EPPLEY PSP

**Precision Spectral Pyranometer
Instruction Manual**

6/92

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CAMPBELL SCIENTIFIC, INC.

EPPLEY PSP
PRECISION SPRECTRAL PYRANOMETER

1. GENERAL

The EPPLEY Precision Spectral Pyranometer (PSP) is a high quality pyranometer. It is primarily used where high accuracy is required or where it is used as a standard to calibrate other pyranometers.

This manual provides information for interfacing a CR10, 21X, and CR7 datalogger to a PSP. An instruction manual provided by EPPLEY contains the sensor calibration constant and serial number. Cross check this serial number against the serial number on your PSP to ensure that the given calibration constant corresponds to your sensor.

2. MEASUREMENT INSTRUCTION

The PSP (refer to Figure 1) outputs a low level voltage ranging from 0 to a maximum of about 12mV depending on sensor calibration and radiation level. A differential voltage measurement (Instruction 2) is recommended because it has better noise rejection than a single-ended measurement.

If a differential channel is not available, a single-ended measurement (Instruction 1) is a possibility. As a test, wire the PSP as shown in Figure 2 and make single-ended and differential measurements. Compare results to determine the acceptability of a single ended measurement.
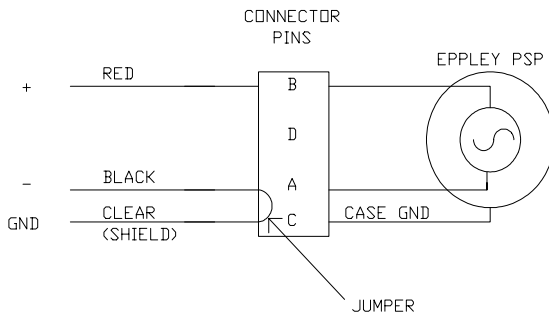

Figure 1. PSP Schematic

NOTE FOR 21X USERS: Slight ground potential differences are created along the 21X analog terminal strip when the datalogger power supply is powering external peripherals. If the peripherals draw 30mA or greater, the PSP must be measured differentially.

INPUT RANGE

An example showing how to determine the optimum input range for a given sensor calibration and maximum irradiance follows. **This is an example only. Your values will be different.**

EXAMPLE

- Sensor Calibration: Assume the sensor calibration is 8.61 microvolts W^{-1} m^2. This is equivalant to 8.61 millivolts kW^{-1} m^2.

- Maximum Irradiance: A reasonable estimate of maximum irradiance at the earth`s surface is 1 kW m^{-2}.

- Input Range Selection: An estimate of the maximum input voltage is obtained by multiplying the calibration by the maximum expected irradiance. That product is 8.61mV for this example. Select the smallest input range which is greater than the maximum expected input voltage. In this case the 15mV range for the 21X and CR7, and the 25mV range for the CR10 are selected.

Measurement integration time is specified in the input range parameter code. A more noise free reading is obtained with the slow or 60 Hz rejection integration. A fast integration takes less power and allows for faster throughput.

MULTIPLIER

The multiplier converts the millivolt reading to engineering units. Commonly used units and how to calculate the multiplier are shown in Table 1.

Table 1. Multipliers and Output Processing

UNITS	MULTIPLIERS	OUTPUT/ PRCSS
kJ m-2	(1/C)*t	(Total)
kW m-2	(1/C)	(Averages)
cal cm-2	(1/C)*t*(0.0239)	(Total)
cal cm-2 min-1	(1/C)*(1.434)	(Averages)

C = (EPPLEY calibration)
t = datalogger program execution interval in seconds

3. OUTPUT FORMAT CONSIDERATIONS

The largest number that the datalogger can output is 6999 in low resolution and 99999 in high resolution (Instruction 78, set resolution). If the measurement value is totalized, there is some danger of overranging the output limits, as shown in the following example.

EXAMPLE

Assume that **daily total flux** is desired, and the datalogger scan rate is 1 second. With a multiplier that converts the readings to units of kJ m^{-2} and an average irradiance of .5 kW m^{-2}, the maximum low resolution output limit will be exceeded in less than four hours.

Solution #1 - Record **average** flux density and later multiply the result by the number of seconds in the output interval to arrive at total flux.

Solution #2 - Record total flux using the high resolution format. The drawback to high resolution is that it requires 4 bytes of memory per data point, consuming twice as much memory as low resolution.

4. CONNECTIONS

Differential and single-ended connections to the datalogger are shown in Figures 2 and 3, respectively.

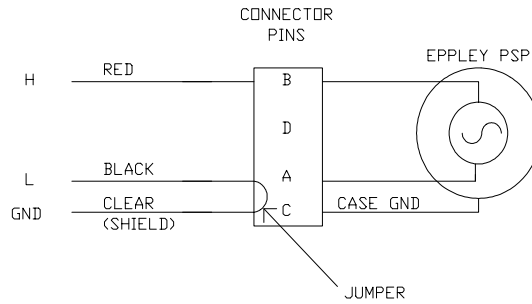*AG in Figure 2 refers to Analog Ground in the CR10 which is the same as ground for the 21X and CR7.

Figure 2. Differential Measurement Connection

On a differential measurement, the low side of the signal is jumpered to AG to keep the signal in common mode range, as shown in Figure 2.
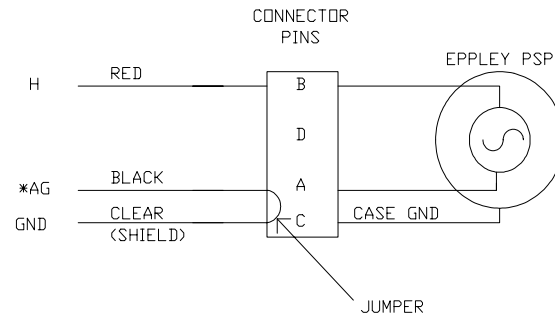

Figure 3. Single-ended Measurement Connection

*AG in Figure 3 refers to Analog Ground in the CR10, which is the same as ground for the 21X and CR7.

5. RESOLUTION

The Eppley PSP outputs approximately 12mV at 1400 watts meter^{-2} (solar constant). The CR10 measures this sensor on the 25mV range while the 21X and CR7 measure it on the 15mV range.

An example of the datalogger resolution of the PSP measurement with a PSP calibration of 8.61 mVw^{-1}m^2 is given below:

CR10 differential resolution:

$= \pm 0.00333mV * (1w/m^2)/(.00861mV)$
$= \pm 0.387w/m^2$

CR10 single=ended resolution:

$= \pm0.00666\text{mV} * (1\text{w/m}^2)/(.00861\text{mV})$

$= \pm0.773\text{w/m}^2$

21X differential resolution:

$= \pm0.001\text{mV} * (1\text{w/m}^2)/(.00861\text{mV})$

$= \pm0.116\text{w/m}^2$

21X single-ended resolution:

$= \pm0.002\text{mV} * (1\text{w/m}^2)/(.00861\text{mV})$

$= \pm0.232\text{w/m}^2$

6. SYSTEM ACCURACY

CR10 accuracy:
0.2% of Full Scale Range
$= \pm(0.002 * 25\text{mV}) * (1 \text{ wm}^{-2}/0.00861\text{mV})$
$= 5.81\text{w}$

21X accuracy:
0.1% of Full Scale Range
$= \pm(0.001 * 15\text{mV}) * (1 \text{ wm}^{-2}/0.00861\text{mV})$
$= 1.74\text{w}$

Eppley temperature dependance:
$\pm1\%$ over range from -20 to $+40^\text{o}$ C

Eppley linearity:
$\pm.5\%$ over range from 0 - 2800wm^{-2}

Eppley cosine response:
$\pm1\%$ over range from 0 - 70°
$\pm3\%$ over range from 70-80°

System accuracy calculation example:

When solar radiation = 1117wm^{-2} at 10° from normal (=1100wm^{-2} at 0°) and the temperature is 25° C.

System accuracy = square root of the sum of the squares of the random individual component accuracies.

$$=\pm[(5.8\text{w/m}^2)^2 + (11\text{w/m}^{-2})^2 + (5.5\text{w/m}^{-2})^2 +(11\text{w/m}^{-2})^2]^{.5}$$

$=\pm17.5\text{w/m}^{-2} = \pm1.6\%$ of reading