Gimbal Motor Drive User Manual

--For GL II

V1.0.0

Content

Precautions

1.Ensure that there are no short circuits in the circuit and that interfaces are connected correctly as required.

2.  The driver board will heat up during output; please use it carefully to avoid burns.

3.  Before use, please check if all parts are intact. If any parts are missing or aged, please stop using it and contact technical support in time.

4.  Multiple optional control methods cannot be switched while the driver board is running, and the communication protocols between different control methods are different. If you need to switch, please restart the power supply before changing. Using the wrong protocol to control may burn out the driver board!

5.  Please strictly follow the working voltage, current, temperature, and other parameters specified in this document; otherwise, it will cause permanent damage to the product!

Product Features

The GL II motor driver board adopts high-performance drive chips in the same class, uses Field Oriented Control (FOC) algorithm, and is equipped with advanced self-disturbance control technology for speed and angle control. It can be used with upper computer software for parameter setting and firmware upgrades.

Disclaimer

Thank you for purchasing the GL II motor. Before using it, please read this statement carefully. Once used, it is considered as recognition and acceptance of all the contents of this statement. Please strictly follow the product manual and relevant laws, regulations, policies, and guidelines for the installation and use of the product. During the use of the product, the user promises to be responsible for their actions and all consequences arising therefrom.

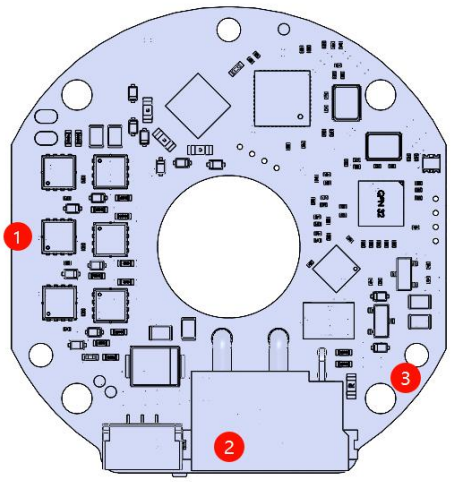
CubeMars will not assume legal responsibility for any losses caused by improper use, installation, or modification by the user.

Version Change Record

Date	Version	Change Content
2024.07.18	Ver. 1.0.0	Create version

1. Driver Product Information

1.1Driver Appearance Introduction & Product Specifications



①Three-phase Power Line Connection Terminal

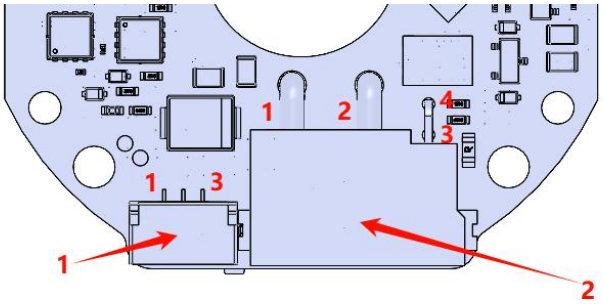
②Connection Port

③Mounting Hole

Product Specification	
Rated operating voltage	24V
Allowable voltage	8~32V
Rated working current	2A
Maximum allowable current	10A
Standby power consumption	≤50mA
CAN bus bit rate	1Mbps
Size	41mm×38mm
Working environment temperature	-20℃ to 65℃
Maximum allowable temperature for control board	120℃
Control Precision	0.1°

1.2Driver Interface and Definitions

1.2.1Driver Interface Diagram



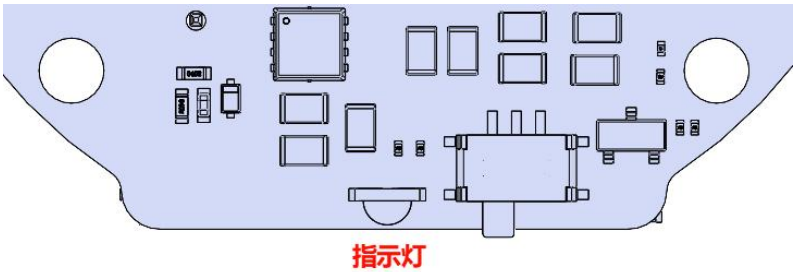
1.2.2 Recommended Brands and Models for Driver Interfaces

No.	Onboard interface model	Brand	Terminal interface model	Brand
1	A1257WR-S-3P	CJT	A1257H-3P	CJT
2	XT30（2+2）PW-M	AMASS	XT30（2+2）-F	AMASS

1.2.3 Driver Interface Pin Definitions

No.	Interface Function	Pin	Description
1	**Serial Communication**	1	Serial signal ground (GND)
		2	Serial Signal Output（TX）
		3	Serial Signal Input（RX）
2	**Power Input and CAN Communication**	1	Positive pole（+）
		2	Negative pole（-）
		3	CAN communication high side（CAN_H）
		4	CAN communication low side（CAN_L）

1.3Driver Indicator Light Definitions



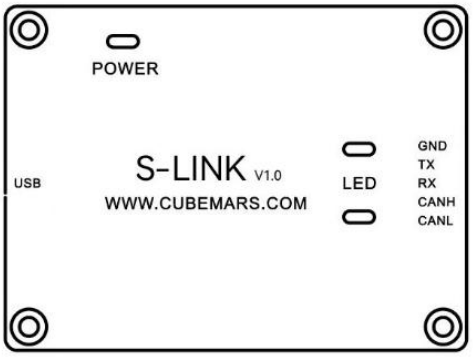
Indicator Light Definitions	
1.Motor Malfuntion Indicator Light（Red when lit）	Malfuntion Indicator Light, used to indicate the motor's operating state.
2.Motor Enable Indicator（Green when lit）	Enable indicator， used to indicate the motor's operating state.
3.Drive Error Indicator（Red light blink）	Drive error indicator light, used to indicate error conditions of the drive board, which normally only blinks when errors occur on the drive board.

1.4 Main Accessories and Specifications

No.	Item	Specifications		Quantity	Remarks
1	Power and signal plug	Power and CAN cable	16AWG - Red and black silicone wire and white and blue - Teflon 30#-OD0.64-300±10mm-4-one end connectorXT30(2+2)-F,other end stripped and tinned 3±1mm	1PCS Each	±2MM
2		Serial cable	Teflon30# OD0.64-300mm-3-GH1.25-3PIN male toJR-3PIN male-NULL	1PCS Each	±2MM

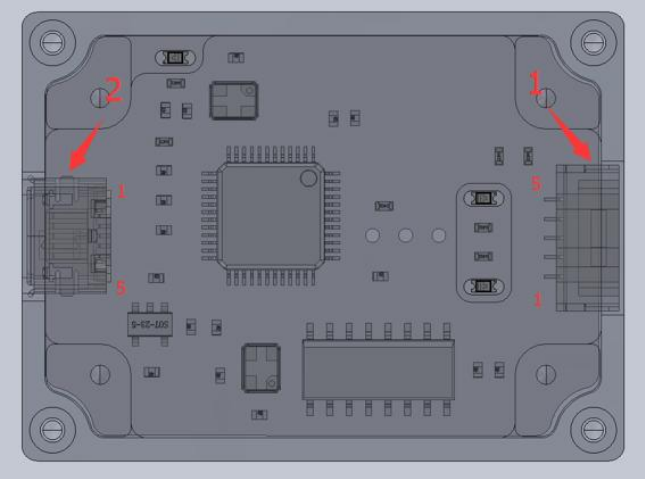
2. S-link Product Information

2.1 S-link Appearance Introduction & Product Specifications



Product Specifications	
Rated working voltage	5V
Standby power consumption	≤30mA
Size	39.2x29.2x10MM
Working environment temperature	-20℃ to 65℃
Maximum allowable temperature for control board	85℃

2.2 S-link Interface and Definitions

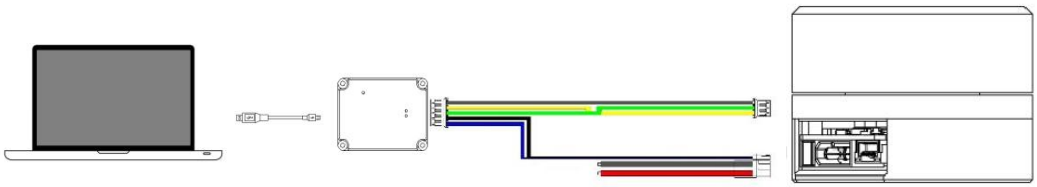


No.	Interface Function	Pin	Descriptions
1	Communication Interface	1	CAN communication low side（CAN_L）
		2	CAN communication high side（CAN_H）
		3	Serial signal input（RX）
		4	Serial signal output（TX）
		5	Serial signal ground（GND）
2	USB Interface	1	VBUS
		2	D-
		3	D+
		4	ID
		5	GND

2.2 S-link Indicator Light Definitions

No.	Color	Descriptions
1	Green	Power indicator light, indicates the power status of the S-link. Under normal conditions, the light turns green when power is connected. If the green light does not come on when power is connected, please immediately remove the power supply and do not attempt to power on again.
2	Blue	Serial communication output (TX), usually off, blinks when data is being output from the S-link serial port.
3	Red	Serial communication input(RX)， usually off, blinks when data is being input into the S-link serial port.

3. Driver and S-link Connection and Precautions



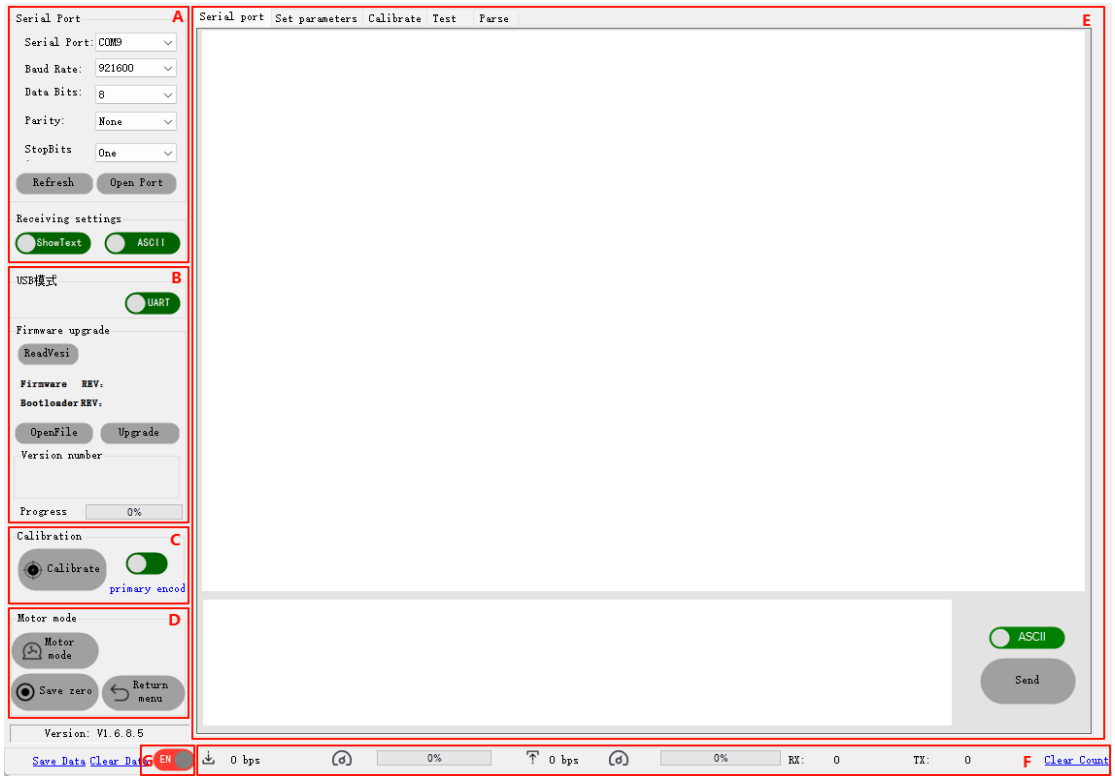
S-link USB cable ---> PC end

2+2Pin terminal (Power and CAN) ---> Motor's 2+2Pin terminal (Power and CAN)

3Pin terminal (UART) ---> Motor's 3Pin terminal (UART)

4.Upper Computer Instruction

4.1Upper Computer Interface and Instructions



A. Communication Settings (Serial Port)

B. Firmware Upgrade

C. Calibration

D. Motor Mode

E. Main Window

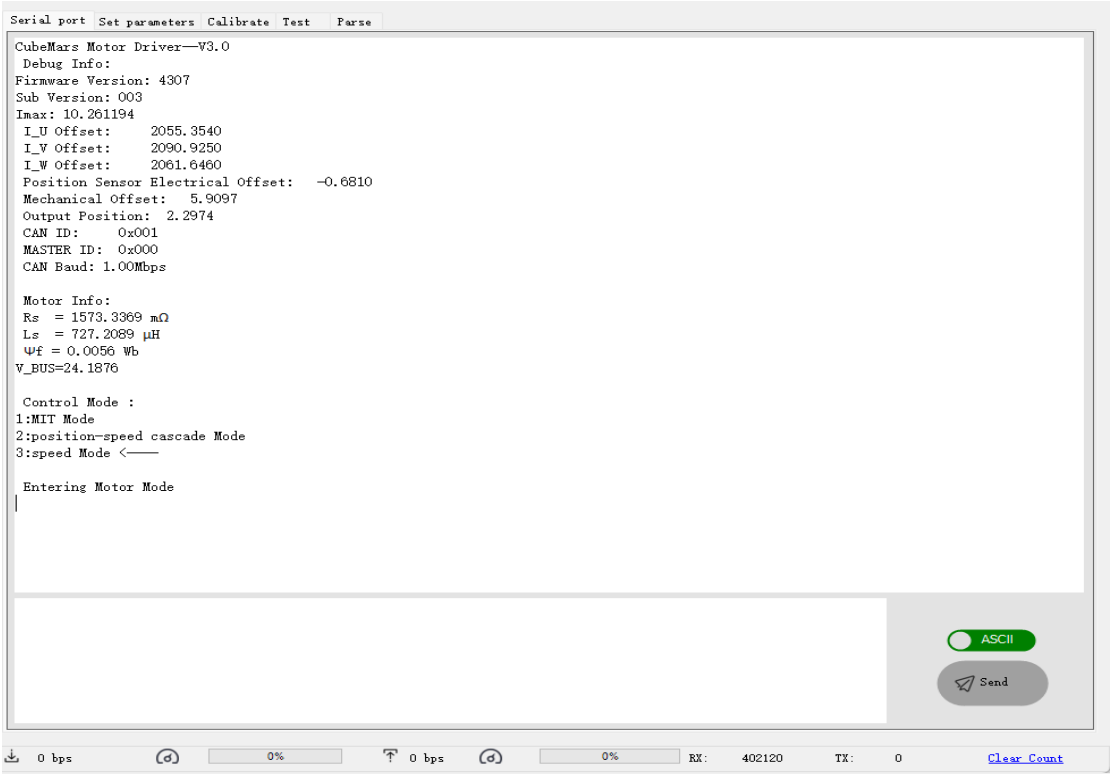
F. Communication Status

G. CN-EN

4.1.1 Main Window

4.1.1.1 Serial Port

This page mainly displays the received data from the serial port and the data sent to the serial port.

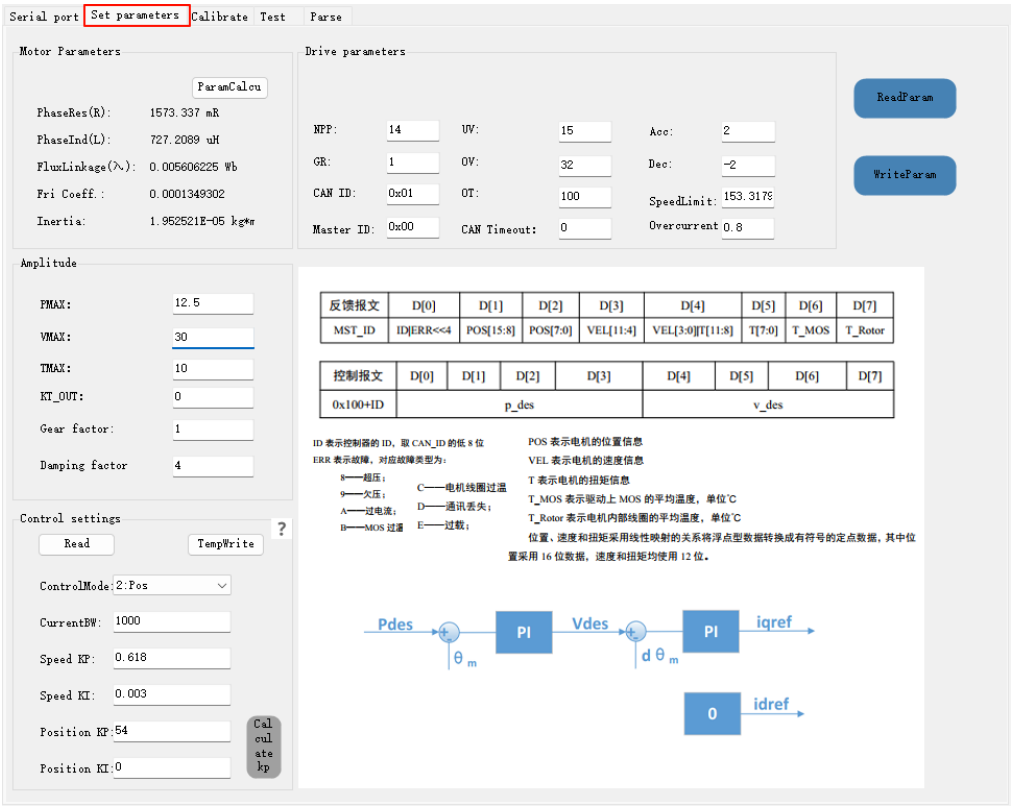


4.1.1.2 Set Parameters

The parameter settings interface includes motor parameters, control amplitudes, control settings, drive parameters, and others.

1. Motor Parameters: Calibrate parameters such as motor phase resistance and inductance;
2. Control Amplitudes: Set amplitude parameters for position, speed, and torque;
3. Control Settings: Modify motor control modes, current bandwidth, and KP, KI values for speed and position, etc. Parameters written with "Temporary" will not be saved after the motor power is turned off ("Temporary" cannot modify motor control modes);
4. Drive Parameters: Modify drive parameters such as pole pairs, reduction ratio, CAN ID, Master ID, voltage, current, temperature, and speed;
5. Others: Buttons for reading and writing parameters and communication format instructions, etc.

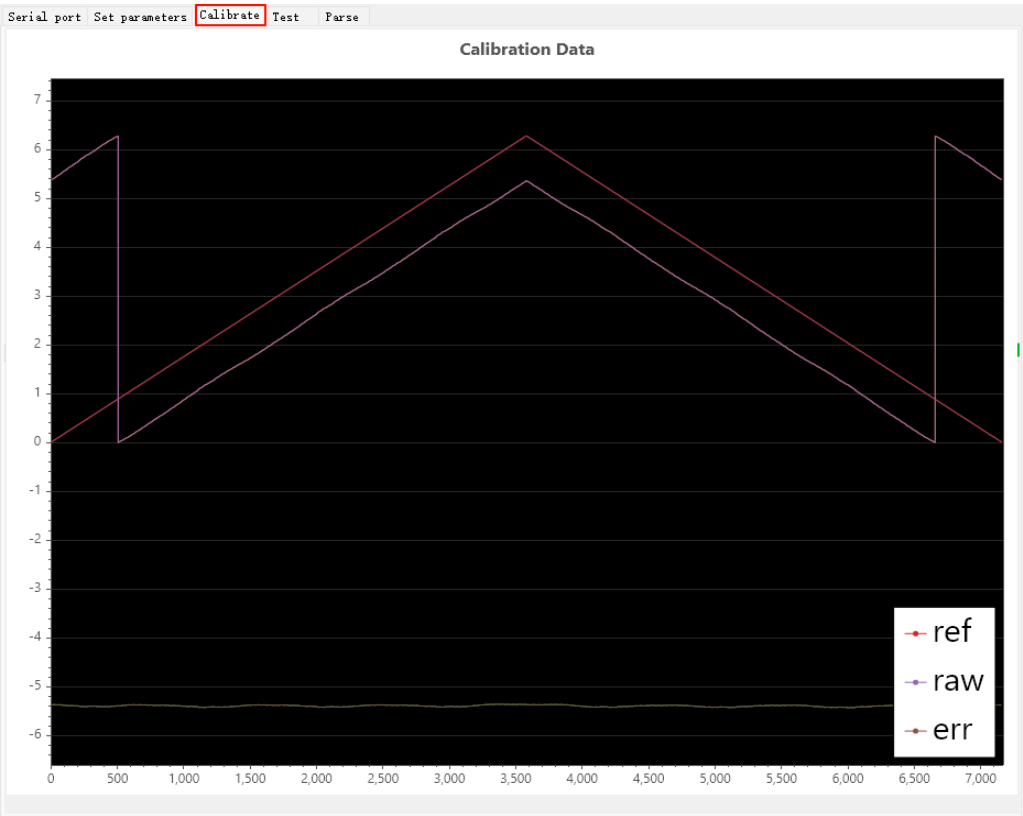
⚠： Please strictly follow the specified voltage, current, power, and temperature. Our company will not assume any legal responsibility for harm to the human body or irreversible damage to the drive board and motor caused by improper operation of this product.



⚠：After modifying the control amplitudes, click "Read Param" again.

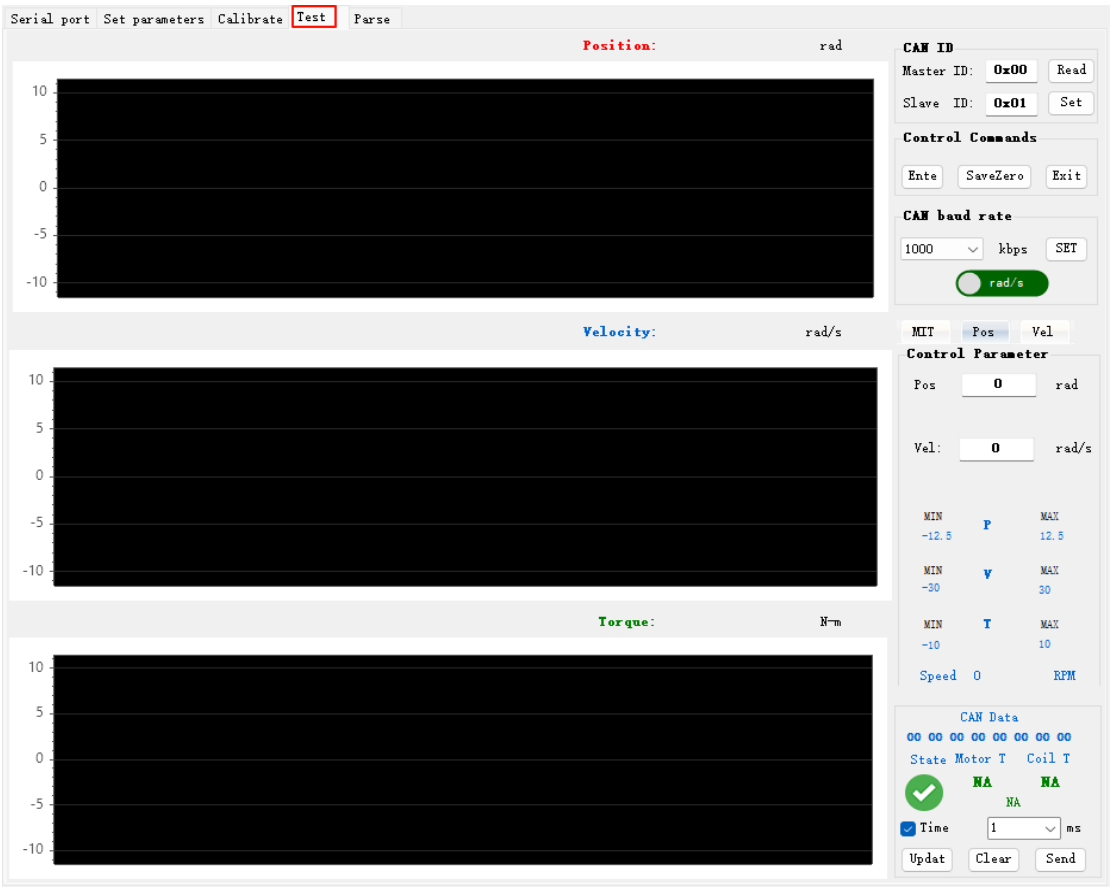
4.1.1.3Calibration

This page displays the calibration process waveform and progress.



4.1.1.4 Test

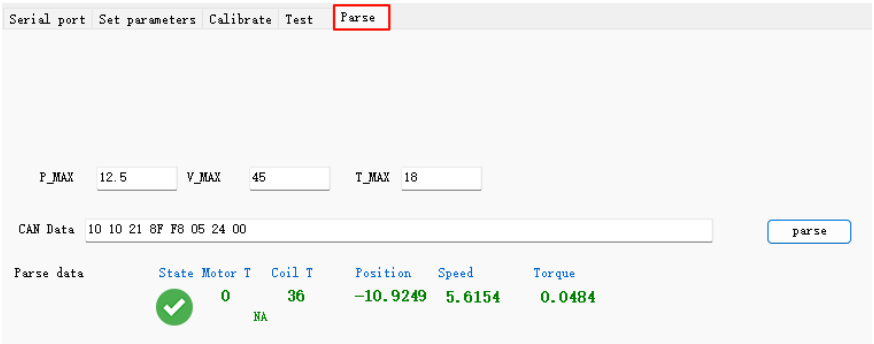
This page is mainly for setting CAN ID, baud rate, and modifying control parameters under MIT mode, position-velocity mode, and velocity mode for testing, and it displays real-time status information such as motor position, speed, torque, and temperature.



⚠: Please strictly follow the specified voltage, current, power, and temperature. Our company will not assume any legal responsibility for harm to the human body or irreversible damage to the drive board and motor caused by improper operation of this product.

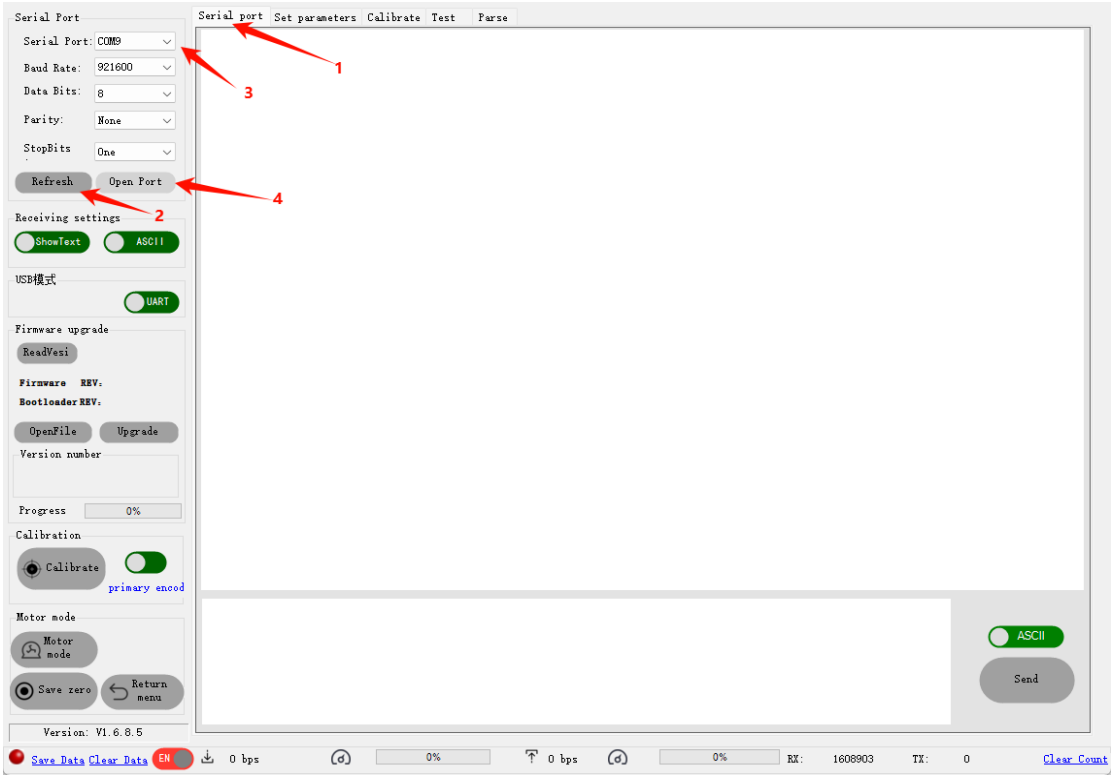
4.1.1.5 Parsing

This page can parse CAN feedback messages and convert CAN feedback messages into actual data by setting the range of position, velocity, and torque.

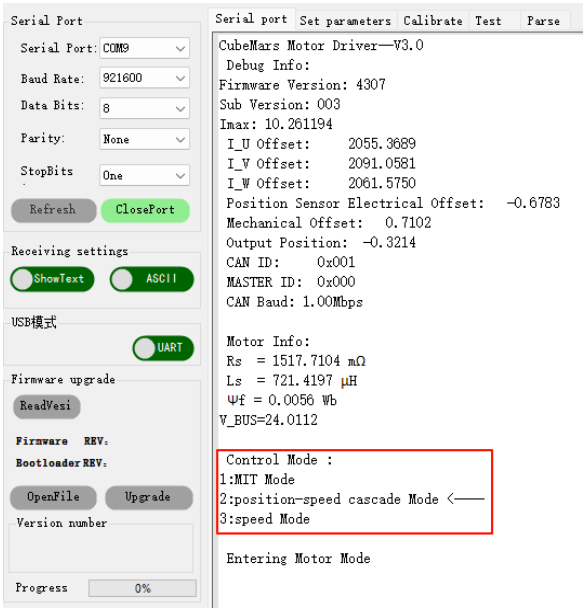


4.2Device Connection

Firstly, connect the motor's serial port, CAN port, and power interface. On the computer, open the upper computer software and select the corresponding serial port device to open the serial port.



At this point, power the motor (momentarily), and the serial port will print the following information. Control Mode: Indicates the current drive mode (the motor automatically enters this mode-enabled state after powering up). Different modes use different command formats (refer to Section 5 Driver Board Communication Protocol and Instructions).



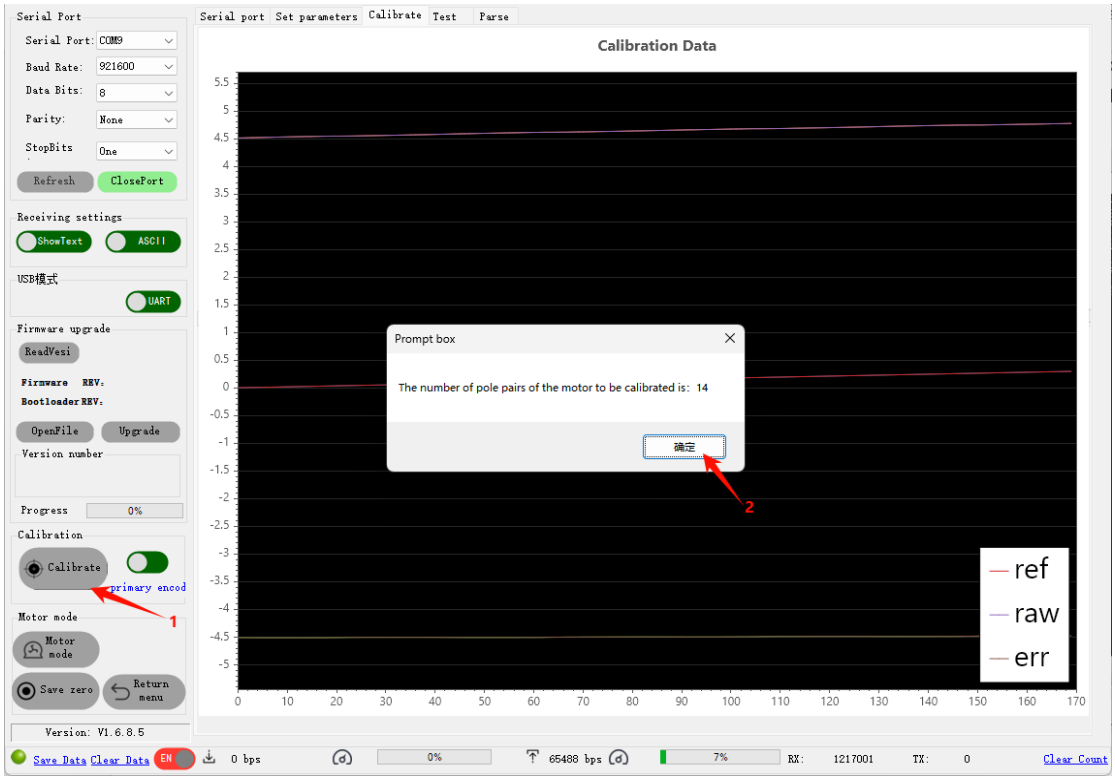
4.3Driver Board Calibration

Whenever you reinstall the driver board on the motor, change the wiring order of the motor's three-phase lines, or update the firmware, calibration must be performed. After calibration, the motor can be used normally; during the process, the motor will rotate forward and backward for one rotor cycle, so ensure the motor can rotate freely.

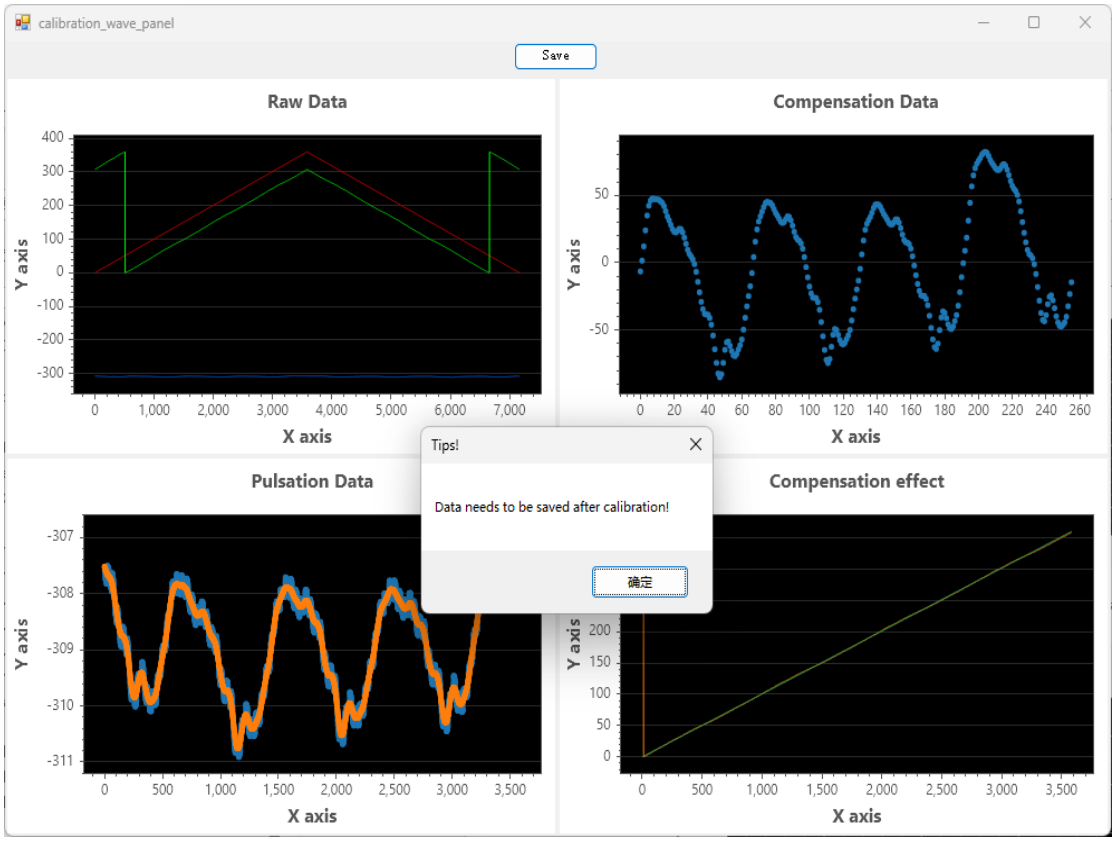
⚠：Ensure the motor runs unloaded, otherwise, calibration may fail.

（1）Sensor Calibration

Click Calibrate, the motor will rotate first, and after the rotation is completed, it will return the number of pole pairs to the upper computer. At the same time, the motor will rotate in both directions to calibrate the sensor data, with a calibration progress bar at the bottom of the interface.



After calibration is completed, a calibration effect diagram will automatically pop up.



（2）Calibration Data Review and Save

Pay special attention to the values of "Compensation Data compensation point cloud", which are

recommended not to exceed ±150. If they exceed 150, there may be several reasons:

① Incorrect identification of pole pairs;

② Excessive motor resistance, causing jamming;

③ Improper sensor installation.

If the above reasons are ruled out and the calibration value is still too high, please contact the manufacturer.

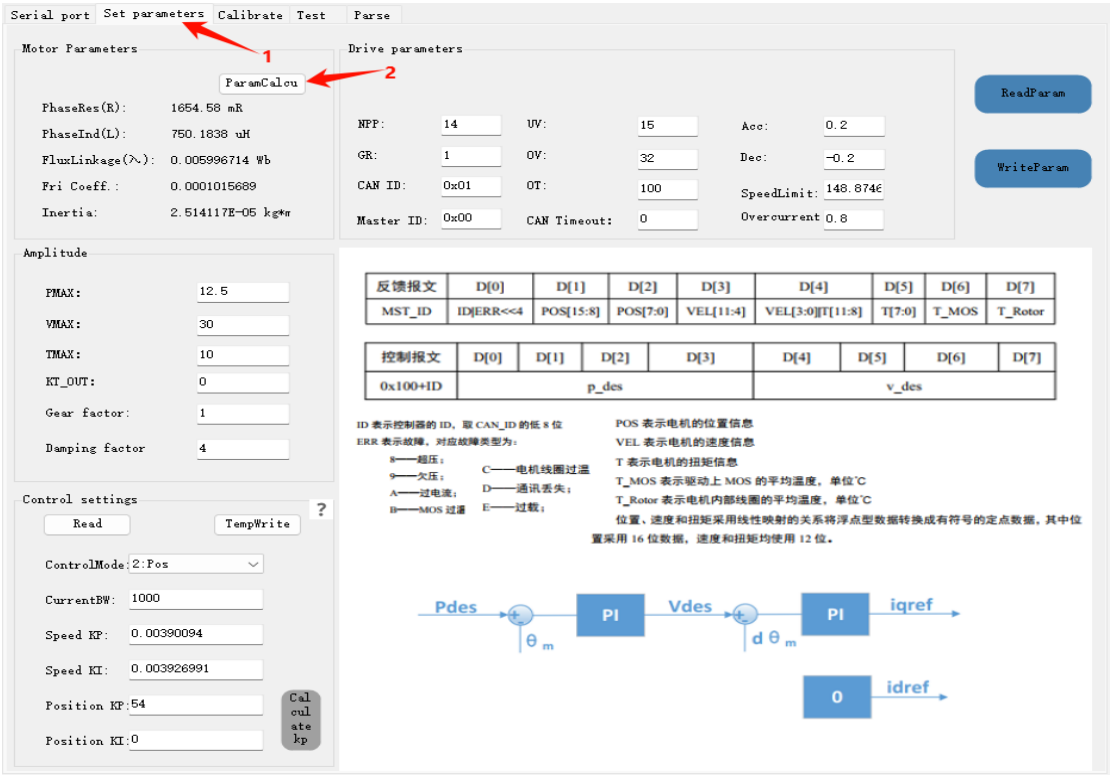
After the calibration data is verified to be correct, click "Save", and the upper computer will transmit the calibration data to the driver for storage.

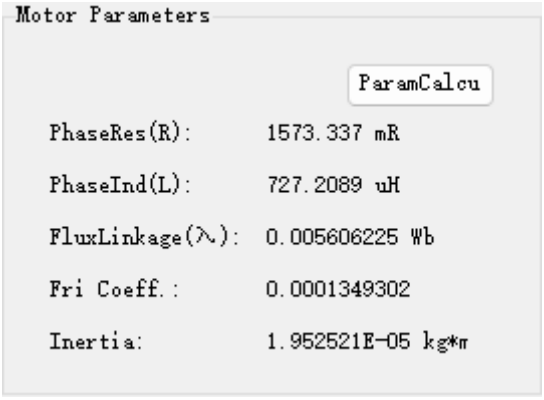
（3）Motor Parameter Identification

After calibration is completed, parameter identification can be performed, mainly identifying important parameters of the motor such as phase resistance, phase inductance, and magnetic flux.

Click on the "Set parameters" tab, then click the "Parameter Calcu" button, the driver will enter the identification step, during which the motor will rotate, and after identification is completed, the results will be automatically uploaded.

⚠：Keep the motor in an unloaded state and secured.





The viscosity coefficient is for reference only and can be calibrated multiple times.

⚠： The above parameters should not have negative values. If negative values appear, please confirm the motor status before recalibrating.

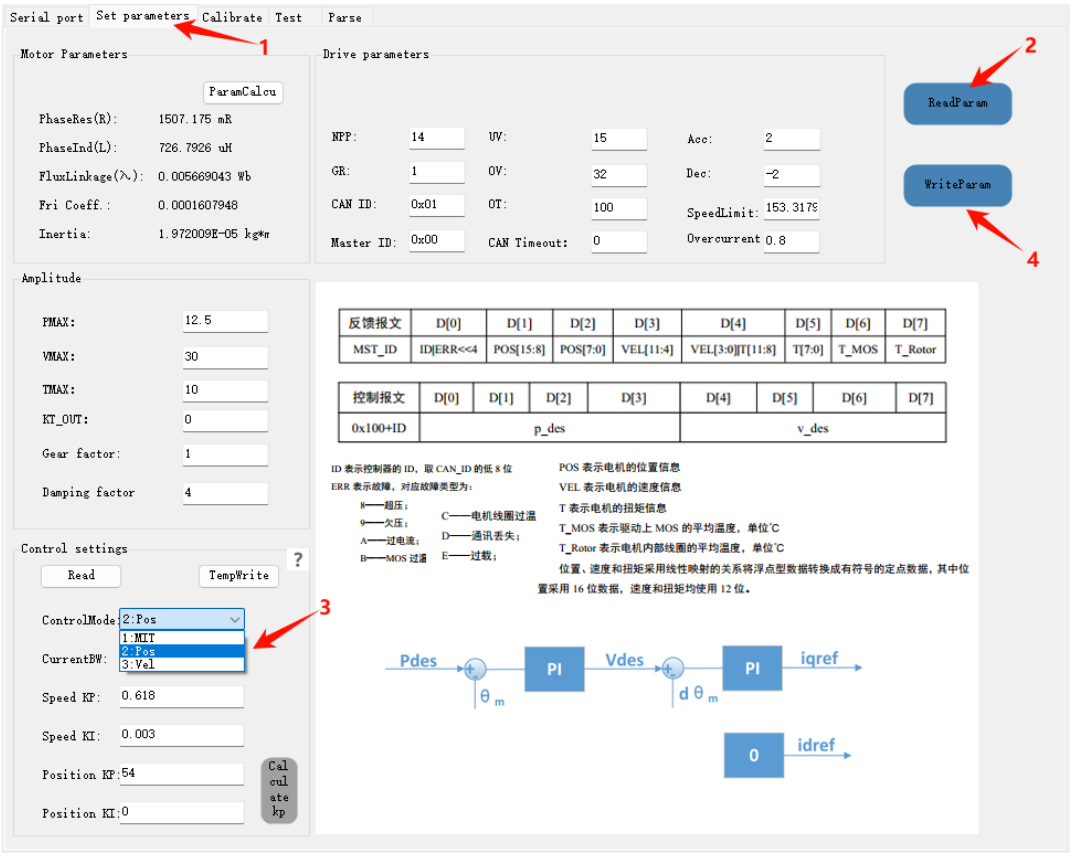
4.4 Control Demonstration

4.4.1 Control Mode Settings

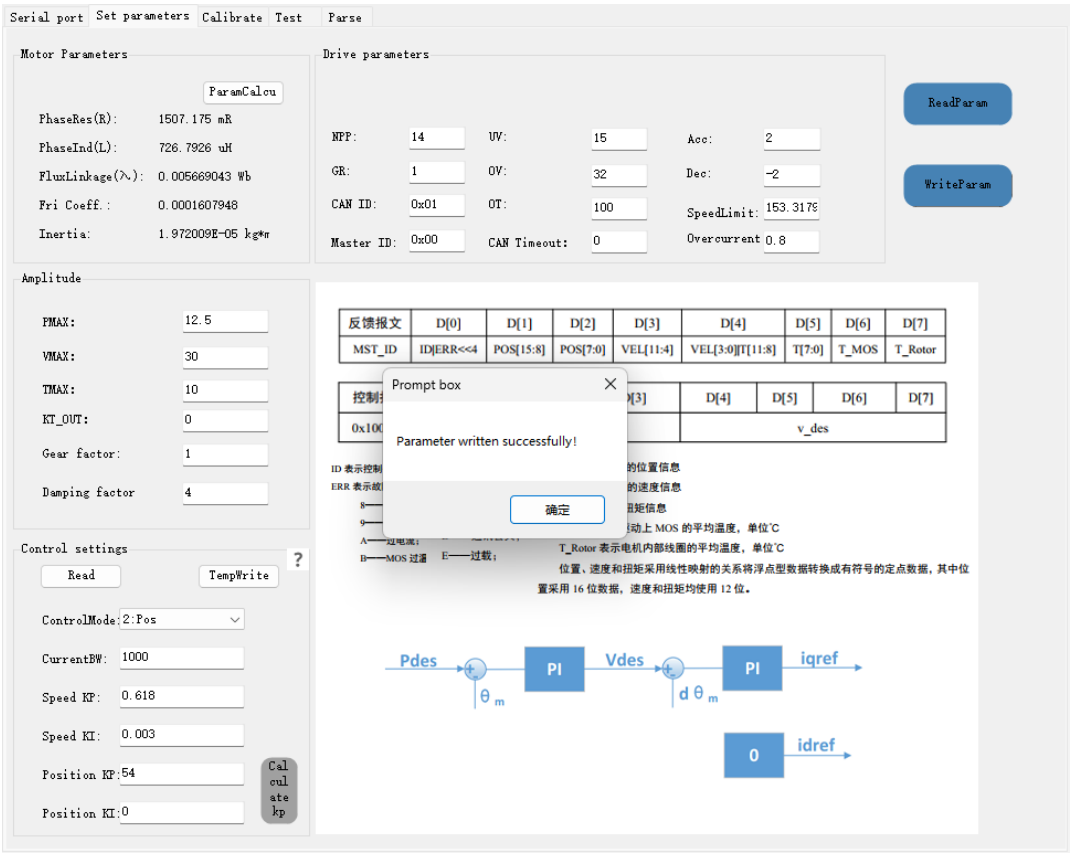
（1）Mode Settings

Confirm that the motor input power is stable, the S-link connection is normal, and after successfully connecting with the upper computer, click on "Set parameters" and "Read Parameters" in sequence, then click on "Control Mode" in the control settings to select MIT mode, speed-position mode, or velocity mode, and then click "Write Parameters" to set the control mode.

⚠： Note that even if you do not need to change the control mode, you must click "Read Parameters" after restarting the software before controlling.

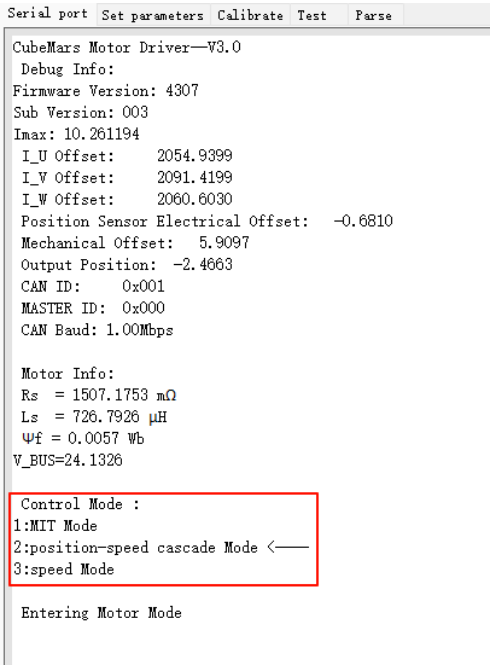


After modification, a prompt window will pop up: "Parameters written successfully!"



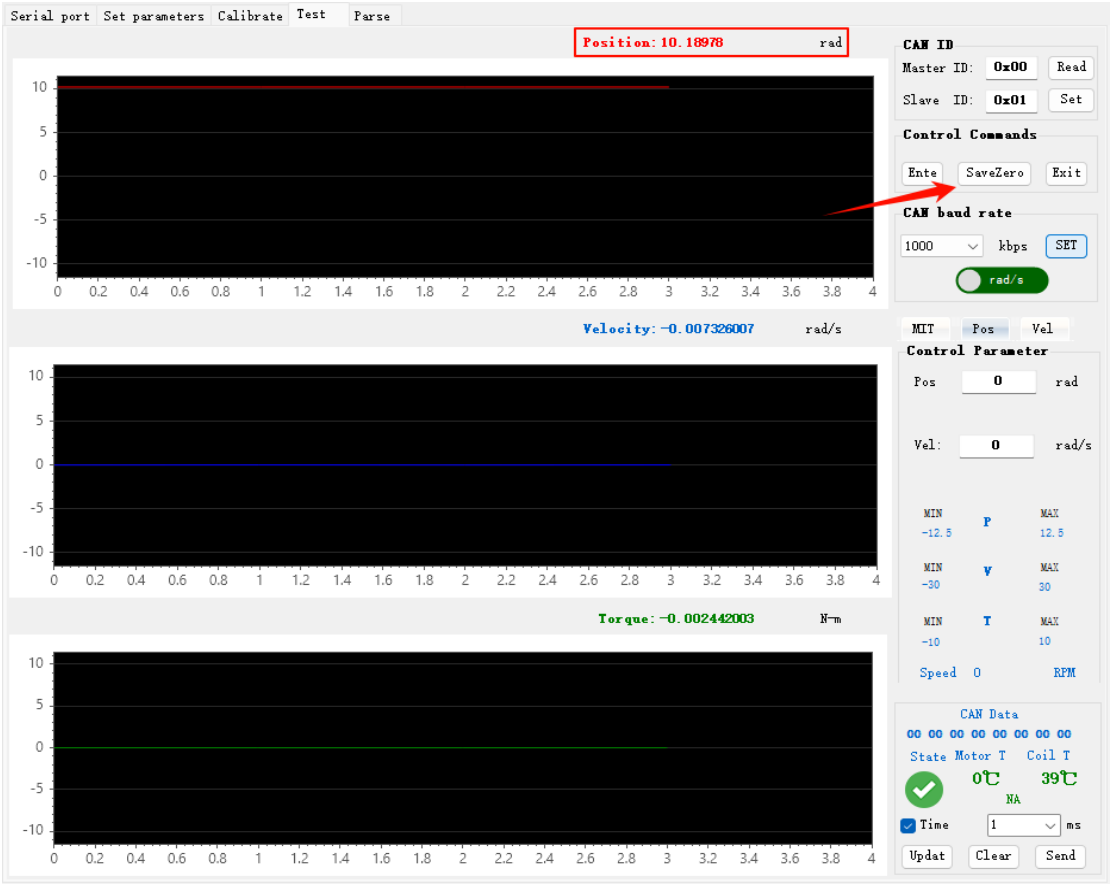
（2）Mode Check

After changing the control mode, power the drive again, The data printed through the serial port after powering on or the information displayed after re-reading the parameters on the parameter setting page indicates that the mode pointed to by the arrow is the current control mode of the driver.



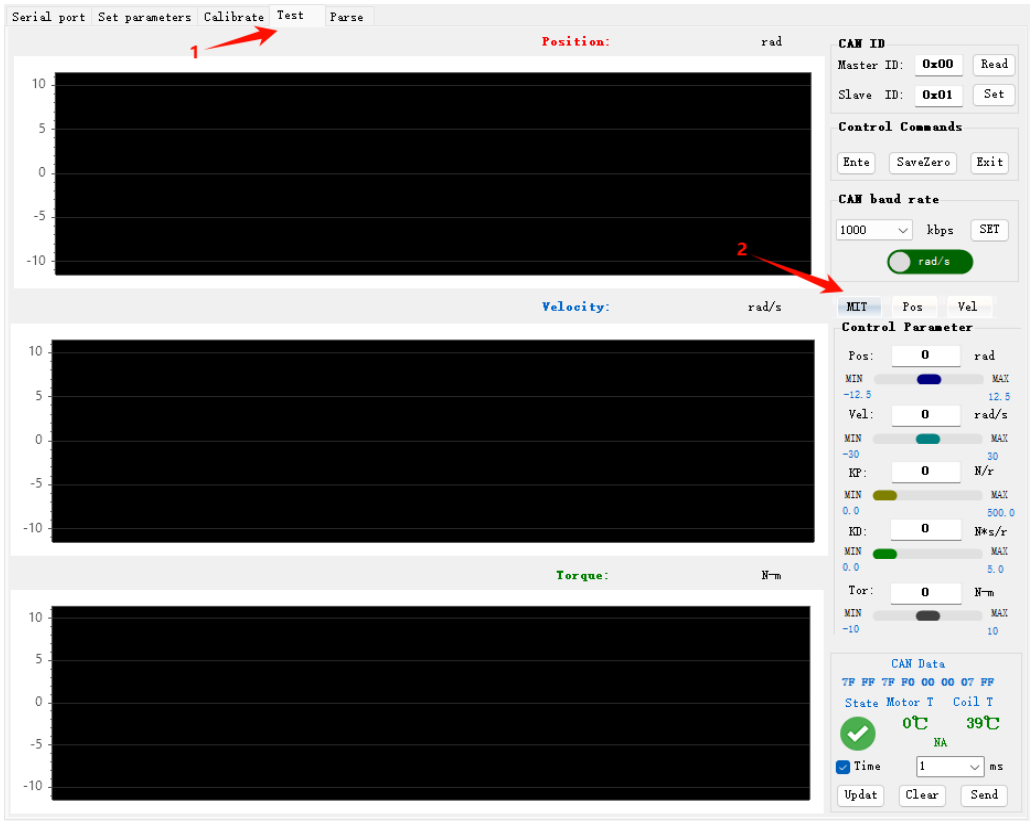
（3）Save Zero

In the "Test" page in the main window, click on "Save Zero" under the motor mode.

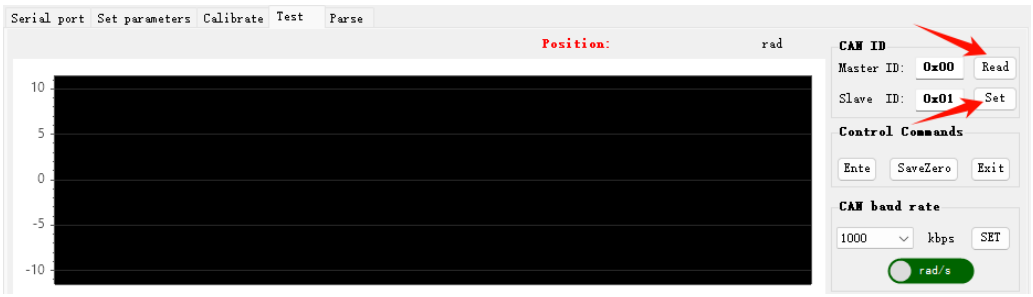


4.4.2 MIT Mode

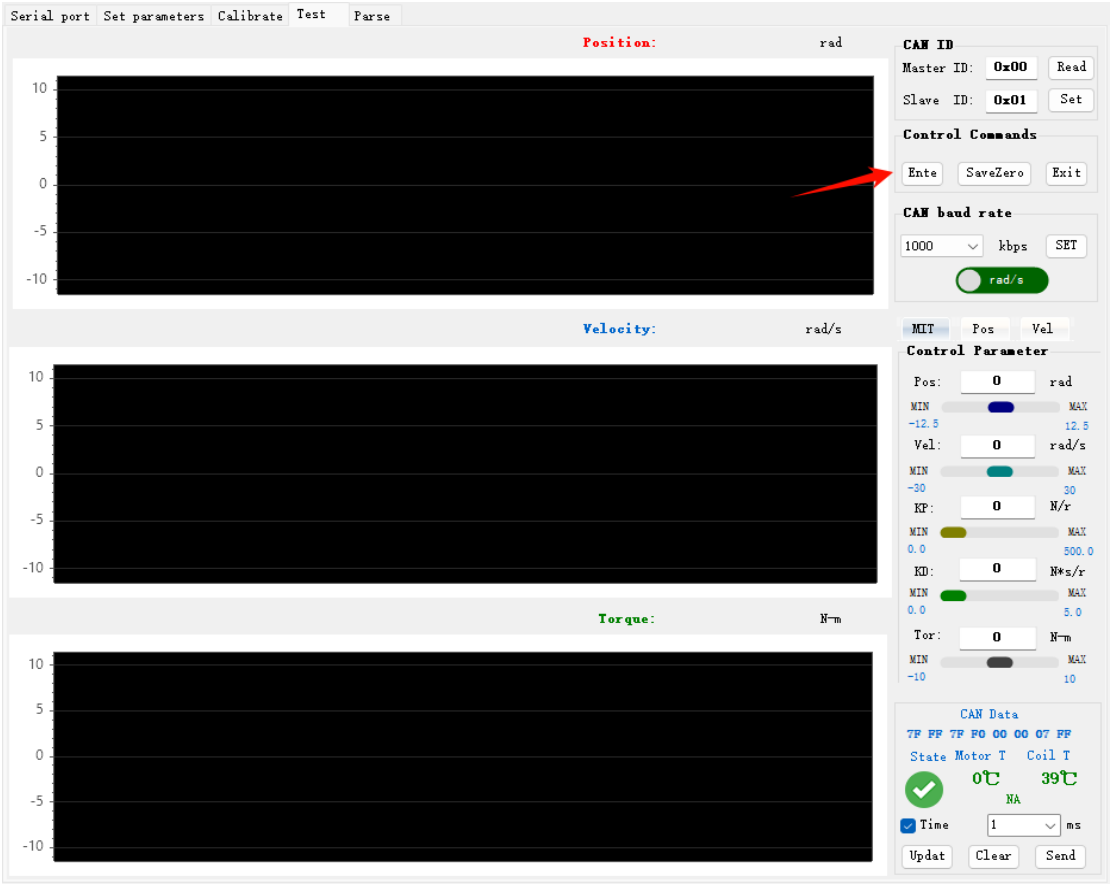
Set the motor control mode according to Section 4.4.1, confirm that the current control mode is MIT mode, and select the corresponding MIT sub-tab in the "Test" page.



Ensure the CAN ID is correct (which can be obtained through serial port print information or parameter setting page, or set through the read and set buttons on the Test page).



Click the "Ente" button in the motor mode bar (the motor defaults to the enabled state upon powering up). At this time, the driver’s green light will light up, indicating that the motor mode has been entered.

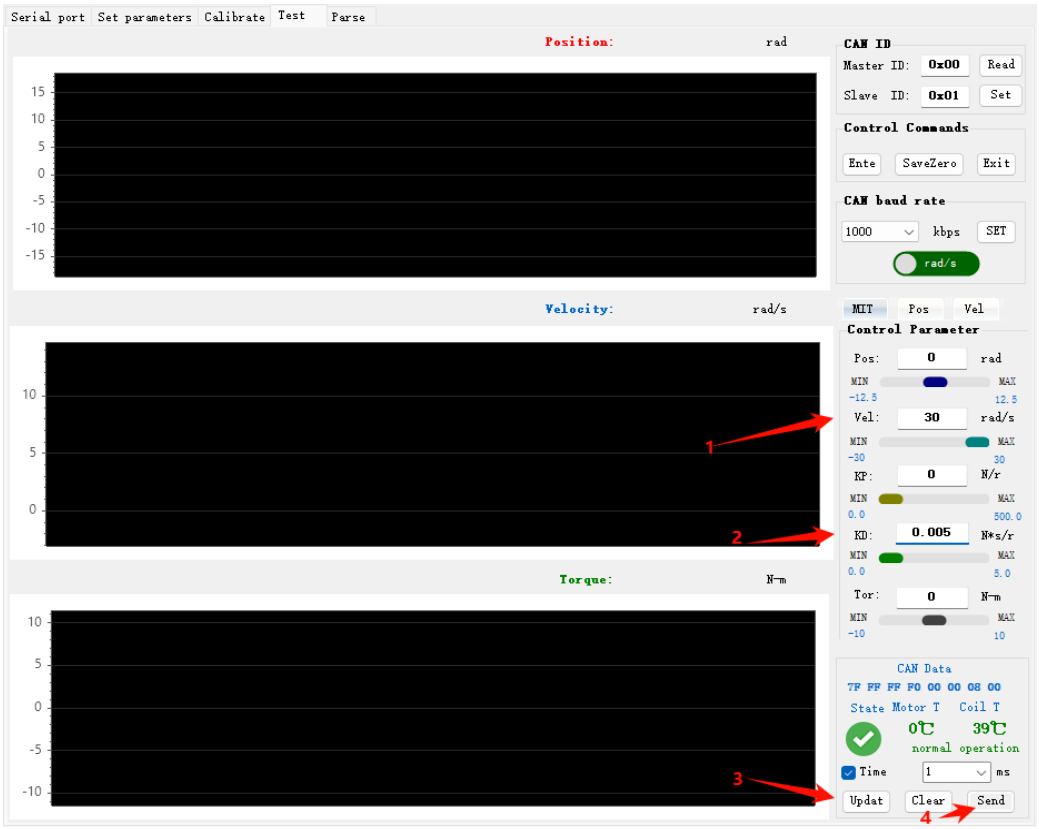


MIT mode has three control methods: velocity, position, and torque (for the three control modes, see 4.4.2.x)

4.4.2.1 Velocity Control

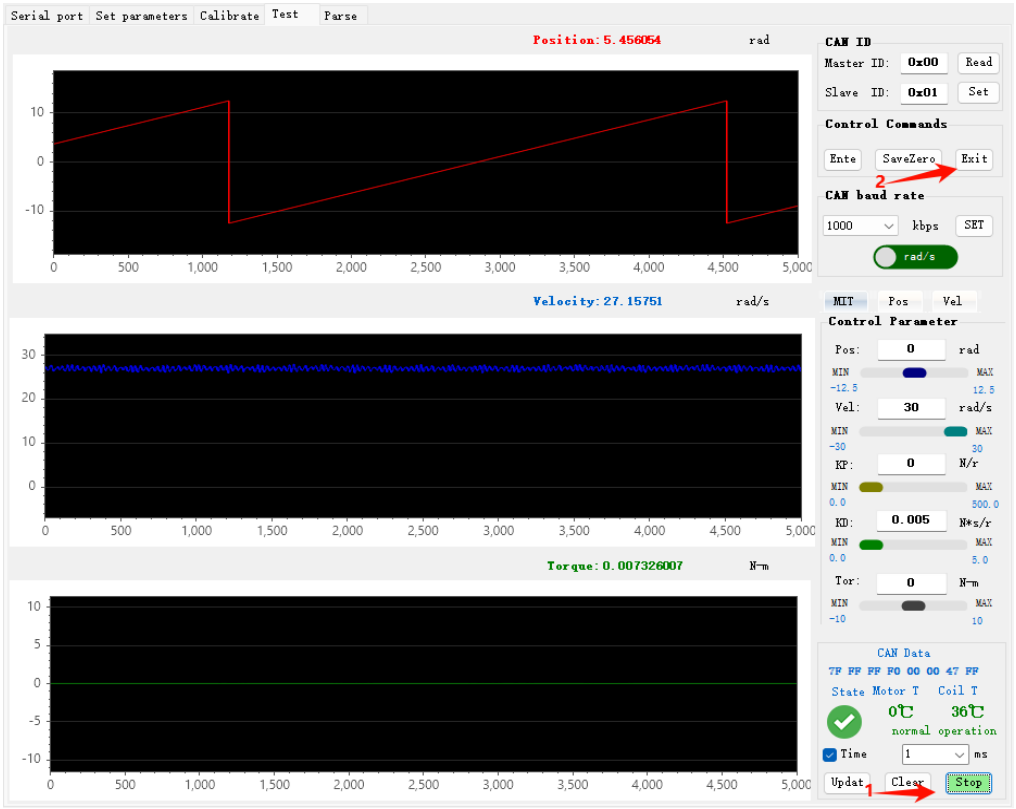
For example: In the "Control Parameters," set the speed to 30r/s, KD to 0.005N*s/r, and all others to 0, and check the "Timing Send" box, then click the "Update" button and the "Send" button in sequence, the motor will run at the desired speed, and you can view the parameter curve change graph on the Test interface.

⚠: Note to secure the motor.



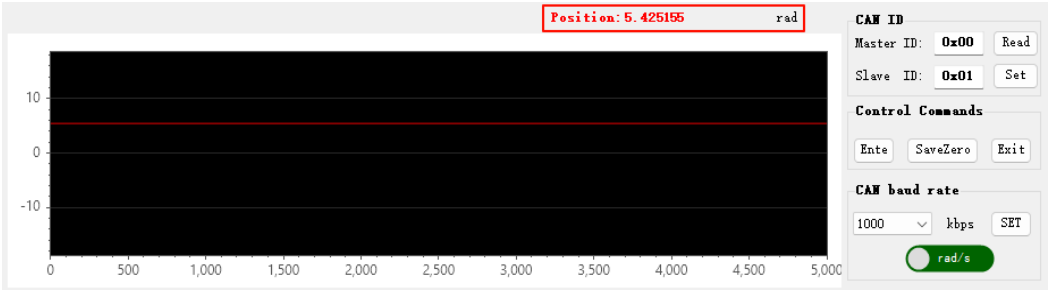
According to the test needs, if you need to modify the control parameters to see the changes during testing, directly modify the parameters on the original interface, and keep the "Timing Send" box checked, click the "Update" button to proceed.

To exit testing, click the "Stop" and "Exit" buttons in sequence. The red light on the driver will light up, indicating that the motor mode has been exited.



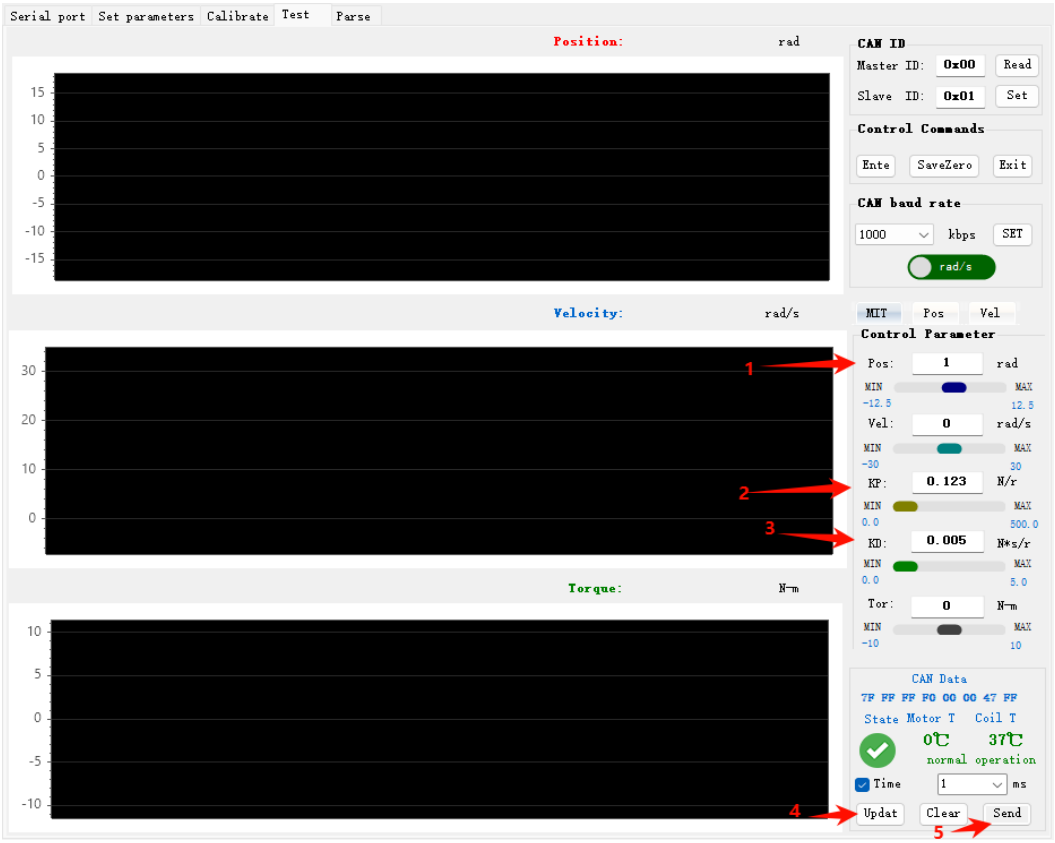
4.4.2.2 Position Control

Before setting the parameters, pay attention to the initial position of the motor, and use this as a reference to set the parameters.



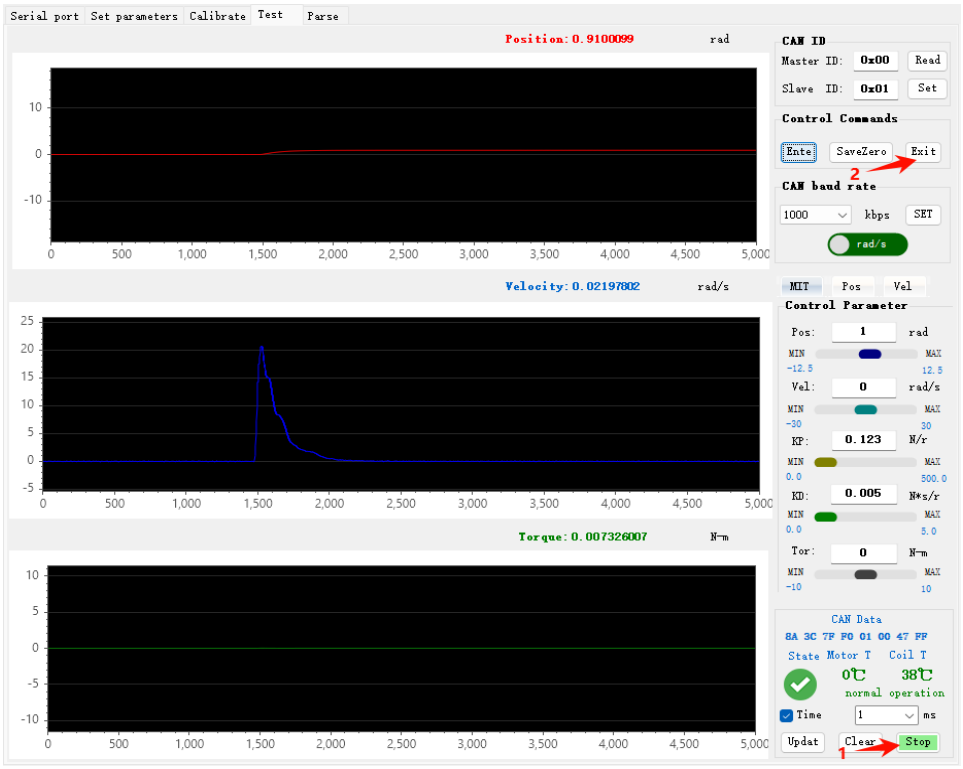
In the "Control Parameters," set the position to rotate the motor to a specified position, for example: In the "Control Parameters," set the position to 1rad, KP to 0.123N/r, KD to 0.005N*s/r, and all others to 0, and check the "Timing Send" box, then click the "Update" button and the "Send" button in sequence, you can view the parameter curve change graph on the test interface.

⚠： Pay attention to the motor's initial position, when setting the "Position" parameter in the control parameters column, avoid a large gap from the initial position to cause motor impact. Note to secure the motor.



According to the testing needs, if you need to modify the control parameters to see the changes during testing, directly modify the parameters on the original interface, and keep the "Timing Send" box checked, click the "Update" button to proceed.

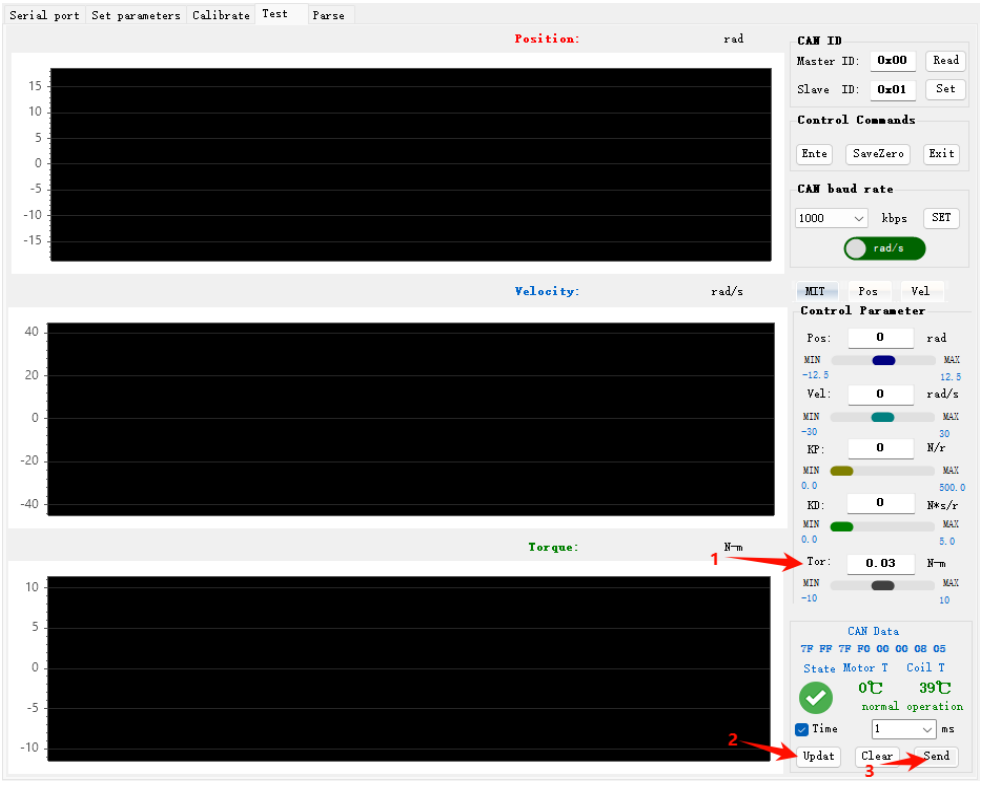
To exit testing, click the "Stop" and "Exit" buttons in sequence. The red light on the driver will light up, indicating that the motor mode has been exited.



4.4.2.3 Torque Control

Set the desired torque in the "Control Parameters," for example: set the torque to 0.03N-m in the "Control Parameters," set all other parameters to 0, and check the "Timing Send" box. Click the "Update" button and then the "Send" button to view the parameter curve change graph on the Test interface.

⚠：Ensure the motor is secured. Under no-load conditions, even a small torque setting can cause the motor to accelerate to maximum speed.

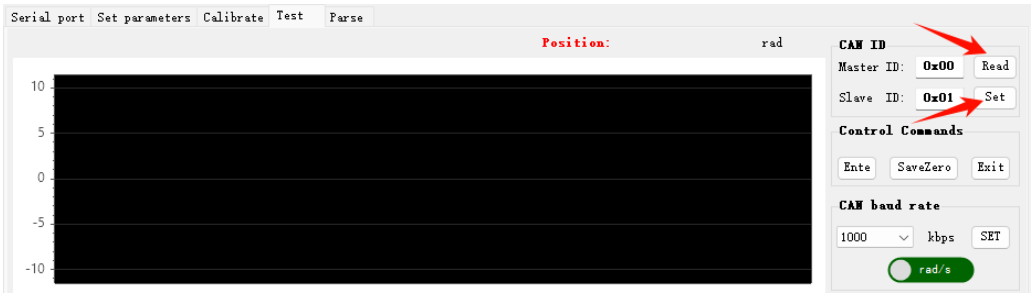


To exit testing, click the "Stop" and "Exit" buttons in sequence. The red light on the driver will light up, indicating that the motor mode has been exited.

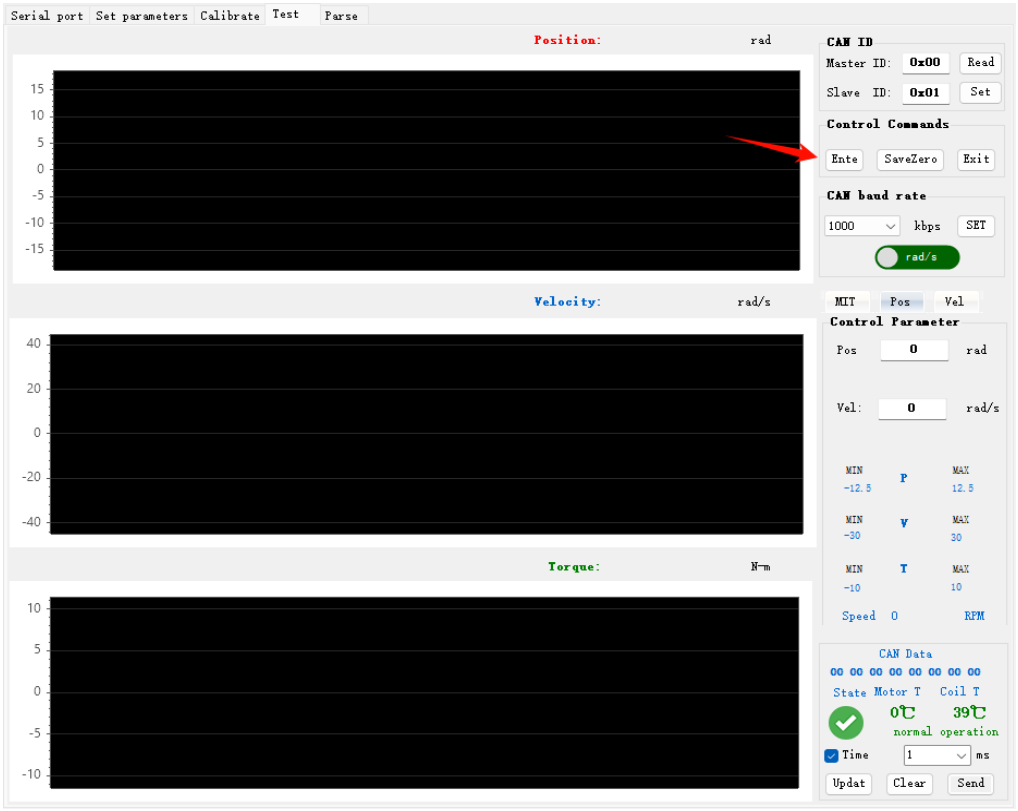
4.4.3 Position-Velocity Mode

Set the motor control mode according to Section 4.4.1, and confirm that the current control mode is the Position-Velocity mode. Select the corresponding "Position" sub-tab in the "Test" page.

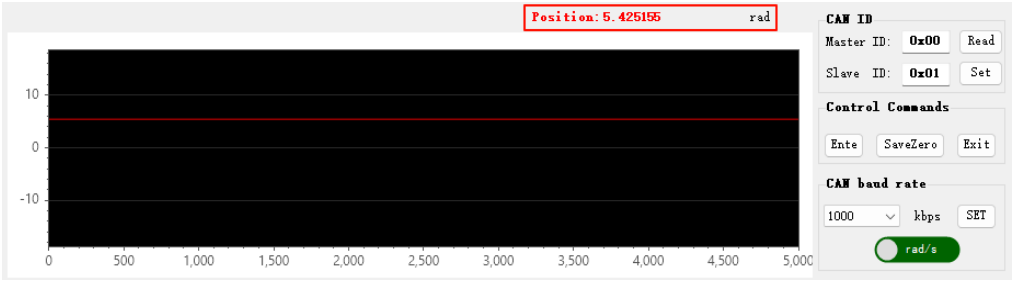
Ensure the CAN ID is correct (which can be obtained through serial port print information or the parameter setting page, or set through the read and set buttons on the test page).



Click the "Ente" button in the motor mode bar (the motor defaults to the enabled state upon powering up). At this time, the green light on the driver will indicate that the motor mode has been entered.

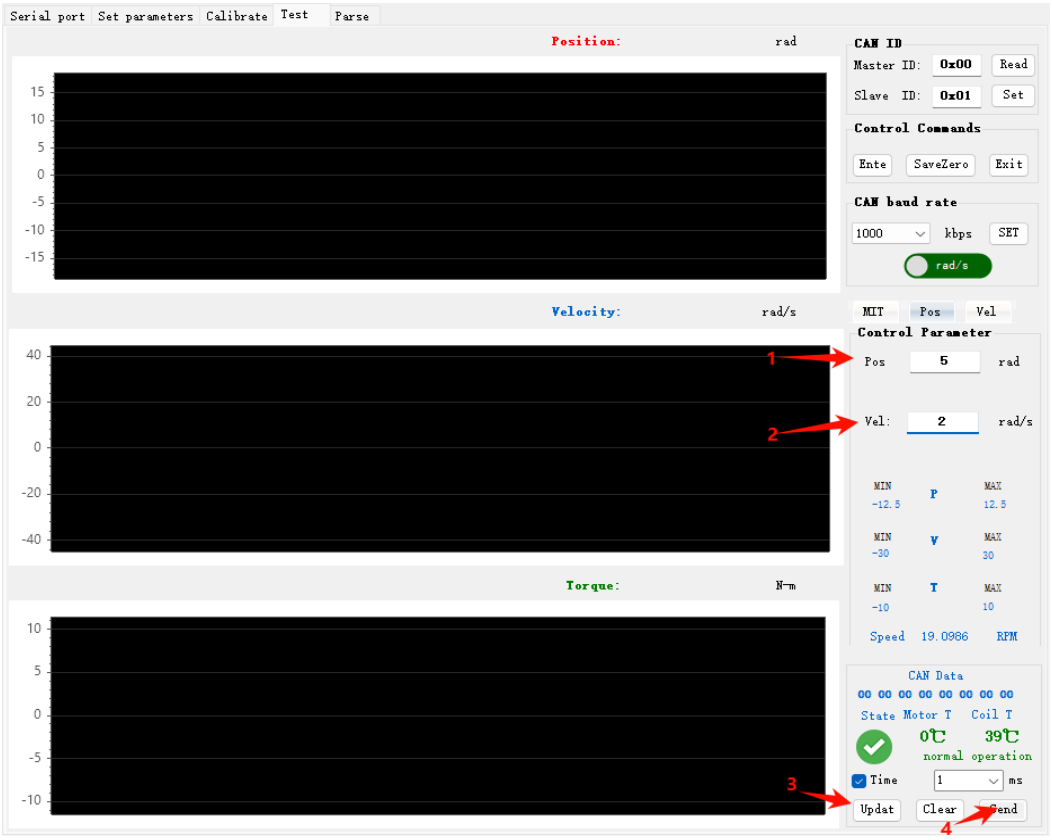


Before setting parameters, pay attention to the motor's initial position and use it as a reference for parameter settings

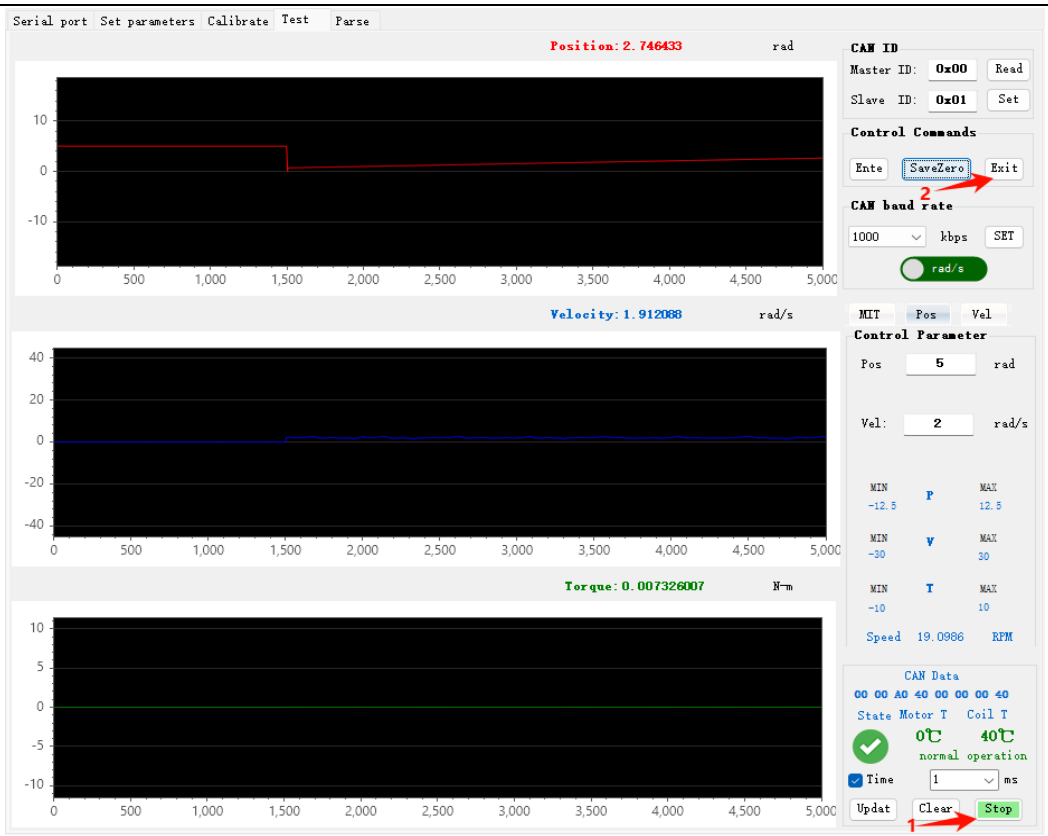


Set the desired speed to rotate to a specified position in the "Control Parameters," for example: set the position to 5rad and the speed to 2rad/s in the "Control Parameters." Check the "Timing Send" box, click the "Update" button, and then the "Send" button to view the parameter curve change graph on the test interface.

⚠: Ensure the motor is secured.



According to testig needs, if you need to modify control parameters to see changes during testing, directly modify the parameters on the original interface, keep the "Timing Send" box checked, and click the "Update" button to proceed.

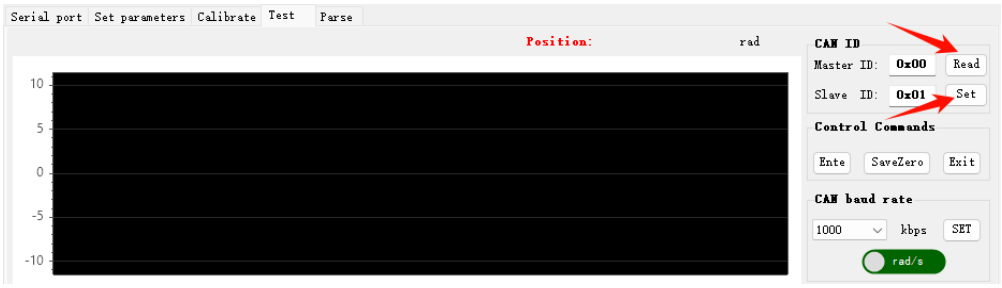


To exit testing, click the "Stop" and "Exit" buttons in sequence. The red light on the driver will light up, indicating that the motor mode has been exited.

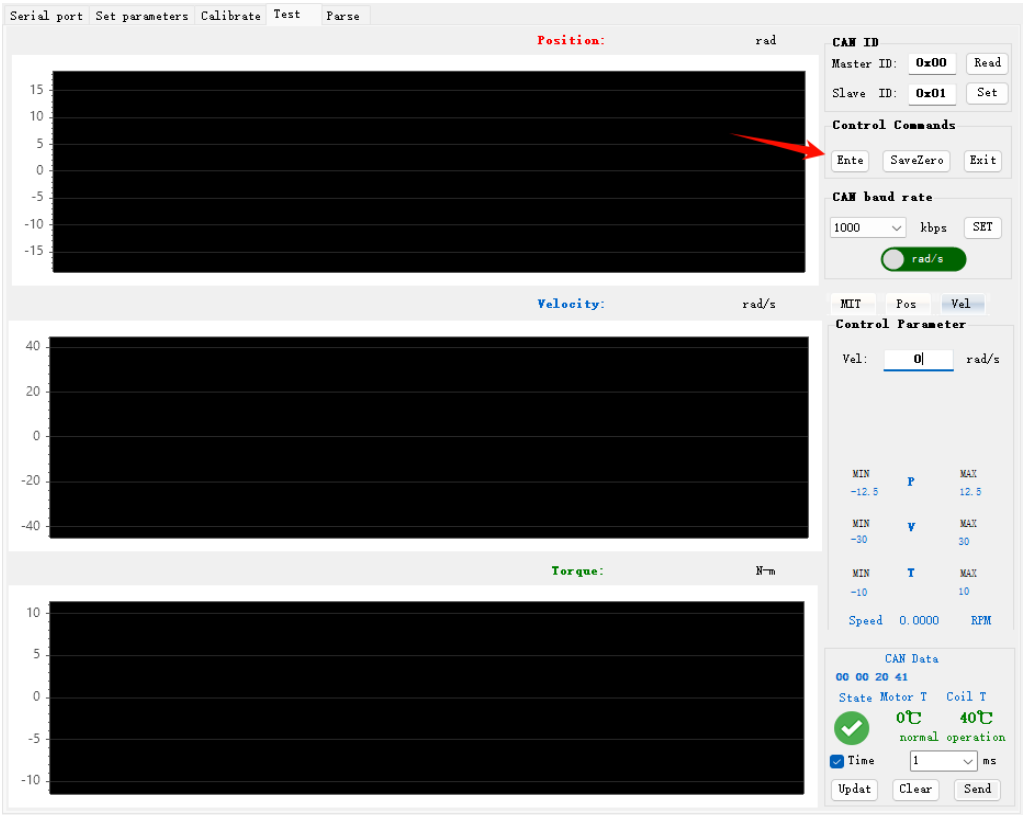
4.4.4 Velocity Mode

Set the motor control mode according to Section 4.4.1, and select the corresponding "Velocity" sub-tab in the debugging page.

Ensure the CAN ID is correct (which can be obtained through serial port print information or the parameter setting page, or set through the read and set buttons on the test page).

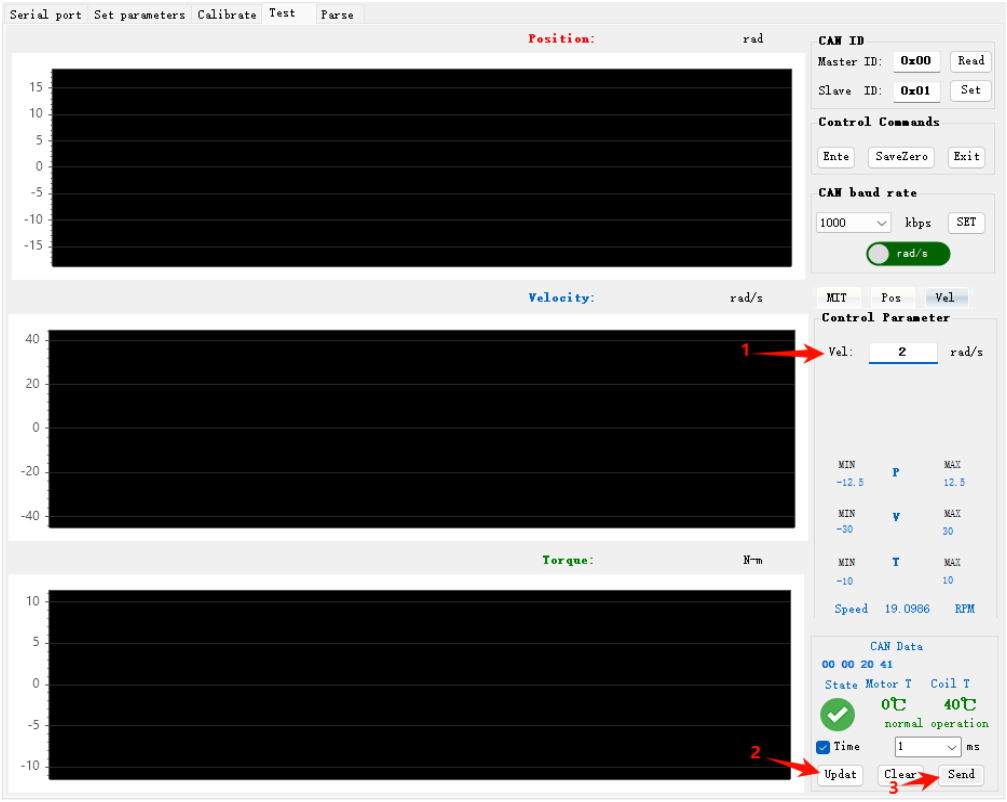


Confirm that the motor input power is stable, the S-link connection is normal, and the motor is in velocity mode. After successfully connecting with the upper computer, click the "Ente" button in the motor mode bar (the motor defaults to the enabled state upon powering up). At this time, the green light on the driver will indicate that the motor mode has been entered.



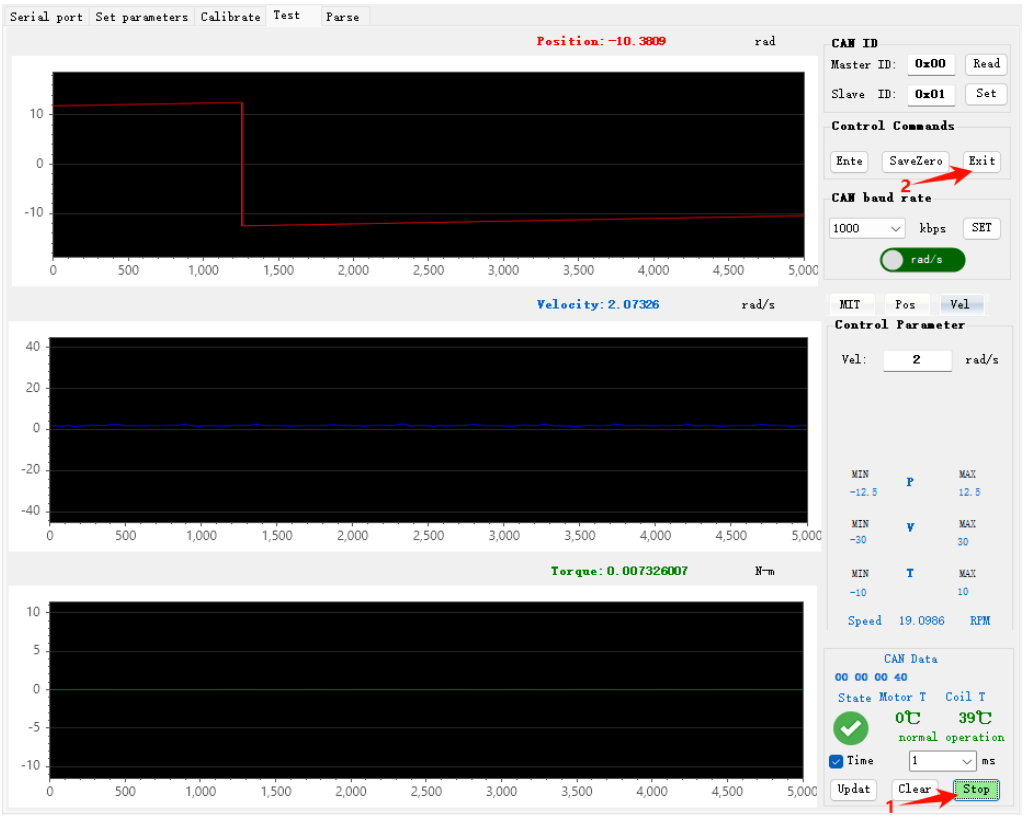
Set the desired speed in the "Control Parameters," for example: set the speed to 2rad/s in the "Control Parameters." Check the "Timing Send" box, click the "Update" button, and then the "Send" button to view the parameter curve change graph on the test interface.

⚠：Ensure the motor is secured.



According to testig needs, if you need to modify control parameters to see changes during testing, directly modify the parameters on the original interface, keep the "Timing Send" box checked, and click the "Update" button to proceed.

To exit testing, click the "Stop" and "Exit" buttons in sequence. The red light on the driver will light up, indicating that the motor mode has been exited.



4.4.5 PWM Mode

PWM pulse control allows input of a PWM signal with a frequency of 50Hz and pulse width range of 800-2200us. You can switch between velocity and position control modes in the upper computer control mode (refer to Section 4.4.1 for control mode settings).

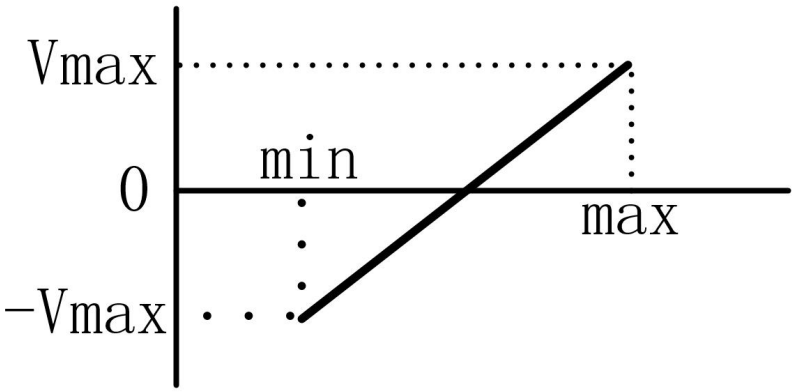
⚠: In cases where PWM and CAN coexist, CAN has the highest priority, meaning that only CAN control commands are received at this time, and PWM control is ignored.

4.4.5.1Motion Calibration

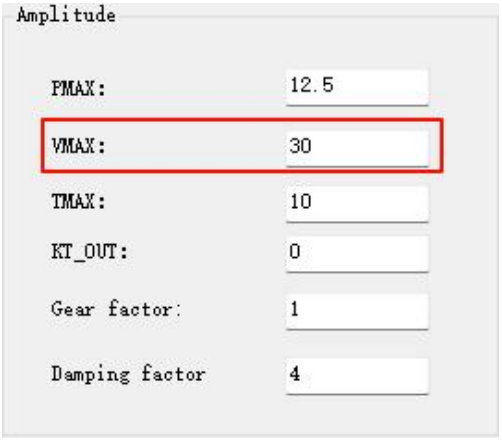
Confirm that the motor input power is stable, the PWM connection is normal, and before powering up, push the PWM input to the longest pulse width position. Then, a green light will indicate that the program has entered the PWM input calibration function, and within 3 seconds, sample the longest pulse width time. When the motor's red and green lights are off, it indicates that the long pulse width data collection is complete, and the process moves to the next stage. Within 2 seconds, please push the PWM input to the shortest pulse width position, and then the green light will come on again, indicating entry into low pulse width data collection. When the red and green lights are off again, it indicates that the long and short pulse width calibration is complete. After that, the driver will write the data into the driver, and the red light will flash for 5 seconds. Please center the PWM position during this time. After the red light flashing is complete, the driver will automatically restart, and the calibration will be complete.

4.4.5.1Velocity Control

Confirm that the motor input power is stable, the PWM connection is normal, and the motor is in velocity mode.

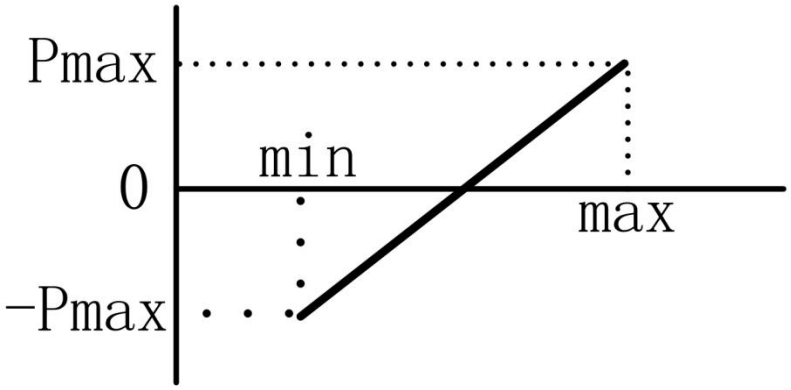


Vmax is the VMAX parameter set in the driver's control amplitude, Max is the maximum pulse width time of the input PWM, and Min is the minimum pulse width time of the input PWM.

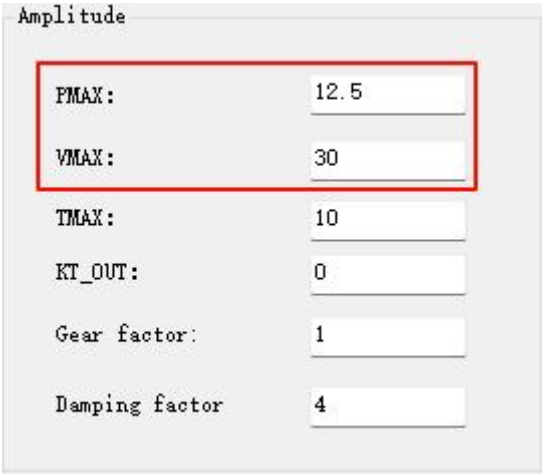


4.4.5.1 Position Control

Confirm that the motor input power is stable, the PWM connection is normal, and the motor is in position-velocity mode.

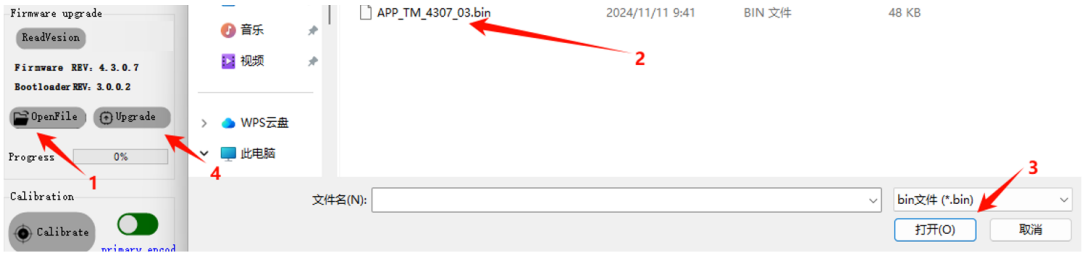


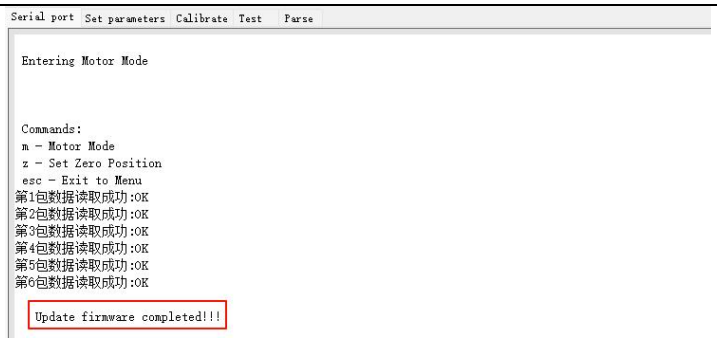
Pmax is the PMAX parameter set in the driver's control amplitude. In this mode, the speed is limited to VMAX, Max is the maximum pulse width time of the input PWM, and Min is the minimum pulse width time of the input PWM.



4.5 Firmware Upgrade

When there are new functions in the firmware or an upgraded version to solve bugs, users can upgrade through the serial port to resolve issues and use new functions. Before use, connect the serial port, then click on "Open File," choose the corresponding firmware, confirm, and then click on "Upgrade." Wait for the upgrade progress bar to complete, or observe whether the upgrade is complete through the serial port interface.





⚠： Please strictly follow the specified voltage, current, power, and temperature. Our company will not assume any legal responsibility for harm to the human body or irreversible damage to the drive board and motor caused by improper operation of this product.

5. Driver Board Communication Protocol and Description

The motor protocol is a CAN protocol, using a standard frame format with a fixed baud rate of 1Mbps. It can be divided into receive frames and feedback frames based on functionality. Receive frames are control data received for implementing command control of the motor; feedback frames are status data sent from the motor to the upper controller. Depending on the different modes selected for the motor, the receive frame format definition and frame ID vary, but the feedback frame is the same in all modes.

The standard frame format is below:

Can ID bits	[10]-[8]	[7]-[0]
Field name	Control mode	Source node ID

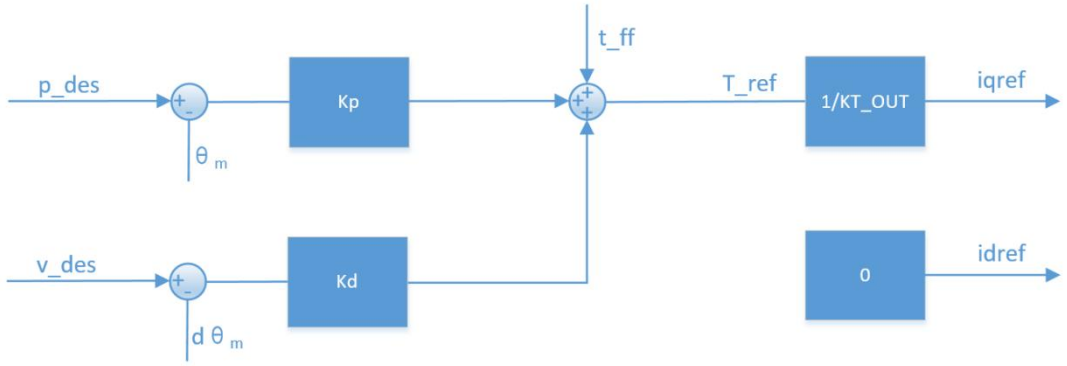
Control mode has{0,1,2} the three features corresponding to 3 control modes.
- MIT mode: 0;
- Position/Velocity mode: 1;
- Velocity mode: 2.

Universal CAN Commands

Commands	CAN Data Bits
Enter Motor Control Mode	0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF,0XFC
Exit Motor Control Mode	0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0XFD
Set Motor Current Position to Zero	0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0XFE
Clear Errors	0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0XFB

5.1 MIT Mode Control Mode and Description

The MIT mode can flexibly set control ranges (P_MAX, V_MAX, T_MAX). The driver converts received CAN data into control variables, calculates the torque value as the current setpoint for the current loop, and the current loop ultimately reaches the given torque current according to its adjustment rules. The control schematic is as follows.



Based on the MIT mode, various control modes can be derived. For example, when kp=0 and kd is not 0, giving v_des can achieve uniform rotation; when kp=0 and kd=0, giving t_ff can achieve a given torque output.

⚠: When controlling position, kd cannot be assigned 0, otherwise it will cause the motor to oscillate and even go out of control.

MIT Mode Data Transmission Definition:

Data Bit	Data[0]	Data[1]	Data[2]	Data[3]
Range	0~0xff	0~0xff	0~0xff	0~0xff
Corresponding Variable	Position bit 15-8	Position bit 7-0	Speed bit 11-4	Speed bit 3-0, Kp bit 11-8

Data Bit	Data[4]	Data[5]	Data[6]	Data[7]
Range	0~0xff	0~0xff	0~0xff	0~0xff
Corresponding Variable	Kp bit 7-0	Kd bit 11-4	Kd bit 3-0 t_ff 11-8 bit	t_ff 7-0 bit

Where:

- The position range of -12.5 to 12.5 represents -12.5 to 12.5 radians;
- The speed range of -200 to 200 represents -200 to 200 revolutions per second;
- The Kp range of 0 to 500 represents 0 to 500 Newtons per radian;

- The Kd range of 0 to 5 represents 0 to 5 Newton-seconds per radian;
- The t_ff range of -10 to 10 represents -10 to 10 Newton-meters.

```
void ctrl_motor(CAN_HandleTypeDef* hcan,uint16_t id, float _pos, float _vel, float _KP, float _KD, float _torq){
    uint16_t pos_tmp,vel_tmp,kp_tmp,kd_tmp,tor_tmp;
    pos_tmp = float_to_uint(_pos, P_MIN, P_MAX, 16);
    vel_tmp = float_to_uint(_vel, V_MIN, V_MAX, 12);
    kp_tmp    = float_to_uint(_KP, KP_MIN, KP_MAX, 12);
    kd_tmp    = float_to_uint(_KD, KD_MIN, KD_MAX, 12);
    tor_tmp = float_to_uint(_torq, T_MIN, T_MAX, 12);

    hcan->pTxMsg->StdId = id;
    hcan->pTxMsg->IDE = CAN_ID_STD;
    hcan->pTxMsg->RTR = CAN_RTR_DATA;
    hcan->pTxMsg->DLC = 0x08;
    hcan->pTxMsg->Data[0] = (pos_tmp >> 8);
    hcan->pTxMsg->Data[1] = pos_tmp;
    hcan->pTxMsg->Data[2] = (vel_tmp >> 4);
    hcan->pTxMsg->Data[3] = ((vel_tmp&0xF)<<4)|(kp_tmp>>8);
    hcan->pTxMsg->Data[4] = kp_tmp;
    hcan->pTxMsg->Data[5] = (kd_tmp >> 4);
    hcan->pTxMsg->Data[6] = ((kd_tmp&0xF)<<4)|(tor_tmp>>8);
    hcan->pTxMsg->Data[7] = tor_tmp;

    HAL_CAN_Transmit(hcan, 100);
}
```

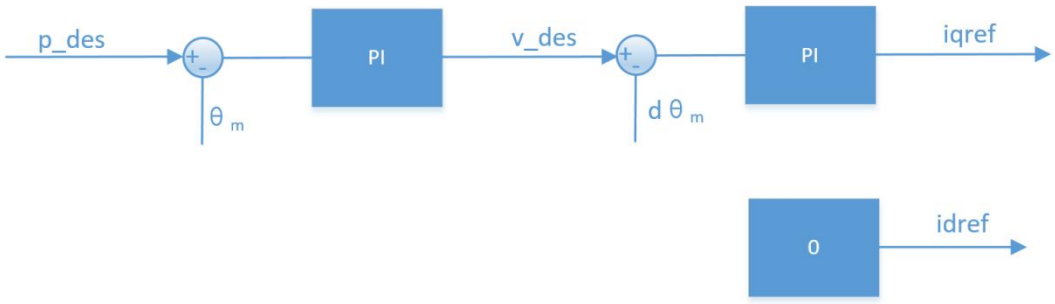
When sending packets, all numerical values must be converted to integer numbers using the following function before being sent to the motor.

```
int float_to_uint(float x, float x_min, float x_max, unsigned int bits){
/// Converts a float to an unsigned int, given range and number of bits ///
    float span = x_max - x_min;
    if(x < x_min) x = x_min;
    else if(x > x_max) x = x_max;
    return (int) ((x- x_min)*((float)((1<<bits)/span)));
}
```

The conversion function requires determining the maximum and minimum values for proportional conversion, which are queried on the parameter setting page. The default maximum and minimum values for KP and KD are 0.0 to 500.0 and 0.0 to 5.0, respectively. Pos, Vel, and Torque are preset to ±12.5, ±200, and ±10, respectively, and these three parameters can be adjusted according to the actual parameters of the motor. When sending control commands, it is essential to maintain consistency with the set values.

5.2 Position/Velocity Mode Control Mode and Description

The position cascade mode is a control mode that uses three cascaded loops. The position loop serves as the outermost loop, and its output serves as the setpoint for the velocity loop, while the output of the speed loop serves as the setpoint for the innermost current loop, which controls the actual current output. The control schematic is shown in the following figure:



p_des is the target position for control.v_des is used to limit the maximum absolute speed during motion.

If controlled with the recommended control parameters, the position-velocity mode can achieve good control precision with a relatively smooth control process, but the response time is relatively long. In addition to v_des other configurable parameters include acceleration/deceleration, which can be adjusted to reduce additional oscillations during the control process.

⚠：The units for p_des and v_des are rad and rad/s , and the data type is float. The damping factor must be set to a non-zero positive number, refer to the notes for the speed mode.

Position/velocity Mode Data Transmission Definition ：

Data Bit	Data[0]	Data[1]	Data[2]	Data[3]	Data[4]	Data[5]	Data[6]	Data[7]
Range	0~0xff	0~0xff	0~0xff	0~0xff	0~0xff	0~0xff	0~0xff	0~0xff
Corresponding Variable	Position bit 7-0	Position bit 15-8	Position bit 23-16	Position bit 31-24	Speed bit 7-0	Speed bit 15-8	Speed bit 23-16	Speed bit 31-24

Where:

- The position is of float type, and the range -12.5 to 12.5 represents -12.5 to 12.5 rad;
- The speed is of float type, and the range -200 to 200 represents -200 to 200 rad/s.

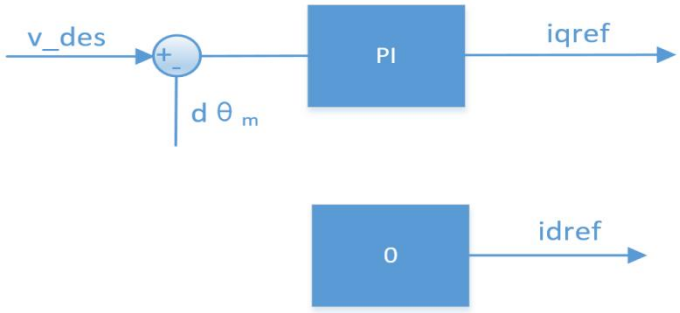
```
void ctrl_motor2(CAN_HandleTypeDef* hcan,uint16_t id, float _pos, float _vel){
    uint8_t *pbuf,*vbuf;
    pbuf=(uint8_t*)&_pos;
    vbuf=(uint8_t*)&_vel;

    hcan->pTxMsg->StdId = id;
    hcan->pTxMsg->IDE = CAN_ID_STD;
    hcan->pTxMsg->RTR = CAN_RTR_DATA;
    hcan->pTxMsg->DLC = 0x08;
    hcan->pTxMsg->Data[0] = *pbuf;
    hcan->pTxMsg->Data[1] = *(pbuf+1);
    hcan->pTxMsg->Data[2] = *(pbuf+2);
    hcan->pTxMsg->Data[3] = *(pbuf+3);
    hcan->pTxMsg->Data[4] = *vbuf;
    hcan->pTxMsg->Data[5] = *(vbuf+1);
    hcan->pTxMsg->Data[6] = *(vbuf+2);
    hcan->pTxMsg->Data[7] = *(vbuf+3);

    HAL_CAN_Transmit(hcan, 100);
}
```

5.3 Velocity Mode Control Mode and Description

The velocity mode allows the motor to operate stably at the set speed, with the control schematic diagram as follows:



⚠： v_des (rad/s), and the data type is float. If you want to use the upper computer to automatically calculate parameters, it is necessary to set the damping factor to a positive non-zero number. Typically, the value ranges from 2.0 to 10.0. A damping factor that is too small will cause speed oscillations and a large overshoot, while a damping factor that is too large will result in a longer rise time. The recommended setting value is 4.0.

Velocity Mode Data Transmission Definition:

Data Bit	Data[0]	Data[1]	Data[2]	Data[3]
Range	0~0xff	0~0xff	0~0xff	0~0xff
Corresponding Variable	Speed bit 7-0	Speed bit 15-8	Speed bit 23-16	Speed bit 31-24

Where: The speed is of float type, and the range -200 to 200 represents -200 to 200 r/s.

```
void ctrl_motor3(CAN_HandleTypeDef* hcan,uint16_t id, float _vel){
    uint8_t *vbuf;
    vbuf=(uint8_t*)&_vel;

    hcan->pTxMsg->StdId = id;
    hcan->pTxMsg->IDE = CAN_ID_STD;
    hcan->pTxMsg->RTR = CAN_RTR_DATA;
    hcan->pTxMsg->DLC = 0x04;
    hcan->pTxMsg->Data[0] = *vbuf;
    hcan->pTxMsg->Data[1] = *(vbuf+1);
    hcan->pTxMsg->Data[2] = *(vbuf+2);
    hcan->pTxMsg->Data[3] = *(vbuf+3);

    HAL_CAN_Transmit(hcan, 100);
}
```

5.4 CAN Feedback Message Protocol

The feedback frame ID is set by the upper computer (Master ID) and default is 0. It primarily provides feedback on the motor's position, speed, and torque information. The frame format is defined as follows:

Data Bit	Data[0]	Data[1]	Data[2]	Data[3]
Range	0~0xff	0~0xff	0~0xff	0~0xff
Corresponding Variable	ERR 7-4bits CAN ID 3-0bits	Position bits 15-8	Position bits 7-0	Position bits 11-4

Data Bit	Data[4]	Data[5]	Data[6]	Data[7]
Range	0~0xff	0~0xff	0~0xff	0~0xff
Corresponding Variable	Speed bits 3-0 Torque bits 11-8	Torque bits 7-0	Drive temperature bits 7-0	Motor temperature bits 7-0

Where:

ID is of int8 type, taking the lower 8 bits of CAN_ID;

ERR is of int8 type, with corresponding codes as follows:

0 — Disable;
1 — Enable;
8 — Over-voltage;
9 — Under-voltage;
A — Over-current;
B — MOS over-temperature;
C — Motor winding over-temperature;
D — Communication loss;
E — Overload.

The range -12.5 to 12.5 represents -12.5 to 12.5 rad;

The range -200 to 200 represents -200 to 200 r/s;

The range -10 to 10 represents -10 to 10 N-m;

The drive temperature is of int8 type, with a range of -128 to 127° C;

The motor temperature is of int8 type, with a range of -128 to 127° C.

```
void motor_receive(float *motor_pos, float *motor_spd, float *motor_t, int_8 *temp1, int_8
*temp2, int_8 *error, rx_message) {
    int_8 err_int = (rx_message)->Data[0] >> 4;
    int16_t pos_int = (rx_message)->Data[1] << 8 | (rx_message)->Data[2];
```

```
    int16_t spd_int = (rx_message)->Data[3] << 4 | (rx_message)->Data[4] >> 4;
    int16_t t_int = ((rx_message)->Data[4] & 0xF) << 8 | (rx_message)->Data[5];
    &motor_error = (rx_message)->Data[0] >> 4;                  // Motor error code
    &motor_pos = uint_to_float(pos_int, P_MIN, P_MAX, 16);   // Motor position
    &motor_spd = uint_to_float(spd_int, V_MIN, V_MAX, 12);   // Motor speed
    &motor_t = uint_to_float(t_int, T_MIN, T_MAX, 12);        // Motor torque
    &motor_temp1 = (rx_message)->Data[6];                       // Drive temperature
    &motor_temp2 = (rx_message)->Data[7];                       // Motor temperature
}
```

When receiving packets, the position, speed, and torque need to be converted to floating-point numbers using the following function:

```
float uint_to_float(int x_int, float x_min, float x_max, int bits){
    /// converts unsigned int to float, given range and number of bits ///
    float span = x_max - x_min;
    float offset = x_min;
    return ((float)x_int)*span/((float)((1<<bits)-1)) + offset;
}
```

The conversion function requires determining the maximum and minimum values for proportional conversion, which are queried on the parameter setting page. The default maximum and minimum values for KP and KD are 0.0 to 500.0 and 0.0 to 5.0. Pos, Vel, and Torque are preset to ±12.5, ±200, and ±10, respectively, and these three parameters can be adjusted according to the actual parameters of the motor. When sending control commands, it is essential to maintain consistency with the set values.

5.5 CAN Port Control Command Examples

Format frame: Standard frame-Data frame (with motor ID 0X10 as an example)

Mode	ID	DATA	Descriptions
MIT speed	00 01	7F FF 83 00 00 00 47 FF	Kd set 0.005 Speed set 6rad/s
	00 01	7F FF 7C E0 00 00 47 FF	Kd set 0.005 Speed set -6rad/s

MIT position	00 01	94 7A 7F F0 01 00 47 FF	Kp set 0.123 Kd set 0.005 Motor rotates to2rad
	00 01	6B 84 7F F0 01 00 47 FF	Kp set 0.123 Kd set 0.005 Motor rotates to-2rad
MIT torque	00 01	7F FF 7F F0 00 00 08 05	Torque set 0.03N-m
	00 01	7F FF 7F F0 00 00 07 F9	Torque set -0.03N-m
Position-velocity mode	01 01	00 00 40 40 00 00 80 3F	3rad 1rad/s
	01 01	00 00 40 C0 00 00 80 3F	-3rad 1rad/s
Velocity mode	02 01	00 00 00 40	2rad/s
	02 01	00 00 00 C0	-2rad/s