# 130 Brushed High Speed Mini DC Motor

This all metal casing permanent magnet field motors have carbon brushes, hardened steel shaft, lubricated for life bearings and internal suppression for EMC emission. They are ideal for low cost applications requiring efficient motors, such as for movement or pumping.

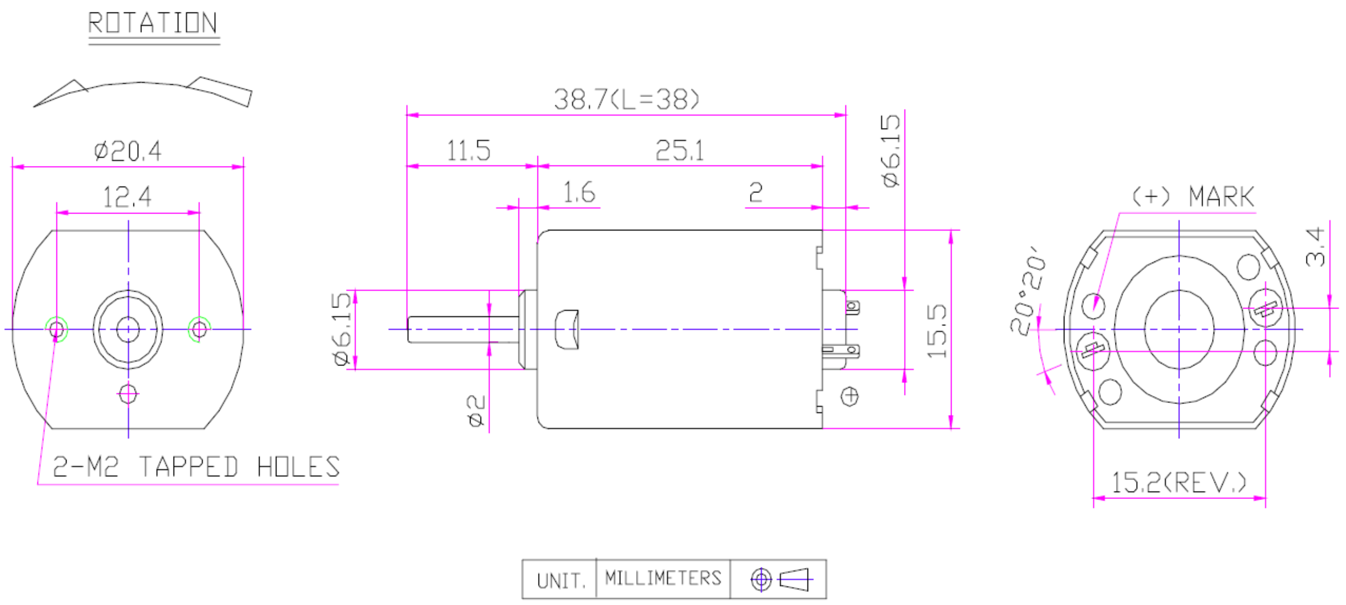
**SKU: FAM1072**

## Specifications:

- Motor Type: 130.
- Shaft Diameter: Ø2.0mm.
- Shaft Type: Round.
- Shaft Length: 11mm.
- Input Voltage: 2~3.7VDC.
- Operating Current: 1.0A@3.7V.
- No Load Speed: 26,000RPM @ 3.7V.
- Dimensions: (Ø20x25) mm
- Electrical Connection: Terminal.
- Weight: 25g.

## Mechanical Dimension:

**Unit: mm**



# Application Note: Useful Motor/Torque Equations

Force (Newtons)
F = m x a
m = mass (kg)
a = acceleration (m/s2)

Motor Torque (Newton-meters)
T = F x d
F = force (Newtons)
d = moment arm (meters)

Power (Watts)
P = I x V
I = current (amps)
V = voltage (volts)

P = T x $\omega$
T = torque (Newton-meters)
$\omega$ = angular velocity (radian/second)

Unit Conversions
Length (1 in = 0.0254 m)
Velocity (1 RPM = 0.105 rad/sec)
Torque (1 in-lb = 0.112985 N-m)
Power (1 HP = 745.7 W)

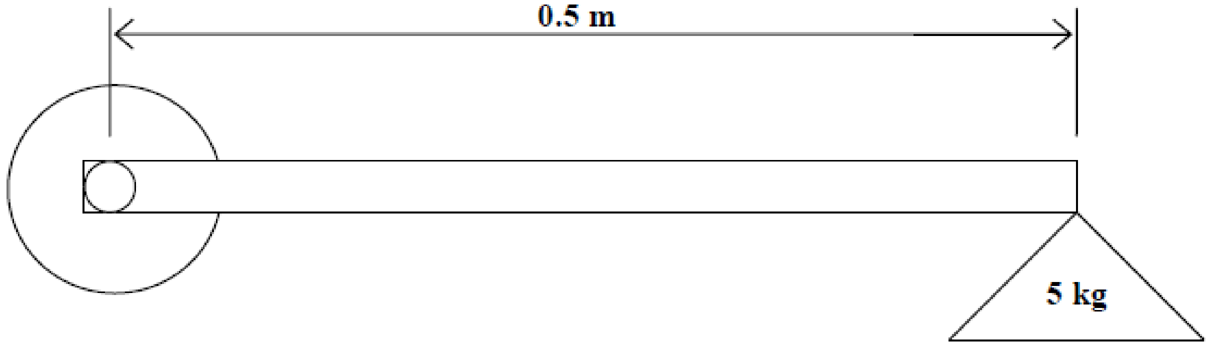
**Example 1**

Determine if the following motor can be used to lift a 5-kg load using a 0.5-m lever arm.

*Merkle-Korff Gearmotor specifications*

Stall Torque = 40 in-lb

Stall Current = 3.5 amps




Solution

Convert Stall Torque from in-lb to N-m

1 in-lb = 0.112985 N-m

40 in-lb = 40 x 0.112985 N-m = 4.5194 N-m

Calculate the Force required to lift the 5-kg load

F = m x a = 5 kg x 9.81 m/s2 = 49.05 N

Calculate the Torque required to lift the Force with the lever arm

T = F x d = 49.05 N x 0.5 m = 24.525 N-m

> We cannot perform the lift with this set-up, because the stall torque is smaller than the torque required for the lift. We must either shorten the length of the lever arm, or we must choose another motor with a higher stall torque to perform this operation.

**Example 2**
Using the same motor as in Example 1 with a 12-V power supply:
a) Calculate the power used by the motor to rotate a 5-kg load at 50 RPM using a 3-inch lever arm.
b) Calculate the current draw from the battery to perform this operation.

Solution
Convert inches to meters:
1 in = 0.0254 m
3 in = 0.0762 m

Calculate the Force required to lift the 5-kg load:
F = m x a = 5 kg x 9.81 m/s2 = 49.05 N

Calculate the Torque required for this operation:
T = F x d = 49.05 N x 0.0762 m = 3.738 N-m

> Note- This toque is lower than the motor's stall torque, so this operation is possible using the specified motor, mass, and lever arm

Convert RPM to radians/second:
1 RPM x $2\pi$ rad/rev x 1 min/60 sec = 0.105 rad/sec
$\omega$ = 50 rev/min x 0.105 rad/sec/RPM = 5.25 rad/sec

Calculate the Power required for this operation:

P = T x $\omega$ = 3.738 N-m x 5.25 rad/sec = 19.622 W

Calculate the Current draw from the battery (use the supply voltage in this calculation):

I = P/V = 19.622 W/12 V = 1.635 Amps

Note- This current is smaller than the maximum allowable current draw of the motor.

**Example 3**
Determine the motor torque necessary to power the robot drive wheels.

Solution
The following approach is merely one way to solve this problem. Several exist.
Assume the robot will be powered by two powered drive wheels and supported by two freely rotating caster wheels. Robot weight is denoted by W and for this simple example we'll assume the weight is distributed evenly over all 4 wheels, as shown in Figure 1 below.

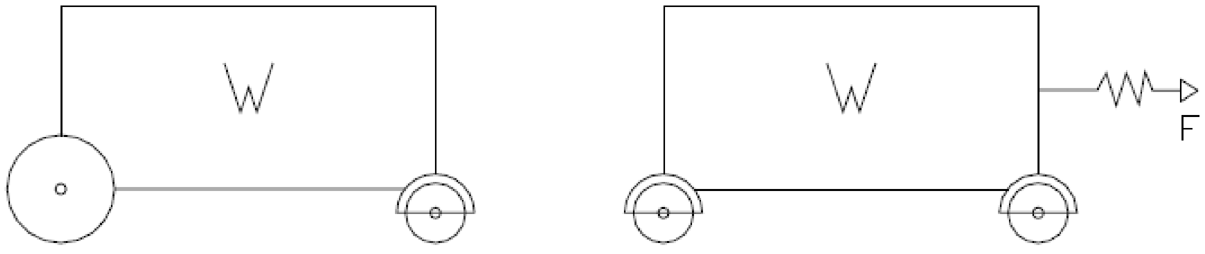


Figure 1 Figure 2

Thinking logically about the problem, we could model the robot as having 4 of the identical caster wheels (Figure 2) and the force required to propel the robot is simply the force needed to start the robot moving (this could be measured empirically with a force scale). The problem is we haven't yet built the robot so testing it in this manner is not an option. We need to calculate the force (and hence motor torque) required to move the robot **before** we build anything.
Looking closer at the caster wheel we can see the actual friction that must be overcome to put the robot in motion. Fw is the friction force between the wheel and the floor and Fa is the friction force between the wheel and the axle. Tw and Ta are the respective torques between the wheel and floor and the wheel and axle.

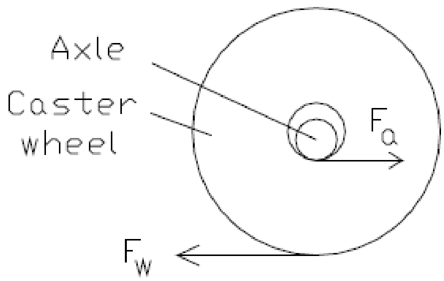


Figure 3

Fa = W/2 * μa
Ta = Fa * Ra
Fw = W/2 * μw
Tw = Fw * Rw
Tw is the *maximum* torque the wheel can transmit to the ground before it slips.

Our goal is to find a realistic range for Tm, the motor torque.
As calculated above, Tw would be the *maximum* amount of torque the motor could transfer to the ground before the wheel begins to slip (ie Tm, max).
Typically, we desire μw > μa, so the wheel does not slip/slide across the floor, but rather rolls. We can easily look up the μa value for the axle/wheel materials in contact. Knowing μa and the weight of the vehicle, Fa can be computed. This is the *minimum* amount of force we would have to provide at the wheel/axle interface to overcome the friction between the two. To relate the computed axle force Fa to the *minimum* amount of

wheel torque required to move the robot, we would use the "virtual radius" of the wheel/axle combination, which is computed as follows:

Rv = Rw – Ra

This is the fictitious radius about which Fa would act to rotate the wheel about the tangent point in contact with the ground at any instant, as shown in Figure 4 below.

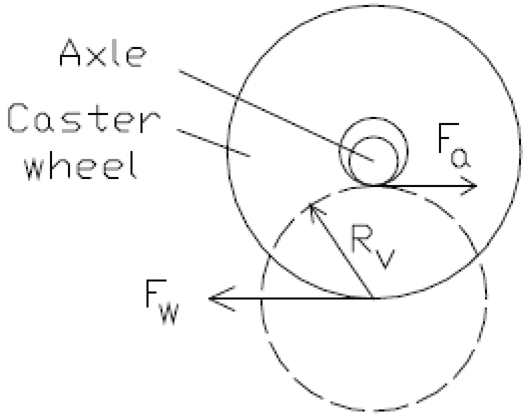



Figure 4

Therefore our equation for the *minimum* amount of torque the motor must transfer to the ground before the wheel begins to roll (thus causing the robot to move) would be:

Tm (min = Fa * Rv = Fa * (Rw – Ra)

In summation, Tm, min ≤ Tm ≤ Tm, max or alternatively, Fa * (Rw – Ra) ≤ Tm ≤ Fw * Rw

## Appendix: Motor Data Calculation:

It is very important to measure different electrical and mechanical parameters of your motor and calculate unknown values using the following helpful formulas. We will use the International System of Units (SI). This is modern metric system that is officially accepted in electrical engineering in the USA.

One of the most important laws of physics is the fundamental Ohm's Law. It states that current through the conductor is directly proportional to applied voltage and is expressed as:

$$I = V / R$$

where I – current, measured in amperes (A);
V – applied voltage, measured in volts (V);
R – resistance, measured in ohms (Ω).

This formula could be used in many cases. You may calculate the resistance of your motor by measuring the consumed current and applied voltage. For any given resistance (in the motors it is basically the resistance of the coil) this formula explains that the current can be controlled by applied voltage.

The consumed electrical power of the motor is defined by the following formula:

$$P_{in} = I * V$$

where $P_{in}$ – input power, measured in watts (W);
I – current, measured in amperes (A);
V – applied voltage, measured in volts (V).

Motors supposed to do some work and two important values define how powerful the motor is. It is motor speed and torque – the turning force of the motor. Output mechanical power of the motor could be calculated by using the following formula:

$$P_{out} = \tau * \omega$$

where $P_{out}$ – output power, measured in watts (W);
τ – torque, measured in Newton meters (N•m);
ω – angular speed, measured in radians per second (rad/s).

It is easy to calculate angular speed if you know rotational speed of the motor in rpm:

$$\omega = rpm * 2\pi / 60$$

where ω – angular speed, measured in radians per second (rad/s);
rpm – rotational speed in revolutions per minute;
π – mathematical constant pi (3.14).
60 – number of seconds in a minute.

If the motor has 100% efficiency all electrical power is converted to mechanical energy. However such motors do not exist. Even precision made small industrial motors such as one we use as a generator in generator kit have maximum efficiency of 50-60%. Motors built from our kits usually have maximum efficiency of about 15% (see *Experiments* section on how we estimated this).

Don't be disappointed with 15% maximum efficiency. All our kits are intended for education and not designed for real applications. This efficiency is not bad at all – it is actually much better than most of other self made designs on Internet can provide. The motors have enough torque and speed to do all kinds of experiments and calculations.

Measuring the torque of the motor is a challenging task. It requires special expensive equipment. Therefore we suggest calculating it.

Efficiency of the motor is calculated as mechanical output power divided by electrical input power:

$$\mathbf{E = P_{out} / P_{in}}$$

therefore

$$\mathbf{P_{out} = P_{in} * E}$$

after substitution we get

$$\boldsymbol{\tau * \omega = I * V * E}$$

$$\boldsymbol{\tau * rpm * 2\pi / 60 = I * V * E}$$

and the formula for calculating torque will be

$$\boldsymbol{\tau = (I * V * E *60) / (rpm * 2\pi)}$$

Connect the motor to the load. Using the motor from generator kit is the best way to do it. Why do you need to connect the motor to the load? Well, if there is no load – there is no torque.

Measure current, voltage and rpm. Now you can calculate the torque for this load at this speed assuming that you know efficiency of the motor.

Our estimated 15% efficiency represents maximum efficiency of the motor which occurs only at a certain speed. Efficiency may be anywhere between zero and the maximum; in our example below 1000 rpm may not be the optimal speed so the for the sake of calculations you may use 10% efficiency (E = 0.1).

Example: speed is 1000 rpm, voltage is 6 Volts, and current is 220 mA (0.22 A):

$$\boldsymbol{\tau = (0.22 * 6 * 0.1 * 60) / (1000 * 2 * 3.14) = 0.00126\ N \bullet m}$$

As the result is small usually it is expressed in milliNewton meters (mN•m). There is 1000 mN•m in 1 N•m, so the calculated torque is 1.26 mN•m. It could be also converted further to still common gram force centimeters (g-cm) by multiplying the result by 10.2, i.e. the torque is 12.86 g-cm.

In our example input electrical power of the motor is 0.22 A x 6 V = 1.32 W, output mechanical power is 1000 rpm x 2 x 3.14 x 0.00126 N•m /60 = 0.132 W.

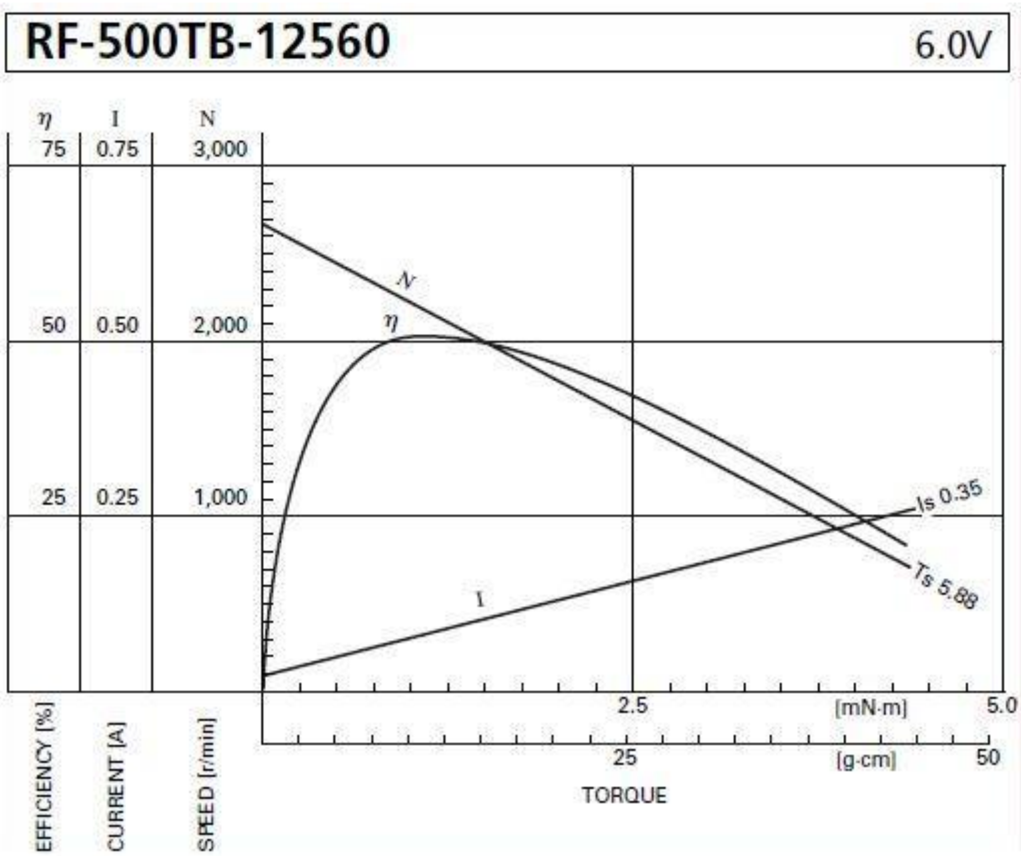
Motor torque changes with the speed. At no load you have maximum speed and zero torque. Load adds mechanical resistance. The motor starts to consume more current to overcome this resistance and the speed decreases. If you increase the load at some point motor stops (this is called stall). When it occurs the torque is at maximum and it is called stall torque. While it is hard to measure stall torque without special tools you can find this value by plotting speed-torque graph. You need to take at least two measurements with different loads to find the stall torque.

How accurate is the torque calculation? While voltage, current and speed could be accurately measured, efficiency of the motor may not be correct. It depends on the accuracy of your assembly, sensor position, friction, alignment of the motor and generator axles etc.

Speed, torque, power and efficiency of the motors are not constant values. Usually the manufacturer provides the following data in a table like this one (sample data from one of the motors used in generator kit):

| MODEL | VOLTAGE | | NO LOAD | | AT MAXIMUM EFFICIENCY | | | | | STALL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OPERATING RANGE | NOMINAL | SPEED | CURRENT | SPEED | CURRENT | TORQUE | | OUTPUT | TORQUE | | CURRENT |
| | | | r/min | A | r/min | A | mN·m | g·cm | W | mN·m | g·cm | A |
| RF-500TB-12560 | 1.5~12.0 | 6V CONSTANT | 2700 | 0.020 | 2180 | 0.084 | 1.13 | 11.6 | 0.26 | 5.88 | 60 | 0.35 |

Also the manufacturers usually provide power curves for the motor at nominal voltage:




These curves are generated by plotting motor speed, consumed current, and efficiency as functions of the motor torque. Sometimes there might be also a curve representing mechanical output power.

As you can see from the graph speed and current are linear functions of torque so you might need only two measurements to draw these graphs. Efficiency and power will need more data. Usually for small motors maximum power is at 50% of stall torque (approximately 50% of no load speed). Maximum efficiency may be 10-30% of motor stall torque (70-90% of no load speed).

While it is technically better to follow the same format and create similar curves for your motor it is not absolutely necessary for a good science project. You may take all measurements, calculate unknown values and plot the graphs where for example speed and torque are represented as functions of applied voltage or current etc.

Simple formulas and calculations described here are essential for calculating most common motor parameters. However this is a simplified approach that does not take into consideration many factors. If you want to extend your research further – see Links section and search the Internet. There is tons of information with more complex calculations.

# Motors, Fans and Accessories Selection

## 40x40x10 mm DC Brushless Cooling Fan

Ultra quiet powerful brushless DC fan, quiet sleeve-bearing design. Specialized design, professional made, stable performance. Operating Temperature: -10 C to +60C. Long Life Expectancy.

| | | |
|---|---|---|
| **EMH-1071** | **GDT4010S12B** | **RM 6.50** |

## GA12-N20 Geared Mini DC Motor

This is a DC Mini Metal Gear Motor, ideal for making robots. Light weight, high torque and low RPM. Fine craftsmanship, durable, not easy to wear. Widely used on boat, model car, robotic, home appliances, linear motion control.

| | | |
|---|---|---|
| **EMH-1176** | **GA12-N20** | **RM 18.50** |

## 30x30x10 mm DC Brushless Cooling Fan

Ultra quiet powerful brushless DC fan, quiet sleeve-baring design. Specialized design, professional made, stable performance. Operating Temperature: -10 C to +60C. Long Life Expectancy.

| | | |
|---|---|---|
| **EMH-1070** | **GDT3010S12B** | **RM 7.50** |

## Nema23 Bipolar/Unipolar Stepper Motor 1.0A

A stepper motor to satisfy all your 3D-Printer, robotics, Linear Motion projects needs! This 6-wire uni-polar/bipolar stepper motor has 1.8° per step for smooth motion and a nice holding torque.

| | | |
|---|---|---|
| **EMH-1179** | **23HS2610** | **RM 110.00** |

## 1.2A Nema 17 Stepper Motor

A stepper motor to satisfy all your 3D-Printer, robotics, Linear Motion projects needs! This 4-wire bipolar stepper has 1.8° per step for smooth motion and a nice holding torque.

| | | |
|---|---|---|
| **EMH-1016** | **42HS40-1204D** | **RM 44.50** |

## 1.7A Nema 17 Stepper Motor

A stepper motor to satisfy all your 3D-Printer, robotics, Linear Motion projects needs! This 4-wire bipolar stepper has 1.8° per step for smooth motion and a nice holding torque.


| | | |
|---|---|---|
| **EMH-1181** | **17HS-4401SD** | **RM 47.00** |

## SG90 Tower Pro Gear Micro Servo Motor

Tiny and lightweight with high output power. Servo can rotate approximately 180 degrees (90 in each direction). Good for beginners who want to make stuff move without building a motor controller with feedback & gear box.

| | | |
|---|---|---|
| **EMH-1140** | **TPSG90S** | **RM 7.40** |

## Nema-17 Planetary Geared Stepper Motor

This high precision NEMA17 Stepper motor has an integrated Planetary Gearbox with 1:5.18 gear ratio, the resolution can reach 0.35°step angle.

| | | |
|---|---|---|
| **EMH-1173** | **42BYGP40P** | **RM 185.00** |

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