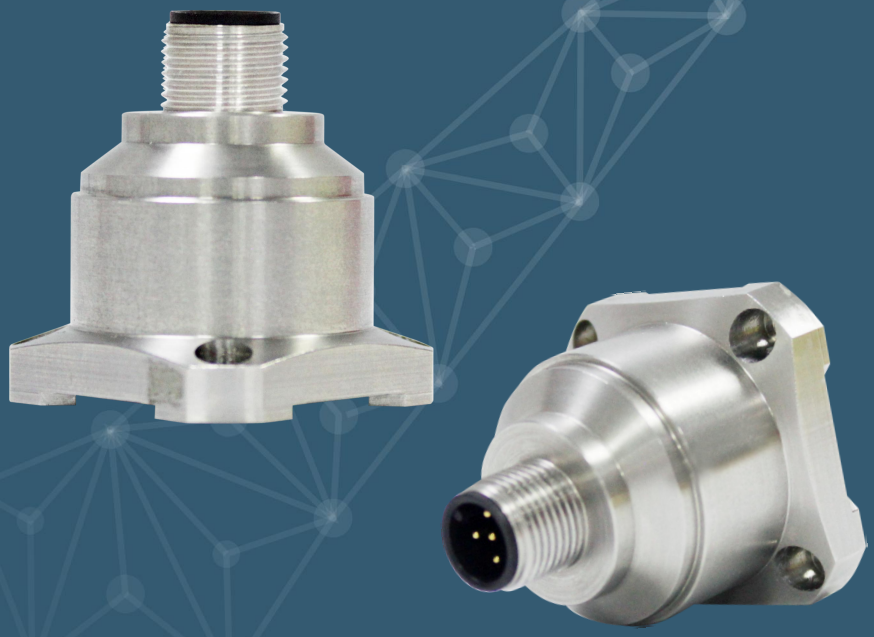
PATENT NO：ZL 201830752896.8
CE certification: AT18250EC101485
RoSH certification: AT18300RC105892



V2.4

MEMS DIGITAL ACCELEROMETER

AKF392

Technical Manual

MEMS MICROMECHANICAL
ACCELERATION SENSOR

★ HIGH PRECISION
★ HIGH STABILITY
★ HIGH FREQUENCY RESPONSE

▶ PRODUCT INTRODUCE

The AKF392B three axis accelerometer is produced using Swiss patented technology.

This acceleration series can be applied to various fields such as vibration testing and impact testing.The product adopts digital interface output, RS232/485/TTL optional, different address codes can be set, and multiple sensors can be used in series for long distances, which is convenient for multi-point measurement and data analysis. The AKF392B is a monocrystal line silicon capacitive sensor, consisting of a micromachined silicon chip、a low-power ASIC for signal conditioning、a microprocessor for storing compensation values and a temperature sensor. This product has low power consumption, Complete calibration system, solid structure and stable output.The new electronic configuration provides solid-state power for reset, and providing full protection for over-current.In the full range,Typical values for long-term stability and bias of the scale factor are less than 0.1%. This series of products has the characteristics of strong structure, low power consumption and excellent deviation stability, which guarantees outstanding output reliability.

▶ FEATURE

★ Three-axis (X、Y、Z)
★ power voltage: 9~36V
★ Storage temp: -40°C to +85°C
★ Excellent performance (impact, vibration and temperature)
★ output: RS232/RS485/TTL
★ work temp: -40°C to +85°C
★ Excellent deviation stability

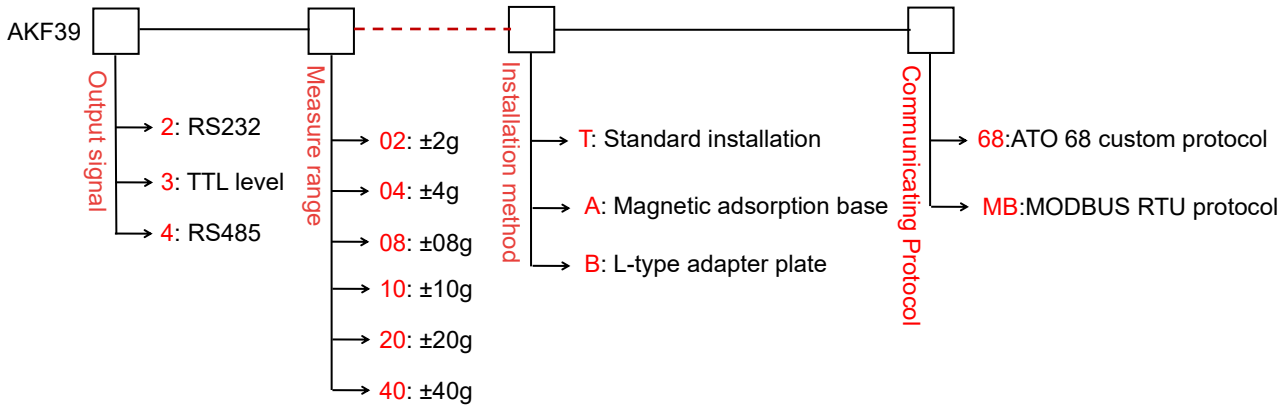
▶ APPLICATION

★ crash record, fatigue monitoring and prediction
★ Low frequency vibration and automatic monitoring
★ Large machinery, engine
★ bridge
★ wind power generation
★ automobile
★ armamentarium
★ road roller

▶ SPECIFICATIONS

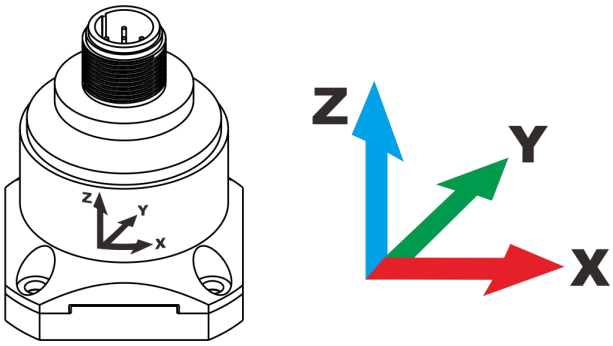
AKF392T	PARAMETER						UNIT
Range	±2	±4	±8	±10	±20	±40	g
Deviation Calibration	<1	<1	<1	<1	<1	<1	mg
Measuring Axial	X,Y,Z	X,Y,Z	X,Y,Z	X,Y,Z	X,Y,Z	X,Y,Z	Axial
Up/Off Power Repeatability	<2	<2	<2	<2	<2	<2	mg(max)
Deviation Temp. Coefficient	0.01	0.01	0.01	0.01	0.01	0.01	%/℃(Typical value)
Resolution/Threshold (@ 1Hz)	< 1	< 1	< 1	< 1	< 1	< 1	mg(max)
Nonlinearity	<0.5	<0.8	<1	<1	<1	<1	% FS(max)
Bandwidth (3Db)	500	500	500	500	500	500	Hz
Cross-axis sensitivity	1	1	1	2	2	2	%
Lateral vibration sensitivity ratio	1	1	2	5	5	5	%
Noise density	21	21	21	86.6	86.6	86.6	μg/√Hz
Resonance frequency	2.4	2.4	2.4	5.5	5.5	5.5	kHz
68 protocol automatic output rate	5Hz、10Hz、25Hz、50Hz、100Hz、200Hz、500Hz、1000Hz						
MODBUS automatic output rate	10Hz、25Hz、50Hz						
Output Interface	RS232/RS485/TTL						
Protocol	ATO Standard Protocol And Modbus Rtu Protocol						
Input（Vdd_Vss）	9~36 VDC						
Current Consumption	<60mA @ 12 VDC						
Connector	Industry standard M12 connector						
Weight	Product net weight: 82g, magnetic base: 48g, L-shaped adapter plate 20g						
Size	Product size: 34.3*34.3*38.5mm Magnetic adsorption base size: 34.23*34.23*6mm L-shaped adapter plate size: 36*44*15mm						

▶ ORDERING INFORMATION

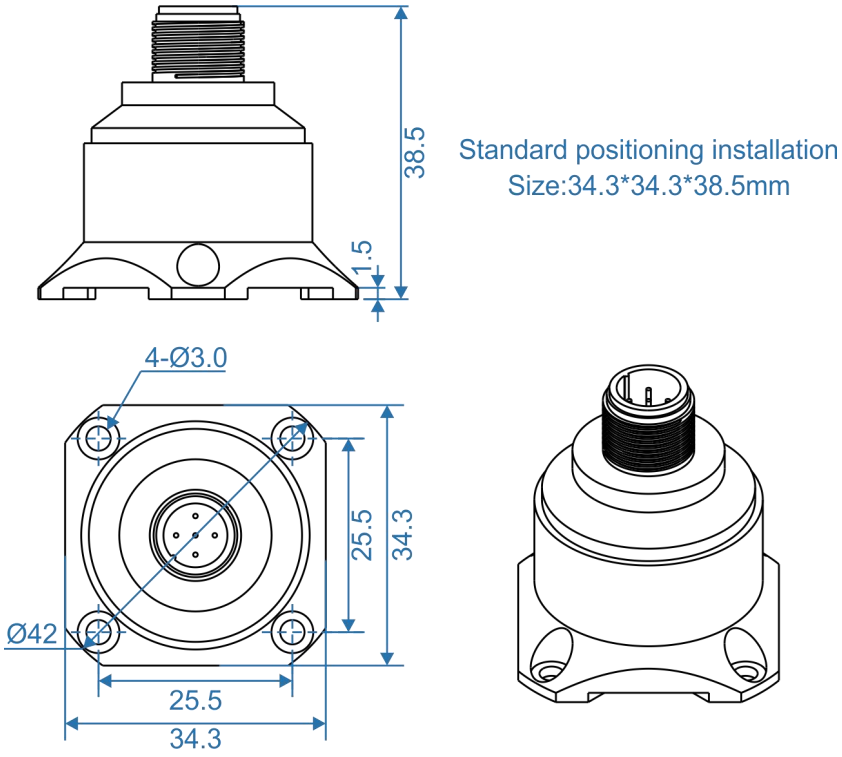


E.g AKF392-02-T-68: RS232 signal output / ±2g range / standard installation / ATO 68 custom protocol.

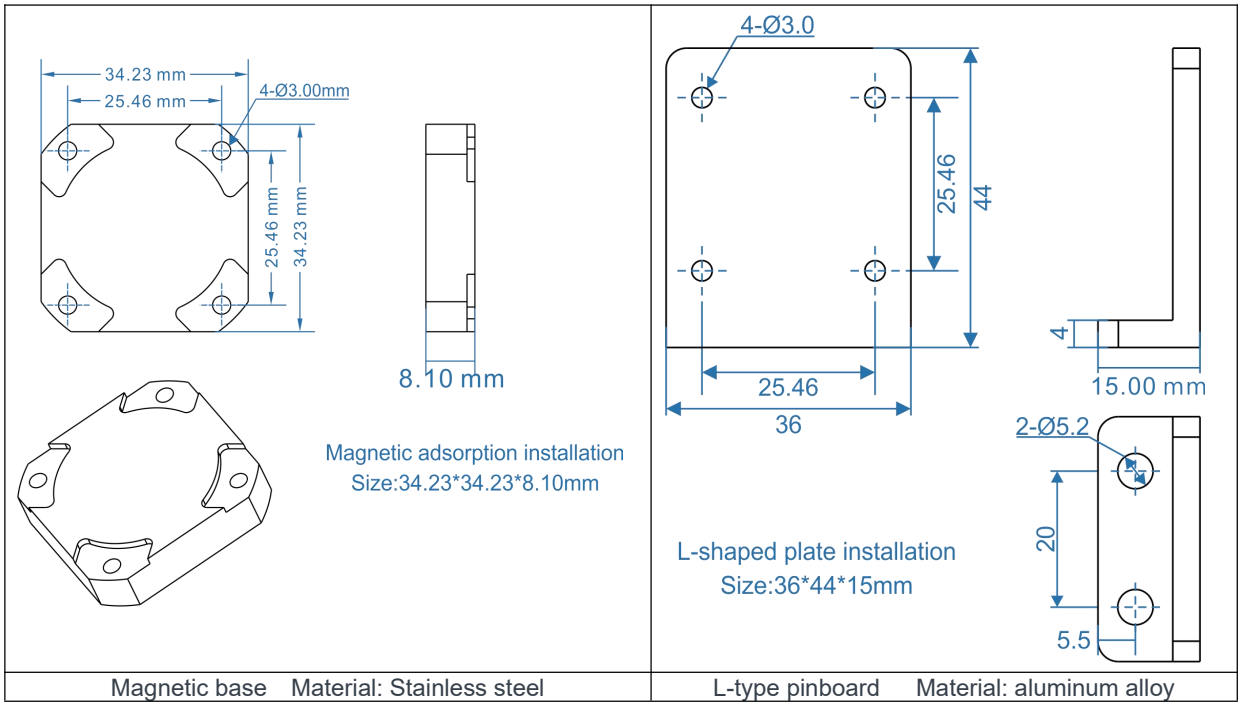
▶ PRODUCT MEASUREMENT DIRECTION



▸ SIZE



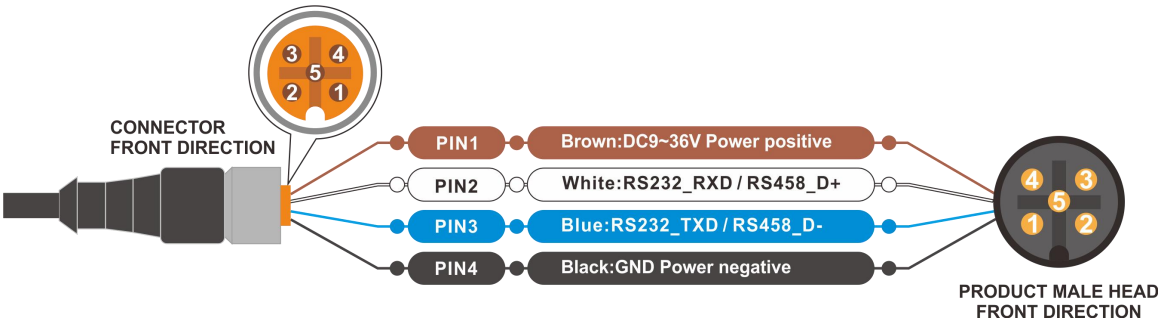
MOUNTING ACCESSORIES SIZE



Magnetic base Material: Stainless steel	L-type pinboard Material: aluminum alloy

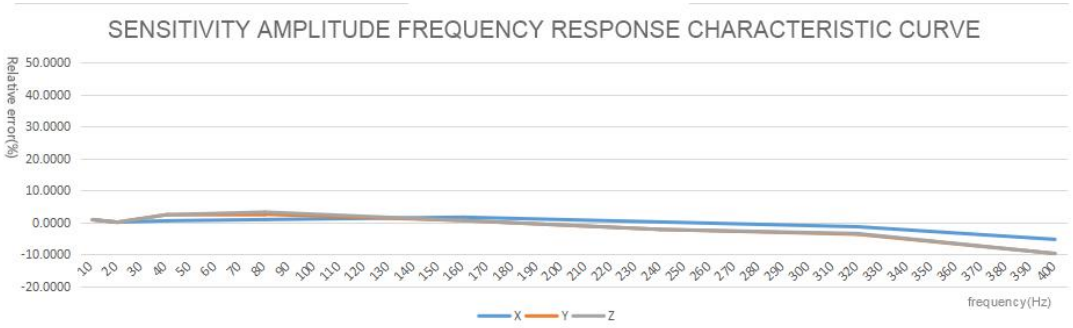
ELECTRICAL CONNECTION

FUNCTION / LINE COLOR	BROWN PIN1	WHITE PIN2	BLUE PIN3	BLACK PIN4
	DC9～36V Power supply positive	RS232(RXD) Or RS485(D+)	RS232(TXD) Or RS485(D-)	GND Power supply Negative



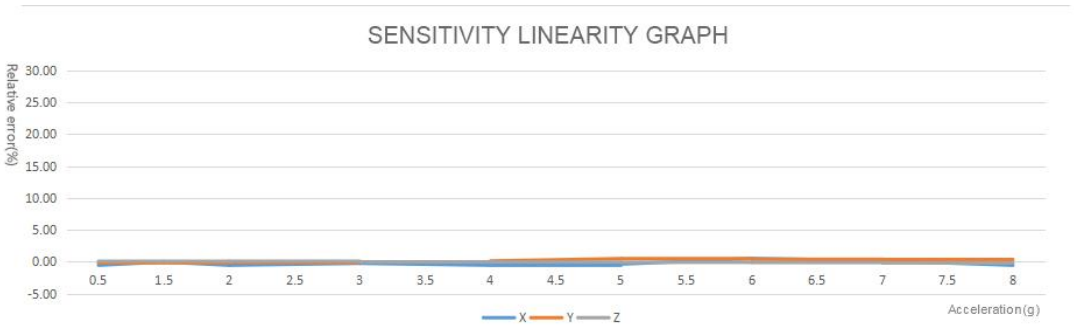
▸ SENSITIVITY AMPLITUDE-FREQUENCY RESPONSE CHARACTERISTIC CURVE

(reference condition: f=20.000Hz, a=2.000G)



Reference diagram of measuring range ±8G

▸ SENSITIVITY LINEARITY GRAPH



▸ COMMUNICATING PROTOCOL

1. DATA FRAME FORMAT: (8 bits date，1 bit stop，No check，Default baud rate 9600)

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

data format : Hex
Identifier：Fixed 68H
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.

2. Command word analysis

Desc.	Meaning/Example	Description
0X04	**Read the acceleration simultaneously** E.g: ***68 04 00 04 08***	Data domain(0byte) No Data domain command
0X84	Sensor answer reply E.g: ***68 0D 00 84 00 20 10 10 40 00 05 05 00 1B***	Data domain（9byte) AA AB BB CC CD DD EE EF FF AA AB BB:three character means X axis; CC CD DD:three character means Y axis; EE EF FF:3 characters means Z axis; The angle format is the same as the X axis or Y axis analysis method. The angle in the left example: X axis 02.010g, Y axis -04.000g, Z axis：+50.500g. **00 20 10** red three bytes return the angle value for the X-axis，For compressed BCD codes，The upper **0** of the first byte is the sign bit (0 positive, 1 negative) **02** is a two-digit integer value, **010** is a three-digit decimal value. The other axis data parsing methods are the same, This angle is resolved to +02.010g. **10 40 00** Blue three bytes return the angle value for the Y axis, the analytical method is the same as the X axis. **05 05 00** Green three bytes are the internal temperature value of the product, and the analytical method is the same as the X-axis angle. **1B**: checksum, all data hexadecimal sum, no prefix 68.
0X0B	**Setting communication rate** E.g: ***68 05 00 0B 03 13*** The command setting is effective	Data domain(1byte)Baud rate：default :9600 00 means 2400　　01 means 4800 02 means 9600　　03 means 19200

	after power off then restart (power off with save function)	04 means 38400 05 means 115200 06 means 230400
0X8B	Sensor answer reply command E.g: ***68 05 00 8B 00 90***	Data domain（1byte） Data domain in the number means the sensor response results 00 Success FF Failure
0X0C	**Setting sensor output mode** Response rule; Need upper computer send reading angle command , the sensor answer the corresponding angle Automatic output rule: The sensor with power on can Automatically output X,Y angle , The output frequency base on what be setted，if you need output High frequency，please set baud rate as 115200 (Power off with save function) E.g: ***68 05 00 0C 00 11***	Data domain (1byte)Factory default: 00 00 Response system 01 5Hz Auto output mode 02 10Hz Auto output mode 03 25Hz Auto output mode 04 50Hz Auto output mode 05 100Hz Auto output mode 06 200Hz Auto output mode 07 500Hz Auto output mode（Baud rate adopt 115200、230400） 08 1000Hz Auto output mode（Baud rate adopt 230400） 09 300Hz Auto output mode（Baud rate adopt 115200、23040） 10 400Hz Auto output mode（Baud rate adopt 115200、23040）
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
0X0F	**Setting module address command** The sensor default address is 00, 1, such as a plurality of sensor to be connected with a bus cable, e.g RS485.requires each sensor is set to a different address, in order to achieve control and response angle . 2, If successfully changed the new address, follow all of the commands and responding Packet address code has to switch to the new address code which already changed then to be effective, otherwise the sensor will not respond to commands.(power off with save function) E.g: ***68 05 00 0F 01 15*** Setting the address to 01 ***68 05 FF 0F 00 13*** Use the common address to reset address	Data domain（1byte）XX Module address Address from 00 to EF range Note: All products have a common address :FF, If forget the address what has been set during operation , can use **FF address to operate the product can still normally respond.**

	to 00	
0X8F	The sensor answer reply command E.g: ***68 05 00 8F 94***	Data domain（1byte）， Data domain in the number means the sensor response results 00 Success FF Failure
0X53	Set save command ***68 04 00 53 57***	
0XD3	Set save command reply ***68 05 00 D3 00 D8***	Data domain（0BYTE） Data domain in the number means the sensor response results 00 Success FF Failure
0XFF	Read version software number instruction ***68 04 00 FF 03***	
	Read software version reply AKF392,SW V1.1	Data domain（BYTE） Data domain in the number means the sensor response results Return is in ASCII code format，model（AKF392），Software version number 1.1

3. Setting instructions and processes

3.1.Set related parameters(Baud rate, address code, automatic output frequency.)Only valid settings are set at this time, but not saved to FLASH,. Power down is not saved.

A Set address code

B Set baud rate

C Set the calibration parameters

D Automatic or inquiry mode

Notice：Take effect immediately after setting the address code and baud rate (but not saved to FLASH)，The subsequent operation instructions need to change the corresponding address code and baud rate to be set successfully.

3.2.Save parameters, write all parameters to FLASH

▸ MODBUS RTU PROTOCOL

1. Data frames format:

RTU Mode

Communication Parameter：Baud rate 9600 bps

Data frames：1 Start bit，8 datas，even parity check，1 stop bit

Please read the following items carefully before use:

1) Because of the MODBUS protocol stipulates between the two data frames should be at least more than 3.5 bytes of time (such as the baud rate of 9600, the time is 3.5 X (1/9600) X 11=0.004s). However, in order to leave enough margin, the sensor will be increased this time to 10ms, so please leave at least of the time interval between each data frame.

The master computer sends commands — — 10ms idle — — slave computer reply command — — 10ms idel - The master computer sends commands.....

2) MODBUS protocol stipulates the broadcast address ----0 relevant content, the sensor can also accept the broadcast address content, but will not reply. Therefore, the broadcast address 0 can be used for the following purposes, for reference only.

①All the sensors mounted on BUS are all set to an address.

②All the sensors mounted on BUS are all set to relative / absolute zero.

③Test all sensors mounted on BUS , that is, the master computer send 0 address to BUS for query angle command, communication lights can flicker that means the communication is normal.

3) In order to improve the reliability of the system, set the address command and set the absolute / relative command, set the baud rate, these three commands must be sent for two consecutive times will be valid. "Two consecutive send" refers to two times sent successfully (the slave machine reply every time) ,must be consecutive in two times, that's means the master compuetr can not insert other frames in the midele of two replies , otherwise, the command will be locked until the power off ,

setting process refer to below :

Send set address command — — waiting for the slave compueter to send command of successful commands - (no other commands) to send the set address command again - waiting for the successful settings from the slave computer to send the command - modify the success

4) After power up, the above two sets of commands can be set only once, if necessary, again need to re power.

5) When the normal communication accumulated to a certain number of times, the communication indicator will flash once.

2. Read the holding register to fetch acceleration data

Modbus FUNC 03H

Master Computer Inquiry Command:		Slave Computer Response:		
Sensor Address	01H	Sensor Address	01H	
FUNC	03H	FUNC	03H	
Visit Register first Address	00H	Data Length 9 bytes	09H	
	02H	Data word 1 upper 8 bits	50H	X Axis Data
Data Length 4 bytes	00H	Data word 1 lower 8 bits	46H	
	04H	Data word 2 upper 8 bits	00H	
CRC	E5C9H	Data word 2 lower 8 bits	23H	Y Axis Data

		Data word 3 upper 8 bits	20H	
		Data word 3 lower 8 bits	00H	
		Data word 4 upper 8 bits	00H	
		Data word 4 lower 8 bits	00H	Z Axis Data
		Data word 5 upper 8 bits	00H	
		CRC	B827H	

Read the measured data command applicaton example 1:								
Master computer sending	01 H	03 H	00 H	02 H	00 H	04 H	E5H	C9H
Slave computer response								

01H	03H	08H	50H	46H	00H	23H	20H	00	00H	00H	B8H	27H

Note: The data field of the slave reply frame is 50H, 46H, 00H, 00H, 23H, 20H, 00H, 00H, 00H

The X axis is the 1-3 bytes of the data field, the Y axis is the 4-6 bytes of the data field, and the Z axis is the 7-9 bytes of the data field, with the low byte first. The expression method of acceleration is the number of points, one point corresponds to 0.001º, 0.001×(number of points-bias) is the acceleration, and the bias is 90000.

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

1) Get the current acceleration points. Note that the low byte is first, the X axis is 004650H, the Y axis is 002023H, and the Z axis is 0.

Converted to decimal, X axis: 4650H→18000, Y axis: 2023H→8227, Z axis: 0.

2) Subtract the bias of 90000 (note: this value is a fixed amount), X axis: 18000-90000=-72000, Y axis: 8227-90000=-891773, Z axis 0-90000=-90000.

3) Get the final accelerometer, X axis: -72000×0.001=-72.000G, Y axis: -81773×0.001=-81.773G, Z axis: -90000×0.001=-90G.

Read acceleration data of input register

Modbus function code 04H, this is format two outputs. Users can adjust the register address and length to access different axis data according to their needs. The register table is as follows:

Register address	Data content	Data type	Unit	Remark
30003	X acceleration	UINT32 (R)	g	data analysis as follow
30005	Y acceleration	UINT32 (R)	g	data analysis as follow
30007	Z acceleration	UINT32 (R)	g	data analysis as follow

Application example of reading measurement data command 1:

Host query command:		Slave response:		
Sensor address	01H	Sensor address	01H	
Function code	04H	Function code	04H	
Access register	00H	Data length12 bytes	0CH	
First address	02H	Data domain	94H	X axis value
Data length 6 bytes	00H		5FH	
CRC	06H		01H	
	D1 C8 H		00H	
			65H	Y axis value
			63H	
			01H	

			00H	
			47H	
			60H	Z axis
			01H	value
			00H	
		CRC	1BE4H	

In the above table, the X axis is the data field 1-4 bytes, the Y axis is the data data field 5-8 bytes, and the Z axis is the data data field 9-12 bytes. Low byte first. The representation method of acceleration is the number of points, one point corresponds to 0.001º, 0.001×(number of points-bias) is the acceleration, and the bias is 90000.

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

1) Get the current acceleration points. Note that the low byte is first, the X axis is 00015F94H, the Y axis is 00016365H, and the Z axis is 00016047H.

Converted to decimal, X axis: 00015F94H → 90004, Y axis: 00016365H → 90981, Z axis: 00016047H->90183.

2) Subtract the bias of 90000 (note: this value is a fixed amount), X axis: 90004-90000=4, Y axis: 90981-90000=981, Z axis 90183-90000=183.

3) Get the final accelerometer, X axis: 4×0.001= 0.004G, Y axis: 981×0.001=0.981G, Z axis: 183×0.001=0.183G.

4. Set the sensor address:

Set sensor address code command:		Slave response:	
Sensor address	01H	Sensor address	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 to be valid

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

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

5 Set sensor Baud rate : (factory default 9600bps)

Set sensor Baud rate code command:		Slave computer response:	
Sensor address	01H	Sensor Address	01H
FUNC	06H	FUNC	06H
Register address	00H	Register address	00H
	12H		12H
Baud rate of the sensor	00H	Baud rate of the sensor	00H

	XX		XX
CRC	CRC LH	CRC	CRC LH

XX： A0H:4800 A1H:9600 A2H:19200 A3H:38400 A4H:115200

Set sensor Baud rate command example:								
Master computer sending	01H	06H	00H	12H	00H	A2H	A8H	76H
Slave computer response								
01H	06H	00H	12 H	00 H	A2H	A8H	76H	

Note: 0012H is the 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 are CRC checksum.

6. Set the sensor communication character format: (Factory default is even parity)

Set the sensor communication character format code command:		Slave response:	
Sensor Address	01H	Sensor Address	01H
FUNC	06H	FUNC	06H
address	00H	register address	00H
	09H		09H
Sensor changes communication character format	00 H	New format of sensors	00H
	01H		01H
CRC	9808	CRC	9808

Application example of Set the sensor communication character format command:								
Host send	01 H	06 H	00 H	09 H	00 H	01H	98H	08H
Slave reply								
01 H	06 H	00 H	09 H	00 H	01H	98 H	08H	

The above example is to set the byte format to: one start bit + 8 data bits, no parity, + 1 stop bit

It is effective after power-on again. The factory default is one start bit + 8 data bits, even parity check + 1 stop bit

Note: 0009 is the register address, which controls the character format of sensor communication.

0000H: One start bit + 8 data bits, even parity +1 stop bit

0001H: One start bit + 8 data bits No parity + 1 stop bit

7. Set sensor automatic output: (factory default 0HZ)

Set sensor automatic output code command:		Slave response:	
Sensor address	01H	Sensor address	01H
Function code	06H	Function code	06H
Address	00H	Register address	00H
	13H		13H
Sensor output frequency	00H	Sensor output frequency	00H
	XX		XX
CRC	CRC LH	CRC	CRC LH

The following table shows the valid values of the data field XX:

frequency	0HZ	10HZ	25HZ	50HZ
Format one output setting command	00H	01H	02H	03H

Format two output setting command	00H	A1H	A2H	A3H

Set sensor automatic output command example:								
Host send			01H	06H	00H	13H	00H	A2H	A8H	76H
Slave reply								
01H	06H	00H	13H	00 H	A2H	A8H	76H	

Note: 0013H is the register address, which controls the output frequency of the sensor. In the above example, the sensor is set to output data at 25HZ according to format two, and the last two bytes are the CRC checksum.

Note: ATO custom protocol and MODBUS protocol switch methods to each other:

At power-on, the upper computer always sends 0xAA. When the accelerometer returns 0XAA, 0XAA, 0XBB, 0XBB, the change is successful.