Part No. 111.1008

CE 2020

USER'S GUIDE

for

MIDDLETON SOLAR

ER08-S, ER08-SE, ER08-SC

FAST RESPONSE
CLASS B/A PYRANOMETER

Date: June 2021

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Middleton Solar, made in Australia.
Solar Measurement Specialists

www.middletonsolar.com

CONTENTS page

1 GENERAL

The ER08-S Pyranometer is for measuring total solar Global Horizontal Irradiance on a plane surface. It exceeds the requirements for an ISO 9060:2018 Fast Response Spectrally Flat Class B or Class A Pyranometer. An available internal heater will keep the dome clear of dew/snow. The ER08-SE version has an in-built signal amplifier. The ER08-SC version has a 4-20mA output.

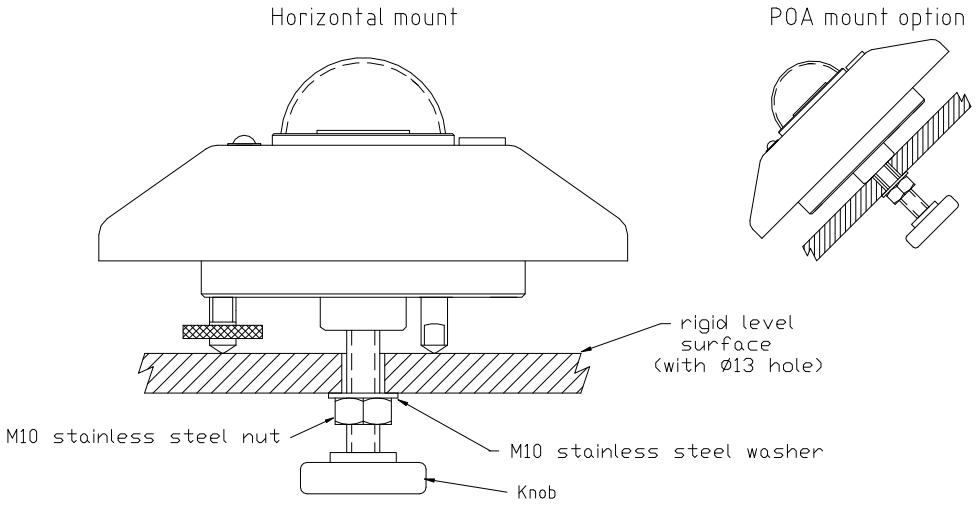
2 CONSTRUCTION

The ER08-S detector incorporates a cosine-corrected entrance aperture, a compact integrating cavity, and an encapsulated thermopile with a Field-Of-View restricted to the cavity. The detector has been designed to give exceptionally low zero off-set and very fast response so that the measurement uncertainty is reduced in comparison to conventional pyranometer designs that use an exposed blackened thermopile. The ER08-S thermopile generates a passive microvolt output proportional to the intensity of the incident radiation; it is equally responsive to all radiation wavelengths. The instrument body is machined from marine-grade aluminium, anodized to provide a durable corrosion-resistant finish.

3 INSTALLATION

3.1 SITE SELECTION

For global radiation measurement, select a site where obstructions do not exceed 5° of elevation, in the path followed by the sun, between earliest sunrise and latest sunset throughout the year. Avoid positioning the instrument near light coloured objects (eg. painted walls) which can cause errors due to reflection of radiation onto the instrument; also avoid siting near sources of artificial light.



3.2 MOUNTING

The ER08-S should be mounted on a rigid level surface. The instrument has a central M10 x 1.5p hole in the base. The mounting knob supplied should be screwed into this hole and the instrument mounted, as shown above, using the washer & nut provided. Adjust the height of the feet so the circular level is centred. Secure the knob & nut finger-tight (do not over-tighten). The feet can be removed for plane-of-array (POA) installation required for photovoltaic (PV) assessment.

3.3 ELECTRICAL CONNECTION, ER08-S

The ER08-S has a shielded output cable. The cable shield can be grounded at the measurement end. Do not connect any power supply to the output wires.
The cable cores are:

red = output +ve (typically 7 μV per W/m^2)
blue = output –ve
(temperature option: yellow & green = thermistor, see Appendix E)
(heater option: yellow & green = 12VDC, 3W)

The measurement equipment should range up to 15mV and have an input impedance of at least 10MΩ. Use differential inputs for measurement.

3.4 ELECTRICAL CONNECTION, ER08-SE

The ER08-SE has a shielded output cable. The cable shield can be grounded at the measurement end.

red = supply +V (7 to 15VDC, 6mA), blue = supply 0V
yellow = output +ve (1mV per W/m^2), green = output –ve

Avoid ground loop interference in your measurement setup by ensuring there is only one ground point for the sensor and measurement system; do not connect the supply 0V (blue) and output –ve (green) together as this may cause a signal offset. The measurement equipment should range up to 2V and have an input impedance of at least 1MΩ. Use differential inputs for measurement.

3.5 ELECTRICAL CONNECTION, ER08-SC

The ER08-SC has a shielded output cable. The cable shield can be grounded at the measurement end.

red = power supply positive (7 to 15VDC, 15 to 20mA)
blue = power supply negative
yellow = signal current output positive (typically 100W/m^2 per mA)
green = signal current output negative

Use 4-20mA current loop input connection to your measurement equipment.

4 MAINTENANCE

Keep the glass dome clean. Use only water and mild detergent to gently wash the surface. If the dome is cracked or pitted it should be replaced.

The ER08-S instrument is hermetically sealed and contains desiccant to ensure that the interior remains dry. The desiccant is orange silica gel (non-toxic). The desiccant should be replaced when the instrument undergoes periodic calibration[1]. The silica gel changes from orange to clear if moisture has entered the instrument.

To gain access to the desiccant remove the three socket screws that hold the body to the top (it is not necessary to remove the shade disk). When refitting the body take care to locate the O-ring in its groove before securing the three socket screws.

[1] desiccant capacity was increased, from S/No. 6062, to enable 5 year before replacement

5 CALIBRATION

Each pyranometer is individually calibrated during manufacture. The ER08-S has excellent long-term stability; however it is recommended that the calibration be checked periodically to maintain measurement confidence.
Two International Standards for pyranometer calibration are:

- ISO 9846: 1993(E), Calibration of a pyranometer using a pyrheliometer.
- ISO 9847: 1992(E), Calibration of field pyranometers by comparison to a reference pyranometer.

6 UNCERTAINTY

The main factors contributing to combined measurement uncertainty are:

Initial calibration: The ER08-S series is calibrated outdoors in sunlight. This method has less uncertainty than indoors calibration, using artificial 'sunlight'.

Temperature response: Thermopiles exhibit a variation in response with temperature. A thermistor based compensation circuit is used in the ER08-S to minimise the response error of the instrument. A temperature output is available on the ER08-S Class A version. Appendix A shows a chart of typical EQ08-S temperature response.

Directional error: The geometry of the ER08-S entrance aperture gives excellent directional response. Use of a single glass dome also reduces the directional error compared to a conventional dual-dome configuration. Appendix B shows a typical chart of ER08-S directional response.

Response Time: The ER08-S has a very fast time constant (0.1s) compared to conventional thermopile type Pyranometers. Fast response gives less 'lag error' in rapidly changing solar irradiance conditions such as caused by scattered clouds. Appendix C shows how a conventional thermopile Pyranometer can under-report true solar energy because the truncated irradiance maxima are incompletely compensated by the elevated minima.

Zero off-set: Infra-red off-set error, due to radiation exchange between the thermopile and the glass dome, is known as 'zero off-set A'. Conventional thermopile Pyranometers use blackened thermal sensors directly exposed to a glass dome and can have significant 'zero off-set A' entangled in their response. The Integrating cavity configuration of the ER08-S isolates the thermopile from the glass dome to diminish the 'zero off-set A' to almost nothing.
Zero off-set error due to temperature transients affecting the thermal balance of the thermopile is known as 'zero off-set B'. The ER08-S thermopile is encapsulated in inert gas; the 'zero off-set B' is almost zero.
Appendix D shows the zero off-set A & B response of the ER08-S.

Non-linearity: The thermopile used in the ER08-S has excellent linearity of response.

Non-stability: The sensitivity of the ER08-S can exhibit a small downward trend of 0.1%/year due to accumulated UV degradation.

On-site installation: User responsibility. The field of view must be clear, and the pyranometer must be level. A tilt error of 0.15deg can give a signal error exceeding 1% when the sun elevation is 10° above the horizon on a clear sunny day.

Measurement equipment: User responsibility. Logger must have high input impedance, high resolution, excellent linearity, and excellent voltage accuracy. No ground-loop errors in measurement equipment wiring.

Internal Heater: The optional internal heater does not compromise the zero off-set performance of the ER08-S because the sensor thermopile is thermally de-coupled from the body and glass dome.

7 TECHNICAL SPECIFICATION

Performance Specification	**ISO 9060:2018[2] Spectrally Flat Class A**	**ER08-S, ER08-SE, ER08-SC**
Response time (to 95%)[3]	< 0.5 sec	0.3 sec
Zero off-set a) -200 $W.m^{-2}$ thermal rad.	± 7 $W.m^{-2}$	< ± 0.2 $W.m^{-2}$ (unventilated)
Zero off-set b) 5 $K.h^{-1}$ ambient temp.	± 2 $W.m^{-2}$	< ± 0.2 $W.m^{-2}$ (heater off) < ± 1.0 $W.m^{-2}$ (heater on)[4]
Zero off-set c) total response	± 10 $W.m^{-2}$	< ± 5 $W.m^{-2}$
Non-stability (1 year interval)	± 0.8 %	< 0.1 %
Non-linearity (100-1000 $W.m^{-2}$)	± 0.5 %	< ± 0.2 %
Directional response (w.r.t. 1000 $W.m^{-2}$)[5]	± 10 $W.m^{-2}$	< ± 10 $W.m^{-2}$
Spectral error (280 to 4,000 nm)	± 0.5 $W.m^{-2}$	< ± 0.4 $W.m^{-2}$
Spectral selectivity (350 to 1,500 nm)[6]	< 3 %	< 3 %
Temperature response (-10 to +40 °C)	± 1 %	< ± 1 %
Tilt response (0-90°)	± 0.5 %	< ± 0.2 %
Additional signal processing errors	± 2 $W.m^{-2}$	ER08-S, not applicable ER08-SE/SC < ± 2 $W.m^{-2}$

General Specification

viewing angle	2π steradians
irradiance	0 - 4,000 $W.m^{-2}$
spectral range	300 – 3,000nm (nominal); 305 - 2,700nm (50% points)
Sensitivity (typical)	ER08-S: 7 $\mu V/W.m^{-2}$; ER08-SE: 1.0 $mV/W.m^{-2}$ ER08-SC: 100±5 $W.m^{-2}$/mA, 0-1,600 $W.m^{-2}$
calibration	outdoors to ISO 9847, traceable to WRR
achievable uncertainty (minute totals)	U_{95} = 3% (RSS of instrument, calibration, measurement)
operating temperature	-40 to +80°C
operating humidity	0-100% RH
output impedance (not ER08-SC)	ER08-S: 6K Ω ; ER08-SE: 65 Ω
measurement input impedance	ER08-S: >10 MΩ ; ER08-SE: >1 MΩ
power requirement (not ER08-S)	7 to 15VDC, 6mA (ER08-SE), 15-20mA (ER08-SC)
available internal heater	12VDC, 3W
bubble level resolution	0.1°
level adjustment	one fixed foot, two adjustable feet
detector type	encapsulated thermopile
dome window	ground from solid optical glass blank; Schott N-BK10
construction	anodized marine-grade aluminium & stainless steel
desiccant	orange silica gel (non-toxic); 5-year replacement cycle
IP rating	sealed to IP67
mounting method	central M10 hole in base (mounting knob supplied), or two M4 holes on 65mm P.C.D.
output lead	6m, with connector at instrument end
net weight	0.8Kg
warranty	2 years (standard) / 5 years (conditional)

[2] ISO 9060:2018 Specification and classification of instruments for measuring hemispherical solar and direct solar radiation

[3] This requirement designates a Pyranometer as 'fast response' in ISO 9060:2018

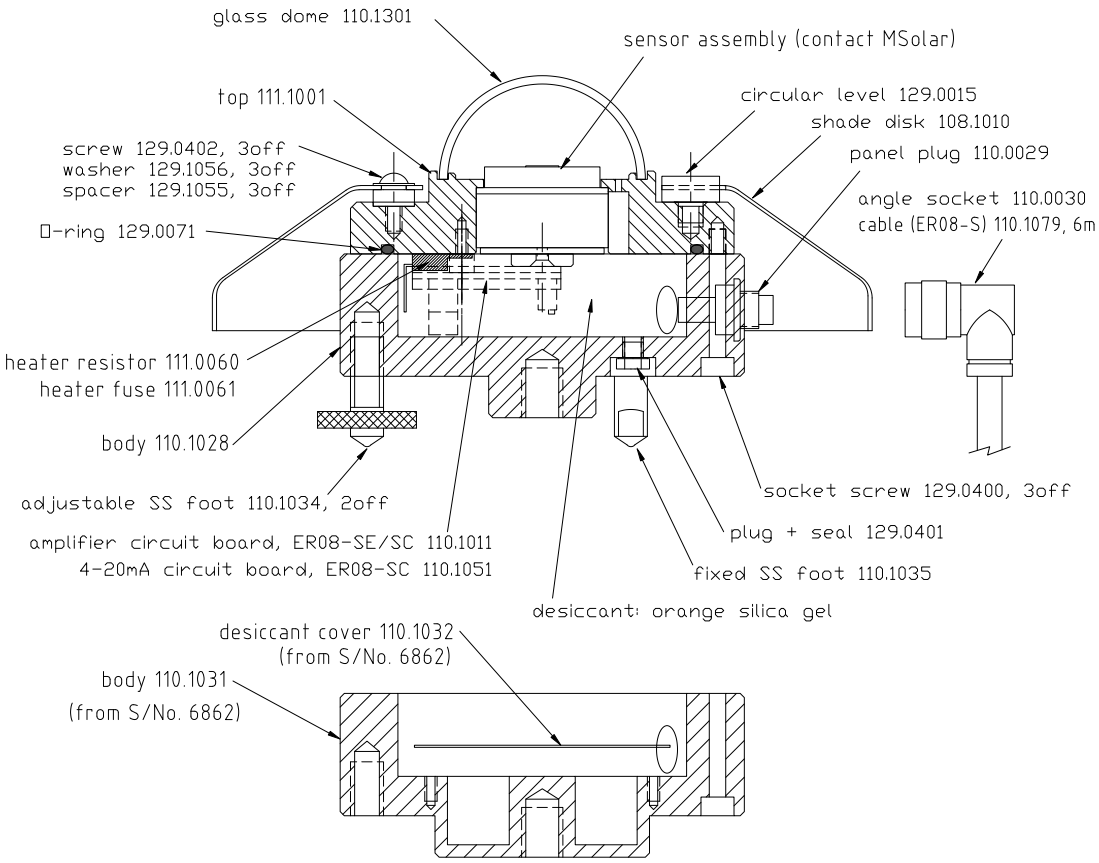
[4] heater is available option on ER08-S version only

[5] ISO 9060:2018 requires that a 'Class A' pyranometer be individually tested for Directional & Temperature Response

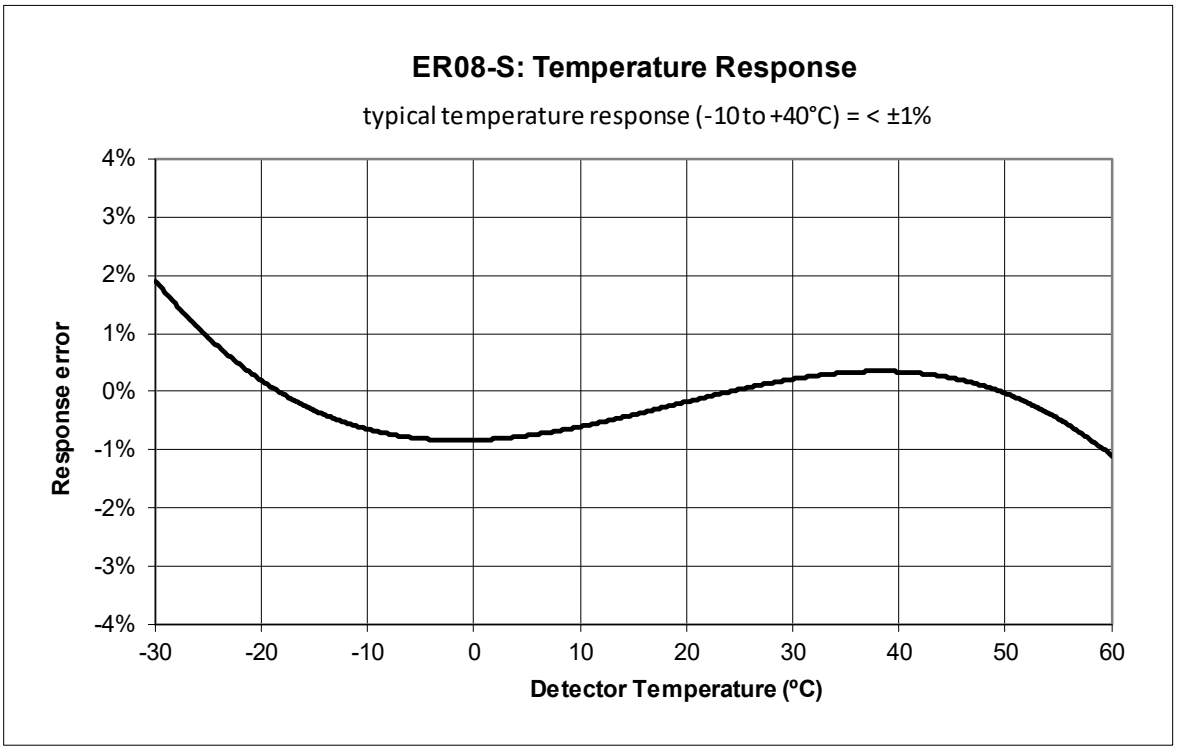
[6] This requirement designates a Pyranometer as 'spectrally flat' in ISO 9060:2018

8 SPARE PARTS

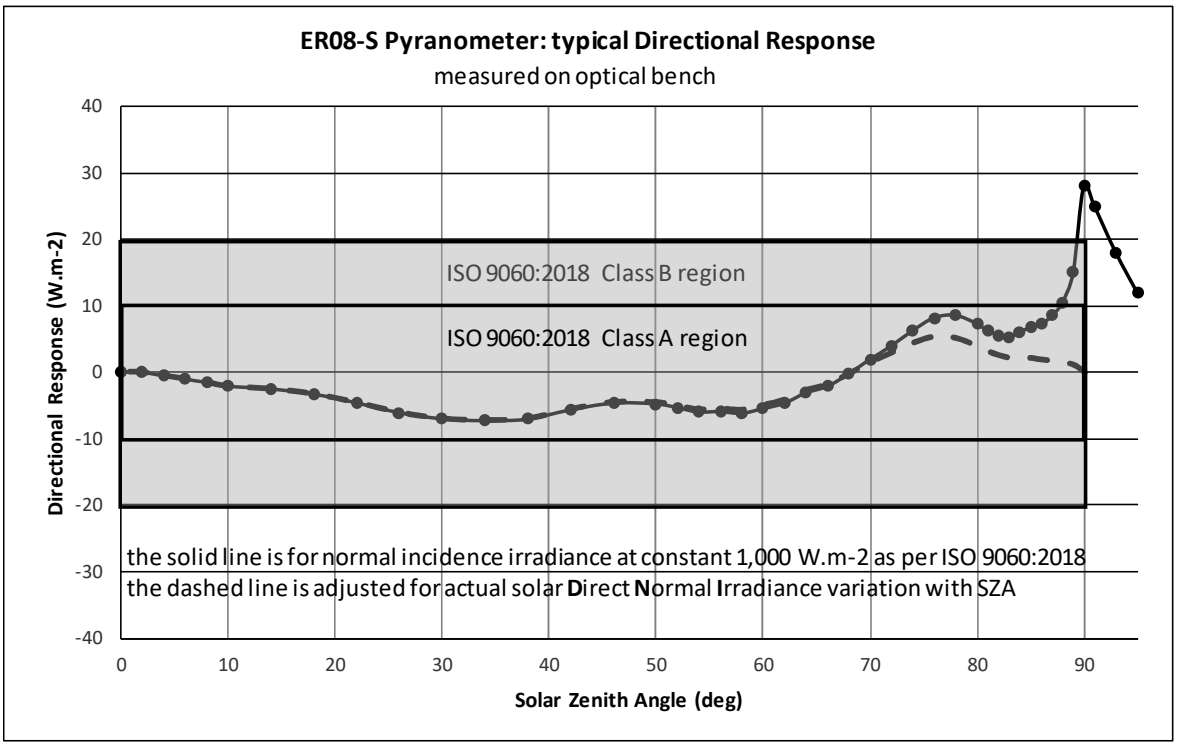
Spare parts may be ordered from the manufacturer or through an approved distributor. For your convenience the part name and number is shown below. Please quote both when ordering. It is also important when ordering parts to include the Serial Number of the instrument, this is inscribed on the identification label of the unit.



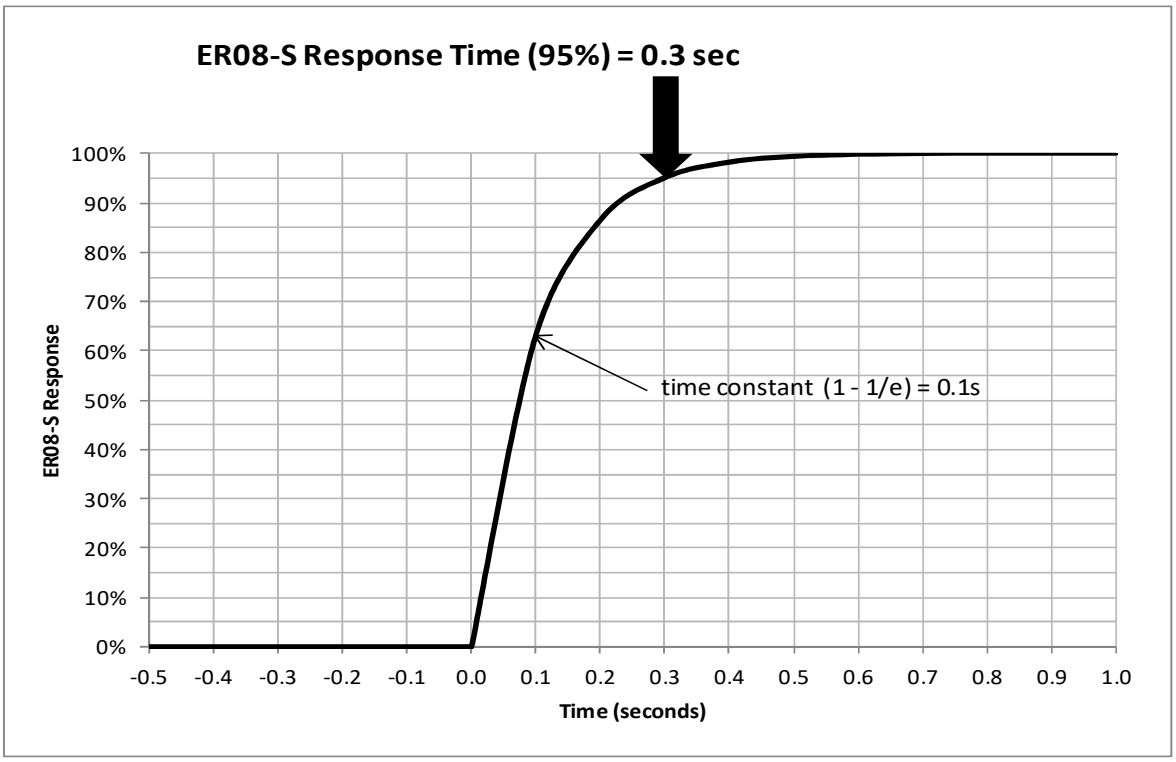
Appendix A: TEMPERATURE RESPONSE

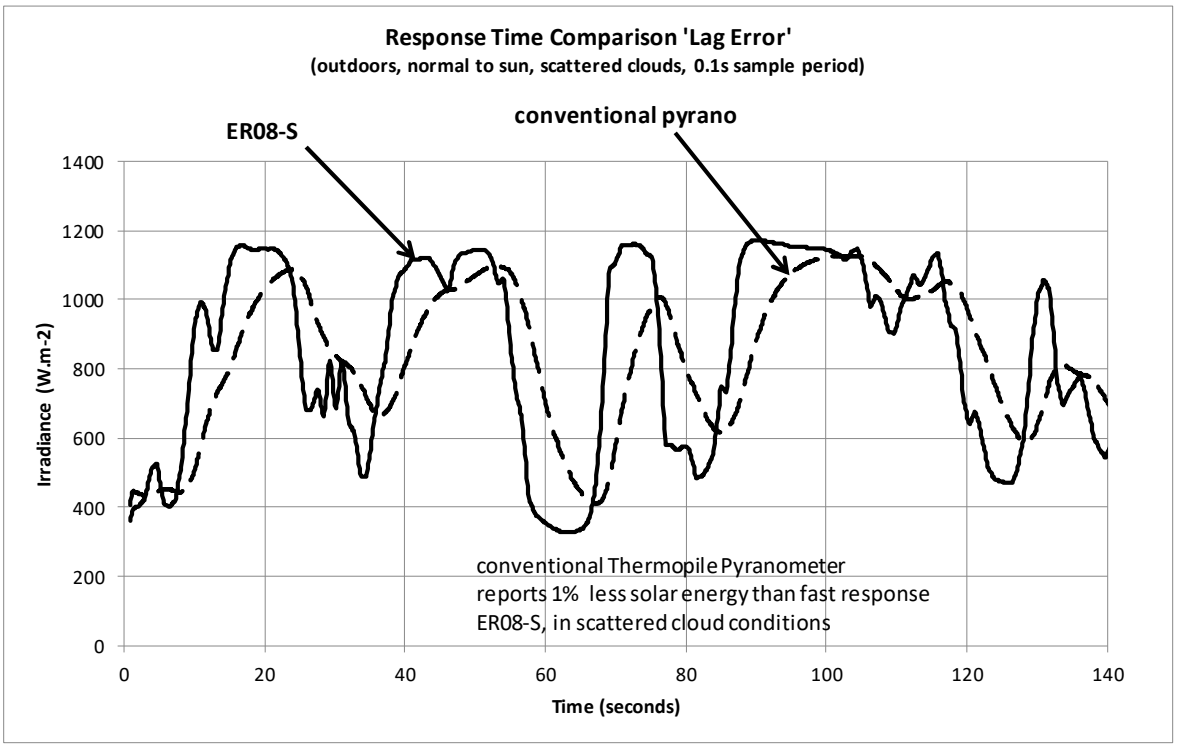


Appendix B: DIRECTIONAL RESPONSE

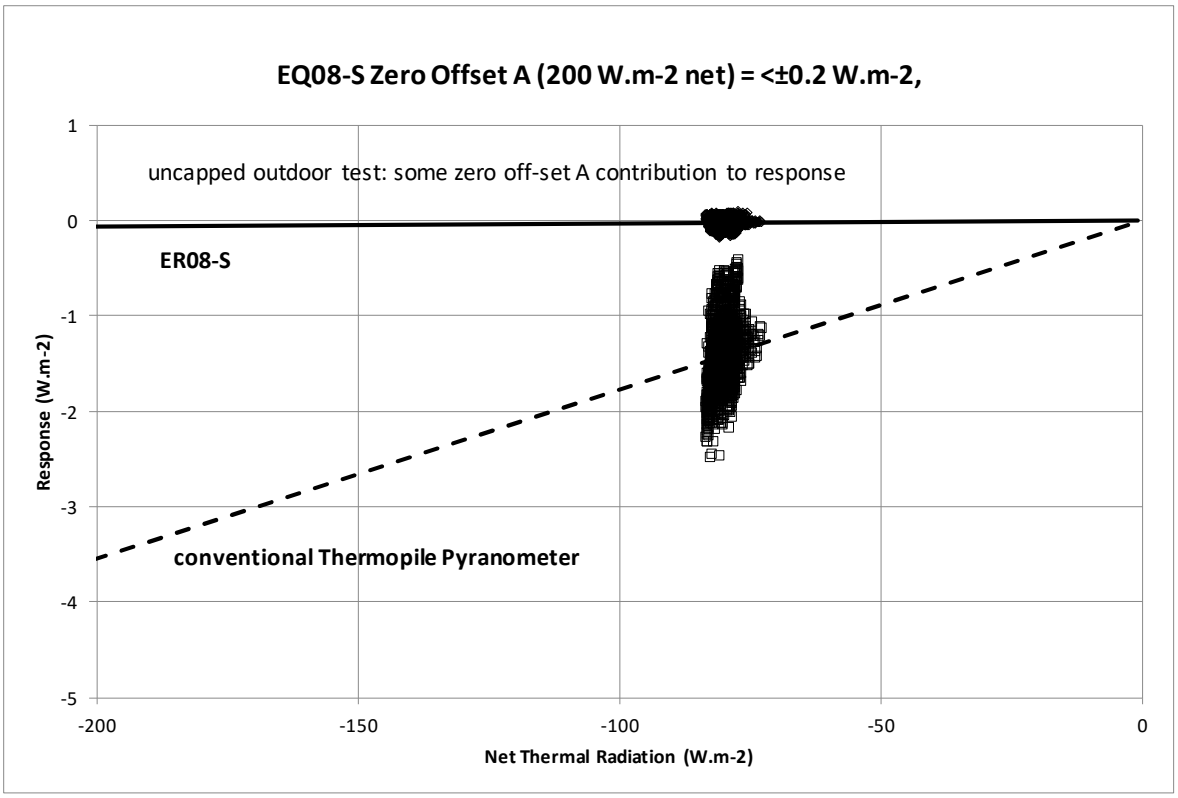


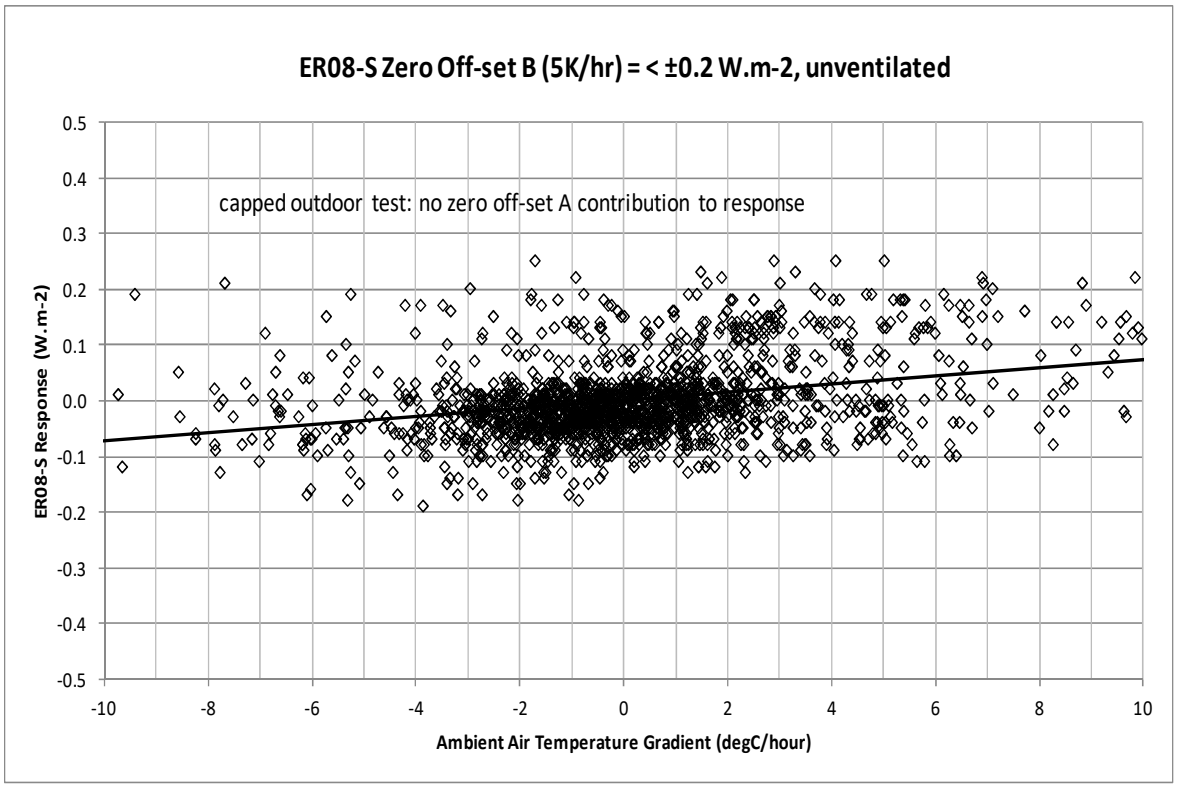
Appendix C: TIME RESPONSE





Appendix D: ZERO OFF-SET RESPONSE





Appendix E: TEMPERATURE vs THERMISTOR RESISTANCE
For ER08-S fitted with temperature output

YSI 44031 Thermistor (accuracy = ±0.2ºC)

Temperature (ºC)	Resistance (Ω)	Temperature (ºC)	Resistance (Ω)
-30	135,200	15	15,130
-29	127,900	16	14,500
-28	121,100	17	13,900
-27	114,600	18	13,330
-26	108,600	19	12,790
-25	102,900	20	12,260
-24	97,490	21	11,770
-23	92,430	22	11,290
-22	87,660	23	10,840
-21	83,160	24	10,410
-20	78,910	25	10,000
-19	74,910	26	9605
-18	71,130	27	9227
-17	67,570	28	8867
-16	64,200	29	8523
-15	61,020	30	8194
-14	58,010	31	7880
-13	55,170	32	7579
-12	52,480	33	7291
-11	49,940	34	7016
-10	47,540	35	6752
-9	45,270	36	6500
-8	43,110	37	6258
-7	41,070	38	6026
-6	39,140	39	5805
-5	37,310	40	5592
-4	35,570	41	5389
-3	33,930	42	5193
-2	32,370	43	5006
-1	30,890	44	4827
0	29,490	45	4655
1	28,150	46	4489
2	26,890	47	4331
3	25,690	48	4179
4	24,550	49	4033
5	23,460	50	3893
6	22,430	51	3758
7	21,450	52	3629
8	20,520	53	3504
9	19,630	54	3385
10	18,790	55	3270
11	17,980	56	3160
12	17,220	57	3054
13	16,490	58	2952
14	15,790	59	2854