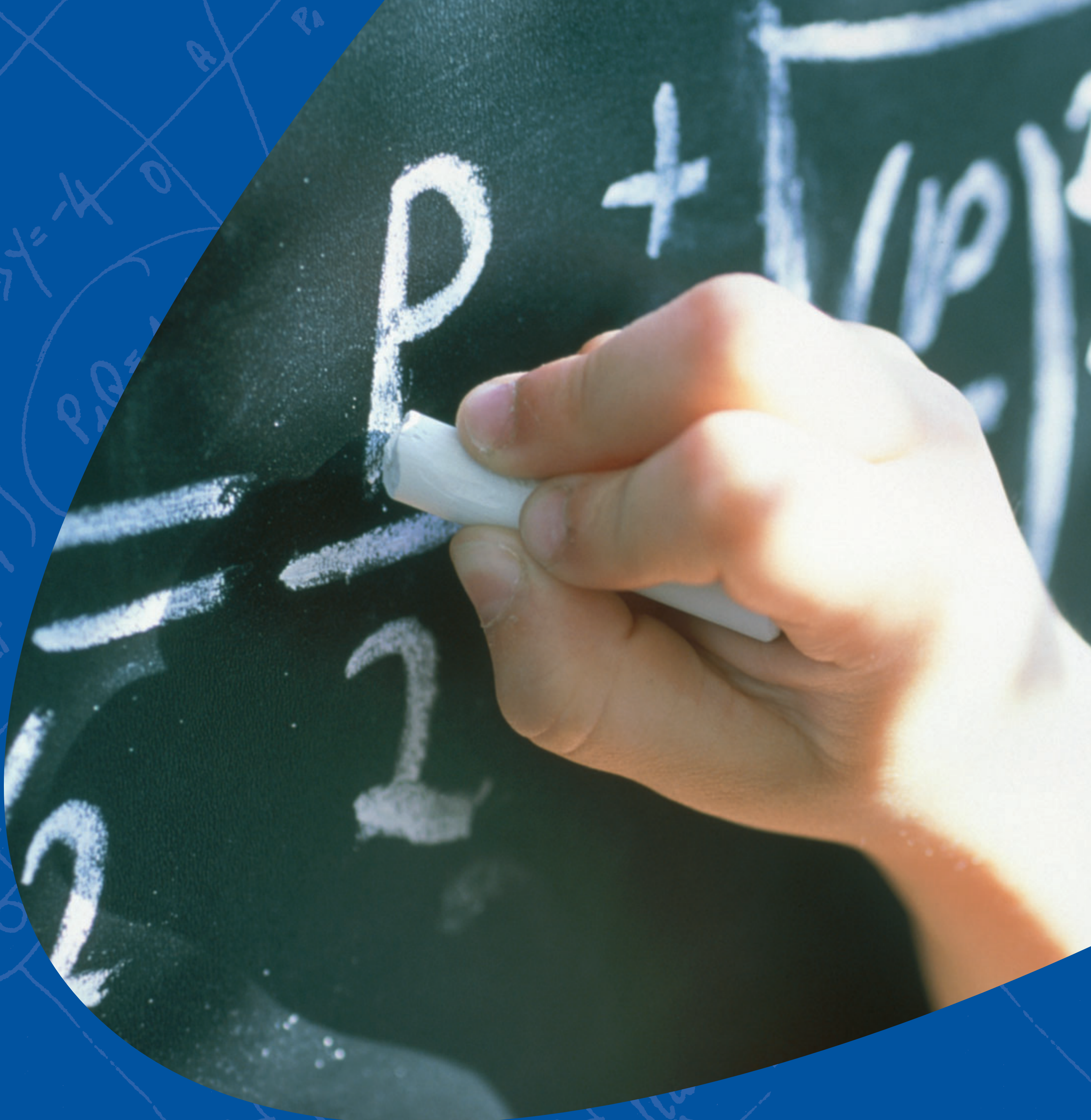


alpha Technical Basics

for Servo Drive Systems

2006 - II

alpha

a **WITTENSTEIN AG** company

Foreword
Technical Basics

Communication, whether external or internally within a company, is an important element in assuring the rapid and successful execution of any project.

Our aim in compiling this catalogue is to improve and intensify our communication with you. This edition is specifically devoted to **alpha** products and includes a comprehensive compendium of fundamental terms used in servo drive technology that will hopefully provide a useful and up to date aid for you as well as for us. **alpha Technical Basics** contains not only common definitions, but also standards and proposals that support our exchange of opinions and ideas to avoid misunderstandings.

We have taken the opportunity presented by our new alpheno and SP^+ products to compile this catalogue for you. As we continue to expand our product range, we will also add new topics to Technical Basics.

Contents

Cutting edge innovations **made by alpha**

We have been developing, manufacturing and distributing low-backlash planetary gearheads, servo right-angled gearheads, complete drive units and planetary elevator machines with an integrated servo motor since 1984. Profit from our comprehensive service package: From individual components to complete systems, backed up by expert engineering services. A thousand employees worldwide are committed to our cause. alpha's home is in Germany – in Igersheim on the Romantic Road in northern Baden-Württemberg.

alpha is a member of the **WITTENSTEIN AG** which has rightly established a name for itself with numerous innovations in industries such as aerospace and simulation, medical technology, elevator drives and Formula One racing.

WITTENSTEIN – being one with the future!

Leaders of the pack

We are driven by a desire to enhance our customers' success with products and systems from alpha. We set benchmarks when it comes to precision, performance and durability. Our trailblazing technology gives our customers an edge in their respective market sectors. Place your trust in premium quality and total reliability from alpha. Choose world class engineering – the foundation for strong partnerships and added value that is passed on to your customers.

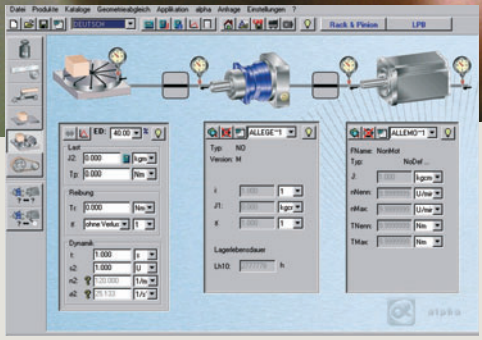
alpha benefits at a glance:

Record-breaking lifespan
Extremely long service life resulting from intelligent design, latest synthetic lubrication technology, exclusive sealing technology, and incredibly strong output bearings.

Motor mounting is almost foolproof
Simple and reliable mounting in a single step.

Top quality from alpha
In-house development and manufacture of all products combined with a pioneering spirit and an insatiable urge to improve.

alpha speedline®
speedline delivery if your production process can't wait. Dispatch of your alpha gearheads from our factory is guaranteed in just 24 or optionally 48 hours.
Our speedline delivery service has been operating successfully throughout Europe since 2004.



Cymex® - finding the right gear reducer quickly and easily

Cymex® the engineering software for all servo drive systems and components – fast and reliable in matching your gearmotor combinations. Cymex® features the world's largest motor database, consisting of over 7,000 different motors from various manufacturers. With over 2,000 alpha gear components, Cymex® guarantees the best possible combinations for your motor and gear reducer requirements.

Application – Gear – Motor

Cymex® reduces your work time by utilizing advanced technologies which allows you to experiment with your requirements.

Try various load parameters and play around with the relevant application specifi cations. Cymex® automatically verifi es your profi le with a system that has been in development for over ten years.

At any time, you may provide more detailed documentation for continuing your work in the future. Come discuss your applications with our specialists. Our experience and expertise are core to our engineering team.

We look forward to a partnership with you.
Cymex®-Call 630 540-5300

TP+ & TP+ HIGH TORQUE® – Compact Precision

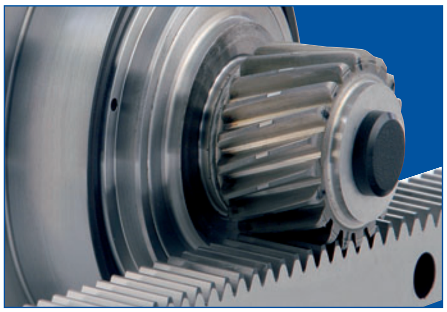
Low-backlash planetary gearheads with output flange. Torsional backlash ≤ 1 arcmin. Acceleration torque up to 10000 Nm. TP+ HIGH TORQUE best qualified for highest positioning accuracy and high-dynamic cycle operation.

SP+® & SP+ HIGH SPEED® – The NEW Generation

Low-backlash planetary gearheads with output shaft. Torsional backlash ≤ 1 arcmin. Acceleration torque up to 3400 Nm. SP+ HIGH SPEED best qualified for highest speed in continuous operation.

LP+ & LPB+ – Value Line

Low-backlash gearheads with output shaft for economical servo applications.
Torsional backlash ≤ 10 arcmin. Acceleration torque up to 450 Nm. Optional available as LPB+, with geared pulley mount.



Rack & Pinion Systems

Precision Rack and Pinion solutions in 3 grades for individual servo applications.
PRECISION CLASS – for exact servo applications
SMART CLASS – for standard servo applications
VALUE CLASS – for economical servo appliccations

Hypoid Gearhead

Right-angle gearhead of highest precision and compactness. Torsional backlash ≤ 4 arcmin.
Acceleration torque up to 640 Nm.
Output shaft variations: SK+: smooth, keywayed, involute toothing to DIN 5480, TK+: hollow flange, HG+: hollow shaft

Hypoid Planetary Gearhead

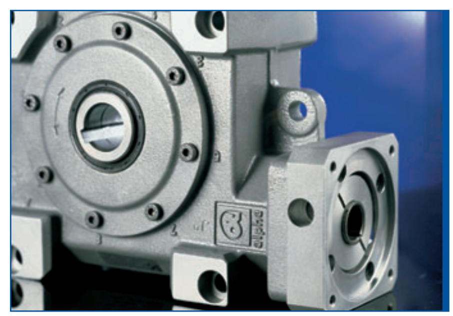
Right-angle planetary gearhead of highest precision and power density.
Torsional backlash ≤ 2 arcmin. Acceleration torque up to 1600 Nm. Output shaft variations:
SPK+: smooth, keywayed, involute toothing to DIN 5480, TPK+: flange

TPM & TPMA - Servoactuators

Ultra-compact and highly precise brushless gear motors featuring high dynamics, high torsional stiffness and a backlash of just 1 to 3 arcmin.
Acceleration torque up to 2600 Nm. Up to 60% shorter overall length and much lower weight than conventional servomotor-gearhead designs.

alphira® – Precision Made Simple

Low backlash · high rigidity · alpha quality
Ideal for simple servo applications.
Acceleration torque up to 200 Nm.



V - Drive®

Right-angle gearhead – short and compact.
Torsional backlash ≤ 3 arcmin.
Acceleration torque up to 718 Nm.
Options output: VDS: smooth, keywayed, involute toothing to DIN 5480, VDT: hollow flange,
VDH: hollow shaft smooth or keywayed.

Coupling – TL / BC / EC

Patented, backlash-free, compact and torsionally stiff metal bellows and safety couplings.
Acceleration torque up to 10,000 Nm.
Disengagement in 1 – 3 ms.
Belt tension 100 – 12000 N. Self-adjusting.

alpha IQ® – The Intelligent Planetary Gearhead

Data capture without interrupting production. Gearhead and measuring instrument in one system. Real-time data capture directly during operation. alpha IQ is compatible with all alpha standard gearheads.

Are you seeking a solution custom tailored to your needs?
We are ready to take up the challenge.
More power in less space!

alpheno – your direct route to success.

		Low-backlash planetary gearheads							Servo right-angle gearheads						AC-Servo-Actuators	
Product		**TP⁺**	**TP⁺ High Torque**	**SP⁺**	**SP⁺ High Speed**	**alphira**	**LP⁺**	**LPB⁺**	**SK⁺ / SPK⁺**	**TK⁺ / TPK⁺**	**HG⁺**	**VDH**	**VDT**	**VDS**	**TPM**	**TPMA**
Torque	[Nm] up to	6000	10000	3400	1200	200	450	220	1100	1600	640	718*	718*	718*	1600	2600
Ratio	min. i =	4	22	3	3	5	3	3	3	3	3	4	4	4	21	110
	max. i =	100	220	100	100	100	100	10	100	100	100	40	40	40	91	220
Form																
Right-angle									●	●	●	●	●	●		
In-Line		●	●	●	●	●	●	●							●	●
Output form																
Output shafts				●	●	●	●		●					●		
Output flanges		●	●					●		●			●		●	●
Hollow shafts											●	●	●			
Torsional backlash																
≤ 1/2 arcmin.		●	●	●					●	●					●	●
≤ 3/4 arcmin.		●		●	●				●	●	●	●	●	●	●	
≤ 8/10 arcmin.							●	●								
≤ 12/15 arcmin.							●	●								
≤ 20/25 arcmin.						●										
Input form																
Motor mounting		●	●	●	●	●	●	●	●	●	●	●	●	●	incl. motor	
Optional (output)																
with belt pulley								●								
with rack and pinion		●	●	●	●		●		●	●			●	●	●	●
with coupling				●	●	●	●		●					●		
with two output shaft											●	●				

Gearhead selection

$$ED^* = \frac{(t_b + t_c + t_d)}{(t_b + t_c + t_d + t_e)} \cdot 100\ [\%]$$

$$ED = t_b + t_c + t_d \quad [\text{min}]\ ^*$$

$$Z_h^* = \frac{3600\ [\text{s/h}]}{(t_b + t_c + t_d + t_e)}$$

* see Diagram 1 “Shock factor”

f_s depends on the cycle number Z_h

T_{2b} depends on the application

$$T_{2b,\ fs} = T_{2b} \cdot f_s$$

n_{2max} depends on the application

i depends on:

n - Required output speed (application)
- Recommended input speed (gearhead/motor)

$$n_{1max} = n_{2max} \cdot i$$

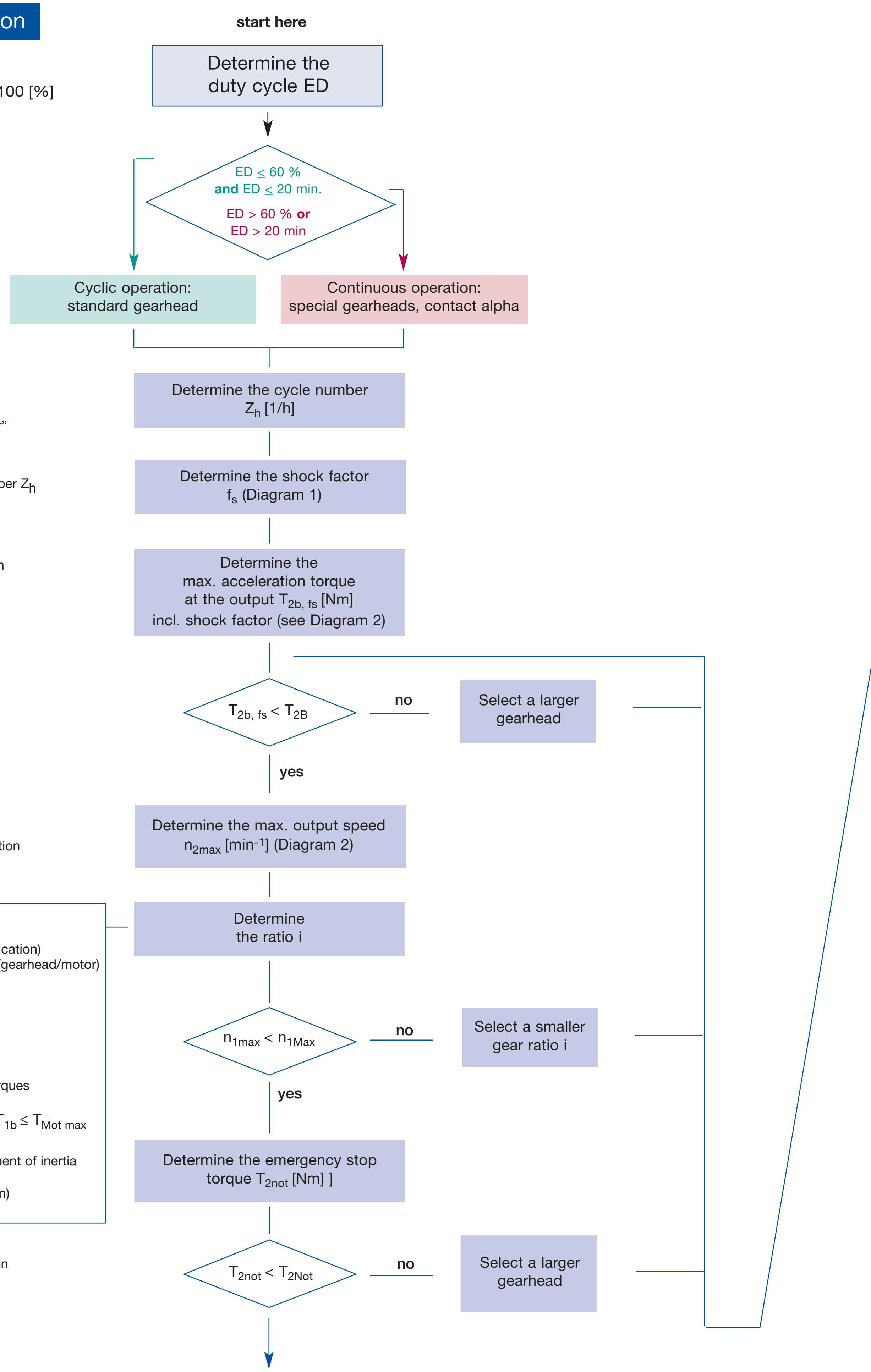
$$n_{1max} \leq n_{1Mot\ max}$$

T - from the input and output torques

$$T_{1b} = T_{2b} \cdot \frac{1}{i} \cdot \frac{1}{\eta} \qquad T_{1b} \leq T_{Mot\ max}$$

λ - from the resulting mass moment of inertia ratio Guide value: $1 \leq \lambda \leq 10$
(see “alphabet” for calculation)

T_{2not} depends on the application



Please refer to the technical data in the relevant product catalogue for the maximum permissible values applicable to your gearhead.

Determine the mean output torque T_{2m} [Nm] (see Diagram 2)

$$T_{2m}^* = \sqrt[3]{\frac{n_{2b} \cdot t_b \cdot T_{2b}^3 + \ldots + n_{2n} \cdot t_n \cdot T_{2n}^3}{n_{2b} \cdot t_b + \ldots + n_{2n} \cdot t_n}}$$

$T_{2m} < T_{2N}$ — no: Select a larger gearhead

yes

Determine the mean output speed n_{2n} [min^{-1}] (see Diagram 2)

$$n_{2n}^* \text{ or } n_{2m} = \frac{n_{2b} \cdot t_b + \ldots + n_{2n} \cdot t_n}{t_b + \ldots + t_n}$$ incl. dwell time

$n_{1m} < n_{1N}$ — no: Smaller gear ratio i

$$n_{1m} = n_{2n} \cdot i$$

yes

Select a motor

* see Diagram 1 "Shock factor"

Compare clamping hub with motor shaft diameter — no: Select another motor or another gearhead, consult alpha if necessary

$D_{W,\,Mot} \leq D_{clamping\text{-}hub}$

It must be possible to insert the motor shaft into the clamping hub.

yes

Compare length of motor shaft with min./max. dimensions in dimensional drawing — no: Select another motor or another gearhead, consult alpha if necessary

1. The motor shaft must be inserted a sufficient distance into the clamping hub without touding its end.

yes

$T_{2max\,(Motor)} \leq T_{2B}$ — no: Limit the motor current!

$$T_{2max\,(Motor)} = T_{1max\,(Motor)} \cdot i \cdot \eta_{gearhead}$$

yes

See next page for Calculation of Bearing Service Life

2. The gearhead must not be damaged when the motor operates at full load.

Diagram 2:

Standard complex of loads at the output.
The gearing will endure permanently if the gearhead is loaded with less than or equal to the nominal torque T_{2N} in continuous operation S1. At input speeds less than or equal to the nominal speed n_{1N}, the gearhead will not heat up to more than 90 °C under average ambient conditions.

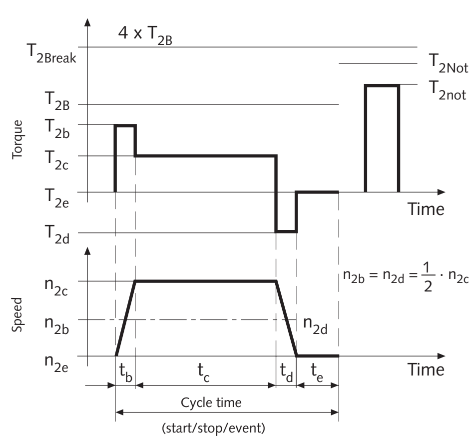
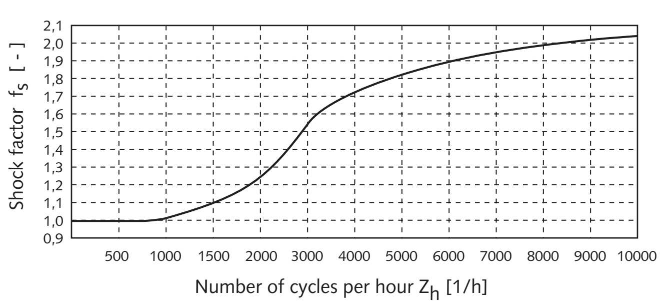


Diagram 1:

High cycle numbers combined with short acceleration times may lead to vibrations in the drive train. The resultant excess torques are taken into account through the shock factor f_s.



Calculation of the bearing service life L_{h10} (Output bearing)

Determine the mean axial and radial force F_{am}, F_{rm} [N]

$$F_{2am} = \sqrt[3]{\frac{n_{2b} \cdot t_b \cdot F_{2ab}^{3} + \ldots + n_{2n} \cdot t_n \cdot F_{2an}^{3}}{n_{2b} \cdot t_b + \ldots + n_{2n} \cdot t_n}}$$

$$F_{2rm} = \sqrt[3]{\frac{n_{2b} \cdot t_b \cdot F_{2rb}^{3} + \ldots + n_{2n} \cdot t_n \cdot F_{2rn}^{3}}{n_{2b} \cdot t_b + \ldots + n_{2n} \cdot t_n}}$$

$\frac{F_{2am}}{F_{2rm}} \leq f$

$x_2 > 0$

no → Contact alpha

yes ↓

Determine the mean tilting moment M_{2km} [Nm]

$$M_{2km} = \frac{F_{2am} \cdot y_2 + F_{2rm} \cdot (x_2 + z_2)}{1000}$$

x_2, y_2 and z_2 in mm

Determine the maximum tilting moment M_{2kmax} [Nm]

$$M_{2kmax} = \frac{F_{2amax} \cdot y_2 + F_{2rmax} \cdot (x_2 + z_2)}{1000}$$

x_2, y_2 and z_2 in mm

$M_{2kmax} \leq M_{2KMax}$

$F_{2rmax} \leq F_{2RMax}$

$F_{2amax} \leq F_{2AMax}$

no → Select a larger gear reducer (gear reducer selection)

yes ↓

Determine the mean speed n_{2m} [min^{-1}]

$$n_{2n}^{*} \text{ or } n_{2m} = \frac{n_{2b} \cdot t_b + \ldots + n_{2n} \cdot t_n}{t_b + \ldots + t_n}$$

Determine the service life L_{h10} [h]

$$L_{h10} = \frac{16666}{n_{2m}} \cdot \left[\frac{K1_2}{M_{2km}}\right]^{p_2}$$

Is the service life L_{h10} sufficient?

no → Select a larger gear reducer (gear reducer selection)

yes ↓

Service life calculation is complete

Conversion table

1 in	=	25.4 mm
1 in.lb	=	0.113 Nm
1 in.lb.s^2	=	1130 kgcm^2
1 lb_f	=	4.44 N
1 lb_m	=	0.4535 kg

	TP+	SP+	LP+/LPB+	alphira	V-Drive
f	0,37	0,40	0,24	0,24	0,40

LP+		050	070 (LPB+)	090 (LPB+)	120 (LPB+)	155
z_2	(mm)	20	28,5	31	40	47
$K1_2$	(Nm)	75	252	314	876	1728
p_2		3,0	3,0	3,0	3,0	3,0

alphira		040	060	080	115
z_2	(mm)	12,5	19,5	23,5	28,5
$K1_2$	(Nm)	15,7	70,0	157,0	255,0
p_2		3,0	3,0	3,0	3,0

SP+ / SPK+		060	075	100	140	180	SP 210	SP 240
z_2	(mm)	42,1	44,7	47,5	60,2	76,2	82,5	91,5
$K1_2$	(Nm)	795	1110	1895	4245	9455	11880	16576
p_2		3,33	3,33	3,33	3,33	3,33	3,33	3,33

TP+ / TPK+		004	010	025	050	110	TP 300	TP 500
z_2	(mm)	57,6	82,7	94,5	81,2	106,8	134,1	152,8
$K1_2$	(Nm)	536	1325	1896	4048	9839	11284	16414
p_2		3,33	3,33	3,33	3,33	3,33	3,33	3,33

Please contact alpha to calculate the bearing service life of the **HG+**, **SK+**, **TK+** and **V-Drive** gear reducer:

Phone +1 630 540 5300 (for USA)
Phone +49 7931 493-0 (for Europe)

Formulae

Torque [Nm]	$\mathbf{T = J \cdot \alpha = F \cdot l}$
Acceleration force [N]	$\mathbf{F_b = m \cdot a}$
Frictional force [N]	$\mathbf{F_{frict} = m \cdot g \cdot \mu}$
Angular velocity [rad/s]	$\mathbf{\omega = 2 \cdot \pi \cdot n / 60}$
Linear velocity [m/s]	$\mathbf{v = \omega \cdot r}$
Linear velocity [m/s] (spindle)	$\mathbf{v_{sp} = \omega \cdot h / (2 \cdot \pi)}$
Linear acceleration [m/s²]	$\mathbf{a = v / t_b}$
Angular acceleration [rad/s²]	$\mathbf{\alpha = \omega / t_b}$

J = Mass moment of inertia [kgm²]
α = Angular acceleration [rad/s²]
F = Force [N]
l = Lever, length [m]
m = Mass [kg]
a = Linear acceleration [m/s²]
g = Acceleration due to gravity 9.81 [m/s²]
μ = Coefficient of friction
n = Speed [rpm]
π = 3.14 ...
v = Linear velocity [m/s]
r = Radius [m]
ω = Angular velocity [1/s]
h = Screw pitch [m]
t_b = Acceleration time [s]

Symbols and index

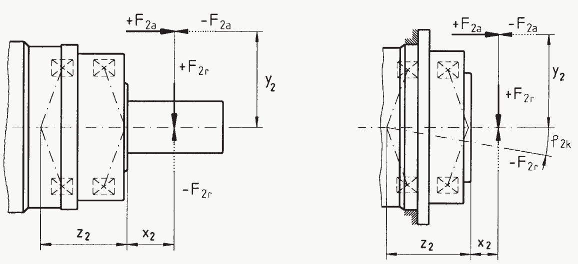
Symbol	Unit	Designation
c	Nm/arcmin	Stiffness / rigidity
ED	%, min	Duty cycle
F	N	Force
f_S	-	Shock factor
i	-	Ratio
j	arcmin	Backlash
J	$kgcm^2$, kgm^2	Mass moment of inertia
K1	Nm	Factor for bearing calculation
L	h	Service life
M	Nm	Torque
n	min^{-1}/rpm	Speed
p	-	Exponent for bearing calculation
η	%	Efficiency
t	s	Time
T	Nm	Torque
x	mm	Distance between radial force and shaft collar
y	mm	Distance between axial force and centre of gear
z	mm	Factor for bearing calculation
Z	1/h	Cycle number

Index	
capital letter	Permissible values
small letter	Actual values
1	Input
2	Output
A/a	Axial
B/b	Acceleration
Break	Break
c	Constant
d	Deceleration
e	Pause
h	Hours
K/k	Tilting
m	Mean
Max/max	Maximum
Mot	Motor
N	Nominal
Not/not	Emergency stop
0	No-load running
R/r	Lateral
t	Torsional

Adapter plate
alpha uses a system of standardized adapter plates to connect the motor and the gear reducer, making it possible to mount an alpha gearbox to any desired motor without difficulty.

Axial force (F_{2AMax})
The axial force F_{2AMax} acting on a gear reducer runs parallel to its output shaft in the case of SP+, LP+ or SPK. For a TP+, the force runs perpendicular to its output flange. It may be applied with axial offset via a lever arm y_2 under certain circumstances, in which case it also generates a bending moment. If the axial force exceeds the permissible catalogue values additional design features (e.g. axial bearing) have to be implemented that absorb these loads.

Example with output shaft and flange:



Acceleration torque (T_{2B})
The acceleration torque T_{2B} is the maximum permissible torque which can briefly be transmitted at the output by the gear reducer at a cycle number $\leq$ 1000. The ➔ Shock factor must also be taken into account at cycle numbers > 1000. T_{2B} is the limiting parameter in cyclical operation.

Arcminute
A degree is subdivided into 60 arcminutes (=60 arcmin=60'). In other words, if the torsional backlash is specified as 1 arcmin, for example, the output can be turned 1/60°. The repercussions of the solid application are determined by the arc length: $b = 2 \cdot \pi \cdot r \cdot \alpha° / 360°$. A pinion with a radius r = 500 mm on a gear reducer can thus be turned b = 0.4 mm with the standard torsional backlash j_t = 3'.

Bushing
If the motor shaft diameter is smaller than the ➔ clamping hub, a bushing is used to compensate the difference in diameter.

cymex® (see page 5)
cymex is the calculation software developed by our company for dimensioning complete drive trains. We can also provide training, to enable you to make full use of all the possibilities provided by the software.

Continuous operation (S1)
Continuous operation is defined via the ➔ Duty cycle. If the Duty cycle is greater than 60% or longer than 20 minutes, it qualifies as continuous operation ➔ Operating modes.

Clamping hub
The clamping hub ensures a frictional connection between motor shaft and gear reducer. A ➔ bushing is used as the connecting element if the motor shaft diameter is smaller than that of the clamping hub.

Cyclical operation (S5)
Cyclic operation is defined via the duty cycle. If the duty cycle is less than 60% and shorter than 20 minutes, it qualifies as cyclic operation (➔ Operating modes).

Operating modes
(Continuous operation **S1** and cyclic operation **S5**). When selecting a gear reducer, it is important to consider whether the motion profile is characterised by frequent acceleration and deceleration phases as well as pauses, or whether it is to be operated in continuous operation, i.e. with long phases of constant motion.

Degree of protection (IP) For details see alpha catalogue downloads.
The various degrees of protection are defined in DIN EN 60529 "Degrees of protection offered by enclosure (IP Code)". The IP degree of protection (IP = International Protection) is described with the aid of two digits. The first digit indicates the protection against ingress of impurities and the second the protection against ingress of water.

Example: **IP65**

Protection against ingress of dust (dust-proof)	Protection against water jets

Duty cycle (ED)
The duty cycle ED is determined by one cycle. The times for acceleration (t_b), constant travel if applicable (t_c) and deceleration (t_d) taken together yield the duty cycle in minutes. The duty cycle is expressed as a percentage with inclusion of the pause time t_e.

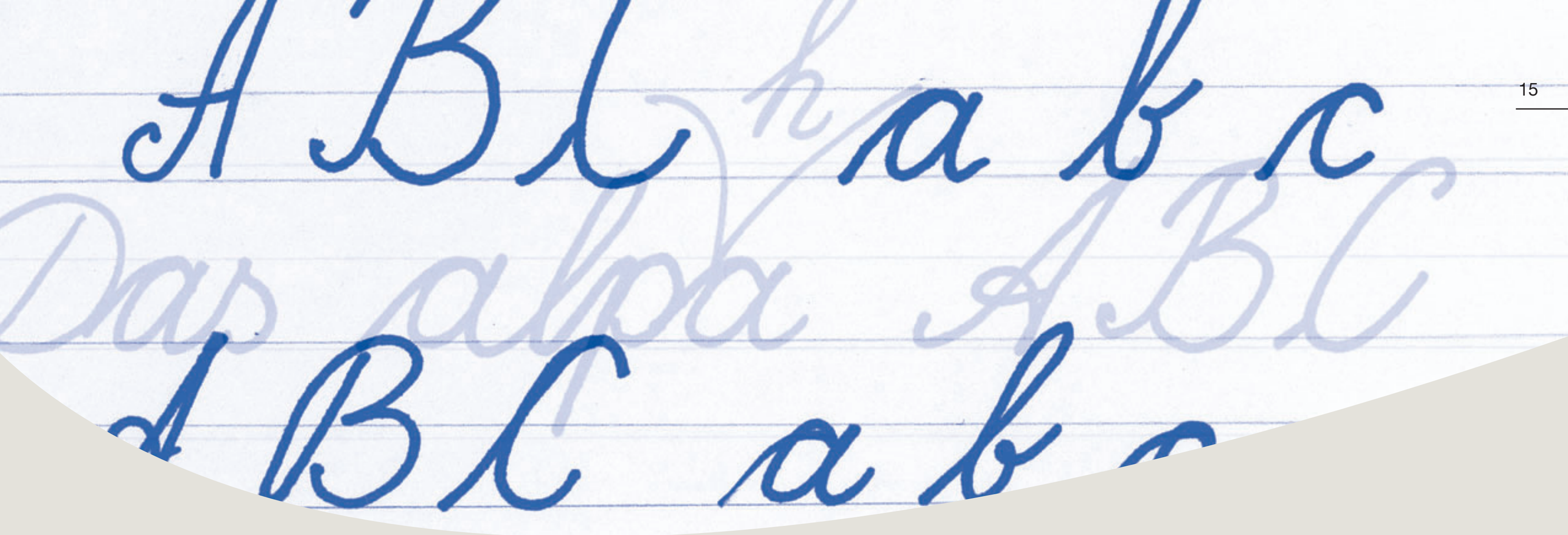
$$ED\,[\%] = \frac{t_b + t_c + t_d}{t_b + t_c + t_d + t_e}$$

Emergency stop torque (T_{2Not})
The emergency stop torque T_{2Not} is the maximum permissible torque at the gear output and must not be reached more than 1000 times during the life of the gear reducer. It must never be exceeded! (T_{2Not} = 2,5 x T_{2B}).

Efficiency (η)
Efficiency η [%] is the ratio of output power to input power. Power lost through friction means that the efficiency is always less than 1 or less than 100%.

$$\eta = \frac{P_{out}}{P_{in}} = \frac{P_{in} - P_{lost}}{P_{in}}$$

High Speed® (MC)
The High Speed version of our **SP+** gear has been specially developed for applications in continuous operation at high input speeds, e.g. as found in the printing and packaging industries.

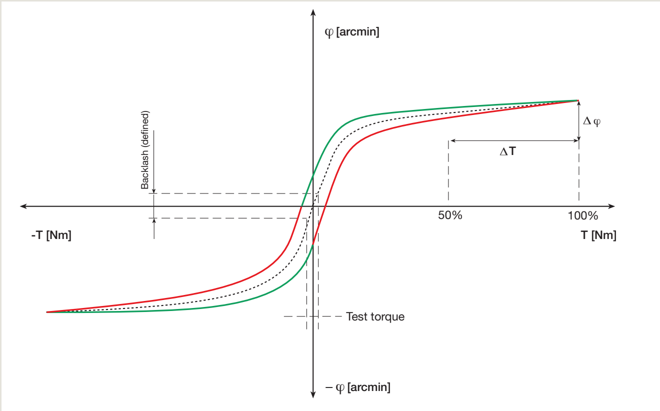


High Torque® (MA)

The High Torque version of our **TP+** gear has been specially developed for applications in continuous operation at high input speeds, e.g. as found in the printing and packaging industries.

Hysteresis curve

The hysteresis is measured to determine the torsional rigidity of a gear reducer. The result of this measurement is known as the hysteresis curve.



The gear reducer is loaded with a torque which increases continuously up to T_{2B} and is then relieved at the output in both directions of rotation with locked input shaft. The torsional angle is plotted against the torque. This yields a closed curve from which the ➔ torsional backlash and ➔ torsional rigidity can be determined.

Jerk

Jerk is derived from acceleration r (t) = da (t) / dt. It is defined as the change in acceleration within a unit of time. The term impact is used if the acceleration curve changes abruptly and the jerk is infinitely large.

Mass moment of inertia (J)

The mass moment of inertia J is a measure for the effort applied by an object to maintain its momentary condition (at rest or moving).

Mesh frequency (f_z)

The mesh frequency may cause problems with regards to vibrations in an application, especially if the excitation frequency corresponds to the intrinsic frequency of the application. It can be calculated using the formula $f_Z = 1.8 \cdot n_2$ [rpm]. If it does indeed become problematic, the intrinsic frequency of the system can be changed or a gear with a different ratio (= different mesh frequency) can be used.

Nominal torque (T_{2N})

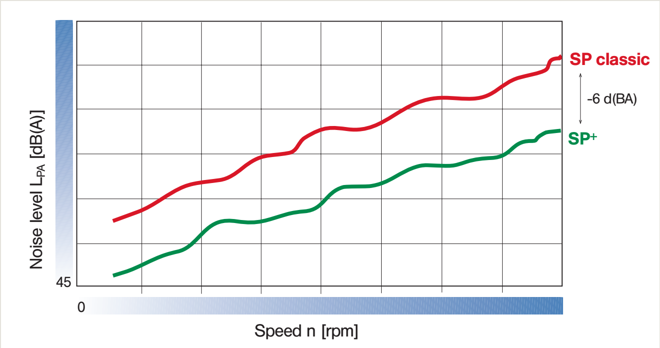
The nominal torque is the torque continuously transmitted by a gear reducer over a long period of time, i.e. in continuous operation (without wear).

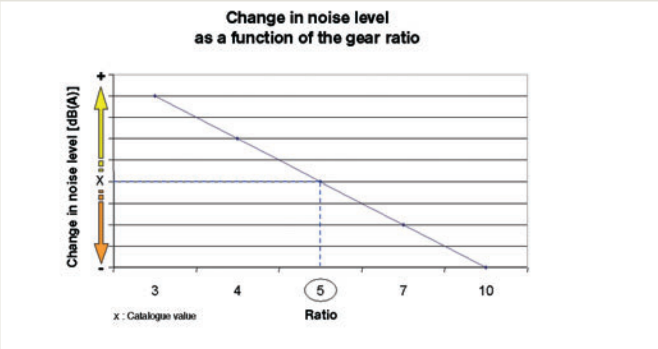
Noise level (L_{PA})

Low noise level is a factor of growing importance for environmental and health reasons. alpha has succeeded in reducing the noise of the new **SP+** gear reducers by another 6 dB(A) over the former SP units (i.e. sound power reduced to 1/4). Depending on the size of gear reducer, it is now only between 64 and 70 dB(A).

The gear ratio and speed both affect the noise level. The relationships are illustrated in the following trend graphs. As a general rule: a higher speed means a higher noise level, while a higher ratio means a lower noise level.

The values specified in our catalogue refer to a gear reducer with ratio i = 5 at a speed of n = 3000 rpm (min^{-1}).





➔ Refer to this term for further details.

No-load running torque (T_{012})

The no-load running torque T_{012} is the torque which must be applied to a gear reducer in order to overcome the internal friction; it is therefore considered lost torque. The values stated in the catalogue are determined by alpha at a speed of n_1 = 3000 rpm and an ambient temperature of 20°C:

T_{012}:	0	1 → 2
	without load	from input side towards output side

Positioning accuracy

The positioning accuracy is determined by the angular deviation from a setpoint and equals the sum of the torsional angles due to load (→ torsional rigidity and torsional backlash) and kinetics (→ synchronisation error) occurring simultaneously in practise.

Ratio (i)

The gear ratio i indicates the factor by which the gear reducer transforms the three relevant parameters of motion (speed, torque and mass moment of inertia). It is the result of the geometry of the gearing elements. (Example: i = 10).

n_1 = 3000 rpm $\xrightarrow{:i}$ n_2 = 300 rpm

T_1 = 20 Nm $\xrightarrow{\cdot i}$ T_2 = 200 Nm

J_1 = 0,10 kgm² $\xleftarrow{:i^2}$ J_2 = 10 kgm² (application)

Ratio of mass moment of inertia (λ = Lambda)

The ratio of mass moment of inertia λ is the ratio of external inertia (application side) to internal inertia (motor and gear reducer side). Since 2/3 of a gear reducer's mass moment of inertia results from the clamping hub, mounted torsionally stiff on the motor shaft, alpha considers the gear reducer and motor to constitute a single internal mass inertia. It is an important parameter determining the controllability of an application. Accurate control of dynamic processes becomes more difficult with differing mass moments of inertia and as λ becomes greater. alpha recommends that a value of $\lambda < 5$ should be maintained as a guideline value. A gear reducer reduces the external mass moment of inertia by a factor of $1/i^2$.

$$\lambda = \frac{J\ \text{external}}{J\ \text{internal}}$$

Radial force (F_R)

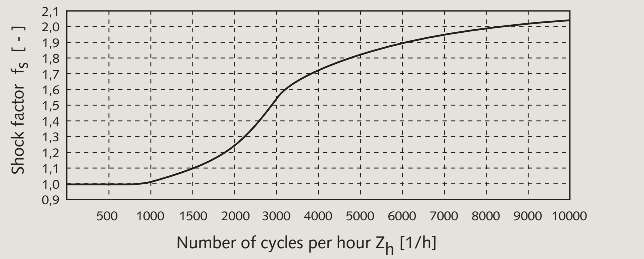
The radial force or cross force is the force component acting at right angles to the output shaft with the SP⁺, LP⁺ and SPK⁺ or parallel to the output flange with the TP⁺. It acts perpendicular to the axial force and can assume an axial distance x_2 in relation to the shaft nut with the SP⁺, LP⁺ and SPK⁺, or shaft flange with the TP⁺. This acts as a lever arm. The lateral force produces a bending moment.

Torque (M)

The torque is the actual driving force of a rotary motion. It is the product of lever arm and force. $M = F \cdot l$

Shock factor (f_s)

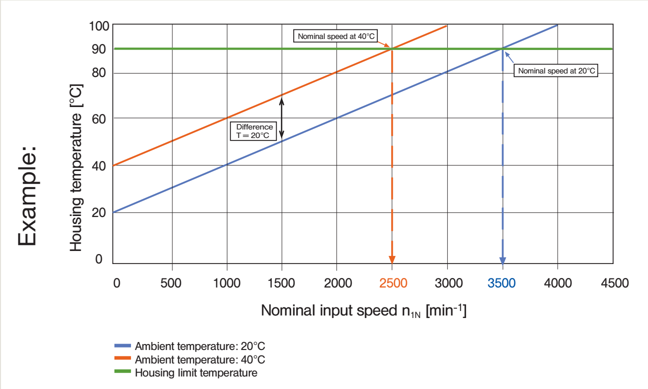
The maximum permissible acceleration torque in cyclical operation as specified in the catalogue applies for a cycle number less than 1000/h. Higher cycle numbers combined with short acceleration times can lead to vibrations in the drive train. The resultant excessive moments are taken into account using the shock factor f_s.



The shock factor f_s can be determined with the aid of this curve. The calculated value is multiplied by the actual acceleration torque T_{2b} and then compared with the maximum permissible acceleration torque T_{2B}.
($T_{2b} \cdot f_s = T_{2b,\,fs} < T_{2B}$)

Speed (n)

Two speeds are of relevance when dimensioning a gear-reducer: the maximum speed and the nominal speed at the input. The maximum permissible speed n_{1max} must not be exceeded; it serves as the basis for dimensioning the → cyclical operation. The nominal speed n_{1N} must not be exceeded in → continuous operation.
The housing temperature limits the nominal speed, which must not exceed 90 °C. The nominal input speed specified in the catalogue applies to an ambient temperature of 20°C. As can be seen from the diagram below, the temperature limit is reached more quickly in the presence of an elevated outside temperature. In other words, the nominal input speed must be reduced if the ambient temperature is high. The values applicable to your gear are available from alpha on request.



Synchronisation error

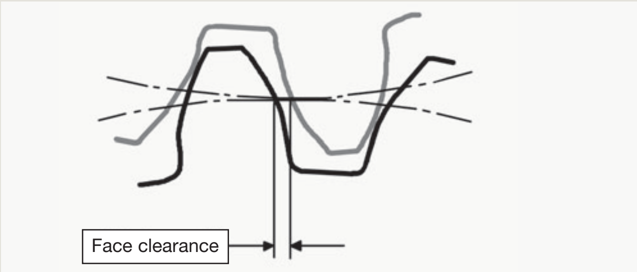
The synchronisation error is equal to the variations in speed measured between the input and output during one revolution of the output shaft. It is the result of manufacturing tolerances and causes minute angular deviations, as well as fluctuations in ratio.

Technical data (www.alphagear.com)

The technical data relating to our products can be downloaded from www.alphagear.com.
Or you can send your requests, suggestions, comments to: info@alphagear.com

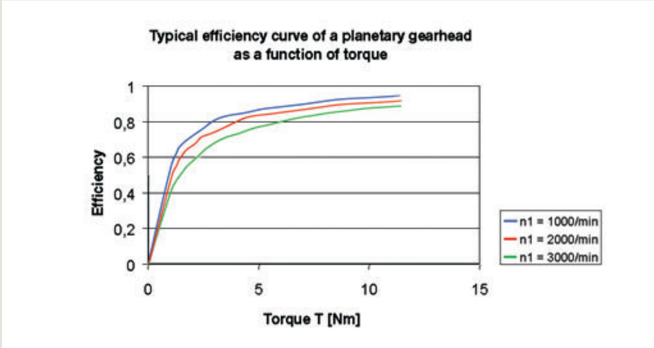
Tilting moment (M_{2K})
The tilting moment M_{2K} is the result of the axial and lateral forces applied and their respective points of application referred to the inner radial bearing on the output side.

Torsional backlash (j_t)
Torsional backlash j_t is the maximum angle of torsion of the output shaft in relation to the input. It is measured with the input shaft locked.



The output is then loaded with a defined test torque (approx. 2% of T_{2B}) in order to overcome the internal gear reducer friction. The main factor affecting torsional backlash is the face clearance between the gear teeth.
The low torsional backlash of alpha gear reducers is due to their high manufacturing accuracy and the specific combination of gear wheels.

Torsional stiffness (C_{t21})
Torsional stiffness C_{t21} is defined as the quotient of applied torque and generated torsion angle ($C_{t21} = \Delta T / \Delta\varphi$).
It consequently shows the torque necessary to turn the output shaft by one arcminute. The torsional rigidity can be determined from the ➔ hysteresis curve. Only the area between 50% and 100% of T_{2B} is considered for this purpose, as the curve profile can be considered linear in this area.



alpha always states the efficiency of a gear reducer in relation to full-load operation (T_{2B}). At lower input power / lower torque, the efficiency decreases due to the constant no-load running torque. The power loss does not increase. Speed also influences the efficiency, as can be seen from the diagram shown above by way of example.

➔ Refer to this term for further details.

We are grateful for all comments or suggestions relating to this catalog.
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