Appearance Patent No.: ZL 201830752874.1

V2.4

IMU DYNAMIC ATTITUDE SENSOR

TL720D

Technical Manual

PRODUCTION EXECUTION STANDARD REFERENCE

○ Quality management system certification: GB/T19001-2016 idt ISO19001:2015 standard (Certificate No.: 128101)

○ Quality management system certification: IATF16949: 2016 (Certificate No.: T178487)

○ GJB9001C-2017 Standard Weaponry Quality Management System Certification (Registration number: 02622J31799R0M)

○ Intellectual property management system certification: GB/T29490-2013 standard (Certificate No.: 41922IP00281-06R0M)

○ High-tech Enterprise (Certificate No.: GR201844204379)

○ ShenZhen Professional Dedicated Unique Innovative Enterprice(No.: SZ20210879)

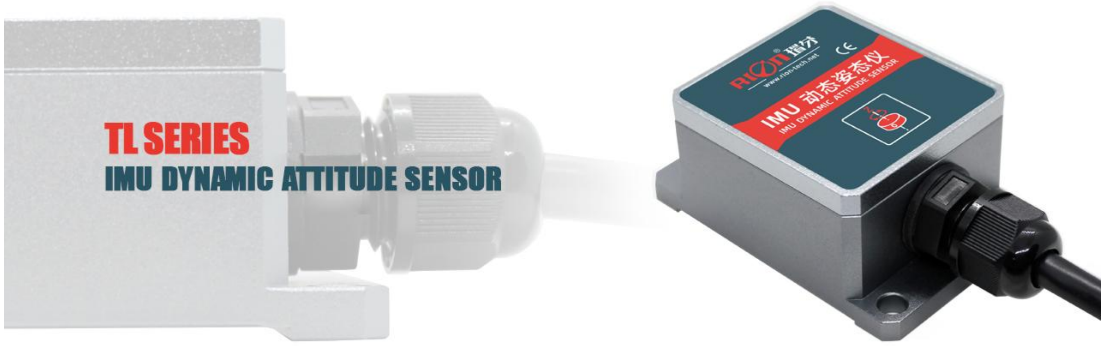
○ CE certification: registration number AT18250EC100757

○ RoSH certification: 18300RC20410801

○ China National Intellectual Property Appearance Patent (patent No.: ZL 201830752874.1)

○ Revision date: 2023-2-17

Note: Product functions, parameters, appearance, etc. will be adjusted as technology upgrades. Please contact our sales to confirm when purchasing.



GENERAL DESCRIPTION

TL720D is RION company newly developed Small volume IMU dynamic attitude sensor based on latest MEMS inertial measurement platform , by means of the dynamic attitude algorithm for the angular velocity of gyroscope ,it can simultaneously output carrier's azimuth angle .The product inernal integrated RION's Patent Inertial navigation algorithm, through the model of attitude angle data fusion , can solve the gyro short time drift problem as much as possible .

This product is specially used for robot car, AVG vehicle azimuth orientation, attitude control and other related applications of the UAV, instead of the traditional robot vehicle magnetic bar guide shortcomings, no need at the site layout of magnetic stripe, is the necessary navigation components for the next generation of robot vehicle automatic tracing and driving.

KEY FEATURES

★ Azimuth angle output
★ Long life,strong stability
★ Compact & light design
★ Strong vibration resistance
★ Cost-effective
★ RS232/RS485 output optional
★ Light weight
★ All solid state

APPLICATION

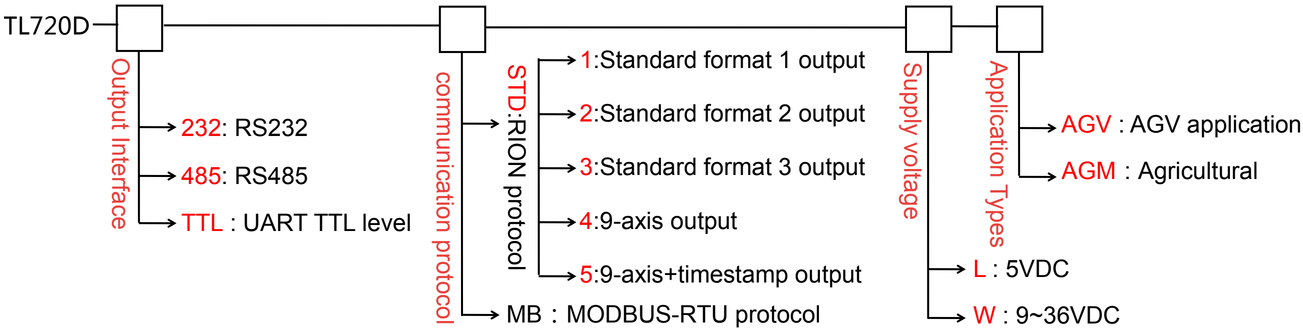
★ AGV truck
★ Platform stability
★ Turck-mounted satellite antenna equipment
★ Robot
★ Car Navigation
★ Auto safety system
★ 3D virtual reality
★ UAV
★ Industrial control

▶ SPECIFICATIONS

TL720D		Parameters
Mesure range		Azimuth Angle (±180)°
Acquisition bandwidth		>100Hz
Resolution		0.01°
Azimuth accuracy		<0.1°
Nonlinear		0.1% of FS
Pitch measurement range		±90°
Pitch measurement accuracy		0.25° (1σ)
Roll measurement range		±180°
Roll measurement accuracy		0.25° (1σ)
Accelerometer	Accelerometer range	±4g
	Acceleroemter resultuion	0.001g
	Acceleroemter accurac	5mg
	Bias instability (allan)	0.05mg
	Speed random walk coefficient (allan)	0.015m/s/sqrt(h)
	Bias stability (10s average)	0.15mg
Gyro	Gyro Angular Velocity Range	±250°/s
	Bias instability (allan)	5.0°/h
	Angle random walk coefficient (allan)	0.30°/sqrt(h)
	Bias stability(10s average value)	10°/h
Starting time		AGV application: 5~6s
		AGM application: 1.5s
Input Voltage		9~36VDC / 5VDC (Optional)
Current		30mA(12V)
Working Temp.		-40℃ ~ +80℃
Storage Temp		-40℃ ~ +85℃
Vibration		5g~10g
Impact		200g pk，2ms，½sine
Working life		10 years
Output rate		5Hz~200Hz can set
Output signal		RS232 or RS485
MTBF		≥50000 hours /times
Insulation resistance		≥100 Megohm
Impact resistance		100g@11ms、3 Axial Direction (Half Sinusoid)
Anti-vibration		10grms、10～1000Hz
Protecting		IP67
Weight		≤135g (including 1 meter standard cable)

Note: AGV application startup time is 5S at rest.

▶ ORDERING INFORMATION



E.g:TL720D-232-STD1-L-AGV:RS232Output Interface/Standard format 1 output/5VDC/AGV application.
Note: AGM does not currently have MODBUS protocol.

Note:1:Standard format 1 output (Z-axis angular rate+Y-axis forward acceleration+z-axis heading angle)

2:Standard format 2 output (X-axis left and right acceleration+Y-axis forward acceleration+z-axis heading angle)

3:Standard format 3 output (Z-axis angular rate+X-axis left and right acceleration+Y-axis forward acceleration+z-axis heading angle)

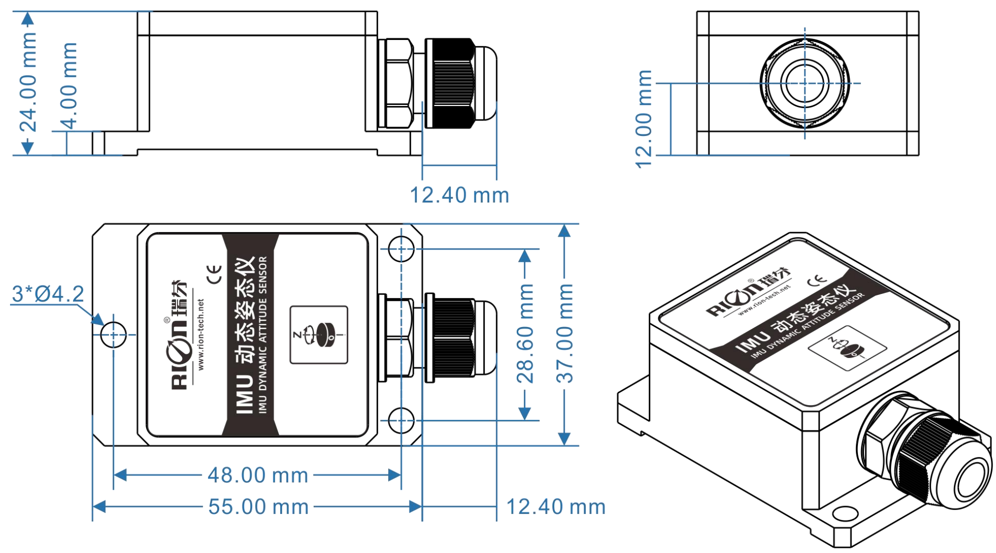
4:9-axis output (attitude angle+3-axis acceleration+3-axis gyro speed)

5:9-axis + timestamp output (attitude angle+3-axis acceleration+3-axis gyro speed+timestamp)

▶ ELECTRICAL CONNECTION

Line Color	BLACK	WHITE	GREEN	RED
Functions	GND Power Negative	TTL(RXD) RS232(RXD) RS485(D+)	TTL(TXD) RS232(TXD) RS485(D-)	9~36VDC / 5VDC Optional Power Positive

▶ SIZE

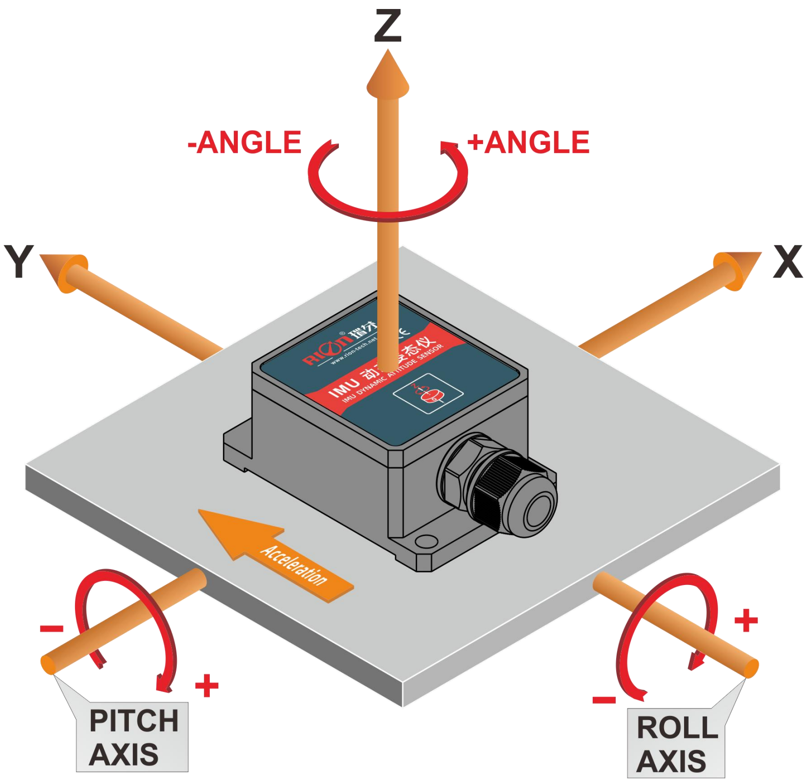


Shell size: L55×W37×H24mm

Installation size: L48×W28.6×H24mm

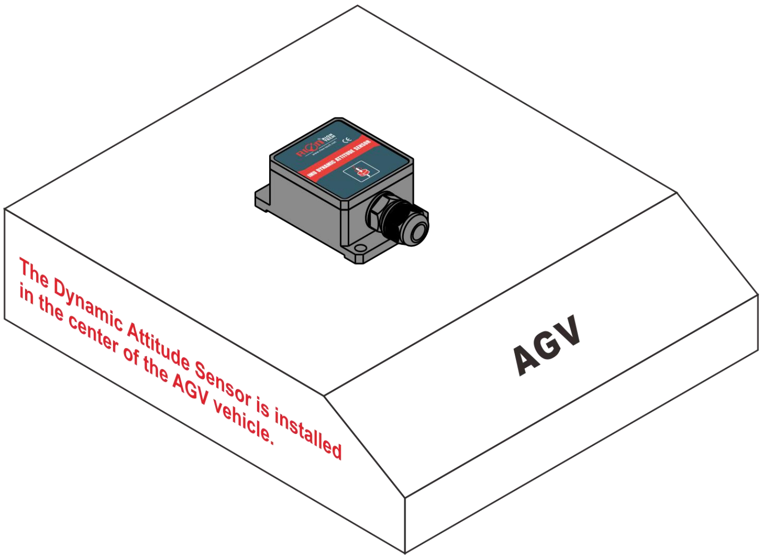
ounting screws: 3 M4 screws

PRODUCT INSTALLATION DIRECTION



NOTICE

1. The angular gyro sensor should be mounted in the center position of the measured object , in order to reduce the influence of linear acceleration on the measurement accuracy. See below diagram as ref.



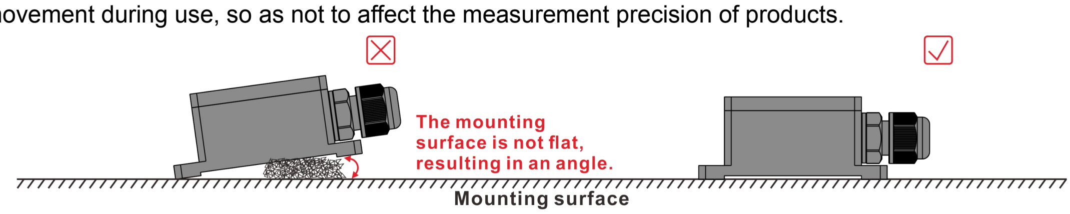
2. The installation of the instrument should be kept parallel to the surface of the measured object, and reduce the influence of the dynamic and acceleration on the angle meter. Incorrect installation will lead to measurement errors, with particular attention to "surface" and" line "

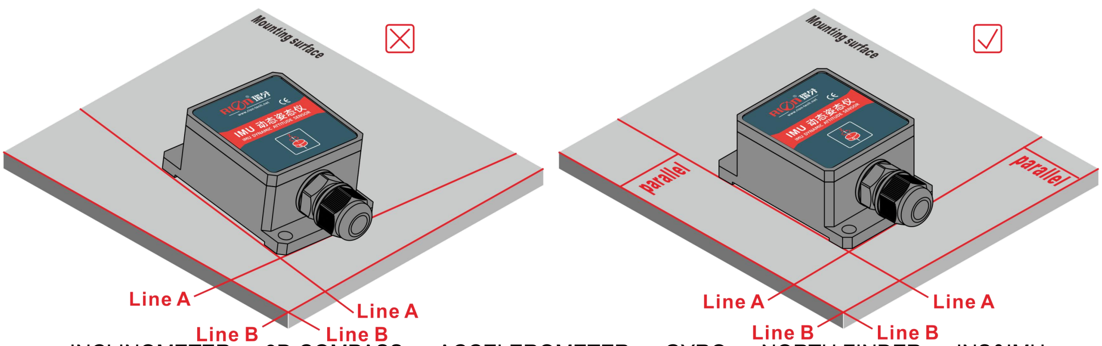
1） The mounting surface of the instrument fixing must be close, smooth and stable with the measured surface. If the mounting surface is not smooth, the angle error of angle measurement can be caused easily.

2)The axis of the instrument must be parallel to the axis of measurement, and the two axis should not be included angle as far as possible.

3. Do not shake violently during the use of the product, avoid violent vibration, away from the vibration source (if you can not avoid please install the shock absorber), so as not to affect the product measurement accuracy;

4. Try to avoid a sharp acceleration, arrest, sharp turn angular velocity greater than 300 DEG /s movement during use, so as not to affect the measurement precision of products.





▶ PRODUCT PROTOCOL

1-1.Data Frame Format：

（8 bits date，1 bit stop，No check，Default baud rate 115200）

Identifier (1byte)	Date Length (1byte)	Address code (1byte)	Command word(1byte)	Date domain	Check sum (1byte)
68H					

Identifier：Fixed68H;

Data length：From data length to check sum（including check sum）length;

Address code：Accumulating module address，Default :00;

Date domain will be changed according to the content and length of command word;

Check sum：Data length、Address code、Command word and data domain sum,No carry.

Note: Because of this product at startup need attitude calculation model of internal construction, so start the required time of 20 seconds, and need to maintain the "angle meter" static (no movment), if move the product within 20 seconds process, is re-start time of 20 seconds, after finishing the start process, automatic output data packet, can not output data packet in the start of 20seconds process .

1-2.Command analysis

Desc.	Meaning/Example	Description
0X04	**Read angle data command** E.g: ***68 04 00 04 08***	Data domain（0byte） No data domain command
0X84	Sensor automatic output angle E.g: **68 0D 00 84 10 50 23 00 23 04 01 80 00 BC**	Data domain（9byte）Using BCD code format **10 50 23:** 3 bytes represent the Z axis angular rate= **-50.23（°/s）** **00 23 04:** 3 bytes represent the forward acceleration=**+2.304（g）** **01 80 00:** 3 bytes represent the azimuth of the Z axis= **+180.00 (°)** Data Desc.: the first byte data every 3 bytes in the high for the "1" is negative, "0" represent positive. The acceleration is 3 - bit decimal analysis, the azimuth and angular rate are 2 - bit decimal. BC: check sum, the sum of all data Hexadecimal, without the word head 68, if the carry is to take the low bit effective.
0X0C	**Setting sensor output mode** Auto output mode:The sensor with power on can Automatically output angle,output rate 25HZ (factory default). (Power off with save function) E.g: ***68 05 00 0C 03 14*** ***Set 25HZ output***	**Data domain** 00 Query 01 5Hz Auto output mode 02 15Hz Auto output mode 03 25Hz Auto output mode 04 35Hz Auto output mode 05 50Hz Auto output mode 06 100Hz Auto output mode 07 200Hz Auto output mode
0X8C	**Sensor answer reply command** E.g: **68 05 00 8C 00 91**	Data domain（1byte） Data domain in the number means the sensor response results 00 Success FF Failure

0X0B	**Setting Communication rate** **E.g: *68 05 00 0B 03 13*** The command setting is effective after power off then restart (power off with save function)	Data domain（1byte）baud rate 02 means 9600 03 means 19200 04 means 38400 05 means 115200(factory default) 06 means 230400 07 means 256000
0X8B	**Sensor answer reply command** E.g: **68 05 00 8B 90**	Data domain（1byte） Data domain in the number means the sensor response results 00 Success FF Failure
0X28	**Azimuth clear command** When the azimuth has an error after long-term work, this command can be sent to clear the azimuth output. E.g: **68 04 00 28 2c**	Data field none
0X28	Sensor response reply command E.g: **68 05 00 28 00 2D**	Data field (1byte) The number in the data field indicates the result of the sensor response 00 Success FF Failure

1-3 Detailed output format table

1：Standard format 1 output

SOF	0x68 (1 byte)				
Length	0x0D (1 byte)				
Address	0x00 (1 byte)				
Payload Contents:	See below:				
Byte Offset	Number Format	name	content	bytes	
0	INT8U	command	0x84	1	Means data
1	INT8U	Gyro_Z	Z axis angular rate	3	10 05 23: 3 bytes means-5.23°/S 00 05 23: 3 bytes means+5.23°/S
4	INT8U	ACC _Y	Forward body acceleration	3	00 10 00: 3 bytes means+1.000g 10 10 00: 3 bytes means-1.000g
7	INT8U	YAW	Azimuth	3	11 60 00: 3 bytes means-160.00° 01 60 00: 3 bytes means+160.00°
10	INT8U	Check sum	Checksum	1	

2 : Standard format 2 output

SOF	0x68 (1 byte)
Length	0x0D (1 byte)
Address	0x00 (1 byte)
Payload Contents	See below:

Byte Offset	Number Format	name	content	bytes	
0	INT8U	command	0x84	1	Means data
1	INT8U	ACC_X	Left and right body acceleration	3	00 00 50: 3 bytes means+0.050g(right) 10 00 50: 3 bytes means -0.050g(Left)
4	INT8U	ACC_Y	Forward body acceleration	3	00 10 00: 3 bytes means+1.000g(forward) 10 10 00: 3 bytes means-1.000g (behind)
7	INT8U	YAW	Azimuth	3	11 60 00: 3 bytes means-160.00°(Clockwise) 01 60 00: 3 bytes means+160.00°(Reverse time)
10	INT8U	Check sum	Checksum	1	

3 : Standard format 3 output

SOF	0x68 (1 byte)
Length	0x10 (1 byte)
Address	0x00 (1 byte)
Payload Contents	See below:

Byte Offset	Number Format	name	content	bytes	
0	INT8U	command	0x84	1	Means data
1	INT8U	Gyro_Z	Z axis angular rate	3	10 05 23: 3 bytes means-5.23°/S 00 05 23: 3 bytes means+5.23°/S
4	INT8U	ACC_ X	Left and right body acceleration	3	00 00 50: 3 bytes means +0.050g(right) 10 00 50: 3 bytes means -0.050g(Left)
7	INT8U	ACC_ Y	Forward body acceleration	3	00 10 00: 3 bytes means +1.000g(forward) 10 10 00: 3 bytes means -1.000g(behind)
10	INT8U	YAW	Azimuth	3	11 60 00: 3 bytes means-160.00°(Clockwise) 01 60 00: 3 bytes means+160.00°(Reverse time)
13	INT8U	Check sum	Checksum	1	

4 : 9-axis output: attitude angle + 3-axis acceleration + 3-axis gyro rotation speed;

SOF	0x68 (1 byte)
Length	0x1F (1 byte)
Address	0x00 (1 byte)

Payload Contents:	See below:				
Byte Offset	Number Format	name	content	bytes	
0	INT8U	command	0x84	1	Means data
1	INT8U	ROLL	Roll angle	3	10 50 23:3 bytes means -50.23°
4	INT8U	PITCH	Pitch angle	3	01 60 00:3 bytes means +160.00°
7	INT8U	YAW	heading angle	3	11 60 00:3 bytes means -160.00°
10	INT8U	ACC X	X axis acceleration	3	00 23 04:3 bytes means Acceleration +2.304g
13	INT8U	ACC Y	Y axis acceleration	3	10 23 04:3 bytes means Acceleration -2.304g
16	INT8U	ACC Z	Z axis acceleration	3	10 23 04:3 bytes means Acceleration -2.304g
19	INT8U	Gyro_ X	X axis gyro	3	10 50 23:3 bytes means -50.23°/S
22	INT8U	Gyro_ Y	Y axis gyro	3	01 80 00:3 bytes means +180.00°/S
25	INT8U	Gyro_ Z	Z axis gyro	3	00 50 23:3 bytes means +50.23°/S
28	INT8U	Check sum	Checksum	1	

5 : 9-axis+timestamp output: attitude angle+3-axis acceleration+3-axis gyro speed + timestamp;

SOF	0x68 (1 byte)				
Length	0x23 (1 byte)				
Address	0x00 (1 byte)				
Payload Contents:	See below:				
Byte Offset	Number Format	name	content	bytes	
0	INT8U	command	0x84	1	Means data
1	INT8U	ROLL	Roll angle	3	10 50 23: 3 bytes means-50.23°
4	INT8U	PITCH	Pitch angle	3	01 60 00: 3 bytes means+160.00°
7	INT8U	YAW	Heading angle	3	11 60 00: 3 bytes means-160.00°
10	INT8U	ACC X	X axis acceleration	3	00 23 04 : 3 bytes means Acceleration+2.304g
13	INT8U	ACC Y	Y axis acceleration	3	10 23 04 : 3 bytes means Acceleration-2.304g
16	INT8U	ACC Z	Z axis acceleration	3	10 23 04 : 3 bytes means Acceleration-2.304g
19	INT8U	Gyro_ X	X axis gyro	3	10 50 23: 3 bytes means-50.23°/S
22	INT8U	Gyro_ Y	Y axis gyro	3	01 80 00: 3 bytes means+180.00°/S
25	INT8U	Gyro_ Z	Z axis gyro	3	00 50 23: 3 bytes means+50.23°/S
28	INT8U	tStam[3]	32-25 bit	1	Uint32_t TimeStamp (mS) ; TimeStamp = (tStam[3]<<24) | (tStam[2]<<16) | (tStam[1] << 8) | tStam[0];
29	INT8U	tStam[2]	24-17 bit	1	
30	INT8U	tStam[1]	16-9 bit	1	
31	INT8U	tStam[0]	8-1 bit	1	
32	INT8U	Check sum	Check sum	1	

Note: The timestamp is the running time of the angle calculation after the IMU is powered on, uint32 (4 bytes), the unit is mS.

◆ **MODBUS-RTU Data frame format:**

1-1.(RTU mode, communication parameter: baud rate 115200bps, data frame: 1 starting bits, 8 bit data, parity check, 1 stop bit)

Please read the following items carefully before use:

1） As the MODBUS protocol stipulates that two data frames should be at least 3.5 byte time, such as 9600 baud rate, the time is 3.5 x (1/9600) * 11=0.004s. But in order to leave enough allowance, the sensor increases this time to 10ms, so leave at least a 10ms interval between each of the data frames. The master sends commands ---10ms idle --slave response command --10ms idle -host machine sends command......

2）**MODBUS** protocol stipulates the broadcast address ----relevant 0 content s --- the sensor can also accept the content of the broadcast address, but it will not be answered. So the broadcast address 0 can be used as the following use only for reference.

1. The address of all the model inclinometer sensors mounted on the BUS is set to a certain address.
2. Azimuth of all the model inclinometer sensors mounted on the BUS is ZERO .

3) In order to improve the reliability of the system, set the address command, set the baud rate and change the parity bit, these commands must be sent twice to be effective. "commands sent twice" means that both times are sent successfully (the slave has a reply each time), and the two questions and answers must be consecutive, that is, the host cannot insert other data frames in the middle of the two questions and answers, otherwise it will be resent twice , the setting process is as follows:

Send the set address command - wait for the setting success command sent by the slave - (no other commands can appear) send the set address command again - wait for the setting success command sent by the slave - the modification is successful

4) Change the parity bit, it will be effective only after power on again.

2-2. Read angle data

Modbus Function code 03H

Master query command :		Slave response :		
Sensor add	01H	Sensor add	01H	
Function code	03H	Function code	03H	
Access register first address	00H	Data length12 bytes	0CH	
	02H	Data word 1 high 8 bits	F3H	Z axis angular rate data (azimuth rate)
Data length 6 bytes	00H	Data word 1 Low 8 bits	49H	
	06H	Data word 2 high 8 bits	02H	
CRCLH	6408H	Data word 2 Low 8 bits	00H	
		Data word 3 high 8 bits	1DH	Y axis acceleration data (forward)
		Data word 3 Low 8 bits	4EH	
		Data word 4 high 8 bits	00H	
		Data word 4 Low 8 bits	00H	
		Data word 5 high 8 bits	02H	Z axis azimuth data
		Data word 5 Low 8 bits	4FH	
		Data word 6 high 8 bits	00H	
		Data word 6 Low 8 bits	00H	
		CRCLH	501CH	

An example of reading the command of measurement data1												
Master send					01H	03H	00H	02H	00H	06H	64H	08H
Slave response												
01H	03 H	0CH	F3H	49 H	02H	00 H	1DH	4EH	00H	00 H	02H	4FH
00H	00H	50H	1CH									

Note: The data fields from the master reply frame are 50H, 46H, 00H, 00H, 23H, 20H, 00H, 00H.

The Z axis rate data (azimuth rate) is the 1~4 byte of the data domain. Y axis acceleration data (forward) is the 5-8 byte of the data domain, and the Z axis azimuth data is the 9-12 byte of the data domain, and the low byte is in front.

Z axis angular rate data (azimuth rate) of the representation for the point representation, one point corresponding to 0.01º/s, 0.01×(- points -offset) is the angular rate. The offset angle rate of 150000, a total of 150000 points to 300000 points, so 150000 corresponding 0º/s, 151000 corresponding to +10º/s, 149000 corresponding to -10º/s。..

The representation of the Y axis acceleration data (forward) is the point number representation, a point corresponding to the 0.001g, and 0.001× (point number-- offset) is the acceleration. The acceleration offset is 20000, and the total number of points is 40000 points, so 20000 corresponds to 0g, 20100 corresponds to +0.100g, and 19900 corresponds to -0.100g.

Z axis azimuth data representation method is point representation, a point corresponding to 0.01º, 0.01×(points - offset) for azimuth. Offset azimuth angle of 18000, a total of 18000 points to 36000 points, so 18000 corresponding 0º/s, 19000 corresponding to +10º ,
17000 corresponding to -10º/s ..

Take the above data frame as an example: the process of data conversion is as follows:

1) Get the current angle of points. Note that the low byte in front , Z angle rate data is 249F3H, the Y axis acceleration data (forward) is 4E1DH, and the Z axis azimuth data is 4F02H.

2) Conversion to decimal, Z axis angular rate: 249F3H →150003, Y axis acceleration: 4E1DH →19997, Z axis azimuth: 4F02H →20226。.

3) minus offset, Z axis angular rate: (150003-150000) ×0.01=0.03º/s; Y axis acceleration data: (19997-20000))×0.001＝-0.003g; Z axis azimuth data: (20226-18000) ×0.01=22.26º

4)Get the final result, Z axis angular rate: 0.03º/s;; Y axis acceleration data: -0.003g data; Z axis angle: 22.26º.

2-3.Setting sensor azimuth ZERO

Modbus function code 06H

Setting sensor azimuth ZERO Command :		Slave response :	
Sensor add	01H	Sensor add	01H
Function code	06H	Function code	06H
Access register first address	00H	Register address	00H
	10H		10H
If the word is nonzero, it is zero azimuth	00 H	If the word is nonzero, it is zero azimuth	00H
	FFH		FFH
CRC	C84FH	CRC	C84FH

Setting sensor azimuth ZERO command example								
Master send	01 H	06 H	00 H	10 H	00 H	FFH	C8H	4FH
Slave response								
01 H	06 H	00 H	10 H	00 H	FFH	C8 H	4FH	

Note: 0010 is a register address, and 00FFH is written to this register. (as the above example, written in 00FFH), the current azimuth is cleared to zero. The last two bytes are CRC check sums

2-4. Set sensor address

Set sensor address code command		Slave response	
Sensor add	01H	Sensor add	01H
Function code	06H	Function code	06H
Address	00H	Register address	00H
	11H		11H
Sensor new address	00H	Sensor new address	00H
	04H		04H
CRC	D80C	CRC	D80C

Commands must be sent two times continuously to be valid

Set sensor address command example								
Master send	01 H	06 H	00 H	11 H	00 H	04H	D8H	0CH
Slave response								
01 H	06 H	00 H	11 H	00 H	04H	D8 H	0CH	

Note: 0011H is a register address, which controls the address of the sensor. In the above example, the address of the sensor is changed to 0004H, and the last two bytes is CRC check sum.

2-5. Set sensor baudrate command : (default 115200bps)

Set sensor baudrate command		Slave response	
Sensor add	01H	Sensor add	01H
Function code	06H	Function code	06H
Address	00H	Register address	00H
	12H		12H
Sensor baudrate	00 H	Sensor baudrate	00 H
	A2		A2
CRC	A876	CRC	A876

A1H : 9600 A2H : 19200 A3H : 38400 A4H : 115200 A5H : 230400 A6H : 256000

Commands must be sent two times continuously to be valid

Set sensor baudrate command example								
Master send	01 H	06 H	00 H	12 H	00 H	A2H	A8H	76H
Slave response								
01 H	06 H	00 H	12 H	00 H	A2H	A8 H	76H	

Note: 0012H is a register address, which controls the baud rate of the sensor. In the above example, the baud rate of the sensor is set to 19200, and the last two bytes is CRC check sum.

2-6.Set sensor auto output : (factory default is 0HZ，query mode)

Set sensor auto output code command		Slave response	
Sensor add	01H	Sensor add	01H
Function code	06H	Function code	06H
Address	00H	Register address	00H
	13H		13H
Sensor output frequency	00H	Sensor output frequency	00H
	00H		00H
CRC	780FH	CRC	780FH

XX: 00 : Query mode; 01 : 5HZ; 02 : 15HZ; 03 : 25HZ;
04 : 35HZ; 05 : 50HZ; 06 : 100HZ; 07 : 200Hz

Set sensor auto output code command example								
Master send	01 H	06 H	00 H	13 H	00 H	00H	78H	0FH

Slave response							
01 H	06 H	00 H	13 H	00 H	00H	78H	0FH

Set sensor query mode .

2-7.Set sensor serial communication parity bit: (factory default is even parity)

Set sensor serial communication parity bit command		Slave response	
Sensor add	01H	Sensor add	01H
Function code	06H	Function code	06H
Address	00H	Register address	00H
	18H		18H
Sensor serial communication parity bit	00H	Sensor serial communication parity bit	00H
	02H		02H
CRC	880C	CRC	880C

set parity bit：

0x0000: PARITY_NONE No check bit

0x0001: PARITY_ODD odd parity bit

0x0002: PARITY_EVEN even parity bit

Commands must be sent twice in a row to be effective after power on again.

Application example of set Sensor serial communication parity bit command								
Master send	01H	06H	00H	18H	00H	02H	88H	0CH

Slave response							
01H	06H	00H	18H	00H	02H	88H	0CH

Note: 0018H is the register address, this register controls the sensor parity bit. In the above example, the parity bit of the sensor is set to even, and the last two bytes are the CRC checksum.

Add : Block 1&Block 6, COFCO(FUAN) Robotics Industrial Park ,

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