DAMIAO | 达妙科技

DM-S3519-1EC Geared Motor

(Including DM3520-1EC Driver)

User Manual 2024.11.18

Disclaimer

Thank you for purchasing the DAMIAO DM-S3519-1EC motor (hereinafter referred to as "the Motor") and DM3520-1EC driver (hereinafter referred to as "the Driver"). Before using this product, please carefully read and comply with this document and all safety guidelines provided by DAMIAO DM-S3519- 1EC. Failure to do so may cause harm to you or others, or damage the product or surrounding items. By using this product, you acknowledge that you have read, understood, and accepted all terms and conditions of this document and any related materials. You agree to use this product solely for legitimate purposes and assume full responsibility for its use and any resulting consequences. DAMIAO DM-S3519-1EC shall not be liable for any damages, injuries, or legal liabilities arising from the direct or indirect use of this product.

Precautions

1. The driver must be operated strictly within the specified working environment and maximum allowable temperature range of the winding, otherwise permanent irreversible damage may occur to the product.
2. Prevent conductive debris from entering the drive, as it may cause abnormal operation.
3. Before use, inspect all components for integrity. Discontinue use if any parts are missing, aged, or damaged.
4. Ensure proper wiring and secure connection to the motor.
5. Do not touch the drive during operation to prevent accidents. The drive may overheat when delivering high current output. Take precautions to avoid burns.
6. Do not remove the drive without permission to avoid damage.

Motor Features

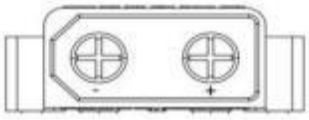
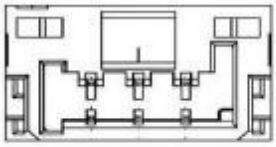
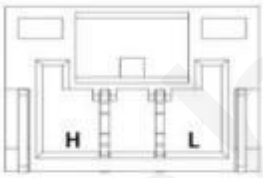
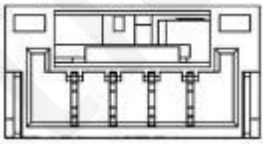
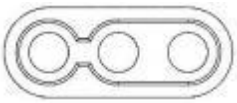
1. The driver is designed with intelligent features, allowing plug-and-play operation after motor replacement without recalibration or parameter adjustment.
2. Support firmware upgrades.
3. The host computer allows visual parameter adjustment, which can be used with simple configuration.
4. Supports CAN FD with a maximum baud rate of 5Mbps.
5. The motor speed, position, torque and temperature can be feedbacked by CAN bus.
6. It has the function of double temperature protection.
7. Low speed and high torque.
8. Multiple control modes can be flexibly switched.

Package Contents

Class	Inventory	Key
Motor set	1、Drive ×1 2、Reduction motor ×1 3、XT30 Power Cord (Double-ended, 200mm) × 1 4、3-pin serial cable (crossed, 300mm) × 1 5、2-pin CAN cable (dual-sided,300mm)× 1 6、4-pin encoder cable (crossed, 250mm) × 1 7、3-pin motor phase wire (crossed, 200mm) × 1	

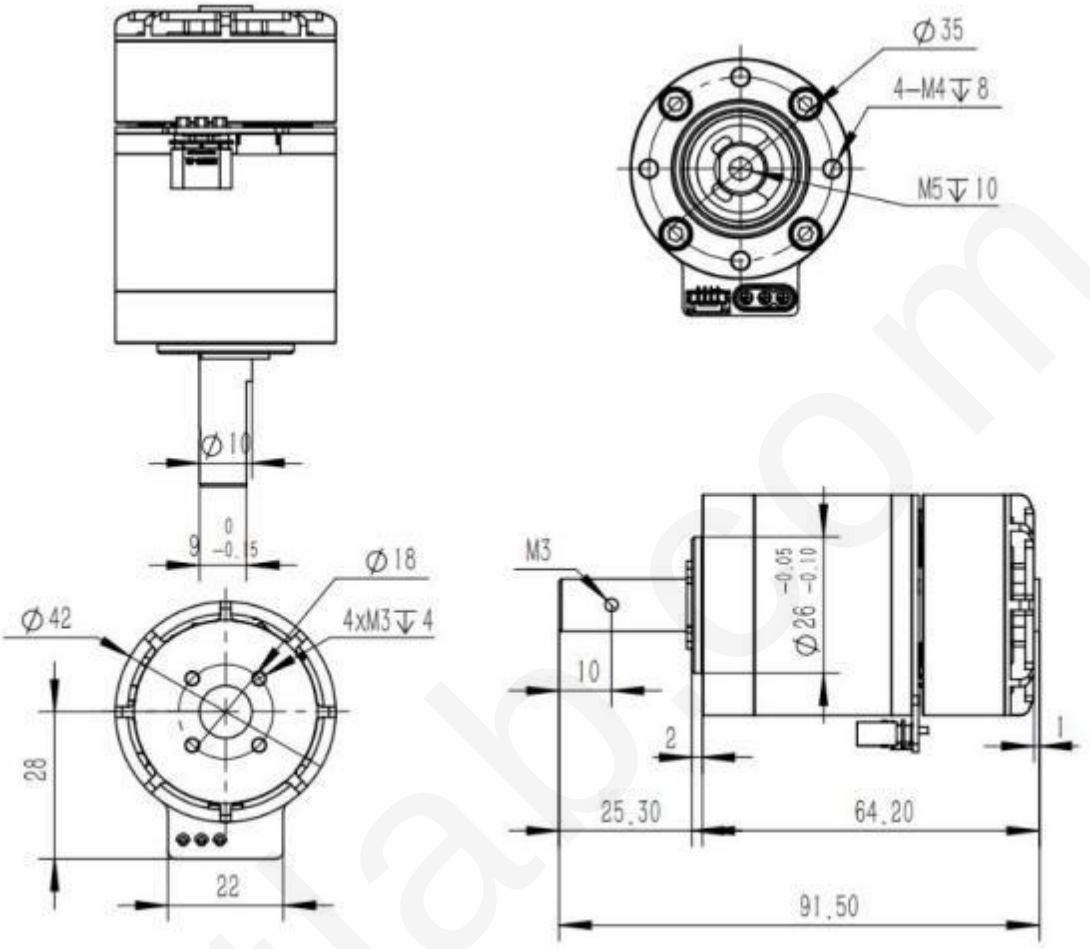
Single motor	1、 Reduction motor ×1	
Single drive	1、 Drive ×1 2、 XT30 Power Cord (Double-ended, 200mm) × 1 3、 3-pin serial cable (crossed, 300mm) × 1 4、 2-pin CAN cable (dual-sided,300mm)× 1 5、 4-pin encoder cable (crossed, 250mm) × 1 6、 3-pin motor phase wire (crossed, 200mm) × 1	

Interface and Wire Sequence Description

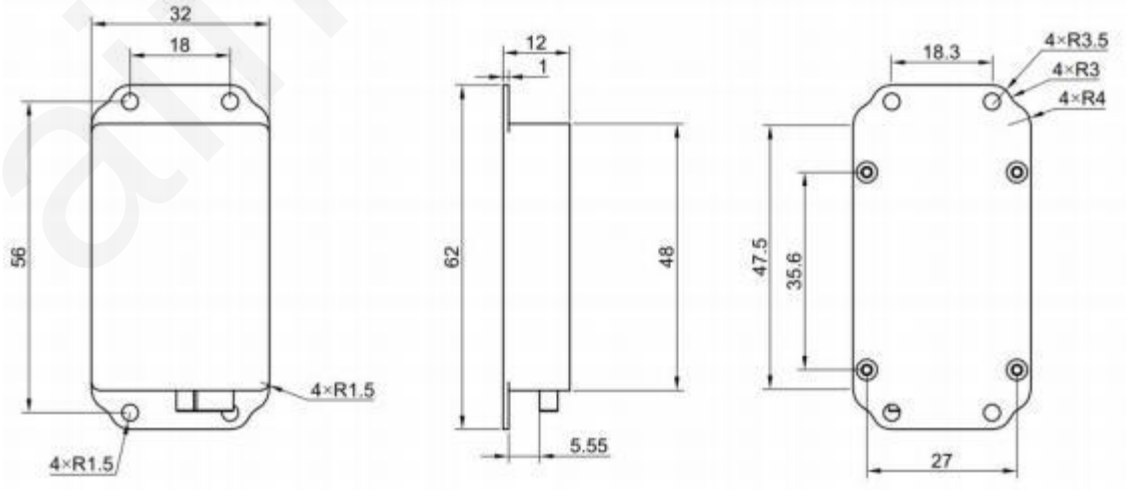
Specific Name-Number	Interface annotation	Explain
Power supply connection interface		Connect the power supply to the XT30-F plug using the power cable, with a rated voltage of 24V to power the motor.
Gorge line		For serial port debugging, parameter adjustment, and other functions
CAN interface		Control driver
Encoder interface		Connects to the DM-S3519-1EC motor using the matching 4-pin cross-type cable.
Three-phase line interface		For connecting motor three-phase wires with auxiliary cables

Dimension and Installation of Reducer & Driver

Refer to the drive installation hole size and position to install the drive on the corresponding device.



Dimension diagram of DM-S3519-2EC speed reducer motor

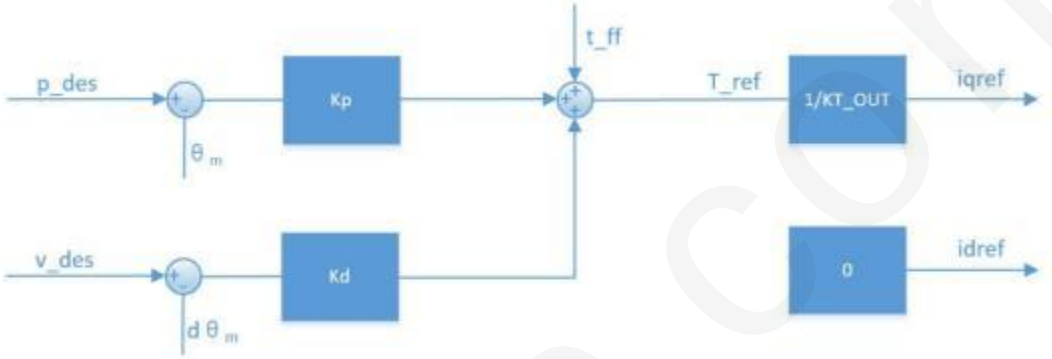


DM3520-1EC driver size diagram

Work Pattern

MIT Pattern

The MIT mode is designed to be compatible with the original MIT mode, enabling seamless switching while allowing flexible control range settings (P_MAX, V_MAX, T_MAX). The driver converts received CAN data into control variables, which are then processed to generate torque values for the current loop. The current loop, following its regulation rules, ultimately achieves the specified torque current. The control schematic diagram is shown below:



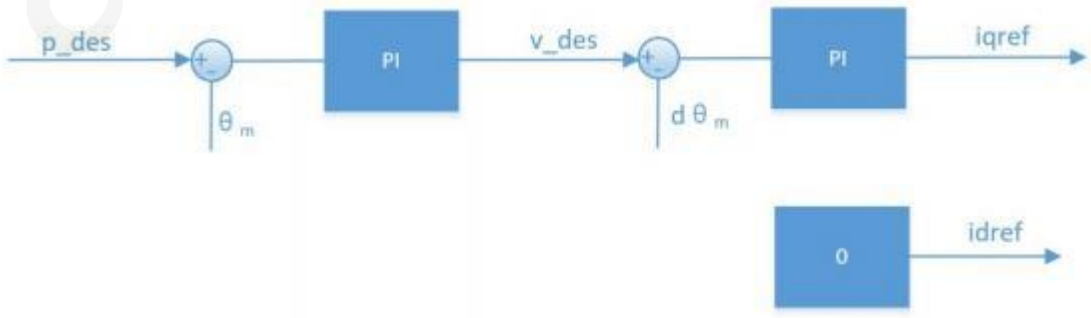
The MIT model can be adapted to various control configurations. For instance, when kp=0 and kd≠0, a constant-speed rotation can be achieved by setting v_des. Similarly, when kp=0 and kd=0, torque output can be controlled by setting t_ff.

Note:1 After power on, the motor position is fixed to 0.0rad.

2、 When controlling the position,kd cannot be assigned 0, otherwise it will cause motor oscillation or even loss of control.

Velocity Position Mode

The position cascade control mode mploys a three-loop series configuration. The outermost position loop provides the speed loop's setpoint, while the inner current loop receives the speed loop's output to regulate actual current. The control block diagram is shown below:



p_des is the target position for control, while v_des defines the maximum absolute speed during motion.

When the cascade mode is controlled using the parameters recommended by the debugging assistant, it achieves better control accuracy with a relatively smooth process, though the response time is longer. In addition to v_des, other configurable parameters include acceleration/deceleration settings.

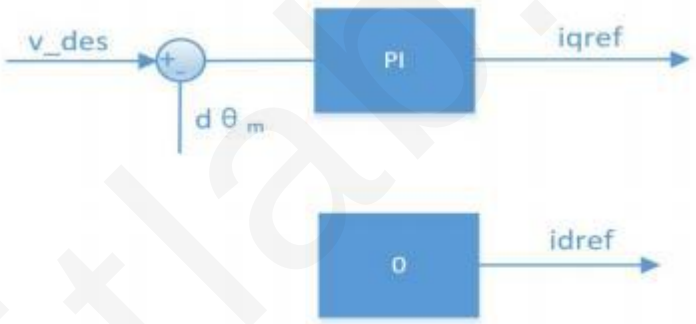
If additional oscillations occur during the control process, the acceleration/deceleration can be increased.

pay attention to：

1 、After power on, the motor position is fixed to 0.0rad. 2,p_des, v_des units are rad and rad/s,data type is float.

Speed Mode

The speed mode enables the motor to operate stably at the set speed, as shown in the control block diagram below.



pay attention to ：

1,v_des is in rad/s,and the data type is float.

Control Protocol Description

The CAN standard frame format is used for control, with a default baud rate of 1Mbps. The baud rate can be changed through commands, as detailed in the Baud Rate Modification section. Functionally, frames are categorized into receiving frames and feedback frames. Receiving frames contain control data for motor command execution, while feedback frames transmit status data from the motor to the upper controller. The feedback mechanism operates on an inquiry-based principle: when the driver receives a frame ID matching the motor's configured CAN ID (with low 8 bits for parity check and high

3 bits ignored), it sends the current status data to the bus. The format and frame ID of receiving frames vary depending on the motor's selected mode, but the feedback frame format and data remain consistent across all modes.

Feedback Frame

The feedback frame ID is set by the debug assistant (Master ID), with a default value of 0. It primarily provides feedback on the motor's position, speed, and torque. The frame format is defined as:

Feedback message	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
MST_ID	ID|ERR<<4	POS[15:8]	POS[7:0]	VEL[11:4]	VEL[3:0]|T[11:8]	T[7:0]	T_MOS	T_Rotor

among：

ID indicates the controller's identifier, with the lower 4 bits of CAN_ID (ERR) representing the status, corresponding to the following status types:

0-disability; 1-Enable;

5-Read out the sensor error;

6-Read motor parameter error; 8—overpressure;

9—Under-voltage;

A—— excess current； B—MOS overheating;

C-Motor coil overheating; D—loss of communication; E—— overload；

POS indicates the motor's position information*. VEL indicates the motor speed information*.

T indicates the motor torque information*.

T_MOS is the average temperature of the upper MOS, in ℃

T_Rotor is the average temperature of the motor's internal coils, measured in ℃

The position, speed and torque are converted to fixed-point data with sign by linear mapping, where the position is 16-bit data, and the speed and torque are 12-bit data.

Note:

1. After power-on, the motor position is fixed at 0.0 rad.

2. Position is measured in radians (rad) and indicates the output shaft's position after deceleration. All subsequent position descriptions follow this definition, which will not be repeated here.

3. The unit of speed is rad/s (radians per second), representing the output shaft's speed after deceleration. All subsequent descriptions of speed follow this definition and will not be repeated.

4. Torque is measured in Nm and refers to the output shaft torque, i.e., the torque after reduction. All subsequent descriptions of torque shall follow this definition and need not be repeated.

Control Frame in MIT Mode

Feedback message	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
ID	p_des [15:8]	p_des [7:0]	v_des [11:4]	v_des[3:0]| Kp[11:8]	Kp [7:0]	Kd [11:4]	Kd[3:0]| t_ff[11:8]	t_ff[7:0]

Frame ID equals the set CAN ID value

P_des:position given

V_des:speed given

Kp: Position Ratio Coefficient

Kd: Positional differential coefficient

T_ff: Torque setpoint

All parameters adhere to the mapping relationships specified in the previous section. The values of p_des, v_des, and t_ff can be configured via the debugging assistant, while Kp ranges from 0 to 500 and Kd ranges from 0 to 5.

Standard CAN data frame only 8 bytes,MIT control command format will Position, Velocity, Kp, Kd, Torque five parameters bit combination in 8 bytes. Among

them:Position occupies 2 bytes 16 bits,Velocity occupies 12 bits,Kp occupies 12 bits,Kd occupies 12 bits.

Control Frame in Position Velocity Mode

Control message	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x100+ID	p_des				V_des			

The frame ID is the set CAN ID value plus an offset of 0x100.

P_des: Position given, floating-point type, with the lower bit first and the higher bit last
V_des: Speed given, floating-point, lower bit first, higher bit last

The CAN ID for the command is 0x100+ID.The speed given is the maximum speed defined during motor operation. Example:

Set the motor with CAN ID 5 to rotate 180 degrees (3. 14159 rad) at a maximum speed of 10 rad/s, as instructed below:

Frame ID	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x105	0xCF	0x0F	0x49	0x40	0x00	0x00	0x20	0x42

Control Frame in Speed Mode

Control message	D[0]	D[1]	D[2]	D[3]
0x200+ID	V_des			

The frame ID is the set CAN ID value plus the offset

V_des of 0x200.

The speed is given, floating point, with the lower bit first and the higher bit last.

The CAN ID for sending the command here is 0x200+ID.

give an example：

Set the motor with CAN ID 3 to rotate at 60rpm (6.283 rad/s) using the following command:

Frame ID	D[0]	D[1]	D[2]	D[3]
0x203	0x56	0x0E	0xC9	0x40

Direction for Use

The motor has been calibrated and marked with its specifications. It can be used directly unless there are any abnormalities, and no further calibration is required.

New calibration and calibration, the following provides the calibration and calibration process,can be skipped under normal circumstances.

Motor Calibration

The purpose of calibration is to correct the installation error of the sensor and the direction of the sensor. During the process, the motor will rotate in a certain direction. Please ensure that the motor can rotate freely,preferably the motor can run unloaded, otherwise the calibration may fail.

The Damiao Debug Assistant can be used to calibrate the motor via serial communication. Any serial tool supporting a baud rate of 921600 is compatible. For example, the calibration process using USB to CAN conversion is demonstrated below:

1. Connect the motor and driver with three-phase wires and sensor wires, ensuring a secure and loose-free connection.

2. Connect the driver to the USB-to-CAN converter using a 3-pin serial cable, ensuring a secure and stable connection.

3. Connect the USB to CAN to the PC and enable the debug assistant on the host computer.

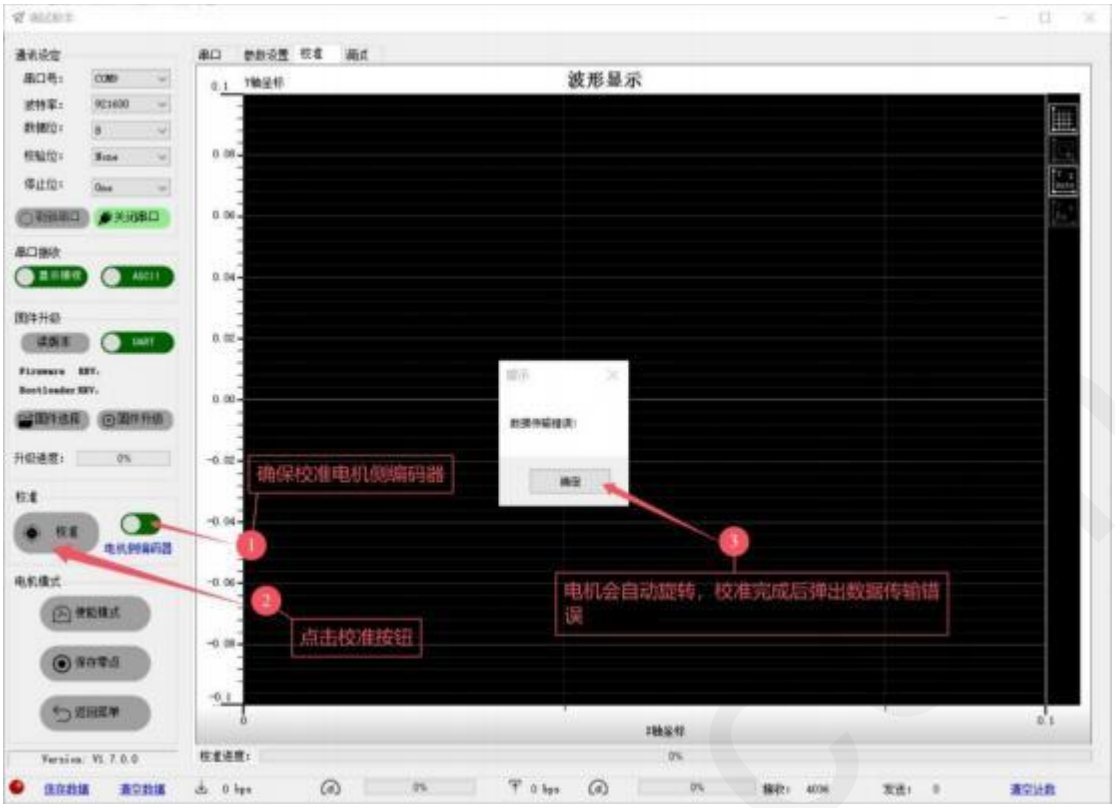
4. Configure the serial port with the following parameters.

5. Select the right side as the motor-side encoder

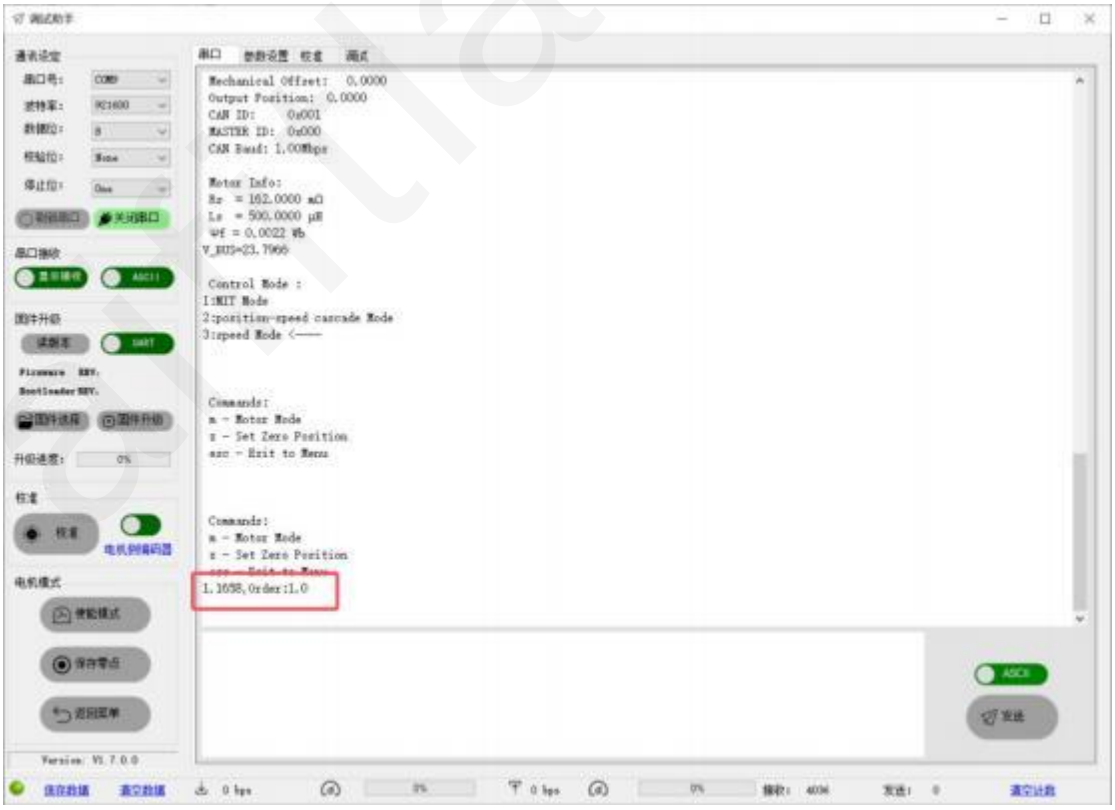
6. Supply the motor with 24V (the calibration process requires approximately 1A current, so use a power supply rated at least 1A).

7. Click Calibrate to start the motor freely. The entire process takes about 2 seconds.

8. After calibration, the driver sends a message to the serial port, which may cause the host computer to display a 'data transfer error' —this can be ignored.



9. Back to the serial interface, the driver prints the current calibration information to the serial port, marking the completion of calibration.



Parameter Calibration

After calibration is completed, parameter identification can be carried out, mainly identifying the phase resistance, phase inductance and magnetic flux of the motor.Please keep the motor in no-load state and fix the motor before carrying out parameter calibration operation.

Click the "Parameter Settings" tab, then select the "Parameter Calibration" button to initiate the drive's identification process. The motor will first vibrate at low frequency, then accelerate to a specific speed before rotating at a constant speed, and finally perform forward and reverse rotation. These are the standard identification procedures. If any abnormalities occur, verify whether the motor has been calibrated and confirm the output shaft rotates normally.

After recognition, the results will be automatically uploaded:

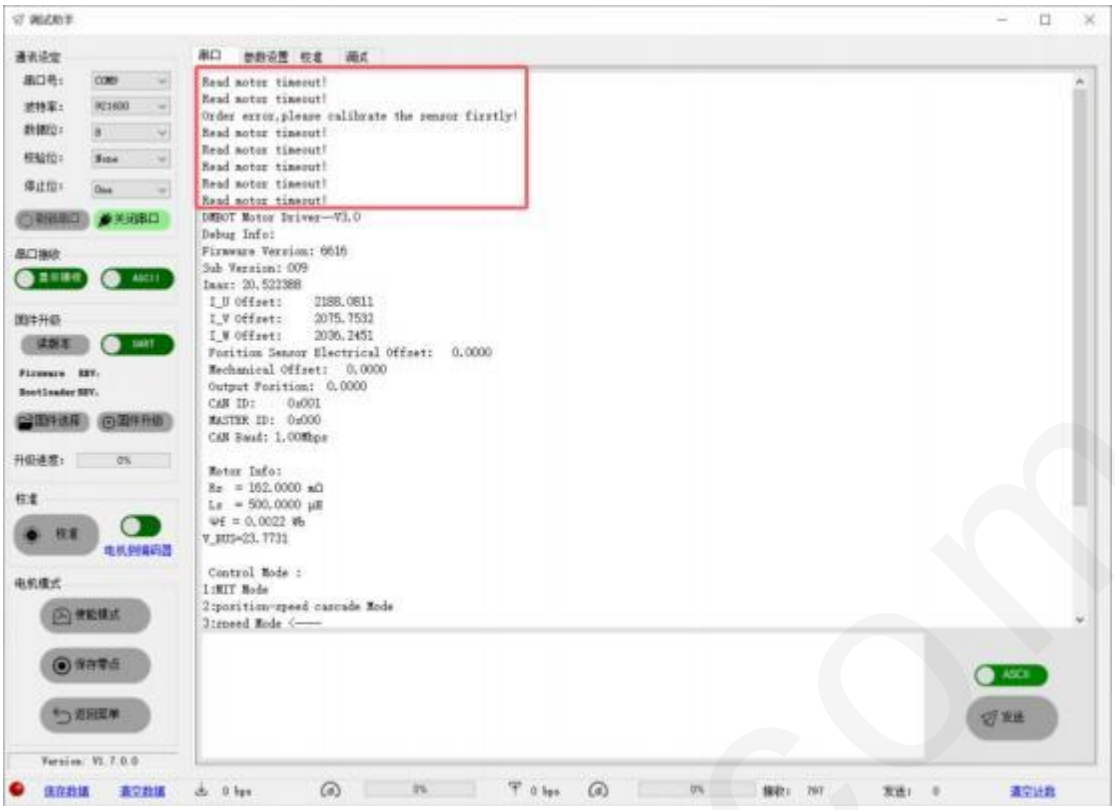
[Note] All parameters except viscosity coefficient must be positive. If negative values occur, verify the motor status before recalibration.

Debugging Steps

Under normal conditions, the motor requires no calibration or adjustment. You can proceed with the debugging process as outlined below.

1. Connect the Motor and the Driver

The motor and driver require a 4-pin sensor cable and a 3-phase power cable. Loose or disconnected communication cables may impair motor operation, causing the driver to display 'read timeout', error messages, and a red light indicator.



2. Connect the Communication Cable and Power Cable

The driver can use the 3Pin serial port for parameter read and write, and the 2PinCAN line can be used to control the motor operation. You can also use the CAN line for parameter read and write. For details, please refer to the CAN Configuration Command section below.

Connect the driver and USB-to-CAN module using a serial cable and CAN cable, ensuring a secure connection without looseness. Verify the CAN cable sequence to confirm proper connections: CAN_H on the USB-to-CAN module should connect to CAN_H on the driver, and CAN_L to CAN_L. After confirming all connections are correct, power the driver. Under normal conditions, the following message will appear on the serial interface:

Includes firmware version, three-phase current bias, motor angle, driver ID configuration, baud rate, and power supply voltage.

3. Serial Port Read/write Parameters

Switch to the parameter settings interface, click the "Read" button, and the driver will upload the current driver configuration parameters and motor parameters.

Check if the parameters meet the requirements. If needed, enter the data in the corresponding fields and click the Write Parameters button.

pay attention to：

① Do not modify the polar logarithm and reduction ratio parameters.

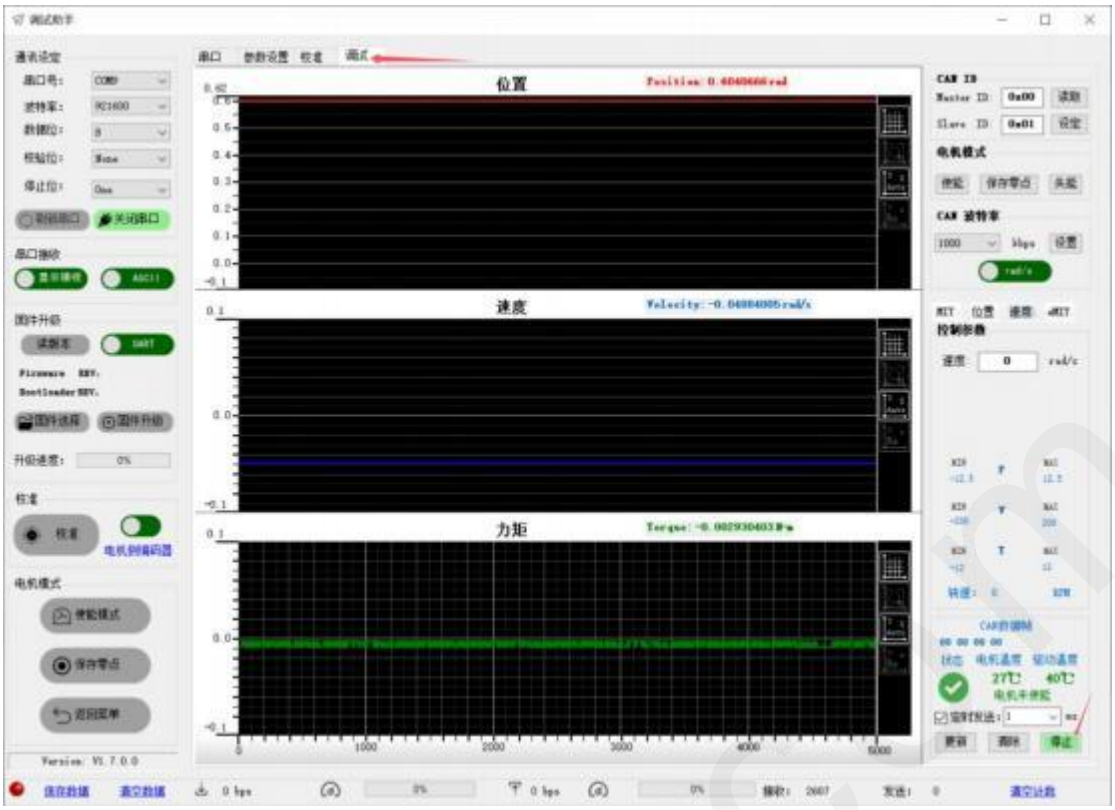
② Click "Write Parameters" to automatically restart the driver without external power.

③ The "Save" button only applies to controller parameters and will be lost after power loss.

4. Shakedown Test

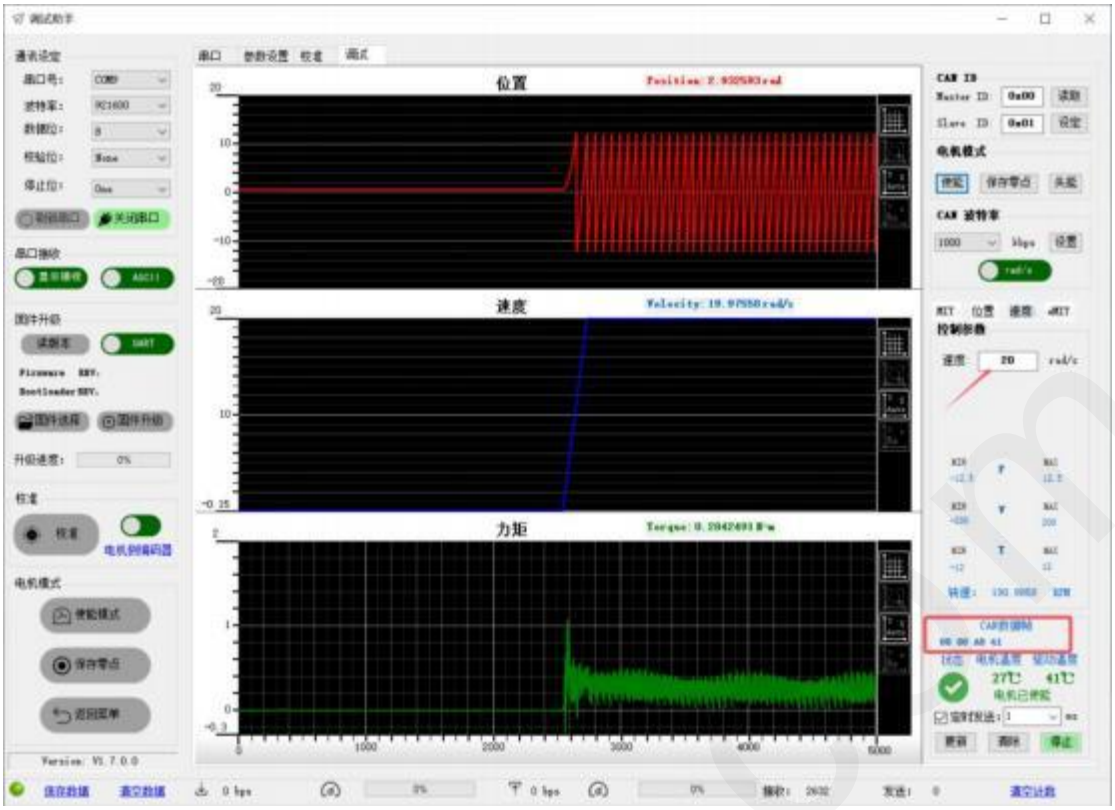
After completing the initial steps correctly, you can proceed with the motor operation debugging. The debugging interface uses CAN communication. Ensure the CAN cable is properly connected before proceeding. Once enabled, the motor will rotate. This step requires securing the motor to prevent accidents.

Click the debug label to enter the debug interface.



After clicking 'Send' and confirming normal communication, the interface will display the motor status curve.

Select the appropriate control mode tab. For instance, in speed mode, enter 20 rad/s and click update. The CAN data frame will automatically refresh the data, which is then sent to the driver. After enabling the motor, it will rotate at 20 rad/s with the waveform scrolling on the interface, completing the debugging process.



CAN Configuration Command

The motor parameters can be configured through both the serial port of the host computer and the CAN bus. In addition to the basic parameter configuration, the system now supports mode switching and baud rate adjustment.

1. Read Parameters

Message ID	Attribute	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x7FF	STD	CANID_L	CANID_H	0x33	RID	xx(don 't care)			

RID is the register address, as defined in Section 6.

After successful read, the data of the register is returned, with the frame format as follows:

Message ID	Attribute	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
MST_ID	STD	CANID_L	CANID_H	0x33	RID	Data			

The data is either floating-point or unsigned integer, occupying 32 bits (4 bytes), with D4 as the least significant bit and D7 as the most significant bit, and so on.

2. In Parameter

Message ID	Attribute	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
0x7FF	STD	CANID_L	CANID_H	0x55	RID	Data			

As described above, after data is written, the driver performs a data range check. If the data falls within the specified range, the write operation succeeds. The driver then loads the corresponding parameters and returns the written data, with the frame format identical to the original sent data.

Message ID	Attribute	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
MST_ID	STD	CANID_L	CANID_H	0x33	RID	Data			

If the range is exceeded, the write operation fails, and the driver returns the original register data.

Write register data takes effect immediately, but cannot be stored and lost after power failure. It is necessary to send a command to store parameters and write all modified parameters into the chip.

3. Storage Parameters

Message ID	Attribute	D[0]	D[1]	D[2]	D[3]
0x7FF	STD	CANID_L	CANID_H	0xAA	XX

After successful write, the return format is:

Message ID	Attribute	D[0]	D[1]	D[2]	D[3]
MST_ID	STD	CANID_L	CANID_H	0xAA	01

pay attention to：

① Storage parameters are only valid in the disabled mode.

② All parameters are retained when saving parameters.

③ This operation writes parameters to the on-chip flash memory. Each operation takes up to 30ms. Ensure you allow sufficient time.

④ The flash memory has approximately 10,000 erase cycles. Avoid frequent transmission of the "storage parameters" command.

4. Mode Switch

Supports switching between multiple modes. The available control modes are:

Encoding	Pattern
1	MIT
2	Velocity of position
3	Velocity

By adjusting the mode register (0x0A), the operating mode can be modified. During mode switching, the motor first resets all command values, including position, speed, and the torque feedforward and KP/KD values in MIT mode.

When switching from a mode to position control mode, to prevent shock, it is recommended to first read the precise position before considering the switch, and to perform the switch when the motor is at zero speed.

After modifying the mode, it won't be saved to flash memory and will be lost when the power is cut. Upon power restoration, the control mode will revert to the last saved mode in flash.

5. Bit Rate Modification

The current CAN communication baud rate can be modified by writing specific data to the baud rate register (address 0x23). The driver supports specific baud rate modifications, with the following supported rates:

Encoding	Baud rate
0	125K
1	200K
2	250K
3	500K
4	1M

5	2M
6	2.5M
7	3.2M
8	4M
9	5M

After successfully modifying the baud rate, the driver initially transmits data at the original baud rate before switching to the new rate. Upon power-on, the motor first checks the stored baud rate. If it exceeds 5Mbps, the system automatically defaults to 1Mbps. For rates above 1Mbps (excluding 1Mbps), the motor switches to CAN FD mode. If the baud rate is ≤1Mbps, it automatically switches to CAN 2.0B. Motors configured as CAN FD can still receive CAN 2.0B data frames but use CAN FD for feedback transmission, causing the upper-layer controller to miss feedback data and triggering continuous driver error reports. Controllers using CAN 2.0B can revert to the original baud rate by issuing a baud rate modification command even after incorrect ID settings.

6. Register Address

Address （HEX）	Address （DEC）	Variable	Description	Read-write	Scope	Type
0x00	0	UV_Value	Low voltage protection value	RW	(10.0,fmax]	float
0x01	1	KT_Value	Torque coefficient	RW	[0.0,fmax]	float
0x02	2	OT_Value	Over temperature protection value	RW	[80.0,200)	float
0x03	3	OC_Value	Overcurrent protection value	RW	(0.0,1.0)	float
0x04	4	ACC	Accelerated speed	RW	(0.0,fmax)	float
0x05	5	DEC	Deceleration	RW	[-fmax,0.0)	float
0x06	6	MAX_SPD	Maximum speed	RW	(0.0,fmax]	float

0x07	7	MST_ID	Feedback ID	RW	[0,0x7FF]	uint32
0x0A	8	ESC_ID	Receive ID	RW	[0,0x7FF]	uint32
0x09	9	TIMEOUT	Timeout alert time	RW	[0,2^32-1]	uint32
0x0A	10	CTRL_MODE	Control model	RW	[0,4]	uint32
0x0B	11	Damp	Motor viscosity coefficient	RO	/	float
0x0C	12	Inertia	Rotating inertia of motor	RO	/	float
0x0D	13	hw_ver	Continue to have	RO	/	uint32
0x0E	14	sw_ver	Software version	RO	/	uint32
0x0F	15	SN	Continue to have	RO	/	uint32
0x10	16	NPP	Number of pole pairs of motor	RO	/	uint32
0x11	17	Rs	Motor phase resistance	RO	/	float
0x12	18	Ls	Motor phase inductance	RO	/	float
0x13	19	Flux	Motor flux linkage	RO	/	float
0x14	20	Gr	Gear reduction ratio	RO	/	float
0x15	21	PMAX	Position mapping range	RW	(0.0,fmax]	float
0x16	22	VMAX	Velocity mapping range	RW	(0.0,fmax]	float
0x17	23	TMAX	Torque mapping range	RW	(0.0,fmax]	float
0x18	24	I_BW	Current loop control bandwidth	RW	[100.0,1.0e4]	float

0x19	25	KP_ASR	Speed ring Kp	RW	[0.0,fmax]	float
0x1A	26	KI_ASR	Speed ring Ki	RW	[0.0,fmax]	float
0x1B	27	KP_APR	Position loop Kp	RW	[0.0,fmax]	float
0x1C	28	KI_APR	Position loop Ki	RW	[0.0,fmax]	float
0x1D	29	OV_Value	Overvoltage protection value	RW	TBD	float
0x1E	30	GREF	Gear torque efficiency	RW	(0.0,1.0]	float
0x1F	31	Deta	Speed loop damping coefficient	RW	[1.0,30.0]	float
0x20	32	V_BW	Speed loop filter bandwidth	RW	(0.0,500.0)	float
0x21	33	IQ_c1	Current loop enhancement factor	RW	[100.0, 1.0e4]	float
0x22	34	VL_c1	Speed loop enhancement coeffici- ent	RW	(0.0,1.0e4]	float
0x23	35	can_br	CAN baud rate code	RW	[0,4]	uint32
0x24	36	sub_ver	Subversion number	RO	/	uint32
0x32	50	u_off	u phase offset	RO	/	float
0x33	51	v_off	v phase offset	RO	/	float
0x34	52	k1	Compensation Factor 1	RO	/	float
0x35	53	k2	Compensation Factor 2	RO	/	float

0x36	54	m_off	Angle offset	RO	/	float
0x37	55	dir	Direction	RO	/	float
0x50	80	p_m	Motor current position	RO	/	float
0x51	81	xout	Output shaft position	RO	/	float

RW: Read-write.

RO:Read-only.

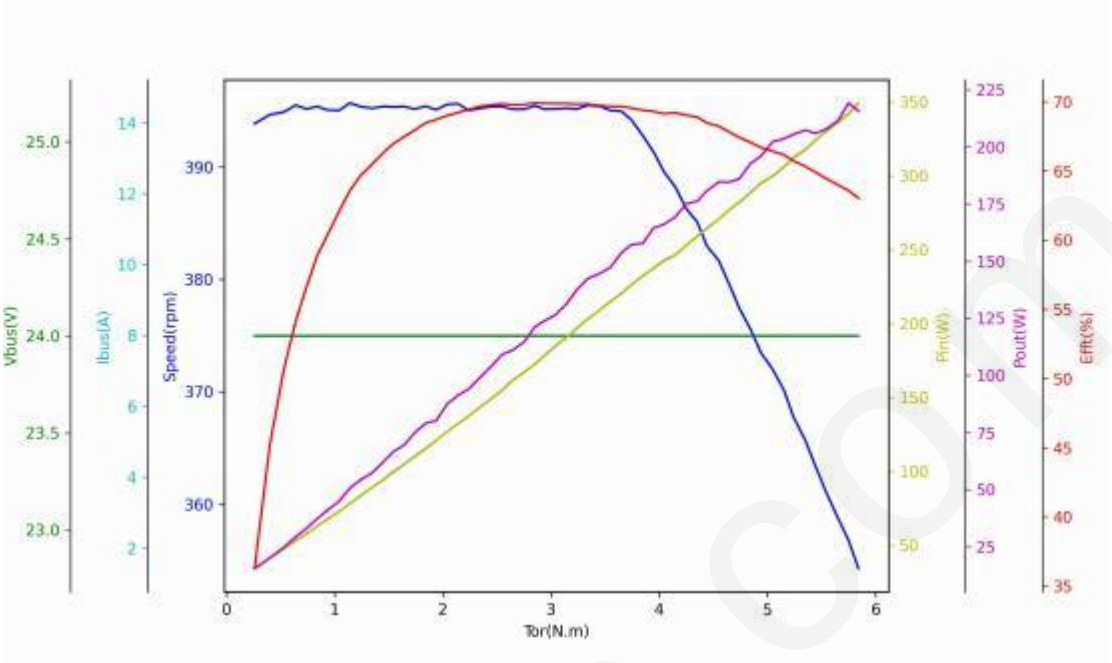
Firmware Upgrade

When new firmware features are added or bug fixes are released, users can perform upgrades via the serial port to resolve issues and access new functionalities. Before proceeding, connect the serial port, select the desired firmware via the "Firmware Selection" menu, confirm the choice, then click the firmware upgrade button. Wait for the progress bar to complete, or check the upgrade status through the serial port interface.

Note: The firmware name must match the motor to avoid selection errors.

Characteristic Curve

Test environment: room temperature 25℃, laboratory environment.



Characteristic Parameter

Use the motor properly according to the following parameters.

Motor Parameters	Rated voltage	24V (supports 15~52V power supply)
	Rated phase current (power supply current)	9.2A(8.6A)
	Peak current (power supply current)	20.5A(16.1A)
	Rating torque	3.5Nm
	Peak torque	7.8Nm
	Rated speed	395rpm
	No-load maximum speed	435rpm
Motor Characteristics	Reduction gear ratio	3591/187(1:19.2)
	Number of pole-pairs	7
	Phase inductance	55uH
	Phase resistance	0.2Ω
Structure and Weight	External diameter	Motor 42mm
	Altitude	Motor 91.5mm
	Motor weight	Approximately 396 grams
Encoder	Encoder type	Incremental encoder
	Control interface	CAN

Communication	Parameter passing interface	UART@921600bps
Control and protection	Control model	MIT pattern
		Speed mode
		Position mode
	Protect	Enable over-temperature protection with a protection temperature of 120°C. The motor will exit the enable mode if overheated.
		Motor over-temperature protection. Set according to usage requirements, recommended not to exceed 100°C. The motor will exit the 'enabled mode' if overheated.
		Motor overvoltage protection. Set according to usage requirements. It is recommended not to exceed 60V. Overvoltage will exit the "enabled mode".
		Communication loss protection. If no CAN commands are received within the set period, the system will automatically exit the enable mode.
		Motor overcurrent protection. Set according to usage requirements, recommended not to exceed 20A (phase current). Overcurrent will exit the 'enabled mode'.
		Motor under-voltage protection: If the power supply voltage drops below the set value, the system exits the enable mode. The power supply voltage must not be lower than 15V.

Data download link 1: https://gl1po2nscb.feishu.cn/drive/folder/KAbsfMgPklFbycdDBdGcpX9Dn6d

Data download link 2: https://gitee.com/kit-miao/damiao-dynamic