# Exercise: Pitch Mechanism

## Product Specifications

The aim of this project is to design and manufacture a prototype for a pitch control mechanism to be fitted to small horizontal axis wind turbine competing in the International Small Wind Turbine Contest (ISWTC) held in the Netherlands in Summer 2022.

International Small Wind Turbine Contest (hanze.nl)

The pitch control mechanism should be able to handle the following loads:

1. Force in the span-wise direction (pulling the blade in the direction of the centrifugal force) = 600 N
2. Wind force on the blade (assumed to be concentrated in the middle of the blade = 130 N
3. Required Pitching Torque = 2.5 Nm

The following **Design Constraints** should be considered:

1. Total length of the blade = 756 mm
2. Maximum Turbine rotor diameter = 1600 m
3. Total swept area = 2 $m^2$
4. The mechanism is connected to the generator via 6 M8 Tap Bolts at PCD = 100 mm, with centering.
5. The blade should be rotated 0-90 Degrees.
6. The whole mechanism should be confined within the turbine nose.
7. The system should be operated by 12 Volt Battery. It can be tested using a power supply.

## General Notes:

1. The manner in which you present your work can be just as important (and in some cases more so) than the work itself. Be sure to clearly explain your designs, the methods used, and the underlying assumptions. Such practices make it possible for us to fairly assess your work and happen also to be good practices for documenting work in industry.
2. The simplicity of the design and the lower cost of manufacturing will be appreciated. These should not jeopardize the quality of the final product.
3. Each group should submit a paper indicating the percentage contribution of each member of the group. The total of the percentages should sum to 100. For the reports with identical contributions, their mark will be reduced by 2. The mark of each member of the group will be determined according to the report mark and his contribution.

## Deadlines

The course competition including the final report and the prototype: The Thursday after 7 days of the final exams.

## Final Report [10 marks]:

At the day of the competition, each group should present the following:

1. Final Construction of the prototype. The drawings should be identical to the manufactured prototype.
2. Working drawings of all parts. The working drawings should match the construction drawing.
3. Final Calculation Sheet for the design.
4. Product Brochure as a marketing tool to your product. The main specifications, important dimensions should be highlighted.

The following parts should be considered:

1. Bracket Calculation
2. Initial Tension on Bracket Bolts
3. Bearings Selection
4. Gears or Power screw
5. Motor Selection

## Testing Procedures [5 marks + Bonus]

After manufacturing and assembly of the mechanism, it will be tested and evaluated according to the following **Testing Procedures**.

1. Step one: Function. The prototype will be fixed on a ground table. The following Criteria will be checked: [80%]
    a. Rigidity and Robustness.
    b. Is able to rotate against the design torque.
    c. Works well with own potentiometer.

    A set of 3 shafts will have the same diameter as the blade base and should be fitted to your mechanism to simulate the blade resisting torque.

2. Step Two: There will be an external input applied to the system to simulate the anemometer voltage. [20%]
    The zero of the blade is the zero level of the straight section in the blade shaft.
    It is easier that each group prints a protractor on a paper and fit it at the base of the rotating mechanism to check the accuracy of the angle.

There are two car batteries available 12 V each.

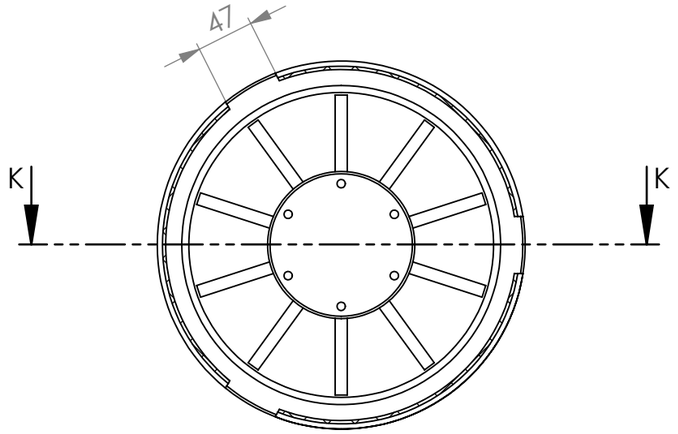
## Year Work Marks Distribution

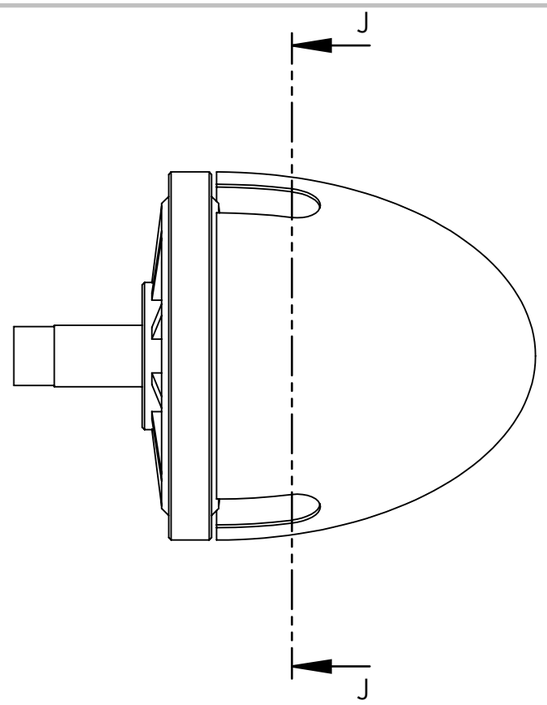
Year work distribution for MDP211 Machine Elements.

| | |
|---|---|
| 20 | MidTerm |
| 5 | Quiz |
| 10 | Sheets |
| 10 | Progress in Lab |
| 10 | Project report (after applying contribution percentage) |
| 5 | Prototype |

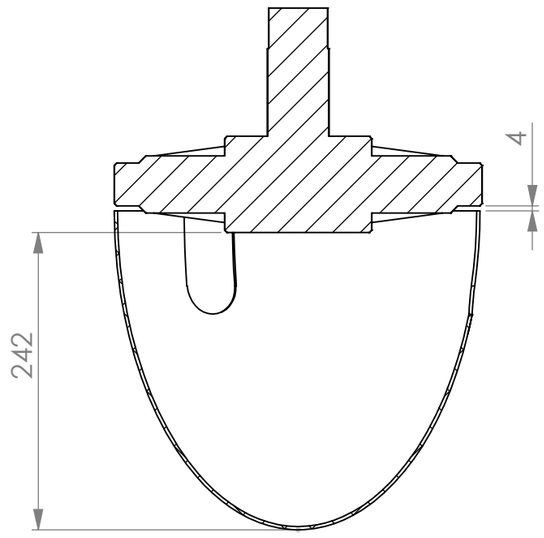
Further Bonus Marks will be offered to the groups which will manufacture the prototype:

- All working projects achieving the goal will get 2 marks bonus.
- The first 5 groups will get bonus marks (5 for 1st place, 4 for 2nd place, 3 for 3rd place, 2 for 4th place, 1 for 5th place).
- Excellent projects and Excellent students will have the possibility to get Full Mark in all Yearwork.



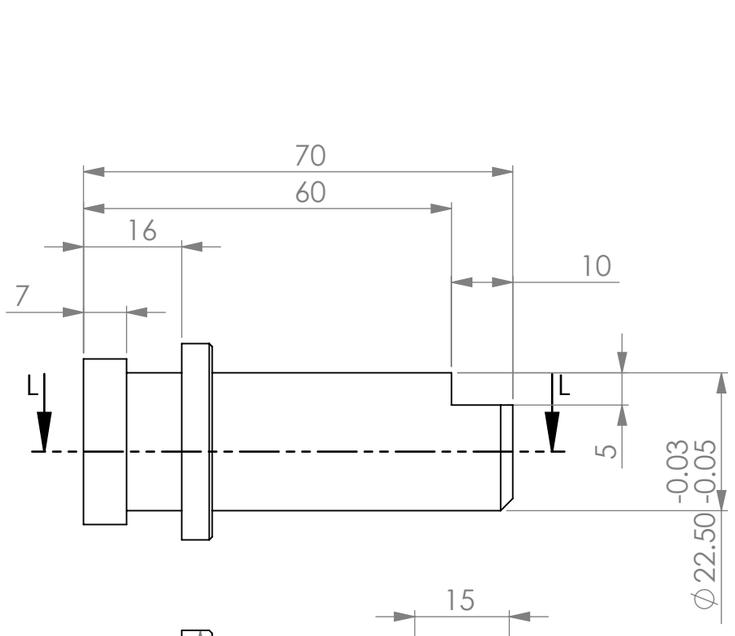



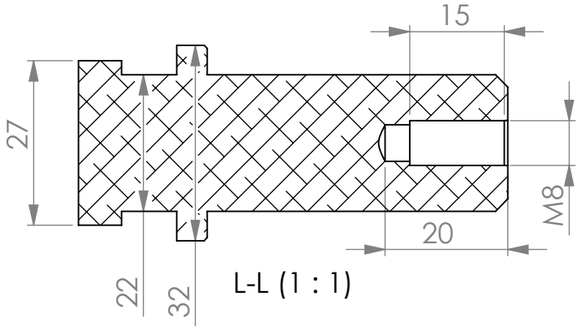

J-J (1 : 5)




K-K (1 : 5)

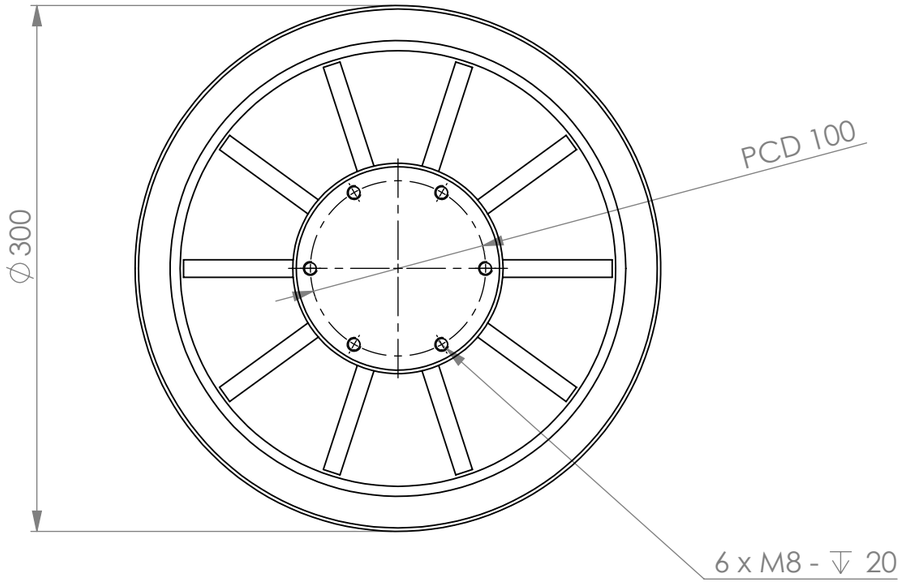
GENERATOR NOSE ASSEMBLY

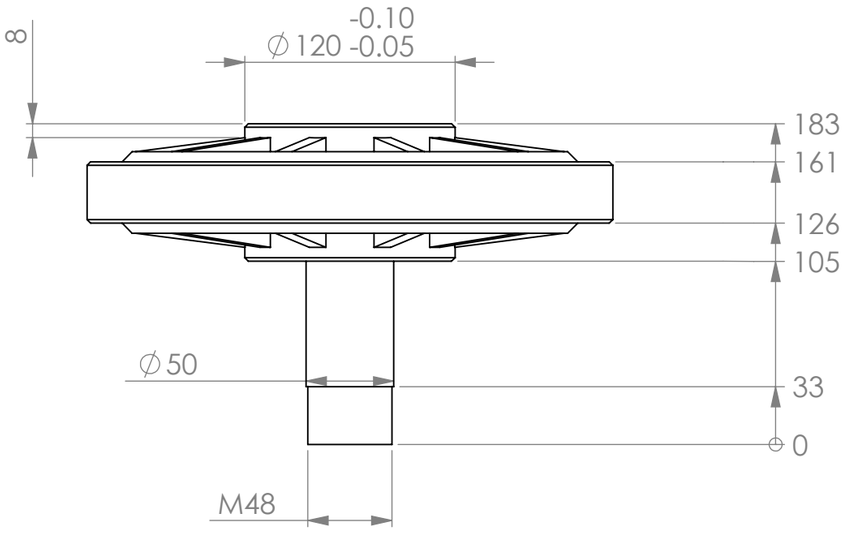



L-L (1 : 1)

WIND TRUBINE BLADE SHAFT




OUTER ROTOR GENERATOR

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| UNLESS OTHERWISE SPECIFIED:<br>DIMENSIONS ARE IN MILLIMETERS<br>SURFACE FINISH:<br>TOLERANCES:<br>LINEAR:<br>ANGULAR: | | FINISH: | | DEBURR AND BREAK SHARP EDGES | | DO NOT SCALE DRAWING | REVISION |
| | NAME | SIGNATURE | DATE | | | TITLE: | |
| DRAWN | | | | | | | |
| CHK'D | | | | | | | |
| APPV'D | | | | | | | |
| MFG | | | | | | | |
| Q.A | | | | MATERIAL: | | DWG NO. Generator-Nose Assembly V2.0 | A3 |
| | | | | | | | |
| | | | | WEIGHT: | | SCALE:1:10 | SHEET 1 OF 1 |

# Wind Speed Sensor Manual

## Model: BGT-FS1

Company name：Beijing Guoxinhuayuan Technology Co., Ltd

Tel：86-10-63205221

Address：Building 306, Guanganmen Street, Xicheng District,Beijing,100053,China

**Please read the instructions carefully before using them and keep them properly.**

Thank you for choosing our products!
Due to the continuous improvement of our products, the products you purchased may differ from the illustrations in this manual without any notice. Please prevail in kind.

## Introduction

The wind speed sensor adopts the traditional three wind cup structure, the wind cup is made of ABS material, and has high strength and small starting wind speed. The cup body built-in signal processing unit can output the corresponding wind speed signal according to the user demand.

It has variety of output method such as RS485/ RS232, pulse, voltage and current, which can be widely used in advertising barrier, meteorology, ocean, environment, airports, ports, laboratories, Industry and agriculture and transportation and other fields.

## Technical Parameters

Measurement range:

☐0～45m/s (Current,voltage output)
☐0～70m/s (Pulse, RS485/RS232 output)

Accuracy：±(0.3+0.03V) m/s (V: real-time wind speed)
Resolution：0.1m/s
Starting wind speed：≤0.5m/s
Power supply mode: ☐DC5V ☐DC9-30V
Output: ☐Pulse: Pulse signal (□NPNR □PNP)
☐Current: 0～20mA
☐Current: 4～20mA
☐Voltage: 0～5V
☐Voltage: 1～5V
☐Voltage: 0～2.5V
☐RS232: (☐ASCII ☐ModBus)
☐RS485: (☐ASCII ☐ModBus)

Cable: ☐Standard: 0.8 m ☐Other
Load capacity:
Current output impedance ≤350Ω (DC12V power supply)
Current output impedance ≤900Ω, Voltage output impedance≥1KΩ. (DC24V power supply)
Operating environment: Temperature -35℃～60℃;
Humidity≤100%RH, No condensation.
Defend grade: IP64
Product weight: 510g
Cable grade: Rated voltage: 300V, 80℃
Maximum power consumption:0.48W

## Calculation formula

1. Pulse mode ( High level: 5V; Low level: 0V):
   F =0; (M= 0)
   F=0.5+0.101*M
   (F: value of wind speed m/s；M：The number of pulses in one second)

2. Current type (Range 45m/s):
   W = (I－4)×45/16
   (W: value of wind speed m/s；I：current type 4-20mA)

3. Voltage type (Range 45m/s):
   W =V/5×45
   (W: Range m/s；V：voltage signal 0-5V)

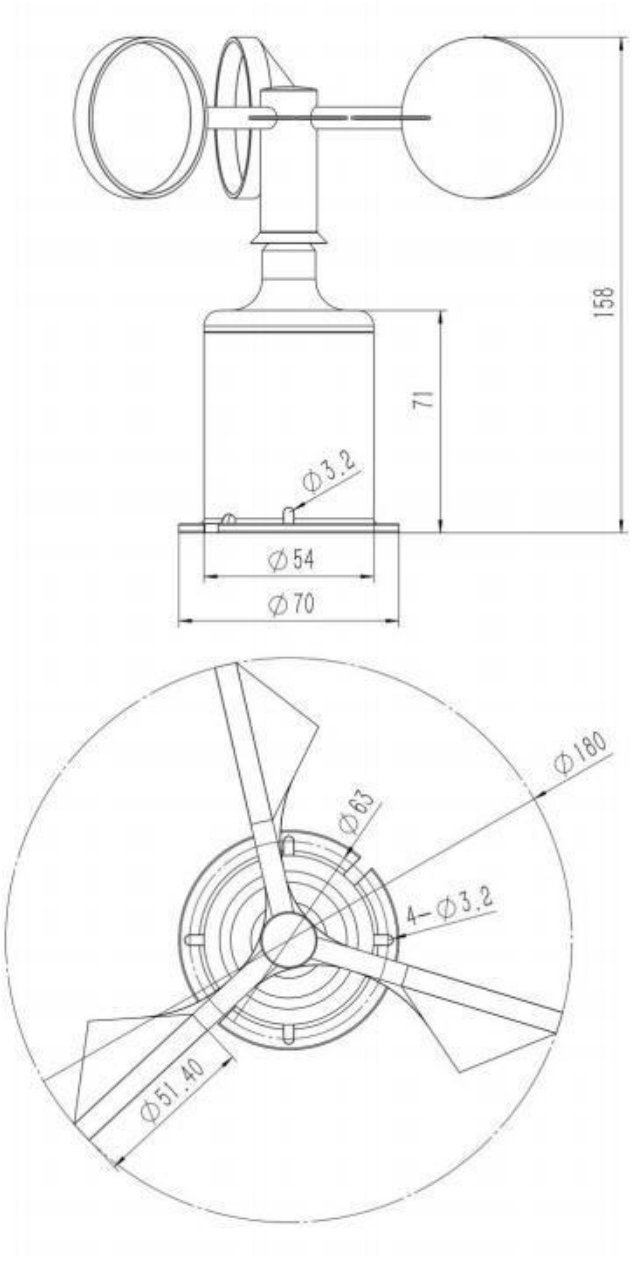
4. Other models of calculation formula:
   W= _____

## Wiring method

(1) If the sensor is equipped with our instrument, directly use the sensor cable to connect the sensor with the corresponding interface on the instrument.
(2) If the sensor is purchased separately, the order of the wires as followed:

| **Cable color** | **Output signal** | | |
|---|---|---|---|
| | **Voltage, current, pulse** | **RS485** | **RS232** |
| Red | VDD | VDD | VDD |
| Black | GND | A+ | Connection equipment RX, computer serial port 2 |
| Yellow | Signal output | B- | Connection equipment TX, computer serial port 3 |
| Green | | GND | GND |

## Structure size




Installation aperture: 3.2mm

Distribution diameter: 63mm

Interface dimension: 15mm (suggest reserving 25mm for wiring, fix sensor after wiring and installing)

## Communication protocol

1. If you are using a single sensor connected to the computer to read data directly, it is recommended to use the ASCII private protocol (see page 4), you can visual display in ASCII (hex send, non-hex receive);

2. If you are multi-sensor connected to the PLC, configuration or access programmable collector, it is recommended to use the Standard ModBus-RTU protocol (see below, hex send and receive).

3. If there is no special requirement, the default address of the device in the sensor parameters is 1, baud rate =9600, and the protocol is ModBus-RTU.

## Standard ModBus-RTU protocol

1. The serial format

8 data bits, 1 stop bit, no parity bit.

Baud rate 9600 bps, serial debugging software set to send and receive hex, the two communication intervals of at least 500ms, the instructions in the CRC for the parity bit, two bytes. The default device address is 1.

2. Communication format

(1) Write device address (eg: write address 01)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Send | 00 | 06 | 00 | 20 | 00 | 01 | 48 | 11 |
| Description | address | write | Start address | | New address | | CRC check | |
| Return | 00 | 06 | 00 | 20 | 00 | 01 | 48 | 11 |
| Description | | write | Start address | | New address | | CRC check | |

If returns 01 86 ****, it indicates that the configuration was not successful.

(2) Read device address (eg: read address 01)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Send | 00 | 03 | 00 | 20 | 00 | 01 | 84 | 11 |
| Description | Address | read | Start address | | Read the number of points | | CRC check | |
| Return | 00 | 03 | 02 | | 00 | | 44 | 44 |
| Description | Address | read | Data length | | Device data | | CRC check | |

(3) Read register data (eg: read address 01)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Send | 01 | 03 | 00 | 00 | 00 | 01 | 84 | 0A |
| Description | Address | Read | Start address | | Read points | | CRC check | |
| Return | 01 | 03 | 02 | | 00 | 26 | 39 | 9E |
| Description | Address | Read | Data bytes | | Device data | | CRC check | |

The sensor returns data 0x0026 converted to decimal 38, indicating a wind speed of 3.8m / s, with a decimal place.

(4) Read device baud rate (eg: read baud rate=9600)

| Send | 01 | 03 | 00 | 10 | 00 | 01 | 85 | CF |
|---|---|---|---|---|---|---|---|---|
| Description | Address | Read | Start address | | Read points | | CRC check | |
| Return | 01 | 03 | 02 | | 00 | 02 | 39 | 85 |
| Description | Address | Read | Data length | | Device data | | CRC check | |

Baud rate = data *4800. Return data ***00 02***, then baud rate =4800*2=9600.

(5) Write device communication baud rate (For example: write baud rate of 9600.)

| Send | 01 | 06 | 00 | 10 | 00 | 02 | 09 | CE |
|---|---|---|---|---|---|---|---|---|
| Description | Address | write | Start address | | New baud rate | | CRC check | |
| Return | 01 | 06 | 00 | 10 | 00 | 02 | 09 | CE |
| Description | Address | write | Start address | | New baud rate | | CRC check | |

Baud rate = data *4800. Return data ***00 02***, then baud rate =4800*2=9600. The supported baud rates are 4800, 9600, 14400, 19200, 38400, 57600, 115200. If other unsupported baud rates are written, they will be automatically restored to 9600 after restart.

If returns 01 86 ****, it indicates that the configuration was not successful.

(6) Change communication protocol (for example, switching to ASCII protocol)

| Send | 01 | 06 | 00 | 14 | 00 | 03 | 89 | CF |
|---|---|---|---|---|---|---|---|---|
| Description | Address | | Start address | | 01-MODBUS 03-ASCII | | CRC check | |
| Return | 01 | 06 | 00 | 14 | 00 | 03 | 89 | CF |
| Description | Address | | Start address | | Data | | CRC check | |

If returns 01 86 ****, it indicates that the configuration was not successful.

Change the protocol from 01-MODBUS to 03-ASCII.

## ASCII private protocol

1. The serial format

Data bit 8, stop bit 1, parity bit none. Baud rate 9600bps, two communication intervals at least 1000ms above.

2. Communication format

(1) Write device address (eg write address 01)

| Send | AA | 00 | 10 | 00 | 01 |
|---|---|---|---|---|---|
| Description | Start | Broadcast address | Write | Write | New address |
| Return | OK | | | | |
| Description | Write new address successfully | | | | |

(2) Read device address

| Send | AA | 00 | 03 | 00 | 00 |
|---|---|---|---|---|---|
| Description | Start | Broadcast address | Read | Read address | |
| Return | Address=001 | | | | |
| Description | Address read: 1 | | | | |

(3) Read real-time data

| Send | AA | 01 | 03 | 0F | 00 |
|---|---|---|---|---|---|
| Description | Start | Device address | Read | Read data | |
| Return | WS=05.1m/s | | | | |
| Description | Return wind speed 5.1 m/s | | | | |

(4 ) Change communication protocol (for example, switching to MODBUS protocol)

| Send | AA | 01 | 10 | 01 | 01 |
|---|---|---|---|---|---|
| Description | Start | address | Write | Write protocol | 01-MODBUS 03-ASCII |
| Return | OK | | | | |
| Description | The new protocol was written successfully | | | | |

Change the protocol from 03-ASCII to 01-MODBUS.

In the above description, the transition characters such as spaces are ignored. Serial software (such as SSCOM3.3) check HEX sent, do not check the HEX display, After the device is powered on, it will return start.

## ModBus CRC check steps

1. Preset 16-bit register hexadecimal FFFF, said the register for the CRC register;
2. The first 8-bit data and CRC register low or XOR, the result placed in the CRC register;
3. The contents of the register to the right one (toward the low), with 0 to fill the most significant bit, check the lowest bit;
4. If the least significant bit is 0: Repeat step 3 (shift again) If the least significant bit is 1: The CRC register is XOR'ed with the polynomial A001 (1010 0000 0000 0001)
5. Repeat steps 3 and 4 until 8 shifts to the right so that the entire 8-bit data is completely processed;
6. Repeat step 2 to step 5 for the next 8-bit data processing;

7. The resulting CRC register is the CRC code (the resulting CRC code is low after high).

## Precautions

1. Please check the packaging is intact, and check the product model is consistent with the selection;
2. Do not live wiring, check the wiring is completed after the correct power;
3. Sensor length will affect the product output signal, do not use when changing products, if there is a need to change, please contact with the manufacturer;
4. Sensor is a precision device, the user when in use, please do not disassemble, with sharp objects or corrosive liquid contact with the sensor surface, so as not to damage the product;

## Troubleshooting

1. Blade is not rotating, large hysteresis. Due to long-term use of foreign bodies or stuck within the bearing. Please send the sensor back to the company for processing;
2. Analog signal or RS232, RS485 output instrument display value is not correct. May not be able to get the correct data due to wiring problems or communication serial port failure. Please check the wiring is correct, solid, serial port is occupied, the serial port settings are correct;
3.If not for the above reasons, please contact the manufacturer.

## Selection table

| Model | Power | Output | Description |
|---|---|---|---|
| BGT-FS1 | | | Wind speed sensor |
| | 5V | | 5V |
| | KV | | 9-30V |
| | | V | 0-5V |
| | | V1 | 1-5V |
| | | V2 | 0-2.5V |
| | | A1 | 4-20mA |
| | | A2 | 0-20mA |
| | | W1 | RS232 ModBus / ACSII |
| | | W2 | RS485 ModBus / ACSII |
| | | M | Pulse(NPNR, PNP ) |