User Manual

for

PST20 series Low Cost MEMS Inclinometer

ASCII programmation

Revision History

Revision	Date	Change Description
A	9/25/2018	Initial Release

CONTENTS

1 OVERVIEW

PST20 inclinometer based on advanced tilt measurement technology, to meet with low cost, high reliability and volume application, performs high performance-cost ratio.

PST20 employed most universal & mass-produced components, casting aluminum alloy house, universal high reliability M12-5pin industrial connector; full epoxy seal with IP67 protection, auto-test/calibration equipment which not only ensure delivery speed, also keep the consistency of goods.

They adopt advanced technologies as:

- CAE/EDA simulation;
- Modal test for both housing and PCB to eliminate resonance due to vibration; - Comprehensive performance & function test for component & firmware;
- Calibration technology based on PST300 high accuracy inclinometer;
- Refer MIL/ EN/ ISO/IEC standards to enhance PST20 durability & reliability.

PST20 support remote diagnosis without disassembling. MTBF more than 10 years per time. Can work in 10m submersible depth long time and has better EMC ability.

PST20 output RS232/RS485/CAN/CANOpen and Voltage/Current signals. Better power management to meet with automotive /truck/vehicle application without regulated power.

OEM service is available with calibrated PCBA or MIL qualified.

Applications for PST20：

- Vessel
- Landslide
- Antenna
- Engineering machinery,
- Automobile/truck/vehicle
- Construction engineering
- High-voltage pylon monitoring,
- Solar/wind energy
- Communication/electric Tower monitoring, etc

PST20 series Inclinometer with M12-5Pin connector

2 TECHNICAL DATA

2.1 Technical Features

PST20 series inclinometer has the following technical features：

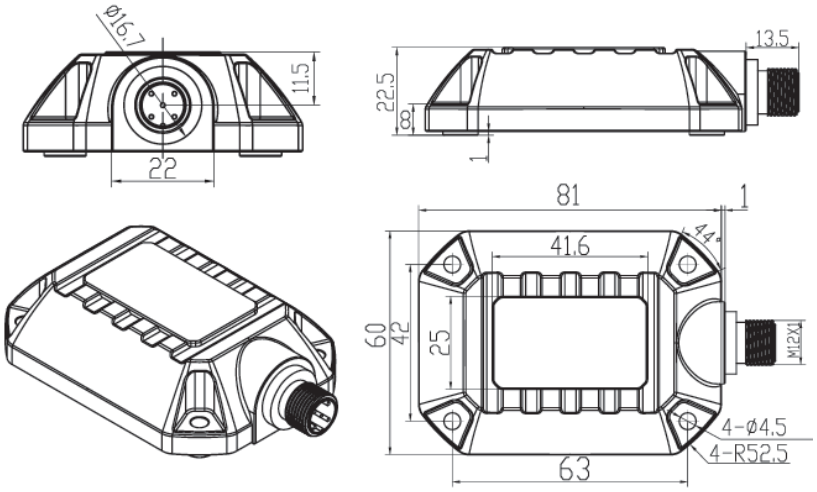
- Low cost, high performance, suitable for batch application
- Up to 50Hz refresh rate, 10Hz response frequency
- ±0.5% Cross-axis error, ±0.15° or ±0.07°accuracy
- Available to horizontal, vertical, headstand, etc installation
- Auto-correct installation error
- IP67 protection
- 9~36VDC supply, compatible to automotive application
- Survive to 1500g shock while operating
- Up to 10 years of MTBF
- OEM available, MIL/ EN/DIN/ISO/IEC testing standard upon request application

Core Competence in Tilt Measurement Field of PST series Inclinometer
：

1. Modal test have to be made on each housing of PST inclinometer, rather than simply fixing a PCBA board into it.2
. PCBA board made a complete model test independently, also made the same test for PCBA & housing together, as it solves resonance interference by environment vibration when suppress by filter.
3. Inclinometer testing is strictly executed as per relevant Chinese and international standard implementation, including GB, GJB, MIL, IEC, ISO, EN, etc...
4. Nearly 30 kinds of invention patents, utility model patents, patents of appearance and software copyrights in the field of tilt measurement.
5. Each inclinometer adopts patented automatic testing technology, which will greatly reduce human interference on the quality, and keep the same quality consistency.

2.2 Dimensions

The dimensions of PST20 are shown in the following figures， and which have units of millimeters：



Mechanical draft with M12-5Pin connector

2.3 General Specifications

The general specifications and technical data of PST20 series inclinometer are listed below:

Measurement range	±5°、±10°、±15°、±30°、±45°、±60°、±90°、0~360°(±180°@single axis)	
Accuracy	Digital output：±0.07°@-15~50℃	Analog output：±0.15°@-15~50℃
Resolution	0.01°	
Cross-axis sensitivity	±0.5%FS	
Repeatability	±0.02°	±0.05°
Offset	±0.02°	±0.05°
Measurement axis	1 or 2 axis	
Bandwidth	Factory 3Hz , 10Hz max	
Response time	0.3s@t90	
Refresh rate	Factory 5Hz，50Hz max	
Cold start warming time	60s	
Function	zeroing、baud rate、refresh rate、zero point correction、bandwidth、ID address	
Output	CAN2.0B: according to ISO11898-2 standard, twisted-pair output,5k~1Mbit/s baud rate, support 127 nodes, max cable length 10Km, built in high speed photoelectric isolator	
	CANopen: according to DS301、DS303、DS305 standard, confirm to CiA 410 protocol standard, 5k~1Mbit/s baud rate support 127 nodes, max cable length 10Km, built in high speed photoelectric isolator	
	Voltage output: 0.5 ~ 4.5VDC；output consumption 0.3Ω；load impedance<100Ω	
	Current output: 4 ~ 20mA；output consumption 50MΩ；load impedance<400Ω	
	RS485 output: 9600bps（adjustable），8 data bits，1 start bit，1 stop bit, none parity	
Power supply	RS485/CAN/CANopen output: current consumption≤15mA@9~36VDC，no-load	
	Voltage/current output: current consumption≤25mA@9~36VDC，no-load	
Operation temperature	-40 ~ 85℃	
Storage temperature	-40 ~ 85℃	
EMC	According to EN610000 and GBT17626	
Insolation	≥100MΩ	
MTBF	10 years	
Shock	100g@11ms，three-axis, half-sine	
Vibration	8grms，20 ~ 2000Hz	
Protection	IP67	
Connecting	M12-5Pin socket	
Weight	≤200g	

Specifications subject to change without notice on account of continued product development！

3 INSTALLATION AND ELECTRICAL CONNECTION

3.1 Instructions before Installation

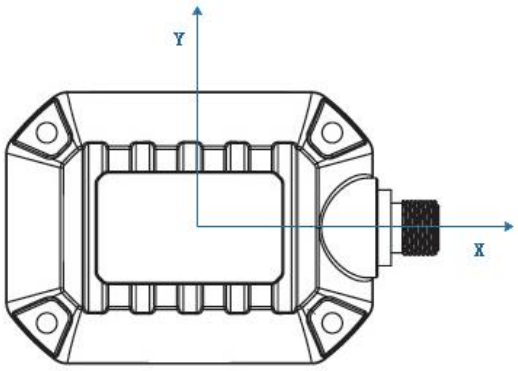
Attention should be paid to the following information before installation：

①PST20series inclinometer should be installed on the measuring plane or the base bracket in parallel.

②The sensitive axis of PST20 needs to be parallel to the tilt axis of measured plane.

③The maximum angle between the measured plane and the horizontal plane should not exceed the range of PST20.

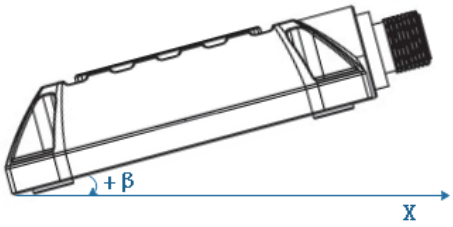
Sensitive axis judgement of PST20：



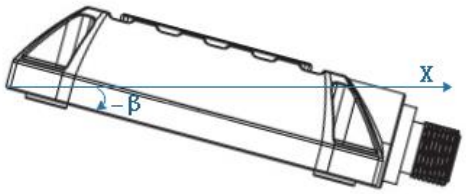
Axial judgement of PST20

Angle judgement of PST20：

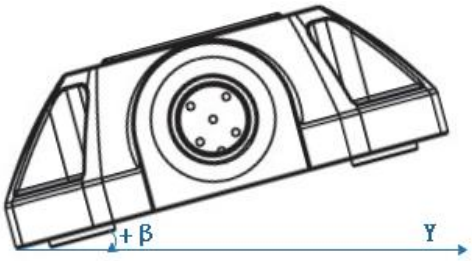
Put PST20 on mounting plane horizontally, and the output plug-in is turned to the right, counterclockwise along the Y-axis, the angle measured by the X-axis is positive, as shown in picture A; PST20 rotates clockwise along the Y-axis and the angle measured by the X-axis is negative, as shown in picture B below. Similarly, the output angle of the Y axis is defined as picture C and picture D.



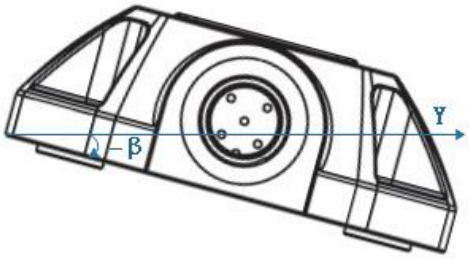
Picture A： X-axis angle positive output



Picture B：X-axis angle negative output



Picture C：Y-axis angle positive output



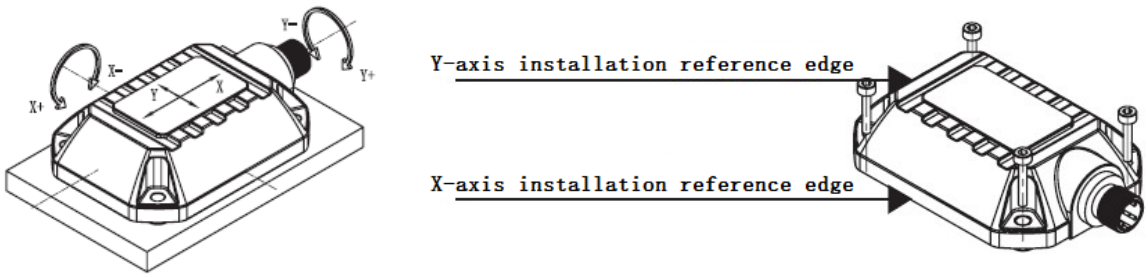
Picture D：Y-axis angle negative output

3.2 Installation

The installation and using of PST20 is very simple, in order to achieve the best measurement results, we provide the instructions of Installation reference edge, choosing a placement and attention in installation.

3.2.1 Installation Reference Edge

The bottom of PST20 is the reference plane for inclination measurement. On the base of the sensor, there are four mounting holes for mounting and fixing PST20. The schematic diagram is shown below:



Installation diagram (with M12-5pin connector)

3.2.2 Choose a Placement

The mounting plane should be rigid, hard and smooth, the base of PST20 should keep rigid contact with the mounting plane.

3.2.3 Attention In Installation

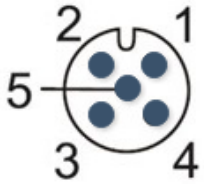
After the installation position is selected, the installation holes are punched on the installation plane according to the installation hole size of PST20, and PST20 should be firmly fixed on the installation plane of the measured target with the correct specifications of bolts with spring gaskets.

Attention when installing：

- Turn the screws equally and forcefully in turn to avoid the installation error caused by excessive mechanical stress causing the deformation of PST20 or mounting plane.
- Ensure the installation reference edge of PST20 parallel to the reference side of mounting plane.
- Ensure that the non-measuring direction of the mounting plane is horizontal which can reduce the effect of cross-axis sensitivity.

3.3 Electrical Connection

PST20 series inclinometer adopts M12-5pin connector with 2m shield 5-wire cable， socket pin diagram and pin definition are as follows：

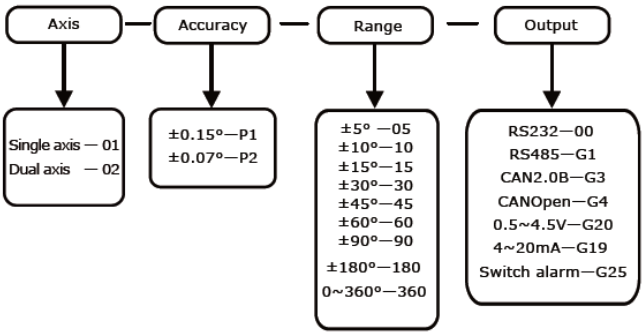


M12 connector socket of PST20
(Male head view from outside)

Socket Pin	Pigtail cable	Output（single or dual axis）	
		RS232	RS485
1	Red	Power+	Power+
2	Black	Power-	Power-
3	Blue	TXD	RS485-A
4	Brown	RXD	RS485-B
5	Green	Signal GND	Signal GND

Users should confirm the output type of PST20 and connect it correctly according to the specific output type befo re making electrical connection or communication.

The ordering information of PST20 series inclinometer is as follows：



The output cable of PST20 is standard 2m， If there are any special needs, customers should communicate in advance before ordering. Cable laying should pay attention to moisture-proof（except for water-proof cable）, anti-corrosion, anti-sharp object extrusion, to avoid high-voltage cable laying at the same time, and to avoid the use of PST20 in strong electric field, strong magnetic field and other conditions.

4 DATA READING AND COMMUNICATION

4.1 Preparation For Data Reading

1） After installing PST20, please correctly connect the power cable and the signal cable according to the connection definition；

2） Check and confirm the correct connection of power cable and signal cable before power on PST20. The sensor should be preheated for 1 minute after the first power on. Be careful not to restart PST20 continuously and instantaneously；

3） Reading the angle data of PST20 according to output type and communication protocol.

The output types and protocols of PST20 series inclinometers are diversified in order to meet different needs from cus tomers. Users need to implement the specific outputs and protocols in the process of reading angle data. Users can also purchase the PSTsoftware which is applicable to communication with all PST series inclinometers to acquire and store angle datas of PST20 series inclinometers.

4.2 ASCII Protocol (RS232 and RS485 output)

If customer does not specify the communication protocol of PST20 before ordering, the PST20 with RS232 and R S485 output interface will default to ASCII protocol when leaving factory, and the default serial port propertied are as below:

Items	Default value
Baud rate	9600bps
Data bits	8 bits
Start bits	1 bit
Stop bits	1 bit
Parity	None
Flow control	None

User can change the baud rate according to the application, and the available baud rates are: 1200bps, 2400bps, 4800bps, 9600bps, 19200bps, 38400bps, 57600bps and 115200bps.

4.2.1 Data Frame Format

For single-axis PST20

PST20 single axis inclinometer has a default X axis, the data frame format is:

X=o□□□.□□□;\r\n …… Data Frame Format 1

In data frame format 1,

- 'o'represents sign. If 'o' equals to '+', it means that the X axis angle is a positive number; if 'o' equals to '-', it means that the X axis angle is a negative number.
- '□' represents number. It can be any number from 0 to 9. '□□□.□□□' represents a float number, it can be one integer part, two or three, and the fractional portion is fixed to three.
- '\r\n' represents CRLF.

Note: If the inclinometer's measured tilt angle exceeded the measurement range, it won't be accurate. If the inclinometer's measured tilt angle is 5 degrees beyond the measurement range, inclinometer will not output angle data. For example, an inclinometer with measurement range of ±10 degrees, when the measured tilt angle is up to +12.123 degrees or -12.123 degrees, this tilt angle is not accurate. When the measured tilt angle is up to +15.005 degrees or -15.005 degrees, tilt sensor will output '++++.+++' or '-+++.+++' .

For dual-axis PST20

PST20 dual axis inclinometer has a default X and Y axis, the data frame format is:

X=o□□□.□□□; Y=o□□□.□□□;\r\n …… Data Frame Format 2

In data frame format 2,

- 'o'represents sign. If 'o' equals to '+', it means that the X axis angle is a positive number; if 'o' equals to '-', it means that the X axis angle is a negative number.
- '□' represents number. It can be any number from 0 to 9. '□□□.□□□' represents a float number, it can be one integer part, two or three, and the fractional portion is fixed to three.
- '\r\n' represents CRLF.

Note: If the inclinometer's measured tilt angle exceeded the measurement range, it won't be accurate. If the inclinometer's measured tilt angle is 5 degrees beyond the measurement range, inclinometer will not output angle data. For example, an inclinometer with measurement range of ±10 degrees, when the measured tilt angle is up to +12.123 degrees or -12.123 degrees, this tilt angle is not accurate. When the measured tilt angle is up to +15.005 degrees or -15.005 degrees, tilt sensor will output '++++.+++' or '-+++.+++' .

4.2.2 ASCII Command

User can use ASCII commands to read configuration parameters or set configuration parameters:

	Command Name	Function Description
1	$OUT ON#	Enable continuous output
2	$OUT OF#	Disable continuous output
3	$AAA#	Step output
4	$DIS UPT#	Read update rate
5	$DIS FIL#	Read filtering parameter
6	$DIS ADR#	Read sensor address
7	$DIS CRD#	Read sensor information
8	$DIS ZER#	Read offset
9	$DIS BW#	Read bandwidth
10	$DIS BAU#	Read baud rate
11	$UPT=□□□#	Set update rate
12	$FIL=o□□□.□#	Set filtering parameter
13	$ADR=□□□#	Set sensor address
14	$ZER XX#	Set current X axis angle to zero point
15	$ZER YY#	Set current Y axis angle to zero point
16	$ZX=o□□□.□□□#	Write X axis offset
17	$ZY=o□□□.□□□#	Write Y axis offset
18	$CLR XX#	Set X axis offset to zero
19	$CLR YY#	Set Y axis offset to zero
20	$BW=□#	Set bandwidth
21	$BAU=□#	Set baud rate
22	$RESET#	Restore sensor parameters

The detail explanation of commands are:

1) $OUT ON#、$OUT OF#、$AAA#

These three commands are used for sensor output mode control:

- '$OUT ON#' is used for enable continuous output, in this working mode, sensor can output tilt angle data automatic with a frequency of the update rate.
- '$OUT OF#' is used for disable continuous output, in this mode, sensor will not output any information automatic unless command request.
- '$AAA#' is used for request tilt angle, step output. This command only works when in disable continuous output mode.

2) $DIS UPT#、$UPT=□□□#

- '$DIS UPT#' is used for reading tilt angle update rate, and the update rate is the output frequency in continuous output mode. The manufactured inclinometers have a default 5Hz update rate, sensor output "UpdateFrequency:005" when using '$DIS UPT#' to read update rate.
- '$UPT=□□□#' is used for setting update rate. '□□□' represents a three digits integer. The available update rates are 1Hz, 3Hz, 5Hz, 10Hz, 20Hz and 50Hz. For example: if user set update rate as 1Hz, then the command should be "$UPT=001#".

3) $DIS FIL#、$FIL=o□□□.□#

- '$DIS FIL#' is used for reading filtering parameter. Most of the manufactured inclinometers have a default 200.0 filtering parameter, sensor output "Filter Para:+200.0;" when using '$DIS FIL#' to read filtering parameter.
- '$FIL=o□□□.□#' is used for setting filtering parameter. 'o' represents sign, can only be '+'. '□□□.□' represents a float number, the available range is from 0.0 to 65535.0. For example: if user set filtering parameter as 50.0, then the command should be "$FIL=+50.0#".
- Once the filtering parameter has been changed, inclinometer need to re-power on.
- Bigger filtering parameter, faster response and bigger ripple; smaller filtering parameter, slower response and smaller ripple. The available filtering parameter range is wide, but we recommend using 50.0, 200.0 and 400.0.

4) $DIS ADR#、$ADR=□□□#

- '$DIS ADR#' is used for reading sensor address. The manufactured inclinometers have a default 255 address, sensor output "SensorAddr=255;" when using "$DIS ADR#" to read sensor address.
- '$ADR=□□□#' is used for setting sensor address. '□□□' represents a three digits integer, the available range is from 000 to 255. For example: if user set address as 000, then the command should be "$ADR=000#".

5) $DIS CRD#

- '$DIS CRD#' is used for reading sensor information. Each manufactured inclinometer has a unique CRD code, this code recorded information of: sensor type, axis, accuracy, measurement range, output interface, special code (unique). For example, if a PST20 with dual axis, ±0.07 degrees accuracy, ±60 degrees measurement range and RS485 output interface, sensor output "CRD=PST2002P260G1-00P002" when using "$DIS CRD#" to read sensor CRD, and the CRD code can explain as:

PST20	→	Sensor Type: PST20
02	→	Axis: dual axis
P2	→	Accuracy: ±0.07°
60	→	Measurement range: ±60°
G1	→	Output interface: RS485
00P002	→	Unique special code

6) $DIS ZER#、$ZER XX#、$ZER YY#、$ZX=o□□□.□□□#、$ZY=o□□□.□□□#、$CLR XX#、$CLR YY#

- '$DIS ZER#' is used for reading sensor's offsets, both of X axis and Y axis. Each manufactured inclinometer has its own offsets. For example: if using command "$DIS ZER#" to read a sensor's offsets, and sensor output " ZX=-0.123 ZY=+0.012 ", then the sensor's X axis offset is -0.123 degrees and the Y axis offset is +0.012 degrees.
- '$ZER XX#' is used for setting X axis current angle to zero point. When sensor accepted this command, X axis current angle will be added to offset and X axis angle output will be around zero.
- '$ZER YY#' is used for setting Y axis current angle to zero point. When sensor accepted this command, Y axis current angle will be added to offset and Y axis angle output will be around zero.
- '$ZX=o□□□.□□□#' is used for writing X axis offset. 'o' represents sign, can be '+' or '-'. '□□□.□□□' represents a float number, this float number can't exceed the measurement range. When sensor accepted this command, the current offset will be erased and the value 'o□□□.□□□' will be new offset.
- '$ZY=o□□□.□□□#' is used for writing Y axis offset. 'o' represents sign, can be '+' or '-'. '□□□.□□□' represents a float number, this float number can't exceed the measurement range. When sensor accepted this command, the current offset will be erased and the value 'o□□□.□□□' will be new offset.
- '$CLR XX#' is used for cleaning up X axis offset, this command has a same function with "$ZX=+0.0#".
- '$CLR YY#' is used for cleaning up Y axis offset, this command has a same function with "$ZY=+0.0#".

7) $DIS BW#、$BW=□#

- '$DIS BW#' is used for read sensor's bandwidth. The manufactured inclinometers have default 3Hz bandwidth, sensor output "Bandwidth is 3Hz;" when using command '$DIS BW#' to read sensor's bandwidth.
- '$BW=□#' is used for setting bandwidth. '□' represents a one digit integer. The available bandwidths are 3Hz, 5Hz and 10Hz.

Bandwidth	→	BW=□
3Hz	→	BW=0
5Hz	→	BW=1
10Hz	→	BW=2

For example, if user set bandwidth as 10Hz, then the command should be "$BW=2#".

8) $DIS BAU#、$BAU=□#

- '$DIS BAU#' is used for read sensor's baud rate. The manufactured inclinometers have default 9600bps baud rate, sensor output "BaudRate=9600" when using command '$DIS BAU#' to read sensor's baud rate.
- '$BAU=□#' is used for setting sensor's baud rate. '□' represents a one digit integer. The available baud rates are:

1200bps	BAU=0
2400bps	BAU=1
4800bps	BAU=2
9600bps	BAU=3
19200bps	BAU=4
38400bps	BAU=5
57600bps	BAU=6
115200bps	BAU=7

Note: sensor's baud rate is relative to update rate, higher baud rate can support higher update rate limit. For example, sensor's default baud rate is 9600bps, default update rate is 5Hz, send command "$UPT=050#" to set update rate to 50Hz, sensor will output:

"The current frame Message Transmission need +20.8mS;The update freq should be less than +48.0Hz;" ,

This sentence shows that the 9600bps baud rate can't support 50Hz update rate, and user should set a higher baud rate first.

9) $RESET#

- '$RESET#' is used for restoring part of the manufactured parameters, include update rate (default 5Hz), filtering parameter (default 200.0), X axis offset (each sensor has a different offset), Y axis offset (each sensor has a different offset) and the bandwidth (default 3Hz). Sensor output

  "UpdateFrequency:005
  FilterPara:+200.0;
  ZX=+0.152
  ZY=-0.083
  Bandwidth is 3Hz;" when user send "$RESET#" command.

Note: once this command be accepted by the sensor, the sensor should be re-power on.

5 ATTENTION AND TROUBLESHOOTING

5.1 Attention

- Power supply higher than 36VDC is prohibited, it will cause internal electronic components to burn down；• Any AC power is prohibited， or it will cause irreparable damage；
- It is forbidden to connect the signal wire when PST20 series inclinometer is powered on；
- Immersing PST20 in a highly corrosive solution (such as H2SO4,NaOH,etc.) is also prohibited；
- Power supply wire cannot connect with any signal wire， or it will cause a serious damage to PCB;
- It is forbidden to put PST20 in the fire, or it will cause unpredictable danger；
- It is forbidden to throw PST20 into rigid pavement from high, it will cause damage to the shell and internal electronic components；
- It is forbidden to use high-power electric hair dryer to heat PST20 locally and quickly, which will easily cause partial overheating of the sensor and permanent damage；
- It is forbidden to strike any part of PST20 by hammers or other articles, it will damage the internal precision components；

5.2 Troubleshooting

Description	Troubleshooting
No output	1.Check whether the power supply is normal 2.Check whether the power wire is right 3.Check whether the signal wire is right 4.Check whether the cable joint is tight 5.Check whether the output is command output 6.Check whether the communication port is correct
Output garbled (for digital output)	1.Check whether the signal wire is right 2.Check whether the setting of baud rate is correct
Output is unstable	1. Check whether the cable joint is tight 2.Check whether the mounting base is fixed tightly 3.Check whether the power supply is stable
Angle output is not accurate	1.Check whether PST20 is installed correctly 2.Check whether the signal GND wire is connected correct
Abnormal power consumption	Check power consumption with a multimeter: 1.If the power consumption is excessive, maybe there is a short circuit, please contact us. 2.If the power consumption is too low, maybe there is a open circuit, please contact us. 3.If the power consumption is normal, please check the failure of power supply.

APPENDIX A: Reference Standards

- GB/T 191 SJ 20873 General requirements for Inclinometer & levelmeter (China)
- GBT 18459 Methods for Calculation the Main static performance specifications for transducers(China)
- JJF 1059 Evaluation and Express of Uncertainty in Measurement(China)
- JJF 1094 Evaluation of the Characteristics of Measuring Instruments(China)
- JJF 1116 Calibration Specification for Linear Accelerometer used precision Centrifuger (China)
- QJ 2318 The test method of gyro & accelerometer(China)
- GJB 2786A General Requirements for Military Software Development(China)
- GJB 2884 General Specification for Three-Axis angular motion simulator(China)
- EN61000-4-11 Voltage dips &Voltage variations

- MIL-HDBD-338B	- MIL-STD-810F-510.4	- MIL-STD-810F-507.4
- ISO 5348 IDT	- MIL-STD-810F-514.4	- EN610000-4-4 EFT
- MIL-STD-810F-501.4	- MIL-STD-810F-516.4	- EN610000-4-5 SURGE
- MIL-STD-810F-502.4	- IEC60529 IP	- EN610000-4-6 CS
- MIL-STD-810F-503.4	- EN610000-4-2 ESD	- EN610000-4-8 PFMF
- MIL-STD-810F-506.4	- EN610000-4-3 RS	- ISTA-2A

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