Solar Radiation Sensor

Operating Manual

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REVISION HISTORY

Revision #	Date	Description
1		Original issue.
2	April 1, 2003	Updated Set-Up Instructions and FTS Address
3	July 29, 2005	Updated Figure 1, Configuration & Address
4	Oct. 11, 2007	Updated for new 01-SDI-SR4 board command set
5	Nov. 27, 2007	Updated sensor specifications
6	April 18, 2008	Correct M command table
7	Aug 17, 2010	Correct Power Supply Voltage Range Upper Limit

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OPERATION

GENERAL DESCRIPTION

The FTS Solar Radiation Sensor is a device that measures the sunlight in a given region. The sensor is available in three wavelength ranges: the Pyranometric range; the Photosynthetic Active Radiation range; and, the Photometric range.

The Pyranometer sensor (SR-PYR) is used for measuring solar radiation received from a whole hemisphere. The measurement region is between 400 and 1000 nm. This sensor is NOT to be used under artificial lighting, within plant canopies or to measure reflected radiation. The units of measurement are Watts per square meter (W/m^2).

The Photosynthetic Active Radiation sensor (SR-PAR) measures radiation in the 400 to 700 nm wave length region. The units of measurement are micromoles per second per square meter ($\mu mol/s/m^2$). The selected region approximates the photosynthetic response of plants for which data is available.

The Photometer sensor (SR-PHO) is used for measuring solar radiation as the human eye sees it. The measurement region is between 400 and 700 nm. The units of measurement are Klux.

The FTS Solar Radiation Sensor consists of a sensing element which converts the radiation to an electrical current. The current is amplified and fed into a microcomputer which processes the measurement and outputs the data via the SDI-12(1) protocol to a data logging device. The measurement process is controlled by the data logger through commands that initiate measurements and return values.

(1) SDI-12 is a serial-digital interface standard for microprocessor based sensors (refer to http://www.sdi-12.org for more information on the SDI-12 standard).

OPERATION

The Solar Radiation sensor is an SDI-12 device and as such has an SDI address and is powered by +12 Vdc from the SDI-12 bus. Normally the sensor's connector is connected directly to the SDI port of an FTS data logger; however, the sensor may be connected to any SDI-12 compliant controller.

The Solar Radiation sensor is user-configurable using SDI-12 commands. Depending on the SDI-12 command sent to the sensor, the sensor can provide several different data measurements and can also provide statistical solar radiation data over the last measurement period. Command details for the sensor are detailed in the "Commands" section of this manual.

INSTALLATION

The Solar Radiation is very easy to install. Installation steps are as follows:

1/ Select a site that has unobstructed sunlight throughout the day.

2/ Mount the sensor on the support arm by passing the securing screw through the horizontal hole in the sensor mounting post and then tighten the screw into the support arm (see Figure 1).

3/ Secure the sensor cable to the mounting structure to prevent cable chaffing.

4/ Plug the sensor connector into the datalogger SDI port.

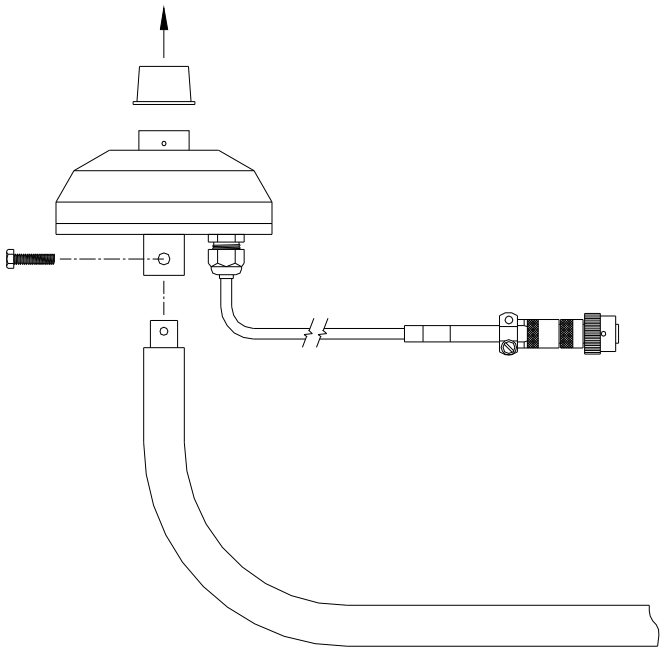

Figure 1: Solar Radiation Sensor Mounting Diagram

CONNECTION

The Solar Radiation Sensor connector is an environmentally sealed, bayonet mount, keyed, military style connector. This connector is waterproof even without a mating connector attached. Electrical signal connections for the SDI-12 connection are shown in Table 1 below.

Pin	Function	Wire Colour
A	+12 Vdc	Red
B	Data	White
C	Ground	Black

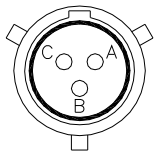

Table 1: SDI Port Signal Connections

CONFIGURATION

The Solar Radiation sensor is shipped with default address 0 (unless shipped as part of an integrated FTS system). The only configuration of the sensor that may be required is to change the address to another value if more than one SDI-12 sensor is on the same bus or to change the Threshold Level if a different setting is desired. Refer to the Command section of this manual for instructions on changing Solar Radiation sensor settings.

CALIBRATION & MAINTENANCE

The Solar Radiation sensor must be returned to the factory every 1 to 2 years for calibration check and, if necessary, recalibration.

Field maintenance required by the Solar Radiation sensor is limited to a periodic check of the sensor cable and connector for deterioration.

Please contact FTS technical support for information on return of the sensors for calibration or if the unit ceases to operate properly.

COMMANDS

Commands implemented in the Solar Radiation sensor conform to SDI-12 version 1.3. The commands for the sensor can be broken into 3 categories; general SDI commands, SDI data commands, and extended SDI commands. SDI-12 commands are sent from the datalogger or a controller using the appropriate software. Refer to the datalogger documentation for information on sending SDI-12 commands.

GENERAL SDI COMMANDS

The General SDI Commands are used for housekeeping issues such as device address configuration, device identification and confirmation of device communications. General SDI-12 version 1.3 commands are as follows.

Address Query ?!

This command is used to determine the address of the SDI sensor.

Example: ?!
Response: 0 : the sensor is configured for address 0

* note: only one SDI device can be connected to the bus when using this command

Acknowledge Active a!

This command is used to determine that a sensor is present on the SDI bus at the specified address.

Example: 0!
Response: 0 : the sensor is present at address 0

Change Address aAb!

This command is used to change a sensor's SDI address.

Example: 0A3! : change the sensor SDI address from 0 to 3
Response: 3

Send Identification aI!

This command is used to identify the specifics of the addressed sensor.

Example: 3I!
Response: 313FTS-----PYR-2--23120

The format is as follows:

3:	sensor SDI address
13:	compatible with SDI-12 version 1.3
FTS:	manufacturer's identifier
PYR:	sensor model
2:	version 2 of sensor firmware
23120:	sensor serial number

SDI DATA COMMANDS

The SDI Data Commands are used to retrieve data from the Solar Radiation sensor. SDI Data commands for the sensor are shown below.

Send Data Command aD#! : where # = {0,1..9}

This command reads data generated by the preceding Measurement (M or C) command. An **aD0!** command is always the first command sent to read the data. If additional data needs to be read, then an **aD1!** command is sent, then and **aD2!** etc. etc., up to **aD9!** (see the example below).

Example: 3M4! : start an M4 measurement
Response: 30019 : the sensor returns its SDI address, the measurement duration, and the number of data points generated by the measurement

The sensor response format is as follows:

3:	sensor SDI address
001:	duration of the measurement is 1 second
9:	nine data points are returned

Followed by: : read the data from the M4 command
Command: 3D0!
Response: 3+215.143+1567+282.5+176.5+2058.76

The Pyranometer sensor response format is as follows:

3:	sensor SDI address
215.143:	average solar radiation in W/m^2
1567:	number of samples in seconds
282.5:	maximum solar radiation in W/m^2
176.5:	minimum solar radiation in W/m^2
2058.76:	variance

Followed by: : read more data from the M4 command
Command: 3D1!
Response: 3+337129+849+200.0+0

3:	sensor SDI address
337129:	total solar radiation in W/m^2
849:	duration above the threshold level in seconds
200.0:	threshold level in W/m^2
0:	status

Followed by: : read more data from the M4 command
Command: 3D2!
Response: 3

3:	sensor SDI address
< no more data to be read >	

Start Measurement Command aM!

This command is used trigger a measurement on the addressed sensor. The sensor will not return data, instead the sensor will return the duration of the measurement as well as the number of data points returned by the measurement. The data is read using a subsequent Read Data command. Refer to Tables 2 and 3 for the specifics of the data returned from the sensor.

Example: 1M!
Response: 10012
The format is as follows:

1: sensor SDI address
001: duration of the measurement is 1 second
2: 2 data points are returned

Additional Measurement Commands aM#! : where # = {1,2..9}

Like the Start Measurement command, this command is used trigger additional measurements on the addressed sensor. Refer to Tables 2 and 3 for the specifics of the data returned from the sensor.

Start Concurrent Measurement Command aC!

The concurrent measurement command allows a sensor to take a measurement while other SDI sensors are also taking measurements. The Start Concurrent Measurement Command operates in the same manner and returns the same information as the Start Measurement command (refer to Table 2).

Additional Concurrent Measurement Commands aC#! : where # = {1,2..9}

The additional Concurrent Measurements commands operate in the same fashion as the Start Concurrent Measurement command. The data returned by the additional Concurrent Measurements commands is the same as that returned by the Additional Measurement commands (refer to Table 2).

Continuous Measurement Command aR#! : where # = {0,1..9}

The Continuous Measurement commands are not supported by the sensor as the sensor cannot immediately return the requested data.

Start Verification Command aV!

This command is not used by the sensor. The response of the sensor to a Start Verification command is shown below.

Example: 3V!
Response: 30000 : the sensor returns its SDI address followed by 4 zeroes
The format is as follows:

3: sensor SDI address
000: duration of the measurement is 0 seconds
0: no data is returned

Command	Measured Values
aM! or aM0!	SDI Voltage, solar radiation
aM1!	solar radiation
aM2!	SDI Voltage
aM3!	none
aM4!	average, number of samples, maximum, minimum, variance, total, duration, threshold level, status **Note: sensor averaging is not affected by this measurement.**
aM5!	average, number of samples, maximum, minimum, variance, total, duration, threshold level, status **Note: sensor averaging is reset by this measurement.**

Table 2: Solar Radiation Sensor Measurement Command Details

Measured Value	Measurement Resolution	Description
Solar Radiation	3 decimal places	The current solar radiation value.
SDI Voltage	2 decimal places	The SDI-12 bus voltage in Volts.
Electronics Temperature	1 decimal place	The temperature of the internal electronics in Celsius.
Average	3 decimal places	The average solar radiation since the last M5 command.
Number of Samples	integer value	The number of measurements, in seconds (1 sample/sec), since the last M5 command.
Maximum	1 decimal place	The maximum solar radiation since the last M5 command.
Minimum	1 decimal place	The minimum solar radiation since the last M5 command.
Variance	2 decimal places	The variance of the solar radiation values since the last M5 command.
Total	integer value	The total accumulated solar radiation since the last M5 command. As the maximum for this number is 9,999,999 W/m^2, an M5 command should be issue hourly to avoid exceeding the maximum value.
Duration	integer value	The duration, in seconds, above the threshold level since the last M5 command.
Threshold Level	1 decimal place	The solar radiation threshold level used to determine the duration statistic (units depend on the sensor type). Note: use the extended SDI commands to set the threshold level.
Status	integer value	0 = statistic calculations are valid 1 = an error or overflow has occurred with the statistic calculation

Table 3: Description of Measured Values

EXTENDED SDI COMMANDS

The Extended SDI Commands are for Solar Radiation Sensor configuration. Extended SDI-12 commands for the sensor are shown below.

The general form of an Extended SDI Command is:

aX cmd option data

The parts of the command must each be separated by either a space, a colon or a slash ('/')

a: sdi address of unit
X: sdi extended command (mandatory). Must be uppercase.

cmd:

se	set
g	get

option:

thr	threshold level for calculating duration above this level
bv	firmware bootloader version (read only)

Threshold Level Command

This command is used to read or set the solar radiation Threshold Level used to determine the Duration above the specified Threshold Level.

Example:	3X se thr 50.0!	: sets the Threshold Level of 50.0
Response:	3	: returns the sensor SDI address

or

Example:	3X g thr!	: read the current Threshold Level setting
Response:	3 50.00	: returns the sensor SDI address followed by the Threshold Level setting

Bootloader Version Command

This command is used to read the custom FTS SDI-12 interface board firmware bootloader version. Note that the bootloader version is different than the sensor's firmware version reported by the "Send Identification" command.

Example:	3X g bv!	: reads the firmware bootloader version
Response:	3 1	: returns the sensor SDI address followed by the Bootloader version

SPECIFICATIONS

GENERAL

Power Supply Voltage Range	12 Vdc nominal (range: 9.6 to 18.6 Vdc)
Standby Current Consumption	Less than 1 mA
SDI-12 Compatibility	Version 1.3
Environmental	Operating temperature: -40 °C to +60 °C Operating humidity: 0% to 100% Waterproof case and connectors
Physical	Irregular shape: approximately 10 cm dia. x 7 cm high Weight: approximately 0.5 kgs

SR-PYR Specifications

Measurement Range	0 to 1800 Wm^{-2}
Accuracy	+/- 5 %
Stability	less than +/- 2% change over 1 year
Response Time	1 second per measurement
Temperature Dependence	+/- 0.15% / °C
Cosine Correction	Cosine Corrected up to 80° angle of incidence
Detector	Silicon photovoltaic detector (Blue Enhanced)

SR-PAR Specifications

Measurement Range	0 to 10000 μmol s^{-1} m^{-2}
Accuracy	+/- 5 %
Stability	less than +/- 2% change over 1 year
Response Time	1 second per measurement
Temperature Dependence	+/- 0.15% / °C
Cosine Correction	Cosine Corrected up to 80° angle of incidence
Detector	Silicon photovoltaic detector (Blue Enhanced)

SR-PHO Specifications

Measurement Range	0 to 100 klux
Accuracy	+/- 5 %
Stability	less than +/- 2% change over 1 year
Response Time	1 second per measurement
Temperature Dependence	+/- 0.15% / °C
Cosine Correction	Cosine Corrected up to 80° angle of incidence
Detector	Silicon photovoltaic detector (Blue Enhanced)

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