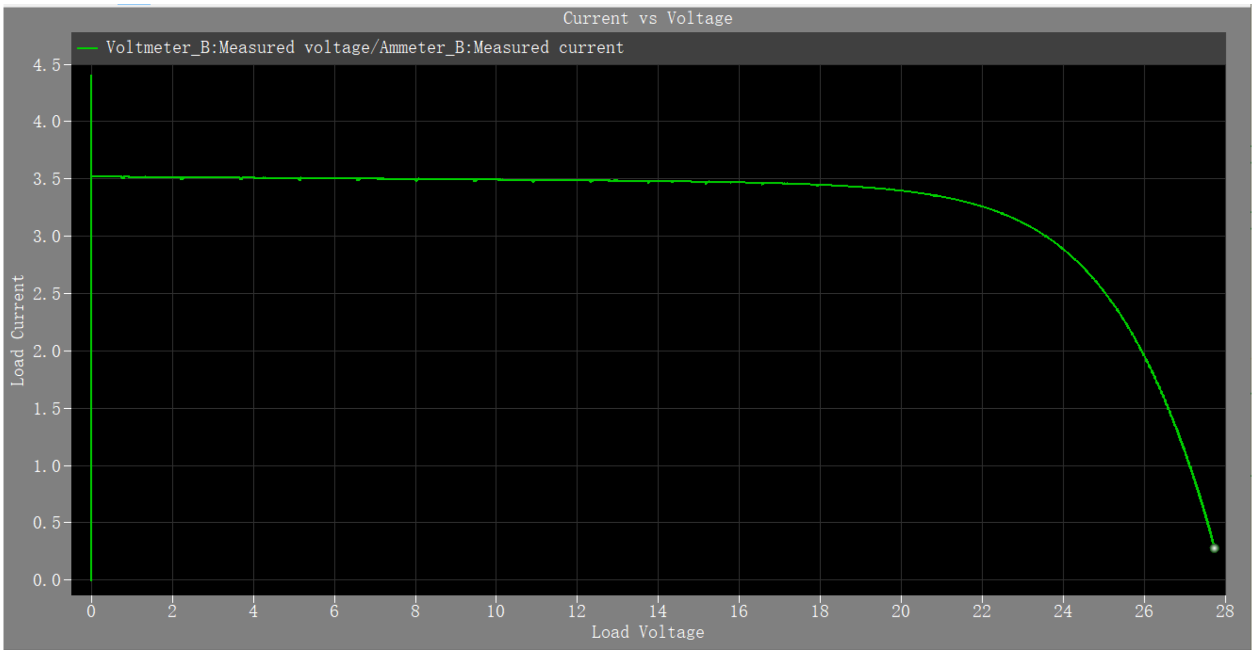

Fig.18. Current vs. Voltage(firing angle 90°)

Comment: We can see as load voltage getting bigger and bigger, load current decays very slowly at first and begin decaying rapidly after load voltage rises to above about 18V

Step 4.

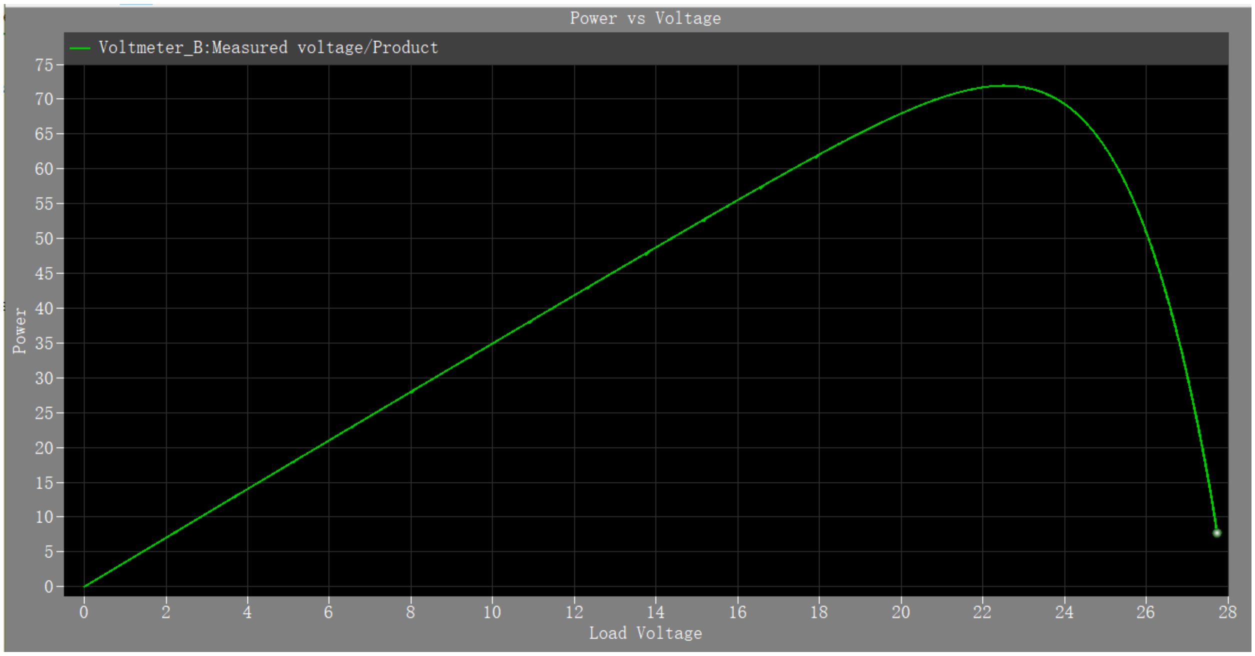

Fig.19. Power vs. Voltage(firing angle 90°)

Comment: Power increases linearly as load voltage increases, but after power reaches its maximum at about 22.5V, it then decays rapidly.

Step 5.

Open circuit voltage:

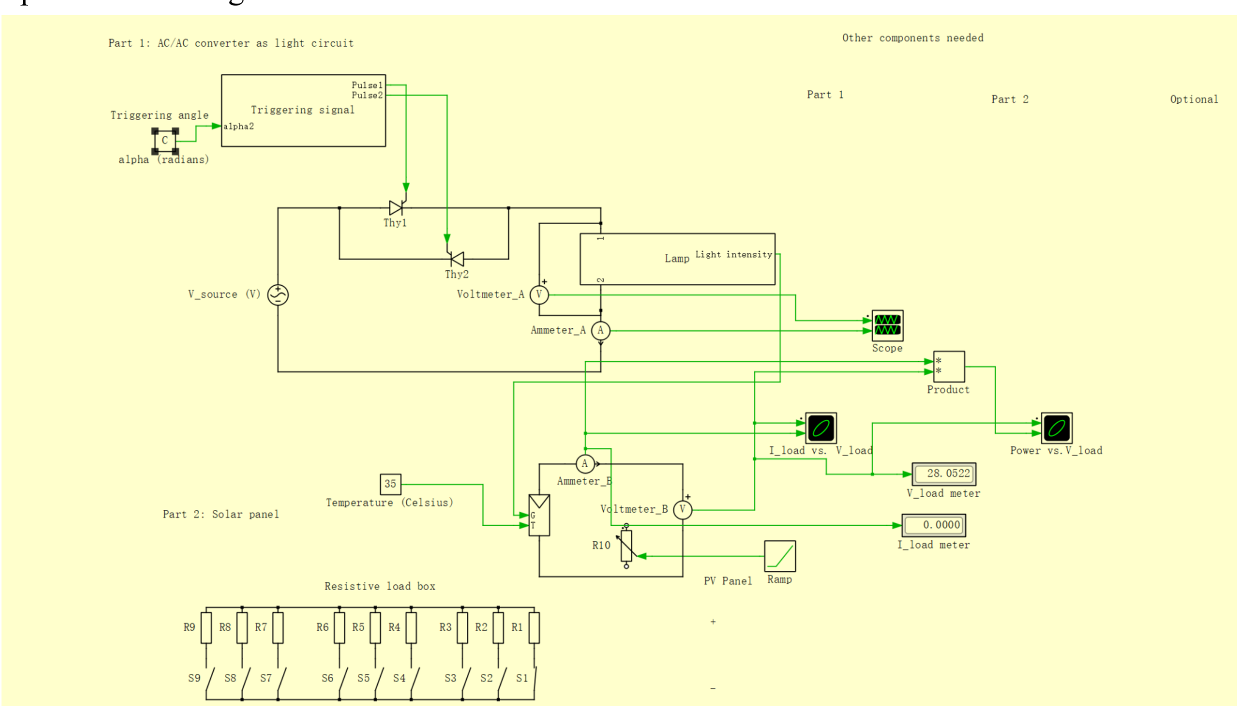

Fig.20. Open circuit voltage(firing angle 90°)

V = 28.0522V

Short circuit current:

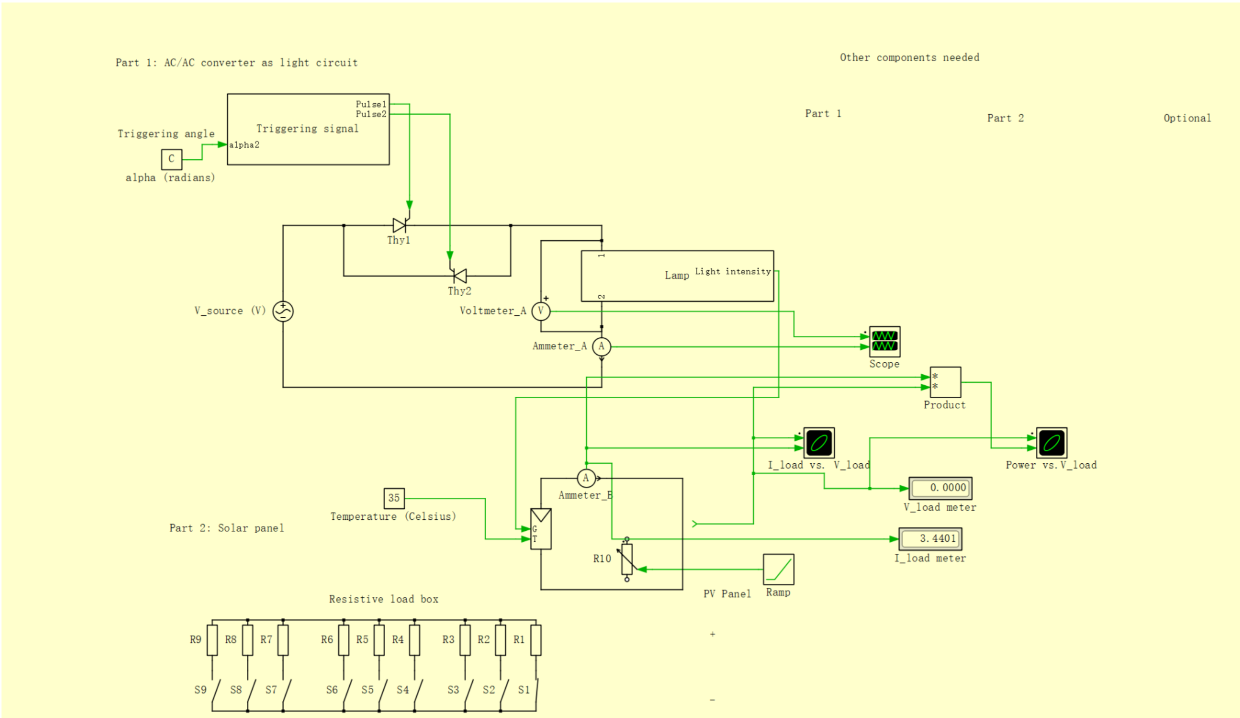

Fig.21. Short circuit current(firing angle 90°)

I = 3.4401A

Maximum power:

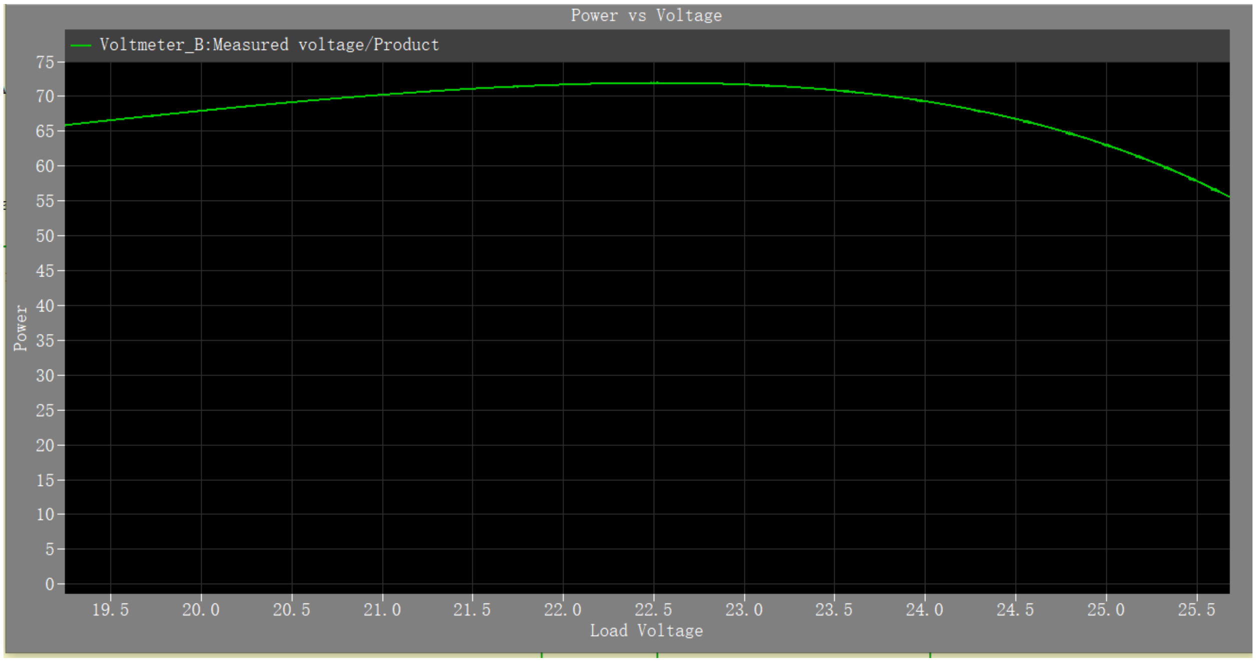

Fig.22. Max Power(firing angle 90°)

Pmax = 72W
Voltage at Maximum power: V = 22.5V

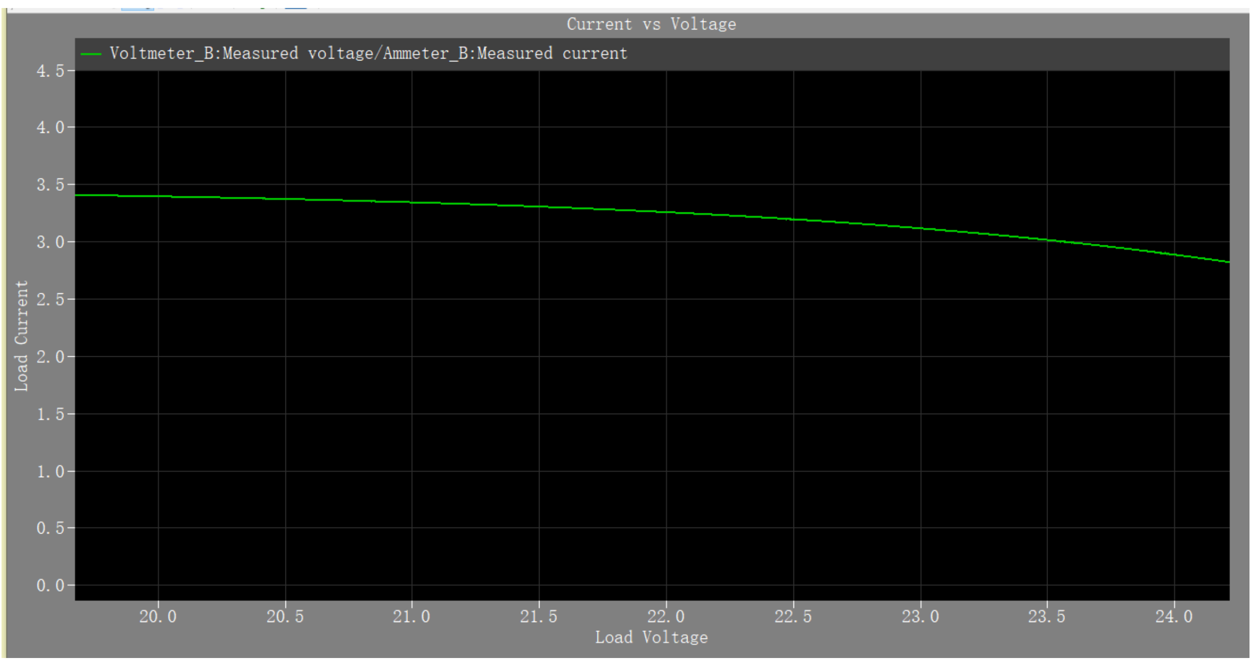

Fig.23. Current vs. Voltage(firing angle 90°)

Current at maximum power: I = 3.2A
Resistance of the load at maximum power: R = V / I = 22.5 / 3.2 =7.03ohm

Step B: Varying temperature

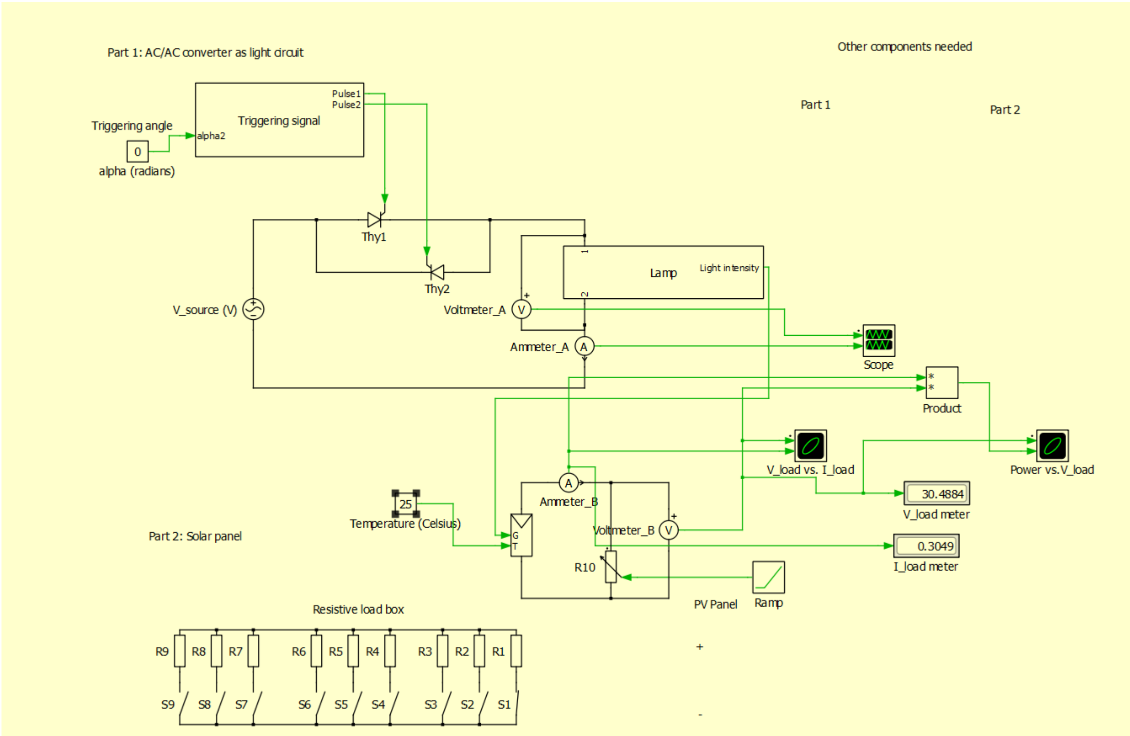

Fig.24. PartII StepB Schematic

Temperature 25°:

Step 3.

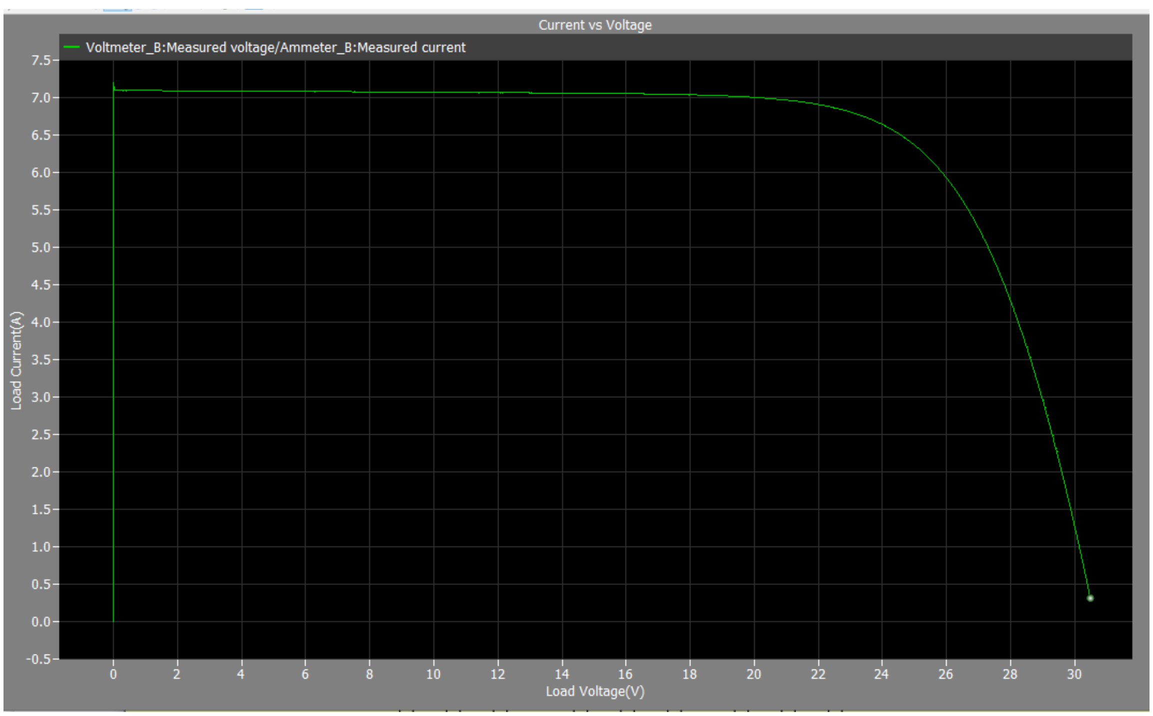

Fig.25. Current vs. Voltage(temperature 25°)

Comment: The load current decreases as the load voltage increases.
According to the graph above, I_sc = 7.1A; V_oc = 30.5V.

Step 4.

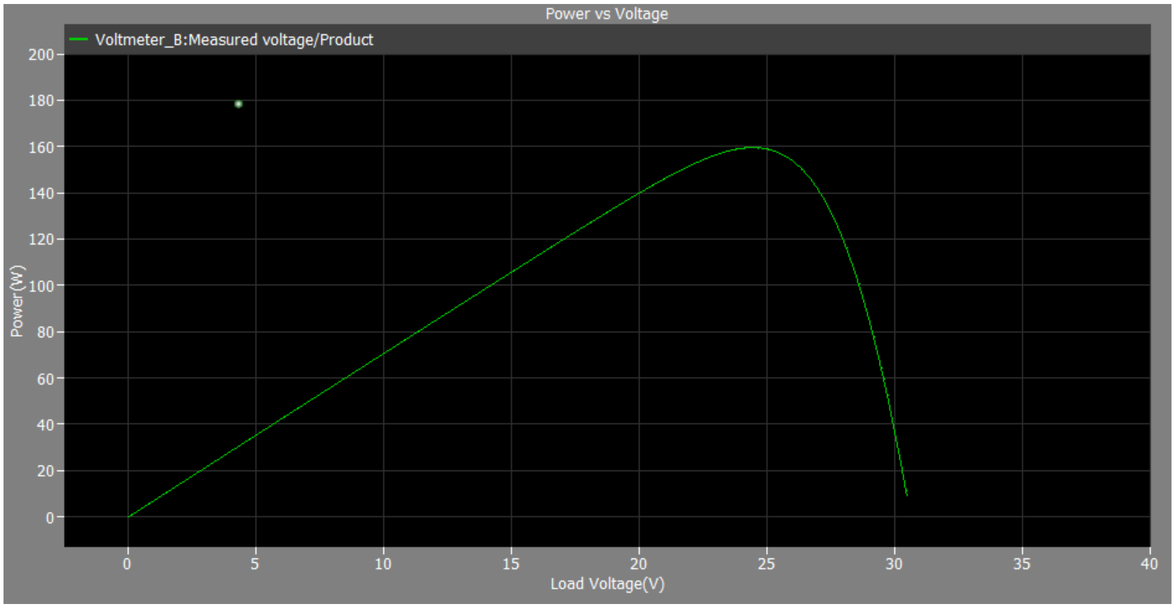

Fig.26. Power vs. Voltage(temperature 25°)

Comment: As the load voltage increases, the load power first increases until reaching maximum, then it decreases rapidly.

Step 5.

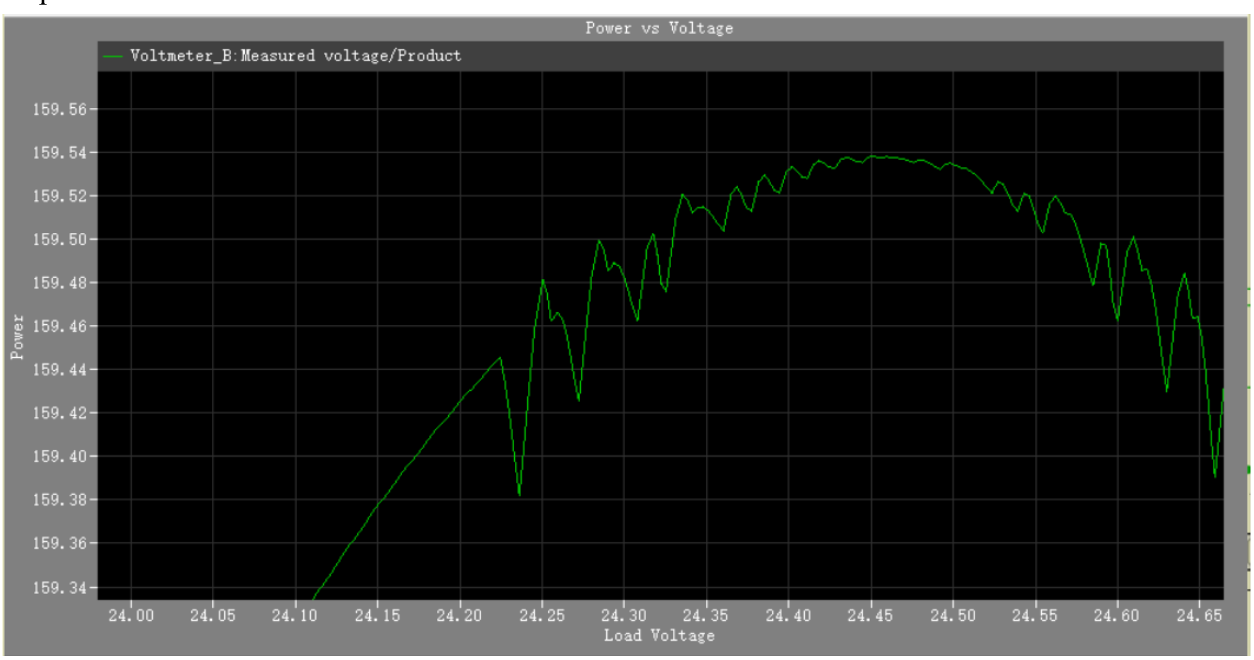

Fig. 27. Zoomed Power vs Voltage plot (Temperature 25°)

From the plot we observe that:
Measured maximum power: 159.54 W
Measured voltage(under max power): 24.45 V

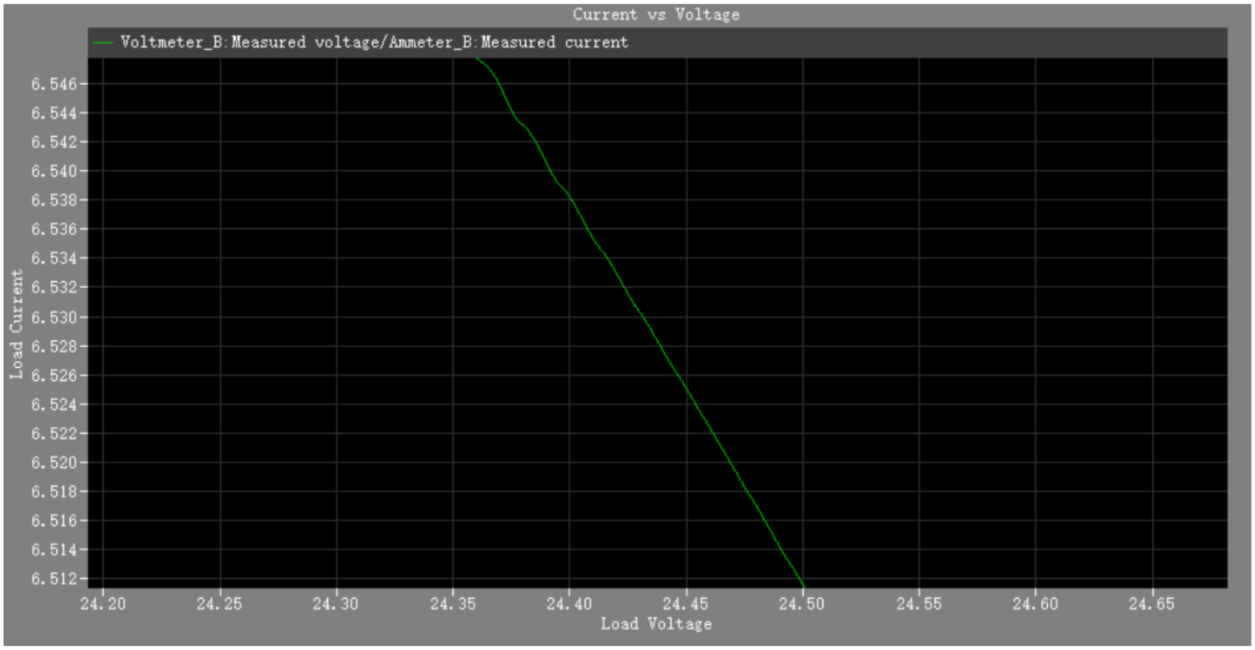

Fig. 28. Zoomed Current vs. Voltage plot (temperature 25°)

Using the previously found voltage, we find the corresponding:
Measured current (under max power) = 6.5 A

Temperature 35°:

Step 3.

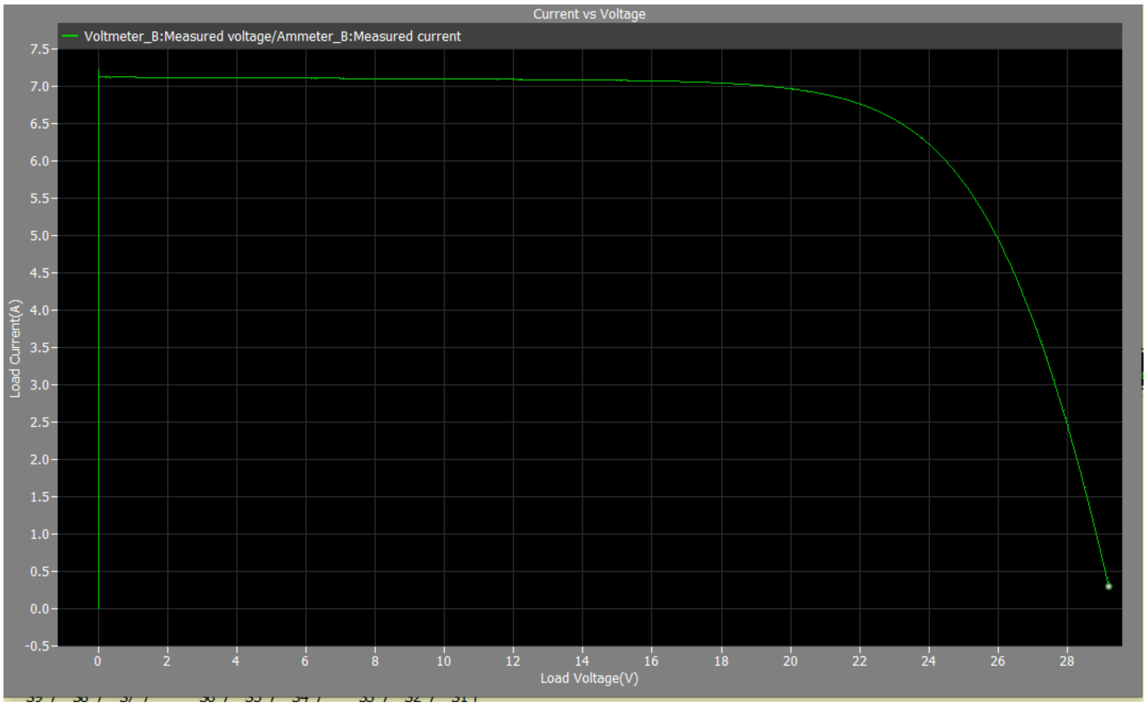

Fig.29. Current vs. Voltage(temperature 35°)

Comment: The load current decreases as the load voltage increases.

According to the graph above, I_sc = 7.1A; V_oc = 29V.

Step 4.

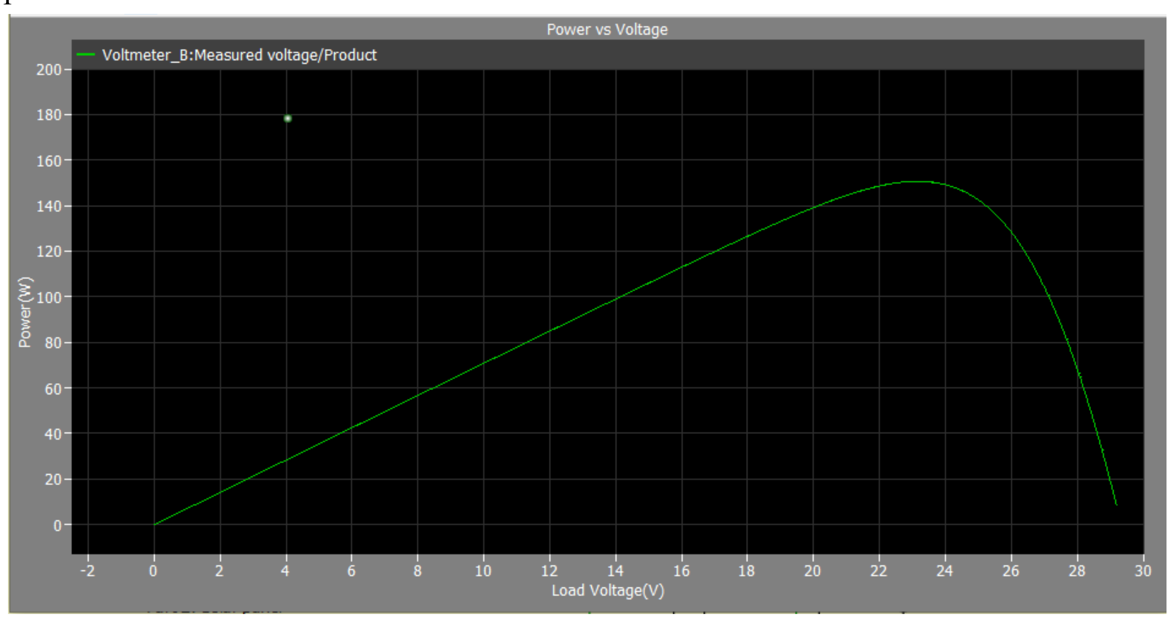

Fig.30. power vs. Voltage(temperature 35°)

Comment: As the load voltage increases, the load power first increases until reaching maximum, then it decreases rapidly.

Step 5.

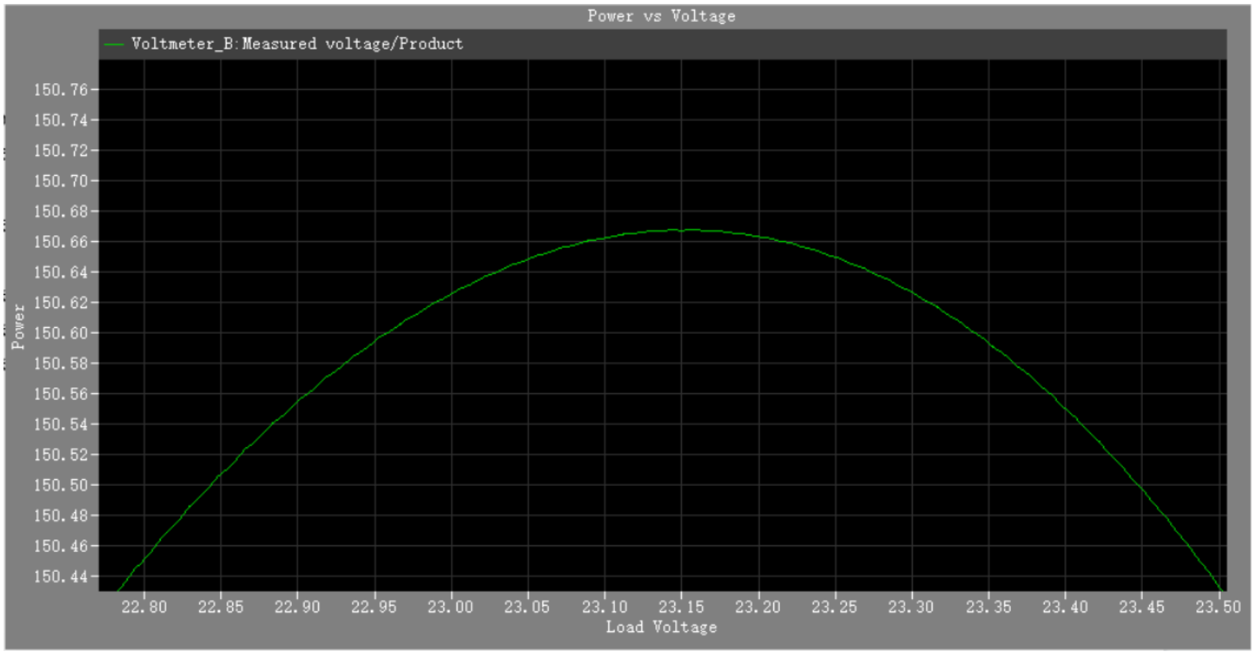

Fig. 31. Zoomed Power vs Voltage plot (Temperature 35°)

Measured maximum power: 150.67 W

Measured voltage(under max power): 23.15 V

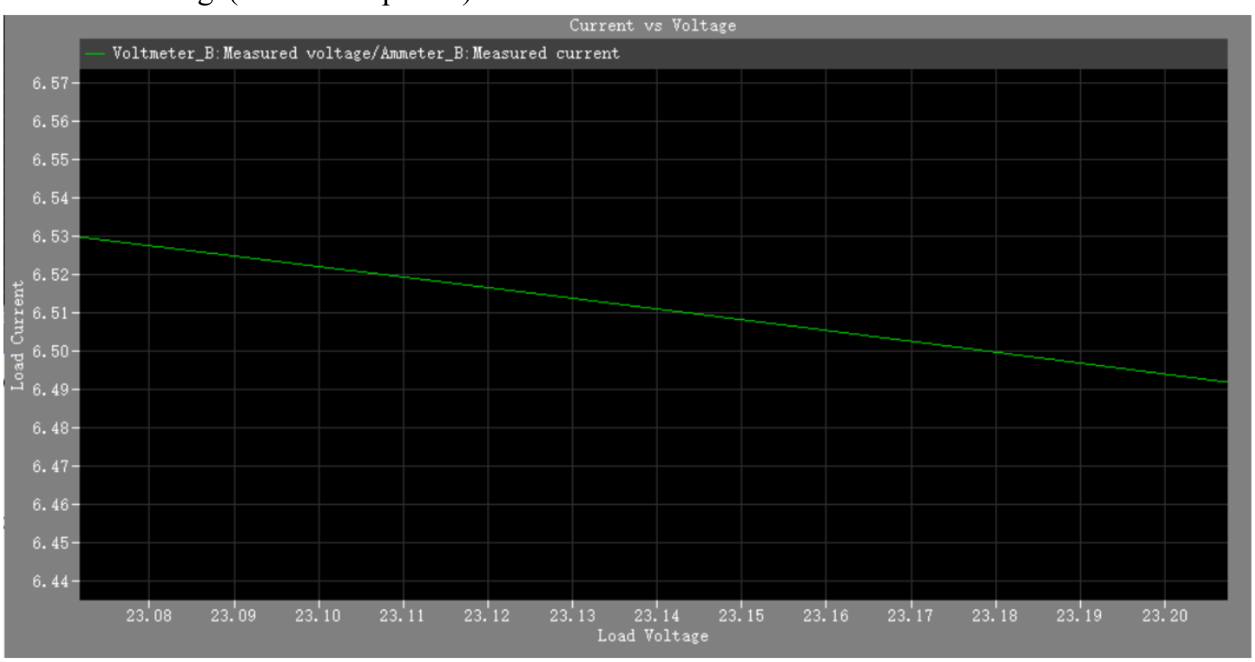

Fig. 32. Zoomed Current vs Voltage plot (Temperature 35°)

Measured current(under max power): 6.51 A

Temperature 65°:

Step 3.

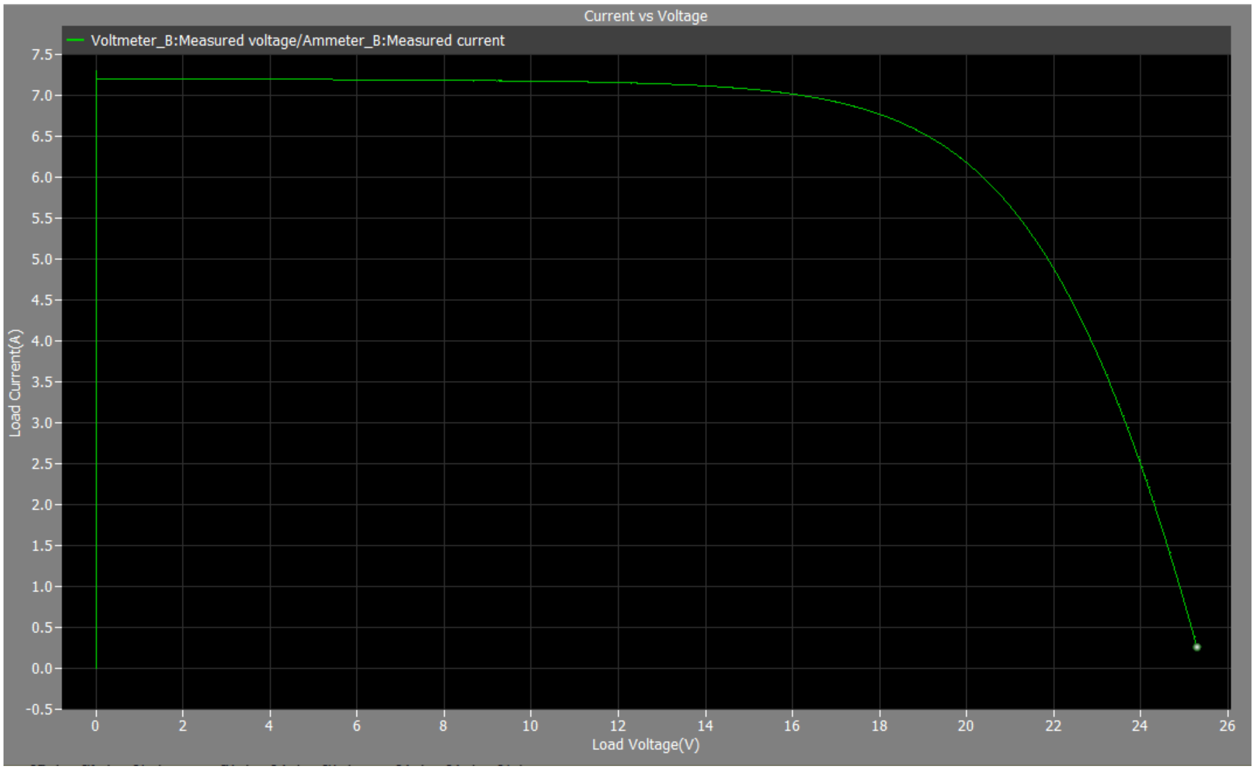

Fig.33. Current vs. Voltage(temperature 65°)

Comment: The load current decreases as the load voltage increases.

According to the graph above, I_sc = 7.3A; V_oc = 25.3V.

Step 4.

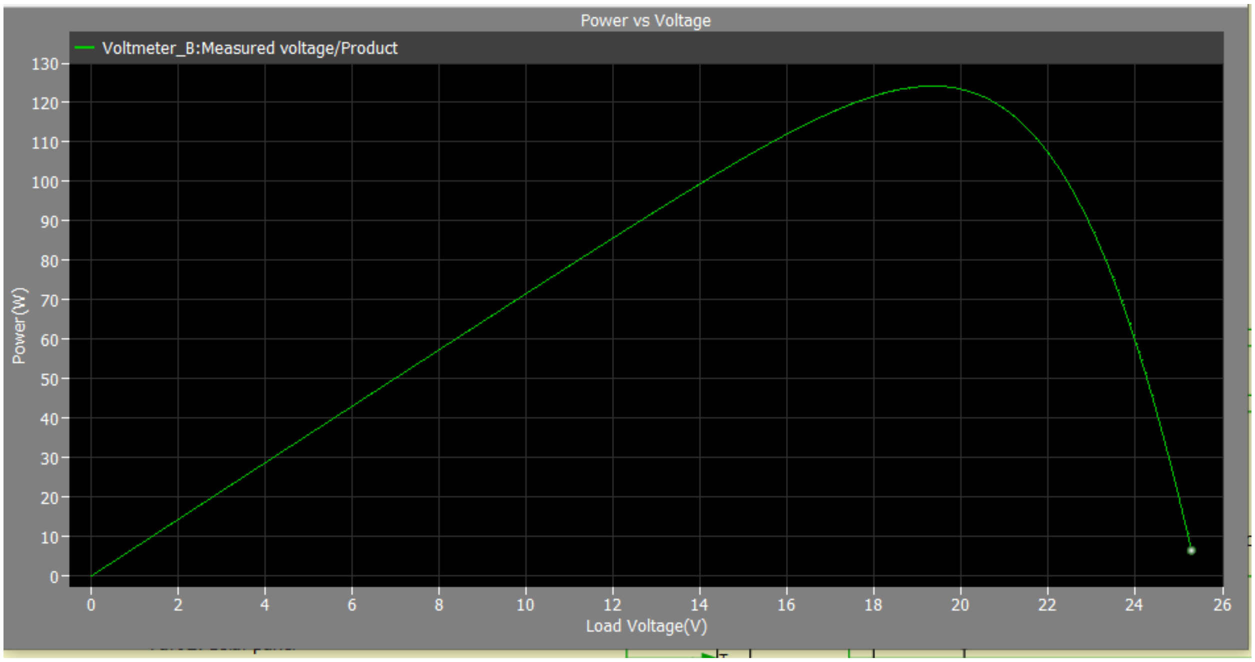

Fig.34. Power vs. Voltage(temperature 65°)

Comment: As the load voltage increases, the load power first increases until reaching maximum, then it decreases rapidly.

Step 5.

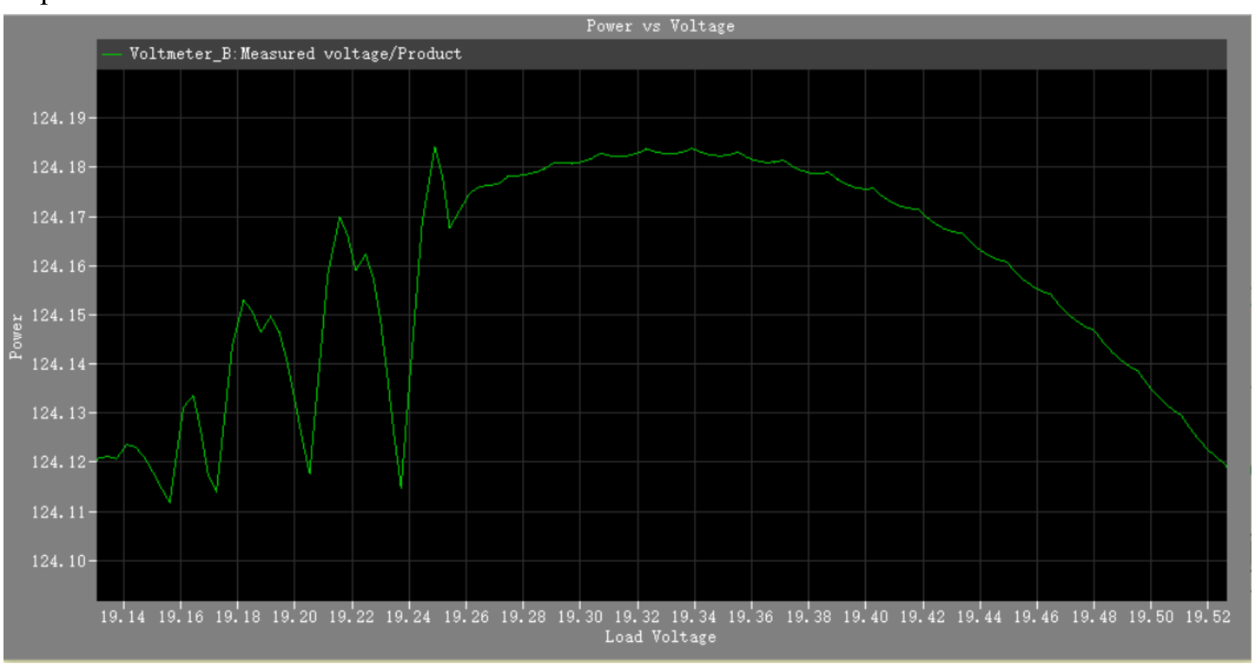

Fig. 35. Zoomed Power vs Voltage plot (Temperature 35°)

Measured maximum power: 124.18 W

Measured voltage(under max power): 19.34 V

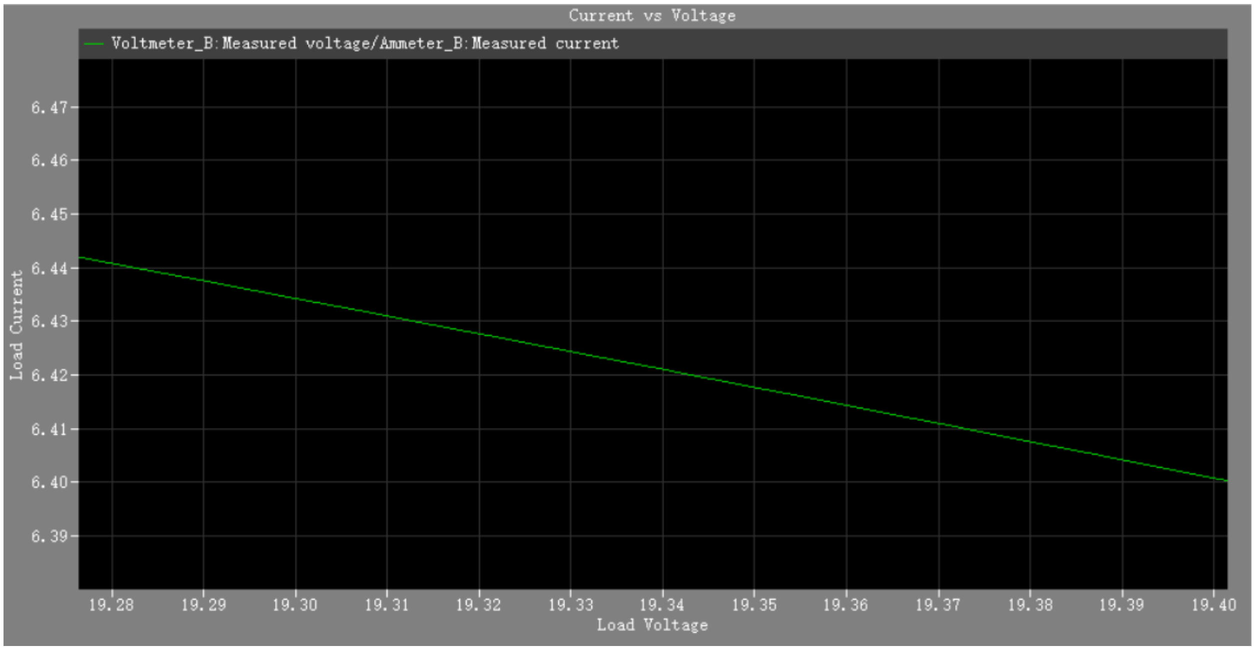

Fig. 36. Zoomed Current vs Voltage plot (Temperature 35°)

Measured current(under max power): 6.42 A

Discussion:

Problem 1:

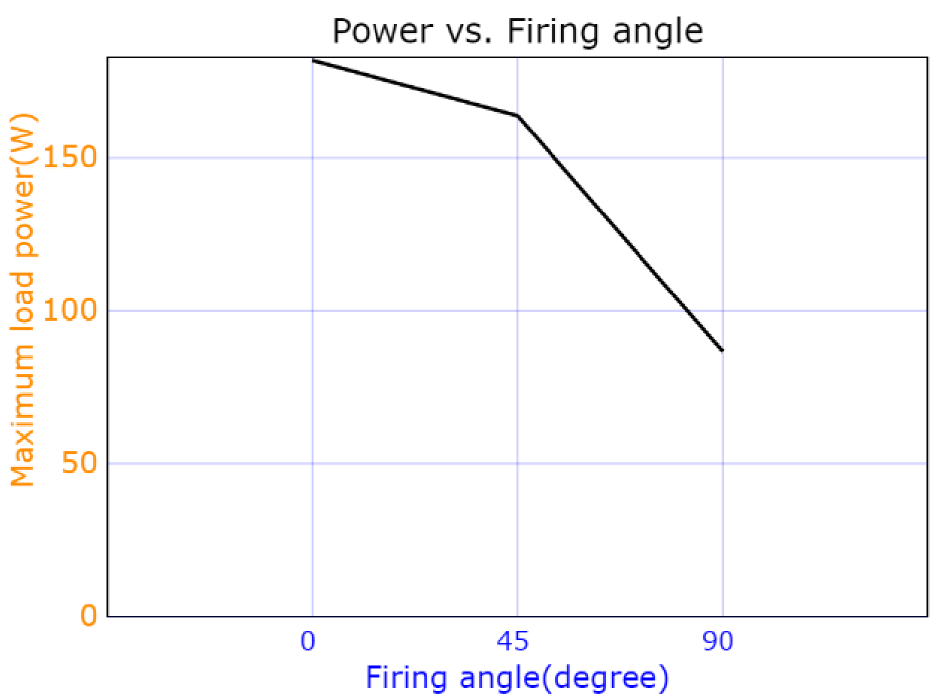

Fig.37. Maximum load power vs. Firing angle

Problem 2:

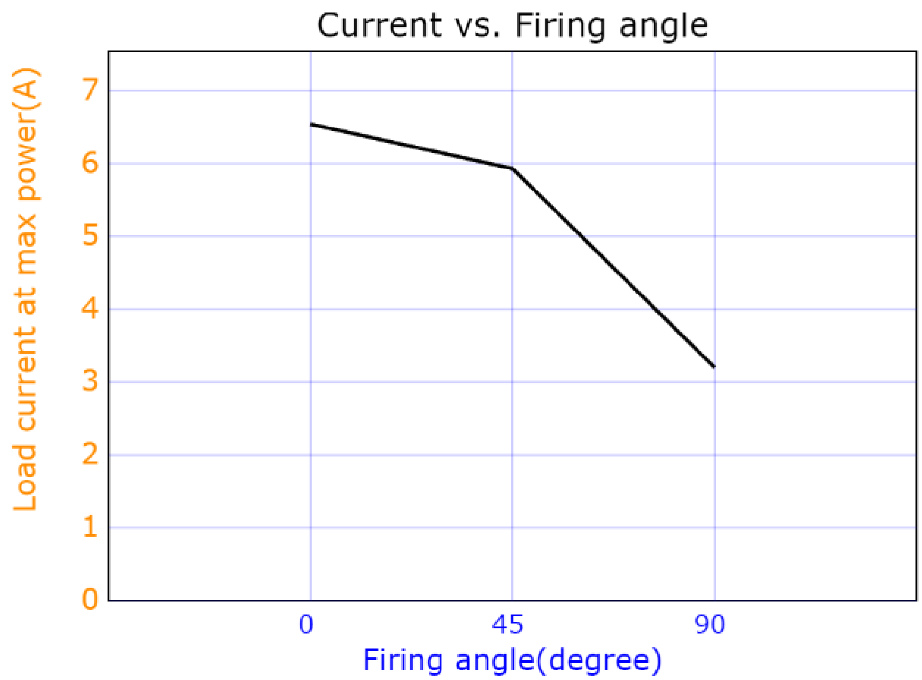

Fig.38. Load current at max power point vs. Firing angle

Problem 3:

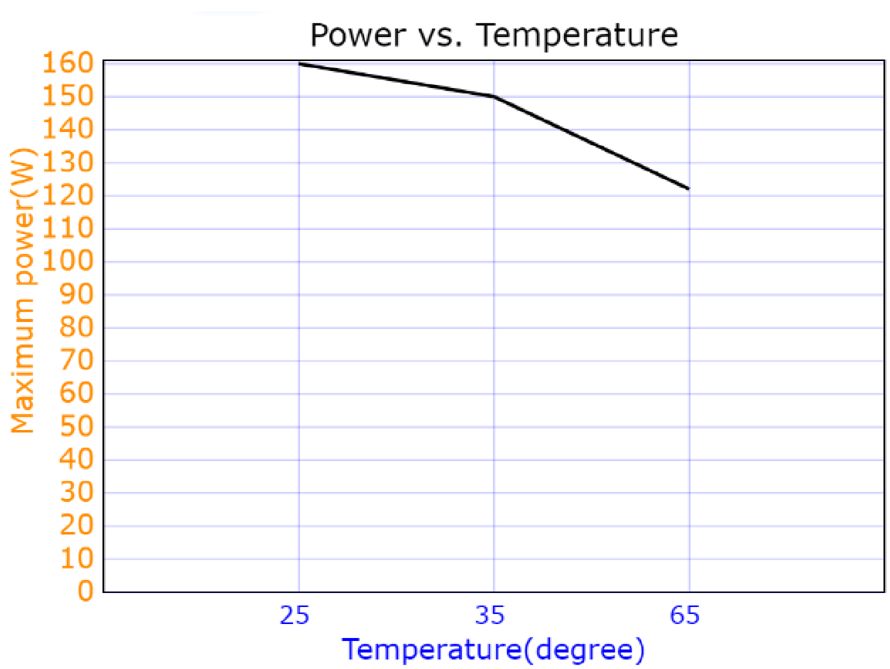

Fig.39. Maximum load power vs. Temperature

Problem 4:

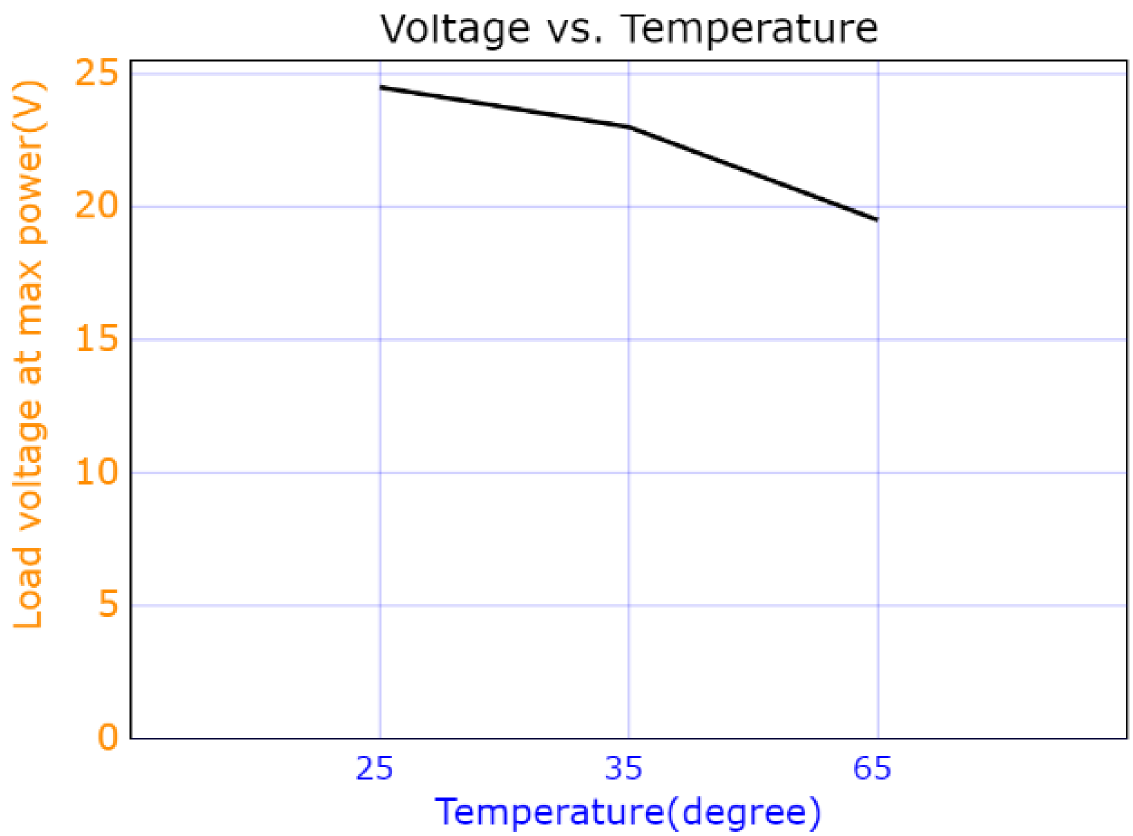

Fig.40. Load voltage at maximum power point vs. Temperature

Problem 5:

We can not control the weather and shading, but we can control the facing angle between the PV panel and the sunlight. We could make this firing angle as close to 0 degree as possible to achieve the maximum light intensity.

Problem 6:

$$\eta = \frac{P_{PV}}{P_{wall}} = \frac{150}{120 \cdot 6.5} = 19.23\%$$

$$\eta = \frac{P_{PV}}{P_{solar}} = \frac{150}{120 \cdot 6.5 \cdot 0.5} = 38.46\%$$

Contribution:

Experiments: **Fan Yang, Simon Chen, Cynthia Li**
Analysis of the results: **Fan Yang, Simon Chen, Cynthia Li**
Preparation of the report: **Fan Yang, Simon Chen, Cynthia Li**