TrackSO
Solar PV Monitoring & Analytics

Pyranometer Shadow Ring Operating Instructions [PM 10]

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MODEL

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Introduction

When properly installed and routinely adjusted, the Shadow-Ring obstructs the daily direct beam solar component from irradiating the radiometer mounted within the shadow-ring, from sunrise to sunset. Mechanical adjustment of the Shadow Ring is recommended every two days for optimal measurement performance. The resulting measurement when optioned with a class 1 Pyranometer is representative of the total global diffuse short-wave irradiance signal in W/m^2. Because the shadow-ring obstructs a portion of the diffuse sky field measured by the Pyranometer, it is recommended to apply a small multiplier correction to account for the sky-field obstruction in the calculated diffuse irradiance measurement results. When used in conjunction with a second non-shaded Pyranometer, it is possible to infer direct beam solar disk irradiance by subtracting the corrected shaded Pyranometer diffuse irradiance values from the non-shaded Pyranometer global solar irradiance values, for the same time indices sampled.

The Shadow Ring provides a reliable cost effective solution for deriving the constitute global short-wave diffuse and direct beam solar irradiance components, in contrast to auto-tracking radiometer instrument solutions costing thousands more.

Figure 1

Shadow-Ring Site Selection

It is recommended to install the Shadow-Ring in a readily accessible location to perform routine cleaning of the Pyranometer dome and to perform mechanical readjustment, at least every two days. The installation site should be free from local obstructions (e.g. buildings, trees, towers) that exceed the horizontal plane of the Pyranometer. If this is not possible, select an installation site in which local obstructions do not exceed 5 degrees elevation within the path of the daily solar course at sunrise and sunset conditions. This is critical when using a second NON shaded global Pyranometer to calculate the direct solar disk component in conjunction with the mounted shaded/diffuse Pyranometer measurement. Care must be taken to avoid local structures that may cast shadow effects or generate increased solar reflectivity effects at certain times of day.

It is critical to mount on a stable mounting surface to ensure that the shadow-ring and Pyranometer remain as perfectly level as possible throughout the field measurement campaign.

Shadow-Ring Positioning & Adjustment

The shading geometry of the Shadow Ring, when properly installed and adjusted, obstructs the daily direct solar beam from irradiating the Pyranometer mounted on it, from sunrise to sunset. The Pyranometer should be mounted on the Shadow Ring goniometer so that the Pyranometer cable gland and signal cable are oriented pointing North upon installation (i.e. assuming installation in the northern hemisphere). For installation in the southern hemisphere, the Pyranometer should be mounted with the Pyranometer cable gland and signal cable oriented pointing south.

The mounting base of the Shadow Ring must be installed parallel and level to the ground below. The leveling base adjustment screws and the spirit level allow for easy and accurate leveling. The Shadow Ring must be positioned and adjusted such that the shadow-ring sliding adjustment bars (2) are parallel to the Earth's axis

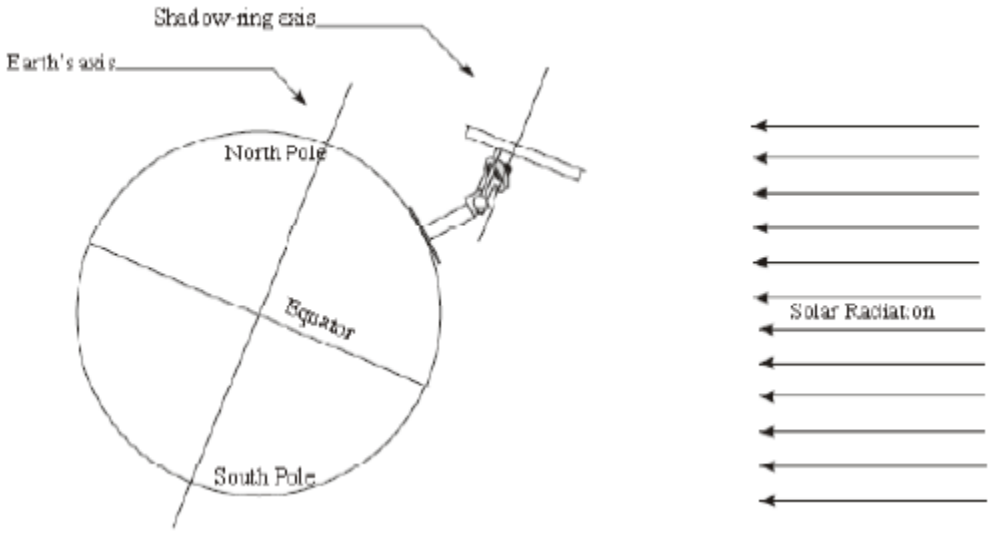

Figure 2

For operation in the northern hemisphere, orient the shadow-ring so that the Pyranometer signal cable and rear side of the shadow-ring are pointing North; for installation in the southern hemisphere, orient pointing South. Next, adjust the shadow-ring tilt. To align the shadow-ring along the North-South axis, observe the following procedure:

1. Adjustments should be conducted at local solar noon under clear sky conditions.
2. Standing or kneeling behind the shadow-ring (rear), gradually rotate along the pillar body vertical axis left or right as required until the Sun/direct beam is visible through the groove slot, located just beneath the goniometer angle adjustment scale.

Sliding Bar Tilt Adjustment

1. Confirm that the shadow-ring sliding bars and the long side of the Pyranometer support are parallel (instruments are delivered factory aligned).
2. Mount the Pyranometer on the goniometer head with supplied metric stainless screws.
3. Adjust the goniometer so that the scale indicator matches that of the local latitude of installation (figure 4), then retighten the goniometer locking screw.
4. 4. Rotate the crossbar (after loosening the crossbar locking screw) until the Pyranometer is parallel/level with respect to the ground below;
   Notes: If the above steps have been carried out correctly, the shadow-ring axis will be parallel to the Earth's axis.
5. Finally adjust the height of the sliding bars until the Pyranometer inner dome is centered within the shadow cast by the shadow-ring

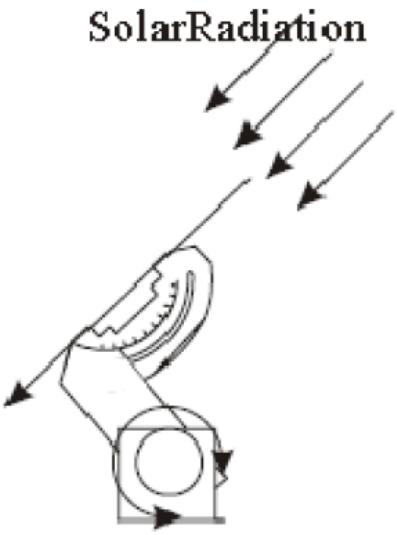

Figure 3

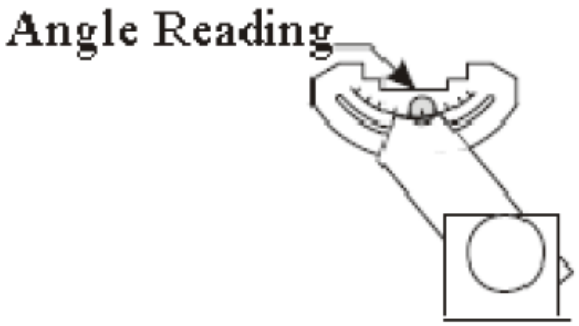

Figure 4

Routine Maintenance

The shadow-ring position must be adjusted at least once every two days.

Procedure:

- Loosen both sliding bar locking screws and position the sliding bars at the height indicated in table 1.
- If the Sun is shining brightly enough to cast sufficient shadowing, the adjustment of the shadow-ring sliding bars can be made simply by looking at the shadow of the ring cast upon the Pyranometer and adjusting accordingly. Adjust the sliding bars as to shade the Pyranometer dome entirely.
- Once sliding bars have been properly adjusted, tighten both sliding bar locking screws and proceed with measurements.
- It is important to keep the Pyranometer dome clean to achieve optimal measurement accuracy. Cleaning the Pyranometer dome can be performed with water and a soft CLEAN cotton cloth, or disposable lens wipes. Pure ethyl alcohol can also be used; it is however recommended to clean the dome a second time with water to remove any residue left by the alcohol.

Diffuse Measurement Correction

Global short-wave diffuse irradiance is measured by a Shadow Ring mounted Pyranometer, by eliminating the contribution of the Sun/direct radiation component via obstruction of the sky-field within the path of the daily solar course from sunrise to sunset. As such the shadow-ring obstructs a portion of the diffuse sky-field under measurement by the Pyranometer. It is therefore necessary to apply a multiplier function/correction factor to the calculated diffuse irradiance measurement results to account for the aforementioned sky-field obstruction in the diffuse measurement. The actual percentage of diffuse sky-field obstructed by the shadow-ring varies with season and latitude; as such so does the recommended multiplier function/correction factor. Refer to Table 2 for Shadow Ring multiplier function/correction factors in the 'Northern Hemisphere', and Table 3 for 'Southern Hemisphere' application use.

CORRECTED DIFFUSE IRRADIANCE EQUATION: _ Corr Diff = (U / E) _ C

The above equation illustrates the corrected global diffuse irradiance where:
_ Corr Diff: is the corrected diffuse irradiance measurement value in W/m²

U: is the output signal voltage from the HFSR01 mounted Pyranometer in milli-volts
E: is the factory supplied calibration factor for the Pyranometer in µV/W/m²
C: is the suggested multiplier function/correction factor, as per lookup tables 2 / 3,

This table shows the values to be used to set the graduated sliding bars for the different declinations of the sun.

Sun's Declination	Date Day/month		Value to be set on the sliding bars (mm) in the Northern Hemisphere	Value to be set on the sliding bars (mm) in the Suthern Hemisphere
-23.26	**21/12**		**101**	**121**
-22	10/1	3/12	96	116
-20	21/1	22/11	87	107
-18	29/1	13/11	77	97
-16	5/2	6/11	68	88
-14	11/2	31/10	58	78
-12	17/2	25/10	49	69
-10	23/2	19/10	39	59
-8	28/2	14/10	29	49
-6	5/3	8/10	19	39
-4	10/3	3/10	10	30
-2	15/3	28/9	0	20
0	**21/3**	**23/9**	**10**	**10**
+2	26/3	18/9	20	0
+4	31/3	12/9	30	10
+6	5/4	6/9	39	19
+8	10/4	2/9	49	29
+10	16/4	27/8	59	39
+12	22/4	21/8	69	49
+14	28/4	15/8	78	58
+16	4/5	9/8	88	68
+18	12/5	1/8	97	77
+20	20/5	23/7	107	87
+22	31/5	12/7	116	96
+23.26	**21/6**		**121**	**101**

Table 1

Correction factors C for installation of in Northern hemisphere

Northern Latitudine	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
Declination of the sun																			
-23	1.11	1.10	1.09	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00
-22	1.11	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00
-20	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00
-18	1.12	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.02	1.01	1.00	1.00	1.00	1.00	1.00
-16	1.12	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00	1.00	1.00
-14	1.13	1.12	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.01	1.00	1.00	1.00	1.00
-12	1.13	1.12	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00	1.00
-10	1.13	1.13	1.12	1.12	1.11	1.10	1.09	1.08	1.08	1.06	1.05	1.04	1.03	1.02	1.01	1.01	1.00	1.00	1.00
-8	1.13	1.13	1.13	1.12	1.11	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00
-6	1.13	1.13	1.13	1.12	1.12	1.11	1.10	1.09	1.08	1.08	1.07	1.06	1.05	1.03	1.02	1.01	1.00	1.00	1.00
-4	1.14	1.13	1.13	1.13	1.12	1.11	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00
-2	1.14	1.14	1.13	1.13	1.12	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.01	1.00	1.00
0	1.14	1.14	1.14	1.13	1.13	1.12	1.11	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00
+2	1.14	1.14	1.14	1.13	1.13	1.13	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01
+4	1.14	1.14	1.14	1.13	1.13	1.13	1.12	1.12	1.11	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.03
+6	1.13	1.13	1.14	1.13	1.13	1.13	1.13	1.12	1.11	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.04	1.04	1.04
+8	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.11	1.11	1.10	1.09	1.08	1.07	1.07	1.05	1.05	1.05
+10	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.12	1.11	1.10	1.09	1.09	1.08	1.08	1.07	1.07	1.06
+12	1.12	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.12	1.11	1.10	1.09	1.09	1.09	1.08	1.08	1.08
+14	1.12	1.12	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.12	1.11	1.10	1.10	1.09	1.10	1.09	1.09	1.09
+16	1.11	1.12	1.12	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.12	1.11	1.11	1.10	1.10	1.11	1.10	1.10	1.09
+18	1.11	1.11	1.12	1.12	1.12	1.13	1.13	1.13	1.12	1.12	1.12	1.12	1.11	1.11	1.11	1.11	1.11	1.11	1.10
+20	1.10	1.11	1.11	1.12	1.12	1.12	1.12	12.12	1.12	1.12	1.12	1.12	1.11	1.11	1.11	1.12	1.12	1.12	1.10
+22	1.10	1.10	1.11	1.11	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.13	1.12	1.11
+23	1.09	1.10	1.10	1.11	1.11	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.13	1.13	1.13	1.12

Table 2

Correction factors C for installation of in southern hemisphere

Southern Latitudine	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
Declination of the sun																			
+23	1.11	1.10	1.09	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00
+22	1.11	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00
+20	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00	1.00	1.00	1.00
+18	1.12	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.02	1.01	1.00	1.00	1.00	1.00	1.00
+16	1.12	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00	1.00	1.00
+14	1.13	1.12	1.12	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.01	1.00	1.00	1.00	1.00
+12	1.13	1.12	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00	1.00
+10	1.13	1.13	1.12	1.12	1.11	1.10	1.09	1.08	1.08	1.06	1.05	1.04	1.03	1.02	1.01	1.01	1.00	1.00	1.00
+8	1.13	1.13	1.13	1.12	1.11	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00	1.00
+6	1.13	1.13	1.13	1.12	1.12	1.11	1.10	1.09	1.08	1.08	1.07	1.06	1.05	1.03	1.02	1.01	1.00	1.00	1.00
+4	1.14	1.13	1.13	1.13	1.12	1.11	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00	1.00
+2	1.14	1.14	1.13	1.13	1.12	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.01	1.00	1.00
0	1.14	1.14	1.14	1.13	1.13	1.12	1.11	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01	1.00
-2	1.14	1.14	1.14	1.13	1.13	1.13	1.12	1.11	1.10	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.02	1.01
-4	1.14	1.14	1.14	1.13	1.13	1.13	1.12	1.12	1.11	1.11	1.10	1.09	1.08	1.07	1.06	1.05	1.04	1.03	1.03
-6	1.13	1.13	1.14	1.13	1.13	1.13	1.13	1.12	1.11	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.04	1.04	1.04
-8	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.11	1.11	1.10	1.09	1.08	1.07	1.07	1.05	1.05	1.05
-10	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.12	1.11	1.10	1.09	1.09	1.08	1.08	1.07	1.07	1.06
-12	1.12	1.13	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.12	1.11	1.10	1.09	1.09	1.09	1.08	1.08	1.08
-14	1.12	1.12	1.13	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.12	1.11	1.10	1.10	1.09	1.10	1.09	1.09	1.09
-16	1.11	1.12	1.12	1.13	1.13	1.13	1.13	1.13	1.12	1.12	1.12	1.11	1.11	1.10	1.10	1.11	1.10	1.10	1.09
-18	1.11	1.11	1.12	1.12	1.12	1.13	1.13	1.13	1.12	1.12	1.12	1.12	1.11	1.11	1.11	1.11	1.11	1.11	1.10
-20	1.10	1.11	1.11	1.12	1.12	1.12	1.12	12.12	1.12	1.12	1.12	1.12	1.11	1.11	1.11	1.12	1.12	1.12	1.10
-22	1.10	1.10	1.11	1.11	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.13	1.12	1.11
-23	1.09	1.10	1.10	1.11	1.11	1.11	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.13	1.13	1.13	1.12

Table 3

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FREE SPIRITS GREEN LABS PVT. LTD.
WZ 49, 1ST Floor, Budella, Vikas Puri, New Delhi - 110018
GST: 07AACCF3845R1Z3

P: +91 8800606858 | E: sales@trackso.in

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