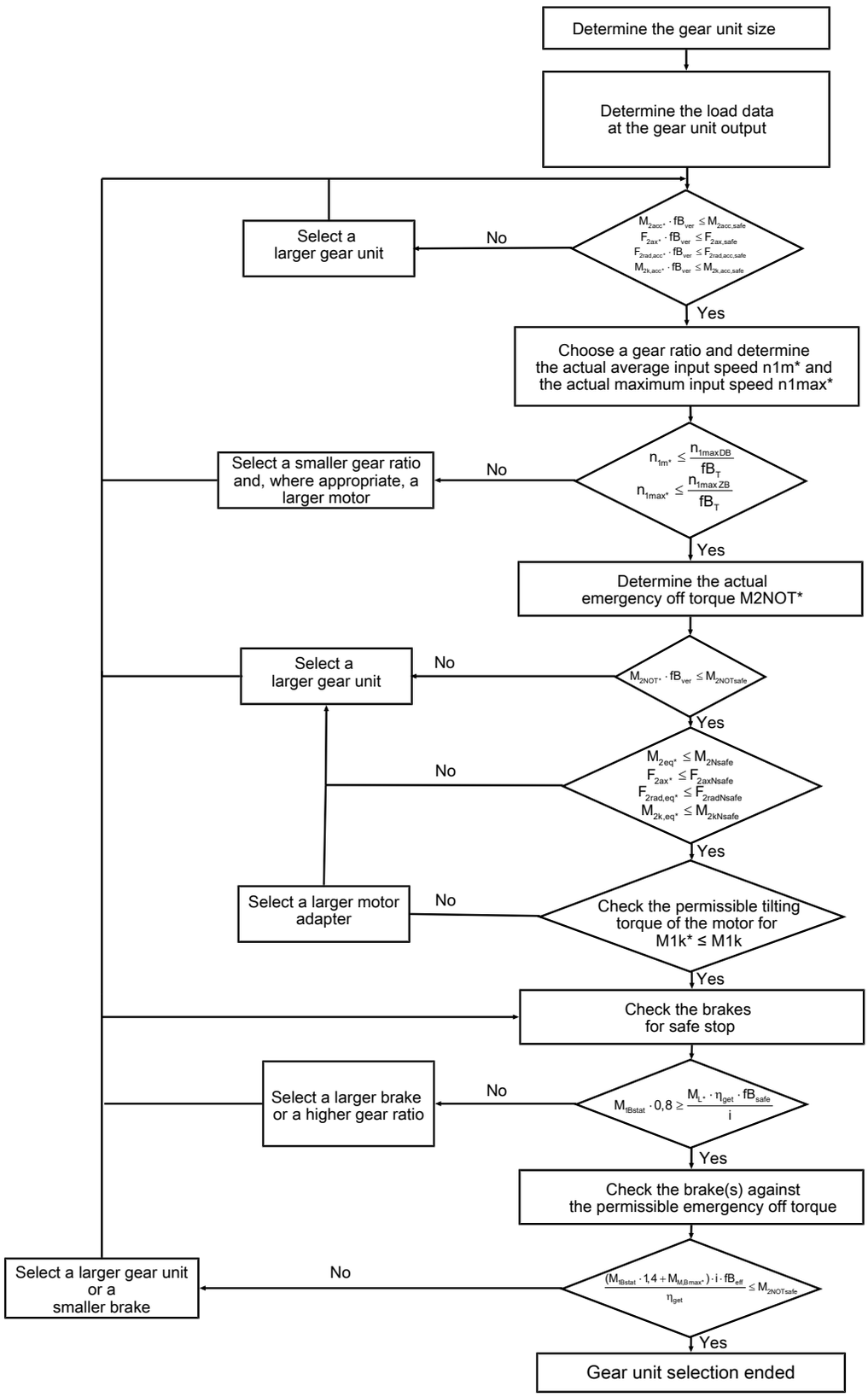
1 Drive selection for gravity-loaded axes with ServoStop

The formula symbols for values actually present in the application are marked with *.



The values for i, n_{1maxDB}, n_{1maxZB} and M_{1Bstat} can be found in selection tables in the respective chapter of catalog ServoStop servo gear units with brake ID 443234_de.

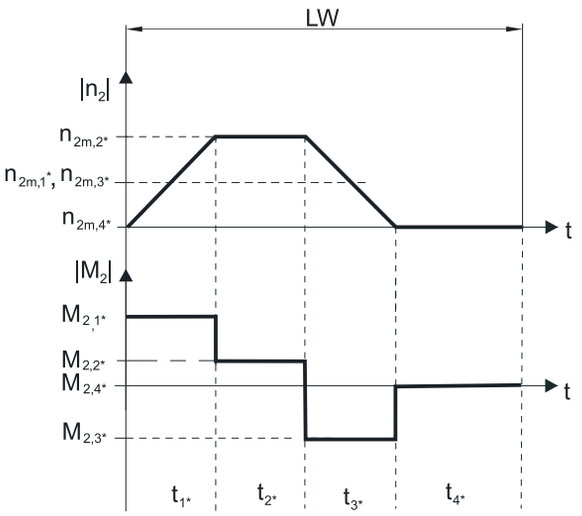
The values for the available maximum motor brake torque $M_{M,Bmax*}$ can be found in the manufacturer catalog.

For STOBER permanent magnet brakes, a tolerance of +100 %, −20 % applies to static and dynamic braking torques, for STOBER spring-loaded brakes +40 %, −20 %.

The values for fB_{op}, fB_{υ}, fB_T, fB_{safe}, fB_{ver} and fB_{eff} can be found in the corresponding tables in this chapter.

Example of cyclic operation

The following calculations are based on a representation of the power taken from the output based in accordance with the following example:



Calculation of the actual maximum acceleration torque

$$M_{2acc*} = J_{tot} \cdot \frac{\Delta n_2}{9.55 \cdot \Delta t} + M_{L*}$$

Calculation of the actual average input speed

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

$$n_{2m*} = \frac{\left|n_{2m,1*}\right| \cdot t_{1*} + \ldots + \left|n_{2m,n*}\right| \cdot t_{n*}}{t_{1*} + \ldots + t_{n*}}$$

If $t_{1*} + \ldots + t_{3*} \geq 6$ min, calculate n_{2m*} without the rest phase t_{4*}.

The values for the ratio i can be found in the selection tables.

Calculation of the actual emergency-off torque

$$M_{2NOT*} = J_{tot} \cdot \frac{\Delta n_2}{9.55 \cdot \Delta t} + M_{L*}$$

Calculation of the actual equivalent torque

$$M_{2eq*} = \sqrt[3]{\frac{\left|n_{2m,1*}\right| \cdot t_{1*} \cdot \left|M_{2,1*}{}^3\right| + \ldots + \left|n_{2m,n*}\right| \cdot t_{n*} \cdot \left|M_{2,n*}{}^3\right|}{\left|n_{2m,1*}\right| \cdot t_{1*} + \ldots + \left|n_{2m,n*}\right| \cdot t_{n*}}}$$

Operating factors

Operating mode P, PH, PHQ

Operating mode	fB_{op}
Uniform continuous operation	1.00
Cyclic operation	1.00
Reversing load cyclic operation	1.00

Operating mode C, F, K, S, PK, PHK, PHQK

Operating mode	fB_{op}
Uniform continuous operation	1.00
Cyclic operation	1.25
Reversing load cyclic operation	1.40

Run time	fB_t
Daily runtime ≤ 8 h	1.00
Daily runtime ≤ 16 h	1.15
Daily runtime ≤ 24 h	1.20

Temperature		fB_T
Motor cooling	**Surrounding temperature**	
Motor with forced ventilation	≤ 20 °C	0.9
	≤ 30 °C	1.0
	≤ 40 °C	1.15
Motor with convection cooling	≤ 20 °C	1.0
	≤ 30 °C	1.1
	≤ 40 °C	1.25

Safe stop	fB_{safe}
Safety-relevant + redundant brake system	≥ 1.00
Safety-relevant + 1 brake	≥ 1.30

Gravity-loaded axes	fB_{ver}
Personal hazard → no	≥ 1.00
Personal hazard → yes	≥ 2.00

Safety emergency off	$fB_{NOTsafe}$
Planetary gear units	0.6

Mass inertia ratio	fB_{eff}				
Load level	**λ 0.5**	**λ 1**	**λ 2**	**λ 5**	**λ 10**
90	0.92	0.95	0.96	0.98	0.99
75	0.83	0.87	0.91	0.95	0.97
50	0.66	0.75	0.83	0.91	0.95
0	0.33	0.50	0.66	0.83	0.90

$$\text{Load level} = 100 \cdot (1 - \frac{(M_{1Bstat} + M_{M,Bmax^*}) - \frac{M_L \cdot \eta}{i}}{(M_{1Bstat} + M_{M,Bmax^*})})$$

$$\lambda = \frac{J_L}{i^2 \cdot J_1}$$

Determining the permitted torques

Calculation of the permissible maximum acceleration torque

$$M_{2acc,safe} = MIN(M_{2verz,sf}; M_{2verz,sh}; .M_{2la,stat}; M_{2acc})$$

$M_{2verz,sf}$ for safety factor foot ≥ 1.1

$M_{2verz,sh}$ for safety factor pitting ≥ 1.03

$M_{2la,stat}$ for static load capacity ≥ 1.5 (for ball bearings) and ≥ 2 (for roller bearings)

The values for $M_{2verz,sf}$, $M_{2verz,sh}$ and $M_{2la,stat}$ can be found in the calculation program GetBer.

The values for M_{2acc} can be found in catalog ServoStop servo gear units with brake ID 443234_de. The M_{2acc} value also includes the shaft-hub connection.

Calculate the values with the maximum occurring torque and the average speed.

Calculation of the permissible nominal torque

$$M_{2Nsafe} = MIN(M_{2L10h}; M_{2N})$$

M_{2L10h} bearing service life ≥ 20000 hours (with simple weight force and n1m*).

The values for M_{2L10h} can be found in the calculation program GetBer.

The values for M_{2N} can be found in catalog ServoStop servo gear units with brake ID 443234_de. The M_{2N} value also includes the shaft-hub connection.

Calculation of the permissible emergency off torque for P, PH, PHQ

$$M_{2NOTsafe} = MIN(2xM_{2acc,safe};M_{2NOT} \cdot 0,9;M_{2zap} \cdot fB_{NOTsafe})$$

Calculation of the permissible emergency off torque for C, F, K, S, PK, PHK, PHQK

$$M_{2NOTsafe} = MIN(2xM_{2acc,safe};M_{2NOT} \cdot 0,9)$$

The values for $M_{2acc,safe}$ and M_{2zap} (only required for planetary gear units) can be found in the calculation program GetBer.

The values for M_{2NOT} can be found in catalog ServoStop servo gear units with brake ID 443234_de. The M_{2NOT} value also includes the shaft-hub connection.

Determining the permitted forces

Determining the permissible radial acceleration force

$F_{2rad,acc,safe}$ = MIN($F_{2rad,acc}$; $F_{2rad,la,stat}$)

$F_{2rad,acc}$ for safety factor shaft ≥ 1.1

$F_{2rad,la,stat}$ for static load capacity ≥ 1.5 (for ball bearings) and ≥ 2 (for roller bearings)

The values for $F_{2rad,acc,safe}$ and $F_{2rad,la,stat}$ can be found in the calculation program GetBer or KissSoft.

Calculation of the permissible axial force

$F_{2ax,safe}$ = MIN(F_{2ax100} bzw. F_{2ax20}; $F_{2ax,la,stat}$)

$F_{2ax,la,stat}$ for static load capacity ≥ 1.5 (for ball bearings) and ≥ 2 (for roller bearings)

The values for F_{2ax100} resp. F_{2ax20} can be found in catalog ServoStop servo gear units with brake ID 443234_de. The values for $F_{2ax,la,stat}$ can be found in the calculation program GetBer or KissSoft.

Calculation of the permissible tilting torque

$M_{2k,acc,safe}$ = MIN($M_{2k,acc}$; $M_{2la,stat}$)

$M_{2k,acc}$ for safety factor shaft ≥ 1.1

$M_{2la,stat}$ for static load capacity ≥ 1.5 (for ball bearings) and ≥ 2 (for roller bearings)

The values for $M_{2k,acc,safe}$ and $M_{2la,stat}$ can be found in the calculation program GetBer or KissSoft.

Calculation of the permissible nominal radial force

$F_{2radNsafe}$ = MIN($F_{2rad,acc,safe}$; $F_{2radL10h}$)

$F_{2radL10h}$ bearing service life ≥ 20000 hours (with simple weight force and n_{1m*}).

The values for $F_{2radL10h}$ can be found in the calculation program GetBer.

Nominal force must not be higher than acceleration force $F_{2radN,safe} \leq F_{2rad,acc,safe}$

Calculation of the permissible nominal axial force

$F_{2axNsafe}$ = MIN(F_{2axN}; $F_{2axL10h}$)

$F_{2axL10h}$ bearing service life ≥ 20000 hours (with simple weight force and n_{1m*}).

The values for $F_{2axL10h}$ can be found in the calculation program GetBer.

Nominal force must not be higher than permissible axial force $F_{2axNsafe} \leq F_{2ax,safe}$

Calculation of the permissible nominal breakdown torque

$M_{2kNsafe}$ = MIN($M_{2k,acc,safe}$; M_{2kL10h})

M_{2kL10h} bearing service life ≥ 20000 hours (with simple weight force and n_{1m*}).

The values for M_{2kL10h} can be found in the calculation program GetBer.

Nominal tilting torque must not be higher than acceleration tilting torque $M_{2kN,safe} \leq M_{2k,acc,safe}$

2 Formula symbols

The formula symbols for values actually present in the application are marked with *.

Symbol	Unit	Explanation
Δn_2	rpm	Speed difference
Δt	s	Timespan
η	%	Efficiency
η_{get}	%	Efficiency of the gear unit at nominal torque
F_{2ax*}	N	Actual axial force at the gear unit output
$F_{2ax,la,stat}$	N	Axial force for defined static bearing capacity on the gear unit output
$F_{2ax,safe}$	N	Permissible axial force on the gear unit output for gravity-loaded axes
F_{2ax100}	N	Permitted axial force at the gear unit output for $n_{2m*} \leq 100$ rpm (without radial force)
F_{2ax20}	N	Permitted axial force at the gear unit output for $n_{2m*} \leq 20$ rpm (without radial force)
$F_{2axL10h}$	Nm	Axial force for defined bearing service life on the gear unit output
F_{2axN}	N	Permitted nominal axial force at the gear unit output (without radial force)
$F_{2axNsafe}$	N	Permitted nominal axial force at the gear unit output (without radial force) for gravity-loaded axes
$F_{2rad,acc}$	N	Permitted radial acceleration force at the gear unit output
$F_{2rad,acc*}$	N	Radial acceleration force present at the gear unit output
$F_{2rad,acc,safe}$	N	Permitted radial acceleration force at the gear unit output for gravity-loaded axes
$F_{2rad,eq*}$	N	Actual equivalent force at the gear unit output
$F_{2rad,la,stat}$	N	Radial force for defined static bearing capacity on the gear unit output
$F_{2radL10h}$	Nm	Radial force for defined bearing service life on the gear unit output
$F_{2radNsafe}$	N	Permissible nominal radial force on the gear unit output for gravity-loaded axes
fB_{eff}	–	Operating factor mass inertia ratio
$fB_{NOTsafe}$	–	Operating factor safety emergency off
fB_{op}	–	Operating mode operating factor
fB_{safe}	–	Operating factor safe stop
fB_t	–	Runtime operating factor
fB_T	–	Temperature operating factor
fB_{ver}	–	Operating factor gravity-loaded axes
i	–	Gear ratio
J_1	$kgcm^2$	Mass moment of inertia relative to the gear unit input
J_L	$kgcm^2$	Mass moment of inertia load
J_{tot}	kgm^2	Total mass moment of inertia (based on the motor shaft)
λ	–	Power factor
LW	-	Load change: A load change (LW) corresponds to an acceleration and a deceleration.
M_{1Bstat}	Nm	Static braking torque of the brake in the motor adapter (tolerance +40%, −20%)
M_{1k}	Nm	Permitted tilting torque at the gear unit input
M_{1k*}	Nm	Existing tilting torque on the gear unit input
$\lvert M_2 \rvert$	Nm	Amount of torque on the output
$M_{2.1*} – M_{2.4*}$	Nm	Actual torque in the respective time segment (1 to 4)
M_{2acc*}	Nm	Actual acceleration torque on the gear unit output
$M_{2acc,safe}$	Nm	Maximum permitted acceleration torque on the gear unit output for gravity-loaded axes
M_{2eq*}	Nm	Equivalent torque present on the gear unit output
$M_{2k,acc}$	Nm	Permitted acceleration tilting torque at the gear unit output
$M_{2k,acc*}$	Nm	Acceleration tilting torque present at the gear unit output
$M_{2k,acc,safe}$	Nm	Permitted acceleration tilting torque on the gear unit output for gravity-loaded axes
$M_{2k,eq*}$	Nm	Actual equivalent tilting torque on the gear unit output
M_{2kL10h}	Nm	Tilting torque for defined bearing service life on the gear unit output
M_{2kN}	Nm	Permitted nominal tilting torque at the gear unit output
$M_{2kNsafe}$	Nm	Permitted nominal tilting torque on the gear unit output for gravity-loaded axes
M_{2L10h}	Nm	Torque for defined bearing service life on the gear unit output
$M_{2,n*}$	Nm	Actual torque in the n-th time segment
M_{2N}	Nm	Nominal torque on the gear unit output (relative to n_{1N})
M_{2NOT}	Nm	Gear unit emergency-off torque on the gear unit output for max. 1000 load changes
M_{2NOT*}	Nm	Actual emergency off torque for the gear unit on the gear unit output
$M_{2NOTsafe}$	Nm	Gear unit emergency-off torque on the gear unit output for max. 1000 load changes for gravity-loaded axes

Symbol	Unit	Explanation
M_{2Nsafe}	Nm	Nominal torque on the gear unit output (relative to n_{1N}) for gravity-loaded axes
$M_{2la,stat}$	Nm	Torque for defined static bearing capacity on the gear unit output
$M_{2verz,sf}$	Nm	Torque for defined safety factor foot on the gear unit output
$M_{2verz,sh}$	Nm	Torque for defined safety factor pitting on the gear unit output
M_{2zap}	Nm	Pin torque on the gear unit output
M_L	Nm	Load torque
M_{L*}	Nm	Actual load torque
$M_{M,Bmax*}$	Nm	Maximum available motor torque for the gear unit in a redundant brake system including any tolerances of the braking torque
n_{1m*}	rpm	Actual average input speed
n_{1max*}	rpm	Actual maximum input speed
n_{1maxDB}	min^{-1}	Maximum permitted input speed of the gear unit in continuous operation
		(at surrounding temperature of 20 °C)
n_{1maxZB}	min^{-1}	Maximum permitted input speed of the gear unit in cyclic operation
		(at surrounding temperature of 20 °C)
$\lvert n_2 \rvert$	rpm	Value of output speed
n_{2m*}	rpm	Actual average output speed
$n_{2m,1*} – n_{2m,4*}$	rpm	Actual average output speed in the respective time segment (1 to 4)
$n_{2m,n*}$	rpm	Actual average output speed in the n-th time segment
t	s	Time
$t_{1*} – t_{4*}$	s	Duration of the respective time segment (1 to 4)
t_{n*}	s	Duration of the n-th time segment

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