Specification for Total Solar Radiation Sensorfor Total Solar Radiation Sensor

TBQ-2L

LiCheng Automation

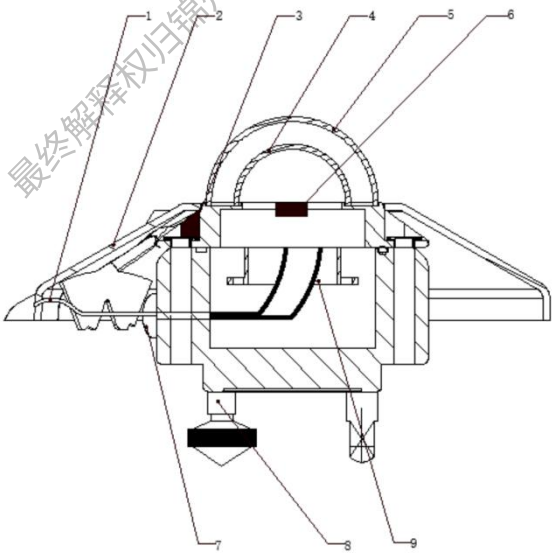
TBQ-2L 太阳总辐射传感器

一、产品简介：
（Product Introduction）

TBQ-2L 总辐射传感器是用来测量水平面从 2π 球面度立体角(半球向)接收到的太阳辐射，单位是 W/㎡。TBQ-2L 总辐射传感器采取完全无源工作方式，利用一个热电堆传感器生成一个与入射辐射通量成正比的输出电压。由于使用了两个球形玻璃罩,减少了测量误差特别是热偏移，因此传感器具有较高的测量精度。

The TBQ-2L total radiation sensor is used to measure the solar radiation received from a 2π spherical solid angle (hemisphere) on the horizontal plane, with units of W/㎡. The TBQ-2L total radiation sensor operates in a completely passive mode, using a thermopile sensor to generate an output voltage proportional to the incident radiation flux. Due to the use of two spherical glass domes, which reduce measurement errors, especially thermal offsets, the sensor has high measurement accuracy.

二、工作原理：
（operational principle）



TBQ-2L 总辐射传感器利用传感器上的黑色涂层吸收太阳辐射，辐射转换成热能进入传感器的内部,在热电堆两端形成温差,从而产生一个与入射太阳辐射成正比的电压输出信号。TBQ-2L 总辐射传感器结构图如图 1 所示:

图 1(Graph 1)

The TBQ-2L total radiation sensor uses a black coating on the sensor to absorb solar radiation, which is converted into heat energy and enters the interior of the sensor. A temperature difference is formed at both ends of the thermoelectric stack,

thus generating a voltage output signal proportional to the incident solar radiation.

The structure diagram of the TBQ-2L total radiation sensor is shown in Figure 1:

(1)电缆(标准长度 3 米)
Cable (standard length 3 m)

(2)防护罩
Hood

(3)水准泡
Level bubble

(4)石英玻璃内罩
Quartz glass inner cover

(5)石英玻璃外罩
Quartz glass cover

(6)带黑色涂层的热电堆传感器
Thermoelectric stack sensor with black coating

(7)电缆防水按头
Cable waterproof head

(8)水平调节脚
Level the feet

(9)印制电路板
Printed-circuit board

三、应用场景:
(Application scenarios)

可以用于气象观测、建筑物理学、气候和太阳光采集试验。通常的应用是作为气象站的一个部分来测量户外的太阳辐射。

It can be used for meteorological observation, building physics, climate and solar light collection experiments. The usual application is as a part of a weather station to measure outdoor solar radiation.

四、产品特点:

1. 依据 ISO9060 和 WMO 技术指标，满足 class B 级标准。
2. 采用高精度热电堆式半导体加工工艺，使得整体批次性能以及测量精度更高更加稳定精准。
3. 优质的 1mm 保护罩和全封闭设计，能够避免外界环境的影响。
4. 响应速度快，内阻低，反应速度快，数据才精准。
5. 可全天候进行数据标定，晴天，阴天，多云多种天气下也可以进行标定，数据更精准。
6. 高精水平泡加工精细地脚螺丝，点状着地水平调节更精准。

1. According to ISO9060 and WMO technical indicators, it meets the class B standard.
2. The adoption of high-precision thermopile semiconductor processing technology ensures higher, more stable, and more accurate overall batch performance and measurement precision.
3. The high-quality 1mm protective cover and fully enclosed design can prevent the impact of external environment.
4. Fast response speed, low internal resistance, and quick reaction speed ensure accurate data.
5. Data calibration can be performed around the clock, including on sunny, cloudy, and overcast days, ensuring more accurate data.
6. High-precision horizontal bubble processing for fine anchor screws, with point-like grounding for more precise horizontal adjustment.

五、技术指标:
(Qualification)

TBQ-2L 总辐射传感器的主要技术指标如表 1:

The main technical indicators of TBQ-2L total radiation sensor are shown in Table 1:

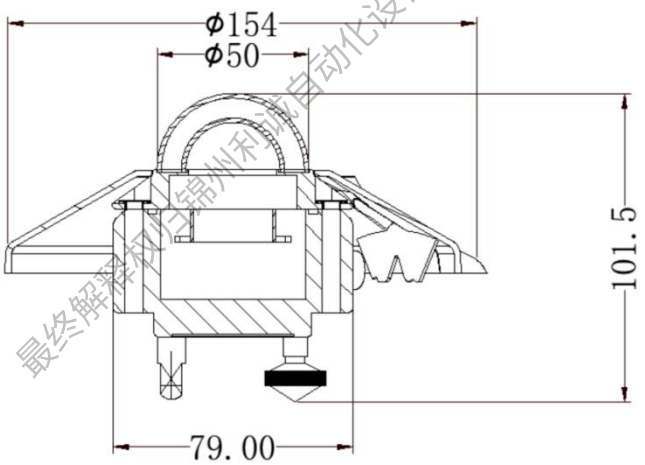
ISO/WMO 技术指标 ISO/WMO technical indicators	TBQ-2L
依据气象标准分级 Classify according to meteorological standards	国标一级表 National standard level 1 table
响应时间(95%响应) Response time (95% response)	<10s
零点偏置: Zero point bias:	
(a) 相应于 200W/m² 净热辐射(通风) Corresponding to 200W/m² net heat radiation (ventilation)	<10 W/m²
(b) 相应于环境温度变化 5K/h 的响应 Corresponding to the response of environmental temperature change 5K/h	<4W/m²
稳定性(变化/年，满度的百分率) Stability (change/year, percentage of full capacity)	±2%
非 线 性 Nonlinear	±1%(100~1000 W/m²)
方向性响应 Directional response	±20 W/m²
温度响应 Temperature response	<4%(-10~40℃)
倾斜响应 Tilt response	<1%
灵敏度范围 Sensitivity range	7-14μV/(W/m²)
工作温度 Working temperature	-40～+80℃
内 阻	<50Ω

Internal resistance	
标准电缆长度 Standard cable length	3m
测量范围 Measuring range	0~2000 W/m²
电缆替换 Cable replacement	用户可以拆除和安装电缆 The user can remove and install the cable
光谱范围 Spectral coverage	280~3000 nm(50%的透过点) (50 per cent penetration)
读取要求 Read requirements	一个差分电压通道或一个单端电压通道 A differential voltage channel or a single-ended voltage channel
水平校准 Horizontal alignment	包括水准泡和调节底脚 It includes a level bubble and an adjustable foot
日曝辐量不确定度 Uncertainty of solar radiation dose	±2%
重量(不包括电缆线) Weight (excluding cable)	0.8kg
校准追溯 Calibration traceability	追溯 WRR, 程序按照 ISO9847 To trace WRR, follow ISO9847
建议校准周期 Suggest calibration cycle	两年一次 Biennial
输出信号 output signal	0~20mV、RS485、4~20mA

六、产品实物尺寸图:
(Product physical dimension diagram)

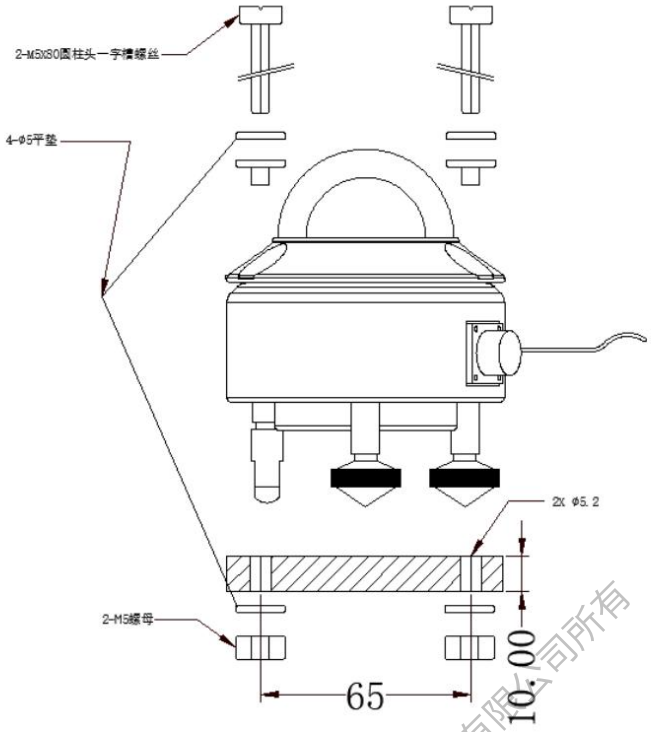
产品实物图 Product physical image

单位：mm



产品尺寸图

Product Dimension Drawing



1、收货检查 Receive inspection

送达客户的货物应该包括如下物件:

总辐射传感器　　1 台(含电缆线)

校准合格证书　　1 份

固定螺钉　　1 套

清洁布　　1 片

用户手册　　1 份

我们建议用户把合格证书存放在安全的地方。

The goods delivered to the customer shall include the following items:

Total radiation sensor 1 (including cable)

One calibration certificate

Set of fixed screws

Clean cloth 1 sheet

User manual 1 copy

We recommend that users store their certificates in a safe place.

七、传感器安装:
(Sensor installation)

TBQ 系列总辐射传感器通常水平安装，但是它也可以倾斜安装或倒置安装。无论在哪种安装方式下，传感器测量的都是入射到与传感器感应面表面平行的平面上的辐射量。

总辐射传感器的安装位置应视野开阔,特别是在一年当中日出和日落方位应没有大于 5°的遮挡物，可选在地面或楼顶平台安装，设置专用的立柱或平台。在台柱上部固定一块比总辐

射传感器底座稍大的金属板，并与仪器的接触面有良好的隔热。立柱平台离地面约 1.5m，要求牢固，即使受到严重冲击振动(如大风等)，也不改变仪器的水平状态。为了获得更高精度的测量，我们建议用户使用加热通风罩。

仪器接线柱方向朝北，用螺钉将仪器初步定在安装板上，然后利用仪器上所附的水准泡，调整底座上调节脚，使总辐传感器的感应面处于水平状态，然后固定安装螺钉。TBQ-2L 固定安装注意事项见表 2

The TBQ series total radiation sensor is usually installed horizontally, but it can also be installed at an angle or upside down. In either case, the sensor measures the amount of radiation incident on a plane parallel to the surface of the sensor's sensing surface.

The installation position of the total radiation sensor should have an open field of view, especially ensuring that there are no obstructions greater than 5 degrees at sunrise and sunset throughout the year. It can be installed on the ground or a rooftop platform, with dedicated pillars or platforms set up. A metal plate slightly larger than the base of the total radiation sensor should be fixed above the pillar, ensuring good thermal insulation between it and the instrument. The platform should be about 1.5 meters above the ground, securely mounted so that even under severe impact or vibration (such as strong winds), the instrument's horizontal position remains unchanged. To achieve higher measurement accuracy, we recommend users use a heated ventilation hood.

The instrument terminal is oriented north, and the instrument is initially fixed on the mounting plate with screws. Then, the adjustment feet on the base are adjusted using the level bubble attached to the instrument to make the sensing surface of the total radiation sensor horizontal, and then the installation screws are fixed. See Table 2 for TBQ-2L fixing installation precautions

表 2　TBQ 系列　总辐射传感器固定安装注意事项 Table 2 Precautions for the fixed installation of TBQ series total radiation sensors	
机械固定 Mechanical fixation	用附件中的螺钉将总辐射传感器固定在安装底板上。 Attach the total radiation sensor to the mounting plate with the screws in the attachment.
安装位置 Installation site	应该避免在太阳光入射路径和仪器之间摆放物品，以防止在仪器上产生阴影。 Items should be avoided between the path of sunlight and the instrument to prevent shadows on the instrument.
水平校准 Horizontal	如果是水平固定，使用仪器上的水准泡需要耐心多次调整水平调节脚。 If the level is fixed, it takes patience to adjust the level feet

alignment	multiple times using the bubble on the instrument.
安装方向 Installation direction	接线端朝北。 The wiring terminal faces north.
安装高度 Mounting height	如果是倒置安装的话，WMO 建议安装在离地面不低于 1.5 米的高度。 If installed upside down, the WMO recommends installing it no less than 1.5 meters above the ground.
倾 斜 Tilt	通常水平安装，但是在一些应用上可以倾斜安装或倒置安装，在各种情况下它测量入射在一个与传感器表面平行的区域表面上太阳辐射通量。 Usually installed horizontally, but can be installed at an angle or upside down in some applications, it measures the solar radiation flux incident on a surface parallel to the sensor surface in various situations.

八、接线定义：
（Definition of wiring）

连接传感器电缆至数据采集系统:
Connect sensor cable to data acquisition system:

表 2　接线方式
Table 2 Wiring mode

信　号 Signal	颜　色 Dyestuff	测 量 系 统 Instrumentationsystem
0-20mV 输出传感器 0-20mV output sensor		
传感器输出+ Sensor output +	红 色 Red	电压输入+ Voltage input +
传感器输出- Sensor output-	蓝 色 Blue	电压输入-或地 Voltage input-or ground
屏　蔽 Shield	屏　蔽 Shield	地 Land
RS485 输出接线方式 RS485 output wiring mode		
电源输入+ Power input +	红 色 Red	电源输出+ Power output +
电源输入- Power input-	黑 色 Black	电源输出-或地 Power output-or ground

RS485-A 信号输出 RS485-A signal output	黄 色 Yellow	RS485-A
RS485-B 信号输出 RS485-B signal output	绿 色 Green	RS485-B
4-20mA 输出接线方式 4-20mA output wiring mode		
电源输入+ Power input +	红 色 Red	电源输出+ Power output +
信号输出 Signal output	黄 色 Yellow	4-20mA 输入 4-20mA input
电源输入- Power input-	蓝 色 Blue	电源输出-或地 Power output-or ground

九、通信协议：
（Communicating protocol）

只限于 485 输出使用

It is limited to 485 output use

一、通讯参数 Communication parameters

通讯波特率：9600 可配置

数据位：8 位

停止位：1

奇偶校验：无效验

通讯方式：RS485

通讯地址范围：1~255 可配置 （默认为 1）

通讯协议：Modbus-RTU 协议

Communication baud rate: 9600 configurable

Data bits: 8 bits

Stop position: 1

Odd and even parity: invalid check

Communication mode: RS485

The range of the mailing address: 1 to 255 is configurable (default is 1)

Communication protocol: Modbus-RTU protocol

二、功能码介绍 Function code introduction

功能码 03H（读多个寄存器）

Function code 03H (read multiple registers)

查询：下行

Query: Downstream

报文格式：设备地址+功能码+寄存器起始地址+寄存器数量+CRC16 校验

Message format: device address + function code + register starting address + number of registers + CRC16 check

例子：Example

设备地址 Device address	功能码 Function code	寄存器起始地址高字节 Register Start address high byte	寄存器起始地址低字节 Register starting address low byte	寄存器数量高字节 Register count High byte	寄存器数量低字节 Register quantity lower byte	CRC16 校验低字节 CRC16 Verification lower byte	CRC16 校验高字节 CRC16 verification high byte
0x01	0x03	0x00	0x00	0x00	0x01	0x84	0x0A

含义如下：

1、设备地址：在一个 485 总线上可以挂接多个设备，此处地址表示想和哪一个地址设备通讯。

2、功能码：读多个寄存器的功能码位 03

3、起始地址高8位、低8位：表示想读取的寄存器的起始地址，例子中起始地址为0。

4、寄存器数量高 8 位、低 8 位：表示从起始地址开始读多少个寄存器。例子中为 1 个寄存器。 注意，在返回的信息中一个寄存器需要返回二个字节。

5、CRC 校验：使用 CRC-16/MODBUS，多项式为：（x16 + x15 + x2 + 1），
低位在前高位在后。

The meaning is as follows:

1、Device address: Multiple devices can be connected to a 485 bus. Here the address indicates which address device you want to communicate with.

2、Function code: Read the function code bit 03 of multiple registers

3、The high 8 bits and low 8 bits of the starting address: indicate the starting address of the register to be read. In this example, the starting address is 0.

4、Register count high 8 bits, low 8 bits: indicates how many registers to read from the starting address. In this example, it is one register. Note that one register in the returned information requires two bytes.

5、CRC verification: Use CRC-16/MODBUS, the polynomial is:(x16 + x15 + x2 + 1),
Low in front and high at the back.

响应：上行

Response: Upstream

设备地址 Device address	功能码 Function code	数据长度字节数 The number of bytes in the data	寄存器 1 高字节 Register 1 high byte	寄存器 1 低字节 Register 1 low byte	CRC 校验低字节 CRC check low byte	CRC 校验高字节 CRC check high byte
0x01	0x03	0x02	0x00	0x6F	0xF8	0x68

含义如下：

1、设备地址与功能码和上面相同。

2、数据长度字节数：表示返回数据的字节个数。例子中返回了二个寄存器数据，因为一个寄存 器要 2 个字节，所以共 4 个字节

3、寄存器 1 高字节，寄存器 1 低字节是第一个寄存器，寄存器 2 高字节，寄存器 2 低字节是第 二个寄存器。例子返回的十进制值分别是 111 ，0

4、CRC 校验同上

The meaning is as follows:

1、The device address is the same as the function code above.

2、Data length in bytes: indicates the number of bytes returned. In this example, two register data are returned, because one register takes 2 bytes, so a total of 4 bytes

3、Register 1 high byte, register 1 low byte is the first register, register 2 high byte, register 2 low byte is the second register. The decimal values returned by the example are 111 and 0

4、CRC verification is the same as above

【1】设置与上位机通讯地址：（标准 MODBUS）

Set the communication address with the host computer: (standard MODBUS)

名称 Name	字节 Byte	数据 Data
采集仪地址 Collector address	1	0xXX：总辐射表地址 Total radiation meter address
功能码 Function code	1	0x10：功能码（固定 0x10） Function code (fixed 0x10)
数据区---寄存器地址高字节 Data area-high byte of register address	1	0x05：设置寄存器高字节 Set the high byte of the register
数据区---寄存器地址低字节 Data area--Low byte of register address	1	0x01：设置寄存器低字节 Set the low byte of the register
数据区---寄存器数量高字节 Data area-high byte of the number of registers	1	0x00：寄存器数量高字节 Register number high byte
数据区---寄存器数量低字节 Data area-low byte of the number of registers	1	0x01：寄存器数量低字节 Register count low byte
数据区---数据字节长度 Data area-data byte length	1	0x02：数据字节长度 Data byte length
数据区---寄存器数据高字节 Data area--high byte of register data	1	0xXX：设备通讯地址 Device communication address
数据区---寄存器数据低字节	1	0x00：寄存器数据低字节

Data area--Low byte of register data		Low byte of register data
CRC 校验和 CRC check sum	2	CRC 校验 CRC verification

2、数据帧-应答：总辐射表 -> 上位机

Data frame-response: total radiation meter-> upper computer

名称 Name	字节 Byte	数据 Data
采集仪地址 Collector address	1	0xXX：总辐射表地址 Total radiation meter address
功能码 Function code	1	0x10：功能码 Function code
数据区---设置寄存器高字节 Data area--Set the high byte of the register	1	0x00：设置寄存器高字节 Set the high byte of the register
数据区---设置寄存器低字节 Data area--Set the low byte of the register	1	0x05：设置寄存器低字节 Set the low byte of the register
数据区---字节长度高字节 Data area-byte length high byte	1	0x00：字节长度高字节 Byte length high byte
数据区---字节长度低字节 Data area--Low byte length	1	0x01：字节长度低字节 Byte length low byte
CRC 校验和 CRC check sum	2	CRC 校验 CRC verification

【2】设置与上位机通讯波特率：（标准 MODBUS）

Set the communication baud rate with the host computer: (standard MODBUS)

名称 Name	字节 Byte	数据 Data
采集仪地址 Collector address	1	0xXX：总辐射表地址 Total radiation meter address
功能码 Function code	1	0x10：功能码（固定 0x10） Function code (fixed 0x10)
数据区---寄存器地址高字节 Data area-high byte of register address	1	0x05：设置寄存器高字节 Set the high byte of the register
数据区---寄存器地址低字节 Data area--low byte of register address	1	0x03：设置寄存器低字节 Set the low byte of the register
数据区---寄存器数量高字节 Data area-high byte of the number of registers	1	0x00：寄存器数量高字节 Register number high byte
数据区---寄存器数量低字节 Data area-low byte of the number of registers	1	0x01：寄存器数量低字节 Low byte of the register count
数据区---数据字节长度 Data area-data byte length	1	0x02：数据字节长度 Data byte length
数据区---寄存器数据高字节 Data area--high byte of register data	1	0xXX：通讯波特率 Communication baud rate 【说明】0x01：4800 Explain 0x02：9600 0x03：19200 0x04：38400 0x05：57600 0x06：115200
数据区---寄存器数据低字节 Data area--Low byte of register data	1	0x00：寄存器数据低字节 Low byte of register data
CRC 校验和 CRC check sum	2	CRC 校验 CRC verification

2、数据帧-应答：总辐射表 -> 上位机

Data frame-response: total radiation meter-> upper computer

名称 Name	字节 Byte	数据 Data
采集仪地址 Collector address	1	0xXX：总辐射表地址 Total radiation meter address
功能码 Function code	1	0x10：功能码 Function code
数据区---设置寄存器高字节 Data area--Set the high byte of the register	1	0x00：设置寄存器高字节 Set the high byte of the register
数据区---设置寄存器低字节 Data area--Set the low byte of the register	1	0x05：设置寄存器低字节 Set the low byte of the register
数据区---字节长度高字节 Data area-byte length high byte	1	0x00：字节长度高字节 Byte length high byte

数据区---字节长度低字节 Data area--Low byte length	1	0x01：字节长度低字节 Byte length low byte
CRC 校验和 CRC check sum	2	CRC 校验 CRC verification

十、维护和故障诊断：
（Maintenance and fault diagnosis）

1、维护 Preventive maintenance

（1）玻璃罩受污染时，用软布沾水或者酒精清洁玻璃罩;检查球玻璃罩内部，是否有凝聚水珠，如有则需返厂维修；

（2）水平状态检查，传感器水平状态发生变化时，需要松开固定螺钉重新调整水平调节脚，直至传感器水平再旋紧固定螺钉;

（3）检查电缆是否有损伤，以防开路；

（4）严格检查数据，功能性误差通常表现为测量值异常，严格检查测量数据是最好的日常维护；

（5）再次校准，建议每两年校准一次。

（1）When the glass cover is contaminated, clean the glass cover with a soft cloth dipped in water or alcohol; check the inside of the ball glass cover to see if there are condensed water droplets, if so, return to the factory for maintenance;

（2）Level status check, when the sensor level status changes, loosen the fixing screw and adjust the level adjustment foot again until the sensor is level and tighten the fixing screw;

（3）Check whether the cable is damaged to prevent open circuit;

（4）Strictly check the data, functional errors are usually manifested as abnormal measurement values, strict check of measurement data is the best daily maintenance;

（5）Re-calibrate, it is recommended to calibrate every two years.

2、故障诊断 Fault diagnosis

传感器不能正常工作时按下表 4 进行故障诊断。

When the sensor does not work properly, press Table 4 for fault diagnosis.

表 4　传感器故障诊断

Table 4 Sensor fault diagnosis

传感器无输出信号 The sensor has no output signal	1. 测量传感器两端电线的阻抗，这个值应该小于 200 欧姆。如果这个值接近零，则表明电路短路(检查电线),如果这个值无限大，则表明电路开路(检查电线)。这个检查也可以在传感器被遮盖时进行； 2.用点亮的白炽灯来检查传感器的响应，将一个 100 瓦的灯泡固定在离传感器 10 厘米的距离能够产生一定程度的响应； 3.通过在 1 毫伏范围内施加给传感器一个毫伏量级的信号源来检查数据采集。 1. Measure the impedance of the wires at both ends of the sensor, which should be less than 200 ohms. If this value is close to zero, it indicates a short circuit (check the wires), if this value is infinite, it indicates an open circuit (check the wires). This check can also be done when the sensor is

	covered; 2. To check the sensor response with a lit incandescent lamp, a 100-watt bulb fixed 10 cm away from the sensor can produce a certain level of response; 3. Data acquisition is checked by applying a millivolt level signal source to the sensor in the 1 millivolt range.
传感器信号不正常的高或低 The sensor signal is abnormally high or low	1. 检查是否在算法中输入正确的灵敏度系数，每一个传感器都有它自己特定的灵敏度系数； 2.查验算法Φ=U/E是否正确，检查数据采集器的接线状况； 3.检查电缆是否断裂； 4.检查数据采集器的读数范围，热流量可以是负数值(这已经超出读数范围)或者幅度可以超出读数范围； 5.通过在毫伏读数范围内施加给传感器一个毫伏量级的信号源来检查数据采集器。 1. Check whether the correct sensitivity coefficient is input in the algorithm, each sensor has its own specific sensitivity coefficient; 2. Check whether the verification algorithm Φ=U/E is correct and check the wiring condition of the data collector; 3. Check whether the cable is broken; 4. Check the reading range of the data collector, the heat flow can be negative (which is beyond the reading range) or the amplitude can exceed the reading range; 5. The data collector is checked by applying a millivolt level signal source to the sensor in the millivolt reading range.
传感器信号显示非预期的波动 The sensor signal shows unexpected fluctuations	1.检查附近是否有强大的电磁辐射信号源(雷达、无线电等)； 2.检查屏蔽情况； 3.检查传感器电缆的连接状况。 1.Check whether there is a strong electromagnetic radiation signal source (radar, radio, etc.) nearby; 2.Check the shielding condition; 3.Check the connection of the sensor cable.