DAMIAO | 达妙科技

DM-H6215 Hub Motor

User Manual 2024.5.21

Disclaimer

Thank you for purchasing the DAMIAO DM-H6215 Wheel Hub Motor (hereinafter referred to as "the Motor"). Before using this product, please carefully read and comply with this document and all safety guidelines provided by DAMIAO Technology. 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 the product solely for legitimate purposes and assume full responsibility for its use and any resulting consequences. DAMIAO Technology shall not be liable for any damages, injuries, or legal liabilities arising from the direct or indirect use of this product.

Precautions

1. The motor must be operated strictly within the specified working environment and maximum allowable temperature range of the windings; otherwise, permanent irreversible damage may occur to the product.

2. Prevent foreign objects from entering the rotor, as this may cause abnormal operation.

3. Before use, check all components for integrity. If any parts are missing, aged, or damaged, stop using the device.

4. Ensure proper wiring and secure, correctly installed motor.

5. Do not touch the electronic rotor during operation to prevent accidents. The motor may overheat when delivering high torque, so take precautions to avoid burns.

6. Users must not disassemble the motor without authorization, as this may compromise its control accuracy or even cause malfunction.

Motor Features

1. The motor and driver are integrated in a compact design with high integration.

2. Support firmware upgrades.

3. The CAN bus provides real-time feedback on motor parameters including speed, position, torque, and temperature.

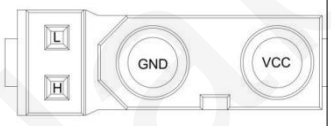
4. Features dual-temperature protection.

5. Low speed, high torque.

Package Contents

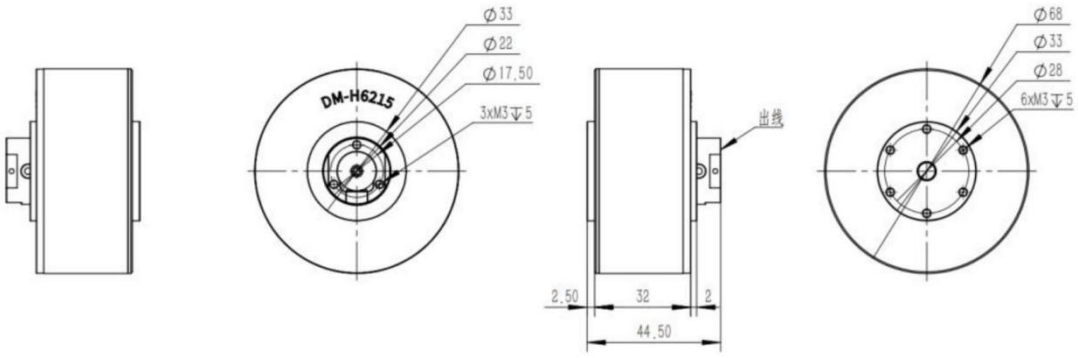
1. Motor (including drive unit, with 240mm power interface cable) × 1

Interface and Wire Sequence Description

Specific Name-Number	Interface annotation	Explain
Power supply connection interface		1. Connect the power supply to the motor via the XT30 (2+2) -F plug's power cable, rated at 24V. 2. The system connects to external control devices via CAN communication terminals, receiving CAN control commands and transmitting motor status data.

Dimension and Installation of Reducer & Driver

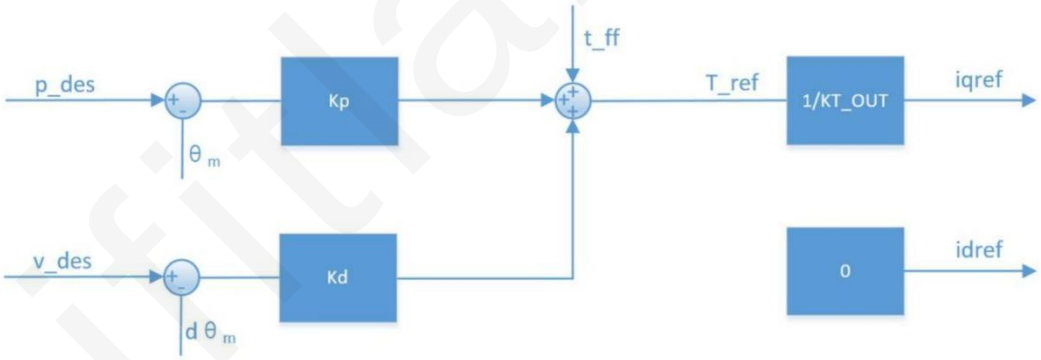
Refer to the motor mounting hole dimensions and positions to install the motor on the corresponding equipment.



Work Pattern

MIT Mode

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 electric controller converts received CAN data into control variables, calculates torque values, and provides current setpoints for the current loop. The current loop then adjusts according to its regulation rules to ultimately achieve the desired torque current. The control block 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.

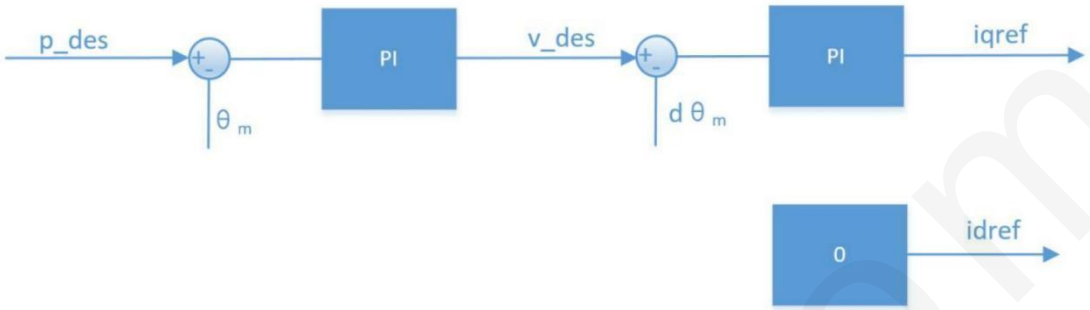
Note:

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

2. When controlling position, the kd value must not be set to 0, as this may cause motor oscillation or even loss of control.

Velocity Position Mode

The position cascade control mode employs 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.

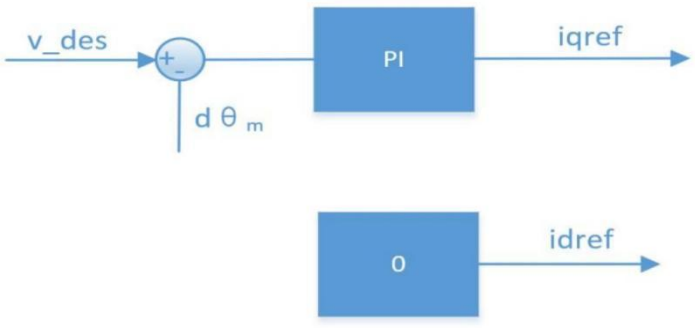
When the cascade mode is controlled using the parameters recommended by the debugging assistant, it achieves better control accuracy and a smoother process, though with a longer response time. In addition to v_des, other configurable parameters include acceleration/deceleration settings. If additional oscillations occur during control, increasing acceleration/deceleration can mitigate them.

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

2. p_des and v_des are measured in radians and radians per second (rad/s) respectively, with data type float. The damping factor must be set to a positive non-zero value. Refer to the speed mode precautions for details.

Speed mode

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



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

2. v_des is measured in rad/s and is a float data type. To enable the debugging assistant to automatically calculate parameters, you need to set

The damping factor is a non-zero positive number, typically ranging from 2.0 to 10.0. A value too small may cause speed oscillations and excessive overshoot, while an excessively large value prolongs the rise time. The recommended setting is 4.0.

Control protocol description

The system employs CAN standard frame formats with a default baud rate of 1Mbps, configurable via commands. Functionally, frames are categorized into two types: receiving frames (controlling motor operations) and feedback frames (transmitting motor status to the host controller). While receiving frames vary in format and frame ID depending on the motor's selected mode, all feedback frames maintain identical structure across all operational 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 ID, with the lower 8 bits of CAN_ID (ERR) representing the status, corresponding to the following status types:

0-Disability;

1—Enable;

8—overpressure;

9-Under-voltage;

A—— excess current；

B—MOS overtemperature;

C-Motor coil overheating;

D-Communication loss;

E—— overload；

POS indicates the motor's position data. Upon power-on, the motor's position is fixed at 0.0 rad.

VEL indicates the motor speed information

T represents the torque information of the motor

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

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

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

Control frame in MIT mode

Control 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]

The frame ID matches 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 relationship from the previous section. The values of p_des, v_des, and t_ff can be configured by the debugging assistant, while Kp ranges from [0,500] and Kd from [0,5].

A standard CAN data frame is 8 bytes long. MIT's control command format encodes five parameters—Position, Velocity, Kp, Kd, and Torque—into 8 bytes using bit combinations. Specifically, Position occupies 2 bytes (16 bits), Velocity 12 bits, Kp 12 bits, and Kd 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 bits first, higher bits last

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

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 an offset of 0x200.

V_des: A floating-point variable with fixed speed, where the lower bit is first and the higher bit is last. The CAN ID for this command is 0x200+ID.

Direction for Use

The hub motor lacks an external serial port, rendering its host computer's calibration, parameter reading, and parameter calibration functions unavailable. The firmware upgrade function differs, as detailed below. The debugging interface follows the same usage as other motors.

Detailed debugging process reference: Debug Assistant User Manual (Dami Driver Control Protocol) V1.4.pdf

Download link：

https://gitee.com/kit-miao/damiao/tree/master/%E5%85%B3%E8%8A%82%E7%94%B5%E6%9C%BA/%E6%8E%A7%E5%88%B6%E5%8D%8F%E8%AE%AE

Calibration, parameter reading, and parameter calibration can only be performed via the CAN bus, as detailed below:

Motor Calibration

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	0x66	0x00	xx(don’t care)			

After calibration is completed, the motor will automatically return a calibration completion status frame with the following format:

message ID	attribute	D[0]	D[1]	D[2]	D[3]
MST_ID	STD	CANID_L	CANID_H	0x66	0x01

Parameter Calibration

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	0x99	0x00	xx(don ’ t care)			

After calibration is completed, the motor will automatically send a completion signal with the following frame format:

message ID	attribute	D[0]	D[1]	D[2]	D[3]
MST_ID	STD	CANID_L	CANID_H	0x99	01

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:

Register address	Variable	Description	Read-write	Data type
0	UV_Value	low voltage protection value	RW	float
1	KT_Value	torque coefficient	RW	float
2	OT_Value	over temperature protection value	RW	float
3	OC_Value	overcurrent protection value	RW	float
4	ACC	accelerated speed	RW	float
5	DEC	deceleration	RW	float
6	MAX_SPD	maximum speed	RW	float
7	MST_ID	feedback ID	RW	uint32
8	ESC_ID	receive ID	RW	uint32
9	TIMEOUT	Timeout alert time	RW	uint32
10	CTRL_MODE	control model	RW	uint32
11	Damp	motor viscosity coefficient	RO	float
12	Inertia	rotating inertia of motor	RO	float
13	Rsv1	Keep parameter 1	RO	uint32
14	sw_ver	Software version	RO	uint32
15	Rsv2	Keep parameter 2	RO	uint32
16	NPP	number of pole pairs of motor	RO	uint32

17	Rs	motor phase resistance	RO	float
18	Ls	motor phase inductance	RO	float
19	Flux	motor flux linkage	RO	float
20	Gr	gear reduction ratio	RO	float
21	PMAX	position mapping range	RW	float
22	VMAX	velocity mapping range	RW	float
23	TMAX	torque mapping range	RW	float
24	I_BW	current loop control bandwidth	RW	float
25	KP_ASR	speed ring Kp	RW	float
26	KI_ASR	speed ring Ki	RW	float
27	KP_APR	position loop Kp	RW	float
28	KI_APR	position loop Ki	RW	float
29	OV_Value	overvoltage protection value	RW	float
30	GREF	gear torque efficiency	RW	float
31	Deta	speed loop damping coefficient	RW	float
32	V_BW	speed loop filter bandwidth	RW	float
33	IQ_c1	Current enhancement coefficient 1	RW	float
34	VL_c1	Speed enhancement coefficient 1	RW	float
35	can_br	CAN baud rate code	RW	uint32
36	sub_ver	Subversion number	RO	uint32
50	u_off	u phase offset	RO	float
51	v_off	v phase offset	RO	float
52	k1	Compensation factor 1	RO	float
53	k2	Compensation Factor 2	RO	float
54	e_off	electro angular deflection	RO	float
55	p_m	Motor position	RO	float

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 floating-point type, with D4 as the least significant bit and D7 as the most significant bit, and so on.

Write 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	0x55	RID	data			

As described above, the RID returns the written data upon successful completion, with the frame format identical to the original sent data.

messag e ID	attribut e	D[0]	D[1]	D[2]	D[3]	D[4]	D[5]	D[6]	D[7]
MST_ID	STD	CANID_ L	CANID_ H	0x3 3	RID	data			

Writing register data takes effect immediately but cannot be stored. The data is lost after power failure. To write all modified parameters into the chip, a command to send storage parameters must be sent.

Storage 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	0xAA	RID	xx(don ’ t care)			

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

Mode switch

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

Encoding	Mode
1	MIT
2	Velocity of position
3	Velocity

By adjusting the mode register values, the system can switch modes. During mode switching, the motor first resets all command values, including position, speed, and torque feedforward as well as KP and KD values in MIT mode.

To prevent shock during mode switching from one to position control, it is recommended to first measure the precise position before proceeding.When switching, do so at the motor's zero speed.

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

Port rate modification

Supports modification of specific baud rates. Currently supported baud rates are:

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

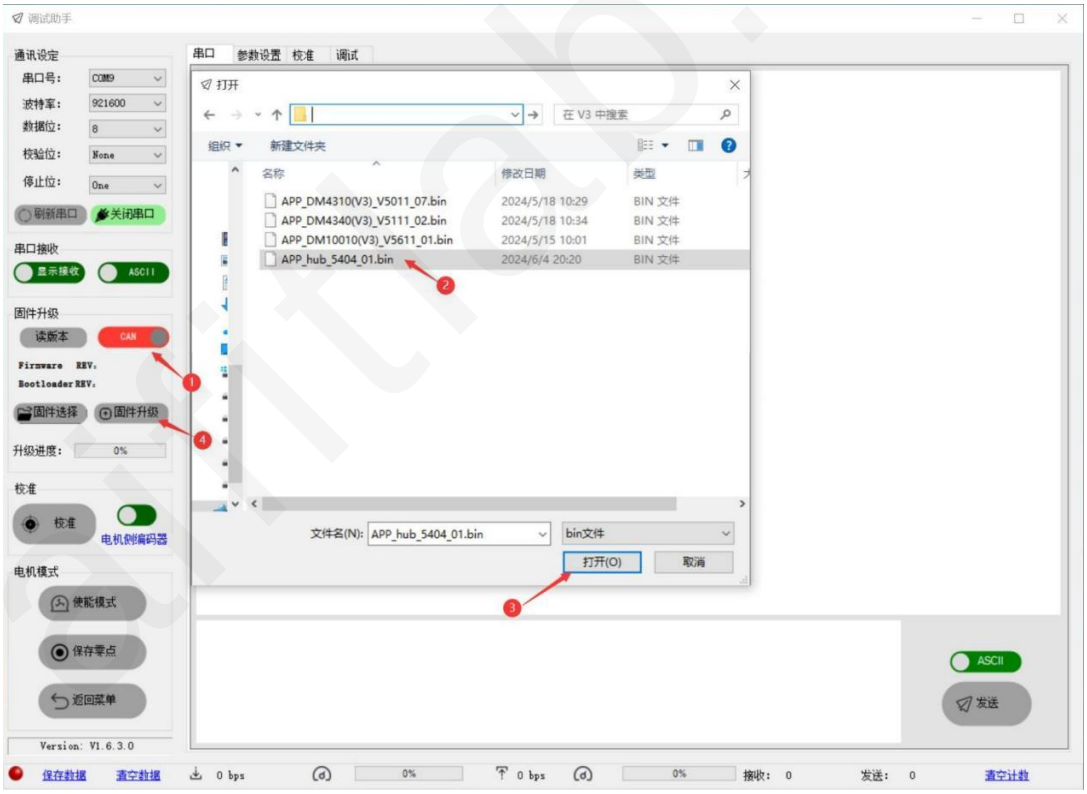
After adjusting the baud rate, CAN automatically initializes and transmits data at the new baud rate.

Firmware Upgrade

The firmware upgrade must be performed with the motor disabled and requires a host computer version 1.6.3.0 or later. Follow these steps:

First, open the serial port at baud rate 921600. Next, click the slider next to the read version to switch to CAN mode, as shown in the figure below.

Step 2: Select the appropriate firmware and click to open:



Step 3: Click Firmware Upgrade and wait for the upgrade to complete.

Characteristic Parameter

Use the motor properly according to the following parameters.

Motor Parameters	Rated voltage	24V
	Rated current	2.5A
	Peak point current	4.3A
	Rating torque	1NM
	Peak torque	2NM
	Rated speed	120rpm
	No-load maximum speed	320rpm
Motor Characteristics	Reduction gear ratio	1：1
	Number of pole-pairs	14
	Phase inductance	2000uh
	Phase resistance	2.5Ω
Structure and Weight	External diameter	68mm
	Altitude	44.5mm
	Motor weight	Approximately 360 grams

Encoder	Encoder type	Hoare
Communication	Control interface	CAN
	Parameter passing interface	CAN
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 exceeding 100°C. The motor will exit the 'enabled mode' if overheated.
		Motor overvoltage protection. Set according to usage requirements, recommended not to exceed 32V. 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, configured according to usage requirements, recommended not to exceed 9.8A. Overcurrent will exit the 'enabled mode'.
		Motor under-voltage protection: If the power supply voltage drops below the set threshold, the system exits the enable mode. The minimum required voltage is 15V.