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Characterization of Photovoltaic Concentrators

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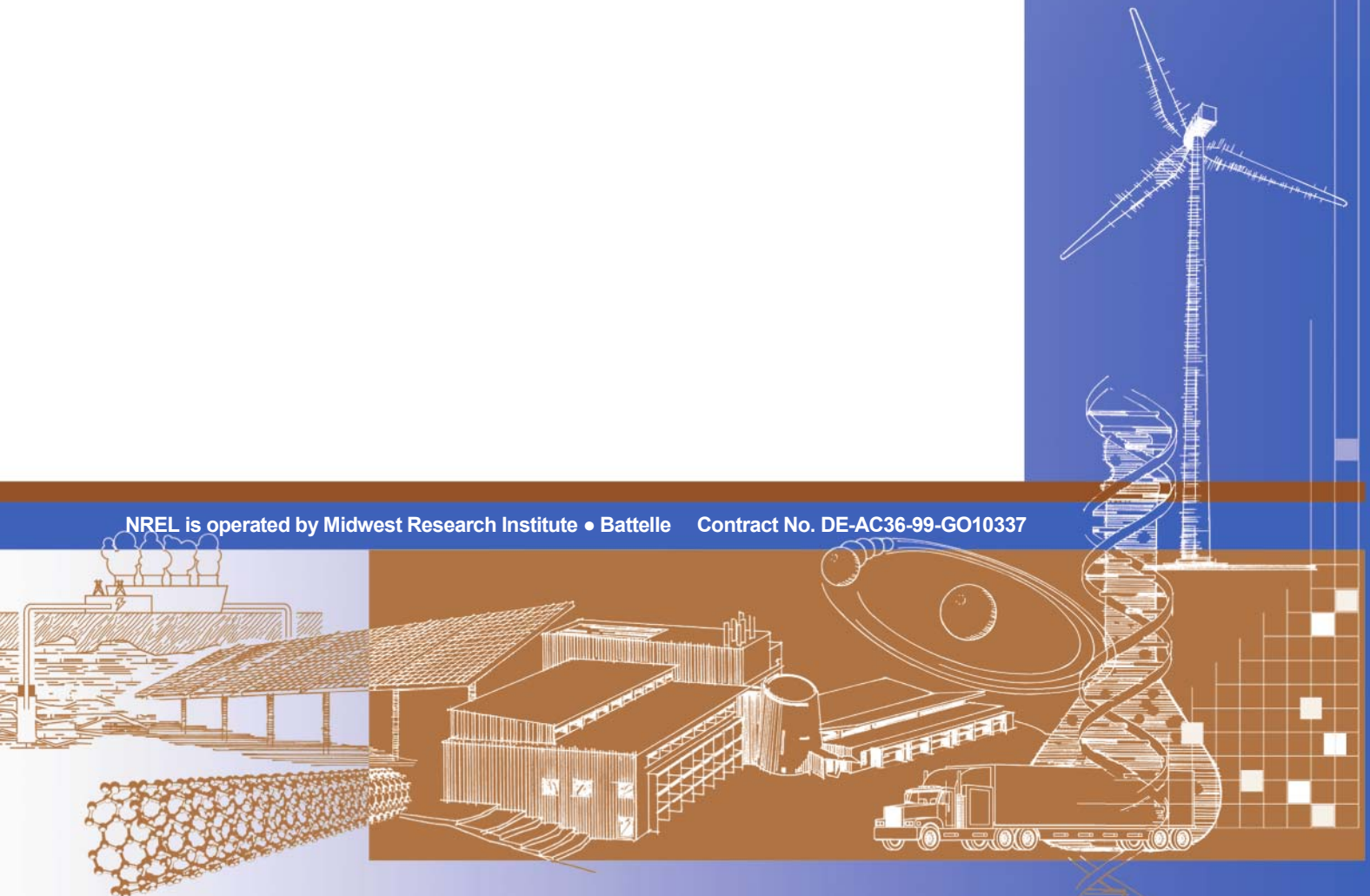

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Characterization of Photovoltaic Concentrators

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ABSTRACT

This paper will describe the resources at the National Renewable Energy Laboratory (NREL) for performing characterization of photovoltaic (PV) materials designed for operation under concentrated light. NREL has the capability to measure devices ranging from very small, unencapsulated research cells to reasonably sized, environmentally protected modules. Data gathering and interpretation are also ongoing areas of revision and improvement. The main goal of the current research is to reduce the measurement uncertainty to the lowest practical value. At present, the state of the art is limited at a ±5% level in measuring efficiency accurately.

1. Objectives

The position of the concentrator measurements within the research of the Measurements and Characterization (M&C) team is unique. The testing is done on experimental cells and modules. In this capacity, the testing should be reliable and reproducible. On the other hand, the test beds themselves need to be researched to improve measurement quality.

This paper deals mainly with two different test beds for concentrator research. The main test bed for concentrator research is the High Intensity Pulsed Solar Simulator (HIPSS). The other is the Outdoor Concentrator I-V system (OCIV). There is also the capability of testing under continuous concentration, which is limited to about 20 suns. The objective of the research is to reduce measurement uncertainties.

2. Technical Approach

The technical approach is in two distinct parts. One is for the HIPSS and the other is for the OCIV.

Fig. 1. HIPSS system. Test bed and hood at left, DAQ at right, PFN in middle back.

For the HIPSS, the hardware is mostly predetermined. Spectrolab manufactures the flash testers, which include two xenon discharge bulbs, a hood, a data acquisition system (DAQ), and a pulse-forming network (PFN). There have been some custom adjustments to the available current range for the test cell and to the bias-direction circuit. These will be discussed in the next section.

The approach to research the HIPSS is a combination of measurement and design. There are some problems that had been identified before the HIPSS was in regular use. These problems were systematically addressed. Other areas of research on the HIPSS have arisen due to difficulties in cell measurement. Some of the samples that are received will not conform to previous measurement techniques, so the limits of the system are pushed. The shortcomings of the system, such as problems with measurements at low intensities, can then be seen in a practical light, and solutions can be researched and applied accordingly.

Fig. 2. The OCIV test bed with bare rack on left; enclosed module with primary optics on right.

The OCIV test bed is used for evaluation of proto-type concentrator modules under outdoor conditions. This test bed uses 80/20 hardware for flexible mounting of a variety of module types. Short term tracking accuracy is about 0.5 °. It is intended to remove tracker performance issues from the data collected.

3. Results and Accomplishments

With regard to the HIPSS system, research has been done on the component circuit boards of the DAQ. A significant portion of this research involved reexamining and correcting

the schematics from the manufacturer to reflect subtle changes in the system. Stability switches for the load were added to increase the chances of reducing or eliminating cell-load oscillation. The ramp generator for the load voltage was analyzed and the component chip was replaced to test the feasibility of replacement components. In addition to the board-level research, there were tests done in relation to the spectrum provided by the flash.

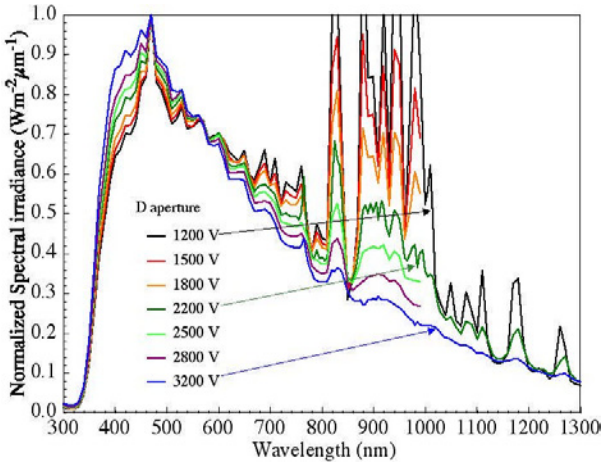

Fig. 3. Graph of spectral variation as a function of lamp discharge voltage. [1]

We have shown that the spectral content of the HIPSS can shift due to lamp discharge voltage and to wavelength-specific variations over the lifetime of the pulse. The lamp discharge voltage is the parameter of most interest. Changing this voltage from 1200 V through 3600 V changes the relative spectral content of the beam. Because the aperture can be used to adjust the intensity of the beam, the spectrum can be tuned to measure a variety of concentration levels at various spectra. This approach is useful to tune a multijunction cell and control the current-limiting junction.

The OCIV test bed was developed based on the original tracker configuration from Entech Inc. One of the main results has been that the tracking algorithm needed to be adjusted and maintained on a relatively frequent basis to ensure on-sun operation. This is mainly due to the fact that the tracker was designed as a line focus tracker. We have modified its use to be a point focus tracker, and are pushing that design to its limits.

In addition, the design was modified to accommodate testing of cell-optics systems on a bare rack [2-3]. On one side there is a fixed lens over an enclosed module and bare cells can be mounted, even adding secondary optics without necessarily having the cell itself encapsulated for environmental protection. On the other side, the module was replaced with a mounting rack with no optics associated. The tracking is linked between the two platforms with up to ten channels of IV information able to be monitored for longer term testing.

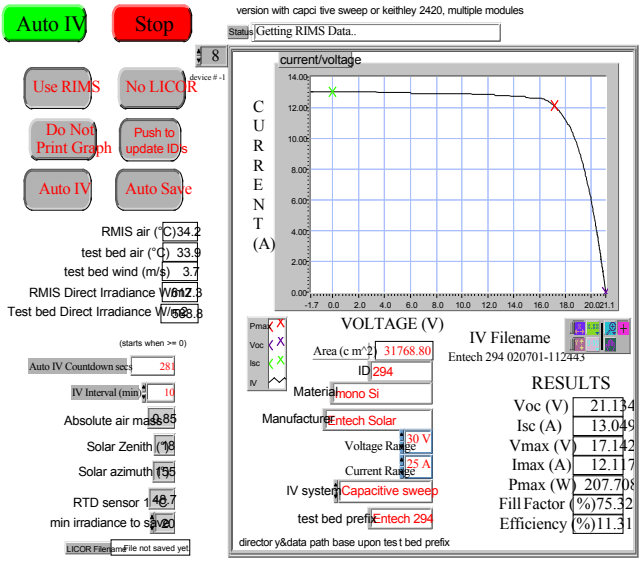

Fig. 4. Screen shot of OCIV DAQ interface.

4. Conclusions

In conclusion, there are four different test beds that we can bring to bear on concentrator cell measurements. There is the OCIV, the HIPSS, the X25 one-sun simulator, and the continuous concentrator test bed.

The X25 is a one-sun simulator that is used for baseline measurements. Typically, the assumption that a cell is linear over the test range can be relaxed by using the X25 data.

The HIPSS is capable of measuring concentrator cells at over 1000 suns, with short-circuit current values up to 50 A. Cells up to 10 cm^2 can be measured with spatial uniformity within 5%.

The OCIV is capable of measuring up to 10 separate channels. On eight of those channels, there is a 66W power limit. On the other two, there is a 200V, 25A limit.

The continuous concentrator is capable of about 20 suns. A chiller plate is used to create a temperature differential that maintains the cell temperature at whatever is desired, usually 25 C.

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15. SUBJECT TERMS
PV; characterization; measure devices; data acquisition system (DAQ)**;** pulse-forming network (PFN); high intensity pulsed solar simulator (HIPSS); Outdoor Concentrator I-V system (OCIV); lamp discharge voltage;

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