



## Strain Gauge - Six Axis Force/Torque Sensor KWR96 Series

# User Manual

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## ■ Introduction

This is the user manual for the strain gauge six-axis force/torque sensor (KWR96 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. KWR96 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                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Rated load</b>  | 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.                                                                                                                                                                                                                           |
| <b>Overload</b>    | The load exceeds the rated load. Failure may occur when the sensor is overloaded.                                                                                                                                                                                                                                                                                                                             |
| <b>Zero output</b> | Output value without load when the mounting section and the ground are horizontal and the mounting section is facing the ground.                                                                                                                                                                                                                                                                              |
| <b>Precision</b>   | 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). |
| <b>Accuracy</b>    | 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

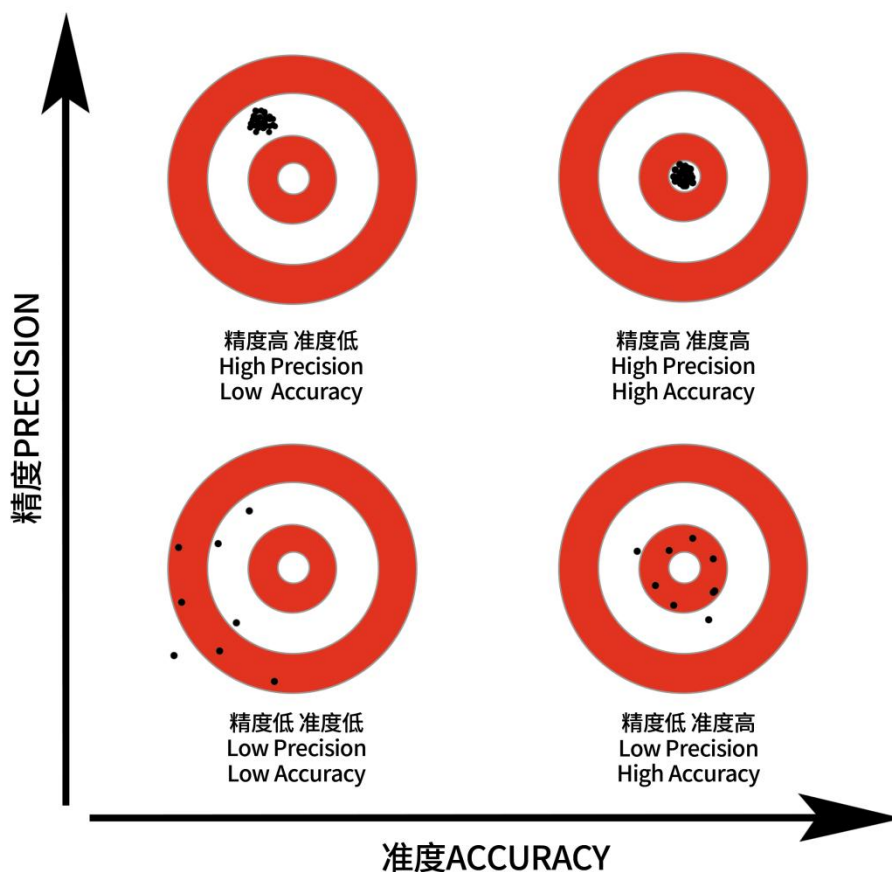


Fig.1 Precision and accuracy schematic diagram



## ■ Brief description of product specifications

| Model  | Rated force (N) |      | Rated torque (Nm) |     | Dimensions (mm)          | Power supply<br>(VDC) |
|--------|-----------------|------|-------------------|-----|--------------------------|-----------------------|
|        | Fx, Fy          | Fz   | Mx, My            | Mz  |                          |                       |
| KWR96A | 100             | 200  | 10                | 10  | $\Phi 96.0 \times H26.0$ | 9~24                  |
| KWR96B | 200             | 400  | 18                | 18  | $\Phi 96.0 \times H26.0$ | 9~24                  |
| KWR96C | 300             | 600  | 24                | 24  | $\Phi 96.0 \times H26.0$ | 9~24                  |
| KWR96D | 400             | 800  | 36                | 36  | $\Phi 96.0 \times H26.0$ | 9~24                  |
| KWR96E | 2000            | 2000 | 100               | 100 | $\Phi 96.0 \times H26.0$ | 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.



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# 1 Product Overview

## 1.1 Product features

The model KWR96 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 the change in the sensor's elastic unit could be measured based on the principle of strain electric measurement. 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.

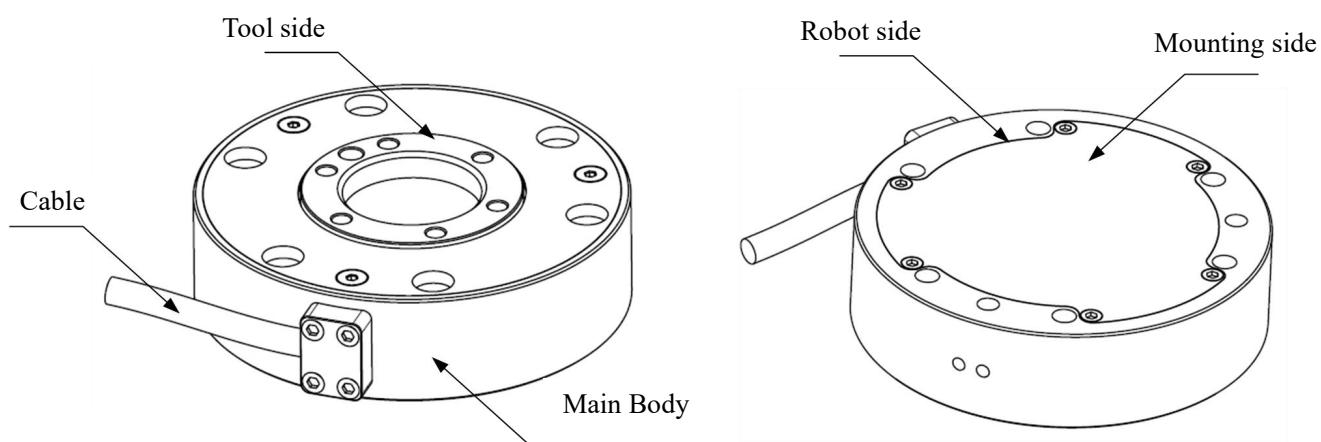


Fig.2 Sensor appearance

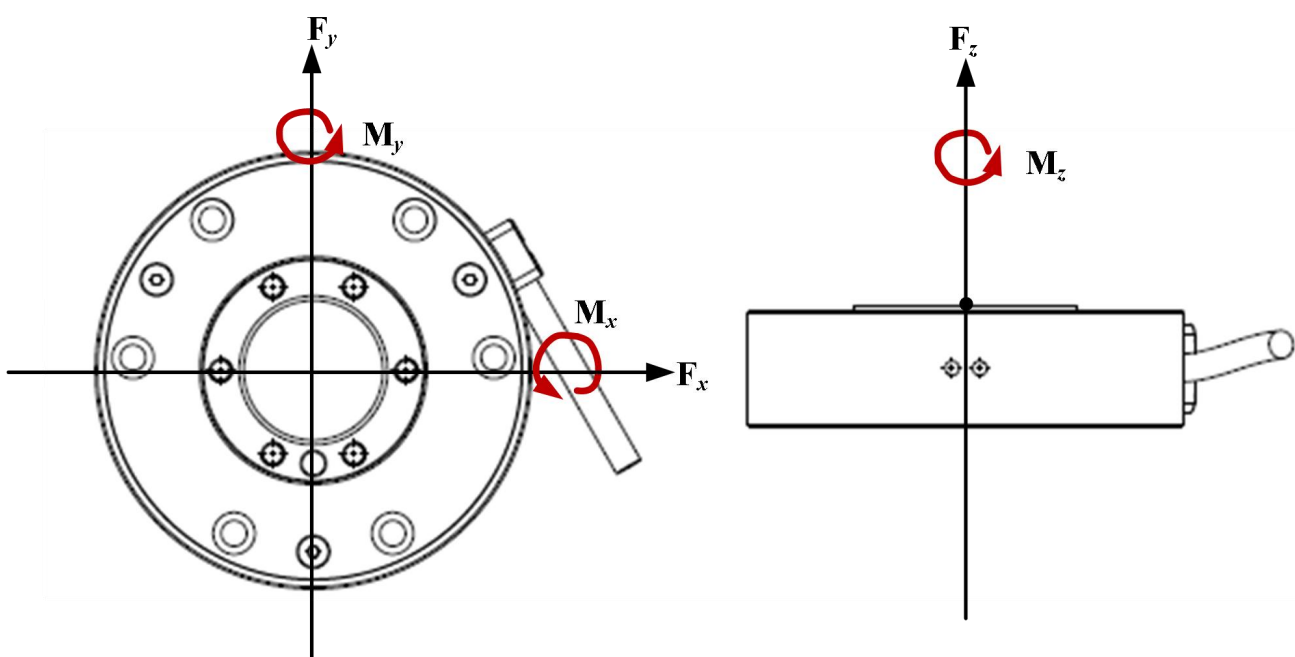


Fig.3 Definition of the sensor coordinate system (the direction of the torque conforms to the right-hand system)



## 1.2 Electrical characteristics

The voltage signal from the strain gauges is processed in real time by the embedded acquisition system, which built in the sensor and converted to the actual load value and output in the form of a digital signal.

## 2 Installation of the sensor

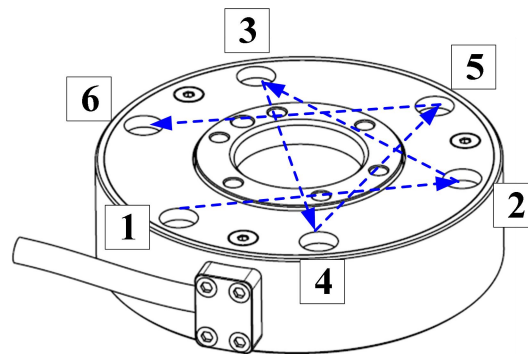
For details of the sensor mounting holes and mounting dimensions see "Section 4.2 Mounting Dimensions".

### 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.4 Screw tightening sequence**

- (1) Check the equipment to be installed, the transfer flange and the sensor

Verify that the equipment to be installed, the transfer flange, 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 flanges) to be installed, which will not guarantee the IP64 performance of the product and will have an effect on the actual sensor output.

- (2) Mount the sensor on the robot device

Adopt six M5 screws to install the sensor on the adapter device or the robot with a matching interface. You need locate the position by  $\Phi 5$  pins firstly, then fix the screws.

\*The 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) Fix the sensor to actuator



Use the pins to position the sensor and the bottom surface of the actuator, and confirm that the sensor is mounted in the same direction as the equipment is used.

Fasten by using the sensor's six built-in screws. The screw tightening sequence is performed in the order of Figure 4.

## 2.2 Connecting cable

The connection cable is delivered with the product.

## 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

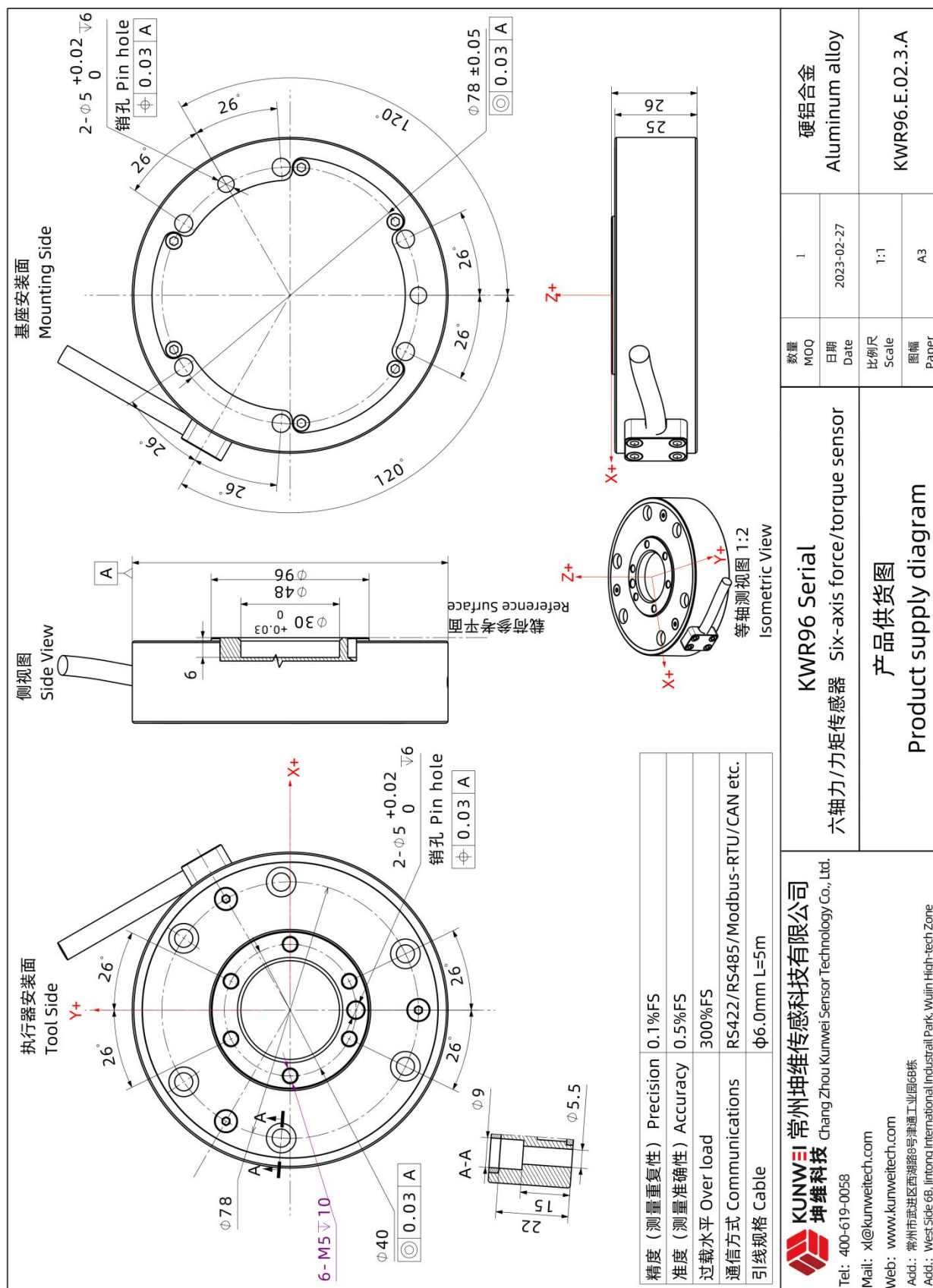
### 4.1 Basic specifications

The KWR96 series six-axis force/torque sensor is a high precision and high response sensor, which equipped with an embedded acquisition system 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                              |      | KWR96A                                            | KWR96B         | KWR96C         | KWR96D         | KWR96E      |
|------------------------------------|------|---------------------------------------------------|----------------|----------------|----------------|-------------|
| <b>F<sub>x</sub>,F<sub>y</sub></b> | (N)  | 100                                               | 200            | 300            | 400            | 2000        |
| <b>F<sub>z</sub></b>               | (N)  | 200                                               | 400            | 600            | 800            | 2000        |
| <b>M<sub>x</sub>,M<sub>y</sub></b> | (Nm) | 10                                                | 18             | 24             | 36             | 100         |
| <b>M<sub>z</sub></b>               | (Nm) | 10                                                | 18             | 24             | 36             | 100         |
| <b>Diameter (mm)</b>               |      | 96                                                | 96             | 96             | 96             | 96          |
| <b>Height (mm)</b>                 |      | 26                                                | 26             | 26             | 26             | 26          |
| <b>Material</b>                    |      | Aluminum Alloy                                    | Aluminum Alloy | Aluminum Alloy | Aluminum Alloy | Alloy Steel |
| <b>Surface treatment</b>           |      | Anodization                                       | Anodization    | Anodization    | Anodization    | /           |
| <b>Overload level (%)</b>          |      | 300                                               | 300            | 300            | 300            | 300         |
| <b>Precision (%FS)</b>             |      | 0.1                                               | 0.1            | 0.1            | 0.1            | 0.5         |
| <b>Accuracy (%FS)</b>              |      | 0.5                                               | 0.5            | 0.5            | 0.5            | 2.0         |
| <b>Sampling resolution (Bit)</b>   |      | 24                                                | 24             | 24             | 24             | 24          |
| <b>Weight (kg)</b>                 |      | 0.3                                               | 0.3            | 0.3            | 0.3            | 1.6         |
| <b>Protection class</b>            |      | IP64                                              | IP64           | IP64           | IP64           | IP64        |
| <b>Operating temperature (°C)</b>  |      | 0 ~ 80                                            | 0 ~ 80         | 0 ~ 80         | 0 ~ 80         | 0 ~ 80      |
| <b>Sampling frequency (kHz)</b>    |      | 1                                                 | 1              | 1              | 1              | 1           |
| <b>Supply voltage (VDC)</b>        |      | 12~48                                             | 12~48          | 12~48          | 12~48          | 12~48       |
| <b>Communication interface</b>     |      | RS422/RS485/ModBUS/CAN/Ethernet/EtherCAT/USB etc. |                |                |                |             |

**\*12~48VDC version product is also available, further information could be acquired from sales.**

## 4.2 Installation dimension drawing





### 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                                                                                                                                              |
|------------------------------|------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Output serial port</b>    | 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. |
| <b>Supply voltage</b>        | 12~48VDC         |                                                                                                                                                      |
| <b>Supply power</b>          | Less than 3W     |                                                                                                                                                      |
| <b>Serial port baud rate</b> | 460800           |                                                                                                                                                      |
| <b>Data bits</b>             | 8                |                                                                                                                                                      |
| <b>Stop bits</b>             | 1                |                                                                                                                                                      |
| <b>Check digit</b>           | 0                |                                                                                                                                                      |

(2) Sensor output data format

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

0x48AAB0751CC19B3FEDC0AE5CF040D4B52DBE5F55993E7C1AB0BB0D0A

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



|                   |                                                                                                         |
|-------------------|---------------------------------------------------------------------------------------------------------|
| <b>0x5F55993E</b> | In Float format it should be 0x3E99555F, which means that the force in the My direction is 0.29948kgm   |
| <b>0x7C1AB0BB</b> | In Float format it should be 0xBBB01A7C, which means that the force in the Mz direction is -0.00537 Kgm |
| <b>00xD0A</b>     | terminator, occupying two bytes                                                                         |

#### 4.4 Input command definitions

| Orders               | Description                                                                                                                                                                                                                                                                                                                                                                                               |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>0x43 AA 0D 0A</b> | Stopping data transmission                                                                                                                                                                                                                                                                                                                                                                                |
| <b>0x48 AA 0D 0A</b> | Convert and send results at the speed of 1KHz, data starts with 0x48                                                                                                                                                                                                                                                                                                                                      |
| <b>0x49 AA 0D 0A</b> | 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 embedded acquisition system for real time data acquisition and processing, which ensures the digital signal is output accurately and effectively.



It is important to check whether the wiring between the sensor and the application is correct, especially if the "Power+" and "Power-" are connected in reserve, the sensor may be damaged..

| Serial number | Core wire colour | Definition                |
|---------------|------------------|---------------------------|
| 1             | Pink -           | Power supply +            |
| 2             | Grey -           | Power supply -            |
| 3             | Yellow-          | 422 Bus sensor receives + |
| 4             | Green -          | 422 Bus sensor receives-  |
| 5             | Brown -          | 422 Bus sensor sends +    |
| 6             | White -          | 422 Bus sensor sends-     |
| 7             | Shielding        |                           |

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.

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.*

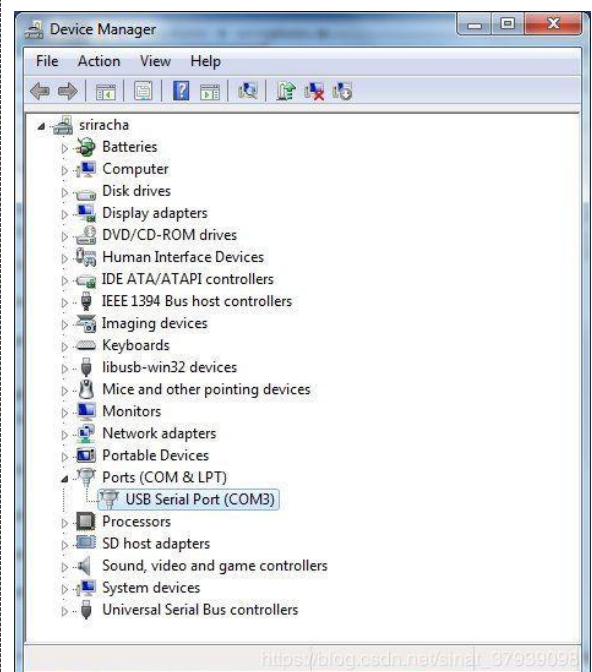
```
sudo usermod -aG dialout $USER && echo 1 | sudo tee
```

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

Available at :

```
/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](https://blog.csdn.net/sinat_37939098/article/details/87915031)



## 5 Product packaging

- |                                   |                               |
|-----------------------------------|-------------------------------|
| ● KWR96 Series Sensor             | 1 pcs                         |
| ● Cable (with plug)               | 1 pcs                         |
| ● KWR96 Series Sensor User Manual | One copy (electronic version) |
| ● Package box                     | 1 pcs                         |

## 6 Contact us

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