

Dexterous Hands

User Manual for RH5DG2

Basic Instructions

- Thank you for choosing and purchasing the RH56F1 Series Dexterous Hand product.

We are always committed to providing you with reliable products and services. Your satisfaction is our primary goal.

- This manual primarily introduces the product information for the RH56F1 Series Dexterous Hand.

- Please read this manual thoroughly before using the product and perform subsequent operations only with a full understanding of the content.

Version Change Record

Revision Date	Release Version	Change Content
2025-6	V1.0	First Release
2026-2	V1.1	Modify the finger joint angle range, and modify the EtherCAT data definition.
2026-2	V1.2	Add the address for the high force deviation state of the index and middle fingers, and add a description for the recommended minimum setting speed.

2026-4	V1.3	Modify the finger angle motion range.
2026-7	V1.4	Modify the Definition of Data Addresses in the EtherCAT Interface

Manual Acquisition Channels

- Printed manual

Please consult the supplier or office where you purchased the product to request a copy.

- Electronic manual

Log on to the official website of Inspire-Robots at <https://www.inspire-robots.com>.

Disclaimer

- The Company makes every effort to ensure the information in this manual is as accurate and up-to-date as possible. However, the manual is not guaranteed to be free from technical inaccuracies or typographical errors.

- If the manual content is updated, revisions will be made in subsequent versions. We reserve the right to make such modifications without prior notice to users.

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contents without prior explicit written permission. Infringement is subject to legal prosecution.

Safety Precautions

- Before using this product, be sure to read this section carefully and operate the product only after fully understanding the instructions regarding its operation, safety, and precautions. Please install and operate the product correctly and with utmost attention to safety.
- Potential hazards associated with product operation are primarily outlined in the "Safety Precautions" section. These are clearly marked with the following safety labels: "DANGER", "WARNING", and "CAUTION". For all other matters, adhere to standard electrical operating procedures.

Safety Level Definitions



Indicates that failure to comply with specified procedures will result in death or severe physical injury.



Indicates that failure to comply with specified procedures could result in death or serious physical injury.



Indicates that failure to comply with specified procedures could result in minor physical injury or device damage.

Safety Precautions

- For clarity of presentation, some product illustrations in this manual may depict the unit with covers or safety shields removed. During product operation, all covers and safety shields must be properly installed and operational procedures must be followed as specified in this manual.
- The product illustrations in this manual are for illustrative purposes only and may exhibit slight variations from the product you ordered. Please refer to the actual product received.

Precautions for Unpacking and Acceptance



- If you find loose screws, damage, corrosion, or other issues with the product and its accessories upon unpacking, do not proceed with installation!
- If, during unpacking, you find any moisture inside the product, missing components, or damaged parts, do not proceed with installation!
- If a careful check against the packing list reveals a discrepancy with the product name, do not proceed with installation!



- Before unpacking, inspect the external shipping package for any damage, including damage, soaking, moisture, or deformation!

- Unpack the product layer by layer according to the sequence. Avoid violent striking!
- When unpacking, inspect the exterior of the device and all accessories for any physical damage, corrosion, or impact marks!
- After unpacking, check the contents against the packing list to verify that the device and its accessories, as well as documentation are all complete!

If any issues are found with the items listed above, please contact the product supplier or office promptly.

Storage and Transportation Precautions



- Please strictly follow the required storage and transportation conditions to avoid potential damage to the product!
- Avoid storage or transportation in environments subject to water splash, rain, direct sunlight, strong electric fields, strong magnetic fields, or severe vibration!
- Limit storage duration to a maximum of three months. If extended storage is necessary, please implement enhanced protective measures and conduct necessary inspections!
- The product must be securely packaged before vehicle transportation. Enclosed containers are mandatory for long-distance transit!
- It is strictly prohibited to transport this product together with any devices or materials that may potentially affect or damage it!

Installation Precautions



- The product manual and safety precautions must be read thoroughly before installation!
- The product must not be installed in locations subject to strong electric fields or electromagnetic interference!
- When installing the product in an enclosed environment (such as inside a cabinet or chassis), it must be adequately cooled using a cooling device (e.g., a cooling fan or air conditioner) to meet environmental requirements. Failure to do so may cause product overheating or fire!
- It is strictly prohibited to modify this product!
- It is strictly prohibited to loosen the fastening bolts of any product components or parts!
- When this product is installed in a cabinet or terminal equipment, the cabinet or terminal equipment must provide corresponding protective devices such as fireproof enclosures, electrical protection enclosures, and mechanical protection enclosures. The protection level shall comply with relevant IEC standards and local laws and regulations!
- When installing equipment that generates strong electromagnetic interference (such as transformers), a shielding device must be installed to prevent malfunction of this product!

- The product must be mounted on a flame-retardant surface (e.g., metal). Keep flammable materials away from the product to avoid fire hazards!



- During installation, cover the top of the product with a cloth or paper to prevent metal chips, oil, water, and other contaminants from entering the product during drilling, which could cause product failure. After installation is completed, remove the covering to prevent it from blocking ventilation holes and affecting heat dissipation, which could lead to overheating of the product!

Wiring Precautions



- Only qualified personnel are permitted to perform installation, wiring, maintenance, inspection, or component replacement of the product!
- Before performing any wiring, ensure that the power supply to all related devices is completely disconnected. After disconnecting the power, capacitors inside the equipment retain residual voltage. Wait at least for the duration specified on the product's warning label before proceeding with wiring or any other operations. Measure the DC voltage of the main circuit to confirm it is at a safe voltage. Failure to do so carries a risk of electric shock!



- It is strictly prohibited to connect the input power supply to the signal, communication

terminal, or output terminals of the device or product, as this may cause device damage or even fire!

- Please use connectors and cables approved by our marketing or technical support personnel to prevent malfunctions caused by non-compliant connectors and cables!
- All cables used for wiring must comply with the requirements for wire gauge and shielding. The shielding layer of shielded cables must be reliably grounded at one end!
- The equipment and product must be properly grounded. Failure to do so may result in electrostatic damage to the product!
- During wiring, exposed metal wires shall be avoided to prevent high-temperatures oxidation or short circuits!



- Please adhere to Electrostatic Discharge (ESD) protection procedures. Wear an anti-static wrist strap during wiring to avoid damaging the device or the internal circuits of the product!
- Ensure the power plug and all other connectors are securely connected to prevent operational issues caused by poor contact!
- When wiring the control circuit, use twisted-pair shielded cable, and connect the shield to the product's grounding terminal. Failure to do so may cause abnormal operation of the

product!

Power-On Precautions



- Before powering on, ensure that the product is installed correctly and all wiring connections are secure!
- Before powering on, ensure that the power supply meets the product requirements to prevent product damage or fire!



- Before powering on, ensure that the power specifications are compatible with the device's ratings to avoid damage from overvoltage!
- After wiring and parameter configuration are completed, perform a test run to confirm the machine operates safely. Failure to do so may result in personal injury or device damage!
- Before energizing, ensure the rated voltage of the product matches the power supply voltage. Incorrect power supply voltage poses a risk of fire!

Abnormality Precautions



- Do not disassemble the device by yourself. If a malfunction is confirmed or suspected, please contact our marketing or technical support personnel!

Decommissioning Precautions



- Decommission the device and product in accordance with relevant national regulations and standards to prevent property loss or personal injury!
 - Decommissioned device and product must be disposed of and recycled according to industrial waste treatment standards to avoid environmental pollution!
-
- Under any of the following conditions, immediately disconnect the power and contact our company.
 - Water ingress into the device.
 - Cracked housing or detached components.
 - Abnormal operation or performance deviation.
 - Unusual odor, smoke, or abnormal noise generated by the device.

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Dexterous Hands

User Manual for RH5DG2

1. Product Overview

1.1 Product Features

RH56DG2 Series Dexterous Hand is a mechanical dexterous hand (hereinafter referred to as "Dexterous Hand") designed to integrate the micro linear servo actuator with small volume and large torque. These dexterous hands feature Thirteen micro linear servo actuators equipped with sensitive force sensors with its user interface supporting RS485, CANFD, and EtherCAT communication. By setting different thresholds, users can easily grasp objects of varying hardness; simple and efficient interface control instructions enable users to quickly operate the dexterous hand; its superior performance makes this dexterous hand suitable for applications in service robots, educational teaching aids, prosthetics, and other fields.

1.2 Structural size

The structural size of the dexterous hand is as shown in Table 1 below.

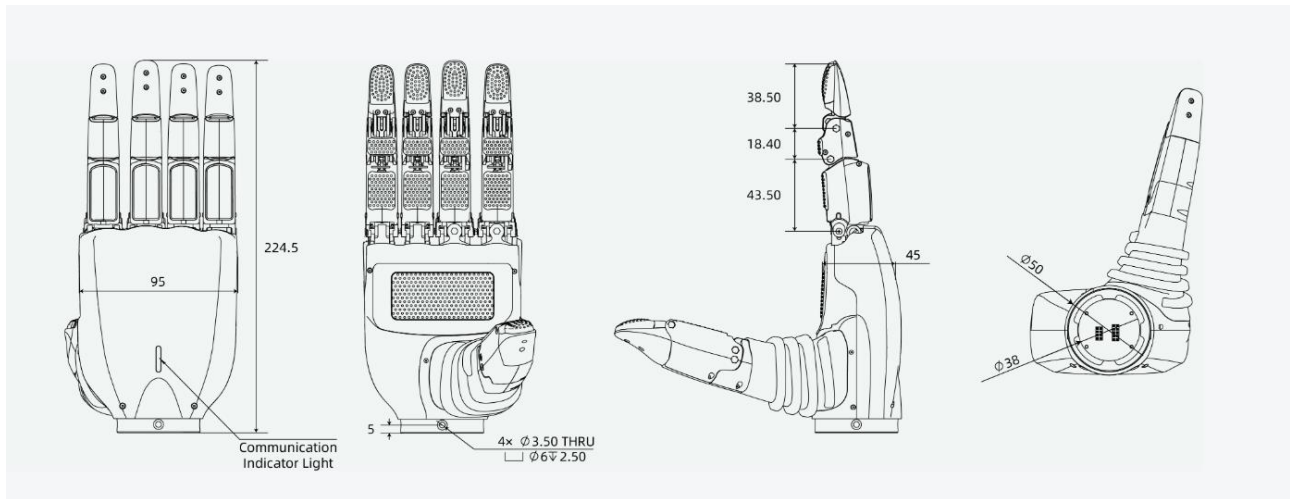


Figure 1 Diagram of structural size

1.3 Performance parameters

See Table 1. for the performance parameters of the dexterous hand.

Table 1 Performance parameters

Total number of joints	18
Degree of freedom (DOF)	13
Number of force sensors	8
Resolution of force sensor	0.1N
Repeated fingertip positioning accuracy	$\pm 0.4\text{mm}$
Four-finger gripping force	>10N
Thumb gripping force	>15N
Operating voltage	24-48V
Quiescent current	$0.4 \pm 0.015\text{A}@24\text{V}$
Average current for no-load operation	1.2A @24V
Current for maximum gripping force	6.0A @24V
Communication interface	RS485+EtherCAT or CANFD + EtherCAT

1.4 Electric connection

1.4.1 Pin definition

The wrist of the dexterous hands uses a 1BZ1G08CLL00000 aviation plug interface (compatible with the Lemo FGG-1B-8P aviation plug interface). The physical image is shown below, and the function definitions are shown in Table 2 below.

Table 2 Function Definitions

S/N.	Definition
1	GND
2	VCC(24-48V)
3	485_A/CANFD_H
4	485_B/CANFD_L
5	TX+ (Data Send Positive)
6	TX- (Data Send Negative)
7	RX+ (Data Receive Positive)
8	RX- (Data Receive Negative)



Figure 2 Physical Diagram of Aviation Plug

The external cables of the dexterous hands are shown in Figure 3 below, with the function definitions shown in Table 3 below

Table 3 Function Definitions of Cables

Cable Description	Function Definition
White	TX+ (Data Send Positive)
Blue	TX- (Data Send Negative)
Red (thin)	RX+ (Data Receive Positive)
Black (thin)	RX- (Data Receive Negative)
Yellow	485_A/CANFD_H
Green	485_B/CANFD_L
Red (thick)	VCC (24-48V)
Black (thick)	GND



(Figure 3) Interface Description

Cable Interface Definitions:

- 1-Aviation Plug Interface: Connects to the dexterous hand's flange aviation plug
- 2-Network Interface: Connects to an Ethernet cable
- 3-CANFD/RS485 Interface
- 4-Power Interface

1.4.2 Explanation of the distribution of electric cylinders and degrees of freedom.

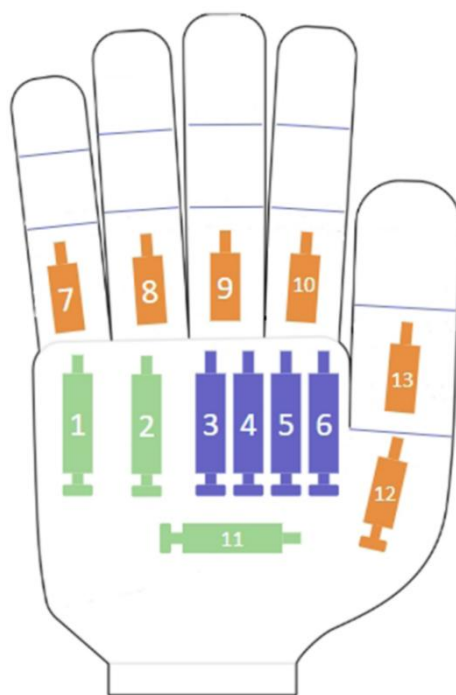


Figure 4: Electric Cylinder Distribution Diagram

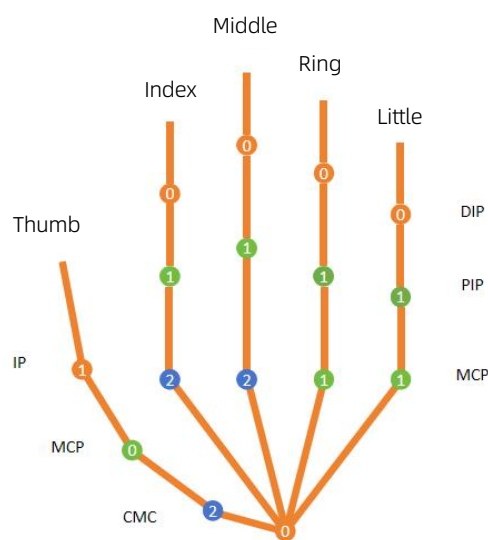


Figure 5: Degrees of Freedom Distribution Diagram

1.4.3 Communication mode

When the RS485 and CANFD interfaces are used, a particular conversion circuit can realize parallel connection of 254 dexterous hands to the same bus.

When the dexterous hand is using the EtherCAT interface, the bus control of multiple dexterous hands can be achieved based on the EtherCAT communication mechanism.

The communication instructions and registers of dexterous hands are open to the product users. Dexterous hands can be connected with users' PC (controller or general computer) via the aforesaid interface. The user can use a PC or an embedded controller to perform parameter configuration, motion control and other actions of dexterous hands via the aforesaid interface.

2. Communication Protocol

2.1 Summary of Communication Protocol

The main control unit (MCU) reads and writes the internal register of a dexterous hand to achieve state acquisition and control for the dexterous hand.

Read the register: The upper system reads the internal register values of a dexterous hand (readable in groups; groups refer to several registers with adjacent addresses); the upper system sends a read instruction to the dexterous hand (including the first address, length and other details of the register group); after the dexterous hand receives and

successfully checks such data, it will return the data content of the corresponding register to the upper system.

Write the register: The upper system writes the corresponding data to the internal register of a dexterous hand (writable in groups); the upper system sends a write instruction to the dexterous hand (including the first address of the register group and the data content to be written); after the dexterous hand receives and successfully checks such data, it will return the acknowledgment signal to the upper system and execute corresponding operation.

2.2 Summary of RS485 Protocol

The RS485 interface is a serial data communication standard widely used in industrial and telecommunications fields, defined by the TIA/EIA-485 standard. It employs differential signal transmission (where the voltage difference between two lines, A and B, represents the data), significantly enhancing interference resistance and ensuring reliable communication over long distances and in high-noise environments.

The communication parameters of RS485 are 8 data bits, 1 stop bit, and no parity, 115200bps by default.

2.2.1 Reading a register of the dexterous hand

The instruction frame format for reading a register of the dexterous hand is shown below.

"Address" is the start address of the register to be read. "Hands_ID" is the ID of the dexterous hand. "Address_L" is the low-order 8 bits of "Address". "Address_H" is the high-order 8 bits of "Address". "Register_Length" is the byte length (one register is composed of two bytes, unit: byte) of the data to be read. "Checksum" refers to the low-order bytes of the sum of all data before checksum except the response frame header, as shown in Table 4 below.

Table 4 Instruction frame format for register reading of RS485

	Value	Description
byte[0]	0xEB	Packet header
byte[1]	0x90	Packet header
byte[2]	Hands_ID	ID of the dexterous hand
byte[3]	0x04	Length of the frame data
byte[4]	0x11	Register reading
byte[5]	Address_L	Low-order 8 bits in the start address of the register
byte[6]	Address_H	High-order 8 bits in the start address of the register
byte[7]	Register_Length	Read the byte length of the data
byte[8]	Checksum	Checksum

The dexterous hand returns the following response frame to the read register instruction, as shown in Table 5 below:

Table 5 Instruction response frame format for register reading of RS485

	Value	Description
--	-------	-------------

byte[0]	0x90	Packet header
byte[1]	0xEB	Packet header
byte[2]	Hands_ID	ID of the dexterous hand
byte[3]	Register_Length+3	Length of the frame data
byte[4]	0x11	This frame is the response to the read register instruction.
byte[5]	Address_L	Low-order 8 bits in the start address of the register
byte[6]	Address_H	High-order 8 bits in the start address of the register
byte[7]	Data[0]	Register value
...	...	
byte[7+Register_Length-1]	Data[Register_Length-1]	
byte[7+ Register_Length]	Checksum	Checksum

For example, the dexterous hand (ID=1) reads the actual angle for each degree of freedom (DOF). The actual angle for DOF is stored in the register group "ANGLE_ACT(m)", with 1064 (0x0428) as start address, and 12 bytes (0x0C) as length. The format of this instruction frame is shown in Table 6 below:

Table 6 RS485 Example Read Register Frame Format

	Value	Description
byte[0]	0xEB	Packet header
byte[1]	0x90	Packet header
byte[2]	0x01	ID of the dexterous hand: 1
byte[3]	0x04	Length of the frame data
byte[4]	0x11	Register reading
byte[5]	0x70	Low-order 8 bits in the start address of the register

byte[6]	0x04	High-order 8 bits in the start address of the register
byte[7]	0x02	Read the byte length of the data
byte[8]	0x8C	Checksum

The dexterous hand returns the following response frame to this instruction, as shown in

Table 7 below:

Table 7 RS485 Example Response Frame Format

	Value	Description
byte[0]	0x90	Packet header
byte[1]	0xEB	Packet header
byte[2]	0x01	ID of the dexterous hand
byte[3]	0x05	Length of the frame data: 12 + 3
byte[4]	0x11	This frame is the response to the read register instruction.
byte[5]	0x70	Low-order 8 bits in the start address of the register
byte[6]	0x04	High-order 8 bits in the start address of the register
byte[7] byte[8]	0xB004	Converted to the integer data 1200 (0x04B0)
byte[9] byte[10]	0x3F	checksum

From this response frame, we can obtain the actual values for DOF: 1200

2.2.2 Writing to a register of the dexterous hand

The instruction frame format for writing to a register of the dexterous hand is shown in

Table 8 below. "Data[0]- Data[Register_Length-1]" is the data to be written to the register.

Table 8 RS485 Write Register Command Frame Format

	Value	Description
byte[0]	0xEB	Packet header
byte[1]	0x90	Packet header
byte[2]	Hands_ID	ID of the dexterous hand
byte[3]	Register_Length+3	Length of the frame data
byte[4]	0x12	Write Register instruction flag
byte[5]	Address_L	Low-order 8 bits in the start address of the register
byte[6]	Address_H	High-order 8 bits in the start address of the register
byte[7] ... byte[7+Register_Length-1]	Data[0] ... Data[Register_Length-1]	Data to be written to the register
byte[7+Register_Length]	checksum	Checksum

The dexterous hand returns the following response frame to the write register instruction, as shown in Table 9 below:

Table 9 RS485 Write Register Command Response Frame Format

	Value	Description
byte[0]	0x90	Packet header
byte[1]	0xEB	Packet header
byte[2]	Hands_ID	ID of the dexterous hand
byte[3]	4	Length of the frame data
byte[4]	0x12	This frame is the response to

		the write register instruction.
byte[5]	Address_L	Low-order 8 bits in the start address of the register
byte[6]	Address_H	High-order 8 bits in the start address of the register
byte[7]	1	
byte[8]	checksum	Checksum

For parameter saving (the register "SAVE" is set to 1), the result information frame will be returned one second after the dexterous hand returns the response frame. The content of the result information frame is shown in Table 10 below:

Table 10 RS485 Return Save Result Information Frame

	Value	Description
byte[0]	0x90	Packet header
byte[1]	0xEB	Packet header
byte[2]	Hands_ID	ID of the dexterous hand
byte[3]	4	Length of the frame data
byte[4]	0x12	This frame is the response to the write register instruction.
byte[5]	0xEC	Low-order 8 bits in the start address of the register "SAVE"
byte[6]	0x03	High-order 8 bits in the start address of the register "SAVE"
byte[7]	**	0x00 saving successful; 0xFF saving failure
byte[8]	checksum	Checksum

For example, the angles of a dexterous hand (ID=1) for degrees of freedom (DOF) are set to 1000, 1000, 1000, 1000, 1400, and 1000. It is necessary to modify the angle setting

register group. The start address of this register group is 1040 (0x0410), and its length is 12 bytes (0x0C). The instruction to be sent is shown in Table 11 below:

Table 11 RS485 Example Write Data Frame Format

	Value	Description
byte[0]	0xEB	Packet header
byte[1]	0x90	Packet header
byte[2]	0x01	ID of the dexterous hand
byte[3]	0x0F	Length of the frame data: 12 + 3
byte[4]	0x12	Write Register instruction flag
byte[5]	0x10	Low-order 8 bits in the start address of the register
byte[6]	0x04	High-order 8 bits in the start address of the register
byte[7] byte[8]	0xE803	Converted to the integer data 1000 (0x03E8)
byte[9] byte[10]	0xE803	Converted to the integer data 1000 (0x03E8)
byte[11] byte[12]	0xE803	Converted to the integer data 1000 (0x03E8)
byte[13] byte[14]	0xE803	Converted to the integer data 1000 (0x03E8)
byte[15] byte[16]	0x7805	Converted to the integer data 1400 (0x0578)
byte[17] byte[18]	0xE803	Converted to the integer data 1000 (0x03E8)
byte[19]	0x4A	Checksum

The dexterous hand returns the following response frame to this instruction, as shown in

Table 12 below:

Table 12 RS485 Example Response Frame Format

	Value	Description
byte[0]	0x90	Packet header
byte[1]	0xEB	Packet header
byte[2]	0x01	ID of the dexterous hand
byte[3]	0x04	Length of the frame data
byte[4]	0x12	This frame is the response to the write register instruction.
byte[5]	0x10	Low-order 8 bits in the start address of the register
byte[6]	0x04	High-order 8 bits in the start address of the register
byte[7]	0x01	
byte[8]	0x2C	Checksum

2.3 Summary of Modbus_RTU Protocol

The Modbus_RTU protocol adopts the master-slave request/response communication mode. The protocol frame contains function codes, data fields, and cyclic redundancy check (CRC). This series actuator supports reading holding register (function code: 0x03), preset single register (function code: 0x06), and preset multiple registers (function code: 0x10).

2.3.1 Read the holding register (function code: 0x03).

Table 13 Modbus reads the holding register

Query frame format of	Slave station address	Function code	Starting register (high-order)	Starting register (low-order)	Number of registers (high-order)	Number of registers (low-order)	CRC
-----------------------	-----------------------	---------------	--------------------------------	-------------------------------	----------------------------------	---------------------------------	-----

master station			r bytes)	bytes)	r bytes)	bytes)	
	0x01	0x03	0x03	0xE8	0x00	0x02	XXXX

Explanation: Read the holding register of Slave Station 1# (0x01), with start address = 0x03E8, number of registers = 0x0002, and end address = 0x03E8+2-1=0x03E9; that is, read the holding register of Slave Station 1#, 0x03E8-0x03E9; there are totally two registers as shown in Table 14 below.

Table 14 Response frame of slave station Modbus

Response frame format of slave station	Slave station address	Function code	Byte count	0x006B register (high-order bytes)	0x006B register (low-order bytes)	0x006C register (high-order bytes)	0x006C register (low-order bytes)	CRC
	0x01	0x03	0x04	0x00	0x01	0x00	0x02	XXXX

Explanation: Return to the holding register of Slave Station 1# (0x01), 0x03E8-0x03E9; there are totally two registers. The value of 0x03E8 register is 0x0001, and that of 0x03E9 register is 0x0002.

2.3.2 Preset single register function code: 0x06

Table 15 Preset single register

Query frame format of master station	Slave station address	Function code	Starting register (high-order bytes)	Starting register (low-order bytes)	Data content (high-order bytes)	Data content (low-order bytes)	CRC
	0x01	0x06	0x03	0xE8	0x10	0x00	XXXX

Explanation: Set the holding register of Slave Station 1# (0x01), with register address = 0x03E8 and data content = 0x1000, as shown in Table 16

Table 16 Response frame of slave station Modbus

Response frame format of slave station	Slave station address	Function code	Starting register (high-order bytes)	Starting register (low-order bytes)	Data content (high-order bytes)	Data content (low-order bytes)	CRC
	0x01	0x06	0x03	0xE8	0x10	0x00	XXXX

2.3.3 Preset multiple registers function code: 0x10

Table 17 Preset multiple registers

Query frame format of master station	Slave station address	Function code	Starting register (high-order bytes)	Starting register (low-order bytes)	Number of registers (high-order bytes)	Number of registers (low-order bytes)	Byte count	Data (high-order bytes)	Data (low-order bytes)	Data (high-order bytes)	Data (low-order bytes)	CRC
0x01	0x01	0x10	0x00	0x01	0x00	0x02	0x04	0x00	0x0A	0x01	0x02	XXXX

Explanation: Set the holding register of Slave Station 1# (0x01), with register start address = 0x0001, number of registers = 0x0002, byte count of data content = 0x04, 0x000A and 0x0102 as data content, as shown in Table 18:

Table 18 Response frame of slave station Modbus

Response frame format of	Slave station address	Function code	Starting register (high-order)	Starting register (low-order)	Number of registers (high-order)	Number of registers	CRC

slave station			bytes)	bytes)	bytes)	(low-order bytes)	
	0x01	0x10	0x00	0x01	0x00	0x02	XXXX

2.4 Summary of CANFD Protocol

CAN FD is a high-performance communication protocol based on the traditional CAN bus, specifically designed to meet the demands of modern industrial equipment for higher bandwidth and greater data capacity.

CANFD default configuration: arbitration domain 1Mbps (80%), data domain 5Mbps (80%).

2.4.1 Explanation of CANFD Extended Frame Format

CANFD extended frame format adopts the extended identifier and data frame format. It does not use the standard identifier and remote frame. The extended identifier has 29 bits, which are defined from low-order to high-order bits as follows:

Bit0~7: dexterous hand ID, supports up to 254 devices;

Bit8~19: Start address of the register to be operated;

Bit20~27: Effective data length of data frame.

Bit28: Read/write flag bits; 0 indicates reading a register of the dexterous hand; 1 indicates writing to a register of the dexterous hand, as shown in Table 19:

Table 19 Explanation of CANFD Extended Frame ID Format

Identifier	Bit 28	Bit 27-20	Bit 19-8	Bit 7-0
Meaning	0: R - Reading a register of the dexterous hand 1: W - Writing to a register of the dexterous hand	Effective data length of data frame	Register address	Hand_ID

2.4.2 CANFD reading a register of the dexterous hand

The identifier settings of register reading are as shown in Table 20 below:

Table 20 Identifier settings of register reading

Identifier	Bit 28	Bit 27-20	Bit 19-8	Bit 7-0
Meaning	Read register flag	Effective data length of data frame	Address	Hand_ID

Effective data length of data frame portion: 1.

Data content of data frame: Length of the register data to be read.

After the dexterous hand receives and correctly analyzes the aforesaid instruction, it will return the following frame:

The identifier is as shown in Table 21 below:

Table 21 Read Register Response Identifier

Identifier	Bit 28	Bit 27-20	Bit 19-8	Bit 7-0
Meaning	Read register flag	Effective data length of data frame	Address	Hand_ID

Data content of data frame: Read the register data of corresponding byte length.

For example, if we want to read the current actual angle of the index finger of the dexterous hand (ID=1), the following frames as shown in Table 22 should be sent to the CANFD bus:

Identifier: The binary number is 0000 0000 0001 0100 0010 1010 0000 0001

Table 22 Example of Read Data Identifier

Bit 28	Bit 27-20	Bit 19-8	Bit 7-0
0	1	The address of the actual angle of the index finger is 1066; The binary number is 010000101010.	1

Effective data length of data frame portion: 1

Data content: 2; the current actual angle of the index finger is an integer data; the data length is 2 bytes.

The dexterous hand returns the frame as shown in Table 23 below:

Identifier: The binary number is 0000 0000 0010 0100 0010 1010 0000 0001

Table 23 Example of Response Data Identifier

Bit 28	Bit 27-20	Bit 19-8	Bit 7-0
0	2	The address of the actual angle of the index finger is 1066; The binary number is 010000101010.	1

Effective data length of data frame portion: 2

Data content of the data frame is as below: The current actual angle of the index finger is an integer, which is an integer. The following data should be converted to integers

(low-order bytes are followed by high-order bytes). After high-order and low-order bytes are exchanged, the hexadecimal number is 0x01F4, and the decimal number is 500 (the current actual angle of the index finger is 500), as shown in Table 24 below.

Table 24 Response Data

byte0	byte1
0xF4	0x01

2.4.3 CANFD writing a register of the dexterous hand

The identifier settings of register writing are as shown in Table 25 below:

Table 25 Description of Write Register Identifier

Identifier	Bit 28	Bit 27-20	Bit 19-8	Bit 7-0
Meaning	Write register flag	Effective data length of data frame	Address	Hand_ID

Effective data length of data frame portion: Length of the data to be written to the register.

Data content of the data frame: Data to be written to the register

After the dexterous hand receives and correctly analyzes the aforesaid instruction, it will return the following frame, as shown in Table 26:

Table 26 Write Register Response Identifier

Identifier	Bit 28	Bit 27-20	Bit 19-8	Bit 7-0
Meaning	Write register flag	Effective data length of data	Address	Hand_ID

		frame		
--	--	-------	--	--

Effective data length of data frame portion: 1

Data content of data frame portion: 1

For example, if we want to set the angle of the index finger of the dexterous hand (ID=1)

to 600, the following frame as shown in Table 27 should be sent to the CANFD bus:

Identifier: The binary number is 0001 0000 0010 0100 0001 0010 0000 0001

Table 27 Example of Write Data Identifier

Bit 28	Bit 27-20	Bit 19-8	Bit 7-0
1	Effective data length of data frame	The set angle of the index finger is 1042; The binary number is 010000010010.	1

Effective data length of data frame portion: 2

Data content of the data frame portion is as below. The current set angle of the index finger is an integer. It is necessary to split the integer data into high-order and low-order bytes and then exchange these bytes; that is, 600 (0x0258) is converted to the following data content, as shown in Table 28 below:

Table 28 Example of Data Frame of Write Data

byte0	byte1
0x58	0x02

The dexterous hand returns the frame as shown in Table 29 below:

Identifier: The binary number is 0001 0000 0001 0100 0001 0010 0000 0001

Table 29 Example of Write Data Response Identifier

Bit 28	Bit 27-20	Bit 19-8	Bit 7-0
1	1	The set angle of the index finger is 1042; The binary number is 010000010010.	1

Effective data length of data frame portion: 1

Data content of data frame portion: 1

2.5 Explanation of RS485, Modbus_RTU, CANFD registers

The register parameters of the dexterous hand which are open to the users are as shown

in Table 30 below:

Table 30 Register address description

Address	Meaning	Length	Permission (read / write)
1000 (0x03E8)	ID	2byte	W/R
1001 (0x03E9)	Baud rate setting	2byte	W/R
1003 (0x03EB)	Error clearance	2byte	W/R
1004 (0x03EC)	Saving data in Flash	2byte	W/R
1005 (0x03ED)	Restoring factory defaults	2byte	W/R
1007 (0x03EF)	Force sensor calibration	2byte	W/R
1024 (0x0400)	Current protection value of the actuator for each DOF	12byte	W/R
1038	Set value of power-on speed	12byte	W/R

(0x040E)	for each DOF		
1052 (0x041C)	Set value of power-on force control threshold for each DOF	12byte	W/R
1066 (0x042A)	Set value of the actuator position for each DOF	12byte	W/R
1080 (0x0438)	Set value of the angle for each DOF	12byte	W/R
1094 (0x0446)	Set value of force control threshold for each DOF	12byte	W/R
1108 (0x0454)	Set value of the speed for each DOF	12byte	W/R
1122 (0x0462)	Actual value of the actuator position for each DOF	12byte	R
1136 (0x0470)	Actual angle for each degree of freedom (DOF)	12byte	R
1150 (0x047E)	Actual force applied to each finger	12byte	R
1164 (0x048C)	Current value of the actuator for each DOF	12byte	R
1178 (0x049A)	Error codes of the actuator for each DOF	12byte	R
1192 (0x04A8)	Status information for each DOF	12byte	R
1206 (0x04B6)	Actuator temperature for each DOF	12byte	R
1220 (0x04C4)	Finger Motion Mode Settings	12byte	W/R
1300 (0x0514)	Pause (Write 1 to enable pause; other values are invalid)	2byte	W/R
1301 (0x0515)	Emergency Stop (Write 1 to enable emergency stop; writing other values	2byte	W/R

	disables emergency stop)		
1304 (0x0518)	Index Finger Force Deviation Flag	2byte	R
1305 (0x0519)	Middle Finger Force Deviation Flag	2byte	R
1431 (0x0597)	Built-in Action Number	2byte	W/R
1432 (0x0598)	Built-in Action Enable	2byte	W/R
2160 (0x0870)	Motion sequence number setting	2byte	W/R
2162 (0x0872)	Motion sequence run flag	2byte	W/R

2.5.1 ID of the dexterous hand

Default value = 1; range: 1-254; it can be saved.

When several dexterous hands are connected on one bus, each of them should be assigned a ID.

2.5.2 Baud rate setting

Default value = 0; range: 0-3; it can be saved.

485 Interface:

0: Baud rate = 115200bps

1: Baud rate = 57600bps

2: Baud rate = 19200bps

3: Baud rate = 921600bps

CAN2.0/CANFD Interface:

CANFD Interface 0: Baud rate 1M (80%) 5M (80%)

CANFD Interface 1: Baud rate 1M (80%) 2M (80%)

CAN2.0 Interface 2: Baud rate 500Kbps

CAN2.0 Interface 3: Baud rate 1000Kbps

2.5.3 Error clearance

Default value = 0; range: 0-1; it cannot be saved.

After 1 is written, clearable errors (actuator errors such as locked-rotor, overcurrent, abnormal operation, or communication error) in the dexterous hand will be cleared.

Note: The over temperature error of the actuator is not clearable. When the temperature falls, such error will be cleared automatically.

2.5.4 Save parameters

Default value = 0; range: 0-1; it cannot be saved.

After 1 is written, the dexterous hand will write current parameters in the Flash. These parameters will not be lost after power failure.

2.5.5 Restoring factory defaults

Default value = 0; range: 0-1; it cannot be saved.

After 1 is written, parameters of the dexterous hand will be restored to factory default settings.

2.5.6 Force sensor calibration

When the user sets the parameter to 1, the dexterous hand initiates the force sensor calibration process with the calibration lasting for 6s. The process is as follows: first, fully spread all five fingers; then bend the four fingers (little finger, ring finger, middle finger, and index finger; next, spread the four fingers while bending the thumb; finally, extend the thumb.

Note: The dexterous hand must be maintained in no-load state during calibration, that is, fingers cannot touch any object.

2.5.7 Current protection value of the actuator for each DOF

This register group consists of 13 registers corresponding to the current protection value of the dexterous hand for 13 DOF. When the current exceeds this value during finger motion, the finger will stop working, and the finger status register will indicate that the finger has stopped due to current protection. The details are as shown in Table 31 below.

These parameters can be saved after power failure (unit: mA).

Table 31 Current protection value of the actuator for each DOF

Address	Description	Data type	Range
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1024	Current Protection Value for Electric Cylinder No. 1	INT16	0-1500
1025	Current Protection Value for Electric Cylinder No. 2	INT16	0-1500
1026	Current Protection Value for Electric Cylinder No. 3	INT16	0-1500
1027	Current Protection Value for Electric Cylinder No. 4	INT16	0-1500
1028	Current Protection Value for Electric Cylinder No. 5	INT16	0-1500
1029	Current Protection Value for Electric Cylinder No. 6	INT16	0-1500
1030	Current Protection Value for Electric Cylinder No. 7	INT16	0-1500
1031	Current Protection Value for Electric Cylinder No. 8	INT16	0-1500
1032	Current Protection Value for Electric Cylinder No. 9	INT16	0-1500
1033	Current Protection Value for Electric Cylinder No. 10	INT16	0-1500
1034	Current Protection Value for Electric Cylinder No. 11	INT16	0-1500
1035	Current Protection Value for Electric Cylinder No. 12	INT16	0-1500
1036	Current Protection Value for Electric Cylinder No. 13	INT16	0-1500

2.5.8 Set value of power-on speed for each DOF

This register group consists of 13 registers corresponding to the set value of the power-on speed of the dexterous hand for 13 DOF, with details as shown in Table 32 below. These parameters can be saved after power failure, without range dimension.

Table 32 Set value of power-on speed for each DOF

Address	Description	Data type	Range
1038	Initial power-on speed of the Electric Cylinder No. 1	INT16	0-2500
1039	Initial power-on speed of the Electric Cylinder No. 2	INT16	0-2500
1040	Initial power-on speed of the Electric Cylinder No. 3	INT16	0-2500
1041	Initial power-on speed of the Electric Cylinder No. 4	INT16	0-2500
1042	Initial power-on speed of the Electric Cylinder No. 5	INT16	0-2500
1043	Initial power-on speed of the Electric Cylinder No. 6	INT16	0-2500
1044	Initial power-on speed of the Electric Cylinder No. 7	INT16	0-2500
1045	Initial power-on speed of the Electric Cylinder No. 8	INT16	0-2500
1046	Initial power-on speed of the Electric Cylinder No. 9	INT16	0-2500
1047	Initial power-on speed of the Electric Cylinder No. 10	INT16	0-2500
1048	Initial power-on speed of the Electric Cylinder No. 11	INT16	0-2500
1049	Initial power-on speed of the Electric Cylinder No. 12	INT16	0-2500
1050	Initial power-on speed of the Electric Cylinder No. 13	INT16	0-2500

Speed = 2000: This means that it will take 1000ms for the fingers in the no-load state to move from a large angle to the minimum angle. If there is a heavy load, the actual speed will be somewhat lower than this value.

2.5.9 Set value of power-on force control threshold for each DOF

This register group consists of 13 registers corresponding to the set value of the power-on force control threshold of the dexterous hand for 13 DOF, with details as shown in Table 33 below. These parameters can be saved after power failure (unit: g).

Table 33 Set value of power-on force control threshold for each DOF

Address	Description	Data type	Range
1052	Initial power-on force control of the Electric Cylinder No. 1	INT16	0-1000
1053	Initial power-on force control of the Electric Cylinder No. 2	INT16	0-1000
1054	Initial power-on force control of the Electric Cylinder No. 3	INT16	0-1000
1055	Initial power-on force control of the Electric Cylinder No. 4	INT16	0-1000
1056	Initial power-on force control of the Electric Cylinder No. 5	INT16	0-1000
1057	Initial power-on force control of the Electric Cylinder No. 6	INT16	0-1000
1058	Initial power-on force control of the Electric Cylinder No. 7	INT16	无力控
1059	Initial power-on force control of the Electric Cylinder No. 8	INT16	无力控
1060	Initial power-on force control of the Electric Cylinder No. 9	INT16	无力控

1061	Initial power-on force control of the Electric Cylinder No. 10	INT16	无力控
1062	Initial power-on force control of the Electric Cylinder No. 11	INT16	0-1000
1063	Initial power-on force control of the Electric Cylinder No. 12	INT16	0-1000
1064	Initial power-on force control of the Electric Cylinder No. 13	INT16	0-1000

This register value indicates the gripping force provided by the fingertip of the corresponding finger. For example, when the initial power-on force control of the ring finger is set to 200, it means that the fingertip of the ring finger is allowed to provide the gripping force of 200g. (If the portion of a finger that touches an object is not the fingertip, the available gripping force will be different. Its magnitude is related to the length of the arm of force. The shorter the arm of force is, the greater the gripping force will be.)

2.5.10 Set value of the actuator position for each DOF

This register group consists of 13 registers corresponding to the set position of the actuator of the dexterous hand for 13 DOF, with details as shown in Table 34 below.

These parameters cannot be saved, without range dimension.

Table 34 Set value of the actuator position for each DOF

Address	Description	Data type	Range
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1066	Setting of the actuator position for the Electric Cylinder No. 1	INT16	-1,0-2000
1067	Setting of the actuator position for the Electric Cylinder No. 2	INT16	-1,0-2000
1068	Setting of the actuator position for the Electric Cylinder No. 3	INT16	-1,0-2000
1069	Setting of the actuator position for the Electric Cylinder No. 4	INT16	-1,0-2000
1070	Setting of the actuator position for the Electric Cylinder No. 5	INT16	-1,0-2000
1071	Setting of the actuator position for the Electric Cylinder No. 6	INT16	-1,0-2000
1072	Setting of the actuator position for the Electric Cylinder No. 7	INT16	-1,0-2000
1073	Setting of the actuator position for the Electric Cylinder No. 8	INT16	-1,0-2000
1074	Setting of the actuator position for the Electric Cylinder No. 9	INT16	-1,0-2000
1075	Setting of the actuator position for the Electric Cylinder No. 10	INT16	-1,0-2000
1076	Setting of the actuator position for the Electric Cylinder No. 11	INT16	-1,0-2000

1077	Setting of the actuator position for the Electric Cylinder No. 12	INT16	-1,0-2000
1078	Setting of the actuator position for the Electric Cylinder No. 13	INT16	-1,0-2000

0: Minimum actuator stroke, corresponding to the maximum finger angle (i.e., holding fingers open);

2000: Maximum actuator stroke, corresponding to the minimum finger angle (i.e., bending fingers);

-1: The actuator does not take any action.

It is not recommended to set the finger position angle by setting this register group.

2.5.11 Set value of the angle for each DOF

This register group consists of 13 registers corresponding to the set value of the angle of the dexterous hand for 13 DOF, with details as shown in Table 35 below. These parameters cannot be saved after power failure. When the angle value for a degree of freedom (DOF) is set to the data in the range shown in the table below, the corresponding finger will take an immediate action. If the angle value is set to -1, the corresponding finger will make no response. For example, after the angle values of six write angle registers are set to 1200, 1200, -1, 1500, 1200, and 1200 respectively, the little and ring fingers and the thumb will be bent, and the thumb will rotate by 4 DOF and

move to an angle corresponding to "1200"; the index finger will move to an angle corresponding to "1200"; and the middle finger will not move (i.e., it will be maintained in the current position without action), unit: 0.1° , the joint angle corresponding to 1200 is 120° .

Table 35 Set value of the angle for each DOF

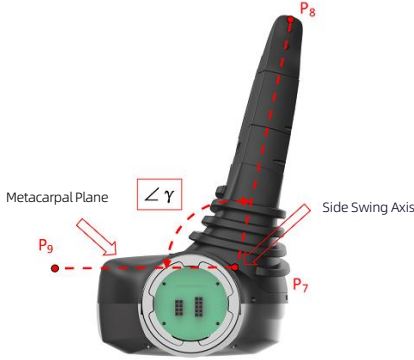
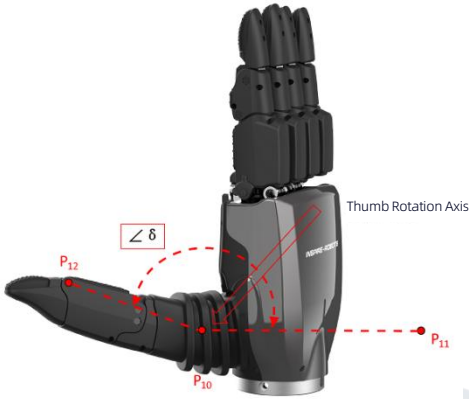
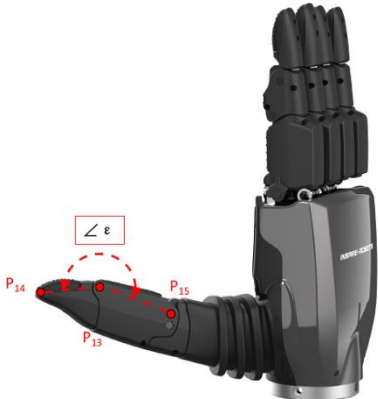
Address	Description	Data type	Range
1080	Little Finger Root Angle Setting Value	INT16	-1,900-1650
1081	Ring Finger Root Angle Setting Value	INT16	-1,900-1650
1082	Middle Finger Root Angle Setting Value	INT16	-1,900-1650
1083	Middle Finger Side Swing Angle Setting Value	INT16	-1,-150-150
1084	Index Finger Root Angle Setting Value	INT16	-1,900-1650
1085	Index Finger Side Swing Angle Setting Value	INT16	-1,-150-150
1086	Little Finger Middle Joint Angle Setting Value	INT16	-1,1050-1900
1087	Ring Finger Middle Joint Angle Setting Value	INT16	-1,1050-1900
1088	Middle Finger Middle Joint Angle Setting Value	INT16	-1,1050-1900
1089	Index Finger Middle Joint Angle Setting Value	INT16	-1,1050-1900
1090	Thumb Side Swing Angle Setting Value	INT16	-1,650-1750
1091	Thumb First Joint Bend Angle Setting Value	INT16	-1,1250-1600

1092	Thumb Second Joint Bend Angle Setting Value	INT16	-1,1500-2040
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The definition of angle and the range of motion for each DOF are described in Table 36 below.

Table 36 Definitions of angle and the range of motion for each DOF

Angle	Legend description	Range
Little finger Ring finger Middle finger Index finger (Four Fingers Root Section)		90°~165°
Little finger Ring finger Middle finger Index finger (Four Fingers Middle Section)		105°~190°
Middle finger Index finger (Side Swing Section)		-15°~15°

Thumb Side Swing Angle		65°~175°
Thumb First Joint Bend Angle		125°~160°
Thumb Second Joint Bend Angle		150°~204°

2.5.12 Set value of force control threshold for each DOF

This register group consists of thirteen registers corresponding to the set value of the force control threshold of the dexterous hand for thirteen DOF, with details in the table below. These parameters cannot be saved after power failure. The user can set this

register group to control the gripping force of fingers. For example, set force control threshold for the index finger to 100, and set the current actual angle of the index finger to 1650 (i.e., fully open). After the user sets the set angle of the index finger to 900, the index finger will bend towards the palm. Once it is detected that the actual force applied to the index finger during bending reaches 100, the index finger will stop moving; otherwise, the index finger will move to the preset angle, unit: g, with details as shown in Table 37 below.

Table 37 Set value of force control threshold for each DOF

Address	Description	Data type	Range
1094	Set value of force control for the Electric Cylinder No. 1	INT16	0-1000
1095	Set value of force control for the Electric Cylinder No. 2	INT16	0-1000
1096	Set value of force control for the Electric Cylinder No. 3	INT16	0-1000
1097	Set value of force control for the Electric Cylinder No. 4	INT16	0-1000
1098	Set value of force control for the Electric Cylinder No. 5	INT16	0-1000
1099	Set value of force control for the Electric Cylinder No. 6	INT16	0-1000

1100	Set value of force control for the Electric Cylinder No. 7	INT16	0-1000
1101	Set value of force control for the Electric Cylinder No. 8	INT16	0-1000
1102	Set value of force control for the Electric Cylinder No. 9	INT16	0-1000
1103	Set value of force control for the Electric Cylinder No. 10	INT16	0-1000
1104	Set value of force control for the Electric Cylinder No. 11	INT16	0-1000
1105	Set value of force control for the Electric Cylinder No. 12	INT16	0-1000
1106	Set value of force control for the Electric Cylinder No. 13	INT16	0-1000

This register value indicates the force fed back by the finger end of the corresponding finger. For example, when the force control threshold for the ring finger is set to 200, it means that the fingertip of the ring finger is allowed to provide the gripping force of 200g. (If the portion of a finger that touches an object is not the fingertip, the available gripping force will be different. Its magnitude is related to the length of the arm of force. The shorter the arm of force is, the greater the gripping force will be.)

2.5.13 Set value of the speed for each DOF

This register group consists of 13 registers corresponding to the set value of the speed of the dexterous hand for 13 DOF, with details as shown in Table 38 below. These parameters cannot be saved after power failure, without range dimension.

Table 38 Set value of the speed for each DOF

Address	Description	Data type	Range
1108	Set value of the speed for the Electric Cylinder No. 1	INT16	0-2500
1109	Set value of the speed for the Electric Cylinder No. 2	INT16	0-2500
1110	Set value of the speed for the Electric Cylinder No. 3	INT16	0-2500
1111	Set value of the speed for the Electric Cylinder No. 4	INT16	0-2500
1112	Set value of the speed for the Electric Cylinder No. 5	INT16	0-2500
1113	Set value of the speed for the Electric Cylinder No. 6	INT16	0-2500
1114	Set value of the speed for the Electric Cylinder No. 7	INT16	0-2500
1115	Set value of the speed for the Electric Cylinder No. 8	INT16	0-2500
1116	Set value of the speed for the Electric Cylinder No. 9	INT16	0-2500

1117	Set value of the speed for the Electric Cylinder No. 10	INT16	0-2500
1118	Set value of the speed for the Electric Cylinder No. 11	INT16	0-2500
1119	Set value of the speed for the Electric Cylinder No. 12	INT16	0-2500
1120	Set value of the speed for the Electric Cylinder No. 13	INT16	0-2500

Speed = 2000: This means that it will take 1000ms for the fingers in the no-load state to move from a large angle to the minimum angle. If there is a heavy load, the actual speed will be somewhat lower than this value.

2.5.14 Actual value of the actuator position for each DOF

This register group consists of 13 registers corresponding to the current actual position of the actuator of the dexterous hand for 13 DOF, with details as shown in Table 39 below.

These parameters can be read only, without range dimension.

Table 39 Actual value of the actuator position for each DOF

Address	Description	Data type	Range
1122	Actual position value of the actuator for the Electric Cylinder No. 1	INT16	0-2000
1123	Actual position value of the actuator for the Electric Cylinder No. 2	INT16	0-2000

1124	Actual position value of the actuator for the Electric Cylinder No. 3	INT16	0-2000
1125	Actual position value of the actuator for the Electric Cylinder No. 4	INT16	0-2000
1126	Actual position value of the actuator for the Electric Cylinder No. 5	INT16	0-2000
1127	Actual position value of the actuator for the Electric Cylinder No. 6	INT16	0-2000
1128	Actual position value of the actuator for the Electric Cylinder No. 7	INT16	0-2000
1129	Actual position value of the actuator for the Electric Cylinder No. 8	INT16	0-2000
1130	Actual position value of the actuator for the Electric Cylinder No. 9	INT16	0-2000
1131	Actual position value of the actuator for the Electric Cylinder No. 10	INT16	0-2000
1132	Actual position value of the actuator for the Electric Cylinder No. 11	INT16	0-2000
1133	Actual position value of the actuator for the Electric Cylinder No. 12	INT16	0-2000
1134	Actual position value of the actuator for the Electric Cylinder No. 13	INT16	0-2000

0: Minimum actuator stroke, corresponding to the maximum finger angle.

2000: Maximum actuator stroke, corresponding to the minimum finger angle.

2.5.15 Actual angle for each degree of freedom (DOF)

This register group consists of 13 registers corresponding to the current actual angle of the dexterous hand for 13 DOF, with details as shown in Table 40 below. These parameters can be read only, unit: 0.1 °.

Table 40 Actual angle value for each DOF

Address	Description	Data type	Range
1136	Little Finger Root Angle Actual Value	INT16	900-1650
1137	Ring Finger Root Angle Actual Value	INT16	900-1650
1138	Middle Finger Root Angle Actual Value	INT16	900-1650
1139	Middle Finger Side Swing Angle Actual Value	INT16	-150-150
1140	Index Finger Root Angle Actual Value	INT16	900-1650
1141	Index Finger Side Swing Angle Actual Value	INT16	-150-150
1142	Little Finger Middle Joint Angle Actual Value	INT16	1050-1900
1143	Ring Finger Middle Joint Angle Actual Value	INT16	1050-1900
1144	Middle Finger Middle Joint Angle Actual Value	INT16	1050-1900
1145	Index Finger Middle Joint Angle Actual Value	INT16	1050-1900
1146	Thumb Side Swing Angle Actual Value	INT16	650-1750

1147	Thumb First Joint Bend Angle Actual Value	INT16	1250-1600
1148	Thumb Second Joint Bend Angle Actual Value	INT16	1500-2040

2.5.16 Actual force applied to each finger

This register group consists of 13 registers corresponding to the actual force applied to 13 fingers of the dexterous hand, with details as shown in Table 41 below. These parameters can be read only, unit: g.

Table 41 Actual force applied to each finger

Address	Description	Data type	Range
1150	Actual force applied to the Electric Cylinder No. 1	INT16	-1000-1000
1151	Actual force applied to the Electric Cylinder No. 2	INT16	-1000-1000
1152	Actual force applied to the Electric Cylinder No. 3	INT16	-1000-1000
1153	Actual force applied to the Electric Cylinder No. 4	INT16	-1000-1000
1154	Actual force applied to the Electric Cylinder No. 5	INT16	-1000-1000
1155	Actual force applied to the Electric Cylinder No. 6	INT16	-1000-1000
1156	Actual force applied to the Electric Cylinder No. 7	INT16	-1000-1000
1157	Actual force applied to the Electric Cylinder No. 8	INT16	-1000-1000
1158	Actual force applied to the Electric Cylinder No. 9	INT16	-1000-1000

1159	Actual force applied to the Electric Cylinder No. 10	INT16	-1000-1000
1160	Actual force applied to the Electric Cylinder No. 11	INT16	-1000-1000
1161	Actual force applied to the Electric Cylinder No. 12	INT16	-1000-1000
1162	Actual force applied to the Electric Cylinder No. 13	INT16	-1000-1000

2.5.17 Current value of the actuator for each DOF

This register group consists of 13 registers corresponding to the current value applied to 13 actuators of the dexterous hand, with details as shown in Table 42 below. These parameters can be read only. unit: mA.

Table 42 Current value of the actuator for each DOF

Address	Description	Data type	Range
1164	Current value of the actuator for the Electric Cylinder No. 1	INT16	0-1500
1165	Current value of the actuator for the Electric Cylinder No. 2	INT16	0-1500
1166	Current value of the actuator for the Electric Cylinder No. 3	INT16	0-1500
1167	Current value of the actuator for the Electric Cylinder No. 4	INT16	0-1500
1168	Current value of the actuator for the Electric Cylinder No. 5	INT16	0-1500
1169	Current value of the actuator for the Electric Cylinder No. 6	INT16	0-1500
1170	Current value of the actuator for the Electric Cylinder No. 7	INT16	0-1500
1171	Current value of the actuator for the Electric Cylinder No. 8	INT16	0-1500

1172	Current value of the actuator for the Electric Cylinder No. 9	INT16	0-1500
1173	Current value of the actuator for the Electric Cylinder No. 10	INT16	0-1500
1174	Current value of the actuator for the Electric Cylinder No. 11	INT16	0-1500
1175	Current value of the actuator for the Electric Cylinder No. 12	INT16	0-1500
1176	Current value of the actuator for the Electric Cylinder No. 13	INT16	0-1500

2.5.18 Error codes of each actuator

This register group consists of 13 registers corresponding to the error code applied to 13 actuators of the dexterous hand, with details as shown in Table 43 below. These parameters can be read only.

Table 43 Error codes of each actuator

Address	Description	Data type
1178	Error code of the actuator for the Electric Cylinder No. 1	INT16
1179	Error code of the actuator for the Electric Cylinder No. 2	INT16
1180	Error code of the actuator for the Electric Cylinder No. 3	INT16
1181	Error code of the actuator for the Electric Cylinder No. 4	INT16
1182	Error code of the actuator for the Electric Cylinder No. 5	INT16
1183	Error code of the actuator for the Electric Cylinder No. 6	INT16
1184	Error code of the actuator for the Electric Cylinder No. 7	INT16

1185	Error code of the actuator for the Electric Cylinder No. 8	INT16
1186	Error code of the actuator for the Electric Cylinder No. 9	INT16
1187	Error code of the actuator for the Electric Cylinder No. 10	INT16
1188	Error code of the actuator for the Electric Cylinder No. 11	INT16
1189	Error code of the actuator for the Electric Cylinder No. 12	INT16
1190	Error code of the actuator for the Electric Cylinder No. 13	INT16

The implication of error codes is as shown in Table 44 below. For example, if the error code of the index finger is 0x06 (00000110 in the binary system), it means that over temperature and overcurrent errors occur in the actuator of the index finger.

Table 44 Description of error codes

	Description
Bit0	Locked-rotor error
Bit1	Over temperature error
Bit2	Overcurrent error
Bit3	Abnormal operation of the motor
Bit4	Communication error

2.5.19 Status information for each DOF

This register group consists of 13 registers corresponding to the status information of the dexterous hand for 13 DOF, with details as shown in Table 45 below. These parameters can be read only.

Table 45 Status information for each DOF

Address	Description	Data type
1192	Status information of Electric Cylinder No. 1	INT16
1193	Status information of Electric Cylinder No. 2	INT16
1194	Status information of Electric Cylinder No. 3	INT16
1195	Status information of Electric Cylinder No. 4	INT16
1196	Status information of Electric Cylinder No. 5	INT16
1197	Status information of Electric Cylinder No. 6	INT16
1198	Status information of Electric Cylinder No. 7	INT16
1199	Status information of Electric Cylinder No. 8	INT16
1200	Status information of Electric Cylinder No. 9	INT16
1201	Status information of Electric Cylinder No. 10	INT16
1202	Status information of Electric Cylinder No. 11	INT16
1203	Status information of Electric Cylinder No. 12	INT16
1204	Status information of Electric Cylinder No. 13	INT16

The meaning of the status code is as shown in Table 46 below:

Table 46 Description of status code

Status code	Description
0	Releasing
1	Gripping
2	Position in-place stop
3	Force control in-place stop
5	Current protection stop
6	Locked-rotor stop of the actuator
7	Fault stop of the actuator

2.5.20 Temperature of each actuator

This register group consists of 13 registers corresponding to the temperature value applied to 13 actuators of the dexterous hand, with details as shown in Table 47 below.

These parameters can be read only.unit: °C

Table 47 Temperature of each actuator

Address	Description	Data type	Range
1206	Temperature value of the actuator for the Electric Cylinder No. 1	INT16	0-100
1207	Temperature value of the actuator for the Electric Cylinder No. 2	INT16	0-100
1208	Temperature value of the actuator for the Electric Cylinder No. 3	INT16	0-100
1209	Temperature value of the actuator for the Electric Cylinder No. 4	INT16	0-100
1210	Temperature value of the actuator for the Electric Cylinder	INT16	0-100

	No. 5		
1211	Temperature value of the actuator for the Electric Cylinder No. 6	INT16	0-100
1212	Temperature value of the actuator for the Electric Cylinder No. 7	INT16	0-100
1213	Temperature value of the actuator for the Electric Cylinder No. 8	INT16	0-100
1214	Temperature value of the actuator for the Electric Cylinder No. 9	INT16	0-100
1215	Temperature value of the actuator for the Electric Cylinder No. 10	INT16	0-100
1216	Temperature value of the actuator for the Electric Cylinder No. 11	INT16	0-100
1217	Temperature value of the actuator for the Electric Cylinder No. 12	INT16	0-100
1218	Temperature value of the actuator for the Electric Cylinder No. 13	INT16	0-100

2.5.21 Finger Motion Mode

This register group consists of six registers corresponding to the operation mode of six fingers of the dexterous hand, with details as shown in Table 48 below.

Introduction of Finger Operation Mode:

0: Speed-Force Protection Mode: Control finger movement based on set position, speed, and force, and finger motion stops upon reaching the set force or position

1: Force Closed-loop Mode: Perform force closed-loop control based on set force, and the finger follows the set force to control

Note: When setting the force control mode for the MCP joints of the index and middle fingers, also set the corresponding side swing degrees of freedom to force control mode.

Table 48 Finger Motion Mode

Address	Description	Range	Data type
1220	Little Finger Root Operation Mode	0、1	INT16
1221	Ring Finger Root Operation Mode	0、1	INT16
1222	Middle Finger Root Operation Mode	0、1	INT16
1223	Middle Finger Side Swing Operation Mode	0、1	INT16
1224	Index Finger Root Operation Mode	0、1	INT16
1225	Ring Finger Side Swing Operation Mode	0、1	INT16
1226	Little Finger Middle Joint Operation Mode	0、1	INT16
1227	Ring Finger Middle Joint Operation Mode	0、1	INT16
1228	Middle Finger Middle Joint Operation Mode	0、1	INT16
1229	Index Finger Middle Joint Operation Mode	0、1	INT16
1230	Thumb Side Swing Operation Mode	0、1	INT16

1231	Thumb First Joint Bend Operation Mode	0、1	INT16
1232	Thumb Second Joint Bend Operation Mode	0、1	INT16

2.5.22 Explanation of each finger tactile format

The fingers are equipped with capacitive tactile sensors. These sensors provide data on the normal force, tangential force, and tangential force direction at the fingertip. The relationship between the data and the actual force is: if the data obtained is 1024, the actual force value is 10.24N. The tangential force direction is 0-359°. The direction increases clockwise from the fingertip (0-359°) as shown in Figure 4, If the acquired tangential force data is 0xFFFF, the angle is invalid. The details of data address and content are as shown in Table 49 below.

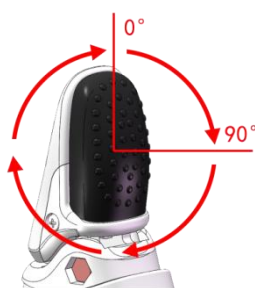


Figure 4 Tangential Force Direction Diagram

Table 49 Explanation of finger tactile format

Address	Meaning	Data type	Resolution	Permission (read / write)
3000	Tactile normal force data for little finger	UINT16	0.01N	R
3001	Tactile tangential force data for	UINT16	0.01N	R

	little finger			
3002	Tactile tangential force direction for little finger	UINT16	Degree	R
3003	Tactile proximity value of little finger is low-order 16-bit	UINT16	24-bit	R
3004	Tactile proximity value of little finger is high-order 16-bit	UINT16		
3005	Tactile normal force data for ring finger	UINT16	0.01N	R
3006	Tactile tangential force data for ring finger	UINT16	0.01N	R
3007	Tactile tangential force direction for ring finger	UINT16	Degree	R
3008	Tactile proximity value of ring finger is low-order 16-bit	UINT16	24-bit	R
3009	Tactile proximity value of ring finger is high-order 16-bit	UINT16		
3010	Tactile normal force data for middle finger	UINT16	0.01N	R
3011	Tactile tangential force data for middle finger	UINT16	0.01N	R
3012	Tactile tangential force direction for middle finger	UINT16	Degree	R
3013	Tactile proximity value of middle finger is low-order 16-bit	UINT16	24-bit	R
3014	Tactile proximity value of middle finger is high-order 16-bit	UINT16		
3015	Tactile normal force data for index finger	UINT16	0.01N	R
3016	Tactile tangential force data for index finger	UINT16	0.01N	R
3017	Tactile tangential force direction for index finger	UINT16	Degree	R
3018	Tactile proximity value of index finger is low-order 16-bit	UINT16	24-bit	R

3019	Tactile proximity value of index finger is high-order 16-bit	UINT16		
3020	Tactile normal force data for thumb	UINT16	0.01N	R
3021	Tactile tangential force data for thumb	UINT16	0.01N	R
3022	Tactile tangential force direction for thumb	UINT16	Degree	R
3023	Tactile proximity value of thumb is low-order 16-bit	UINT16	24-bit	R
3024	Tactile proximity value of thumb is high-order 16-bit	UINT16		
3025	Tactile normal force data for palm (right)	UINT16	0.01N	R
3026	Tactile tangential force data for palm (right)	UINT16	0.01N	R
3027	Tactile tangential force direction for palm (right)	UINT16	Degree	R
3028	Tactile normal force data for palm (middle)	UINT16	0.01N	R
3029	Tactile tangential force data for palm (middle)	UINT16	0.01N	R
3030	Tactile tangential force direction for palm (middle)	UINT16	Degree	R
3031	Tactile normal force data for palm (left)	UINT16	0.01N	R
3032	Tactile tangential force data for palm (left)	UINT16	0.01N	R
3033	Tactile tangential force direction for palm (left)	UINT16	Degree	R

2.5.23 Built-in Action Library Usage Instructions

Address: 1431 (0x0597), 1432 (0x0598)

The dexterous hand has 30 built-in actions. Address 1431 (0x0597) is used to set the

desired action number (range: 1-30), corresponding to different hand gestures. For example, setting address 1431 to 1 corresponds to the gesture of making a fist. Address 1432 (0x0598) is the action enable flag; writing 1 enables the action. To ensure the action is executed, after enabling, the dexterous hand will first return to the open state and then perform the corresponding gesture. Once all degrees of freedom are in place, address 1432 will automatically change to 0.

The corresponding actions are shown in the table below.

1	2	3	4	5	6
握拳	五指张开	比耶	OK	中指捏	三指捏 1
7	8	9	10	11	12
两指夹	握鼠标	666	三指捏 2	单指点	单指弯钩
13	14	15	16	17	18
四指托	摇滚手势	五指抓	侧捏	夹笔 1	夹笔 2
19	20	21	22	23	24
捏瓶盖	点赞	抓握按压	五指抠/抓	拿筷子	抽卡片捏
25	26	27	28	29	30
三指捏圆球	五指握	两指捏圆球	比心	单指捏握	无名指对捏

2.6 EtherCAT Protocol Overview

The I/O mode of the EtherCAT bus is an efficient data exchange mechanism based on real-time Ethernet. Its core lies in achieving ultra-low latency input/output control through distributed clock synchronization and Process Data Objects (PDO). Currently,

EtherCAT only supports the I/O protocol and does not support the CIA402 protocol or DC mode.

2.6.1 Introduction to the PDO Object Dictionary

Table 50 PDO Object Dictionary

Address	Name	Meaning	Data type	Permission (read / write)
0x6000: 01	ANGLEACT1	Little Finger Root Angle Actual Value	INT16	R
0x6000: 02	ANGLEACT2	Ring Finger Root Angle Actual Value	INT16	R
0x6000: 03	ANGLEACT3	Middle Finger Root Angle Actual Value	INT16	R
0x6000: 04	ANGLEACT4	Middle Finger Side Swing Angle Actual Value	INT16	R
0x6000: 05	ANGLEACT5	Index Finger Root Angle Actual Value	INT16	R
0x6000: 06	ANGLEACT6	Index Finger Side Swing Angle Actual Value	INT16	R
0x6000: 07	ANGLEACT7	Little Finger Middle Joint Angle Actual Value	INT16	R
0x6000: 08	ANGLEACT8	Ring Finger Middle Joint Angle Actual Value	INT16	R
0x6000: 09	ANGLEACT9	Middle Finger Middle Joint Angle Actual Value	INT16	R
0x6000: 0A	ANGLEACT10	Index Finger Middle Joint Angle Actual Value	INT16	R
0x6000: 0B	ANGLEACT11	Thumb Side Swing Angle Actual Value	INT16	R
0x6000: 0C	ANGLEACT12	Thumb First Joint Bend	INT16	R

		Angle Actual Value		
0x6000: 0D	ANGLEACT13	Thumb Second Joint Bend Angle Actual Value	INT16	R
0x6000: 0E	FORCEACT1	Actual force applied to the Electric Cylinder No. 1	INT16	R
0x6000: 0F	FORCEACT2	Actual force applied to the Electric Cylinder No. 2	INT16	R
0x6000: 10	FORCEACT3	Actual force applied to the Electric Cylinder No. 3	INT16	R
0x6000: 11	FORCEACT4	Actual force applied to the Electric Cylinder No. 4	INT16	R
0x6000: 12	FORCEACT5	Actual force applied to the Electric Cylinder No. 5	INT16	R
0x6000: 13	FORCEACT6	Actual force applied to the Electric Cylinder No. 6	INT16	R
0x6000: 14	FORCEACT7	Actual force applied to the Electric Cylinder No. 7	INT16	R
0x6000: 15	FORCEACT8	Actual force applied to the Electric Cylinder No. 8	INT16	R
0x6000: 16	FORCEACT9	Actual force applied to the Electric Cylinder No. 9	INT16	R
0x6000: 17	FORCEACT10	Actual force applied to the Electric Cylinder No. 10	INT16	R
0x6000: 18	FORCEACT11	Actual force applied to the Electric Cylinder No. 11	INT16	R
0x6000: 19	FORCEACT12	Actual force applied to the Electric Cylinder No. 12	INT16	R
0x6000: 1A	FORCEACT13	Actual force applied to the Electric Cylinder No. 13	INT16	R
0x6000: 1B	ERROR1	Error code of the actuator for the Electric Cylinder No. 1	INT16	R

0x6000: 1C	ERROR2	Error code of the actuator for the Electric Cylinder No. 2	INT16	R
0x6000: 1D	ERROR3	Error code of the actuator for the Electric Cylinder No. 3	INT16	R
0x6000: 1E	ERROR4	Error code of the actuator for the Electric Cylinder No. 4	INT16	R
0x6000: 1F	ERROR5	Error code of the actuator for Electric Cylinder No. 5	INT16	R
0x6000: 20	ERROR6	Error code of the actuator for the Electric Cylinder No. 6	INT16	R
0x6000: 21	ERROR7	Error code of the actuator for the Electric Cylinder No. 7	INT16	R
0x6000: 22	ERROR8	Error code of the actuator for the Electric Cylinder No. 8	INT16	R
0x6000: 23	ERROR9	Error code of the actuator for the Electric Cylinder No. 9	INT16	R
0x6000: 24	ERROR10	Error code of the actuator for the Electric Cylinder No. 10	INT16	R
0x6000: 25	ERROR11	Error code of the actuator for the Electric Cylinder No. 11	INT16	R
0x6000: 26	ERROR12	Error code of the actuator for the Electric Cylinder No. 12	INT16	R
0x6000: 27	ERROR13	Error code of the actuator for the Electric Cylinder No. 13	INT16	R
0x6000: 28	TEMP1	Temperature value of the	INT16	R

		actuator for the Electric Cylinder No. 1		
0x6000: 29	TEMP2	Temperature value of the actuator for the Electric Cylinder No. 2	INT16	R
0x6000: 2A	TEMP3	Temperature value of the actuator for the Electric Cylinder No. 3	INT16	R
0x6000: 2B	TEMP4	Temperature value of the actuator for the Electric Cylinder No. 4	INT16	R
0x6000: 2C	TEMP5	Temperature value of the actuator for the Electric Cylinder No. 5	INT16	R
0x6000: 2D	TEMP6	Temperature value of the actuator for the Electric Cylinder No. 6	INT16	R
0x6000: 2E	TEMP7	Temperature value of the actuator for the Electric Cylinder No. 7	INT16	R
0x6000: 2F	TEMP8	Temperature value of the actuator for the Electric Cylinder No. 8	INT16	R
0x6000: 30	TEMP9	Temperature value of the actuator for the Electric Cylinder No. 9	INT16	R
0x6000: 31	TEMP10	Temperature value of the actuator for the Electric Cylinder No. 10	INT16	R
0x6000: 32	TEMP11	Temperature value of the actuator for the Electric Cylinder No. 11	INT16	R
0x6000: 33	TEMP12	Temperature value of the actuator for the Electric Cylinder No. 12	INT16	R
0x6000: 34	TEMP13	Temperature value of the	INT16	R

		actuator for the Electric Cylinder No. 13		
0x6010: 01	Touch_group1_data1	Tactile normal force data for little finger	UINT16	R
0x6010: 02	Touch_group1_data2	Tactile tangential force data for little finger	UINT16	R
0x6010: 03	Touch_group1_data3	Tactile tangential force direction for little finger	UINT16	R
0x6010: 04	Touch_group1_data4	Tactile proximity value of little finger is low-order 16-bit	UINT16	R
0x6010: 05	Touch_group1_data5	Tactile proximity value of little finger is high-order 16-bit	UINT16	R
0x6010: 06	Touch_group1_data6	Tactile normal force data for ring finger	UINT16	R
0x6010: 07	Touch_group1_data7	Tactile tangential force data for ring finger	UINT16	R
0x6010: 08	Touch_group1_data8	Tactile tangential force direction for ring finger	UINT16	R
0x6010: 09	Touch_group1_data9	Tactile proximity value of ring finger is low-order 16-bit	UINT16	R
0x6010: 0A	Touch_group1_data10	Tactile proximity value of ring finger is high-order 16-bit	UINT16	R
0x6010: 0B	Touch_group1_data11	Tactile normal force data for middle finger	UINT16	R
0x6010: 0C	Touch_group1_data12	Tactile tangential force data for middle finger	UINT16	R
0x6010: 0D	Touch_group1_data13	Tactile tangential force direction for middle finger	UINT16	R
0x6010: 0E	Touch_group1_data14	Tactile proximity value of middle finger is low-order 16-bit	UINT16	R

0x6010: 0F	Touch_group1_data15	Tactile proximity value of middle finger is high-order 16-bit	UINT16	R
0x6010: 10	Touch_group1_data16	Tactile normal force data for index finger	UINT16	R
0x6010: 11	Touch_group1_data17	Tactile tangential force data for index finger	UINT16	R
0x6010: 12	Touch_group1_data18	Tactile tangential force direction for index finger	UINT16	R
0x6010: 13	Touch_group1_data19	Tactile proximity value of index finger is low-order 16-bit	UINT16	R
0x6010: 14	Touch_group1_data20	Tactile proximity value of index finger is high-order 16-bit	UINT16	R
0x6010: 15	Touch_group1_data21	Tactile normal force data for thumb	UINT16	R
0x6010: 16	Touch_group1_data22	Tactile tangential force data for thumb	UINT16	R
0x6010: 17	Touch_group1_data23	Tactile tangential force direction for thumb	UINT16	R
0x6010: 18	Touch_group1_data24	Tactile proximity value of thumb is low-order 16-bit	UINT16	R
0x6010: 19	Touch_group1_data25	Tactile proximity value of thumb is high-order 16-bit	UINT16	R
0x6010: 1A	Touch_group1_data26	Tactile normal force data for palm (right)	UINT16	R
0x6010: 1B	Touch_group1_data27	Tactile tangential force data for palm (right)	UINT16	R
0x6010: 1C	Touch_group1_data28	Tactile tangential force direction for palm (right)	UINT16	R
0x6010: 1D	Touch_group1_data29	Tactile normal force data for palm (middle)	UINT16	R
0x6010: 1E	Touch_group1_data30	Tactile tangential force data for palm (middle)	UINT16	R

0x6010: 1F	Touch_group1_data31	Tactile tangential force direction for palm (middle)	UINT16	R
0x6010: 20	Touch_group1_data32	Tactile normal force data for palm (left)	UINT16	R
0x6010: 21	Touch_group1_data33	Tactile tangential force data for palm (left)	UINT16	R
0x6010: 22	Touch_group1_data34	Tactile tangential force direction for palm (left)	UINT16	R
0x7000: 01	ENABLE_SET	Motion Control Enable	INT16	R/W
0x7000: 02	ANGLESET1	Little Finger Root Angle Setting Value	INT16	R/W
0x7000: 03	ANGLESET2	Ring Finger Root Angle Setting Value	INT16	R/W
0x7000: 04	ANGLESET3	Middle Finger Root Angle Setting Value	INT16	R/W
0x7000: 05	ANGLESET4	Middle Finger Side Swing Angle Setting Value	INT16	R/W
0x7000: 06	ANGLESET5	Index Finger Root Angle Setting Value	INT16	R/W
0x7000: 07	ANGLESET6	Index Finger Side Swing Angle Setting Value	INT16	R/W
0x7000: 08	ANGLESET7	Little Finger Middle Joint Angle Setting Value	INT16	R/W
0x7000: 09	ANGLESET8	Ring Finger Middle Joint Angle Setting Value	INT16	R/W
0x7000: 0A	ANGLESET9	Middle Finger Middle Joint Angle Setting Value	INT16	R/W
0x7000: 0B	ANGLESET10	Index Finger Middle Joint Angle Setting Value	INT16	R/W
0x7000: 0C	ANGLESET11	Thumb Side Swing Angle Setting Value	INT16	R/W
0x7000: 0D	ANGLESET12	Thumb First Joint Bend Angle Setting Value	INT16	R/W
0x7000: 0E	ANGLESET13	Thumb Second Joint Bend	INT16	R/W

		Angle Setting Value		
0x7000: 0F	FROCESET1	Set value of force control for the Electric Cylinder No. 1	INT16	R/W
0x7000: 10	FROCESET2	Set value of force control for the Electric Cylinder No. 2	INT16	R/W
0x7000: 11	FROCESET3	Set value of force control for the Electric Cylinder No. 3	INT16	R/W
0x7000: 12	FROCESET4	Set value of force control for the Electric Cylinder No. 4	INT16	R/W
0x7000: 13	FROCESET5	Set value of force control for the Electric Cylinder No. 5	INT16	R/W
0x7000: 14	FROCESET6	Set value of force control for the Electric Cylinder No. 6	INT16	R/W
0x7000: 15	FROCESET7	Set value of force control for the Electric Cylinder No. 7	INT16	R/W
0x7000: 16	FROCESET8	Set value of force control for the Electric Cylinder No. 8	INT16	R/W
0x7000: 17	FROCESET9	Set value of force control for the Electric Cylinder No. 9	INT16	R/W
0x7000: 18	FROCESET10	Set value of force control for the Electric Cylinder No. 10	INT16	R/W
0x7000: 19	FROCESET11	Set value of force control for the Electric Cylinder No. 11	INT16	R/W
0x7000: 1A	FROCESET12	Set value of force control for the Electric Cylinder	INT16	R/W

		No. 12		
0x7000: 1B	FROCESET13	Set value of force control for the Electric Cylinder No. 13	INT16	R/W
0x7000: 1C	SPEEDSET1	Set value of the speed for the Electric Cylinder No. 1	INT16	R/W
0x7000: 1D	SPEEDSET2	Set value of the speed for the Electric Cylinder No. 2	INT16	R/W
0x7000: 1E	SPEEDSET3	Set value of the speed for the Electric Cylinder No. 3	INT16	R/W
0x7000: 1F	SPEEDSET4	Set value of the speed for the Electric Cylinder No. 4	INT16	R/W
0x7000: 20	SPEEDSET5	Set value of the speed for the Electric Cylinder No. 5	INT16	R/W
0x7000: 21	SPEEDSET6	Set value of the speed for the Electric Cylinder No. 6	INT16	R/W
0x7000: 22	SPEEDSET7	Set value of the speed for the Electric Cylinder No. 7	INT16	R/W
0x7000: 23	SPEEDSET8	Set value of the speed for the Electric Cylinder No. 8	INT16	R/W
0x7000: 24	SPEEDSET9	Set value of the speed for the Electric Cylinder No. 9	INT16	R/W
0x7000: 25	SPEEDSET10	Set value of the speed for the Electric Cylinder No. 10	INT16	R/W
0x7000: 26	SPEEDSET11	Set value of the speed for the Electric Cylinder No. 11	INT16	R/W
0x7000: 27	SPEEDSET12	Set value of the speed for the Electric Cylinder No. 12	INT16	R/W
0x7000: 28	SPEEDSET13	Set value of the speed for the Electric Cylinder No. 13	INT16	R/W

2.6.2 Introduction to the SDO Object Dictionary

Table 51 SDO Object Dictionary

Address	Name	Meaning	Data type	Permissi on (read / write)
0x2000: 01	Redu_ratio	Device ID	INT16	R/W
0x2000: 02	Clear_error	Baud rate of the device	INT16	R/W
0x2000: 03	Save	Clear fault	INT16	R/W
0x2000: 04	Reset_para	Save parameters	INT16	R/W
0x2000: 05	Gesture_force_clb	Restoring factory defaults	INT16	R/W
0x2000: 06	Action_seq_index	Motion sequence number setting	INT16	R/W
0x2000: 07	Action_seq_run	Motion sequence execution flag	INT16	R/W
0x2000: 08	FINGER_PAUSE	Pause instruction	INT16	R/W
0x2000: 09	FINGER_STOP	Emergency Stop instruction	INT16	R/W

3. Example of common instructions

Example 1 (modify ID)

Change the dexterous hand of ID=1 to ID=2

Instruction frame: EB 90 01 05 12 E8 03 02 00 06

Response frame: 90 EB 02 04 12 E8 03 01 04

In the instruction frame, “EB 90” is the packet header, “01” is the current dexterous hand ID, “04” is the frame data length, “12” is the write register instruction flag, “E8 03” is the register address, ‘02’ is the data to be written to the register, and “04” is the checksum. In the response frame, “90 EB” is the packet header, “02” is the current

dexterous hand ID, "04" is the frame data length, "12" is the write register instruction flag, "E8 03" is the register address, and "04" is the checksum.

The ID change takes effect immediately upon completion. Subsequent communication will use the new ID. To save this new ID after power failure, the "Save Parameters" operation must be performed.

Example 2 (modify baud rate)

Change the baud rate 115200 for the dexterous hand (ID=1) to 57600:

Instruction frame: EB 90 01 05 12 E9 03 01 00 05

Response frame: 90 EB 01 04 12 EA 03 01 05

The baud rate modification does not take effect immediately. With the "Save Parameters" operation, the modification will take effect after power cycling.

Example 3 (Error clearance)

Clear the fault information for the dexterous hand (ID=1). When the dexterous hand is subject to faults such as locked-rotor, overcurrent or abnormalities, normal operation can be restored by issuing a Clear Fault reset instruction:

Instruction frame: EB 90 01 05 12 EB 03 01 00 07

Response frame: 90 EB 01 04 12 EC 03 01 07

Example 4 (Save parameters)

When modifying parameters such as ID or baud rate, the dexterous hand will write parameters in the Flash, then these parameters will not be lost after power failure.

Instruction frame: EB 90 01 05 12 EC 03 01 00 08

Response frame: 90 EB 01 04 12 ED 03 01 08, 90 EB 01 04 11 ED 03 00 06

The Save Parameters instruction will have two response frames.

Example 5 (Force sensor calibration)

Instruction frame: EB 90 01 05 12 F1 03 01 00 0B

Response frame: 90 EB 01 04 12 F1 03 01 0C, 90 EB 01 04 11 02 00 00 18

When executing sensor calibration, a response frame will be received. A second response frame will be received upon completion of calibration. The dexterous hand must be maintained in no-load state during calibration.

Example 6 (Set the force control threshold value for each DOF)

Set the force control threshold of the dexterous hand (ID=1) for each DOF to 1000:

Instruction frame: EB 90 01 1D 12 46 04 E8 03 E8 03 E8 03 E8 03 E8 03 E8 03 E8

03 E8 03 E8 03 E8 03 E8 03 69

Response frame: 90 EB 01 04 12 46 04 01 62

The force control threshold takes effect immediately after setting and is not saved upon power cycling.

Example 7 (Set the speed for each DOF)

Set the speed of the dexterous hand (ID=1) for each DOF to 1000:

Instruction frame: EB 90 01 1D 12 54 04 E8 03 E8 03 E8 03 E8 03 E8 03 E8 03 E8
03 E8 03 E8 03 E8 03 E8 03 E8 03 77

Response frame: 90 EB 01 04 12 54 04 01 70

The speed takes effect immediately after setting and is not saved upon power cycling.

Example 8 (Set the angle for each DOF)

Set the angle of the dexterous hand (ID=1) for each DOF to 1000:

Instruction frame: EB 90 01 1D 12 38 04 E8 03 E8 03 E8 03 00 00 E8 03 00 00 E8 03 E8
03 E8 03 E8 03 E8 03 E8 03 E8 03 5B

Response frame: 90 EB 01 04 12 38 04 01 54

Example 9 (Read the current angle position for each DOF)

Read the current angle position of the dexterous hand (ID=1) for each DOF:

Instruction frame: EB 90 01 04 11 70 04 02 8C

Response frame: see examples in 2.2.1 herein