WT901BLECL Attitude Angle Sensor SPECIFICATION

Model ：WT901BLECL

Description: 10-axis Bluetooth 4.0 attitude angle sensor with battery

Production Standard

Enterprise quality system standard: ISO9001:2016

Tilt switch production standard：GB/T191SJ 20873-2016

Criterion of detection：GB/T191SJ 20873-2016

Revision date：2018.06.20

Version	Update content	Author	Date
V1.0	Release	Sharlene	20180620

Catalog

1 Description

◆ Module integrates high-precision gyroscopes, accelerometer, mpu9250 geomagnetic sensor, high-performance microprocessors and advanced dynamics solves dynamic Kalman filter algorithm to quickly solve the current real-time movement of the module attitude .

◆ The use of advanced digital filtering technology, can effectively reduce the measurement noise and improve measurement accuracy.

◆ Integrates gesture solver, with dynamic Kalman filter algorithm, can get the accurate attitude in dynamic environment, attitude measurement precision is up to 0.05 degrees with high stability, performance is even better than some professional Inclinometer!

◆ Integrate voltage stabilization circuit, working voltage is 3.3v ~ 5v, pin level compatible 3.3V and 5V embedded system .

◆ High-performance cortex-M0 core processor runs at up to 48MHz, taking into account low power consumption and high performance.

◆ BLE4.0 wireless transmission, transmission stability, distance greater than 10 meters.

◆ Low power consumption, long standby time, self-contained battery.

2 Product Size

3 Features

1、Voltage：3.3V~5V

2、Consumption current：<16mA (normal)　Standby current：<0.1mA

3、Volume：51.3mm X 36mm X 15mm

4、Measuring dimensions:
  Acceleration: X Y Z
  Angular velocity: X Y Z
  Attitude angle:X Y Z
  Magnetic field：X Y Z
  Atmospheric pressure:YES

6、Range: Acceleration: ± 16g, Angular velocity: ± 2000 ° / s,Angle:X Z ±180° Y ±90°

7、Stability: Acceleration: 0.01g,　Angular speed 0.05° / s.

8、Attitude measurement stable:X Y　0.05°　Z :1°

9、Data output: Acceleration, Angular velocity, Angle,Magnetic field, Pressure,Height, Port status

10、　The data output frequency: 0.1Hz ~50Hz (10Hz default)

11、Data Interface: UART(TTL , Baud rate 115200)

12、Expansion port function：　Analog input（0~VCC, Digital input, Digital output)

13、Bluetooth transmission distance：>10m

14、BLE4.0：Support Android /IOS

4 Axial Diron

As shown in the figure above, the coordinates of the module are indicated, and the upper is the X-axis, the left is Y axis, the Z axis is perpendicular to the surface of the paper to yourself. The direction of rotation is defined by the right hand rule. that is, the thumb of the right hand is pointed to the axial direction, and the four is the direction of the bending of the right hand.

5 Method

5.1 Connect App

1.Connect USB-micro data line (Ignore when the battery is powered)

2、Turn on the phone APP, click “scan” and then search the Bluetooth which is called WT901BLE.

3、Click the Bluetooth and then you can get the data.

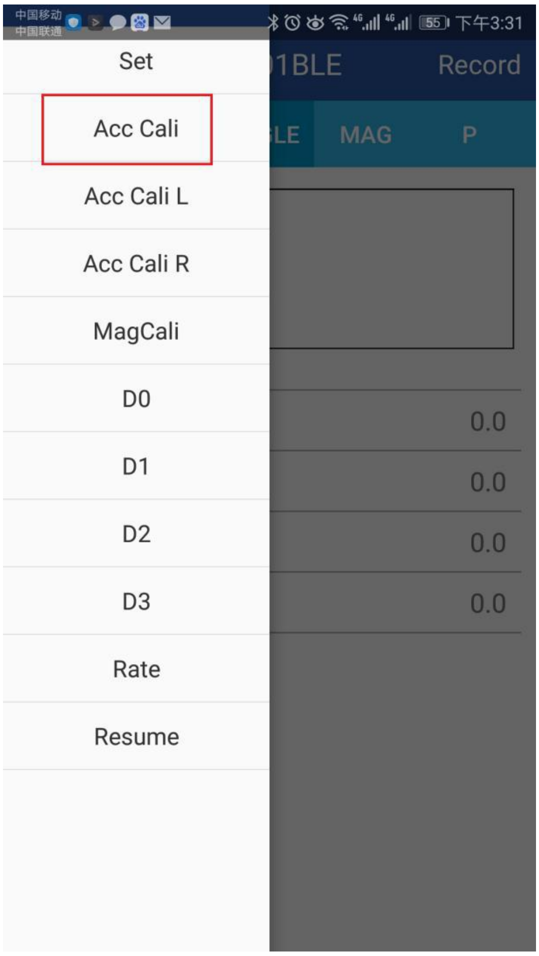
5.2Module Calibration

The module need to be calibrated before the module is used. The calibration of WT901BLECL includes accelerometer calibration and magnetic calibration.

5.2.1Accelerometer Calibration

The accelerometer calibration is used to remove the zero bias of the accelerometer. When the sensor is out of the factory, there will be different degrees of bias error. After manual calibration, the measurement will be accurate.

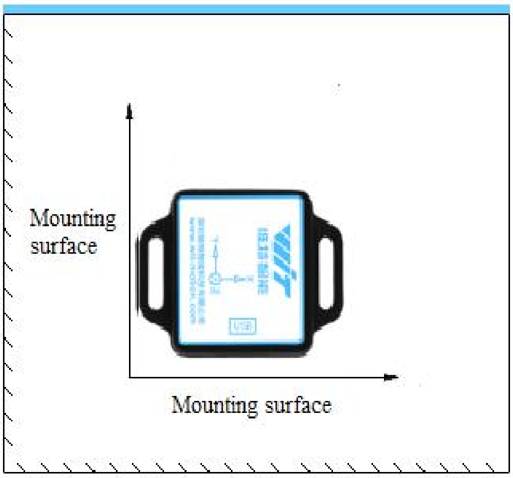
1、Methods as below: Firstly keep the module horizontally stationary, click “Acceleration”, after 1~2s the acceleration X Y Z value will at 0 0 1. X Y angle: 0° . After calibration the value will be accurate.

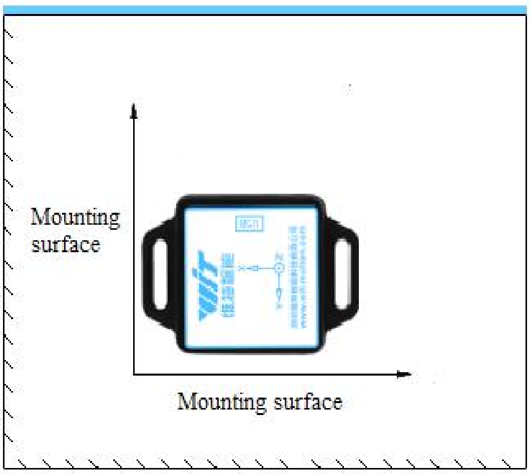


2、Accelerometer Calibration L, Accelerometer Calibration R

In the case that the surface is not very flat, and the data is still in error after the calibration, the calibration L and R can be used for re-calibration. Methods as below:

The module is still at left, click on the calibration L, 2S after and then put the module to the right and click on the calibration R, so that the X Y-axis angle is accurate when used after two calibrations.





Accelerometer Calibration L　　　　　　Accelerometer Calibration R

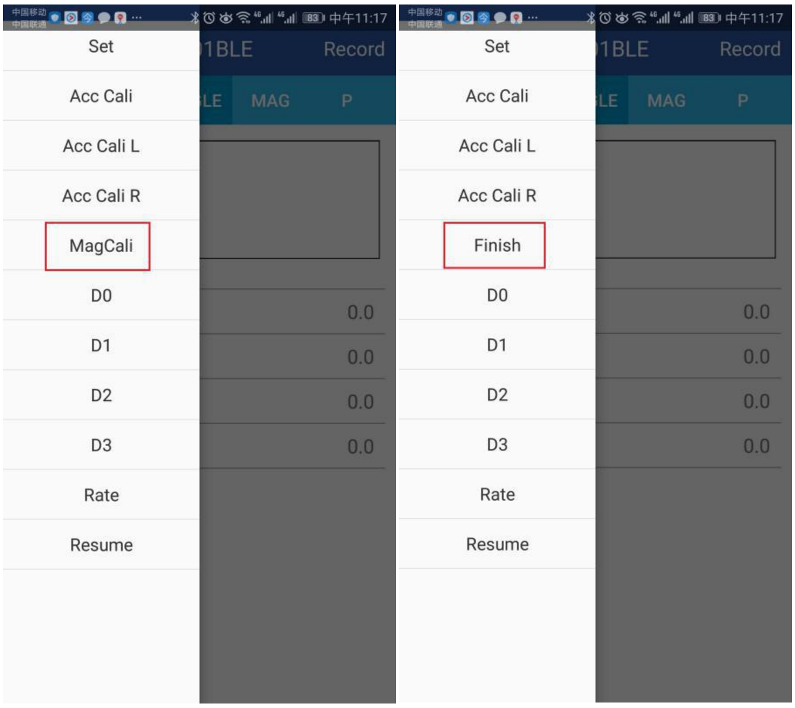
5.2.2 Magnetic Calibration

Magnetic field calibration is used to remove the magnetic field sensor's zero offset. Usually, the magnetic field sensor will have a large zero error when it is manufactured. If it is not calibrated, it will bring about a large measurement error and affect the accuracy of the Z-axis angle measurement of the heading angle.

Calibration methods as follow:

1. When calibrating, first connect the module and the computer, and place the module in a place far away from the disturbing magnetic field (ie, more than 20 CM away from magnets and iron, etc.), and then open the upper computer software.

2. Click the “Magnetic Field Calibration”and rotate 360° around the X axis of the module (you can rotate around the Y axis or the Z axis first). Rotate a few turns, then turn 360° around the Y axis. Then turn 360° around the Z axis, then turn a few turns at random, then click the “Finish” to complete the calibration.



Note: The data displayed on the APP will not change when the calibration is completed. After the calibration is completed, the data will continue to be transmitted back. When the calibration is added, the module should be stationary. When the magnetic field is calibrated and used, it must be kept away from the magnetic field interference.

5.2.3 Calibration by Instruction

1.Instruct Accelerometer Calibration:

First keep the module horizontal and still, send the instruction: FF AA 01 01 00, after

1~2s the acceleration X Y Z value will at 0 0 1. X Y angle: 0°. After calibration the value will be accurate.

2. Accelerometer Calibration L/R:

Keep the module is still at left, send the instruction L: FF AA 01 05 00

After 2s, turn the module to the right side and send the instruction R: FF AA 01 06 00

Calibrate two times the data will be accurate.

3. Instruct Magnetic Calibration:

When calibrating, place the module in a place far away from the disturbing magnetic field (ie, more than 20 CM away from magnets and iron, etc.). Send the instruction: FF AA 01 07 00

Rotate 360° around the X axis of the module (you can rotate around the Y axis or the Z axis first). Rotate a few turns, then turn 360° around the Y axis. Then turn 360° around the Z axis, then turn a few turns at random, then click the "Finish" to complete the calibration.

Send the instruction: FF AA 01 00 00 to finish the calibration.

Send the instruction: FF AA 00 00 00 to save the Configuration.

5.3 Restore Factory Setting

Method: After connecting the WT901BLECL and APP via Bluetooth, click the "Resume" .Reconnect the module after recovery.

5.4 Sleep/ Wake up

Enter the sleep mode right two methods. One is to disconnect the Bluetooth connection directly, and the module will go directly to sleep mode. The other is to send a serial port command, the instruction content is 5 hexadecimal data: 0xff 0xaa 0x67 0x01 0x00

There are two ways to wake up the module. One is to directly search for and connect to Bluetooth. The module will wake up automatically and start working. The other is wake-up from the serial port. Any serial port command can be sent to wake up the module.

6 Communication Protocol

6.1 Module to APP

Module upload Flag=0x61 (Angle,Angular velocity, Acceleration) data default.
Flag=0x71(Magnetic field, Air pressure and altitude, Port status) need to send the corresponding register instruction.
Bluetooth upload data: Bluetooth uploads up to 20 bytes per data.

6.1.1 Acceleration, Angular velocity, Angle, Data pack(default)

Packet header 1Byte	Flag bit 1Byte	axL	axH	…….	YawL	YawH
0x55	Flag	0xNN	0xNN	…….	0xNN	0xNN

Note: 0xNN is a accurate value you received. Data return sequence: Acceleration X Y Z Angular velocity X Y Z Angle X Y Z , low byte first, high byte last.
Flag = 0x61 Data content: 18Byte is Acceleration, Angular velocity, Angle.

0x55	Packet header
0x61	Flag bit
axL	X Acceleration low 8 byte
axH	X Acceleration high 8 byte
ayL	Y Acceleration low 8 byte
ayH	Y Acceleration high 8 byte
azL	Z Acceleration low 8 byte
azH	Z Acceleration high 8 byte
wxL	X Angular velocity low 8 byte
wxH	X Angular velocity high 8 byte
wyL	Y Angular velocity low 8 byte
wyH	Y Angular velocity high 8 byte
wzL	Z Angular velocity low 8 byte
wzH	Z Angular velocity high 8 byte
RollL	X Angle low 8 byte
RollH	X Angle high 8 byte
PitchL	Y Angle low 8 byte
PitchH	Y Angle high 8 byte
YawL	Z Angle low 8 byte
YawH	Z Angle high 8 byte

Acceleration calculation method: Unit: g

a_x=((axH<<8)|axL)/32768*16g(g is Gravity acceleration, 9.8m/s^2)

a_y=((ayH<<8)|ayL)/32768*16g(g is Gravity acceleration, 9.8m/s^2)

a_z=((azH<<8)|azL)/32768*16g(g is Gravity acceleration, 9.8m/s^2)

Calculation method: Unit: °/s

w_x=((wxH<<8)|wxL)/32768*2000(°/s)

w_y=((wyH<<8)|wyL)/32768*2000(°/s)

w_z=((wzH<<8)|wzL)/32768*2000(°/s)

Calculation method: Unit: °

Roll（x axis）Roll=((RollH<<8)|RollL)/32768*180(°)

Pitch（y axis）Pitch=((PitchH<<8)|PitchL)/32768*180(°)

Yaw angle（z axis）Yaw=((YawH<<8)|YawL)/32768*180(°)

Note:

1. Attitude angle use the coordinate system for the Northeast sky coordinate system, the X axis is East,the Y axis is North, Z axis toward sky. Euler coordinate system rotation sequence defined attitude is z-y-x, first rotates around the Z axis. Then, around the Y axis, and then around the X axis.
2. In fact, the rotation sequence is Z-Y-X, the range of pitch angle (Y axis) is only ±90 degrees, when the pitch angle (Y axis) is bigger than 90 degrees and the pitch angle (Y axis) will become less than 90 degrees. At the same time, the Roll Angle(X axis) will become larger than 180 degree. Please search on Google about more information of Euler angle and attitude information.
3. Since the three axis are coupled, the angle will be independent only when the angle is small. It will be dependent of the three angle when the angle is large when the attitude angle change, such as when the X axis close to 90 degrees, even if the attitude angle around the X axis, Y axis angle will have a big change, which is the inherent characteristics of the Euler angle.

Explanation:

1. The data is sent in hexadecimal format, not ASCII code.

2. Each data is transmitted in descending order of high byte and high byte, and the two are combined into one signed short type of data.

X axis acceleration data Ax: AxL is low byte, AxH is high byte, conversion method as below:

Presume Data is a real data, DataH is high byte, DataL is low byte, so: Data=((short)DataH<<8)|DataL. Please note that DataH need to transform a signed short type of data and then shift. The Data type has a signed short type, so that it display negative number.

6.1.2 Single Return Register Data Packet

Single Return Data Packet need to send register instruction first:

FF AA 27 XX 00

--XX is register number. The register number please refer to 7.3. Example as below:

Function	Instruction
Read magnetic field	FF AA 27 3A 00
Read air pressure and altitude	FF AA 27 45 00
Read port status	FF AA 27 41 00
Read quaternion	FF AA 27 51 00
Read temperature	FF AA 27 40 00

After send instruction, the module turn back a data packet 0x55 0x71. There are register address and 7 registers data (Fixed upload 8 registers). Return data format as below:

Start register(2 byte) + register data(16 byte, 8 registers)

Packet header	Sign	Start register low byte	Start register high byte	Start(No.1) register data low byte	Start(No.1) register data high byte	......	No.8 register data low byte	No.8 register data high byte
0x55	0x71	RegL	RegH	0xNN	0xNN	......	0xNN	0xNN

Note: 0xNN is a accurate value, low byte first, high byte last.

1. Magnetic field output

0x71	0x3A	0x00	HxL	HxH	HyL	HyH	HzL	HzH	......

Calculated formular：Unit: mG

Magnetic field（x axis）Hx=((HxH<<8)| HxL)

Magnetic field（y axis）Hy=((HyH <<8)| HyL)

Magnetic field（z axis）Hz =((HzH<<8)| HzL)

EX: Send instruction to read magnetic field in APP: FF AA 27 3A 00 (Please refer to 7.2.8) The module return data to APP: 55 71 3A 00 68 01 69 00 7A 00 00 00 00 00 00 00 00 00 00 00 Total: 20 bytes.

Calculate the no.5 to no.10 bytes as described above, magnetic field x=360，y=105,z=122

2. Air pressure and altitude output

0x55	0x71	0x45	0x00	P0	P1	P2	P3	H0	H1	H2	H3	......

Calculated formular：

Air pressure P = ((P3<<24)| (P2<<16)| (P1<<8)| P0 （Pa）

Atitude output H = ((H3<<24)| (H2<<16)| (H1<<8)| H0 （cm）

EX: Send instruction to read Air pressure and altitude data in APP: FF AA 27 45 00 (Please refer to 7.2.8) The module return data to APP: 55 71 45 00 E2 88 01 00 56 18 00 00 00 00 00 00 00 00 00 00 Total: 20 bytes.

Calculate the no.5 to no.12 bytes as described above, p=100578 pa,H=6230 cm

3. Port status data output

0x55	0x71	0x41	0x00	D0L	D0H	D1L	D1H	D2L	D2H	D3L	D3H	......

Calculated formular：

D0 = (D0H<<8)| D0L

D1 = (D1H<<8)| D1L

D2 = (D2H<<8)| D2L

D3 = (D3H<<8)| D3L

Explanation:

When the port mode is set to analog input, the port status data represents the analog voltage. The actual voltage is calculated according to the following formula:

$U=DxStatus/1024*U_{vcc}$

U_{vcc} is chip supply voltage, there is LDO in it, If the module supply voltage > 3.5V, U_{vcc} is 3.3V. If the module supply voltage <3.5V, U_{vcc}=voltage-0.2V.

When the port mode is set to digital input, the port status data indicates the digital level status of the port, with a high level of 1 and a low level of 0.

The port status data is 1 when the port mode is set to high output mode.
The port status data bit is 0 when the port mode is set to low output mode.
4, Quaternion output

0x55	0x71	0x51	0x00	Q0L	Q0H	Q1L	Q1H	Q2L	Q2H	Q3L	Q3H	......

Calculated formular：

Q0=((Q0H<<8)|Q0L)/32768
Q1=((Q1H<<8)|Q1L)/32768
Q2=((Q2H<<8)|Q2L)/32768
Q3=((Q3H<<8)|Q3L)/32768
Checksum：
Sum=0x55+0x59+Q0L+Q0H+Q1L +Q1H +Q2L+Q2H+Q3L+Q3H

4. Temperature output

0x55	0x71	0x40	0x00	TL	TH	......

Calculated formular：

T=((TH<<8)|TL) /100 ℃

6.2 APP to Module

Send instruction:

6.2.1 Read register value

FF AA 27 XX 00	Read register value

--XX is register.

EX: Read magnetic field：FF AA 27 3A 00
Read air pressure and altitude：FF AA 27 45 00
Read port status：FF AA 27 41 00
Read quaternion：FF AA 27 51 00
Read temperature：FF AA 27 40 00

After send instruction, the module turn back a data packet 0x55 0x71. There are register address and 7 registers data (Fixed upload 8 registers). Return data format please refer to 7.1.2.

6.2.2 Accelerometer Calibration and Magnetic Calibration

FF AA 01 01 00	Accelerometer Calibration
FF AA 01 05 00	Accelerometer Calibration L
FF AA 01 06 00	Accelerometer Calibration R
FF AA 01 07 00	Magnetic Calibration
FF AA 01 00 00	Magnetic Calibration Finish

6.2.3 Save Settings

FF AA 00 SAVE 00	Save Settings

SAVE：Set

0：Save current configuration

1：Restore default configuration and save

6.2.4 Set Return Rate

FF AA 03 RATE 00	Set return rate

RATE：return rate

0x01：0.1Hz

0x02：0.5Hz

0x03：1Hz

0x04：2Hz

0x05：5Hz

0x06：10Hz（default）

0x07：20Hz

0x08：50Hz

0x09：100Hz

6.2.5 Set Port D0

FF AA 0E D0MODE 00	Set port D0

D0MODE：D0

0x00：Analog input（default）

0x01：Digital input

0x02：Output digital high level

0x03：Output digital low level

6.2.6 Set Port D1

FF AA 0F D1MODE 00	Set port D1

D1MODE：D1

0x00：Analog input（default）

0x01：Digital input

0x02：Output digital high level

0x03：Output digital low level

6.2.7 Set Port D2

FF AA 10 D2MODE 00	Set port D2

D2MODE：D2

0x00：Analog input（default）

0x01：Digital input

0x02：Output digital high level

0x03：Output digital low level

6.2.8 Set Port D3

FF AA 11 D3MODE 00	Set port D3

D3MODE：D3

0x00：Analog input（default）

0x01：Digital input

0x02：Output digital high level

0x03：Output digital low level

Note: After the above settings are completed, you must send a save command to save.

6.3 Register address

Address	Symbol	Mean
0x00	SAVE	Save current configuration
0x01	CALSW	Calibration
0x02	KEEP	
0x03	RATE	Return rate
0x04	BAUD	UART Baud rate
0x05	AXOFFSET	X Acceleration zero offset
0x06	AYOFFSET	Y Acceleration zero offset
0x07	AZOFFSET	Z Acceleration zero offset
0x08	GXOFFSET	X Angular velocity zero offset
0x09	GYOFFSET	Y Angular velocity zero offset
0x0a	GZOFFSET	Z Angular velocity zero offset
0x0b	HXOFFSET	X Magnetic field zero offset
0x0c	HYOFFSET	Y Magnetic field zero offset
0x0d	HZOFFSET	Z Magnetic field zero offset
0x0e	D0MODE	D0
0x0f	D1MODE	D1
0x10	D2MODE	D2
0x11	D3MODE	D3
0x12	KEEP	

0x13	KEEP	
0x14	KEEP	
0x15	KEEP	
0x16	KEEP	
0x17	KEEP	
0x18	KEEP	
0x19	KEEP	
0x1a	KEEP	
0x1b	KEEP	
……	……	……
0x30	YYMM	Year, Month
0x31	DDHH	Date, Hour
0x32	MMSS	Minute, Second
0x33	MS	Millisecond
0x34	AX	X Acceleration
0x35	AY	Y Acceleration
0x36	AZ	Z Acceleration
0x37	GX	X Angular velocity
0x38	GY	Y Angular velocity
0x39	GZ	Z Angular velocity
0x3a	HX	X Magnetic field
0x3b	HY	Y Magnetic field
0x3c	HZ	Z Magnetic field
0x3d	Roll	X Angle
0x3e	Pitch	Y Angle
0x3f	Yaw	Z Angle
0x40	TEMP	Module temperature
0x41	D0Status	D0 Status
0x42	D1Status	D1 Status
0x43	D2Status	D2 Status
0x44	D3Status	D3 Status
0x45	PressureL	Pressure low byte
0x46	PressureH	Pressure high byte
0x47	HeightL	Height low byte
0x48	HeightH	Height high byte
0x49	KEEP	
0x4a	KEEP	
0x4b	KEEP	
0x4c	KEEP	
0x4d	KEEP	
0x4e	KEEP	
0x4f	KEEP	
0x50	KEEP	

0x51	Q0	Quaternion Q0
0x52	Q1	Quaternion Q1
0x53	Q2	Quaternion Q2
0x54	Q3	Quaternion Q3

7 Application Area

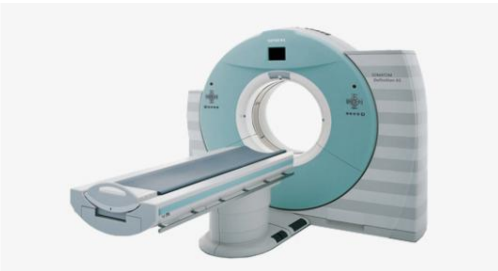
Agricultural machinery

Internet of things

Solar energy

Power monitoring

Medical instruments



Construction machinery

Geological monitoring

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