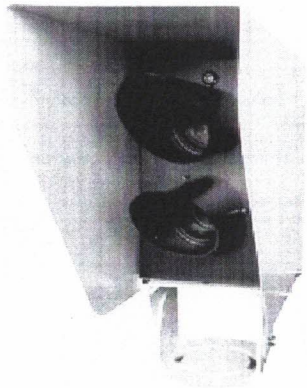
HONGYUV



HY-RSS11E Infrared Road State Sensor

User Manual

Contents

About this manual

This manual provides information for installing, operating, maintaining of HY-RSS11E remote road surface state sensor. The contents are subject to change without prior notice.

Product safety

HY-RSS11E remote road surface state sensor emits invisible light by built-in light emitter through transmitter hood. The light is eye safe in accordance to IEC/EN 60825-1.

ESD Protection

Electrostatic Discharge (ESD) can cause immediate or latent damage to electronic circuits. HY-RSS11E 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:

Handle ESD sensitive components on a properly grounded and protected ESD workbench. 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 Hongyuv normally gives a limited one 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.

Disclaimer

Notwithstanding anything to the contrary mentioned in this agreement or in any other document signed between the parties, Hongyuv shall not under any circumstances be liable for any direct, indirect, consequential or incidental damage, whatsoever including but not limited to loss of sales, business, profits, or any other pecuniary loss,

loss of data, loss of use of other equipment or goodwill or damages for traffic, vehicles or human beings arising out of the use of or inability to use Hongyuv HY-RSS11E Remote Road Surface State Sensor.

Although the performance of Hongyuv HY-RSS11E Remote Road Surface State Sensor is expected to be reliable, malfunction may however occur in the form of missing or inaccurate data. Hongyuv shall not be liable for any defects caused through wrong installation, assembly, service or repairs made by unauthorized personnel not approved in writing by Hongyuv or the omission of service and repair.

Hongyuv shall not be liable for technical or editorial errors or omissions contained herein.

Introduction

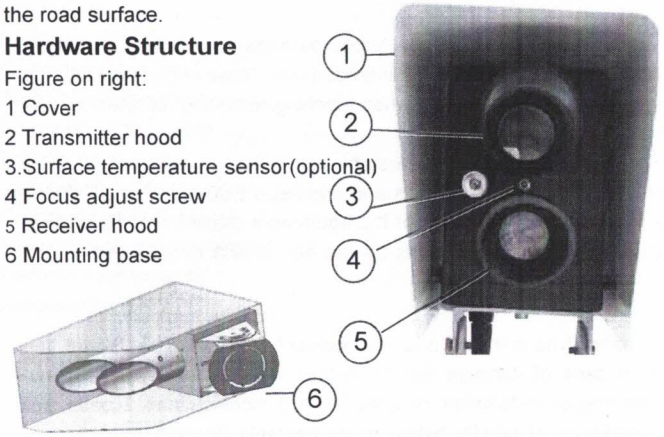
HY-RS11 Remote Road Surface State Sensor eliminates disruption to the road surface and hence to traffic which was previously associated with the installation of a road weather station. Due to remote installation, there is no need to slot-cut the surface or close the road.

The spectroscopic measuring principle enables accurate measurement of the amounts of water, ice, and snow. In addition, HY-RSS11E provides a measurement of slipperiness and reports the state of the road surface.

Hardware Structure

Figure on right:

1 Cover
2 Transmitter hood
3.Surface temperature sensor(optional)
4 Focus adjust screw
5 Receiver hood
6 Mounting base



Operating Principles

HY-RSS11E Remote Road Surface State Sensor is intended for revealing slipperiness of road surfaces due to atmospheric icing. HY-RSS11E is based on a spectroscopic short-range remote measurement of a road surface. The sensor has an infrared transmitter aimed at a selected location on the road surface and a detector to integrate the back reflection of the transmitted light from the measurement spot.

The sensor can distinguish the reflection at specific wavelengths and is thus able to sense the presence of water and ice on the road surface. It also detects the presence of snow or frost, that is, white ice.

Normally, the road surface can become slippery with ice layers of approximately 30 μm.The sensitivity of HY-RSS11E is high enough to easily detect this amount of ice. However, the amount of ice alone does not fully correlate with slipperiness. Research results show that a road surface with soft ice having a high water or salt content is much less slippery than a surface with hard ice having a low water content.

Since RSS11E is capable of detecting water and ice independently, it is possible to build a realistic slipperiness index. This index is called a "grip", which is scaled to the value of friction of a typical road surface and a car tire. On a dry road the grip is scaled to approximately 0.8, whereas with hard ice or a large amount of snow it can be reduced to less than 0.1. The scaling is based on actual friction measurements with different road weather conditions so that the correlation between the grip and the friction values is maximized.

RSS11E is installed by the road side so that it can be oriented to face the road surface at a horizontal angle of about 30 degrees or higher. It can also be located above the driveways, for example on bridges or traffic signal gantries. Traffic passing across the measurement spot does not interfere with the measurement unless there is a complete stop of a car on the spot for several minutes.

RSS11E is a processor-based system and is capable of serving as a slave unit on an RS-485 network.

Technical Parameters

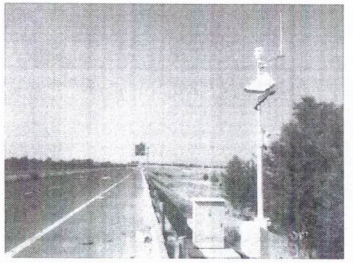
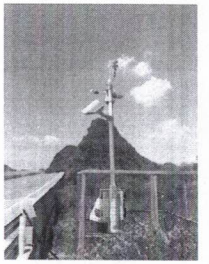
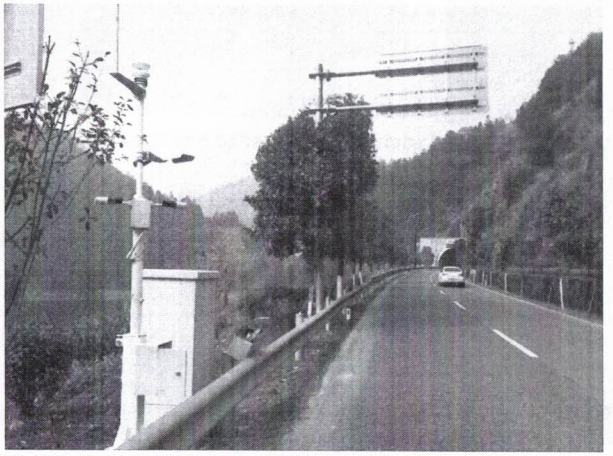
Measuring distance	2~13 meters	
Measuring area diameter	23 cm	
Angle	30-90°	
Power supply	12-24VDC	
Max. Power consumption	4W(including heating of lens)	
Operating temperature	-40 ℃~ +70 ℃	
Operating humidity	0~100%	
Road surface state parameters output	Water film:0.00~10mm	Resolution:0.01mm
	Ice:0.00~10mm	Resolution:0.01mm
	Snow:0.00~10mm	Resolution:0.01mm
	Level of grip: 0.00~1	Resolution:0.01
	*Road surface temperature： -40 ℃~+60 ℃ (optional with extra cost)	
Road status report	Dry,moist,wet,snow,ice,mixture of ice and water(frost)	
Lens contamination detection	Measure contamination level and automatic internal compensation	
Material of road surface	Concrete, asphalt	
Communication	RS485 or RS232	
Protection Grade	IP65	
Dimension	400(L)×136（W）×220（H）	
Safety	No safety problem – remote infrared detection	

Specifications may be subject to change without prior notice.

Installation site photos

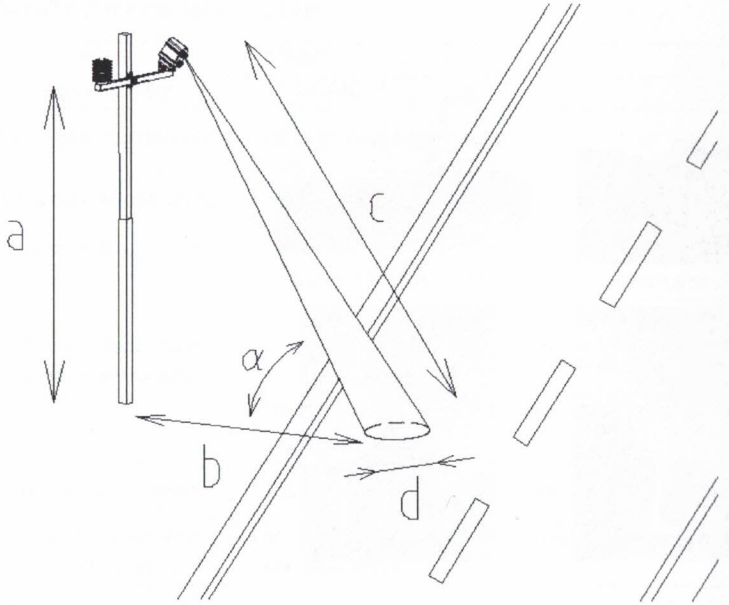
RSS11E is to be installed on a pole adjacent to the road as a stand- alone sensor, or as an addition to the Hongyuv Weather Station. We customize different shell for our client as you can see below:



Installation sketch

If you can choose between different angles (α) and measuring distances (c), choose a short measuring distance.



Installation distance

Measuring distance(C): 2—15 meters;

Installation angle from the horizontal line(α):30°—85°;

Installation height: 3—8 meters

Diameter of measuring area(D) is proportional to the measuring distance（C）.When measuring distance is 10m, diameter of measuring area is 20cm.When measuring distance is 5m, diameter of measuring area is 10cm.

HY-RSS11E should be adjusted and done dry calibration on site for different measuring distance.

Installation Guidance

Notice: Calibration can only be conducted when road is bone-dry.

Avoid aiming RSS11E to following position:

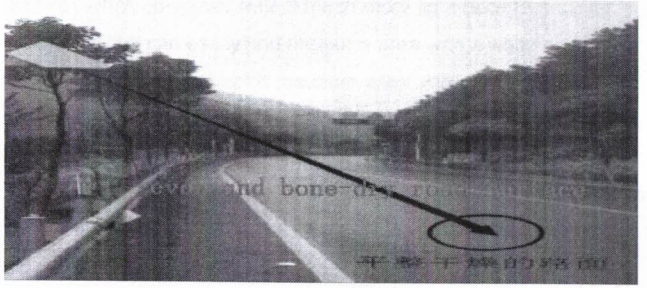
Seam of Road

Marking line on Road

Pothole

Surface with much litter

By aiming at even and bone-dry road surface to optimize HY-RSS11E performance.



One. Preparation

RS485 to USB converter, Laptop, RoadConditionDetector software.

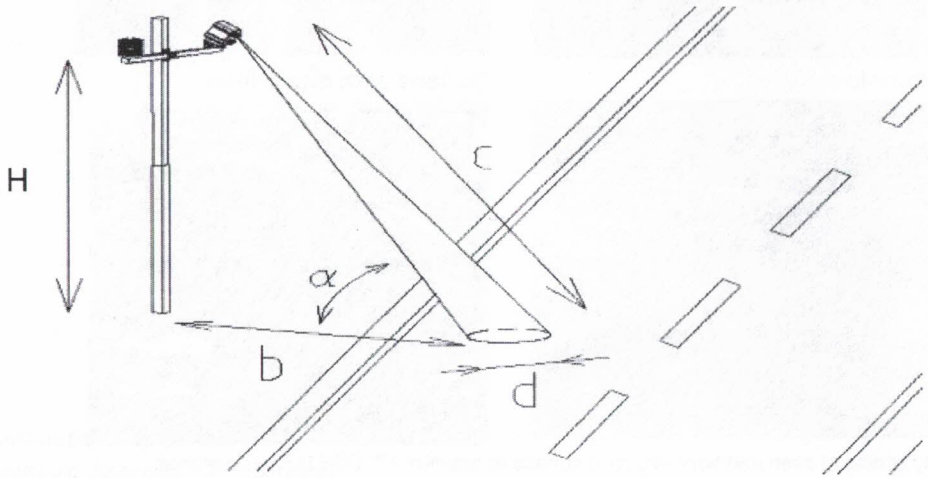
You can download our software at:

https://drive.google.com/file/d/1PXKwlVQpGiEUUk_d9KZJ2aw9TxktGrLK/view?usp=sharing

Two. Installation distance

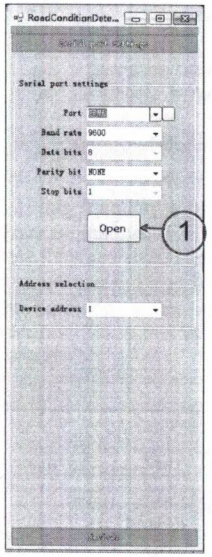
If there is variable installation angle for option, the shorter measure distance one is more preferable. Measure distance(C) in following diagram decided by emit angle(α) and installation height(H). C should be 2~15 meters;

The angle(α) should fall in 30°－85°; Installation height(H) should be 3~8 meters.The diameter (D) of the sensing area is proportional to the measured distance (C). When the measuring distance is 10 m, the diameter of measuring range is 20 cm. When the measuring distance is 5 m, the diameter of measuring range is 10 cm, and so on.

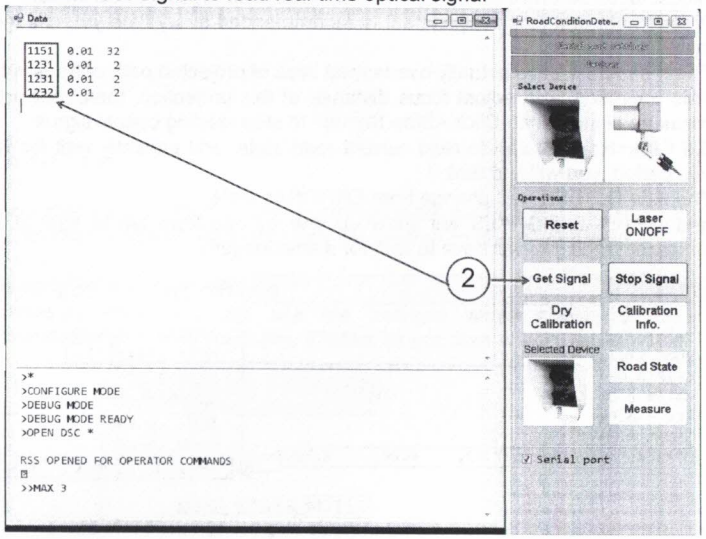


Three. Adjust instrument and find sensing area

3.1 Open software



3.2 Click Get Signal to read real-time optical signal



3.3 Find sensing area

The measure area is on the ground where in line with probe direction and projected by probe.

After roughly installing instrument, put a foam board(or white paper) on road, try to find measure area by moving white paper around roughly estimated area. The raw light signal value will sharply increase once white paper come into measure area.

The one I use to demonstrate is shown at right side.

Notice: White object will reflect much more light back to receiver.

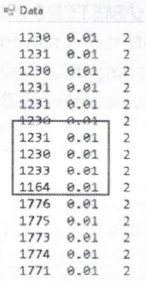
Therefore, we can easily find measure area with a white paper.

After putting white paper on measure area, reflected optical signal

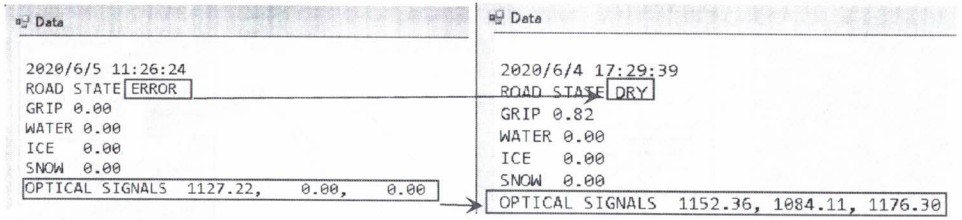
Increased to over 1700 in my case(this value vary from location

to location, you just need to make sure it's higher than 10.

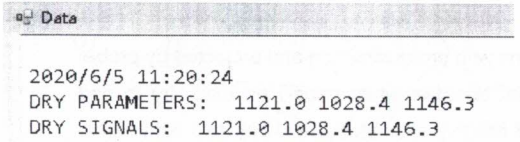
Make sure that optical signal is projected at ideal surface(refer to Page 9)



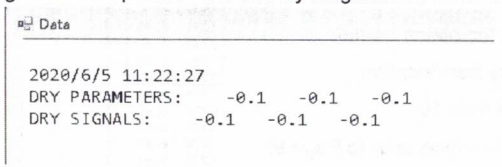
3.4 Focus adjustment
Adjust focus screw(refer to Page 4) to achieve a strongest optical signal.
Please note that focus adjustment is recommended every time you change aiming angle or installation height.
The measure area is actually overlapped area of projected path of transmitter and receiver.
This operation is to adjust focus distance of this projection, thereafter achieve a strongest measure signal. Then Click <Stop Signal> to stop reading optical signal.
3.5 Click<Road State> to read current road state, and patiently wait for 10 minutes, during this period, you will find that:
The ROAD STATE will change from ERROR to DYR,
and OPTICAL SIGNALS will show up one by one from left to right.(0.00 means it's not initialized, then you will have to wait for a little longer.)



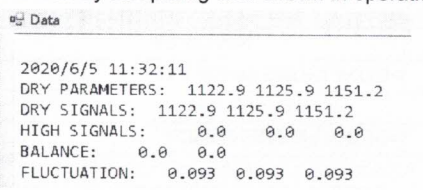
3.6 Make sure road is bone-dry by visually inspecting road surface,
After OPTICAL SIGNALS in 3.5 are stable and then click <Dry Calibration>



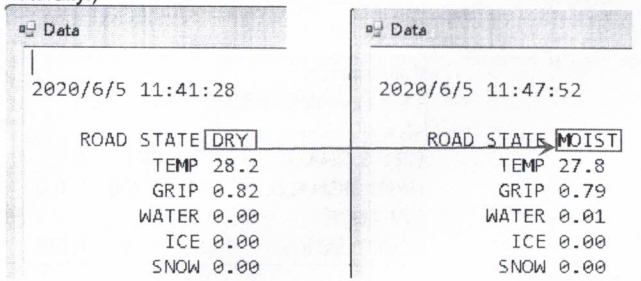
DRY PARAMETERS is the calibration info that will stored in our device.
DRY SIGNALS is current reflected optical signals.
3.7 If following information shown at operation 3.6, it means dry calibration failed, then you have to go back to operation 3.5 and try it again.



3.8 Click <Calibration Info.> to check if dry calibration was well conducted and information are saved by comparing data shown in operation 3.6



3.9 (this function is only workable for our HYPT protocol, not workable for MODBUS-RTU protocol,you can use '3.5 Click<Road State>' instead.) Click <Measure> to continuous read data from our road state sensor.
You will find out that data is updated every two seconds.
By spraying water on measure area, you can see the changes within about 10 minutes.(Since this is created deliberately and manually, it takes longer than water created naturally.)



You can also use commands below to read raw signal, get dry calibration signal, read road state,do dry calibration.

Commands		Content	Response
Instruction 1	ASCII	>*\r\n	>CONFIGURE MODE\r\n
Remark	Enter Setting Mode		
Instruction 2	ASCII	>DEBUG MODE\r\n	>DEBUG MODE READY
Remark	Enter DEBUG MODE Mode		
Instruction 3	ASCII	>OPEN DSC *\r\n	>RSS OPENED FOR OPERATOR COMMANDS
Remark	Enter OPERATION MODE Mode		
Instruction 4	ASCII	>MAX 3\r\n	Device will keep outputing lines of signal raw
Remark	Request raw signal		
Instruction 5	ASCII	>#RC\r\n	>DETECT MODULE RESET OK
Remark	Exit DEBUG MODE Mode(stop raw signal)		
Instruction 6	ASCII	>DRY\r\n	For example DRY PARAMETERS: -0.1 -0.1 -0.1 DRY SIGNALS: -0.1 -0.1 -0.1 HIGH SIGNALS: 0.0 0.0 0.0 BALANCE: 0.0 0.0 FLUCTUATION: 0.093 0.093 0.093
Remark	Fetch Dry Calibration Information		
Instruction 7	ASCII	>DRY ON\r\n	For example DRY PARAMETERS: 76.1 84.1 115.9 DRY SIGNALS: 76.1 84.1 115.9 Note: Those three values stand for optical strength received, they should be all greater than 10 once sensor is stable unless road state is not DRY or something else is abnormal. You can wait one more minute and conduct calibration again to make sure their value >10
Remark	Conduct Dry Cailbration		
Notice: 1. Characters "\r\n" is CRLF Carriage-Return Line-Feed, corresponding to HEX (0x0D,0x0A)			

Operation procedures of commands

No.	Function	Instructions
1	Get Raw Signal	1→2→3→4
2	Stop Raw Sigal	5
3	Fetch Dry Calibration Information	1→2→3→6
4	Conduct Dry Calibration	1→2→3→7 Note: Those three values stand for optical strength received, they should be all greater than 10 once sensor is stable unless road state is not DRY or something else is abnormal. You can wait one more minute and conduct calibration again to make sure their value >10

Noted: HY-RSS11E may exit configure mode if interval between above commands is too long.
If you fail to conduct any operation, please try to shorten interval between each commands or simply use our software.

Communication Protocol

MODBUS-RTU Protocol V1.0

Serial Port Configuration

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.

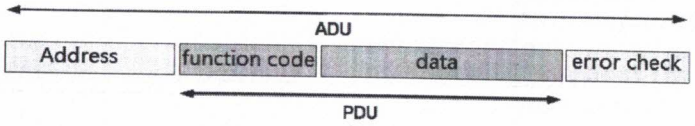


Figure 2. Commonly used MODBUS frame

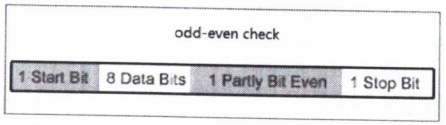
MODBUS has two transmission mode:RTU and ASCII.

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**



- **Modbus RTU message frame**

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

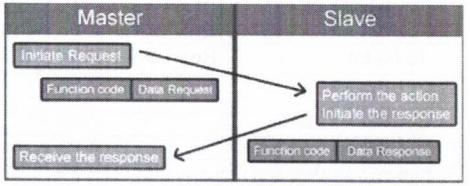
- **CRC Check**

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.

1. Protocol of Device

- **Function Code Supported**

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

- **Definition of registers**

Register	Length	Data Type	Definition
0x0000	Register 1	16 bit int	Device State Sheet1
0x0001	Register 2	32 bit float	Road surface temperature
0x0002	Register 3		
0x0003	Register 4	32 bit float	Thickness of water film
0x0004	Register 5		
0x0005	Register 6	32 bit float	Thickness of ice
0x0006	Register 7		
0x0007	Register 8	32 bit float	Thickness of snow
0x0008	Register 9		
0x0009	Register 10	32 bit float	Grip
0x000A	Register 11		
0x000B	Register 12	16 bit int	Road state Sheet2

- **32 bit float type format**

D3	D2	D1	D0
Higher byte	Middle byte 1	Middle byte 2	Lower byte

- **Format of data stored in register**

Definition	Register	Bit	Byte position	Example
Grip	Register 10-higher byte	8 bit	D2	EB
	Register 10-lower byte	8 bit	D3	85
	Register 11-higher byte	8 bit	D0	3F
	Register 11-lower byte	8 bit	D1	51

Convert 3F51EB85 as decimal value is 0.82

◆ **Function code(0x03) description - read holding register**

A remote device can use function code to read data of holding register. The request PDU specifies starting address and quantity of registers. Register address from zero,therefore, the address register 1-3 corresponds to address 0-2.

Response packet from each register is divided into two bytes in binary format. The first byte is higher bits, the second byte is lower bits.

Request

Function Code	1 byte	0x03
Starting Address	2 bytes	0x0000 ~ 0x0025
Register Quantity	2 bytes	1 ~ 38

Response

Function Code	1 byte	0x03
Bytes Quantity	2 bytes	N*2
Register Data	N*2 bytes	

Note: N is quantity of registers

Error response

Error Code	1 byte	0x83
Exception Code	1 byte	01 or 02 or 03 or 06

Communication example:

Request		Response		Interpretation
Definition	HEX	Definition	HEX	
Instrument address (Default address 01)	01	Instrument address		
Function code (Read data from internal register)	03	Function code	03	
Starting address higher byte	00	Bytes Quantity	1A	26 bytes will be read
Starting address lower byte	00	Register 1 data higher byte	00	Device state（0003） '3'=>binary:'11' First 1 means road temperature funciton is valid. Second 1 means road state is valid.
Quantity of register will be read- higher byte	00	Register 1 data lower byte	03	
Quantity of register will be read- lower byte	0D	Register 2 data higher byte	AE	Road surface temperature（4206AE14）33.67 ℃
CRC higher byte		Register 2 data lower byte	14	
CRC lower byte		Register 3 data higher byte	42	
		Register 3 data lower byte	06	
		Register 4 data higher byte	D7	Thickness of water film（4063D70A）3.56 mm
		Register 4 data lower byte	0A	
		Register 5 data higher byte	40	
		Register 5 data lower byte	63	
		Register 6 data higher byte	51	Thickness of ice film（401851EC）2.38 mm
		Register 6 data lower byte	EC	
		Register 7 data higher byte	40	
		Register 7 data lower byte	18	
		Register 8 data higher byte	70	Thickness of snow film（3F9D70A4）1.23 mm
		Register 8 data lower byte	A4	
		Register 9 data higher byte	3F	
		Register 9 data lower byte	9D	
		Register 10 data higher byte	EB	Grip（3F51EB85）
		Register 10 data lower byte	85	

		Register 11 data higher byte	3F	0.82
		Register 11 data lower byte	51	
		Register 12 data higher byte	00	Road state Sheet 2
		Register 12 data lower byte	D1	
		Register 13 data higher byte	00	Reserved
		Register 13 data lower byte	00	
		CRC higher byte	60	CRC checksum
		CRC lower byte	9F	

Above complete communication cycle:

- **Request:**
  (HEX) **01 03 00 00 00 0D 84 0F**
- **Response:**
  (HEX) **01 03 1A 00 03 AE 14 42 06 D7 0A 40 63 51 EC 40 18 70 A4 3F 9D EB 85 3F 51 00 D1 00 00 60 9F**

Sheet 1 Device state

Bits	BIT7	BIT6	BIT5	BIT4	BIT3	BIT2	BIT1	BIT0
Value	x	x	x	x	x	x	1/0	1/0
Function validity							Road surface temperature	Water thickness Ice thickness Snow thickness Road surface state Grip

Note: Function is valid only corresponding bit is '1'.

Sheet2 Road state code(convert to decimal first, and only last single bit is useful)

Single bit	
0	ERROR
1	DRY
2	MOIST
3	WET
6	SNOW
7	ICE
9	SLUSHY
4、5、8(Reserved)	

Parameters Setting Commands

Following parameters such as communication address or baudrate.

Commands		Content	Response
Instruction 1	ASCII	>*\r\n	>CONFIGURE MODE\r\n
	HEX	3E 2A 0D 0A	0A 3E 43 4F 4E 46 49 47 55 52 45 20 4D 4F 44 45 0D 0A
Remark	Enter Setting Mode		
Instruction 2	ASCII	>#CUS 38400 8-N-1\r\n	>CMD IS SET
	HEX	3E 23 43 55 53 20 39 36 30 30 20 38 2D 4E 2D 31 0D 0A	3E 43 4D 44 20 49 53 20 53 45 54 0D 0A
Remark	Configure serial port configuration as Baud Rate 9600 bps; Data bits:8 bits; Parity:NONE; Stop bits:1 bit.		
Instruction 3	ASCII	>#ID 2\r\n	>CMD IS SET
	HEX	3E 23 49 44 20 32 0D 0A	3E 43 4D 44 20 49 53 20 53 45 54 0D 0A
Remark	Configure address of device as 2. Inquiry address command is HEX: 3E 49 44 0D 0A		
Instruction 4	ASCII	>#RESET\r\n	System start ok!\r\n
	HEX	3E 23 52 45 53 45 54 0D 0A	53 79 73 74 65 6D 20 73 74 61 72 74 20 6F 6B 21 0D 0A
Remark	Reboot device		
Instruction 5	ASCII	>!\r\n	>NORMAL MODE\r\n
	HEX	3E 21 0D 0A	3E 4E 4F 52 4D 41 4C 20 4D 4F 44 45 0D 0A
Remark	Exit setting mode to normal mode.		
Instruction 6	ASCII	>#CMP\r\n	>CMP : MODBUS-RTU\r\n
	HEX	3E 23 43 4D 50 0D 0A	
Remark	Inquiry current communication protocol		
Instruction 7	ASCII	>#CMP 2\r\n	>>CMD IS SET\r\n
	HEX	3E 23 43 4D 50 0D 0A	
Remark	Change protocol as MODBUS, if you want to change it as active output then replace 2 as 3 2: MODBUS-RTU 3:Active output		
Notice: 1. Characters "\r\n" is CRLF Carriage-Return Line-Feed, corresponding to HEX (0x0D,0x0A)			

Operation procedures of commands

No.	Function	Instructions
1	Set Communication Address	1→3→5→4
2	Set Serial Port Parameters	1→2→5→4
3	Inquiry current protocol	1→6→5→4
4	Change protocol	1→7→5→4

I .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.

Maintenance and troubleshooting

RSS11E normally needs only a few maintenance actions. A basic check once a year before winter is usually sufficient. However, if the sensor easily gets dirty due to installation location, or there is a remarkable change of color in road paving, additional maintenance actions are needed.

Periodic Maintenance

- Visual Check: Check that there are no outer damages in the device, cables, or connectors. Check that the device is aimed at the desire area on the road surface by looking along the straight part of the cover lower edger.
- Functional Check: Request a message from RSS11E and check that all data parameters are displayed.
- RSS11E including two hoods need to be cleaned, receiver lens and transmitter lens. RSS11E will automatically check contamination of lens and alarm when it's dirty. Normally, these lens are well protected by hood and don't need to be cleaned.

Accessories & Wiring

Packing items:
Host * 1 pcs
4 meters communication cable with water-proof plug connector * 1 pcs
Screw driver to adjust focus * 1 pcs

For RS485 output, communication cable is four cores, connected as below:

POWER(12-24VDC)		RS485	
Red	Black	Yellow	Green
V+	GND	RS485 DA+	RS485 DB-