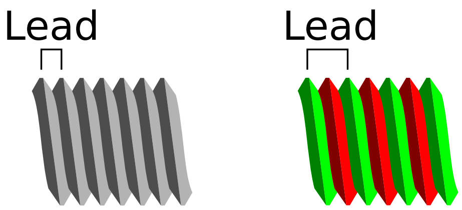
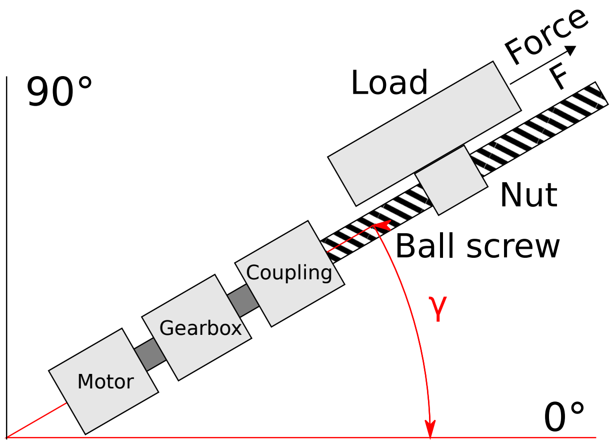
Ball Screw



Pitch Vs Lead



Ball Screw Positioner

The screw mechanism converts rotational motion into linear motion. Ball screws use circulating ball bearings to minimize friction and obtain high performance, high thrust and high precision. They are used in machinery such as injection molding machines, dosing and filling machines, simulators and test benches, machine tools, small and medium servo-presses, X-Y tables, tool bit positioning, pick & place machines, engraving machines, motorized microscope devices, etc. They are however not recommended for high cycle rates with high turning speeds, due to their high noise generation in these conditions. Do not confuse with conventional trapezoidal thread screws, such as those with acme threads, that offer much lower efficiency and performance.

Disclaimer

System Efficiency

$$\eta_t = \eta_{bs} \cdot \eta_r$$

Weight Force

$$F_w = m \cdot g \cdot \sin\left(\frac{\gamma \cdot \pi}{180}\right) \quad [N]$$

Friction Force

$$F_f = m \cdot g \cdot \mu \cdot \cos\left(\frac{\gamma \cdot \pi}{180}\right) \quad [N]$$

Acceleration Force

$$F_a = \frac{m \cdot v}{t_a} \quad [N]$$

Constants

Pi	$\pi \simeq 3.141592654$
Acceleration of Gravity on Earth	$g = 9.80665 \; \frac{m}{s^2}$
Density of Steel	$\rho_{steel} = 7850 \; \left[\frac{kg}{m^3}\right]$

Inputs

System Inclination	$\gamma \; [degrees]$
Ball Screw Lead	$p \; \left[\frac{mm}{rev}\right]$
Ball Screw Length	$L \; [mm]$
Ball Screw Diameter	$D \; [mm]$
Ball Screw Efficiency	η_{bs}
Friction Coefficient	μ
Service Factor	K_A
Traveling Mass	$m \; [kg]$
Linear Speed	$v \; \left[\frac{m}{s}\right]$
Acceleration Time	$t_a \; [s]$
Machining Force	$F_m \; [N]$
Max. Motor Speed During Cycle	$n_1 \; [rpm]$
Gearbox Efficiency	η_r
Gearbox Inertia	$J_R \; [kg \cdot cm^2]$
Motor Inertia	$J_M \; [kg \cdot cm^2]$

Total Force

$$F_T = F_w + F_f + F_a + F_m \quad [N]$$

Traveling Mass Inertia

$$J_L = 10000 \cdot m \cdot \left(\frac{p}{2000 \cdot \pi}\right)^2 \quad [kg \cdot cm^2]$$

Ball Screw Inertia

$$J_{bs} = 5 \cdot \rho_{steel} \cdot \pi \cdot L \cdot \left(\frac{D}{2000}\right)^4 \quad [kg \cdot cm^2]$$

Total Inertia

$$J_T = J_L + J_{bs} \quad [kg \cdot cm^2]$$

Total Inertia as seen by the motor

$$J_{T1} = \frac{J_T}{i^2} \quad [kg \cdot cm^2]$$

Load to Motor Inertia Ratio

$$\Lambda = \frac{J_{T1}}{J_M + J_r}$$

Screw Rotational Acceleration

$$\alpha_{bs} = \frac{\omega_{bs}}{t_a} \quad \left[\frac{rad}{s^2}\right]$$

Screw Rotational Speed

$$\omega_{bs} = \frac{2000 \cdot \pi \cdot v}{p} \quad \left[\frac{rad}{s}\right]$$

Screw Rotational Speed

$$n_{bs} = \omega_{bs} \cdot \frac{30}{\pi} \quad [rpm]$$

Ideal Gearbox Ratio

$$i = \frac{n_1}{n_{bs}}$$

Required Gearbox Output Torque

$$T_2 = \frac{p \cdot F_T}{2000 \cdot \pi \cdot \eta_{bs}} \quad [N \cdot m]$$

Required Gearbox Output Torque, Adjusted for Service Factor

$$T_{2KA} = K_A \cdot T_2 \quad [N \cdot m]$$

Motor Power

$$P_1 = \frac{T_2 \cdot n_{bs}}{9550 \cdot \eta_r} \quad [kW]$$