TBQ-2HTotal Solar Radiation Sensor

instruction manual

TBQ-2H 型太阳总辐射传感器

一、产品简介：
(Product Introduction)

TBQ-2H 总辐射传感器是一种应用于太阳辐射观测的短波总辐射传感器。它是符合最新的 ISO9060 和 WMO 技术标准的 A 级总辐射传感器。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-2H 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-2H total radiation sensor is a shortwave total radiation sensor designed for solar radiation observation. It is a Class A total radiation sensor that complies with the latest ISO9060 and WMO technical standards. It is used to measure the solar radiation received by the horizontal surface from a 2π spherical degree solid angle (hemispherical direction), with the unit being W/㎡. The TBQ-2H total radiation sensor operates in a completely passive manner, utilizing a thermopile sensor to generate an output voltage proportional to the incident radiation flux. Due to the use of two spherical glass covers, measurement errors, especially thermal drift, are reduced, thus the sensor exhibits high measurement accuracy.

二、工作原理：
(Working principle)

TBQ-2H 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-2H 总辐射传感器结构图如图 1 所示:

The TBQ-2H total radiation sensor utilizes the black coating on the sensor to absorb solar radiation, which is converted into thermal energy and enters the interior of the sensor. A temperature difference is formed at both ends of the thermoelectric stack, generating a voltage output signal proportional to the incident solar radiation. The structural diagram of TBQ-2H total radiation sensor is shown in Figure 1:

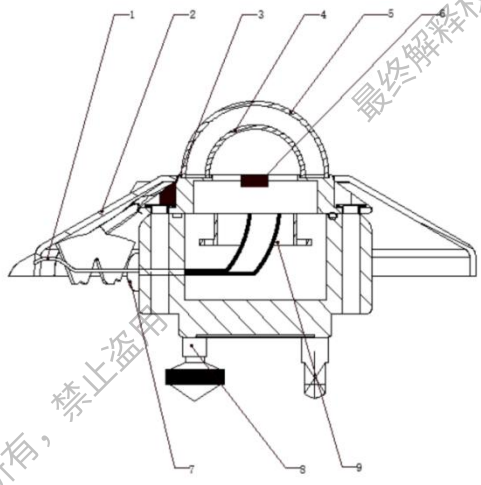


图 1 (Graph 1)

(1)电缆(标准长度 5 米)
Cable (standard length 5 meters)

(2)防护罩
Protective cover

(3)水准泡
Leveling 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
Waterproof cable head

(8)水平调节脚
Horizontal adjustment foot

(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。

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

四、产品特点:

1. 依据 ISO9060 和 WMO 技术指标，满足 class A 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 A 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 rapid reaction speed ensure accurate data.
5. Data calibration can be performed around the clock, even in various weather conditions such as sunny, cloudy, and overcast, 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:
(Technical indicators)

TBQ-2H 总辐射传感器的主要技术指标如表 1:

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

ISO/WMO 技术指标 ISO/WMO Technical Indicators	TBQ-2H
依据 ISO 9060/WMO 标准分级	A 级良好质量

According to ISO 9060/WMO standard grading	A-level good quality
响应时间(95%响应) Response time (95% response)	<5s
零点偏置: Zero bias:	
(a) 相应于 200W/m² 净热辐射(通风) Corresponding to 200W/m ² net thermal radiation (ventilation)	<7W/m²
稳定性(变化/年，满度的百分率) Stability (change/year, percentage of fullness)	±0.5%
非 线 性 Nonlinear	±0.2%(100~1000 W/m²)
方向性响应 Directional response	±10 W/m²
温度响应 Temperature response	<1%(-10~40℃)
倾斜响应 Tilt response	<0.5%
灵敏度范围 Sensitivity range	7-14μV/(W/m²)
工作温度 Operation temperature	-40～+80℃
内 阻 Internal resistance	<50Ω
标准电缆长度 Standard cable length	3m
测量范围 Measuring range	0~4000 W/m²
电缆替换 Cable replacement	用户可以拆除和安装电缆 Users can remove and install cables
光谱范围 Spectral range	280~3000 nm(50%的透过点) 280~3000 nm (50% transmittance)
读取要求 Reading requirements	一个差分电压通道或一个单端电压通道 A differential voltage channel or a

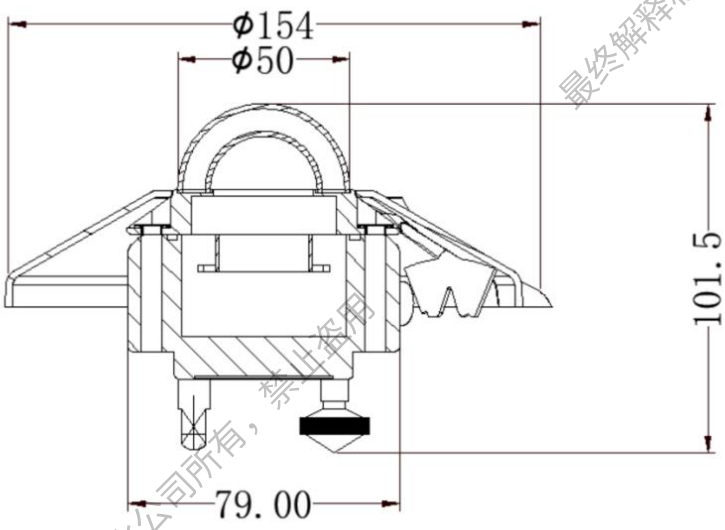
	single ended voltage channel
水平校准 Horizontal calibration	包括水准泡和调节底脚 Including leveling bubbles and adjustable feet
日曝辐量不确定度 Uncertainty of daily exposure radiation	±1%
重　　量(不包括电缆线) Weight (excluding cables)	0.8kg
校准追溯 Calibration traceability	追溯 WRR,　程序按照 ISO9847 Tracing WRR, the program follows ISO9847
建议校准周期 Suggested 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

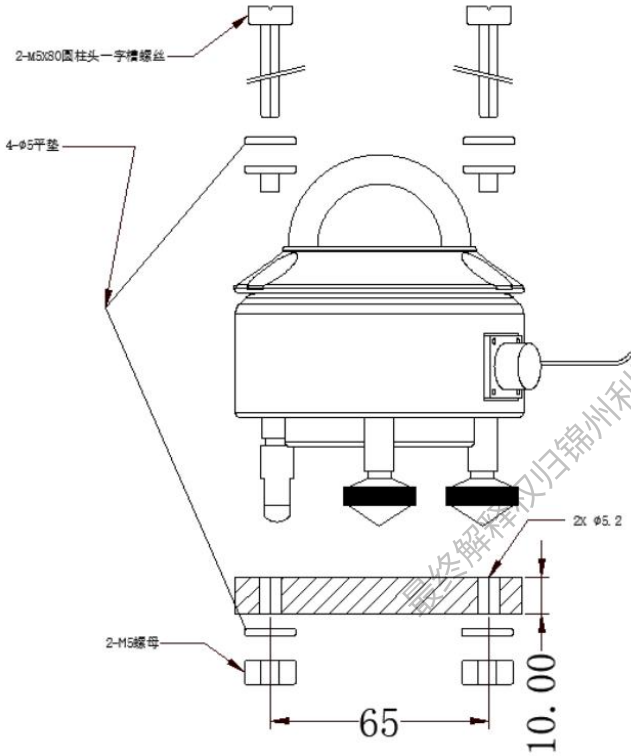
Product physical image

单位：mm



产品尺寸图

Product Dimension Drawing



七、装箱清单:

(packing list)

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

擦镜布　　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 should include the following items:

One total radiation sensor (including cable)

1 copy of calibration certificate of conformity

1 set of fixing screws

1 piece of mirror cloth

1 user manual

We recommend that users store their certificates of conformity in a secure location.

八、传感器安装:
(Sensor installation)

TBQ-2H 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-2H total radiation sensor is usually installed horizontally, but it can also be installed diagonally or upside down. Regardless of the installation method, the sensor measures the amount of radiation incident on a plane parallel to the sensing surface of the sensor.

The installation location of the total radiation sensor should have a wide field of view, especially in the sunrise and sunset directions throughout the year, there should be no obstructions greater than 5 degrees. It can be installed on the ground or rooftop platform, with dedicated columns or platforms. Fix a metal plate slightly larger than the base of the total radiation sensor on the upper part of the column, and provide good insulation to the contact surface with the instrument. The column platform is about 1.5m above the ground and is required to be firm. Even if it is subjected to severe impact and vibration (such as strong winds), it will not change the horizontal state of the instrument. To achieve higher precision measurements, we recommend that users use heated ventilation hoods.

The direction of the instrument terminal is facing north. Use screws to preliminarily position the instrument on the mounting plate. Then, use the leveling bubble attached to the instrument to adjust the adjusting foot on the base so that the sensing surface of the total radiation sensor is in a horizontal state. Finally, fix the mounting screws. TBQ-2L fixed installation precautions are shown in Table 2

表 2　TBQ 系列　总辐射传感器固定安装注意事项 Table 2 Precautions for Fixed Installation of TBQ Series Total Radiation Sensor	
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。 Use the screws in the attachment to secure the total radiation sensor to the mounting base plate.
安装位置 Installation position	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 from being placed between the path of sunlight and the instrument to prevent shadows from appearing on the instrument.
水平校准 Horizontal calibration	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 it is fixed horizontally, using the leveling bubble on the instrument requires patient adjustment of the horizontal adjustment foot multiple times.
安装方向 Installation direction	接线端朝北。 The terminal faces north.
安装高度 Installation 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, WMO recommends installing at a height of no less than 1.5 meters above the ground.
倾　斜 Incline	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 in some applications it can be installed diagonally or upside down, measuring the solar radiation flux incident on a surface parallel to the sensor surface in various situations.

九、接线定义:
（Wiring Definition）

连接传感器电缆至数据采集系统:

Connect the sensor cable to the data acquisition system:

表 3-1　TBQ 系列总辐射接线方式（0-20mv） Table 3-1 TBQ series total radiation wiring method (0-20mv)		
信　号	颜　色	测　量

Signal	Colour	Measure
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 Ground

表 3-2 TBQ 系列总辐射接线方式（485）

Table 3-2 TBQ series total radiation wiring method (485)

信 号 Signal	颜 色 Colour	测 量 Measure
电源输入+ Power input+	红 色 Red	电源输出+ Power Output+
电源输入- Power input-	黑 色 Black	GND
RS485-A 信号输出 Signal output	黄 色 Yellow	RS485-A
RS485-B 信号输出 Signal output	绿 色 Green	RS485-B

表 3-3 TBQ 系列总辐射接线方式（4-20ma）

Table 3-3 TBQ series total radiation wiring method (4-20ma)

信 号 Signal	颜 色 Colour	测 量 Measure
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

十、通信协议：
（Communication protocol）

只限于485输出使用 Limited to 485 output use only

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

Parity check: No verification

Communication method: RS485

Communication address range: 1~255 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）

读取设备数据命令

命令格式：设备地址+功能码+寄存器起始地址+寄存器长度+CRC16 校验

例子：

Function code 03H (read multiple registers)

Read device data command

Command format: Device address+Function code+Register starting address+ Register length +CRC16 check

Example:

设备地址 Device Address	功能码 Function code	寄存器起始地址 高字节 Register starting address high byte	寄存器起始地址 低字节 Register starting address low byte	寄存器长度 高字节 Register length high byte	寄存器长度 低字节 Register length low byte	CRC16校验 低字节 CRC16 check low byte	CRC16校验 高字节 CRC16 check high byte
0x01	0x03	0x00	0x00	0x00	0x01	0x84	0x0A

含义如下：

The meaning is as follows

1、设备地址：在一个485总线上可以挂接多个设备，此处设备地址表示需要与哪一个设备进行通讯。

2、功能码：读多个寄存器的功能码为03H

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

4、寄存器长度高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。

1、Device address: Multiple devices can be connected to a 485 bus, where the device address indicates which device needs to be communicated with.

2、Function code: The function code for reading multiple registers is 03H

3、Register starting address high 8 bits, low 8 bits: indicates the starting address of the register to be read, in the example, the starting address of the register is 0.

4、Register length of 8 bits high and 8 bits low: indicates how many registers are read from the starting address. In the example, there is one register. Note that in the returned information, a register needs to return two bytes.

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

设备应答

Device acknowledge

设备地址 Device address	功能码 Function code	数据长度字节数 Data length in bytes	寄存器0 数据高字节 Register 0 data high byte	寄存器 0 数据低字节 Register 0 data low byte	CRC16校验低字节 CRC16 check low byte	CRC16校验高字节 CRC16 check high byte
0x01	0x03	0x02	0x00	0x6F	0xF8	0x68

含义如下：The meaning is as follows

1、设备地址和功能码与上面相同。

2、数据字节长度字节：表示返回数据的字节个数。例子中返回了一个寄存器数据，因为一个寄存 器要2个字节，所以共2个字节。

3、寄存器0 数据高字节，寄存器 0 数据低字节是第0个寄存器内的数据。

4、CRC16校验同上

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

2、 Data length of bytes: represents the number of bytes returned for the data. In the example, a register data is returned, which is 2 bytes in total because a register requires 2 bytes.

3、Register 0 data high byte, register 0 data low byte is the data in the 0th register.

4、CRC16 verification is the same as above.

功能码 10H（写多个寄存器）
Function code 10H (write multiple registers)

（1）设置设备的通讯地址命令：
Set the communication address of the device：

名称 Name	字节数 Byte	数据 Data
设备地址 Device address	1	0xXX：设备地址 Device address
功能码 Function code	1	0x10：功能码 Function code
寄存器起始地址高字节 Register starting address high byte	1	0x05：寄存器起始地址高字节 Register starting address high byte
寄存器地址低字节 Register starting address low byte	1	0x01：设置寄存器低字节 Register starting address low byte
寄存器长度高字节 Register length high byte	1	0x00：寄存器数长度字节 Register length high byte
寄存器长度低字节 Register length low byte	1	0x01：寄存器长度低字节 Register length low byte
数据字节长度 Data length in bytes	1	0x02：数据字节长度 Data length in bytes
写入寄存器的数据高字节 High byte data written into the register	1	0xXX：设备通讯地址 Device communication address
写入寄存器的数据低字节 Low byte data written into the register	1	0x00：预留 Reserve
CRC16 校验和 CRC16 check	2	CRC16 校验 CRC16 check

设备应答

名称 Name	字节数 Byte	数据 Data
设备地址 Device address	1	0xXX：设备地址 Device address
功能码 Function code	1	0x10：功能码 Function code
寄存器起始地址高字节 Register starting address high byte	1	0x05：寄存器起始地址高字节 Register starting address high byte
寄存器地址低字节 Register starting address low byte	1	0x01：设置寄存器低字节 Register starting address low byte
寄存器长度高字节 Register length high byte	1	0x00：寄存器数长度字节 Register length high byte
寄存器长度低字节	1	0x01：寄存器长度低字节

Device	Register length low byte		Register length low byte
	CRC16 校验和 CRC16 check	2	CRC16 校验 CRC16 check

acknowledge

（2）设置设备的通讯波特率：

Set the communication baud rate of the device:

名称 Name	字节数 Byte	数据 Data
设备地址 Device address	1	0xXX：设备地址 Device address
功能码 Function code	1	0x10：功能码 Function code
寄存器起始地址高字节 Register starting address high byte	1	0x05：寄存器起始地址高字节 Register starting address high byte
寄存器地址低字节 Register starting address low byte	1	0x03：设置寄存器低字节 Register starting address low byte
寄存器长度高字节 Register length high byte	1	0x00：寄存器数长度字节 Register length high byte
寄存器长度低字节 Register length low byte	1	0x01：寄存器长度低字节 Register length low byte
数据字节长度 Data length in bytes	1	0x02：数据字节长度 Data length in bytes
写入寄存器的数据高字节 High byte data written into the register	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
写入寄存器的数据低字节	1	0x00：预留

Low byte data written into the register		Reserve
CRC16 校验和 CRC16 check	2	CRC16 校验 CRC16 check

设备应答

Device response

名称 Name	字节数 Byte	数据 Data
设备地址 Device address	1	0xXX：设备地址 Device address
功能码 Function code	1	0x10：功能码 Function code
寄存器起始地址高字节 Register starting address high byte	1	0x05：寄存器起始地址高字节 Register starting address high byte
寄存器地址低字节 Register starting address low byte	1	0x03：设置寄存器低字节 Register starting address low byte
寄存器长度高字节 Register length high byte	1	0x00：寄存器数长度字节 Register length high byte
寄存器长度低字节 Register length low byte	1	0x01：寄存器长度低字节 Register length low byte
CRC16 校验和 CRC16 check	2	CRC16 校验 CRC16 check

十一、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 it with a soft cloth dipped in water or alcohol; Check the inside of the ball glass cover for condensed water droplets. If so, it needs to be returned to the factory for repair;

(2) Horizontal status check: When the horizontal status of the sensor changes, it is necessary to loosen the fixing screw and readjust the horizontal adjustment foot until the sensor is level, and then tighten the fixing screw;

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

(4) Strictly checking data, functional errors usually manifest as abnormal measurement values, and strict inspection 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 is not working properly, perform fault diagnosis according to Table 4.

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 in the circuit (check wires), and if this value is infinitely large, it indicates an open circuit in the circuit (check wires). This inspection can also be performed when the sensor is covered; 2. Use a lit incandescent lamp to check the response of the sensor. Fixing a 100 watt bulb at a distance of 10 centimeters from the sensor can produce a certain degree of response:

	3. Check data acquisition by applying a millivolt level signal source to the sensor within the range of 1 millivolt.
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 if the correct sensitivity coefficient is inputted into the algorithm, as each sensor has its own specific sensitivity coefficient: 2. Check if the algorithm Φ=U/E is correct and verify the wiring status of the data collector; 3. Check if the cable is broken; 4. Check the reading range of the data collector. The heat flow rate can be a negative value (which is already outside the reading range) or the amplitude can exceed the reading range; 5. Check the data collector by applying a millivolt level signal source to the sensor within 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 if there are strong electromagnetic radiation signal sources (radar, radio, etc.) nearby; 2. Check the shielding situation; 3. Check the connection status of the sensor cable;