7 Planetary geared motors

PE

7.1 Overview

Cost-efficient helical-geared planetary geared motors

Features

Power density	★★★☆☆
Backlash	★★★☆☆
Price category	€
Shaft load	★★☆☆☆
Smooth operation	★★★☆☆
Torsional stiffness	★★★☆☆
Mass moment of inertia	★★★★★
Helical gearing	✓
Maintenance-free	✓
Any installation position	✓
Non-contact sealing at the input	✓
Compact and dynamic due to direct motor attachment	✓

Key: ★☆☆☆☆ good | ★★★★★ excellent
€ Economy | €€€€€ Premium

Technical data

i	3 – 20
M_{2acc}	13 – 310 Nm
$\Delta\phi_2$	8 – 10 arcmin
η_{get}	≤ 97 %

7.2 Selection tables

The technical data specified in the selection tables applies to:

- Installation altitudes up to 1000 m above sea level
- Surrounding temperatures from 0 °C to 40 °C
- Drives with convection-cooled motors

An explanation of the formula symbols can be found in the Chapter [▷ 15.1].

n_{2N} [rpm]	M_{2N} [Nm]	$M_{2,0}$ [Nm]	a_{th}	S	Type	M_{2acc} [Nm]	M_{2NOT} [Nm]	i	i_{exakt}	n_{1max} DB [rpm]	n_{1max} ZB [rpm]	J_1 [10^{-4} kgm²]	$\Delta\varphi_2$ [arcmin]	C_2 [Nm/arcmin]	m [kg]
PE3 (n_{1N} = 3000 rpm, $M_{2acc,max}$ = 55 Nm)															
188	36	35	9.0	0.84	PE312_0160 LM401U	55	75	16.00	16/1	3700	6000	1.7	10	4.2	6.6
250	27	26	10	1.1	PE312_0120 LM401U	51	75	12.00	12/1	3700	6000	1.8	10	4.2	6.6
429	16	16	3.1	1.1	PE311_0070 LM401U	31	75	7.000	7/1	4000	6000	1.7	8	3.8	6.0
600	11	11	4.6	1.6	PE311_0050 LM401U	22	75	5.000	5/1	3700	6000	1.7	8	4.1	6.0
600	21	22	8.7	0.85	PE311_0050 LM402U	40	75	5.000	5/1	3700	6000	3.1	8	4.1	7.7
750	9.2	8.9	6.3	1.9	PE311_0040 LM401U	17	75	4.000	4/1	3700	6000	1.7	8	4.2	6.0
750	17	17	12	1.0	PE311_0040 LM402U	38	75	4.000	4/1	3700	6000	3.1	8	4.2	7.7
1000	6.9	6.7	9.4	2.4	PE311_0030 LM401U	13	64	3.000	3/1	3500	6000	1.8	8	3.6	6.0
1000	13	13	18	1.3	PE311_0030 LM402U	28	64	3.000	3/1	3500	6000	3.1	8	3.6	7.7
PE4 (n_{1N} = 3000 rpm, $M_{2acc,max}$ = 120 Nm)															
188	67	68	8.7	0.97	PE412_0160 LM402U	120	190	16.00	16/1	3400	6000	3.2	10	14	10
250	50	51	10	1.3	PE412_0120 LM402U	110	190	12.00	12/1	3400	5500	3.4	10	14	10
250	69	71	14	0.94	PE412_0120 LM403U	120	190	12.00	12/1	3400	5500	4.7	10	14	12
300	43	44	2.4	0.84	PE411_0100 LM402U	90	190	10.00	10/1	3600	6000	3.1	8	10	9.2
429	30	31	3.3	1.3	PE411_0070 LM402U	66	190	7.000	7/1	3600	6000	3.1	8	12	9.2
429	41	42	4.5	0.96	PE411_0070 LM403U	87	190	7.000	7/1	3600	6000	4.4	8	12	11
600	21	22	4.9	1.9	PE411_0050 LM402U	47	190	5.000	5/1	3400	6000	3.3	8	13	9.2
600	29	30	6.7	1.4	PE411_0050 LM403U	62	190	5.000	5/1	3400	6000	4.6	8	13	11
600	46	49	10	0.86	PE411_0050 LM503U	99	190	5.000	5/1	3400	6000	11	8	13	14
750	17	17	6.4	2.3	PE411_0040 LM402U	38	190	4.000	4/1	3400	6000	3.3	8	14	9.2
750	24	24	8.7	1.7	PE411_0040 LM403U	50	190	4.000	4/1	3400	6000	4.6	8	14	11
750	37	39	14	1.1	PE411_0040 LM503U	79	190	4.000	4/1	3400	6000	11	8	14	14
1000	13	13	10	2.8	PE411_0030 LM402U	28	180	3.000	3/1	3000	5500	3.5	8	13	9.2
1000	18	18	14	2.0	PE411_0030 LM403U	37	180	3.000	3/1	3000	5500	4.8	8	13	11
1000	28	29	21	1.3	PE411_0030 LM503U	59	180	3.000	3/1	3000	5500	11	8	13	14
1000	40	45	31	0.90	PE411_0030 LM505U	90	180	3.000	3/1	3000	5500	17	8	13	18
PE5 (n_{1N} = 3000 rpm, $M_{2acc,max}$ = 310 Nm)															
150	180	191	7.6	0.89	PE512_0200 LM503U	310	480	20.00	20/1	2600	5000	11	10	35	19
188	144	153	8.4	1.1	PE512_0160 LM503U	310	480	16.00	16/1	2600	5000	11	10	35	19
200	135	143	11	0.96	PE512_0150 LM503U	250	480	15.00	15/1	2500	4500	12	10	33	19
250	108	115	9.8	1.5	PE512_0120 LM503U	230	480	12.00	12/1	2500	4500	12	10	35	19
250	156	176	14	1.0	PE512_0120 LM505U	310	480	12.00	12/1	2500	4500	18	10	35	24
300	92	98	5.7	0.95	PE511_0100 LM503U	200	400	10.00	10/1	3000	5000	10	8	27	17
429	64	68	7.3	1.6	PE511_0070 LM503U	140	400	7.000	7/1	2800	5000	11	8	31	17
429	93	105	11	1.1	PE511_0070 LM505U	220	400	7.000	7/1	2800	5000	17	8	31	21
600	46	49	11	2.2	PE511_0050 LM503U	99	390	5.000	5/1	2600	5000	11	8	34	17
600	66	75	16	1.6	PE511_0050 LM505U	160	390	5.000	5/1	2600	5000	17	8	34	21
600	93	103	22	1.1	PE511_0050 LM704U	200	400	5.000	5/1	2600	5000	37	8	34	27
600	125	145	30	0.83	PE511_0050 LM706U	250	400	5.000	5/1	2600	5000	54	8	34	34
750	37	39	14	2.8	PE511_0040 LM503U	79	310	4.000	4/1	2600	5000	11	8	35	17
750	53	60	21	1.9	PE511_0040 LM505U	120	310	4.000	4/1	2600	5000	17	8	35	21
750	75	82	29	1.4	PE511_0040 LM704U	160	400	4.000	4/1	2600	5000	37	8	35	27
750	100	116	39	1.0	PE511_0040 LM706U	240	400	4.000	4/1	2600	5000	54	8	35	34
1000	28	29	29	2.6	PE511_0030 LM503U	59	240	3.000	3/1	2500	4500	11	8	35	17
1000	40	45	42	1.8	PE511_0030 LM505U	93	240	3.000	3/1	2500	4500	17	8	35	21
1000	56	62	60	1.3	PE511_0030 LM704U	120	390	3.000	3/1	2500	4500	37	8	35	27
1000	75	87	79	0.96	PE511_0030 LM706U	180	390	3.000	3/1	2500	4500	54	8	35	34

7.3 Dimensional drawings

In this chapter you can find the dimensions of the geared motors.

There is a dimensional drawing for every possible shaft/housing design, each with the tables for gear unit dimensions, motor dimensions and geared motor dimensions.

Dimensions can exceed the specifications of ISO 2768-mK due to casting tolerances or accumulation of individual tolerances.

We reserve the right to make dimensional changes due to ongoing technical development.

You can download CAD models of our standard drives at http://cad.stoeber.de.

Combination options and the dimensions of forced ventilated geared motors can be found at http://cad.stoeber.de.

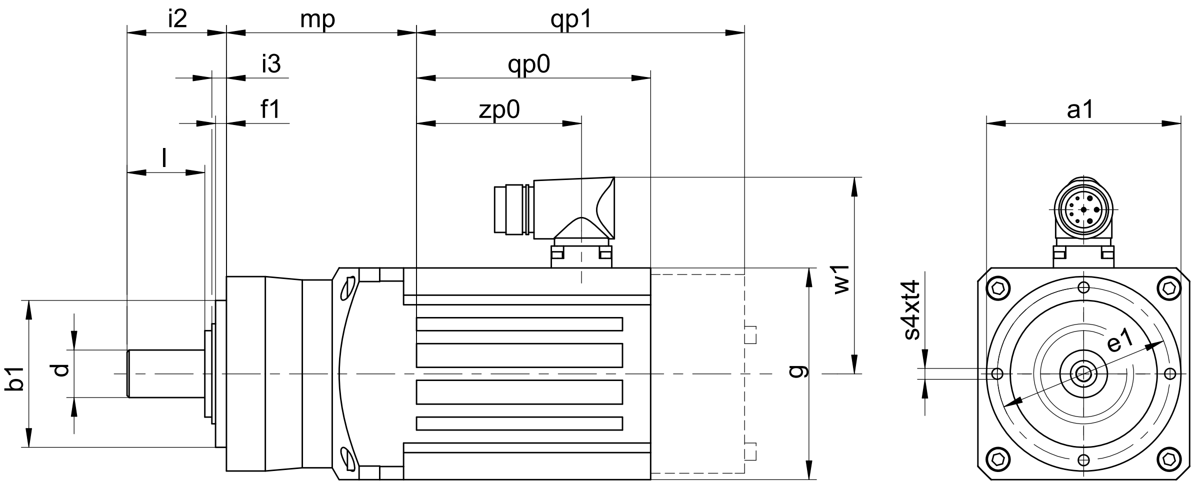
Tolerances

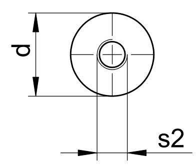
Solid shaft	Tolerance
Shaft ∅ fit ≤ 50 mm	DIN 748-1, ISO k6
Shaft ∅ fit > 50 mm	DIN 748-1, ISO m6
Feather keys	DIN 6885-1, high form A
Balance quality	Q 2.5 (balanced with half feather key)

Centering holes in solid shafts in accordance with DIN 332-2, DR shape

Thread size	M4	M5	M6	M8	M10	M12	M16	M20	M24
Thread depth [mm]	10	12.5	16	19	22	28	36	42	50

7.3.1 G shaft design (solid shaft without feather key)





qp0 Applies to motors without brake.

qp1 Applies to motors with brake.

Dimensions of gear units

Type	∅a1	∅b1	∅d	∅e1	f1	i2	i3	l	s2	s4	t4
PE311	70	52_{h6}	16_{k6}	62	5	36	6.0	28	M5	M5	10
PE312	70	52_{h6}	16_{k6}	62	5	36	6.0	28	M5	M5	10
PE411	90	68_{h6}	22_{k6}	80	5	46	6.5	36	M8	M6	13
PE412	90	68_{h6}	22_{k6}	80	5	46	6.5	36	M8	M6	13
PE511	120	90_{h6}	32_{k6}	108	6	70	8.0	58	M12	M8	16
PE512	120	90_{h6}	32_{k6}	108	6	70	8.0	58	M12	M8	16

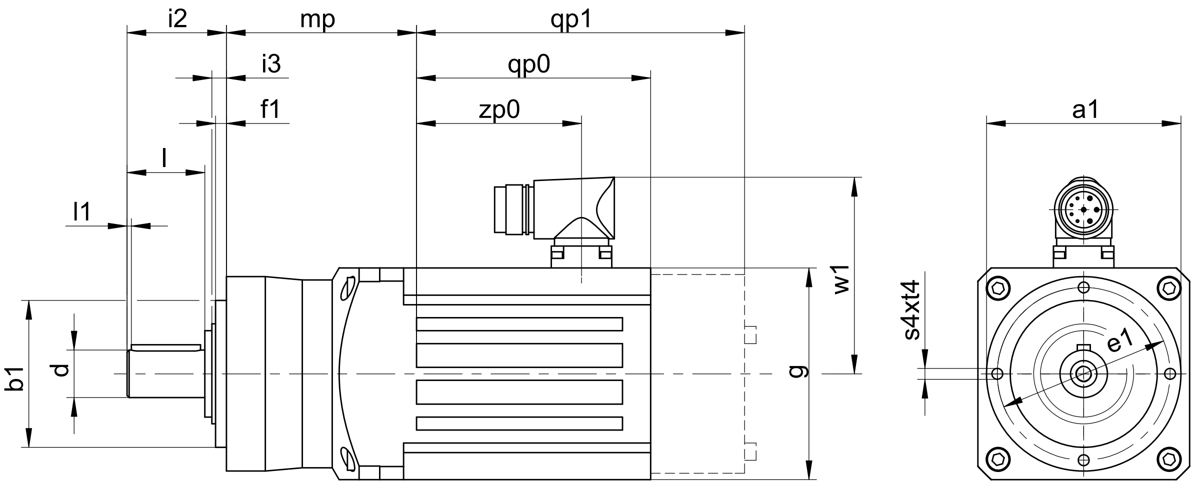
Dimensions of motors

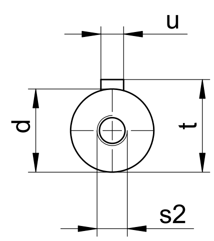
Type	□g	qp0	qp1	w1	zp0
LM401U	98	108.5	152.0	91	76.5
LM402U	98	147.5	191.0	91	115.5
LM403U	98	178.5	222.0	91	146.5
LM503U	115	186.5	234.5	100	156.0
LM505U	115	256.5	304.5	100	226.0
LM704U	145	236.5	295.5	115	204.0
LM706U	145	306.5	365.5	115	274.0

Dimensions of geared motors

Type	LM4	LM5	LM7
	mp	mp	mp
PE311	82.5	–	–
PE312	115.0	–	–
PE411	88.0	90.5	–
PE412	126.0	–	–
PE511	–	105.5	111.5
PE512	–	151.0	–

7.3.2 P shaft design (solid shaft with feather key)





qp0 Applies to motors without brake.

qp1 Applies to motors with brake.

Dimensions of gear units

Type	∅a1	∅b1	∅d	∅e1	f1	i2	i3	l	l1	s2	s4	t	t4	u
PE311	70	52_{h6}	16_{k6}	62	5	36	6.0	28	2	M5	M5	18.0	10	A5×5×22
PE312	70	52_{h6}	16_{k6}	62	5	36	6.0	28	2	M5	M5	18.0	10	A5×5×22
PE411	90	68_{h6}	22_{k6}	80	5	46	6.5	36	2	M8	M6	24.5	13	A6×6×32
PE412	90	68_{h6}	22_{k6}	80	5	46	6.5	36	2	M8	M6	24.5	13	A6×6×32
PE511	120	90_{h6}	32_{k6}	108	6	70	8.0	58	4	M12	M8	35.0	16	A10×8×50
PE512	120	90_{h6}	32_{k6}	108	6	70	8.0	58	4	M12	M8	35.0	16	A10×8×50

Dimensions of motors

Type	□g	qp0	qp1	w1	zp0
LM401U	98	108.5	152.0	91	76.5
LM402U	98	147.5	191.0	91	115.5
LM403U	98	178.5	222.0	91	146.5
LM503U	115	186.5	234.5	100	156.0
LM505U	115	256.5	304.5	100	226.0
LM704U	145	236.5	295.5	115	204.0
LM706U	145	306.5	365.5	115	274.0

Dimensions of geared motors

Type	LM4	LM5	LM7
	mp	mp	mp
PE311	82.5	–	–
PE312	115.0	–	–
PE411	88.0	90.5	–
PE412	126.0	–	–
PE511	–	105.5	111.5
PE512	–	151.0	–

7.4 Type designation

In this chapter, you can find an explanation of the type designation with the associated options.

Additional ordering information not included in the type designation can be found at the end of the chapter.

Sample code

PE	4	1	2	S	G	R	0120	LM403U

Explanation

Code	Designation	Design
PE	Type	Planetary gear unit
4	Size	4 (example)
1	Generation	Generation 1
1	Stages	Single-stage
2		Two-stage
S	Housing	Standard
G	Shaft	Solid shaft without feather key
P		Solid shaft with feather key
R	Bearing	Standard bearing
0120	Transmission ratio (i x 10)	i = 12 (example)
LM403U	Motor	LM Lean motor

In order to complete the type designation, also specify:

- A detailed type designation of the motor, see the chapter [▸ 2]

7.5 Product description

7.5.1 Installation conditions

The specified torques and forces only apply when attaching gear units at the machine side using screws of quality 10.9. In addition, the gear housing must be adjusted at the pilot (H7).

7.5.2 Lubricants

STOBER fills the gear units with the amount and type of lubricant specified on the nameplate.

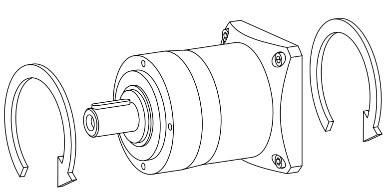
Lubricant filling quantities for gear units, document ID 441871, can be found online at http://www.stoe-ber.de

7.5.3 Other product features

Feature	Value
Max. permitted gear unit temperature (on the surface of the gear unit)	≤ 80 °C
Paint	Black RAL 9005
(ATEX) Directive 2014/34/EU	Not suitable
Protection class: [1]	
Gear unit	IP64
Motor	IP56, optionally IP66

7.5.4 Direction of rotation

The input and output rotate in the same direction.



[1] Observe the protection class of all the components.

7.6 Project configuration

Project your drives using our SERVOsoft designing software. You can receive SERVOsoft for free from your adviser at one of our sales centers. Observe the limit conditions in this chapter to ensure a safe design for your drives.

An explanation of the formula symbols can be found in Chapter Symbols in formulas.

7.6.1 Calculation of the operating point

Check the following conditions for operating points other than the nominal point M_{2N} specified in the selection tables.

$$n_{1m*} \leq \frac{n_{1maxDB}}{fB_T}$$

$$n_{1max*} \leq \frac{n_{1maxZB}}{fB_T}$$

$$M_{2eff*} \leq M_{2th}$$

$$M_{2acc*} \leq M_{2acc}$$

$$M_{2NOT*} \leq M_{2NOT}$$

$$M_{2eq*} \leq M_{2N} \cdot \frac{S}{fB_{op} \cdot fB_t}$$

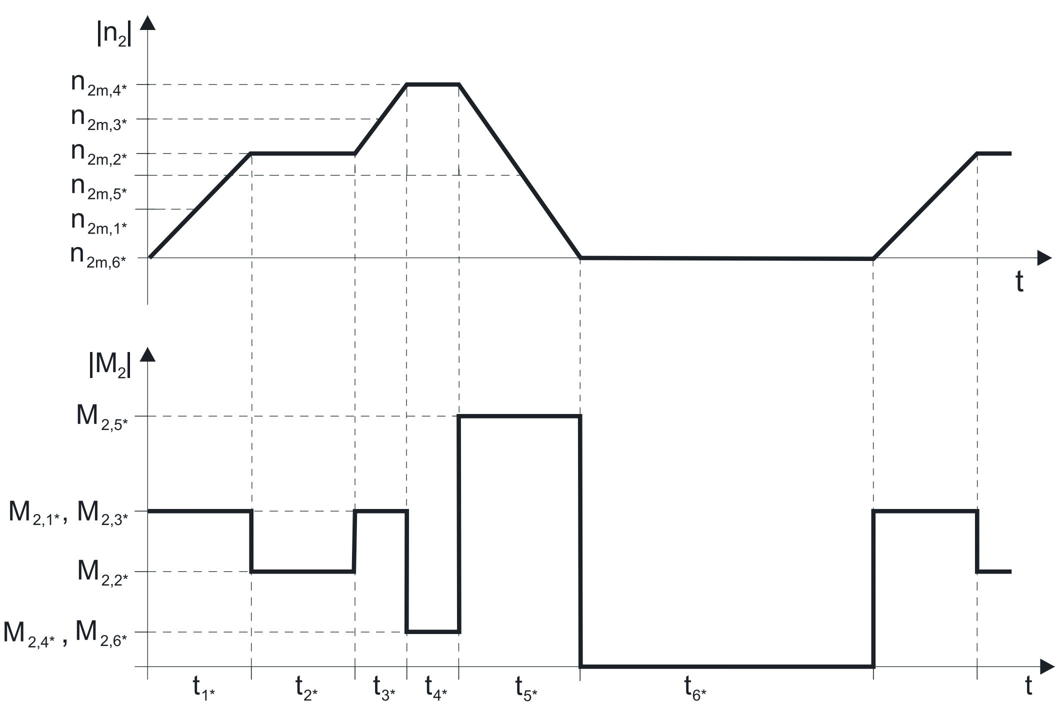
The values for n_{1maxDB}, n_{1maxZB}, M_{2acc}, M_{2NOT}, M_{2N} and S can be found in the selection tables.

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

Calculate the thermal limit torque M_{2th} for a duty cycle > 50%.

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 average input speed

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

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

If t_{1*} + ... + $t_{5*} \geq$ 20 min, calculate n_{2m*} without the rest phase t_{6*}.

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

Calculation of the actual effective torque

$$M_{2eff*} = \sqrt{\frac{t_{1*} \cdot M_{2,1*}^{2} + \ldots + t_{n*} \cdot M_{2,n*}^{2}}{t_{1*} + \ldots + t_{n*}}}$$

Calculation of the actual equivalent torque

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

Calculation of the thermal limit torque

Calculate the thermal limit torque M_{2th} for a duty cycle ED_{20} > 50% and the actual average input speed n_{1m*}. (At $K_{mot,th} \leq 0$ you must reduce the average input speed n_{1m*} accordingly or select another geared motor size.)

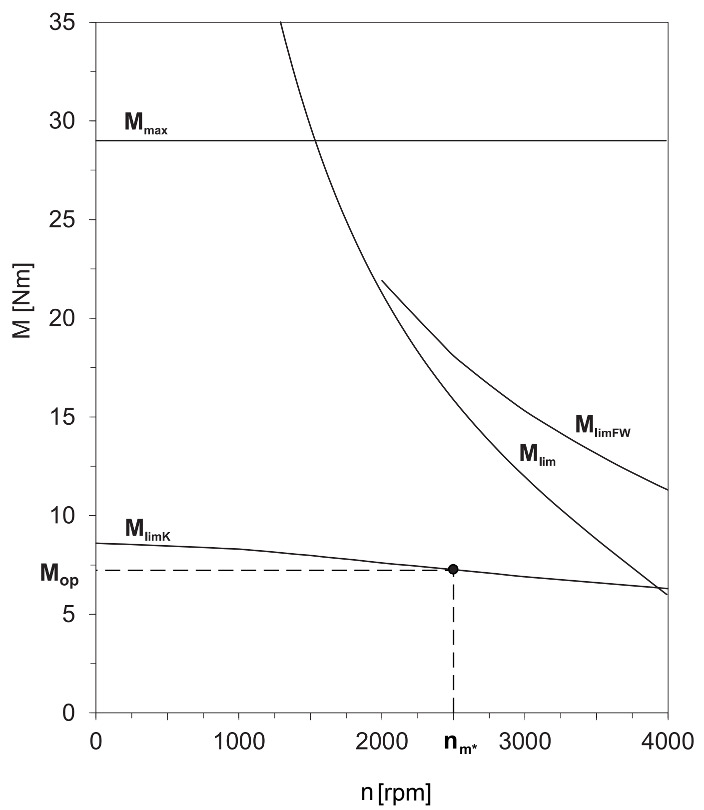
$$M_{2th} = M_{op} \cdot i \cdot K_{mot,th}$$

$$K_{mot,th} = 0{,}95 - \frac{a_{th}}{1000} \cdot fB_{T} \cdot \left(\frac{n_{1m*}}{1000}\right)^{3}$$

The values for i and a_{th} can be found in the selection tables.

The values for fB_T can be found in the corresponding table in this chapter.

The value for the torque of the motor at operating point M_{op} with the determined average input speed n_{1m*} can be found in the motor curve of Chapter [▸ 2.3]. Note the size and nominal speed n_N of the motor. The figure below shows an example of reading the torque M_{op} of a motor with convection cooling at the operating point.



Operating factors

Operating mode	Number of load changes/ hour	fB_{op}
Uniform continuous operation	–	1.00
Cyclic operation	–	1.00
Cyclic operation – reversing load[2]	≤ 1000	1.00
	2000	1.20
	3000	1.40
	4000	1.60
	≥ 5000	1.80

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

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

Notes

- The maximum permitted gear unit temperature (see the "Other product features" chapter) must not be exceeded. Doing so may result in damage to the geared motor.
- For braking from full speed (for example when the power fails or when setting up the machine), note the permitted gear unit torques (M_{2acc}, M_{2NOT}) in the selection tables.
- The values specified in the selection tables for M_{2acc} refer to the gear units with a solid shaft design without feather key (G). We recommend this shaft design in general for cyclic operation.

7.6.2 Permitted shaft loads for the output shaft

The values specified in the tables apply to the permitted shaft loads:

- For shaft dimensions in accordance with the catalog
- For output speeds n_{2m*} ≤ 100 rpm ($F^{2axN} = F_{2ax100}$; $F_{2radN} = F_{2rad100}$; $M_{2kN} = M_{2k100}$)
- Only if radial forces on the gear unit are stabilized by its pilots (housing, flange shaft)

Permitted shaft loads for standard bearing R

Type	z_2 [mm]	F_{2ax100} [N]	$F_{2rad100}$ [N]	$F_{2rad,acc}$ [N]	M_{2k100} [Nm]	$M_{2k,acc}$ [Nm]
PE2	8.0	400	800	800	13	13
PE3	11.0	800	1600	1600	40	40
PE4	13.0	1900	2400	2400	73	73
PE5	16.0	4000	4600	4600	206	206

For other output speeds, download diagrams at http://products.stoeber.de.

The following applies to output speeds n_{2m*} > 100 rpm:

$$F_{2axN} = \frac{F_{2ax100}}{\sqrt[3]{\frac{n_{2m*}}{100\ \text{rpm}}}} \qquad F_{2radN} = \frac{F_{2rad100}}{\sqrt[3]{\frac{n_{2m*}}{100\ \text{rpm}}}} \qquad M_{2kN} = \frac{M_{2k100}}{\sqrt[3]{\frac{n_{2m*}}{100\ \text{rpm}}}}$$

The values for F_{2ax100}, $F_{2rad100}$ and M_{2k100} can be found in the table "Permitted shaft loads" in this chapter.

[2] Values between 1000 and 5000 load changes per hour can be interpolated.

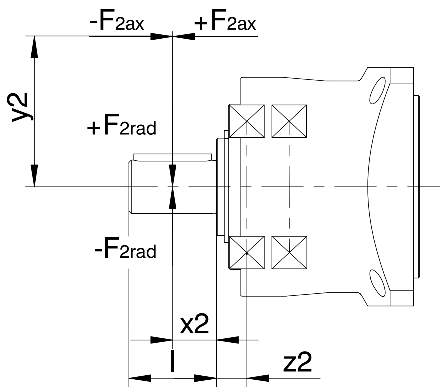


Fig. 1: Force application points

The specified values for $F_{2rad100}$ and $F_{2rad,acc}$ refer to an application of force at the center of the output shaft: x_2 = l/2.

Shaft dimensions can be found in the "Dimensional drawings" chapter.

The following applies to other force application points:

$$M_{2k,acc^*} = \frac{2 \cdot F_{2ax^*} \cdot y_2 + F_{2rad,acc^*} \cdot (x_2 + z_2)}{1000} \leq M_{2k,acc}$$

$$F_{2rad,acc^*} \leq F_{2rad,acc}$$

$$F_{2ax^*} \leq F_{2axN}$$

The values for $F_{2rad,acc}$ and $M_{2k,acc}$ can be found in the table "Permitted shaft loads" in this chapter.

For applications with multiple axial and/or radial forces, you must add the forces as vectors.

In the event of EMERGENCY OFF operation (max. 1000 load changes), you can multiply the permitted forces and torques for F_{2ax100}, $F_{2rad100}$ and M_{2k100} by a factor of two.

Also note the calculation for equivalent values:

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

$$F_{2rad,eq^*} = \sqrt[3]{\frac{|n_{2m,1^*}| \cdot t_{1^*} \cdot |F_{2rad,acc,1^*}{}^3| + \ldots + |n_{2m,n^*}| \cdot t_{n^*} \cdot |F_{2rad,acc,n^*}{}^3|}{|n_{2m,1^*}| \cdot t_{1^*} + \ldots + |n_{2m,n^*}| \cdot t_{n^*}}} \leq F_{2radN}$$

The following apply to the bearing service life L_{10h} (ED_{20} ≤ 40%):

L_{10h} > 10000 h with 1 < M_{2kN}/M_{2k^*} < 1.25

L_{10h} > 20000 h with 1.25 < M_{2kN}/M_{2k^*} < 1.5

L_{10h} > 30000 h with 1.5 < M_{2kN}/M_{2k^*}

For different duty cycles:

$$L_{10h} > L_{10h(ED_{20}=40\%)} \cdot \frac{40\%}{ED_{20}}$$

7.6.3 Radial shaft seal rings

Leak-proofness

Our gear units are equipped with high-quality radial shaft seal rings and checked for leak-proofness. However, a leak cannot be fully ruled out over the length of use of a gear unit. If you use a gear unit with goods incompatible with the lubricant, you must take measures to prevent direct contact with the gear unit lubricant in case of a leak.

7.7 Additional documentation

Additional documentation related to the product can be found at http://www.stoeber.de/en/download

Enter the ID of the documentation in the Search... field.

Documentation	ID
Operating manual for P/PA/PE/PH/PHA/PHQ/PHQA/PHV/PHVA planetary gear units and planetary geared motors	443029_en
Lubricant filling quantities for gear units	441871