Using Gearheads

Oriental Motor gearheads are specially designed for easy and direct attachment to most of our AC motors with a pinion shaft. With the reduction of the motor speed through the gearhead, an increase of torque is achieved. A large number of speed-reduction ratios are available for many applications.

1. *Type of Gearhead and Gearedmotor*

Depending on the motor type and output power, the following types are available.

For normal loads	**GN** type
For heavy loads	**GU** type, **BH** series
For high speed motor	**FBLⅡ** series
	AXH series
	HBL series

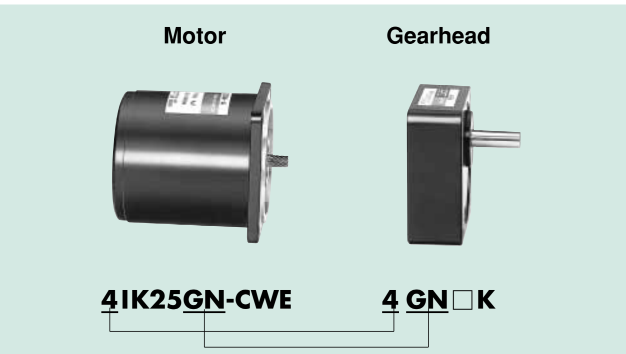
These gearheads listed below are all low noise types. Motors that can be used with these gearheads have a helical cut spline on the shaft that mates with the first stage of gears in the gearhead. This helical gear mating with the first stage, which is the primary source of noise in a gearhead, along with a redesigned gearcase and ball bearings, reduces noise by 10 to 15 dB.
All of the gearheads included in this catalogue use ball bearings.

Gearheads and Gearedmotors

Application	Gearheads/Gearedmotors	Decimal Gearheads
normal load	**2GN□K**	**2GN10XK**
	3GN□K	**3GN10XK**
	4GN□K	**4GN10XK**
	5GN□K	**5GN10XK**
heavy load	**5GU□KB**	**5GU10XKB**
	5GU□KBH	—
heavy load **BH** series	**BHI62□T-□**	—
heavy and / or high speed load	**FBLⅡ** series	—
	AXH series	—
	HBL series	—

The box (□) in the model number represents the desired gear ratio, which thereby becomes part of the code for the gearhead.

Connection Procedures

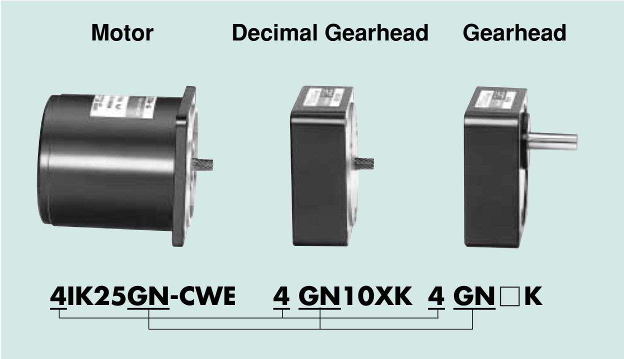


When connecting gearheads, be sure to match the pinion shafts and frame sizes.

Decimal Gearheads

The **GN** and **GU** type gearheads are also available gear as decimal gearheads (sold separately) with a gear ratio of 10:1. They should be used in applications in which large gear ratios cannot be attained with a single gearhead unit. Any number of decimal gearheads can be used in series.

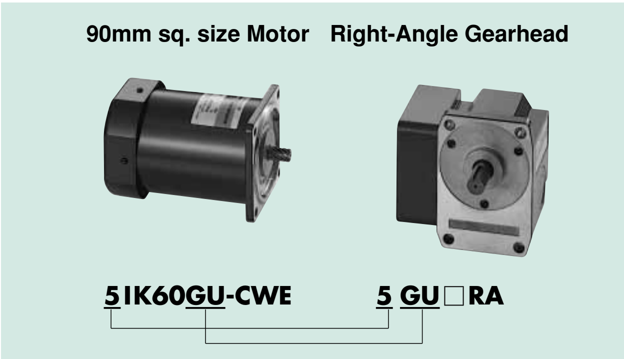
Note:
Although the gear ratio of 10:1 of the decimal gearhead theoretically translates into a 10 time increase of torque available on the output shaft, it is not possible to make full use of this torque. The torque permissible in actual use is limited by the physical construction of the gearhead and is expressed as its rated maximum torque. (Refer to the torque table of each product)



Right-Angle Gearheads

The **4GN, 5GN** and **5GU** type gearheads are also available as right-angle gearheads.

Type	Model	Motor Output Power
Hollow shaft	**4GN□RH**	25W
	5GN□RH	40W
	5GU□RH	60 · 90W
Solid shaft	**4GN□RA**	25W
	5GN□RA	40W
	5GU□RA	60 · 90W

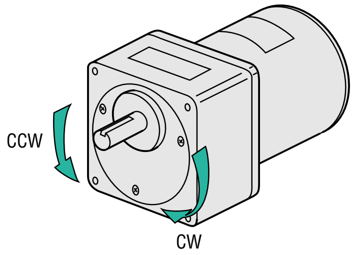


2. Speed and Direction of Rotation

The speed when a gearhead is directly coupled to a motor is calculated according to the following formula :

- **Speed**……$N_G = \dfrac{N_M}{i}$

  N_G : Speed of Gearhead [r/min]
  N_M : Speed of motor [r/min]
  i : Gear ratio of gearhead



□……Same direction as the motor shaft
□……Opposite direction as the motor shaft

The direction of gearhead shaft rotation may differ from motor shaft rotation depending on the reduction ratio of the gearhead.

<table>
<tr><th>Gear Ratio / Gearhead Model</th><th>3</th><th>3.6</th><th>5</th><th>6</th><th>7.5</th><th>9</th><th>12.5</th><th>15</th><th>18</th><th>25</th><th>30</th><th>36</th><th>50</th><th>60</th><th>75</th><th>90</th><th>100</th><th>120</th><th>150</th><th>180</th></tr>
<tr><td>2GN□K, 3GN□K, 4GN□K, 5GN□K</td><td colspan="9"></td><td colspan="3"></td><td colspan="8"></td></tr>
<tr><td>5GU□KB</td><td colspan="6"></td><td colspan="3"></td><td colspan="5"></td><td colspan="6"></td></tr>
<tr><td>5GU□KBH</td><td colspan="12"></td><td colspan="2"></td><td colspan="6"></td></tr>
<tr><td>BHI62□T-□</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2"></td><td></td><td colspan="2"></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Connection of a decimal gearhead reduces the speed by 10 : 1 but does not affect the direction of rotation.

- Refer to page A-180 for further detail on the right-angle gearheads.

<table>
<tr><th>Gear Ratio / Model</th><th>5</th><th>10</th><th>15</th><th>20</th><th>30</th><th>50</th><th>100</th><th>200</th></tr>
<tr><td>FBL575CY-□, FBL5120CY-□
AXH230KC-□, AXH450KC-□
HBL560N-□, HBL5100N-□</td><td colspan="4"></td><td colspan="3"></td><td></td></tr>
<tr><td>AXH015K-□</td><td colspan="3"></td><td colspan="2"></td><td colspan="2"></td><td>–</td></tr>
</table>

3. Output Torque of Gearmotor

The output torque when a gearhead is directly connected is calculated as follows :

- **Torque**……$T_G = T_M \times i \times \eta$

  T_G : Output Torque at Gear Shaft [N·m]
  T_M : Motor Torque [N·m]
  i : Gear Ratio of Gearhead
  η : Gearhead Efficiency

Gearhead Efficiency

<table>
<tr><th>Gear Ratio / Gearhead Model</th><th>3</th><th>3.6</th><th>5</th><th>6</th><th>7.5</th><th>9</th><th>12.5</th><th>15</th><th>18</th><th>25</th><th>30</th><th>36</th><th>50</th><th>60</th><th>75</th><th>90</th><th>100</th><th>120</th><th>150</th><th>180</th></tr>
<tr><td>2GN□K, 3GN□K, 4GN□K, 5GN□K</td><td colspan="9">81%</td><td colspan="3">73%</td><td colspan="8">66%</td></tr>
<tr><td>5GU□KB</td><td colspan="6">81%</td><td colspan="3">73%</td><td colspan="5">66%</td><td colspan="6">59%</td></tr>
<tr><td>5GU□KBH</td><td colspan="12"></td><td colspan="2">66%</td><td colspan="6">59%</td></tr>
<tr><td>BHI62□T-□</td><td>90%</td><td></td><td>90%</td><td></td><td>90%</td><td></td><td colspan="2">86%</td><td></td><td colspan="2">86%</td><td></td><td>81%</td><td></td><td>81%</td><td></td><td>81%</td><td></td><td>81%</td><td></td></tr>
</table>

Gearhead efficiency of all the decimal gearheads is 81%.

- Refer to page A-180 for further detail on the right-angle gearheads.

<table>
<tr><th>Gear Ratio / Model</th><th>5</th><th>10</th><th>15</th><th>20</th><th>30</th><th>50</th><th>100</th><th>200</th></tr>
<tr><td>FBL575CY-□, FBL5120CY-□
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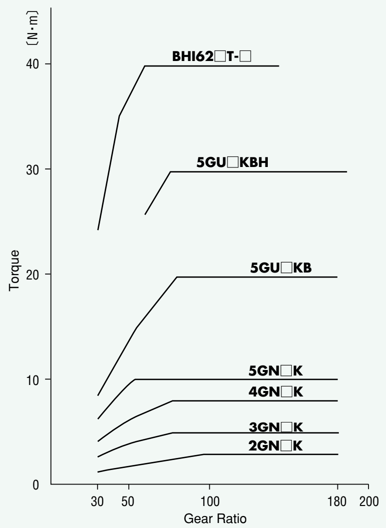
HBL560N-□, HBL5100N-□</td><td colspan="4">90%</td><td colspan="3">86%</td><td>81%</td></tr>
<tr><td>AXH015K-□</td><td colspan="3">90%</td><td colspan="2">86%</td><td colspan="2">81%</td><td>–</td></tr>
</table>

Maximum Permissible Torque

Since the output torque of the gearhead increases proportionally with the reduction of speed, a high gear ratio will result in an output torque that cannot be handled by physical construction of the gearhead. The maximum permissible torque of the gearhead and the speed-reduction ratio is as follows:

〈Maximum Permissible Torque of Gearheads〉



Example: If induction motor **4IK25GN-CWE** is combined with gearhead **4GN100K**, the output torque is...
The rated torque of motor **4IK25GN-CWE** is 205mN·m.
The gearhead output torque is calculated using the equation on the previous page.

Output torque $T_G = T_M \times i \times \eta$
$= 0.205 \times 100 \times 0.66$
$= 13.53$ N·m

The maximum permissible torque for **4GN100K** is 8.0 N·m as shown in the diagram above. Therefore, the load torque that can be exerted is only 8.0 N·m even if the gearhead has theoretical output torque is 13.53 N·m.

4. Permissible Load Inertia for Gearheads

When a high load inertia (J) is connected to a gearhead, high torques are exerted instantaneously on the gearhead when starting up in frequent, discontinuous operations (or when stopped by an electromagnetic brake).
Excessive impact loads can be the cause of gearhead or motor damage.
The table shown below gives values for permissible inertial load on the motor shaft. Use the motor and gearhead within these parameters.
The permissible inertial load value shown for three-phase motors is the value when reversing after a stop.
The permissible (J) on the gearhead output shaft is calculated with the following equation. The life of the gearhead when operating at the permissible inertial load with instantaneous stops of the motors with electromagnetic brakes is at least 2 million cycles.

Permissible Inertia Load

Gear ratio 1/3～1/50 ··················$J_G = J_M \times i^2$
Gear ratio 1/60 or higher ············$J_G = J_M \times 2500$

J_G : Permissible J (kg·m^2) on the gearhead output shaft
J_M : Permissible J (kg·m^2) on the motor shaft
i : Gear ratio (Example : $i = 3$ means the gear ratio of 1/3)

<Permissible Load Inertia on the motor shaft>

AC Motor

No. of Phase	Frame Size	Output Power (W)	Permissible Inertial Load at Motor Shaft J ($\times 10^{-4}$kg·m^2)
Single-Phase	60mm sq.	6	0.062
	70mm sq.	15	0.14
	80mm sq.	25	0.31
	90mm sq.	40	0.75
		60	1.1
		90	1.1
	104mm sq.	200	2.0
Three-Phase	80mm sq.	25	0.31
	90mm sq.	40	0.75
		60	1.1
		90	1.1

5. Service Life of a Gearhead

The service life of a gearhead is reached when power can no longer be transmitted because the bearing's mechanical life has ended. Therefore, the actual life of a gearhead varies depending on the load size, how the load is applied, and the allowable speed of rotation. Oriental Motor defines service life under certain conditions as "rated lifetime," based on which the useful life under actual operation is calculated according to load conditions and other factors.

Rated Lifetime

Oriental Motor defines the rated lifetime as the service life of a gearhead under the following operating conditions:

[Operating conditions]
Torque: Permissible torque
Load: Uniform continuous load
Input rotational speed: Reference-input rotational speed
Rotational speed at the rated lifetime of each gear type
Overhung load: Permissible overhung load
Thrust load: Permissible thrust load

[Table 1: Rated Lifetime per Gear Type]

Series/Motor type	Gear type	Reference-input rotational speed	Rated lifetime (L1)
AC motor Brushless motor	**GN**, **GU** gear type **BH** (parallel shaft) combination type	1500r/min	5000 hrs.
	GFB, **GFH** combination type	3000r/min	
	BH (right angle) combination type	1500r/min	10000 hrs.

Estimating Lifetime

Lifetime under actual conditions of use is calculated based on the permissible rotational speed, load size and load type, using the following formula:

$$\mathrm{L(lifetime)} = L_1 \times \frac{K_1}{(K_2)^3 \times f} \quad \mathrm{[h]}$$

L_1: Rated lifetime [hrs.]
See Table 1 to find the applicable rated lifetime from the type of gear.

K_1: Rotational speed coefficient
The rotational speed coefficient (K_1) is calculated based on the reference-input rotational speed listed in Table 1 and the actual-input rotational speed.

$$K_1 = \frac{\text{Reference-input rotational speed}}{\text{Actual-input rotation speed}}$$

K_2: Load factor
The load factor (K_2) is calculated based on actual operating torque and the allowable torque for each gear.

The average torque may be considered operating torque if the gear is subjected to load while starting and stopping only, as when driving an inertial body. The calculation of average torque is explained later in this section.

$$K_2 = \frac{\text{Operating torque}}{\text{Permissible torque}}$$

Permissible torque is per the specified values listed in the product catalogue and operating manual.

f : Load-type factor

The factor (f) may be determined based on load type, using the following examples as a reference:

Load type	Example	Factor (f)
Uniform load	・One-way continuous operation ・For driving belt conveyors and film rollers that are subject to minimal load fluctuation.	1.0
Light impact	・Frequent starting and stopping ・Cam drive and inertial body positioning via stepping motor	1.5
Medium impact	・Frequent instantaneous bidirectional operation, starting and stopping of reversible motors ・Frequent instantaneous starting and stopping of brushless motors	2.0

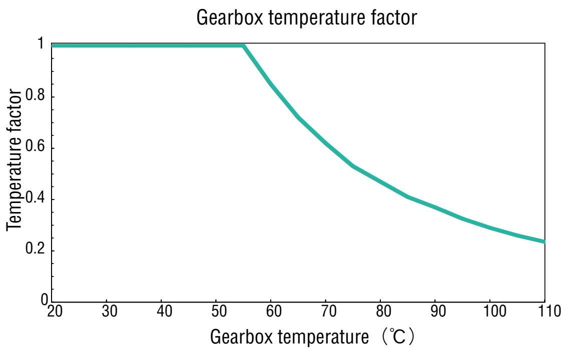
《Notes regarding the effects of overhung load and thrust load》

- The above estimated lifetime is calculated according to the overhung and thrust loads, which are in proportion to a given load factor. For example, if the load factor is 50 percent, the lifetime is calculated using 50-percent overhung and thrust loads.
- The actual life of a gearhead having a low load factor and a large overhung or thrust load will be shorter than the value determined through the above equation.

Operating Temperature

An increase in gearhead temperature affects the lubrication of the bearing. However, since the effect of temperature on gearhead life varies according to the condition of the load applied to the gearhead bearings, model number and many other factors, it is difficult to include the temperature effect in the equation to estimate the lifetime, which was described earlier.

The graph shows the temperature effect on the gearhead bearings. The gearhead life is affected when the gearbox's surface temperature is 55˚C or above.



Notes

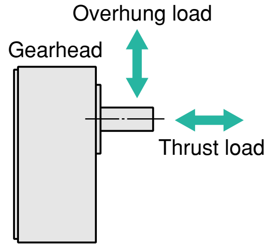
In some cases a lifetime of several ten thousand hours may be obtained from the calculation. Use the estimated life as a reference only.

The above life estimation is based on the reasoning of bearing life.

An application in excess of the specified value may adversely affect parts other than the bearings. Use the product within the range of specified values listed in the product catalogue or operating manual.

6. Permissible Overhung Load and Permissible Thrust Load

"Overhung load" refers to load placed on the output shaft as shown in the figure below. The "thrust load" is a load applied in the axial direction of the output shaft. Since the overhung load and thrust load have a great influence on the life of the bearings and strength of the shaft, be careful not to exceed the maximum values shown in the chart below.



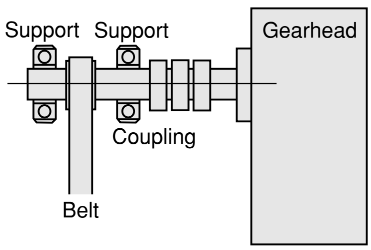
● **Overhung Load**...... $W = \dfrac{K \times T \times f}{\gamma}$

W : Overhung Load [N]
K : Load Coefficient for Driving Method (See table below)
T : Torque at Gearhead Output Shaft [N·m]
f : Service Factor
γ : Effective Radius of Gear or Pulleys [m]

Drive System	K
Chain or toothed belt	1
Gear	1.25
V-belt	1.5
Flat belt	2.5

Take precautions so that the overhung load as calculated by the above equation does not exceed the permissible values given in the table to the right. If the overhung load greatly exceeds the permissible value, it will lead to the shortening of bearing life or damage to the bearing, as well as warping or breaking the output shaft after continued heavy load. In such situations, a support such as the one shown below must be designed to take up the overhung load.

Since connecting a transmission mechanism directly to the output shaft exerts an unbalanced load on the shaft, connect mechanisms as close to the gearhead as possible.



Permissible Overhung Load and Permissible Thrust Load

Gearhead Model	Gear Ratio	Maximum Permissible Torque [N·m]	Permissible Overhung Load [N] 10mm from shaft end	Permissible Overhung Load [N] 20mm from shaft end	Permissible Thrust Load [N]
2GN□K	**3~18**	3.0	50	80	30
	25~180		120	180	
3GN□K	**3~18**	5.0	80	120	40
	25~180		150	250	
4GN□K	**3~18**	8.0	100	150	50
	25~180		200	300	
5GN□K	**3~18**	10	250	350	100
	25~180		300	450	
5GU□KB	**3~9**	20	400	500	150
	12.5~18		450	600	
	25~180		500	700	
5GU□KBH	**50~180**	30	400	600	150
BHI62□T-□	**3~30**	40	550	800	200
	50~150		650	1000	
FBL575CY-□ **FBL5120CY-□**	**5**	30	300	400	150
	10~20		400	500	
	30~200		500	650	
AXH015K-□	**5~100**	2.0	50	–	30
AXH230KC-□	**5**	6.0	100	150	40
	10~20		150	200	
	30~200		200	300	
AXH450KC-□	**5**	16	200	250	100
	10~20		300	350	
	30~200		450	550	
HBL560N-□ **HBL5100N-□**	**5~20**	30	300	400	150
	30~100		400	500	
	200		500	650	
4GN□RA	**3~15**	8.0	100	150	100
	25~150		200	300	
5GN□RA	**3~15**	10	250	350	200
	25~150		300	450	
5GU□RA	**3~7.5**	20	400	500	250
	12.5~25		450	600	
	30~150		500	700	
FPW425C-□E	**3~18**	8.0	100	150	50
	25~180		200	300	
FPW540C-□E	**3~18**	10	250	350	100
	25~180		300	450	
FPW560C-□E	**3~9**	15	400	500	150
	12.5~18		450	600	
	25~180		500	700	
FPW690C-□E	**3~9**	30	550	800	200
	12.5~180		650	1000	

Refer to page A-181 for Right-Angle gearhead **RH** type.

Note: Permissible torque varies with the gear ratio. Do not exceed the maximum value.

When using transmission mechanisms involving helical gears or worm gears, they are subject not only to overhung load but to thrust load as well. Ensure that thrust load does not exceed the permissible levels given in the above table.