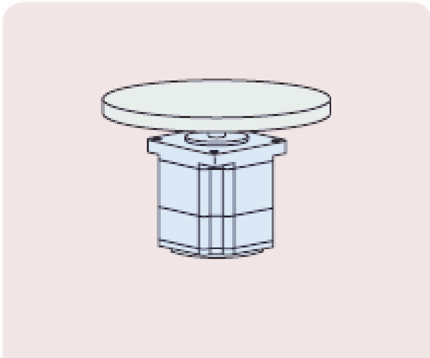
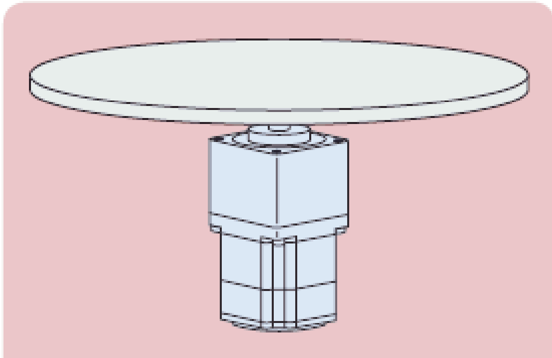
How to Address Increased Loads in Both Size and Weight





Increasing the size and weight will increase the inertia of the load and the torque required to move the load. Gearing is a great option for overcoming large inertia loads as it will decrease the reflected inertia on the motor by the gear ratio squared.

$$J_M = J_G \left(\frac{1}{GR^2} \right)$$

Adding a gear ratio will also increase the amount of torque generated. Typically, the torque produced is equal to the motor torque multiplied by the gear ratio and the efficiency of the gear. However, there are instances when the output torque is limited based on other mechanical reasons, such as gear teeth strength, gear case strength, or gear carrier strength.

Tg = Tm x GR x efficiency

There are multiple gear options available for use. The decision on which gear to use will come down to torque, speed, and backlash requirements. A summary of each gear type is listed below.

In order to make the quickest move possible, acceleration torque must be considered. The more torque available to accelerate, the quicker the move can be made. When comparing gears, planetary gears will have more available torque than taper hobbed or spur gears. This is due to the fact that planetary gears can disperse the force among all of the planetary gears versus each gear taking the entire force. Therefore, planetary gears will be able to make the move quicker than taper hobbed or spur gears.

	Gear Type	Features	Frames Sizes	Gear Ratios
Basic	 Spur Gear (SH)	Wide variety of low gear ratios, high-speed operation Offset output shaft	1.10 in. (28 mm) 1.65 in. (42 mm) 2.36 in. (60 mm) 3.54 in. (90 mm)	3.6:1 7.2:1 9:1 10:1 18:1 36:1
Low Backlash	 Taper Hobbed (TH)	Wide variety of low gear ratios, high-speed operation Backlash: 45 arc min Offset output shaft	1.10 in. (28 mm) 1.65 in. (42 mm) 2.36 in. (60 mm) 3.54 in. (90 mm)	3.6:1 7.2:1 9:1 10:1 20:1 30:1
Low Backlash	 Planetary (PL)	High permissible torque Backlash: up to 35 arc min Centered output shaft	1.65 in. (42 mm) 2.36 in. (60 mm)	5:1 10:1 36:1
Low Backlash	 Planetary (PS)	High speed (low gear ratio) High permissible / maximum torque Backlash: 15 arc min Centered output shaft	1.10 in. (28 mm) 1.65 in. (42 mm) 2.36 in. (60 mm) 3.54 in. (90 mm)	5:1 7.2:1 10:1 25:1 36:1 50:1
Non-backlash	 Planetary (PN)	High speed (low gear ratio), high accuracy positioning High permissible/maximum torque Backlash: 3 arc min Centered output shaft	1.10 in. (28 mm) 1.65 in. (42 mm) 2.36 in. (60 mm) 3.54 in. (90 mm)	5:1 7.2:1 10:1 25:1 36:1 50:1
Non-backlash	 Harmonic (HG)	High accuracy positioning High permissible/maximum torque Backlash: 0 arc min Centered output shaft	0.79 in. (20 mm) 1.65 in. (42 mm) 2.36 in. (60 mm) 3.54 in. (90 mm)	50:1 100:1

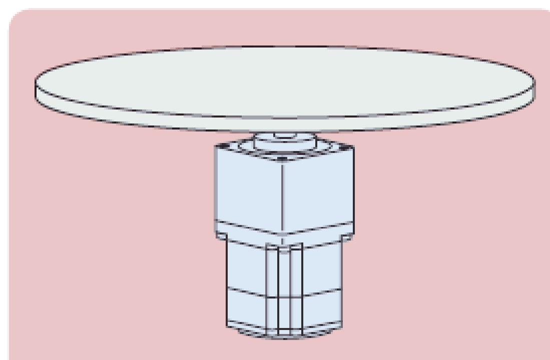
$$T = k\frac{T'}{n}$$

T:

T: Torque applied to each planetary gear (Nm)
T': Total torque transference (Nm)
n: Number of planetary gears
k: Dispersion coefficient

Below is an example on how greater available torque allows for faster acceleration. The taper hobbed gear and the PS planetary gear are used with the 60mm motor in the example.

Sizing Example:



Disk
- 20 inch diameter
- 20 lbs

Motion Profile
- 360° in 1.5 sec
- One direction of motion (CW)

Safety Factor
- 1.5 minimum

System Requirements
- Single phase 115 VAC
- Motor and drive needed

Load Inertia

$$J_t = (1/8)(w \times 16)D^2$$
$$= (1/8) \times (20 \times 16)\ 20^2 = 1.600e+4\ [oz \cdot in^2]$$
$$J_S = (1/8)(w_2 \times 16)D_2^2$$
$$= (1/8) \times (1 \times 16) \times 1^2 = 2.000\ [oz \cdot in^2]$$
$$J_L = J_t + J_s$$
$$= 1.600e+4 + 2.000 = 1.600e+4\ [oz \cdot in^2]$$

In order to keep the load inertia to rotor inertia ratio below 10:1, a gear ratio of at least 40.8 must be used. This eliminates taper hobbed and spur gears from possible solutions. Since the motion only goes clockwise, backlash is not a concern, so we will take a look at the 50:1 PS planetary gear.

Required Speed

$V_m = (\theta / 360)(60 / (t_0 - t_1))$

$= (360 / 360) \times (60 / (1.5 - .375)) = 53.33$ [r/min]

The 50:1 planetary gear has a maximum speed of 60 RPM, so this is still an option.

Acceleration Torque

$T_a = (((J_o \times i^2) + J_L) / 386)(V_m / (9.55 \times t_1))(1/16)$

$= (((.96 \times 50^2) + 1.600e{+}4) / 386) \times (53.33 / (9.55 \times 3.750e{-}1)) \times (1/16) = 44.37$ [lb·in]

$= 710.0$ [oz·in]

Load Torque

$W = W$

$= 20.00 = 20.00$ [lb]

$T_L = W \mu l (1 / (\eta \times 0.01))$

$= 20.00 \times 0.05 \times 1 \times (1 / (90 \times 0.01)) = 1.111$ [lb·in]

$= 17.78$ [oz·in]

The load torque calculated above is based on a 0.05 coefficient of friction, a 1" distance from the center of the table to the support mechanism, and a 90% overall system efficiency.

Required Torque

$T = (T_a + T_L) \times (\text{Safety Factor})$

$= (44.37 + 1.111) \times 1.5 = 68.23$ [lb·in]

$= 1092$ [oz·in]

The required torque is 1092 oz-in or 68.25 lb-in.

Recommended Motor:
RK564AAE-PS50
0-60 RPM
70.625 lb-in permissible torque
177 lb-in maximum torque

1.55 safety factor, but the maximum torque can be used for acceleration and deceleration. This gives a safety factor of 3.89 for this time period.

RK564□AE-PS50/RK564□CE-PS50