



**LP PYRA 02 - LP PYRA 03 - LP PYRA 12**  
**LP PYRA 05 - LP PYRA 06 - LP NET 07**



# PYRANOMETERS - ALBEDOMETERS - NET IRRADIANCE METER

## PYRANOMETERS

Delta Ohm manufactures First Class **LP PYRA 02** and **LP PYRA 12** and Second Class **LP PYRA 03** pyranometers which fully comply with ISO 9060 standards, and meet the requirements defined by the World Meteorological Organization (WMO). These are strong and reliable ground-based instruments, especially designed to be used under all weather conditions. They are suitable for installation on the field.

**Recommended use:** atmospheric research, weather stations, climatology, energy saving research, productive efficiency test of photovoltaic plants, etc...

Pyranometers LP PYRA 02 and LP PYRA 03 are well suited for the measurement of incoming global solar radiation (0.3µm ÷ 3µm spectral range). LP PYRA 12 shadow ring is designed to shield the instrument sensor from direct radiation; by that, an exact measurement of the diffuse sky radiation is possible.

No power supply is needed; pyranometers generate a voltage which is usually equal to:

$$10 \frac{\text{mV}}{\text{kW} \cdot \text{m}^2}$$

Every pyranometer is calibrated separately and is supplied standard with a WRR (World Radiometric Reference) Report of Calibration.

Technical Specification	LP PYRA 02 / LP PYRA 12*	LP PYRA 03
Typical sensitivity	10 µV/(W/m <sup>2</sup> )	
Impedance	33 Ω ÷ 45 Ω	
Measuring range	0 ÷ 2000 W/m <sup>2</sup>	
Viewing field	2π sr	
Spectral field	305 nm ÷ 2800 nm W/m <sup>2</sup> (50%)	
Operating temperature	-40 °C ÷ 80 °C	
Working temperature	0.90 Kg	0.45 Kg
<b>ISO 9060 Specifications</b>		
Response time	< 28 sec	< 30sec
Zero Off-set		
a) Response to thermal radiation (200W/m <sup>2</sup> )	15 W/m <sup>2</sup>	25 W/m <sup>2</sup>
b) Response to temperature change 5K/h	<± 4W/m <sup>2</sup>	<± 6W/m <sup>2</sup>
3a) Non stability over 1 year	<± 1.51%	<± 2.51%
3b) Non linearity	<± 11%	<± 21%
3c) Spectral selectivity	<±18W/m <sup>2</sup>	<±22W/m <sup>2</sup>
3e) Response with regard to temperature	<±51%	<±71%
3f) Tilt-response	< 4 %	< 8 %
3f) Risposta in funzione del Tilt	<± 21%	<± 41%
<b>Shadow ring for LP PYRA 12</b>		
Weight		5.90 Kg
Diameter		570 mm
Height		54 mm
Basis diameter		300 mm

## ORDERING CODE

**LP PYRA 02:** First class pyranometer according to ISO 9060. Complete with: shade disk LP SP1, desiccant sachet with silica-gel crystals, 2 cartridges, spirit level, 4-pole flying connector and Report of Calibration. Typical sensitivity 10µV/(W/m<sub>2</sub>). **Connection cable has to be ordered separately.**

**LP PYRA 02AC:** First class pyranometer according to ISO 9060. Complete with shade disk LP SP 1, desiccant sachet with silica-gel crystals, 2 cartridges, spirit level, 4-pole flying connector and Report of Calibration. **Connection cable has to be ordered separately. Current output 4...20mA.** 4mA = 0W/m<sup>2</sup>, 20mA = 2000W/m<sup>2</sup>. Power supply: 10...30Vdc.

**LP PYRA 02AV:** First class pyranometer according to ISO 9060. Complete with shade disk LP SP 1, desiccant sachet with silica-gel crystals, 2 cartridges, spirit level, 4-pole flying connector and Report of Calibration. **Connection cable has to be ordered separately. Voltage output 0...1Vdc, 0...5Vdc, 0...10Vdc.** 0V = W/m<sup>2</sup>, 1/5/10Vdc = 2000W/m<sup>2</sup>. Power supply: 10...30Vdc (15...30Vdc for models with output 0...10Vdc).

**LP S1:** Mounting kit for LP PYRA 02: bracket for attachment to a mast, including fasteners and leveling screws.

**LP SP1:** Shade disk for LP PYRA 02

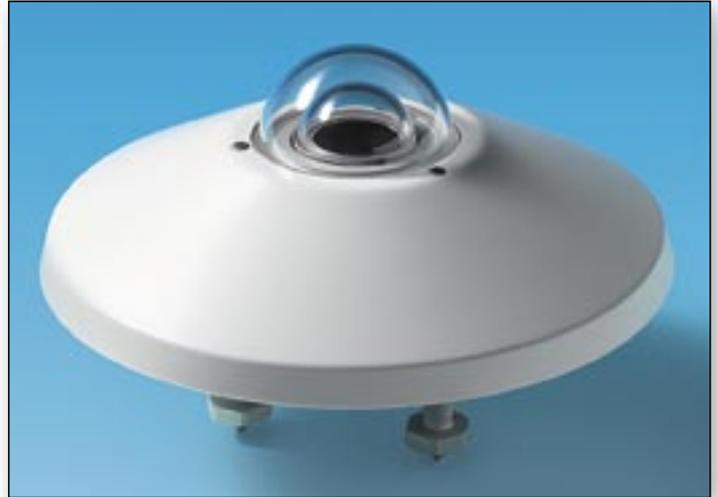
**LP SG:** Drying cartridge with silicagel crystals, complete with O-ring.

**LP G:** Pack of 5 cartridges of silicagel.

**LP PYRA 03:** Second class pyranometer according to ISO 9060. Complete with spirit level, 4-pole flying connector and Report of Calibration. Typical sensitivity 10µV/(W/m<sub>2</sub>). **Connection cable has to be ordered separately.**

**LP PYRA 03AC:** Second class pyranometer according to ISO 9060. Complete with spirit level, 4-pole flying connector and Report of Calibration. Typical sensitivity 10µV/(W/m<sub>2</sub>). **Connection cable has to be ordered separately. Current output 4...20mA.** 4mA = 0W/m<sup>2</sup>, 20mA = 2000W/m<sup>2</sup>. Power supply: 10...30Vdc.

**LP PYRA 03AV:** Second class pyranometer according to ISO 9060. Complete with spirit level, 4-pole flying connector and Report of Calibration. Typical sensitivity 10µV/(W/m<sub>2</sub>).



LP PYRA 02



LP PYRA 02



LP PYRA 12



LP PYRA 03



LP PYRA 03

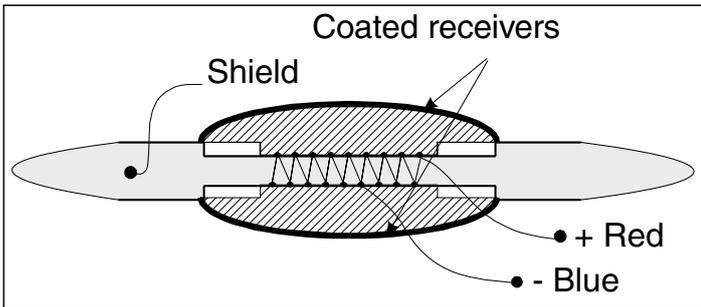


FIG. 1

Connection cable has to ordered separately. Voltage output 0...1Vdc, 0...5Vdc, 0...10Vdc. 0V = W/m<sup>2</sup>, 1/5/10Vdc = 2000W/m<sup>2</sup>. Power supply: 10...30Vdc (15...30Vdc for models with output 0...10Vdc).

**LP S2:** Mounting kit: spirit level and stud for mounting LP PYRA 03 on a support which is also part of the kit. Fasteners, shade disk LP SP2 are included.

**LP SP2:** Shade disk.

**LP PYRA 12:** First Class Pyranometer (LP PYRA 02) according to ISO 9060. Complete with shade disk, shadow ring for diffuse radiation, drying cartridge for silicagel crystals, 2 silicagel cartridges and Report of Calibration. Typical sensitivity 10µV/(W/m<sub>2</sub>). **Connection cable has to be ordered separately.**

**LP PYRA 12AC:** First Class Pyranometer (LP PYRA 02) according to ISO 9060. Complete with shade disk, shadow ring for diffuse radiation, drying cartridge for silicagel crystals, 2 silicagel cartridges and Report of Calibration. Typical sensitivity 10µV/(W/m<sub>2</sub>). **Connection cable has to ordered separately. Current output 4...20mA.** 4mA = 0W/m<sup>2</sup>, 20mA = 2000W/m<sup>2</sup>. Power supply: 10...30Vdc.

**LP PYRA 12AV:** First Class Pyranometer (LP PYRA 02) according to ISO 9060. Complete with shade disk, shadow ring for diffuse radiation, drying cartridge for silicagel crystals, 2 silicagel cartridges and Report of Calibration. Typical sensitivity 10µV/(W/m<sub>2</sub>). **Connection cable has to ordered separately. Voltage output 0...1Vdc, 0...5Vdc, 0...10Vdc.** 0V = W/m<sup>2</sup>, 1/5/10Vdc = 2000W/m<sup>2</sup>. Power supply: 10...30Vdc (15...30Vdc for models with output 0...10Vdc).

**CP AA 2.5:** Flying 7-pole connector, complete with UV-resistant cable L=5m. For the instruments LP PYRA 05- LP PYRA 06 - LP UVB 02.

**CP AA 2.10:** Flying 7-pole connector, complete with UV-resistant cable L=10m. For the instruments LP PYRA 05- LP PYRA 06 - LP UVB 02.

### ALBEDOMETERS

Delta Ohm manufactures two different models of albedometers:

**LP PYRA 05** is constructed starting from two 1<sup>st</sup> class\* pyranometers and the **LP PYRA 06** starting from two 2<sup>nd</sup> class\* pyranometers (\* according to ISO 9060 standards and to specifications published by the World Meteorological Organization). An albedometer basically consists of two pyranometers, mounted back-to-back, one looking upward (sky) and one downward (earth). The upward pyranometer measures the incident global radiation (direct radiation + diffuse radiation) striking the ground, while the downward one, measures the global radiation reflected from the ground. The outputs of the two pyranometers electric signals (the two pyranometers which made up of the LP PYRA 05 are coupled in order to have the same sensitivity) can be directly sent to a data logger or to an automatic data processor. Albedo is the fraction of solar radiation that is reflected from the ground, with respect to incident radiation:

$$\text{ALBEDO} = \frac{\text{Reflected Global Radiation}}{\text{Incident Global Radiation}}$$

By using albedometers, we can calculate the net radiation obtained through the difference between incident global radiation and reflected global radiation.

Delta Ohm albedometers operate within 0.3 µm ±3 µm spectral range. No power supply is needed, as the two pyranometers generate a voltage which is usually equal to:

$$10 \frac{\text{mV}}{\text{kW} \cdot \text{m}^2}$$

Every pyranometer composing the albedometer is calibrated separately as per the WRR (World Radiometric Reference) standard and is supplied with the relevant Report of Calibration.

These are strong and reliable ground-based instruments, especially designed to be used under all weather conditions. They are suitable for installation of the field.

**Recommended use:** climatological research, weather stations, road weather stations, agriculture stations, etc...

Technical Specification	LP PYRA 05*	LP PYRA 06*
Typical sensitivity	10 µV/(W/m <sup>2</sup> )	
Typical Impedance	33 Ω ± 45 Ω	
Irradiance range	0 ÷ 2000 W/m <sup>2</sup>	
Viewing angle	2π sr	
Spectral range	305 nm ÷ 2800 nm W/m <sup>2</sup> (50%)	
Operating Temperature	-40 °C ÷ 80 °C	
Weight (pyranometer only)	1.35 Kg	1.1 Kg
<b>ISO 9060 Specifications</b>		
Response time (95 %)	< 28 sec	< 30sec
Zero off-set		
a) thermal radiation (200 Wm <sup>-2</sup> )	15 W/m <sup>2</sup>	25 W/m <sup>2</sup>
b) temperature change 5K/h	<± 4 W/m <sup>2</sup>	<± 6 W/m <sup>2</sup>
Non- stability	<± 1.5 %	<± 2.5 %
Non linearity	<± 1 %	<± 2 %
directional error	<±18 W/m <sup>2</sup>	<±22 W/m <sup>2</sup>
Spectral seletivity	<±5 %	<±7 %
Temperature response	< 4 %	< 8 %
Tilt response	<± 2 %	<± 4 %

\* All technical data, excluding weight, are referred to one of the two pyranometers composing the albedometer.

### ORDERING CODES

**LP PYRA 05:** Albedometer made up of two 1<sup>st</sup> Class pyranometers, according to ISO 9060. Complete with: top shade disk and bottom shade disc, drying cartridge with silicagel crystals, 2 silica gel cartridges, spirit level, rod for attachment to a mast, and Report of Calibration. Typical sensitivity 10µV/(W/m<sup>2</sup>). **The connection cable has to be ordered separately.**

**LP SP1:** Top shade disc for albedometer LP PYRA 05 (upward pyranometer).

**LP SP3:** Bottom shade disk for albedometer LP PYRA 05 (downward pyranometer).

**LP SG:** Drying cartridge with silicagel crystals, complete with O-ring.

**LP G:** Pack of 5 cartridges of silicagel.

**LP PYRA 06:** Albedometer made up of two 2<sup>nd</sup> Class pyranometers, according to ISO 9060. Complete with: top shade disk and bottom shade disc, spirit level, rod for attachment to a mast, connecting cable 5m and Report of Calibration. Typical sensitivity 10µV/(W/m<sup>2</sup>). **The connection cable has to be ordered separately.**

**CP AA 2.5:** Flying 7-pole connector, complete with UV-resistant cable L=5m. For the instruments LP PYRA 05- LP PYRA 06 - LP UVB 02.

**CP AA 2.10:** Flying 7-pole connector, complete with UV-resistant cable L=10m. For the instruments LP PYRA 05- LP PYRA 06 - LP UVB 02.



LP NET 07

**NET IRRADIANCE METER**

LP NET 07 net radiometer is designed to measure the Net radiation passing through a surface, across the spectral range between the near ultraviolet and the far infrared. The Net radiation is defined as the difference between the radiation that strikes the top surface, and the radiation that strikes the bottom surface of the net radiometer. The upward facing surface measures direct and diffuse solar radiation plus long-wave irradiance from the sky (clouds), while the downward facing surface measures the reflected solar radiation (Albedo) plus the terrestrial long-wave irradiance.

LP NET 07 is designed for continuous outdoor use, and is suitable for all weather conditions. Although net radiometers are generally used in meteorology to measure radiation balance, the LP NET 07 can also be used to measure indoor radiant temperature (ISO 7726).

**Working Principle**

LP NET 07 is based on a thermopile sensor with one set of hot junctions in contact with the upper surface and a set of cold junctions in contact with the lower surface. The difference in temperature between the two receivers is proportional to the net radiation. Through the Seebeck effect, the difference in temperature between hot and cold junctions is translated into a Potential Difference. A hemispheric Teflon®-coated dome protects the two receivers, and their particular shape allows an optimal cosine corrected response. The Teflon® coating allows both a continuous outdoor use and a constant spectral response, ranging from the near ultraviolet (200nm) to the far infrared (100µm) spectral regions.

**Installing and mounting the net radiometer for total irradiance measurements:**

- To allow cleaning the two receiving surfaces regularly, LP NET 07 should be mounted in easily reachable places. The surfaces can be washed with plain water or pure ETHIL alcohol.
- Mount the instrument so that no shadow will be cast on it at any time of day and of the seasons, from obstructions such as buildings, trees, or any other obstacle.
- In the NORTHERN hemisphere, the net radiometer is normally oriented towards the SOUTH, while it should be oriented NORTHWARD, in the SOUTHERN hemisphere.
- The instrument should be mounted at least 1.5 meters above the ground surface. The flux on the downward facing sensor is representative for a circular area having a radius of 10 times the height.
- While mounting the net radiometer, avoid touching both receiving surfaces.

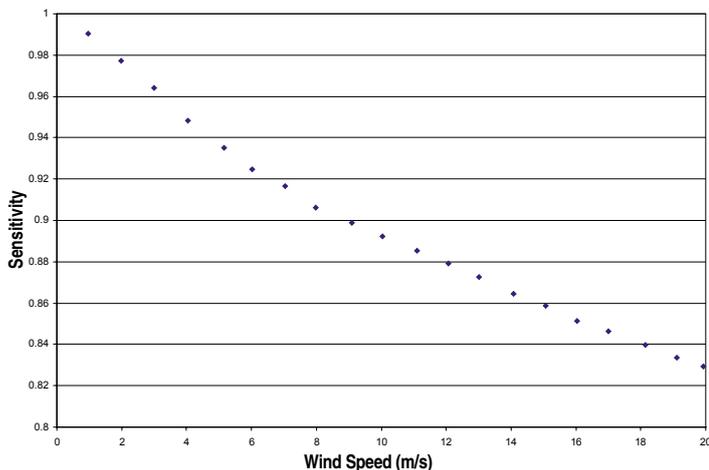


FIG. 2



LP PYRA 05



LP PYRA 05

**Electrical Connections and requirements for electronic readout devices:**

- LP NET 07 does not require any power supply.
- It is available with a 5 m. output cable
- It is supplied with a PTFE, UV resistant, braided shield and 2-wire cable. The color code is as follows:
  - black → connected to the housing
  - red → (+) positive pole of the signal generated by the detector
  - blue → (-) negative pole of the signal generated by the detector
 Fig.1 shows the wiring diagram.
- It has to be connected to a millivoltmeter or to a data acquisition system with input impedance higher than 4000kΩ. Normally, the output signal from the net radiometer does not exceed ±20 mV. In order to grant the best performances in measurements, the instrument resolution should be of 1µV.

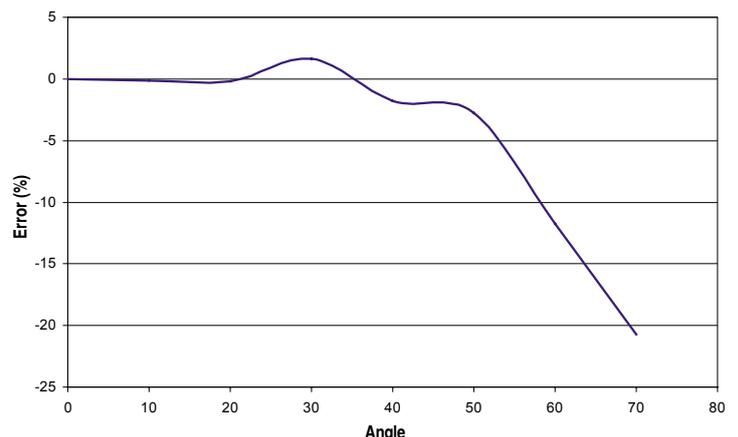


FIG. 3



LP PYRA 06

**Maintenance:**

In order to grant the instrument's best performance, the two receiving surfaces must be always kept clean; the cleaner you keep the instrument, the better the accuracy in measurements will be. Washing can be made with water and standard lens paper; in case this wouldn't work, use pure ETHIL alcohol. After using alcohol, the domes must be washed with water only. We strongly recommend checking LP NET 07 calibration every year. Calibration can be checked directly in the field, by mounting another net radiometer (sample) alongside, and comparing results. Calibration in the field is less precise than the one carried out in a laboratory, but has the advantage of not having to remove the probe from its holder.

**Calibration and measurements:**

Net radiometer sensitivity, indicated as S (or calibration factor), allows determining the net radiant flux passing through a surface. **S factor is measured in  $\mu V/(Wm^2)$ .**

- Once the potential difference (DDP) has been measured at sensor ends,  $E_e$  flux is obtained through the following formula:

$$E_e = DDP/S$$

where;

$E_e$ : indicates the radiant flux expressed in  $W/m^2$ ,

DDP: indicates the potential difference expressed in  $\mu V$  and measured by the multi-meter,



LP PYRA 06

S: indicates the calibration factor expressed in  $\mu V/(W/m^2)$  and shown on the net radiometer label (calibration factor is also mentioned in the calibration report).

N.B. If the difference of potential (DDP) is positive, the radiation on the upper surface is higher than the radiation on the lower surface (it happens normally in daily hours); if DDP is negative, the radiation on the lower surface is higher than the one on the upper surface (it happens in nightly hours).

Each net radiometer comes factory calibrated and has its own calibration factor. Calibration is performed inside Delta Ohm Metrological Laboratory, and is carried out by comparison with a reference net radiometer, using a solar simulator as a light source. Calibration is performed using a parallel light beam.

**Sensitivity to wind speed:**

At the same radiant flux density, by increasing the wind speed, the net radiometer output signal will decrease (by increasing the wind speed, sensitivity will decrease).

Measurements taken inside the wind tunnel, have shown that  $S_e$  sensitivity, related to the wind speed for LP NET 07, can be corrected by using the following functions:

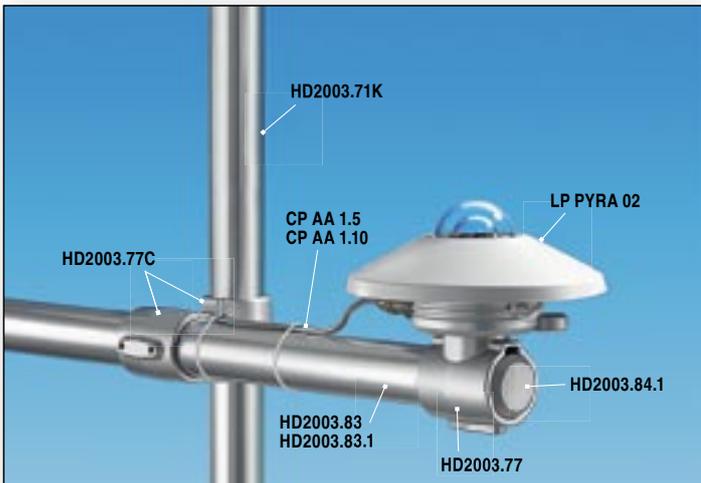
$$S_e = S_0(1 - 0.011 \times V) \quad V \leq 10m/s$$

$$S_e = S_0(0.95 - 0.006 \times V) \quad 10m/s < V < 20m/s$$

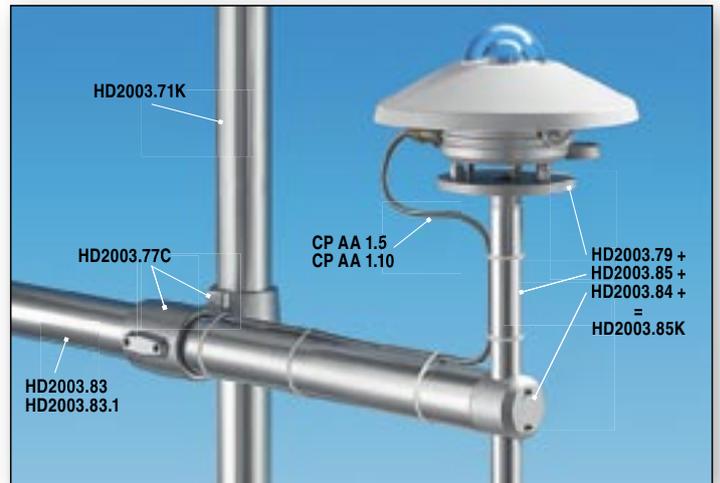
Where:  $S_0$  = sensitivity at zero wind speed

$V$  = wind speed in m/s

Fig. 2 shows the calibration factor related with wind speed.



LP PYRA 02 + HD2003.77C + HD2003.77



LP PYRA 02 + HD2003.85K + HD2003.77C



HD2013.2.14 + LPPYRA05 + LPPYRA06

Once we know both the net radiation - calculated through the sensitivity at zero wind speed ( $F_{net,0}$ ) - and the wind speed in (V) in m/s, the correct data is obtained by using the following formula:

$$F_{net} = F_{net,0} / (1 - 0.011 \times V) \quad V \leq 10 \text{ m/s}$$

$$F_{net} = F_{net,0} / (0.95 - 0.006 \times V) \quad 10 \text{ m/s} < V < 20 \text{ m/s}$$

**Cosine response/Directional error:**

The radiation falling on a surface should be measured with a sensor, whose response related to the light incidence angle, has to be a Lambertian Response. A receiver is known as Lambertian when its sensibility ( $S_\theta$ ), related to the incidence angle between the light and the detector surface, has the following behavior:

$$S_\theta = S_0 \cos(\theta)$$

Where:  $S_0$  is the sensibility when light strikes perpendicular to the surface,  $\theta$  is the angle between the incident light beam and the line which is normal to the surface.

Fig. 3 shows the typical behavior of the error related to the angle of incidence.

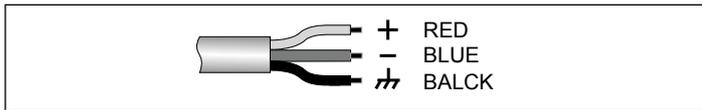
**Technical specifications:**

Typical sensitivity:	10 $\mu\text{V}/(\text{W}/\text{m}^2)$
Impedance:	$2\Omega \div 4\Omega$
Measuring range:	$\pm 2000 \text{ W}/\text{m}^2$
Spectral range:	$0.2 \mu\text{m} \div 100 \mu\text{m}$
Operating temperature:	$-40^\circ\text{C} \div 80^\circ\text{C}$
Weight:	0.35 Kg
Response time (95%):	<75 sec

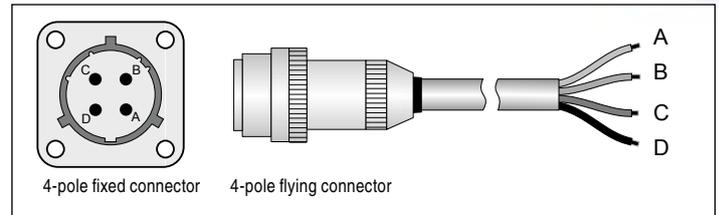
**ORDERING CODE**

**LP NET 07:** Net radiometer. Connecting cable: 5 m standard length. Different cable lengths upon request.

**CONNECTION DIAGRAM LP NET 07**

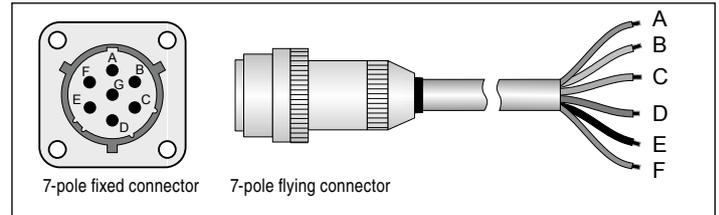


**CONNECTION DIAGRAM LP PYRA 02 - LP PYRA 03**

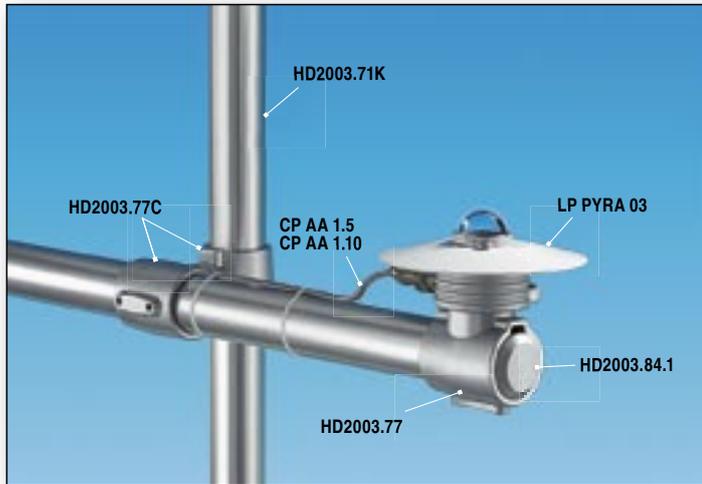


Connector	Function	Colour
A	Shield ( $\pm$ )	Black
B	Positiv (+)	Red
C	Negativ (-)	Blue
D	Housing ( $\neq$ )	White

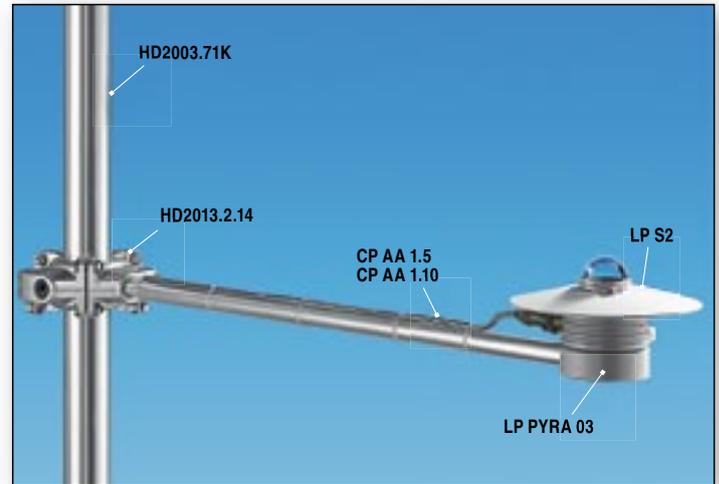
**CONNECTION DIAGRAM LP PYRA 05 - LP PYRA 06**



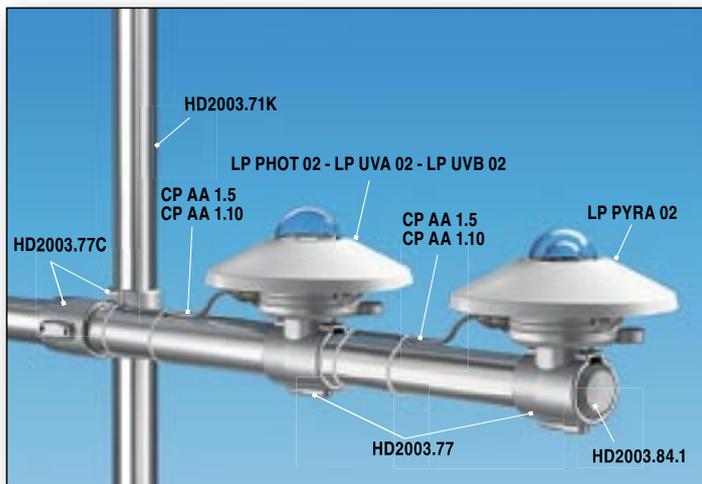
Connector	Function	Colour
A	V out (+) lower generator	Green
B	Housing ( $\neq$ )	White
C	V out (-) upper generator	Blue
D	V out (+) upper generator	Red
E	Shield ( $\pm$ )	Black
F	V out (-) lower generator	Brown



LP PYRA 03 + HD2003.77 + HD2003.77C



HD2013.2.14 + LP PYRA 03 + LP SP2 + LP S2



LP PYRA 02 + LP PHOT 02 + HD2003.77C + HD2003.77



LP PYRA 03 + HD2003.77C + HD2003.85K