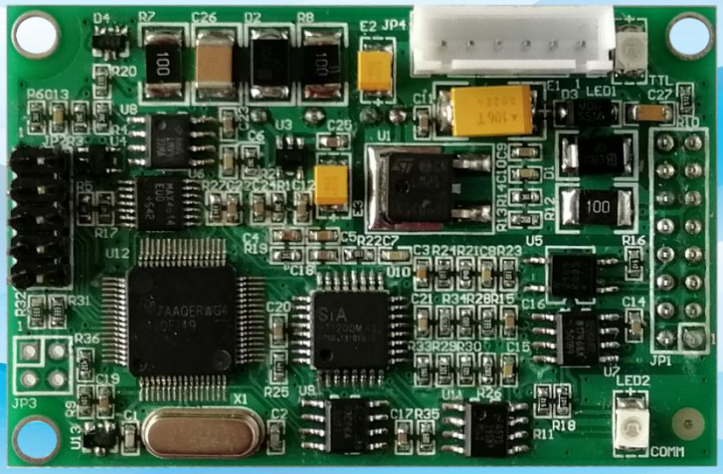
MICROCYBER

M0310-ACT

Modbus to HART Module

User Manual



Warning

1. It is forbidden to disassemble the temperature module by user.

2. Please check if the supply voltage of temperature transmitter meets the power supply voltage requirements in the manual.

Version：V2.2

Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions. Any suggestions for improvement are welcome.

Company Introduction

Microcyber Corporation established as a high-tech enterprise by the Shenyang Institute of Automation Chinese Academy of Sciences, mainly engages in advanced industrial control systems, equipments, instruments and chips for industrial process automation control solutions in the research, development, production and application. Microcyber undertakes a number of national scientific and technical key task and “863” project, and has Liaoning Province networked control systems engineering research center.

Microcyber successfully developed the first domestically certified fieldbus protocol master stack, the first nationally certified fieldbus instrument, and the first domestic safety instrument certified by German TüV, and co-hosted with other units It has formulated the first domestic industrial Ethernet protocol standard EPA and the first industrial wireless communication protocol standard WIA-PA, which have become IEC international standards.

The products and technologies of Microcyber have won two second prizes of National Science and Technology Progress Award, one National Science and Technology Invention Award, one first prize of Science and Technology Progress of Chinese Academy of Sciences, and one first prize of Liaoning Province Science and Technology Progress. The products are exported to Europe and the United States, etc. In developed countries, top companies in the industry such as Emerson in the United States, Rotork in the United Kingdom, and Bifold in the United Kingdom have adopted Microcyber 's key technologies or key components in their products, and have successfully completed more than 200 large-scale automation engineering projects.

Microcyber passed the Authentication of ISO 9001 Quality System, and has an outstanding innovative R&D team, plentiful practical experiences of design of the Automatic engineering, a leading product series, a huge market network, a strict quality management system and an excellent enterprise culture. All these further a solid foundation of entrepreneurship and sustainable development for Microcyber.

Carrying the ideals of employees, creating customer value and promoting enterprise development.

Terminology

Common Commands – Set of HART commands that the HART device must support

Common Commands – Set of HART commands that HART devices can optionally support

Special Commands – Customized HART command set by HART device manufacturer

HART master station device - It can be a PC, handheld terminal or DCS HART module, etc., it is the initiator and command issuer of HART communication

DD file – An electronic description file of a HART device. It is a file that describes the HART commands and processing methods supported by the device in a proprietary format. It is mainly used for the adjustment and configuration of HART devices by HART master stations from other manufacturers.

Polling address – Short address, value range 0-63 (HART5.0 is 0-15). It is only used in HART digital communication when the master device takes turns asking whether the slave device on the bus exists.

Equipment variables – Variables inherent in HART equipment, such as instantaneous flow, cumulative flow, flow rate, medium density, medium temperature and other variables in the flow meter

Dynamic variables – A collective name for the four variables that can only be directly operated in the HART command, namely the primary variable (PV), the second variable (SV), the third variable (TV) and the fourth variable (QV). The HART device has an initial. The corresponding relationship between dynamic variables and equipment variables can also be changed by general commands. For example, for a flow meter: the main variable is assigned to instantaneous flow, the second variable is assigned to flow rate, the third variable is assigned to medium temperature, and the fourth variable is assigned to cumulative traffic

Upper limit of main variable range – Stored in the HART device (here refers to the HART module), used to indicate the maximum value of the main variable range

Current output device – It can be a measuring instrument such as flow, level, temperature, etc., which is used as a parameter input device in the control system and uses a 4-20mA analog signal to transmit the measured value of the main variable to the control system.

Two-wire equipment – Field equipment has only two bus connections, which not only supplies power to the field equipment but also realizes 4-20mA analog and HART digital communication. Used for field devices with current consumption not greater than 4mA, such as common temperature and pressure transmitters. Currently, the HART module does not support field devices that are expected to be connected in a two-wire system.

Three-wire equipment – Field equipment is powered by two power lines, and another line forms a HART bus with the positive power line to transmit 4-20mA analog quantities and HART digital communication. Used for field devices with current consumption greater than 4mA, such as Coriolis mass flowmeters and most electromagnetic flowmeters

Four-wire equipment – The field device is powered by two power lines, and the other two lines are connected to the HART bus to realize 4-20mA analog output and HART digital communication. The purpose is the same as that of three-wire equipment

Single point mode – In the entire HART system, there is only one HART slave device connected to the HART bus, and the polling address is '0'. At this time, the HART 4~20mA analog signal is valid and can represent the value of the main variable PV.

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Networking mode – In the entire HART system, the HART bus is connected to multiple HART devices, and the polling addresses are ‘1~63’. At this time, the output current of all HART devices is 4mA, and the analog current does not represent the value of the main variable PV.

CONTENTS

1 Product Overview

Microcyber Corporation (hereinafter referred to as' Microcyber ') has customized multiple embedded protocol conversion modules for field device manufacturers, supporting the connection of Modbus RTU protocol (hereinafter referred to as' Modbus' protocol) from station devices to various fieldbus systems. The function of the M0310-ACT embedded Modbus to HART module (hereinafter referred to as the 'HART module') is to convert the Modbus protocol slave device to the HART protocol slave device.

1.1 Conversion Logic

The HART module (M0310-ACT) is an embedded conversion module that converts input devices in the Modbus device category into HART signal devices. The HART module is embedded into Modbus protocol input devices (such as valve positioners, electric actuators, and other measuring instruments) and runs the Modbus application layer protocol through TTL level signals. The HART module serves as the Modbus master station and the HART slave station to convert data from data registers (such as input registers and hold registers) in the Modbus device into dynamic variables used in the HART command. For example, if the holding register with address 30000 (range 1-65536) in an actuator stores the instantaneous flow value, we can configure the holding register to the device variable 0 (range 0-5) of the HART module, and then specify the device variable 0 as the main variable (or the second, third, and fourth variables). The conversion logic is shown in the following figure.

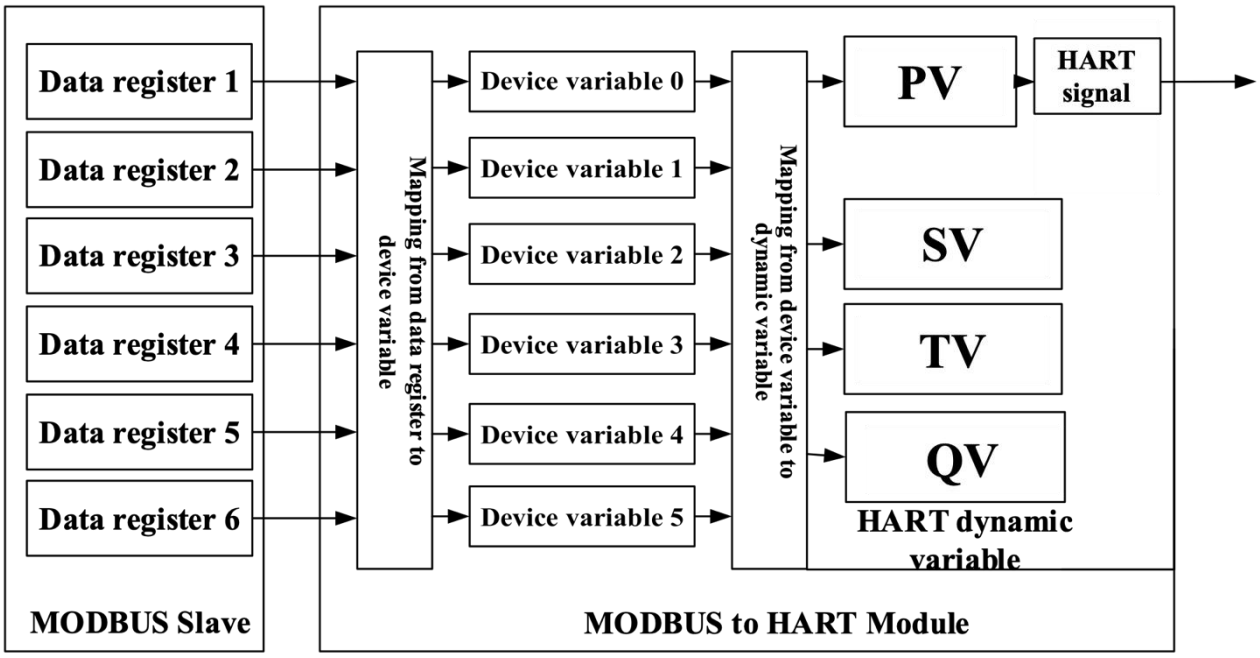


Figure 1.1 Data mapping logic diagram

As a universal product, the HART module needs to face the different interface characteristics of various Modbus devices (slave address, communication rate, communication verification method, etc.), data storage methods (data register address, data type, byte arrangement order, etc.), and end users'

requirements for the allocation of dynamic variables in HART (data register mapping to device variable, device variable mapping to dynamic variable), These can be reconfigured by the device manufacturer.

The above configuration can be done by using the upper computer configuration software provided by Microcyber, or by importing the HART module DD file provided by Microcyber from a HART master station (such as a PC or communicator) with DD file parsing capability. The HART master station configures the HART module through HART communication to determine the interface characteristics between the HART module and Modbus devices, data storage methods, and mapping of device variables to HART dynamic variables.

After the above configuration, the HART master device can access the dynamic variables of the HART module using the HART command, thus achieving digital transmission of data from the Modbus data register to the HART master.

1.2 Configuration Interface

The HART module is located between the HART bus and the Modbus device, and is plugged into the main control board (hereinafter referred to as the user board) of the field device through a back socket. It is externally connected to the HART bus and internally connected to the field device, as shown in the following figure:

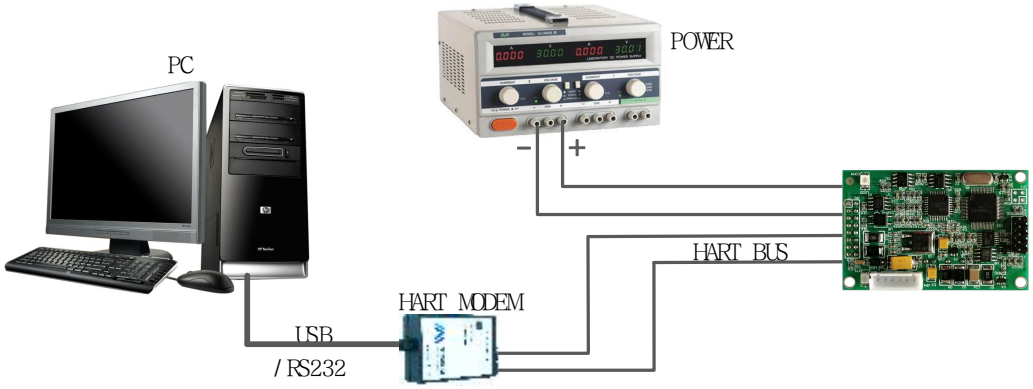


Figure 1.2 Configure the HART module wiring diagram

Taking a PC as the master station device and connecting the field devices through the HART bus as an example. Connect the DC stabilized power supply to the module for power supply, and connect the PC to the HART modem through a USB interface (or RS-232 interface). On the other side of the HART modem, there are two alligator clips with no polarity difference, which are clamped at both ends of the module's HART interface. The configuration software of Microcyber can be run on the PC to configure the HART module. The configured HART module is integrated with the field device, making it a HART field device that can be connected to other HART networks.

When using a communicator with DD file parsing capability for configuration, simply replace the PC and HART modem shown in the figure with the manual operator.

1.3 Hardware User Interface

The HART module uses a 2.54mm pitch 16-core (IDC16, 2x8) standard socket (JP1) to plug into the user board. The pin number definition is shown in the following figure1. When the HART bus is routed on the user board, the HART bus is introduced into the HART module by two pins in the socket.

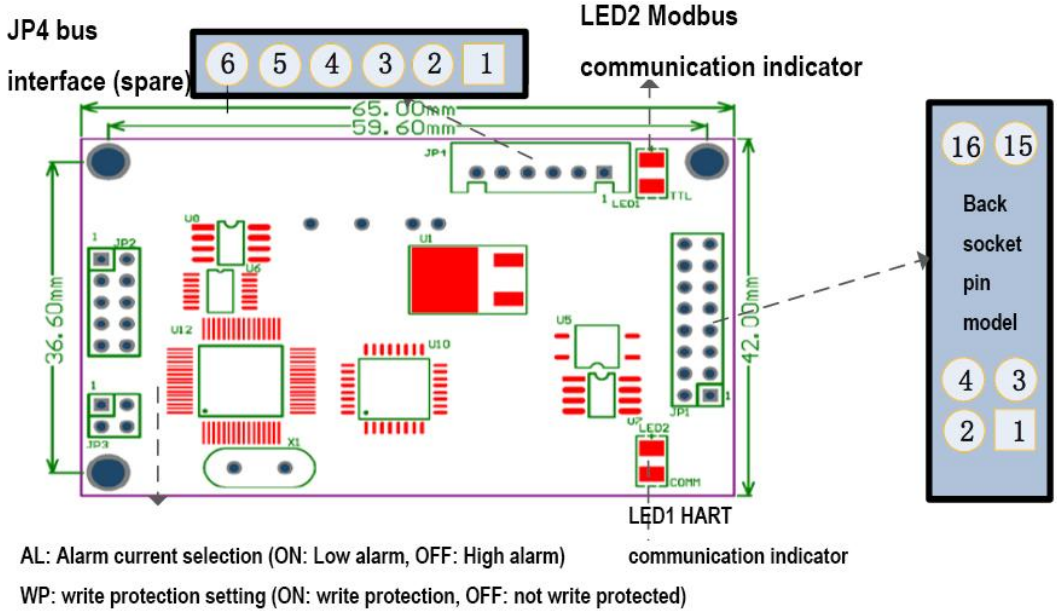


Figure 1.3 Schematic diagram of the hardware user interface

Table 1.1 JP1 pin definition list of HART module socket

Pin	I/O	Name	Description	Pin	I/O	Name	Description
1	I	VCC	Power provided by user's PCB 3.3V/5VDC	2	I	GND	Ground reference provided by user's PCB
3	-	-	No connect	4	-	-	No connect
5	O	TxD	MCU UART Sender	6	I	RDY	Device status bit
7	-	-	No connect	8	I	RxD	MCU UART Receiver
9	-	-	No connect	10	-	-	No connect
11	I	+24V	24V power supply positive by HART circuit provided by user's PCB or terminal	12	I	-24V	24V power supply negative by HART circuit provided by user's PCB or terminal
13	I/O	HART+	HART input / output positive	14	I/O	HART-	HART input / output negative
15	-	-	No connect	16	-	-	No connect

The HART module also has a spare bus interface JP4. It is used to connect HART bus directly when HART bus is not routed on the user board.

Tale 1.2 HART module socket JP4 pin definition list

Pin	1	2	3	4	5	6
Description	HART- Communication negative end	HART+ Communication positive end	HART- Communication negative end	HART+ Communication positive end	24V+ Positive terminal of power supply	24V- Negative terminal of power supply

The HART module is connected to the main controller on the user board using an isolated TTL level. On both sides of the isolation are the UART interfaces of two MCUs. In order to isolate the user board circuit from the HART bus, the user board needs to provide 3.3 or 5VDC isolated power supply. The HART module working power supply comes from the HART bus. Since the HART module does not provide power to the user board, currently the HART module can only support field devices to become three-wire or four-wire HART devices.

The HART module is equipped with two LED indicators to indicate the current working status.

Table 1.3LED Indicator status description

	LED1	LED2	State description
Initial power up	Light On	Light On	Module initialization, not enter working status
Continuously working	Normally on	Normally on	After module initialization, no any HART and Modbus communication
	--	Twinkle	Indicate there's HART communication at present
	Twinkle	--	Indicate there's Modbus communication at present
	Light off	Light off	Indicate there's no any communication or fault status

1.4 User Interface of Software

The link layer and application layer specifications for using Modbus protocol between the HART module and the user board. The HART module serves as the master station, and the user board serves as the slave station. The HART fieldbus interface of the HART module implements the HART7.0 protocol and supports burst mode operation. The supported common commands and general commands are shown in the table below:

Table 1.4 Command table supported by the HART interface

Normal Command No.	Command Name	Normal Command No.	Command Name
0	Read device unique identifier	33	Read Device Variables
1	Read the unit and value of the main variable	34	Write the damping value of the main variable
2	Read the current value and percentage of the main variable	35	Write the upper and lower range values of the main variable
3	Reading dynamic variables and main variable current	36	Set the upper range limit of the main variable with the current value
6	Write polling address	37	Set the lower range limit of the main variable with the current value
7	Read polling address and current mode	40	Entering/exiting fixed current output mode
8	Read dynamic variable categories	41	Device performs self testing
9	Read device variables and status	42	Device performs self reset
11	Read the unique identification of the device using the device station number	43	Set the zero point of the main variable with the current value
12	Read messages	44	Write the unit of the main variable
13	Read labels, descriptions, dates	45	Adjust the low end current value of the current loop (4.000mA)
14	Read main variable sensor information	46	Adjust the high-end current value of the current loop (20.000mA)
15	Read the output information of the main variable	47	Write the main variable transfer function
16	Read the final assembly number	49	Write the serial number of the main

			variable sensor
17	Write a message	50	Read dynamic variable assignment
18	Write labels, descriptions, dates	51	Write dynamic variable assignment
19	Write the final assembly number	53	Write device variable units
20	Read Long Label	59	Write the number of leading characters
21	Read device unique identification using long tags		
22	Write Long Label		
38	Reset configuration change flag		
48	Read additional transmitter status		

The default polling address (short address) for the HART module at the factory is' 0 '.

The serial transmission mode supported by the HART module is ModbusRTU mode, and the supported serial communication interface features are shown in the table below:

Table 1.5 Modbus communication interface feature table

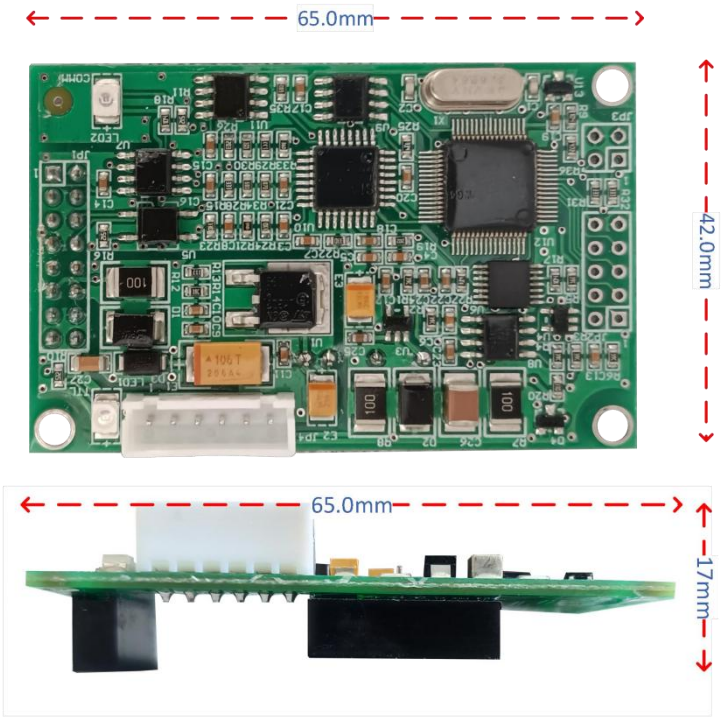
	Default parameter	Optional range
Slave address	1	1-247
Baud rate	9600	1200,2400,4800,9600, 19200,35700,38400,57600
Data bits	8	7, 8 (Only ModbusRTU is supported in this version, so setting 8 bits is valid)
Stop bit	1	1，2
Check	EVEN	ODD，EVEN，NONE
CRC verification	Low-High Order	Low-High Order，High-Low Order

The Modbus commands supported by the HART module Modbus communication interface are shown in the following table:

Table 1.6 Command list supported by Modbus communication interface

Normal Command No.	Command Name	Normal Command No.	Command Name
1	Reading coil status	4	Read register value
2	Read discrete input status	5	Write coil
3	Read register value	16	Write multiple register values

1.5 Hardware Dimension



2 Quick Configuration

2.1 Introduction to configuration tools

As mentioned earlier, the upper computer configuration software provided by Microcyber can be used to configure the HART module, or a HART master station with DD file parsing ability (such as a PC or communicator) can import the HART module DD file provided by Microcyber, and the above configuration can also be done. Taking the configuration software of Microcyber running on a PC as an example, the hardware connection is shown in the connection diagram in section 1.2, and the connection instructions are described in section 1.3.

For instructions on the use and status of the HART modem, please refer to Microcyber's "HART Modem Manual".

For the installation and general operation of the upper computer configuration software, please refer to Microcyber's "HART Configuration Software User Manual". This only introduces the configuration and simple general operations of the HART module.

After completing the wiring according to section 1.2 and powering up the field device with the HART module inserted, double-click the desktop shortcut icon 

on a PC with the installed HART configuration software (HartMPT.exe) (Or run"C:\Program Files\Microcyber\HartMPT\HartMPT.exe "）, to enter the initial interface of the HART computer configuration software, as shown in the following figure:

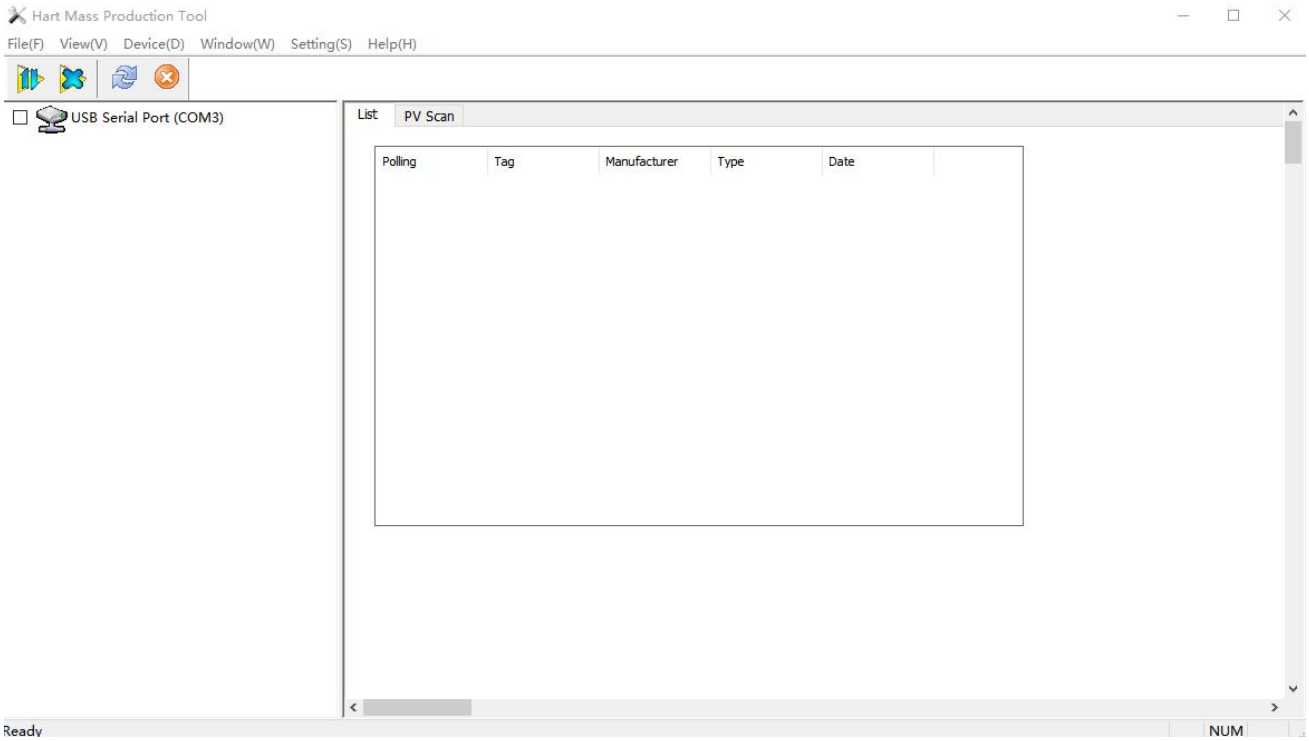


Figure 2.1 Configuration software icon and initial interface

The 'COM3' shown in the above figure is a virtual serial port created by the Windows operating system for a USB interface HART modem. If the driver of the HART modem (virtual serial port chip) is

installed correctly and the USB interface HART modem is inserted into the PC, the green indicator light will light up; Otherwise, check the wiring and drive installation results. After the module is powered on, check the LED1 and LED2 states of the HART module. If both are in a steady on state, it indicates that the HART module is in a standby state.

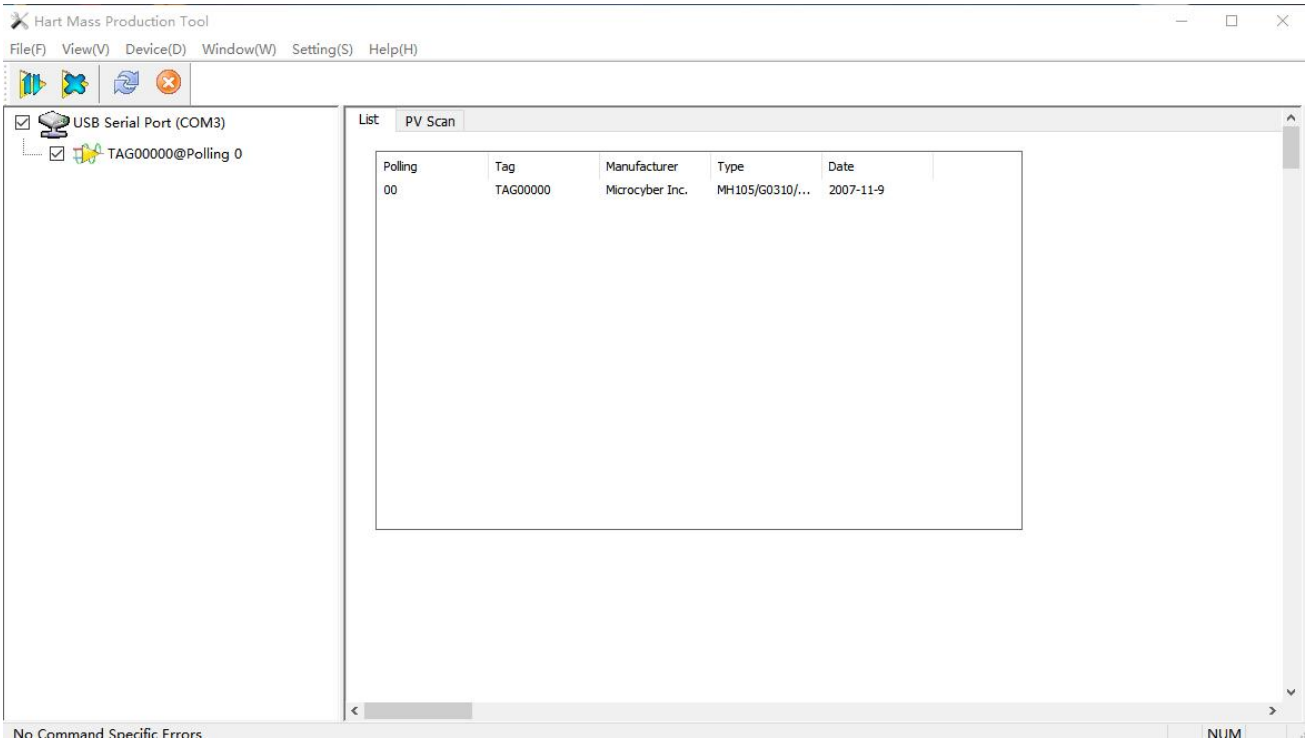


Figure 2.2 Polling online HART devices

In the network view of the initial interface, right-click on the serial port node (COM3) and select 'Single Node' → 'Node 0'. The configuration software sends a '0' ordinary command to inquire if the short address of the HART device with '0' is online. When the HART module leaves the factory, the default short address is' 0 '. If there are no errors in wiring and power supply, the HART configuration software will list the inquiry results, as shown in the above figure. The device with a short address of '0' (hereinafter referred to as device 0) shown in the diagram is online. Left click on device 0 with the mouse, and after continuous communication between the configuration software and the HART module, the tab view changes as shown in the following figure:

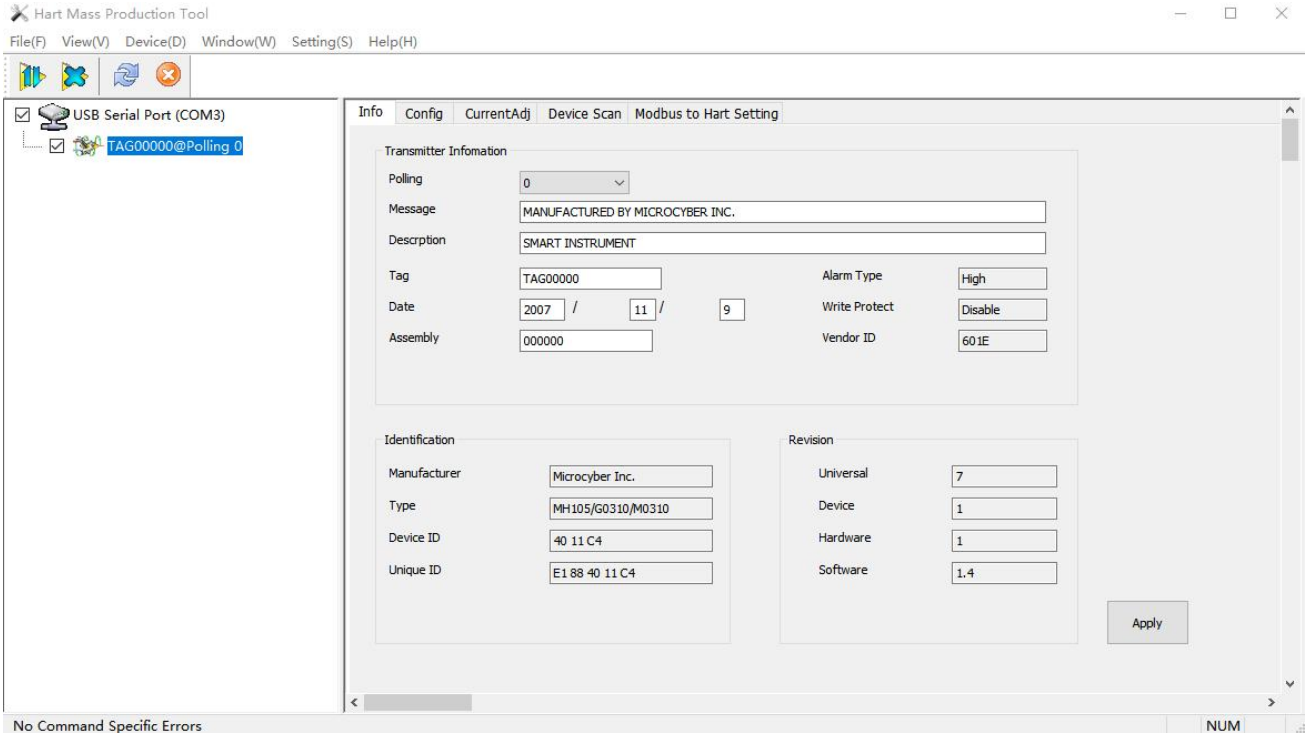


Figure 2.3 HART module tab

Compared to other types of HART devices, the tab 'Gateway Configuration' is unique to the HART module, and the other four tabs in the figure are common to all HART devices. The focus here is only on the ' Gateway Configuration ' of the HART module, as shown in the following figure:

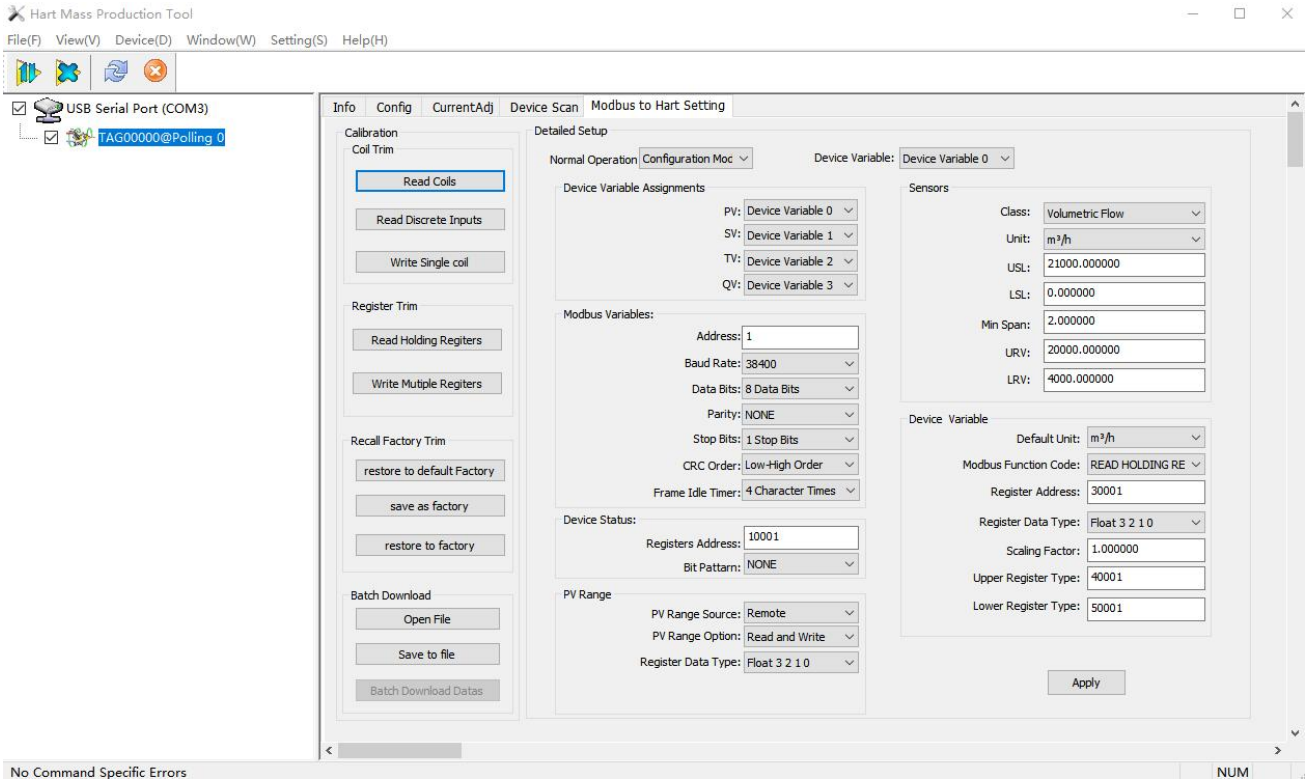


Figure 2.4 Gateway Configuration Tab

If you want to configure the HART module, first change the 'Gateway Configuration \Detailed Settings \Operation Mode' option group to 'Configuration Mode'. In this mode, users can only operate other functional items in the detailed settings; In configuration mode, the HART module will not actively loop Modbus data packets to the user board.

There are three steps to configuring a HART module: 1 Configure Modbus interface; 2. Configure device variables; 3. Configure dynamic variables.

Step 1: Configure the Modbus interface, that is, use the 'Gateway Configuration\Detailed Settings\Modbus Variables' option group to configure the Modbus interface according to different Modbus device interface characteristics. Step 2: Configure device variables, that is, use the 'Gateway Configuration\Detailed Settings\Device Variables' option group to configure device variables according to different Modbus device data storage methods, that is, map data registers to device variables. Step 3: Configure dynamic variables, that is, use the 'Gateway Configuration\Detailed Settings\Device Variable Assignment' option group to configure dynamic variables according to different end users' requirements for the allocation of HART dynamic variables, that is, mapping device variables to dynamic variables.

As mentioned earlier, the configuration function of the configuration software can also be achieved by a HART master station (such as a PC or communicator) with the ability to parse DD files. The functions described in the DD file of the HART module are basically the same as those of the HartMPT configuration software. The following figure shows the DD file function menu tree, which allows users to quickly find the parameters that need to be configured in 475 communicator.

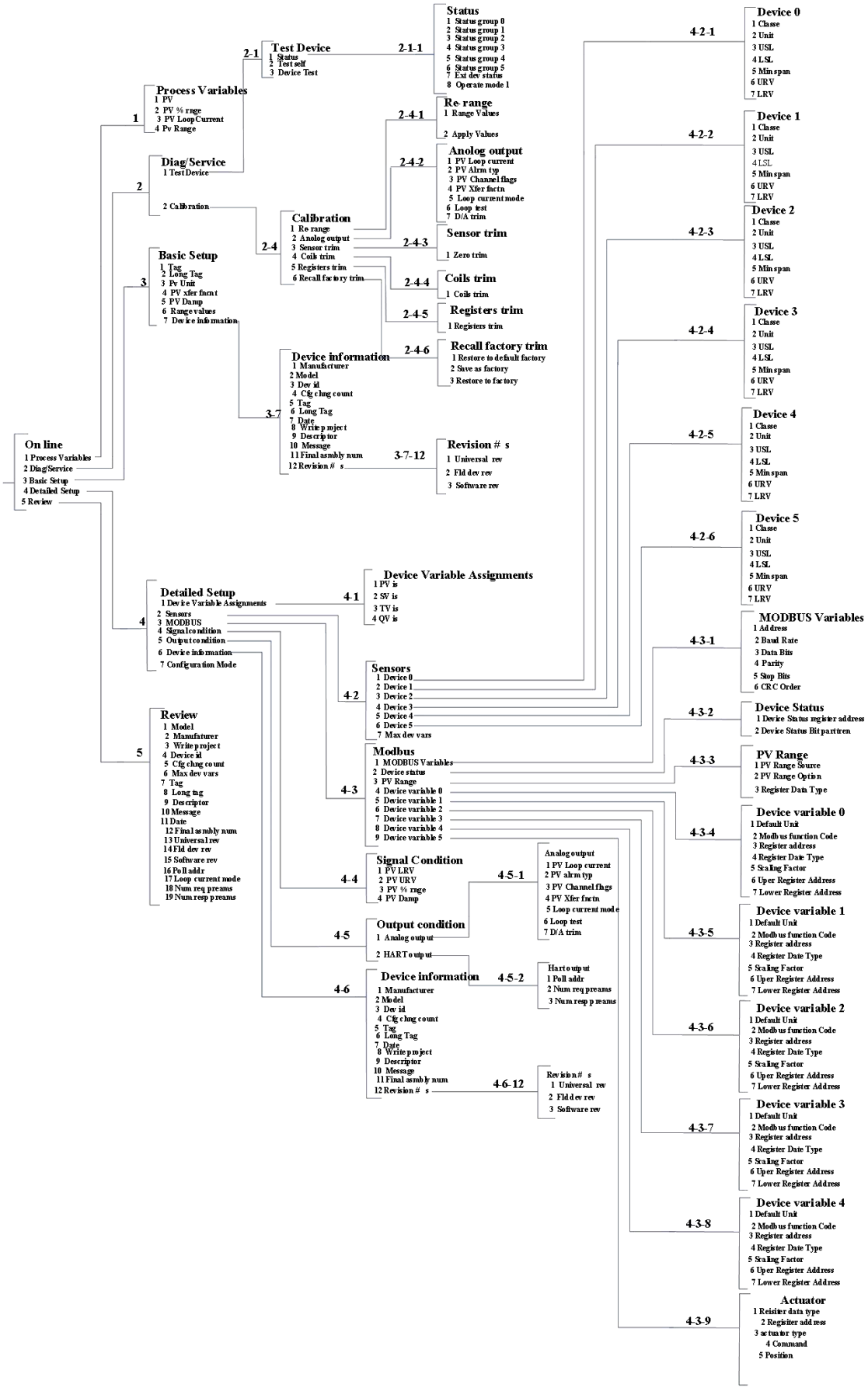


Figure 2.5 DD file structure tree

2.2 Configure Modbus Interface

The key to enabling communication between the HART module and the user board is to first unify communication parameters. The communication between them adopts the Modbus-RTU protocol, and uses the 'Gateway Configuration\Detailed Settings\Modbus Variables' option group in the configuration software. Users can configure the Modbus interface based on their own Modbus device (user board) interface characteristics, as shown in the following figure:

Figure 2.6 Modbus communication parameters

Table 2.1 Modbus communication parameter meanings

Function Name	Usage	Default Parameter
Address	The address of the user's Modbus slave device	1
Baud rate	The baud rate used for communication between the HART module and the user board	9600bps
Data bits	The length of data bits during communication between the HART module and the user board	8
Check digit	Byte verification methods used: odd, even, and no verification	EVEN
Stop bit	Number of stop bits	1
CRC Byte Order	The sending order of the last 2 bytes of CRC in Modbus protocol packets	Low-High Order

Only when all communication parameters in Table 2.1 fully match the interface characteristics of the user's Modbus device can communication be ensured to be normal. After the user sets the parameters, click the 'Apply' button to save the configuration data to the HART module. In the future, when exchanging data between the HART module and the user board, the communication parameters described in Table 2.1 will be used for communication.

2.3 Configure Device Variables

The configuration of device variables refers to the configuration of device data (such as instantaneous flow rate, cumulative flow rate, flow rate, medium density, medium temperature, etc.) in the user Modbus device onto the device variables of the HART module, which can support the configuration of 6 device variables. Use the 'Gateway Configuration\Detailed Settings\Device Variables' option group of the configuration software to configure. The specific information that needs to be configured is shown in the following figure:

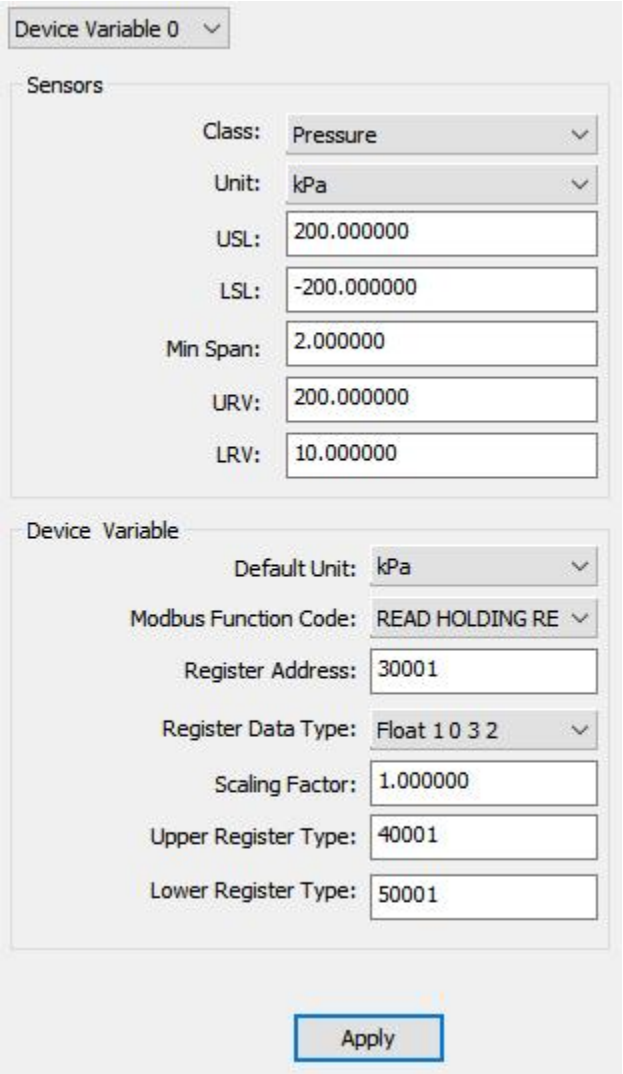


Figure 2.7 Device variable configuration

The meaning of each item used in quick configuration is shown in the table below.

Table 2.2 Device variable configuration

Device variable n (n = 0 ~ 5)	
Function Name	Purpose
Type	Select the corresponding item (such as volume flow rate, temperature, pressure, density, etc.) in the 'Type' drop-down list based on the type of user Modbus device data.
unit	The current unit of use and display of data on the HART device (in PV)
Upper and lower limits of sensor range	The maximum limit value of the device variable n that the user's Modbus device can collect
Lower limit of sensor range	The minimum limit value of the device variable n that the user's Modbus device can collect
Minimum span	Range span, usually set as the upper limit of the sensor range divided by 100
Upper Range Limit	Between the upper/lower range of the sensor
Lower Range Limit	Between the upper/lower range of the sensor
Default Units	The units of variable values read from Modbus devices
Modbus function code	Function code to be sent when reading device variable n
Register Address	The data register address where the device variable n is located in the Modbus device
Register Data Type	Byte order of device variable n in Modbus data register

Among them, the upper and lower range limits can only be modified when the current device variable is mapped as the primary variable; The upper/lower range of the device variable here is the same parameter as the upper/lower range in the HART device.

Users can configure the number and importance of device data in their Modbus device to each of these 6 device variables. After configuration, click the 'Apply' button to save the data to the HART module;

Note: The (data register address=data register address+1 in the user's device) used in this configuration software. For example, if the device variable 0 (flow) in the user device corresponds to a register with address 30000, then 30001 should be filled in the configuration software.

The association between units and default units in Table 2.2 is as follows:

HART device main variable value (PV)=HART device variable n (value converted from default unit to current unit)

2.4 Configure Dynamic Variables

This function is to select up to 4 device variables from the 6 device variables configured in the previous step and map them to 4 dynamic variables, and configure them using the 'Gateway Configuration\Detailed Settings\Device Variable Assignment' option group of the configuration software, as shown in the following figure.

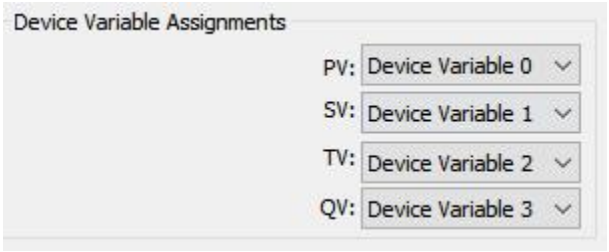


Figure 2.8 Assignment of device variables to dynamic variables

As mentioned earlier, the HART protocol specifies four dynamic variables: PV, SV, TV and QV; The 6 device variables configured by the user in section 2.3 can be mapped to these 4 dynamic variables without any restrictions; For specific descriptions, please refer to the description in 1.2. Users can map one of the six device variables to PV according to system needs. The mapping relationship between device variables and dynamic variables can be seen in the figure above.

2.5 Operational inspection

If you have read this, it indicates that you have completed the first three steps of configuring the Modbus interface, configuring device variables, and configuring dynamic variables in the quick configuration steps of the HART module. If you are confident that the first three steps are correctly configured, please change the 'Gateway Configuration\Detailed Settings\Operation Mode' option group to 'Operation Mode'. After this step is completed, the HART module will actively and cyclically send

Modbus protocol data packets to the user board, request the values of 6 device variables. At this point, users can switch to the 'Variable Monitoring' interface in the configuration software, where they can monitor their own variables in real-time. As shown in the following figure:

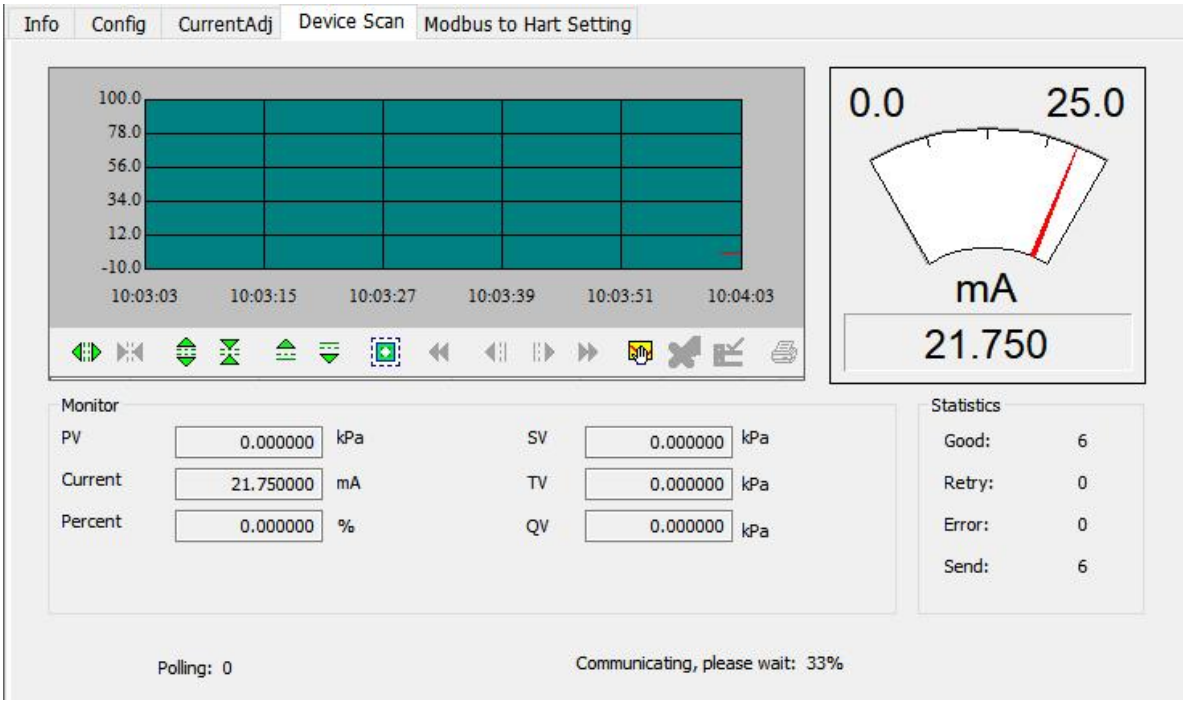


Figure 2.9 Variable monitoring

3 Other Configuration

For the configuration of the HART module, users can convert Modbus device variables into HART device variables through simple and fast configuration according to the description in the Quick Configuration section, and finally input the values of these variables into the HART control system for decision-making use by the upper system.

In addition to providing the above quick configuration functions, this configuration software also has seven special functional sections for users to further configure the HART module. These sections will be described in detail below.

3.1 Device status

The state of the HART device reflects some of the current state of the HART module. There are a total of 8 states of the HART device, which are represented by 8 bits and form a byte, with 1 representing the occurrence of the state; The 1-byte state of the HART device is represented by the second byte of the response frame data field when the HART slave device responds to a request from the master station. Users can open the device status area through the 'View/Hide Alarm Window' menu item in the configuration software, as shown in the upper right area in the following figure:

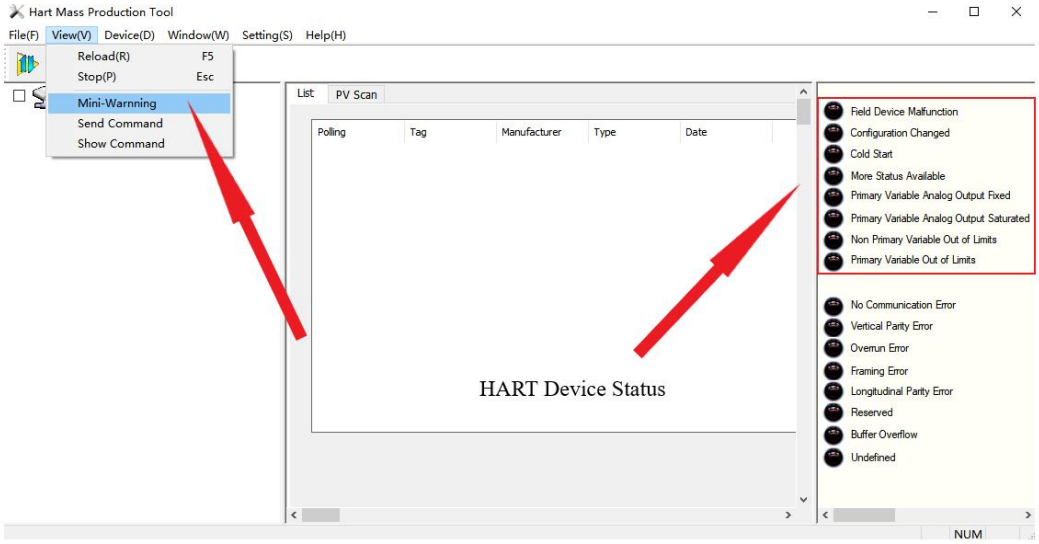


Figure 3.1 Device status

The state of the HART device can only reflect 8 specific states of the HART module, which is not sufficient to reflect some special device states of the user's Modbus device; Therefore, users can configure the status of Modbus devices to the state of HART additional devices through the 'Gateway Configuration\Detailed Settings\Device Status' option group of the configuration software. The device status parameters can be used to reflect certain current states in the user's Modbus device.

In the HART module, the first three bytes of the additional device status are used, and the lower six bits of the first byte represent whether the reading of the channel values of the six device variables was successful (0: successful, 1: faulty or misconfigured); The other 2 bytes represent 16 states of the user's Modbus device.

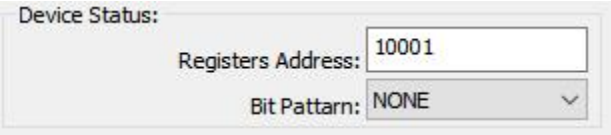


Figure 3.2 Device status

The device status parameter is mapped from a register representing the device status of the user's device. Each bit can represent two states, and the specific bits of the device status used are determined by the 'Bit mode'. Using Bit (1-8) corresponds to the 8 bits of the HART additional device status byte 2, and Bit (9-16) corresponds to the 8 bits of the HART additional device status byte 3, from low to high, as shown in the following figure.

The 'register address' is the register address where the user's device status is located, plus 1. After configuration is completed, click the' Apply 'button to save the configuration to the HART module. Then, when the HART module is in normal operating mode, the user's device status will be periodically read by the HART module by sending a Modbus request packet (default read coil) to read the status value.

In this configuration software, there is currently no graphical interface support for reading the device status from the user's Modbus device. It can be read by sending the HART universal command 48. However, users can visually see the status of each bit of the HART additional device through software that can parse DD files, as shown in the following figure:

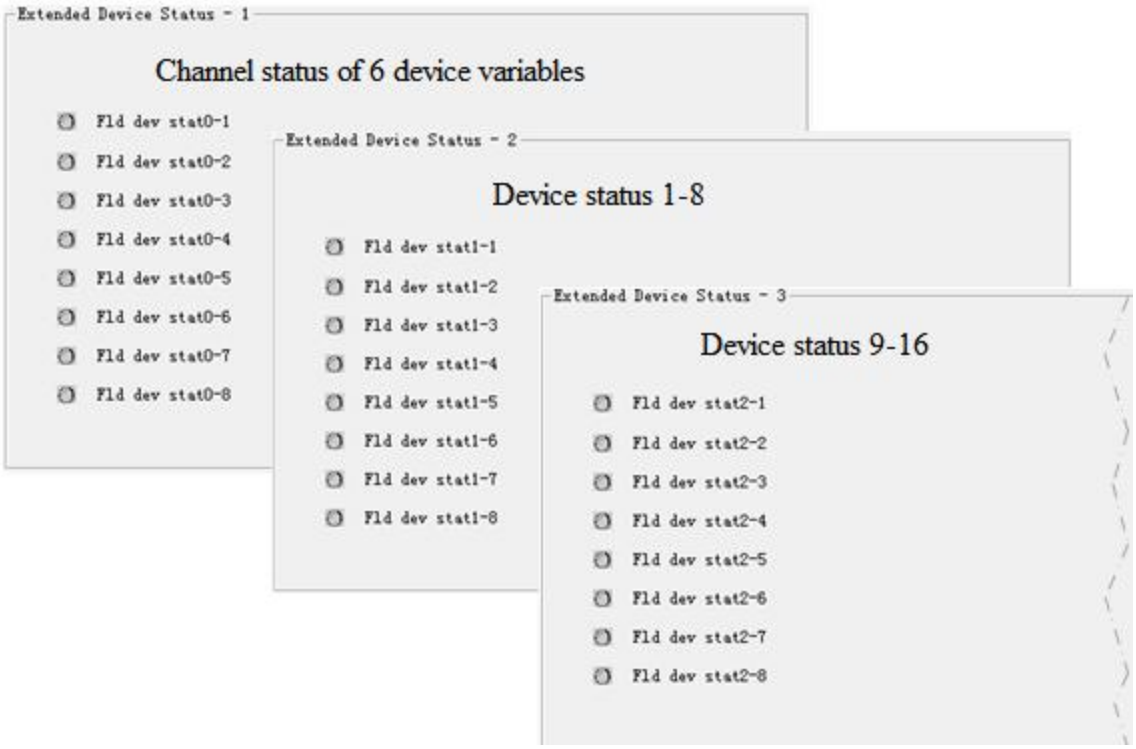


Figure 3.3 HART additional device status

The HART module is a universal module, therefore, the DD file we provide is also a universal version, and every bit of the status of the additional devices for the HART is provided in the form of 'Fld dev statB-b'; If users need to specify a name for each state, they can provide us with the name and we can customize your own DD file.

3.2 Configuring PV range

Users can configure the source and read/write mode of the upper and lower limits of the main variable range through the 'Gateway Configuration\Detailed Settings\PV Range' option group.

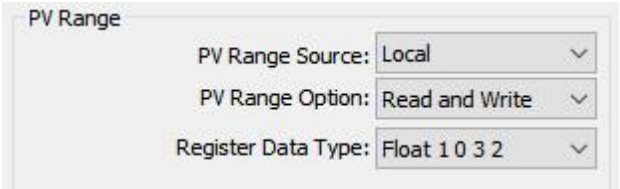


Figure 3.4 PV range operation

The 'PV range source' represents whether the upper and lower range limits of the main variable are manually configured through configuration software or remotely read from the user's Modbus device‘ PV range operation mode 'refers to whether it is possible to read and write the upper and lower limits of the

range stored in the user's Modbus device in remote mode‘ Register data type 'refers to the format in which the upper and lower limits of the range stored in the user Modbus device are stored in the register in remote mode.

The following figure briefly describes the mapping of device variable 0 to the main variable PV in both 'local' and 'remote' modes:

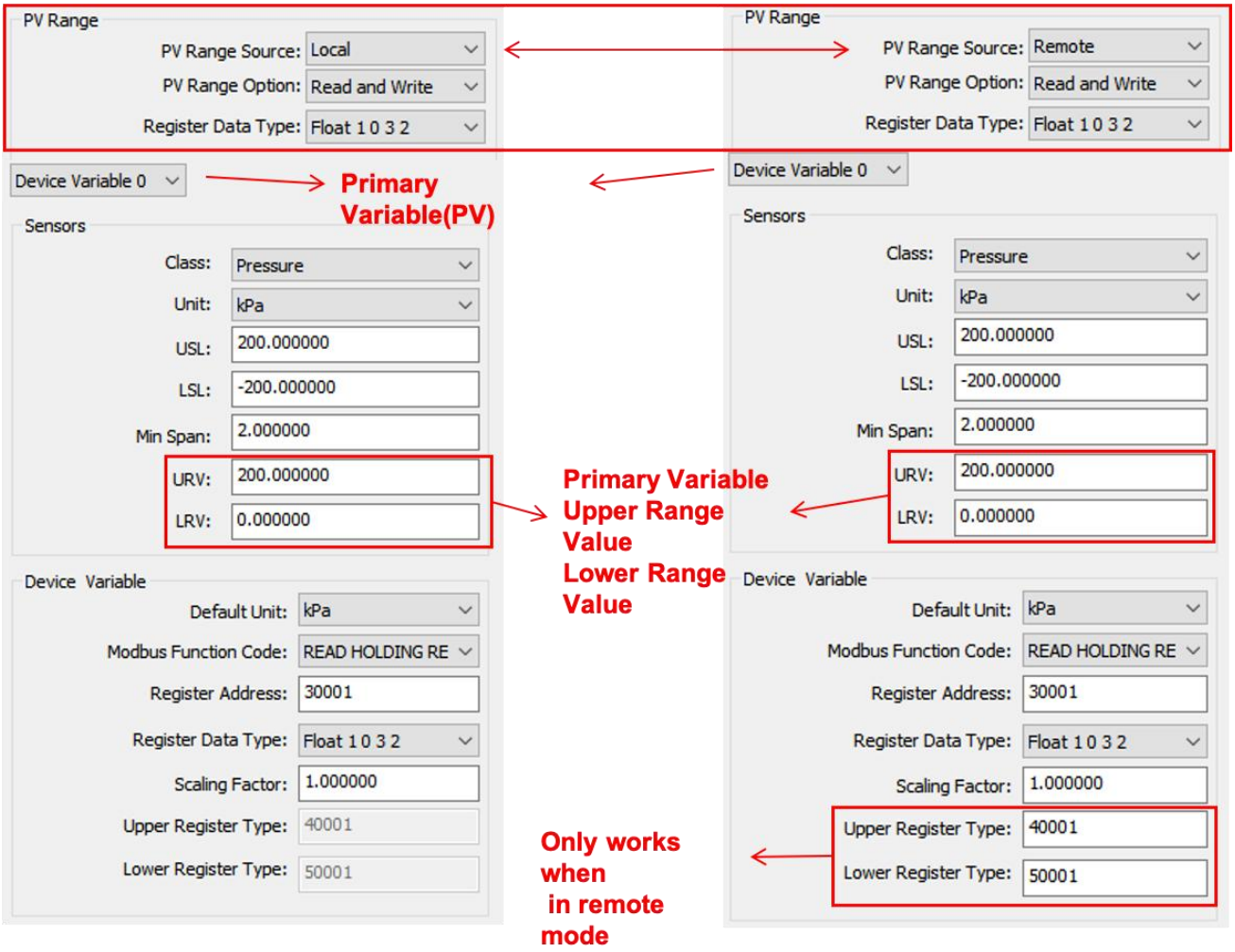


Figure 3.5 PV Range Operation Example

In the above figure, if the device variable 0 is not mapped as the main variable, then the upper and lower range limits, as well as their register addresses, are all inoperable. When the 'PV Range Source' is set to 'Remote' and the operation mode is set to 'Read and Write', the user sets the upper and lower range values and their register addresses. After clicking the 'Apply' button, the HART module will send the upper and lower range values to the user's Modbus device in the set data type (default function code 16 is used to write multiple registers); When it is' read-only ', the HART module periodically reads the upper and lower range values from the specified register in the user device (default read hold register).

3.3 Configure Scaling Factors

The HART module is specially equipped with a scaling factor parameter for each device variable, making it convenient for users to scale the data. The conversion method is:

HART device variable n=Modbus device variable n * scaling factor

If the user does not need to perform numerical scaling, there is no need to modify the value of the scaling factor. The factory default is 1.0.

3.4 Debugging and calibration area operations

The function of the debugging and calibration area is for users to perform joint debugging when configuring the HART module for the first time. The device is debugged through the 'Coil' and 'Register' options in the 'Gateway Configuration\Calibration' option group of the configuration software. The functional area is shown in the following figure:

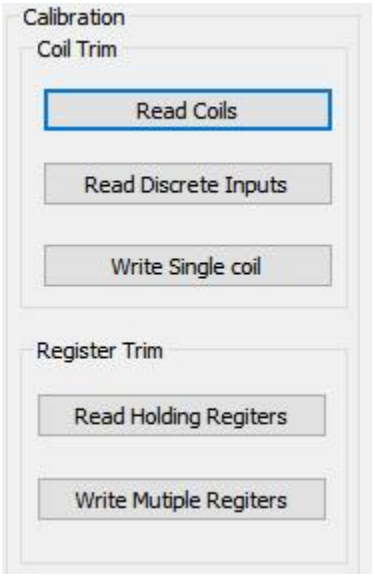


Figure 3.6 Debugging calibration function

When the user first uses the HART module, after completing the hardware connection and configuring all communication parameters in the 'Gateway Configuration\Detailed Settings\Modbus Variables' option group, the user can use the function shown in the above figure to read and write data to the Modbus device. If the returned and written data is correct, it indicates that the hardware connection and Modbus communication parameters between the HART module and the user's device are correct; On the contrary, it is necessary to further check the hardware connection or software configuration.

3.5 Data storage and recovery

The data storage and recovery function is achieved through the 'Gateway Configuration\Calibration Restore\Factory Settings' option group of the configuration software, as shown in the following figure:

Figure 3.7 Data storage and recovery

Restore to factory default values: Restore all configuration data in the HART module to the initial values of the system. Users should use it with caution. After performing this function, all user configured data will be lost;

Save to factory settings: Save all user configuration information as factory values (data has a backup in the HART module);

Restore to factory settings: Restore the user configuration information backed up during the last execution of 'Save to Factory Values' in the HART module to its current usage state;

3.6 Batch Download

- Batch download function: A quick configuration function specifically provided for manufacturers to facilitate the configuration of multiple HART modules. This is achieved through the 'Gateway Configuration\Batch Download' option group of the configuration software, as shown in the following figure:

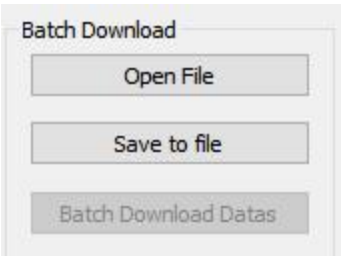


Figure 3.8 Batch download

When users have multiple HART modules that require the same configuration operation, they only need to configure one HART module and click the 'Save to File' button to save the configuration information of the current HART module as a file; When configuring other HART modules, simply click the 'Open File' button to read in the configuration information saved in the file, and then click the 'Batch Download Data' button to download all the configuration information displayed on the current page to the HART module and complete the configuration.

3.7 Definition of special commands

- Command 136: Read actuator type

  - **Requesting data**

Byte	Format	Description
0	Enum	0x31(Index)

  - **Response data**

Byte	Format	Description
0	Enum	0x31(Index)
1	Enum	ACTUATORFunctionType 0x00,"DISABLE", 0x01,"POSITIONOR" 0x02,"ON_OFF"

  - **Response code**

Code	Category	Description
0	Success	No errors
1-4		Undefined
5	Error	Too few request parameters
6-127		Undefined

- Command 137: Write actuator type

- **Requesting data**

Byte	Format	Description
0	Enum	0x31(Index)
1	Enum	ACTUATORFunctionType 0x00,"DISABLE", 0x01,"POSITIONOR" 0x02,"ON_OFF"

  - **Response data**

Byte	Format	Description
0	Enum	0x31(Index)
1	Enum	ACTUATORFunctionType 0x00,"DISABLE", 0x01,"POSITIONOR" 0x02,"ON_OFF"

  - **Response code**

Code	Category	Description
0	Success	No errors
1-4		Undefined
5	Error	Too few request parameters
6	Error	Device command special error

Code	Category	Description
7	Error	Device is in write-protected mode
8-15		Undefined
16	Error	Restricted access
17-31		Undefined
32	Error	Device busy
33-127		Undefined

- Command 146: Read actuator specific parameters
- **Requesting data**

Byte	Format	Description
No data requested		

- **Response data**

Byte	Format	Description
0	Enum	Command 0x00,"DISABLE" 0x01,"STOP" 0x02,"CLOSE" 0x04,"OPEN" 0x08,"ESD" 0x10,"SETPOINT"
1-4	Float	Desired Position 0~100%

- **Response code**

Code	Category	Description

Code	Category	Description
0	Success	No errors
1-127		Undefined

- Command 147: Write actuator specific parameters
- **Requesting data**

Byte	Format	Description
0	Enum	Command 0x00,"DISABLE" 0x01,"STOP" 0x02,"CLOSE" 0x04,"OPEN" 0x08,"ESD" 0x10,"SETPOINT"
1-4	Float	Desired Position 0~100%

- **Response data**

Byte	Format	Description
0	Enum	Command 0x00,"DISABLE" 0x01,"STOP" 0x02,"CLOSE" 0x04,"OPEN" 0x08,"ESD" 0x10,"SETPOINT"
1-4	Float	Desired Position 0~100%

- **Response code**

Code	Category	Description
0	Success	No errors
1-4		Undefined
5	Error	Too few request parameters
6	Error	Device command special error
7	Error	Device is in write-protected mode
8-15		Undefined
16	Error	Restricted access
17-31		Undefined
32	Error	Device busy
33-127		Undefined

4 Specification

4.1 Basic parameters

Table 4.1 Basic parameters

Measurement object	Modbus RTU Slave device
Power supply	(6 ~ 42)VDC (both ends of the device)
Bus protocol	2-wire HART
Load resistance	(0 ~ 1500)Ω (normally) (230 ~ 1100)Ω (HART communication)
Isolation voltage	Modbus and HART bus interface,500 VAC
Temperature range	(-40 ~ 85) ℃
Humidity range	(5 ~ 95) %RH
Start Time	≤5s
Update time	0.2s
Damping adjustment	Time constant 0~32 seconds
Output current accuracy	The maximum error within the full temperature range is no more than 50μA
Dimension	65mmx42mmx17mm

4.2 Electrical interface

Table 4.2 Electrical interface

Module socket pin definition list							
pin	I/O	name	description	pin	I/O	name	description
1	I	VCC	Requires user board to provide 3.3 or 5VDC isolated power supply	2	I	GND	VCC reference ground
3	I	-	reserved	4	O	-	reserved
5	O	TxD	MCU UART Sender	6	O	-	reserved
7	O	-	reserved	8	I	RxD	MCU UART Receiver
9	O	-	reserved	10	O	LED	External LED cathode, HART communication indication
11	O	+24V	Power supply positive	12	O	-24V	Negative power supply
13	I/O	H+	HART input / output positive	14	I/O	H-	HART input / output negative
15	I	-	reserved	16	I	-	reserved
Module electrical interface characteristics							
VCC,GND	3.3V-5.0VDC, Icc<0.8mA			/RST	3.3V-5.0VDC, Icc<0.01mA		
HART+ HART-	6-32VDC3.75-21.75mA			TxD	3.3V-5.0VDC, Icc<0.01mA		
LED	VO<0.3V,IO<-2.0mA			RxD	3.3V-5.0VDC, Icc<0.01mA		
Others	None, not connected						

5 Troubleshooting

Table 5.1 Device phenomenon elimination

No.	Phenomena	Reason	Solution
1	No communication on instrument board	a. Connection failure b. Multipoint mode	a. Check the circuit wiring b. Check the network
2	The HART communication light does not light up	a. No HART communication b. Power supply failure	a. Check the HART host device and HART modem b. Check the power supply and connections
3	Modbus communication light does not light up	a. No Modbus communication b. Slave device failure	a. Check Modbus devices b. Check the slave devices and connections
4	Modbus communication is normal, but the dynamic variable reading is incorrect	a. The configuration of the device variable corresponding to the dynamic variable is incorrect b. Modbus communication parameter configuration incorrect	a. Check the data register address and data type parameters for dependent device variables b. Check baud rate and parity bit

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