Solution to High Response

High-Gain Rubber Type Coupling **XG2**

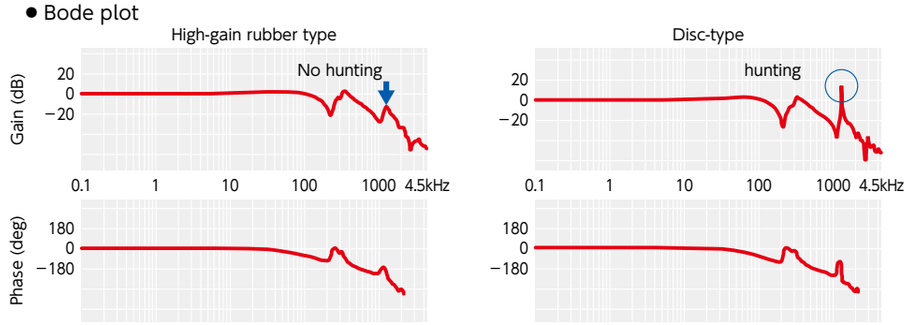
XG2 eXtra Gain Patent Pending

1. Reduction of Stabilization Time

Improvement in servomotor's limit gain can reduce stabilization time.

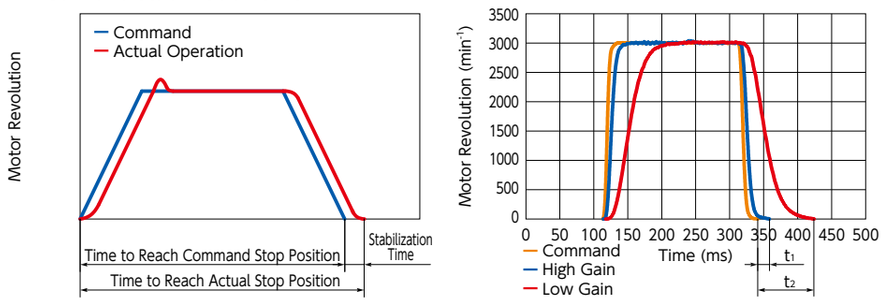
Hunting suppression

● Bode plot



Improvement in limit gain

● Gain and stabilization time



Reduction of Stabilization Time

● Measurement of stabilization time and overshoot

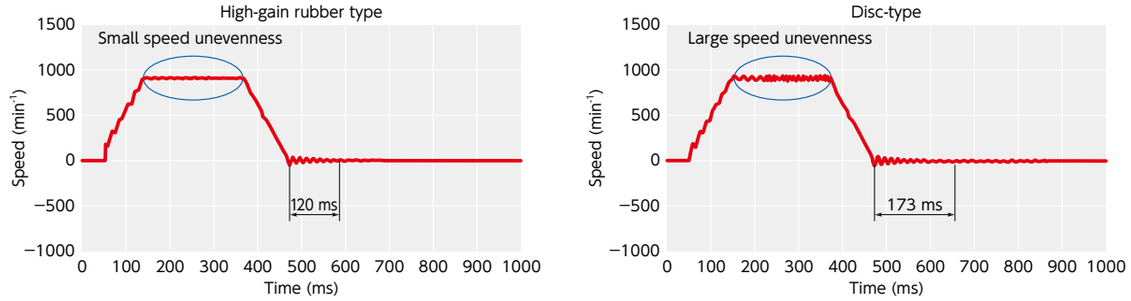
Gain*		XG2 Series 	XG Series 	Disc-type 
25	Stabilization time (ms)	12	12	12
	Overshoot (μm)	0.4	0.9	0.6
27	Stabilization time (ms)	8	8	Occurrence of hunting
	Overshoot (μm)	0.6	1	
32	Stabilization time (ms)	3	Occurrence of hunting	Occurrence of hunting
	Overshoot (μm)	1.7		

* Values after adjustment of all gains including position control gain and speed control gain (1 - 32)
● The values in the table vary depending on the test conditions.

Improved Productivity (Movie featuring comparison with disc-type is available on NBK website.)

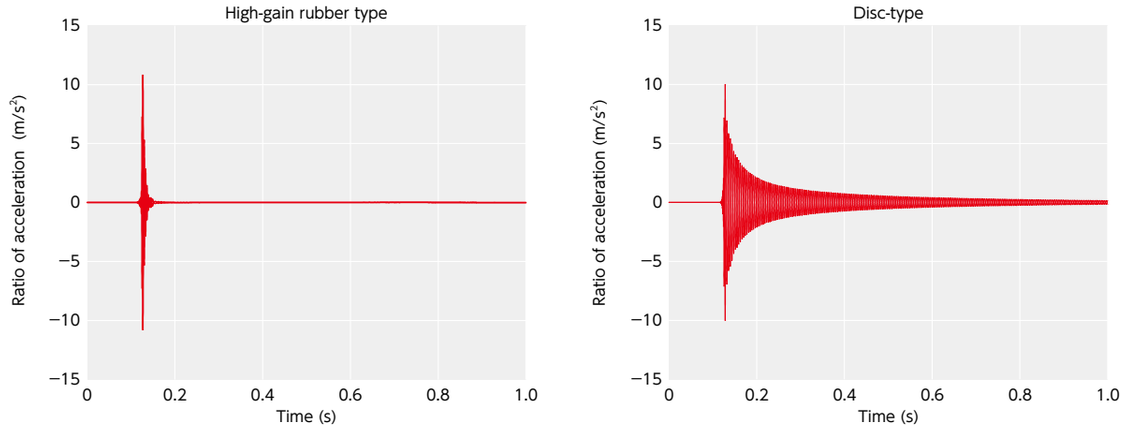
2. Speed Unevenness Suppression

Speed and torque unevenness arising from misalignment will be suppressed.



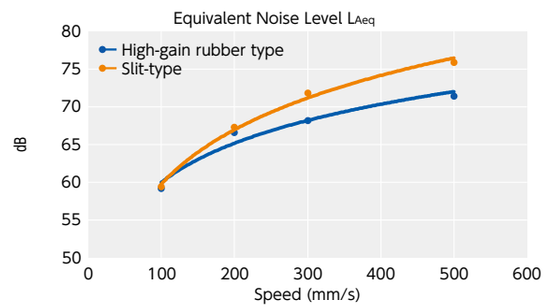
3. Vibration Suppression

High damping ratio will enable quick absorption of vibrations.



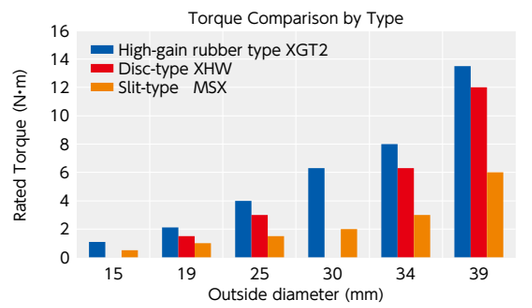
4. Quietness

Actuator drive noise can be reduced.



5. High Torque

High torque use is possible compared with disc-type and slit-type.



XGT2/XGL2/XGS2 Flexible coupling - High - gain rubber type Additional Size Patent Pending

WEB Selection Tool WEB CAD Download Zero Backlash High gain supported High torque High Rigidity Vibration absorption

Structure

● Clamping type

XGT2-C Standard type ➡ P.39

XGL2-C Long type ➡ P.43

XGS2-C Short type ➡ P.41

● Internal Structure

● Recommended applicable motor

	XGT2 / XGL2 / XGS2
Servomotor	◎
Stepping Motor	◎
General-purpose motor	△

◎: Excellent ○: Very good △: Available

● Property

	XGT2 / XGL2 / XGS2
Zero Backlash	◎
For servomotor high gain	◎
High torque	◎
High Torsional Stiffness	◎
Allowable Misalignment	○
Vibration absorption	◎
Allowable operating temperature	−10℃ to 120℃

◎: Excellent ○: Very good

- High-gain flexible coupling which surpasses of XGT XGL XGS in performance. This is a singlepiece construction with the two aluminum hubs molded with vibration-absorbing rubber.
- He optimal damping and rigidity design enables realization of even greater servomotor gain, leading to a reduction in stabilization time.
  ➡ P.31 (Technical Information)
- Suppresses speed unevenness during stepping motor operation. ➡ P.36
- Contributes to improved productivity and quality by suppressing residual vibration during positioning.
- Features outstanding thermal, oil and chemical resistance.
  ➡ P.37 (Physical properties and chemical resistance of vibration-absorbing rubber)
- Standard type XGT2 , Long type XGL2 and Short type XGS2 standardized.
- Application

Semiconductor manufacturing equipment / Mount machines / Machine tools / Packaging machines

● Material/Finish RoHS2 Compliant

	XGT2 / XGL2 / XGS2
Hub	A2017
Vibration-absorbing rubber	FKM
Hex Socket Head Cap Screw	SCM435 Ferrosoferric Oxide Film (Black)

● Part number specification

XGT2 - 19C - 6-8

Product Code / Size / Bore Diameter

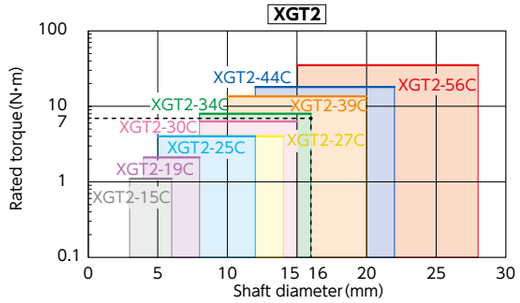
Please refer to dimensional table for part number specification.

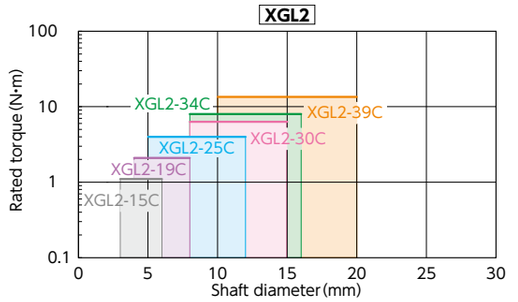
Additional Keyway at Shaft Hole ➡ P.803	Cleanroom Wash & Packaging ➡ P.807	Change to Stainless Steel Screw ➡ P.805
Available / Add'l charge	Available / Add'l charge	Available / Add'l charge

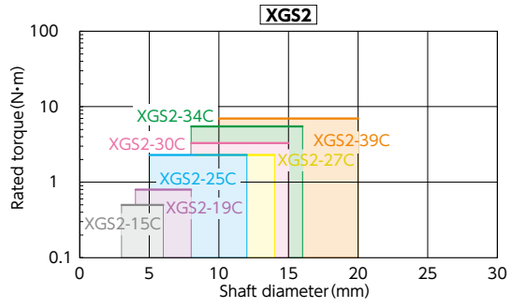
Selection

● Selection based on shaft diameter and rated torque

The area bounded by the shaft diameter and rated torque indicates is the selection size.







● Selection example

In case of selected parameters of shaft diameter of ϕ 16 and load torque of 7N•m, the selection size is XGT2-34C .

● Selection based on the rated output of the servomotor

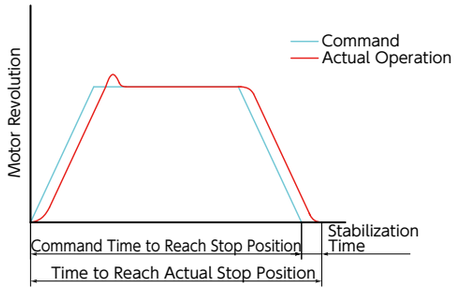
Rated output (W)	Servomotor specifications*1			Selection size		
	Diameter of motor shaft (mm)	Rated torque (N・m)	Instantaneous max. torque (N・m)	XGT2	XGL2	XGS2
10	5 - 6	0.032	0.096	15C	15C	15C
20	5 - 6	0.064	0.19	15C	15C	15C
30	5 - 7	0.096	0.29	19C	19C	19C
50	6 - 8	0.16	0.48	19C	19C	19C
100	8	0.32	0.95	19C	19C	25C
200	9 - 14	0.64	1.9	27C	30C	27C
400	14	1.3	3.8	27C	30C	34C
750	16 - 19	2.4	7.2	39C	39C	–

*1 : Motor specifications are based on general values. For details, see the motor manufacturer's catalogs. This is the size for cases where devices such as reduction gears are not used.

Technical Information

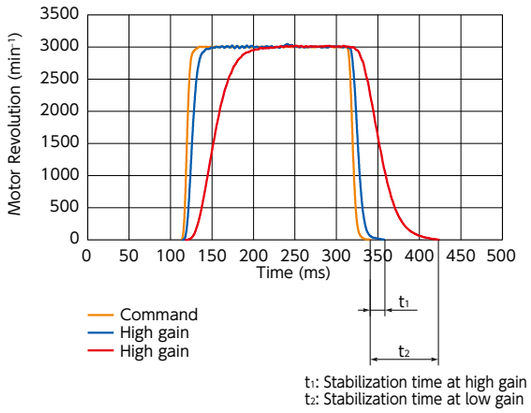
● Productivity and stabilization time

In a production facility, using servomotor's and actuator's, operating these components accurately, as directed by the program, can lead to the improvement of productivity.
Reality, in actual operation, execution of commands may be delayed. For example, when trying to stop the actuator at a predetermined position, the actuator stops somewhat later than the command. We call this delay "stabilization time."
Since the operation does not shift to next process until the actuator completely stops, it is important to shorten the stabilization time to improve productivity.



● Gain and stabilization time of servomotor

Servomotor's gain is an indicator representing to what degree the motor operation can follow the command.
Although raising the gain can reduce the stabilization time, excessive gain increases are likely to cause hunting, thereby disable the control of the servomotor.
Raising the gain while suppressing hunting requires fine adjustment of respective parameters of the servomotor.
However, when a servomotor is combined with a coupling with a metal disk type in the elastic segment, raising the gain tends to cause hunting, making it difficult to resolve the problem by fine adjustments to parameters.
When hunting occurs, it is usually recommended to change to a more rigid coupling to increase the rigidity of the rotating system.
However, in reality, it is difficult to increase the rigidity of the entire rotating system including the ball screw simply by changing the coupling. So, changing to a highly-rigid coupling such as a disk-type may not be effective.



● High-gain rubber type

XGT2 XGL2 XGS2 XGT XGL XGS

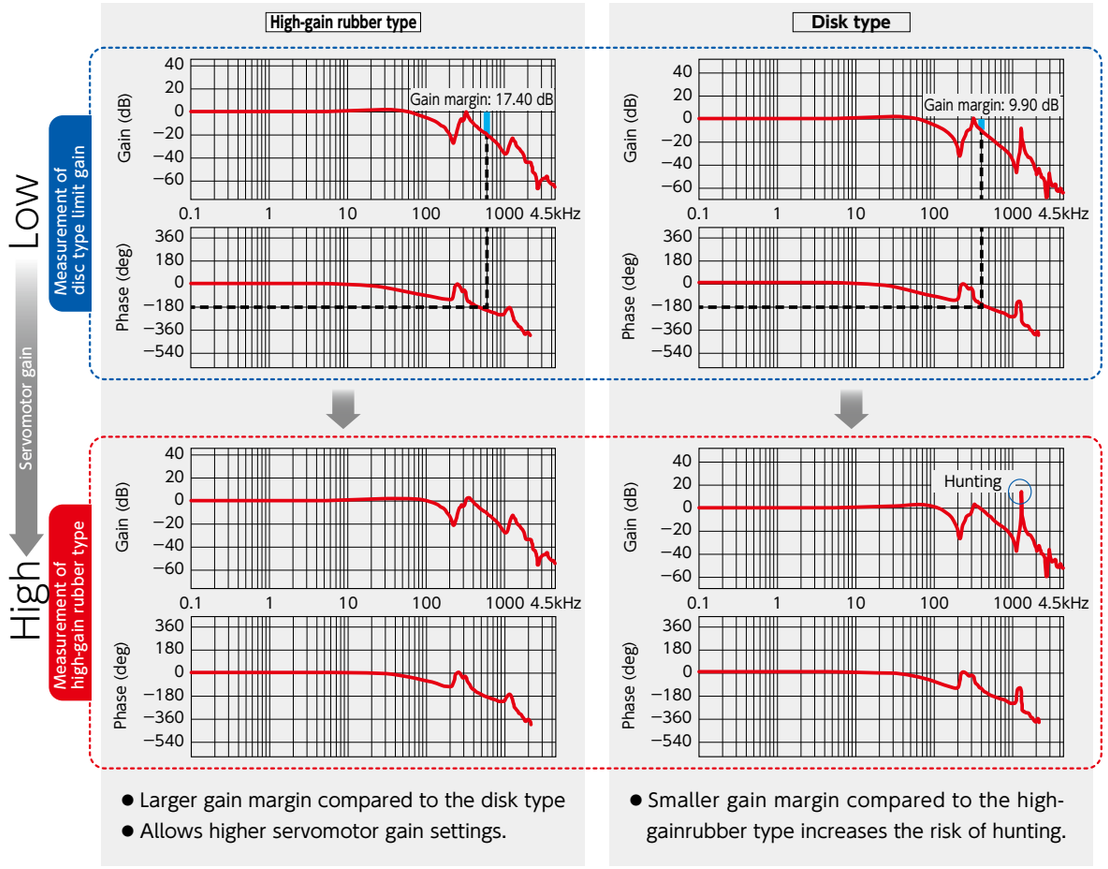
The high-gain rubber type can be used at higher gain than the disk type, enabling reduction of stabilization time.
In addition, the outstanding damping performance reduces the amount of troublesome parameter adjustments required, making it possible to make optimal actuator adjustments in a shorter time.

● Why does the high-gain rubber type allows higher gain setting than the disk type?

The main reasons can be understood from the bode plot.
Intersection point between 0 dB gain line the phase lag in the board wiring is −180 degrees is called the "gain margin".
As a general guideline, in servo systems, the gain margin should be 10 - 20 dB, and when the servomotor gain is increased, the gain margin decreases, with the risk of hunting occurs at 10 dB or lower.
A comparison at the disk type limit gain shows not only that the high-gain rubber type features a larger gain margin, but also that the gain margin is over 10 dB. This is why the high-gain rubber type allows greater servomotor gain than the disk type.
To increase the gain margin are that both coupling damping ratio and dynamic rigidity are high.
➡ P.33

Gain margin at the disk type limit gain
High-gain rubber type : 17.40 dB
Disk type : 9.90 dB

● Bode plot



- Larger gain margin compared to the disk type
- Allows higher servomotor gain settings.

- Smaller gain margin compared to the high-gainrubber type increases the risk of hunting.

XGT2/XGL2/XGS2 Flexible Coupling - High - Gain Rubber Type

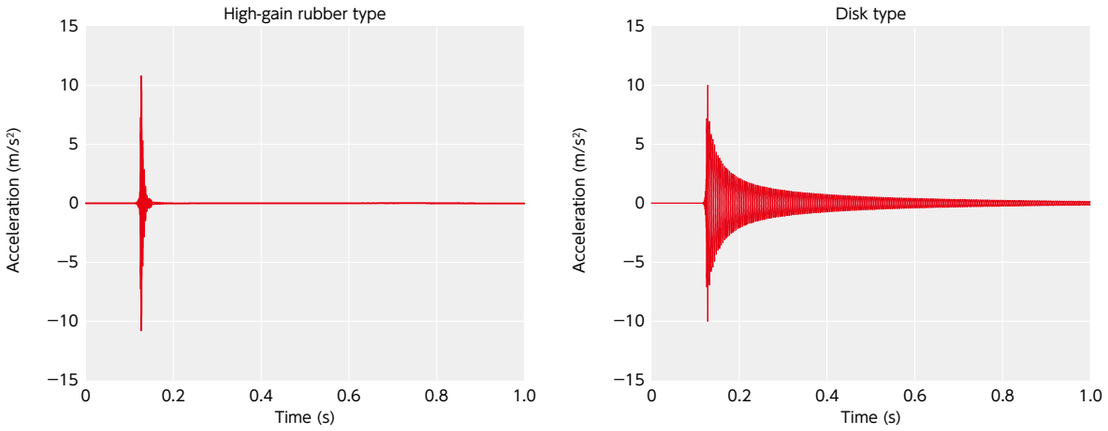
Additional Size Patent Pending

Selection Tool | CAD Download | Zero Backlash | High gain supported | High torque | High Rigidity | Vibration absorption

Technical Information

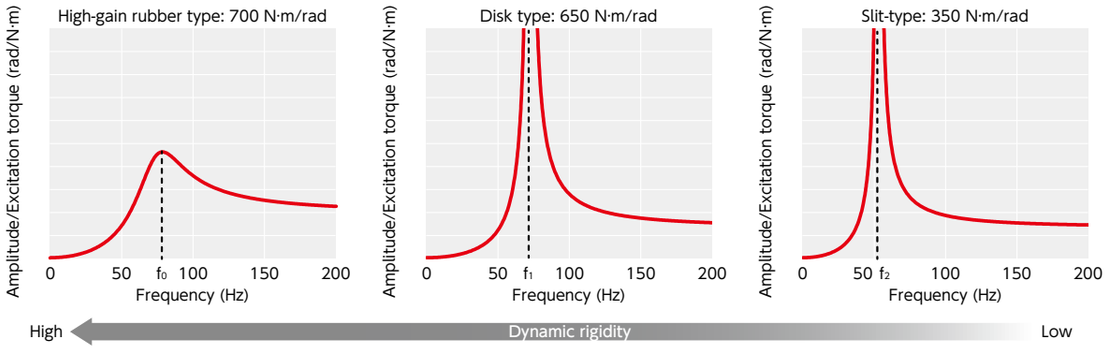
● Damping ratios of high-gain rubber and disk types

Damping ratio of high-gain rubber type is far higher than that of the disk type, enabling rapid absorption of vibration.



● Dynamic rigidity of high-gain rubber and disk types

The dynamic rigidity of the high-gain rubber type is equivalent to or higher than that of the disk type.
Dynamic rigidity (N·m/rad) = Excitation torque (N·m) / Amplitude (rad) at natural frequency (fn)



● Comparison of High-gain Rubber Type (XG2 Series/ XG Series) and Disk Type Couplings

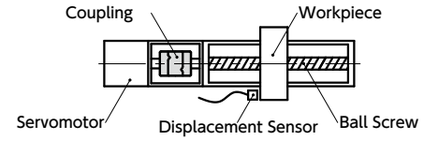
In tests using servo motors and actuators, the followings are verified.

- Stabilization time
  No differences between couplings as long as the gain is the same.
  To reduce stabilization time, higher gains enabled by the use of the high-gain rubber types, especially the XG2 series, demonstrates clear advantage against the disk type.
- Positioning accuracy/Repeated positioning accuracy
  No differences observed attributable to factors such as gain or coupling.
- Overshoot
  Normally higher gain increases the degree of overshoot. At the same gain, the XG2 series demonstrates the smallest overshoot.
- The XG2 Series allows of higher servomotor gain settings than the existing XG series, enabling shorter stabilization time.

- Test Devices
- Actuator : MCM08 Manufactured by NSK Ltd.
  ∗Ball screw lead: 10 mm
- Servomotor : HF-KP13 Mitsubishi Electric
- Test conditions

Motor revolution	: 3000min^{-1}
Acceleration/Deceleration time	: 50ms
Load on the work	: 3.0kg
Load inertia moment ratio	: 3.5

- Test Operation
  Normal rotation (1 rev) → Stop (500 ms) → Reverse rotation (1 rev)
- Test Method
  Measure the work movement with a displacement sensor and also measure the work piece's travel distance and stabilization time.



- Measurement of stabilization time, positioning accuracy and overshoot

Gain∗1		XG2 series	XG series	Disk type	Consideration
25	Stabilization time (ms)	12	12	12	This is the upper gain limit for the disk type. XG series and XG2 series have no problems.
	Positioning accuracy (mm)	0.002	0.002	0.002	
	Repeated positioning accuracy (mm)	±0.001	±0.002	±0.002	
	Overshoot (μm)	0.4	0.9	0.6	
27	Stabilization time (ms)	8	8	Occurrence of hunting	This is the upper gain limit for XG series. XG2 series have no problems. The disk type is not usable due to hunting.
	Positioning accuracy (mm)	0.002	0.003		
	Repeated positioning accuracy (mm)	±0.002	±0.002		
	Overshoot (μm)	0.6	1		
32	Stabilization time (ms)	3	Occurrence of hunting	Occurrence of hunting	The disk type and XG series are not usable due to hunting. XG2 series have no problems.
	Positioning accuracy (mm)	0.003			
	Repeated positioning accuracy (mm)	±0.001			
	Overshoot (μm)	1.7			

∗1 : Values (1 - 32) are after adjustment of all gains including Position Control Gain and Speed Control Gain.
Positioning accuracy : Positioning operation is performed and the absolute value of the difference between the target point and the actual stop position is determined. Max. value of the values found by performing this measurement from the home position at all positions within the max. stroke range.
Repeated Positioning Accuracy : Positioning is repeated 7 times from the same direction of movement to a randomly-selected point and the stopping position are measured and the difference between the max. and minimum values of the stopping position is determined. This method of measurement is applied at positions at the middle and both ends of the max. stroke range, then the max. value becomes the measured value, halved and prefixed with ±.
● The values in the table vary depending on the test conditions.

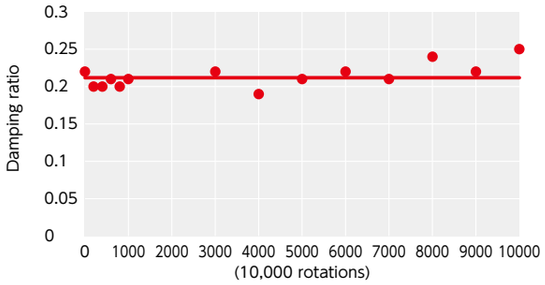
Technical Information

● Changes in performance after cycles

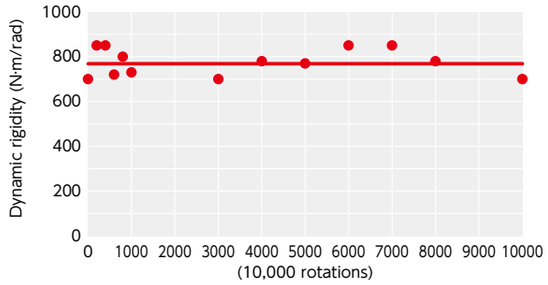
● Test Method ①
Rated torque load is applied to a coupling which rotates in a single direction, and the damping ratio and dynamic rigidity are measured.

● Test Sample
XGT2 - 25C-12 - 12

● Changes in Damping Ratio depends on the number of cycles.



● Changes in Dynamic Rigidity depends on the number of cycles.



∗No changes are observed in the damping ratio or dynamic rigidity after 100,000,000 rotations.

● Test Method ②
A motor and coupling are mounted on a single-shaft actuator, the work is set in reciprocating motion and the damping ratio and dynamic rigidity are measured.

● Test Sample
XGT-25C-12 - 12

● Test Devices
Actuator : BG46 Manufactured by Nippon Bearing Co., Ltd.
∗Ball screw lead: 10 mm
Servomotor : HF-KP13 Mitsubishi Electric

● Test conditions
Motor revolution : 3000min^{-1}
Acceleration/Deceleration time : 10ms
Load on the work : 3.0kg
Load inertia moment ratio : 3.5

● Test Operation
Normal rotation (10 rev) → Reverse rotation (10 rev). This operation is repeated.
Stroke: 100 mm, Total travel distance: 4400 km

● Test Method
The damping ratio and dynamic rigidity of the coupling are measured before and after the testing.

● Measurement of Damping Ratio and Dynamic Rigidity

	Before testing	After testing
Damping ratio	0.07	0.07
Dynamic rigidity (N・m/rad)	330	330

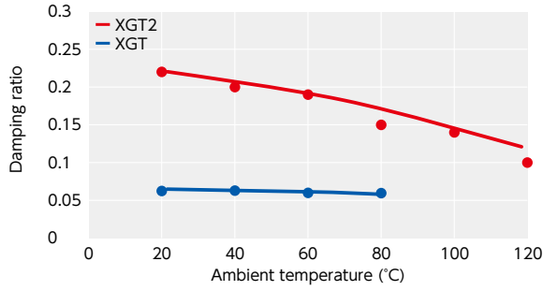
∗No changes are observed in the coupling performance even after a total travel distance of 4400 km.

● Temperature-triggered changes in performance

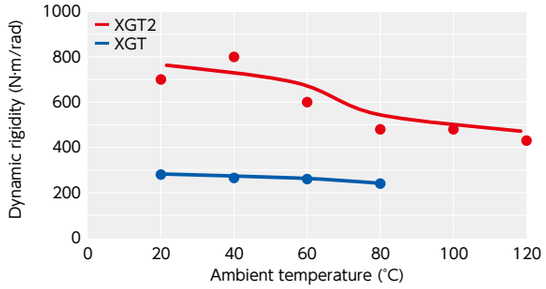
● Test Method
A coupling is left at the prescribed ambient temperature for 4 hours and damping ratio and dynamic rigidity measured.

● Test Sample
XGT2 - 25C-12 - 12、XGT-25C-12 - 12

● Temperature-triggered changes in damping ratio

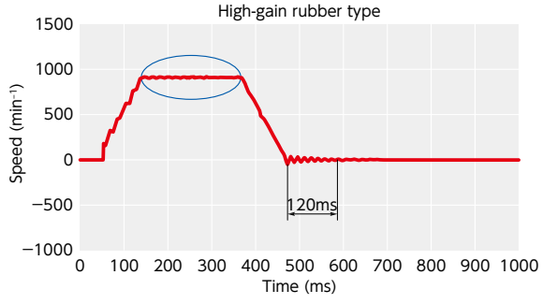


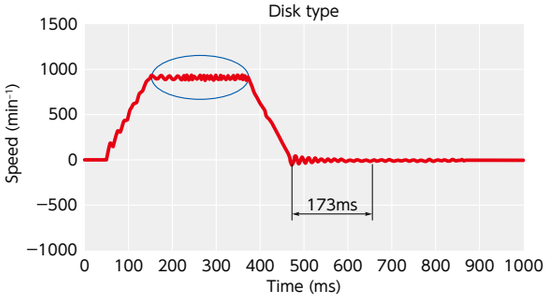
● Temperature-triggered changes in dynamic rigidity



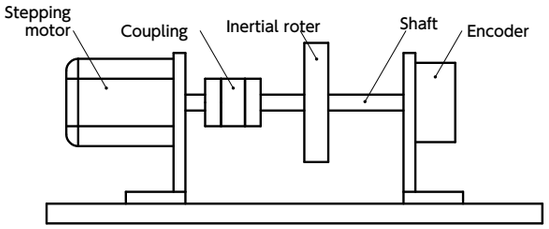
∗Although the damping ratio and dynamic rigidity decrease as the temperature rises, **XGT2** exceeds the damping ratio and dynamic rigidity of **XGT** across the entire temperature range.

● Suppressing speed unevenness Control during Stepping Motor Operation





● Test Devices
Motor : α step AR66AK-1 Manufactured by Oriental Motor Co., Ltd.
Set voltage: ————24 VDC,
Resolution: ————1000p/r
Moment of inertia: —1250×10^{-7}kg・cm^2
Encoder : RD5000 Manufactured by Nikon Corporation

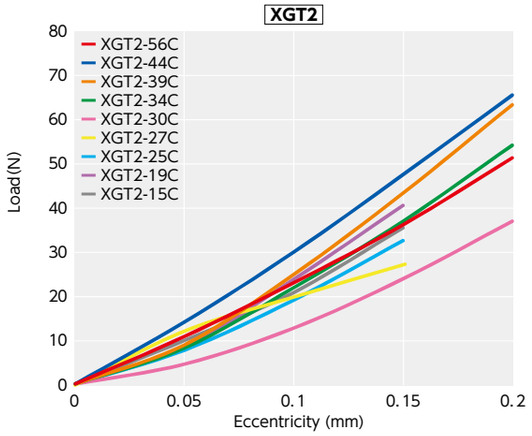


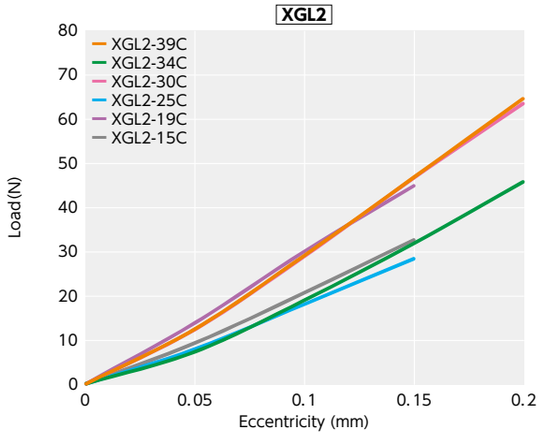
● Drive Parameters
Startup speed : 60min^{-1}
Drive speed : 900min^{-1}
Rotation angle : 1800°
Acceleration/Deceleration time : 0.1s

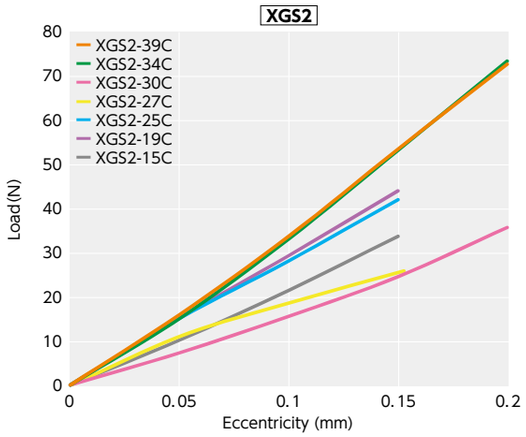
∗The high-gain rubber type is effective to suppress speed unevenness during fixed-speed rotation.

Technical Information

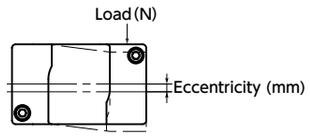
● Eccentric reaction force







This is a force generated when making **XGT2** **XGL2** **XGS2** in eccentric condition.
As the eccentric reaction force becomes smaller, the force acting on the shaft bearing also becomes smaller.

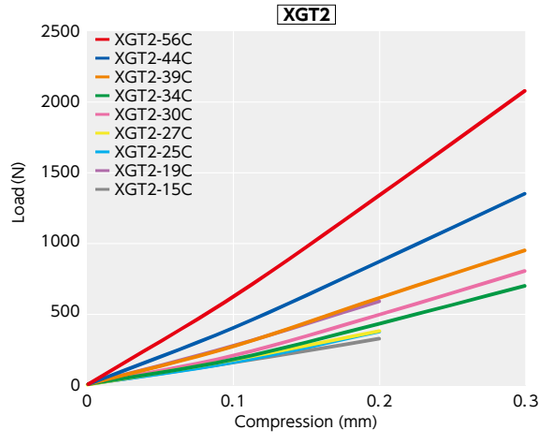


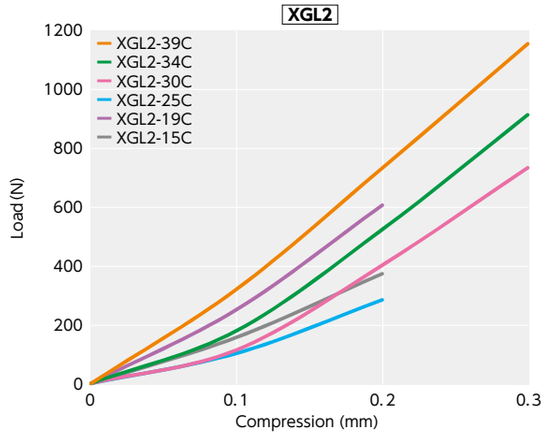
● Physical property and chemical resistance of vibration-resistance rubber (FKM)

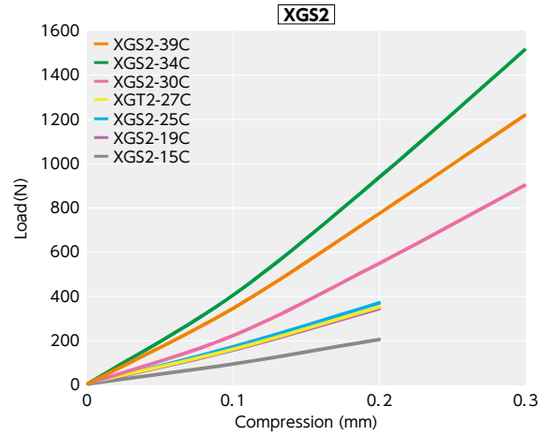
	Effect
Aging resistance	◎
Weather resistance	◎
Ozone resistance	◎
Gasoline/Gas Oil	◎
Benzene/Toluene	◎
Alcohol	◎
Ether	×～△
Ketone (MEK)	×
Ethyl acetate	×
Water	◎
Organic acid	×
High concentration inorganic acid	◎
Low concentration inorganic acid	◎
Strong alkali	×
Weak alkali	△

◎ : Very Good ○ : Available △ : Fair pending on condition
× : Not available

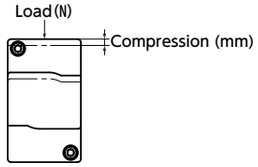
● Thrust Reaction Force







This is a force generated when compressing **XGT2** **XGL2** **XGS2** in the shaft direction. As the thrust reaction force becomes smaller, the force acting on the motor also becomes smaller.



● Slip Torque

Concerning the sizes shown in the following table, please note that the shaft's slip torque is smaller than the rated torque.

Unit : N・m

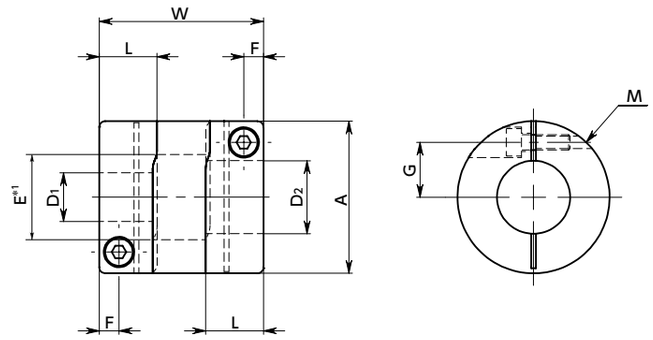
Part number	Bore Diameter (mm)		
	3	5	10
XGT2-15C, XGL2-15C	1		
XGT2-27C, XGL2-27C		3.8	
XGT2-39C, XGL2-39C			13.3

● These are test values based on the condition of shaft's dimensional allowance: h7, hardness: 34 - 40 HRC, and screw tightening torque of the values described in Dimension table.

XGS2-C Flexible Couplings - High-gain Rubber Type - Short Type Patented

Selection Tool | CAD Download | Zero Backlash | High gain supported | High torque | High Rigidity | Vibration absorption | Electrical Insulation

XGS2-C



*1： $E=D_2+0.5 (D_2<5)$
$E=D_2+1 (D_2\geq 5)$

Dimensions

Unit : mm

Part Number 1	A	L	W	F	G	M	Screw Tightening Torque (N・m)
XGS2-15C	15	6.5	18	2.15	5	M1.6	0.25
XGS2-19C	19	7.7	20	2.65	6.5	M2	0.5
XGS2-25C	25	9.5	27	3.25	9	M2.5	1
XGS2-27C	27	9.5	27	3.25	10	M2.5	1
XGS2-30C	30	11	30	4	11	M3	1.5
XGS2-34C	34	12	35	4	12.25	M3	1.5
XGS2-39C	39	15.5	40	4.5	14.5	M4	2.5

Part Number	Standard Bore Diameter D_1-D_2 2									
XGS2-15C	3 - 5	3 - 6	4 - 4	4 - 5	4 - 6	4.5 - 5	5 - 5	5 - 6	6 - 6	
XGS2-19C	4 - 5 8 - 8	5 - 5	5 - 6	5 - 7	5 - 8	6 - 6	6 - 6.35	6 - 7	6 - 8	6.35 - 8
XGS2-25C	5 - 6 8 - 10	5 - 8 8 - 11	6 - 6 8 - 12	6 - 8 10 - 10	6 - 10 10 - 12	6 - 11 12 - 12	6 - 12	6.35 - 8	6.35 - 10	8 - 8
XGS2-27C	5 - 6 8 - 10	5 - 8 8 - 11	5 - 14 8 - 12	6 - 6 8 - 14	6 - 8 10 - 10	6 - 10 10 - 12	6 - 11 10 - 14	6 - 12 12 - 12	6 - 14 12 - 14	8 - 8 14 - 14
XGS2-30C	8 - 8 10 - 15	8 - 10 11 - 12	8 - 11 12 - 12	8 - 12 12 - 14	8 - 14 12 - 15	8 - 15 14 - 14	10 - 10 14 - 15	10 - 11 15 - 15	10 - 12	10 - 14
XGS2-34C	8 - 8 10 - 15	8 - 10 11 - 11	8 - 11 11 - 12	8 - 12 12 - 12	8 - 14 12 - 14	8 - 15 12 - 15	10 - 10 14 - 14	10 - 11 14 - 15	10 - 12 15 - 15	10 - 14 16 - 16
XGS2-39C	10 - 10 12 - 20	10 - 12 14 - 14	10 - 14 14 - 15	10 - 15 14 - 16	10 - 16 15 - 15	12 - 12 15 - 16	12 - 14 15 - 19	12 - 15 16 - 16	12 - 16 17 - 17	12 - 19 20 - 20

- All products are provided with hex socket head cap screw.
- Recommended tolerance for shaft diameters is h6 and h7.
- In case of mounting on D-cut shaft, be careful about the position of the D-cut surface of the shaft. ➡ P.xxxx

Additional Keyway at Shaft Hole ➡ P.xxxx	Cleanroom Wash & Packaging ➡ P.xxxx	Change to Stainless Steel Screw ➡ P.xxxx
Available / Add'l charge	Please combine with Stainless Steel Screw Alteration Service	Available / Add'l charge

Performance

Part Number	Max. Bore Diameter (mm)	Keyway Additional Modification Max. Bore Diameter (mm)	Rated *1 Torque (N・m)	Max. Rotational Frequency (min^{-1})	Moment*2 of Inertia ($kg \cdot m^2$)	Static Torsional Stiffness (N・m/rad)	Max. Lateral Misalignment (mm)	Max. Angular Misalignment (°)	Max. Axial Misalignment (mm)	Mass *2 (g)
XGS2-15C	6	–	0.5	42000	2.1×10^{-7}	64	0.15	1.5	±0.2	7
XGS2-19C	8	6	0.8	33000	5.9×10^{-7}	170	0.15	1.5	±0.2	12
XGS2-25C	12	9	2.3	25000	2.4×10^{-6}	290	0.15	1.5	±0.2	24
XGS2-27C	14	10	2.3	23000	3.2×10^{-6}	290	0.15	1.5	±0.2	28
XGS2-30C	15	11	3.3	21000	5.2×10^{-6}	430	0.2	1.5	±0.3	38
XGS2-34C	16	12	5.5	18000	1.1×10^{-5}	800	0.2	1.5	±0.3	61
XGS2-39C	20	15	7	16000	2.1×10^{-5}	930	0.2	1.5	±0.3	90

*1： Correction of rated torque due to load fluctuation is not required. If ambient temperature exceeds 30℃, be sure to correct the rated torque with temperature correction factor shown in the following table.
The allowable operating temperature of XGS2-C is −10℃ to 120℃.
※ The shaft's slip torque may be smaller than the coupling's rated torque depending on the shaft bore. ➡ P.xxxx

*2： These are values with max. bore diameter.

- Ambient Temperature / Temperature Correction Factor

Ambient Temperature	Temperature Correction Factor
−10℃ to 30℃	1.00
30℃ to 40℃	0.80
40℃ to 60℃	0.70
60℃ to 120℃	0.55

- Part number specification

XGS2-34C - 11-12
1 2