Digital Hall Current Sensor

CYHCSD-S3

User's Manual

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The sensor CYHCSD-S3 is a Hall Effect current sensor for the measurement of AC current. The sensor has galvanic isolation between the high-power primary conductor and the secondary electronic circuit. The sensor has an analog and different digital output signals under different power supplies. The data communication between sensor and digital equipment can be realized directly through the interface RS-485 MODBUS.

1. Characteristics

- AC current measurement
- High measuring accuracy
- Analog output voltage 2.5VDC±2.5VAC, 5VDC±5VAC
- Digital output (RS-485 Modbus)
- Protection against overvoltage
- Protection against reversed polarity
- Output protection against electrical disturbances

2. Technical Data

Analog Electrical Data

Rated input current (RMS, AC)	25A,30A,40A,50A,60A,70A,80A,90A, 100A,200A,300A
Instantaneous output voltage	2.5VDC ± 2.5VAC (peak value), 5VDC ± 5VAC (peak value)
Power supply	+12V DC, +15VDC, +24V DC
Measuring accuracy	±1.0%FS for 25A~49A; ±0.5%FS for 50A~300A
Linearity (10% - 100%), 25°C	±0.5%FS for 25A~49A, ±0.2%FS for 50A~300A
Zero offset voltage	±10mV
Hysteresis error	±10mV
Thermal drift of offset voltage	≤300ppm/°C
Thermal Drift (-10°C to 50°C)	≤1000ppm/°C
Galvanic isolation	3 kV DC, 1min.

Isolation resistance	≥100MΩ
Response time	≤10μs for instantaneous output
Frequency Bandwidth (-3dB)	45 – 65 Hz
di/dt following accuracy	50A/μs
Overload capacity	5 times of rated current
Current consumption	≤25mA
Output load	≥2kΩ

General Data:

Mounting	35mm DIN Rail
Case style and Window size	S3 with aperture Ø20mm
Protection of Case	IP20
Operating temperature	-40°C ~ +70°C
Storage temperature	-40°C ~ +70°C
Relative humidity	5%~95% no dew
MTBF	≥ 100k hours

Digital Electrical Data:

Digital output	Current I • Measuring Range > 100A RMS value with 1 decimal places in binary code • Measuring Range ≤ 100A RMS value with 2 decimal places in binary code Frequency F (real frequency with 3 decimal places in binary code)
Output interface:	RS-485, MODBUS
Baud rate:	1200, 2400, 4800, 9600 (default), 19.2K, 38.4K, 57.6K, 115.2K bps
Refreshing period	5ms
Measuring accuracy	±0.5%FS
Linearity (10% - 100%), 25°C	±0.2%FS
Galvanic isolation	2500V rms for 1 min. per UL 1577
Bus protection	±15kV ESD protection on RS-485 input/output pins, open- and short circuit, fail-safe receiver inputs
Power consumption	<650mW (under power supply +12V)

3. Definition of Part number

CYHCSD	-	S3	-	m	-	x	n	y
(1)		(2)		(3)		(4)	(5)	(6)

(1)	(2)	(3)	(4)	(5)	(6)
Series name	Case style	Rated input current (RMS)	Analog output voltage	Power supply	Interface
CYHCSD	S3	m = 25A, 30A, 40A, 50A, 60A, 70A, 80A, 90A, 100A, 200A, 300A	**x=3:** 2.5VDC±2.5VAC (peak value) **x=8:** 5VDC±5VAC (peak value)	**n=2:** +12V DC **n=3:** +15V DC **n=4:** +24V DC	**y=3:** RS485 MODBUS

Example 1: CYHCSD-S3-50A-323 for AC Current Sensor with
Rated input current: 0-50A AC (RMS)

	Analog output voltage:	2.5VDC ± 2.5VAC (peak value)
	Power supply:	+12V DC
	Interface:	RS-485 MODBUS

Example 2: CYHCSD-S3-50A-843 for AC Current Sensor with

Rated input current:	0-50A AC (RMS)
Analog output voltage:	5VDC ± 5VAC (peak value)
Power supply:	+24V DC
Interface:	RS-485, MODBUS

Relation between Input and Output:

Sensor CYHCSD-S3-50A-323		
Input Current (A)	Analog Output Voltage (V)	Received Digital Output
$-50\sqrt{2}$	0	01 03 02 EC78 F4A6
$-25\sqrt{2}$	1.25	01 03 02 F63C FFF5
0	2.5	01 03 02 0000 B844
$25\sqrt{2}$	3.75	01 03 02 09C4 BF87
$50\sqrt{2}$	5	01 03 02 1388 B512

Sensor CYHCSD-S3-50A-843		
Input Current (A)	Analog Output Voltage (V)	Received Digital Output
$-50\sqrt{2}$	0	01 03 02 EC78 F4A6
$-25\sqrt{2}$	2.5	01 03 02 F63C FFF5
0	5	01 03 02 0000 B844
$25\sqrt{2}$	7.5	01 03 02 09C4 BF87
$50\sqrt{2}$	10	01 03 02 1388 B512

4. Case Style and Connection

Fig.1 Case S3 with Aperture Ø20mm

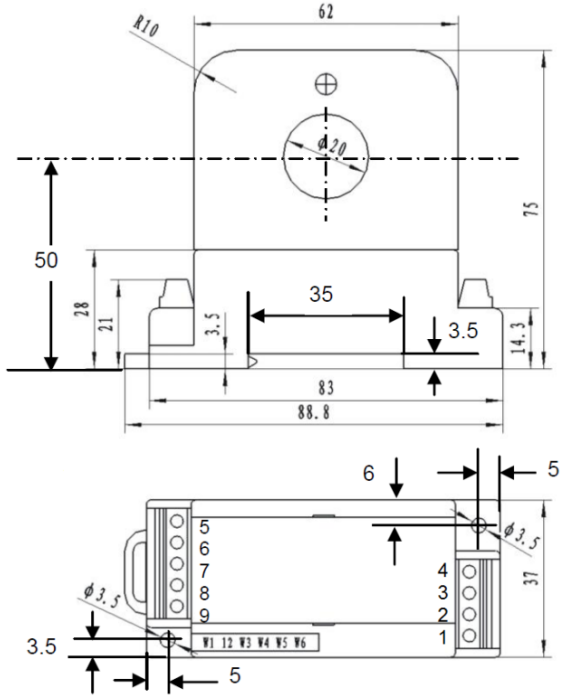

Fig.2 Case Dimensions

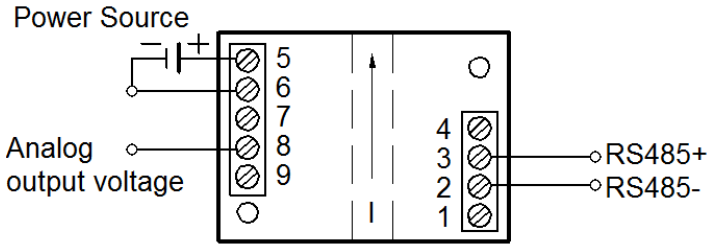

Fig.3 Pin Definition

5. Communication Protocol and Order Sets

The orders of the digital Hall Effect current sensor series CYHCSD-S3 are MODBUS format. Their output communication protocol is RS-485 interface protocol.

5.1 Register Address Table

Register Address	Content	Register Number	R/W	Data Range
0x0010	Reserved	1		
0x0011	Current	1	R	According to measuring range
0x0012-0x0018	Reserved	7		
0x0019	Frequency	1	R	45000 - 65000
0x0020	Address and baud rate	1	R/W	Address 0x01-0xF7 Baud rate 0x03-0x0A
0x0021	Device name	2	R	"CSS3"
0x0023	Serial data format	1	R/W	Parity check: 0x00-0x02 Length of stop bit: 0x00-0x02
0x0024	Internal output low-pass filter cutoff frequency*10	1	R/W	1-10000
0x0025-0x002F	Reserved	11		

Notice: 0x means the number is hex number, same as below.

5.2 Frame Format and Example

5.2.1 Function code 0x03 --- read data from digital sensors

Request frame of master equipment

Sensor address	(0x01-0xF7	1 byte)
Function code	(0x03	1 byte)
Start register address	(2 bytes)	
Register number	(2 bytes)	
CRC	(2 bytes)	

Notice: CRC means Cyclic Redundancy Check. In this product CRC is calculated according to CRC-16 (Modbus) standard, same as below.

Read Data Examples:

(1) Read current value (RMS)

Address	Function	Register Address		Register Number		CRC-L	CRC-H
0x01	0x03	0x00	0x11	0x00	0x01	0xD4	0x0F

(2) Read frequency value

Address	Function	Register Address		Register Number		CRC-L	CRC-H
0x01	0x03	0x00	0x19	0x00	0x01	0x55	0xCD

(3) Read device name and settings

Address	Function	Register Address		Register Number		CRC-L	CRC-H
0x01	0x03	0x00	0x20	0x00	0x05	0x84	0x03

Answer frame of digital sensors

Sensor address	(0x01-0xF7	1 byte)

Function code	(0x03	1 byte)
Data byte length	(2*register number	1 byte)
Data read from register	(Register contents bytes)	2*register number
CRC	(2 bytes)	

Answer of Read Data Examples:

(1) Received current value

Measuring Range > 100A

Address	Function	Data byte length	Data		CRC-L	CRC-H
0x01	0x03	0x02	0x0B	0xB8	0xBF	0x06

Current value format

2 bytes data in binary code with 1 decimal places, original code by positive values, two complement code by negative values

data range 0~3000 (measuring range is 300A as an example)

Signification: 3000 corresponds to positive input with rated RMS value. E.g. when input current equals 300A AC, expected output result is 3000 or 0x0BB8.

Measuring Range ≤ 100A

Address	Function	Data byte length	Data		CRC-L	CRC-H
0x01	0x03	0x02	0x0B	0xB8	0xBF	0x06

Current value format

2 bytes data in binary code with 2 decimal places, original code by positive values, two complement code by negative values

Data range 0~3000 (measuring range is 30A as an example)

Signification: Data 3000 corresponds to positive input with rated RMS value. E.g. when input current equals 30A AC, expected output result is 3000 or 0x0BB8; when input current equals 15A AC, expected output result is 1500 or 0x05DC

(2) Received frequency value

Address	Function	Data byte length	Data	CRC-L	CRC-H
0x01	0x03	0x02	0xC3 0x50	0xE8	0x88

Frequency value format

2 bytes data in binary code with 3 decimal places

Data range 45000~65000

Signification: Data/1000 is the real frequency. E.g. when input current frequency equals 50 Hz, expected output result is 50000 or 0xC350.

(3) Received device name and settings

Address	Function	Length	Data				CRC-L	CRC-H
0x01	0x03	0x0A	0x0106	0x43535333	0x0000	0x0000	0x71	0x94

Explanation of data:

0x0106 is sensor address and baud rate.

Valid addresses: 0x01 to 0xF7

Baud rate: 0x03 -- 1200 bps, 0x04 -- 2400 bps, 0x05 -- 4800 bps,0x06 -- 9600 bps (default), 0x07 -- 19.2 kbps, 0x08 -- 38.4 kbps, 0x09 -- 57.6 kbps, 0x0A -- 115.2kbps

0x43535333 is the ASCII code of “CSS3”.

0x0000 is parity check and length of stop bit.

Parity check: 0x00 -- none (default), 0x01 -- odd, 0x02 -- even

Length of stop bit: 0x00 – 1 bit (default), 0x01 -- 1.5 bits, 0x02 -- 2 bits

0x0000 is the cutoff frequency of internal output low-pass filter.

Internal low-pass filter cutoff frequency:

0 -- no low-pass filter (default),

others -- cutoff frequency*10

5.2.2 Function code 0x10 --- write data to digital sensors

Request frame of master equipment

Sensor address	(0x01-0xF7	1 byte)
Function code	(0x10	1 byte)

Start register address	(2 bytes)
Register number	(2 bytes)
Data byte length	(2*register number 1 byte)
Data write to register	(2*register number bytes)
CRC	(2 bytes)

Write Data Examples:
(1) Change address and baud rate

Address from 01 (default) to 02, baud rate from 9600 (default) to 19.2K.

Address	Function	Register Address		Register Number		Data Number	Data		CRC-L	CRC-H
0x01	0x10	0x00	0x20	0x00	0x01	0x02	0x02	0x07	0xE1	0x92

Explanation:

Data 0x0207 is written into register 0x0020. The high byte 0x02 means the sensor address on the RS485 bus. The low byte 0x07 means the baud rate of communication.

(2) Change serial data format

Parity check from none (default) to even, length of stop bit from 1 bit (default) to 2 bits.

Address	Function	Register Address		Register Number		Data Number	Data		CRC-L	CRC-H
0x01	0x10	0x00	0x23	0x00	0x01	0x02	0x02	0x02	0x21	0xA2

Explanation:

Data 0x0202 is written into register 0x0023. The high byte 0x02 means the parity check. The low byte 0x02 means the length of stop bit.

(3) Change cutoff frequency of internal output low-pass filter
From no low-pass filter (default) to cutoff frequency 65.5Hz.

Address	Function	Register Address		Register Number		Data Number	Data		CRC-L	CRC-H
0x01	0x10	0x00	0x24	0x00	0x01	0x02	0x02	0x8F	0xE0	0x70

Explanation:

This current sensor has a first order digital low-pass filter for output, which keeps the output result with higher stability when cutoff frequency is low. But a lower cutoff frequency also causes slower response. User can turn off this low-pass filter or adjust the cutoff frequency by setting this register.

Please note that this low pass filter is not directly applied to the input signal. So, it doesn't cause additional attenuation of amplitude. But the output response is slower, when the input RMS value variants.

Data 0x028F is written into register 0x0024. 0x028F=655, which corresponds cutoff frequency 65.5Hz.

Answer frame of digital sensors

Sensor address	(0x01-0xF7	1 byte)
Function code	(0x10	1 byte)
Start register address	(2 bytes)	
Register number	(2 bytes)	
CRC	(2 bytes)	

Answer of Write Data Examples:

(1) Received correct answer of changing address and baud rate

Address	Function	Register Address		Register Number		CRC-L	CRC-H
0x01	0x10	0x00	0x20	0x00	0x01	0x00	0x03

(2) Received correct answer of changing serial data format

Address	Function	Register Address		Register Number		CRC-L	CRC-H
0x01	0x10	0x00	0x23	0x00	0x01	0xF0	0x03

(3) Received correct answer of changing cutoff frequency

Address	Function	Register Address		Register Number		CRC-L	CRC-H
0x01	0x10	0x00	0x24	0x00	0x01	0x41	0xC2

5.2.3 Error frame from digital sensors

Error frame of digital sensors

Sensor address	(0x01-0xF7	1 byte)
Function code	(0x80 | function code	1 byte)

Error Code	(0x01-0x04	1 byte)
CRC	(2 bytes)	

The symbol "|" means logic "OR"

Error code

0x01: illegal function
0x02: illegal register address
0x03: illegal data value or register number
0x04: sensor failures (read or write error)

Examples of Error:

(1) Wrong function code has been sent

For example, the function code 0x04 has been sent in a sending frame. Received error answer is

Address	Function	Error Code	CRC-L	CRC-H
0x01	0x84	0x01	0x82	0xC0

(2) Wrong register address has been sent

The sending frame is for reading the current value as shown in paragraph 5.2.1, but the register address is 0x0001. Received error answer is

Address	Function	Error Code	CRC-L	CRC-H
0x01	0x83	0x02	0xC0	0xF1

(3) Wrong register number has been sent

The sending frame is for reading device name and settings as shown in paragraph 5.2.1, but the register number is 0x0010. In this situation, the last register address that should be written is 0x0030, which is beyond the valid address range 0x0010 to 0x002F. Received error answer is

Address	Function	Error Code	CRC-L	CRC-H
0x01	0x83	0x02	0xC0	0xF1

(4) Register number must be greater than 0

The sending frame is for reading the current value as shown in paragraph 5.2.1, but the register number is 0x0000. Received error answer is

Address	Function	Error Code	CRC-L	CRC-H
0x01	0x83	0x03	0x01	0x31

(5) Wrong data number has been sent

The sending frame is for changing cutoff frequency as shown in paragraph 5.2.2, but the data number is 0x03, which doesn't match register number*2. Received error answer is

Address	Function	Error Code	CRC-L	CRC-H
0x01	0x90	0x03	0x0C	0x01

(6) Data written is beyond valid data range

The sending frame is for changing device address and baud rate as shown in paragraph 5.2.2, but the data is 0xF807, which is beyond the valid device address range 0x01-0xF7. Received error answer is

Address	Function	Error Code	CRC-L	CRC-H
0x01	0x90	0x03	0x0C	0x01

(7) The case (0x04: Sensor failures) should not occur in this sensor.

Notes:

1. If digital sensor address or CRC is wrong, no answer frame or error frame will be back from sensor.
2. Low byte of CRC is transmitted first. By register address, register number and data, high byte is transmitted first.
3. Register word length is 16 bits (2 bytes).
4. Every valid request frame has a corresponding answer. The master equipment should send the next request after the answer has been received. The maximum waiting time for data reading equals the data refreshing period. And the waiting time for configuration changing is up to 25ms.

6. Measuring Procedure

The terminal program **HTerm** for serial communication is used to test the sensor. The sensor is connected to PC via a USB to RS485 converter, which is shown below.

*Other adapters could also be used.

Fig.4 USB to RS485 Converter

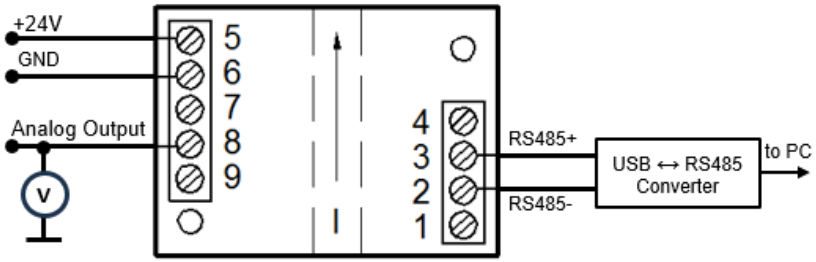

Fig.5 Sensor Connecting Diagram to Master Equipment with RS-485 Interface

1) Install the sensor.
2) Connect the power supply (not turned on) of the sensor through Pin 5 and Pin 6.
3) Connect the analog output of the sensor through Pin 8.
4) Connect the pin 3 (RS485+) to the converter pin port RS485+, and Connect the pin 2 (RS485-) to the converter pin port RS485-.
5) Connect the USB of the converter to the PC.
6) Open the terminal program HTerm and set the parameters as the following Fig. 6.

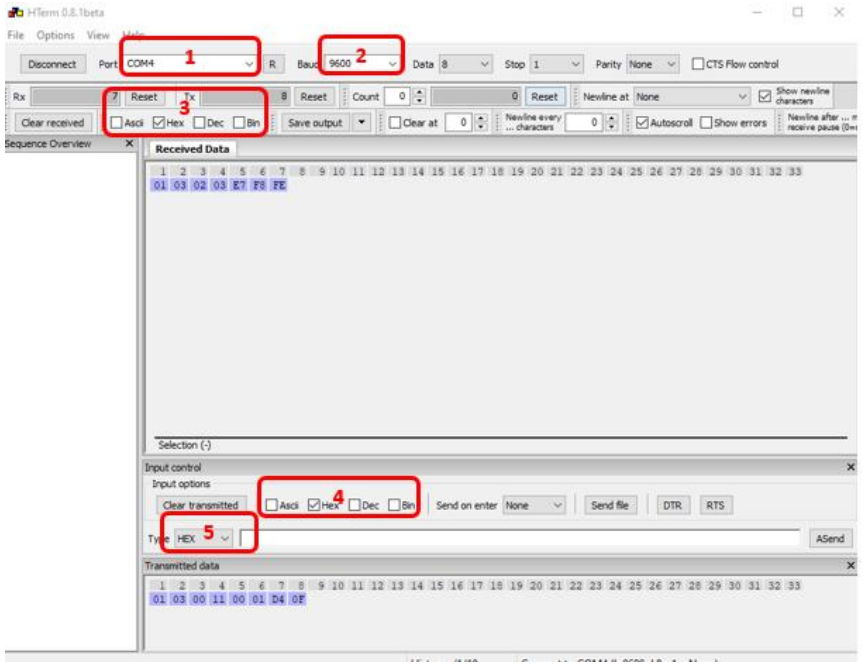

Fig.6 HTerm Parameter Interface

1 Port Name: ***COM4*** (Not fixed, subject to actual conditions)
2 Baud rate ***9600*** (default), Data ***8***, Stop ***1***, Parity ***None***
3 Received data type: ***HEX***
4 Sent data displayed type: ***HEX***
5 Command sent type: ***HEX***

7) Turn on the power supply for the sensor, click the “connect” button in terminal program Hterm.
8) Start the test.
9) Use a digital multimeter to measure the analog voltage output of pin 8.
10) Read the digital current value by Command Code sent in area 5 through RS485. Command code definition will be explained in part 7 Explanation of the Communication Protocol.

7. Explanation of the Communication Protocol

Here the function code 0x03 “reading data from digital sensor” will be used as an example.

Request frame of master equipment

Sensor address	(0x01-0xF7	1 byte)
Function code	(0x03	1 byte)
Start register address	(2 bytes)	
Register number	(2 bytes)	
CRC	(2 bytes)	

Answer frame of digital sensors

Sensor address	(0x01-0xF7	1 byte)
Function code	(0x03	1 byte)
Data byte length	(2*register number	1 byte)
Data read from register	(Register contents number bytes)	2*register
CRC	(2 bytes)	

Notice: CRC means Cyclic Redundancy Check. In this product CRC is calculated according to CRC-16 (Modbus) standard, same as below

- **CRC code generation**

CRC code could be generated through online CRC code calculator.
https://crccalc.com/?crc=123456789&method=&datatype=ascii&outtype=hex

Input/output: HEX
Type: CRC-16
and then find the result for CRC-16/Modbus.

7.1 Read current value from digital sensors

- **Read current value**

Address	Function	Register Address		Register Number		CRC-L	CRC-H
0x01	0x03	0x00	0x11	0x00	0x01	0xD4	0x0F

- The CRC code from the calculator for "0103 0011 0001" is 0x0FD4, which consists of two bytes (high byte and low byte). 0F is the high byte and D4 is the low byte.
  Make sure the bytes are transmitted in the correct order, as reversing them may cause communication errors.
- The register address must be correct. In some PLC or terminal program, there will be a shift in register address. This is very important since incorrect register addresses can cause communication errors.

- **Received current value**

Measuring Range > 100A

Address	Function	Data byte length	Data		CRC-L	CRC-H
0x01	0x03	0x02	0x0B	0xB8	0xBF	0x06

Current value format

2 bytes data in binary code with 1 decimal places, original code by positive values, two complement code by negative values
data range 0~3000 (measuring range is 300A as an example)

Digital current (RMS) with unit A = decimal value of (Data)/10

Signification: 3000 corresponds to positive input with rated RMS value. E.g. when input current equals 300A AC, expected output result is 3000 or 0x0BB8.

Measuring Range ≤ 100A

Address	Function	Data byte length	Data		CRC-L	CRC-H
0x01	0x03	0x02	0x0B	0xB8	0xBF	0x06

Current value format

2 Bytes
data in binary code with 2 decimal places, original code by positive values, two complement code by negative values

Data Range
0x0000 (decimal 0) ~ 0x0BB8 (decimal 3000) (measuring range is 30A as an example)

Digital current (RMS) with unit A = decimal value of (Data)/100

E.g.

when input current equals 30A (RMS) AC, expected output result is 0x0BB8 (in received data, decimal value is 3000 then using 3000/100 is the measured current value with unit A).

7.2 Read frequency from digital sensors

- **Read frequency value**

Address	Function	Register Address		Register Number		CRC-L	CRC-H
0x01	0x03	0x00	0x19	0x00	0x01	0x55	0xCD

➢ The CRC code from the calculator for "0103 0019 0001" is 0xCD55, which consists of two bytes (high byte and low byte). CD is the high byte and 55 is the low byte.
Make sure the bytes are transmitted in the correct order, as reversing them may cause communication errors.

- **Received frequency value**

Address	Function	Data byte length	Data		CRC-L	CRC-H
0x01	0x03	0x02	0xC3	0x50	0xE8	0x88

Frequency value format

2 bytes data in binary code with 3 decimal places
Data range 45000~65000

Signification: Data/1000 is the real frequency. E.g. when input current frequency equals 50 Hz, expected output result is 50000 or 0xC350.

Digital frequency with unit Hz = decimal value of (Data)/1000

7.3 Read device name and settings from the sensor

- **Read device name and settings from the sensor**

Address	Function	Register Address	Register Number	CRC-L	CRC-H
0x01	0x03	0x00	0x20	0x00	0x05	0x84	0x03

➢ The CRC code from the calculator for "0103 0020 0005" is 0x0384, which consists of two bytes (high byte and low byte). 03 is the high byte and 84 is the low byte.
Make sure the bytes are transmitted in the correct order, as reversing them may cause communication errors.

- **Received device name and settings**

Address	Function	Length	Data				CRC-L	CRC-H
0x01	0x03	0x0A	0x0106	0x43535333	0x0000	0x0000	0x71	0x94

0x0106 is sensor address and baud rate.

0x01 Valid addresses 0x01 to 0xF7

0x06 Baud rate
0x03 -- 1200 bps
0x04 -- 2400 bps
0x05 -- 4800 bps
0x06 -- 9600 bps (**default**)
0x07 -- 19.2 kbps
0x08 -- 38.4 kbps
0x09 -- 57.6 kbps
0x0A -- 115.2kbps

0x43535333 is the ASCII code of "CSS3".

0x0000 is parity check and length of stop bit.

0x00 Parity check:
0x00 -- none (**default**)
0x01 -- odd
0x02 – even

0x00 Length of stop bit:
0x00 – 1 bit (**default**)
0x01 -- 1.5 bits
0x02 -- 2 bits

0x0000 is the cutoff frequency of internal output low-pass filter.
0x0000 -- no low-pass filter (**default**)

others -- cutoff frequency*10 (range 1-10000)
i.e. 0x028F=655, which corresponds cutoff frequency 65.5Hz.