HIGH INTENSITY LIGHT-CYCLING OF HCPV CELL ASSEMBLIES USING THE XT-30 SOLAR SIMULATOR

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1. Introduction

The thermal and electrical loads generated within highly-concentrating photovoltaic systems (HCPV) are significantly greater than those produced in flat plate photovoltaics. In addition, cyclical loading is also more severe, due to the limited acceptance angles of HCPV systems. Subsequently, the long-term reliability of solar cells, and cell-on-carrier (CoC) assemblies, under such operating conditions is of significant interest to the CPV community.

The Spectrolab XT-30 is a high intensity, continuous wave solar simulator capable of emitting 10 - 100 W/cm^2 (100 -1000 suns) onto a 5.5mm x 5.5mm solar cell. As such, it has significant potential as a lab-based tool for investigating the reliability of HCPV cell-on-carrier assemblies. This poster details the use of the XT-30's as a tool for exploring the degradation effects of accelerated, high-intensity light-cycling.

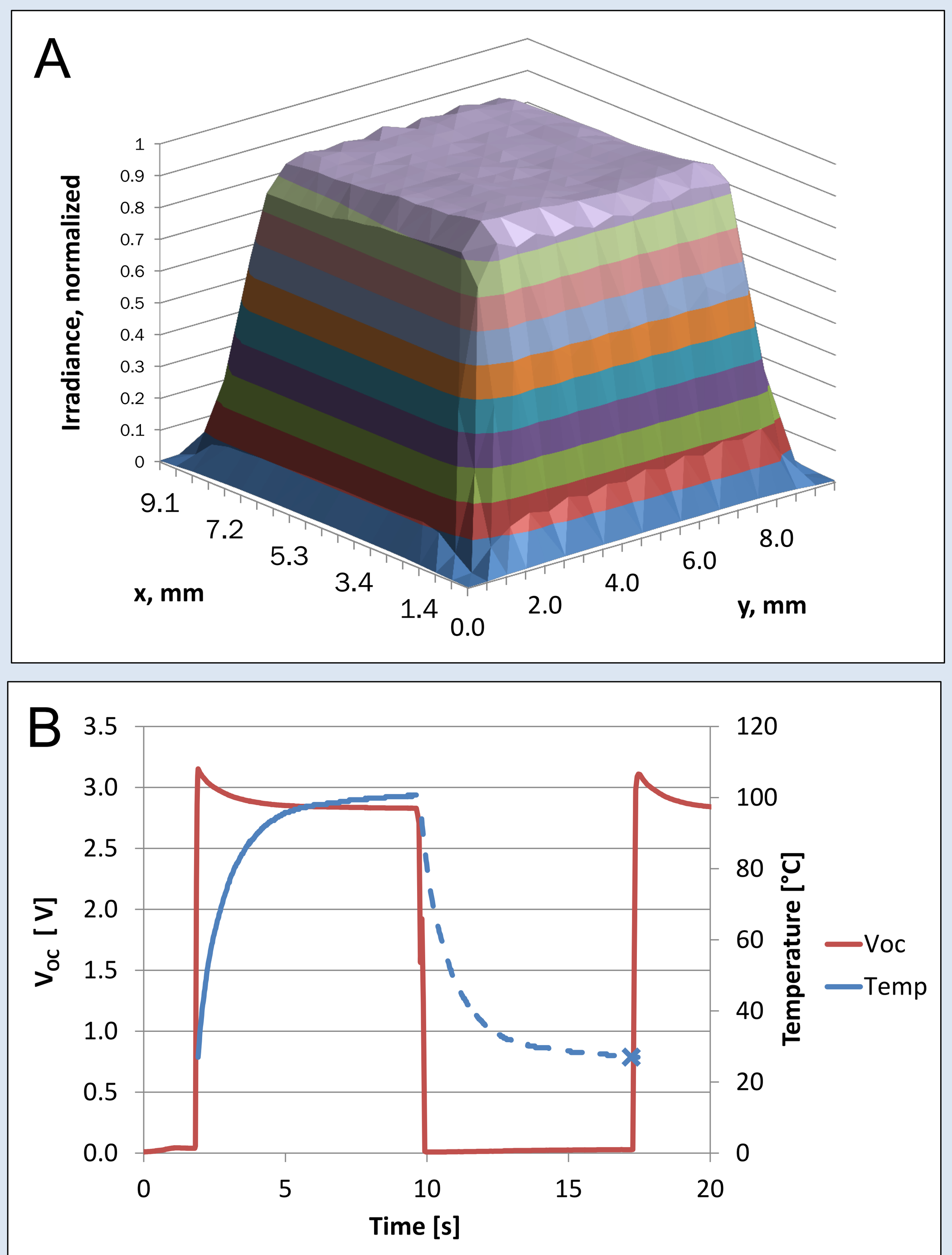

Figure 2. A) Spatial irradiance map of the XT-30 solar simulator beam. B) Transient V_{OC} and estimated temperature of the solar cell under test.

2. Measurement Set-up

- The experimental set-up is shown in Figure 1. The XT-30 was equipped with an automated shutter and CoCs were subjected to approximately 640-suns, at a frequency of 67 mHz (15 seconds per cycle, see Figure 2B), for 9 hours. A water-cooled sample stage was employed to moderate the cell temperature.
- The design of the XT-30 leads to a trade-off between spatial uniformity and total irradiance. Figure 2A shows a spatial uniformity map of the XT-30 beam. Uniformity of 9%. With optimal alignment, the XT-30 has achieved uniformity of 2.9%.
- The test cell's (Spectrolab C3MJ-CCA-030) I-V behavior was measured each hour using a Keithley 2420 SMU and lab-built data acquisition software.
- An ASDi Field Spec 3 spectroradiometer was used to measure the solar simulator spectra at the start and end of the measurement run to check the lamp stability.

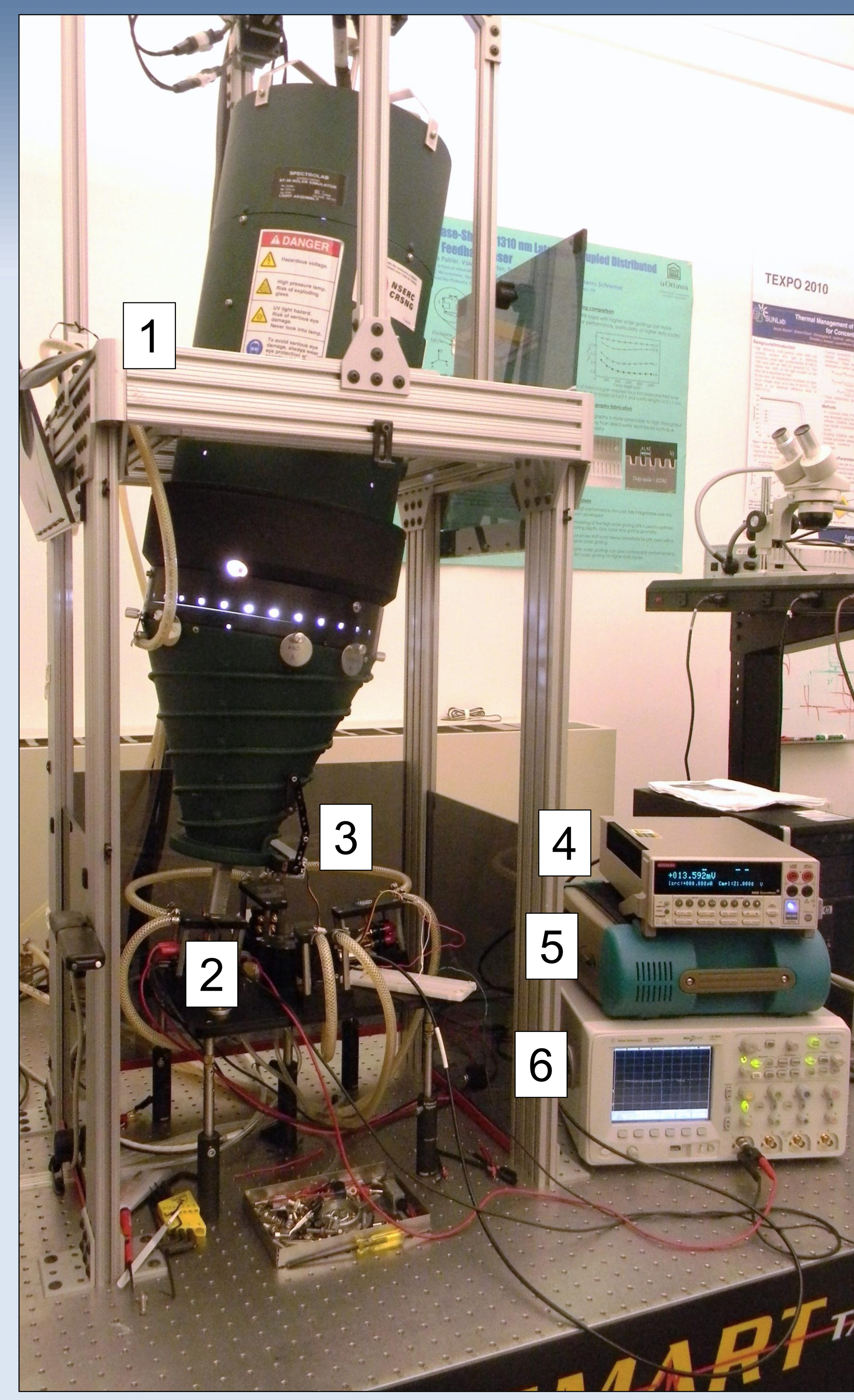

Figure 1. The light-cycle experimental setup showing the XT-30 solar simulator (1), water-cooled sample stage (2), automated shutter (3), SMU (4), spectroradiometer (5) and oscilloscope (6)

3. Temperature Range

- The temperature limits experienced by the CoC during the light cycling tests were estimated using transient V_{OC} measurements (Agilent DSO6014A oscilloscope) and the V_{OC} shift method.
- Figure 2B presents a typical transient voltage trace overlaid with the estimated cell temperature
- Tell experiences a maximum cell temperature of approximately 100 °C, significantly higher than standard HCPV operating temperatures.
- Although the sample stage is water cooled to 15.6°C. The minimum cell temperature is only approximately 27°C, due to the heating effect of the XT-30's fans.

4. Results

- Dark and light I-V curves were measured each hour during the 9 hour experiment. The I-V curve parameters are presented in Figure 3.
- Negligible change is seen in the CoC's I-V characteristics over the course of the experiment.
- Possible that I_{SC} and P_{MAX} exhibit slight signs of degradation but further work is required to ensure this isn't an artifact of the measurement regime.
- The XT-30 data acquisition system has a repeatability error of ± 1.5 % making it impossible to distinguish changes in device performance below this threshold.

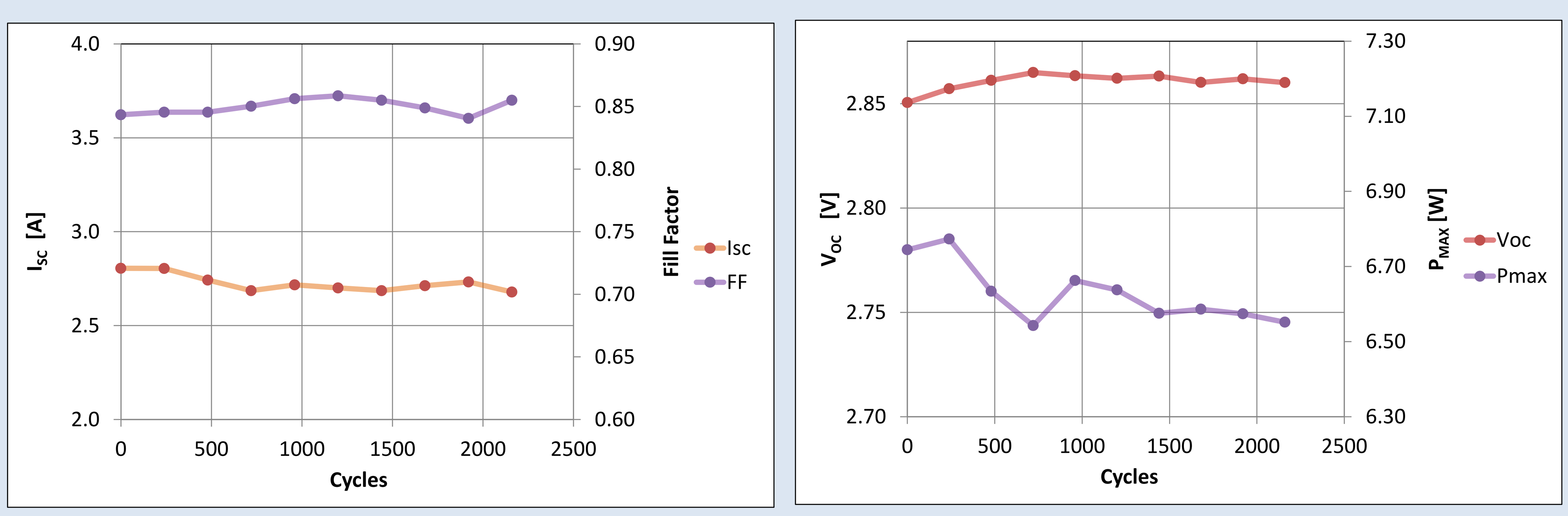

Figure 3. I-V characteristics of the device under test, as a function of the number of light-cycles

5. Conclusions

- The uOttawa SUNLAB has designed and installed equipment to facilitate light-cycling measurements on the XT-30 solar simulator.
- For an irradiance range of 660 suns, the maximum and minimum cell temperatures are estimated as 90°C and 27°C respectively.
- Spectrolab C3MJ CCA-030 cells on commercial carriers exhibited negligible degradation in I-V performance after 2,000, 65 Hz cycles at open circuit conditions.

6. Next Steps

- Optimize cycle time vs. temperature range.
- Light cycling at maximum power point.
- Increase irradiance to 1000 suns.

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