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DPA870/873 Modbus Pyranometer

User Manual

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1 Introduction

DPA870 Modbus® Pyranometer in a high quality, *ISO 9060 first class pyranometer* produced by LSI LASTEM. It allows the measurement of solar irradiance (direct and diffuse radiation within 305 and 2800 nm) and a surface or ambient temperature measured from an optional external Pt100 sensor. This device allows a practical and easy connection with PLC/SCADA systems using Modbus RTU communication protocol in environmental and photovoltaic applications. It is factory calibrated, so irradiance and temperature measurements comes out ready to use, without the need to set scaling or calibrating factors on the receiving system.

The *sampling rate* (reading cycle of the input signals) has been set at 1 second. The instrument uses the *instantaneous* date, sampled within a programmable period (*processing* rate) and fixed in advance in order to supply a set of statistic processing; both the instantaneous data and the statistical processing can be transferred by means of Modbus protocol.

DPA873 model share most DPA870 characteristics except for lower measurement performance, comply with the *ISO 9060 second class pyranometer*.

1.1 Notes about this manual

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The information contained in this manual may be changed without prior notification. No part of this manual may be reproduced, neither electronically or mechanically, under any circumstance, without the prior written permission of LSI LASTEM.

LSI LASTEM reserves the right to carry out changes to this product without timely updating of this document.

2 Product installation

2.1 General safety rules

Please read the following general safety rules in order to avoid injuries to people and prevent damages to the product or to possible other products connected with it. In order to avoid any damages, use this product exclusively according to the instructions herein contained.

The installation and maintenance procedures must be carried-out only by authorized and skilled service personnel.

Power the instrument in a suitable manner. Pay attention and observe the power supplies like indicated for the model in your possession.

Carry-out all connections in a suitable manner. Pay strict attention to the connection diagrams supplied with the instrument.

Do not use the product in case of suspected malfunctions. In case of suspected malfunction, do not power the instrument and contact authorized technical support immediately.

Before you carry-out any operation on electrical connections, power supply system, sensors and communication apparatus:

- Disconnect the power supply.
- Discharge the accumulated electrostatic discharges touching an earthed conductor or apparatus.

2.2 Mechanical installation

The pyranometer must face equator and be exposed in a place with no shades throughout the day in every season; best installed at a height of 2 m on grassy ground. Do the Installation on pole using a DYA051 collar and DYA034 support. Follow these steps:

1. Remove the radiant protective screen from the pyranometer body.
2. Fix the DYA034 support the DYA051 collar and mount them on pole.
3. Turn the support until the sensor points to the terrestrial equator.
4. Mount the body of the sensor on the DYA034 support, having care to level the sensor horizontally using the two leveling feet and the bubble level.
5. Fix the pyranometer to the supporting disc using the two longest screws; use an Allen wrench n° 4 for this purpose.
6. Reassemble the protective screen on the pyranometer body.

2.3 Electrical connection

Power the instrument according to the technical specifications. Particularly you will get the correct operation using the suitable earthing of the power lines and communication lines.

Follow the electrical diagram at §10 that shows the wiring of the RS-485 communication line and sensors; it is briefly reported in the following table:

Wire color	***Name***	***Meaning***
Red	Power In	Power, Vdc or Vac
Blue	Power In	Power, Vdc or Vac
Shield	Gnd	Earthing
Green	RS-485 D+	Serial Line - positive RS-485 (non-inverting signal)
Brown	RS-485 D-	Serial Line - negative RS-485 (inverting signal)

Connect the optional external temperature sensor (cod. DLE125) removing the screw cap. Assure to securely tighten the cable to the pyranometer for good immunity to water and dust.

In principle, we recommend to divide the power supply lines from the measurement lines used for the external temperature connection, in order to reduce the possible electromagnetic disturbances to a minimum; so avoid the use of the same raceways for these different types of wiring. Use line terminations on both the ends of the RS-485 bus using 120 Ω resistors.

3 System configuration and management

The device is equipped with several functions easily configurable through a terminal emulation program (for example *Windows HyperTerminal* or any other commercial or free program available from Internet).

The device configuration and management is carried-out connecting the PC serial line (through USB/RS-232 to RS-485 adapter) to the serial line of the probe. Configure the terminal program as follow:

- Bit rate: default 9600 bps.
- Terminal Mode: ANSI.
- Echo: disabled.
- Flow control: none.

At power-on the device starts operating with Modbus protocol on the serial line thus allowing data communication with external devices. When the configuration operations are needed, the device let to switch to the TTY protocol when a special *escape sequence* is transmitted to it. The protocol switch procedure can be done in this way:

1. Disconnect the sensor RS-485 line from the operating bus where the Modbus master device operates.
2. Connect the PC to the sensor RS-485 line using a proper media converter.
3. On the PC terminal program press slowly three or more times the '#' character.
4. The sensor should propose its main menu. If nothing happens, check the PC terminal configuration against the sensor/Modbus master serial communication configuration, and retry.

The device allows access to its functions through an easy menu interface. You can access to the main menu pressing ESC until the terminal program will show the following instructions:

```
Main Menu:
 1: About this device...
 2: Communication parameters
 3: Sampling
 4: Data Tx
 5: Save configuration
 6: Restart system
 7: Statistics
```

The main menu is made up of several items. You can access to the different functions pressing, on terminal, the numeric keypad corresponding to the desired item. The next function may be a new menu or the request to change the selected parameter; in this case it is shown the current value of parameter and the system awaits for the input of a new value; press *Enter* to confirm the new input value, or press *Esc* to return to previous menu without changing the selected parameter; the *Esc* key also performs the move to previous menu.

Note: when you need to express decimal values use the dot as decimal separator for numbers input.

3.1 Functions available from menu

The programming menu offers the following functions:

- *About this device…*: to display the registry data of the instrument: model, serial number and version of the program.
- *Communication parameters*: it allows to program some parameters useful for communication between the device and the external apparatus (PC, PLC, etc.), particularly:
    - *Bit rate* and *Stop bits*: it allows to modify the serial communication parameters.
    - *Network address*: the network address of the instrument. It is especially necessary for Modbus protocol, in order to address (in univocal way) this instrument with respect to other devices connected on the same RS-485 loop.
    - *Modbus parameters*: it offers the possibility to modify some parameters that are typical of Modbus protocol, particularly:
        - *Swap floating point values*: it is useful in case the host system requires the inversion of two 16 bit registers, which represent the floating point value.
        - *Floating point error value*: it shows the value used when the device has to specify an error datum in the registers that collect the floating point data.
        - *Integer error value*: it shows the value used when the device has to specify an error datum in the registers that collect the integer format data.
- *Sampling*: it includes the parameters that adjust the sampling and the processing of detected signals from the inputs, particularly:
    - *Radiometer sensitivity*: this parameter is factory programmed and corresponds to the sensitivity of the sensor, expressed in mV/Wm^{-2}; this value is shown in the calibration report of the sensor and can be changed after re-calibration;
    - *Elaboration rate*: it is the processing time used for the supplying of statistic data (mean, minimum, maximum, total values); values included into the correspondent Modbus registries are updated according to the time expressed by this parameter.
- *Data Tx*: this menu allows the execution of a fast diagnostic check of the sampled data and processed by the device; directly from the terminal emulation program, it is possible evaluate the right signals acquisition by the instrument:
    - *Tx rate*: it shows the transmission rate of data to terminal; if this parameter is set to a value different from zero and saved in the configuration, the sensor will start automatically, after the next power up, the transmission of data in text format; in this way the Modbus protocol is disabled; in order to remove this functionality, set again this parameter to zero and save the configuration data.
    - *Start Tx*: it starts the transmission according to the specified rate; it is proposed the measures sampled by means of the device (the display sequence is “irradiance, ext. temperature, int. temperature”), updating the display automatically; press *Esc* to stop the transmission of data to terminal.
- *Save configuration*: after a confirmation request, all changed parameters are saved; please note that the device changes its operation immediately from the first variation of each parameter (except for serial bit rates, that necessarily implies instrument re-start), in order to allow an

immediate evaluation of the modifications; re-starting the instrument without saving changes, will reset the device to the previous saved configuration parameters .

- *Restart system*: after a confirmation request, it restart the system; warning: this operation cancels the variation of any parameters that have been modified but not definitively stored.
- *Statistics*: this menu allows the display of same statistic data relative to the operation of the instrument, particularly:
    - *Show*: it shows the time from last start or re-start of the instrument, the time from last reset of statistical data, the statistical counts relevant to communications over the serial communication line (number of received and transferred byte, number of total received messages, wrong messages and transferred messages). For further information about these data read §6.1.
    - *Reset*: it resets the statistical counts.

3.2 Minimal configuration

In order to operate the pyranometer with its Modbus system correctly, you usually have at least to set as follow:

- *Network address*: the default set value is 1;
- *Bit rate*: the default set value is 9600 bps;

After modification of the parameters remember to store them definitively through *Save configuration* command and re-start the system in order to make them active (reset button, switch off/switch on or *Restart system* command). It is possible to check if the instrument works correctly using the *Data Tx* function, available on the configuration menu.

3.3 Restart of the instrument

The device can be restarted through menu (see §0) or with a switch off/on sequence. In both cases the changes to configuration, made through menu and not yet saved, will be cancelled completely.

4 Modbus protocol

The device implements Modbus protocol in slave RTU mode. The controls *Read holding registers* (0x03) and *Read input registers* (0x04) are supported for access to acquired data and calculated by the device; both commands supply the same result.

Information available in the Modbus registers are both instantaneous values (last sampled according to the acquisition rate of 1 s), and processed values (mean, minimum, maximum and total of the sampled data for the period corresponding to the processing rate).

The instantaneous and processed data are available in two different formats: floating point and integer; in the first case the datum is included in two consecutive registers of 16 bit and it is expressed in 32 bit IEEE754 format; the storage sequence in two registers (*big endian* or *little endian*) is programmable (see §3); in the second case each datum is included in a single 16 bit register; its value, as it does not have any floating point, is multiplied by a factor fixed according to the type of measurement it represents and therefore it has to be divided by the same factor in order to obtain the primary factor (expressed with right decimals); the table below shows the multiplication factor for each measurement:

Measurement	***Multiplication Factor***
Irradiance	10
Temperature	100

It is possible use tool *Modpoll* in order to check the connectivity through Modbus in an easy and fast way: it is a free tool that can be downloaded from this site: www.modbusdriver.com/modpoll.html.

You can use Modpoll by command line of Windows or Linux prompt. For example, for Windows version you can execute the command:

```
Modpoll –a 1 –r 1 –c 4 –t 3:float –b 9600 –p none com1
```

Replace *com1* with port really used by PC and, if necessary, the other communication parameters, in case they have been modified in comparison with the default parameters set in the device. Modpoll program executes a query every second to the device and displays the results on the PC display. Through –r and –c parameters it is possible to choose from the device which measures and elaborated items. For further information about the commands use –h parameter.

When an Ethernet/RS-232/RS-485 converter is required, Modbus requests can be encapsulated inside TCP/IP using this command (for example considering the Ethernet converter available on port 7001 and IP address 192.168.0.10):

```
Modpoll –m enc –a 1 –r 1 –c 4 –t 3:float –p 7001 192.168.0.10
```

4.1 Addresses map

The following table shows the relation between the address of Modbus register and sampled (instantaneous) or calculated (statistic processing) values.

Value Type	*Measurement*	*Address*	*Value*
Floating point, 2 x 16 bit	Irradiance	0	Instantaneous
		2	Mean
		4	Minimum
		6	Maximum
		8	Total
	Ext. temperature	10	Instantaneous
		12	Mean
		14	Minimum
		16	Maximum
		18	Total
	Int. temperature	20	Instantaneous
		22	Mean
		24	Minimum
		26	Maximum
		28	Total
Integer, 1 x 16 bit	Irradiance	1000	Instantaneous
		1001	Mean
		1002	Minimum
		1003	Maximum
		1004	Total
	Ext. temperature	1005	Instantaneous
		1006	Mean
		1007	Minimum
		1008	Maximum
		1009	Total
	Int. temperature	1010	Instantaneous
		1011	Mean
		1012	Minimum
		1013	Maximum
		1014	Total

5 Specifications

- **Pyranometer DPA870** (values expressed as (*italic*) are related to **DPA873** model; single values reported are common for both models)
  - Operating principle: thermopile
  - Sampling rate: 1 Hz
  - Measurement scale: 0 ÷ 2000 Wm^{-2}
  - Comply with *ISO 9060 Class 1 Piranometer* norm
  - Response time: 26 (*28*) s (95 % response)
  - Zero offset:
    - Response to 200 Wm^{-2} net thermal radiation (ventilated): 12 (*14*) Wm^{-2}
    - Response to 5 Kh^{-1} change in ambient temperature: 2 (*3*) Wm^{-2}
  - Stability (change per year, percentage of full scale): < 1 (*1.5*) %
  - Non-linearity (percentage deviation from the responsivity at 500 Wm^{-2} due to any change of irradiance within the range 100 to 1000 Wm^{-2}): 0.75 (*1.5*) Wm^{-2}
  - Directional response for beam radiation (the range of errors caused by assuming that the normal incidence responsivity is valid for all directions when measuring, from any direction, a beam radiation whose normal incidence irradiance is 1000 Wm^{-2}): 20 (*30*) Wm^{-2}
  - Spectral sensitivity (percentage deviation of the product of spectral absorption and spectral transmittance from the corresponding mean within the range 200 to 3000 nm): < 2 %
  - Temperature response (percentage maximum error due to any change of ambient temperature within an interval of 50 K): < 4 (*7*) %
  - Total uncertainty (WMO n° 8, 7 th ed., Pyranometer table 7.5): hourly < 8 (*20*) %, daily < 5 (*10*) %
- **Temperature sensor input**
  - Type: Pt100
  - Sampling rate: 1 Hz
  - Measurement scale: -20 ÷ 100 °C
  - Resolution: ≈ 0.04 °C
  - Accuracy: < ±0.2 °C
  - Thermal drift: 0.1 °C / 10 °C
  - Compensation of the line resistance: error 0.06 °C / Ω
  - Connector: M8, three wires
- **Internal temperature sensor**
  - Type: Pt100
  - Sampling rate: 1 Hz
  - Measurement scale: -20 ÷ 100 °C
  - Resolution: ≈ 0.04 °C
  - Accuracy: < ±0.2 °C
  - Thermal drift: 0.1 °C / 10 °C
- **Processing of the measurements**
  - All processed measures with common rate programmable from 1 to 3600 s
  - Application on all measurements of calculations of mean, minimum, maximum and total
- **Communication line**

  - Serial parameters: no parity, 8 data bit, 1 or 2 stop bit programmable, bit rate programmable from 1200 to 115200 bps
  - Modbus RTU communication protocol for reading of sampled and processed measures (values expressed in floating point 32 bit IEEE754 format or in 16 bit whole format)
  - Two wires RS-485 (half duplex mode)
  - Galvanic insulation (3 kV, according to rule UL1577)
  - Connector M8 shared with power line
- **Power**
  - Input voltage: 10 ÷ 30 Vdc/ac
  - Power consumption: < 0.4 W
  - Connector: M8 shared with communication line
- **Electrical protections**
  - Against electrostatic discharge on sensor input, RS-485 communication line and power line
  - Maximum power that can be dispelled: 600 W (10/1000 µs)
- **Environmental limits**
  - Operative temperature: -20 ÷ 60 °C
  - Temperature of warehousing/transport: -40 ÷ 70 °C
- **Mechanics**
  - Environmental protection grade: IP65
  - Body materials: anodized aluminium
  - Weight: ≈530 g

6 Diagnostic

6.1 Statistical information

The device collects statistical data that can be useful for diagnostics of possible operation problems. The statistics data can be obtained from the programming and management menu for (see §3.1) and through the proper menu entry.

The activation of display of statistics data produces the following result:

```
Power on time: 0000 00:01:00
Statistical info since: 0000 00:01:00

Com Rx bytes Tx bytes Rx msg  Rx err msg Tx msg
1   0        1        0       0          0
```

Here below you can read the meaning of displayed information:

- *Power on time*: power-up time of the apparatus or from last reset [dddd hh:mm:ss].
- *Statistical info since*: time from last reset of statistics [dddd hh:mm:ss].
- *Com*: number of the device serial port (1=RS-485).
- *Rx bytes*: number of bytes received from serial port.
- *Tx bytes*: number of bytes transferred from serial port.
- *Rx msg*: total number of messages received from serial port (Modbus or TTY/CISS protocol).
- *Rx err msg*: number of wrong messages received from serial port.
- *Tx msg*: number of messages transferred from serial port.

6.2 Trouble shooting

The table below shows the causes of some problems detected by the system and the pertinent remedies that it can be adopted. In case of errors detection by the system, we recommend to check the statistical data too (§6.1) in order to have a complete picture of the situation.

Error	***Cause***	***Remedy***
The statistics reports the error 1 or an error message has been reported during the final storage of the modifications of configuration parameters	It has been found a storage error of configuration parameters after their modification	The memory (store) of the instrument has an important malfunction that probably cannot be recovered; enter again the storage command; in case of persistence of the error contact LSI LASTEM after-sale service. In this situation the calibration parameters of the device may have been compromised; be sure that the measurements carried out by the apparatus are correct (indicatively); for example using reference signals instead of external sensor, before you consider the problem solved
The statistical reports the error 2	The instrument has restarted and the	Try to restart the instrument checking if the signaling of non-valid configuration persists; in case of persistence of the error contact LSI LASTEM post-sale service

	configuration memory is damaged	
The statistics reports an error higher than 2	It is a non-serious error caused by the survey of a condition of internal invalid operation	Try to restart the instrument; if, within some hours of operation in standard operating conditions (sensors acquisition and active Modbus communication) , you'll find again the problem, try to reduce the bit rate or the query rate of the instrument from the master device; check the power supply and the signals generated by the sensors; check the grounding quality.
Modbus reports wrong or non-consistent instantaneous values	The cause of the problem can due to a not optimal connection of the external sensor, an operation problem of the sensor, a misunderstanding of data from the system connected through Modbus	Check in the order: 1. If the problem concerns the external Pt100 temperature sensor: check that measurement is included into the estimated output scale, measuring the resistance at the ends of three signal available on the M8 connector: in a couple it must be around 100 Ω, for the other couple it must measure a value closed to zero. If the problem concerns the solar irradiance: check that the calibration factor stored in the configuration memory corresponds to the value reported on the sensor body or on the calibration report (see §3). 2. The correct access to the information through Modbus: use the corresponding register according to the kind of format (floating point or whole) considered by the system (look it up in §0); in case of floating point format try to invert the content of two registers through the proper function (see §0); in case of whole format divide the read value by a factor depending on the type of measurement.

7 Maintenance

The pyranometer does not require special maintenance, anyway it is a precision measurement apparatus so, in order to maintain the specified measurement precision over the time, LSI LASTEM recommends to check and re-calibrate periodically the instrument (see §7.1).

It is also advisable to check the status of the external dome in the winter months, during which an icy layer may form on it as well as to check the status of the silica salt every 3-6 months depending on humidity of the site.

7.1 Calibration

Each pyranometer is supplied with a *Calibration Report* produced by comparison, under the sun or under a lamp (ISO 9847), with a pyranometer calibrated at the WRC-PMOD in Davos (WRC: World Radiation Center; PMOD: Phisikalisch Meteorologisches Observatorium Davos). The Calibration Report contains the c*alibration factor* whit its expanded uncertainty.

An overall uncertainty value is not supplied; there are however many characteristics available according to the classes of the WMO n°8 and ISO 9060. Besides, the accuracy of this instrument is influenced by the quick temperature changes owing to the intervention of clouds and rain.

It is not necessary to re-calibrate the instrument frequently. It is advisable to re-calibrate the instrument every 2 years in order to keep calibration uncertainty variations in the specified limits.

8 Disposal

This pyranometer is a device with high electronic content. In accordance with the standards of environmental protection and collection, LSI LASTEM recommends to handle this device as waste of electrical and electronic equipment (RAEE). For this reason, at the end of its life, the instrument must be kept apart from other wastes.

LSI LASTEM is liable for the compliance of the production, sales and disposal lines of this product, safeguarding the rights of the consumer. Unauthorized disposal of this device will be punished by the law.

9 How to contact LSI LASTEM

In case of problem contact the technical support of LSI LASTEM sending an e-mail to support@lsi-lastem.it, or compiling the technical support request module at www.lsi-lastem.it.

For further information make reference to addresses and numbers below:

- Phone number: +39 02 95.414.1 (exchange)
- Address: via ex S.P. 161 – Dosso n. 9 - 20090 Settala Premenugo, Milano
- Web site: www.lsi-lastem.it
- Commercial service: info@lsi-lastem.it
- After-sales service: support@lsi-lastem.it, riparazioni@lsi-lastem.it

10 Connection drawings and mechanics

On www.lsi-lastem.it Internet site are available the drawings related to the probe mechanical and electrical connections:

- Sensor mod. DPA870: document DISACC6019.
- Sensor mod. DPA873: document DISACC6071.

11 CE conformity declaration

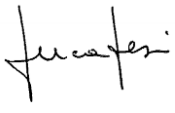
Product description: Pyranometer with Modbus output

Models: DPA870, DPA873

Issuer: LSI LASTEM Srl

LSI Lastem Srl declare under sole responsibility the above products are made under European directives 2004/108/EC and, specifically to the electromagnetic conformity, with the relevant provision of the following harmonized standards:

- EN 61000-4-2 (1995) + A1 (1998) + A2 (2001): Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test.
- EN 61000-4-3 (2002): Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test.
- EN 61000-4-4 (2004): Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test.
- EN 61000-4-5 (1995) + A1 (2001): Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test.
- EN 61000-4-6 (2003): Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields.
- EN 61000-4-8 (1993) + A1 (2001): Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test.
- EN 61000-4-11 (2004): Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests.



Settala, 29 October 2013 Luca Lesi