



Strain Gauge - Six Axis Force/Torque Sensor KWR46 Series

User Manual

(Ver. 20.6.46.7.4LA)

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■ Introduction

This is the user manual for the strain gauge six-axis force/torque sensor (KWR46 series - RS422 communication), which is suitable for some communications, such as RS422, RS422 converted to USB. When the RS485 receiving device is used to connect this type of sensor, the sensor only sends data and does not receive data.



This manual mainly introduces the product's specifications, functions, methods of use and interface forms, and informs the user of the precautions associated with this product. Please read this manual before and during the use of the product as improper operation may lead to product failure or accidents.

■ Statement

1. The information contained in this manual is current at the date of publication. If modified, further notice is not available.
2. This manual uses two representations: decimal and hexadecimal. All unspecified values are expressed in decimal representation.
3. This product is a precision instrument and it is important to use the product within the specification range specified in this manual. In particular, use of the product under conditions where the load is greater than the rated load may cause the product to malfunction. Please ensure that all six axes (3 force axis and 3 torque axes) are within the rated load range.
4. Different batches of products may have color difference or scratch, which has no impact on performance.
5. If specific environment is necessary, such as radiation environment, dustless room, strong magnetic field, spray oil or chemicals, please contact sales for further information.
6. This product complies with protection class IP64, but only if the product is installed correctly. Please read the installation instructions described in this manual carefully and install it correctly.
7. This product has not been designed or manufactured for inclusion in systems requiring a high degree of safety and reliability such as nuclear power, aviation, railways, safety equipment, etc. If this product is incorporated into such equipment and control systems, there may be a risk of serious impact or damage to human life, health, property, etc., for which we cannot be held responsible.
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9. Kunwei Tech shall not be liable for any incidental damage (loss of business interests, business interruption, etc.) arising from the inability to use or disable the product.
10. We are not responsible for any damage caused by failure to comply with the contents of this manual.
11. We are not responsible for any damage caused by malfunctions caused by equipment and software combinations that do not involve our company.
12. When exporting overseas, please comply with the relevant laws and regulations of China's foreign trade and the relevant laws and regulations of the importing country, and carry out the necessary procedures. Please contact our sales representatives if you require relevant information or qualification certificates.
13. The warranty period for this product is twelve months from the date of delivery of the product. Repairs after the warranty period will be subject to a charge depending on the repair. In addition, the warranty does not cover "faults caused by the use of external specifications", "faults caused by user negligence" or "disassembly of the product without permission" during the warranty period.
14. KWR46 is one of the product names of our strain gauge six-axis force/torque sensors and is owned by Kunwei (Beijing) Technology Co., Ltd.
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■ Terms and definitions

Terms	Definitions
Rated load	The maximum load that meets the sensor specification. If this value is exceeded, there is no guarantee that the technical specifications required by the specification will be met.
Overload	The load exceeds the rated load. Failure may occur when the sensor is overloaded.
Zero output	Output value without load when the mounting section and the ground are horizontal and the mounting section is facing the ground.
Precision	Precision is an evaluation indicator of the degree of agreement between multiple measured values, i.e. the degree of consistency of the output curve obtained when the sensor measure the same load group (combined of three-directional force and three-directional torque) multiple times. Repeatability precision is the standard deviation of the output error as a percentage of the rated output (%FS).
Accuracy	Accuracy is an evaluation indicator of the degree of deviation of the measured value from the true value. Accuracy is the standard deviation of the amount of deviation between the output and the theoretical true value as a percentage of the rated output (%FS)



Zero point temperature characteristics Changes in zero output with changes in ambient temperature. The difference between the maximum and minimum values of the zero output over the operating temperature range is divided by the operating temperature range and expressed as a percentage change per 1°C relative to the rated output (%FS /°C), expressed in absolute terms.

Baud rate Baud rate is the number of symbols transmitted per second. It is a index to measure the rate of data transmission. It is expressed by the number of carrier modulation state changes per unit time. In the information transmission channel, the signal unit carrying data information is called a code element, and the number of code elements transmitted through the channel per second is called the code element transmission rate, or baud rate for short.

IP64 The IEC (International Electrotechnical Commission) has drawn up a classification of electrical appliances according to their resistance to dust and moisture. IP64 has the following properties:

Dust protection: protection against foreign objects and dust

Waterproof: prevents splashing water from soaking in

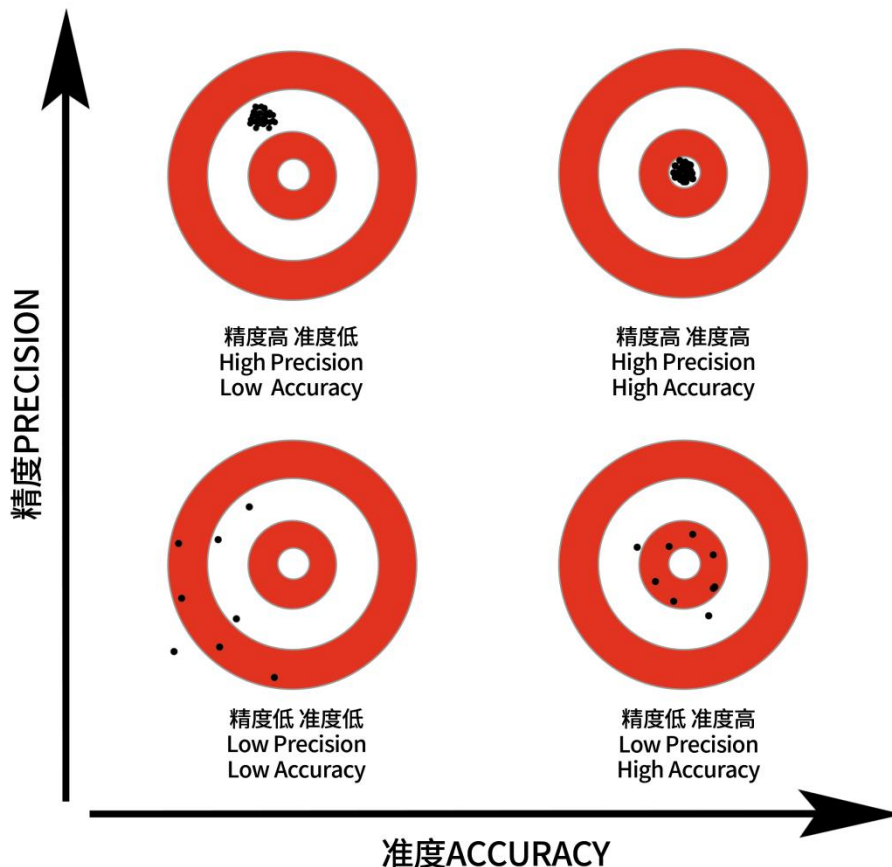


Fig.1 Precision and accuracy schematic diagram



■ Brief description of product specifications

Model	Rated force (N)		Rated torque (Nm)		Dimensions (mm)	Power supply (VDC)
	Fx, Fy	Fz	Mx, My	Mz		
KWR46A	50	50	2.0	2.0	$\Phi 46.0 \times H19.4$	9~24
KWR46B	150	150	5.0	5.0	$\Phi 46.0 \times H19.4$	9~24
KWR46C	200	200	7.0	7.0	$\Phi 46.0 \times H19.4$	9~24

Note: The overall dimensions do not include the connector housing and the input/output connection interface. For more information, please see the installation dimensions drawing.

Note: This kind of sensor needs to be used with high precision data acquisition box(9~24VDC) produced by our company.



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1 Product Overview

1.1 Product features

The model KWR46 series is a strain gauge six-axis force/torque sensor that detects three forces and three moments in real time. The sensor detects the relative deformation between the 'tool side' and the 'main body' caused by the applied force and uses strain gauges to measure the change in the sensor's elastic unit. The sensor contains an embedded system that collects and processes the signal changes from the strain gauges and outputs the magnitude and direction of the applied force in real time, providing high accuracy and responsiveness. When using the sensor, please install it correctly to avoid any interference with the output effect.

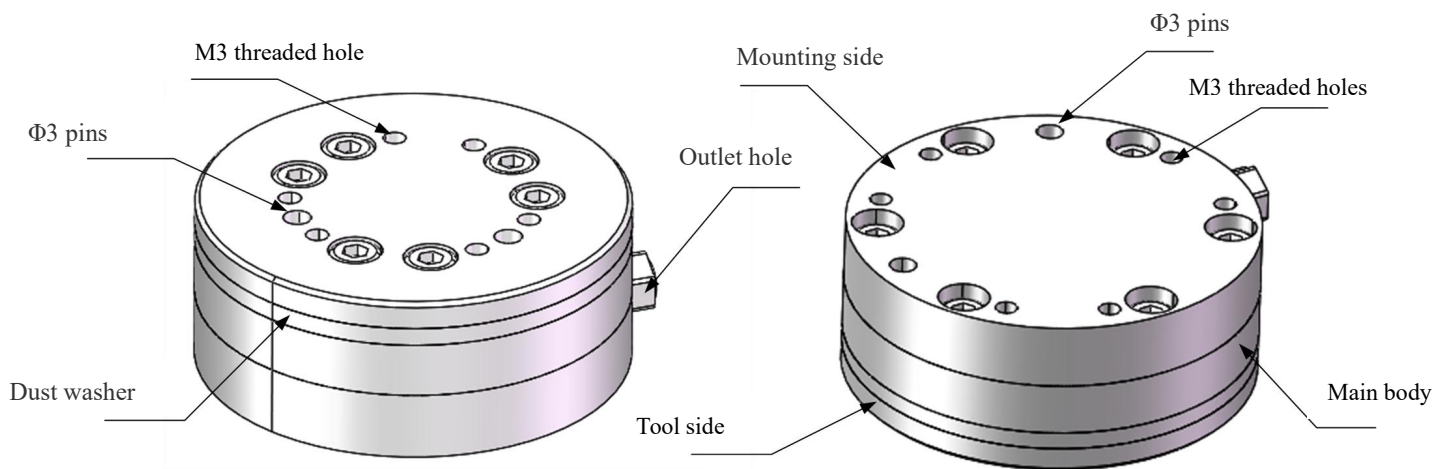


Fig.2 Sensor appearance

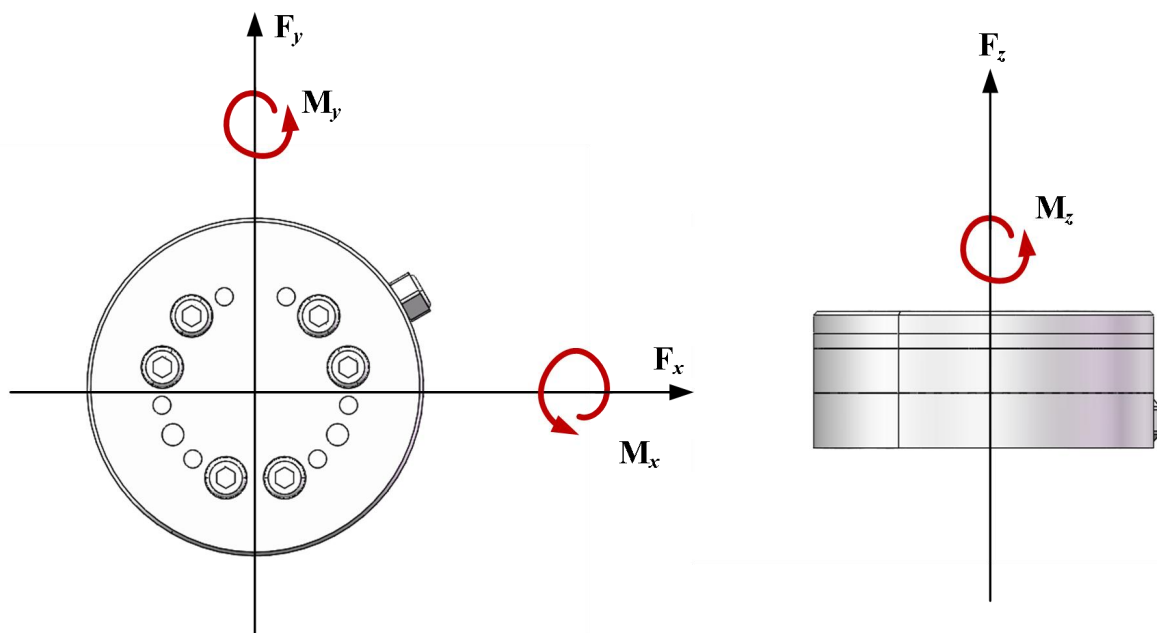


Fig.3 Definition of the sensor coordinate system (the direction of the torque conforms to the right-hand system)



1.2 Electrical characteristics

The voltage signal from the strain gauges is processed in real time by the external high precision data acquisition box , and converted to the actual load value and output in the form of a digital signal.

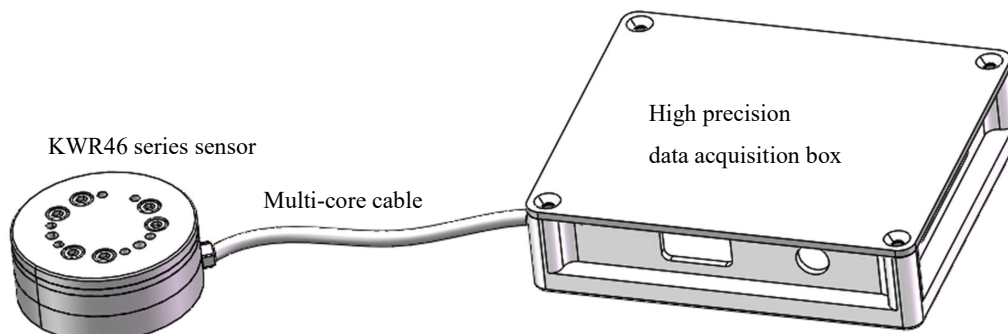


Fig.4 The electrical connection diagram of the F/T Sensor

2 Installation of the sensor

For details of the sensor mounting holes and mounting dimensions see "Section 4.2 Mounting Dimensions".

2.1 Operating procedures for sensor installation

The operating procedures given in this manual are typical of those for applications such as robotic arm mounting.



In the process of tightening the screws, gradually tighten the screws in the diagonal order shown in the illustration. Make sure that the sensor is in even contact with the device or adapter to be mounted.

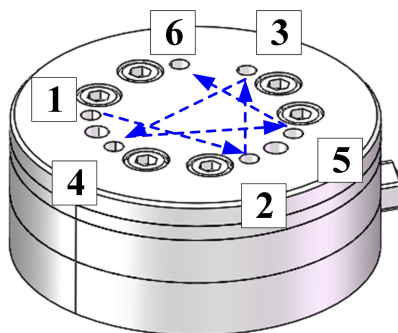


Fig.5 Screw tightening sequence

The transfer flange is not provided by default when the sensor delivered. If you need the adapter flange, our sales will confirm the demension and form of the flange with you. The flanges and sensor can be delivered in the form of bulk parts, or in the form of assembly to reduce the learning process. In order to ensure the completeness of the manual, it contains the installation guidance of the flange, and the form of the flange is only indicated.

(1) Check the equipment to be installed, the adapter flanges attached to the robot and tool side, and the sensor

Verify that the equipment to be installed, the adapter flanges, and the sensor surfaces are free of damage or foreign matter.



*If the contact is not uniform due to factors such as inclusions of foreign matter, gaps will form between the devices (or transfer flange) to be installed, which will not guarantee the IP64 performance of the product and will have an effect on the actual sensor output.

(2) Install the sensor on the flange attached to the robot side

The flange attached to the robot is matched with the bottom surface of the sensor, which is located to the sensor by two $\Phi 3$ Pins, and then we need to fix the flange to the sensor by using six M3 hexagon socket screws.

*The Locating pins are used to obtain a consistent connection for the installation of the device, If the pins are not used, the sensor performance will not be affected.

(3) Fasten the sensor to the flange attached to the tool side.

Use the pins to position the sensor to fit the transfer flange and confirm that the sensor is mounted in the same direction as the equipment is used.

Fasten by using the sensor's 6 in-built screws, then turn it in the direction of the right-hand screw to fix it. The screw tightening sequence is performed in the order of Figure 5.

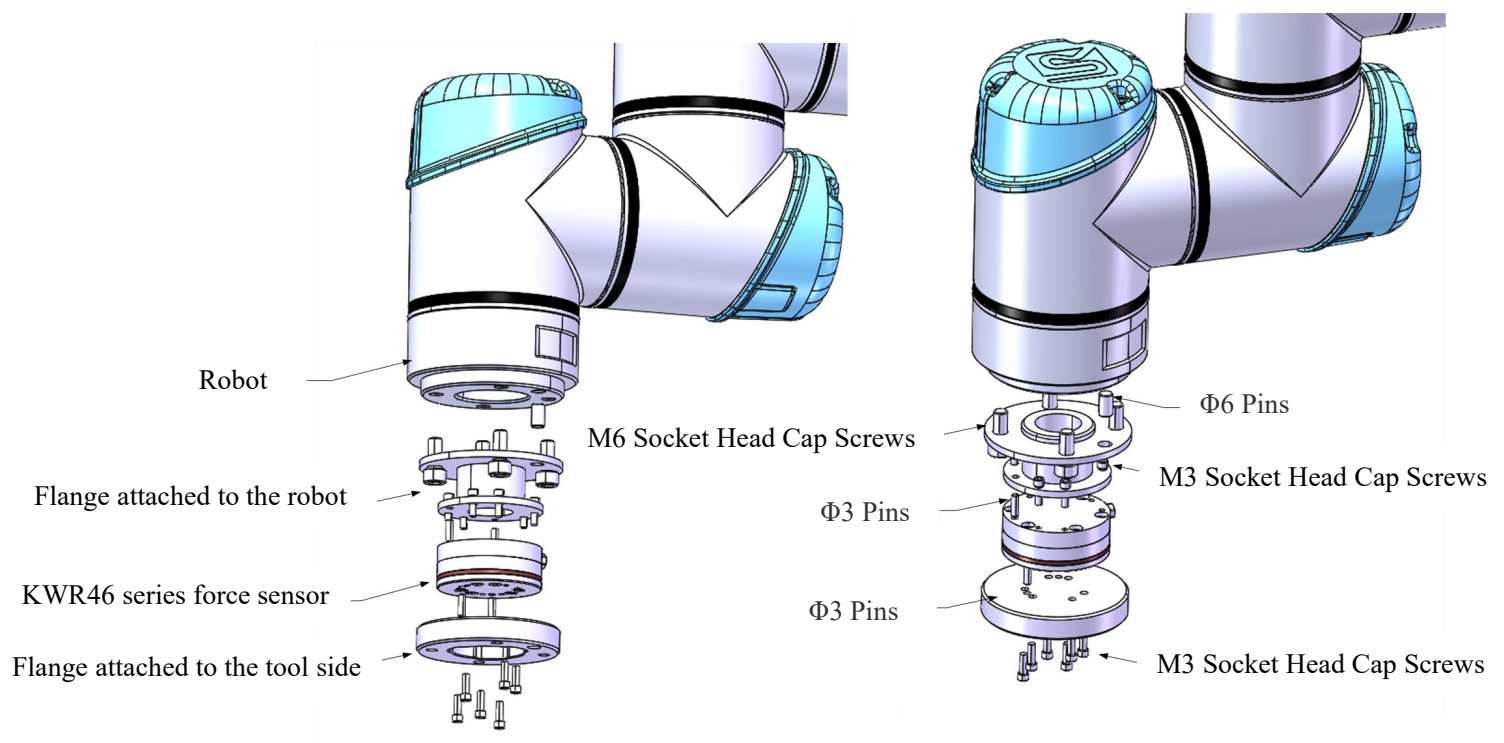


Fig.6 Diagram of the sensor and device connection installation

(4) Install the sensor assembled with the flanges on the robot

We need to locate the flange to the robot by $\Phi 6$ Pins, and then fix the flange to the robot by using six M3 hexagon socket screws. Finally, the installation of the sensor and flange is completed, but the actuator installation need to be carried out by the customer.

*The sensor tool side flange pins are used to obtain a consistent installation of the equipment tool, If the pins are



not used, the sensor performance will not be affected.

2.2 Connecting the cable

The connection cable is delivered with the product. The connection cable is a multi-core cable, that is extracted from the inside of the sensor, and the end of the cable is connected to the data acquisition box by DB25 or DB15 interface. As shown in the figure 7, align the connector of the multi-core cable with the box interface, then push it into the box. Once pushed in, the threaded connection housing out of the multi-core cable interface must be tightened to avoid loosening of the cable and to achieve IP64 performance.



Fig.6 Diagram of the cable connection operation

When connecting the data acquisition box to the terminal equipment, set the electrical interface parameters according to this manual and connect the output cables for the power supply and the signal accordingly.



During installation, please make sure that the wiring of each cable core follows the color definitions of the given cores. If the positive and negative of the power supply are connected in the opposite direction, the sensor will be damaged , pls connect carefully.

Note: The specific wiring mode and related electrical interface parameters are described in sections 4.3 to 4.5.

3 Caution

- (1) Do not use in a temperature and humidity environment outside the allowable range of specifications.
- (2) The wiring must be completely correct. When switching on the power please check whether the colours of the connecting cables are connected one to the other according to the form provided in this manual. If an error is made in the connection terminals, the internal circuit of the sensor may be short-circuited and possibly damaged, so be sure to note and check this.
- (3) The sensors have been tested for vibrations and shocks due to the built-in embedded system and other sophisticated components. If the product is dropped, excessive vibration etc. It may still cause a malfunction.
- (4) Knocking is strictly forbidden during the installation of the sensor. Especially when fitting to the adapter flange, if the gap fit is tight due to the processing of the adapter flange and other factors, please do not knock the sensor, otherwise it will cause damage to the sensor performance.



- (5) If the device outputs this value for a long time, please check whether the sensor is under normal force and the force range is normal. Long-term over-range stress may cause irreversible damage to the equipment and cannot output data accurately. Due to space constraints, the circuit board does not have reverse polarity protection, please be sure to check whether the power cable connection is correct when powering up, reverse connection may cause the circuit power supply to burn out.
- (6) After the sensor has been installed and powered on, it is recommended that to preheating for an hour.
- (7) The actual use of the sensor requires consideration of the mass of the equipment mounted on it in order to avoid overloading.
- (8) If the original package is damaged or lost, please wrap the sensor well in all directions, and ensure there will be no heavy load during the delivery process.
- (9) If you have any doubts or malfunctions during use, please do not try to operate without permission, but contact us directly.



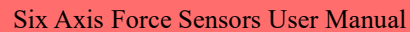
4 Product specifications

4.1 Basic specifications

The KWR46 series six-axis force/torque sensor is a high precision and high response sensor, which equipped with an external data acquisition box to achieve a level of real-time response and output that meets the needs of most robot manufacturers. If the customer has other special size and interface requirements, we undertake a customization service to provide a one-to-one technical solution.

Model		KWR46A	KWR46B	KWR46C
F_x,F_y	N)	50	150	200
F_z	(N)	50	150	200
M_x,M_y	(Nm)	2	5	6.5
M_z	(Nm)	2	5	6.5
Diameter (mm)		46	46	46
Height (mm)		19.4	19.4	19.4
Material		Aluminum Alloy	Aluminum Alloy	Aluminum Alloy
Surface treatment		Anodization	Anodization	Anodization
Overload level (%)		300	300	300
Precision (%FS)		0.1	0.1	0.1
Accuracy (%FS)		0.5	0.5	0.5
Sampling resolution (Bit)		24	24	24
Weight (kg)		0.26	0.28	0.32
Protection class		IP64	IP64	IP64
Operating temperature (°C)		5 ~ 80	5 ~80	5 ~ 80
Sampling frequency (kHz)		1	1	1
Supply voltage (VDC)		9~24	9~24	9~24
Communication interface		RS422/RS485/EtherCAT/Ethernet/CAN/USB		

Note: The above electrical parameters are high-precision data acquisition box parameters matched by KWR46 series sensors.





4.3 Data input/output specifications

(1) The sensor can respond to input commands with the communication specifications shown in the table below.

Communication parameters	Parameter values	Remarks
Output serial port	RS-422	When RS422 communication products are connected to RS485 devices using two data transmission lines, the sensor can only send data, not receive data
Supply voltage	9~24VDC	
Supply power	Less than 3W	
Serial port baud rate	460800	
Data bits	8	
Stop bits	1	
Check digit	0	

(2) Sensor output data format

Each frame of data is 28 bytes and is written in hexadecimal form as follows.

0x48AA0751CC19B3FEDC0AE5CF040D4B52DBE5F55993E7C1AB0BB0D0A

Of which:

0x48 (0x49) is the command code; 0xAA is the fixed identification, each frame of data is 0xAA; Since then every 4 bytes for a component of data, the transmission order is the low byte first, MSB first; the transmission order and units of data components are: Fx (Kg), Fy (Kg), Fz (Kg), Mx (Kgm) My (Kgm), Mz (Kgm); the data ends with 0D and 0A; each component is a set of 4 bytes of single floating point (Float) type data, Supervisory Computer will arrange the received data in order and then directly defined as Float type, you can get the actual force or moment.

Specific examples are shown in the table below.

Data	Description
0x48(0x49)	The start command code, which is determined by the supervisory computer sending 0x48 or 0x49 command
0xAA	Fixed identification, each frame of data is 0xAA
0xB0751CC1	In Float format it should be 0xC11C75B0, which means that the force in Fx direction is -9.7787 Kg
0x9B3FEDC0	In Float format it should be 0xC0ED3F9B, which means that the force in the Fy direction is -7.4140kg
0xAE5CF040	The arrangement in Float type format should be 0x40F05CAE, which means that the force in the Fz direction is 7.5113 Kg
0xD4B52DBE	In Float format it should be 0xBE2DB5D4, which means that the force in the Mx direction is -0.16964 Kgm
0x5F55993E	In Float format it should be 0x3E99555F, which means that the force in the My direction is



0.29948kgm

0x7C1AB0BB In Float format it should be 0xBBB01A7C, which means that the force in the Mz direction is -0.00537 Kgm

0x0D0A terminator, occupying two bytes

4.4 Input command definitions

Orders	Description
0x43 AA 0D 0A	Stopping data transmission
0x48 AA 0D 0A	Convert and send results at the speed of 1KHz, data starts with 0x48
0x49 AA 0D 0A	When the sensor is commanded to send a conversion result, the sensor will immediately reply with 28 bytes of data starting with 0x49 and ending with 0x0D0A, which will be constantly refreshed at a rate of 1 KHz inside the sensor (the sensor will only start refreshing the first time it receives this command after power-up, and will start replying from the second time it receives the command)



The system works at the 460800 baud rate by default. The output range of the device should be within the range of the device, if the device output exceeds the range for a long time, please check whether the sensor is under stressed normally and whether the stress range is normal, long-term over-range stress may cause irreversible damage to the device and can't output data accurately.



Please be sure to check whether the power cable connection is correct when powering up, reverse connection may cause the circuit power supply to burn.

4.5 Dedicated cables and wiring definitions

Sensor communication is carried out using a dedicated multi-core cable. The output signal is RS-422, the default connection requirement is the RS-422 serial port. If the RS-485 serial port is connected, the sensor can only send data, not receive it. But it can also output signals in other formats through various converter, such as analog signal and USB, please contact us if you need.

The sensor uses an external data acquisition box for real time data acquisition and processing. The box is equipped with a special power connector, which can be used directly according to DC power supply.



Serial number	Core wire colour	Definition
1	Red-	422 Bus sensor receives +
2	Black -	422 Bus sensor receives-
3	Green-	422/485 Bus sensor sends +
4	White -	422/485 Bus sensor sends -

Upon explicit request, we can provide 422/485-USB converters and the corresponding DC power supply to provide maximum convenience to our customers when they use this product. At the same time, we will provide technical support to help customers better understand the working and performance of the product.

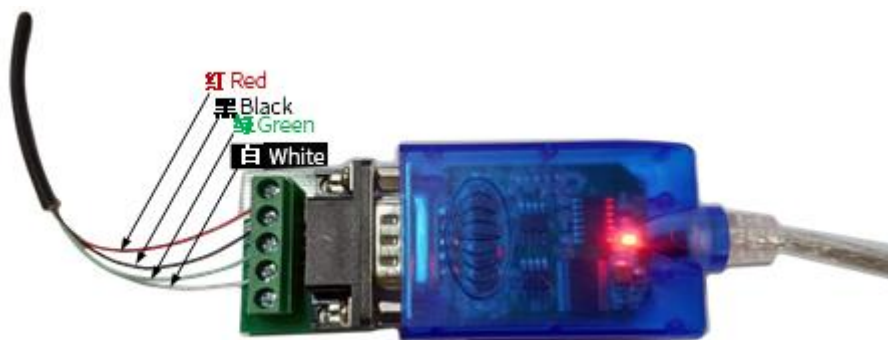


Fig.9 Diagram of 422/485-USB converter and power plug wiring

USB converted to serial devices have a default delay of 16ms when communicating, which is often unacceptable in control tasks, to improve this, you need to change the latency to a minimum value of 1.

In a Windows environment, this can be done as follows :

Right click Properties - Port Settings - Advanced - Delay Timer (milliseconds) set to 1 (see right for details)

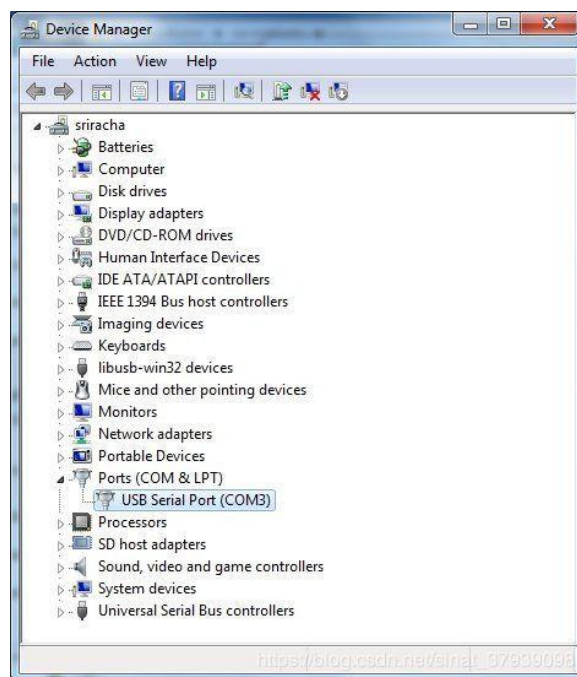
In a Linux environment, this can be done as follows.

```
sudo usermod -aG dialout $USER && echo 1 | sudo tee /sys/bus/usb-serial/devices/ttyUSB0/latency_timer
```

Available at :

```
cat/sys/bus/usb-serial/devices/ttyUSB0/latency_timer
```

if it is 1, then the modification is successful.



Source: https://blog.csdn.net/sinat_37939098/article/details/87915031



5 Product packaging

- | | |
|-----------------------------------|-------------------------------|
| ● KWR46 Series Sensor | 1 pcs |
| ● Data acquisition module | 1 pcs |
| ● KWR46 Series Sensor User Manual | One copy (electronic version) |
| ● Package box | 1 pcs |

6 Contact us

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