

CE 2026

USER'S GUIDE

for

MIDDLETON SOLAR

ER09-AE and ER09-AI

FAST RESPONSE

CLASS B/A PYRANOMETER

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Middleton Solar, made in Australia.
Solar Measurement Specialists

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1 GENERAL

The ER09 series 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 ER09-AE version has a precision signal amplifier to give a millivolt output for easy measurement. The ER09-AI has the signal amplifier configured for a 4-20mA output.

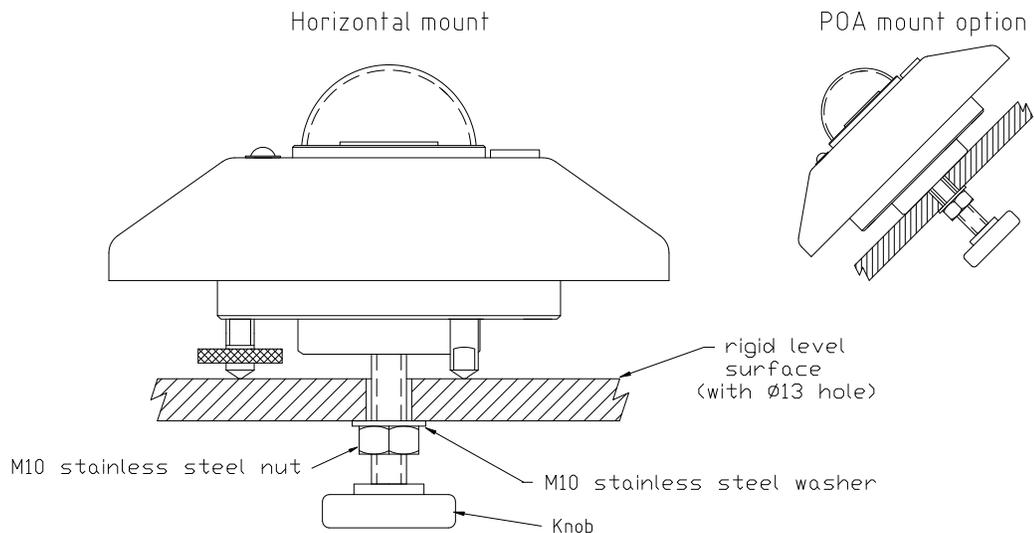
2 CONSTRUCTION

The ER09 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 ER09 thermopile generates a passive microvolt output proportional to the intensity of the incident radiation; it is equally responsive to all radiation wavelengths. The instrument fabricated 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 ER09 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, ER09-AE (analog volt output).

The ER09-AE has a shielded output cable. The shield can be grounded at the measurement end. Do not connect any power supply to the output wires.

The cable cores are:

red = supply +V (12VDC, 20mA),	blue = supply 0V
yellow = output +ve (1mV per $W.m^{-2}$),	green = output -ve
(temperature option: white & black = thermistor, see Appendix E)	
(heater option: white & black = 12VDC, 3W)	

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 $1M\Omega$. Use differential inputs for measurement.

3.4 ELECTRICAL CONNECTION, ER09-AI (4-20mA output).

The ER09-AI has a shielded output cable. The shield can be grounded at the measurement end. Do not connect any power supply to the output wires.

The cable cores are:

red = supply +V (12VDC, 20mA),	blue = supply 0V
yellow = output +ve (0.01 mA/ $W.m^{-2}$),	green = output -ve
(temperature option: white & black = thermistor, see Appendix E)	
(heater option: white & black = 12VDC, 3W)	

The measurement equipment should accept 4-20mA input. 4mA represents a signal of 0 $W.m^{-2}$, and 20mA represents a signal of 1,600 $W.m^{-2}$.

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 ER09 instrument is hermetically sealed and contains desiccant to ensure that the interior remains dry. The desiccant is orange silica gel (non-toxic). The silica gel colour changes to green if moisture has entered the instrument. The desiccant life is up to 5-years.

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.

5 CALIBRATION

Each pyranometer is individually calibrated during manufacture. The ER09 has excellent long-term stability; however it is recommended that the calibration be checked every 2-years to maintain measurement confidence.

Two International Standards for pyranometer calibration are:

ISO 9846:2025, calibration of a pyranometer using a pyrliometer;

ISO 9847:2023, calibration of pyranometers by comparison to a reference pyranometer

6 UNCERTAINTY

The main factors contributing to combined measurement uncertainty are:

Initial calibration: The ER09 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 ER09 to minimise the response error of the instrument. A temperature output is an available option. Appendix A shows a sample plot ER09 temperature response.

Directional response: The ER09 uses a Hybrid Glass Diffuser to scatter efficiently from the UV to the NIR wavelengths. The geometry of the ER09 entrance aperture gives excellent directional response. Use of a single glass dome also reduces the directional error, compared to a conventional dual-dome configuration, as the internal-reflection caustic from the inner dome is not present. Appendix B shows a sample plot of ER09 directional response.

Response Time: The ER09 has a very fast time constant (0.1s) compared to conventional thermopile type Pyranometers (3.0s). Fast response gives less 'lag error' in rapidly changing solar irradiance conditions such as caused by scattered clouds. A slow-response conventional thermopile Pyranometer can under-report true solar energy because maxima are underestimated and minima are overestimated. Appendix C shows the ER09 time response.

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 ER09 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 ER09 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 ER09.

Non-linearity: The thermopile used in the ER09 has excellent linearity of response.

Non-stability: The sensitivity of the ER09 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 unduly compromise the zero off-set performance of the ER09 because the sensor thermopile is thermally decoupled from the body and the glass dome, and it has a fast response time to quickly re-establish thermal equilibrium.

7 TECHNICAL SPECIFICATION

Performance Specification	ISO 9060:2018 ¹ Spectrally Flat Class A	ER09-AE and ER09-AI
Response time (to 95%) ²	< 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)
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) ³	± 10 W.m ⁻²	< ± 10 W.m ⁻²
Spectral error (280 to 4,000 nm)	± 0.5 %	< ± 0.5 %
Spectral selectivity (350 to 1,500 nm) ⁴	< 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	< ± 2 W.m ⁻²

General Specification

viewing angle	2π steradians
irradiance (max)	ER09-AE: 0 - 4,000 W.m ⁻² ; ER09-AI: 0 - 1,600 W.m ⁻²
spectral range	300 – 3,000nm (nominal); 305 - 2,700nm (50% points)
sensitivity	ER09-AE: 1.0 mV/W.m ⁻² ER09-AI: 0.01 mA/W.m ⁻²
output signal range (typical)	ER09-AE: 0 - 2V ER09-AI: 4 - 20mA
calibration (factory)	outdoors, based on ISO 9847; SI traceable
achievable uncertainty (minute totals)	U ₉₅ = 3% (RSS of instrument, calibration, measurement)
operating temperature	-35 to +60°C (-40 to +80°C available option)
operating humidity	0-100% RH
measurement input impedance	ER09-AE: >1 MΩ
power requirement	12VDC ±1V, < 20mA
available internal heater	12VDC, 3W
bubble level resolution	0.1°
level adjustment	one fixed foot, two adjustable feet
detector type	miniature encapsulated thermopile
dome window	ground from solid optical glass
construction	anodized marine-grade aluminium & stainless steel
desiccant	orange silica gel (non-toxic); up to 5-year life
IP rating	sealed to IP67
mounting method	central M10 hole in base (mounting knob supplied)
output lead	6m, with connector at instrument end
User's Guide & Calibration Certificate	included
net weight	0.8Kg
shipping size & weight	230 x 230 x 180mm, 2Kg
warranty	2 years (standard) / 5 years (conditional)

¹ ISO 9060:2018 Specification and classification of instruments for measuring hemispherical solar and direct solar radiation

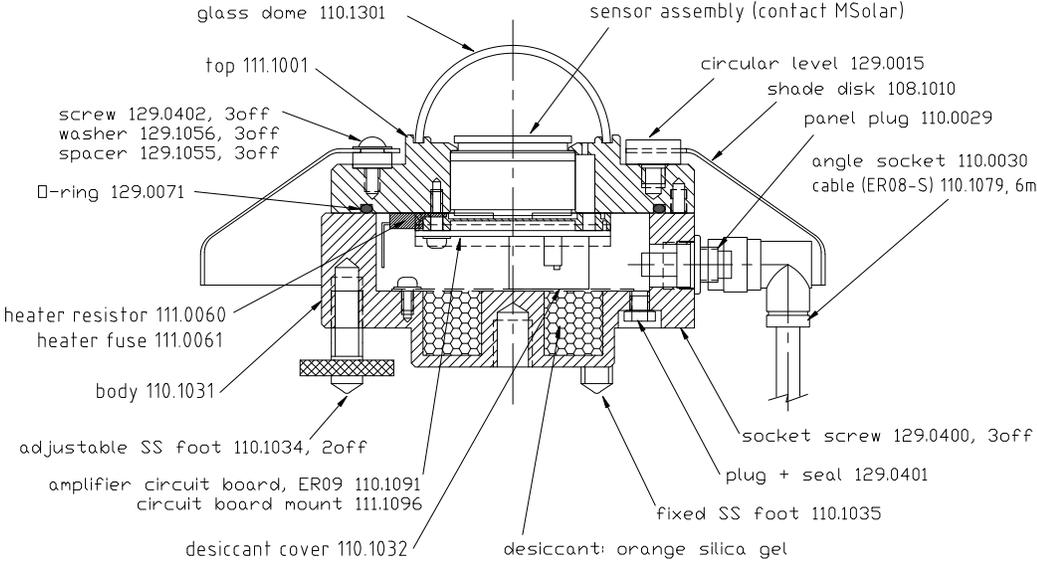
² This requirement designates a Pyranometer as 'fast response' in ISO 9060:2018

³ ISO 9060:2018 requires that a 'Class A' pyranometer be individually tested for Directional & Temperature Response

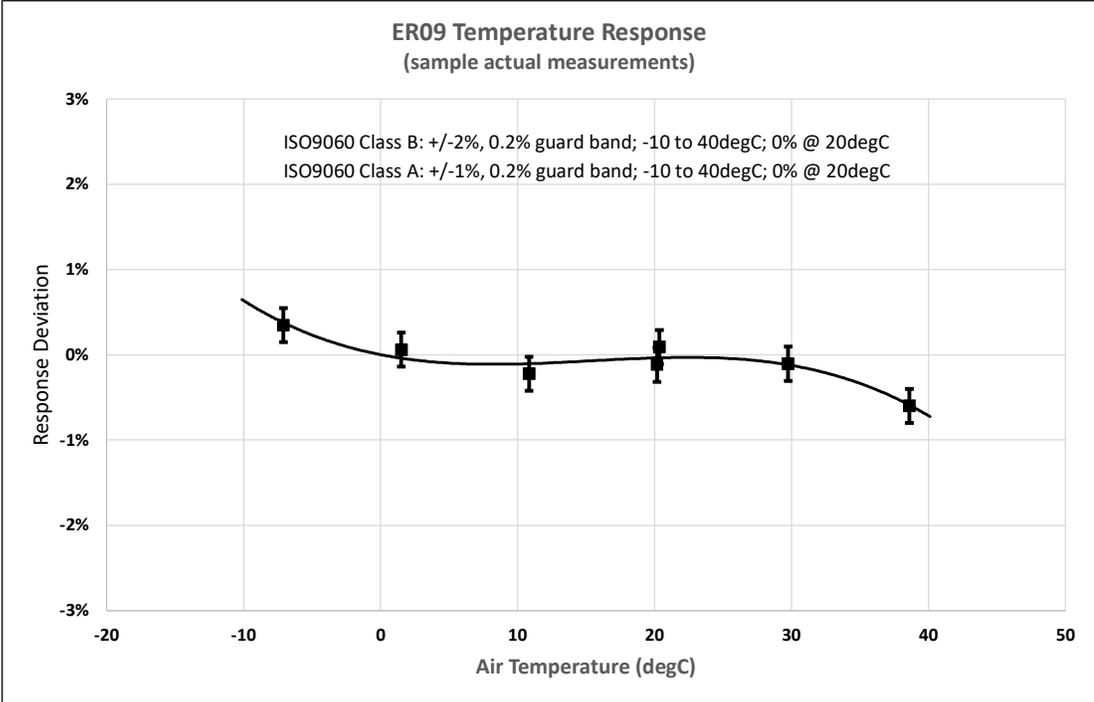
⁴ This requirement designates a Pyranometer as 'spectrally flat' in ISO 9060:2018

8 SPARE PARTS

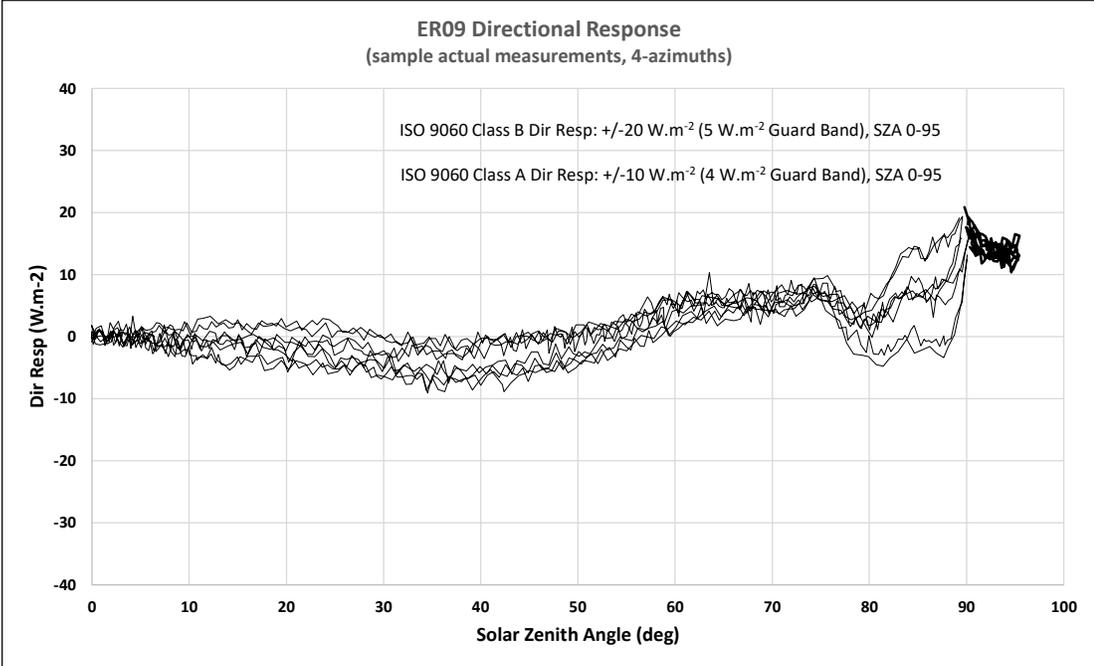
ER09 spare parts may be ordered from the manufacturer or through an approved distributor. For your convenience the part name and number is shown below. Please quote both when ordering. It is also important when ordering parts to include the Serial Number of the instrument, this is inscribed on the identification label of the unit.



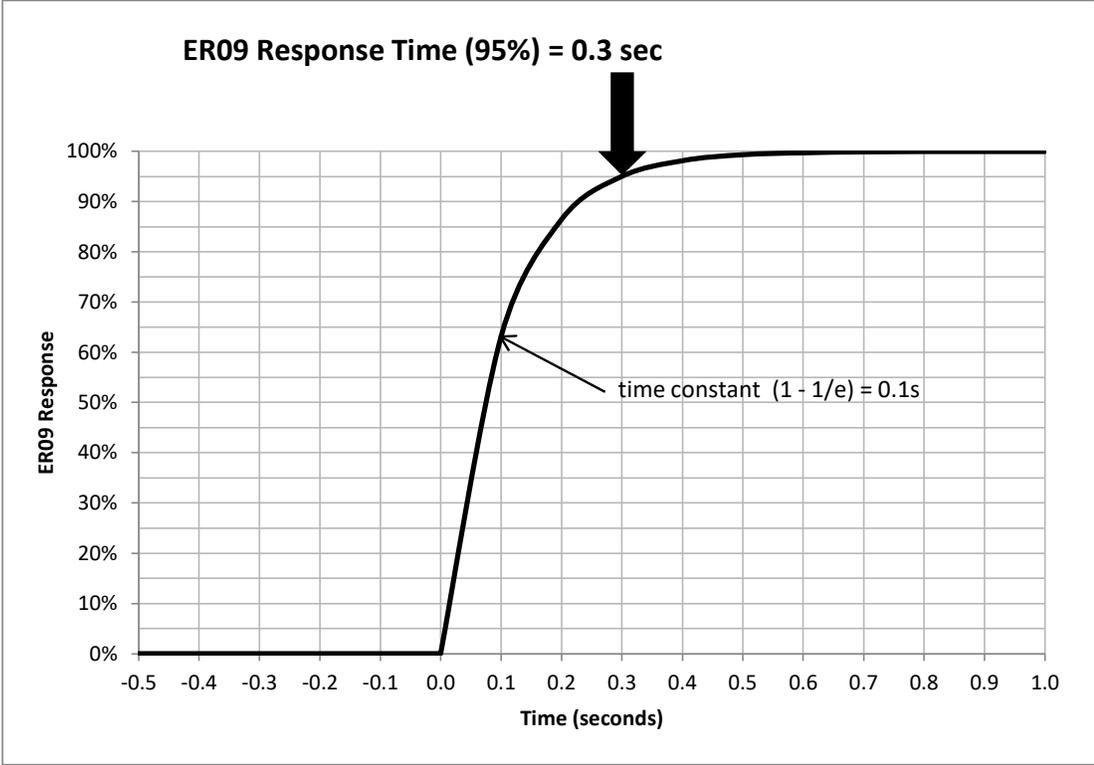
Appendix A: TEMPERATURE RESPONSE



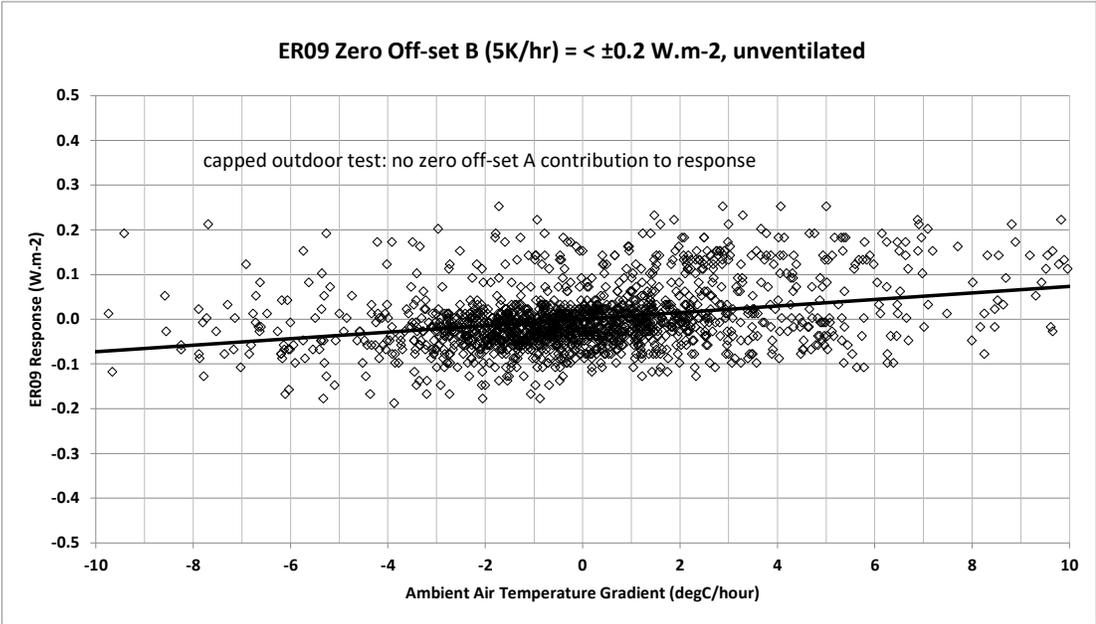
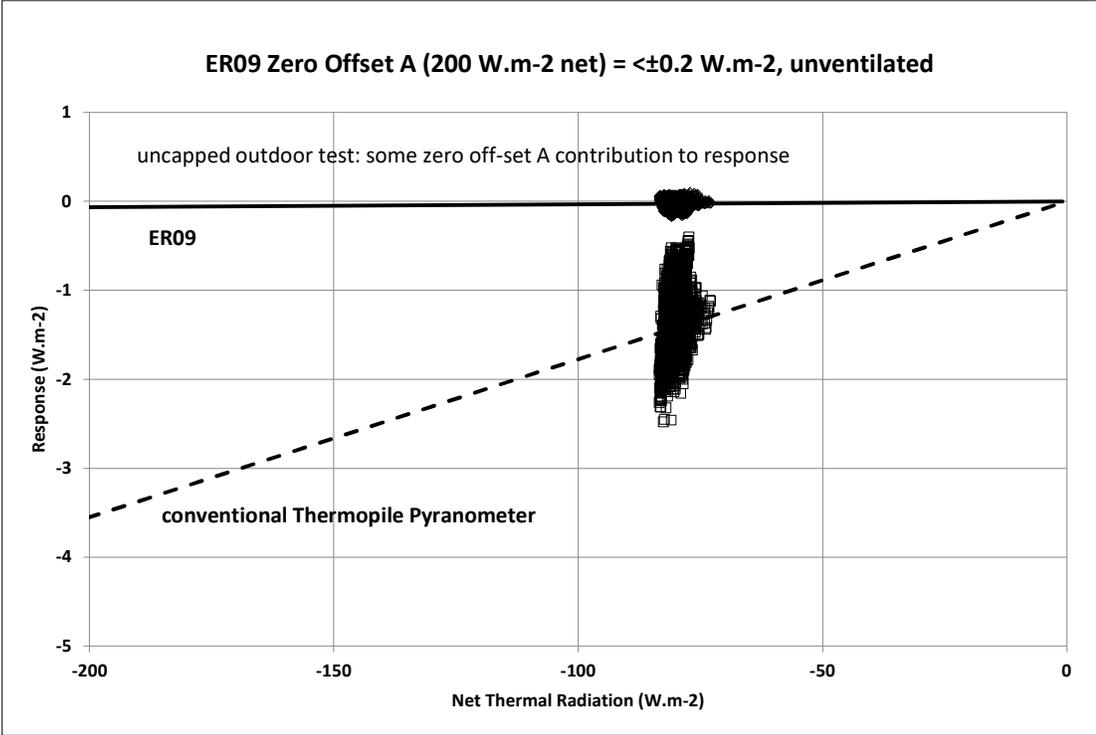
Appendix B: DIRECTIONAL RESPONSE



Appendix C: TIME RESPONSE



Appendix D: ZERO OFF-SET RESPONSE



Appendix E: TEMPERATURE vs THERMISTOR RESISTANCE
For ER09 fitted with available temperature output

YSI 44031 Thermistor (accuracy = $\pm 0.2^{\circ}\text{C}$)

Temperature ($^{\circ}\text{C}$)	Resistance (Ω)	Temperature ($^{\circ}\text{C}$)	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