Move Profile

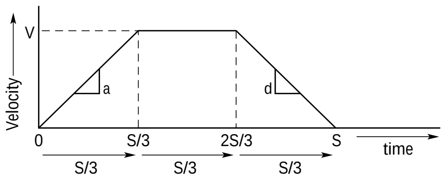
Before calculating torque requirements of an application, you need to know the velocities and accelerations needed. For those positioning applications where only a distance (X) and a time (S) to move that distance are known, the trapezoidal motion profile and formulas given below are a good starting point for determining your requirements. If velocity and acceleration parameters are already known, you can proceed to one of the specific application examples on the following pages.

Move distance X in time S.

Assume that:

1. Distance X/4 is moved in time S/3 (Acceleration)
2. Distance X/2 is moved in time S/3 (Run)
3. Distance X/4 is moved in time S/3 (Deceleration)

The graph would appear as follows:



The acceleration (a), velocity (v) and deceleration (d) may be calculated in terms of the knowns, X and S.

$$a = -d = \frac{2X}{t^2} = \frac{2\left(\frac{X}{4}\right)}{\left(\frac{S}{3}\right)^2} = \frac{\frac{X}{2} \times 9}{S^2} = \frac{4.5X}{S^2}$$

$$v = at = \frac{4.5X}{S^2} \times \frac{S}{3} = \frac{1.5X}{S}$$

Example

You need to move 6" in 2 seconds

$$a = -d = \frac{4.5\text{ (6 inches)}}{\text{(2 seconds)}^2} = 6.75 \frac{\text{inches}}{\text{second}^2}$$

$$v = \frac{1.5\text{ (6 inches)}}{\text{(2 seconds)}} = 4.5 \frac{\text{inches}}{\text{second}}$$

Common Move Profile Considerations

Distance: ____________ Inches of Travel ______________________ revolutions of motor

Move Time: ____ seconds

Accuracy: ____ arcminutes, degrees or inches

Repeatability: ____ arcseconds, degrees or inches

Duty Cycle

on tme: ____ seconds

off time: ____ seconds

Cycle Rate: ____ sec. min. hour

Motor/Drive Selection

Based on Continuous Torque Requirements

Having calculated the torque requirements for an application, you can select the motor/drive suited to your needs. Microstepping motor systems (S Series, Zeta Series OEM650 Series, LN Series) have speed/torque curves based on continuous duty operation. To choose a motor, simply plot total torque vs. velocity on the speed/torque curve. This point should fall under the curve and allow approximately a 50% margin for safety. An S106-178 and an S83-135 curve are shown here.

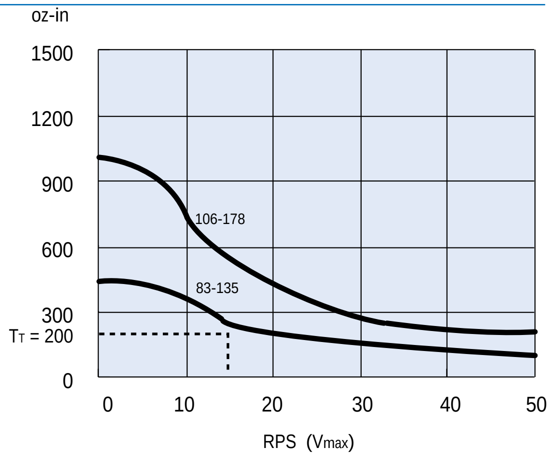
Note: When selecting a ZETA Series product, a 50% torque margin is not required.

Example

Assume the following results from load calculations:

T_F =	25 oz-in	Friction torque
T_A =	175 oz-in	Acceleration torque
T_T =	200 oz-in	Total torque
V =	15 rev/sec	Maximum velocity

You can see that the total torque at the required velocity falls within the motor/drive operating range for both motors by plotting T_T .



The S83-135 has approximately 250 oz-in available at V max (25% more than required). The S106-178 has 375 oz-in available, an 88% margin.

In this case, we would select the S106-178 motor/drive to assure a sufficient torque margin to allow for changing load conditions.

Motor/Drive Selection

Based on peak torque requirements

Servo-based motor/drives have two speed/torque curves: one for continuous duty operation and another for intermittent duty. A servo system can be selected according to the total torque and maximum velocity indicated by the continuous duty curve. However, by calculating the root mean square (RMS) torque based on your duty cycle, you may be able to take advantage of the higher peak torque available in the intermittent duty range.

$$T_{RMS} = \sqrt{\frac{\Sigma Ti^2\ ti}{\Sigma ti}}$$

Where:

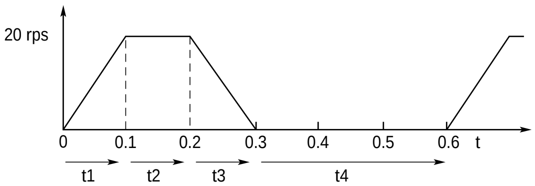
- Ti is the torque required over the time interval ti
- Σ means "the sum of"

Example

Assume the following results from your load calculations.

T_F	= 25 oz-in	Friction Torque
T_A	= 775 oz-in	Acceleration Torque
T_T	= 800 oz-in	Total Torque
V_{max}	= 20 rps	Maximum Velocity

Motion Profile



Duty Cycle

Index 4 revs in 0.3 seconds, dwell 0.3 seconds then repeat.

If you look at the S106-178 speed/torque curve, you'll see that the requirements fall outside the curve.

T_1 = Torque reqired to accelerate the load from zero speed to maximum speed ($T_F + T_A$)

T_2 = Torque required to keep the motor moving once it reaches max speed (T_F)

T_3 = Torque required to decelerate from max speed to a stop ($T_A - T_F$)

T_4 = Torque required while motor is sitting still at zero speed (Ø)

t_1 = Time spent accelerating the load

t_2 = Time spent while motor is turning at constant speed

t_3 = Time spent decelerating the load

t_4 = Time spent while motor is at rest

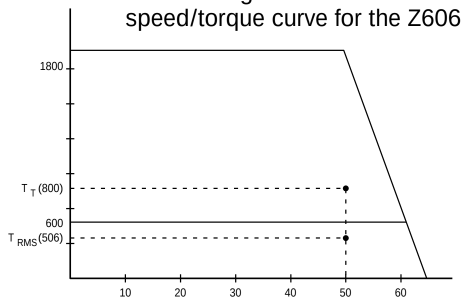
$$T_{RMS} = \sqrt{\frac{T_1^2 t_1 + T_2^2 t_2 + T_3^2 t_3 + T_4^2 t_4}{t_1 + t_2 + t_3 + t_4}}$$

$$= \sqrt{\frac{(800)^2(.1) + (25)^2(.1) + (750)^2(.1) + (0)^2(.3)}{(.1) + (.1) + (.1) + (.3)}}$$

T_{RMS} = 447 oz. in.

Now plot T_{RMS} and T_T vs. T_{max} on the speed/torque curve.

The drawing below resembles the speed/torque curve for the Z606 motor.



The Z606 motor will meet the requirements. RMS torque falls within the continuous duty cycle and total torque vs. velocity falls within the intermittent range.

How to Use a Step Motor Horsepower Curve

Horsepower (HP) gives an indication of the motor's top usable speed. The peak or "hump" in a horsepower curve indicates a speed that gives maximum power. Choosing a speed beyond the peak of the HP curve results in no more power: the power attained at higher speeds is also attainable at a lower speed. Unless the speed is required for the application, there is little benefit to going beyond the peak as motor wear is faster at higher speeds.

Applications requiring the most power the motor can generate, not the most torque, should use a motor speed that is *just* below the peak of the HP curve.