HarmonicDrive®

Brushless DC Actuator

FLA series manual

ISO14001

ISO9001

Introduction

Thank you for purchasing our FLA series Brushless DC Actuator.

Improper handling or mis-use of this product may result in unexpected accidents or a shorter life of the product. Read this document carefully and use the product correctly so that the product can be used safely for many years.

Product specifications are subject to change without notice for improvement purposes.
Keep this manual in a convenient location and refer to it whenever necessary in operating or maintaining the units.

The end user of the actuator should have a copy of this manual.

SAFETY GUIDE

To use this actuator safely and correctly, be sure to read SAFETY GUIDE and other parts of this document carefully and fully understand the information provided herein before using the actuator.

Safety Alert Symbol

Important safety information is described in this section. Be sure to observe these instructions.

 WARNING	Warning of a hazard which could result in life hazard or serious injury.
 CAUTION	Indicates a potentially hazardous situation, which, if not avoided, may result in minor or moderate personal injury and/or damage to the equipment.
Caution	Caution for preventing malfunction and negative effects to the performance and function.

SPECIAL APPLICATIONS

When using this product for applications listed below, please consult with us first.

- Space equipment
- Automobile, automotive parts
- Aircraft, aeronautic equipment
- Amusement equipment, sport equipment, game machines
- Nuclear equipment
- Machine or devices acting directly on the human body
- Household apparatus
- Instruments or devices to transport or carry people
- Vacuum equipment
- Apparatus or devices used in special environments


CAUTION

Safety measures are essential to prevent accidents resulting in death, injury or damage of the equipment due to malfunction or faulty operation.

SAFETY NOTE

ITEMS YOU SHOULD NOTE WHEN USING THE ACTUATOR

●CAUTIONS RELATED TO THE DESIGN

Always use under followings conditions.

The actuator is designed to be used indoors. Observe the following conditions:

- Ambient temperature: 0℃ to 40℃
- Ambient humidity: 20% to 80%RH (Non-condensation)
- Impact: Max 300 m/s^2
- Vibration: Max 25 m/s^2
- No contamination by dust, metal powder, water or oil
- No corrosive or explosive gas

Follow exactly the instructions in the relating manuals to install the actuator in the equipment.

- Ensure exact alignment of the actuator center and the center of the corresponding machine by following the manual.
- Failure to observe this caution may lead to vibration, resulting in damage of output elements.

●CAUTIONS FOR USAGE

Keep limited torques of the actuator.

- Keep limited torques of the actuator.
- Be aware, that if arms attached to output element hits by accident an solid, the output element may be uncontrollable.

Never connect cables directly to a power supply socket.

- Each actuator must be operated with a proper driver.
- Failure to observe this caution may lead to injury, fire or damage of the actuator.

Do not apply impacts and shocks

- Actuators are equipped with a sensor circuit. Do not tap them with a hammer or other tool.
- If the sensor circuit is damaged, the actuator may become uncontrollable.

Avoid handling of actuators by cables.

- Failure to observe this caution may damage the wiring, causing uncontrollable or faulty operation.

Caution

- FLA series actuators have a simple sealed structure, which does not completely prevent lubricant leaks. Take additional measures to prevent leaks as necessary.

DISPOSAL

All products or parts have to be disposed of as industrial waste.

Since the case or the box of drivers have a material indication, classify parts and dispose them separately.

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Conformance to overseas standards

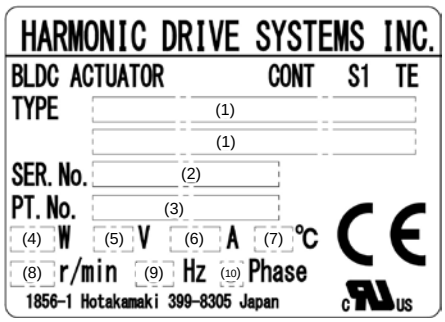
The FLA series actuator conforms to following overseas standards.

UL Standard	UL1004-1 (File No. E328070)
CSA Standard	C22.2 No.100
European Low Voltage EC Directives	EN60034-1, EN60034-5

Nameplate sticker

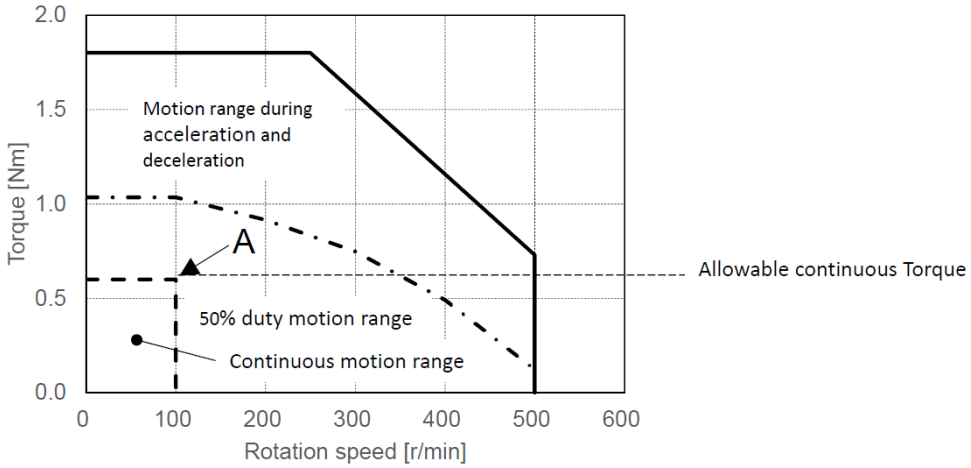
The following specifications of the FLA series actuators are shown.

Nameplate field	Explanation
(1)	Model
(2)	Serial Number
(3)	Part No.
(4)	Rated output [W]
(5)	Input voltage [V]
(6)	Allowable continuous current [A]
(7)	Allowable range temperature [℃]
(8)	Rotation speed [rpm] at point A on the graph below
(9)	Current fundamental frequency [Hz] at point A on the graph below
(10)	Number of phase



Nameplate sticker

Rotation plate: 220*220*8 (mm)



The nameplate values are shown below.

HP (24VDC)

Item \ Model		FLA-11A	FLA-14A	FLA-17A	FLA-20A
(1) Output at point A	W	7	13	31	43
(2) Input voltage	V	24			
(3) Allowable continuous current	A	3.0	6.0	10.4	10.7
(4) Allowable range temperature	℃	40			
(5) Rotational speed at point A	rpm	100			
(6) Frequency at point A	Hz	67	67	75	120
(7) Number of phase	—	3			

HP (48VDC)

Item \ Model		FLA-11A	FLA-14A	FLA-17A	FLA-20A
(1) Output at point A	W	7	13	31	43
(2) Input voltage	V	48			
(3) Allowable continuous current	A	1.6	3.0	5.3	6.0
(4) Allowable range temperature	℃	40			
(5) Rotational speed at point A	rpm	100			
(6) Frequency at point A	Hz	67	67	75	120
(7) Number of phase	—	3			

FB (24VDC)

Item \ Model		FLA-11A		FLA-14A		FLA-17A		FLA-20A
		50	100	50	100	50	100	50
(1) Output at point A	W	11	8	16	12	49	36	68
(2) Input voltage	V	24						
(3) Allowable continuous current	A	1.9	1.7	3.0	2.5	6.8	5.3	8.7
(4) Allowable range temperature	℃	40						
(5) Rotational speed at point A	rpm	60	30	60	30	60	30	50
(6) Frequency at point A	Hz	250	250	250	250	250	250	333
(7) Number of phase	—	3						

FB (48VDC)

Item \ Model		FLA-11A		FLA-14A		FLA-17A		FLA-20A
		50	100	50	100	50	100	50
(1) Output at point A	W	11	8	16	12	49	36	68
(2) Input voltage	V	48						
(3) Allowable continuous current	A	1.0	0.8	1.5	1.2	3.4	2.9	5.1
(4) Allowable range temperature	℃	40						
(5) Rotational speed at point A	rpm	60	30	60	30	60	30	50
(6) Frequency at point A	Hz	250	250	250	250	250	250	333
(7) Number of phase	—	3						

Chapter 1

Outlines

This chapter explains the features, functions and specifications of the actuator.

1-1 Outline

FLA series actuators are ultra-flat brushless DC actuators that combine brushless DC motors with high performance speed reducers. Compact, high power brushless DC motors are combined with high-performance speed reducers to deliver flat and light brushless DC actuators.

There are 2 types of speed reducers: HP with a HarmonicPlanetary® speed reducer incorporated that features high speed and high efficiency, and FB with a HarmonicDrive® strain wave gear speed reducer incorporated that features lightweight and high output torque. FLA Actuators are available in four sizes, 11, 14, 17 and 20. They can be operated with a battery, and 24 VDC and 48 VDC input voltages are also supported. FLA series actuators play an important role in a variety of applications such as driving wheels of AGVs (Automated Guided Vehicles) and power assist devices.

◆ Ultra-Flat Shape and Lighter Weight

The HarmonicPlanetary® speed reducer features high speed and high efficiency, where the HarmonicDrive® strain wave gear speed reducer features lightweight and high output torque. Our speed reducers are used in combination with our self-developed brushless DC motors to deliver unprecedented ultra-flat, light weight actuators. They help reduce the weight and size of various equipment such as AGVs and exoskeleton, power assist suits.

◆ Wide Range of Products

We have 24 models available to choose from. Select the best actuator according to your application.

1-2 Model

Model names for the FLA series actuators and how to read the symbols are explained below.
Examples of models:

FLA	-	11	A	-	08	HP	-	H	-	24	-	SP
(1)	-	(2)	(3)	-	(4)	(5)	-	(6)	-	(7)	-	(8)

(1) Model: Brushless DC Actuator FLA series
(2) Size: 11, 14, 17, 20
(3) Version symbol
(4) Reduction ratio (indicated by R in R:1 format)
HarmonicPlanetary® speed reducer
08：8:1 (Size: 11, 14)
09：9:1 (Size: 17, 20)
HarmonicDrive® strain wave gear speed reducer
50：50:1 (Size: 11, 14, 17, 20)
100：100:1 (Size: 11, 14, 17)
(5) Speed reducer

HP	HarmonicPlanetary® speed reducer
FB	HarmonicDrive® strain wave gear speed reducer

(6) Sensor type

H	Hall sensor

(7) Input power supply

24	DC24V
48	DC48V

(8) Special specification

No description	Standard product
SP	Special specification

1-3 Recommended drives

We recommend the drives listed below to use with FLA actuators.
Low voltage brushless DC motor drive (S series, F series) by YASKAWA CONTROLS CO., LTD

Model	FLA-11A	FLA-14A	FLA-17A	FLA-20A
CCMDSP-D40P4YC1 (S series)	○	○	○	○
CCMDPE-D40P3YC1 (F series)	○	○	○*1	○*1

*1: With this combination, the actuator output is restricted due to the drive capacity limitation.
For more specifications, refer to [1-4 Specifications] (P1-5).
*2: For details on drives, please contact YASKAWA CONTROLS CO., LTD.
Home page address: http://www.yaskawa-control.co.jp/
Technical support telephone service: 0120-854-388
Technical support email address: cmec@yaskawa-control.co.jp

When Using a Recommended Drive

The characteristics of the recommended drives have been adjusted according to the actuators and each model has its own drive parameters. Ensure that you check the drive and actuator models and use with the appropriate parameters. Using with invalid parameters may cause the actuator to burn out due to insufficient torque or overcurrent, resulting in an injury or fire.

When Using a Drive Other Than Recommended Drives

When using a drive other than the recommended drives, ensure that the specifications of the actuator are not exceeded. Using the drive exceeding the actuator specifications may cause an actuator malfunction or failure.

[Related Manuals]

The table below lists related manual. Check each item as necessary.

[CCMDSP-D40P4YC1 (S series)]

Title	Manual No.	Description
S series startup manual	SIE-C801-1.2A X	General product descriptions

Note: X in the end of document numbers indicate revision code.

[CCMDPE-D40P3YC1 (F series)]

Title	Manual No.	Description
F series startup manual	SIE-C801-2.2A X	General product descriptions

Note: X in the end of document numbers indicate revision code.

1-4 Specifications

HP (DC24V)

Item \ Size		FLA-11A-08HP	FLA-14A-08HP	FLA-17A-09HP	FLA-20A-09HP
Combined drive	-	CCMDSP-D40P4YC1 CCMDPE-D40P3YC1		CCMDSP-D40P4YC1 (CCMDPE-D40P3YC1)*5	
Driver input power supply	V	DC24			
Max. torque*1	N·m	1.8	3.7	7.3 (5.4)*5	12.1 (7.5)*5
Allowable continuous torque*1*2	N·m	0.6	1.2	3.0 (1.6)*5	4.1 (2.3)*5
Max. rotational speed*1	rpm	500	500	500	400
Allowable continuous rotational speed*1*2	rpm	100	100	100	100
Torque constant*1	N·m/A	0.32	0.30	0.39	0.51
Max. current*1	A_{rms}	8.7	18.0	26.2 (18.0)*5	31.4 (18.0)*5
Allowable continuous current*1*2	A_{rms}	3.0	6.0	10.4 (6.0)*5	10.7 (6.0)*5
MEF constant*3	V/(rpm)	0.039	0.036	0.044	0.056
Number of poles in the motor	-	10	10	10	16
Phase resistance	Ω(20℃)	0.45	0.11	0.05	0.03
Phase inductance	mH	0.48	0.18	0.1	0.07
Inertia moment ($GD^2/4$)	$kg·m^2$	0.00013	0.00039	0.0010	0.0026
Reduction ratio	-	1:8	1:8	1:9	1:9
Motor position detector	-	Hall sensor			
Single motor resolution	P/R	30	30	30	48
Output shaft resolution	P/R	240	240	270	432
Mass	g	390	620	870	1060
Environmental conditions		Operating temperature: 0 to 40℃/Storage temperature: -20 to 60℃ Operating humidity/storage humidity: 20 to 80%RH (no condensation) Resistance to vibration: 25 m/s^2 (frequency: 10 to 400Hz) Shock resistance: 300 m/s^2 *4 No dust, no metal powder, no corrosive gas, no inflammable gas, no oil mist To be used indoors, no direct sunlight Altitude: less than 1,000 m above sea level			
Motor insulation		Insulation resistance: 100MΩ or more (by DC500V insulation tester) Dielectric strength: AC1,500V/1 min Insulation class: A			
Mounting direction		Can be installed in any direction.			
Protection structure		Totally enclosed self-cooled type (IP40)			

The table shows typical output values of actuators.

*1: Typical characteristics when driven in combination with compatible drives.

*2: Values after the temperature has risen and saturated with the aluminum radiation plates with the following sizes installed.

FLA-11A: 220 x 220 x 8 [mm], FLA-14A: 250 x 250 x 10 [mm]

FLA-17A: 280 x 280 x 12 [mm], FLA-20A: 300 x 300 x 15 [mm]

*3: Value of phase induced voltage constant multiplied by 3.

*4: For testing conditions, refer to [1-9 Shock resistance] (P1-21) and [1-10 Resistance to vibration] (P1-22).

*5: When combined with this drive, the specifications are limited to the values in the parentheses.

HP (DC48V)

Item \ Size		FLA-11A-08HP	FLA-14A-08HP	FLA-17A-09HP	FLA-20A-09HP
Combined drive	-	CCMDSP-D40P4YC1 CCMDPE-D40P3YC1			
Driver input power supply	V	DC48			
Max. torque*1	N·m	1.8	3.7	7.3	12.1
Allowable continuous torque*1*2	N·m	0.6	1.2	3.0	4.1
Max. rotational speed*1	rpm	500	500	500	400
Allowable continuous rotational speed *1*2	rpm	100	100	100	100
Torque constant*1	N·m/A	0.61	0.59	0.75	0.92
Max. current*1	A_{rms}	4.5	9.6	13.6	17.8
Allowable continuous current*1*2	A_{rms}	1.6	3.0	5.3	6.0
MEF constant*3	V/(rpm)	0.076	0.072	0.087	0.103
Number of poles in the motor	-	10	10	10	16
Phase resistance	Ω(20℃)	1.65	0.35	0.15	0.09
Phase inductance	mH	1.75	0.72	0.41	0.22
Inertia moment ($GD^2/4$)	$kg·m^2$	0.00013	0.00039	0.0010	0.0026
Reduction ratio	-	1:8	1:8	1:9	1:9
Motor position detector	-	Hall sensor			
Single motor resolution	P/R	30	30	30	48
Output shaft resolution	P/R	240	240	270	432
Mass	g	390	620	870	1060
Environmental conditions		Operating temperature: 0 to 40℃/Storage temperature: -20 to 60℃ Operating humidity/storage humidity: 20 to 80%RH (no condensation) Resistance to vibration: 25 m/s^2 (frequency: 10 to 400Hz) Shock resistance: 300 m/s^2 *4 No dust, no metal powder, no corrosive gas, no inflammable gas, no oil mist To be used indoors, no direct sunlight Altitude: less than 1,000 m above sea level			
Motor insulation		Insulation resistance: 100MΩ or more (by DC500V insulation tester) Dielectric strength: AC1,500V/1 min Insulation class: A			
Mounting direction		Can be installed in any direction.			
Protection structure		Totally enclosed self-cooled type (IP40)			

The table shows typical output values of actuators.

*1: Typical characteristics when driven in combination with compatible drives.

*2: Values after the temperature has risen and saturated with the aluminum radiation plates with the following sizes installed.

FLA-11A: 220 x 220 x 8 [mm], FLA-14A: 250 x 250 x 10 [mm]

FLA-17A: 280 x 280 x 12 [mm], FLA-20A: 300 x 300 x 15 [mm]

*3: Value of phase induced voltage constant multiplied by 3.

*4: For testing conditions, refer to [1-9 Shock resistance] (P1-21) and [1-10 Resistance to vibration] (P1-22).

FB (DC24V)

Item \ Size		FLA-11A-xxFB		FLA-14A-xxFB		FLA-17A-xxFB		FLA-20A-xxFB
		50	100	50	100	50	100	50
Combined drive	-	CCMDSP-D40P4YC1 CCMDPE-D40P3YC1				CCMDSP-D40P4YC1 (CCMDPE-D40P3YC1)*5		
Driver input power supply	V	DC24						
Max. torque*1	N·m	6.7	11.0	11.2	18.2	23 (22)*5	34 (34)*5	33 (30)*5
Allowable continuous torque*1*2	N·m	1.7	2.4	2.6	3.8	7.9 (6.5)*5	11.4 (11.4)*5	13.0 (9.1)*5
Max. rotational speed*1	rpm	100	50	100	50	100	50	80
Allowable continuous rotational speed *1*2	rpm	60	30	60	30	60	30	50
Torque constant*1	N·m/A	1.6	3.2	1.5	3.0	1.7	3.3	2.3
Max. current*1	A_{rms}	6.0	5.0	9.7	8.7	18.4 (18.0)*5	14.3 (14.3)*5	19.2 (18.0)*5
Allowable continuous current*1*2	A_{rms}	1.9	1.7	3.0	2.5	6.8 (6.0)*5	5.3 (5.3)*5	8.7 (6.0)*5
MEF constant*3	V/(rpm)	0.24	0.49	0.23	0.45	0.24	0.49	0.31
Number of poles in the motor	-	10		10		10		16
Phase resistance	Ω(20℃)	0.45		0.11		0.05		0.03
Phase inductance	mH	0.48		0.18		0.10		0.07
Inertia moment ($GD^2/4$)	$kg·m^2$	0.0073	0.029	0.019	0.077	0.048	0.19	0.12
Reduction ratio	-	1:50	1:100	1:50	1:100	1:50	1:100	1:50
Motor position detector	-	Hall sensor						
Single motor resolution	P/R	30		30		30		48
Output shaft resolution	P/R	1,500	3,000	1,500	3,000	1,500	3,000	2,400
Mass	g	420		720		940		1170
Environmental conditions		Operating temperature: 0 to 40℃/Storage temperature: -20 to 60℃ Operating humidity/storage humidity: 20 to 80%RH (no condensation) Resistance to vibration: 25 m/s^2 (frequency: 10 to 400Hz) Shock resistance: 300 m/s^2 *4 No dust, no metal powder, no corrosive gas, no inflammable gas, no oil mist To be used indoors, no direct sunlight Altitude: less than 1,000 m above sea level						
Motor insulation		Insulation resistance: 100MΩ or more (by DC500V insulation tester) Dielectric strength: AC1,500V/1 min Insulation class: A						
Mounting direction		Can be installed in any direction.						
Protection structure		Totally enclosed self-cooled type (IP40)						

The table shows typical output values of actuators.

*1: Typical characteristics when driven in combination with compatible drivers.

*2: Values after the temperature has risen and saturated with the aluminum radiation plates with the following sizes installed.

FLA-11A: 220 x 220 x 8 [mm], FLA-14A: 250 x 250 x 10 [mm]

FLA-17A: 280 x 280 x 12 [mm], FLA-20A: 300 x 300 x 15 [mm]

*3: Value of phase induced voltage constant multiplied by 3.

*4: For testing conditions, refer to [1-9 Shock resistance] (P1-21) and [1-10 Resistance to vibration] (P1-22).

*5: When combined with this driver, the specifications are limited to the values in the parentheses.

FB (DC48V)

Item \ Size		FLA-11A-xxFB		FLA-14A-xxFB		FLA-17A-xxFB		FLA-20A-xxFB
		50	100	50	100	50	100	50
Combined drive	-	CCMDSP-D40P4YC1 CCMDPE-D40P3YC1						
Driver input power supply	V	DC48						
Max. torque[*1]	N·m	6.7	11.0	11.2	18.2	23	34	33
Allowable continuous torque[*1*2]	N·m	1.7	2.4	2.6	3.8	7.9	11.4	13.0
Max. rotational speed[*1]	rpm	100	50	100	50	100	50	80
Allowable continuous rotational speed[*1*2]	rpm	60	30	60	30	60	30	50
Torque constant[*1]	N·m/A	3.0	5.9	3.0	5.9	3.4	6.5	4.2
Max. current[*1]	A_{rms}	3.1	2.6	4.8	4.2	9.4	7.2	10.7
Allowable continuous current[*1*2]	A_{rms}	1.0	0.8	1.5	1.2	3.4	2.9	5.1
MEF constant[*3]	V/(rpm)	0.48	0.95	0.45	0.90	0.49	0.97	0.57
Number of poles in the motor	-	10		10		10		16
Phase resistance	Ω(20℃)	1.65		0.35		0.15		0.09
Phase inductance	mH	1.75		0.72		0.41		0.22
Inertia moment ($GD^2/4$)	$kg·m^2$	0.0073	0.029	0.019	0.077	0.048	0.19	0.12
Reduction ratio	-	1:50	1:100	1:50	1:100	1:50	1:100	1:50
Motor position detector	-	Hall sensor						
Single motor resolution	P/R	30		30		30		48
Output shaft resolution	P/R	1,500	3,000	1,500	3,000	1,500	3,000	2,400
Mass	g	420		720		940		1170
Environmental conditions		Operating temperature: 0 to 40℃/Storage temperature: -20 to 60℃ Operating humidity/storage humidity: 20 to 80%RH (no condensation) Resistance to vibration: 25 m/s^2 (frequency: 10 to 400Hz) Shock resistance: 300 m/s^2 [*4] No dust, no metal powder, no corrosive gas, no inflammable gas, no oil mist To be used indoors, no direct sunlight Altitude: less than 1,000 m above sea level						
Motor insulation		Insulation resistance: 100MΩ or more (by DC500V insulation tester) Dielectric strength: AC1,500V/1 min Insulation class: A						
Mounting direction		Can be installed in any direction.						
Protection structure		Totally enclosed self-cooled type (IP40)						

The table shows typical output values of actuators.

*1: Typical characteristics when driven in combination with compatible drives.

*2: Values after the temperature has risen and saturated with the aluminum radiation plates with the following sizes installed.

FLA-11A: 220 x 220 x 8 [mm], FLA-14A: 250 x 250 x 10 [mm]

FLA-17A: 280 x 280 x 12 [mm], FLA-20A: 300 x 300 x 15 [mm]

*3: Value of phase induced voltage constant multiplied by 3.

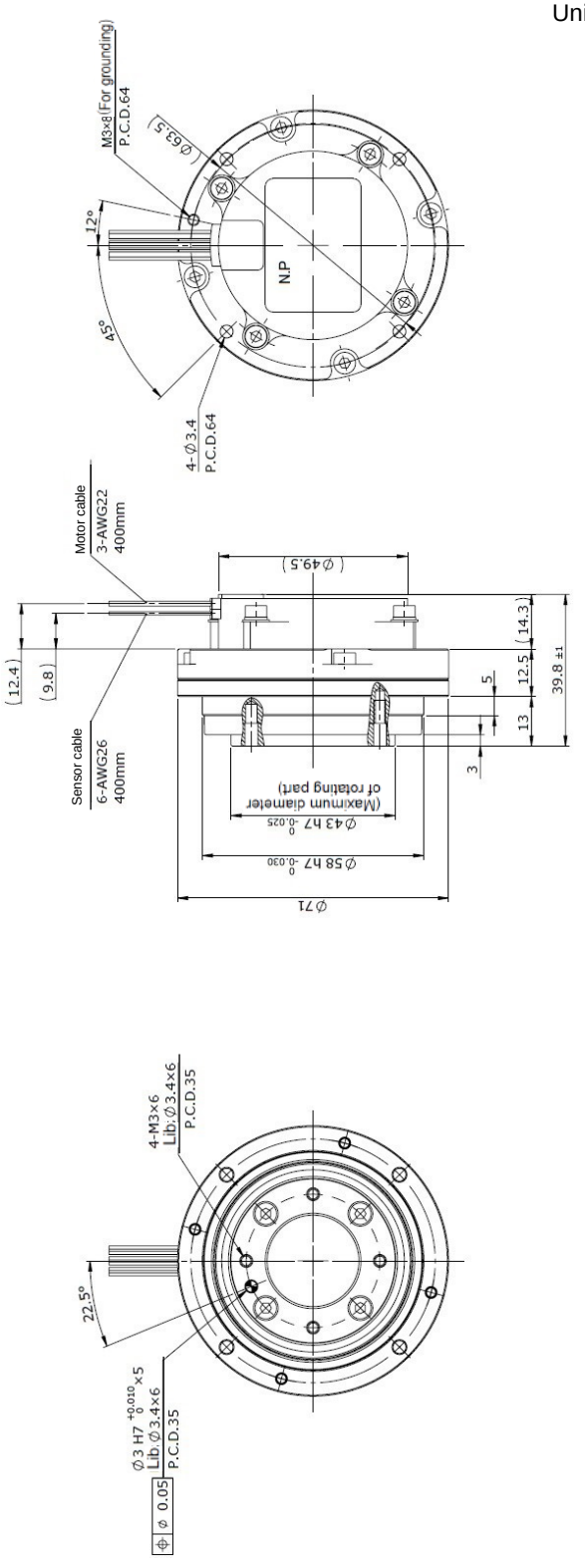
*4: For testing conditions, refer to [1-9 Shock resistance] (P1-21) and [1-10 Resistance to vibration] (P1-22).

1-5 External dimensions

The external dimensions of FLA series actuators are shown below.

- **FLA-11A-HP (Speed reducer: HarmonicPlanetary®)**

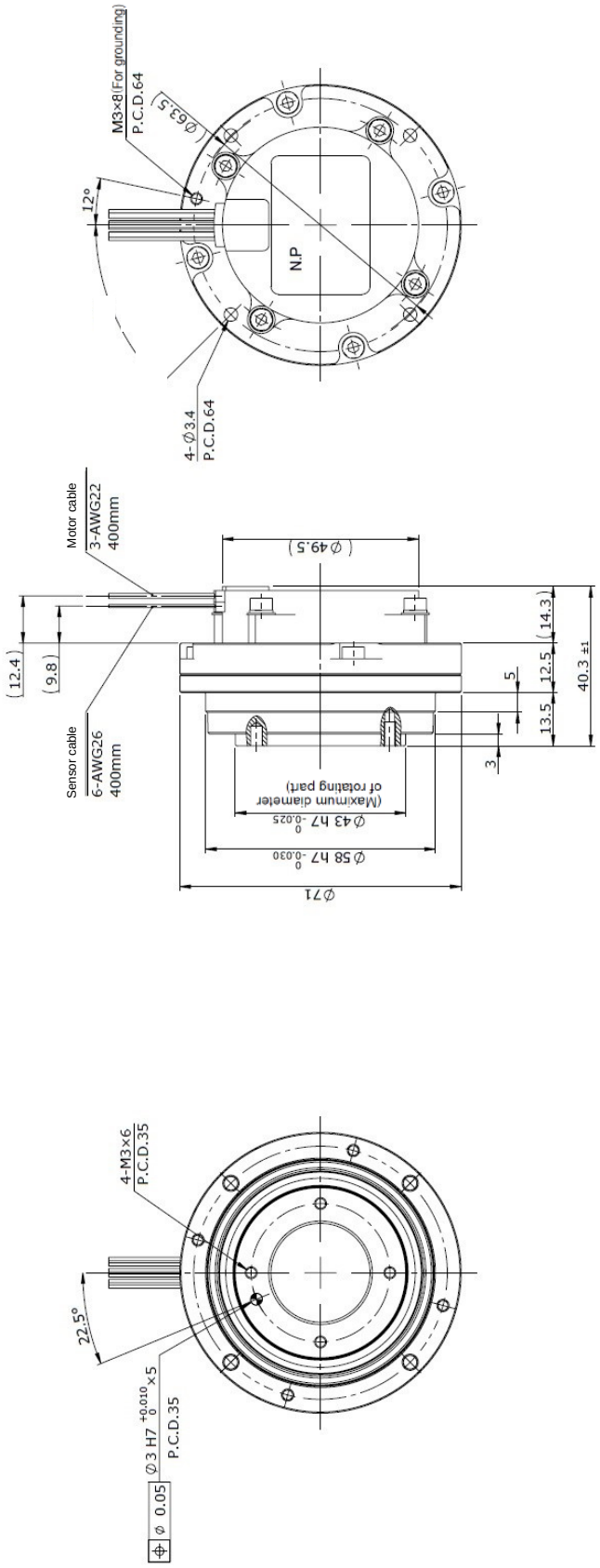
Unit: mm (third angle projection)



Note:
Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing.

- **FLA-11A-FB (Speed reducer: HarmonicDrive®)**

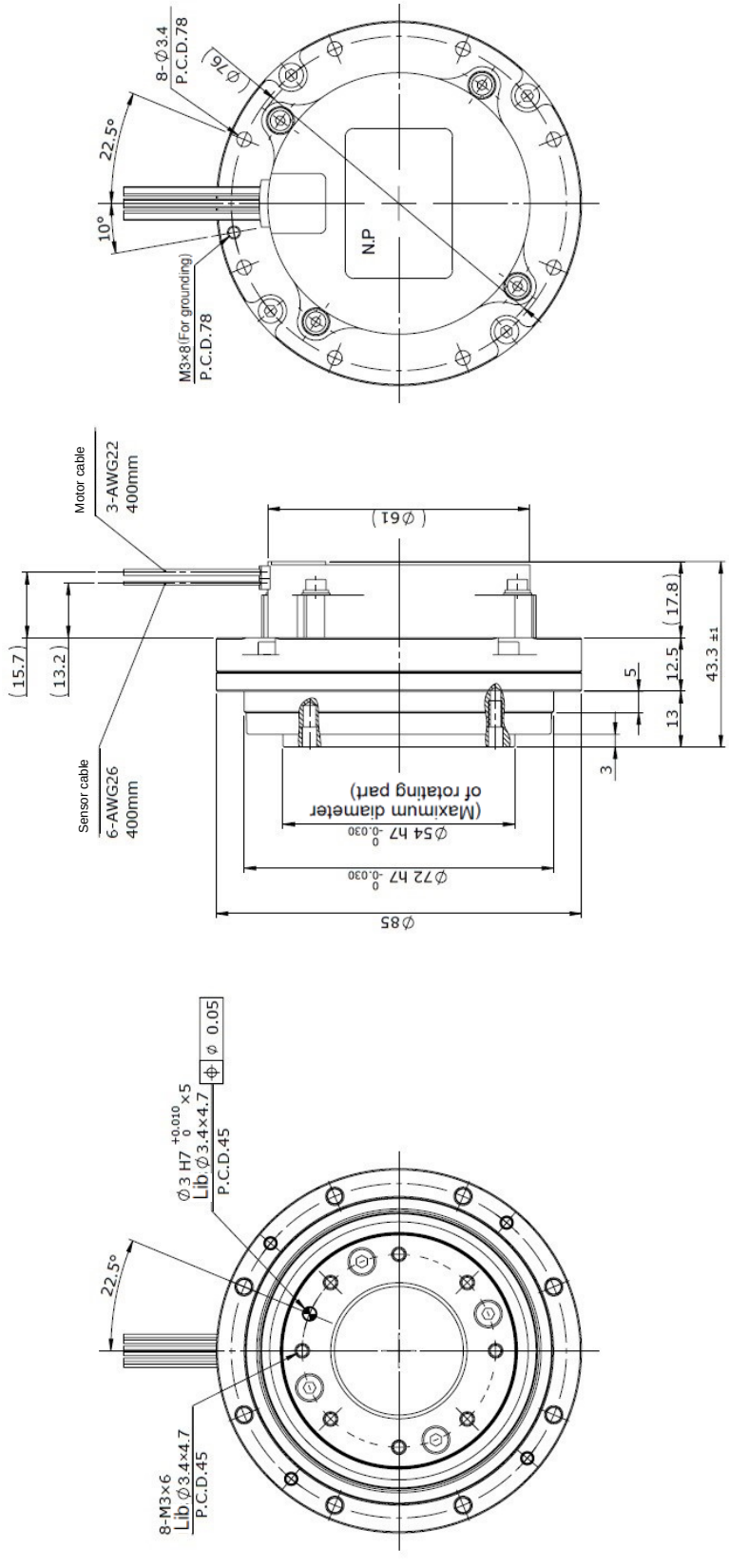
Unit: mm (third angle projection)



Note: Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing.

- **FLA-14A-HP (Speed reducer: HarmonicPlanetary®)**

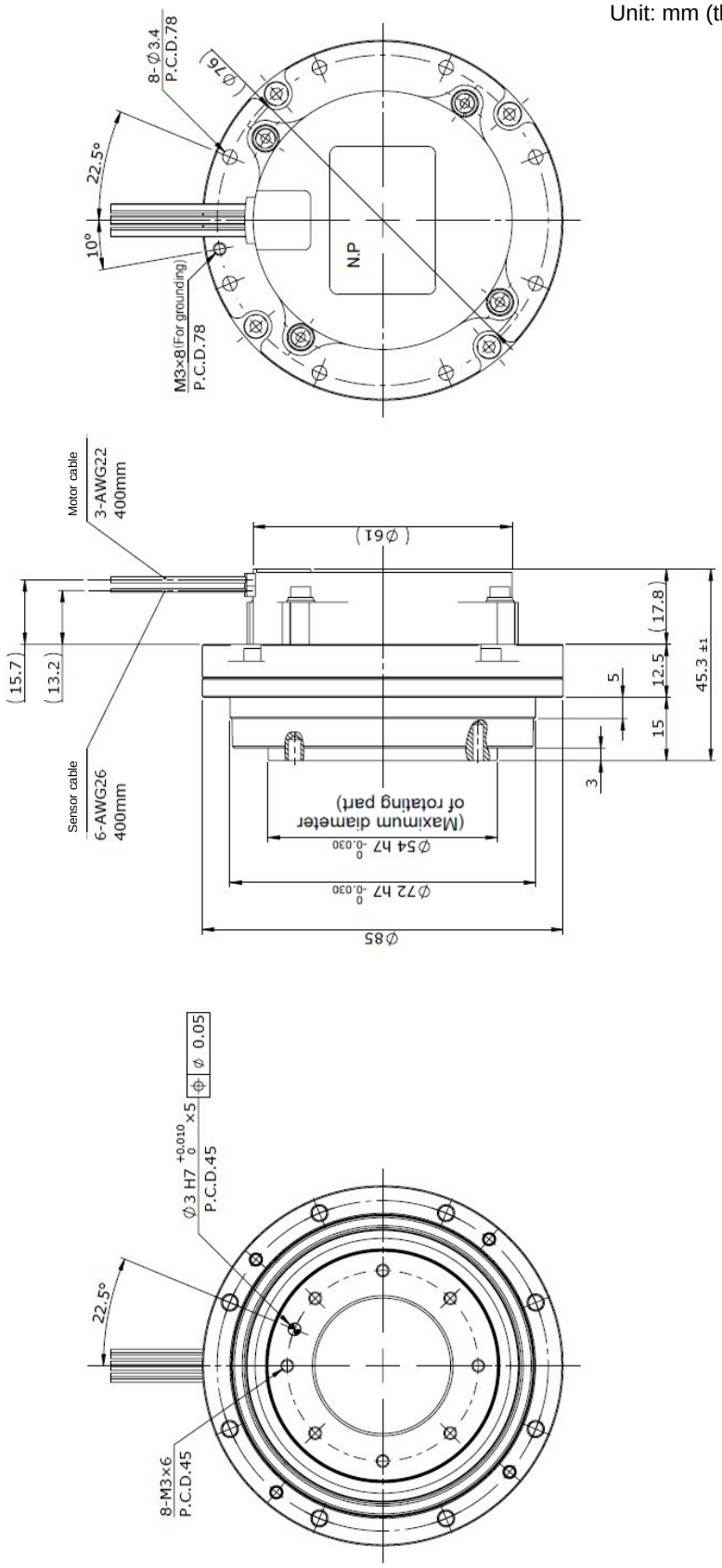
Unit: mm (third angle projection)



Note: Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing.

- **FLA-14A-FB (Speed reducer: HarmonicDrive® speed reducer)**

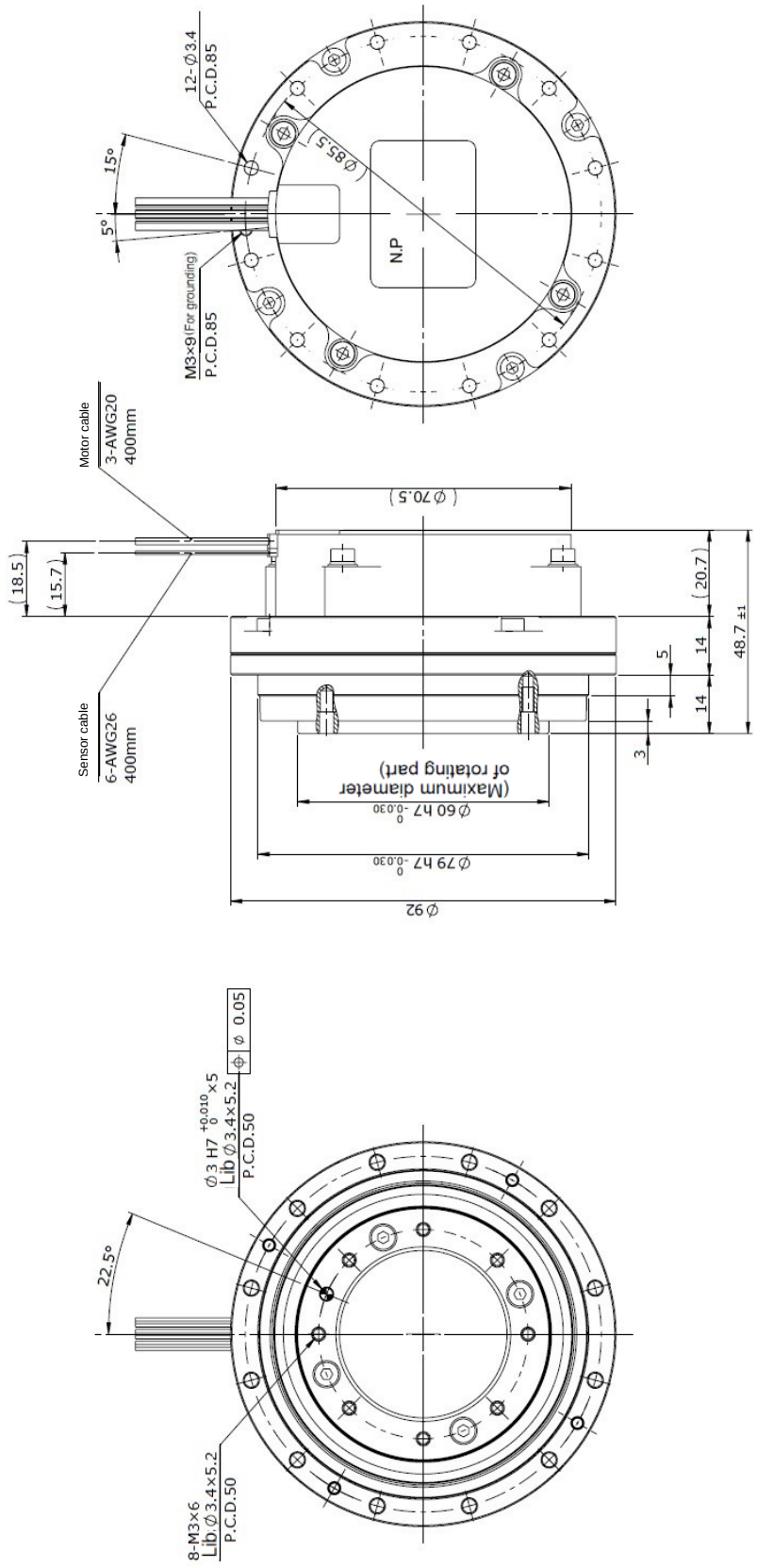
Unit: mm (third angle projection)



Note: Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing.

- **FLA-17A-HP (Speed reducer: HarmonicPlanetary®)**

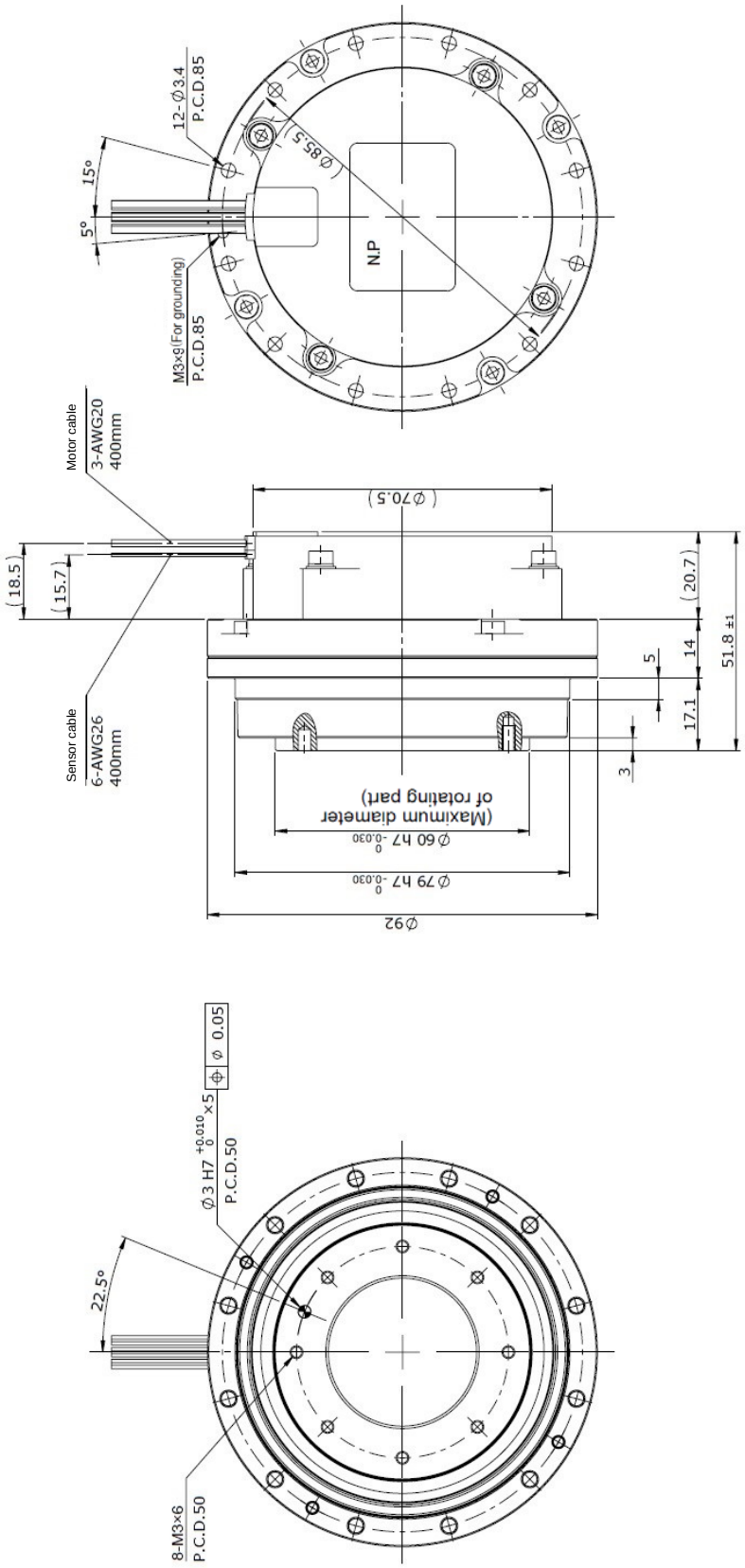
Unit: mm (third angle projection)



Note: Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing.

- **FLA-17A-FB (Speed reducer: HarmonicDrive®)**

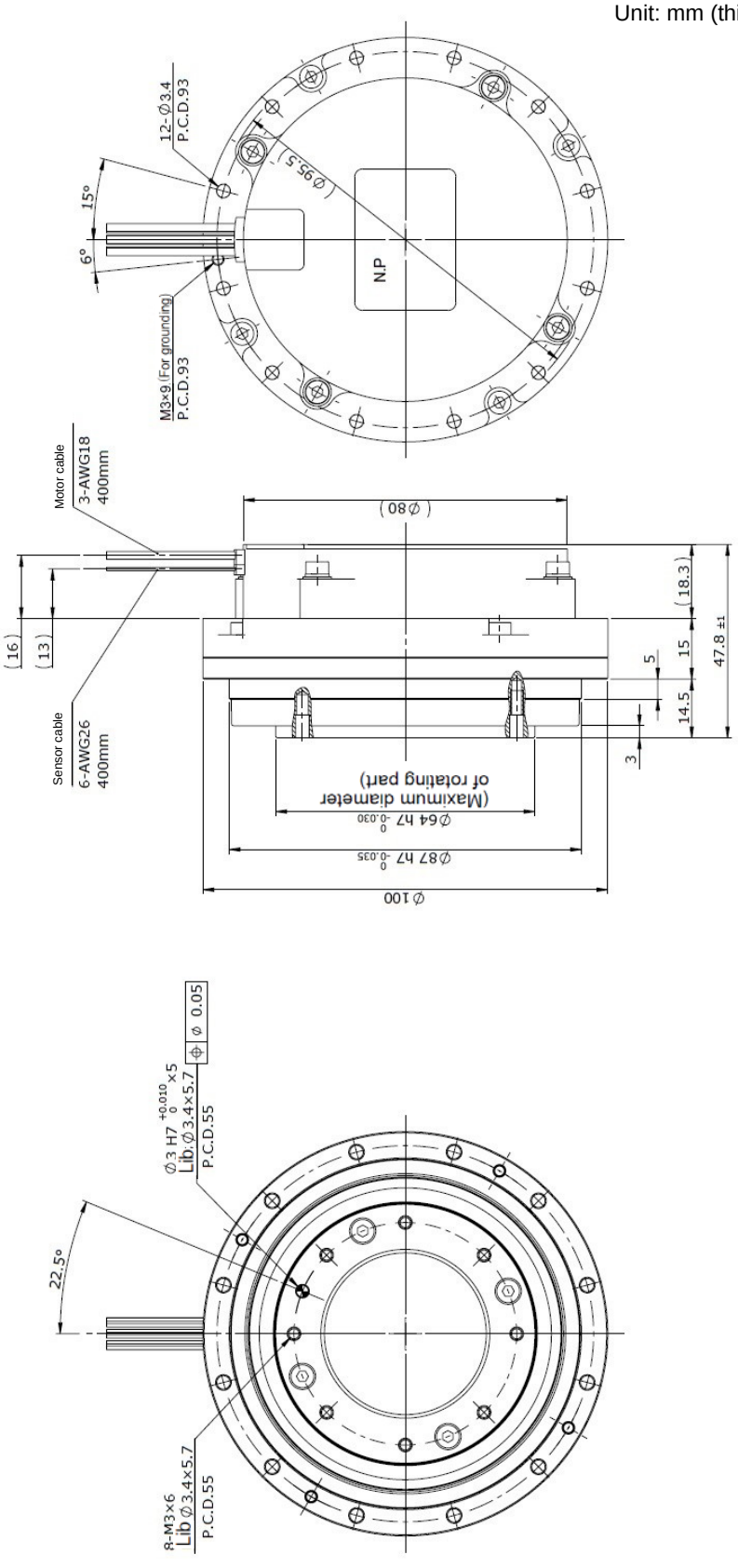
Unit: mm (third angle projection)



Note: FPlease check the confirmation drawing or contact us for dimension tolerances not shown on the drawing.

- **FLA-20A-HP (Speed reducer: HarmonicPlanetary®)**

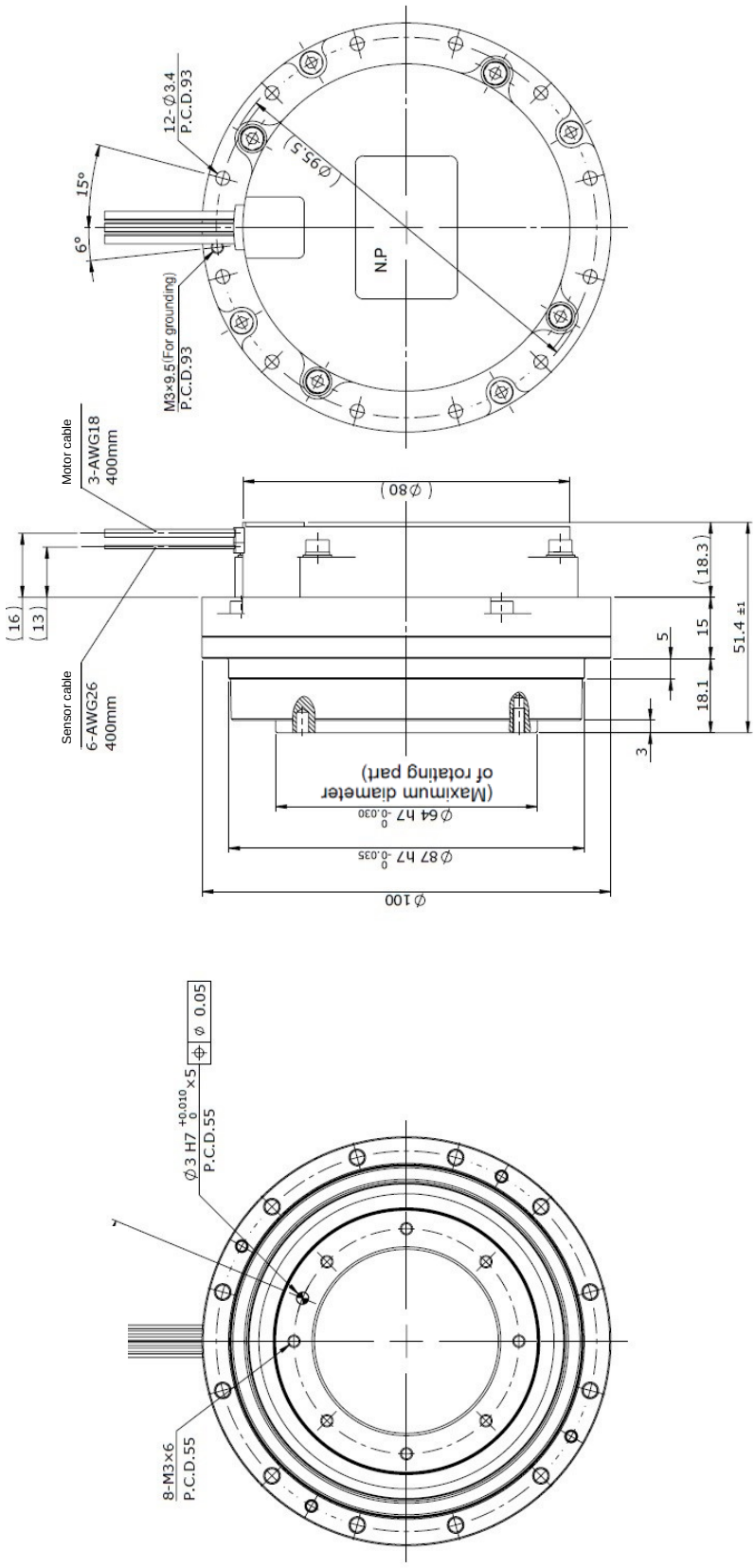
Unit: mm (third angle projection)



Note: Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing.

- **FLA-20A-FB (Speed reducer: HarmonicDrive®)**

Unit: mm (third angle projection)



Note: Please check the confirmation drawing or contact us for dimension tolerances not shown on the drawing.

1-6 Detector specifications

The specifications of the detector mounted on FLA series actuators are shown below.

Specifications [Position detector]

- Main specifications

Model	FLA-11A	FLA-14A	FLA-17A	FLA-20A
Detection system	Hall sensor			
Output type	Open collector output			
Input voltage [V]	DC 5±5%			
Resolution per motor revolution [P/R]	30	30	30	48

Caution

- When using a drive other than recommended drives, install a pull-up resistor in the input circuit. The output inflow current must be 10 mA or less.

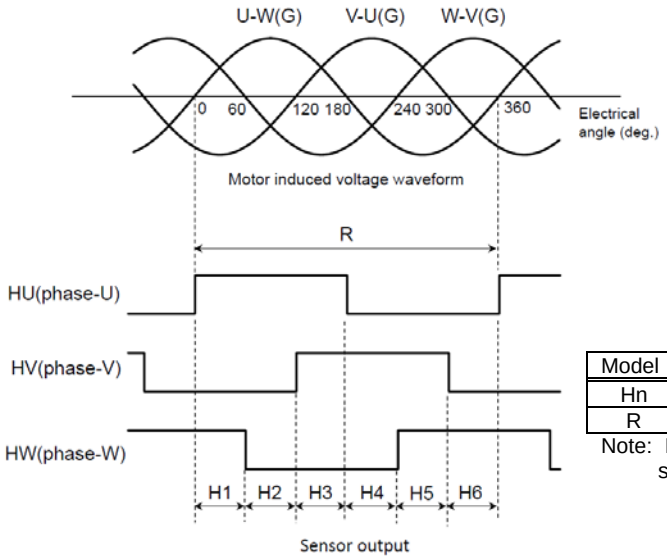
- Resolution of output shaft

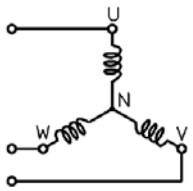
Model	FLA-11A			FLA-14A		
Reduction ratio	1:8	1:50	1:100	1:8	1:50	1:100
Resolution of output shaft [P/R]	240	1,500	3,000	240	1,500	3,000
Resolvable angle per pulse [degrees]	1.5	0.24	0.12	1.5	0.24	0.12

Model	FLA-17A			FLA-20A	
Reduction ratio	1:9	1:50	1:100	1:9	1:50
Resolution of output shaft [P/R]	270	1,500	3,000	432	2,400
Resolvable angle per pulse [degrees]	Approx. 1.4	0.24	0.12	Approx. 0.9	0.15

- Signal phase

The phase relationships between the hall sensor output HU, HV, HW and the motor induced voltage are shown.
(Rotation direction: When externally driven CW as viewed from the actuator output shaft side.)





Model	FLA-11,14,17A	FLA-20A
Hn	12°	7.5°
R	72°	45°

Note: Indicated by the mechanical angles of the motor shaft.

Specifications [Temperature detector]

FLA series actuators have a temperature detector inside the motor. The temperature detector allows real-time measurement of the temperature inside the motor, which is useful to prevent overheating the motor circumference or other purposes. Note that the recommended drives are not equipped with the interface for the temperature detector.

- Main specifications

Model	FLA-11A	FLA-14A	FLA-17A	FLA-20A
Detection system	Thermistor			
Input voltage [V]	DC 5±5%			
Applicable temperature range [℃]	40 to 100			
Characteristic of detected temperature [℃]	Detected temperature [℃] = 132.9 - (Output voltage [V]) x 23.1			
Detection error [℃]	±6			

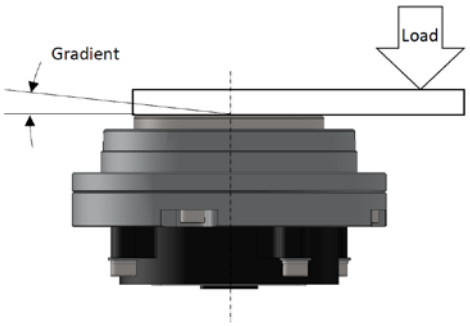
Caution

- Voltage is output from the cable even when a temperature detector is not used. When not using the temperature detector, insulate the cable terminal.

1-7 Output Shaft Characteristics

Moment stiffness and Tilt Angle

The moment stiffness refers to the torsional stiffness when a moment load is applied to the output shaft of the actuator (shown in the figure).
For example, when a load is applied to the end of an arm attached on the output shaft, the face of the output shaft tilts in proportion to the moment load. The moment stiffness is expressed as the load/gradient angle.



Items near the permissible moment load (Mc)

- Tilt angles: θ_0
- Moment stiffness: K_m

Item \ Model		FLA-11A	FLA-14A	FLA-17A	FLA-20A
Mc	Nm	1.2	1.6	2.0	2.4
θ_0	$x10^{-3}$ rad	1.0	0.8	0.75	1.2
K_m	$x10^3$ Nm/rad	2.0	3.3	4.4	5.1

Note: The values shown above are typical values.

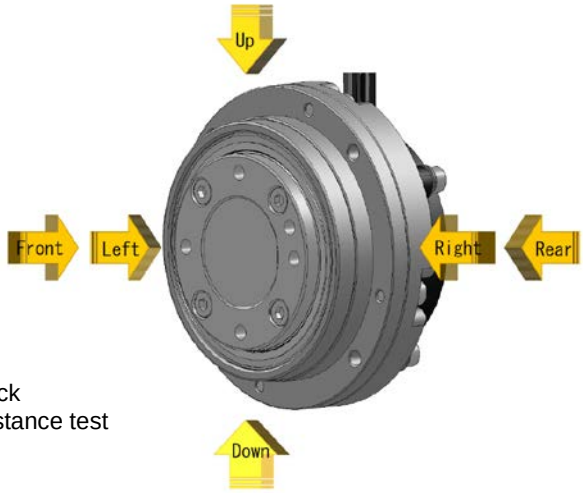
1-8 Rotation direction

The actuator rotates CCW as viewed from the output shaft when a CW drive command is given from a recommended drive (S series/F series). When a CCW drive command is given, it rotates CW as viewed from the output shaft.

Counterclockwise rotation direction (with a CW drive command)

1-9 Shock resistance

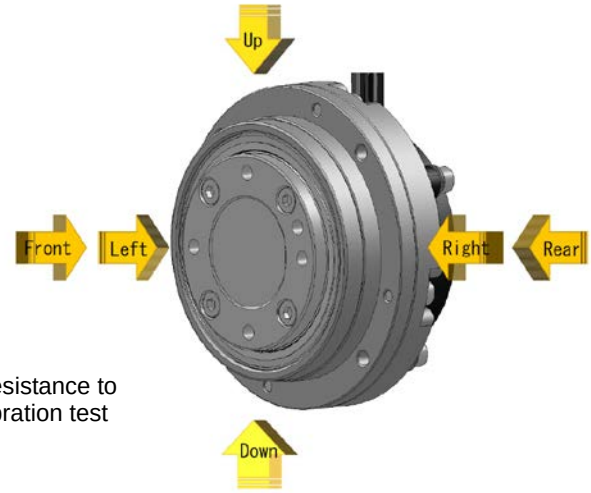
The shock resistance of the actuator is as follows, and this value is the same in up/down, left/right and front/rear directions:
Impact acceleration: 300 m/s^2
In our shock resistance test, the actuator is tested 3 times in each direction. Actuator operation is not guaranteed in applications that subject it to constant rated stock.



Shock
resistance test

1-10 Vibration Resistance

The resistance to vibration of the actuator is as follows, and this value is the same in up/down, left/right and front/rear directions:
Vibration acceleration: 25 m/s^2 (frequency: 10 to 400Hz)
In our test, the actuator is tested for 2 hours in each direction at a vibration frequency sweep period of 10 minutes.



Resistance to vibration test

1-11 Operable range

The graphs on the following pages indicate the operable range of each drive when combined with a FLA series actuator. For details, refer to [Chapter 2 Selection guidelines].

1. Continuous motion range

The actuator can run continuously within the range.

2. 50% duty motion range

The actuator can run at 50% duty cycle within the range. (the ratio of operating time and delay time is 50:50).
Limit the operation cycle to a period of several minutes, and keep it within a range where the overload alarm or overheat alarm of the drive does not sound.

3. Motion range during acceleration and deceleration

The actuator can run instantaneously within the range. The range allows instantaneous operation like acceleration and deceleration, usually.
The continuous and 50% duty motion ranges in each graph are measured on the condition where the radiation plate specified in the graph is installed.

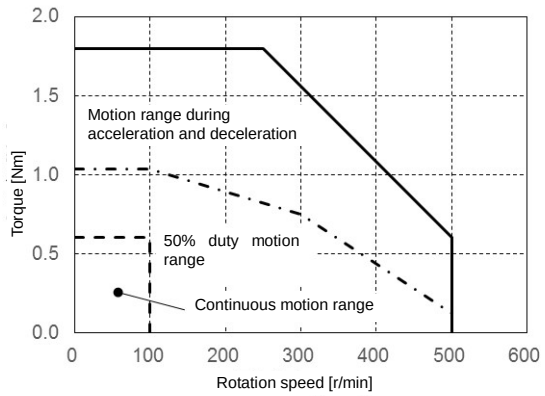
Caution

- The aforementioned continuous motion range and 50% duty motion range represent allowable ranges where the actuator installed on a specified aluminum radiation plate is operated under natural air cooling. If the radiation area of the mounting member is small or heat conduction of the material is poor, adjust the operating conditions to keep the rise in the actuator's ambient temperature to 40 K or less as a guide.
- Depending on the operating conditions or load conditions such as during acceleration/deceleration or when a load is connected, it may become difficult to drive at a constant low speed.

HP (24VDC)
Combined drive: CCMDSP-D40P4YC1（S series）

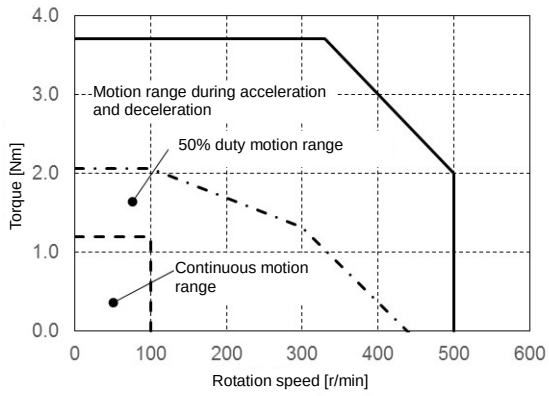
■FLA-11A-08HP-H-24

Radiation plate: 220*220*8 mm



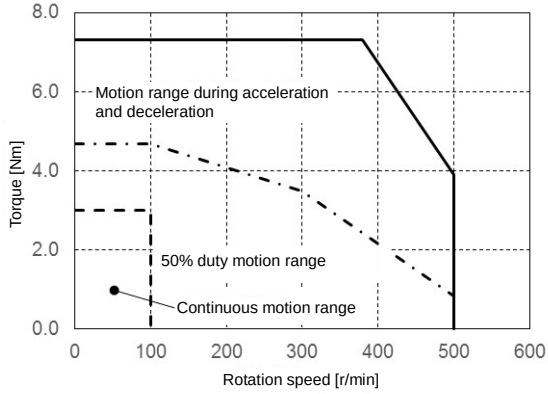
■FLA-14A-08HP-H-24

Radiation plate: 250*250*10 mm



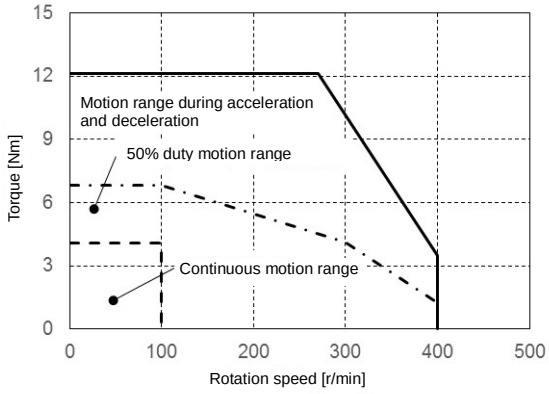
■FLA-17A-09HP-H-24

Radiation plate: 280*280*12 mm



■FLA-20A-09HP-H-24

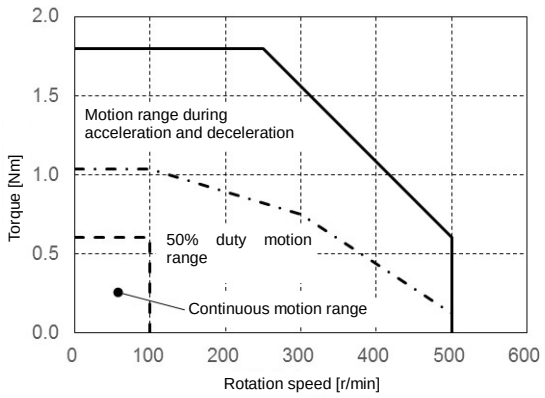
Radiation plate: 300*300*15 mm



HP (24VDC)
Combined drive: CCMDPE-D40P3YC1 (F series)

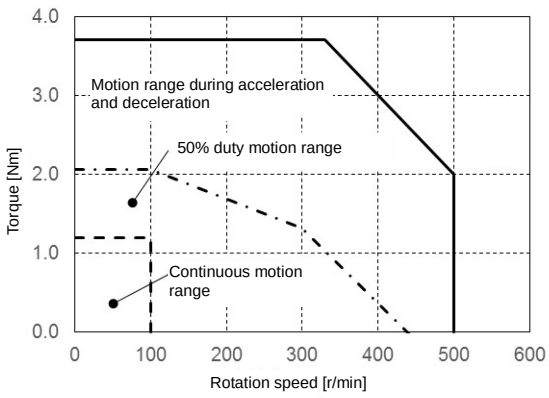
■FLA-11A-08HP-H-24

Radiation plate: 220*220*8 mm



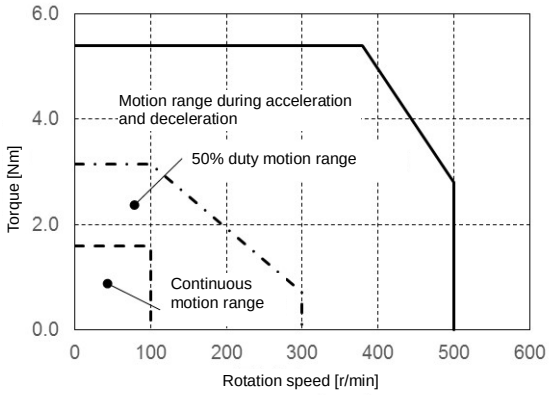
■FLA-14A-08HP-H-24

Radiation plate: 250*250*10 mm



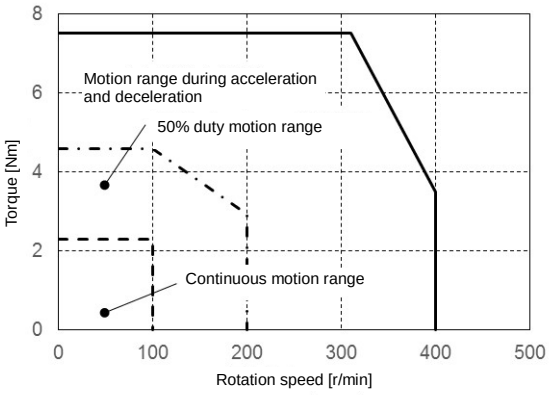
■FLA-17A-09HP-H-24

Radiation plate: 280*280*12 mm



■FLA-20A-09HP-H-24

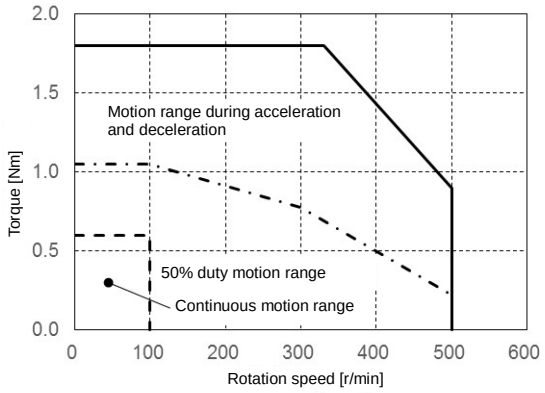
Radiation plate: 300*300*15 mm



HP (48VDC)
Combined drive: CCMDSP-D40P4YC1 (S series)
CCMDPE-D40P3YC1 (F series)

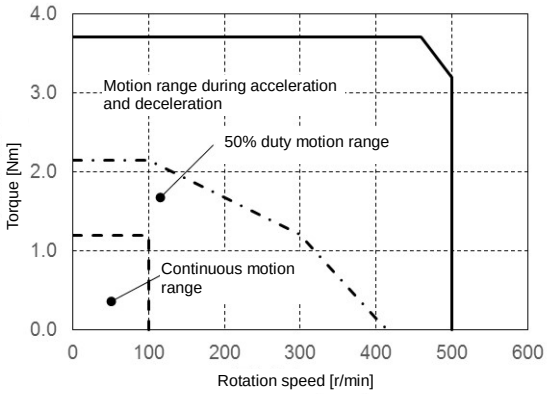
■FLA-11A-08HP-H-48

Radiation plate: 220*220*8 mm



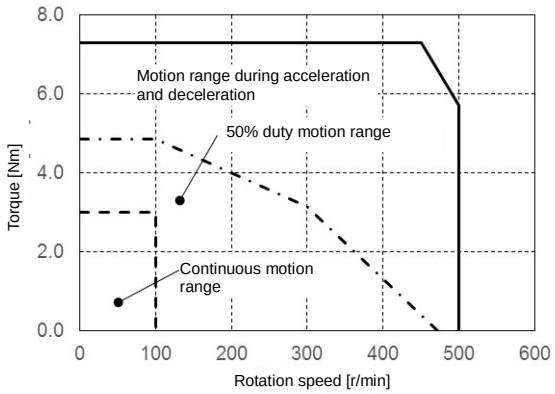
■FLA-14A-08HP-H-48

Radiation plate: 250*250*10 mm



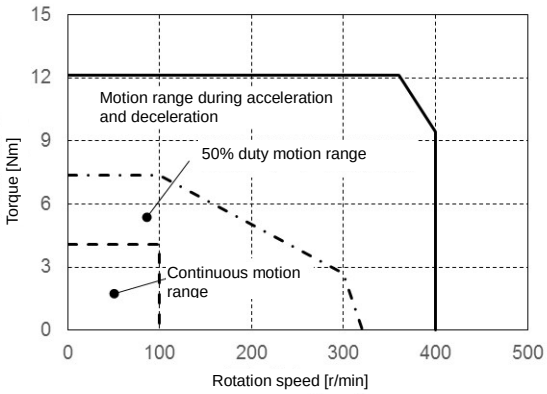
■FLA-17A-09HP-H-48

Radiation plate: 280*280*12 mm



■FLA-20A-09HP-H-48

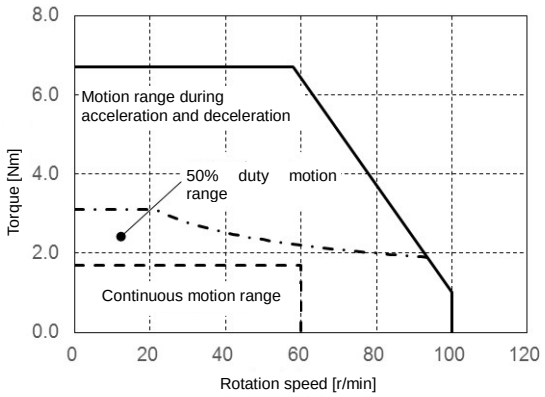
Radiation plate: 300*300*15 mm



FB (Speed ratio 50, 24VDC)
Combined drive: CCMDSP-D40P4YC1 (S series)

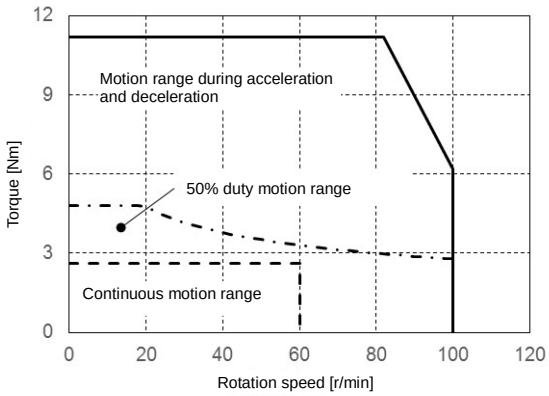
■FLA-11A-50FB-H-24

Radiation plate: 220*220*8 mm



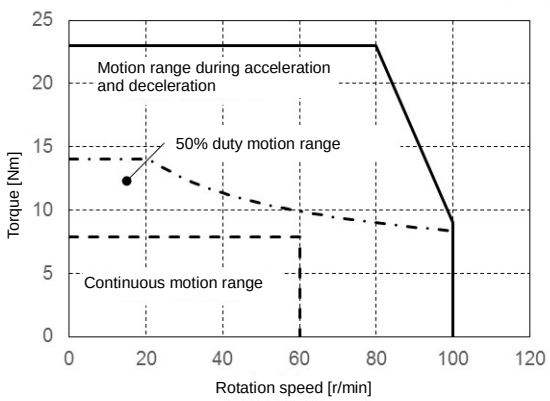
■FLA-14A-50FB-H-24

Radiation plate: 250*250*10 mm



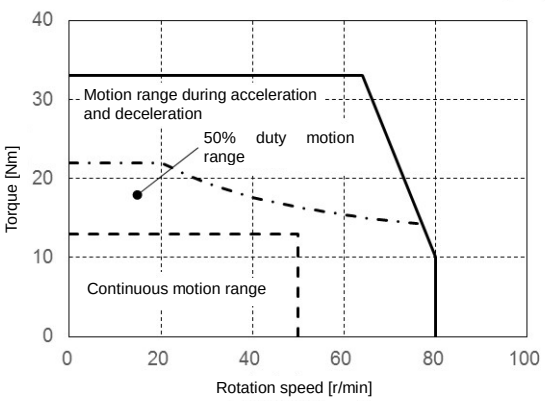
■FLA-17A-50FB-H-24

Radiation plate: 280*280*12 mm



■FLA-20A-50FB-H-24

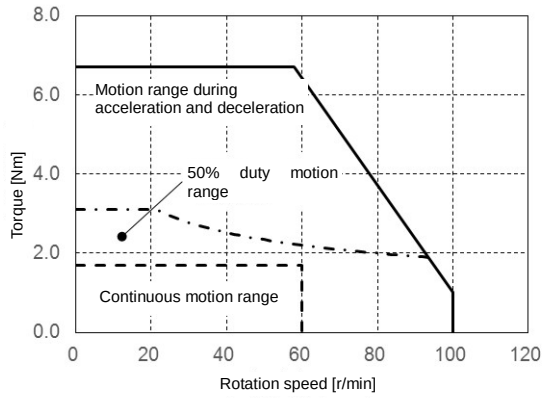
Radiation plate: 300*300*15 mm



FB (Speed ratio 50, 24VDC)
Combined drive: CCMDPE-D40P3YC1 (F series)

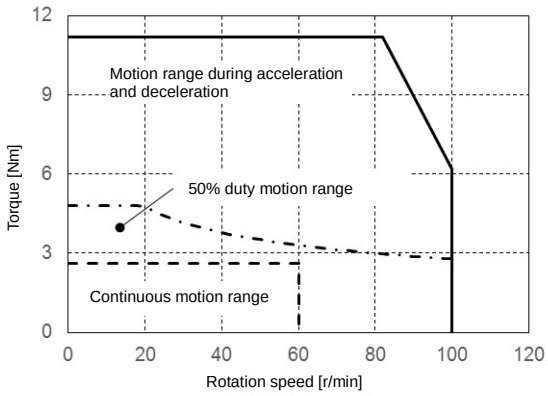
■FLA-11A-50FB-H-24

Radiation plate: 220*220*8 mm



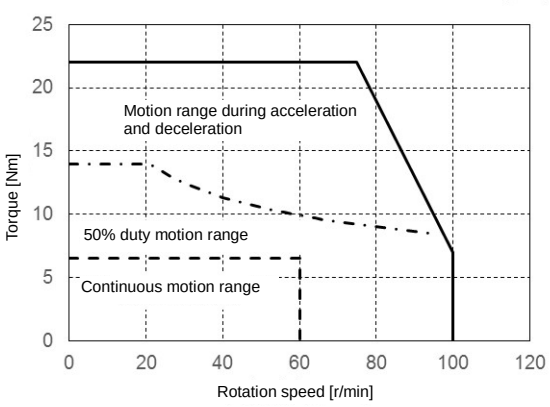
■FLA-14A-50FB-H-24

Radiation plate: 250*250*10 mm



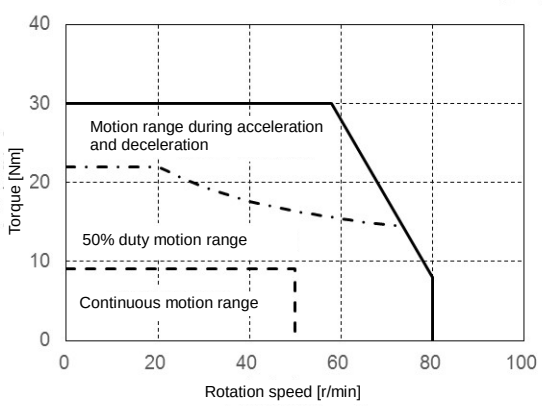
■FLA-17A-50FB-H-24

Radiation plate: 280*280*12 mm



■FLA-20A-50FB-H-24

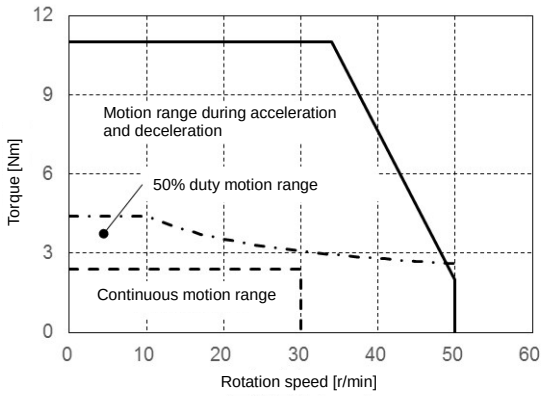
Radiation plate: 300*300*15 mm



FB (Speed ratio 100, 24VDC)
Combined drive: CCMDSP-D40P4YC1 (S series)

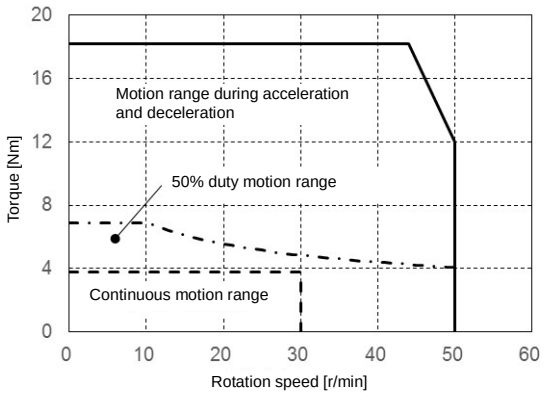
■FLA-11A-100FB-H-24

Radiation plate: 220*220*8 mm



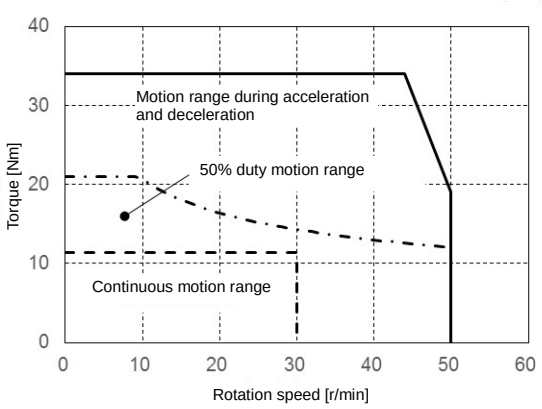
■FLA-14A-100FB-H-24

Radiation plate: 250*250*10 mm



■FLA-17A-100FB-H-24

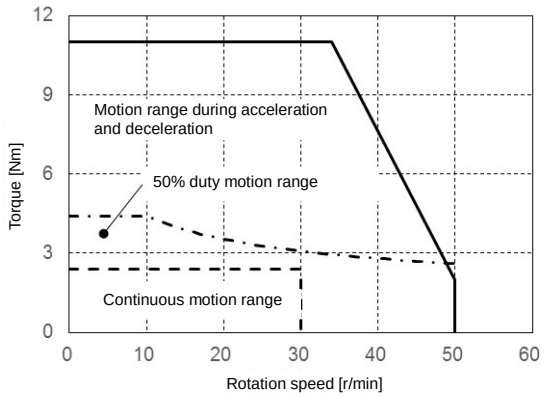
Radiation plate: 280*280*12 mm



FB (Speed ratio 100, 24VDC)
Combined drive: CCMDPE-D40P3YC1 (F series)

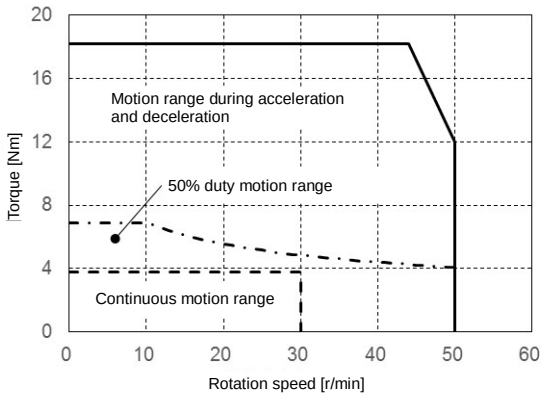
■FLA-11A-100FB-H-24

Radiation plate: 220*220*8 mm



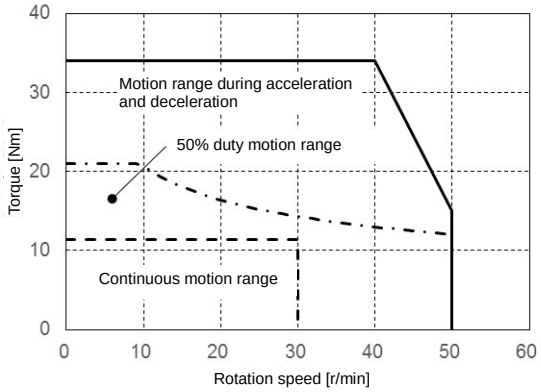
■FLA-14A-100FB-H-24

Radiation plate: 250*250*10 mm



■FLA-17A-100FB-H-24

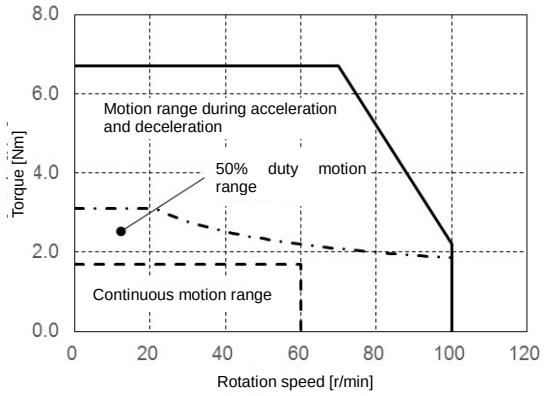
Radiation plate: 280*280*12 mm



FB (Speed ratio 50, 48VDC)
Combined drive: CCMDSP-D40P4YC1 (S series)
CCMDPE-D40P3YC1 (F series)

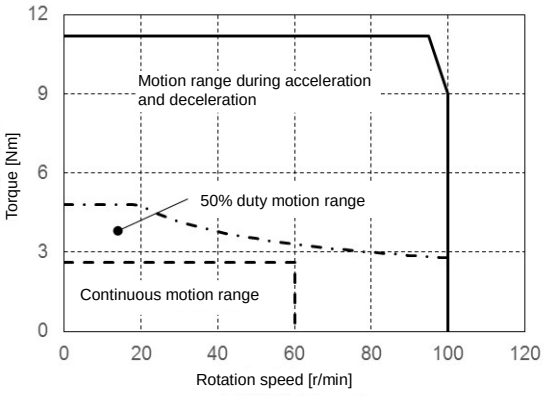
■FLA-11A-50FB-H-48

Radiation plate: 220*220*8 mm



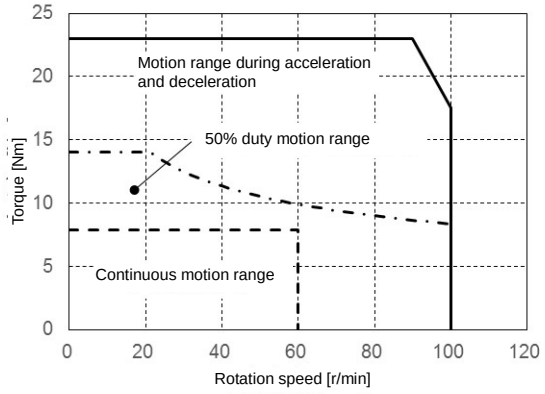
■FLA-14A-50FB-H-48

Radiation plate: 250*250*10 mm



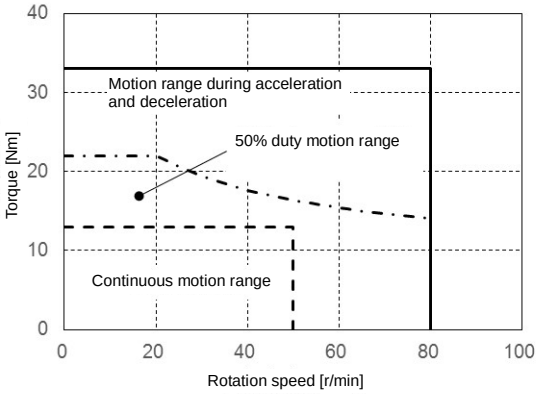
■FLA-17A-50FB-H-48

Radiation plate: 280*280*12 mm



■FLA-20A-50FB-H-48

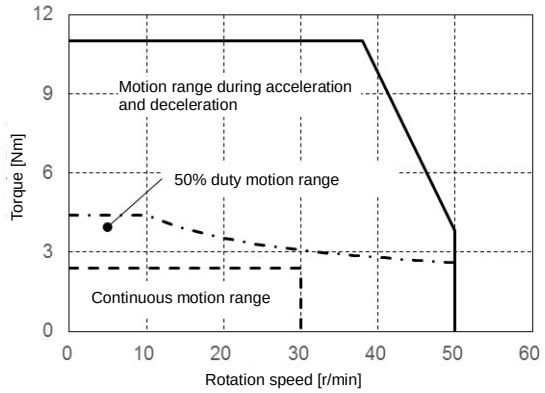
Radiation plate: 300*300*15 mm



FB (Speed ratio 100, 48VDC)
Combined drive: CCMDSP-D40P4YC1 (S series)
CCMDPE-D40P3YC1 (F series)

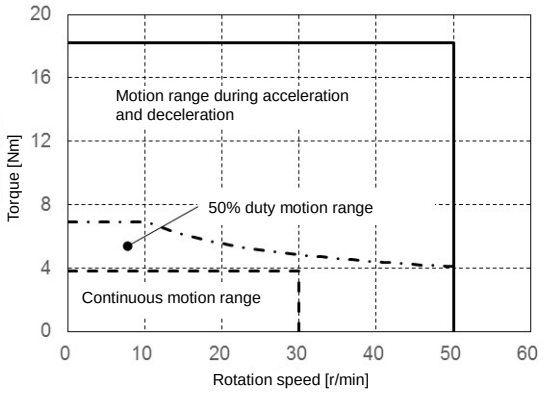
■FLA-11A-100FB-H-48

Radiation plate: 220*220*8 mm



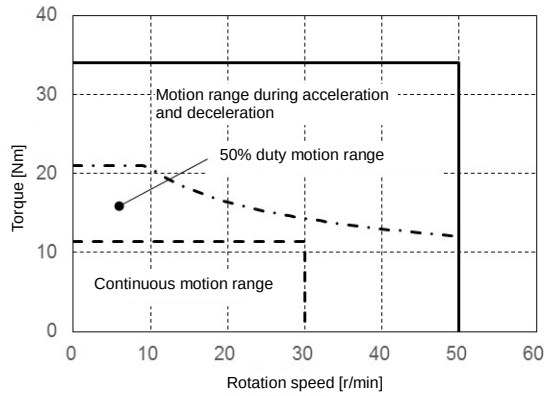
■FLA-14A-100FB-H-48

Radiation plate: 250*250*10 mm



■FLA-17A-100FB-H-48

Radiation plate: 280*280*12 mm



1-12 Cable specifications

The following tables show specifications of the motor and sensor cables of the FLA series actuators.

Motor cable specifications

- Cable specifications

Color	Name
Red	Motor phase-U
White	Motor phase-V
Black	Motor phase-W

- Wire diameter

Model No.	Nominal outer diameter (mm)	Conductor size
11	1.70	AWG22
14	1.70	AWG22
17	1.86	AWG20
20	2.17	AWG18

Sensor cable specifications

- Cable specifications

Color	Signal name	Remarks
Red	+5V	Power supply input +5V
Black	0V	Power supply input 0V (GND)
White	HU	Hall sensor output (phase-U)
Green	HV	Hall sensor output (phase-V)
Blue	HW	Hall sensor output (phase-W)
Yellow	TH	Thermistor output

- Wire diameter

Size	Nominal outer diameter (mm)	Conductor size
11, 14, 17, 20	0.81	AWG26

Caution

- FLA series actuators have a tapped hole for a grounding wire instead of a ground cable. When grounding, refer to the illustrated specifications for the requirements of the tapped hole for a grounding wire. If not grounded, a malfunction may occur due to noise or other causes.
- Incorrect wiring such as a reversed power input connection may cause a malfunction or failure.
- Voltage is output from the cable even when a temperature detector (thermistor) is not used. When not using the temperature detector, insulate the cable terminal.

Chapter 2

Selection guidelines

This chapter explains how to select a proper FLA series actuator.

2-1 Load inertia moment

When using a recommended drive (S series/F series) to drive a FLA series actuator, the driver parameter (Pn.201: Inertia ratio) needs to be changed according to the inertia moment of a load. "Inertia moment ratio" is the percentage value of the ratio of the total inertia moment to the inertia moment of the motor incorporated into the FLA series actuators. Calculate the inertia moment according to the formula shown below to set Pn.201. To calculate the inertia moment of a load, refer to "A-2 Calculating inertia moment" on page 4-3.
The symbols in the formulas are:

J_L: Load inertia moment
J_A: Inertia moment of actuator (output shaft conversion)
J_M: Inertia moment of motor
J_S: Total inertia moment converted to motor shaft
R: Reduction ratio of FLA series actuator
Pn.201 : Inertia moment ratio [%]

$$J_S = (J_L + J_A) \times \frac{1}{R^2} \quad [\times 10^{-4}\ \mathrm{kg \cdot m^2}]$$

$$Pn.201 = \frac{J_S - J_M}{J_M} \times 100 \quad [\%]$$

Table 1 Inertia moment

Model \ Item	Inertia moment of actuator (output shaft conversion) J_A	Inertia moment of motor J_M
	x10^{-4} kg・m^2	x10^{-4} kg・m^2
FLA-11A-08HP	1.3	0.017
FLA-11A-50FB	73	0.017
FLA-11A-100FB	290	0.017
FLA-14A-08HP	3.9	0.044
FLA-14A-50FB	190	0.044
FLA-14A-100FB	770	0.044
FLA-17A-09HP	10	0.117
FLA-17A-50FB	480	0.117
LA-17A-100FB	1900	0.117
FLA-20A-09HP	26	0.311
FLA-20A-50FB	1200	0.311

2-2 Verifying and examining load weights

FLA series actuators have a bearing incorporated to directly support an external load (at the output flange). Ensure that the maximum load moment load and maximum axial load are not exceeding the permissible values.

Maximum load moment load and maximum axial load

The formula below shows how to calculate the maximum load moment load (M_{max}).
(1) Verify that the maximum load moment load (M_{max}) is less than or equal to the permissible moment load (Mc).
(2) Verify that the maximum axial load (F_{amax}) is less than or equal to the permissible axial load (F_{ac}).

◆ **Formula (1): Maximum load moment load**

$$M\ max = \frac{Fr\ max \cdot (Lr + R) + Fa\ max \cdot La}{1000}$$

Symbols used in the formula

M*max*	Maximum load moment load	Nm	
Fr*max*	Max. radial load	N	Refer to Fig.1.
Fa*max*	Max. axial load	N	Refer to Fig.1.
Lr ,La	———	mm	Refer to Fig.1.
R	Offset amount	mm	Refer to Fig.1 and Table 1.

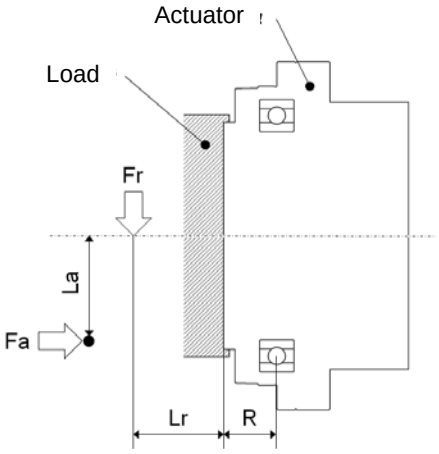


Fig. 1: External load action

Table 1 Main roller bearing specifications

Model \ Item	Offset amount R	permissible moment load Mc	Permissible axial load Fac
	mm	Nm	N
FLA-11A-HP	13.5	1.2	29
FLA-11A-FB	11.4	1.2	29
FLA-14A-HP	13.5	1.6	78
FLA-14A-FB	11.4	1.6	78
FLA-17A-HP	14.0	2.0	171
FLA-17A-FB	12.5	2.0	171
FLA-20A-HP	14.5	2.4	318
FLA-20A-FB	13.0	2.4	318

Note: Please contact us for the specifications of the main roller bearing and other parts used on this product.

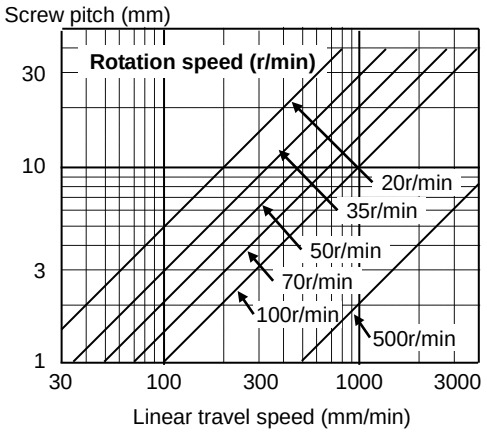
2-3 Examining operating status

The actuator generates heat if started/stopped repeatedly or operated continuously at high speed. Accordingly, examine whether or not the generated heat can be accommodated.
The study is as follows:

Examining actuator rotation speed

Calculate the required rotation speed (r/min) of the load driven by the FLA series.
For linear operation, use the rotation speed conversion formula below:

$$\text{Rotation speed (r/min)} = \frac{\text{Linear travel speed (mm/min)}}{\text{Screw feed pitch (mm)}}$$



Select an appropriate reduction ratio from 8, 9, 50 and 100 so that the calculated rotation speed does not exceed the maximum rotational speed of the FLA series actuator.

Calculating and examining load inertia moment

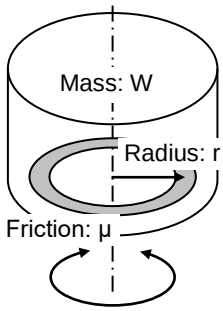
Calculate the load inertia moment of the load driven by the FLA series actuator.
Refer to [A-2 Calculating inertia moment] (P4-3) for the calculation.

Load torque calculation

Calculate the load torque as follows:

● Rotary motion

The rotary torque for the rotating mass W on the ring of radius r from the center of rotation is shown in the figure to the right.



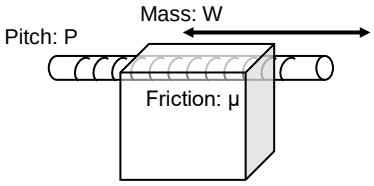
$$T = 9.8 \times \mu \times W \times r$$

T : Rotary torque (Nm)
μ : Friction coefficient
W : Mass (kg)
r : Average radius of friction side (m)

● Linear operation (horizontal operation)

The rotary torque when the mass W moves horizontally due to the screw of pitch P is shown below.

$$T = 9.8 \times \mu \times W \times \frac{P}{2 \times \pi}$$

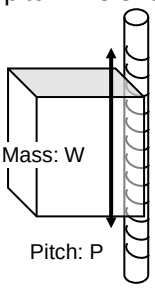


T : Rotary torque (Nm)
μ : friction coefficient
W : mass (kg)
P : Screw feed pitch (m)

● Linear operation (vertical operation)

The rotary torque when the mass W moves vertically due to the screw of pitch P is shown below.

$$T = 9.8 \times W \times \frac{P}{2 \times \pi}$$



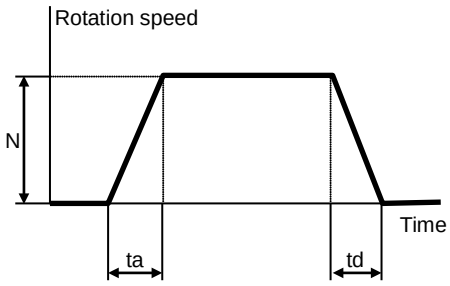
Acceleration time and deceleration time

Calculate acceleration and deceleration times for the selected actuator.

Acceleration time: $t_a = k \times (J_A + J_L) \times \frac{2 \times \pi}{60} \times \frac{N}{T_M - T_L}$

Deceleration time: $t_d = k \times (J_A + J_L) \times \frac{2 \times \pi}{60} \times \frac{N}{T_M + 2 \times T_F + T_L}$

ta: Acceleration time (s)
td: Deceleration time (s)
J_A: Actuator inertia moment ($kg \cdot m^2$)
J_L: Load inertia moment ($kg \cdot m^2$)
N: Actuator rotation speed (r/min)
T_M: Maximum actuator torque (Nm)
T_F: Actuator friction torque (Nm)



$T_F = K_T \times I_R - T_R$
K_T: Torque constant (Nm/A)
T_R: Allowable continuous torque (Nm)
I_R: Allowable continuous current (A)

T_L: Load torque (Nm); The polarity is positive (+) when the torque is applied in the rotation direction, or negative (-) when it is applied in the opposite direction.

- **Calculation example 1**

Select an actuator that best suits the following operating conditions:
- Rotation speed: 50 rpm
- Load inertia moment: 0.2 $kg \cdot m^2$
- Since the load mechanism is mainly inertia, the load torque is negligibly small.

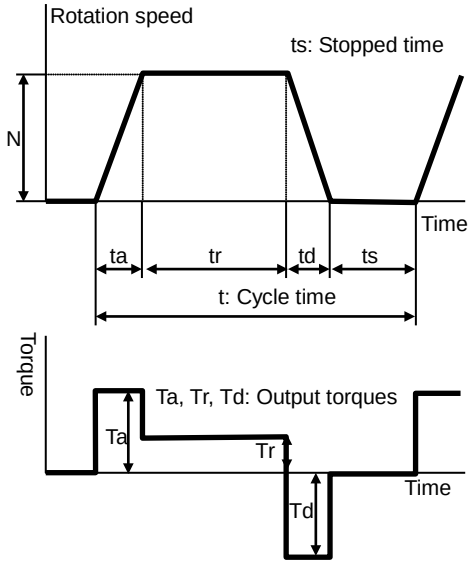
(1) FLA-14A-100FB-H-24 is tentatively selected.
(2) From the rated table, the following values are obtained: J_A = 0.077 $kg \cdot m^2$, T_M = 18.2 Nm, T_R = 3.8 Nm, K_T = 3.0 Nm/A, I_R = 2.5A.
(3) Based on the above formula, the actuator's friction torque T_F is calculated as 3.0 x 2.5 – 3.8 = 3.7 Nm.
(4) The acceleration time and deceleration time can be obtained as follows from the above formulas:
ta = (0.077+0.2) x 2 x π /60 x 50/18.2 = 0.080 s
td = (0.077+0.2) x 2 x π /60 x 50/(18.2+2 x 3.7) = 0.057 s
(5) If the calculated acceleration/deceleration times are too long, correct the situation by:
- Reducing load inertia moment
- Selecting an actuator with a larger frame size

Examining effective torque and average rotation speed

One way to check if the heat generated from the actuator during operation would present a problem is to determine if the point of operation, determined by the effective torque and average rotation speed, is inside the continuous motion range explained in [1-11 Operable range] (P1-23).
Using the following formula, calculate the effective torque T_m and average rotation speed N_{av} when the actuator is operated repeatedly in the drive pattern shown to the right.

$$T_m = \sqrt{\frac{T_a^2 \times t_a + T_r^2 \times t_r + T_d^2 \times t_d}{t}}$$

$$N_{av} = \frac{N/2 \times t_a + N \times t_r + N/2 \times t_d}{t}$$



ta : Acceleration time from speed 0 to N (s)
td : Deceleration time from speed N to 0 (s)
tr : Operation time at constant speed N (s)
t : Cycle time (s)
Tm : Effective torque (Nm)
Ta : Torque during acceleration (Nm)
Tr : Torque at constant speed (Nm)
Td : Torque during deceleration (Nm)
Nav : Average rotation speed (r/min)
N : Rotation speed at constant speed (r/min)

- **Calculation example 2**

An example of FLA-14A-100FB-H-24 is explained.
Operating conditions: Accelerate an inertia load and then let it move at a constant speed, followed by deceleration, based on conditions similar to those used in calculation example 1. The travel angle per cycle is 120° and the cycle time is 1 second.

(1) The travel angle is calculated from the area of the rotation speed vs. time diagram shown above. In other words, the travel angle is calculated as follows:

θ = (N / 60) x {t_r + (t_a + t_d) / 2} x 360

Accordingly, t_r = θ / (6 x N) – (t_a + t_d) / 2

When θ = 120°, and t_a = 0.080 (s), t_d = 0.057 (s), N = 50 (r/min) in calculation example 1, are applied to this formula, t_r is calculated as 0.332 (s).

(2) Next, calculate the torque during acceleration and torque during deceleration. Based on the acceleration/deceleration time formulas in the preceding section, the relational expressions for torque during acceleration and torque during deceleration are as follows:

$T_a = (J_a+J_L) \times 2\pi / 60 \times N / t_a + T_L$

$T_d = (J_a+J_L) \times 2\pi / 60 \times N / t_d - 2 \times T_F - T_L$

When the values in calculation example 1 are applied to this formula, T_a = 18.1 (Nm) and T_d = 18.0 (Nm) are obtained.

(3) Calculate the effective torque. Apply the values in (1) and (2), and T_r = 0 (Nm) and t = 1 (s), to the above formulas.

$$T_m = \sqrt{\frac{18.1^2 \times 0.080 + 0^2 \times 0.332 + 18.0^2 \times 0.057}{1}} = 6.7 \text{Nm}$$

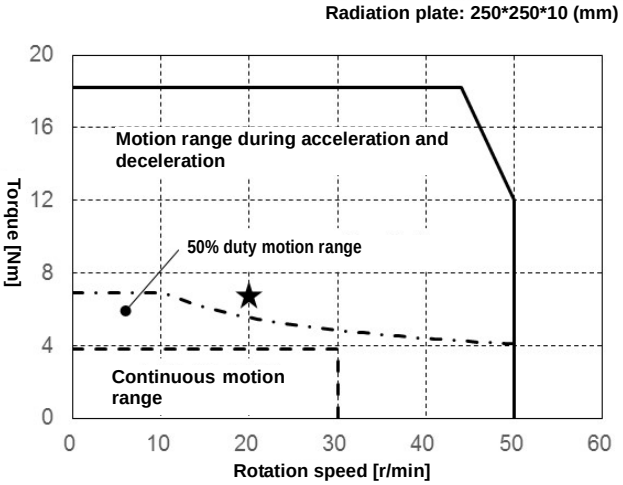
(4) Calculate the average rotation speed. Apply the values in (1), and N = 50 (r/min) and t = 1 (s), to the above formulas.

$$N_{av} = \frac{50/2 \times 0.080 + 50 \times 0.332 + 50/2 \times 0.057}{1} = 20.0 \text{r/min}$$

(5) The figure below shows the points of operation determined by the effective torque and average rotation speed calculated above, plotted on the graph of operable range of FLA-14A-100FB-H-24, exceeding the continuous motion range. The conclusion is that this actuator cannot be operated continuously under these conditions. Accordingly,

◆the operation pattern
◆load (possible reduction)
◆actuator model No.

etc., must be reexamined.



The following formula is a modified version of the formula for effective torque. By applying the value of allowable continuous torque to T_m in this formula, the allowable cycle time can be calculated.

$$t = \frac{T_a^{\,2} \times t_a + T_r^{\,2} \times t_r + T_d^{\,2} \times t_d}{T_m^{\,2}}$$

Apply the following: T_a = 18.1 Nm, T_r = 0 Nm, T_d = 18.0 Nm, T_m = 3.8 Nm, t_a = 0.080 s, t_r = 0.332 s, t_d = 0.057 s. Then, the following equation is obtained:

$t = (18.1^2 \times 0.080 + 18.0^2 \times 0.057) / 3.8^2 = 3.09$ s

Based on the result, setting the cycle time to 3.1 seconds or more to provide a longer stopped time gives T_m = 3.8 Nm or less, thereby permitting continuous operation within the allowable continuous torque.

Caution

- The aforementioned continuous motion range represents an allowable range where the actuator installed on a specified aluminum radiation plate is operated under natural air cooling. If the radiation area of the mounting member is small or heat conduction of the material is poor, adjust the operating conditions to keep the rise in the actuator's ambient temperature to 40 K or less as a guide.

Chapter 3

Installing the actuator

The following explains the installation procedures of the actuators.

3-1 Receiving Inspection

Check the following items after unpacking the package.

Inspection procedure

1 Check the items thoroughly for damage sustained during transportation.

If any item is damaged, immediately contact the dealer.

2 Check if the actuator is what you ordered.

The nameplate is found on the rear cover of the FLA series actuator. Check the TYPE field on the nameplate to confirm that it is indeed the model you have ordered. If any item is wrong, immediately contact the dealer.
Refer to the section [1-2 Model] (P1-2) in this manual for the detail of the model codes.

When Using a Recommended Drive

The characteristics of the recommended drivers have been adjusted according to the actuators and each model has its own drive parameters. Ensure that you check the drive and actuator models and use with the appropriate parameters. Using with invalid parameters may cause the actuator to burn out due to insufficient torque or overcurrent, resulting in an injury or fire.

When Using a Drive Other Than Recommended Drives

When using a drive other than the recommended drives, ensure that the specifications of the actuator are not exceeded. Using the drive exceeding the actuator specifications may cause an actuator malfunction or failure.

3-2 Notices on handling

Handle the FLA series actuator carefully by observing the notices specified below.

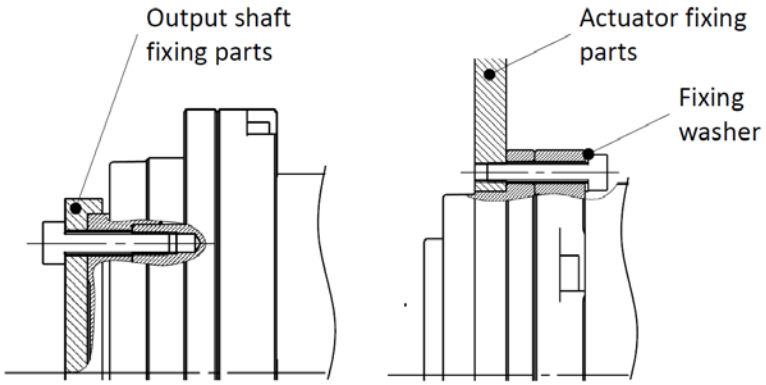
CAUTION

(1) Do not apply any excessive force or impact, especially to the actuator's output shaft.
(2) Do not put the actuator on a table, shelf, etc., where the actuator could easily fall.
(3) Do not connect the actuator terminals directly to the power supply. The actuator may burn and cause fire or electric shock.
(4) The allowable storage temperature is -20 to +60℃. Do not expose the actuator to direct sunlight for long periods of time or store it in areas in low or high temperature.
(5) The allowable relative storage humidity is 80% or less. Do not store the actuator in a very humid place or in areas where temperatures are likely to fluctuate greatly during day and night.
(6) Do not use or store the actuator in locations subject to flammable or corrosive gases or dust particles.

Installation and transmission torque

Examples of the FLA series actuator assembly are shown below. Use high-tension bolts and tighten them with a torque wrench to control the tightening torque. When fastening the actuator in place, use flat washers for bolt seating surfaces because the tightening torque is high and the actuator flange is made of aluminum.

[Assembly example]



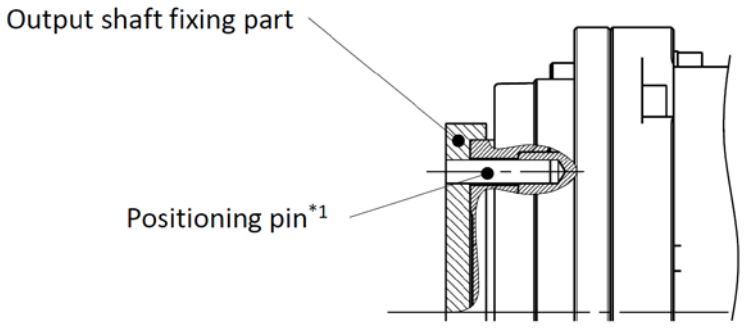
- **Recommended tightening torque and transmission torque**

Item \ Model		FLA-11A		FLA-14A		FLA-17A		FLA-20A	
		Output shaft	Actuator	Output shaft	Actuator	Output shaft	Actuator	Output shaft	Actuator
Number of bolts, size		4-M3	4-M3	8-M3	8-M3	8-M3	12-M3	8-M3	12-M3
Bolt installation P.C.D.	mm	35	64	45	78	50	85	55	93
Tightening torque	Nm	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Transmission torque	Nm	29.2	53.3	75.0	130.0	83.3	212.5	91.7	232.5

Note 1) The female thread material is premised to withstand the bolt tightening torque
2) Recommended bolt: Hexagonal bolt per JIS B 1176 Intensity category: JIS B 1051 12.9 or higher
3) Calculation conditions Torque efficiency: 0.2 Tightening efficiency: 1.4 Tightening friction coefficient: 0.15

Use of positioning pins

The FLA series actuator has positioning pin holes in the output rotary unit.
Use these pins as necessary. For details, refer to [1-5 External dimensions] (P**Error! Bookmark not defined.**) or the illustrated
specifications.



Example of use of positioning pins

*1: Do not drive positioning pins, but keep proper fitting clearances to the actuator axises. Failure to do so may result in damage to the actuator, deformation of the actuator shaft, or decreased pin positional accuracy.

Surface treatments

Standard FLA series actuators are given the following surface treatments:

Location	Surface treatments
Housing	No treatment (aluminum and plastic materials are exposed)
Speed reducer rotating part (output flange)	Raydent treatment
Bolt	Chrome plating or no treatment (SUS material is exposed)

The surface treatments given to FLA series actuators do not fully prevent rust.

3-3 Location and installation

Environment of location

The environmental conditions of the installation location for FLA series actuators must be as follows. Determine an appropriate installation location by observing these conditions without fail.

- ◆ Operating temperature: 0 to 40℃
  The temperature in the cabinet may be higher than the atmosphere depending on the power loss of housed devices and size of the cabinet. Plan the cabinet size, cooling system, and device locations so the ambient temperature of the actuator is kept 40℃ or below.
- ◆ Operating humidity: Relative humidity of 20 to 80%.
  Make sure no condensation occurs. Take note that condensation is likely to occur in a place where there is a large temperature change between day and night or when the actuator is started/stopped frequently.
- ◆ Vibration: 25 m/s^2 (10 to 400Hz) or less (Refer to [1-10 Resistance to vibration] (P1-22))
- ◆ Impact: 300 m/s^2 or less (Refer to [1-9 Shock resistance] (P1-21))
- ◆ Use environment: Free from condensation, metal powder, corrosive gases, water, oil mist, flammable gases, etc.
- ◆ Protection class: Standard products are structurally designed to meet the IP-40 requirements.

  The protection class against water entry is as follows:
  0: Not protected against entry of water.

  The protection class against contact and entry of foreign matter is as follows:
  4: Protected against wires and etc. Protected against entry of a wire or solid matter that has a diameter of 1.00 mm or more.
- ◆ Do not expose it to the sunlight.
- ◆ Altitude: lower than 1,000 m above sea level
- ◆ FLA series actuators have a simple sealed structure, which does not completely prevent lubricant leaks. Take additional measures to prevent leaks as necessary.

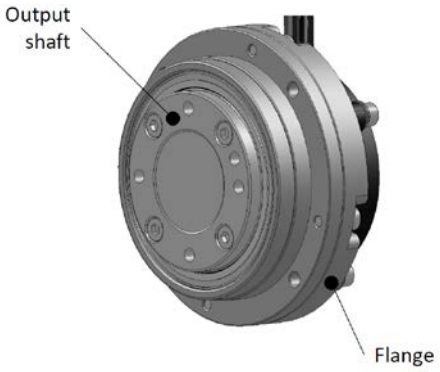
Installation

When installing the actuator, pay attention to precision and do not tap the actuator output part with a hammer, etc. The actuator has built-in detectors such as a hall sensor. Excessive impact may damage the detectors.

Installation procedure

1 Align the axis of rotation of the actuator and the load mechanism precisely.

Note 1: Perform this alignment carefully, especially when a rigid coupling is used. Even slight misalignment may cause the permissible load of the actuator to be exceeded, resulting in damage to the output shaft.



2 Connect the driver and wiring.

For details on wiring, refer to [1-12 Cable specifications] (P1-33) and the related manuals of recommended drives (S series/F series).

3 Wire the motor cable and sensor cable.

Do not pull the cables with a strong force. The connection points may be damaged. Install the cable with slack not to apply tension to the actuator. Provide a sufficient bending radius (at least 7 times the cable diameter), especially when the cable flexes.

Caution

- Do not bring strong magnetic bodies (magnet chucks, permanent magnets, etc.) near the rear cover of the actuator. A sensor abnormality or failure may result.

WARNING

Do not disassemble/reassemble the actuator.

The actuator uses many precision parts. If the actuator is disassembled/reassembled by the customer, it may cause burned damage or uncontrollable operation of the actuator, resulting in fire or injury.

Appendix

A-1 Unit conversion

This manual employs SI system for units. Conversion factors between the SI system and other systems are as follows:

(1) Length

SI system	m	
Unit	ft.	in.
Factor	3.281	39.37

Unit	ft.	in.
Factor	0.3048	0.0254
SI system	m	

(2) Linear speed

SI system	m/s			
Unit	m/min	ft./min	ft./s	in/s
Factor	60	196.9	3.281	39.37

Unit	m/min	ft./min	ft./s	in/s
Factor	0.0167	5.08×10^{-3}	0.3048	0.0254
SI system	m/s			

(3) Linear acceleration

SI system	m/s^2			
Unit	m/min^2	$ft./min^2$	$ft./s^2$	in/s^2
Factor	3600	1.18×10^4	3.281	39.37

Unit	m/min^2	$ft./min^2$	$ft./s^2$	in/s^2
Factor	2.78×10^{-4}	8.47×10^{-5}	0.3048	0.0254
SI system	m/s^2			

(4) Force

SI system	N		
Unit	kgf	lb (force)	oz (force)
Factor	0.102	0.225	4.386

Unit	kgf	lb (force)	oz (force)
Factor	9.81	4.45	0.278
SI system	N		

(5) Mass

SI system	kg	
Unit	lb.	oz.
Factor	2.205	35.27

Unit	lb.	oz.
Factor	0.4535	0.02835
SI system	kg	

(6) Angle

SI system	rad		
Unit	deg.	min.	sec.
Factor	57.3	3.44×10^3	2.06×10^5

Unit	deg.	min.	sec.
Factor	0.01755	2.93×10^{-4}	4.88×10^{-6}
SI system	rad		

(7) Angular speed

SI system	rad/s			
Unit	deg/s	deg/min	r/s	r/min
Factor	57.3	3.44×10^3	0.1592	9.55

Unit	deg/s	deg/min	r/s	r/min
Factor	0.01755	2.93×10^{-4}	6.28	0.1047
SI system	rad/s			

(8) Angular acceleration

SI system	rad/s^2

↓

Unit	deg/s^2	deg/min^2
Factor	57.3	3.44x10^3

Unit	deg/s^2	deg/min^2
Factor	0.01755	2.93x10^{-4}

↓

SI system	rad/s^2

(9) Torque

SI system	N·m

↓

Unit	kgf·m	lb·ft	lb·in	oz·in
Factor	0.102	0.738	8.85	141.6

Unit	kgf·m	lb·ft	lb·in	oz·in
Factor	9.81	1.356	0.1130	7.06x10^{-3}

↓

SI system	N·m

(10) Inertia moment

SI system	kg·m^2

↓

Unit	kgf·m·s^2	kgf·cm·s^2	lb·ft^2	lb·ft·s^2	lb·in^2	lb·in·s^2	oz·in^2	oz·in·s^2
Factor	0.102	10.2	23.73	0.7376	3.42x10^3	8.85	5.47x10^4	141.6

Unit	kgf·m·s^2	kgf·cm·s^2	lb·ft^2	lb·ft·s^2	lb·in^2	lb·in·s^2	oz·in^2	oz·in·s^2
Factor	9.81	0.0981	0.0421	1.356	2.93x10^{-4}	0.113	1.829x10^{-5}	7.06x10^{-3}

↓

SI system	kg·m^2

(11) Torsional spring constant, moment stiffness

SI system	N·m/rad

↓

Unit	kgf·m/rad	kgf·m/arc min	kgf·m/ deg	lb·ft/ deg	lb·in/ deg
Factor	0.102	2.97 x10^{-5}	1.78x10^{-3}	0.0129	0.1546

Unit	kgf·m/rad	kgf·m/arc min	kgf·m/ deg	lb·ft/ deg	lb·in/ deg
Factor	9.81	3.37 x10^4	562	77.6	6.47

↓

SI system	N·m/rad

A-2 Calculating inertia moment

Formula of mass and inertia moment

(1) Both centerlines of rotation and gravity are the same:

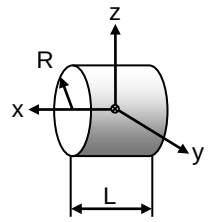
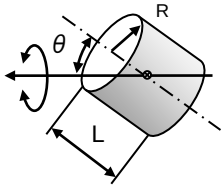
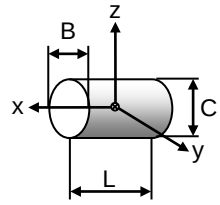
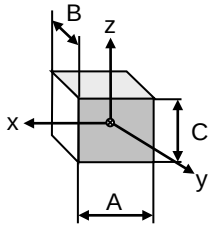
The following table includes formulas to calculate mass and inertia moment.

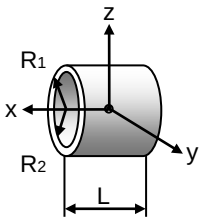
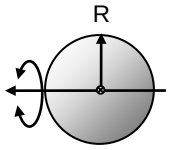
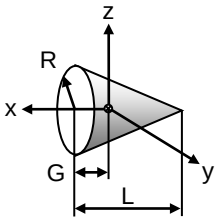
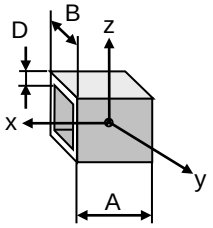
m : mass (kg), Ix, Iy, Iz: inertia moments which rotates around x-, y-, z-axes respectively (kg·m²)

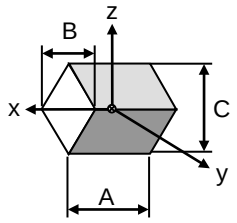
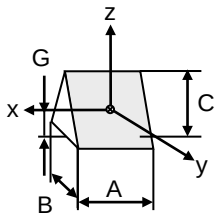
G : distance from end face of gravity center (m)

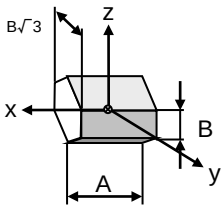
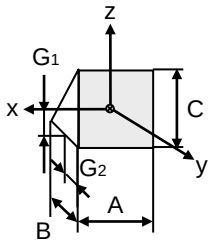
ρ : specific gravity

Unit Length: m, Mass: kg, Inertia moment: kg·m²

Object form	Mass, inertia, gravity center
Cylinder 	$m = \pi R^2 L \rho$ $Ix = \frac{1}{2} m R^2$ $Iy = \frac{1}{4} m \left(R^2 + \frac{L^2}{3} \right)$ $Iz = \frac{1}{4} m \left(R^2 + \frac{L^2}{3} \right)$
Slanted cylinder 	$m = \pi R^2 L \rho$ $I_\theta = \frac{1}{12} m$ $\times \left\{ 3R^2 \left(1 + \cos^2\theta \right) + L^2 \sin^2\theta \right\}$
Ellipsoidal cylinder 	$m = \frac{1}{4} BCL\rho$ $Ix = \frac{1}{16} m \left(B^2 + C^2 \right)$ $Iy = \frac{1}{4} m \left(\frac{C^2}{4} + \frac{L^2}{3} \right)$ $Iz = \frac{1}{4} m \left(\frac{B^2}{4} + \frac{L^2}{3} \right)$
Rectangular pillar 	$m = ABC\rho$ $Ix = \frac{1}{12} m \left(B^2 + C^2 \right)$ $Iy = \frac{1}{12} m \left(C^2 + A^2 \right)$ $Iz = \frac{1}{12} m \left(A^2 + B^2 \right)$

Object form	Mass, inertia, gravity center
Circular pipe  R1: Outer diameter R2: Inner diameter	$m = \pi \left(R_1^{\,2} - R_2^{\,2} \right) L \rho$ $Ix = \frac{1}{2} m \left(R_1^{\,2} + R_2^{\,2} \right)$ $Iy = \frac{1}{4} m \left\{ \left(R_1^{\,2} + R_2^{\,2} \right) + \frac{L^2}{3} \right\}$ $Iz = \frac{1}{4} m \left\{ \left(R_1^{\,2} + R_2^{\,2} \right) + \frac{L^2}{3} \right\}$
Ball 	$m = \frac{4}{3} \pi R^3 \rho$ $I = \frac{2}{5} m R^2$
Cone 	$m = \frac{1}{3} \pi R^2 L \rho$ $Ix = \frac{3}{10} m R^2$ $Iy = \frac{3}{80} m \left(4R^2 + L^2 \right)$ $Iz = \frac{3}{80} m \left(4R^2 + L^2 \right)$ $G = \frac{L}{4}$
Square pipe 	$m = 4AD(B - D)\rho$ $Ix = \frac{1}{3} m \left\{ (B - D)^2 + D^2 \right\}$ $Iy = \frac{1}{6} m \left\{ \frac{A^2}{2} + (B - D)^2 + D^2 \right\}$ $Iz = \frac{1}{6} m \left\{ \frac{A^2}{2} + (B - D)^2 + D^2 \right\}$

Object form	Mass, inertia, gravity center
Rhombus pillar 	$m = \frac{1}{2}ABC\rho$ $Ix = \frac{1}{24}m\left(B^2 + C^2\right)$ $Iy = \frac{1}{24}m\left(C^2 + 2A^2\right)$ $Iz = \frac{1}{24}m\left(B^2 + 2A^2\right)$
Isosceles triangle pillar 	$m = \frac{1}{2}ABC\rho$ $Ix = \frac{1}{12}m\left(\frac{B^2}{2} + \frac{2}{3}C^2\right)$ $Iy = \frac{1}{12}m\left(A^2 + \frac{2}{3}C^2\right)$ $Iz = \frac{1}{12}m\left(A^2 + \frac{B^2}{2}\right)$ $G = \frac{C}{3}$

Object form	Mass, inertia, gravity center
Hexagonal pillar 	$m = \frac{3\sqrt{3}}{2}AB^2\rho$ $Ix = \frac{5}{12}mB^2$ $Iy = \frac{1}{12}m\left(A^2 + \frac{5}{2}B^2\right)$ $Iz = \frac{1}{12}m\left(A^2 + \frac{5}{2}B^2\right)$
Right triangle pillar 	$m = \frac{1}{2}ABC\rho$ $Ix = \frac{1}{36}m\left(B^2 + C^2\right)$ $Iy = \frac{1}{12}m\left(A^2 + \frac{2}{3}C^2\right)$ $Iz = \frac{1}{12}m\left(A^2 + \frac{2}{3}B^2\right)$ $G_1 = \frac{C}{3}$ $G_2 = \frac{B}{3}$

- **Example of specific gravity**

The following tables show references of specific gravity. Confirm the specific gravity for the material of the drive load.

Unit: g/cm^3

Material	Specific gravity
SUS304	7.93
S45C	7.86
SS400	7.85
Cast iron	7.19
Copper	8.92
Brass	8.50

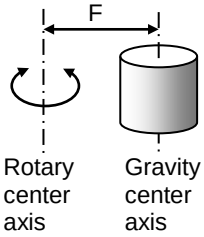
Material	Specific gravity
Aluminum	2.70
Duralumin	2.80
Silicon	2.30
Quartz glass	2.20
Teflon	2.20
Fluorocarbon resin	2.20

Material	Specific gravity
Epoxy resin	1.90
ABS	1.10
Silicon resin	1.80
Polyurethane rubber	1.25

(2) Both centerlines of rotation and gravity are not the same:

The following formula calculates the inertia moment when the rotary center is different from the gravity center.

$$I = Ig + mF^2$$



I: Inertia moment when the gravity center axis does not match the rotational axis (kg·m^2)

Ig: Inertia moment when the gravity center axis matches the rotational axis (kg·m^2)
Calculate according to the shape by using formula (1).

m: mass (kg)

F: Distance between rotary center and gravity center (m)

(3) Inertia moment of linear operation objects

The inertia moment, converted to actuator axis, of a linear motion object driven by a screw, etc., is calculated using the formula below.

$$I = m\left(\frac{P}{2\pi}\right)^2$$

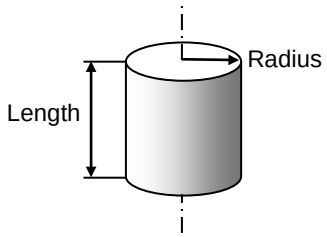
I: Inertia moment of a linear operation object converted to actuator axis (kg·m^2)

m: mass (kg)

P: Linear travel per actuator one revolution (m/rev)

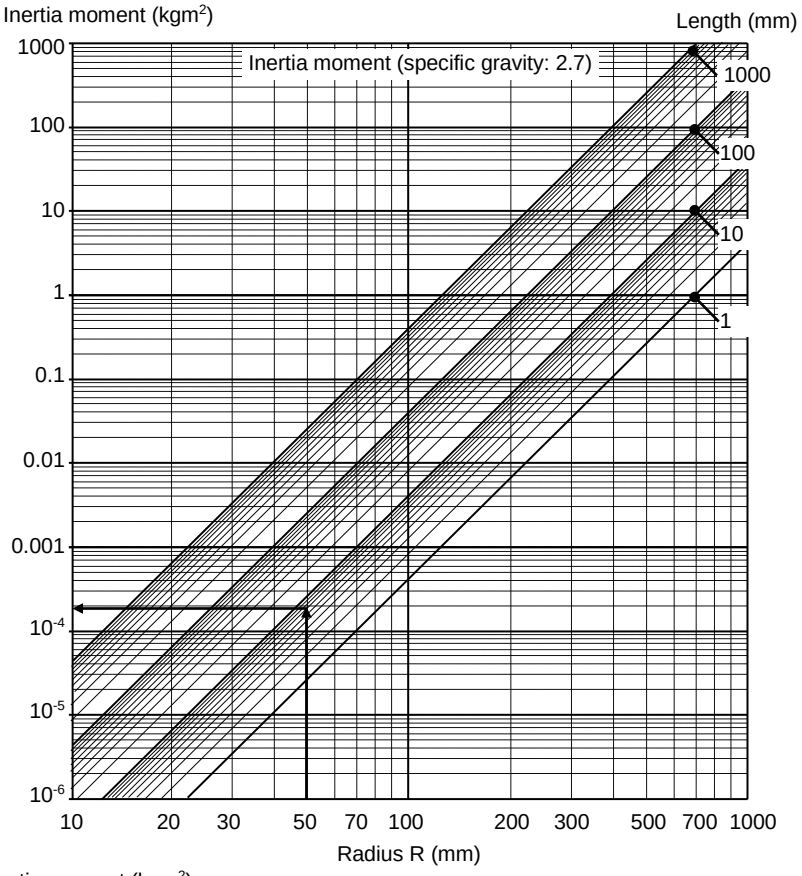
Inertia moment of cylinder

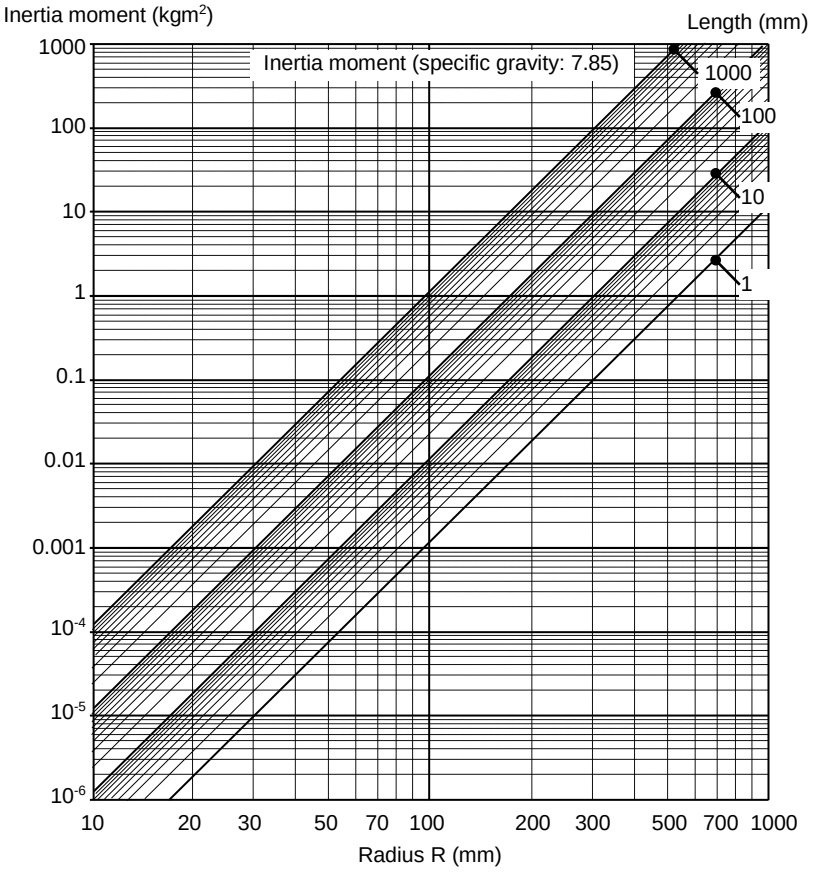
The inertia moment of a cylinder may be obtained from the graphs to the right.



Apply the top graph to aluminum materials (specific gravity: 2.7) and bottom graph to steel materials (specific gravity: 7.85).

(Example)
Material: Aluminum
Outer diameter: 100mm
Length: 7mm
Shape: Column
Since the outer diameter is 100mm, the radius is 50mm. Therefore, the above graph gives the inertia moment as follows:
Approx. 1.9 x 10^{-4}kg·m^2
(Calculated value: 0.000186 kg·m^2)





Warranty Period and Terms

The equipment listed in this document is warranted as follows:

■Warranty period

Under the condition that the actuator are handled, used and maintained properly followed each item of the documents and the manuals, all the applicable products are warranted against defects in workmanship and materials for the shorter period of either one year after delivery or 2,000 hours of operation time.

■Warranty terms

All the applicable products are warranted against defects in workmanship and materials for the warranted period. This limited warranty does not apply to any product that has been subject to:

(1) user's misapplication, improper installation, inadequate maintenance, or misuse.
(2) disassembling, modification or repair by others than Harmonic Drive Systems, Inc.
(3) imperfection caused by a non-applicable product.
(4) disaster or others that does not belong to the responsibility of Harmonic Drive Systems, Inc.

Our liability shall be limited exclusively to repairing or replacing the product only found by Harmonic Drive Systems, Inc. to be defective. Harmonic Drive Systems, Inc. shall not be liable for consequential damages of other equipment caused by the defective products, and shall not be liable for the incidental and consequential expenses and the labor costs for detaching and installing to the driven equipment.

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HarmonicGearhead®
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All specifications and dimensions in this manual subject to change without notice.
This manual is correct as of September 2018.

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