Design of Solar Power System Demonstration Unit

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Abstract

The research focuses on developing a demonstration unit which includes a solar ray simulator, power converters, microprocessor-based controllers, photovoltaic cells, and a battery. The process involves designing several function blocks, constructing a fixture, integrating the power electronics with the controller, testing the system and measuring a variety of data.

Problem Statement

Need:

A solar power system allows instructors to bring in functional systems to classrooms to demonstrate several aspects of solar power systems, addressing sustainability and renewable energy issues.

Objectives:

1. To design and test a solar power system demonstration unit.
2. To develop a measurement fixture and integrate its software with spectrometer for testing solar simulators in future.

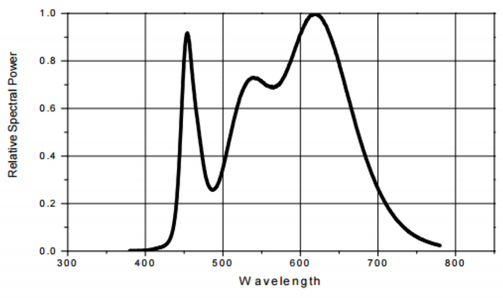

Fig. 1 : Warm white LED spectrum [1]

Methods

We used an aluminum block shaped in a hexagonal array with 30 spaces to construct the LED light source. LED modules were assembled, soldered and connected to the DC power supply.

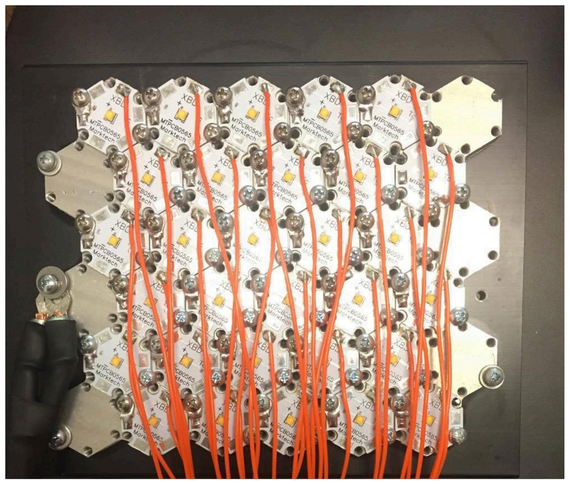

Fig. 2 : The constructed LED array

This block was attached to a heatsink using screws and silicone compound to fill any micro-gaps. Fans were added to help airflow in the heatsink.

Two Solar panels were glued onto a plastic board and attached to a swivel to test tilt right above the LED block. This was connected to a solar charger controller.

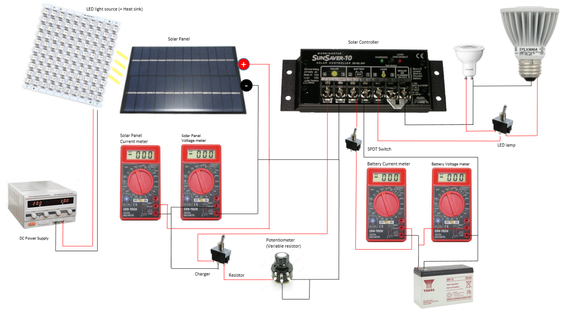

Fig. 3 : Connection diagram for demo unit

Results

A sealed-lead acid battery successfully stored and demonstrated reuse of energy with a bedside lamp. Four digital multi-meters were connected to the panels and battery to measure the current and voltage of input and storage.

A variable resistor was added to demonstrate how the input and storage would act under various types of loads. SPDT switches were also added to change functionality.

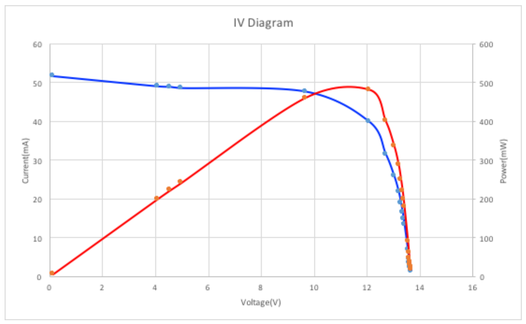

Fig. 4 : IV diagram obtained from testing the unit

The system was tested under various loads and the IV diagram was created above. The measured power output of the LED array was about 628 W/m^{2}. From this the max. power output of the panel was about 4W and had a efficiency of about 5%.

References

[1] www.seoulsemicon.com/_upload/Goods_Spec/X42182(0).pdf

[2] IEC 60904-9 Ed.2, Photovoltaic devices, Part 9: Solar simulator performance requirements, 2007.

Future Development

We have successfully built a solar system demo unit but we need to apply this to a larger scale (in development) and test required IEC specifications [2] such as Spectral Match, Irradiance Uniformity, and Temporal Stability when the light source consists of multi color LEDs.

This will allow us to understand the applicability of a LED based solar simulator to test solar panels.

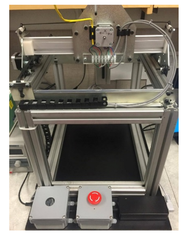

Fig. 5 : LED measurement fixture

Faith and Engineering

As Christians we believe that our world belongs to God and we are stewards in it. As stewards we have a responsibility to take care and judiciously use the resources we are blessed with. This project furthers our understanding of sustainability and renewable energy sources.

This Solar power demonstration unit highlights the usefulness of harnessing sunlight using photovoltaic cells as an energy source and further grasp god's gifts and make better use of them.

Acknowledgements

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