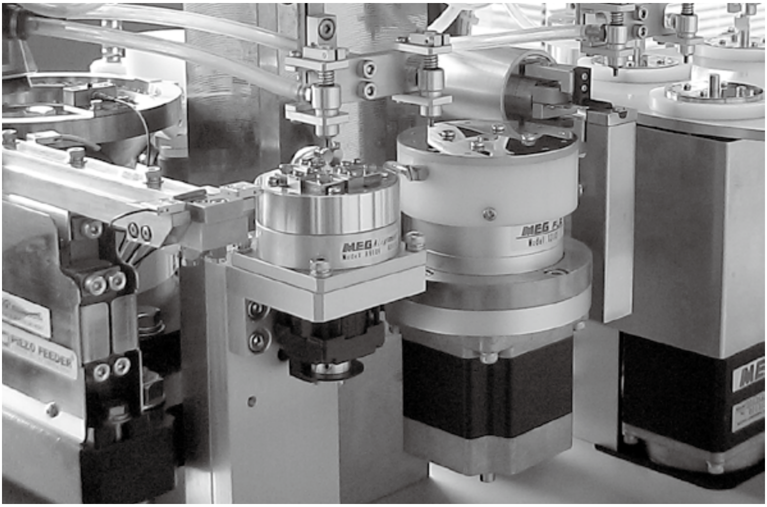
FLA

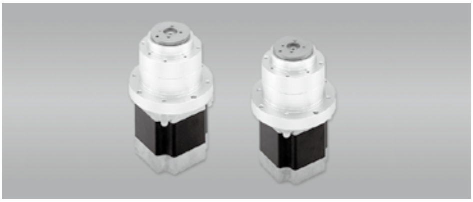
(Flexible actuator)

Compact actuator for integer indexing that allows easy mounting of a table or arm

The high-accuracy positioning actuator is equipped with a proven planet reduction gear accommodating numbers of indexes that cannot be handled directly with a stepping motor (3, 6, 9, 12...).



Highly flexible indexing equipment used for automated assembly systems are required to provide an agile positioning function with a high degree of freedom, which is shown in workpiece changeover and sorting.One general example is stepping motors but they raise fears of various adverse effects including the restriction of the number of indexes (number of divisions) when direct rotation of the table is attempted and accuracy degradation caused by shaft deflection or play. Another method is transmission to the output shaft via a timing belt but it requires a large space and the number of parts tends to increase as well. “Capability of constant high-accuracy positioning without the restriction of the number of indexes and easy mounting of a table” is the challenge we have met by applying the original technology for high-accuracy long-life reduction mechanism we have developed over the years and incorporating new ideas. Use this flexible actuator that realizes high-accuracy positioning for automated assembly and inspection systems and other factory automation plans.


Flexible actuator

Flexible actuator

Model selection

Model list

Basic step angle	Type	Model No.	Page
0.1°	5-phase	X3101 	E-6
0.2°	2-phase	X3102 	E-6

- Models with the output shaft are also available.
- For restriction of applications and safety precautions, see E-14.
- For precautions, see E-10.

■ Characteristics of FLA

Positioning accuracy (X1): within ±4 minutes

- The displacement of the result of the output shaft rotational angle relative to the specified angle (accuracy).
- Measuring procedure: With no load on the output shaft, find the value for the positioning display angle (B) after rotation of the output shaft relative to the specified angle (A).
  X1 = (A - B): Absolute value

Lost motion: within 2 minutes

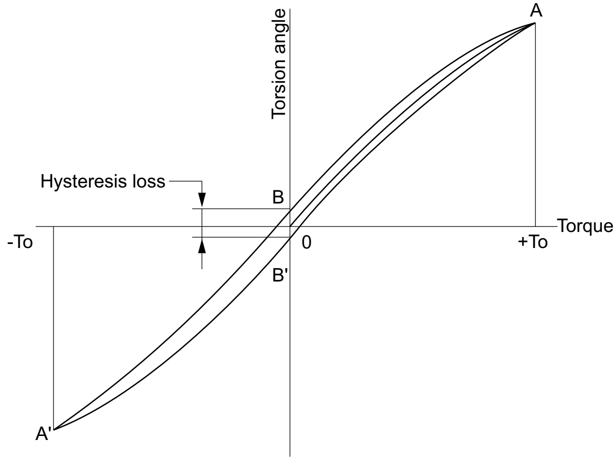
- Return repeatability achieved when rotated in the forward and reverse directions relative to the stop position (origin).
- Measuring procedure:

(1) After rotating in the forward direction by a certain angle from the origin, rotate in the reverse direction by the same angle and measure the difference from the initial value at the origin (A).
(2) After rotating in the reverse direction by the same angle as (1) from the origin, carry out the return-to-origin operation and measure the difference from the initial value (B).
(3) The maximum difference between (A) and (B) is the lost motion.

Hysteresis loss: within 4 minutes

- Output shaft returning characteristic.
- Measuring procedure:

(1) After applying the rated torque in the forward direction (A), apply no load and measure the remaining difference from the initial value (B).
(2) After applying the rated torque in the reverse direction (A'), measure the value as described above (B').
(A) + (B) = Hysteresis loss



X3101, X3102

Integer indexing actuator

FLA basic step (with full step)

5-phase: 0.1°   2-phase: 0.2°

With direct drive of a stepping motor, it may be impossible to feed to an arbitrary position on the circumference.

To feed in units of 10°, for example:

5-phase
Direct drive

10°/0.72° = 13.888 pulses → 14 pulses
14 pulses x 0.72° = **10.08°**

A displacement of as much as 0.08° (4 minutes 48 seconds) per feed is generated!!

FLA 5-phase type

10°/0.1° = 100 pulses
100 pulses x 0.1° = **10°**

The output shaft feeds in units of 0.1°, which offers a complete agreement.

■ High-accuracy positioning of ±4 minutes

The high-accuracy reduction mechanism realizes high-accuracy positioning.

■ Direct table mounting

If the output section is of a shaft type, a flange is required for mounting a table, which causes problems such as “inability to save space,” “a large number of parts” and “accuracy degradation due to the effect of rigidity.” FLA allows direct mounting of a table and realizes simple, space-saving and stable-accuracy tooling.

■ Compactness

The drive section does not project out of the main body, which contributes to size reduction of the equipment.

■ 2-phase and 5-phase stepping motors available

Can be selected according to the application.

■ Backlashless mechanism adopted

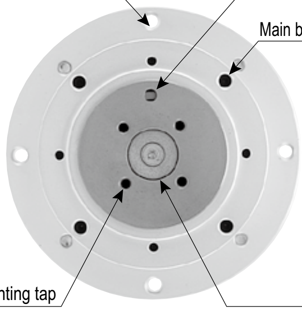
Lost motion of within 2 minutes has been realized. No looseness at start/stop and eliminates the need for a wait in operation.

■ Manual adjustment

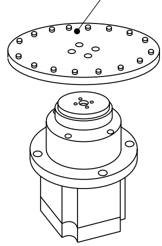
The shaft of the motor rear section can be rotated, which allows easy maintenance.

■ Output shaft options available

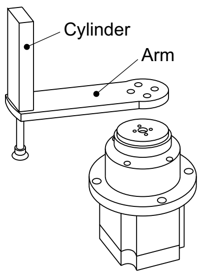
Options with shaft have been added. Can be selected according to the application.



■ How to utilize



Index table



Pick & place unit

FLA (Flexible actuator)

X3101, X3102

X3102

X3101

● High-accuracy

The high-accuracy reduction mechanism realizes high-accuracy positioning.

● Direct table mounting

If the output section is of a shaft type, a flange is required for connection, which causes problems such as “inability to save space,” “a large number of parts” and “accuracy degradation due to the effect of rigidity.” A table can be directly mounted, which realizes simple, space-saving and stable-accuracy tooling.

■ Variations

Model No.	Basic step angle	Model No.	
		5-phase	2-phase
X3101	0.1°	×	
X3102	0.2°		×

*Basic step angle: with full step

Product number configuration

X310 □ - P0

Model No.

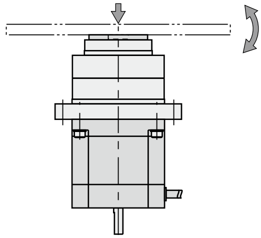
1: 0.1° step (5-phase)
2: 0.2° step (2-phase)

Output shaft option
No symbol: Not provided
P0: Output shaft provided

X310□-P0

■ Basic specifications

Driving method	Stepping motor
Operation method	Planet gear type
Ambient temperature	5 to 50°C
Lubricant	Grease filled Non-lubrication use
Mass	1.4 kg
Allowable thrust load	100 N (10 kgf)
Allowable moment load	2N•m (20 kgf•cm)



■ Input/output shaft specifications

Model No.	Input shaft specifications		Output shaft specifications		
	Equivalent GD² (kgf•cm²)	Allowable rotating speed (rpm)	Allowable torque (kg•cm)	Allowable rotating speed (rpm)	Basic step angle (Deg)
X3101	1.16	3,000	7.2	416	0.1
X3102	1.23	3,000	9.0	333	0.2

*Input shaft equivalent GD² includes the inertia moment of the motor rotor.
*The output shaft allowable torque is an allowable torque accepted by this product and is not an output torque.

■ Accuracy

Positioning accuracy	The displacement of the output shaft angle relative to the specified angle (indexing accuracy)	Within ±4 minutes
Lost motion	Displacement of angle at the same point when rotation is reversed	Within 2 minutes
Hysteresis loss (residual stress)	Refers to a total of the differences between the initial value and the value after the rated torque is applied in the forward and reverse directions at the same point and no load applied.	Within 4 minutes
Output shaft surface runout	Runout of the output shaft flange surface (with no load)	Within 0.03 mm

■ Motor specifications

Model No.	Motor product name (Manufacturer: Oriental Motor)	Basic step angle	Amperage (A/phase)	Voltage (V)	Winding resistance (Ω/phase)	Rotor inertia moment (kgf•cm²)
X3101	PK566H-B special	0.72	1.4	-	1.1	0.28
X3102	PK266-02B	1.8	2	3.6	1.8	0.3

*PK566H-B special: motor shaft diameter φ6

■ Driver (recommended)

Model No.	Manufacturer: Oriental
X3101	RKD514L-A (100 V) RKD514L-C (single phase 200 V)
X3102	CMD2120P (24 VDC)

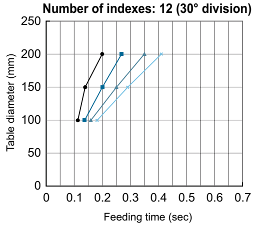
* Must be provided by the customer.
* The performance of the stepping motor depends on the driver.
  See the driver catalog for details.

X3101, X3102

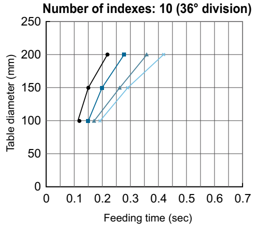
Feeding time and table size

X3101 (5-phase)

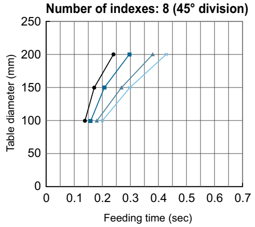
Number of indexes: 12 (30° division)



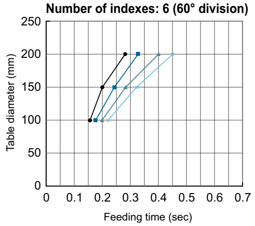
Number of indexes: 10 (36° division)



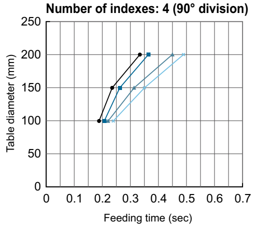
Number of indexes: 8 (45° division)



Number of indexes: 6 (60° division)

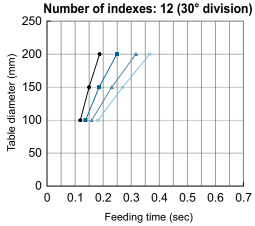


Number of indexes: 4 (90° division)

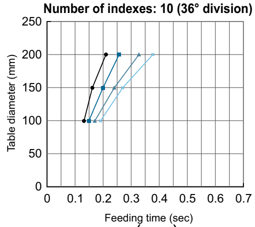


X3102 (2-phase)

Number of indexes: 12 (30° division)

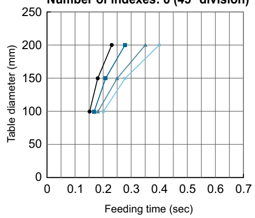


Number of indexes: 10 (36° division)

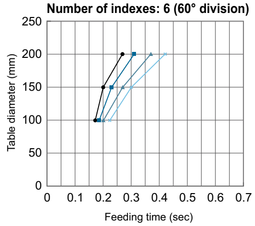


(mm)

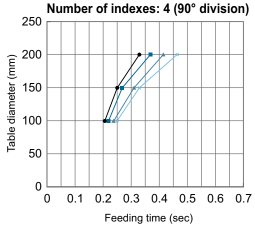
Number of indexes: 8 (45° division)

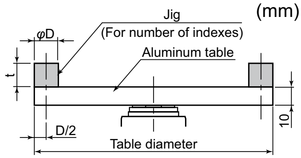


Number of indexes: 6 (60° division)



Number of indexes: 4 (90° division)

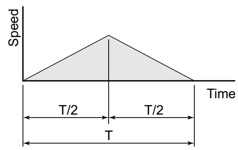




Jig dimensions/material

- No jig
- 0.05 kg: φ20 x 20 Fe
- 0.10 kg: φ38 x 18 Fe
- 0.25 kg: φ40 x 25 Fe

Acceleration/deceleration time standard



* With the acceleration/deceleration time set at 1/2 of the feeding time (T), feeding time for a given table diameter has been found.

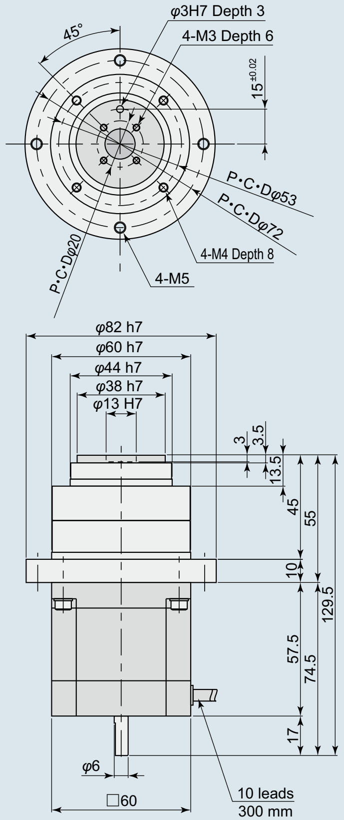
Precautions

- These are values when there is no load resistance from the outside during feeding.
- If there is sliding resistance, etc., the table diameter becomes further smaller.
- These are values with horizontal operation (table top facing upward).
- When the iron table is used, the cycle time is selected for the plate thickness 3.3 mm.
- The performance may be degraded depending on the performance of the driver.

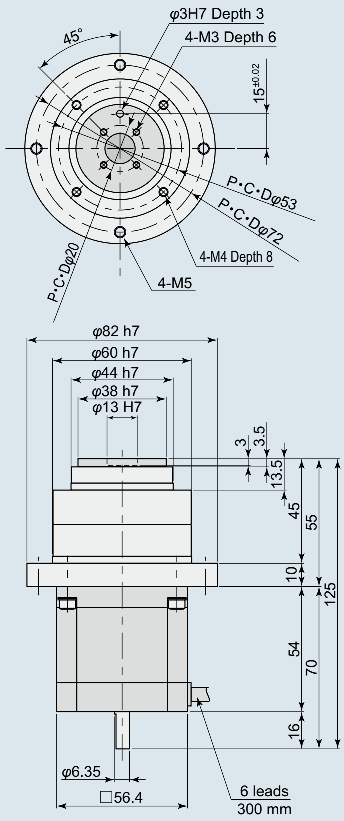
■ Dimensional drawing

(mm)

X3101 (5-phase)

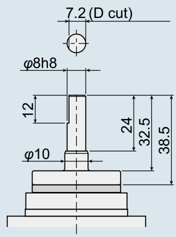


X3102 (2-phase)



X310□-P0

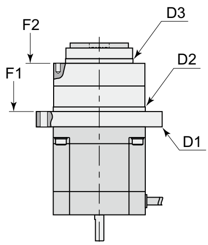
Dimensions of optional output shaft



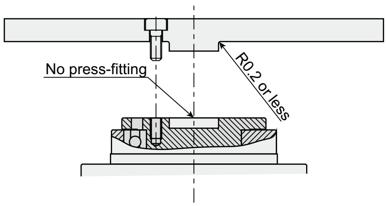
Precautions

Mounting precautions

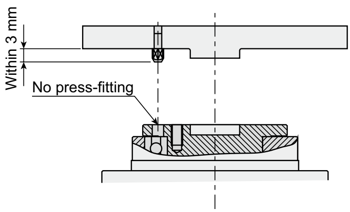
- Since the parts D2 and D3 are finished to h7, mount by using four mounting holes with the F1 and F2 as location faces for the fitting. If it is difficult to mount in this direction, secure it from the motor side with D1 as the fitting. Mounting from the motor side requires relief for motor and lead wiring.



- Secure the table onto the end of the output shaft using the screw. The fitting part of 13 mm diameter is chamfered to C0.3. Install the table side at R0.2 or less.



- For positioning in the direction of rotation, press-fit the diamond pin on the table side and insert into the output shaft. (Do not press-fit on the output side.)



- If the driven side is guided with a ball bearing, etc., be sure to use a coupling.
- The mounting direction is arbitrary.
- For the optional model with the output shaft, use the D cut part made in the shaft to secure the attachment on the output shaft. The mounting can be further secured by using a split clamp, friction fastening element, etc.
- The optional output shaft is provided with a positioning pin.

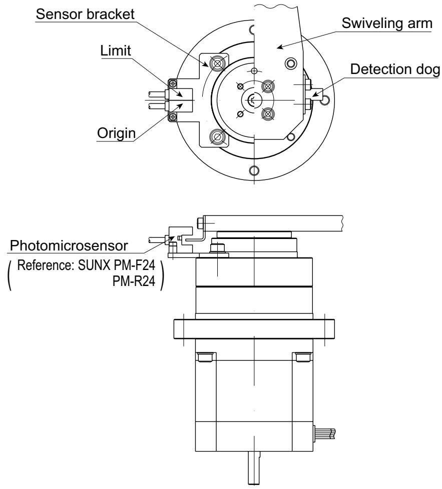
Detection of indexing and origin positions

- In principle, mount a dog and sensor on the output side for detecting the indexing completion position and the origin position.
- For the numbers of divisions shown below, a slit dog can be mounted on the motor shaft to use for detection.

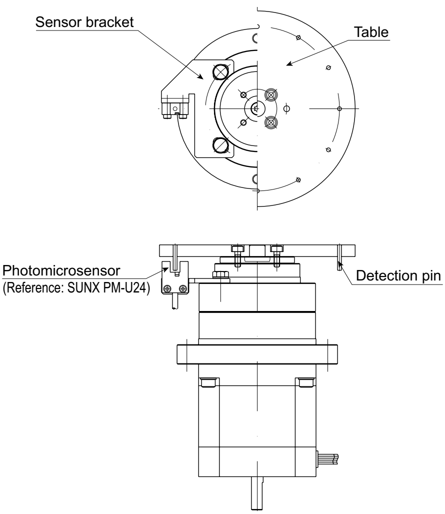
Output shaft number of divisions	Output shaft angle	5-phase		2-phase	
		Motor feed angle	Number of slits	Motor feed angle	Number of slits
180	2°			18°	20 divisions
72	5°	36°	10 divisions	45°	8 divisions
45	8°			72°	5 divisions
36	10°	72°	5 divisions	90°	4 divisions
18	20°			180°	2 divisions
9	40°			360°	1 division

Example of mounting of detection sensor

- For swiveling arm



- For table



Handling precautions

- Make sure that the load capacity on the output shaft is within the output shaft allowable torque.
- The moment load and thrust load may have a significant impact on the bearing life and shaft strength. Make sure that they do not exceed the allowable values.
- Ensure interlock with other devices to prevent interference.
- Ensure that the temperature on the surface of the motor case does not exceed 75°C in use. In view of the life of the gears, bearings, etc. in the product, mounting on a metal plate, etc. with high thermal conductivity and use at as low a temperature as possible is recommended.
- Disassembling or modifying the product may significantly affect the performance and life. Never disassemble or modify the product.
- This product is comprised of precision parts. Do not allow any excessive force applied on the product. It may cause damage and/or accuracy degradation.
- Before use, read and understand the instruction manual for correct use.

Selection of stepping motor

Calculate the accelerating torque first and then calculate the load torque. Finally, check the characteristics of the motor and reduction gear. Follow the steps in the description. For selection, be sure to use the procedure described here to achieve the performance potential by correct handling.

1. Find the load on the stepping motor.

The values to be calculated first are the accelerating torque required for indexing rotation acceleration and deceleration and load torque for driving friction load.
For the calculation, use (kgf) for the load, (kg) for the weight and (cm) for the length as the units.

Calculation of accelerating torque (Ta)

When the speed in use is high, the accelerating torque may be larger than expected. For that reason, correct calculation is important. The accelerating torque can be determined by finding the inertia moment from the flywheel effect (GD^2) and multiplying it with the acceleration.

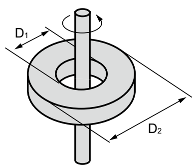
Step 1

Find the (GD^2) of the respective rotating object according to its shape. (GD^2) is simply a symbol and not a calculation expression.
For the constant (density) required for weight calculation, use the following values.

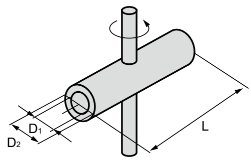
Iron	$\rho = 7.9 \times 10^{-3}$ (kg/cm³)
Aluminum	$\rho = 2.8 \times 10^{-3}$ (kg/cm³)
Brass	$\rho = 8.5 \times 10^{-3}$ (kg/cm³)
Nylon	$\rho = 1.1 \times 10^{-3}$ (kg/cm³)

► Center of load coaxial with axis of rotation

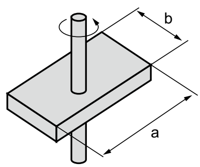
W: Load weight (kg)



$$GD^2 = \frac{1}{2} W (D_1^2 + D_2^2)$$



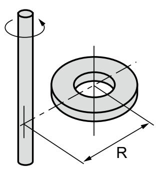
$$GD^2 = W \left[\frac{1}{4} (D_1^2 + D_2^2) + \frac{1}{3} L^3 \right]$$



$$GD^2 = \frac{1}{3} W (a^2 + b^2)$$

► Center of load not aligned with axis of rotation

The figure shows an example with a cylindrical shape.

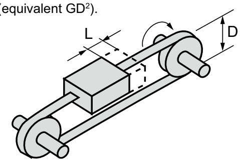


$$GD^2 = [GD_0^2] + 4WR^2$$

GD_0^2: GD^2 with center of load coaxial with axis of rotation
W: Load weight (kg)
R: Distance between center of load and center of axis of rotation (cm)

► Linearly moving load

The value is GD^2 on the axis of rotation (equivalent GD^2).



$$GD^2 = WD^2 = W\left[\frac{L}{\pi} \right]^2$$

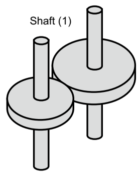
W: Load weight (kg)
For screw feed, substitute the screw pitch (cm/rev) for L.

Step 2

Add up the GD^2 for the coaxial axes of rotation to find the sum total. If any relief is made due to the shape of the load, find GD^2 with the shape of the relief and subtract it as the negative load.

Step 3

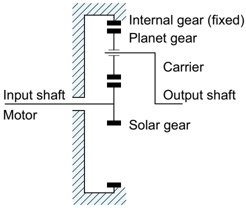
Convert to equivalent GD^2 on the drive shaft (motor shaft).



► To determine GD^2 of shaft (2) as equivalent GD^2 of shaft (1)

$$GD^2 = GD_2^2 \times \left[\frac{N_2}{N_1} \right]^2$$

GD_1^2: Equivalent GD when GD_2^2 of shaft (2) is replaced with shaft (1)
GD_2^2: GD_2^2 of shaft (2)
N_1: Rotating speed (rpm) of shaft (1): For selecting a motor, replace N_1 value with the rotating speed of the motor shaft for calculation.
N_2: Rotating speed (rpm) of shaft (2)



The flexible actuator reduces the step angle of the stepping motor by the backlashless planet gear mechanism for an integer angle.
Convert GD^2 of the output shaft to GD^2 of the motor shaft to check the performance.

The sum total of the GD^2 for all axes of rotation converted to equivalent GD^2 on the drive shaft is the GD^2 value on the drive shaft. Add GD^2 of the motor and reduction gear.

Equivalent GD2 on FLA input shaft (kgf·cm²)

Specifications	Model No.	Reduction ratio	GD^2
With 2-phase motor	X3102	1:9	1.23
With 5-phase motor	X3101	1:7.2	1.16

Step 4

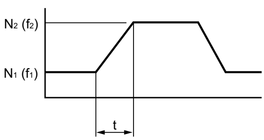
Find the inertia moment (I) from GD^2 in the drive section.

$$I = \frac{GD^2}{4\,g}$$

I: Inertia moment (kgf•cm•sec²)
g: Gravitational acceleration 980.7 (cm•sec²)

Step 5

Find the angular acceleration based on the operation mode of the stepping motor.



$$\omega = \frac{2\pi}{60} \times \frac{(N_2 \cdot N_1)}{t} = \frac{\pi \cdot \theta_s}{180} \times \frac{(f_2 - f_1)}{t}$$

ω : Angular acceleration (Rad/sec²)
N_1 : Rotating speed at start of stepping motor (rpm)
N_2 : Rotating speed at high speed of stepping motor (rpm)
f_1 : Pulse speed at start of stepping motor (PPS)
f_2 : Pulse speed at high speed of stepping motor (PPS)
θ_s : Step angle of stepping motor (deg)
t : Acceleration (deceleration) time (sec)

Step 6

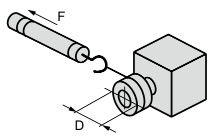
Determine the accelerating torque (Ta) from the inertia moment (I) and angular acceleration (ω).

$$Ta = I \times \omega \times S$$

Ta: Accelerating torque on drive shaft (motor shaft) (kg•cm)
I: Sum total of inertia moments on drive shaft (kgf•cm•sec²)
ω: Max. angular acceleration of drive shaft (Rad/sec²)
S: Service factor (factor = 1.5 to 2)

Calculation of load torque (TL)

► Rotating load



$$TL = \frac{FD}{2} \times \frac{N_2}{N_1} \times S \text{ (kgf•cm)}$$

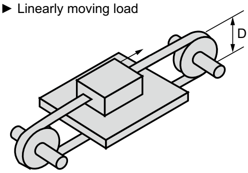
F: Force at start of shaft rotation (kgf)
N_1: Rotating speed of motor shaft (rpm)
N_2: Rotating speed of output shaft of reduction gear (rpm)
S: Service factor (factor = 1.5 to 2)

Calculation of required torque (T)

Calculate the required torque for rotating the load based on the accelerating torque (Ta) and load torque (TL).

$$T = Ta + TL \text{ (kgf•cm)}$$

► Linearly moving load



$$TL = \frac{\mu WD}{2} \times \frac{N_2}{N_1} \cdot S \text{ (kgf•cm)}$$

W: Load weight (kg)
μ: Friction coefficient
N_1: Rotating speed of motor shaft (rpm)
N_2: Rotating speed of output shaft of reduction gear (rpm)
S: Service factor (factor = 1.5 to 2)

2. When the load on the stepping motor has been calculated, check the compatibility with the reduction gear.

Check on characteristics of motor and reduction gear

See the torque and speed characteristics (figure) and check the points below.

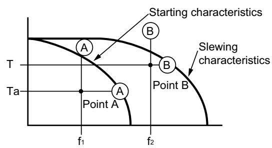
$$f_1 = \frac{N_1}{60} \times \frac{360}{\theta s}$$

N_1: Rotating speed at start of stepping motor (rpm)
θ_s: Step angle of stepping motor (deg)

and

$$f_2 = \frac{N_2}{60} \times \frac{360}{\theta s}$$

N_2: Rotating speed at high speed of stepping motor (rpm)
θ_s: Step angle of stepping motor (deg)



● Points to check
The desired stepping motor can be used as long as the answers to all of the questions 1 to 3 below are YES. If any of the requirements is not met, review the load and operation mode.
1. Is point A within the range of starting characteristics?
2. Is point B within the range of slewing characteristics?
3. Is the required torque (T) value within the range of output shaft allowable torque of the reduction gear?

Applications

1. Restriction of applications

This FLA (flexible actuator) is a stepping motor-driven table type actuator incorporating a backlashless reduction gear and is intended to serve as a device for precision indexing (indexing, pitch feed, etc.) and precision positioning.

2. Safety precautions

⚠ DANGER

- Do not use the product for the following applications.
  1. Medical devices related to the support and maintenance of human life and body
  2. Mechanisms and machinery used for the purpose of moving and transporting people
  3. Important security components of machinery

  This product is not developed or designed for applications that require a high degree of safety. Use of this product for such applications may cause death.
- Do not use the product in a place where hazardous substances such as combustible or flammable substances exist.
  There is a possibility of the product catching fire.
- Never modify the product. Doing so may cause injury due to abnormal operation, electric shock, fire, etc.
- Do not perform improper disassembly/assembly that affects the product's basic structure, performance, or functions.
- Do not pour water on the product. Pouring water on the product, washing it or using it immersed in water may cause injury due to abnormal operation, electric shock, fire, etc.

⚠ WARNING

- Be sure to confirm the safety of the operating range of devices before supplying power to and operating the product. If the power is supplied improperly, there is a risk of electric shock and injury caused by contact with a movable part.
- Keep away from the operating range of machinery when a product is in operation or ready to operate. Failure to do so may result in injury due to unexpected operation of the product.
- Do not touch the terminal blocks or switches while the power is turned on. There is a risk of abnormal operation and electric shock.
- Do not damage any of the cables. Damaging, forcibly bending, pulling, winding or pinching cables, placing heavy objects on them may cause electric shock, abnormal operation, etc.
- Do not get on top of the product, use it as a foothold or put any object on it. It may cause an accidental fall, tumbling of the product, injury due to a fall, damage to the product or malfunction due to damage.
- Do not throw the product into the fire. The product may explode or poisonous gases may be discharged.
- Be sure to completely remove the supply of electricity before performing various tasks such as maintenance, inspection, service, or replacement.

⚠ CAUTION

- When mounting the product, ensure reliable retention and securing. Otherwise, fall or abnormal operation of the product may cause injury.
- This product is not equipped with a non-excitation brake. If there is any possibility that the output shaft load is moved by external load (gravity, spring force, etc.), provide a braking mechanism. Otherwise it may cause damage to the machine or injury.
- Do not use this product in places subjected to direct sunlight (ultraviolet light) or dust, iron, iron powder, or in an atmosphere containing organic solvent, phosphate-ester hydraulic oil, sulphurous acid gas, chlorine gas, acids, etc. The product may stop functioning in a short period of time, or the performance may be deteriorated and the lifetime of the product may be significantly reduced.

- Use protective covers to prevent the moving parts of machinery from coming in direct contact with human body.
- When working on the product, ensure safety by wearing protective gloves, safety glasses, safety shoes, etc. as required.
- When the product has become unserviceable or unnecessary, dispose of it properly as industrial waste.
- As you incorporate the products into your system, add all safety information to the instruction manual of your system and make sure the operators of the system follow the instructions.
  Be sure to add to the instruction manual all new safety information that needs to be provided as a result of the incorporation.