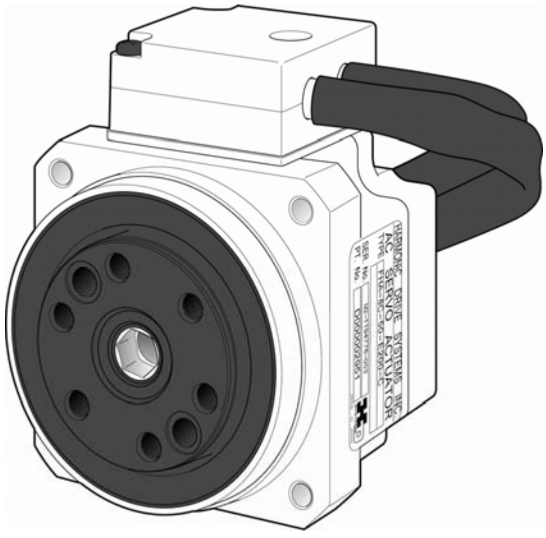
HarmonicDrive®

AC Servo Actuator

FHA-Cmini series manual



ISO14001
(Hotaka plant)
ISO9001

Introduction

Thank you very much for your purchasing our FHA-Cmini series servo actuator.
Wrong handling or use of this product may result in unexpected accidents or 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 driver.

NOTATION

Important safety information you must note is provided herein. Be sure to observe these instructions.

WARNING	Indicates a potentially hazardous situation, which, if not avoided, could result in death or serious personal 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	Indicates what should be performed or avoided to prevent non-operation or malfunction of the product or negative effects on its performance or function.

LIMITATION OF APPLICATIONS

The equipment listed in this document may not be used for the applications listed below:

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

If the above list includes your intending application for our products, please consult us.

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

- **CAUTIONS FOR ACTUATORS AT APPLICATION DESIGNING**

CAUTION

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)**
- **Vibration: Max 24.5 m/S2**
- **Impact: Max 294 m/S2**
- **No contamination by water, 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 motor shaft center and corresponding center in the application.**
- **Failure to observe this caution may lead to vibration, resulting in damage of output elements.**

- **CAUTION FOR ACTUATORS IN OPERATIONS**

WARNING

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.

- **Do not use a hammer during installation.**
- **Failure to observe this caution could damage the encoder and may cause uncontrollable operation.**

Avoid handling of actuators by cables.

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

CAUTION

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.**

- **CAUTIONS FOR DRIVERS AT APPLICATION DESIGNING**

CAUTION

Always use drivers under followings conditions:

- **Mount in a vertical position keeping sufficient distance to other devices to let heat generated by the driver radiate freely.**
- **0℃ to 50℃, 95% RH or below (Non condensation)**
- **No vibration or physical shock**
- **No corrosive, inflammable or explosive gas**

Use sufficient noise suppressing means and safe grounding.

- **Keep signal and power leads separated.**
- **Keep leads as short as possible.**
- **Ground actuator and driver at one single point, minimum ground resistance class: D (less than 100 ohms)**
- **Do not use a power line filter in the motor circuit.**

Pay attention to negative torque by inverse load.

- **Inverse load may cause damages of drivers.**
- **Please consult our sales office, if you intent to apply products for inverse load.**

Use a fast-response type ground-fault detector designed for PWM inverters.

- **Do not use a time-delay-type ground-fault detector.**

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

- **CAUTION FOR DRIVERS IN OPERATIONS**

WARNING

Never change wiring while power is active.

Make sure of power non-active before servicing the products. Failure to observe this caution may result in electric shock or personal injury.

Do not touch terminals or inspect products at least 15 minutes after turning OFF power.

- **Otherwise residual electric charges may result in electric shock. In order to prevent electric shock, perform inspections 15 minutes after the power supply is turned OFF and confirming the CHARGE lamp is turned OFF.**
- **Make installation of products not easy to touch their inner electric components.**

CAUTION

Do not make a voltage resistance test.

- **Failure to observe this caution may result in damage of the control unit.**
- **Please consult our sales office, if you intent to make a voltage resistance test.**

Do not operate control units by means of power ON/OFF switching.

- **Start/stop operation should be performed via input signals.**
- **Failure to observe this caution may result in deterioration of electronic parts.**

DISPOSAL OF AN ACTUATOR, A MOTOR, A CONTROL UNIT AND/OR THEIR PARTS

CAUTION

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.

Structure of this document

Chapter 1	**Outlines**	Outlines of product models, specifications, external drawings, etc., are explained.
Chapter 2	**Selection guidelines**	Selection guidelines for the FHA-C mini series actuator are explained in this chapter.
Chapter 3	**Installation**	This chapter explains the procedure for installing the FHA-C mini series actuator.
Appendix		How to calculate unit conversions and inertia moments are explained in this chapter.

Contents

Chapter 1 Outlines

Chapter 2 Selection guidelines

Chapter 3 Installation

Appendix

Chapter 1

Outlines

Outlines of product models, specifications, external drawings, etc., are explained in this chapter.

1-1 Outlines

FHA-C mini series AC Servo Actuators provide high torque and highly accurate rotary operation. These integrated AC Servo Actuators are each composed of a thin type speed reducer HarmonicDrive® for precision control from models No. 8 to No. 14 and a flat AC servo motor.
The first feature of the FHA-C mini series actuators is their shape. The body is thinner and more compact than those of any models that have been produced by the industry so far. The second feature is its hollow structure. A through-hole is provided at the center of the actuator, through which wirings, air pipes, and even laser beams can be passed to supply power and give/receive signals to moving parts of machines and devices. (*1)
The HA-800 and the HA-680 drivers are a family of servo drive units for position/speed control, developed exclusively for driving FHA-C mini series actuators. The small, multi-functional drivers control the FHA-C mini series actuators' operations with great accuracy and precision.
FHA-C mini series actuators play an important role in driving various factory automation (FA) equipment, such as robot joints, alignment mechanisms for semi-conductor LCD devices, etc.

Main features

Slim line body

The FHA-C mini series actuator is the union of a thin type speed reducer HarmonicDrive® for precision control and a flat AC servo motor. The length from the mounting flange face to the actuator end is 1/3 or less of our previous AC Servo Actuator models. The compact size allows much smaller machines and devices to be designed.

Hollow structure (*1)

A through-hole is provided at the center of the actuator, through which wirings, air pipes, and even laser beams can be passed to supply power and give/receive signals to moving parts of machines and devices. This feature simplifies the structure of machines and devices.

High torque

The thin type speed reducer HarmonicDrive® for precision control allows the FHA-C mini series actuator to have a much higher output torque per external drawing than direct drive motors.

High positional accuracy

The FHA-C mini series actuators provide superior positioning accuracy of up to 90 seconds (FHA-14C-100) with uni-directional positional accuracy as well as a detector resolution of 800,000/rev (incremental encoder) and 13,107,200/rev (absolute encoder).

High torsional stiffness

Uses the high stiffness, HarmonicDrive® CSF series.

Absolute encoder

The FHA-C mini series actuator uses previous model incremental encoders and has an absolute encoder added. We offer a wide variation to meet for a wide range of needs.

(*1): The absolute encoder model does not come with a hollow structure.

1-2 Model

Model names for the FHA-C mini series actuators and how to read the symbols are explained below.

Incremental encoder

FHA-8 C-30-E200-C □ □

- **FHA**: Model: AC Servo Actuator FHA-C mini series
- **8**: Model No.: 8, 11, 14
- **C**: Version symbol
- **30**: Reduction ratio of the HarmonicDrive®
  - 30: 1/30
  - 50: 1/50
  - 100: 1/100
- **E200**: Encoder type and resolution

E200	Incremental encoder	2,000 p/rev

- **C**: With connector (standard specification)
- **□**: Input power supply
  - None: 100VAC, 200V specification
  - E: 24VDC specification
- **□**: Cable lead-out direction
  - None : Lateral (standard specification)
  - K : Rear (option specification)

Absolute encoder

FHA-8 C-30-12S17b A-C

- **FHA**: Model: AC Servo Actuator FHA-C mini series
- **8**: Model No.: 8, 11, 14
- **C**: Version symbol
- **30**: Reduction ratio of the HarmonicDrive®
  - 30: 1/30
  - 50: 1/50
  - 100: 1/100
- **12S17b**: Encoder type and resolution

12S17b	Absolute encoder	131,072p/rev (17bit)

- **A**: Input power supply
  - A: 100VAC specification
  - G: 200VAC specification
  - E: 24VDC specification
- **C**: With connector (standard specification)

1-3 Combinations with drivers

The HA-800 and HA-680 driver models are available for use with FHA-C mini series actuators. The driver comes in models based on input voltages. The correct combinations are listed below.

Actuator series	Model No.	Input voltage (V)	Encoder type	Combined driver		
				General I/O command type	MECHATROLINK-II type	CC-Link type
FHA-C mini series	8	AC200	4-wire wire-saving incremental	HA-800A-1C-200	HA-800B-1C-200	HA-800C-1C-200
	11	AC200				
	14	AC200				
	8	AC100		HA-800A-1C-100	HA-800B-1C-100	HA-800C-1C-100
	11	AC100				
	14	AC100				
FHA-C mini series	8	AC200	17-bit absolute	HA-800A-1D-200	HA-800B-1D-200	HA-800C-1D-200
	11	AC200				
	14	AC200				
	8	AC100		HA-800A-1D-100	HA-800B-1D-100	HA-800C-1D-100
	11	AC100				
	14	AC100				
FHA-C mini series	8	DC24	4-wire wire-saving incremental	HA-680-4-24	HA-680ML-4-24	HA-680CL-4-24
	11	DC24				
	14	DC24		HA-680-6-24	HA-680ML-6-24	HA-680CL-6-24
	8	DC24		HA-680-4-24	HA-680ML-4-24	HA-680CL-4-24
	11	DC24				
	14	DC24		HA-680-6-24	HA-680ML-6-24	HA-680CL-6-24

1-4 Specifications

Input voltage 100VAC/200VAC specification

The specifications for the FHA-C mini series actuators with 100VAC/200VAC input voltages are as follows.

Item	Model		FHA-8C			FHA-11C			FHA-14C		
			30	50	100	30	50	100	30	50	100
Maximum torque Note 3		N·m	1.8	3.3	4.8	4.5	8.3	11	9.0	18	28
		kgf·m	0.18	0.34	0.49	0.46	0.85	1.1	0.92	1.8	2.9
Max. rotational speed		r/min	200	120	60	200	120	60	200	120	60
Torque constant		N·m/A	3.9	6.7	14	3.8	6.6	13	4.2	7.2	15
		kgf·m/A	0.40	0.68	1.4	0.39	0.67	1.4	0.43	0.74	1.5
Max. current Note 3		A	0.61	0.64	0.48	1.5	1.6	1.1	2.9	3.2	2.4
Allowable continuous current Note 3		A	0.31	0.34	0.26	0.74	0.69	0.54	1.27	1.06	0.85
Input power supply (driver)		V	AC200, AC100								
MEF constant (interphase)		V/(r/min)	0.48	0.80	1.6	0.48	0.80	1.6	0.52	0.86	1.70
Phase resistance		Ω (20°C)	14			3.7			1.4		
Phase inductance		mH	5.7			3.2			1.8		
Inertia moment INC	**$(GD^2/4)$**	kg·m^2	0.0026	0.0074	0.029	0.0060	0.017	0.067	0.018	0.050	0.20
	(J)	kgf·cm·s^2	0.0270	0.0750	0.30	0.0610	0.170	0.680	0.180	0.510	2.00
Inertia moment ABS	**$(GD^2/4)$**	kg·m^2	0.0026	0.0073	0.029	0.0062	0.017	0.069	0.019	0.054	0.215
	(J)	kgf·cm·s^2	0.0270	0.0747	0.298	0.0630	0.176	0.705	0.197	0.547	2.189
Reduction ratio			30	50	100	30	50	100	30	50	100
Permissible moment load		N·m	15			40			75		
		kgf·m	1.5			4.1			7.7		
Moment stiffness		N·m/rad	2×10^4			4×10^4			8×10^4		
		kgf·m/rad	0.2×10^4			0.4×10^4			0.8×10^4		
Motor position detector	**INC**		Incremental encoder: 2,000 pulse/rev								
	ABS		Absolute encoder: Multi-rev 16 bit (65,536 rev), 1 rev 17 bit (131,072 pulse/rev)								
Detector resolution Note 5 **INC (quadruplicate)**		Pulse/rev	240,000	400,000	800,000	240,000	400,000	800,000	240,000	400,000	800,000
ABS (output shaft conversion)		Pulse/rev	3,932,160	6,553,600	13,107,200	3,932,160	6,553,600	13,107,200	3,932,160	6,553,600	13,107,200
Uni-directional positional accuracy		Sec. (angle)	150	120	120	120	90	90	120	90	90
		Angle compensated	The uni-directional positional accuracies are improved 30% more than the above values at no disturbance by the angle compensation feature of the HA-800 driver. Note 6								
Mass **INC**		kg	0.40			0.62			1.2		
ABS		kg	0.50			0.75			1.3		
Protection structure			Totally enclosed self-cooled type (equivalent to IP44)								
Environmental conditions			Operating temperature: 0 to 40°C /Storage temperature: -20 to 60°C Operating humidity/storage humidity: 20 to 80% RH (no condensation) Resistance to vibration: 24.5 m/s^2 (frequency 10 to 400 Hz) Shock resistance: 294 m/s^2 No dust, metal powder, corrosive gas, inflammable gas, or oil mist. To be used indoors, no direct sunlight. Altitude: less than 1,000 m above sea level Magnetic noise resistance: 0.01 tesla (ABS)								
Motor insulation			Insulation resistance: 100 MΩ or more (by 500VDC insulation tester) Dielectric strength: 1,500VAC/1 min Insulation class: B								
Safety standard compliance			CE marking (the absolute encoder will soon be compliant)								
Mounting direction			Can be installed in any direction.								

Note 1: (INC) stands for the incremental encoder and (ABS) stands for the absolute encoder.

Note 2: The table shows the output shaft values of the actuators.
Note 3: The value when combined with a HA-800 driver.
Note 4: All values are typical.
Note 5: The values listed below are for the detector resolution.
Incremental encoder: (motor shaft encoder quadruplicate resolution) x (reduction ratio).
Absolute encoder: (motor shaft encoder resolution) x (reduction ratio)
Note 6: Refer to the HA-800 driver manual for further details.

Input voltage: 24VDC specification

The specifications for FHA-C mini series actuators with a 24VDC input voltage are as follows.

Item	Model	FHA-8C			FHA-11C			FHA-14C		
		30	50	100	30	50	100	30	50	100
Maximum torque Note 2	N·m	1.8	3.3	4.8	4.5	8.3	11	9.0	18	28
	kgf·m	0.18	0.34	0.49	0.46	0.85	1.1	0.92	1.8	2.9
Max. rotational speed	r/min	200	120	60	200	120	60	200	120	60
Torque constant	N·m/A	0.8	1.3	2.7	0.8	1.3	2.6	0.8	1.4	2.9
	kgf·m/A	0.08	0.13	0.28	0.08	0.13	0.27	0.08	0.14	0.30
Max. current Note 2	A	3.0	3.3	2.4	7.8	8.2	5.6	14.8	16.4	12.3
Allowable continuous current Note 2	A	1.6	1.7	1.3	3.7	3.5	2.8	6	5.4	4.4
Input power supply (driver)	V	DC24								
MEF constant (interphase)	V/(r/min)	0.10	0.16	0.32	0.09	0.15	0.31	0.10	0.17	0.34
Phase resistance	Ω (20°C)	0.54			0.19			0.07		
Phase inductance	mH	0.22			0.11			0.06		
Inertia moment INC **(GD^2/4)**	kg·m^2	0.0026	0.0074	0.029	0.0060	0.017	0.067	0.018	0.050	0.20
(J)	kgf·cm·s^2	0.0270	0.0750	0.30	0.0610	0.170	0.680	0.180	0.510	2.00
Reduction ratio		30	50	100	30	50	100	30	50	100
Permissible moment load	N·m	15			40			75		
	kgf·m	1.5			4.1			7.7		
Moment stiffness	N·m/rad	2 x 10^4			4 x 10^4			8 x 10^4		
	kgf·m/rad	0.2 x 10^4			0.4 x 10^4			0.8 x 10^4		
Motor position detector		Incremental encoder: 2,000 pulse/rev								
Detector resolution (quadruplicate) Note 4	Pulse/rev	240,000	400,000	800,000	240,000	400,000	800,000	240,000	400,000	800,000
Uni-directional positional accuracy	Sec. (angle)	150	120	120	120	90	90	120	90	90
	Angle compensated	The uni-directional positional accuracies are improved 30% more than the above values at no disturbance by the angle compensation feature of the HA-680 driver. Note 5								
Mass	kg	0.40			0.62			1.2		
Protection structure		Totally enclosed self-cooled type (equivalent to IP44)								
Environmental conditions		Operating temperature: 0 to 40°C /Storage temperature: -20 to 60°C Operating humidity/storage humidity: 20 to 80% RH (no condensation) Resistance to vibration: 24.5 m/s^2 (frequency 10 to 400 Hz) Shock resistance: 294 m/s^2 No dust, metal powder, corrosive gas, inflammable gas, or oil mist. To be used indoors, no direct sunlight. Altitude: less than 1,000 m above sea level								
Motor insulation		Insulation resistance: 100 MΩ or more (by 500VDC insulation tester) Dielectric strength: 500VAC/1 min Insulation class: B								
Safety standard compliance		CE marking								
Mounting direction		Can be installed in any direction.								

Note 1: The table shows the output shaft values of the actuators.
Note 2: The value when combined with a HA-680 driver.
Note 3: All values are typical.
Note 4: The value of the detector resolution is (motor shaft encoder quadruplicate resolution) x (reduction ratio).
Note 5: Refer to the HA-680 driver manual for further details.
Note 6: The 24 V input voltage model does not support the absolute encoder. It will combine with the incremental encoder.

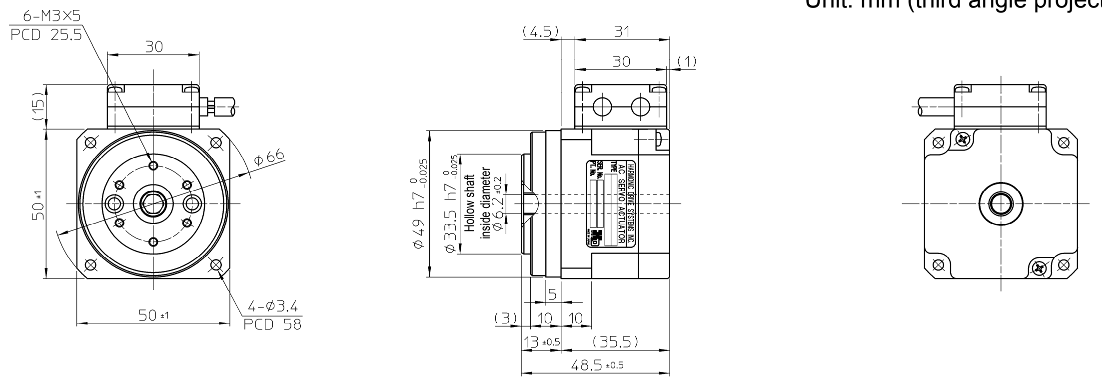
1-5 External drawing

The external drawings of FHA-C mini series actuators are shown below.

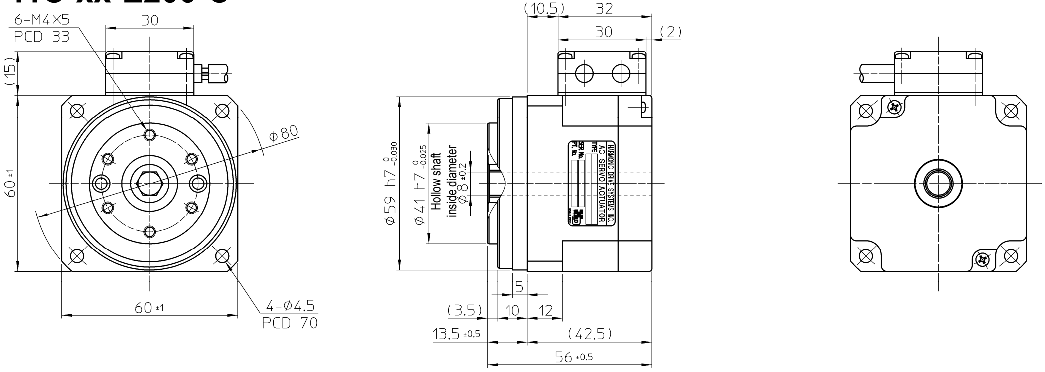
Side-leading cables (standard specification/incremental encoder model)

FHA-8C-xx-E200-C

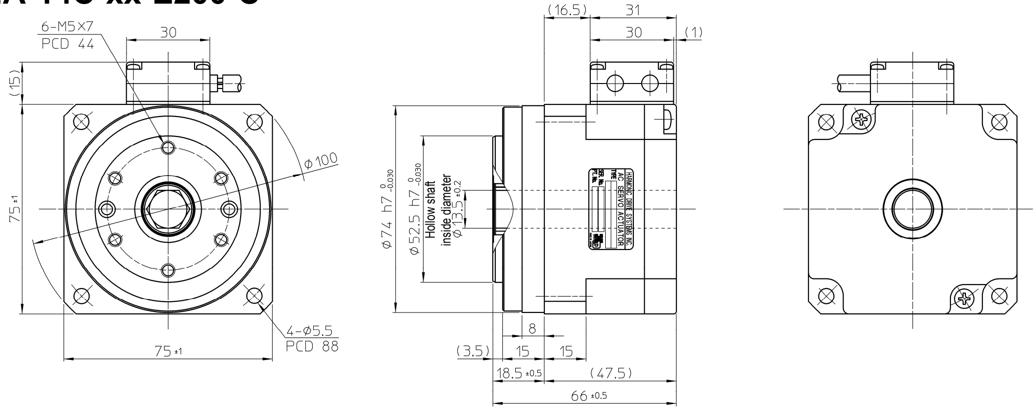
Unit: mm (third angle projection)



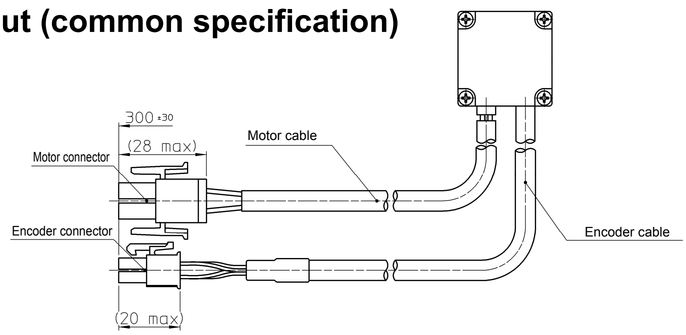
FHA-11C-xx-E200-C



FHA-14C-xx-E200-C



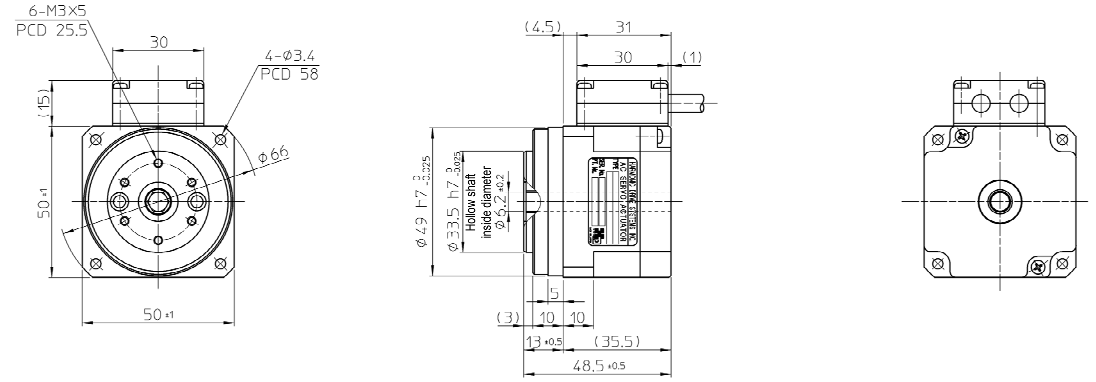
Cable pullout (common specification)



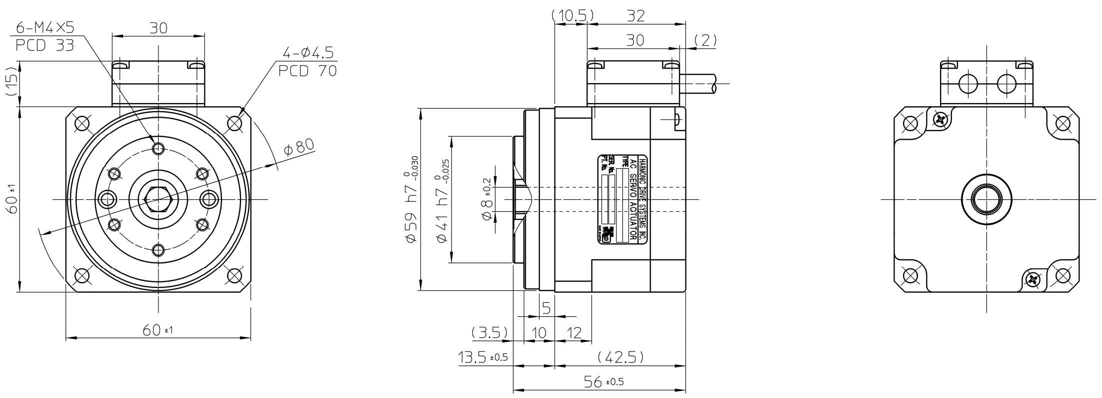
Side-leading rear cables (option specification/incremental encoder model)

FHA-8C-xx-E200-CK

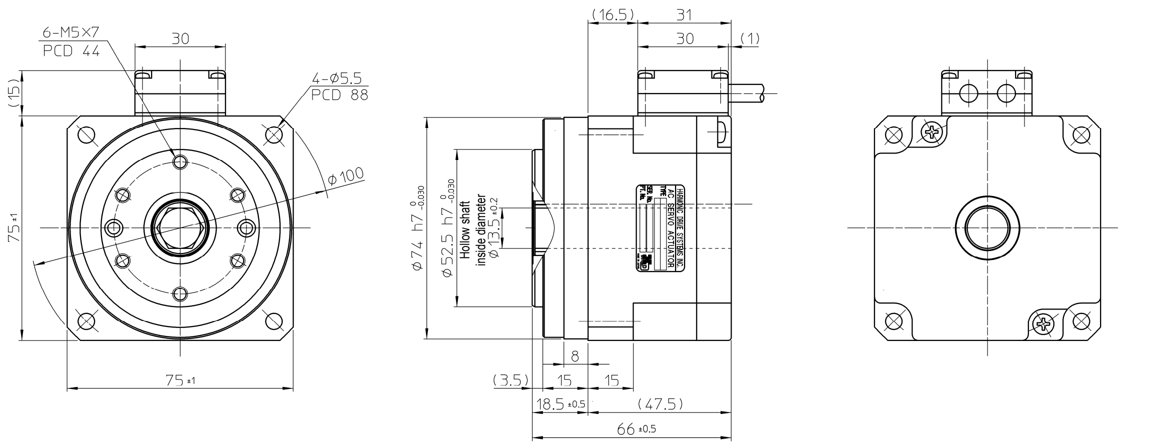
Unit: mm (third gle projection)



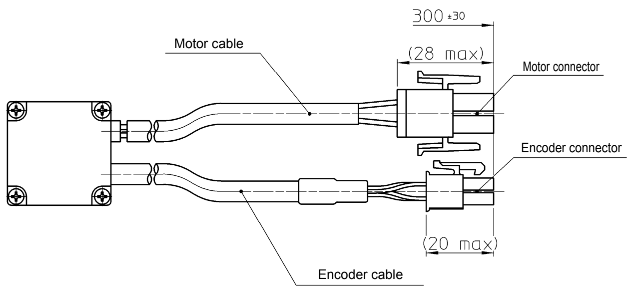
FHA-11C-xx-E200-CK



FHA-14C-xx-E200-CK



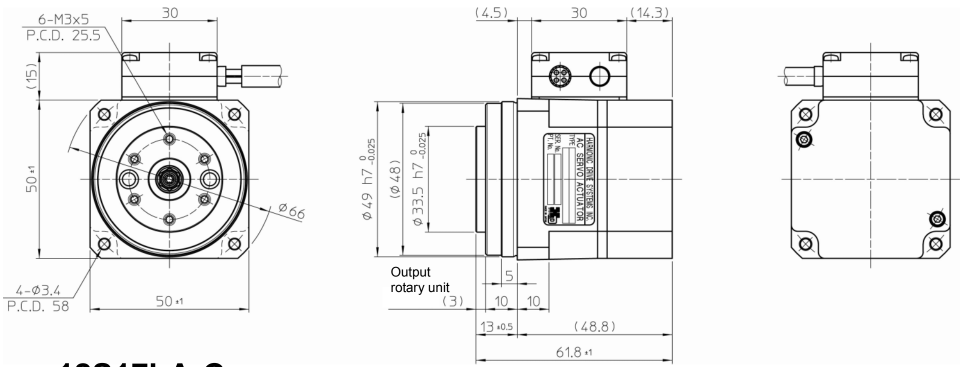
Cable pullout (common specification)



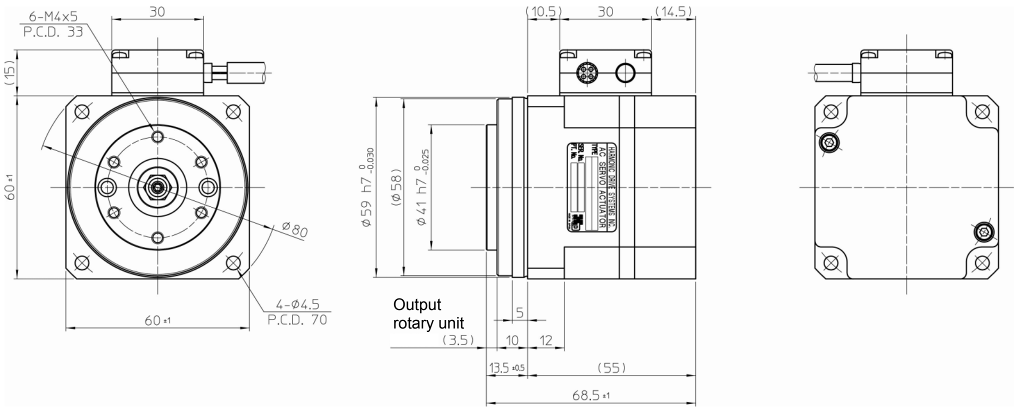
Side-leading cables (standard specification/absolute encoder model)

FHA-8C-xx-12S17bA-C

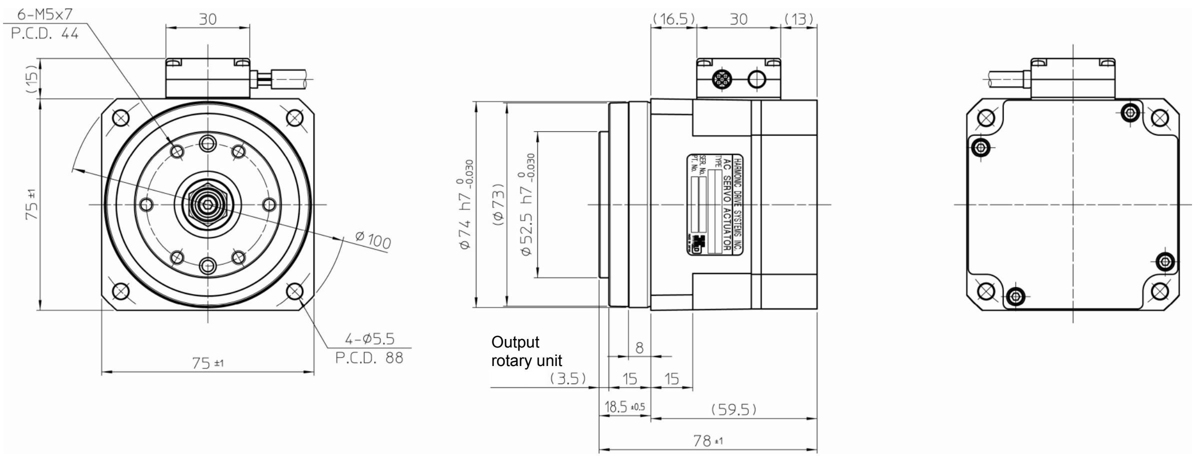
Unit: mm (third angle projection)



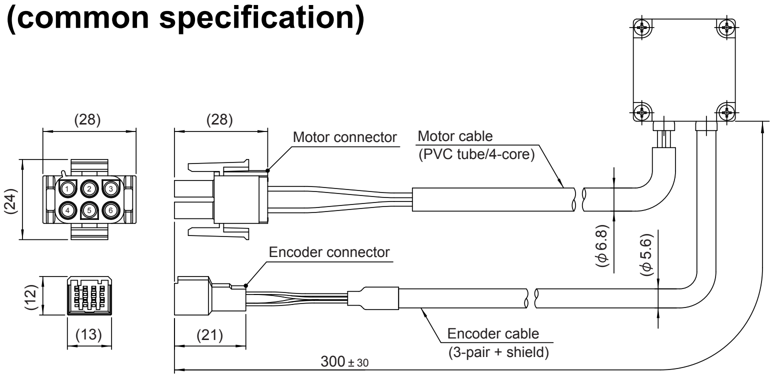
FHA-11C-xx-12S17bA-C



FHA-14C-xx-12S17bA-C



Cable pullout (common specification)



1-6 Mechanical accuracy

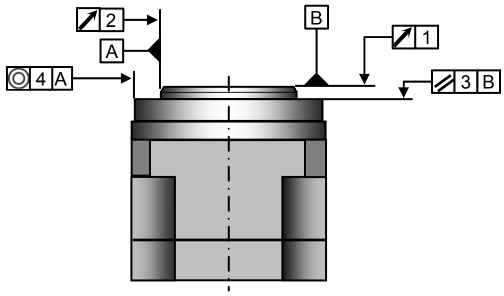
The mechanical accuracies of the output shaft and mounting flange are shown below for FHA-C mini series actuators.

Mechanical accuracy

Unit: mm

Accuracy items	FHA-8C	FHA-11C	FHA-14C
1. Output shaft surface runout	0.010		
2. Deflection of output shaft	0.010		
3. Parallelism between the output shaft end mounted surface	0.040		
4. Concentricity between the output shaft and fitting part	0.040		

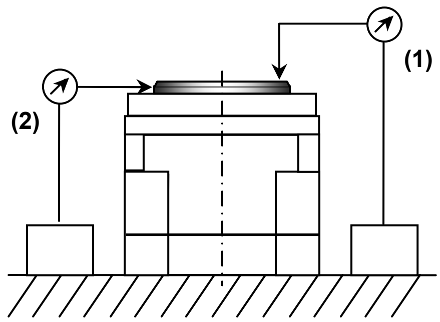
Note: All values are T.I.R. (Total Indicator Reading).



The measuring for the values are as follows:

1 Output shaft surface runout

The dial gauge on the fixed part measures the axial runout (maximum runout width) of the outermost periphery of output shaft of the output rotary unit per revolution.

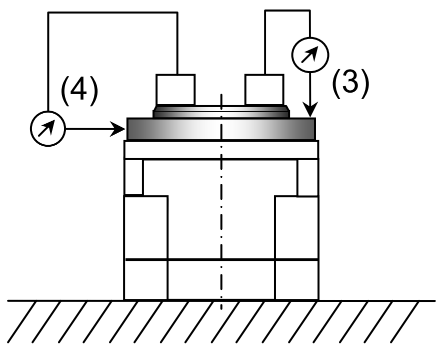


2 Deflection of output shaft

The dial gauge on the fixed part measures the radial runout (maximum runout width) of output shaft of the output rotary unit per revolution.

3 Parallelism between the output shaft end mounted surface

The dial gauge on the output rotary unit measures the axial runout (maximum runout width) of the outermost periphery of the mounting surface (both on the output shaft side and opposite side) of the output rotary unit per revolution.

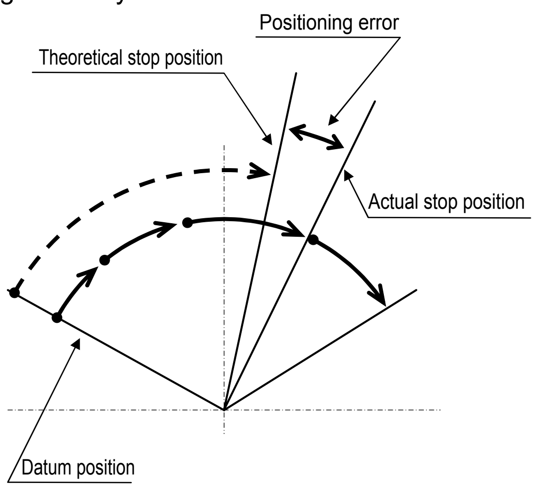


4 Concentricity between the output shaft and fitting part

The dial gauge on the output rotary unit measures the radial runout (maximum runout width) of the fitting part of the output rotary unit per revolution.

1-7 Uni-directional positional accuracy

The uni-directional positional accuracy means the maximum positional difference between the actual rotated angle from the datum position and its theoretical rotational angle in 1 revolution when series of positionings are performed in the same rotation direction.
(refer to JIS B-6201-1987.)
FHA-C mini series actuators house speed reducer HarmonicDrive® for precision control, so the positioning error of the motor shaft is compressed to 1/30, 1/50 or 1/100 by the gearing. The actual angle transmission error of the speed reducer determines the uni-directional positional accuracy. Therefore, the measurement value of the angle transmission error of the speed reducer is expressed as the uni-directional positioning accuracy of the FHA-C mini series.



The uni-directional positional accuracy is shown in the table below:

Item \ Model		FHA-8C			FHA-11C			FHA-14C		
		-30	-50	-100	-30	-50	-100	-30	-50	-100
Uni-directional positional accuracy	Sec. (angle)	150	120	120	120	90	90	120	90	90

Angle correction function during horizontal indexing

The FHA-C mini series driver provides an angle compensation function. This function analyzes the angle transmission error of the HarmonicDrive® beforehand and compensates for this erroneous difference to improve uni-directional positioning accuracy. The function improves the value of the uni-directional positional accuracy by 30% or more. For large fluctuant loads, check that the function is effective before applying it. (Refer to the driver manual on how to use this function.)

1-8 Detector resolution

The motors of the FHA-C mini series actuators are equipped with an incremental encoder of 2,000 pulses per revolution, and an absolute encoder of 131,072 pulses per revolution. The function reduces the motor output to 1/30, 1/50 and 1/100 by using a speed reducer HarmonicDrive® for precision control. The resolution per revolution is 30, 50 or 100 times. Additionally, the incremental encoder signal has a x4 electrical interpolation.
The high resolutions obtained from the information above are summarized in the table below.

Incremental encoder

Item \ Model		FHA-8C FHA-11C FHA-14C -30	FHA-8C FHA-11C FHA-14C -50	FHA-8C FHA-11C FHA-14C -100
Encoder resolution		2,000 (8,000 pulse/rev: quadruplicate)		
Reduction ratio		30	50	100
Detector resolution (quadruplicate)	**Pulse/rev**	240,000	400,000	800,000
Resolvable angle per pulse (approximate value)	**Sec.**	5.40	3.24	1.62

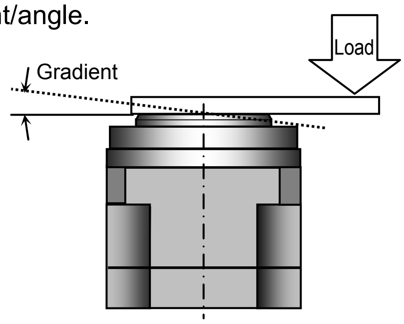
Absolute encoder

Item \ Model		FHA-8C FHA-11C FHA-14C -30	FHA-8C FHA-11C FHA-14C -50	FHA-8C FHA-11C FHA-14C -100
Encoder resolution		2^{17} (131,072 pulse/rev)		
Reduction ratio		30	50	100
Detector resolution (quadruplicate)	**Pulse/rev**	3,932,160	6,553,600	13,107,200
Resolvable angle per pulse (approximate value)	**Sec.**	Approx. 0.33	Approx. 0.2	Approx. 0.1

1-9 Rigidity

Moment stiffness

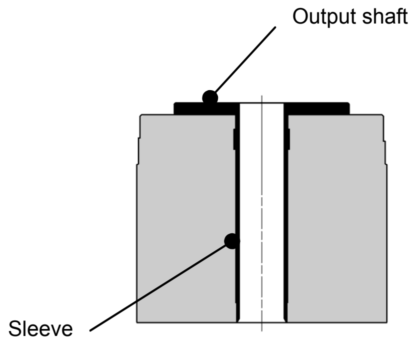
The moment stiffness refers to the torsional stiffness when a moment load is applied to the output shaft of the actuator (shown below).
For example, when a load is applied to the end of an arm attached on the actuator output shaft, the face of the output shaft tilts in proportion to the moment load (shown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



Item \ Model		FHA-8C	FHA-11C	FHA-14C
Moment stiffness	N·m/rad	2 x 10^4	4 x 10^4	8 x 10^4
	kgf·m/rad	0.2 x 10^4	0.4 x 10^4	0.8 x 10^4
	kgf·m/arc min	0.59	1.2	2.4

CAUTION

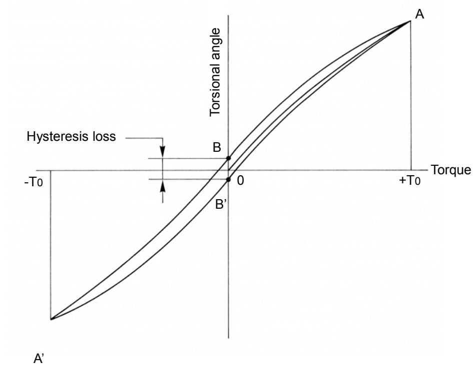
Do not apply torque or load to the hollow shaft (sleeve).
The hollow shaft (sleeve) is adhered to the output rotary shaft. When a load is applied to the hollow shaft (sleeve), delamination may occur on the output shaft and hollow shaft (sleeve).
Do not apply or use any torque, moment load or thrust load directly to the hollow shaft (sleeve).
* The shape of the hollow shaft will only support the incremental encoder.



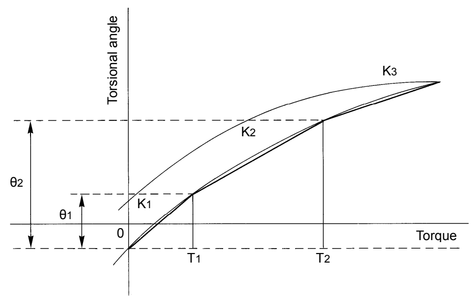
Rotation direction torsional stiffness

If a torque is applied to the output shaft of the actuator with the servo locked, the output shaft generates a torsional stress roughly in proportion to the torque.

The upper right figure shows the torsional angle of the output shaft when a torque starting from zero and increased to positive side [+T_0] and negative side [–T_0] is applied to the output shaft. This is called [torque vs. torsional angle] diagram, which typically follows a loop 0→A→B→A'→B'→A. The torsional rigidity of the FHA-C mini series actuator is expressed by the slope of this [torque vs. torsional angle] diagram representing a spring constant (unit: N·m/rad).



As shown by lower right figure, this [torque vs. torsional angle] diagram is divided into 3 regions and the spring constants in these regions are expressed by K_1, K_2, and K_3, respectively.
K_1: Spring constant for torque region 0 to T_1
K_2: Spring constant for torque region T_1 to T_2
K_3: Spring constant for torque region over T_2



The torsional angle for each region is expressed as follows:

*φ : Torsional angle

- Range where torque T is T1 or below: $\varphi = \frac{T}{K_1}$
- Range where torque T is T1 to T2: $\varphi = \theta_1 + \frac{T - T_1}{K_2}$
- Range where torque T is T_2 or above: $\varphi = \theta_2 + \frac{T - T_2}{K_3}$

The table below shows the average value of each actuator.

Item	Model	FHA-8C			FHA-11C			FHA-14C		
		-30	-50	-100	-30	-50	-100	-30	-50	-100
T_1	N·m	0.29	0.29	0.29	0.80	0.80	0.80	2.0	2.0	2.0
	kgf·m	0.030	0.030	0.030	0.082	0.082	0.082	0.20	0.20	0.2
K_1	$\times 10^4$ N·m/rad	0.034	0.044	0.091	0.084	0.22	0.27	0.19	0.34	0.47
	kgf·m/arc min	0.010	0.013	0.027	0.025	0.066	0.080	0.056	0.10	0.14
θ_1	$\times 10^{-4}$ rad	8.5	6.6	3.2	9.5	3.6	3.0	10.5	5.8	4.1
	arc min	3.0	2.3	1.1	3.3	1.2	1.0	3.6	2.0	1.4
T_2	N·m	0.75	0.75	0.75	2.0	2.0	2.0	6.9	6.9	6.9
	kgf·m	0.077	0.077	0.077	0.20	0.20	0.20	0.70	0.70	0.7
K_2	$\times 10^4$ N·m/rad	0.044	0.067	0.10	0.13	0.30	0.34	0.24	0.47	0.61
	kgf·m/arc min	0.013	0.020	0.031	0.037	0.090	0.10	0.07	0.14	0.18
θ_2	$\times 10^{-4}$ rad	19	13	8	19	8	6	31	16	12
	arc min	6.6	4.7	2.6	6.5	2.6	2.2	10.7	5.6	4.2
K_3	$\times 10^4$ N·m/rad	0.054	0.084	0.12	0.16	0.32	0.44	0.34	0.57	0.71
	kgf·m/arc min	0.016	0.025	0.036	0.047	0.096	0.13	0.10	0.17	0.21

The table below shows reference torque values calculated for different torsional angles. (Unit: N·m)

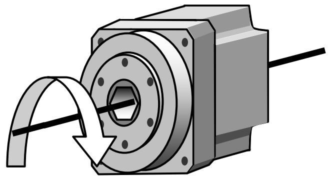
Torsional angle (arc min) \ Model	FHA-8C			FHA-11C			FHA-14C		
	-30	-50	-100	-30	-50	-100	-30	-50	-100
2	0.20	0.25	0.56	0.49	1.3	1.8	1.1	2.0	3.0
4	0.42	0.63	1.2	1.1	3.3	4.2	2.3	4.7	6.5
6	0.68	1.1	1.9	1.8	5.2	6.8	3.6	7.6	11

1-10 Rotation direction

Forward rotation direction of the actuator is defined as clockwise (CW) rotation as viewed from the output shaft side when a forward command is given to a FHA-C mini series actuator from a driver.
This rotation direction can be changed on the driver by selecting [Parameter settings]. For details on the settings, refer to the manual of your driver.

Setting of the [Parameter: Rotation direction] driver

Set value	Forward input	Reverse input	Setting
0	FWD rotation	Reverse	Default
1	Reverse	FWD rotation	



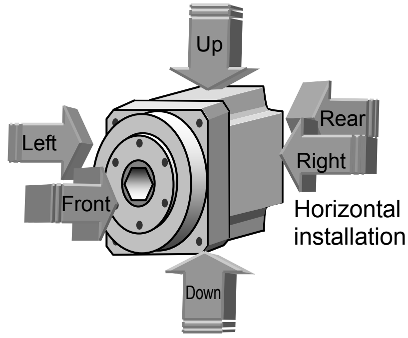
FWD rotation: Clockwise direction

1-11 Shock resistance

The shock acceleration when applying a impact in the up/down and left/right directions with the center shaft of the actuator installed horizontally is as follows.

Shock acceleration: 294 m/s^2
Direction: top/bottom, right/left, front/back
Repeating times: three each

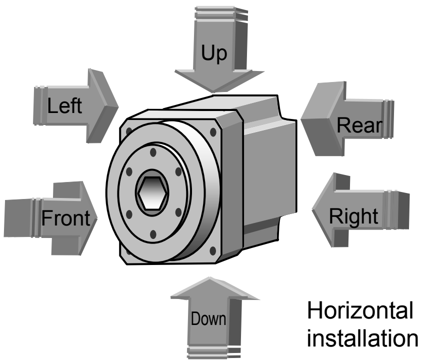
However, never apply a direct impact to the output shaft.



Shock resistance test

1-12 Resistance to vibration

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: 24.5 m/s^2 (frequency: 10 to 400Hz)
This specification does not have a warranty period and terms against fletting wear of mechanical parts due to micro-vibration.



Resistance to vibration test

1-13 Operable range

The graphs below show the operable range when a FHA-C mini series actuator and an HA-800 or HA-680 driver combination is selected. Refer to [Chapter 2 Selection guidelines] for the most efficient use of FHA-C mini series actuators' output.

(1) Continuous motion range

The range allows continuous operation for the actuator.

(2) 50% duty motion range

This range indicates the torque rotation speed which is operable in the 50% duty operation (the ratio of operating time and delay time is 50:50). Refer to p2-10 [Duty cycles] for information on duty.

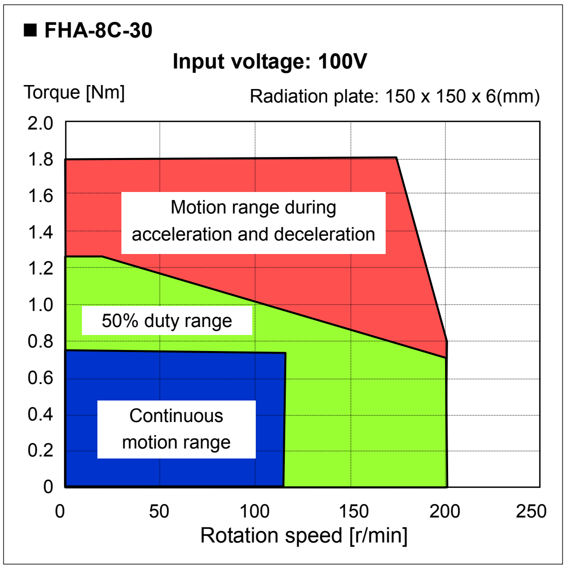
(3) Motion range during acceleration and deceleration

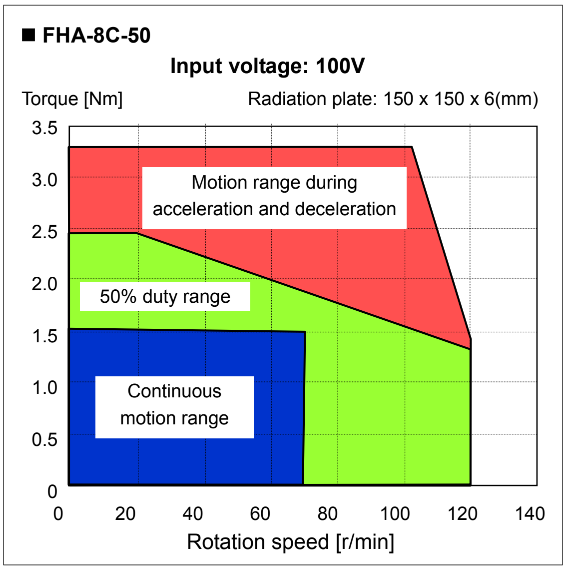
This range indicates the torque rotation speed which is operable momentarily. The range allows instantaneous operation like acceleration and deceleration, usually.

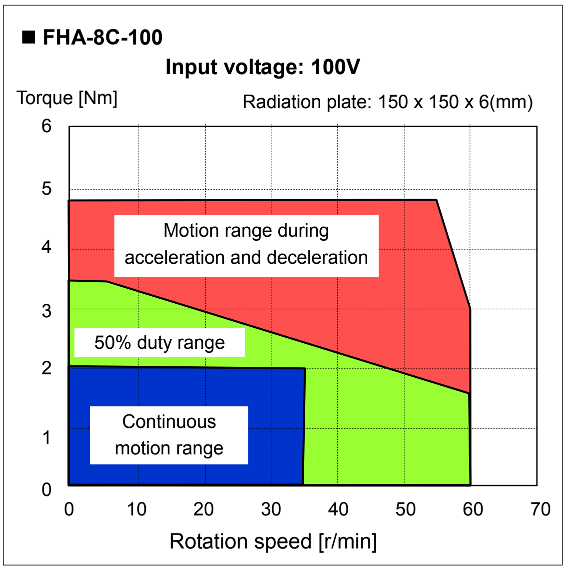
The continuous and 50% duty motion ranges shown on each graph are measured on the condition where the radiation plate specified in the graph is installed.

FHA-8C

- **100V**





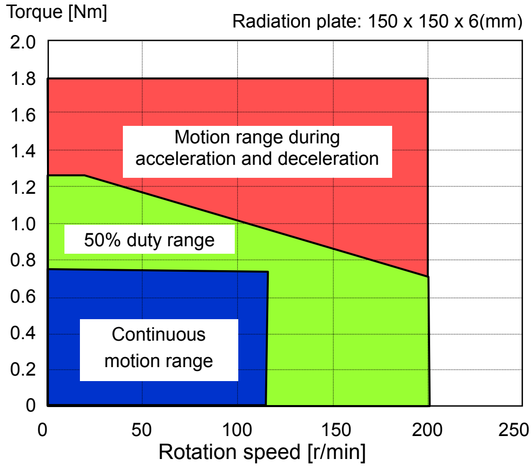


Note: If you are continuously using a single direction for the continuous motion range, please consult us.

● 200V

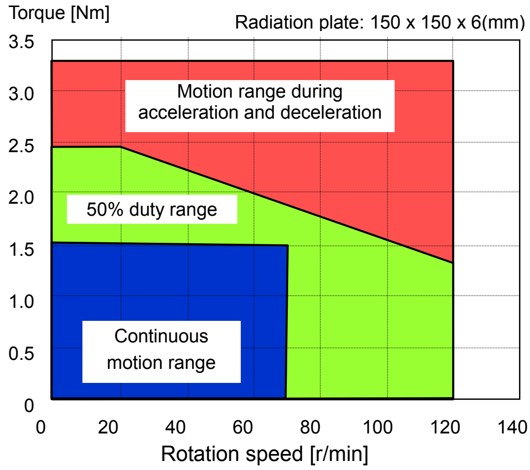
■ FHA-8C-30

Input voltage: 200V



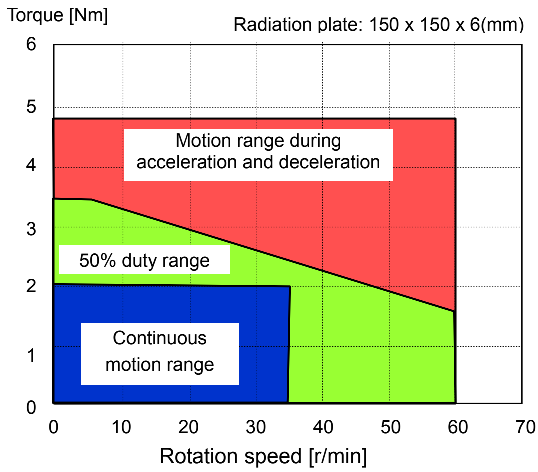
■ FHA-8C-50

Input voltage: 200V



■ FHA-8C-100

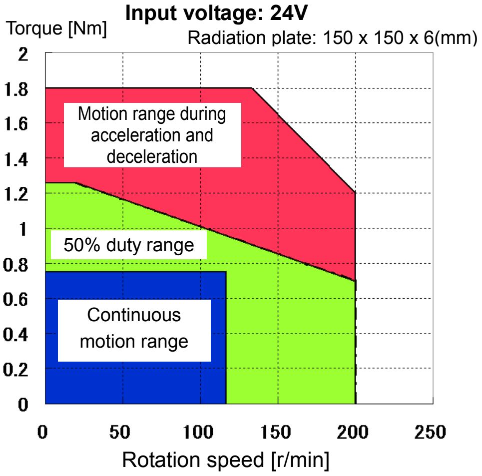
Input voltage: 200V



● 24V

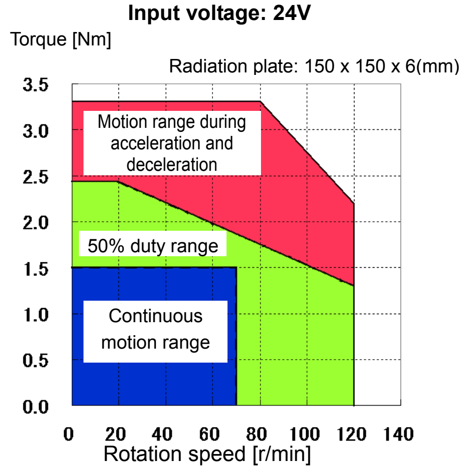
■FHA-8C-30

Input voltage: 24V



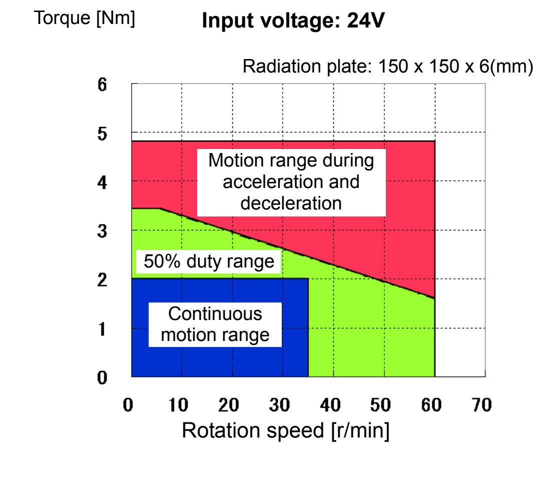
■FHA-8C-50

Input voltage: 24V



Note: If you are continuously using a single direction for the continuous motion range, please consult us.

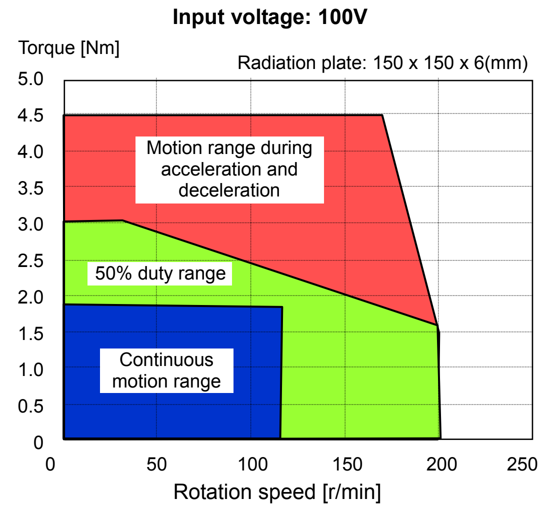
■FHA−8C−100



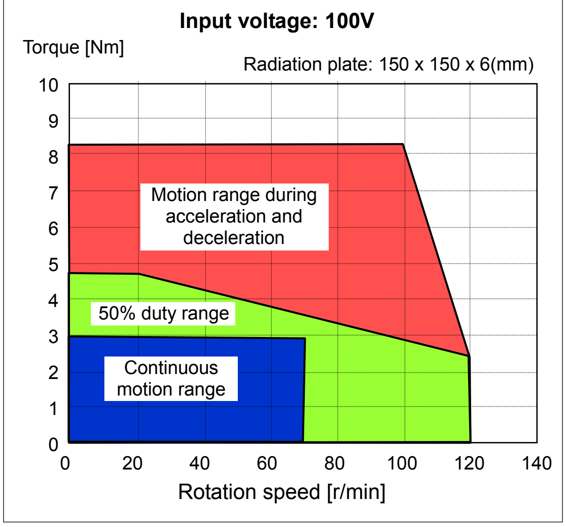
FHA-11C

● **100V**

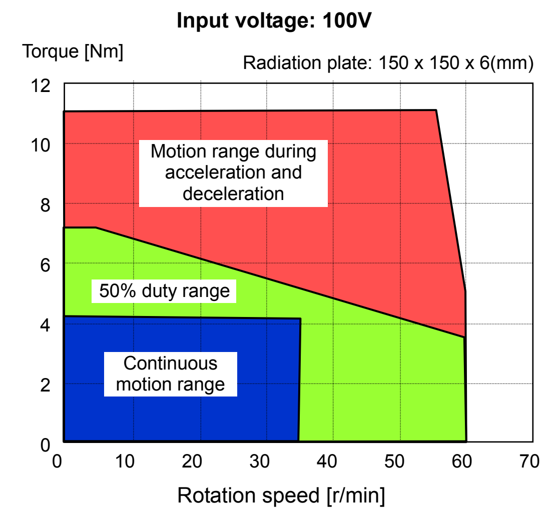
■ FHA-11C-30



■ FHA-11C-50

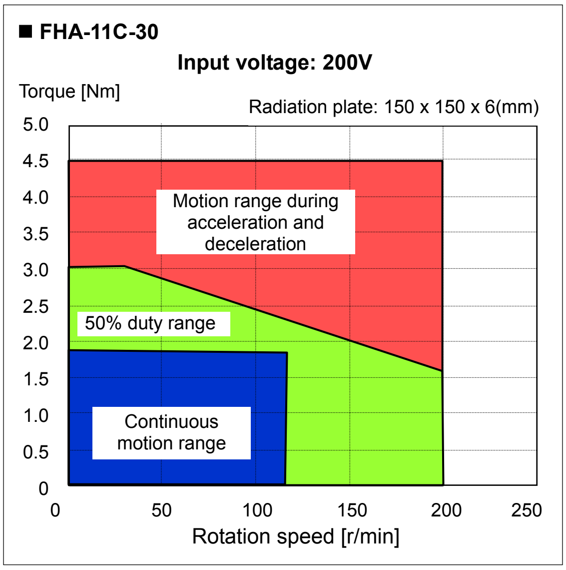


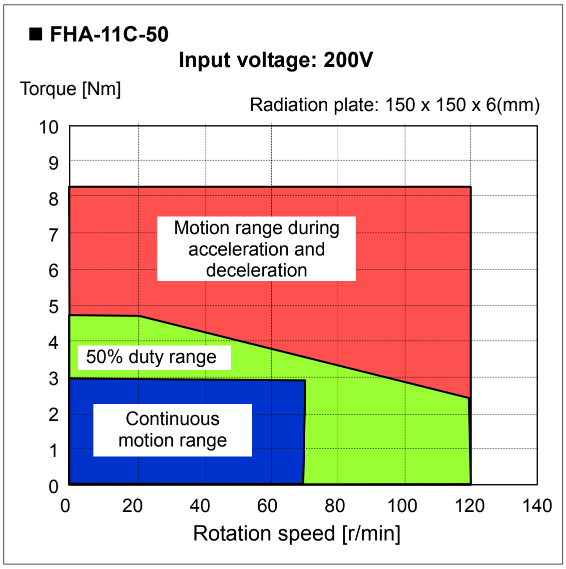
■ FHA-11C-100

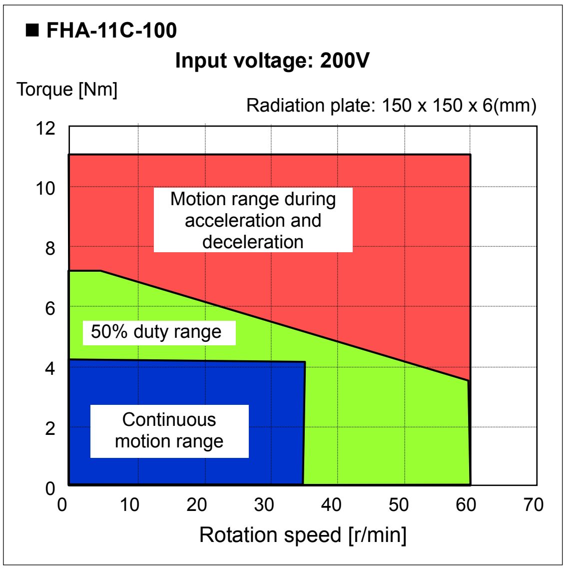


Note: If you are continuously using a single direction for the continuous motion range, please consult us.

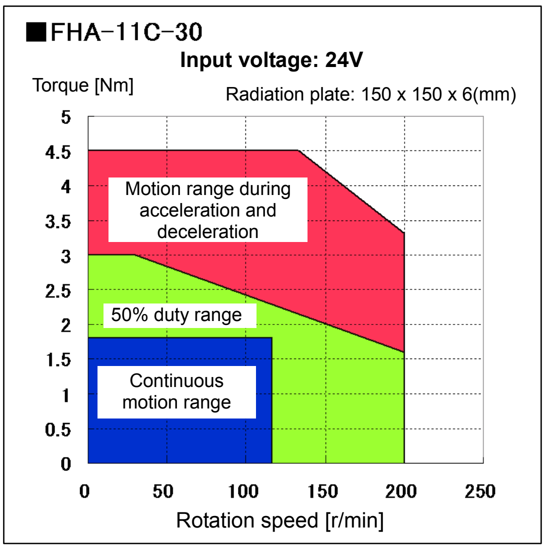
● 200V

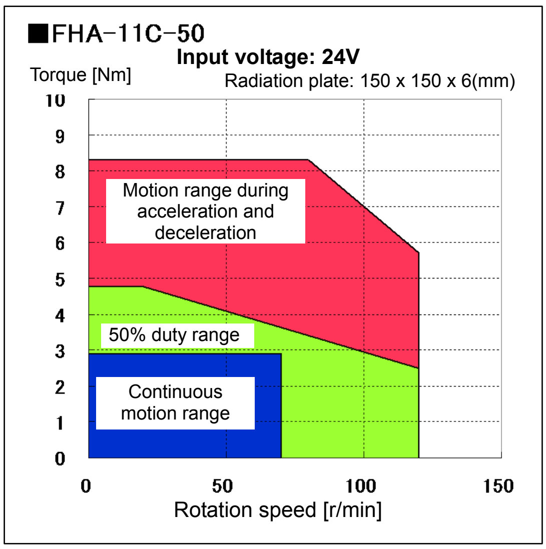




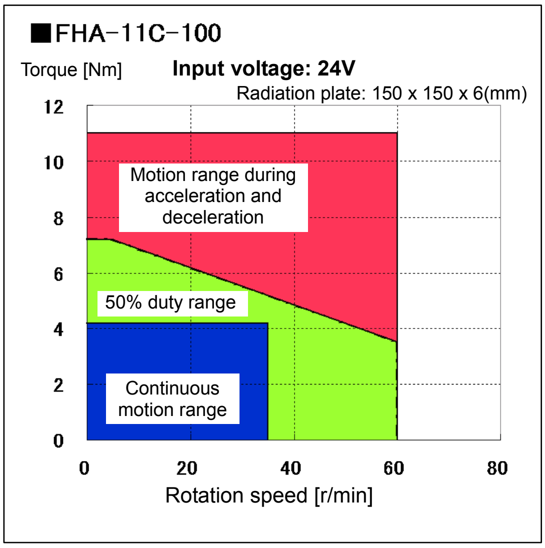


● 24V



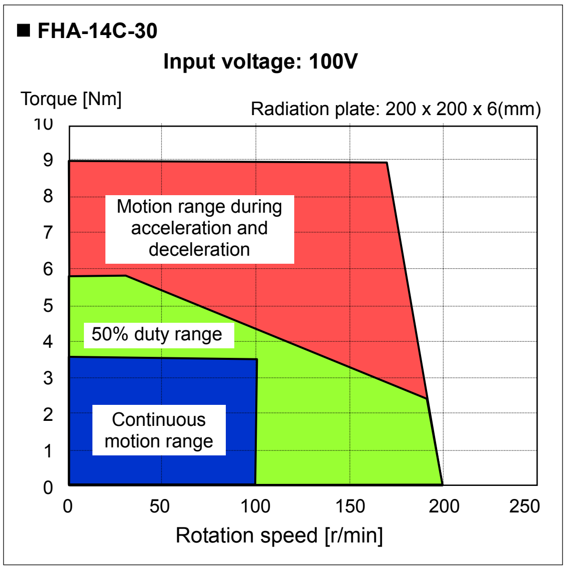


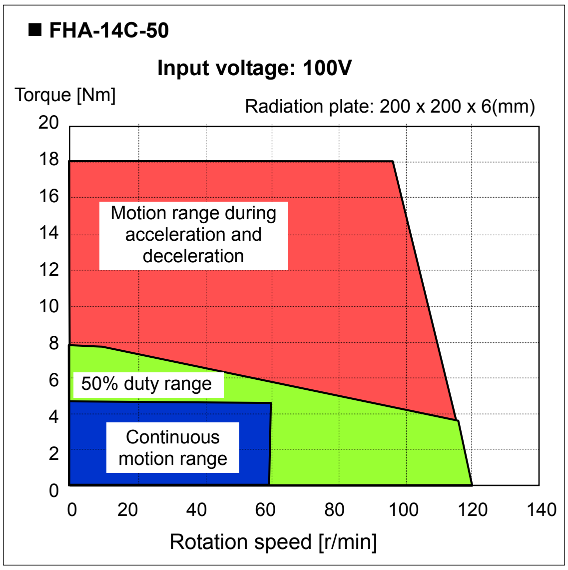
Note: If you are continuously using a single direction for the continuous motion range, please consult us.

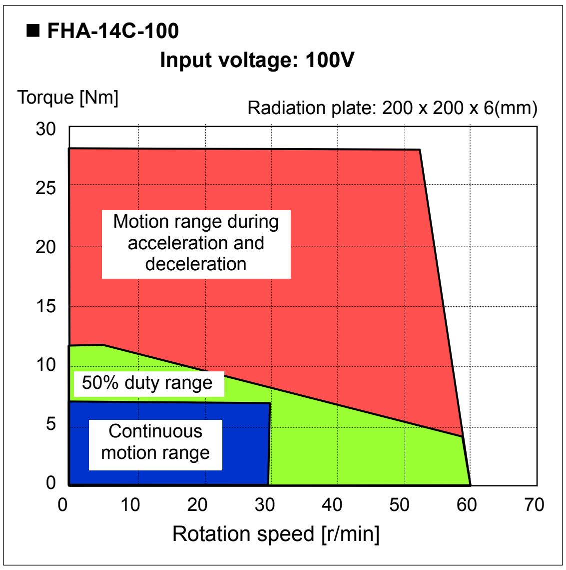


FHA-14C

● 100V

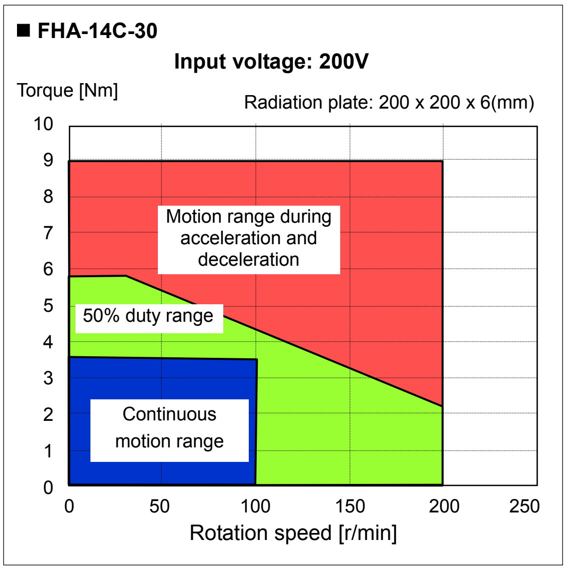


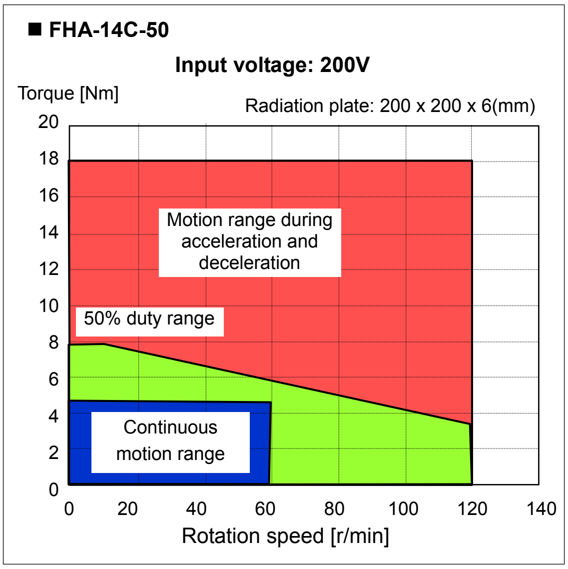


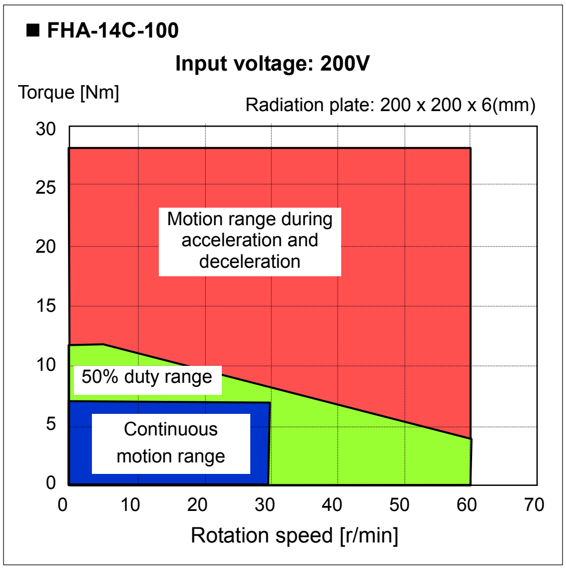


Note: If you are continuously using a single direction for the continuous motion range, please consult us.

● 200V

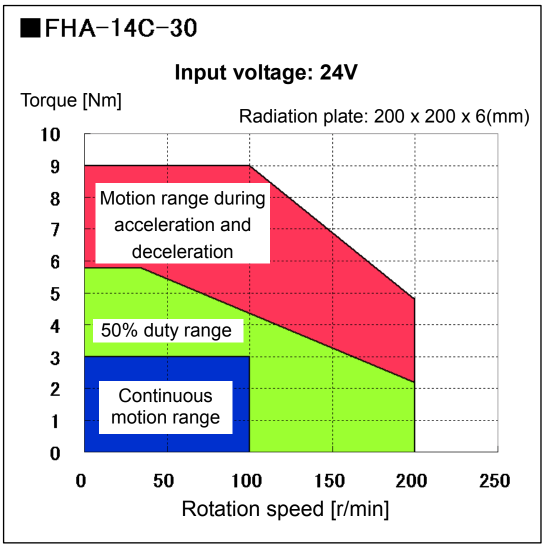


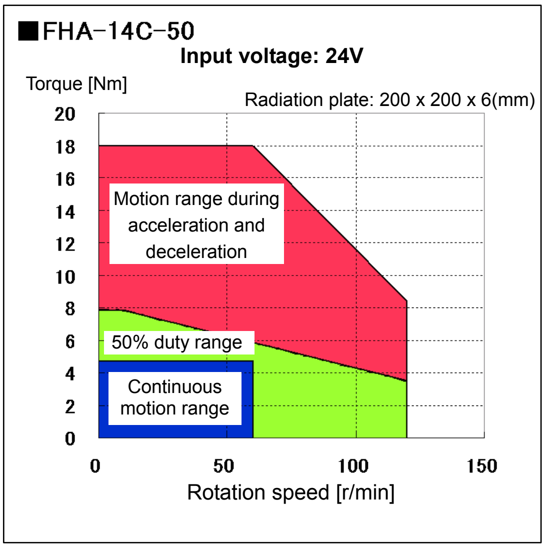


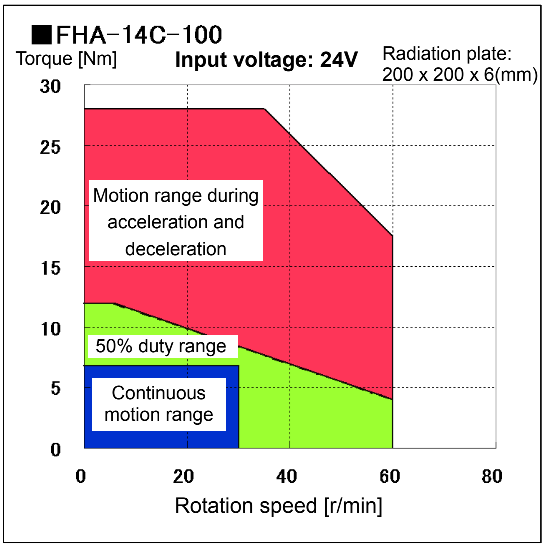


Note: If you are continuously using a single direction for the continuous motion range, please consult us.

- **24V**







Note: If you are continuously using a single direction for the continuous motion range, please consult us.

1-14 Cable specifications

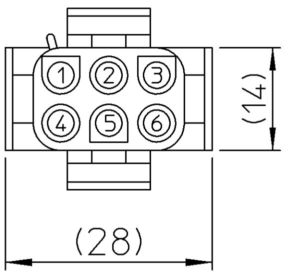
The following tables show specifications of the motor and encoder cables of the FHA-C mini series actuators.

Motor power cable

- **Pin layout**

Pin No.	Color	Motor cable
1	Red	Motor phase-U
2	White	Motor phase-V
3	Black	Motor phase-W
4	Green/Yellow	PE
5	—	—
6	—	—

- **Pin position**



Connector model: 350715-1
Pin model: 3506901 (E: 770210-1)
by AMP

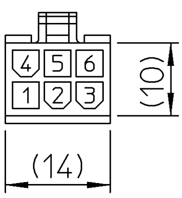
Encoder cable

- **Incremental encoder**

Pin layout

Pin No.	Color	Signal name	Remarks
1	Red	+5V	Power input
2	Black	0V	
3	Yellow	SD	Serial signal differential output
4	Blue	$\overline{SD}$	
5	—	—	
6	Shield	FG	

Pin position



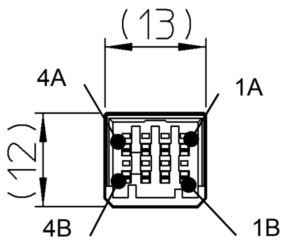
Connector model: Receptacle: 5557-06R
Terminal: 5556
by Molex Japan Co., Ltd.,

● Absolute encoder

Pin layout

Pin No.	Color	Signal name	Remarks
1A	White	Vcc	Power supply input +5V
1B	Black	GND(Vcc)	Power supply input 0V (GND)
2A	Blue	SD+	Serial signal differential output (+)
2B	Purple	SD-	Serial signal differential output (-)
3A	—	No connection	—
3B	Shield	FG	
4A	Orange	Vbat	Battery +
4B	Brown	GND(bat)	Battery - (GND)

Pin position



Connector model: 1-1903130-4
Pin model: 1903117-2
by AMP

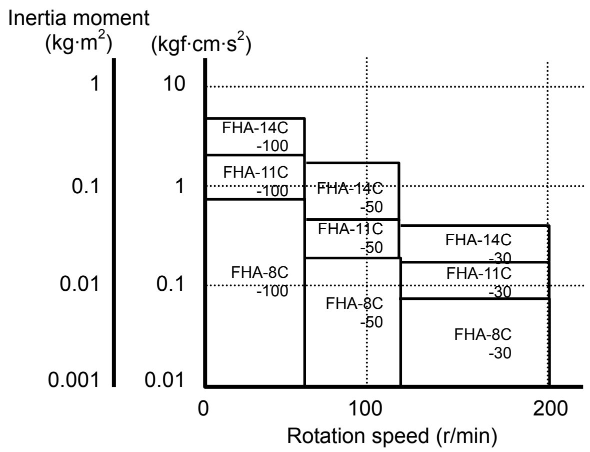
Chapter 2

Selection guidelines

The following explains the guidelines for selecting actuators.

2-1 Connecting power cables

To achieve high accuracy and performance, select a FHA-C mini series actuator where the allowable load inertia moment (reference value) specified for the applicable model No. is not exceeded.
Refer to appendix 1 (★★) for the calculation of inertia moment.



When temporarily selecting an actuator, make certain that the inertia moment and rotation speed do not exceed the allowable values shown in the table below.

Actuator model				FHA-8C			FHA-11C			FHA-14C		
				-30	-50	-100	-30	-50	-100	-30	-50	-100
Reduction ratio				30	50	100	30	50	100	30	50	100
Max. rotational speed			r/min	200	120	60	200	120	60	200	120	60
Inertia moment	INC	$(GD^2/4)$	kg·m^2	0.0026	0.0074	0.029	0.0060	0.017	0.067	0.018	0.050	0.20
		(J)	kgf·cm·s^2	0.027	0.075	0.30	0.061	0.17	0.68	0.18	0.51	2.0
	ABS	$(GD^2/4)$	kg·m^2	0.0026	0.0073	0.029	0.0062	0.017	0.069	0.019	0.054	0.215
		(J)	kgf·cm·s^2	0.027	0.0747	0.298	0.063	0.176	0.705	0.197	0.547	2.189
Allowable load inertia moment			kg·m^2	0.0078	0.022	0.087	0.018	0.051	0.20	0.054	0.15	0.60
			kgf·cm·s^2	0.081	0.23	0.90	0.18	0.51	2.0	0.54	1.5	6.0

2-2 Change in moment of inertia of load

FHA-C mini series actuators include HarmonicDrive® gearing that has a high reduction ratio. Because of this, the effects of change in load inertia moment on the servo performance are minimal. In comparison to direct servo drive mechanisms, therefore, this benefit allows the load to be driven with a better servo response.

For example, assume that the load inertia moment increases to N-times. The total inertia moment converted to motor shaft which has an effect on servo response is as follows:

The symbols in the formulas are:

J_S: Total inertia moment converted to motor shaft

J_M: Motor inertia moment

R: Reduction ratio of FHA-C mini series actuators

L: Ratio of load inertia moment to inertia moment of motor

N: Rate of change in load inertia moment

- Direct drive

Before: $Js = J_M(1+L)$ After: $Js' = J_M(1+NL)$ Ratio: $Js'/Js = \dfrac{1+NL}{1+L}$

- Driven by FHA-C mini series

Before: $Js = J_M\left(1+\dfrac{L}{R^2}\right)$ After: $Js' = J_M\left(1+\dfrac{NL}{R^2}\right)$ Ratio: $Js'/Js = \dfrac{1+NL/R^2}{1+L/R^2}$

With the FHA-C mini series, the value of R increases to 30, 50 or 100, which means that the value of R^2 increases substantially to 900, 2500 or 10000. Then the ratio is $Js'/Js \fallingdotseq 1$. This means that FHA-C mini series are hardly affected by the load variation. Therefore, it is not necessary to take change in load inertia moment into consideration when selecting a FHA-C mini series actuator or setting up the initial HA-800/HA-680 driver parameters.

2-3 Verifying and examining load weights

The FHA-C mini series actuator incorporates a precise cross roller bearing for directly supporting an external load (output flange). To demonstrate the full ability of the actuator, verify the maximum load weight as well as the life and static safety coefficient of the cross roller bearing.

Checking procedure

- **Checking the maximum load weight (M*max*, Fr*max*, Fa*max*)**
  Calculate the maximum load weight (M*max*, Fr*max*, Fa*max*)
  ↓
  Check the maximum load weight (M*max*, Fr*max*, Fa*max*) is less than or equal to the permissible loads (Mc, Fr, Fa)
- **Checking the life of the cross roller bearing**
  Calculate the average radial load (Fr*av*) and average axial load (Fa*av*).
  ↓
  Calculate the radial load coefficient (X) and the axial load coefficient (Y).
  ↓
  Calculate the life of the bearing and verify the life is allowable.
- **Verifying the static safety coefficient**
  Calculate the static equivalent radial load (Po).
  ↓
  Verify the static safety coefficient (fs).

Specifications of the main roller bearing

The following table shows the specifications of the main roller bearings built in FHA-C mini series actuators.

Table 1

Model \ Item	Pitch circle diameter of a roller (dp)	Offset amount (R)	Basic dynamic rated load (C)	Basic static rated load (Co)	Permissible axial load (Fa)	Permissible moment capacity (Mc)
	mm	mm	N	N	N	N·m
FHA-8C	35	12.9	5800	8000	200	15
FHA-11C	42.5	14	6500	9900	300	40
FHA-14C	54	14	7400	12800	500	75

Maximum load weight

The table below shows how to calculate the maximum load weight (M*max*, Fr*max*, Fa*max*).
Confirm that each maximum load weight is less than or equal to each permissible load.

◆ Formula (1)

$$M_{max}=Fr_{max}(Lr+R)+Fa_{max}\cdot La$$

Symbols used in the formulas

M*max*	Max. moment capacity	N·m(kgf·m)	
Fr*max*	Max. radial load	N(kgf)	See Fig.1.
Fa*max*	Max. axial load	N(kgf)	See Fig.1.
Lr ,La	———	mm	See Fig.1.
R	Offset amount	mm	See Fig.1 and Table 1.

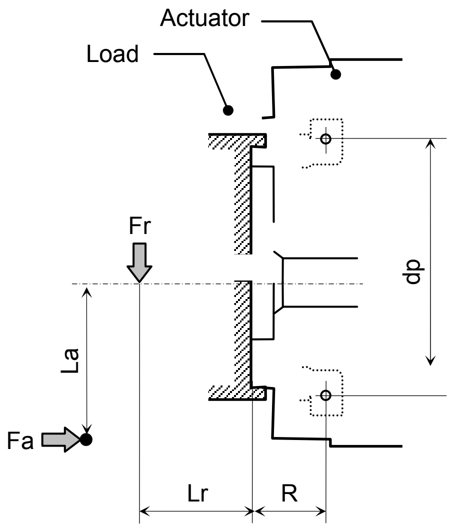


Fig. 1: External load action diagram

Calculating average loads (average radial and axial loads, average output rotational speed)

When the radial and/or axial loads vary during motion, calculate and verify the life of the cross roller bearing converting the loads to their average values.

◆ **Formula (2): Average radial load (Frav)**

$$Fr_{av}=\sqrt[10/3]{\frac{n_1t_1|Fr_1|^{10/3}+n_2t_2|Fr_2|^{10/3}\cdots n_nt_n|Fr_n|^{10/3}}{n_1t_1+n_2t_2+\cdots+n_nt_n}}$$

The maximum radial load in section t_1 is given by Fr_1, while the maximum radial load in section t_3 is given by Fr_3.

◆ **Formula (3): Average axial load (Faav)**

$$Fa_{av}=\sqrt[10/3]{\frac{n_1t_1|Fa_1|^{10/3}+n_2t_2|Fa_2|^{10/3}\cdots n_nt_n|Fa_n|^{10/3}}{n_1t_1+n_2t_2+\cdots+n_nt_n}}$$

The maximum axial load in section t_1 is given by Fa_1, while the maximum axial load in section t_3 is given by Fa_3.

◆ **Formula (4): Average output rotational speed (Nav)**

$$N_{av}=\frac{n_1t_1+n_2t_2+\cdots+n_nt_n}{t_1+t_2+\cdots+t_n}$$

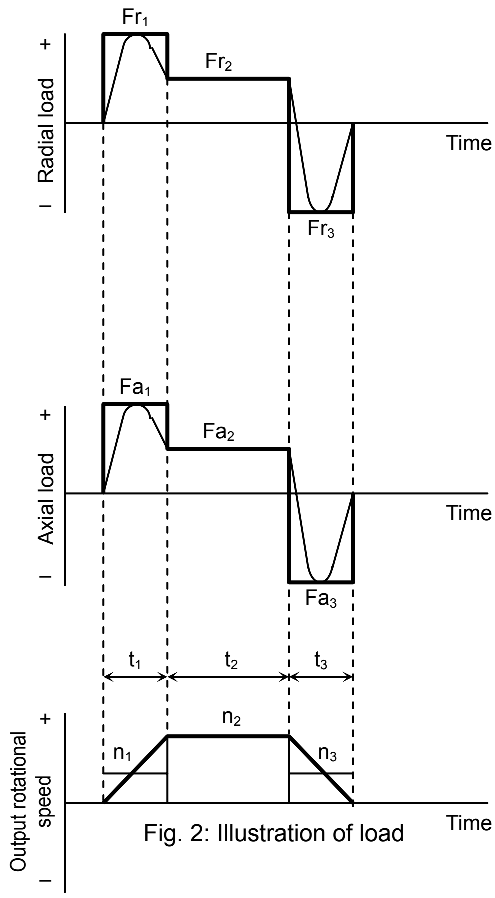


Fig. 2: Illustration of load

Radial load coefficient and axial load coefficient

Table 2: Radial load coefficient (X), axial load coefficient (Y)

◆ **Formula (5)**	X	Y
$\frac{Fa_{av}}{Fr_{av}+2(Fr_{av}(Lr+R)+Fa_{av}\cdot La)/dp}\leq 1.5$	1	0.45
$\frac{Fa_{av}}{Fr_{av}+2(Fr_{av}(Lr+R)+Fa_{av}\cdot La)/dp}> 1.5$	0.67	0.67

Symbols used in the formulas

Fr*av*	Average radial load	N(kgf)	Refer to the average load.
Fa*av*	Average axial load	N(kgf)	Refer to the average load.
Lr ,La	————	m	See Fig.1.
R	Offset amount	mm	See Fig.1 and Table 1.
dp	Pitch circle diameter of a roller	mm	See Fig.1 and Table 1.

2

Selection guidelines

Dynamic equivalent radial load

◆ **Formula (6): Dynamic equivalent radial load**

$$Pc = X \cdot \left(Fr\,av + \frac{2(Fr\,av\,(Lr + R) + Fa\,av \cdot La)}{dp} \right) + Y \cdot Fa\,av$$

Symbols used in the formulas

Pc	Dynamic equivalent radial load	N(kgf)	
Fr*av*	Average radial load	N(kgf)	Obtained by formula (2).
Fa*av*	Average axial load	N(kgf)	Obtained by formula (3).
dp	Pitch circle diameter of a roller	mm	See Table 1.
X	Radial load coefficient	—	See Table 2.
Y	Axial load coefficient	—	See Table 2.
Lr, La	—	mm	See Fig.1.
R	Offset amount	mm	See Fig.1 and Table 1.

Life of cross roller bearing

Calculate the life of cross roller bearing with the formula (7) below:

◆ **Formula (7): Cross roller bearing life**

$$L_{B-10} = \frac{10^6}{60 \times N\,av} \times \left(\frac{C}{fw \cdot Pc} \right)^{10/3}$$

Symbols used in the formulas

L_{B-10}	Life	hour	—
N*av*	Average output rotational speed	r/min	Obtained by formula (4).
C	Basic dynamic rated load	N(kgf)	See Table 1.
Pc	Dynamic equivalent radial load	N(kgf)	Obtained by formula (6).
fw	Load coefficient	—	See Table 3.

Table 3 Load coefficient

Loaded state	fw
Smooth operation free from impact/vibration	1 to 1.2
Normal operation	1.2 to 1.5
Operation subject to impact/vibration	1.5 to 3

Cross roller bearing life based on oscillating movement

Use formula (8) to calculate the cross roller bearing life against oscillating movement.

◆ **Formula (8): Cross roller bearing life (oscillating)**

$$Loc = \frac{10^6}{60 \times n_1} \times \frac{90}{\theta} \times \left(\frac{C}{fw \cdot Pc} \right)^{10/3}$$

Symbols used in the formulas

Loc	Life	hour	—
n_1	Number of reciprocating oscillation per min.	cpm	—
C	Basic dynamic rated load	N(kgf)	See Table 1.
Pc	Dynamic equivalent radial load	N(kgf)	Obtained by formula (6).
fw	Load coefficient	—	See Table 3.
θ	Oscillating angle/2	—	See Fig.3.

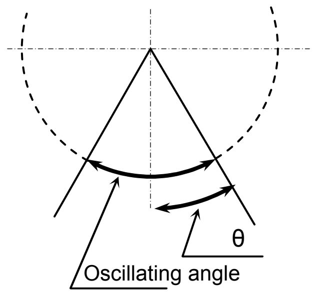


Fig. 3: Oscillating movement

If the oscillating angle is 5° or less, fretting wear may occur because oil film does not form effectively on the contact surface between the race and rolling element of the cross roller bearing. In such cases, consult HDS.

Static equivalent radial load

◆ **Formula (9): Static equivalent radial load**

$$Po = Fr\,max + \frac{2M\,max}{dp} + 0.44Fa\ max$$

Symbols used in the formulas

Fr*max*	Max. radial load	N(kgf)	See Fig.1.
Fa*max*	Max. axial load	N(kgf)	See Fig.1.
M*max*	Max. moment load	N·m (kgf·m)	Refer to the maximum load weight calculation methods.
dp	Pitch circle diameter of a roller	mm	See Table 1.

Static safety coefficient

Generally, the static equivalent load is limited by the basic static rated load (Co). However, the specific limit should be calculated according to the using conditions and required conditions. In this case, calculate the static safety coefficient (fs) by formula (10).

Table 4 shows general values representing using conditions. Calculate the static equivalent radial load (Po) by formula (9).

◆ **Formula (10): Static safety coefficient**

$$fs = \frac{Co}{Po}$$

Symbols used in the formulas

fs	Static safety coefficient	—	See Table 4.
Co	Basic static rated load	N(kgf)	See Table 1.
Po	Static equivalent radial load	N(kgf)	Obtained by formula (9).

Table 4 Static safety coefficient

Using conditions	fs
High rotational accuracy is required, etc.	≥3
Operation subject to impact/vibration	≥2
Normal operation	≥1.5

2-4 Examining operating status

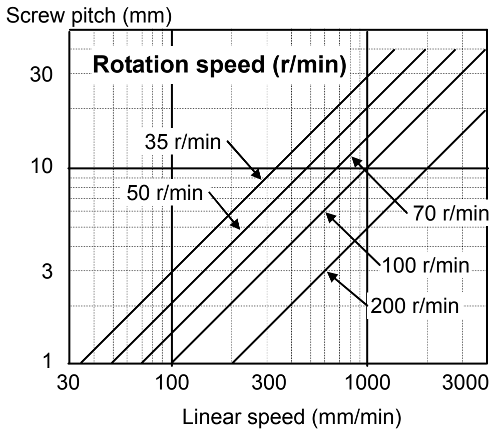
The actuator generates heat, and starting and braking currents to the motor flow at a high frequency if during its active state it is started/stopped repeatedly (duty cycle). Therefore, it is necessary to examine the duty cycle.
The study is as follows:

Examining actuator rotation speed

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

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

Select an appropriate reduction ratio from the 30, 50 or 100 series so that the calculated rotation speed does not exceed the maximum rotational speed of the FHA-C mini series actuator.



Calculating and examining load inertia moment

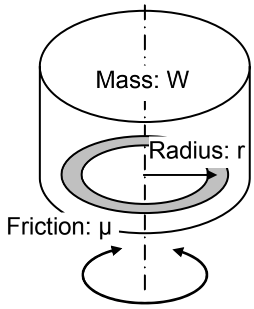
Calculate the inertia moment of the load driven by the FHA-C mini series actuator.
Refer to appendix 2 (Apx-3) for the calculation.
Based on the calculated result, tentatively select a FHA-C mini series actuator by referring to [2-1 Allowable load inertia moment].

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.



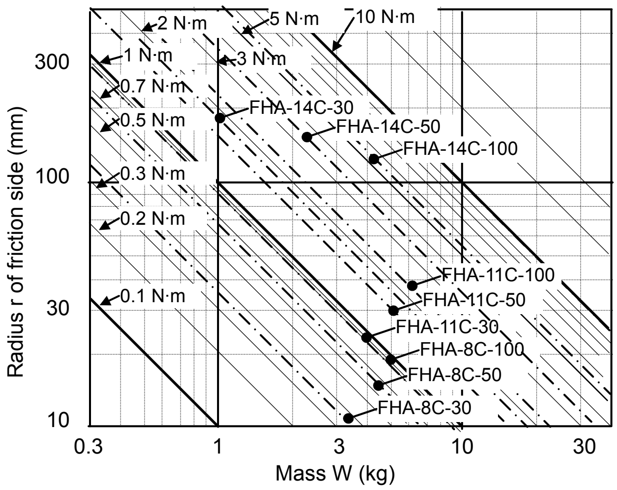
$T = 9.8 \times \mu \times W \times r$

T: Rotary torque (N·m)

- μ: Friction coefficient
- W: Mass (kg)
- r: Average radius of friction side (m)

The right graph gives a calculation example when the friction coefficient μ is assumed as 0.1 and the horizontal axis and vertical axis represent mass and rotational radius of friction side, respectively. The actuator toque shown in the graph indicates 20% of the maximum torque.

Example of rotary torque calculation (friction coefficient = 0.1)
FHA: shows 20% torque lines of maximum torque

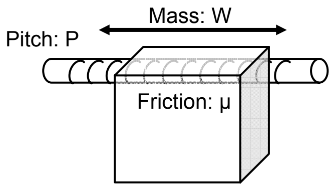


Linear operation (horizontal operation)

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

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

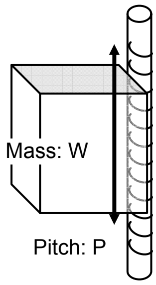
T: Rotary torque (N·m)
μ: Friction coefficient
W: Mass (kg)
P: Screw feed pitch (m)



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.

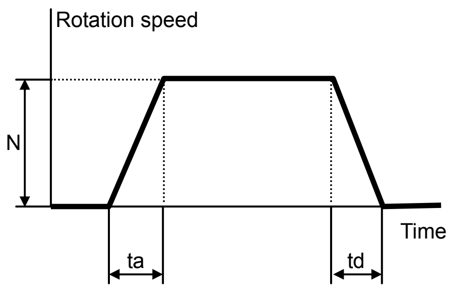
Acceleration time: $$t_a = (J_A + J_L) \times \frac{2 \times \pi}{60} \times \frac{N}{T_M - T_L}$$

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

T_a: Acceleration time	(s)
T_d: Deceleration time	(s)
J_A: Actuator inertia moment	(kg·m^2)
J_L: Load inertia moment	(kg·m^2)
N: Actuator rotation speed	(r/min)
T_M: Maximum actuator torque	(N·m)
T_F: Actuator friction torque	(N·m)

$T_F = K_T \times I_M - T_M$

K_T: Torque constant	(N·m/A)
I_M: Max. current	(A)



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

Example 1

Select an actuator that best suits the following operating conditions:

- Rotation speed: 100 r/min
- Load inertia moment: 0.04 kg·m^2
- Since the load mechanism is mainly inertia, the load torque is negligibly small.

1 **After applying these conditions to the graph in [2-1], FHA-11C-50 is tentatively selected.**

2 **From the rated table in [1-4], the following values are obtained: J_A = 0.017 kg·m^2, T_M = 8.3 N·m. K_T = 6.6 N·m/A, I_M = 1.6A.**

3 **Based on the above formula, the actuator's friction torque TF is calculated as 6.6 x 1.6 - 8.3 = 2.3 N·m.**

4 **Therefore, the acceleration time and deceleration time can be obtained as follows from the above formulas:**

t_a = (0.017 + 0.04) x 2 x π / 60 x 100 / 8.3 = 0.072 s
t_d = (0.017 + 0.04) x 2 x π / 60 x 100 / (8.3 + 2 x 2.3) = 0.046 s

5 **If the calculated acceleration/deceleration times are too long, correct the situation by:**

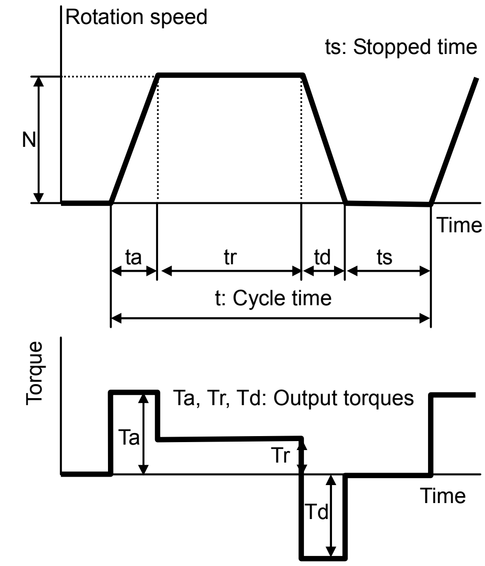
- Reducing moment of inertia of load
- Selecting an actuator with a larger frame size

Duty cycles

To select the appropriate FHA-C mini series, you must consider the change with time of torque and rotation speed. Also more importantly, when accelerating and decelerating, you must take into account the flow of large current for generating large torque, and the large amount of heat that is generated.
Using the following formula, calculate the duty: %ED when the actuator is operated repeatedly in the drive pattern shown to the right.

$$\%ED = \frac{K_{La} \times t_a + K_{Lr} \times t_r + K_{Ld} \times t_d}{t} \times 100$$

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)
KLa:	Duty factor for acceleration time	
KLr:	Duty factor for operation time at constant speed	
KLd:	Duty factor for deceleration time	



Example 2: Calculating duty and getting K_{La}, K_{Lr} and K_{Ld}

With the duty factor graph for FHA-11C-50 as an example, calculate duty factors as follows.
The operating conditions are similar to those described in example 1. Accelerate an inertia load by the maximum torque of the actuator and then let it move at a constant speed, followed by deceleration by the maximum torque. The travel angle per cycle is 120° and the cycle time is 0.8 second.

1 **KLa and KLd: rotation speed change is 50 r/min at an average speed of 0 to 100 r/min. Then from the graph, KLa = KLd ≒ 1.7.**

2 **KLr: is the inertia load, Tr ≒ 0. Then from the graph, KLr ≒ 0.9.**

3 **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 {tr + (ta + td) / 2} x 360
Then, tr =θ / (6 x N) – (ta + td) / 2
Substituting θ = 120°, ta = 0.072(s), td = 0.046(s) and N = 100r/min from example 1 will be tr = 0.14(s).

4 **Because the cycle time is 0.8 (s), the duty (%ED) is obtained as follows:**

%ED = (1.7 x 0.072 + 0.9 x 0.14 + 1.7 x 0.048) / 0.8 x 100 = 41.2%

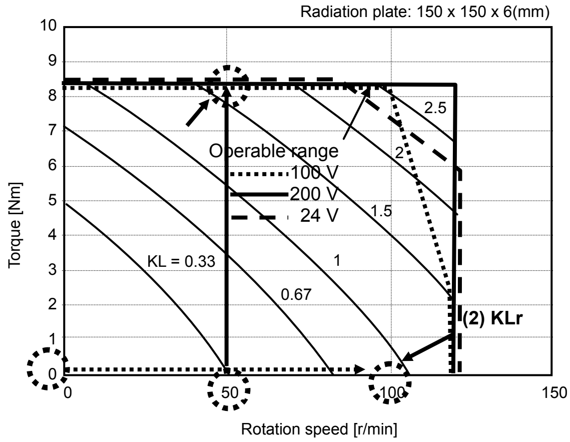
It is possible to drive the actuator continuously with this cycle time, because the %ED is less than 100%.

If the %ED is over 100%,

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

etc., must be reexamined.

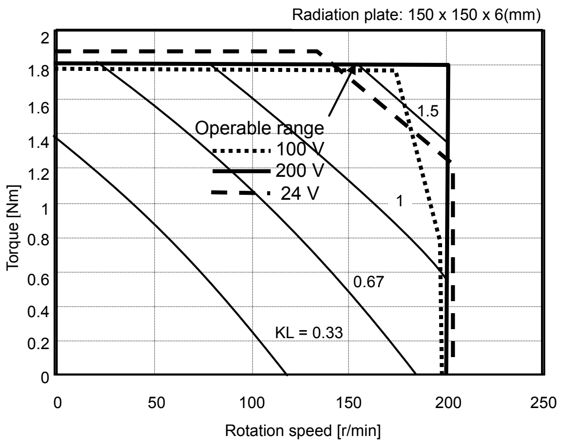
■ FHA-11C-50



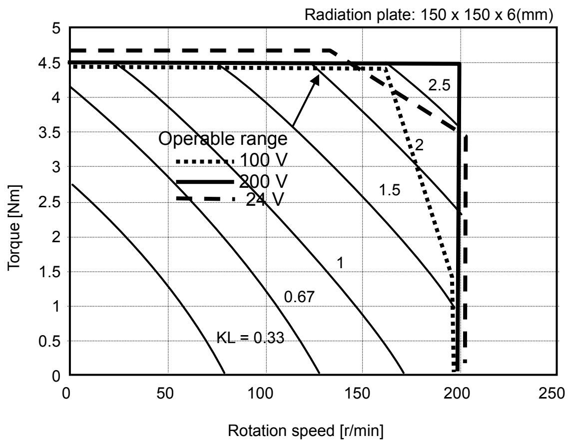
Duty factor graphs

FHA-8C

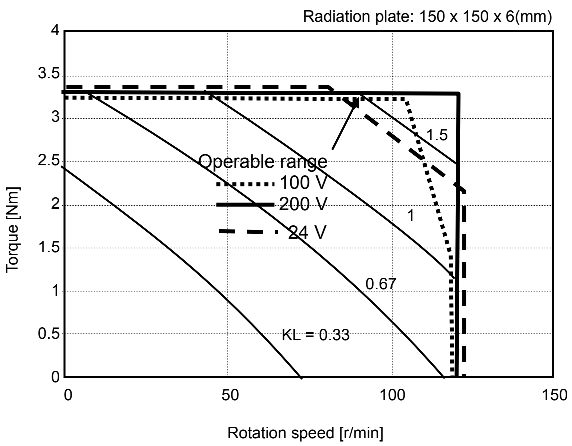
■ FHA-8C-30



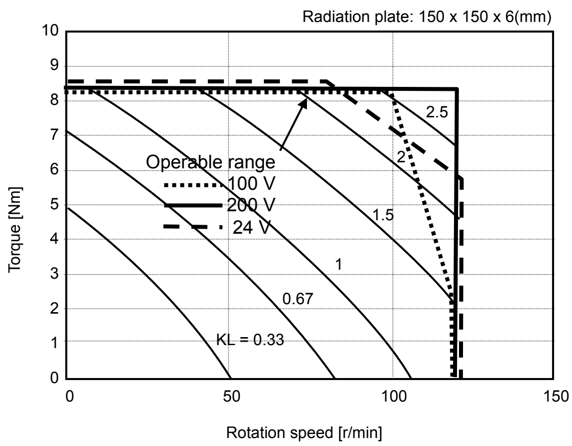
■ FHA-11C-30



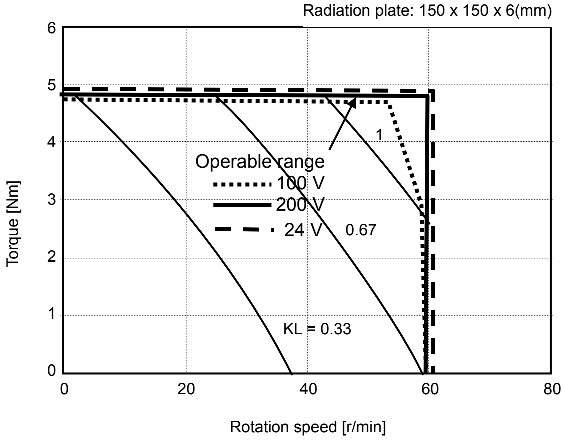
■ FHA-8C-50



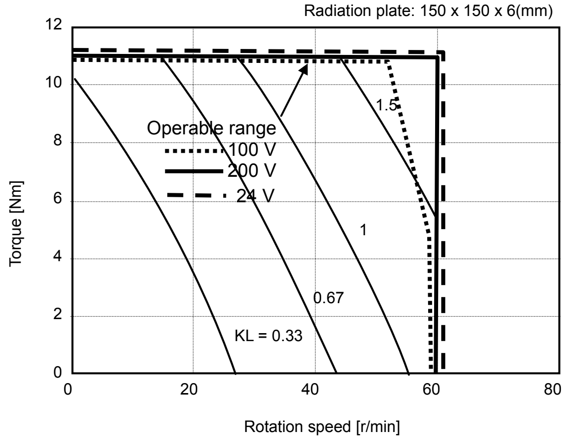
■ FHA-11C-50



■ FHA-8C-100

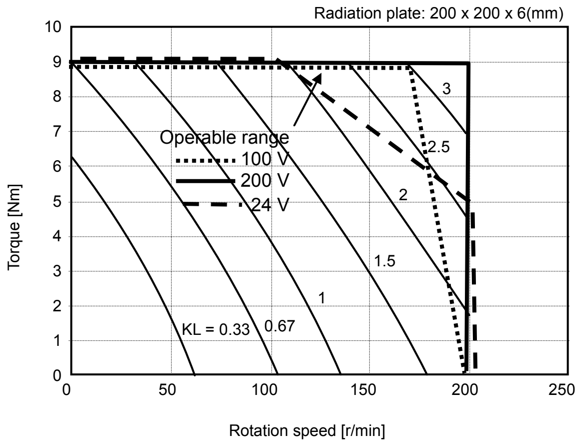


■ FHA-11C-100

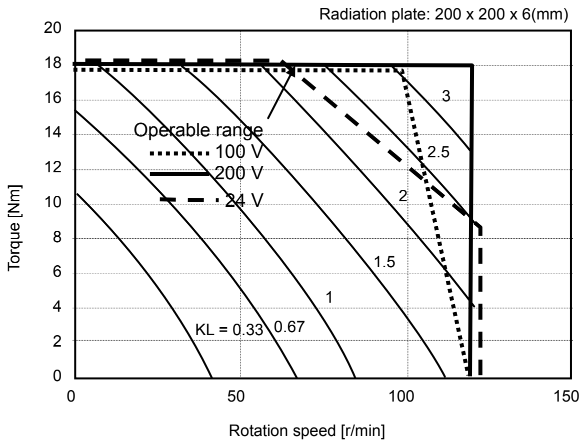


FHA-14C

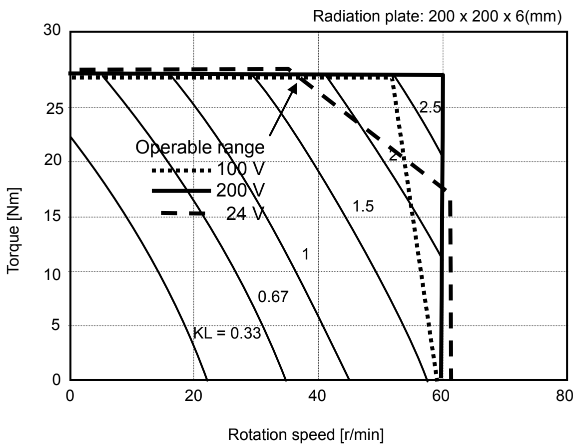
■ FHA-14C-30



■ FHA-14C-50



■ FHA-14C-100



2

Selection guidelines

Examining effective torque and average rotation speed

Consider the following two points when obtaining the effective torque and average rotational speed.
The effective torque should be less than the allowable continuous torque.
The average rotational speed should be less than the allowable continuous rotational speed.
Using the following formula, calculate the effective torque T_m and average rotation speed N_{av} when the operating cycle shown in [Duty cycles] (P2-10) is operated repeatedly.

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

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

T_m: Effective torque (N·m)
T_a: Maximum torque (N·m)
T_r: Load torque (N·m)
t_a: Acceleration time (s), td: deceleration time (s)
t_r: Operation time at constant speed (s), t: time for 1 duty cycle (s)
N_{av}: Average rotation speed (r/min)
N: Rotation speed at constant speed (r/min)

If the effective torque is greater than the allowable continuous torque in the table below, calculate once again after reducing the duty cycle.

Item \ Model		FHA-8C			FHA-11C			FHA-14C		
		-30	-50	-100	-30	-50	-100	-30	-50	-100
Reduction ratio		1:30	1:50	1:100	1:30	1:50	1:100	1:30	1:50	1:100
Allowable continuous torque	N·m	0.75	1.5	2	1.8	2.9	4.2	3.5 (3.0)	4.7	6.8
Allowable continuous rotational speed	r/min	117	70	35	117	70	35	100	60	30

Note: The values of the allowable continuous torque in ( ) are for the 24VDC input power model.

Example 3: Examining effective torque and average rotation speed

Use the operating conditions found in example 1 and 2 to get the effective torque and average rotation speed.

1) Examining effective torque

Substituting 8.3 N·m for T_a, 8.3 N·m for T_d, 0 N·m for T_r, 0.072 s for t_a, 0.14 s for t_r, 0.046 s for t_d, and 0.8 s for t:

$$T_m = \sqrt{\frac{8.3^2 \times (0.072 + 0.046)}{0.8}} = 3.19 \text{ N·m}$$

As T_m exceeds its allowable continuous torque of the FHA-11C-50 temporarily selected in example 1, it is impossible to drive the actuator continuously with the duty cycle in example 2. 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.

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

Substituting 8.3 N·m for T_a, 8.3 N·m for T_d, 0 N·m for T_r, 3.03 N·m for T_m, 0.072 s for t_a, 0.14 s for t_r, and 0.046 s for t_d: Then, the following equation is obtained:

$$t = \frac{8.3^2 \times (0.072 + 0.046)}{2.9^2} = 0.97$$

Setting the cycle time to 0.97 seconds or more gives T_m = 2.9 N·m or less, thereby permitting continuous operation within the allowable continuous torque.

2) Examining average rotation speed

Calculate the average speed by substituting in parameters N = 100 r/min, t_a = 0.072 s, t_r = 0.14 s, t_d = 0.046 s and t = 0.97 s.

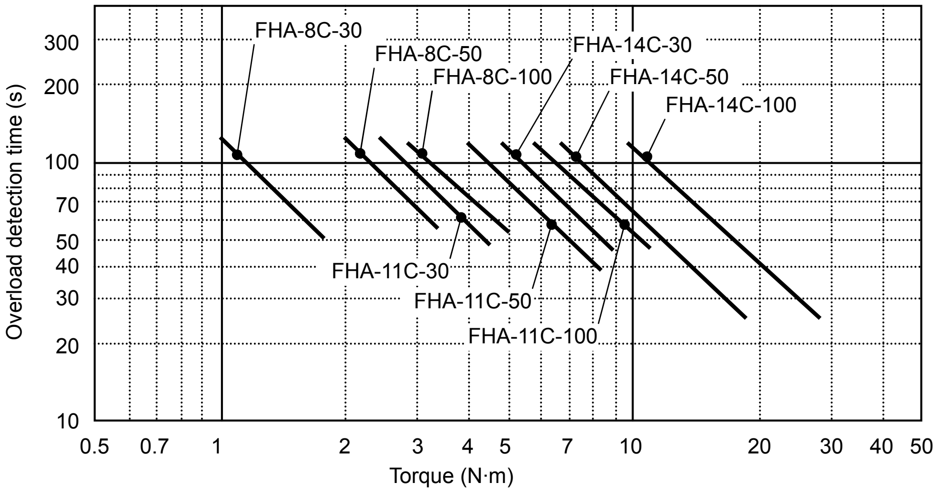
$$N_{av} = \frac{100/2 \times 0.072 + 100 \times 0.14 + 100/2 \times 0.046}{0.97} = 20.5 \text{ r/min}$$

As the average speed is less than the allowable continuous rotation speed (70 r/min) of FHA-11C-50, it can be driven continuously.

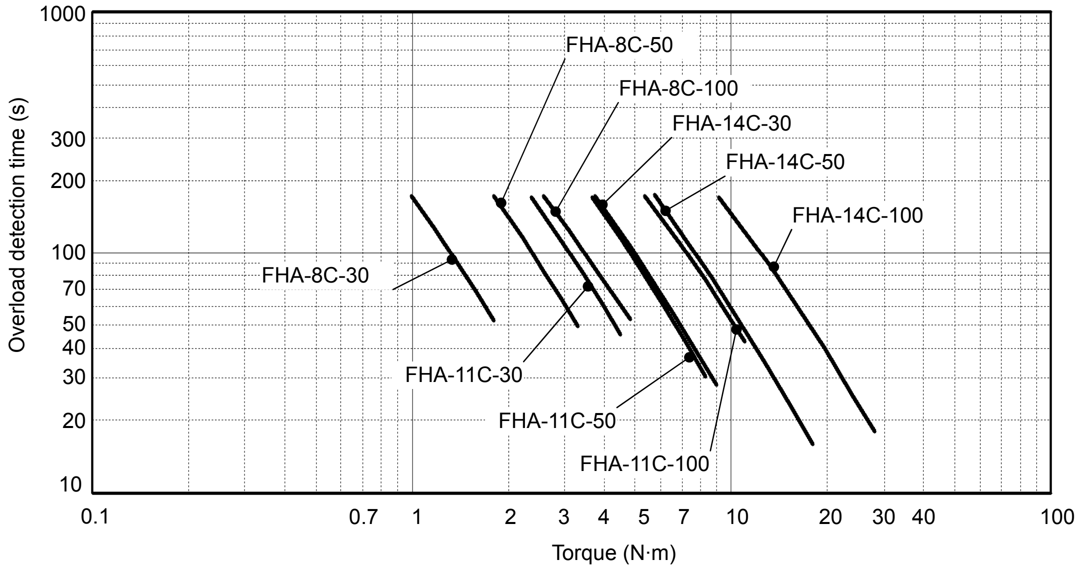
Overload detection time

If the FHA-C mini series is intermittently driven more than its allowable continuous torque, the output time and continuous torque is limited by a overload detection function in the driver even if the duty cycle is allowed. The overload detection times are shown in the graph below:

Input voltage 100VAC/200VAC specification



Input voltage 24VDC specification (will only support the incremental encoder model)



Chapter 3

Installation

This chapter explains the procedure for installing the FHA-C mini series actuator.

3-1 Receiving inspection

Check the following items after unpacking the package.

Check procedure

1 Check the items thoroughly for damage sustained during transportation.

If any item is damaged, immediately contact the dealer.

2 The nameplate is found on the side face of the FHA-C mini 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.

The model code indicates the following information:

FHA-8 C-30-E200-C □ □

- FHA — Model: AC Servo Actuator FHA-C mini series
- 8 — Model No.: 8, 11, 14
- C — Version symbol
- 30 — Reduction ratio of the HarmonicDrive®
  - 30: 1/30
  - 50: 1/50
  - 100: 1/100
- E200 — Encoder type and resolution

E200	Incremental encoder	2000 p/rev
12S17b	Absolute encoder	131,072 p/rev (17 bit)

- C — With connector (standard specification)
- □ — Input power supply
  - None: 100VAC, 200V specification
  - E: 24VDC specification
- □ — Cable lead-out direction
  - None: Lateral (standard specification)
  - K : Rear (option specification/ incremental encoder support only)

3 The applicable FHA-C mini series actuator models are shown in the ADJUSTED FOR USE WITH field of the nameplate on the HA-800 or HA-680 drivers.

Make sure your actuator is combined with the correct driver.

WARNING

Only connect the actuator specified on the driver label.

The characteristics of this driver have been adjusted according to the actuator. Wrong combinations of drivers and actuators may cause low torque problems or overcurrent that may cause burned damage to the actuator, injury or fire.

4 **The driver's model code is shown in the TYPE field of the driver's nameplate. The last digits of this model code indicate the input voltage to be input.**

200: 3-phase/single-phase 200V power supply
100: indicates a 100VAC power.
24: indicates a 24VDC power.

If the input voltage to be supplied is different from the label voltage, immediately contact the dealer it was purchased from.

Do not connect a supply voltage other than the voltage specified on the driver's nameplate.
The wrong power supply voltage may damage the driver resulting physical injury and fire.

3-2 Notices on handling

Handle the FHA-C mini series actuator carefully by observing the notices specified below.

WARNING

Do not connect the actuator terminals directly to the power supply. The actuator may burn and cause fire or electric shock.

CAUTION

(1) Do not apply any excessive force or impact, especially to the actuator's output shaft.
(2) Do not put the FHA-C mini series actuator on a table, shelf, etc., where the actuator could easily fall.
(3) The allowable storage temperature is -20 to +60°C. Do not expose the actuator to direct sunlight for long periods of time or store it in areas in low or high temperature.
(4) The allowable relative storage humidity is 80% or less. In particular, do not store the actuator in a very humid place or in areas where temperatures are likely to fluctuate greatly during day and night.
(5) Do not use or store the actuator in locations subject to corrosive gases or dust particles.

3-3 Installation location and installation

Environment of installation location

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

- Operating temperature: 0°C to 40°C
  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°C or below.
- Operating humidity: humidity 20 to 80%. Make sure without condensation.
  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: 24.5 m/s^2 (2.5 G) (10 to 400 Hz) or less
- Impact: 294 m/s^2 (30 G) or less
- Free from dust, dirt, condensation, metal powder, corrosive gases, water, water droplets, oil mist, etc.
- Protection class: Standard products are structurally designed to meet the IP-44 requirements.

  The protection class against contact and entry of foreign matter is as follows:
  4: Protected against large solid objects (up to 1mm)

  The protection class against water entry is as follows:
  4: Protected against water splashed from all directions

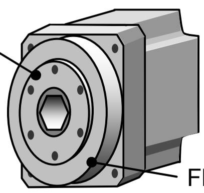
  However, rotating and sliding areas (oil seal areas) and connectors are not IP-44-compliant.
- Locate the driver indoors or within an enclosure, and do not expose it to sunlight.
- Altitude: lower than 1,000 m above sea level

Installation

The FHA-C mini series actuator drives mechanical load system at high accuracy.
When installing the actuator, pay attention to precision and do not tap the actuator output part with a hammer, etc. As an encoder is incorporated in the actuator, excessive impact may damage the encoder.

Installation procedure

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



Caution

- 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.
- Do not apply shock or impact during installation.

2 **Fasten the flange of the actuator on the load machine with flat washers and high-tension bolts.**

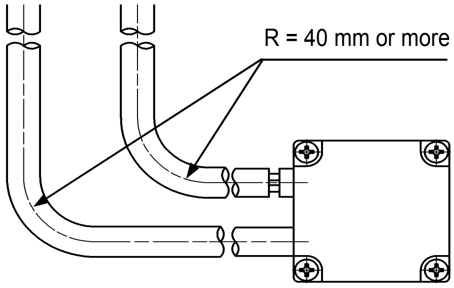
When tightening, use a torque wrench to control the tightening torque.
The tightening torques are shown in the table below:

Item \ Model		FHA-8C		FHA-11C		FHA-14C	
		Output shaft	Flange	Output shaft	Flange	Output shaft	Flange
Tightening torque	Screw, hole depth	6-M3 Depth 5	4-M3	6-M4 Depth 5	4-M4	6-M5 Depth 7	4-M5
	N·m	2	1.2	4.5	2.7	9.0	5.4
	kgf·cm	20	12	46	28	92	55

3 **Refer to the HA-800 or HA-680 driver manual for wiring work.**

4 **Motor cable and encoder cable**

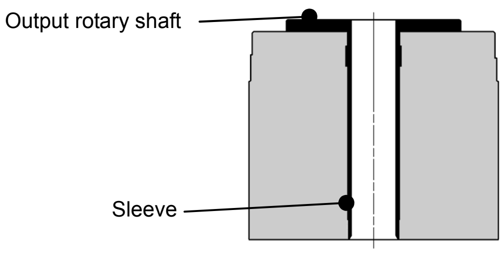
Do not pull the cables with a strong force. The connection points may be damaged. Install the cable wiring with slack so that no tension is applied to the actuator. Provide a sufficient bending radius (R = 40 mm or more), especially when the cable flexes.



CAUTION

Do not apply torque or load to the hollow shaft (sleeve).

The hollow shaft (sleeve) is adhered to the output rotary shaft. When a load is applied to the hollow shaft (sleeve), delamination may occur on the output shaft and hollow shaft (sleeve).
Do not apply or use any torque, moment load or thrust load directly to the hollow shaft (sleeve).
* The shape of the hollow shaft will only support the incremental encoder.



CAUTION

Do not disassemble/reassemble the actuator.

The actuator uses many precision parts. We cannot guarantee if assembly or disassembly by the customer will cause lower precision and performance.

Appendix

This chapter explains the default settings, etc.

Apx-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	Degree	Min.	Sec.
Factor	57.3	3.44×10^3	2.06×10^5

Unit	Degree	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	3.44 x 10^3

Unit	deg/s^2	deg/min^2
Factor	0.01755	2.93 x 10^{-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	7.06 x 10^{-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	3.42 x 10^3	8.85	5.47 x 10^4	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	2.93 x 10^{-4}	0.113	1.829 x 10^{-5}	7.06 x 10^{-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 x 10^{-5}	1.78 x 10^{-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 x 10^4	562	77.6	6.47
↓					
SI system	N·m/rad				

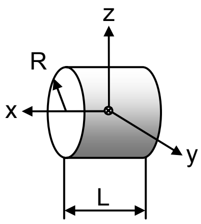
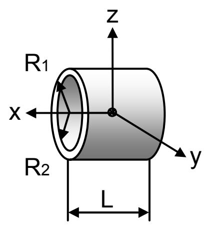
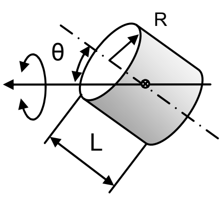
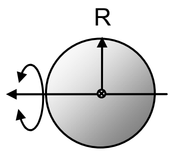
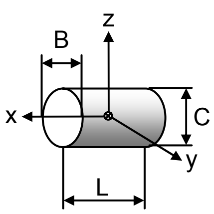
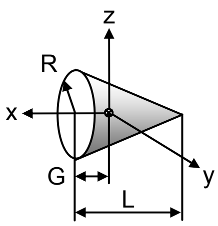
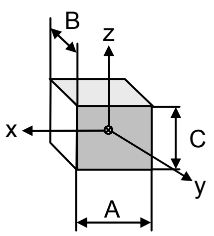
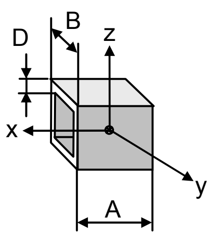
Apx-2 Calculating inertia moment

Formula of mass and inertia moment

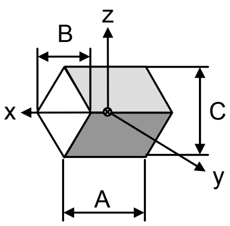
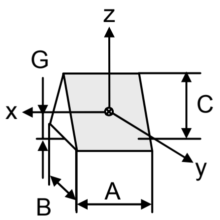
(1) Both centerlines of rotation and gravity are the same:

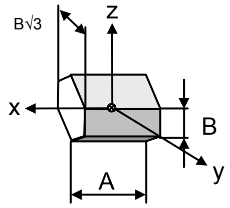
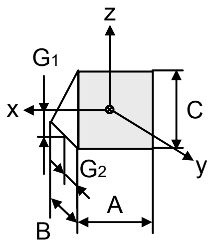
The following table includes formulas to calculate mass and inertia moment.
m: mass (kg); Ix, Iy, Iz: inertia moments which rotate around x-, y-, z-axes respectively (kg·m^2)
G: distance from end face of gravity center
ρ: specific gravity

Unit Length: m; Mass: kg; Inertia moment: kg·m^2

Object form	Mass, inertia, gravity center	Object form	Mass, inertia, gravity center
Cylinder 	$m = \pi R^2 L \rho$ $Ix = \frac{1}{2} m R^2$ $Iy = \frac{1}{4} m \left(R^2 + \frac{L^2}{3} \right)$ $Iz = \frac{1}{4} m \left(R^2 + \frac{L^2}{3} \right)$	Circular pipe  R1: outer diameter, R2: inner diameter	$m = \pi \left(R_1{}^2 - R_2{}^2 \right) L \rho$ $Ix = \frac{1}{2} m \left(R_1{}^2 + R_2{}^2 \right)$ $Iy = \frac{1}{4} m \left\{ \left(R_1{}^2 + R_2{}^2 \right) + \frac{L^2}{3} \right\}$ $Iz = \frac{1}{4} m \left\{ \left(R_1{}^2 + R_2{}^2 \right) + \frac{L^2}{3} \right\}$
Slanted cylinder 	$m = \pi R^2 L \rho$ $I_\theta = \frac{1}{12} m$ $\times \left\{ 3R^2 \left(1 + \cos^2\theta \right) + L^2 \sin^2\theta \right\}$	Ball 	$m = \frac{4}{3} \pi R^3 \rho$ $I = \frac{2}{5} m R^2$
Ellipsoidal cylinder 	$m = \frac{1}{4} BC\ L\ \rho$ $Ix = \frac{1}{16} m \left(B^2 + C^2 \right)$ $Iy = \frac{1}{4} m \left(\frac{C^2}{4} + \frac{L^2}{3} \right)$ $Iz = \frac{1}{4} m \left(\frac{B^2}{4} + \frac{L^2}{3} \right)$	Cone 	$m = \frac{1}{3} \pi R^2 L \rho$ $Ix = \frac{3}{10} m R^2$ $Iy = \frac{3}{80} m \left(4R^2 + L^2 \right)$ $Iz = \frac{3}{80} m \left(4R^2 + L^2 \right)$ $G = \frac{L}{4}$
Rectangular pillar 	$m = ABC\rho$ $Ix = \frac{1}{12} m \left(B^2 + C^2 \right)$ $Iy = \frac{1}{12} m \left(C^2 + A^2 \right)$ $Iz = \frac{1}{12} m \left(A^2 + B^2 \right)$	Square pipe 	$m = 4AD(B - D)\rho$ $Ix = \frac{1}{3} m \left\{ (B - D)^2 + D^2 \right\}$ $Iy = \frac{1}{6} m \left\{ \frac{A^2}{2} + (B - D)^2 + D^2 \right\}$ $Iz = \frac{1}{6} m \left\{ \frac{A^2}{2} + (B - D)^2 + D^2 \right\}$

Apx
Appendix

Object form	Mass, inertia, gravity center
Rhombus pillar 	$m = \frac{1}{2}ABC\rho$ $Ix = \frac{1}{24}m(B^2 + C^2)$ $Iy = \frac{1}{24}m(C^2 + 2A^2)$ $Iz = \frac{1}{24}m(B^2 + 2A^2)$
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 	$m = \frac{1}{2}ABC\rho$ $Ix = \frac{1}{36}m(B^2 + C^2)$ $Iy = \frac{1}{12}m\left(A^2 + \frac{2}{3}C^2\right)$ $Iz = \frac{1}{12}m\left(A^2 + \frac{2}{3}B^2\right)$ $G_1 = \frac{C}{3}$ $G_2 = \frac{B}{3}$

Example of specific gravity

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

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

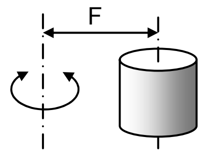
Material	Specific gravity
Aluminum	2.70
Duralumin	2.80
Silicon	2.30
Quartz glass	2.20
Teflon	2.20
Fluorocarbon resin	2.20

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 ($kg \cdot m^2$)

I_g: Inertia moment when the gravity center axis matches the rotational axis ($kg \cdot m^2$)

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 motion objects

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

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

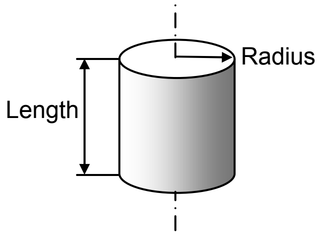
I: Inertia moment of a linear motion object converted to actuator axis ($kg \cdot m^2$)

m: Mass (kg)

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

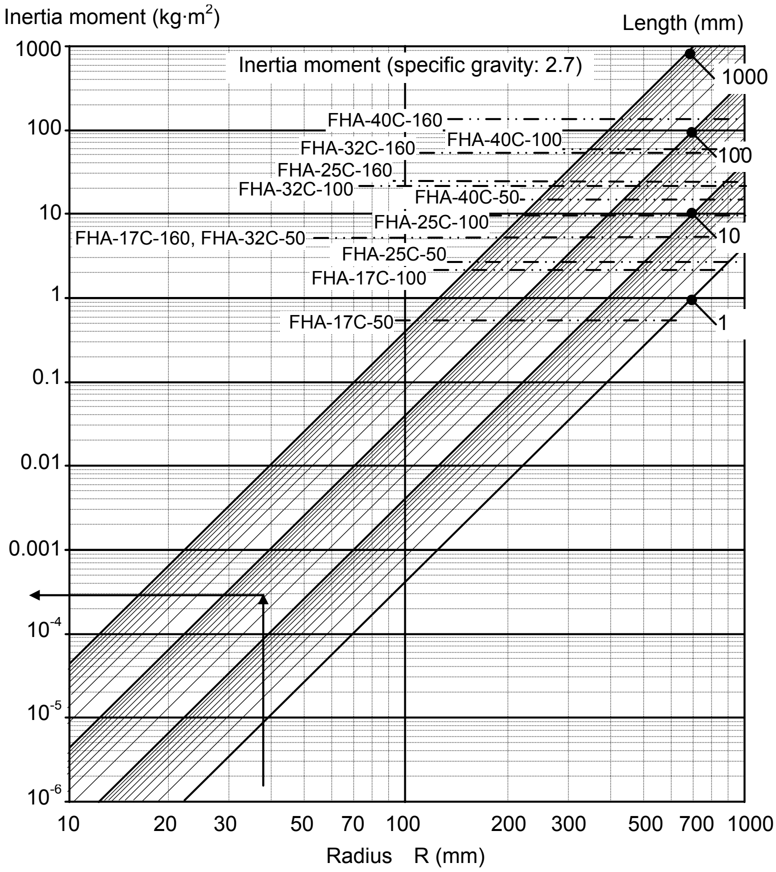
Inertia moment of a cylinder

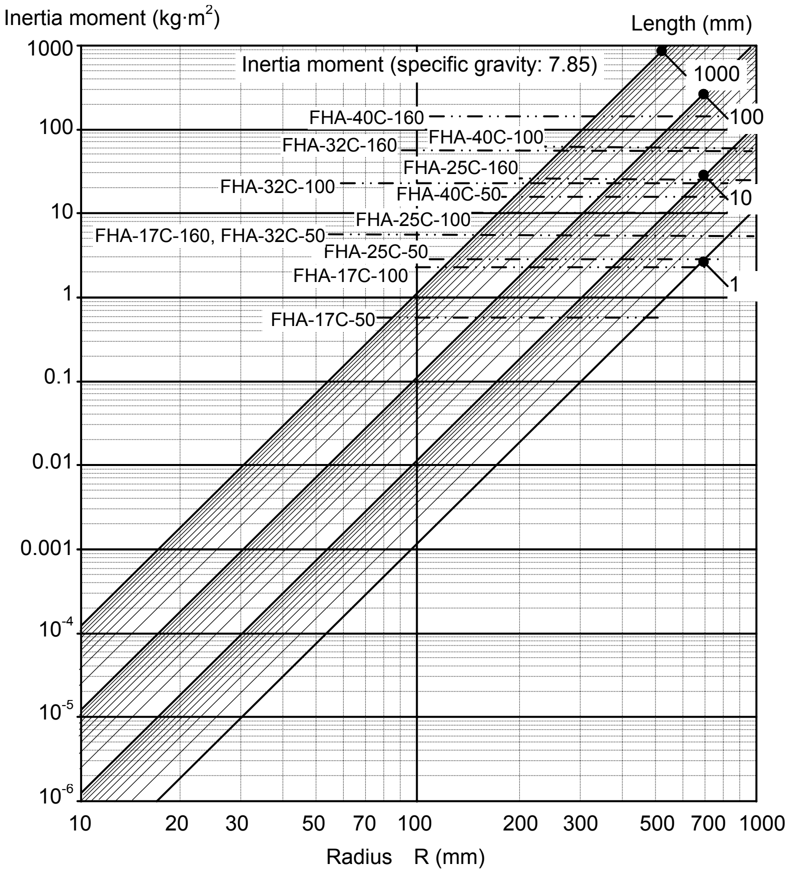
The moment of inertia of a cylinder may be obtained from the graphs to the right.



Apply the top graph to aluminum materials (specific gravity: 2.7) and bottom graph to steel materials (specific gravity: 7.85):
The double-dot dash lines in the graph indicate the allowable maximum inertia moment (estimated value) for each FHA-C series actuator.

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





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Warranty period and terms

The warranty period of the FHA-Cmini series and warranty terms are explained below.

■ Warranty period

Under the condition that it is used properly according to each item specified in the manuals and operation manuals, this product is warranted for the period of 1 year after delivery or 2,000 hours of operation (this product), whichever ends first.

■ Warranty terms

If the product fails due to any defect in workmanship or material during the warranty period specified above, the defective product will be repaired or replaced free of charge.

This limited warranty does not apply to any product that has been subject to:

(1) Improper handling or use by the customer;
(2) Modification or repair carried out other than by Harmonic Drive Systems, Inc.;
(3) Failure not attributable to this product; or
(4) Natural disaster or any other event beyond the control of Harmonic Drive Systems, Inc.

The warranty covers only the above-named product purchased from Harmonic Drive Systems, Inc.

Harmonic Drive Systems, Inc. shall not be liable for any consequential damages of other equipment caused by the defective product, or expenses and labor costs for removing and installing the defective product from/to your system.

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Certified to ISO14001 (HOTAKA Plant)/ISO9001 (TÜV Management Service GmbH)
All specifications and dimensions in this manual subject to change without notice.
This manual is correct as of July 2011.

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