Modernizing control system for absolute cavity radiometer

Words: Dr. Ajay Singh, Application Scientist, Renewable Energy, Campbell Scientific
Libbie Anderson, Marketing Assistant, Renewable Energy, Campbell Scientific

Accurate measurements of broadband solar irradiance require radiometers with proper design and performance characteristics, correct installation, and documented operation and maintenance procedures, including regular calibration. With any measuring tool, calibrations must be traceable to a recognized reference standard. For direct normal irradiance (DNI) measurements of broadband solar radiation, the World Radiometric Reference (WRR) is the internationally recognized measurement standard.

The WRR was established by the World Meteorological Organization (WMO) in 1977 and has been maintained by the Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center (PMOD/WRC) in Switzerland. The center maintains a group of five cavities as part of world primary reference standard.

The ACR model HF manufactured by The Eppley Laboratory has been one such reference standard-level device since 1978.

Field pyranometers and pyrheliometers must be calibrated against more accurate pyrheliometers with clear WRR traceability. The most accurate pyrheliometers are electrically self-calibrating absolute cavity radiometers (ACR). These are typically not deployed in the field as they are an order of magnitude more expensive than regular pyrheliometers and are often used without any optical windows.

ACRs require a controller unit to make periodic self-calibrations and solar radiation measurements. Signals produced are very small and high-accuracy levels are desired. Traditionally, high end laboratory equipment is used for this application. Campbell Scientific's newer data loggers, the CR6 and CR1000X, have the desired accuracy levels and are field deployable.

As a result, an ACR controller was designed and built in 2016 that was first tested at National Renewable Energy Laboratory's (NREL) Solar Radiation Research Laboratory (SRRL) in Golden, Colorado in the United States, and later at the World Radiation Center (PMOD/WRC) in Switzerland. Since then, several of these controllers were built using CR1000X dataloggers. These controllers are routinely included in international and national pyrheliometer comparisons.

Dr. Ajay Singh

Libbie Anderson

The University of Oregon Solar Radiation Monitoring Lab (UO SRML) is a regional solar radiation data center directed by Frank Vignola, who is a well-known figure in the solar radiation monitoring field. Since the beginning of its operation in 1975, the UO SRML has become one of the premier monitoring networks in the country. The lab provides high-quality solar-resource data for planning, designing, deployment, and operation of solar electric facilities in the Pacific Northwest, United States.

The UO SRML measures various components of solar irradiance at 14 different stations in Oregon, Idaho, Wyoming, and Utah. The dataset is made available for future solar electric generation. To ensure the accuracy of the dataset, the sensors are periodically calibrated against an Eppley ACR.

'The ACR is critical in calibrating the rest of our sensors,' said Josh Peterson, a member of the project team.

When a crucial component of the UO SRML's previous control system failed and could not be replaced, the lab called upon Campbell Scientific for a solution.

Based on the lab's needs, Campbell Scientific supplied a CR1000X as the new controller for the ACR. The CR1000X is a flagship data logger that provides measurements and control for environmental applications

'The CR1000X and other components of the system are working great,' said Peterson.

For daily deployment, Peterson says the team mounts the sensor to the two-axis tracker, connects all the wires, starts the computer, and then starts the program. At the end of the day, the files are exported to the computer and the data is then analyzed.

In an original controller, manual user entry was needed about every 30 minutes for the controller to keep measuring. In comparison, the CR1000X is fully automated and requires minimal operator input.

'From my point of view, I don't want the logger component to get in the way of me doing science,' Peterson said. 'The data logger works great as a workhorse behind the scenes so that I can concentrate on what I need to do that day.'

Peterson said there are many challenges in maintaining a solar network, making it crucial to the high accuracy of the network for the CR1000X to be a compatible control system for the ACR.

'We take data every minute of every day for 14 monitoring stations and we operate around five sensors at each station,' said Peterson. 'Having a good system in place to process this volume of data is critical.'

A few features Peterson said are important for an ACR controller to have include 'voltage measurement with the minimum required

uncertainty and high resolution, a reliable clock, quick measurements, and the system must be able to process the data in a timely fashion.' In this application, the CR1000X is a full measurement and control system.

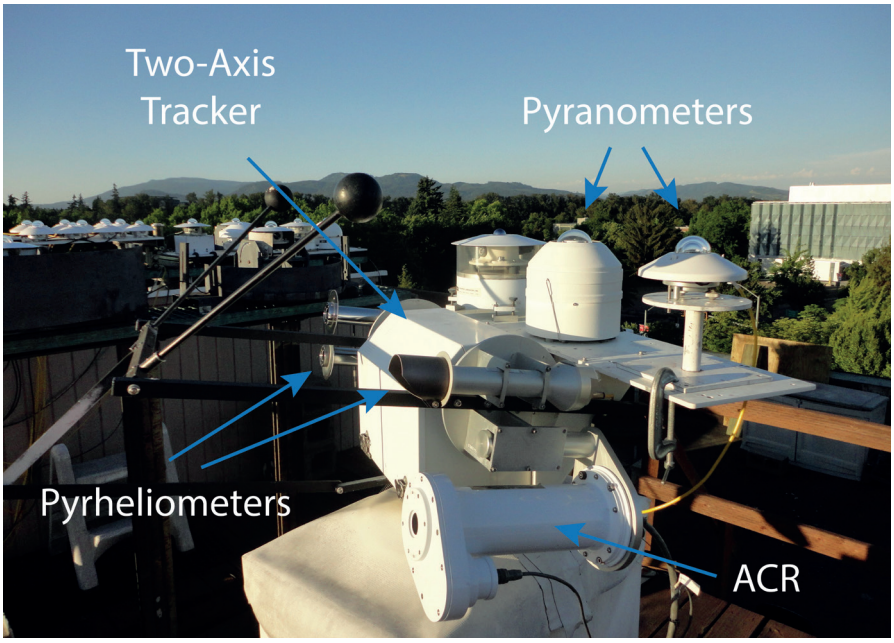
Lab director, Frank Vignola, described how they used to digitize data strip charts, and they even built their own data loggers using 8085 chips.

'Those days are long gone,' said Vignola. 'The Campbell Scientific data loggers have been a tremendous help, not only providing reliable access to our sensors in the field, but in enhancing the completeness of the dataset.'

Another change has been the convenience of today's solar radiation sensors, which has increased the volume of data needed for real-time data resolution, according to Peterson, who has been in the field for a decade.

'Operators of solar photovoltaic (PV) facilities want to know what the resource is in real time, so we collect and publish the data to the web,' Peterson said. 'The sensors are getting better, faster, more accurate, and having less systematic errors.'

New expectations also include measuring the circumsolar radiation. Vignola said this is not an easy task, but the 'Campbell Scientific data loggers enable some of these systems to provide useful data as the devices are still being developed.'



'The ability of Campbell Scientific data loggers to not only gather and store the data, but to process the data in real time, helps make these new ideas develop,' remarked Vignola.

Overall, Vignola sees the science community wanting bigger and faster data while getting numbers they can plug into formulas for useful results.

'People prefer systems they do not have to check and that will notify them if there is a problem,' said Vignola. 'I believe Campbell systems can do this and have done it for other industries.'

asingh@campbellsci.com

landerson@campbellsci.com

www.campbellsci.com/pes21a2.