Rotating Shadowband Radiometer

The Irradiance, Inc. Rotating Shadowband Radiometer (RSR) provides accurate and reliable on-site measurements of global, diffuse, and direct solar radiation for solar power system design and financial analysis. RSR's are also used for solar energy resource assessment, solar power system monitoring, metering and evaluation, and in atmospheric physics to quantify irradiative energy transfers in global energy balance research.

Ground station solar irradiance measurement is the most accurate way to assess the amount of solar energy available at a particular site. While satellite-derived or other methods of interpolation may be suitable in some cases, only actual on-site irradiance measurements are accurate and reliable enough for many applications, particularly those requiring large investments.

Solar energy reaches the earth's surface along two paths: direct normal (or "beam") irradiance from the "disk" of the sun and diffuse irradiance from the sky. While it is relatively easy to measure the combined total of these two "components", accurate measurement of direct and diffuse irradiance individually has historically been quite expensive and problematic until the advent of the Irradiance, Inc. RSR.

The necessity for accurate measurement of direct normal irradiance, in particular is of critical importance for large-scale sun-tracking and concentrating solar technologies

The Irradiance RSR2 is an improved, second-generation instrument based on the Ascension Technology instrument produced in the 1990s and operated at over 150 locations in the U.S., Brazil, Mexico, Pakistan, Bahrain, Morocco, Spain, Greece, Russia, Costa Rica, South Africa and India. This rugged, integrated system is easy to install and operate, and in most cases requires little routine maintenance.

The RSR-2 sensor head unit includes a moving shadowband that momentarily casts a shadow over a silicon photodiode pyranometer. Irradiance's patented and proprietary pattern recognition algorithm uses data taken during the passage of the shadow to determine direct normal and diffuse horizontal irradiance. An ambient air temperature sensor with a gill shield is included to make small temperature corrections to the photodiode signal.

The RSR2 control unit includes a Campbell Scientific measurement and control system, a shadowband motor controller, and a photovoltaic power system; numerous options are available for wired and wireless data retrieval.

An extensive range of additional sensors, available from Campbell Scientific and others can be easily configured with the RSR2 control unit, to measure additional meteorological and solar power system performance parameters.

Figure 1 Irradiance RSR-2 head unit and solar resource measurement system.

Figure 1 shows the RSR2 system head unit's pyranometer sensor, shadowband and motor housing mounted on top of the measurement and control system housing. In this configuration the instrument can be easily mounted on the ground or flat roof with an optional ballast tray. It can also be mounted to any vertical 1.65" (41.9 mm) outside diameter pipe rigidly supported in any manner. A optional tripod mount is under development.

SPECIFICATIONS

The RSR2 design incorporates significant improvements in accuracy and mechanical reliability stemming from collaborative research conducted at the U.S. National Renewable Energy Laboratory (NREL), Sandia National Laboratory, the University of Oregon Solar Monitoring Lab, and the 150MW KJC Solar Electric Generating Station in California. The results of this study at each of four test installations were that the RSR-2 measurements were within 2% of reference measurement systems.

Rotating Shadowband Radiometer Head Unit: Licor LI-200SZ pyranometer, shadow-band, drive mechanism, wiring harness and mounting bracket.

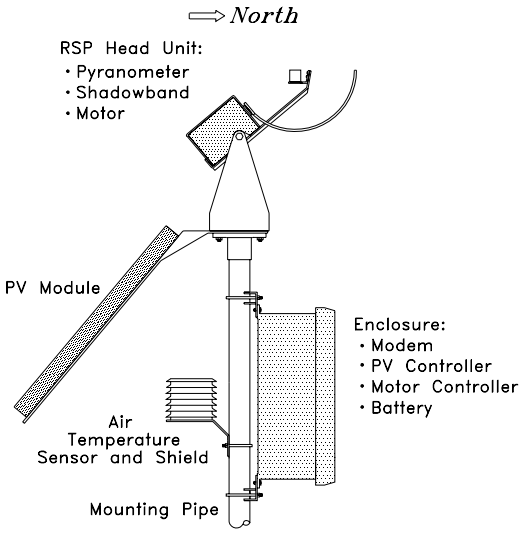
Ambient Air: Air temperature sensor rated -5C to + 50C, gill radiation shield, wiring and mounting. Optional temperature and relative humidity sensor. Optional barometer.

Photovoltaic solar power supply: 10-Watt photovoltaic module, wiring harness and mounting bracket. Optional additional 10-Watt panel for low sunlight locations.

Instrument enclosure: Fiberglass enclosure 30.48 cm (12") wide x 35.56 cm (14") high x 15.24 cm (6") deep, mounting hardware, CR800 (Optional CR1000) Campbell Scientific Measurement and Control System, and head unit motor controller.

Irradiance RSR2 software: Software license for Campbell CRBasic code to control the RSR and determine global, diffuse and direct irradiance and ambient air temperature.

Mounting hardware: Pipe with flanges for bolting to flat surfaces; optional ballast tray and hardware for mounting an RSR on a flat roof. Optional tripod for ground mounting.



MEASUREMENT SERVICES

Irradiance and its partners offer RSR2 installation, operation and maintenance and data retrieval and reporting services related to solar energy resource assessment and solar power system performance analysis. Contact us to discuss specific requirements.

PRICE

The Base Price of RSR2 with a CR800 Measurement and control systems is $8,750, FOB Massachusetts, USA. Contact us for pricing and availability of sensor and communication options.

CONTACT

The RSR2 is marketed and serviced by Irradiance in collaboration with Augustyn + Company and New Energy Options, Inc.

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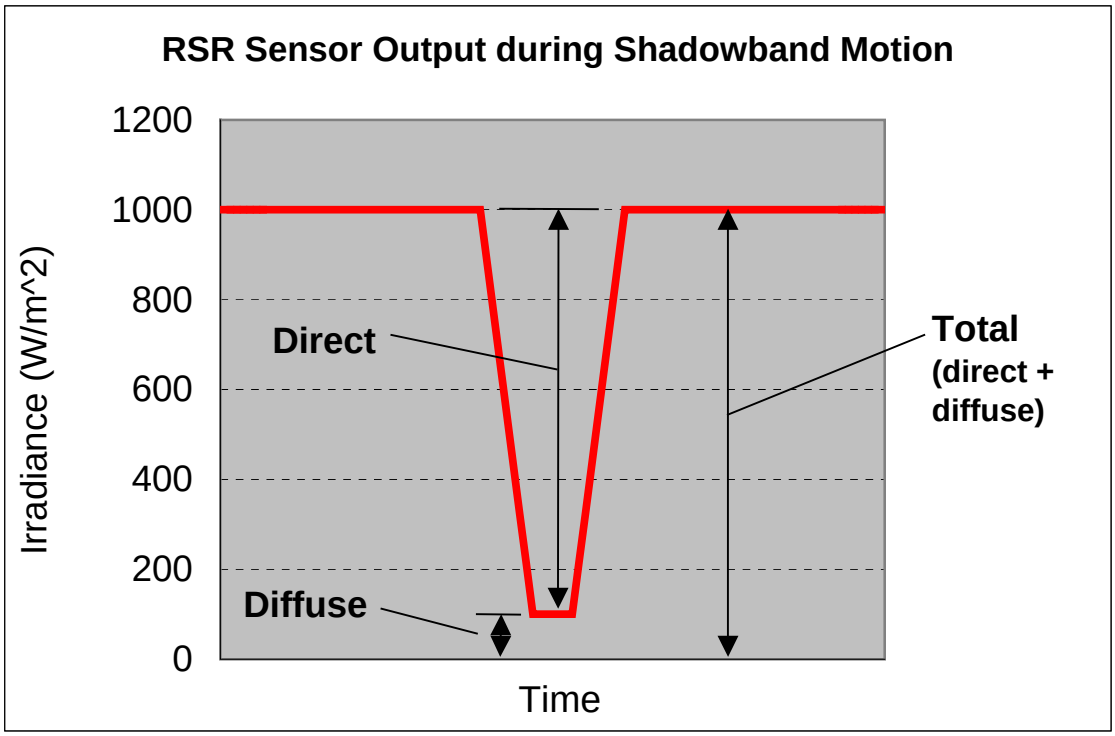
FUNDAMENTALS OF OPERATION



The Irradiance RSR2 uses a single light sensor (pyranometer) to measure the total and diffuse irradiance, allowing accurate derivation of the direct irradiance. These terms are related by:

Total = Direct x cos (zenith angle) + Diffuse

Where:

- Total is the total irradiance falling on a horizontal surface.
- Direct is the direct beam or direct normal irradiance coming from the disk of the sun.
- Diffuse is the irradiance from the entire sky falling on a horizontal surface excluding irradiance coming from the disk of the sun.
- Zenith Angle is measured from straight overhead down an arc to a point at the center of the sun

The graph illustrates measurements during a single shadowband rotation on a clear day. Once per minute the shadowband moves over the sensor, taking about one second for this motion. During this period the sensor signal is sampled about 1000 times. The lowest readings in the middle of the graph occur when the sensor is completely shaded from the sun by the shadowband; here the instrument reads only the diffuse irradiance. The stream of high-sample-rate data is processed to determine the drop in the signal as the shadow passes over, which is equal to the direct irradiance times the cosine of the zenith angle. The zenith angle is derived from an independent calculation using the instrument's latitude, longitude and time. The total irradiance is measured only when there is no shading.

National Renewable Energy Laboratory studies have shown the RSR2 instrument to report values within 2% of reference instruments with comparison trials at four reference stations.