万拿灵巧手SDK使用手册 V2.1

🍔概述

万拿灵巧手 SDK（Software Development Kit）是为万拿灵巧手设备开发的软件工具包，提供完整的编程接口和控制功能。SDK 面向教育. 工业. 机器人等领域的开发者，支持 C++ 和 Python 开发语言，提供常用的示例代码帮助开发者实现对灵巧手设备的快速入门。

🧂SDK能力说明

- 灵巧手状态信息获取
- 灵巧手动作控制
- 根据配置文件执行动作演示
- 操作日志、通讯日志全量记录
- 将modbus_rtu封装为统一总线，上层应用无需关注底层通讯实现

🍿 系统需求

操作系统：

Ubuntu22.04

系统架构：

支持X64、ARM架构

RS485接口：

波特率115200 8-n-1

🍟硬件连接

1. 通过RS485接口连接灵巧手和你的控制器（工控机、开发板、PC）
2. 启动灵巧手的电源

🍕SDK代码的获取和使用

1. 代码获取

通过git获取sdk源码，

```
拉取代码
1   $ git clone ssh://git@192.168.1.251:2222/embedded-team/mcu/wn_hand_sdk.git
2   $ cd wn_hand_sdk/
3   $ git checkout develop_v2.1
```

2. 安装依赖

```
安装依赖
1   $ sudo apt update
2   $ sudo apt install libspdlog-dev libboost-all-dev libfmt-dev libyaml-cpp-dev
    libmodbus-dev
3   $ sudo apt install libasio-dev pybind11-dev python3-pip
4   $ pip install pybind11
```

3. 代码编译

```
代码编译
1   $ cd wn_hand_sdk/
2   $ mkdir build && cd build
3   $ cmake ..
4   $ make
5   $ make install
```

编译成功后，build/outputs目录下会生成samples和sdk。

🥿运行示例代码

用法: ./wn_hand_api_demo

示例: ./wn_hand_api_demo

```
代码块
1   $ cd build/outputs/samples/wn_hand_api_demo
2   $ sudo ./wn_hand_api_demo
3
```

```
========== WnHandApi Test Demo ==========

--- Get SDK Version ---
SDK Version: V2.1

--- Bus Service Init ---
[2026-07-29 11:17:31.883] [api_log] [info] Timed rotating logger initialized successfully
[2026-07-29 11:17:31.883] [api_log] [info] Log directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_api_demo/wn_hand_logs/api
[2026-07-29 11:17:31.883] [api_log] [info] Max file size: 10MB, Max files: 10
[2026-07-29 11:17:31.883] [api_log] [info] Custom spdlog_utility logger initialized successfully
[2026-07-29 11:17:31.883] [api_log] [info] Logger parameters:
[2026-07-29 11:17:31.883] [api_log] [info]   Directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_api_demo/wn_hand_logs/api
[2026-07-29 11:17:31.883] [api_log] [info]   File prefix: api_log
[2026-07-29 11:17:31.883] [api_log] [info]   Max file size: 10485760 bytes
[2026-07-29 11:17:31.883] [api_log] [info]   Max backup files: 10
[2026-07-29 11:17:31.883] [api_log] [info]   Log level: debug
[2026-07-29 11:17:31.883] [api_log] [info]   console_Log level: debug
[2026-07-29 11:17:31.883] [api_log] [info] IO线程已启动
[2026-07-29 11:17:31.883] [api_log] [info] bus_type read from config: modbus_rtu
[2026-07-29 11:17:31.884] [api_log] [info] setting driver to ModbusRtuBus
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] Timed rotating logger initialized successfully
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] Log directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_api_demo/wn_hand_logs/modbus_rtu
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] Max file size: 10MB, Max files: 50
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] Custom spdlog_utility logger initialized successfully
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] Logger parameters:
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info]   Directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_api_demo/wn_hand_logs/modbus_rtu
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info]   File prefix: modbus_rtu_log
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info]   Max file size: 10485760 bytes
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info]   Max backup files: 50
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info]   Log level: debug
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info]   console_Log level: debug
```

```
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] [ModbusRtuBus] init() called
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 1] Checking config file existence...
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] [ModbusRtuBus] config path: ./config/hand_system.yaml
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ File exists
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] [ModbusRtuBus]   file size: 700 bytes
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] [ModbusRtuBus] permissions: 100644
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 2] Loading YAML config file...
[2026-07-29 11:17:31.884] [modbus_rtu_log] [info] [ModbusRtuBus] config file loaded successfully
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] 'modbus_rtu' node found in config
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ device read from config: '/dev/ttyUSB0'
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ baud_rate parsed successfully: 115200
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ slave_id parsed successfully: 1
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 3] Final configuration summary
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus]   device: /dev/ttyUSB0
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus]   baud_rate: 115200
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus]   slave_id: 1
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus]   parity: N
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus]   data_bits: 8
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus]   stop_bits: 1
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
```

```
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 4] Initializing Modbus RTU context...
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus]   calling modbus_new_rtu(/dev/ttyUSB0, 115200, 'N', 8, 1)...
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] modbus_new_rtu succeeded, handle: 0x61517e43d760
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] setting slave address to 1...
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] slave address set successfully
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] setting response timeout: 500ms
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] setting byte timeout: 100ms
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] setting error recovery mode: LINK | PROTOCOL
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] enabling debug mode
[2026-07-29 11:17:31.885] [modbus_rtu_log] [info] [ModbusRtuBus] init() completed successfully
Opening /dev/ttyUSB0 at 115200 bauds (N, 8, 1)
[2026-07-29 11:17:31.902] [modbus_rtu_log] [info] [ModbusRtuBus] start OK
[2026-07-29 11:17:31.902] [api_log] [info] connected ok
[2026-07-29 11:17:31.902] [api_log] [debug] get_hand_hardware_version
[2026-07-29 11:17:31.902] [modbus_rtu_log] [info] [ModbusRtuBus] reading hardware version from address 0xd0 (2 registers)
[01][03][00][D0][00][02][C5][F2]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:17:32.019] [modbus_rtu_log] [debug] [ModbusRtuBus] hardware version (raw): 0xffffffff
[2026-07-29 11:17:32.019] [modbus_rtu_log] [info] [ModbusRtuBus] hardware version: 4294967295
[2026-07-29 11:17:32.019] [api_log] [info] hardware_version: 4294967295
[2026-07-29 11:17:32.019] [api_log] [debug] get_hand_software_version
[2026-07-29 11:17:32.019] [modbus_rtu_log] [info] [ModbusRtuBus] reading software version from address 0xd2 (2 registers)
[01][03][00][D2][00][02][64][32]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:17:32.131] [modbus_rtu_log] [debug] [ModbusRtuBus] software version (raw): 0xffffffff
[2026-07-29 11:17:32.131] [modbus_rtu_log] [info] [ModbusRtuBus] software version: 4294967295
[2026-07-29 11:17:32.131] [api_log] [info] software_version: 4294967295
[2026-07-29 11:17:32.131] [api_log] [debug] get_hand_joint_num
```

```
[2026-07-29 11:17:32.131] [modbus_rtu_log] [info] [ModbusRtuBus] reading joint number from address 0xd4 (1 register)
[01][03][00][D4][00][01][C4][32]
Waiting for a confirmation...
<01><03><02><FF><FF><B9><F4>
[2026-07-29 11:17:32.260] [modbus_rtu_log] [debug] [ModbusRtuBus] joint_num (raw): 0xffff
[2026-07-29 11:17:32.260] [modbus_rtu_log] [info] [ModbusRtuBus] joint_num: 65535
[2026-07-29 11:17:32.260] [api_log] [info] joint_num: 65535
[2026-07-29 11:17:32.260] [api_log] [info] hardware_version 4294967295
[2026-07-29 11:17:32.260] [api_log] [info] software_version 4294967295
[2026-07-29 11:17:32.260] [api_log] [info] joint_num 65535
bus_service_init: [PASS]

--- Connection Status ---
is_connected: [PASS]

--- Get Hand Information ---
[2026-07-29 11:17:32.260] [api_log] [debug] get_hand_hardware_version
[2026-07-29 11:17:32.260] [modbus_rtu_log] [info] [ModbusRtuBus] reading hardware version from address 0xd0 (2 registers)
[01][03][00][D0][00][02][C5][F2]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:17:32.372] [modbus_rtu_log] [debug] [ModbusRtuBus] hardware version (raw): 0xffffffff
[2026-07-29 11:17:32.372] [modbus_rtu_log] [info] [ModbusRtuBus] hardware version: 4294967295
[2026-07-29 11:17:32.372] [api_log] [info] hardware_version: 4294967295
Hardware Version: 4294967295
[2026-07-29 11:17:32.372] [api_log] [debug] get_hand_software_version
[2026-07-29 11:17:32.372] [modbus_rtu_log] [info] [ModbusRtuBus] reading software version from address 0xd2 (2 registers)
[01][03][00][D2][00][02][64][32]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:17:32.485] [modbus_rtu_log] [debug] [ModbusRtuBus] software version (raw): 0xffffffff
[2026-07-29 11:17:32.485] [modbus_rtu_log] [info] [ModbusRtuBus] software version: 4294967295
[2026-07-29 11:17:32.485] [api_log] [info] software_version: 4294967295
Software Version: 4294967295
[2026-07-29 11:17:32.485] [api_log] [debug] get_hand_joint_num
[2026-07-29 11:17:32.485] [modbus_rtu_log] [info] [ModbusRtuBus] reading joint number from address 0xd4 (1 register)
[01][03][00][D4][00][01][C4][32]
```

```
Waiting for a confirmation...
<01><03><02><FF><FF><B9><F4>
[2026-07-29 11:17:32.613] [modbus_rtu_log] [debug] [ModbusRtuBus] joint_num (raw): 0xffff
[2026-07-29 11:17:32.613] [modbus_rtu_log] [info] [ModbusRtuBus] joint_num: 65535
[2026-07-29 11:17:32.613] [api_log] [info] joint_num: 65535
Joint Number: 65535
[FATAL] Invalid joint number: 65535
Using default joint number: 1

--- Test: set_hand_start ---
[2026-07-29 11:17:32.613] [api_log] [debug] set_hand_start
[2026-07-29 11:17:32.613] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0x6 to addr 0x0
[01][06][00][00][00][06][09][C8]
Waiting for a confirmation...
<01><06><00><00><00><06><09><C8>
[2026-07-29 11:17:32.726] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0x7 to addr 0x0
[01][06][00][00][00][07][C8][08]
Waiting for a confirmation...
<01><06><00><00><00><07><C8><08>
[2026-07-29 11:17:32.841] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0xF to addr 0x0
[01][06][00][00][00][0F][C9][CE]
Waiting for a confirmation...
<01><06><00><00><00><0F><C9><CE>
[2026-07-29 11:17:32.955] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start OK
[2026-07-29 11:17:32.955] [api_log] [info] set_hand_start OK
set_hand_start: [PASS]

--- Test: set_hand_target_position + get_hand_current_position ---
[2026-07-29 11:17:32.955] [api_log] [debug] set_hand_target_position 0.000000
[2026-07-29 11:17:32.956] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:17:32.956] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=1
[01][10][00][01][00][01][02][00][00][A7][81]
Waiting for a confirmation...
<01><10><00><01><00><01><50><09>
[2026-07-29 11:17:33.070] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:17:33.070] [api_log] [info] set_hand_target_position OK
set_hand_target_position (target: 0): [PASS]
[2026-07-29 11:17:34.071] [api_log] [debug] get_hand_current_position
```

```
[2026-07-29 11:17:34.071] [modbus_rtu_log] [info] [ModbusRtuBus] get_hand_current_position: slave=0x1, addr=0x51, count=20
[01][03][00][51][00][14][14][14]
Waiting for a confirmation...
<01><03><28><00><01><00><6A><FF><F3><FF><FB><FF><E1><FF><BC><FF><DA><FF><DA><FF><EB><FF><CE><FF><CE><FF><ED><FF><E9><FF><F3><FF><C0><FF><E3><00><00><00><00><00><00><00><00><3F><17>
[2026-07-29 11:17:34.203] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[0]: 1 -> 0.01
[2026-07-29 11:17:34.203] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[1]: 106 -> 1.06
[2026-07-29 11:17:34.203] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[2]: -13 -> -0.13
[2026-07-29 11:17:34.203] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[3]: -5 -> -0.05
[2026-07-29 11:17:34.203] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[4]: -31 -> -0.31
[2026-07-29 11:17:34.203] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[5]: -68 -> -0.68
[2026-07-29 11:17:34.203] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[6]: -38 -> -0.38
[2026-07-29 11:17:34.203] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[7]: -38 -> -0.38
[2026-07-29 11:17:34.203] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[8]: -21 -> -0.21
[2026-07-29 11:17:34.203] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[9]: -50 -> -0.5
[2026-07-29 11:17:34.203] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[10]: -50 -> -0.5
[2026-07-29 11:17:34.203] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[11]: -19 -> -0.19
[2026-07-29 11:17:34.203] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[12]: -23 -> -0.23
[2026-07-29 11:17:34.203] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[13]: -13 -> -0.13
[2026-07-29 11:17:34.204] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[14]: -64 -> -0.64
[2026-07-29 11:17:34.204] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[15]: -29 -> -0.29
[2026-07-29 11:17:34.204] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[16]: 0 -> 0
[2026-07-29 11:17:34.204] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[17]: 0 -> 0
[2026-07-29 11:17:34.204] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[18]: 0 -> 0
[2026-07-29 11:17:34.204] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[19]: 0 -> 0
```

```
[2026-07-29 11:17:34.204] [api_log] [info] get_hand_current_position OK, count=20
get_hand_current_position: [PASS], pos[0]=0.01, Diff: 0.01, Match: [PASS]

--- Test: set_hand_target_position (single joint) + get_hand_current_position ---
[2026-07-29 11:17:34.204] [api_log] [debug] set_hand_target_position id:1 angle:0
[2026-07-29 11:17:34.204] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: id=0x1, addr=0x1, angle=0, scaled=0
[01][06][00][01][00][00][D8][0A]
Waiting for a confirmation...
<01><06><00><01><00><00><D8><0A>
[2026-07-29 11:17:34.334] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:17:34.334] [api_log] [info] set_hand_target_position OK
set_hand_target_position(id=0x01, target: 0): [PASS]
[2026-07-29 11:17:35.335] [api_log] [debug] get_hand_current_position
[2026-07-29 11:17:35.335] [modbus_rtu_log] [info] [ModbusRtuBus] get_hand_current_position: slave=0x1, addr=0x51, count=20
[01][03][00][51][00][14][14][14]
Waiting for a confirmation...
<01><03><28><00><00><00><6A><FF><F3><FF><FB><FF><E4><FF><B5><FF><DA><FF><DA><FF><EB><FF><CE><FF><D2><FF><E9><FF><E9><FF><F3><FF><C0><FF><E3><00><00><00><00><00><00><00><00><00><B2><E5>
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[0]: 0 -> 0
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[1]: 106 -> 1.06
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[2]: -13 -> -0.13
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[3]: -5 -> -0.05
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[4]: -28 -> -0.28
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[5]: -75 -> -0.75
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[6]: -38 -> -0.38
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[7]: -38 -> -0.38
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[8]: -21 -> -0.21
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[9]: -50 -> -0.5
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[10]: -46 -> -0.46
```

```
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[11]: -23 -> -0.23
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[12]: -23 -> -0.23
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[13]: -13 -> -0.13
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[14]: -64 -> -0.64
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[15]: -29 -> -0.29
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[16]: 0 -> 0
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[17]: 0 -> 0
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[18]: 0 -> 0
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[19]: 0 -> 0
[2026-07-29 11:17:35.466] [api_log] [info] get_hand_current_position OK, count=20
get_hand_current_position: [PASS], pos[0]=0.00, Diff: 0.00, Match: [PASS]

--- Test: set_hand_work_mode ---
[2026-07-29 11:17:35.466] [api_log] [debug] set_hand_work_mode 2
[2026-07-29 11:17:35.466] [modbus_rtu_log] [debug] [ModbusRtuBus] mode[0]: 2
[2026-07-29 11:17:35.466] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_work_mode: slave=0x1, addr=0x15, count=1
[01][10][00][15][00][01][02][00][02][25][54]
Waiting for a confirmation...
<01><10><00><15><00><01><10><0D>
[2026-07-29 11:17:35.598] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_work_mode OK
[2026-07-29 11:17:35.598] [api_log] [info] set_hand_work_mode OK
set_hand_work_mode: [PASS]

--- Test: set_hand_work_mode (single joint) ---
[2026-07-29 11:17:35.598] [api_log] [debug] set_hand_work_mode id:1 mode:0
[2026-07-29 11:17:35.598] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_work_mode: id=0x1, addr=0x15, mode=0
[01][06][00][15][00][00][98][0E]
Waiting for a confirmation...
<01><06><00><15><00><00><98><0E>
[2026-07-29 11:17:35.712] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_work_mode OK
[2026-07-29 11:17:35.712] [api_log] [info] set_hand_work_mode OK
set_hand_work_mode(id=0x01): [PASS]

```

```
--- Test: set_hand_speed + get_hand_speed ---
[2026-07-29 11:17:35.712] [api_log] [debug] set_hand_speed 50.000000
[2026-07-29 11:17:35.712] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[0]: 50 -> 5000
[2026-07-29 11:17:35.713] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_speed: slave=0x1, addr=0x29, count=1
[01][10][00][29][00][01][02][13][88][AC][FF]
Waiting for a confirmation...
<01><10><00><29><00><01><D0><01>
[2026-07-29 11:17:35.843] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_speed OK
[2026-07-29 11:17:35.843] [api_log] [info] set_hand_speed OK
set_hand_speed (target: 50): [PASS]
[2026-07-29 11:17:35.843] [api_log] [debug] get_hand_speed
[2026-07-29 11:17:35.843] [modbus_rtu_log] [info] [ModbusRtuBus] get_hand_speed: slave=0x1, addr=0x29, count=20
[01][03][00][29][00][14][94][0D]
Waiting for a confirmation...
<01><03><28><13><88><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><D7><9F>
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[0]: 5000 -> 50
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[1]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[2]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[3]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[4]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[5]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[6]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[7]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[8]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[9]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[10]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[11]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[12]: 0 -> 0
```

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[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[13]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[14]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[15]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[16]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[17]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[18]: 0 -> 0
[2026-07-29 11:17:35.974] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[19]: 0 -> 0
[2026-07-29 11:17:35.974] [api_log] [info] get_hand_speed OK, count=20
get_hand_speed: [PASS], speed[0]=50.00, Diff: 0.00, Match: [PASS]

--- Test: set_hand_speed (single joint) + get_hand_speed ---
[2026-07-29 11:17:35.974] [api_log] [debug] set_hand_speed id:1 speed:30
[2026-07-29 11:17:35.974] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_speed: id=0x1, addr=0x29, speed=30, scaled=3000
[01][06][00][29][0B][B8][5F][40]
Waiting for a confirmation...
<01><06><00><29><0B><B8><5F><40>
[2026-07-29 11:17:36.089] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_speed OK
[2026-07-29 11:17:36.089] [api_log] [info] set_hand_speed OK
set_hand_speed(id=0x01, target: 30): [PASS]
[2026-07-29 11:17:36.090] [api_log] [debug] get_hand_speed
[2026-07-29 11:17:36.090] [modbus_rtu_log] [info] [ModbusRtuBus] get_hand_speed: slave=0x1, addr=0x29, count=20
[01][03][00][29][00][14][94][0D]
Waiting for a confirmation...
<01><03><28><0B><B8><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><DC><C1>
[2026-07-29 11:17:36.220] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[0]: 3000 -> 30
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[1]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[2]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[3]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[4]: 0 -> 0
```

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[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[5]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[6]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[7]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[8]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[9]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[10]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[11]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[12]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[13]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[14]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[15]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[16]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[17]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[18]: 0 -> 0
[2026-07-29 11:17:36.221] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[19]: 0 -> 0
[2026-07-29 11:17:36.221] [api_log] [info] get_hand_speed OK, count=20
get_hand_speed: [PASS], speed[0]=30.00, Diff: 0.00, Match: [PASS]

--- Get Status Information ---
[2026-07-29 11:17:36.221] [api_log] [debug] get_hand_current
[2026-07-29 11:17:36.221] [modbus_rtu_log] [info] [ModbusRtuBus] get_hand_current: slave=0x1, addr=0x100, count=20
[01][03][01][00][00][14][44][39]
Waiting for a confirmation...
<01><03><28><00><00><00><01><00><07><00><01><00><03><00><07><00><07><00><05><00><06><00><00><00><04><00><02><00><04><00><06><00><02><00><02><00><00><00><00><00><00><00><00><00><3E><59>
[2026-07-29 11:17:36.352] [modbus_rtu_log] [debug] [ModbusRtuBus] current[0]: 0 -> 0
[2026-07-29 11:17:36.353] [modbus_rtu_log] [debug] [ModbusRtuBus] current[1]: 1 -> 0.01
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[2026-07-29 11:17:36.353] [modbus_rtu_log] [debug] [ModbusRtuBus] current[2]: 7 -> 0.07
[2026-07-29 11:17:36.353] [modbus_rtu_log] [debug] [ModbusRtuBus] current[3]: 1 -> 0.01
[2026-07-29 11:17:36.353] [modbus_rtu_log] [debug] [ModbusRtuBus] current[4]: 3 -> 0.03
[2026-07-29 11:17:36.353] [modbus_rtu_log] [debug] [ModbusRtuBus] current[5]: 7 -> 0.07
[2026-07-29 11:17:36.353] [modbus_rtu_log] [debug] [ModbusRtuBus] current[6]: 7 -> 0.07
[2026-07-29 11:17:36.353] [modbus_rtu_log] [debug] [ModbusRtuBus] current[7]: 5 -> 0.05
[2026-07-29 11:17:36.353] [modbus_rtu_log] [debug] [ModbusRtuBus] current[8]: 6 -> 0.06
[2026-07-29 11:17:36.353] [modbus_rtu_log] [debug] [ModbusRtuBus] current[9]: 0 -> 0
[2026-07-29 11:17:36.353] [modbus_rtu_log] [debug] [ModbusRtuBus] current[10]: 4 -> 0.04
[2026-07-29 11:17:36.353] [modbus_rtu_log] [debug] [ModbusRtuBus] current[11]: 2 -> 0.02
[2026-07-29 11:17:36.353] [modbus_rtu_log] [debug] [ModbusRtuBus] current[12]: 4 -> 0.04
[2026-07-29 11:17:36.354] [modbus_rtu_log] [debug] [ModbusRtuBus] current[13]: 6 -> 0.06
[2026-07-29 11:17:36.354] [modbus_rtu_log] [debug] [ModbusRtuBus] current[14]: 2 -> 0.02
[2026-07-29 11:17:36.354] [modbus_rtu_log] [debug] [ModbusRtuBus] current[15]: 2 -> 0.02
[2026-07-29 11:17:36.354] [modbus_rtu_log] [debug] [ModbusRtuBus] current[16]: 0 -> 0
[2026-07-29 11:17:36.354] [modbus_rtu_log] [debug] [ModbusRtuBus] current[17]: 0 -> 0
[2026-07-29 11:17:36.354] [modbus_rtu_log] [debug] [ModbusRtuBus] current[18]: 0 -> 0
[2026-07-29 11:17:36.354] [modbus_rtu_log] [debug] [ModbusRtuBus] current[19]: 0 -> 0
[2026-07-29 11:17:36.354] [api_log] [info] get_hand_current OK, count=20
get_hand_current: [PASS], count=20
[2026-07-29 11:17:36.354] [api_log] [debug] get_normal_force
[2026-07-29 11:17:36.354] [modbus_rtu_log] [info] [ModbusRtuBus] get_normal_force: slave=0x1, addr=0x65, count=10
[01][03][00][65][00][0A][D5][D2]
Waiting for a confirmation...
<01><03><14><00><00><00><03><FF><00><00><09><00><00><00><00><FE><00><00><05><00><01><00><0B><1D><21>
[2026-07-29 11:17:36.483] [modbus_rtu_log] [debug] [ModbusRtuBus] force[0]: raw=0x30000, X=0, Y=0, Z=3
```

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[2026-07-29 11:17:36.483] [modbus_rtu_log] [debug] [ModbusRtuBus] force[1]: raw=0x9ff00, X=0, Y=255, Z=9
[2026-07-29 11:17:36.483] [modbus_rtu_log] [debug] [ModbusRtuBus] force[2]: raw=0x0, X=0, Y=0, Z=0
[2026-07-29 11:17:36.483] [modbus_rtu_log] [debug] [ModbusRtuBus] force[3]: raw=0x5fe00, X=0, Y=254, Z=5
[2026-07-29 11:17:36.483] [modbus_rtu_log] [debug] [ModbusRtuBus] force[4]: raw=0xb0001, X=1, Y=0, Z=11
[2026-07-29 11:17:36.484] [api_log] [info] get_normal_force OK, count=15
get_normal_force: [PASS], count=15
[2026-07-29 11:17:36.484] [api_log] [debug] get_hand_temperature
[2026-07-29 11:17:36.484] [modbus_rtu_log] [info] [ModbusRtuBus] get_hand_temperature: slave=0x1, addr=0x13c, count=20
[01][03][01][3C][00][14][84][35]
Waiting for a confirmation...
<01><03><28><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><67><9A>
[2026-07-29 11:17:36.614] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[0]: 0 -> 0
[2026-07-29 11:17:36.614] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[1]: 0 -> 0
[2026-07-29 11:17:36.614] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[2]: 0 -> 0
[2026-07-29 11:17:36.614] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[3]: 0 -> 0
[2026-07-29 11:17:36.614] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[4]: 0 -> 0
[2026-07-29 11:17:36.614] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[5]: 0 -> 0
[2026-07-29 11:17:36.614] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[6]: 0 -> 0
[2026-07-29 11:17:36.614] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[7]: 0 -> 0
[2026-07-29 11:17:36.614] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[8]: 0 -> 0
[2026-07-29 11:17:36.614] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[9]: 0 -> 0
[2026-07-29 11:17:36.614] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[10]: 0 -> 0
[2026-07-29 11:17:36.614] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[11]: 0 -> 0
[2026-07-29 11:17:36.615] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[12]: 0 -> 0
[2026-07-29 11:17:36.615] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[13]: 0 -> 0
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[2026-07-29 11:17:36.615] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[14]: 0 -> 0
[2026-07-29 11:17:36.615] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[15]: 0 -> 0
[2026-07-29 11:17:36.615] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[16]: 0 -> 0
[2026-07-29 11:17:36.615] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[17]: 0 -> 0
[2026-07-29 11:17:36.615] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[18]: 0 -> 0
[2026-07-29 11:17:36.615] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[19]: 0 -> 0
[2026-07-29 11:17:36.615] [api_log] [info] get_hand_temperature OK, count=20
get_hand_temperature: [PASS], count=20
[2026-07-29 11:17:36.615] [api_log] [debug] get_hand_fault_code
[2026-07-29 11:17:36.615] [modbus_rtu_log] [info] [ModbusRtuBus] get_hand_fault_code: slave=0x1, addr=0x128, count=20
[01][03][01][28][00][14][C4][31]
Waiting for a confirmation...
<01><03><28><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><67><9A>
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[0]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[1]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[2]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[3]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[4]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[5]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[6]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[7]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[8]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[9]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[10]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[11]: 0x0
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[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[12]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[13]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[14]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[15]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[16]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[17]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[18]: 0x0
[2026-07-29 11:17:36.729] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[19]: 0x0
[2026-07-29 11:17:36.730] [api_log] [info] get_hand_fault_code OK, count=20
get_hand_fault_code: [PASS], count=20

--- Test: clear_hand_fault + get_hand_fault_code ---
[2026-07-29 11:17:36.730] [api_log] [debug] clear_hand_fault
[2026-07-29 11:17:36.730] [modbus_rtu_log] [info] [ModbusRtuBus] clear_hand_fault: addr=0x0, value=0x80
[01][06][00][00][00][80][88][6A]
Waiting for a confirmation...
<01><06><00><00><00><80><88><6A>
[2026-07-29 11:17:36.844] [modbus_rtu_log] [info] [ModbusRtuBus] clear_hand_fault OK
clear_hand_fault: [PASS]
[2026-07-29 11:17:36.844] [api_log] [debug] get_hand_fault_code
[2026-07-29 11:17:36.844] [modbus_rtu_log] [info] [ModbusRtuBus] get_hand_fault_code: slave=0x1, addr=0x128, count=20
[01][03][01][28][00][14][C4][31]
Waiting for a confirmation...
<01><03><28><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><67><9A>
[2026-07-29 11:17:36.975] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[0]: 0x0
[2026-07-29 11:17:36.975] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[1]: 0x0
[2026-07-29 11:17:36.975] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[2]: 0x0
[2026-07-29 11:17:36.975] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[3]: 0x0
[2026-07-29 11:17:36.975] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[4]: 0x0
```

```
[2026-07-29 11:17:36.975] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[5]: 0x0
[2026-07-29 11:17:36.975] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[6]: 0x0
[2026-07-29 11:17:36.975] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[7]: 0x0
[2026-07-29 11:17:36.975] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[8]: 0x0
[2026-07-29 11:17:36.976] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[9]: 0x0
[2026-07-29 11:17:36.976] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[10]: 0x0
[2026-07-29 11:17:36.976] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[11]: 0x0
[2026-07-29 11:17:36.976] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[12]: 0x0
[2026-07-29 11:17:36.976] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[13]: 0x0
[2026-07-29 11:17:36.976] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[14]: 0x0
[2026-07-29 11:17:36.976] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[15]: 0x0
[2026-07-29 11:17:36.976] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[16]: 0x0
[2026-07-29 11:17:36.976] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[17]: 0x0
[2026-07-29 11:17:36.976] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[18]: 0x0
[2026-07-29 11:17:36.976] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[19]: 0x0
[2026-07-29 11:17:36.976] [api_log] [info] get_hand_fault_code OK, count=20
get_hand_fault_code after clear: [PASS], Fault Cleared: [PASS]

--- Test: set_hand_stop ---
[2026-07-29 11:17:36.976] [api_log] [debug] set_hand_stop
[2026-07-29 11:17:36.977] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_stop: writing 0x0 to addr 0x0
[01][06][00][00][00][00][89][CA]
Waiting for a confirmation...
<01><06><00><00><00><00><89><CA>
[2026-07-29 11:17:37.090] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_stop OK
set_hand_stop: [PASS]

--- Bus Service Restart ---
[2026-07-29 11:17:37.097] [modbus_rtu_log] [info] [ModbusRtuBus] stop OK
[2026-07-29 11:17:37.097] [modbus_rtu_log] [info] [ModbusRtuBus] deinit OK
```

```
[2026-07-29 11:17:37.098] [modbus_rtu_log] [info] Timed rotating logger initialized successfully
[2026-07-29 11:17:37.098] [modbus_rtu_log] [info] Log directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_api_demo/wn_hand_logs/modbus_rtu
[2026-07-29 11:17:37.098] [modbus_rtu_log] [info] Max file size: 10MB, Max files: 50
[2026-07-29 11:17:37.098] [modbus_rtu_log] [info] Custom spdlog_utility logger initialized successfully
[2026-07-29 11:17:37.098] [modbus_rtu_log] [info] Logger parameters:
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info]   Directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_api_demo/wn_hand_logs/modbus_rtu
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info]   File prefix: modbus_rtu_log
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info]   Max file size: 10485760 bytes
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info]   Max backup files: 50
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info]   Log level: debug
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info]   console_Log level: debug
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info] [ModbusRtuBus] ==========
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info] [ModbusRtuBus] init() called
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info] [ModbusRtuBus] ==========
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 1] Checking config file existence...
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info] [ModbusRtuBus] config path: ./config/hand_system.yaml
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ File exists
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info] [ModbusRtuBus]   file size: 700 bytes
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info] [ModbusRtuBus] permissions: 100644
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 2] Loading YAML config file...
[2026-07-29 11:17:37.099] [modbus_rtu_log] [info] [ModbusRtuBus] config file loaded successfully
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] 'modbus_rtu' node found in config
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ device read from config: '/dev/ttyUSB0'
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ baud_rate parsed successfully: 115200
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ slave_id parsed successfully: 1
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] ==========
```

```
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 3] Final configuration summary
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus]   device: /dev/ttyUSB0
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus]   baud_rate: 115200
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus]   slave_id: 1
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus]   parity: N
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus]   data_bits: 8
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus]   stop_bits: 1
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 4] Initializing Modbus RTU context...
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus]   calling modbus_new_rtu(/dev/ttyUSB0, 115200, 'N', 8, 1)...
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] modbus_new_rtu succeeded, handle: 0x61517e434d70
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] setting slave address to 1...
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] slave address set successfully
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] setting response timeout: 500ms
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] setting byte timeout: 100ms
[2026-07-29 11:17:37.100] [modbus_rtu_log] [info] [ModbusRtuBus] setting error recovery mode: LINK | PROTOCOL
[2026-07-29 11:17:37.101] [modbus_rtu_log] [info] [ModbusRtuBus] enabling debug mode
[2026-07-29 11:17:37.101] [modbus_rtu_log] [info] [ModbusRtuBus] init() completed successfully
Opening /dev/ttyUSB0 at 115200 bauds (N, 8, 1)
[2026-07-29 11:17:37.110] [modbus_rtu_log] [info] [ModbusRtuBus] start OK
bus_service_restart: [PASS]
is_connected after restart: [PASS]

--- Bus Service Stop ---
[2026-07-29 11:17:37.115] [modbus_rtu_log] [info] [ModbusRtuBus] stop OK
[2026-07-29 11:17:37.116] [modbus_rtu_log] [info] [ModbusRtuBus] deinit OK
bus_service_stop: [PASS]
```

```
521
522   ========== Test Completed ==========
```

用法: ./wn_hand_16_joint_demo

示例: ./wn_hand_16_joint_demo

代码块

```
1   $ cd build/outputs/samples/wn_hand_16_joint_demo
2   $ sudo ./wn_hand_16_joint_demo
3   [sudo] password for ethan:
4
5   ========== WnHand 16 Joint Action Demo ==========
6
7   --- Bus Service Init ---
8   [2026-07-29 11:14:06.866] [api_log] [info] Timed rotating logger initialized
    successfully
9   [2026-07-29 11:14:06.866] [api_log] [info] Log directory:
    /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_jo
    int_demo/wn_hand_logs/api
10  [2026-07-29 11:14:06.866] [api_log] [info] Max file size: 10MB, Max files: 10
11  [2026-07-29 11:14:06.866] [api_log] [info] Custom spdlog_utility logger
    initialized successfully
12  [2026-07-29 11:14:06.866] [api_log] [info] Logger parameters:
13  [2026-07-29 11:14:06.866] [api_log] [info]   Directory:
    /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_jo
    int_demo/wn_hand_logs/api
14  [2026-07-29 11:14:06.866] [api_log] [info]   File prefix: api_log
15  [2026-07-29 11:14:06.866] [api_log] [info]   Max file size: 10485760 bytes
16  [2026-07-29 11:14:06.866] [api_log] [info]   Max backup files: 10
17  [2026-07-29 11:14:06.866] [api_log] [info]   Log level: debug
18  [2026-07-29 11:14:06.866] [api_log] [info]   console_Log level: debug
19  [2026-07-29 11:14:06.866] [api_log] [info] IO线程已启动
20  [2026-07-29 11:14:06.866] [api_log] [info] bus_type read from config:
    modbus_rtu
21  [2026-07-29 11:14:06.866] [api_log] [info] setting driver to ModbusRtuBus
22  [2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Timed rotating logger
    initialized successfully
23  [2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Log directory:
    /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_jo
    int_demo/wn_hand_logs/modbus_rtu
24  [2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Max file size: 10MB, Max
    files: 50
```

```
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Custom spdlog_utility logger initialized successfully
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Logger parameters:
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   Directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_joint_demo/wn_hand_logs/modbus_rtu
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   File prefix: modbus_rtu_log
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   Max file size: 10485760 bytes
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   Max backup files: 50
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   Log level: debug
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   console_Log level: debug
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] init() called
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 1] Checking config file existence...
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] config path: ./config/hand_system.yaml
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ File exists
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]   file size: 700 bytes
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] permissions: 100644
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 2] Loading YAML config file...
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] config file loaded successfully
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] 'modbus_rtu' node found in config
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ device read from config: '/dev/ttyUSB0'
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ baud_rate parsed successfully: 115200
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ slave_id parsed successfully: 1
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 3] Final configuration summary
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]   device: /dev/ttyUSB0
```

```
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]   baud_rate: 115200
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]   slave_id: 1
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus]   parity: N
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus]   data_bits: 8
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus]   stop_bits: 1
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 4] Initializing Modbus RTU context...
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus]   calling modbus_new_rtu(/dev/ttyUSB0, 115200, 'N', 8, 1)...
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] modbus_new_rtu succeeded, handle: 0x5b45e3328dd0
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] setting slave address to 1...
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] slave address set successfully
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] setting response timeout: 500ms
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] setting byte timeout: 100ms
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] setting error recovery mode: LINK | PROTOCOL
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] enabling debug mode
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] init() completed successfully
Opening /dev/ttyUSB0 at 115200 bauds (N, 8, 1)
[2026-07-29 11:14:06.879] [modbus_rtu_log] [info] [ModbusRtuBus] start OK
[2026-07-29 11:14:06.879] [api_log] [info] connected ok
[2026-07-29 11:14:06.879] [api_log] [debug] get_hand_hardware_version
[2026-07-29 11:14:06.879] [modbus_rtu_log] [info] [ModbusRtuBus] reading hardware version from address 0xd0 (2 registers)
[01][03][00][D0][00][02][C5][F2]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:14:07.000] [modbus_rtu_log] [debug] [ModbusRtuBus] hardware version (raw): 0xffffffff
[2026-07-29 11:14:07.000] [modbus_rtu_log] [info] [ModbusRtuBus] hardware version: 4294967295
[2026-07-29 11:14:07.000] [api_log] [info] hardware_version: 4294967295
[2026-07-29 11:14:07.000] [api_log] [debug] get_hand_software_version
```

```
[2026-07-29 11:14:07.000] [modbus_rtu_log] [info] [ModbusRtuBus] reading software version from address 0xd2 (2 registers)
[01][03][00][D2][00][02][64][32]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:14:07.112] [modbus_rtu_log] [debug] [ModbusRtuBus] software version (raw): 0xffffffff
[2026-07-29 11:14:07.112] [modbus_rtu_log] [info] [ModbusRtuBus] software version: 4294967295
[2026-07-29 11:14:07.112] [api_log] [info] software_version: 4294967295
[2026-07-29 11:14:07.112] [api_log] [debug] get_hand_joint_num
[2026-07-29 11:14:07.112] [modbus_rtu_log] [info] [ModbusRtuBus] reading joint number from address 0xd4 (1 register)
[01][03][00][D4][00][01][C4][32]
Waiting for a confirmation...
<01><03><02><FF><FF><B9><F4>
[2026-07-29 11:14:07.226] [modbus_rtu_log] [debug] [ModbusRtuBus] joint_num (raw): 0xffff
[2026-07-29 11:14:07.227] [modbus_rtu_log] [info] [ModbusRtuBus] joint_num: 65535
[2026-07-29 11:14:07.227] [api_log] [info] joint_num: 65535
[2026-07-29 11:14:07.227] [api_log] [info] hardware_version 4294967295
[2026-07-29 11:14:07.227] [api_log] [info] software_version 4294967295
[2026-07-29 11:14:07.227] [api_log] [info] joint_num 65535
bus_service_init: [PASS]

--- Hand Start ---
[2026-07-29 11:14:07.227] [api_log] [debug] set_hand_start
[2026-07-29 11:14:07.227] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0x6 to addr 0x0
[01][06][00][00][00][06][09][C8]
Waiting for a confirmation...
<01><06><00><00><00><06><09><C8>
[2026-07-29 11:14:07.341] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0x7 to addr 0x0
[01][06][00][00][00][07][C8][08]
Waiting for a confirmation...
<01><06><00><00><00><07><C8><08>
[2026-07-29 11:14:07.455] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0xF to addr 0x0
[01][06][00][00][00][0F][C9][CE]
Waiting for a confirmation...
<01><06><00><00><00><0F><C9><CE>
[2026-07-29 11:14:07.586] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start OK
[2026-07-29 11:14:07.586] [api_log] [info] set_hand_start OK
set_hand_start: [PASS]
```

```
116
117 --- Execute Action Sequence ---
118 [INFO] Starting action sequence... (Press Ctrl+C to stop)
119
120 [Cycle 1/1]
121 [Action 3] 手握紧
122 [2026-07-29 11:14:07.586] [api_log] [debug] set_hand_target_position 0.000000
    0.000000 0.000000 90.000000 90.000000 90.000000 90.000000 90.000000
    90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000
123 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -
    > 0
124 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -
    > 0
125 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -
    > 0
126 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 90
    -> 9000
127 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 90
    -> 9000
128 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 90
    -> 9000
129 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 90
    -> 9000
130 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 90
    -> 9000
131 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 90
    -> 9000
132 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 90
    -> 9000
133 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]:
    90 -> 9000
134 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]:
    90 -> 9000
135 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]:
    90 -> 9000
136 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]:
    90 -> 9000
137 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]:
    90 -> 9000
138 [2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]:
    90 -> 9000
139 [2026-07-29 11:14:07.587] [modbus_rtu_log] [info] [ModbusRtuBus]
    set_hand_target_position: slave=0x1, addr=0x1, count=16
140 [01][10][00][01][00][10][20][00][00][00][00][00][00][23][28][23][28][23][28]
    [23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28]
    [28][F4][BF]
141 Waiting for a confirmation...
```

```
<01><10><00><01><00><10><90><05>
[2026-07-29 11:14:07.715] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:14:07.715] [api_log] [info] set_hand_target_position OK
[Action 2] 半张开
[2026-07-29 11:14:08.216] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 90.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 90 -> 9000
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][23][28][11][94][11][94][11][94][11][94][11][94][11][94][11][94][11][94][11][94][11][94][07][54]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
```

```
[2026-07-29 11:14:08.335] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:14:08.335] [api_log] [info] set_hand_target_position OK
[Action 1] 手张开
[2026-07-29 11:14:08.836] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][42][61]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
```

```
[2026-07-29 11:14:08.953] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:14:08.953] [api_log] [info] set_hand_target_position OK
[Action 3] 手握紧
[2026-07-29 11:14:09.454] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 90 -> 9000
[2026-07-29 11:14:09.455] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][F4][BF]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
```

```
[2026-07-29 11:14:09.573] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:14:09.573] [api_log] [info] set_hand_target_position OK
[Action 1] 手张开
[2026-07-29 11:14:10.074] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][48][61]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
```

```
239 [2026-07-29 11:14:10.193] [modbus_rtu_log] [debug] [ModbusRtuBus]
    set_hand_target_position OK
240 [2026-07-29 11:14:10.193] [api_log] [info] set_hand_target_position OK
```

用法: ./wn_hand_16_joint_demo_py

示例: ./wn_hand_16_joint_demo_py

代码块

```
1  $ cd build/outputs/samples/wn_hand_16_joint_demo_py
2  $ sudo python3 wn_hand_16_joint_demo.py
3
4  ========== WnHand 16 Joint Action Demo ==========
5
6  --- Bus Service Init ---
7  [2026-07-29 11:16:07.451] [api_log] [info] Timed rotating logger initialized
   successfully
8  [2026-07-29 11:16:07.451] [api_log] [info] Log directory:
   /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_jo
   int_demo_py/wn_hand_logs/api
9  [2026-07-29 11:16:07.451] [api_log] [info] Max file size: 10MB, Max files: 10
10 [2026-07-29 11:16:07.451] [api_log] [info] Custom spdlog_utility logger
   initialized successfully
11 [2026-07-29 11:16:07.451] [api_log] [info] Logger parameters:
12 [2026-07-29 11:16:07.451] [api_log] [info]   Directory:
   /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_jo
   int_demo_py/wn_hand_logs/api
13 [2026-07-29 11:16:07.451] [api_log] [info]   File prefix: api_log
14 [2026-07-29 11:16:07.451] [api_log] [info]   Max file size: 10485760 bytes
15 [2026-07-29 11:16:07.451] [api_log] [info]   Max backup files: 10
16 [2026-07-29 11:16:07.451] [api_log] [info]   Log level: debug
17 [2026-07-29 11:16:07.451] [api_log] [info]   console_Log level: debug
18 [2026-07-29 11:16:07.451] [api_log] [info] IO线程已启动
19 [2026-07-29 11:16:07.451] [api_log] [info] bus_type read from config:
   modbus_rtu
20 [2026-07-29 11:16:07.451] [api_log] [info] setting driver to ModbusRtuBus
21 [2026-07-29 11:16:07.452] [modbus_rtu_log] [info] Timed rotating logger
   initialized successfully
22 [2026-07-29 11:16:07.452] [modbus_rtu_log] [info] Log directory:
   /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_jo
   int_demo_py/wn_hand_logs/modbus_rtu
23 [2026-07-29 11:16:07.452] [modbus_rtu_log] [info] Max file size: 10MB, Max
   files: 50
```

```
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] Custom spdlog_utility logger initialized successfully
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] Logger parameters:
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info]   Directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_joint_demo_py/wn_hand_logs/modbus_rtu
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info]   File prefix: modbus_rtu_log
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info]   Max file size: 10485760 bytes
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info]   Max backup files: 50
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info]   Log level: debug
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info]   console_Log level: debug
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] init() called
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 1] Checking config file existence...
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] config path: ./config/hand_system.yaml
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ File exists
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus]   file size: 700 bytes
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus]   permissions: 100644
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 2] Loading YAML config file...
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] config file loaded successfully
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] 'modbus_rtu' node found in config
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ device read from config: '/dev/ttyUSB0'
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ baud_rate parsed successfully: 115200
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ slave_id parsed successfully: 1
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 3] Final configuration summary
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus]   device: /dev/ttyUSB0
```

```
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus]   baud_rate: 115200
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus]   slave_id: 1
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus]   parity: N
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus]   data_bits: 8
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus]   stop_bits: 1
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 4] Initializing Modbus RTU context...
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus]   calling modbus_new_rtu(/dev/ttyUSB0, 115200, 'N', 8, 1)...
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] modbus_new_rtu succeeded, handle: 0x60f1b1624940
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] setting slave address to 1...
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] slave address set successfully
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] setting response timeout: 500ms
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] setting byte timeout: 100ms
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] setting error recovery mode: LINK | PROTOCOL
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] enabling debug mode
[2026-07-29 11:16:07.452] [modbus_rtu_log] [info] [ModbusRtuBus] init() completed successfully
Opening /dev/ttyUSB0 at 115200 bauds (N, 8, 1)
[2026-07-29 11:16:07.460] [modbus_rtu_log] [info] [ModbusRtuBus] start OK
[2026-07-29 11:16:07.460] [api_log] [info] connected ok
[2026-07-29 11:16:07.460] [api_log] [debug] get_hand_hardware_version
[2026-07-29 11:16:07.460] [modbus_rtu_log] [info] [ModbusRtuBus] reading hardware version from address 0xd0 (2 registers)
[01][03][00][D0][00][02][C5][F2]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:16:07.586] [modbus_rtu_log] [debug] [ModbusRtuBus] hardware version (raw): 0xffffffff
[2026-07-29 11:16:07.586] [modbus_rtu_log] [info] [ModbusRtuBus] hardware version: 4294967295
[2026-07-29 11:16:07.586] [api_log] [info] hardware_version: 4294967295
[2026-07-29 11:16:07.586] [api_log] [debug] get_hand_software_version
```

```
[2026-07-29 11:16:07.586] [modbus_rtu_log] [info] [ModbusRtuBus] reading software version from address 0xd2 (2 registers)
[01][03][00][D2][00][02][64][32]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:16:07.697] [modbus_rtu_log] [debug] [ModbusRtuBus] software version (raw): 0xffffffff
[2026-07-29 11:16:07.697] [modbus_rtu_log] [info] [ModbusRtuBus] software version: 4294967295
[2026-07-29 11:16:07.697] [api_log] [info] software_version: 4294967295
[2026-07-29 11:16:07.697] [api_log] [debug] get_hand_joint_num
[2026-07-29 11:16:07.697] [modbus_rtu_log] [info] [ModbusRtuBus] reading joint number from address 0xd4 (1 register)
[01][03][00][D4][00][01][C4][32]
Waiting for a confirmation...
<01><03><02><FF><FF><B9><F4>
[2026-07-29 11:16:07.810] [modbus_rtu_log] [debug] [ModbusRtuBus] joint_num (raw): 0xffff
[2026-07-29 11:16:07.810] [modbus_rtu_log] [info] [ModbusRtuBus] joint_num: 65535
[2026-07-29 11:16:07.810] [api_log] [info] joint_num: 65535
[2026-07-29 11:16:07.810] [api_log] [info] hardware_version 4294967295
[2026-07-29 11:16:07.810] [api_log] [info] software_version 4294967295
[2026-07-29 11:16:07.810] [api_log] [info] joint_num 65535
bus_service_init: [PASS]

--- Hand Start ---
[2026-07-29 11:16:07.811] [api_log] [debug] set_hand_start
[2026-07-29 11:16:07.811] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0x6 to addr 0x0
[01][06][00][00][00][06][09][C8]
Waiting for a confirmation...
<01><06><00><00><00><06><09><C8>
[2026-07-29 11:16:07.938] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0x7 to addr 0x0
[01][06][00][00][00][07][C8][08]
Waiting for a confirmation...
<01><06><00><00><00><07><C8><08>
[2026-07-29 11:16:08.051] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0xF to addr 0x0
[01][06][00][00][00][0F][C9][CE]
Waiting for a confirmation...
<01><06><00><00><00><0F><C9><CE>
[2026-07-29 11:16:08.179] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start OK
[2026-07-29 11:16:08.179] [api_log] [info] set_hand_start OK
set_hand_start: [PASS]
```

```
115
116 --- Execute Action Sequence ---
117 [INFO] Starting action sequence... (Press Ctrl+C to stop)
118
119 [Cycle 1/1]
120 [Action 3] 手握紧
121 [2026-07-29 11:16:08.183] [api_log] [debug] set_hand_target_position 0.000000
    0.000000 0.000000 90.000000 90.000000 90.000000 90.000000 90.000000
    90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000
122 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -
    > 0
123 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -
    > 0
124 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -
    > 0
125 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 90
    -> 9000
126 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 90
    -> 9000
127 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 90
    -> 9000
128 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 90
    -> 9000
129 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 90
    -> 9000
130 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 90
    -> 9000
131 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 90
    -> 9000
132 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]:
    90 -> 9000
133 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]:
    90 -> 9000
134 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]:
    90 -> 9000
135 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]:
    90 -> 9000
136 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]:
    90 -> 9000
137 [2026-07-29 11:16:08.183] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]:
    90 -> 9000
138 [2026-07-29 11:16:08.183] [modbus_rtu_log] [info] [ModbusRtuBus]
    set_hand_target_position: slave=0x1, addr=0x1, count=16
139 [01][10][00][01][00][10][20][00][00][00][00][00][00][23][28][23][28][23][28]
    [23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23]
    [28][F4][BF]
140 Waiting for a confirmation...
```

```
<01><10><00><01><00><10><90><05>
[2026-07-29 11:16:08.307] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:16:08.307] [api_log] [info] set_hand_target_position OK
[Action 2] 半张开
[2026-07-29 11:16:08.808] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 90.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000
[2026-07-29 11:16:08.808] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:16:08.808] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:16:08.808] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:16:08.808] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 90 -> 9000
[2026-07-29 11:16:08.808] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 45 -> 4500
[2026-07-29 11:16:08.808] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 45 -> 4500
[2026-07-29 11:16:08.808] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 45 -> 4500
[2026-07-29 11:16:08.808] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 45 -> 4500
[2026-07-29 11:16:08.809] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 45 -> 4500
[2026-07-29 11:16:08.809] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 45 -> 4500
[2026-07-29 11:16:08.809] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 45 -> 4500
[2026-07-29 11:16:08.809] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 45 -> 4500
[2026-07-29 11:16:08.809] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 45 -> 4500
[2026-07-29 11:16:08.809] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 45 -> 4500
[2026-07-29 11:16:08.809] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 45 -> 4500
[2026-07-29 11:16:08.809] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 45 -> 4500
[2026-07-29 11:16:08.809] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][23][28][11][94][11][94][11][94][11][94][11][94][11][94][11][94][11][94][11][94][11][94][07][54]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
```

```
[2026-07-29 11:16:08.934] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:16:08.935] [api_log] [info] set_hand_target_position OK
[Action 1] 手张开
[2026-07-29 11:16:09.435] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 0 -> 0
[2026-07-29 11:16:09.436] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][42][61]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
```

```
[2026-07-29 11:16:09.561] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:16:09.561] [api_log] [info] set_hand_target_position OK
[Action 3] 手握紧
[2026-07-29 11:16:10.062] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 90 -> 9000
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 90 -> 9000
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 90 -> 9000
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 90 -> 9000
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 90 -> 9000
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 90 -> 9000
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 90 -> 9000
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 90 -> 9000
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 90 -> 9000
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 90 -> 9000
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 90 -> 9000
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 90 -> 9000
[2026-07-29 11:16:10.062] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 90 -> 9000
[2026-07-29 11:16:10.062] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][F4][BF]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
```

```
[2026-07-29 11:16:10.188] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:16:10.188] [api_log] [info] set_hand_target_position OK
[Action 1] 手张开
[2026-07-29 11:16:10.689] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 0 -> 0
[2026-07-29 11:16:10.689] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][42][61]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
```

```
[2026-07-29 11:16:10.814] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:16:10.815] [api_log] [info] set_hand_target_position OK
```

用法: ./wn_hand_api_demo_py

示例: ./wn_hand_api_demo_py

代码块

```
$ cd build/outputs/samples/wn_hand_api_demo_py
$ sudo python3 wn_hand_api_demo.py

========== WnHandApi Test Demo ==========

--- Get SDK Version ---
SDK Version: V2.1

--- Bus Service Init ---
[2026-07-29 11:19:51.034] [api_log] [info] Timed rotating logger initialized successfully
[2026-07-29 11:19:51.034] [api_log] [info] Log directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_api_demo_py/wn_hand_logs/api
[2026-07-29 11:19:51.034] [api_log] [info] Max file size: 10MB, Max files: 10
[2026-07-29 11:19:51.034] [api_log] [info] Custom spdlog_utility logger initialized successfully
[2026-07-29 11:19:51.034] [api_log] [info] Logger parameters:
[2026-07-29 11:19:51.034] [api_log] [info]   Directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_api_demo_py/wn_hand_logs/api
[2026-07-29 11:19:51.034] [api_log] [info]   File prefix: api_log
[2026-07-29 11:19:51.034] [api_log] [info]   Max file size: 10485760 bytes
[2026-07-29 11:19:51.034] [api_log] [info]   Max backup files: 10
[2026-07-29 11:19:51.034] [api_log] [info]   Log level: debug
[2026-07-29 11:19:51.034] [api_log] [info]   console_Log level: debug
[2026-07-29 11:19:51.034] [api_log] [info] IO线程已启动
[2026-07-29 11:19:51.034] [api_log] [info] bus_type read from config: modbus_rtu
[2026-07-29 11:19:51.034] [api_log] [info] setting driver to ModbusRtuBus
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] Timed rotating logger initialized successfully
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] Log directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_api_demo_py/wn_hand_logs/modbus_rtu
```

```
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] Max file size: 10MB, Max files: 50
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] Custom spdlog_utility logger initialized successfully
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] Logger parameters:
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info]   Directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_api_demo_py/wn_hand_logs/modbus_rtu
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info]   File prefix: modbus_rtu_log
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info]   Max file size: 10485760 bytes
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info]   Max backup files: 50
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info]   Log level: debug
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info]   console_Log level: debug
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] init() called
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 1] Checking config file existence...
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] config path: ./config/hand_system.yaml
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ File exists
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus]   file size: 700 bytes
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] permissions: 100644
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 2] Loading YAML config file...
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] config file loaded successfully
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] 'modbus_rtu' node found in config
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ device read from config: '/dev/ttyUSB0'
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ baud_rate parsed successfully: 115200
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ slave_id parsed successfully: 1
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 3] Final configuration summary
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
```

```
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus]   device: /dev/ttyUSB0
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus]   baud_rate: 115200
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus]   slave_id: 1
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus]   parity: N
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus]   data_bits: 8
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus]   stop_bits: 1
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 4] Initializing Modbus RTU context...
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus]   calling modbus_new_rtu(/dev/ttyUSB0, 115200, 'N', 8, 1)...
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] modbus_new_rtu succeeded, handle: 0x6351760f6820
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] setting slave address to 1...
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] slave address set successfully
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] setting response timeout: 500ms
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] setting byte timeout: 100ms
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] setting error recovery mode: LINK | PROTOCOL
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] enabling debug mode
[2026-07-29 11:19:51.035] [modbus_rtu_log] [info] [ModbusRtuBus] init() completed successfully
Opening /dev/ttyUSB0 at 115200 bauds (N, 8, 1)
[2026-07-29 11:19:51.047] [modbus_rtu_log] [info] [ModbusRtuBus] start OK
[2026-07-29 11:19:51.047] [api_log] [info] connected ok
[2026-07-29 11:19:51.047] [api_log] [debug] get_hand_hardware_version
[2026-07-29 11:19:51.047] [modbus_rtu_log] [info] [ModbusRtuBus] reading hardware version from address 0xd0 (2 registers)
[01][03][00][D0][00][02][C5][F2]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:19:51.170] [modbus_rtu_log] [debug] [ModbusRtuBus] hardware version (raw): 0xffffffff
[2026-07-29 11:19:51.170] [modbus_rtu_log] [info] [ModbusRtuBus] hardware version: 4294967295
```

```
[2026-07-29 11:19:51.170] [api_log] [info] hardware_version: 4294967295
[2026-07-29 11:19:51.170] [api_log] [debug] get_hand_software_version
[2026-07-29 11:19:51.170] [modbus_rtu_log] [info] [ModbusRtuBus] reading software version from address 0xd2 (2 registers)
[01][03][00][D2][00][02][64][32]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:19:51.283] [modbus_rtu_log] [debug] [ModbusRtuBus] software version (raw): 0xffffffff
[2026-07-29 11:19:51.283] [modbus_rtu_log] [info] [ModbusRtuBus] software version: 4294967295
[2026-07-29 11:19:51.283] [api_log] [info] software_version: 4294967295
[2026-07-29 11:19:51.283] [api_log] [debug] get_hand_joint_num
[2026-07-29 11:19:51.283] [modbus_rtu_log] [info] [ModbusRtuBus] reading joint number from address 0xd4 (1 register)
[01][03][00][D4][00][01][C4][32]
Waiting for a confirmation...
<01><03><02><FF><FF><B9><F4>
[2026-07-29 11:19:51.396] [modbus_rtu_log] [debug] [ModbusRtuBus] joint_num (raw): 0xffff
[2026-07-29 11:19:51.396] [modbus_rtu_log] [info] [ModbusRtuBus] joint_num: 65535
[2026-07-29 11:19:51.396] [api_log] [info] joint_num: 65535
[2026-07-29 11:19:51.396] [api_log] [info] hardware_version 4294967295
[2026-07-29 11:19:51.396] [api_log] [info] software_version 4294967295
[2026-07-29 11:19:51.397] [api_log] [info] joint_num 65535
bus_service_init: [PASS]

--- Connection Status ---
is_connected: [PASS]

--- Get Hand Information ---
[2026-07-29 11:19:51.397] [api_log] [debug] get_hand_hardware_version
[2026-07-29 11:19:51.397] [modbus_rtu_log] [info] [ModbusRtuBus] reading hardware version from address 0xd0 (2 registers)
[01][03][00][D0][00][02][C5][F2]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:19:51.509] [modbus_rtu_log] [debug] [ModbusRtuBus] hardware version (raw): 0xffffffff
[2026-07-29 11:19:51.509] [modbus_rtu_log] [info] [ModbusRtuBus] hardware version: 4294967295
[2026-07-29 11:19:51.509] [api_log] [info] hardware_version: 4294967295
Hardware Version: 4294967295
[2026-07-29 11:19:51.509] [api_log] [debug] get_hand_software_version
[2026-07-29 11:19:51.509] [modbus_rtu_log] [info] [ModbusRtuBus] reading software version from address 0xd2 (2 registers)
```

```
[01][03][00][D2][00][02][64][32]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:19:51.639] [modbus_rtu_log] [debug] [ModbusRtuBus] software version (raw): 0xffffffff
[2026-07-29 11:19:51.639] [modbus_rtu_log] [info] [ModbusRtuBus] software version: 4294967295
[2026-07-29 11:19:51.639] [api_log] [info] software_version: 4294967295
Software Version: 4294967295
[2026-07-29 11:19:51.639] [api_log] [debug] get_hand_joint_num
[2026-07-29 11:19:51.639] [modbus_rtu_log] [info] [ModbusRtuBus] reading joint number from address 0xd4 (1 register)
[01][03][00][D4][00][01][C4][32]
Waiting for a confirmation...
<01><03><02><FF><FF><B9><F4>
[2026-07-29 11:19:51.751] [modbus_rtu_log] [debug] [ModbusRtuBus] joint_num (raw): 0xffff
[2026-07-29 11:19:51.752] [modbus_rtu_log] [info] [ModbusRtuBus] joint_num: 65535
[2026-07-29 11:19:51.752] [api_log] [info] joint_num: 65535
Joint Number: 65535
[FATAL] Invalid joint number: 65535
Using default joint number: 1

--- Test: set_hand_start ---
[2026-07-29 11:19:51.752] [api_log] [debug] set_hand_start
[2026-07-29 11:19:51.752] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0x6 to addr 0x0
[01][06][00][00][00][06][09][C8]
Waiting for a confirmation...
<01><06><00><00><00><06><09><C8>
[2026-07-29 11:19:51.881] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0x7 to addr 0x0
[01][06][00][00][00][07][C8][08]
Waiting for a confirmation...
<01><06><00><00><00><07><C8><08>
[2026-07-29 11:19:51.994] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0xF to addr 0x0
[01][06][00][00][00][0F][C9][CE]
Waiting for a confirmation...
<01><06><00><00><00><0F><C9><CE>
[2026-07-29 11:19:52.107] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start OK
[2026-07-29 11:19:52.107] [api_log] [info] set_hand_start OK
set_hand_start: [PASS]

--- Test: set_hand_target_position + get_hand_current_position ---
```

```
[2026-07-29 11:19:52.107] [api_log] [debug] set_hand_target_position 0.000000
[2026-07-29 11:19:52.107] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:19:52.107] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=1
[01][10][00][01][00][01][02][00][00][A7][81]
Waiting for a confirmation...
<01><10><00><01><00><01><50><09>
[2026-07-29 11:19:52.220] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:19:52.220] [api_log] [info] set_hand_target_position OK
set_hand_target_position (target: 0): [PASS]
[2026-07-29 11:19:53.220] [api_log] [debug] get_hand_current_position
[2026-07-29 11:19:53.221] [modbus_rtu_log] [info] [ModbusRtuBus] get_hand_current_position: slave=0x1, addr=0x51, count=20
[01][03][00][51][00][14][14][14]
Waiting for a confirmation...
<01><03><28><00><00><00><6A><FF><F3><FF><FB><FF><E4><FF><B9><FF><DD><FF><DA><FF><EB><FF><C7><FF><D2><FF><ED><FF><E9><FF><F3><FF><C0><FF><E3><00><00><00><00><00><00><00><00><00><96><F8>
[2026-07-29 11:19:53.354] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[0]: 0 -> 0
[2026-07-29 11:19:53.355] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[1]: 106 -> 1.06
[2026-07-29 11:19:53.355] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[2]: -13 -> -0.13
[2026-07-29 11:19:53.355] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[3]: -5 -> -0.05
[2026-07-29 11:19:53.355] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[4]: -28 -> -0.28
[2026-07-29 11:19:53.355] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[5]: -71 -> -0.71
[2026-07-29 11:19:53.355] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[6]: -35 -> -0.35
[2026-07-29 11:19:53.355] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[7]: -38 -> -0.38
[2026-07-29 11:19:53.355] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[8]: -21 -> -0.21
[2026-07-29 11:19:53.355] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[9]: -57 -> -0.57
[2026-07-29 11:19:53.355] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[10]: -46 -> -0.46
[2026-07-29 11:19:53.355] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[11]: -19 -> -0.19
[2026-07-29 11:19:53.356] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[12]: -23 -> -0.23
```

```
[2026-07-29 11:19:53.356] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[13]: -13 -> -0.13
[2026-07-29 11:19:53.356] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[14]: -64 -> -0.64
[2026-07-29 11:19:53.356] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[15]: -29 -> -0.29
[2026-07-29 11:19:53.356] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[16]: 0 -> 0
[2026-07-29 11:19:53.356] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[17]: 0 -> 0
[2026-07-29 11:19:53.356] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[18]: 0 -> 0
[2026-07-29 11:19:53.356] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[19]: 0 -> 0
[2026-07-29 11:19:53.356] [api_log] [info] get_hand_current_position OK, count=20
get_hand_current_position: [PASS], pos[0]=0.00, Diff: 0.00, Match: [PASS]

--- Test: set_hand_target_position (single joint) + get_hand_current_position ---
[2026-07-29 11:19:53.356] [api_log] [debug] set_hand_target_position id:1 angle:0
[2026-07-29 11:19:53.357] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: id=0x1, addr=0x1, angle=0, scaled=0
[01][06][00][01][00][00][D8][0A]
Waiting for a confirmation...
<01><06><00><01><00><00><D8><0A>
[2026-07-29 11:19:53.474] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:19:53.474] [api_log] [info] set_hand_target_position OK
set_hand_target_position(id=0x01, target: 0): [PASS]
[2026-07-29 11:19:54.475] [api_log] [debug] get_hand_current_position
[2026-07-29 11:19:54.475] [modbus_rtu_log] [info] [ModbusRtuBus] get_hand_current_position: slave=0x1, addr=0x51, count=20
[01][03][00][51][00][14][14][14]
Waiting for a confirmation...
<01><03><28><00><00><00><6A><FF><F3><FF><FB><FF><E4><FF><B9><FF><DA><FF><DA>
<FF><E7><FF><CB><FF><D2><FF><E9><FF><E9><FF><F3><FF><C0><FF><E3><00><00><00>
<00><00><00><00><00><B2><EC>
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[0]: 0 -> 0
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[1]: 106 -> 1.06
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[2]: -13 -> -0.13
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[3]: -5 -> -0.05
```

```
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[4]: -28 -> -0.28
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[5]: -71 -> -0.71
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[6]: -38 -> -0.38
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[7]: -38 -> -0.38
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[8]: -25 -> -0.25
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[9]: -53 -> -0.53
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[10]: -46 -> -0.46
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[11]: -23 -> -0.23
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[12]: -23 -> -0.23
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[13]: -13 -> -0.13
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[14]: -64 -> -0.64
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[15]: -29 -> -0.29
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[16]: 0 -> 0
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[17]: 0 -> 0
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[18]: 0 -> 0
[2026-07-29 11:19:54.600] [modbus_rtu_log] [debug] [ModbusRtuBus] pos[19]: 0 -> 0
[2026-07-29 11:19:54.601] [api_log] [info] get_hand_current_position OK, count=20
get_hand_current_position: [PASS], pos[0]=0.00, Diff: 0.00, Match: [PASS]

--- Test: set_hand_work_mode ---
[2026-07-29 11:19:54.601] [api_log] [debug] set_hand_work_mode 2
[2026-07-29 11:19:54.601] [modbus_rtu_log] [debug] [ModbusRtuBus] mode[0]: 2
[2026-07-29 11:19:54.601] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_work_mode: slave=0x1, addr=0x15, count=1
[01][10][00][15][00][01][02][00][02][25][54]
Waiting for a confirmation...
<01><10><00><15><00><01><10><0D>
[2026-07-29 11:19:54.724] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_work_mode OK
[2026-07-29 11:19:54.724] [api_log] [info] set_hand_work_mode OK
```

```
set_hand_work_mode: [PASS]

--- Test: set_hand_work_mode (single joint) ---
[2026-07-29 11:19:54.724] [api_log] [debug] set_hand_work_mode id:1 mode:0
[2026-07-29 11:19:54.724] [modbus_rtu_log] [info] [ModbusRtuBus]
set_hand_work_mode: id=0x1, addr=0x15, mode=0
[01][06][00][15][00][00][98][0E]
Waiting for a confirmation...
<01><06><00><15><00><00><98><0E>
[2026-07-29 11:19:54.847] [modbus_rtu_log] [debug] [ModbusRtuBus]
set_hand_work_mode OK
[2026-07-29 11:19:54.848] [api_log] [info] set_hand_work_mode OK
set_hand_work_mode(id=0x01): [PASS]

--- Test: set_hand_speed + get_hand_speed ---
[2026-07-29 11:19:54.848] [api_log] [debug] set_hand_speed 50.000000
[2026-07-29 11:19:54.848] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[0]: 50
-> 5000
[2026-07-29 11:19:54.848] [modbus_rtu_log] [info] [ModbusRtuBus]
set_hand_speed: slave=0x1, addr=0x29, count=1
[01][10][00][29][00][01][02][13][88][AC][FF]
Waiting for a confirmation...
<01><10><00><29><00><01><D0><01>
[2026-07-29 11:19:54.971] [modbus_rtu_log] [debug] [ModbusRtuBus]
set_hand_speed OK
[2026-07-29 11:19:54.971] [api_log] [info] set_hand_speed OK
set_hand_speed (target: 50): [PASS]
[2026-07-29 11:19:54.971] [api_log] [debug] get_hand_speed
[2026-07-29 11:19:54.972] [modbus_rtu_log] [info] [ModbusRtuBus]
get_hand_speed: slave=0x1, addr=0x29, count=20
[01][03][00][29][00][14][94][0D]
Waiting for a confirmation...
<01><03><28><13><88><00><00><00><00><00><00><00><00><00><00><00><00><00>
<00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00>
<00><00><00><00><00><D7><9F>
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[0]:
5000 -> 50
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[1]: 0 -
> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[2]: 0 -
> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[3]: 0 -
> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[4]: 0 -
> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[5]: 0 -
> 0
```

```
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[6]: 0 -> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[7]: 0 -> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[8]: 0 -> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[9]: 0 -> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[10]: 0 -> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[11]: 0 -> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[12]: 0 -> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[13]: 0 -> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[14]: 0 -> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[15]: 0 -> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[16]: 0 -> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[17]: 0 -> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[18]: 0 -> 0
[2026-07-29 11:19:55.096] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[19]: 0 -> 0
[2026-07-29 11:19:55.096] [api_log] [info] get_hand_speed OK, count=20
get_hand_speed: [PASS], speed[0]=50.00, Diff: 0.00, Match: [PASS]

--- Test: set_hand_speed (single joint) + get_hand_speed ---
[2026-07-29 11:19:55.096] [api_log] [debug] set_hand_speed id:1 speed:30
[2026-07-29 11:19:55.096] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_speed: id=0x1, addr=0x29, speed=30, scaled=3000
[01][06][00][29][0B][B8][5F][40]
Waiting for a confirmation...
<01><06><00><29><0B><B8><5F><40>
[2026-07-29 11:19:55.220] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_speed OK
[2026-07-29 11:19:55.220] [api_log] [info] set_hand_speed OK
set_hand_speed(id=0x01, target: 30): [PASS]
[2026-07-29 11:19:55.221] [api_log] [debug] get_hand_speed
[2026-07-29 11:19:55.221] [modbus_rtu_log] [info] [ModbusRtuBus] get_hand_speed: slave=0x1, addr=0x29, count=20
[01][03][00][29][00][14][94][0D]
Waiting for a confirmation...
```

```
<01><03><28><0B><B8><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><DC><C1>
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[0]: 3000 -> 30
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[1]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[2]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[3]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[4]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[5]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[6]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[7]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[8]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[9]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[10]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[11]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[12]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[13]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[14]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[15]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[16]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[17]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[18]: 0 -> 0
[2026-07-29 11:19:55.345] [modbus_rtu_log] [debug] [ModbusRtuBus] speed[19]: 0 -> 0
[2026-07-29 11:19:55.345] [api_log] [info] get_hand_speed OK, count=20
get_hand_speed: [PASS], speed[0]=30.00, Diff: 0.00, Match: [PASS]

--- Get Status Information ---
```

```
[2026-07-29 11:19:55.345] [api_log] [debug] get_hand_current
[2026-07-29 11:19:55.345] [modbus_rtu_log] [info] [ModbusRtuBus]
get_hand_current: slave=0x1, addr=0x100, count=20
[01][03][01][00][00][14][44][39]
Waiting for a confirmation...
<01><03><28><00><00><00><01><00><07><00><01><00><03><00><07><00><07><00><05>
<00><06><00><00><00><04><00><02><00><04><00><06><00><02><00><02><00><00><00>
<00><00><00><00><00><3E><59>
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[0]:
0 -> 0
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[1]:
1 -> 0.01
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[2]:
7 -> 0.07
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[3]:
1 -> 0.01
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[4]:
3 -> 0.03
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[5]:
7 -> 0.07
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[6]:
7 -> 0.07
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[7]:
5 -> 0.05
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[8]:
6 -> 0.06
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[9]:
0 -> 0
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[10]:
4 -> 0.04
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[11]:
2 -> 0.02
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[12]:
4 -> 0.04
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[13]:
6 -> 0.06
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[14]:
2 -> 0.02
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[15]:
2 -> 0.02
[2026-07-29 11:19:55.469] [modbus_rtu_log] [debug] [ModbusRtuBus] current[16]:
0 -> 0
[2026-07-29 11:19:55.470] [modbus_rtu_log] [debug] [ModbusRtuBus] current[17]:
0 -> 0
[2026-07-29 11:19:55.470] [modbus_rtu_log] [debug] [ModbusRtuBus] current[18]:
0 -> 0
```

```
[2026-07-29 11:19:55.470] [modbus_rtu_log] [debug] [ModbusRtuBus] current[19]: 0 -> 0
[2026-07-29 11:19:55.470] [api_log] [info] get_hand_current OK, count=20
get_hand_current: [PASS], count=20
[2026-07-29 11:19:55.470] [api_log] [debug] get_normal_force
[2026-07-29 11:19:55.470] [modbus_rtu_log] [info] [ModbusRtuBus] get_normal_force: slave=0x1, addr=0x65, count=10
[01][03][00][65][00][0A][D5][D2]
Waiting for a confirmation...
<01><03><14><00><00><00><03><FF><00><00><09><00><00><00><00><FE><00><00><04><00><01><00><0B><20><E1>
[2026-07-29 11:19:55.594] [modbus_rtu_log] [debug] [ModbusRtuBus] force[0]: raw=0x30000, X=0, Y=0, Z=3
[2026-07-29 11:19:55.594] [modbus_rtu_log] [debug] [ModbusRtuBus] force[1]: raw=0x9ff00, X=0, Y=255, Z=9
[2026-07-29 11:19:55.594] [modbus_rtu_log] [debug] [ModbusRtuBus] force[2]: raw=0x0, X=0, Y=0, Z=0
[2026-07-29 11:19:55.594] [modbus_rtu_log] [debug] [ModbusRtuBus] force[3]: raw=0x4fe00, X=0, Y=254, Z=4
[2026-07-29 11:19:55.594] [modbus_rtu_log] [debug] [ModbusRtuBus] force[4]: raw=0xb0001, X=1, Y=0, Z=11
[2026-07-29 11:19:55.594] [api_log] [info] get_normal_force OK, count=15
get_normal_force: [PASS], count=15
[2026-07-29 11:19:55.594] [api_log] [debug] get_hand_temperature
[2026-07-29 11:19:55.594] [modbus_rtu_log] [info] [ModbusRtuBus] get_hand_temperature: slave=0x1, addr=0x13c, count=20
[01][03][01][3C][00][14][84][35]
Waiting for a confirmation...
<01><03><28><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><67><9A>
[2026-07-29 11:19:55.718] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[0]: 0 -> 0
[2026-07-29 11:19:55.718] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[1]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[2]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[3]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[4]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[5]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[6]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[7]: 0 -> 0
```

```
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[8]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[9]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[10]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[11]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[12]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[13]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[14]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[15]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[16]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[17]: 0 -> 0
[2026-07-29 11:19:55.719] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[18]: 0 -> 0
[2026-07-29 11:19:55.720] [modbus_rtu_log] [debug] [ModbusRtuBus] temperature[19]: 0 -> 0
[2026-07-29 11:19:55.720] [api_log] [info] get_hand_temperature OK, count=20
get_hand_temperature: [PASS], count=20
[2026-07-29 11:19:55.720] [api_log] [debug] get_hand_fault_code
[2026-07-29 11:19:55.720] [modbus_rtu_log] [info] [ModbusRtuBus] get_hand_fault_code: slave=0x1, addr=0x128, count=20
[01][03][01][28][00][14][C4][31]
Waiting for a confirmation...
<01><03><28><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><67><9A>
[2026-07-29 11:19:55.842] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[0]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[1]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[2]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[3]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[4]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[5]: 0x0
```

```
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[6]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[7]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[8]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[9]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[10]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[11]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[12]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[13]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[14]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[15]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[16]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[17]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[18]: 0x0
[2026-07-29 11:19:55.843] [modbus_rtu_log] [debug] [ModbusRtuBus] fault_code[19]: 0x0
[2026-07-29 11:19:55.843] [api_log] [info] get_hand_fault_code OK, count=20
get_hand_fault_code: [PASS], count=20

--- Test: clear_hand_fault + get_hand_fault_code ---
[2026-07-29 11:19:55.843] [api_log] [debug] clear_hand_fault
[2026-07-29 11:19:55.843] [modbus_rtu_log] [info] [ModbusRtuBus] clear_hand_fault: addr=0x0, value=0x80
[01][06][00][00][00][80][88][6A]
Waiting for a confirmation...
<01><06><00><00><00><80><88><6A>
[2026-07-29 11:19:55.967] [modbus_rtu_log] [info] [ModbusRtuBus] clear_hand_fault OK
clear_hand_fault: [PASS]
[2026-07-29 11:19:55.967] [api_log] [debug] get_hand_fault_code
[2026-07-29 11:19:55.967] [modbus_rtu_log] [info] [ModbusRtuBus] get_hand_fault_code: slave=0x1, addr=0x128, count=20
[01][03][01][28][00][14][C4][31]
Waiting for a confirmation...
```

```
<01><03><28><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00>
<00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00><00>
<00><00><00><00><00><67><9A>
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[0]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[1]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[2]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[3]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[4]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[5]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[6]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[7]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[8]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[9]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[10]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[11]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[12]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[13]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[14]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[15]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[16]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[17]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[18]: 0x0
[2026-07-29 11:19:56.093] [modbus_rtu_log] [debug] [ModbusRtuBus]
fault_code[19]: 0x0
[2026-07-29 11:19:56.093] [api_log] [info] get_hand_fault_code OK, count=20
get_hand_fault_code after clear: [PASS], Fault Cleared: [PASS]

--- Test: set_hand_stop ---
```

```
[2026-07-29 11:19:56.093] [api_log] [debug] set_hand_stop
[2026-07-29 11:19:56.093] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_stop: writing 0x0 to addr 0x0
[01][06][00][00][00][00][89][CA]
Waiting for a confirmation...
<01><06><00><00><00><00><89><CA>
[2026-07-29 11:19:56.217] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_stop OK
set_hand_stop: [PASS]

--- Bus Service Restart ---
[2026-07-29 11:19:56.225] [modbus_rtu_log] [info] [ModbusRtuBus] stop OK
[2026-07-29 11:19:56.226] [modbus_rtu_log] [info] [ModbusRtuBus] deinit OK
[2026-07-29 11:19:56.226] [modbus_rtu_log] [info] Timed rotating logger initialized successfully
[2026-07-29 11:19:56.226] [modbus_rtu_log] [info] Log directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_api_demo_py/wn_hand_logs/modbus_rtu
[2026-07-29 11:19:56.226] [modbus_rtu_log] [info] Max file size: 10MB, Max files: 50
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] Custom spdlog_utility logger initialized successfully
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] Logger parameters:
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info]   Directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_api_demo_py/wn_hand_logs/modbus_rtu
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info]   File prefix: modbus_rtu_log
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info]   Max file size: 10485760 bytes
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info]   Max backup files: 50
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info]   Log level: debug
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info]   console_Log level: debug
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] [ModbusRtuBus] init() called
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 1] Checking config file existence...
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] [ModbusRtuBus] config path: ./config/hand_system.yaml
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ File exists
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] [ModbusRtuBus]   file size: 700 bytes
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] [ModbusRtuBus] permissions: 100644
```

```
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 2] Loading YAML config file...
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] [ModbusRtuBus] config file loaded successfully
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] [ModbusRtuBus] 'modbus_rtu' node found in config
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ device read from config: '/dev/ttyUSB0'
[2026-07-29 11:19:56.227] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ baud_rate parsed successfully: 115200
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ slave_id parsed successfully: 1
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus] ==========
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 3] Final configuration summary
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus] ==========
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus]   device: /dev/ttyUSB0
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus]   baud_rate: 115200
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus]   slave_id: 1
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus]   parity: N
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus]   data_bits: 8
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus]   stop_bits: 1
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus] ==========
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 4] Initializing Modbus RTU context...
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus]   calling modbus_new_rtu(/dev/ttyUSB0, 115200, 'N', 8, 1)...
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus] modbus_new_rtu succeeded, handle: 0x6351760fb310
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus] setting slave address to 1...
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus] slave address set successfully
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus] setting response timeout: 500ms
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus] setting byte timeout: 100ms
```

```
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus] setting error recovery mode: LINK | PROTOCOL
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus] enabling debug mode
[2026-07-29 11:19:56.228] [modbus_rtu_log] [info] [ModbusRtuBus] init() completed successfully
Opening /dev/ttyUSB0 at 115200 bauds (N, 8, 1)
[2026-07-29 11:19:56.236] [modbus_rtu_log] [info] [ModbusRtuBus] start OK
bus_service_restart: [PASS]
is_connected after restart: [PASS]

--- Bus Service Stop ---
[2026-07-29 11:19:56.242] [modbus_rtu_log] [info] [ModbusRtuBus] stop OK
[2026-07-29 11:19:56.242] [modbus_rtu_log] [info] [ModbusRtuBus] deinit OK
bus_service_stop: [PASS]

========== Test Completed ==========
```

🥓集成SDK到你自己的工程

🍋C++版本

1. 新建一个工程目录，假设目录名称为wn_hand_demo

代码块

```
$ mkdir wn_hand_demo
$ cd wn_hand_demo
```

2. 添加源码文件到工程目录下

代码块

```
$ cp <path_to_sdk_src>/samples/wn_hand_16_joint_demo/wn_hand_16_joint_demo.cpp ./main.cpp
```

3. 安装动态库文件

代码块

```
$ cp <path_to_sdk_src>/RELEASE/wn_hand_sdk_for_linux_v2.1.tar.gz ./
$ tar -xzvpf wn_hand_sdk_for_linux_v2.1.tar.gz --strip-components=1
```

4. 开始编译

复制头文件

```
$ g++ main.cpp -o app -lwn_hand_api -lyaml-cpp -L./ -Wl,-rpath=./
```

5. 运行程序

开始编译

```
$ sudo ./app

========== WnHand 16 Joint Action Demo ==========

--- Bus Service Init ---
[2026-07-29 11:14:06.866] [api_log] [info] Timed rotating logger initialized successfully
[2026-07-29 11:14:06.866] [api_log] [info] Log directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_joint_demo/wn_hand_logs/api
[2026-07-29 11:14:06.866] [api_log] [info] Max file size: 10MB, Max files: 10
[2026-07-29 11:14:06.866] [api_log] [info] Custom spdlog_utility logger initialized successfully
[2026-07-29 11:14:06.866] [api_log] [info] Logger parameters:
[2026-07-29 11:14:06.866] [api_log] [info]   Directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_joint_demo/wn_hand_logs/api
[2026-07-29 11:14:06.866] [api_log] [info]   File prefix: api_log
[2026-07-29 11:14:06.866] [api_log] [info]   Max file size: 10485760 bytes
[2026-07-29 11:14:06.866] [api_log] [info]   Max backup files: 10
[2026-07-29 11:14:06.866] [api_log] [info]   Log level: debug
[2026-07-29 11:14:06.866] [api_log] [info]   console_Log level: debug
[2026-07-29 11:14:06.866] [api_log] [info] IO线程已启动
[2026-07-29 11:14:06.866] [api_log] [info] bus_type read from config: modbus_rtu
[2026-07-29 11:14:06.866] [api_log] [info] setting driver to ModbusRtuBus
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Timed rotating logger initialized successfully
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Log directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_joint_demo/wn_hand_logs/modbus_rtu
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Max file size: 10MB, Max files: 50
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Custom spdlog_utility logger initialized successfully
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Logger parameters:
```

```
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   Directory: /home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_joint_demo/wn_hand_logs/modbus_rtu
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   File prefix: modbus_rtu_log
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   Max file size: 10485760 bytes
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   Max backup files: 50
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   Log level: debug
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   console_Log level: debug
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] init() called
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 1] Checking config file existence...
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] config path: ./config/hand_system.yaml
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ File exists
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]   file size: 700 bytes
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] permissions: 100644
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 2] Loading YAML config file...
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] config file loaded successfully
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] 'modbus_rtu' node found in config
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ device read from config: '/dev/ttyUSB0'
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ baud_rate parsed successfully: 115200
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ slave_id parsed successfully: 1
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 3] Final configuration summary
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ==========================================
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]   device: /dev/ttyUSB0
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]   baud_rate: 115200
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]   slave_id: 1
```

```
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus]   parity:
 N
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus]   data_bits:
 8
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus]   stop_bits:
 1
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus]
========================================
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 4]
Initializing Modbus RTU context...
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus]   calling
modbus_new_rtu(/dev/ttyUSB0, 115200, 'N', 8, 1)...
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus]
modbus_new_rtu succeeded, handle: 0x5b45e3328dd0
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] setting slave
address to 1...
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] slave address
set successfully
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] setting
response timeout: 500ms
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] setting byte
timeout: 100ms
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] setting error
recovery mode: LINK | PROTOCOL
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] enabling
debug mode
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] init()
completed successfully
Opening /dev/ttyUSB0 at 115200 bauds (N, 8, 1)
[2026-07-29 11:14:06.879] [modbus_rtu_log] [info] [ModbusRtuBus] start OK
[2026-07-29 11:14:06.879] [api_log] [info] connected ok
[2026-07-29 11:14:06.879] [api_log] [debug] get_hand_hardware_version
[2026-07-29 11:14:06.879] [modbus_rtu_log] [info] [ModbusRtuBus] reading
hardware version from address 0xd0 (2 registers)
[01][03][00][D0][00][02][C5][F2]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:14:07.000] [modbus_rtu_log] [debug] [ModbusRtuBus] hardware
version (raw): 0xffffffff
[2026-07-29 11:14:07.000] [modbus_rtu_log] [info] [ModbusRtuBus] hardware
version: 4294967295
[2026-07-29 11:14:07.000] [api_log] [info] hardware_version: 4294967295
[2026-07-29 11:14:07.000] [api_log] [debug] get_hand_software_version
[2026-07-29 11:14:07.000] [modbus_rtu_log] [info] [ModbusRtuBus] reading
software version from address 0xd2 (2 registers)
[01][03][00][D2][00][02][64][32]
Waiting for a confirmation...
```

```
<01><03><04><FF><FF><FF><FB><A7>
[2026-07-29 11:14:07.112] [modbus_rtu_log] [debug] [ModbusRtuBus] software version (raw): 0xffffffff
[2026-07-29 11:14:07.112] [modbus_rtu_log] [info] [ModbusRtuBus] software version: 4294967295
[2026-07-29 11:14:07.112] [api_log] [info] software_version: 4294967295
[2026-07-29 11:14:07.112] [api_log] [debug] get_hand_joint_num
[2026-07-29 11:14:07.112] [modbus_rtu_log] [info] [ModbusRtuBus] reading joint number from address 0xd4 (1 register)
[01][03][00][D4][00][01][C4][32]
Waiting for a confirmation...
<01><03><02><FF><FF><B9><F4>
[2026-07-29 11:14:07.226] [modbus_rtu_log] [debug] [ModbusRtuBus] joint_num (raw): 0xffff
[2026-07-29 11:14:07.227] [modbus_rtu_log] [info] [ModbusRtuBus] joint_num: 65535
[2026-07-29 11:14:07.227] [api_log] [info] joint_num: 65535
[2026-07-29 11:14:07.227] [api_log] [info] hardware_version 4294967295
[2026-07-29 11:14:07.227] [api_log] [info] software_version 4294967295
[2026-07-29 11:14:07.227] [api_log] [info] joint_num 65535
bus_service_init: [PASS]

--- Hand Start ---
[2026-07-29 11:14:07.227] [api_log] [debug] set_hand_start
[2026-07-29 11:14:07.227] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0x6 to addr 0x0
[01][06][00][00][00][06][09][C8]
Waiting for a confirmation...
<01><06><00><00><00><06><09><C8>
[2026-07-29 11:14:07.341] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0x7 to addr 0x0
[01][06][00][00][00][07][C8][08]
Waiting for a confirmation...
<01><06><00><00><00><07><C8><08>
[2026-07-29 11:14:07.455] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0xF to addr 0x0
[01][06][00][00][00][0F][C9][CE]
Waiting for a confirmation...
<01><06><00><00><00><0F><C9><CE>
[2026-07-29 11:14:07.586] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start OK
[2026-07-29 11:14:07.586] [api_log] [info] set_hand_start OK
set_hand_start: [PASS]

--- Execute Action Sequence ---
[INFO] Starting action sequence... (Press Ctrl+C to stop)

```

```
[Cycle 1/1]
[Action 3] 手握紧
[2026-07-29 11:14:07.586] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][F4][BF]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
[2026-07-29 11:14:07.715] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:14:07.715] [api_log] [info] set_hand_target_position OK
```

```
[Action 2] 半张开
[2026-07-29 11:14:08.216] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 90.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 90 -> 9000
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][23][28][11][94][11][94][11][94][11][94][11][94][11][94][11][94][11][94][11][94][11][94][07][54]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
[2026-07-29 11:14:08.335] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:14:08.335] [api_log] [info] set_hand_target_position OK
[Action 1] 手张开
```

```
[2026-07-29 11:14:08.836] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][42][61]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
[2026-07-29 11:14:08.953] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:14:08.953] [api_log] [info] set_hand_target_position OK
[Action 3] 手握紧
```

```
[2026-07-29 11:14:09.454] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 90 -> 9000
[2026-07-29 11:14:09.455] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][F4][BF]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
[2026-07-29 11:14:09.573] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:14:09.573] [api_log] [info] set_hand_target_position OK
[Action 1] 手张开
```

```
[2026-07-29 11:14:10.074] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][42][61]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
[2026-07-29 11:14:10.193] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:14:10.193] [api_log] [info] set_hand_target_position OK
```

🍋python版本

1. 新建一个工程目录，假设目录名称为wn_hand_demo_py

代码块

```
$ mkdir wn_hand_demo_py
$ cd wn_hand_demo_py
```

2. 添加源码文件到工程目录下

代码块

```
$ cp
<path_to_sdk_src>/samples/wn_hand_16_joint_demo_py/wn_hand_16_joint_demo.py ./
```

3. 安装动态库文件

代码块

```
$ cp <path_to_sdk_src>/RELEASE/wn_hand_sdk_for_linux_v2.1.tar.gz ./
$ tar -xzvpf wn_hand_sdk_for_linux_v2.1.tar.gz --strip-components=1
```

4. 运行程序

复制头文件

```
$ sudo python3 wn_hand_16_joint_demo.py

========== WnHand 16 Joint Action Demo ==========

--- Bus Service Init ---
[2026-07-29 11:14:06.866] [api_log] [info] Timed rotating logger initialized
successfully
[2026-07-29 11:14:06.866] [api_log] [info] Log directory:
/home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_jo
int_demo/wn_hand_logs/api
[2026-07-29 11:14:06.866] [api_log] [info] Max file size: 10MB, Max files: 10
[2026-07-29 11:14:06.866] [api_log] [info] Custom spdlog_utility logger
initialized successfully
[2026-07-29 11:14:06.866] [api_log] [info] Logger parameters:
[2026-07-29 11:14:06.866] [api_log] [info]   Directory:
/home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_jo
int_demo/wn_hand_logs/api
[2026-07-29 11:14:06.866] [api_log] [info]   File prefix: api_log
[2026-07-29 11:14:06.866] [api_log] [info]   Max file size: 10485760 bytes
```

```
[2026-07-29 11:14:06.866] [api_log] [info]   Max backup files: 10
[2026-07-29 11:14:06.866] [api_log] [info]   Log level: debug
[2026-07-29 11:14:06.866] [api_log] [info]   console_Log level: debug
[2026-07-29 11:14:06.866] [api_log] [info] IO线程已启动
[2026-07-29 11:14:06.866] [api_log] [info] bus_type read from config:
modbus_rtu
[2026-07-29 11:14:06.866] [api_log] [info] setting driver to ModbusRtuBus
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Timed rotating logger
initialized successfully
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Log directory:
/home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_jo
int_demo/wn_hand_logs/modbus_rtu
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Max file size: 10MB, Max
files: 50
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Custom spdlog_utility logger
initialized successfully
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] Logger parameters:
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   Directory:
/home/ethan/workspace/update/vanex_hand_sdk/build/outputs/samples/wn_hand_16_jo
int_demo/wn_hand_logs/modbus_rtu
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   File prefix: modbus_rtu_log
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   Max file size: 10485760
bytes
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   Max backup files: 50
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   Log level: debug
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info]   console_Log level: debug
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]
========================================
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] init() called
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]
========================================
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 1]
Checking config file existence...
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] config path:
./config/hand_system.yaml
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ File exists
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]   file size:
700 bytes
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]
permissions: 100644
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 2]
Loading YAML config file...
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] config file
loaded successfully
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] 'modbus_rtu'
node found in config
```

```
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ device read from config: '/dev/ttyUSB0'
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ baud_rate parsed successfully: 115200
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ✓ slave_id parsed successfully: 1
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 3] Final configuration summary
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]   device: /dev/ttyUSB0
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]   baud_rate: 115200
[2026-07-29 11:14:06.867] [modbus_rtu_log] [info] [ModbusRtuBus]   slave_id: 1
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus]   parity: N
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus]   data_bits: 8
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus]   stop_bits: 1
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] ========================================
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] [STEP 4] Initializing Modbus RTU context...
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus]   calling modbus_new_rtu(/dev/ttyUSB0, 115200, 'N', 8, 1)...
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] modbus_new_rtu succeeded, handle: 0x5b45e3328dd0
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] setting slave address to 1...
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] slave address set successfully
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] setting response timeout: 500ms
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] setting byte timeout: 100ms
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] setting error recovery mode: LINK | PROTOCOL
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] enabling debug mode
[2026-07-29 11:14:06.868] [modbus_rtu_log] [info] [ModbusRtuBus] init() completed successfully
Opening /dev/ttyUSB0 at 115200 bauds (N, 8, 1)
```

```
[2026-07-29 11:14:06.879] [modbus_rtu_log] [info] [ModbusRtuBus] start OK
[2026-07-29 11:14:06.879] [api_log] [info] connected ok
[2026-07-29 11:14:06.879] [api_log] [debug] get_hand_hardware_version
[2026-07-29 11:14:06.879] [modbus_rtu_log] [info] [ModbusRtuBus] reading hardware version from address 0xd0 (2 registers)
[01][03][00][D0][00][02][C5][F2]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:14:07.000] [modbus_rtu_log] [debug] [ModbusRtuBus] hardware version (raw): 0xffffffff
[2026-07-29 11:14:07.000] [modbus_rtu_log] [info] [ModbusRtuBus] hardware version: 4294967295
[2026-07-29 11:14:07.000] [api_log] [info] hardware_version: 4294967295
[2026-07-29 11:14:07.000] [api_log] [debug] get_hand_software_version
[2026-07-29 11:14:07.000] [modbus_rtu_log] [info] [ModbusRtuBus] reading software version from address 0xd2 (2 registers)
[01][03][00][D2][00][02][64][32]
Waiting for a confirmation...
<01><03><04><FF><FF><FF><FF><FB><A7>
[2026-07-29 11:14:07.112] [modbus_rtu_log] [debug] [ModbusRtuBus] software version (raw): 0xffffffff
[2026-07-29 11:14:07.112] [modbus_rtu_log] [info] [ModbusRtuBus] software version: 4294967295
[2026-07-29 11:14:07.112] [api_log] [info] software_version: 4294967295
[2026-07-29 11:14:07.112] [api_log] [debug] get_hand_joint_num
[2026-07-29 11:14:07.112] [modbus_rtu_log] [info] [ModbusRtuBus] reading joint number from address 0xd4 (1 register)
[01][03][00][D4][00][01][C4][32]
Waiting for a confirmation...
<01><03><02><FF><FF><B9><F4>
[2026-07-29 11:14:07.226] [modbus_rtu_log] [debug] [ModbusRtuBus] joint_num (raw): 0xffff
[2026-07-29 11:14:07.227] [modbus_rtu_log] [info] [ModbusRtuBus] joint_num: 65535
[2026-07-29 11:14:07.227] [api_log] [info] joint_num: 65535
[2026-07-29 11:14:07.227] [api_log] [info] hardware_version 4294967295
[2026-07-29 11:14:07.227] [api_log] [info] software_version 4294967295
[2026-07-29 11:14:07.227] [api_log] [info] joint_num 65535
bus_service_init: [PASS]

--- Hand Start ---
[2026-07-29 11:14:07.227] [api_log] [debug] set_hand_start
[2026-07-29 11:14:07.227] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0x6 to addr 0x0
[01][06][00][00][00][06][09][C8]
Waiting for a confirmation...
<01><06><00><00><00><06><09><C8>
```

```
[2026-07-29 11:14:07.341] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0x7 to addr 0x0
[01][06][00][00][00][07][C8][08]
Waiting for a confirmation...
<01><06><00><00><00><07><C8><08>
[2026-07-29 11:14:07.455] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start: writing 0xF to addr 0x0
[01][06][00][00][00][0F][C9][CE]
Waiting for a confirmation...
<01><06><00><00><00><0F><C9><CE>
[2026-07-29 11:14:07.586] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_start OK
[2026-07-29 11:14:07.586] [api_log] [info] set_hand_start OK
set_hand_start: [PASS]

--- Execute Action Sequence ---
[INFO] Starting action sequence... (Press Ctrl+C to stop)

[Cycle 1/1]
[Action 3] 手握紧
[2026-07-29 11:14:07.586] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 90 -> 9000
```

```
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 90 -> 9000
[2026-07-29 11:14:07.587] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][F4][BF]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
[2026-07-29 11:14:07.715] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:14:07.715] [api_log] [info] set_hand_target_position OK
[Action 2] 半张开
[2026-07-29 11:14:08.216] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 90.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000 45.000000
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 90 -> 9000
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 45 -> 4500
```

```
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 45 -> 4500
[2026-07-29 11:14:08.216] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][23][28][11][94][11][94][11][94][11][94][11][94][11][94][11][94][11][94][11][94][11][94][07][54]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
[2026-07-29 11:14:08.335] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:14:08.335] [api_log] [info] set_hand_target_position OK
[Action 1] 手张开
[2026-07-29 11:14:08.836] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 0 -> 0
```

```
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 0 -> 0
[2026-07-29 11:14:08.836] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][42][61]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
[2026-07-29 11:14:08.953] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:14:08.953] [api_log] [info] set_hand_target_position OK
[Action 3] 手握紧
[2026-07-29 11:14:09.454] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000 90.000000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 90 -> 9000
```

```
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 90 -> 9000
[2026-07-29 11:14:09.454] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 90 -> 9000
[2026-07-29 11:14:09.455] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][23][28][F4][BF]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
[2026-07-29 11:14:09.573] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:14:09.573] [api_log] [info] set_hand_target_position OK
[Action 1] 手张开
[2026-07-29 11:14:10.074] [api_log] [debug] set_hand_target_position 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[0]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[1]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[2]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[3]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[4]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[5]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[6]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[7]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[8]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[9]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[10]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[11]: 0 -> 0
```

```
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[12]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[13]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[14]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [debug] [ModbusRtuBus] joint[15]: 0 -> 0
[2026-07-29 11:14:10.074] [modbus_rtu_log] [info] [ModbusRtuBus] set_hand_target_position: slave=0x1, addr=0x1, count=16
[01][10][00][01][00][10][20][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][00][42][61]
Waiting for a confirmation...
<01><10><00><01><00><10><90><05>
[2026-07-29 11:14:10.193] [modbus_rtu_log] [debug] [ModbusRtuBus] set_hand_target_position OK
[2026-07-29 11:14:10.193] [api_log] [info] set_hand_target_position OK
```

配置文件说明

1. SDK系统配置文件

系统配置文件为 hand_system.yaml，需放置在可执行程序目录下的 config/hand_system.yaml

代码块

```yaml
bus_type: "modbus_rtu"

modbus_rtu:
  device: "/dev/ttyUSB0"
  baud_rate: 115200
  slave_id: 1

api_Log:
  log_dir: "wn_hand_logs/api"
  log_prefix: "api_log"
  max_file_size: 10485760  # 等价于10*1024*1024，可直接写数值简化
  max_files: 10
  log_level: "debug"  # trace/debug/info/warn/err/critical
  console_log_level: "debug"  # trace/debug/info/warn/err/critical

modbus_rtu_log:
  log_dir: "wn_hand_logs/modbus_rtu"
  log_prefix: "modbus_rtu_log"
  max_file_size: 10485760  # 等价于10*1024*1024，可直接写数值简化
  max_files: 50
```

```
    log_level: "debug"  # trace/debug/info/warn/err/critical
    console_log_level: "debug"  # trace/debug/info/warn/err/critical
```

通讯配置参数

参数名	层级	类型	默认值	说明
bus_type	顶层	string	modbus_rtu	总线类型，当前支持 modbus_rtu
device	modbus_rtu	string	/dev/ttyUSB0	串口设备路径
baud_rate	modbus_rtu	int	115200	波特率
slave_id	modbus_rtu	int	1	Modbus从机地址

日志配置参数

参数名	层级	类型	默认值	说明
log_dir	api_Log / modbus_rtu_log	string	wn_hand_logs/api / wn_hand_logs/modbus_rtu	日志存储目录，支持相对路径和绝对路径
log_prefix	api_Log / modbus_rtu_log	string	api_log / modbus_rtu_log	日志文件前缀，最终文件名格式为 {log_prefix}_{timestamp}.log
max_file_size	api_Log / modbus_rtu_log	int	10485760	单个日志文件最大大小，单位字节，默认 10MB
max_files	api_Log / modbus_rtu_log	int	10 / 50	最大保留日志文件数量，超过后自动删除最旧的日志
log_level	api_Log / modbus_rtu_log	string	debug	文件日志级别：trace/debug/info/warn/err/critical

console_log_level	api_Log / modbus_rtu_log	string	debug	控制台日志级别：trace/debug/info/warn/err/critical

2. 动作演示文件

动作演示文件为 action_five.yaml，默认放置在可执行程序目录下的 config/action_five.yaml

代码块

```yaml
# 执行动作序列
project: "16自由度演示"    #配置文件名称
owner: "john"              #创建人
joint_num: 16              #自由度
cycle: 1                   #整个动作序列执行次数
task_sequence: [3, 2, 1, 3, 1]     #动作序列 依次执行 action id预定义的动作
date: 2026-03-12           #日期


#预定义动作
action:
  - id: 1
    title: "手张开"        #动作名称
    active: true           #动作开关 true:此动作使能 false:此动作禁用
    duration: 500          #动作延时 单位是ms
    angle: [0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0] #每个关节角度

  - id: 2
    title: "半张开"        #动作名称
    active: true           #动作开关 true:此动作使能 false:此动作禁用
    duration: 500          #动作延时 单位是ms
    angle: [0, 0, 0, 90, 45, 45, 45, 45, 45, 45, 45, 45, 45, 45, 45, 45] #每个关节角度

  - id: 3
    title: "手握紧"        #动作名称
    active: true           #动作开关 true:此动作使能 false:此动作禁用
    duration: 500          #动作延时 单位是ms
    angle: [0, 0, 0, 90, 90, 90, 90, 90, 90, 90, 90, 90, 90, 90, 90, 90] #每个关节角度
```

动作配置参数

参数名	层级	类型	默认值	说明

project	顶层	string	-	配置文件名称
owner	顶层	string	-	创建人
joint_num	顶层	int	-	自由度数量
cycle	顶层	int	1	整个动作序列执行次数
task_sequence	顶层	array	-	动作序列，依次执行 action id 预定义的动作
date	顶层	string	-	配置日期
id	action	int	-	动作ID，唯一标识
title	action	string	-	动作名称
active	action	bool	true	动作开关，true:使能，false:禁用
duration	action	int	500	动作延时，单位毫秒
angle	action	array	-	每个关节角度，元素数量等于自由度数量，范围0~90

🌭API清单

1. bus_service_init

函数原型

代码块

```
bool bus_service_init();
```

功能说明

> 使用sdk首个要调用函数，进行sdk的一些初始化工作，会自动连接目标设备，并查询设备信息，此函数返回成功才可以进行后面其他API调用

参数说明

类别	参数	说明
返回值	bool	true:成功 false:失败

2. bus_service_stop

函数原型

代码块

```
1   bool bus_service_stop();
```

功能说明

> 停止总线服务

参数说明

类别	参数	说明
返回值	bool	true:已停止 false:未停止

3. bus_service_restart

函数原型

代码块

```
1   bool bus_service_restart();
```

功能说明

> 重启总线服务

参数说明

类别	参数	说明

返回值	bool	true:成功 false:失败

4. is_connected

函数原型

代码块

```
1    bool is_connected();
```

功能说明

> 获取当前连接状态

参数说明

类别	参数	说明
返回值	bool	true:已连接 false:未连接

5. set_hand_target_position

函数原型

代码块

```
1    bool set_hand_target_position(const uint8_t id, const std::vector<float>
    &joint_angles);
2    bool set_hand_target_position(const std::vector<float> &joint_angles);
```

功能说明

> 设置各个关节电机的位置

参数说明

类别	参数	说明

入参	id	目标电机id，范围1~21 不传id表示一次控制多个电机
	joint_angles	目标位置角度，范围0~90 joint_angles[0]表示电机1的角度 ... joint_angles[15]表示电机16的角度 joint_angles元素数量等于自由度数量
返回值	bool	true:成功 false:失败

6. set_hand_work_mode

函数原型

代码块

```
1    bool set_hand_work_mode(const uint8_t id, std::vector<int> & mode);
2    bool set_hand_work_mode(const std::vector<int> &mode);
```

功能说明

> 设置各个关节电机的工作模式（停止或者位置模式）

参数说明

类别	参数	说明
入参	id	目标电机id，范围1~21 不传id表示一次控制多个电机

	mode	工作模式， 0：停止在当前位置 2：位置模式 mode[0]表示电机1的角度 ... mode[15]表示电机16的角度 mode元素数量等于自由度数量
返回值	bool	true:成功 false:失败

7. set_hand_speed

函数原型

代码块

```
bool set_hand_speed(const uint8_t id, const std::vector<float> &speed);
bool set_hand_speed(const std::vector<float> &speed);
```

功能说明

> 设置各个关节电机的工作模式（停止或者位置模式）

参数说明

类别	参数	说明
入参	id	目标电机id，范围1~21 不传id表示一次控制多个电机
	speed	速度值，speed[0]表示电机1的速度 speed[15]表示电机16的速度speed元素数量等于自由度数量
返回值	bool	true:成功 false:失败

8. set_hand_start

函数原型

代码块

```
1   bool set_hand_start();
```

功能说明

> 打开关节电机电源

参数说明

类别	参数	说明
返回值	bool	true:成功 false:失败

9. set_hand_stop

函数原型

代码块

```
1   bool set_hand_stop();
```

功能说明

> 关闭关节电机电源

参数说明

类别	参数	说明
返回值	bool	true:成功 false:失败

10. clear_hand_fault

函数原型

代码块

```
1   bool clear_hand_fault();
```

功能说明

> 清除模组错误

参数说明

类别	参数	说明
返回值	bool	true:成功 false:失败

11. get_hand_hardware_version

函数原型

代码块

```
1   std::pair<bool, std::string> get_hand_hardware_version();
```

功能说明

> 读取主板硬件版本

参数说明

类别	参数	说明
返回值	bool	true:成功 false:失败
	string	硬件版本字符串

12. get_hand_software_version

函数原型

代码块

```
1    std::pair<bool, std::string> get_hand_software_version();
```

功能说明

> 读取主板软件版本

参数说明

类别	参数	说明
返回值	bool	true:成功 false:失败
	string	软件版本字符串

13. get_hand_joint_num

函数原型

代码块

```
std::pair<bool, int> get_hand_joint_num();
```

功能说明

> 读取关节数量

参数说明

类别	参数	说明
返回值	bool	true:成功 false:失败
	int	关节数量

14. get_hand_current_position

函数原型

代码块

```
std::pair<bool, std::vector<float>> get_hand_current_position();
```

功能说明

> 读取各个关节电机当前位置

参数说明

类别	参数	说明
返回值	bool	true:成功 false:失败
	vector<float>	vector[0]表示第1个电机的位置 ... vector[15]表示第16个电机的位置

15. get_hand_speed

函数原型

代码块

```
std::pair<bool, std::vector<float>> get_hand_speed();
```

功能说明

> 读取各个关节电机实时速度

参数说明

类别	参数	说明
返回值	bool	true:成功 false:失败
	vector<float>	vector[0]表示第1个电机的速度 ... vector[15]表示第16个电机的速度

16. get_hand_current

函数原型

代码块

```
std::pair<bool, std::vector<float>> get_hand_current();
```

功能说明

> 读取各个关节电机实时电流

参数说明

类别	参数	说明
返回值	bool	true:成功 false:失败
	vector<float>	vector[0]表示第1个电机的电流 ... vector[15]表示第16个电机的电流

17. get_hand_temperature

函数原型

代码块

```
std::pair<bool, std::vector<float>> get_hand_temperature();
```

功能说明

> 读取各个关节电机实时温度

参数说明

类别	参数	说明
返回值	bool	true:成功 false:失败
	vector<float>	vector[0]表示第1个电机的温度 ... vector[15]表示第16个电机的温度

18. get_hand_fault_code

函数原型

代码块

```
1   std::pair<bool, std::vector<uint32_t>> get_hand_fault_code();
```

功能说明

> 读取灵巧手的错误码

参数说明

类别	参数	说明
返回值	bool	true:成功 false:失败
	vector<uint32_t>	vector[0]表示第1个电机的错误码 ... vector[15]表示第16个电机的错误码

19. get_sdk_version

函数原型

代码块

```
1   std::string get_sdk_version();
```

功能说明

> 获取SDK版本号

参数说明

类别	参数	说明
返回值	string	SDK版本字符串

20. get_normal_force

函数原型

代码块

```
std::pair<bool, std::vector<float>> get_normal_force();
```

功能说明

读取各个指尖的触觉结果，单位是：0.01N

例子：合力值 Fz 读取数据为 10 时，Fz 测量的力的大小为 10*0.01N=0.1N

x：指尖x方向的合力，数值为正时朝向x正方向，数值为负数时朝向x负方向

y：指尖y方向的合力，数值为正时朝向y正方向，数值为负数时朝向y负方向

z：指尖z方向的合力，数值为正,表示垂直向指尖方向(指向指腹)压力大小



参数说明

类别	参数	说明
返回值	bool	true:成功 false:失败
	vector<float>	vector[0]表示第1个手指的x合力

		vector[1]表示第1个手指的y合力 vector[2]表示第1个手指的z合力 ... vector[12]表示第5个手指的x合力 vector[13]表示第5个手指的y合力 vector[14]表示第5个手指的z合力