RK300-10 Visibility Sensor

User Manual

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About this manual

This manual is a general information source as well as a detailed operational guide to the RK300-10 visibility sensor.

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About visibility

Visibility is the term commonly used to express how far a person can see. But the question is actually quite complicated due to the complex psychological and physical nature of the measurement. As reported by the World Meteorological Organization (WMO), “any visual estimate of visibility is subjective.” Visibility, better known as meteorological optical range (MOR), is the greatest distance that a large dark object can be seen and recognized against a light sky background. Questions often arise as to the size and color of the object or target. The object must be large (subtend an angle of >0.5 degrees). Depending on the distance from the observer, a white church steeple that is 4 feet wide and 1000 feet away is an unacceptable target since it only subtends an angle of 0.2 degrees and is the wrong color. A light pole that is only 1 foot in diameter is an even worse choice as a target! Some of the other factors that affect a humans ability to measure visibility are the ambient light level, the persons corrected vision, and the training of that person to be a qualified weather observer. Even with all these factors equal between two trained observers, they will not agree in their assessment of the visibility.Our ability to “see” a long distance is altered by what are known as obstructions to vision. These obstructions fall into two classes, hydrometeors that are wet and lithometeors that are dry. Examples of hydrometeors include rain, snow, fog, mist, drizzle, and spray. Examples of lithometeors include salt, pollen, smoke, and dust.

Safety

RK300-10 visibility sensor emits invisible light, comply to international standard IEC/EN 60825-1, and classified as Class 1 laser device. It means under any reasonably predictable operating conditions, RK300-10 is safe for eyes.

ESD Protection

Electrostatic Discharge (ESD) can cause immediate or latent damage to electronic circuits. Our company products are adequately protected against ESD for their intended use. However, it is possible to damage the product by delivering electrostatic discharges when touching, removing, or inserting any objects inside the equipment housing. To make sure you are not delivering high static voltages yourself, take the following precautions:

- Handle ESD sensitive components on a properly grounded and protected ESD workbench. When this is not possible, ground yourself to the equipment chassis before touching the boards. Ground yourself with a wrist strap and a resistive connection cord. When neither of the above is possible, touch a conductive part of the equipment chassis with your other hand before touching the boards. - Always hold the boards by the edges and avoid touching the component contacts.

Warranty

For certain products Our company normally gives a limited two-year warranty. Please observe that any such warranty may not be valid in case of damage due to normal wear and tear, exceptional operating conditions, negligent handling or installation, or unauthorized modifications. Please see the applicable supply contract or conditions of sale for details of the warranty for each product.

Technical Support

You can contact Our company for any technical problems

Disclaimer

In no event shall Our company be liable for any direct, indirect or consequential damages, including but not limited to, sales, business, profits or other financial losses, data loss, loss of use of other equipment, loss of goodwill, vehicles or personnel losses, should not be held responsible.

Although the performance of Our company Technology Road Visibility Detector is reliable, failures that occur in the form of missing data or data inaccuracies are also likely to occur.

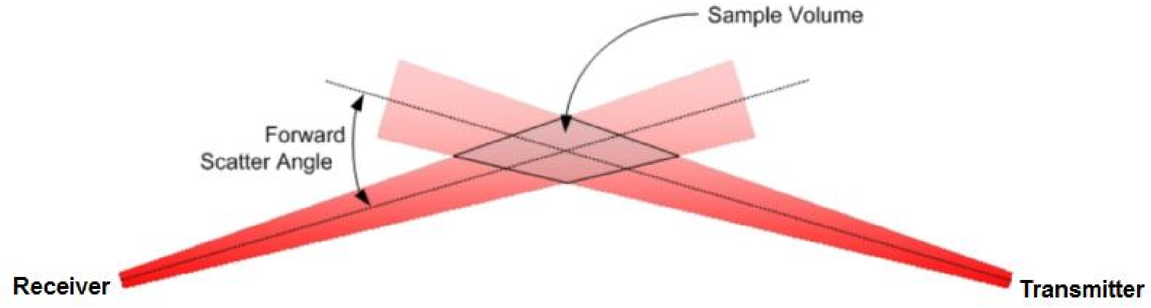
Rika is not responsible for problems caused by wrong installation, assembly, service or maintenance by personnel not authorized by Our company or due to neglect of service and maintenance.

1. Introduction

1.1 PRODUCT OVERVIEW

RK300-10 uses the principle of forward scattering as shown below. The optical system is designed such that the infra-red light projected from the transmitter (TX) intersects the field of view of the receiver (RX) with a forward angle of 39~51º, emitting module emits a bunch of infrared light with a center wavelength of 0.87μm through the infrared light emitting diode to the atmosphere. The area of intersection is known as the sample volume. The 39~51º forward angle ensures performance over a wide range of particle sizes in the sample volume including smoke, dust, haze, fog, rain and snow.

When the air is clear, very little light is scattered since there are few particles in the sample volume resulting in a small signal received by the sensor. As the number of particles in the sample volume increases, the amount of light detected by the receiver also increases. In other words, the received signal strength is inversely proportional to the visibility.



Forward Scatter Geometry

Measure Range and Accuracy a) Range: 10－10 000m(10-80 000 m is optional)

b) Accuracy: ±10%

Main Features a）Continuous monitoring of atmosphere’s visibility

b）RS485 or RS232 serial port output

c）Powered by DC12-24V

Dimension and Weight

a）Dimension: 819mm×232mm×238mm；

b）Weight: <3.8kg

Visibility Sensor is compose of following modules:

a）Emitting Module;

b）Receiving Module;

c）Control Module;

1.2 WORKING PRINCIPLE

When RK300-10 is working, emitting module emits a bunch of infrared light with a center wavelength of 870 nm through the infrared light emitting diode to the atmosphere, and the receiver converges a certain volume of atmospheric forward-scattered light onto the receiving surface of the silicon photoelectric sensor and converts strength of light to electrical signal, then signal is processed and collected by DAM(Data Acquisition Module), and then processed as visibility values putted via RS232/RS485.

Fig 1 RK300-10 visibility exterior

Safety Notice

- Do not let RK300-10 working under circumstance out of its operating condition.
- Read this manual carefully before using it, and strictly following guidance written in this manual.
- Component replacement or internal adjustments must be made by qualified maintenance personnel. Operating personnel must not remove instrument covers.
- The power should be turned off when wiring or connecting cables.
- Do not operate in an explosive atmosphere.
- Keep away from live circuits.
- Do not substitute parts or modify the instrument.
- Ground the product, and verify outdoor installation grounding periodically to minimize shock hazard
- In order to make sure that measured value can represent meteorological conditions of environment around, the installation location should far away from from large buildings or other facilities to produce heating, fog, smoke flashing lights. Installation direction of instrument should avoid direct sunshine on the receiver's perspective range.

1.3 Technical Parameters

Visibility measurement	
Measures Range	10m to 10km (80km can be customized)
Accuracy	±10%
Measurement principle	Forward scatter meter with 39° to 51° angle
Output	
Baud Rate	9600
Serial outputs	RS232 or RS485
Protocol	ModBus-RTU or ASCII
Environmental	
Operating temperature	-40°C to +60°C
Operating humidity	0 – 100% RH
Air pressure	≥650hPa
Protection rating	IP65
Power Requirements	
Sensor power	12-24 VDC
Power consumption	<6W
Physical	
Material	Powder coated Hard-Anodized Aluminium
Weight	3.2 Kg
Dimensions	706x250x170mm
Lifetime	>10 Years

1.4 Quick start

The sensor is shipped set to the following default communication:

For active ASCII string output: 8N1, 9600 bps

For MODBUS-RTU protocol: 8E1, 9600 bps,sensor ID = 01.

2.Installation

Site selection and preparation are critical for the successful performance of the VTF306BE Visibility Sensor. If a good location for the sensor is not chosen or the sensor is not installed correctly, the measured data will not be representative of the visibility in the area. Therefore, it's very important to investigate installation site before you conduct installation, following steps are recommended to optimize performance of our sensor.

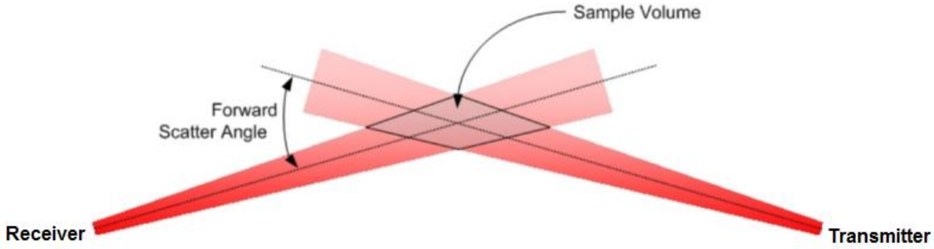
1. Surveying the site:

- Find the most representative measurement site.
- Determine orientation of the Visibility Sensor.

Orientation and Location.

-Make sure the site is free of obstacles and reflective surfaces, which can generate light contamination, thereafter affect measurement.

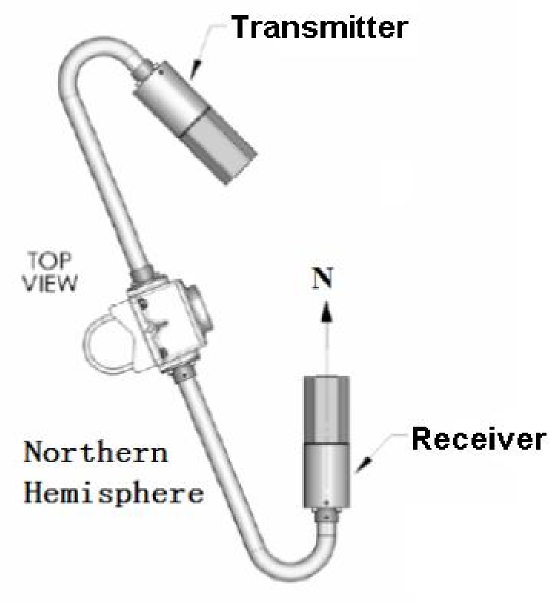
There must not be any obstacles within sample volume.

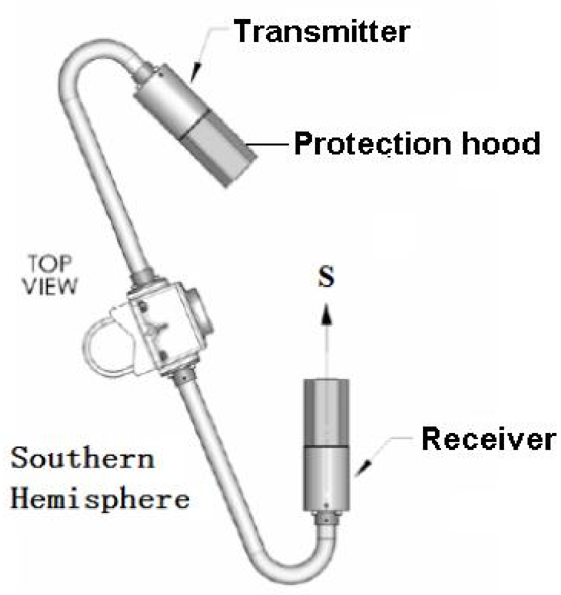


-If the transmitter beam is reflected by obstacles back to the receiver Unit, the sensor will report low MOR values since the reflected signal cannot be distinguished from the real scattered signal. Reflections are detected by rotating the sensor crossarm.

Rotating visibility's orientation to get rid such interference.

-The receiver and transmitter optics should not point towards powerful light sources or, in bright daylight, reflective surfaces such as snow or sand. The receiver should point north in the Northern Hemisphere and south in the Southern Hemisphere.





Protection hood is used to protect the optics from direct sunlight and precipitation.
Our lens come with automatical heating function to prevent water from condensing on the lens.
-The transmitter and receiver should face away from any obvious source of contamination such as spray from passing vehicles.
-Dirty lenses will cause the sensor to report too high visibility values. Excessive contamination is automatically detected by the sensor.
1. Check the power supply and communication cable's layout.
Make sure ground wire, power supply wire, communication wire are sufficient.
2. Install RK300-10 on mounting pole
3. Connect power cable, communication cable and ground cable to electric control box, and connect sensor to PC/data logger.

ELECTRICAL CONNECTIONS

Cable	RS485/4-20mA
Red	12VDC+
Black	12VDC-
Yellow	RS485A
Green	RS485B
Brown	4-20mA+
White	4-20mA-

Orientation and location

Basic requirement of installation:

a) To make sure the measured value can represent weather condition nearby, the ideal installation place should be at least 10 meters away from trees or construction that can create heating, shady or influence rain.

b) Make sure there isn't light contamination or air pollutant that will affect measurement.

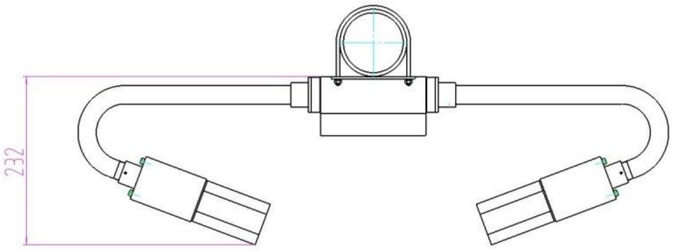
c) Avoid the receiver exposed under direct sunshine, the orientation of sensor therefore should be north-oriented in the northern hemisphere, vice versa. In general, orient the sensor receiver optics so they face within 30 degrees of North in the Northern hemisphere or South in the Southern hemisphere to eliminate direct sunlight contamination

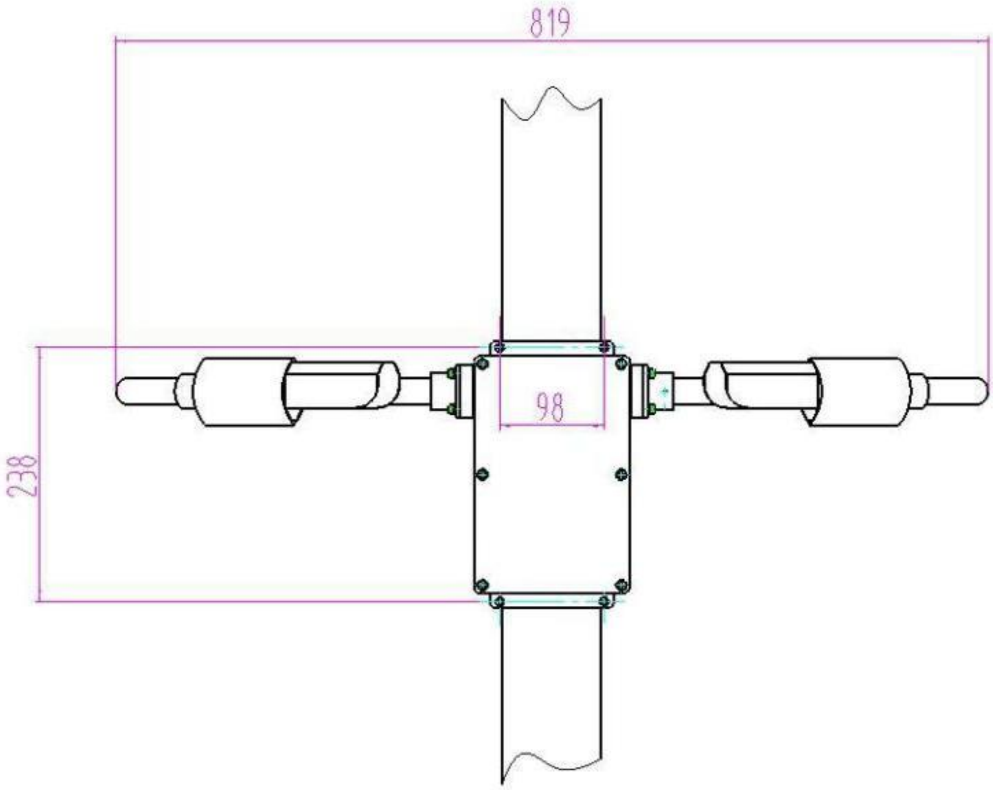
d)Mount the sensor so the optics are at least 2.5-3 meters (8-10 feet) above ground or 2.5 meters (8 feet) above the average maximum snow depth, whichever is higher.

For installations in road weather information systems (RWIS), special conditions may apply:

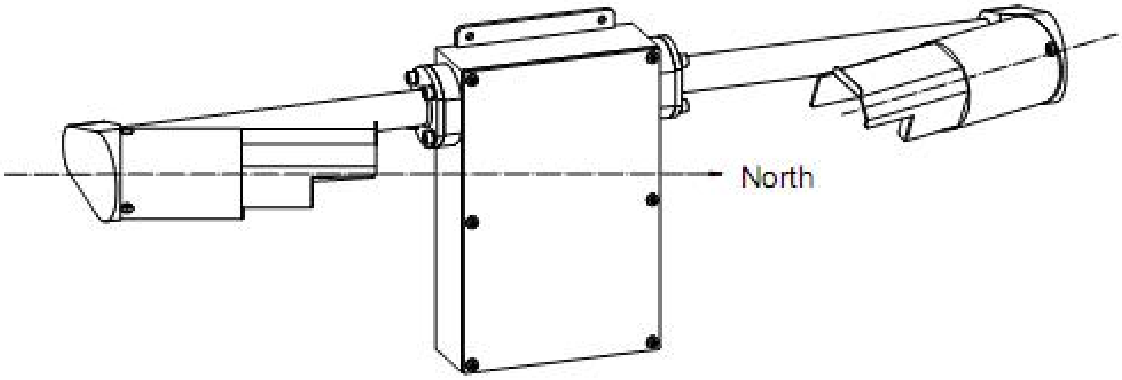
- Do not locate the sensor on the top of a hill or bottom of a basin unless you wish to measure the visibility in that limited area as may be required for road weather applications.
- Do not locate the sensor too near a roadway to avoid the wet, dirty plumes from passing vehicles that may contaminate the sensor optics.

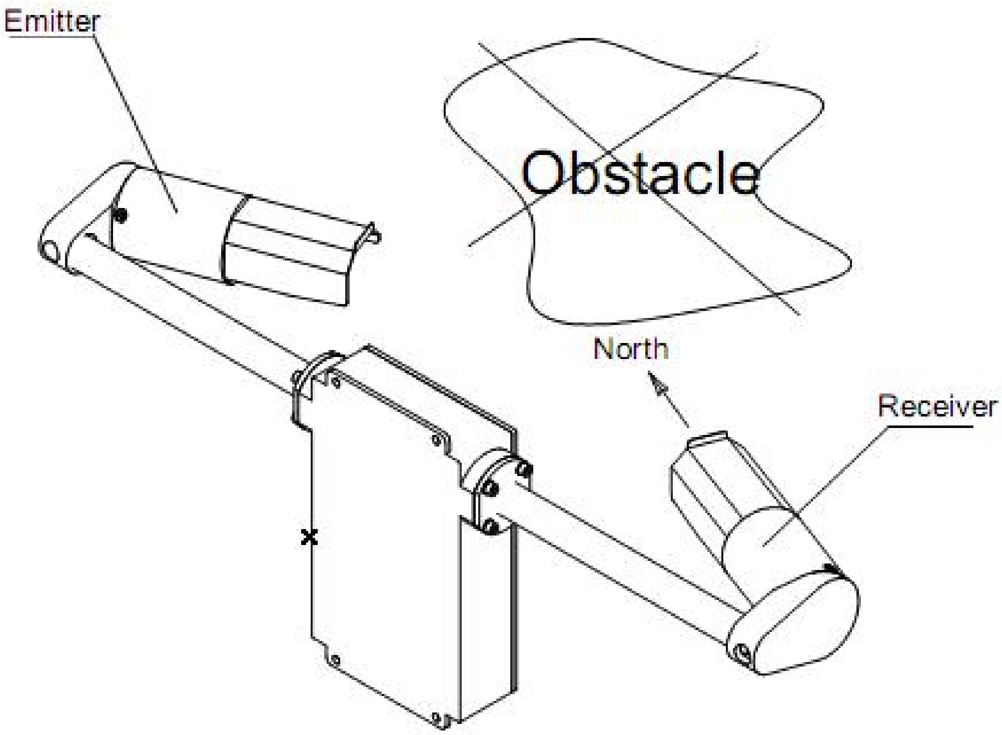
Installation Sketch：





Things need to pay attention to:





Please note that receiver hood should be oriented to NORTH, forbid to orient it to EAST or WEST to avoid interference from sun light.

3.Maintenance

The lens protection window of the visibility meter should be kept clean for accurate measurements, and the visibility values measured when the window is dirty will be high. Normally, the window should be cleaned every three month, but cleaning should be more frequent in some places, such as highways, seaside boats, ships, etc., and windy and dusty areas. Check the protective cover and window glass should be non-condensing water or ice and snow, remove the protective cover dust on the outside and inside.

Wipe the window glass with a soft, lint-free cloth or cotton and ethanol, taking care not to scratch the glass surface.

4.Trouble Shooting

PC is not receiving any data:

a) Check serial port setting of PC(Baud Rate, structure of data frame)

b) Check if the sensor is powered on

c) Contact manufacturer

Visibility value is obviously too high

Many reasons can result in this error. Mostly it’s caused by block of light path between emitting and receiving module.

a) Lens protection window is dirty, clean it.Clean the lenses – this is the most likely cause of the measured visibility being too high!

b) Check for physical damage to the sensor heads or cross arm.Misalignment of these parts will result in TX and RX beams not intersecting correctly – replace sensor.

c) There is blockage on protective cover, remove it.

d) Contact manufacturer

Visibility value is obviously too low

a) Something interferes with sampling, checking for the presence of branches, cobwebs, etc. in or near the sample space.Check for spider webs or insect nests under the hoods or anywhere within the sensor sample volume-clean as needed.

b)Check for other sources of interference that would cause light scattering such as physical damage to hoods or other parts of the head – remove interference or replace sensor as needed.

b) Contact manufacturer

RK300-10 MODBUS-RTU Communication Protocol

V1.1

Modbus Specification

Start Bit	1 bit
Data Bits	8 bit
Parity	EVEN
Stop Bits	1 bit
Baud Rate	9600 Baud

Communication mode

Communication mode:RS485 or RS232, default mode:RS485。

Communication Protocol

MODBUS Protocol - RTU Mode.

Protocol Description

MODBUS protocol defines a simple protocol data unit(PDU) independent from basic communication layer.

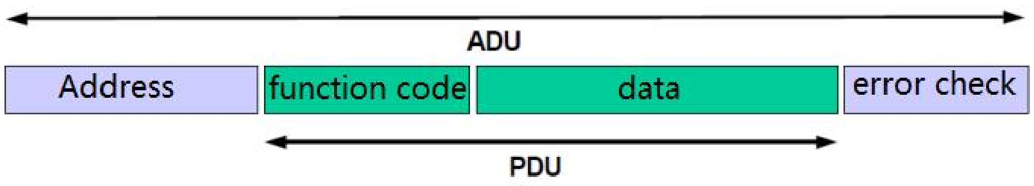


Figure 2. Commonly used MODBUS frame

MODBUS has two transmission mode:RTU and ASCII.

Our sensor adopts RTU mode.

1. RTU transmission mode

When controllers are setup to communicate on a Modbus network using RTU (Remote Terminal Unit) mode, each eight-bit byte in a message contains two four-bit hexadecimal characters. The main advantage of this mode is that its greater character density allows better data throughput than ASCII for the same baud rate. Each message must be transmitted in a continuous stream.

RTU Mode serial bits

odd-even check			
1 Start Bit	8 Data Bits	1 Partly Bit Even	1 Stop Bit

Modbus RTU message frame

child node address	function code	data	CRC	
one bytes	one bytes	0~252 bytes	two bytes	
			CRC low	CRC high

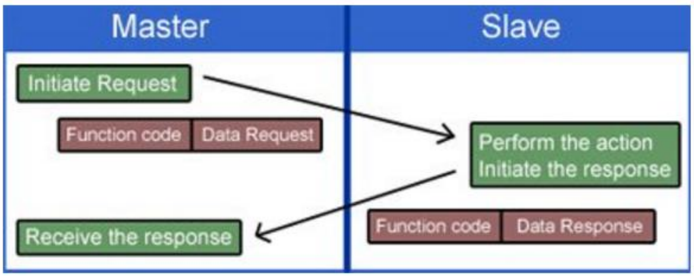
CRC Check

RTU Mode has Cyclical Redundancy Checking(CRC) on all content of message, no matter if there is an odd-even check or not.

CRC check code is a 16 bits value composed by two 8 bits value and added as tail of message. After calculation, lower byte first then high byte. CRC higher byte is the last byte of message.

The CRC check code is calculated by sender. Receiver will recalculate CRC check code and compare it with CRC code received, if they are different, then there is an error happen during transmission.

MODBUS communication Mode



Data Coding

MODBUS use ”big-Endian” to indicate address and data, which means when there is several bytes be sent out, the most significant bit is sent and received first.

Eg.

Register Size	Value
16bit	0x1234

The first byte is 0x12, then 0x34

Protocol of Device

Function Code Supported

Function code type	Length	Function Code （HEX）	Description
Data access	16 bit	03	Read data from internal register

Error Code Supported

Error code	Description
01	Function Code Error
02	Register Address Error
03	Register Value error
06	Device Busy

Internal Register Description

Register	Length	Data Type	Definition
Register 1	16 bit	16 bit int	Visibility

Communication Example:

Read 1 registers:

Request		Response	
Name	HEX	Name	HEX
Instrument address (Default address 01)	01	Instrument address	01
Function code (Read data from internal register)	03	Function code	03
Starting address higher byte	00	Bytes Quantity	02
Starting address lower byte	00	Register 1 data higher byte	27
Quantity of register will be read- higher byte	00	Register 1 data lower byte	10
Quantity of register will be read- lower byte	01	Checksum higher byte	A2
Checksum higher byte	84	Checksum lower byte	78
Checksum lower byte	0A		

Analysis：

2 bytes of Register 1 is reading in 16bit int of visibility. .

Communication Example：

Read 2 internal registers

Communication Example：

Request：

(HEX)   01 03 00 00 00 01 84 0A

Response：

(HEX)   01 03 02 27 10 A2 78

Analysis

Take visibility for example

D1	D0
Register 1 higher bit	Register 1 lower bit
27	10
higher bit	lower bit

Convert it to int, value: 10000

Unit: meter

Appendix CRC Verification

The CRC we are using is 16 bits, lower byte comes first.

The cyclic redundancy check (CRC) field is two bytes which contain 16 bits binary value. The value of the CRC appended to the message is calculated by the transmitting device. When receiving the message, the receiving device recalculates the CRC value and compares the calculated result with the actual received CRC value. If the two values are not equal, it is an error.

During the generation of CRC, each 8-bits characters are XOR with the value in the register. The result then shifts 1 bit in the LSB direction, while the MSB position is charged to zero. Then extract and check LSB: if LSB is 1, the value in the register is XOR with a fixed preset value; if LSB is 0, no XOR operation is performed. This process will be repeated until 8 shifts have been performed. After the last (8th) shift and related operations, the next 8-bit byte is XOR with the current value of the register, and then repeat 8 times as described above. The final value in the register obtained after all sub sections of the message are calculated is CRC.

Procedure of calculating a CRC:

1. Load a 16 bit register with hexadecimal FFFF (all 1). Call it CRC register
2. XOR the first byte of 8 bits in message with the low er byte of the 16 bit CRC register, and place the result in the CRC register
3. Move the CRC register to the right by 1 bit (in the direction of LSB), fill the MSB with zero, extract and detect LSB
4. If LSB is 0: repeat step 3 (do another shift)
(if LSB is 1): conduct XOR operation with CRC register.
5. Repeat steps 3 and 4 until 8 shifts have been completed. When this is done, the full 8-bit byte operation will be completed.
6. Repeat steps 2 to 5 for the next byte in the message, and continue the operation until all messages are processed.
7. The final content in CRC register is CRC value
8. When placing CRC value in message, as described below, higher and lower byte must be exchanged.