Design of a Solar Power System Demonstration Unit

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Currently High-Powered LEDs are used in a variety of industrial applications. The reason for this being their affordability, efficiency, portability and versatility. Solar panel manufacturers need to test their products in a controlled environment which calls for an artificial light source. Traditionally Xenon bulbs have been used for this as they are very similar to white light. However, these systems are expensive, bulky and require constant maintenance. The development of LEDs has led to a stage where they are easily able to emit various wavelengths (colors) and intensities through use of sophisticated microcontrollers. When assembled as an array the system (through mixing of wavelengths) can emit white light (artificial sunlight) and can better satisfy IEC specifications of Spectral match, Non-uniformity of irradiance and temporal instability than the traditional Xenon solar simulator. This research is based on past projects titled 1. Development of Solar Simulator System with High-Power Multi-Array LEDs and 2. Development of Constant-Current DC-DC Modules for High-Power LEDs and is aimed at testing and validating the built hardware and simulations.

The goal of this research project is to design a demonstration unit using a CNC machine (XYZ-axis probe) in conjunction with the High-power LED solar ray simulator, power converters, microprocessor-based controllers, photovoltaic cells and various types of batteries. LabVIEW software, a graphical programming language is used to control the CNC machine with and a microcontroller using a serial communication protocol. LabVIEW also controls a wide band spectrometer which collects irradiance data. This data is then analyzed through a solar match monitor which find the power of the emitted light in each wavelength (Spectral match) and and different positions (Uniformity) and for different durations of time (temporal instability).

At this stage several functional blocks have been designed; the solar simulator fixture has been built with a strong aluminum alloy attached to the CNC machine, the power electronics have been designed and are being integrated into the system and the microprocessor-based controllers are in place and functioning optimally. The Virtual Instruments in LabVIEW are in the process of being integrated to create a seamless program for testing. The system is still to be integrated completely, which is when unforeseen design faults may come up for which the software or hardware need to be adapted to.

I have been interested in optics (especially high-powered devices) for a long time and this research experience is a great way to expand my knowledge in the field of sustainability. I believe that this system will enable faculty members and instructors to bring demonstrate photovoltaic cells and LEDs in classrooms and across campus to illustrate various aspects of solar power systems, and address sustainability and energy issues. Personally, this has been a great experience for me to learn about scientific programming, spectrometry, High-power LEDs, Integrated and printed circuits, machine shop equipment and microcontroller software. I hope to apply my knowledge further, in developing testing systems for sustainable power systems. Certainly, with guidance from Prof. Kim I have learnt a lot about mathematics, physics, design and testing processes and research methods from doing research which will greatly benefit me in the future. It has been a great blessing.