LS152 Vacuum Coating Thickness Measuring System Communication Protocol (Customer) V5.2

Contents

I. Introduction to MODBUS communication protocol

1. Hardware parameters

- Hardware uses RS-485, master-slave half-duplex communication, central-switch calling system and switch-central answering communication.
- There are 10 bits, 1 start bit, 8 data bits and I stop bit, no parity.
- Baud rate: 19200 bps (Special requirements, please specify in the contract).

2. Communication function code 03H, 04H (read register value)

- Note: In this protocol, the 03H and 04H function codes are in common use
- ***Host transmit:***

1	2	3	4	5	6	7	8
ADR	03H	Start register high byte	Start register low byte	Register number high byte	Register number low byte	CRC low byte	CRC high byte

1st byte ADR : Slave address code (1 ~ 254)
2nd byte 03H : Read register value function code
3rd and 4th bytes : Register start address to be read
5th and 6th bytes : Register number to be read
7th and 8th bytes : Checksum of CRC16 from byte 1 to 6

- ***When the slave receives correctly, the slave returns:***

1	2	3	4, 5	6, 7		M-1, M	M+1	M+2
ADR	03H	The total number of bytes	Register data 1	Register data 2	…	Register data M	CRC low byte	CRC high byte

1st byte ADR : Slave address code (= 001 ~ 254)
2nd byte 03H : Return to read function code
3rd byte : The total number of bytes from 4 to M (including 4 and M)
4th and M bytes : Register data
M + 1, M + 2 bytes : Checksum of CRC16 from byte 1 to M

- ***When the slave receives an error, the slave returns:***

1	2	3	4	5
ADR	83H	Information code	CRC low byte	CRC high byte

1st byte ADR : Slave address code (= 001 ~ 254)

2nd byte 83H : Read register value error

3rd byte information code : See information code table

Byte 4 and 5 : Checksum of CRC16 from byte 1 to 3

3. Communication function code 10H (write register value)

- ***Host transmit:***

1	2	3	4	5	6	7
ADR	10H	Start register high byte address	Start register low byte address	Register the number of high bytes	Register the number of low bytes	Total number of data bytes

8,9	10,11	N,N+1	N+2	N+3
Register data 1	Register data 2	Register data M	CRC code low byte	CRC code high byte

- ***When the slave receive correctly, the slave returns:***

1	2	3	4	5	6	7	8
ADR	10H	Register high byte address	Register low byte address	Register number high bytes	Register number low bytes	CRC code low byte	CRC code high byte

- ***When the slave receives an error, the slave returns:***

1	2	3	4	5
ADR	90H	Error message code	CRC low byte	CRC high byte

1st byte ADR : Slave address code (= 001 ~ 254)

2nd byte 90H : Read register value error

3rd byte wrong information code : See information code table

Byte 4 and 5 : Checksum of CRC16 from byte 1 to 3

4. Communication function code 06H (write register value)

- ***Host transmit:***

1	2	3	4	5	6	7	8
ADR	06H	Register high byte address	Register low byte address	Register number high bytes	Register number low bytes	CRC code low byte	CRC code high byte

- ***When the slave receive correctly, the slave returns:***

1	2	3	4	5	6	7	8
ADR	06H	Register high byte address	Register low byte address	Register number high bytes	Register number low bytes	CRC code low byte	CRC code high byte

- ***When the slave receives an error, the slave returns:***

1	2	3	4	5
ADR	90H	Error message code	CRC low byte	CRC high byte

1st byte ADR : Slave address code (= 001 ~ 254)

2nd byte 86H : Read register value error

3rd byte wrong information code : See information code table

Byte 4 and 5 : Checksum of CRC16 from byte 1 to 3

5. Broadcast command

The slave address "0" is a broadcast command.

II. Instructions of Vacuum Coating Thickness Measuring System Console

1. The console of the vacuum coating thickness measuring system is an independent controller for every three test points. Each controller has an independent slave address. The address of the controller starts from 1 and increases sequentially.

   Example: The vacuum coating thickness measuring system needs 12 test points. Then, four controllers (independent control boards) are needed and the addresses of the four controllers are 1, 2, 3, and 4, in that order. Inside the instrument, the controller has been connected via the 485 bus. Then the PLC and PC need to read the internal register contents of the 4 controllers to access this device.

   The vacuum coating thickness measuring system needs 25 test points. Then, 9 controllers (independent control boards) are needed and the addresses of the 9 controllers are 1,2,3,4,5,6,7,8,9. Inside the instrument, the controller has been connected via the 485 bus. Then when PLC and PC access this device, they need to read the internal register contents of 9 controllers respectively. Among them, No. 9 controller has only one valid test point and the other two extra test points are default data.

   The number of the light source probe, the receiving probe and the controller of the console are one-to-one corresponding. They are sequentially increased. For example, the number of the light source probe and the receiving probe corresponding to the controller No. 2 must be No. 4, 5 and 6. The

increasing order of the address is the same as the register.

2. In order to make it convenient for customers to communicate with the host computer (PC) or use in the closed-loop control, the station number (controller address) and baud rate of RS485 ○ 2 port can be set. If the user needs to change the RS485 ○ 2 parameters, it is recommended that the user use the matching HMI settings. For specific operations, please refer to Section 2.5 "Communication Configuration" in the "LS152 HMI User Manual".
3. The instrument provides Float and int16 data for the transmittance value and optical density value. The float data provides two decoding methods, "2-3412" and "0-1234". Developers can choose any type according to actual needs. For register addresses, see "**Controller Address Map**".
4. The amount of float indicates the transmittance and optical density. One data requires 4 bytes. So the contents of the two registers are a variable.

III. Register address mapping table

- Out of considerations for compatibility and convenience, mapping of different formats with various addresses are made for the same datum. Please read as needed.
- Every three test points are an independent controller, independent address and independent communication.
- The test point number corresponds to the test point number of the console.
- The float is 4 bytes and occupies two registers.
- The instrument provides two decoding methods for float data, "2-3412" and "0-1234". Corresponds to register addresses 3-14 and 103-114, respectively.

Table 1: Address of 2-3412 decoding process:

Register address	Type	Data content	Instruction
0	Read only	Transmittance 1	uint16, two decimal places, transmittance expressed as percentage
1	Read only	Transmittance 2	uint16, two decimal places, transmittance expressed as percentage
2	Read only	Transmittance 3	uint16, two decimal places, transmittance expressed as percentage
3	Read only	Transmittance 1	Transmittance, float, “2-3412” decoding
4	Read only	Transmittance 1	Transmittance, float, “2-3412” decoding
5	Read only	Transmittance 2	Transmittance, float, “2-3412” decoding
6	Read only	Transmittance 2	Transmittance, float, “2-3412” decoding
7	Read only	Transmittance 3	Transmittance, float, “2-3412” decoding
8	Read only	Transmittance 3	Transmittance, float, “2-3412” decoding
9	Read only	Optical density 1	OD, float, “2-3412” decoding

10	Read only	Optical density 1	OD, float, “2-3412” decoding
11	Read only	Optical density 2	OD, float, “2-3412” decoding
12	Read only	Optical density 2	OD, float, “2-3412” decoding
13	Read only	Optical density 3	OD, float, “2-3412” decoding
14	Read only	Optical density 3	OD, float, “2-3412” decoding

Table 2: 0-1234 decoding process address:

Register address	Type	Data content	Instruction
99	Read only	Temperature	uint16, one decimal place, transmittance expressed as percentage
100	Read only	Transmittance 1	uint16, two decimal places, transmittance expressed as percentage
101	Read only	Transmittance 2	uint16, two decimal places, transmittance expressed as percentage
102	Read only	Transmittance 3	uint16, two decimal places, transmittance expressed as percentage
103	Read only	Transmittance 1	Transmittance, float, “2-3412” decoding
104	Read only	Transmittance 1	Transmittance, float, “2-3412” decoding
105	Read only	Transmittance 2	Transmittance, float, “2-3412” decoding
106	Read only	Transmittance 2	Transmittance, float, “2-3412” decoding
107	Read only	Transmittance 3	Transmittance, float, “2-3412” decoding
108	Read only	Transmittance 3	Transmittance, float, “2-3412” decoding
109	Read only	Optical density 1	OD, float, “0-1234” decoding
110	Read only	Optical density 1	OD, float, “0-1234” decoding
111	Read only	Optical density 2	OD, float, “0-1234” decoding
112	Read only	Optical density 2	OD, float, “0-1234” decoding
113	Read only	Optical density 3	OD, float, “0-1234” decoding
114	Read only	Optical density 3	OD, float, “0-1234” decoding

Note:The data in address 99 is signed 16-bit integer data with one decimal place. If the data is 255, the temperature value is 25.5.

Table 3: Address represented by temperature and optical density signed integer numbers

Register address	Type	Data content	Instruction
199	Read only	Temperature	int16, a decimal, an integer divided by 10
200	Read only	Optical density 1	int16, three decimals, an integer divided by 1000
201	Read only	Optical density 2	int16, three decimals, an integer divided by 1000
202	Read only	Optical density 3	int16, three decimals, an integer divided by 1000

Note:

- The data of address 199 register is a signed 16-bit integer data with one decimal. If the data is 255, the temperature value is 25.5.
- The data of address 200,201,202 registers are signed 16-bit shaping data with three decimals. For example, the 1996 data represents the optical density value of 1.996.

1. "2-3412" and "0-1234" decoding instruction

Based on IEEEE754 standard, 123.4567 of float amount will be represented by 0x3F9E064B in hexadecimal.

Byte number	1	2	3	4
Byte data	0x3F	0x9E	0x06	0x4B

3412 is the transmission order of "2-3412" decoding data. 1234 is the transmission order of "0-1234" decoding data.

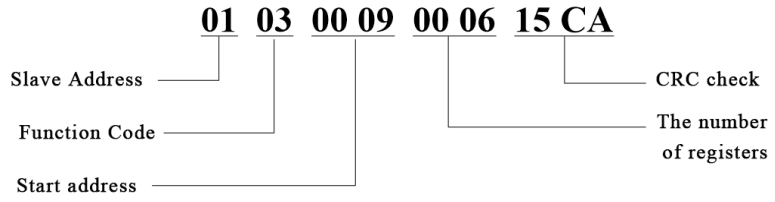
Example: Read the optical density value of test point 1, 2, 3. Assume the optical density value is 1.234567. The test point 1, 2, 3 corresponds to the No.1 controller, so the slave address of test point 1, 2, 3 is 1.

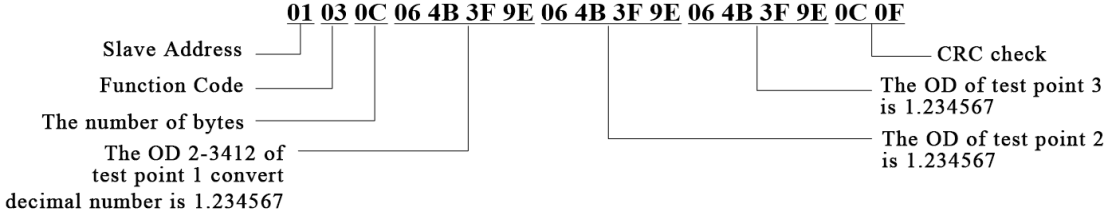
A. The code of reading "2-3412" decoding data is as follows:

Send source code -> 01 03 00 09 00 06 15 CA

Receive source code -> 01 03 0C 06 4B 3F 9E 06 4B 3F 9E 06 4B 3F 9E 0C 0F

The meaning of the code is as follows:



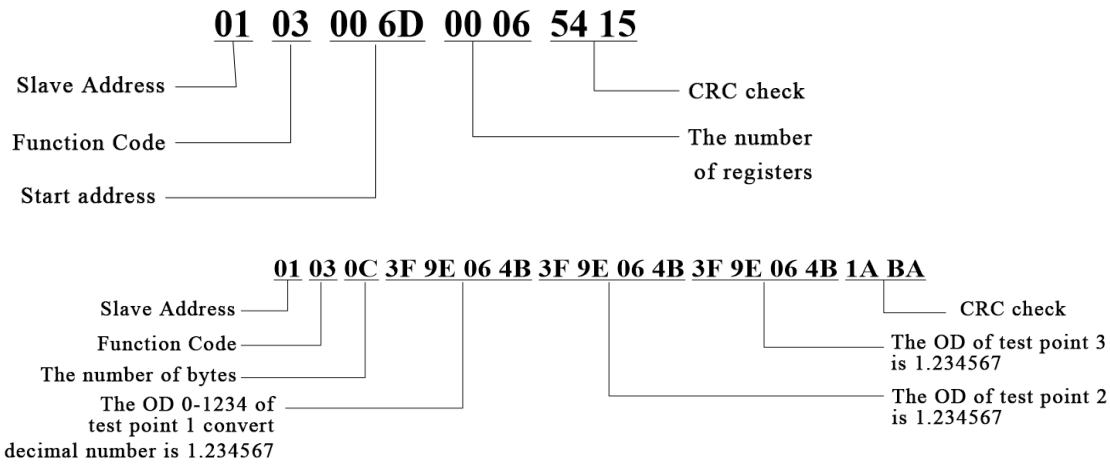


B. The code of reading "0-1234" decoding data is as follows:

Send source code ->01 03 00 6D 00 06 54 15

Receive source code->01 03 0C 3F 9E 06 4B 3F 9E 06 4B 3F 9E 06 4B 1A BA

The meaning of the code is as follows:



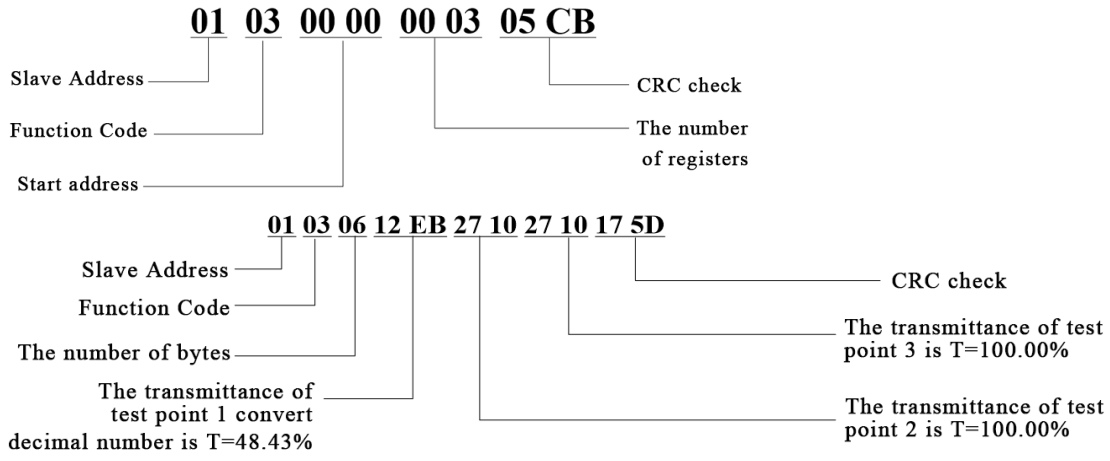
2. Example of reading unsigned integer transmittance decoding

Read the transmittance values of test points 1, 2 and 3, assuming that the transmittance value of test point 1 is equal to 48.43%. The transmittance value of test points 2, 3 is equal to 100.00%.

Send source code->01 03 00 00 00 03 05 CB

Receive source code->01 03 06 12 EB 27 10 27 10 17 5D

The meaning of the code is as follows:



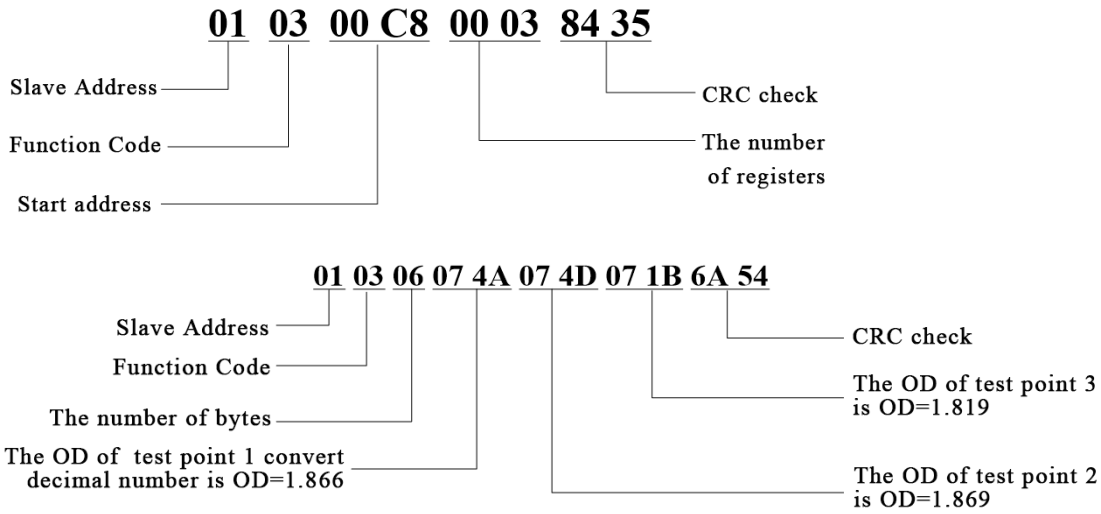
3. Example of reading signed integer optical density value decoding

Read the optical density values of test points 1, 2 and 3, assuming that the optical density value of test point 1 is 1.866. The optical density values of test points 2, 3 are 1.869, 1.819, respectively.

Send source code->01 03 00 C8 00 03 84 35

Receive source code->01 03 06 07 4A 07 4D 07 1B 6A 54

The meaning of the code is as follows:



IV. Instrument calibration and zeroing

- The instrument can be calibrated and zeroed by the 10H function code.
- The calibration operation is to calibrate the instrument by using standard foils or materials with known transmittance.
- Zero adjustment, when there is no test object, the transmittance should be calibrated to 100% or the optical density should be calibrated to 0.
- Supports broadcast commands. One command operates on all the controllers in a link. (**Note: wait 50ms after sending the broadcast command before sending the second command**).
- The instrument also supports single-point operation commands, which can perform calibration and zeroing adjustment on one test point of the controller.

Register address	Type	Data content	Instruction
41	Read and write	Optical density 1 calibration value	int16, three decimals, an integer divided by 1000, signed 16-bit integer data
42	Read and write	Optical density 2 calibration value	int16, three decimals, an integer divided by 1000, signed 16-bit integer data

43	Read and write	Optical density 3 calibration value	int16, three decimals, an integer divided by 1000, signed 16-bit integer data
44	Read and write	The sign of system automatic and manual adjustment	A: "0" means manual adjustment B: "1" means automatic adjustment
45	Read and write	Transmittance 1 calibration value	uint16, two decimals, transmittance expressed as percentage, unsigned 16-bit shaped data
46	Read and write	Transmittance 2 calibration value	uint16, two decimals, transmittance expressed as percentage, unsigned 16-bit shaped data
47	Read and write	Transmittance 3 calibration value	uint16, two decimals, transmittance expressed as percentage, unsigned 16-bit shaped data

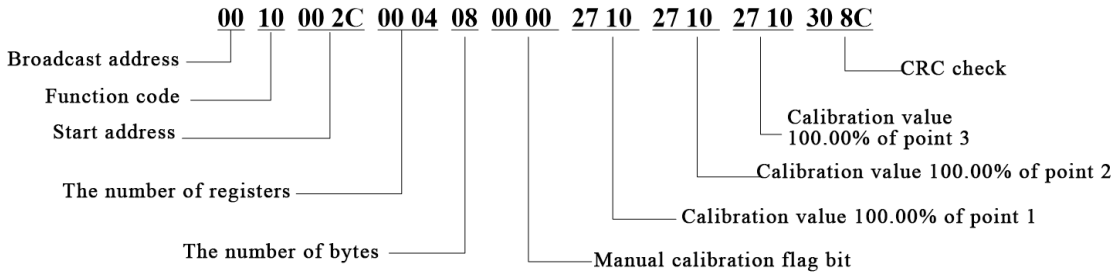
1. Transmittance calibration or zeroing (broadcast command)

- If a sample is placed, the transmittance of the sample can be adjusted to the standard transmittance value.
- When the test slot is empty, zero adjustment can be performed.

For example, make zero adjustment of all test points to 100% for all controllers.

Send source code->00 10 00 2C 00 04 08 00 00 27 10 27 10 27 10 30 8C

The meaning of the code is as follows:



2. Transmittance calibration or zeroing (one controller calibration)

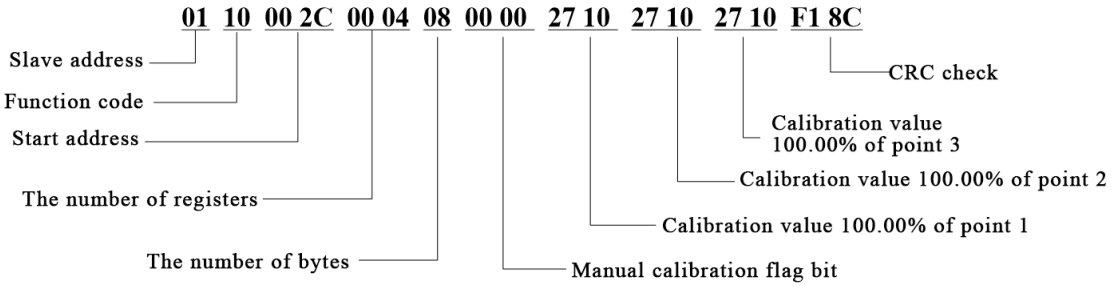
- If a sample is placed, the transmittance of the sample can be adjusted to the standard transmittance value.
- When the test slot is empty, zero adjustment can be performed.

Take the No.1 controller as an example, the transmittance of three test points will be calibrated to 100%.

Send source code->01 10 00 2C 00 04 08 00 00 27 10 27 10 27 10 F1 8C

Receive source code->01 10 00 2C 00 04 00 03

The meaning of the code is as follows:



3. Transmittance calibration or zeroing (single test point calibration)

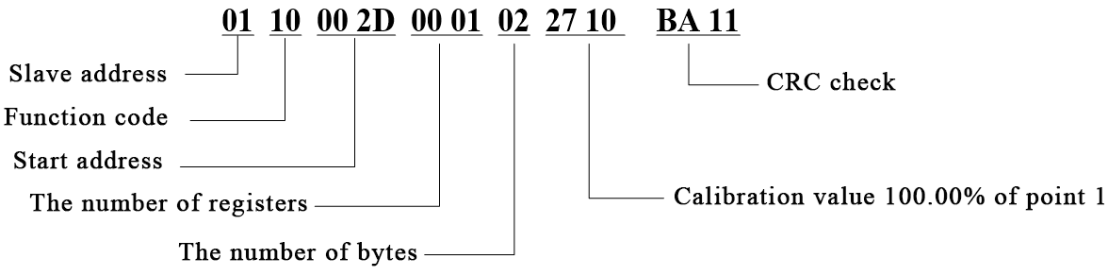
- Single-point manual calibration must be performed in manual mode, that is, the value of address 44 is 0. Set the system to manual mode by command alone then perform the corresponding operation.

Take the test point 1 of No.1 controller as an example, the transmittance of test point 1 will be calibrated to 100%.

Send source code->01 10 00 2D 00 01 02 27 10 BA 11

Receive source code->01 10 00 2D 00 01 91 C0

The meaning of the code is as follows:



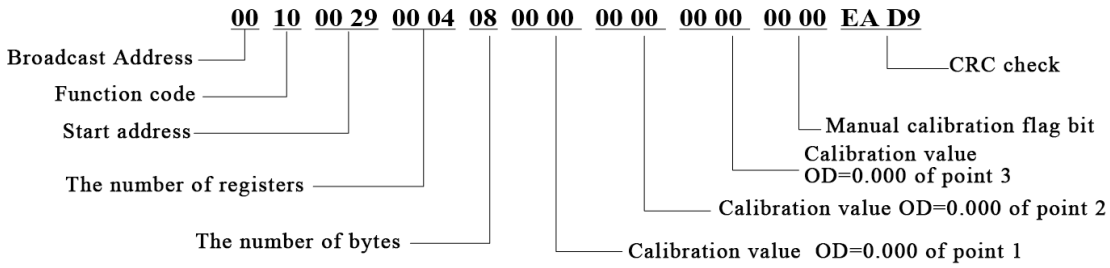
4. Optical density calibration or zeroing (broadcast command)

- If a sample is placed, the transmittance of the sample can be adjusted to the standard optical density value.
- When the test slot is empty, zero adjustment can be performed.

For example, calibrate all the test points of all the controllers to OD 0.

Send source code->00 10 00 29 00 04 08 00 00 00 00 00 00 00 00 EA D9

The meaning of the code is as follows:



5. Optical density calibration or zeroing (one controller calibration)

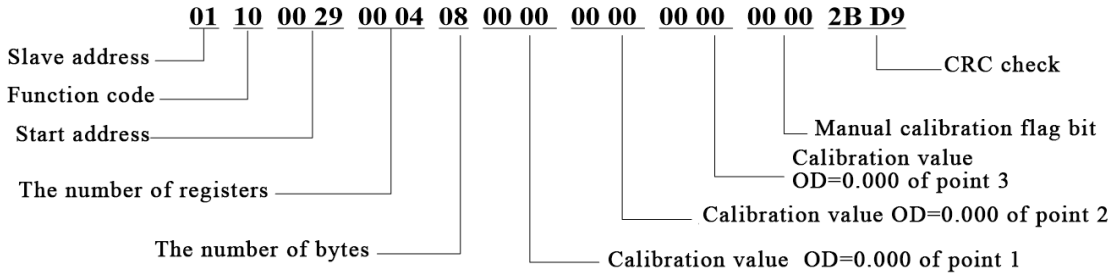
- If a sample is placed, the transmittance of the sample can be adjusted to the standard transmittance value.
- When the test slot is empty, zero adjustment can be performed.

Take the No.1 controller as an example, the optical density of three test points will be calibrated to OD0.

Send source code->01 10 00 29 00 04 08 00 00 00 00 00 00 00 00 2B D9

Receive source code->01 10 00 29 00 04 10 02

The meaning of the code is as follows:



6. Optical density calibration or zeroing (single test point calibration)

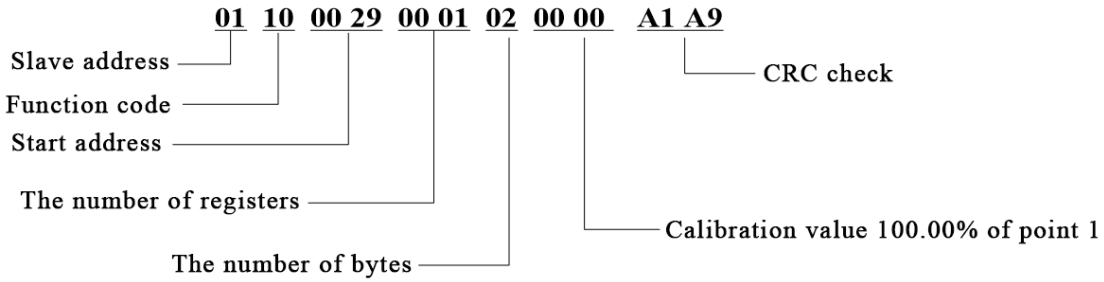
- Single-point manual calibration must be performed in manual mode, that is, the value of address 44 is 0. Set the system to manual mode by command alone then perform the corresponding operation.

Take the test point 1 of No.1 controller as an example, the optical density of test point 1 will be calibrated to OD 0.

Send source code->01 10 00 29 00 01 02 00 00 A1 A9

Receive source code->01 10 00 29 00 01 D0 01

The meaning of the code is as follows:



V. Controller RS485② setting

- Set the station number (controller address) and baud rate of RS485 ② through 06H/10H function code.

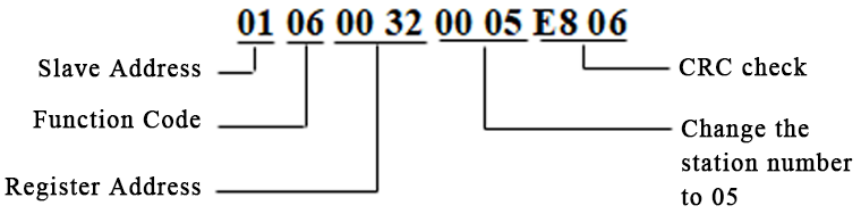
Register address	Type	Data content	Instruction
48	Read only	RS485① station number	uint16, 16-bit integer data, range (1-15) .The hardware configuration cannot be changed.
49	Read only	RS485① baud rate	2 represents 19200, fixed baud rate
50	Read and write	RS485① station number	uint16, 16-bit integer data, range (1-247)
51	Read and write	RS485① baud rate	uint16, 0 for 4800, 1 for 9600, 2 for 19200, 3 for 38400

A. The following example changes the station number of RS485 to 05 by 06H code

Send source code->01 06 00 32 00 05 E8 06

Receive source code->01 06 00 32 00 05 E8 06

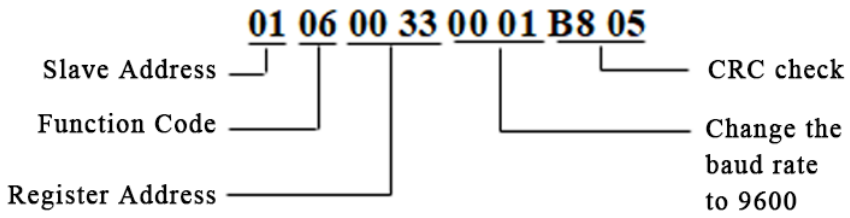
The meaning of the code is as follows:



B. The following example changes the baud rate of RS485 to 9600 by the 06H code

Send source code->01 06 00 33 00 01 B8 05

The meaning of the code is as follows:



VI. System status

- Real-time monitoring of the normal operation of the instrument by reading status bits.

Register address	Type	Data content	Instruction
52	Read only	Point 1 status bit	uint16, 16-bit integer data, bit0: 0 indicates normal calibration, 1 indicates abnormal calibration. Bit1-bit15 is temporarily unused. The default value is 0.
53	Read only	Point 2 status bit	uint16, 16-bit integer data, bit0: 0 indicates normal calibration, 1 indicates abnormal calibration. Bit1-bit15 is temporarily unused. The default value is 0.
54	Read only	Point 3 status bit	uint16, 16-bit integer data, bit0: 0 indicates normal calibration, 1 indicates abnormal calibration. Bit1-bit15 is temporarily unused. The default value is 0.

***Note*:** Possible reasons for abnormal calibration:

1. The light path is blocked by dust. Wipe the lens glass at the corresponding point with a dust-free cloth.
2. In the self-calibration state, there is a sample in the test slot at startup.
3. During manual calibration, there is a large difference between the manual calibration value and the standard value of the calibration plate.
4. The light source is permanently damaged, please send it back to the factory for maintenance.

VII. Error information code table

Information code	Instruction
01	Invalid information code
02	Wrong memory address or quantity
03	In auto calibration mode, changing the calibration value has no effect.
04	Write register value is not within the allowed range

VIII. Instruction of register special value and abnormal handling

1. Abnormal communication description

After the power is turned on, when the communication indicator in the upper left corner of the display unit shows that there is something abnormal, and the calibration indicator is abnormal, and when there is no temperature display, the user can enter the “System State” interface to check.
If all the controller are abnormal, it indicates that the Human Machine Interface is not communicating. There are three general reasons for the communication abnormality:

1. The power supply of the “measure and control host” is abnormal. Check whether the 7.5V power cable of the “measure and control host” and the “Human Machine Interface control box” is correctly connected. The multimeter can be used to measure whether the Power Supply voltage is 7.5V.

2. The communication cable is not wired correctly. Check if the RS485①communication line of the “measure and control host” and “Human Machine Interface control box” is connected correctly.

3. The controller is damaged and needs to be returned to the factory for repair. If only some of the test points communicate abnormally, it is because the corresponding controller is damaged, or it is because there is a problem with the connection line, and it should be returned to the supplier for repair.

2. Abnormal calibration description

When the calibration indicator in the upper left corner of the HMI is red, or the register value of the controller is shown in Table 8.1, it indicates that the instrument is abnormally calibrated. At this time, the user should enter the "System Status" interface to see which point or points is abnormal, the general calibration status is abnormal for the following four reasons:

1. The light path is blocked by dust. Wipe the lens glass at the corresponding point with a dust-free cloth.
2. In the auto-calibration state, there is a sample in the test slot when the machine is turned on.
3. During manual calibration, the manual calibration value differs greatly from the standard value of the calibration plate.
4. The light source is permanently damaged, please send it back to the factory for repair.

Register address	Data content	Register value
52	Point 1 status bit	1
53	Point 2 status bit	1
54	Point 3 status bit	1

Table 8.1 register value under abnormal calibration

3. Abnormal controller description

- When the transmittance value of the test point in the human-machine interface always shows “11.1100” or the measured value of the optical density always shows “0.9543”, or the register value of the controller is shown in Table 8.2, regardless of whether there is a test object or a restart. The following phenomena are still the same, indicating that the controller corresponding to the test point is faulty (*the three test points controlled by the controller will display the above faults*) and the controller needs to be returned to the factory for inspection and maintenance.

Register address	Data content	Register value
0 or 100	Transmittance 1(uint16)	1111
1or 101	Transmittance 2(uint16)	1111
2 or 102	Transmittance 3(uint16)	1111
3 or 103	Transmittance 1(float)	0.1111
4 or 104	Transmittance 1(float)	
5 or 105	Transmittance 2(float)	0.1111
6 or 106	Transmittance 2(float)	
7 or 107	Transmittance 3(float)	0.1111
8 or 108	Transmittance 3(float)	
9 or 109	Optical density1(float)	0.1111
10 or 110	Optical density 1(float)	
11or 111	Optical density 2(float)	0.1111
12 or 112	Optical density 2(float)	
13 or 113	Optical density 3(float)	0.1111
14 or 114	Optical density 3(float)	
200	Optical density 1(int16)	1111
201	Optical density 2(int16)	1111
202	Optical density 3(int16)	1111

Table 8.2 register value when the controller is abnormal

- When the transmittance value of the test point in the human-machine interface always shows “88.8800” or the measured optical density always shows “0.0512”, or the register value of the controller is shown in Table 8.3, regardless of whether there is a test object or a restart. The above phenomenon is still the same afterwards, indicating that the test point is not connected to the

receiving probe.

If a probe is connected and the above situation still occurs, the probe may be badly connected or the corresponding controller or the receiving probe may be faulty. You need to return the controller and the corresponding receiving probe to the factory for inspection and maintenance.

Register address	Data content	Register value
0 or 100	Transmittance 1(uint16)	8888
1or 101	Transmittance 2(uint16)	8888
2 or 102	Transmittance 3(uint16)	8888
3or 103	Transmittance 1(float)	0.8888
4 or 104	Transmittance 1(float)	
5 or 105	Transmittance 2(float)	0.8888
6 or 106	Transmittance 2(float)	
7 or 107	Transmittance 3(float)	0.8888
8 or 108	Transmittance 3(float)	
9 or 109	Optical density 1(float)	0.8888
10 or 110	Optical density 1(float)	
11or 111	Optical density 2(float)	0.8888
12 or 112	Optical density 2(float)	
13 or 113	Optical density 3(float)	0.8888
14 or 114	Optical density 3(float)	
200	Optical density 1(int16)	8888
201	Optical density 2(int16)	8888
202	Optical density 3(int16)	8888

Table 8.3 register value when the probe is unconnected

When the temperature on the main interface of the HMI keeps showing "88.8", or in the "System Status" interface, the temperature of the controller keeps showing "88.8", or the controller register value is shown in Table 8.4, indicating the temperature probe of the controller is damaged, you can send the corresponding controller to the factory for maintenance.

Register address	Data content	Register value
99 or 199	Temperature	888

Table 8.4 register value when the temperature is abnormal