

The
Irradiance

RSR2 Rotating Shadowband Radiometer

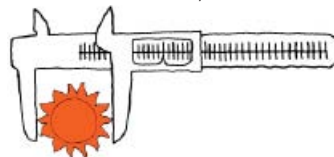


... when solar measurements matter ...

Distributed worldwide by:

Augustyn & Company

609 Santa Rosa Avenue Berkeley CA 94707 510-525-2505



Measuring the Sun since 1983

THE Irradiance RSR2 ROTATING SHADOWBAND RADIOMETER

The Irradiance, Inc. Rotating Shadowband Radiometer (RSR) provides accurate and reliable on-site measurement of total and diffuse horizontal, and of direct normal solar radiation for solar power and environmental applications. RSR's are used in large scale solar power development, solar energy resource assessment, solar power system monitoring, metering and evaluation, and in atmospheric physics to quantify radiative 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. Accurate measurement of direct normal irradiance, in particular is of critical importance for large-scale sun-tracking and concentrating solar technologies.

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 RSR is not only considerably less expensive than traditional methods of two and three component measurement, but is also more reliable. It is also effectively more accurate, being far easier and less costly to properly maintain and operate.

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 RSR2 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. Numerous options are available for wired and wireless data retrieval, and for photovoltaic power supplies.

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.

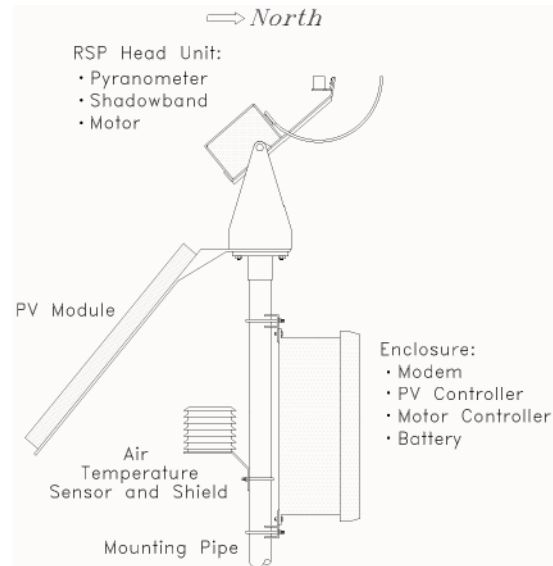


Figure 1

Figure 1 shows the essential components of an RSR2 system. It shows how the head unit's pyranometer sensor, shadowband and motor housing are 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. Ground mounting is readily accomplished with the optional tripod, which in its standard configuration, places the RSR sensor 2 meters above the ground. It can also be mounted to any vertical 1.65" (41.9 mm) outside diameter pipe rigidly supported in any manner.



FUNDAMENTALS OF OPERATION

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

$$\text{Total} = \text{Direct} \times (\cosine \text{ Zenith}) + \text{Diffuse}$$

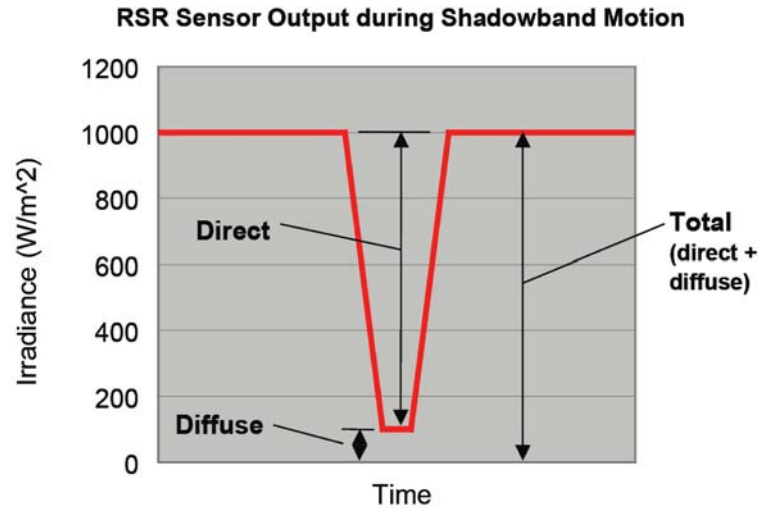
“Total” is the total solar irradiance falling on a horizontal surface

“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 the “Direct”

“Zenith” is the angle measured from straight overhead down an arc to a point at the center of the sun

The adjacent 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, elevation, 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.

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 thermopile 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: Optional 10-Watt photovoltaic module, wiring harness and mounting bracket. Optional additional 20-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 determine global, diffuse and direct irradiance and other measurements.

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.

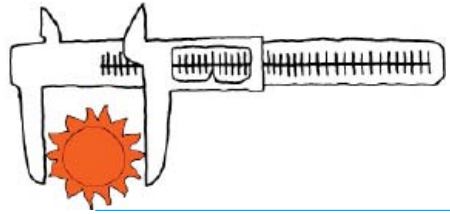
CALIBRATION & ACCURACY

Units shipped from the factory come with the sensor manufacturer’s (Li-Cor) calibration, resulting in a minimum measurement uncertainty from the World Radiation Reference (WRR) of about 6%. The RSR datalogger program code contains a field calibration subroutine, which, by use of a properly calibrated secondary reference pyrheliometer, field calibrations can be performed after installation. Preliminary research indicates that such a calibra-

tion can result in total measurement uncertainties from the WRR of 3.5 to 4.5% for direct irradiance. Irradiance Inc., through a Cooperative Research and Development Agreement with National Renewable Energy Laboratory is in process of confirming these preliminary uncertainty estimates as well as and developing a new approach to sensor calibration to lower cost, while maintaining the best possible results.

Augustyn & Company

609 Santa Rosa Avenue Berkeley CA 94707 510-525-2505



Measuring the Sun since 1983



RSR system with 10 meter wind measurement pole installed for PV system site evaluation in California



RSR system installed at CSP plant in California



NREL's chief solar measurement scientist explaining Irradiance RSR operating principles at dedication of SunSpot 1 Solar Measurement Station near Alamosa, Colorado



Rooftop mounted RSR system installed for PV/CSP plant developer in southern Spain

MEASUREMENT SERVICES

Augustyn & Company, Irradiance, and their partners offer RSR2 sales, installation, operation, maintenance, data retrieval and reporting services supporting solar power development and system performance evaluation. Contact us to discuss specific requirements.

RSR2 PRICING

The Base Price of an RSR2 with a CR800 Measurement and Control system is \$8,750, as of 2008-09-01. Quantity and educational discounts are available. Contact us for current pricing and availability of optional mounting, solar power, sensor and wired and wireless communication equipment.