

# RoboMaster

## GM6020 Brushless DC Motor

### User Guide

V1.0 2018.12





# Disclaimer

Thank you for purchasing the ROBOMASTER™ GM6020 Brushless DC Motor (hereinafter referred to as “product”). Read this disclaimer carefully before using this product. By using this product, you hereby agree to this disclaimer and signify that you have read it fully. Install and use this product in strict accordance with the User Guide. SZ DJI TECHNOLOGY CO., LTD. and its affiliated companies assume no liability for damage(s) or injuries incurred directly or indirectly from using, installing, or modifying this product improperly, including but not limited to using non-designated accessories.

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# Warning

1. Visit the official RoboMaster website and download the RoboMaster GM6020 Brushless DC Motor User Guide before use. Be sure to read the whole manual and strictly follow the instructions when using the motor.
2. DO NOT allow any foreign materials to come into contact with the rotors, as it may negatively affect the performance.
3. Ensure all the cables are properly connected.
4. Ensure the motor is securely mounted.
5. Avoid damage to the cables or wires, as it may negatively affect the performance.
6. DO NOT touch the rotors, as doing so may cause injury.
7. The motor heats when the output torque is high. Although this is normal, take caution to avoid scalding.
8. DO NOT disassemble the motor, as this may negatively affect the accuracy of the motor’s control and may lead to permanent malfunction.

# Introduction

The GM6020 Brushless DC Motor is a high-performance motor with a built-in driver designed for use in fields such as educational research, automation, and robotic competition.

The motor boasts a high pole number design, fractional slot concentrated windings, and rare earth magnets, making it an optimal solution for situations that require low rotational speed, direct driving, and large torque.

The Field Oriented Control (FOC) algorithm of the built-in driver and the high-precision angle sensor allows for precision control of the motor’s torque and position. If an error is detected, the motor issues warnings and automatically responds to protect itself. Multiple communication methods are supported to facilitate the users in motor control and firmware update.

# Features

- A hollow shaft to attach slip rings or other accessories when required.
- Compact design combining the motor and driver in one.
- Multiple communication methods are supported (e.g. CAN, PWM).
- With RoboMaster Assistant, users can set parameters online and update firmware.
- Use a CAN cable to acquire information such as rotor position, rotational speed, and motor temperature.

- Use the DIP switch to set ID and to enable/disable the CAN terminal resistance.
- Includes over-temperature and overvoltage protection.

## In the Box

Motor ×1



XT30 Power Cable ×1



CAN Cable ×1

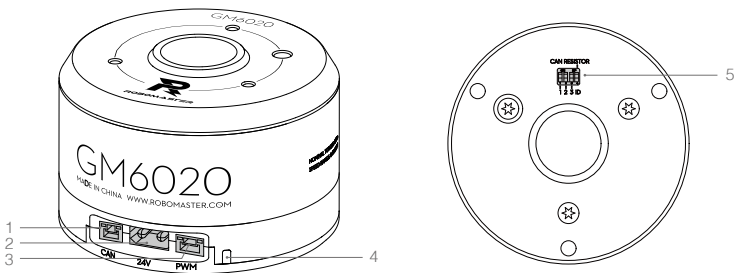


PWM Cable ×1



## Overview

### GM6020 Motor



#### 1. CAN Port

Connects to the external device and receives the CAN control signal to give feedback to the motor's status. The bitrate of the CAN bus is 1 Mbps.

#### 2. Power Port

Connects to a power outlet with a rated voltage of 24 V using the XT30 power cable to provide power to the motor.

#### 3. PWM Port

Connects to the PWM port on an external device using the PWM cable to control the motor's rotational speed and position (analog servo mode). It can also connect to a USB to serial converter to your computer with the provided PWM cable to set parameters or update the motor's firmware via RoboMaster Assistant.

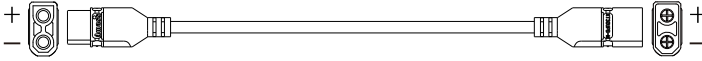
#### 4. Status LED

Indicates the motor's operating status. Refer to "Status LED and DIP Switch" for more details.

#### 5. DIP switch

Set the motors' ID and enable or disable the CAN terminal resistance. Refer to "Status LED and DIP Switch" for more details.

## XT30 Power Cable



## CAN Cable



A: CAN\_H (Red) B: CAN\_L (Black)

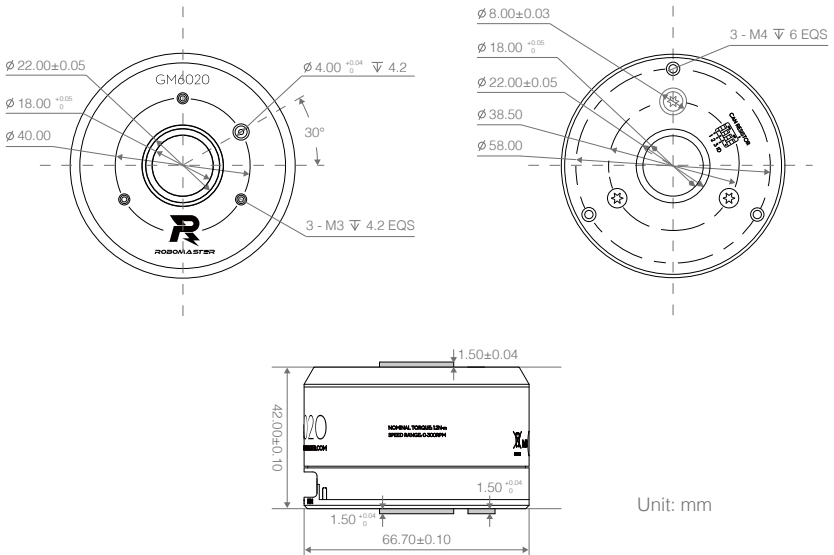
## PWM Cable



A: PWM/RX (White) B: TX (Grey) C: GND (Black)

## Mounting the Motor

Refer to the dimensions below to mount the motor to an appropriate platform.



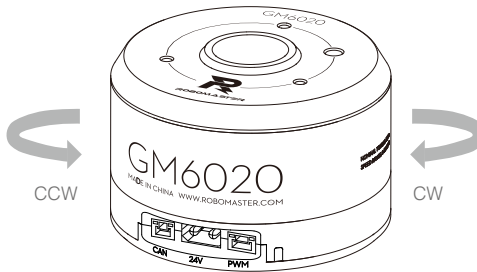
- 
- ⚠ The motor rotor is outfitted with M3 mounting holes at a depth of 4 mm while the motor stator is outfitted with M4 holes at a depth of 6 mm. Use appropriately-sized screws to mount properly and avoid damage.
- 

On the top and bottom of the motor there is a boss, with an inner diameter of 18 mm and an outer diameter of 22 mm. The bosses can help to attach other devices to the motor.

Additionally, on the top of the motor is a blind hole with a diameter of 4 mm and a depth of 4.2 mm. On the bottom of the motor there is also a boss, with an inner diameter of 8 mm and a height of 1.5mm. Both the blind hole and the boss can help protect the screws from being damaged and also help locate when mounting.

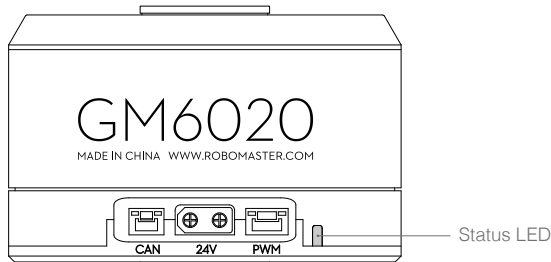
- 
- ⚠ Make sure to keep the motor away from strong electromagnetic environments and magnetic materials, like iron. Otherwise, the motor will vibrate or may even malfunction.
- 

## Motor Rotation Direction



When viewed from the top of the output axis: counterclockwise rotation (CCW) is called the positive direction (+) and clockwise rotation (CW) is called the reverse direction (-).

## Status LED and DIP Switch



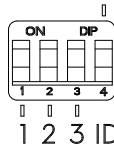
## Status LED Description

The status LED is used to indicate the motor's operational status. In situations that indicate warning and abnormal working conditions, the LED will only indicate the abnormal working condition. In situations that indicate multiple warning or abnormal working conditions, the LED will only indicate the condition that emits the least amount of blinks. Note: the driver automatically cuts off the output stream when it is in abnormal status.

Normal		Description
Blinks green N times every second	The number of blinks indicate the current ID of the motor	
Blinks green slowly	PWM communication is normal	
Solid green	PWM signal is being calibrated	
Warning		Description
Blinks orange once every second	The temperature of motor is higher than 212° F (100° C)	
Blinks orange twice every second	More than one motor share the same ID connected to the CAN bus	
Blinks orange three times every second	PWM signal cannot be detected	
Blinks orange four times every second	Temperature sensor is abnormal	
Blinks orange quickly	PWM signal calibration is failed	
Abnormal		Description
Blinks red once every second	The voltage of the power supply is too high	
Blinks red four times every second	The temperature of motor is higher than 257° F (125° C)	

## DIP Switch

### CAN RESISTOR



### ID Setting

The first three bits refer to Bit0, Bit1, and Bit2 which are used to control the motors' ID. Toggling the bit to the ON position is recorded as 1 while the off position is recorded as 0.

Bit[2:0] is the ID value of the motor, which will affect the identifier of the CAN communication. Their corresponding relationships are shown as below:

Bit[2:0]	000	001	010	011	100	101	110	111
Motor ID	Invalid	1	2	3	4	5	6	7
Feedback identifier		0x205	0x206	0x207	0x208	0x209	0x20A	0x20B
Control identifier		0x1FF			0x2FF			

### CAN Resistance Setting

The fourth bit controls if the CAN terminal resistance should be enabled or not. Toggle it to the ON position to enable the resistance.

# CAN Communication Protocol

## Motor Receiving Message Format

Users send command message to the motor to control the voltage output. The controllable voltage range is -30000~0~30000.

Identifier: 0x1FF                      Frame type: Standard  
 Frame format: DATA                  DLC: 8 Bytes

Data Field	Description	Motor ID
DATA[0]	Controls the voltage value in higher order byte (8 bits)	1
DATA[1]	Controls the voltage value in lower order byte (8 bits)	
DATA[2]	Controls the voltage value in higher order byte (8 bits)	2
DATA[3]	Controls the voltage value in lower order byte (8 bits)	
DATA[4]	Controls the voltage value in higher order byte (8 bits)	3
DATA[5]	Controls the voltage value in lower order byte (8 bits)	
DATA[6]	Controls the voltage value in higher order byte (8 bits)	4
DATA[7]	Controls the voltage value in lower order byte (8 bits)	

Identifier: 0x2FF                      Frame type: Standard  
 Frame format: DATA                  DLC: 8 Bytes

Data Field	Description	Motor ID
DATA[0]	Controls the voltage value in higher order byte (8 bits)	5
DATA[1]	Controls the voltage value in lower order byte (8 bits)	
DATA[2]	Controls the voltage value in higher order byte (8 bits)	6
DATA[3]	Controls the voltage value in lower order byte (8 bits)	
DATA[4]	Controls the voltage value in higher order byte (8 bits)	7
DATA[5]	Controls the voltage value in lower order byte (8 bits)	
DATA[6]	Null	Null
DATA[7]	Null	

## Motor Sending Message Format

The format in which the motor sends feedback data to the CAN bus.

Identifier: determined by 0x204+ driver ID      Frame type: Standard  
 Frame format: DATA                                  DLC: 8 Bytes

Data Field	Description
DATA[0]	Controls the rotor mechanical angle in higher order byte (8 bits)
DATA[1]	Controls the rotor mechanical angle in lower order byte (8 bits)
DATA[2]	Controls the rotational speed in higher order byte (8 bits)
DATA[3]	Controls the rotational speed in lower order byte (8 bits)
DATA[4]	Actual torque current in higher order byte (8 bits)
DATA[5]	Actual torque current in lower order byte (8 bits)
DATA[6]	Motor temperature
DATA[7]	Null



Sending frequency: 1KHz  
Rotor mechanical angle value range: 0 ~ 8191  
Rotor speed value unit: rpm

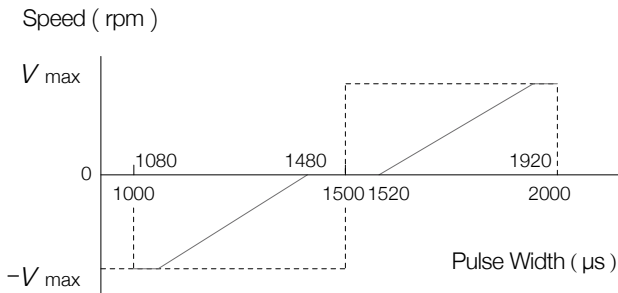
## PWM Signal Description

### PWM signal control

A PWM signal with an input frequency of 50Hz and a pulse width of 1000-2000  $\mu$  s. Users can switch between speed control mode and position control mode inside RoboMaster Assistant. (Position control mode is selected by default).

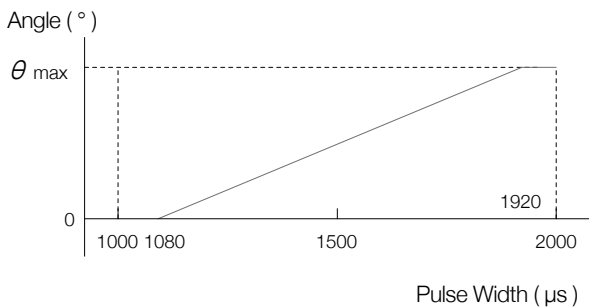
#### Speed Control Mode

In this mode, the motor can be controlled to rotate continuously in two directions. The diagram below describes the mapping between PWM pulse width and speed.



#### Position Control Mode

In this mode, the motor can be simulated as servo. The diagram below shows the mapping between PWM pulse width and position. The center point and the rotational angle range can be set inside RoboMaster Assistant.

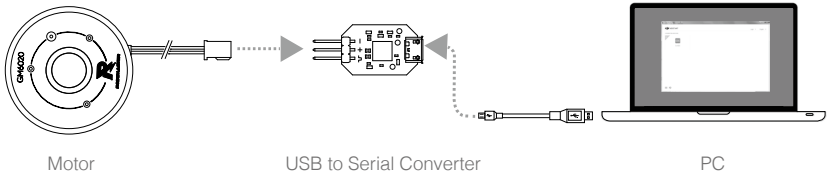


## PWM Signal Calibration

1. Connect the motor and a PWM-supported device via the provided PWM cable.
2. Adjust the pulse width to the maximum (1900~2100 $\mu$ s) and power on the motor. The PWM signal calibration starts with the status LED being solid green.
3. Adjust the pulse width to the minimum (900~1100 $\mu$ s) within 3 seconds. The motor driver will record the pulse width figure, and then enters normal working mode if the calibration is successful, with the status LED blinking green slowly. If calibration fails, the status LED will blink orange quickly and the motor's parameters will not be changed.

## Using RoboMaster Assistant

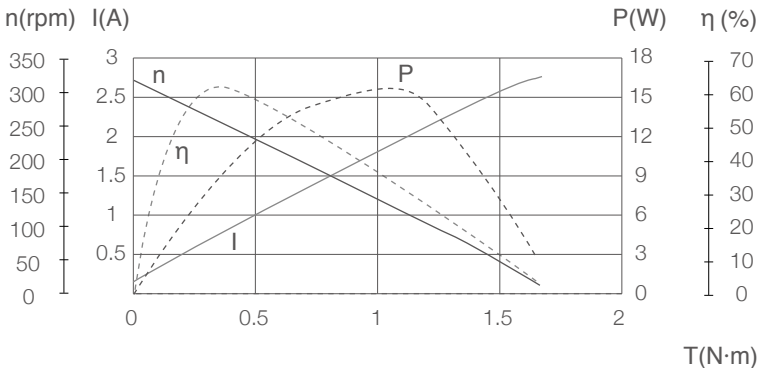
Configure the motor or update its firmware using a USB to serial converter via RoboMaster Assistant.



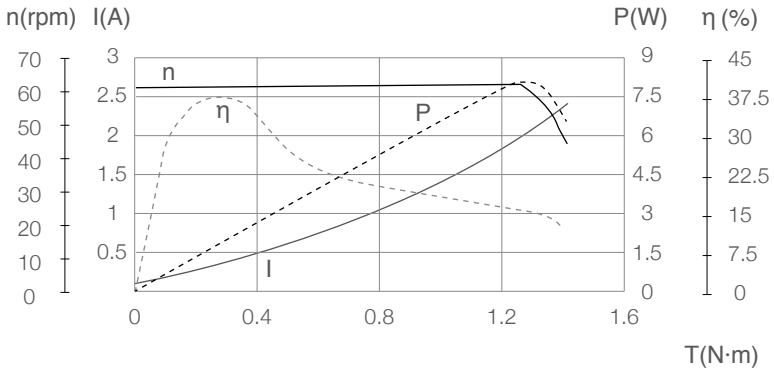
1. Download RoboMaster Assistant from the RoboMaster official website.  
<https://www.robomaster.com/en-US/products/components/general/GM6020#downloads>
2. Connect the motor to the converter using the PWM cable, and then connect the converter to a computer. Make sure the PWM cable is correctly connected; black for GND, grey for TX, and white for PWM/RX.
3. Connect the motor to a power supply.
4. Launch the RoboMaster Assistant and check if the motor is successfully connected to your computer.
5. Click Settings to adjust parameters.
6. Click Firmware Update and select the version you would like for the controller. RoboMaster Assistant will automatically download and update the firmware.

## Performance

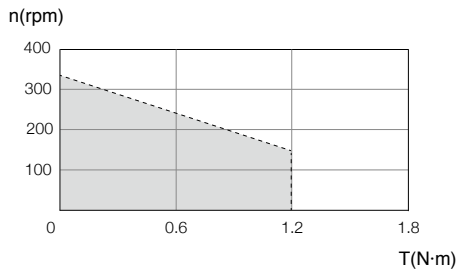
Load characteristics (speed open-loop control)



Load characteristics (speed closed-loop control)



Operating Range



Continuous Operating Range

η – Electrical Efficiency, T – Torque, I – Current, P – Output Power, n – Rotational Speed

The data above was generated in a laboratory setting with an output of 24 V, at the temperature of 77° F (25° C), and under normal dissipation conditions. These figures should be used for reference only. Make sure to control running time properly in accordance with actual working temperature, dissipation, etc.

## Characteristic Parameters

Refer to the parameters below to make proper use of your motor.

Motor specifications at rated voltage	
Maximum no-load speed	320 rpm
No-load current	78 mA
Rated torque (max continuous torque)	1.2N·m
Adjustable speed range	(No-load: 0-320 rpm) (At rated torque: 0-132 rpm)
Torque pulsation factor	3.32%
Locating precision	13 bit
Rated current	1.62 A
Max efficiency	67.85%
Stall Torque (continuous)	0.86N·m
Stall Current (continuous)	0.90 A

Motor Characteristic Parameters	
Rated voltage	DC 24 V
Torque constant	741 mN·m/A
Speed constant	13.33 rpm/V
Speed/Torque Gradient	156 rpm/(N·m)
Mechanical Time Constant	3 ms
Phase Resistance	1.8 Ω
Phase Inductance	5.78 mH
Operating Temperature Range	32°~ 131 ° F (0°~55° C)
Max Permissible Winding Temperature	257° F (125° C)
Number of Pole Pairs	10
Phase Number	3
Maximum radial load of bearing(dynamic load)	3.5 KN
Basic static radial load of bearing	2.2 KN
Motor weight	Approx. 468 g
Dimensions	Hallow shaft inner diameter: 18 mm Motor diameter: 66.7 mm Total height: 45 mm
Cables' length	XT30 power cable: 500 mm CAN cable: 500 mm PWM cable: 500 mm

DJI Support

<http://www.dji.com/support>

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