WRIST MODULE OF THE DEXTEROUS HAND INSTRUCTIONS

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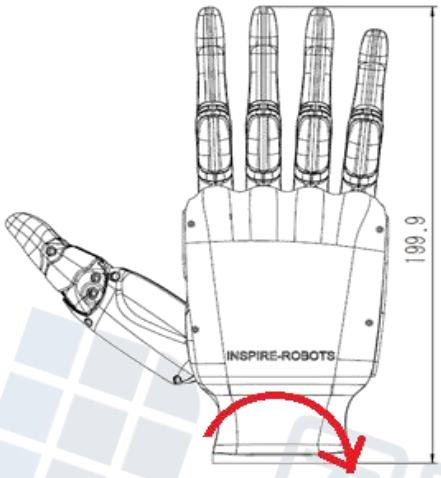
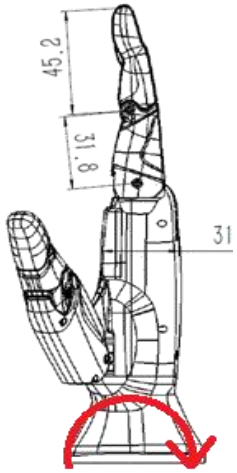
Wrist Module of THE Dexterous Hand Instructions

1 Overview

The wrist has two degrees of freedom (DOF), i.e., yawing and pitching, as shown below:

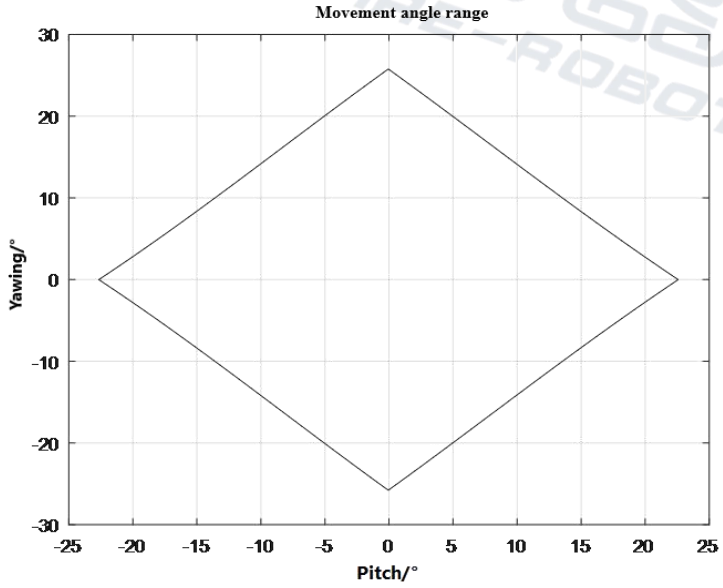


Yawing



Pitching

The movement angle range of two DOF is shown below:



Pitch range: [-22.66°, 22.12°]

Yawing angle range: [-25.50°, 25.50°]

2 Communication Protocol

2.1 Register description

Wrist-related control and status registers are defined as follows. The setting and reading methods are the same as those of other registers in the dexterous hand. Specific methods are described in the User Manual for Dexterous Hand.

Wrist-related Register Addresses under the RS232/CAN Protocol					
Address	Meaning	Abbreviation	Length	Permission (read / write)	Remarks
1020	Actual pitch of the wrist	WRIST_PITCH_ANGLE	2byte	R	The value "100" means "1°". For example, 1125 indicates 11.25°.
1022	Actual yawing angle of the wrist	WRIST_YAW_ANGLE	2byte	R	Same as above
1026	Current of Servo Actuator #1 of the wrist	WRIST_CURRENT1	2byte	R	Unit: mA
1024	Current of Servo Actuator #2 of the wrist	WRIST_CURRENT2	2byte	R	Unit: mA
1028	Error code of Servo Actuator #1 of the wrist	WRIST_ERROR1	1byte	R	
1030	Error code of Servo Actuator #2 of the wrist	WRIST_ERROR2	1byte	R	
1032	Temperature of Servo Actuator #1 of the wrist	WRIST_TEMP1	1byte	R	
1033	Temperature of Servo Actuator #2 of the wrist	WRIST_TEMP2	1byte	R	
1038	Yawing angle setting of the wrist	WRIST_YAW_ANGLE_SET	2byte	W/R	The value "100" means "1°". For example, 1125 indicates 11.25°.
1040	Pitch setting of the wrist	WRIST_PITCH_ANGLE_SET	2byte	W/R	Same as above
1042	Time setting of wrist movement	PROFILE_TIME_MS_SET	2byte	W/R	Unit: ms; elapsed time for moving from the current position to the

					target position; change the parameter in "Settings" to control the wrist movement speed.

2.2 Register reading/writing of RS232 and RS485

The communication parameters of RS232 and RS485 are 115200bps, 8 data bits, 1 stop bit, and no parity.

Wrist register reading

The instruction frame format for reading a register of the wrist 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 length (unit: byte) of the register to be read. "Checksum" refers to the low-order bytes of the sum of all data before checksum except the response frame header.

	Value	**Description**
byte[0]	0xEB	Packet header
byte[1]	0x90	Packet header
byte[2]	ID	Wrist ID
byte[3]	0x04	Length of the frame data
byte[4]	0x30	Register reading flag
byte[5]	0x46	Low-order 8 bits in the start address of the register
byte[6]	0x06	High-order 8 bits in the start address of the register
byte[7]	18	Length of the register to be read
byte[8]	Checksum	Checksum

The dexterous hand returns the following response frame to the read register instruction:

	Value	**Description**
byte[0]	0x90	Packet header
byte[1]	0xEB	Packet header

byte[2]	ID	ID of the dexterous hand
byte[3]	Register_Length+3	Length of the frame data
byte[4]	0x30	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] ... byte[7+Register_Length-1]	Data[0] ... Data[Register_Length-1]	Register value
byte[7+ Register_Length]	Checksum	Checksum

For example, read the current of two servo actuators for the wrist. The servo actuator current data is stored in the register group "WRIST_CURRENT", with 1024 (0x03FC) as start address, and 4 bytes (0x04) as length. The format of this instruction frame is shown below:

	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]	0x30	Register reading flag
byte[5]	0xFC	Low-order 8 bits in the start address of the register
byte[6]	0x03	High-order 8 bits in the start address of the register
byte[7]	0x02	Length of the register to be read
byte[8]	0x36	Checksum

The wrist returns the following response frame to this instruction:

	Value	**Description**
byte[0]	0x90	Packet header
byte[1]	0xEB	Packet header
byte[2]	0x01	ID
byte[3]	0x05	Length of the frame data: 2 + 3
byte[4]	0x30	This frame is the response to the read register

		instruction.
byte[5]	0xFC	Low-order 8 bits in the start address of the register
byte[6]	0x03	High-order 8 bits in the start address of the register
byte[7] byte[8]	0x0000	Converted to the integer data 00x0000
byte[9] byte[10]	0x000	Converted to the integer data 0 (0x0000)
byte[11]	0x35	Checksum

From this response frame, it can be determined that the current value of the two servo actuators is 0 A.

2.2.1 Wrist register writing

The instruction frame format for writing to a register of the wrist is shown below. "Data[0]- Data[Register_Length-1]" is the data to be written to the register.

	Value	**Description**
byte[0]	0xEB	Packet header
byte[1]	0x90	Packet header
byte[2]	ID	ID
byte[3]	Register_Length+3	Length of the frame data
byte[4]	0x31	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:

	Value	**Description**
byte[0]	0x90	Packet header
byte[1]	0xEB	Packet header
byte[2]	ID	ID of the dexterous hand
byte[3]	4	Length of the frame data

byte[4]	0x31	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 example, set the pitch and yawing angle of the wrist (ID=1) to -10.00°and 10.00°. It is necessary to modify the registers "WRIST_YAW_ANGLE_SET (1038) and "WRIST_PITCH_ANGLE_SET (1040)". The following instructions should be sent:

	Value	**Description**
byte[0]	0xEB	Packet header
byte[1]	0x90	Packet header
byte[2]	0x01	ID
byte[3]	0x07	Length of the frame data: 4 + 3
byte[4]	0x31	Write Register instruction flag
byte[5]	0x0E	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]	0x18FC	-10.00°; the register should be set to -1000(0xFC18).
byte[9] byte[10]	0xEB03	10.00°; the register should be set to 1000(0x03EB).
byte[11]	0x4D	Checksum

The wrist returns the following response frame to this instruction:

	Value	**Description**
byte[0]	0x90	Packet header
byte[1]	0xEB	Packet header
byte[2]	0x01	ID
byte[3]	0x04	Length of the frame data
byte[4]	0x31	This frame is the response to the write register instruction.
byte[5]	0x0E	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]	0x49	Checksum

2.3 Register reading/writing of CAN

The baud rate is 1000K. It 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:

bit0-13: Hand_ID supports up to 16383 devices;

bit14-25: Start address of the register to be operated;

bit26-28: Read/write flag bits; 0 indicates reading a register of the dexterous hand; 1 indicates writing to a register of the dexterous hand; 4 indicates reading the wrist register of the dexterous hand; 5 indicates writing to the wrist register of the dexterous hand.

Identifier	bit 31-29	bit 26-28	bit14-25	bit 13-0
Meaning	Reserve	W/R 0:R - Reading a register of the dexterous hand 1:W - Writing to a register of the dexterous hand 4:R - Reading the wrist register of the dexterous hand 5:R - Writing to the wrist register of the dexterous hand	Register address	Hand_ID

2.3.1 Register reading

The identifier settings of register reading are as follows:

Identifier	bit 31-29	bit 26-28	bit14-25	bit 13-0
Meaning	Reserve	4	Address	Hand_ID

The data length is 1 byte.

Data content: Length of the register content to be read

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

Identifier:

Identifier	bit 31-29	bit 26-28	bit14-25	bit 13-0

Meaning	Reserve	4	Address	Hand_ID

Data length: Length of the data to be returned to the register

Data content: Register data

For example, if we want to read the current of two servo actuators for the wrist in the dexterous hand (ID=1), the following frame should be sent to the CAN bus:

Identifier: The binary number is 0001 0001 0000 0000 0000 0000 0000 0001.

bit 31-29	bit 26-28	bit14-25	bit 13-0
0	4	Address of CURRENT_ACT(0) = 1024; The binary number is 010000000000.	1

Data length: 1

Data content: 4; the current of two servo actuators is an integer data; the data length is 2 bytes.

The dexterous hand returns the following frame:

Identifier: The binary number is 0000 0001 1000 0100 0000 0000 0000 0001.

bit 31-29	bit 26-28	bit14-25	bit 13-0
0	4	Address of CURRENT_ACT(0) = 1024; The binary number is 010000000000.	1

Data length: 4

Data content: The current of servo actuators 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 0x0000, and the decimal number is 0.

byte0	byte1	Byte2	Byte3
0x00	0x00	0x00	0x00

2.3.2 Register writing

The identifier settings of register writing are as follows:

Identifier	bit 31-29	bit 26-28	bit14-25	bit 13-0
Meaning	Reserve	5	Address	Hand_ID

Data length: Length of the data to be written to the register

Data content: Data to be written to the register

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

Identifier	bit 31-29	bit 26-28	bit14-25	bit 13-0
Meaning	Reserve	5	Address	Hand_ID

Data length: 0

For example, if we want to set the pitch and yawing angle of the dexterous hand wrist (ID=1) to -10.00°and 10.00°, the following frame should be sent to the CAN bus:

Identifier: The binary number is 0001 0101 0000 0011 1000 0000 0000 0001.

bit 31-29	bit 26-28	bit14-25	bit 13-0
0	5	Address of ANGLE_SET(0) = 1492; The binary number is 010000001110.	1

Data length: 4

Data content: Set the pitch and yawing angle of the wrist to -10.00°(0xFC18) and 10.00°(0x03EB).

byte0	byte1	Byte2	Byte3
0xFC	0x18	0x03	0xEB

The dexterous hand returns the following frame:

Identifier: The binary number is 0001 0101 0000 0011 1000 0000 0000 0001.

bit 31-29	bit 26-28	bit14-25	bit 13-0
0	5	Address of ANGLE_SET (0) = 1038; The binary number is 010000001110.	1

Data length: 0