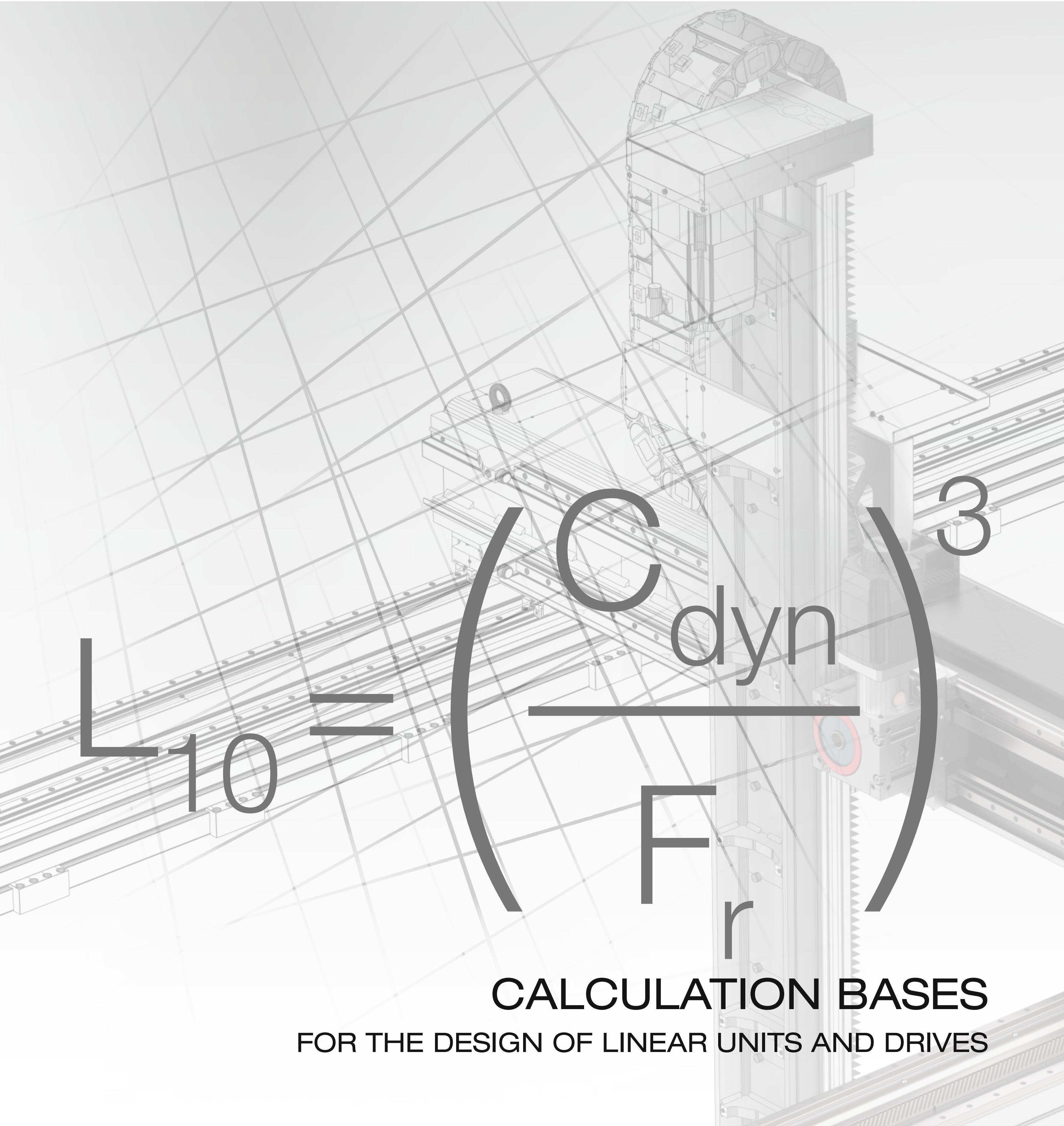
LINE TECH



$$L_{10} = \left(\frac{C_{dyn}}{F_r}\right)^3$$

CALCULATION BASES

FOR THE DESIGN OF LINEAR UNITS AND DRIVES

SWISS MADE LINEAR TECHNOLOGY

CALCULATION BASES

Design of LINE TECH linear units and their drives

Concept

The determination of service life must be calculated based on the respective documents of the linear guide system and the ball screw drives. Also for the toothed belt drive and the rack and pinion drive we shall refer to the specific literature.

Since the service life is normally dependent on the linear guide system, the following formulae can be applied for approximate determination:

Dynamic load

Nominal service life L_{10} is derived from dynamic load rating C_{dyn} [N] and load F_r [N]:

$$L_{10} = \left(\frac{C_{dyn}}{F_r}\right)^3 \quad [10^5 \text{ m rolling distance}]$$

Static load

For purely static loading or impacts, static parameter f_S is calculated to verify that a bridge module with a sufficiently high load-bearing capacity is selected.
Factoring in static load rating C_0 [N] and load F_r [N] gives:

$$f_S = \frac{C_0}{F_r}$$

If $f_S \geq 1$, the safety margin is large enough.
If $f_S \leq 1$, please check with LINE TECH.

Remark

The above formulas are only valid if all linear bearings are loaded evenly, i.e. if the load F_r acts on the centre of the carriage.

The drive (ball screw / toothed belt drive / rack and pinion drive) must be checked if any linear units are installed vertically. LINE TECH disposes of different test programs. If you provide us all the necessary information, we'll be pleased to assist you.

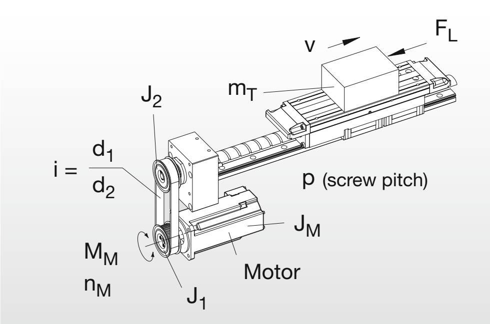
Definition of the drive motor

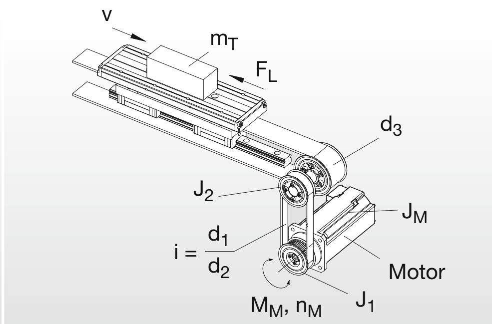
The drive motor forms the link between the control signal and the movement to be applied to a given load.
Size and type of the drive motor primarily depend on the load, the required displacement speed and the acceleration factor.
All calculations should be based on the most unfavourable operating conditions.

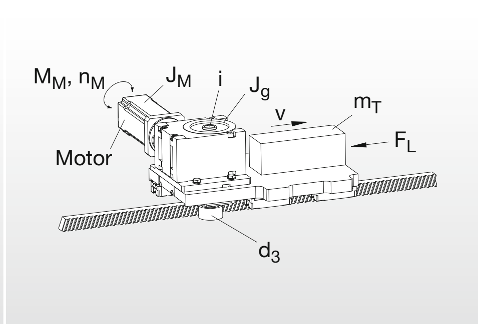
The necessary formulas are listed opposite to help you determine the correct motor characteristics for your application.

FORMULA COLLECTION

Design of LINE TECH linear units and their drives







Motor speed	[min^{-1}]	$n_M = \frac{v \cdot 6 \cdot 10^4}{p \cdot i}$	$n_M = \frac{v \cdot 6 \cdot 10^4}{\pi \cdot d_3 \cdot i}$	$n_M = \frac{v \cdot 6 \cdot 10^4}{\pi \cdot d_3 \cdot i}$
Critical speed	[min^{-1}]	$n_K = 120 \cdot 10^6 \cdot \frac{d}{l^2}$	–	–
Load torque	[Nm]	$M_L = p \cdot i \frac{F_L}{2000 \cdot \pi}$	$M_L = d_3 \cdot i \frac{F_L}{2000}$	$M_L = d_3 \cdot i \frac{F_L}{2000}$
Translatory mass moment of inertia	[kgm^2]	$J_T = m_T \left(\frac{p}{2 \cdot \pi}\right)^2 \cdot 10^{-6}$	$J_T = m_T \left(\frac{d_3}{2}\right)^2 \cdot 10^{-6}$	$J_T = m_T \left(\frac{d_3}{2}\right)^2 \cdot 10^{-6}$
Rotatory mass moment of inertia (for steel)	[kgm^2]	$J_R = 7{,}7 \cdot d^4 \cdot l \cdot 10^{-13}$	$J_R = 7{,}7 \cdot d_3^4 \cdot l_R \cdot 10^{-13}$	$J_R = 7{,}7 \cdot d_3^4 \cdot l_R \cdot 10^{-13}$
Sum of reduced mass moments of inertia	[kgm^2]	$J = J_M + J_1 + i^2 (J_R + J_T + J_2)$	$J = J_M + J_1 + i^2 (J_R + J_T + J_2)$	$J = J_M + J_g + i^2 (J_R + J_T)$
Acceleration or Braking moment $M_B = f(n_M)$	[Nm]	$M_B = \frac{n_M \cdot J}{9.55 \cdot t_B}$	$M_B = \frac{n_M \cdot J}{9.55 \cdot t_B}$	$M_B = \frac{n_M \cdot J}{9.55 \cdot t_B}$
Acceleration or Braking moment $M_B = f(s_B)$	[Nm]	$M_B = \frac{4 \cdot \pi \cdot s_B \cdot J}{p \cdot i \cdot t_B^2}$	$M_B = \frac{4 \cdot s_B \cdot J}{d_3 \cdot i \cdot t_B^2}$	$M_B = \frac{4 \cdot s_B \cdot J}{d_3 \cdot i \cdot t_B^2}$
Acceleration or Braking time $t_B = f(n_M)$	[s]	$t_B = \frac{n_M \cdot J}{9.55 \cdot M_B}$	$t_B = \frac{n_M \cdot J}{9.55 \cdot M_B}$	$t_B = \frac{n_M \cdot J}{9.55 \cdot M_B}$
Acceleration or Braking time $t_B = f(s_B)$	[s]	$t_B = \sqrt{\frac{4 \cdot \pi \cdot s_B \cdot J}{p \cdot i \cdot M_B}}$	$t_B = \sqrt{\frac{4 \cdot s_B \cdot J}{d_3 \cdot i \cdot M_B}}$	$t_B = \sqrt{\frac{4 \cdot s_B \cdot J}{d_3 \cdot i \cdot M_B}}$
Speed reached after acceleration	[min^{-1}]	$n_M = \frac{120 \cdot s_B}{p \cdot i \cdot t_B}$	$n_M = \frac{120 \cdot s_B}{d_3 \cdot \pi \cdot i \cdot t_B}$	$n_M = \frac{120 \cdot s_B}{d_3 \cdot \pi \cdot i \cdot t_B}$
Distance travelled during acceleration	[mm]	$s_B = \frac{n_M \cdot t_B \cdot p \cdot i}{120}$	$s_B = \frac{n_M \cdot t_B \cdot d_3 \cdot \pi \cdot i}{120}$	$s_B = \frac{n_M \cdot t_B \cdot d_3 \cdot \pi \cdot i}{120}$
Sum of torques to be overcome by the motor	[Nm]	$M_M = \frac{1}{\eta} (M_L + M_B)$	$M_M = \frac{1}{\eta} (M_L + M_B)$	$M_M = \frac{1}{\eta} (M_L + M_B)$
Power output [W]		$P_A = \frac{M_M \cdot n_M}{9.55}$	$P_A = \frac{M_M \cdot n_M}{9.55}$	$P_A = \frac{M_M \cdot n_M}{9.55}$
Effective value of motor output torque	[Nm]	$M_{eff} = \sqrt{\frac{\sum t_B (M_M/M_d)^2 + \sum t_L (M_L/M_d)^2}{\sum t_B + \sum t_L + t_0}} \cdot M_d$	$M_{eff} = \sqrt{\frac{\sum t_B (M_M/M_d)^2 + \sum t_L (M_L/M_d)^2}{\sum t_B + \sum t_L + t_0}} \cdot M_d$	$M_{eff} = \sqrt{\frac{\sum t_B (M_M/M_d)^2 + \sum t_L (M_L/M_d)^2}{\sum t_B + \sum t_L + t_0}} \cdot M_d$

Key to the formulas shown opposite:

d	[mm]	=	ball screw diameter
d_1	[mm]	=	diametre driving pinion
d_2	[mm]	=	diameter driven pinion
d_3	[mm]	=	pulley diameter
F_L	[N]	=	feed force
i	[-]	=	gear reduction (at gear reduction 1:2 => i = 0.5)
J	[kgm^2]	=	mass moment of inertia
J_1	[kgm^2]	=	mass moment of inertia of the driving wheel
J_2	[kgm^2]	=	mass moment of inertia of the driven wheel
J_g	[kgm^2]	=	mass moment of inertia of the gearbox (relative to input)
J_M	[kgm^2]	=	mass moment of inertia of the drive motor
J_R	[kgm^2]	=	rotatory mass moment of inertia
J_T	[kgm^2]	=	translatory mass moment of inertia
l	[mm]	=	ball screw length
l_R	[mm]	=	pinion / pulley width
M_B	[Nm]	=	acceleration or braking torque
M_d	[Nm]	=	motor continuous torque (see specs. of your prefered motor)
M_{eff}	[Nm]	=	effective motor output torque
M_L	[Nm]	=	load torque
M_M	[Nm]	=	motor torque (see motor specs.)
M_{max}	[Nm]	=	peak motor torque
m_T	[kg]	=	external load (linear moved mass)
n_k	[min^{-1}]	=	critical speed for ball screw drive
n_M	[min^{-1}]	=	motor speed
p	[mm]	=	screw pitch
P_A	[W]	=	power output
s_B	[mm]	=	acceleration/braking path
t_B	[s]	=	acceleration/braking time
t_L	[s]	=	running time under load torque
t_0	[s]	=	stop time without load
v	[m/s]	=	feed rate
η	[-]	=	mechanical efficiency on motor shaft

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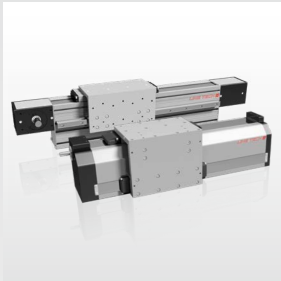

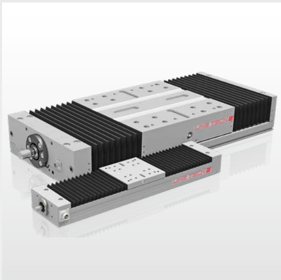


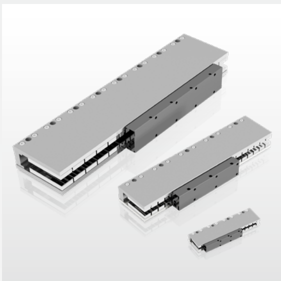



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