



## Data Specs

### Nema17 Planetary 1:5.18 Geared Stepper Motor

This stepper motors integrated with Planetary or Spur gearbox, it created huge torque at lower speed. This high precision NEMA 17 Stepper motor has Gearbox with gear ration of 1:5.18. The resolution can reach 0.35° step angle. It's a good solution in applications that need very low rotation speeds and lots of torque. Commonly use in 3-D printer filament extruder application.



#### Brief Data:

- Manufacturer Part Number: 42BYGP40P160S.
- Motor Type: Bipolar Stepper.
- Gearbox Type: Planetary
- Gear ratio: 1:5.18
- Step Angle: 0.35°.
- Phase Current: 1.6A.
- Phase resistance:  $1.5\Omega \pm 10\%$ .
- Phase Voltage: 2.7V.
- Phase inductance:  $3.2\text{mH} \pm 20\%$ .
- Holding Torque: 230N.cm.
- Max Permissible Torque: 200N.cm.
- Moment Permissible Torque: 400N.cm.
- Number of leads: 4
- Weight: 450 grams.

## Gearbox Specifications

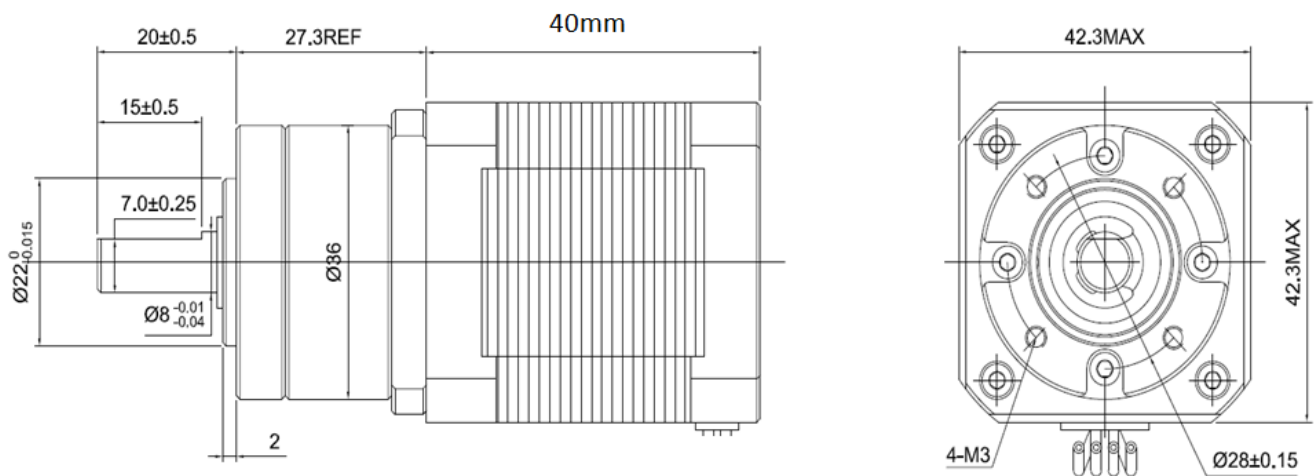
- Gearbox Type: Planetary.
- Gear Ratio: 1:5.18.
- Efficiency: 90%.
- Backlash at No-load:  $\leq 1^\circ$ .
- Max.Permissible Torque: 200N.cm(283oz-in).
- Moment Permissible Torque: 400N.cm(566oz-in).
- Shaft Maximum Axial Load: 50N.
- Shaft Maximum Radial Load: 100N.

## Physical Specifications

- Frame Size: 42 x 42mm.
- Motor Length: 40mm.
- Gearbox Length: 27.3mm.
- Shaft Diameter:  $\Phi 8$ mm.
- Shaft Length: 20mm.
- D-cut Length: 15mm.

## Dimension Drawing:

Unit: mm



## How to choose a geared stepper motor?

- Selecting a geared stepper motor will result in increasing the output torque and decreasing the speed. Simply, the Gearbox Output Speed is:

$$\text{Output Speed} = \frac{\text{Motor Speed}}{\text{Gear Ratio}}$$

- The gearbox output torque will depend on many factors, it can be calculated by:

$$\text{Output Torque} = \text{Motor Output Torque} \times \text{Gear Ratio} \times \text{Gearbox Efficiency}$$

- The Gearbox Step Angle can be determined by:

$$\text{Gearbox Step Angle} = \frac{\text{Motor Step Angle}}{\text{Gear Ratio}}$$

- When choosing a stepper motor with a gearbox, keep in mind that the gearbox Max Permissible Torque, beyond which the gearbox could become damaged.

## Application Note: Useful Motor/Torque Equations

### Force (Newtons)

$$F = m \times a$$

m = mass (kg)

a = acceleration (m/s<sup>2</sup>)

### Motor Torque (Newton-meters)

$$T = F \times d$$

F = force (Newtons)

d = moment arm (meters)

### Power (Watts)

$$P = I \times V$$

I = current (amps)

V = voltage (volts)

$$P = T \times \omega$$

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)

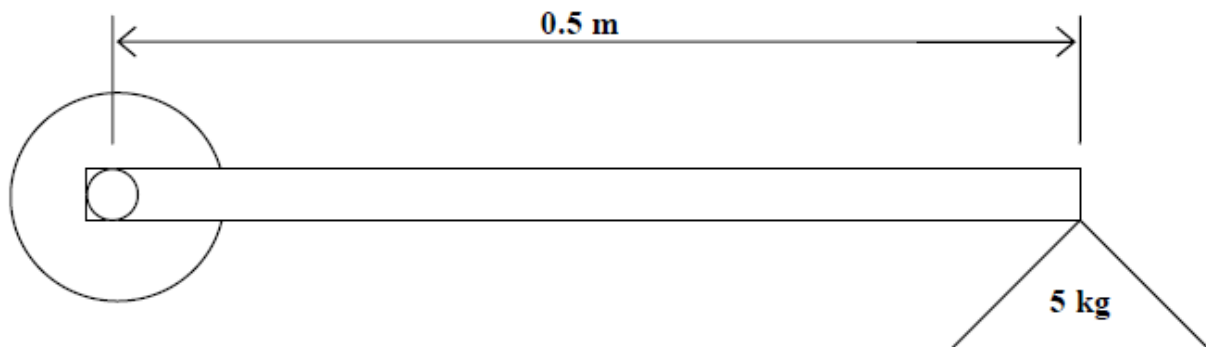
### **Example 1**

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

$$1 \text{ in-lb} = 0.112985 \text{ N-m}$$

$$40 \text{ in-lb} = 40 \times 0.112985 \text{ N-m} = 4.5194 \text{ N-m}$$

Calculate the Force required to lift the 5-kg load

$$F = m \times a = 5 \text{ kg} \times 9.81 \text{ m/s}^2 = 49.05 \text{ N}$$

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

$$T = F \times d = 49.05 \text{ N} \times 0.5 \text{ m} = 24.525 \text{ N-m}$$

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:

$$1 \text{ in} = 0.0254 \text{ m}$$

$$3 \text{ in} = 0.0762 \text{ m}$$

Calculate the Force required to lift the 5-kg load:

$$F = m \times a = 5 \text{ kg} \times 9.81 \text{ m/s}^2 = 49.05 \text{ N}$$

Calculate the Torque required for this operation:

$$T = F \times d = 49.05 \text{ N} \times 0.0762 \text{ m} = 3.738 \text{ N-m}$$

Note- This torque 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:

$$1 \text{ RPM} \times 2\pi \text{ rad/rev} \times 1 \text{ min}/60 \text{ sec} = 0.105 \text{ rad/sec}$$

$$\omega = 50 \text{ rev/min} \times 0.105 \text{ rad/sec/RPM} = 5.25 \text{ rad/sec}$$

Calculate the Power required for this operation:

$$P = T \times \omega = 3.738 \text{ N-m} \times 5.25 \text{ rad/sec} = 19.622 \text{ W}$$

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

$$I = P/V = 19.622 \text{ W}/12 \text{ V} = 1.635 \text{ Amps}$$

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.

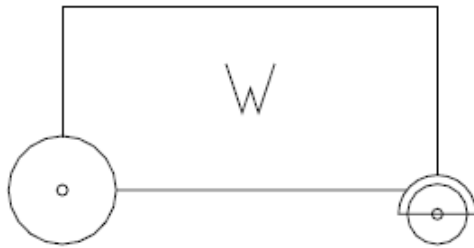


Figure 1

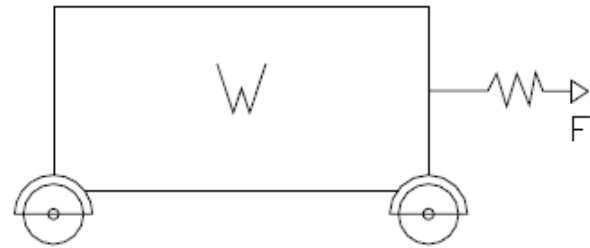


Figure 2

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.  $F_w$  is the friction force between the wheel and the floor and  $F_a$  is the friction force between the wheel and the axle.  $T_w$  and  $T_a$  are the respective torques between the wheel and floor and the wheel and axle.

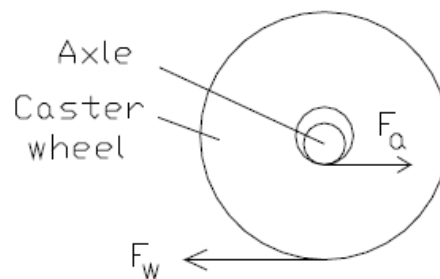


Figure 3

$$F_a = W/2 * \mu_a$$

$$T_a = F_a * R_a$$

$$F_w = W/2 * \mu_w$$

$$T_w = F_w * R_w$$

$T_w$  is the *maximum* torque the wheel can transmit to the ground before it slips.

Our goal is to find a realistic range for  $T_m$ , the motor torque.

As calculated above,  $T_w$  would be the *maximum* amount of torque the motor could transfer to the ground before the wheel begins to slip (ie  $T_m$ , max).

Typically, we desire  $\mu_w > \mu_a$ , so the wheel does not slip/slide across the floor, but rather rolls. We can easily look up the  $\mu_a$  value for the axle/wheel materials in contact. Knowing  $\mu_a$  and the weight of the vehicle,  $F_a$  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  $F_a$  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:

$$R_v = R_w - R_a$$

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

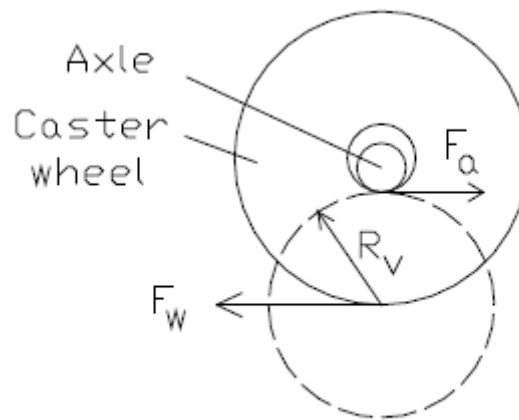


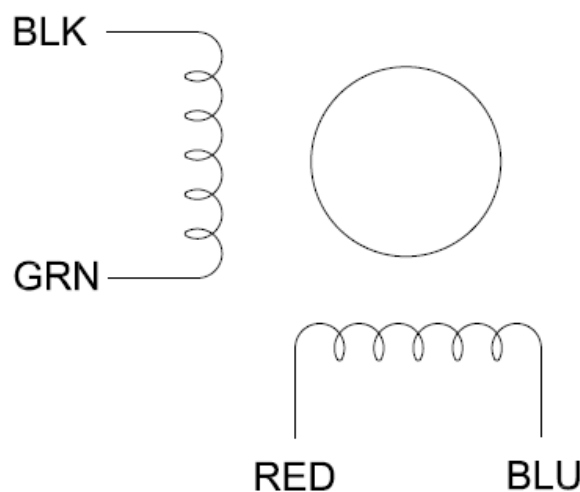
Figure 4

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:

$$T_m (\text{min}) = F_a * R_v = F_a * (R_w - R_a)$$

In summation,  $T_m, \text{min} \leq T_m \leq T_m, \text{max}$  or alternatively,  $F_a * (R_w - R_a) \leq T_m \leq F_w * R_w$

**Connection Diagram:**



Wire Color	Black	Green	Red	Blue
Board Connector	A	C	B	D





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