RSF-B mini Series

AC Servo Actuator Manual

(RSF-8B, 11B, 14B 24VDC specification)

- Thank you very much for your purchasing our RSF-B mini series servo actuator.

- Be sure to use appropriate safety measures when installing and operating the equipment. Failure to do so may result in malfunction of the unit and personal injury.

- Product specifications are subject to change without notice.

- 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

For RSF-B mini series

Read this manual thoroughly before designing the application, installation, maintenance or inspection of the actuator.

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.

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
- ✶ Machine or devices acting directly on the human body
- ✶ Instruments or devices to transport or carry people
- ✶ Apparatus or devices used in special environments
- ✶ Instruments or devices to prevent explosion

Safety measures are essential for safe operation.

Precautions when using a direct drive motor

CAUTIONS FOR ACTUATORS AT THE APPLICATION DESIGN PHASE

CAUTION	Always use under followings conditions: • The motor is designed to be used for indoor. - Ambient temperature: 0°C to 40°C - Ambient humidity: 20% to 80%RH (Non-condensation) - Vibration: 24.5m/s^2 - No contamination by water, oil - No corrosive or explosive gas	CAUTION	Follow exactly the instructions 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 shaft.

CAUTION FOR ACTUATOR IN OPERATION

CAUTION	Keep limited torques of the actuator. • Keep limited torques of the actuator. • Be aware to balance the gravity for load mounting to output shaft.	WARNING	Never connect cables directly to a power supply socket. • Direct drive motor cannot be operated unless it is connected to dedicated driver. • Never connect it to commercial power supply directly. Direct drive motor may be damaged and causes fire.
CAUTION	Do not apply shocks to actuator. • Do not apply shocks because direct drive motor is directly connected to high precision encoder. • If the encoder is damaged, it may cause uncontrollable operation.	WARNING	Avoid handling of motor by cables. • Failure to observe this caution may damage the wiring, causing uncontrollable or faulty operation of direct drive motor.

Precautions when using a driver

CAUTIONS FOR DRIVERS AT APPLICATION DESIGN PHASE

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. - Ambient temperature: 0°C to 50°C - Ambient humidity: less than 90% RH (Non condensation) - No vibration or shocks - No dust, dirt, corrosive, inflammable or explosive gas	CAUTION	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.
CAUTION	Pay attention to negative torque by inverse load. • Inverse load may cause damages of direct drive motor. • Please consult our sales office, if you intend to apply products for inverse load.	CAUTION	Use a fast-response type ground-fault detector designed for PWM inverters. • Do not use a time-delay-type ground-fault detector.

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.	WARNING	Do not touch terminals at least 5 minutes after turning OFF power. • Otherwise, residual electric charges may result in electric shock. Wait for 5 min or more before inspection. • 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 intend to make a voltage resistance test.	CAUTION	Do not operate control units by means of power ON/OFF switching. • Frequent power ON/OFF may result in deterioration of internal circuit elements. • Start/stop operation of direct drive motor should be performed via input signals.

DISPOSAL OF DIRECT DRIVE MOTOR, A MOTOR, A CONTROL UNIT AND/OR THEIR PARTS

CAUTION	All products or parts should be disposed of as industrial waste. • Since the case or the box of drivers have a material indication, classify parts and dispose them separately.

Contents

Memo

Chapter 1 Overview

RSF-B mini series are AC brushless servo actuators combined with a zero backlash Harmonic Drive gear for precise motion control.

RSF-B mini series actuators are ideal for robot joint drives, semi-conductor, LCD panel manufacturing, machine tools and other various types of factory automation devices.

1-1 Features

- Exceptional positional accuracy
- Compact design
- High rotational accuracy
- High resolution

1-2　Ordering Code

Ordering codes for the RSF-B mini series actuators are as follows:

RSF-8 B-30-F 100-24 B-C -SP

- RSF — Model: AC servo actuator
- 8 — Frame size: 8,11,14
- B — Design version
- 30 — Reduction ratio
  30:1, 50:1, 100:1
- F — Encoder specifications
  F: incremental encoder & magnetic pole sensor
- 100 — Encoder Resolution
  100：1000P/rev
- 24 — Power Supply Voltage　24：24V
- B — Encoder Output Form　A：0°
  B：30°
- C — Option
  No symbol：Without connector
  C：with connector (standard)
- SP — Special specification　No symbol：Standard item
  SP：Special item

1-3　Combinations with drivers

RSF-B mini series actuators can be used with the following drivers. Setting of the driver varies depending on the actuator combined.

Model	HD Systems Drive	HDLLC Drive
RSF-8B	HA-680-4B-24	DCJ-055-09, DDP-090-09, DEP-090-09
RSF-11B	HA-680-6B-24	DDP-090-36, DEP-090-36
RSF-14B	HA-680-6B-24	DDP-090-36, DEP-090-36

1-4 Specifications

Time rating:	Continuous	Service temperature:	0~40°C
Excitation method:	Permanent magnet type	Storage temperature:	-20~+60°C
Insulation class:	B	Service/ storage temp.:	20~80%RH (no condensation)
Withstanding voltage:	500VAC/min	Vibration resistance:	25m/s^2
Insulation resistance:	500VDC 100MΩor more	Lubricant:	Grease (Harmonic Grease)
Structure:	Totally enclosed self cooling type		

Item \ Model		RSF-8B			RSF-11B			RSF-14B		
		30	50	100	30	50	100	30	50	100
Rated output *	W	7.7	8.2	6.3	11.5	12.6	12.6	17.8	18.9	18.9
Input power voltage *	V	24DC±10%								
Rated current *	A_{rms}	2.0		1.5	5.0	4.9		4.9	4.7	
Rated torque *	Nm	0.78	1.4	2.0	1.1	2.0	4.0	1.7	3.0	6.0
Allowable continuous speed *	rpm	100	60	30	100	60	30	100	60	30
Stall torque	Nm	0.95	1.7	3.5	1.7	3.0	5.7	2.5	4.5	9.0
Maximum current *	A_{rms}	3.8	3.9	2.9	14.4	15.8	9.4	14.4	17.2	12.3
Maximum torque *	Nm	1.8	3.3	4.8	4.5	8.3	11	9.0	18	28
Max. speed *	rpm	200	120	60	200	120	60	200	120	60
Torque constant	Nm/A_{rms}	0.62	1.1	2.1	0.40	0.66	1.5	0.76	1.3	2.6
EMF constant	V/(rpm)	0.07	0.11	0.22	0.04	0.07	0.15	0.08	0.13	0.28
Phase resistance	Ω(20℃)	0.93			0.19			0.26		
Phase inductance	mH	0.45			0.10			0.19		
Moment of inertia Note — $GD^2/4$	kgm^2	0.06 ×10^{-2}	0.16 ×10^{-2}	0.65 ×10^{-2}	0.18 ×10^{-2}	0.49 ×10^{-2}	2.0 ×10^{-2}	0.41 ×10^{-2}	1.1 ×10^{-2}	4.5 ×10^{-2}
Moment of inertia Note — J	kgfcms^2	0.60 ×10^{-2}	1.7 ×10^{-2}	6.6 ×10^{-2}	1.8 ×10^{-2}	5.0 ×10^{-2}	20 ×10^{-2}	4.1 ×10^{-2}	11 ×10^{-2}	46 ×10^{-2}
Allowable radial load	N	196			245			392		
Allowable axial load	N	98			196			392		
Encoder pulses (motor shaft)	p/rev	1000								
Encoder resolution (Output shaft) Note 5	p/rev	120,000	200,000	400,000	120,000	200,000	400,000	120,000	200,000	400,000
Mass	g	300			500			800		
Combined driver		DCJ-055-09, DDP-090-09, DEP-090-09			DDP-090-36, DEP-090-36					
		HA-680-4B-24			HA-680-6B-24					

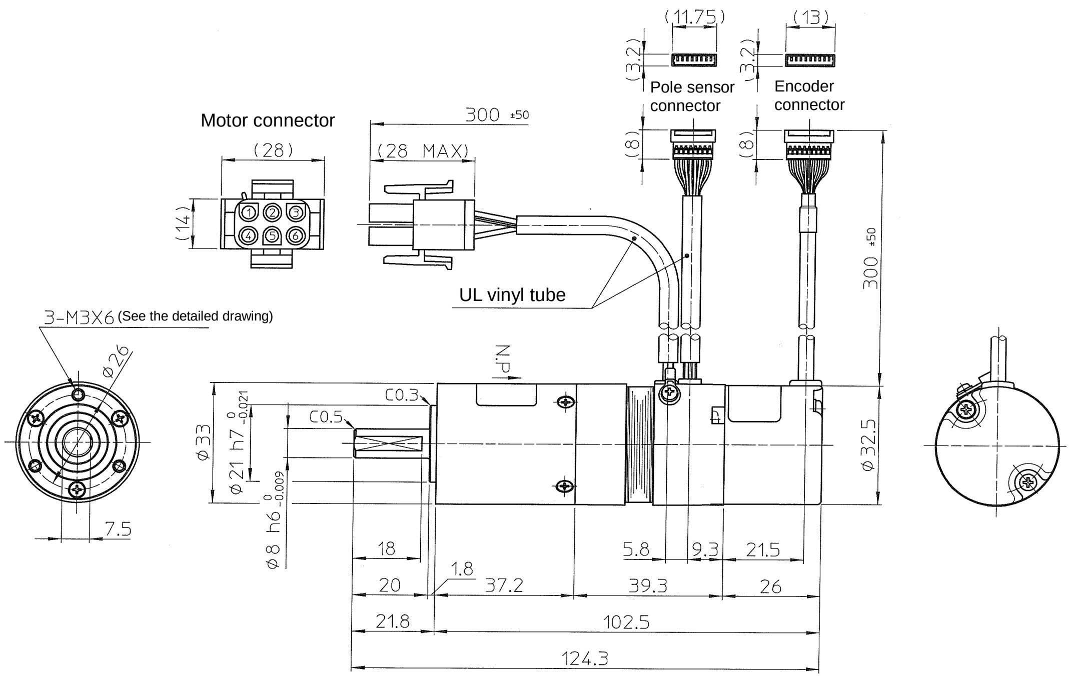
Note 1: The table shows output values of the actuator.
Note 2: All specifications are applicable for actuators mounted on an aluminum heat sink of size: 150 x 150 x 6(mm).
Note 3: Values indicated by an asterisk (*) are those for the saturated temperature rise. Other values indicate the temperature at 20ºC. All values are typical.
Note 4: The moment of inertia is the total value of the motor shaft and gear moment of inertia values converted to the output side.
Note 5: Quad encoder resolution is (motor shaft encoder resolution when multiplied by 4) x (gear ratio).

1-5 External dimensions

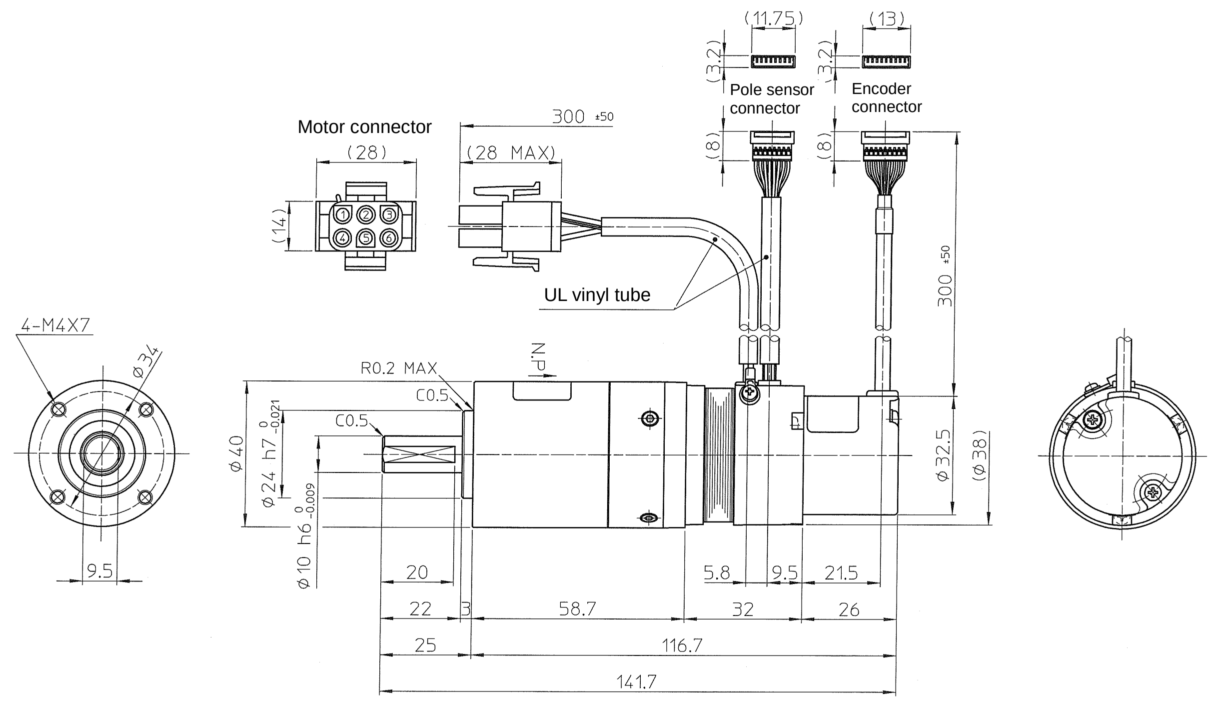
Unit : mm (third angle projection method)

The external drawings are shown as follows:

■ RSF-8B

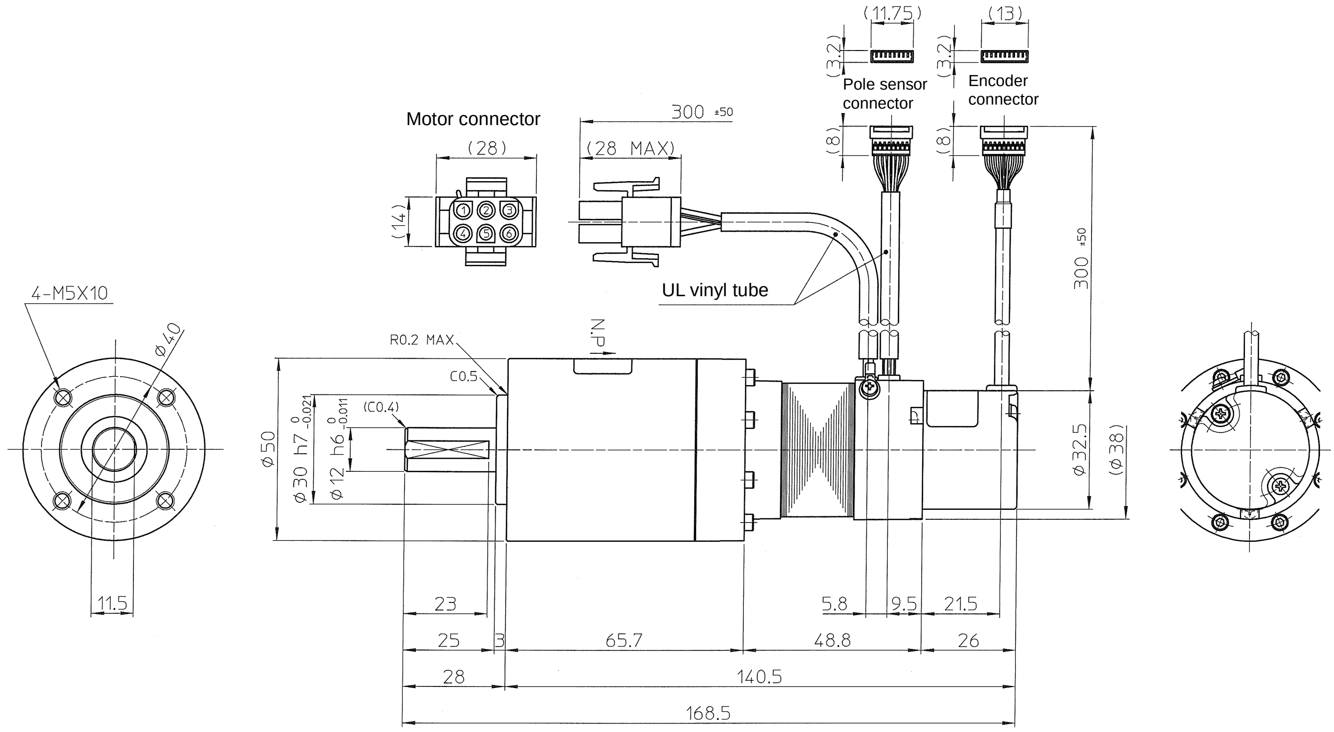


■ RSF-11B



Note) For detailed outside dimensions, check the confirmation drawing

■RSF-14B



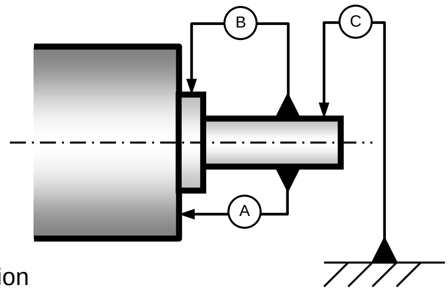
Note) For detailed outside dimensions, check the confirmation drawing

1-6 Machine accuracy

The machining accuracy of the output flange and the mounting flange of RSF-B mini actuators are indicated in the table below.

Machine accuracy　　　Unit：mm

	A	B	C
RSF-8B	0.04	0.04	0.03
RSF-11B	0.04	0.04	0.03
RSF-14B	0.04	0.04	0.03



Note）Values by T.I.R(Total Indicator Reading)

A：Squareness of the output shaft and the mounting surface

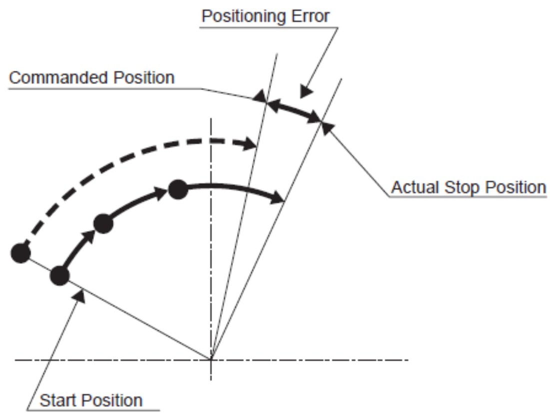
B：Coaxial degree of the output shaft and the mounting connection

C：Deflection of the output shaft end

1-7　One-way positioning accuracy

The one-way positioning accuracy is defined as the maximum positional difference between the commanded position and the actual stop position when a series of positioning moves are performed in the same rotation direction. (Refer to JIS B-6201-1987).

The RSF actuator incorporates a Harmonic Drive gear which inherently has high rotational position accuracy. Because of the gearing's high ratio, any rotational error at the input (i.e. motor shaft position error or motor feedback error) is reduced by a factor of the ratio (1/ratio) and typically becomes negligible at the output. Therefore most of the error is represented by the transmission error of the Harmonic Drive gear itself.



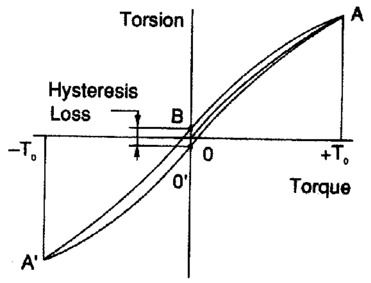
The one-way positioning accuracy is shown in the table below:.

Item \ Model		RSF-8B			RSF-11B			RSF-14B		
		30	50	100	30	50	100	30	50	100
One-way positioning accuracy	arc min	3	2.5		2.5	2		2.5	2	
	rad	8.73×10^{-4}	7.27×10^{-4}		7.27×10^{-4}	5.82×10^{-4}		7.27×10^{-4}	5.82×10^{-4}	

1-8 Torsional stiffness

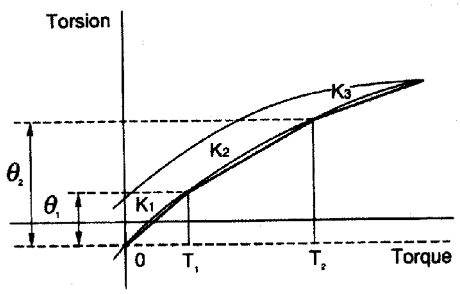
When a torque is applied to the output flange of the actuator with the motor locked, the resulting torsional wind up is near proportional to the torque.

The upper right figure shows the torsional stiffness characteristics of the output flange applying torque starting from zero to plus side [$+T_0$] and minus side [$–T_0$]. This trajectory is called torque-torsion characteristics which typically follows a loop 0→A→B→A'→B'→A as illustrated. The torsional stiffness of the RSF-B mini actuator is expressed by the slope of the curve that is a spring rate (wind-up) (unit:N･m/rad).



The torsional stiffness may be evaluated by dividing torque-torsion characteristics curve into three major regions. The spring rate of each region is expressed K_1, K_2, and K_3 respectively.

K_1: spring rate for torque region 0-T_1
K_2: spring rate for torque region T_1-T_2
K_3: spring rate for torque region over T_2



The wind-up for each region is expressed as follows:

- ◆ wind-up for torque region 0-T_1: $\varphi = \dfrac{T}{K_1}$
- ◆ wind-up for torque region T_1-T_2: $\varphi = \theta_1 + \dfrac{T - T_1}{K_2}$
- ◆ wind-up for torque region over T_2: $\varphi = \theta_2 + \dfrac{T - T_2}{K_3}$

The following table shows average values of T_1 through T_3, K_1 through K_3, and θ_1 through θ_2 for different gear ratios.

Model		RSF-8B			RSF-11B			RSF-14B		
Gear ratio		1 : 30	1 : 50	1 : 100	1 : 30	1 : 50	1 : 100	1 : 30	1 : 50	1 : 100
T_1	Nm	0.29			0.80			2.0		
	kgfm	0.03			0.082			0.2		
K_1	x10^4 Nm/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	0.1	0.14
θ_1	x10^{-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	Nm	0.75			2.0			6.9		
	kgf･m	0.077			0.20			0.7		
K_2	x10^4 Nm/rad	0.044	0.067	0.10	0.037	0.30	0.34	0.24	0.47	0.61
	kgfm/arc min	0.013	0.020	0.031	0.13	0.090	0.10	0.07	0.14	0.18
θ_2	x10^{-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	x10^4 Nm/rad	0.054	0.084	0.12	0.047	0.32	0.44	0.34	0.57	0.71
	kgfm/arc min	0.016	0.025	0.036	0.16	0.096	0.13	0.10	0.17	0.21

1-9　Detector resolution

An encoder with 1000 pulses per rotation is incorporated in the motor unit of the RSF-B mini series actuators, and the motor output is decelerated by the precision Harmonic Drive® gear. Therefore, the resolution per one rotation of the actuator output shaft is multiplied by gear ratio of the actual encoder resolution. In addition, the encoder signal is electrically multiplied by 4.

The following table shows the resolution at the output shaft for different gear ratios.

Item \ Model		RSF- 8B RSF-11B RSF-14B		
Gear ratio		30:1	50:1	100:1
Detector resolution (when multiplied by 4))	Pulse/Rotation	120,000	200,000	400,000
Angle per one pulse	Second	About 10.8	About 6.5	About 3.2

1-10 Allowable load

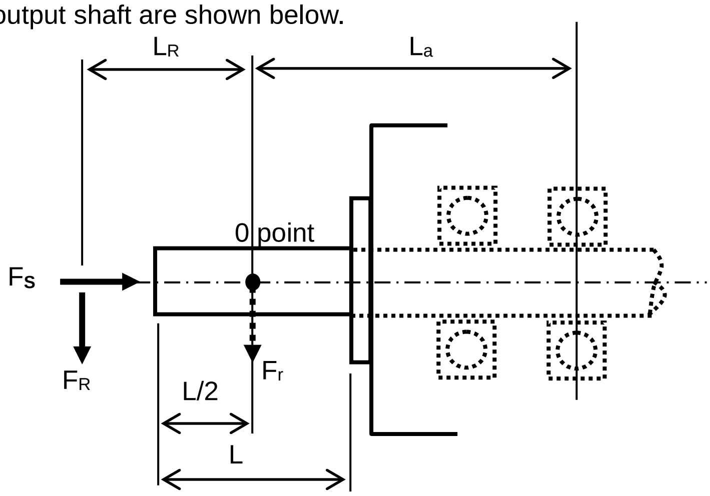
1-10-1 Allowable radial load and allowable thrust load

The allowable radial load and thrust load of the output shaft are shown below.

The allowable radial load F_r is obtained with respect to the center (L/2) 0 point of the output shaft.

The values in the following table are designed by considering the life of the bearing.

The allowable values must not be exceeded.



Item \ Model		RSF-8B	RSF-11B	RSF-14B
Allowable radial load (F_r)	N	196	245	392
	kgf	20	25	40
Allowable thrust load (F_S)	N	98	196	392
	kgf	10	20	40

1-10-2 Radial load when the operating point is different

If the operating point of radial load is different, the allowable radial load value is also different.

The relation between radial load position L_R and allowable radial value F_R is obtained from the following formula.

The allowable values must not be exceeded.

$$F_R = \frac{L_a}{L_a + L_R} F_r$$

F_R : Allowable radial load at distance L_R from the 0 point [N]
F_r : Allowable radial load at the 0 point [N]
L_a : Distance from the bearing starting point to the 0 point [mm]
L_R : Distance from the position where radial load is exerted to the 0 point [mm]
L : Shaft length [mm]

Item \ Model		RSF-8B	RSF-11B	RSF-14B
Allowable radial load (F_r)	N	196	245	392
	kgf	20	25	40
L_a	mm	23	30.5	43.2
L	mm	20	22	25

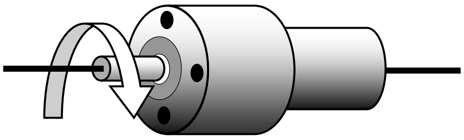
1-11 Rotary direction

The rotary direction of the RSF-B mini series actuators when a forward rotation command is given from the HA-680 driver is forward rotation seen from the output shaft side (i.e. counterclockwise: CW).

The rotary direction of the HA-680 can be switched by using the Parameter → "20: Rotary direction command" setting.

"20: Rotary direction command" setting

Value	FWD command	REV command	Setting
0	FWD rotation	REV rotation	Default
1	REV rotation	FWD rotation	



FWD: CW rotation

* The model shape is RSF-5A. RSF-3A is also the same.

* For details of the driver, refer to "AC Servo Driver HA-680 Series Technical Data."

1-12 Impact resistance

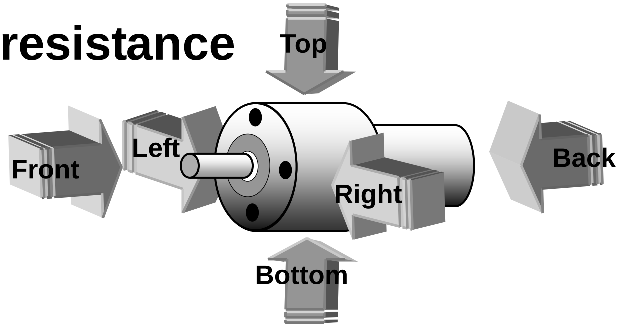
The impact resistance of the actuators is as follows.

Impact acceleration: 300 m/s^2

Direction: top/bottom, right/left, front/back

Repeating times: three

However, do not apply impact to the output shaft.



Impact resistance

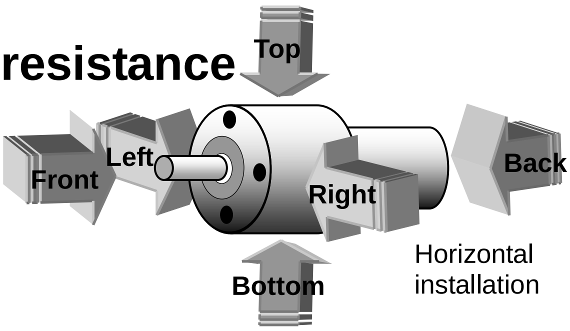
1-13 Vibration resistance

The vibration resistance of the actuators for up/down, left/right, and front/back is as follows.

Vibration acceleration:　25m/s^2 (5G)

Frequency:　10~400Hz

This specification does not guarantee fretting wear of mechanism components due to micro vibrations.

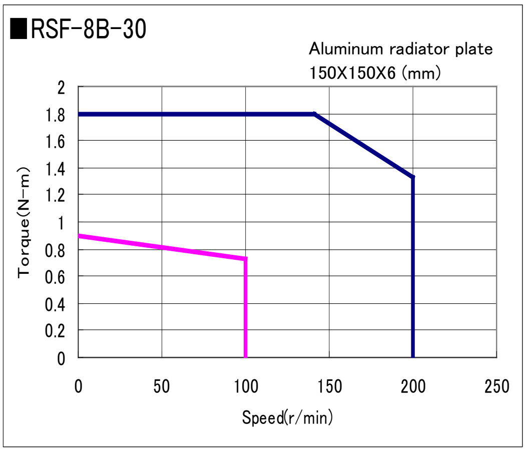


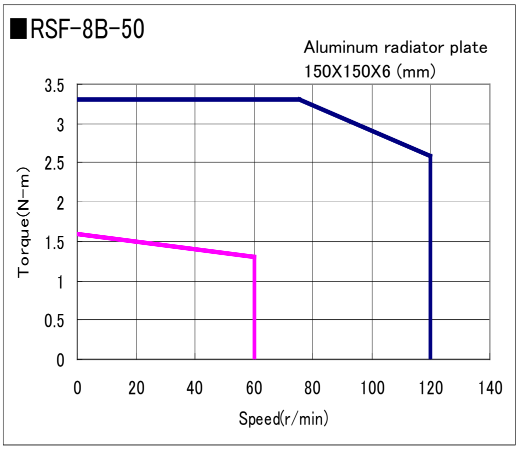
Vibration resistance

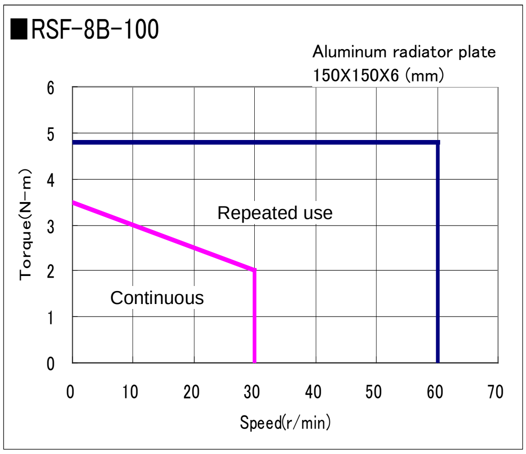
1-14 Torque-speed characteristics

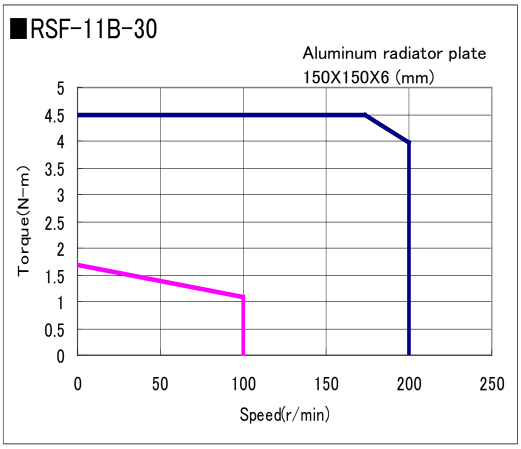
The following graphs show the usable ranges of the RSF-B mini series actuators combined with the dedicated AC servo driver HA-680 by the power voltage 24VDC input.

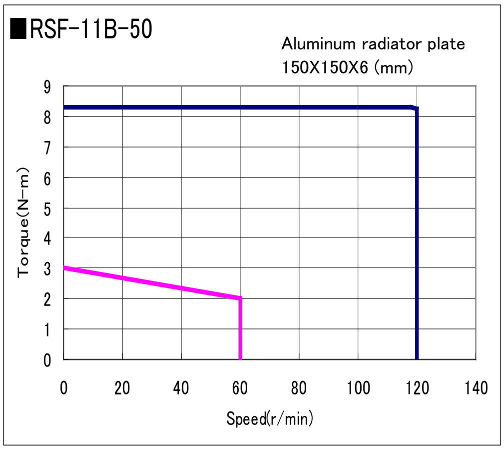
1) Continuous duty range:
   The range allows continuous operation for the actuator.
2) Repeated use range:
   The range allows repeated operation for the actuator. This range is used for acceleration and deceleration.

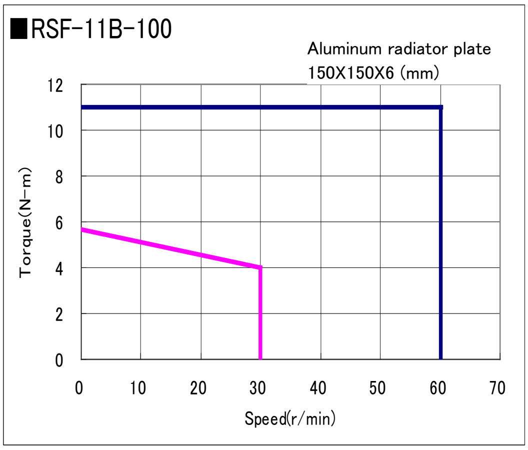


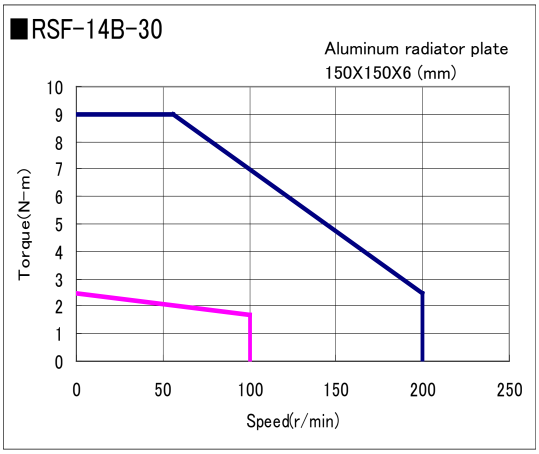


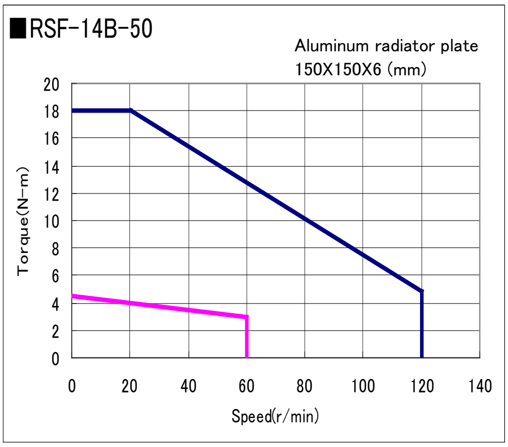


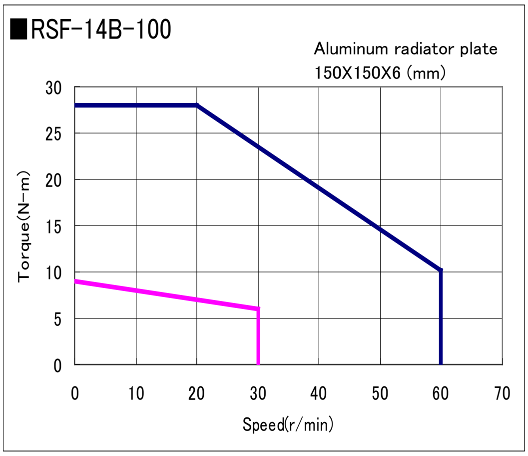












Note: Even in the continuous range, if it is used continuously in one direction, please consult with us.

1-15 Cable specifications

The following tables show specifications of the cable for the motor and the encoder of the RSF-B mini actuators.

Motor connector cable

Pin No.	Color		Signal name
1	Red	(RED)	U
2	White	(WHT)	V
3	Black	(BLK)	W
4	Green	(GRN)	E
5	–	–	–
6	–	–	–

Connector used　Plug: 350715-1(AMP)
Pin: 350690-1(AMP)

Pole sensor connector cable

Pin No.	Color	Signal name
1	Brown	U＋
2	Blue	U－
3	Red	V＋
4	Green	V－
5	Yellow	W＋
6	Orange	W－
7	White	DC＋5V±5%
8	Black	COMMON

Connector used　Housing: 51047-0800(Molex)
Terminal: 50133-8000(Molex)

Encoder connector cable

Pin No.	Color	Signal name
1	Brown	A＋
2	Blue	A－
3	Red	B＋
4	Green	B－
5	Yellow	Z＋
6	Orange	Z－
7	White	DC＋5V±5%
8	Black	COMMON
9	Shield	FG

Connector used　Housing: 51047-0900(Molex)
Terminal: 50133-8000(Molex)

Chapter 2　Installing the actuator

2-1　Receiving Inspection

Check the following when products are received.

- Inspection procedure

(1) Check the items thoroughly for damage sustained during transportation.
If any item is damaged, immediately contact the dealer.

(2) Confirm the actuator is what you ordered. A label is attached on the right side of the RSF-B mini series actuator. Check the [TYPE] field on the nameplate to confirm that it is indeed the model you have ordered. If it is different, immediately contact the dealer it was purchased from.

The model code is interpreted as follows:

RSF-11 B-50-F 100-□

- RSF: RSF-B mini series actuator
- 11: Frame size: 8,11,14
- B: Design version
- 50: Reduction ratio of Harmonic Drive® gear
- F: Encoder specifications
- 100: Number of pulses of the encoder
- □: Specification

For details of model symbols, refer to “1-2 Models” on page 2.

WARNING

Only connect the actuator specified on the driver label.

The drivers have been tuned for the actuator specified on the driver label. Wrong combination of “drivers” and “actuators” may cause low torque problems or over current that may cause physical injury and fire.

(3) The [INPUT VOL.] line of the driver label indicates the power supply voltage.

The value 24 means 24VDC power supply.

If the power supply voltage written on the label differs from the power supply voltage to be connected to, immediately contact the dealer it was purchased from.

WARNING

Do not connect a supply voltage other than the voltage specified on the label.

The wrong power supply voltage from those written on the label may damage the driver resulting physical injury and fire.

2-2 Notice on handling

Handle RSF-B mini series actuators with care, specifically:

WARNING

Do not plug the actuators directly into a commercial power line source.

This could burn out the actuator, potentially resulting in a fire and/or electrical hazard.

CAUTION

(1) Do not apply impact or unnecessary excessive force to output flange of actuators.

(2) Do not put actuators on a location where the driver could easily fall.

(3) The allowable temperature for storage is from -20°C to +60°C. Do not expose it to the sunlight for a long time and do not store it in areas with widely fluctuating temperatures.

(4) The allowable relative humidity for storage is 80% or less. Do not store it in a highly humid place or in a place where temperature changes excessively during the course of a day.

(5) Do not store units in locations with corrosive gas or particles.

2-3 Location and installation

2-3-1 Environment of location

The environmental conditions of the location for RSF-B mini series actuators must be as follows.

- Service temperature: 0°C to 40°C
  When the actuator is installed in a closed space, the temperature in the space may be higher than the atmosphere because of heat emission by the actuator. Design the closed space size, ventilation system, and device locations so the ambient temperature near the actuator is always 40°C or less.
- Service humidity: 20 to 80% relative humidity, without condensation
  Make sure no water condensation occurs at the place where there is a large temperature change in a day or due to frequent heat-and-cool cycles due to the operation of the actuator.
- Vibration: 25 m/sec^2 (10Hz~400Hz) or less
- Impact: 300 m/sec^2 or less
- Make sure the actuator is in an area free from: dust, water condensation, metal powder, corrosive gas, water, water drops, and oil mist.
- Locate the driver indoors. Do not expose it to the sunlight.

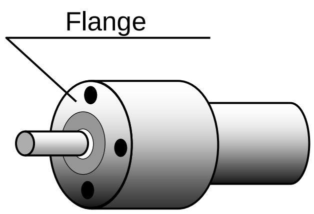
2-3-2 Installation

The RSF-B mini series actuator is a high precision servo mechanism, careful attention is required for proper installation.

Install the actuator taking care not to damage accurately machined surfaces. Take note that actuators provide a glass encoder, which may be damaged by impact.

- Procedure

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



Note 1: Very careful alignment is required especially when a rigid coupling is applied. Slight differences between centerlines will cause failure of the output shaft of the actuator.

Note 2: If needed, carefully use a wooden hammer for coupling installation.

(2) Fasten the flange of the actuator with flat washers and high strength bolts. Use a torque wrench when tightening the fasteners.

The recommended tightening torque is shown in the table below:

Item \ Model		RSF-8B	RSF-11B	RSF-14B
Number of bolt holes		3	4	4
Wrenching torque	Bolt; Hole depth	M3; Depth: 6mm	M4; Depth: 7mm	M5; Depth: 10mm
	Nm	1.4	3.2	6.3
	kgfcm	14	33	64

(3) For wiring operation, refer to the "Technical Data" of the driver.

(4) Motor cable and encoder + magnetic sensor cable
Do not pull the cables with a strong force. The connection points may be damaged. Be sure to provide enough cable slack to avoid tension on the cable. Do not use the actuator if the cable is bent repeatedly.

CAUTION

Do not disassemble and re-assemble the actuator.

This may cause damage to electrical and mechanical components and will void warranty.

Chapter 3 Options

3-1　Extension cables

There are 2 types of extension cables for motors and an incremental encoder + pole sensor. Note that the model and shape vary depending on the connecting driver.

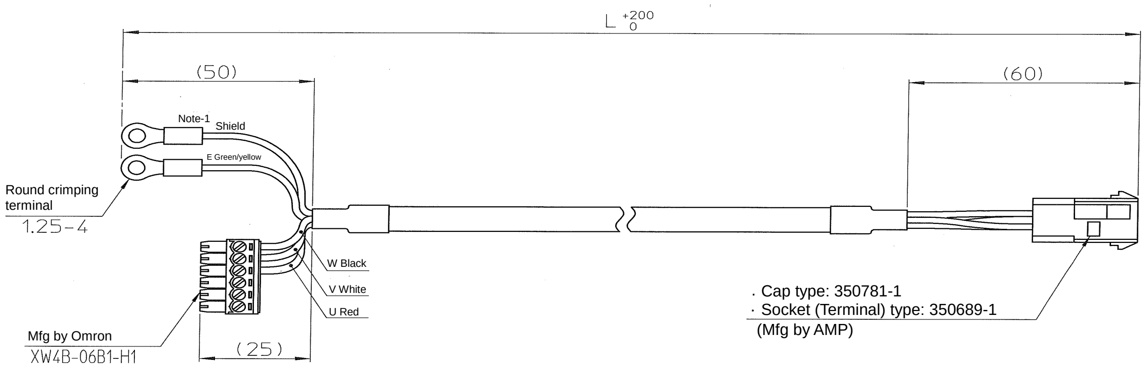
● **Extension cable type** (XX indicates the cable length 3m, 5m, or 10m.)

■Connecting driver: HA-680 series

①For motors:

EWC－MB**－A06－TN2

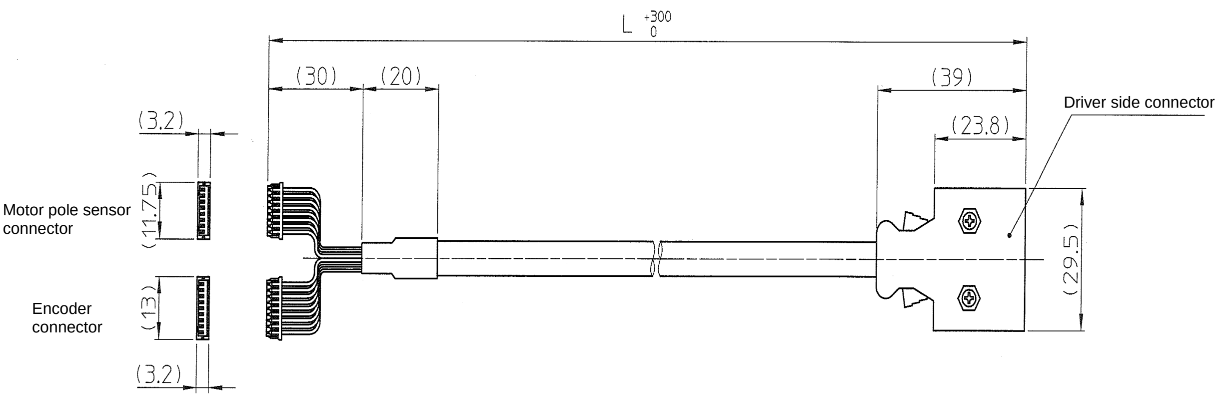
Cable length (03=3m, 05=5m, 10=10m)



②For an incremental encoder + pole sensor:

EWB－F**－M0809－3M14

Cable length (03=3m, 05=5m, 10=10m)

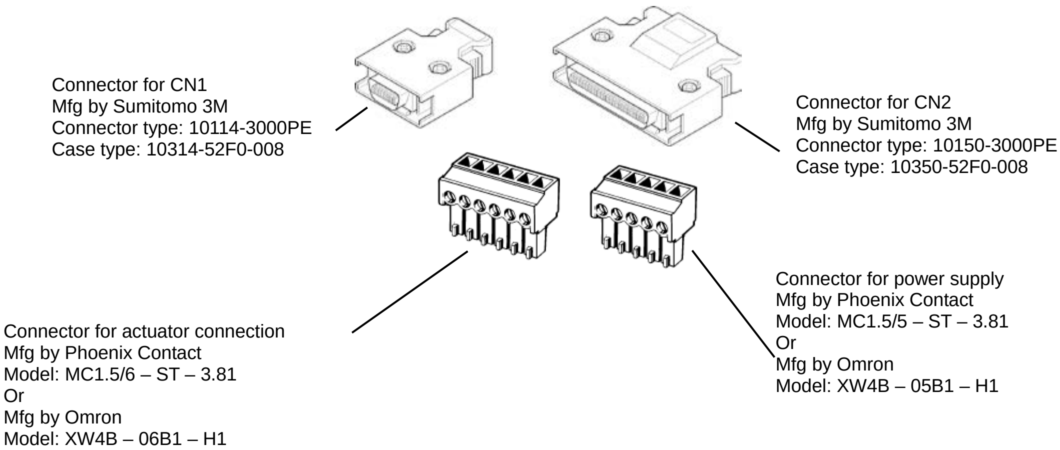


3-2 Connectors

■Connecting driver: Connectors for CN1, CN2, motor wire connection and the power supply connection of the HA-680 driver

- Connector type: CNK-HA68-S1
  For CN1, CN2, motor wire connection, power supply connection............................4 types

- Connector type: CNK-HA68-S2
  For CN2, power supply connection...2 types



Appendix 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 unit	m	
Unit	ft.	in.
Coefficient	3.281	39.37

Unit	ft.	in.
Coefficient	0.3048	0.0254
SI unit	m	

(2) Linear speed

SI unit	m/s			
Unit	m/min	ft./min	ft./s	in/s
Coefficient	60	196.9	3.281	39.37

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

(3) Linear acceleration

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

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

(4) Force

SI unit	N		
Unit	kgf	lb (force)	oz (force)
Coefficient	0.102	0.225	4.386

Unit	kgf	lb (force)	oz (force)
Coefficient	9.81	4.45	0.278
SI unit	N		

(5) Mass

SI unit	kg	
Unit	lb.	oz.
Coefficient	2.205	35.27

Unit	lb.	oz.
Coefficient	0.4535	0.02835
SI unit	kg	

(6) Angle

SI unit	rad		
Unit	Deg.	Min.	Sec.
Coefficient	57.3	3.44×10^3	2.06×10^5

Unit	Deg.	Min.	Sec.
Coefficient	0.01755	2.93×10^{-4}	4.88×10^{-6}
SI unit	rad		

(7) Angular speed

SI unit	rad/s			
Unit	Deg./s	Deg./min	r/s	r/min
Coefficient	57.3	3.44×10^3	0.1592	9.55

Unit	Deg./s	Deg./min	r/s	r/min
Coefficient	0.01755	2.93×10^{-4}	6.28	0.1047
SI unit	rad/s			

(8) Angular acceleration

SI unit	rad/s^2	
Unit	$Deg./s^2$	$Deg./min^2$
Coefficient	57.3	3.44×10^3

Unit	$Deg./s^2$	$Deg./min^2$
Coefficient	0.01755	2.93×10^{-4}
SI unit	rad/s^2	

(9) Torque

SI unit	Nm			
Unit	kgfm	lbft	lbin	ozin
Coefficient	0.102	0.738	8.85	141.6

Unit	kgfm	lbft	lbin	ozin
Coefficient	9.81	1.356	0.1130	7.06×10^{-3}
SI unit	Nm			

(10) Moment of inertia

SI unit	kgm^2							
Unit	$kgfms^2$	$kgfcms^2$	$lbft^2$	$lbfts^2$	$lbin^2$	$lbins^2$	$ozin^2$	$ozins^2$
Coefficient	0.102	10.2	23.73	0.7376	3.42×10^3	8.85	5.47×10^4	141.6

Unit	$kgfms^2$	$kgfcms^2$	$lbft^2$	$lbfts^2$	$lbin^2$	$lbins^2$	$ozin^2$	$ozins^2$
Coefficient	9.81	0.0981	0.0421	1.356	2.93×10^{-4}	0.113	1.829×10^{-5}	7.06×10^{-3}
SI unit	kgm^2							

(11) Torsional spring constant, moment of rigidity

SI unit	Nm/rad				
Unit	kgfm/rad	kgfm/arc min	kgfm/Deg.	lbft/Deg.	lbin/Deg.
Coefficient	0.102	2.97×10^{-5}	1.78×10^{-3}	0.0129	0.1546

Unit	kgfm/rad	Kgfm/arc min	kgfm/Deg.	lbft/Deg.	lbin/Deg.
Coefficient	9.81	3.37×10^4	562	77.6	6.47
SI unit	Nm/rad				

Appendix 2 Calculations of moment of inertia

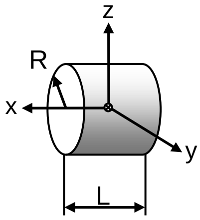
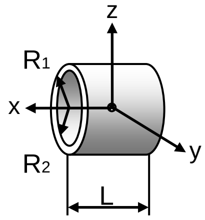
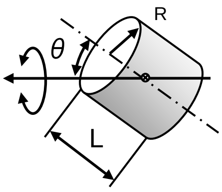
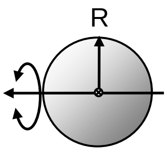
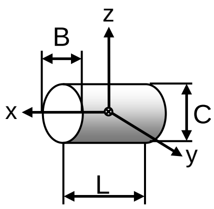
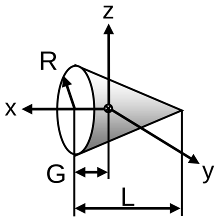
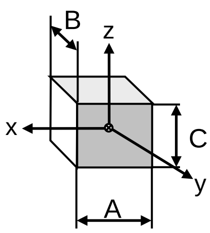
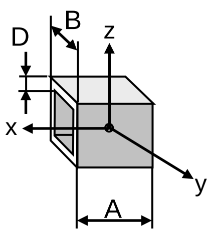
1. Calculation formulas for mass and moment of inertia

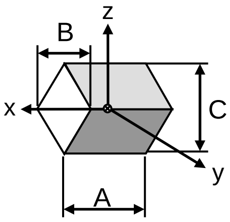
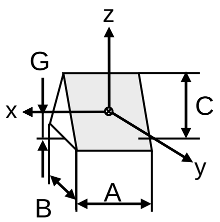
(1) When center of revolution and line of center of gravity match

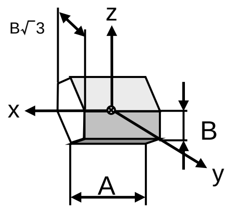
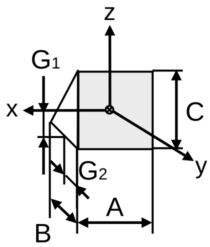
Calculation formulas for mass and moment of inertia are shown below.

m: Mass (kg)
Ix, Iy, Iz: moment of inertia (kgm^2) making Axes x, y and z as centers of revolution
G: Distance from edge surface of center of gravity
ρ: Specific gravity

Units - Length: m, mass: kg, moment of inertia: kgm^2

Shape of object	Mass, inertia, position of center of gravity	Shape of object	Mass, inertia, position of center of gravity
Circular cylinder 	$m=\pi R^2 L\rho$ $Ix=\frac{1}{2}mR^2$ $Iy=\frac{1}{4}m\left(R^2+\frac{L^2}{3}\right)$ $Iz=\frac{1}{4}m\left(R^2+\frac{L^2}{3}\right)$	Round pipe  R1: Outside diameter R2: Inside diameter	$m=\pi\left(R_1{}^2-R_2{}^2\right)L\rho$ $Ix=\frac{1}{2}m\left(R_1{}^2+R_2{}^2\right)$ $Iy=\frac{1}{4}m\left\{\left(R_1{}^2+R_2{}^2\right)+\frac{L^2}{3}\right\}$ $Iz=\frac{1}{4}m\left\{\left(R_1{}^2+R_2{}^2\right)+\frac{L^2}{3}\right\}$
Tilted circular cylinder 	$m=\pi R^2 L\rho$ $I_\theta=\frac{1}{12}m$ $\times\left\{3R^2\left(1+\cos^2\theta\right)+L^2\sin^2\theta\right\}$	Sphere 	$m=\frac{4}{3}\pi R^3\rho$ $I=\frac{2}{5}mR^2$
Elliptic circular cylinder 	$m=\frac{1}{4}\pi BCL\rho$ $Ix=\frac{1}{16}m\left(B^2+C^2\right)$ $Iy=\frac{1}{4}m\left(\frac{C^2}{4}+\frac{L^2}{3}\right)$ $Iz=\frac{1}{4}m\left(\frac{B^2}{4}+\frac{L^2}{3}\right)$	Cone 	$m=\frac{1}{3}\pi R^2 L\rho$ $Ix=\frac{3}{10}mR^2$ $Iy=\frac{3}{80}m\left(4R^2+L^2\right)$ $Iz=\frac{3}{80}m\left(4R^2+L^2\right)$ $G=\frac{L}{4}$
Prism 	$m=ABC\rho$ $Ix=\frac{1}{12}m\left(B^2+C^2\right)$ $Iy=\frac{1}{12}m\left(C^2+A^2\right)$ $Iz=\frac{1}{12}m\left(A^2+B^2\right)$	Regular square pipe 	$m=4AD(B-D)\rho$ $Ix=\frac{1}{3}m\left\{(B-D)^2+D^2\right\}$ $Iy=\frac{1}{6}m\left\{\frac{A^2}{2}+(B-D)^2+D^2\right\}$ $Iz=\frac{1}{6}m\left\{\frac{A^2}{2}+(B-D)^2+D^2\right\}$

Shape of object	Mass, inertia, position of center of gravity
Rhombic prism 	$m = \frac{1}{2}ABC\rho$ $Ix = \frac{1}{24}m\left(B^2 + C^2\right)$ $Iy = \frac{1}{24}m\left(C^2 + 2A^2\right)$ $Iz = \frac{1}{24}m\left(B^2 + 2A^2\right)$
Equilateral triangular prism 	$m = \frac{1}{2}ABC\rho$ $Ix = \frac{1}{12}m\left(\frac{B^2}{2} + \frac{2}{3}C^2\right)$ $Iy = \frac{1}{12}m\left(A^2 + \frac{2}{3}C^2\right)$ $Iz = \frac{1}{12}m\left(A^2 + \frac{B^2}{2}\right)$ $G = \frac{C}{3}$

Shape of object	Mass, inertia, position of center of gravity
Regular hexagon prism 	$m = \frac{3\sqrt{3}}{2}AB^2\rho$ $Ix = \frac{5}{12}mB^2$ $Iy = \frac{1}{12}m\left(A^2 + \frac{5}{2}B^2\right)$ $Iz = \frac{1}{12}m\left(A^2 + \frac{5}{2}B^2\right)$
Right-angled triangular prism 	$m = \frac{1}{2}ABC\rho$ $Ix = \frac{1}{36}m\left(B^2 + C^2\right)$ $Iy = \frac{1}{12}m\left(A^2 + \frac{2}{3}C^2\right)$ $Iz = \frac{1}{12}m\left(A^2 + \frac{2}{3}B^2\right)$ $G_1 = \frac{C}{3}$ $G_2 = \frac{B}{3}$

◆ Example of specific gravity

The following table shows informative values of specific gravity. Please check actual specific gravities of materials individually.

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

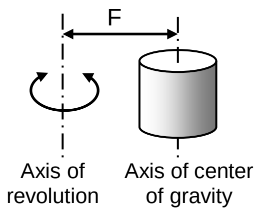
Material	Specific gravity
Aluminum	2.70
Duralumin	2.80
Silicone	2.30
Quartz glass	2.20
Teflon	2.20
Fluorine resin	2.20

Material	Specific gravity
Epoxy resin	1.90
ABS	1.10
Silicone resin	1.80
Urethane rubber	1.25

(2) When center of revolution and line of center of gravity do not match

Moment of inertia when axis of center of gravity and axis of revolution of an inertia field do not match is calculated by the following formula.

$$I = Ig + mF^2$$



I: Moment of inertia when axis of center of gravity and axis of revolution do not match (kgm^2)
Ig: Moment of inertia when axis of center of gravity and axis of revolution match (kgm^2)
Calculated by formula shown in (1) in accordance with shape.
m: Mass (kg)
F: Distance between axis of revolution and axis of center of gravity (m)

(3) Moment of inertia of linear motion object

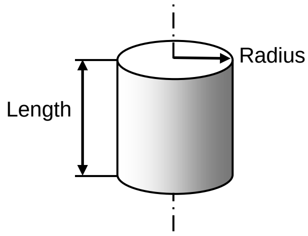
The moment of inertia converted into an FHA-C actuator axis of a linear motion object driven by a screw is calculated by the following formula.

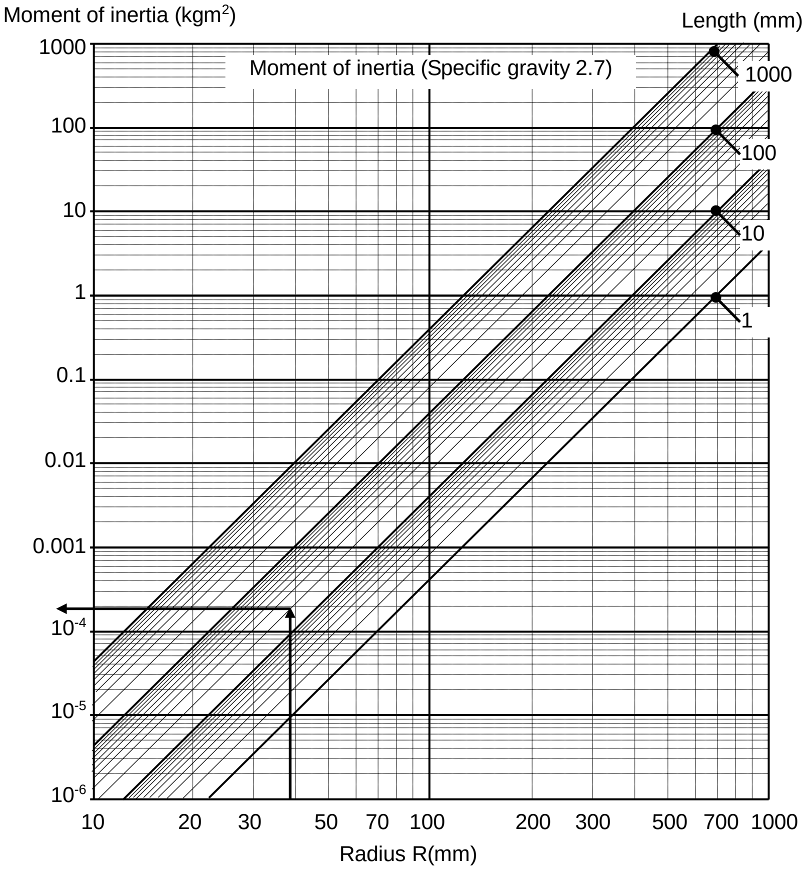
$$I = m\left(\frac{P}{2\pi}\right)^2$$

I: Moment of inertia converted into actuator axis of a linear motion object (kgm^2)
m: Mass (kg)
P: Amount of linear movement per revolution of actuator (m/rev)

2. Moment of inertia of circular cylinder

Approximate values of moment of inertia of circular cylinder can be calculated from the graph on the right.





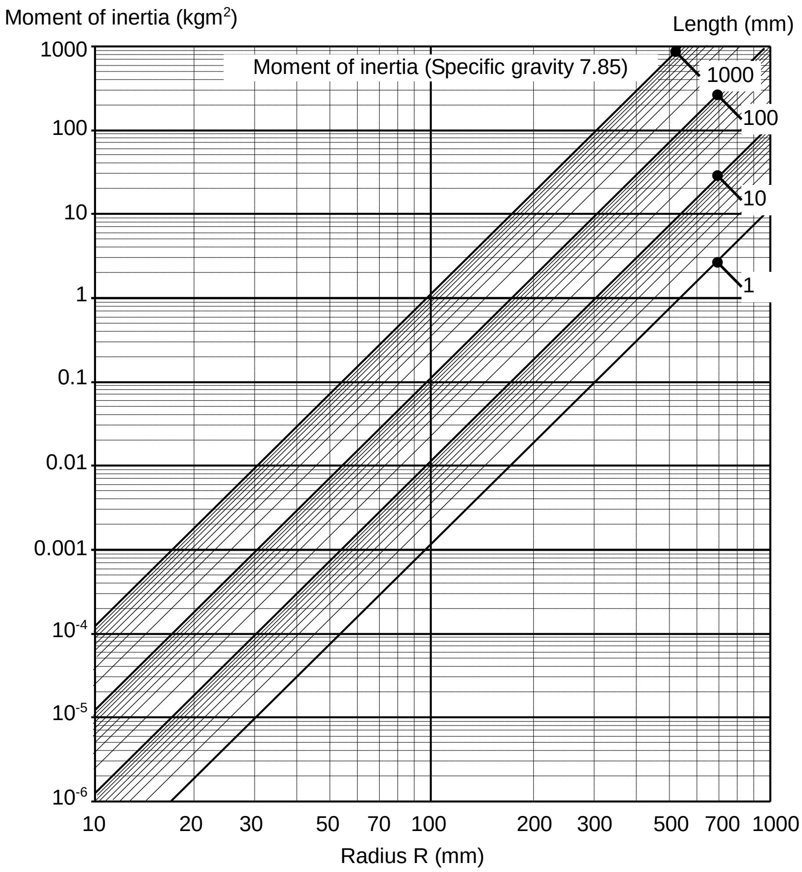
The top graph is applied to aluminum (specific gravity 2.7) and the bottom graph, to steel (specific gravity 7.85).

(Example)

Material: Aluminum
Outside diameter: 100mm
Length: 7mm
Shape: Circular cylinder
Outside diameter: 100mm

Since the outside diameter is 100mm, the radius is 50mm.
Based on the top graph, moment of inertia is about 1.9 x 10-4 kgm^2.

(Calculated value: 0.000186kgm^2)



Memo

Memo

Warranty Period and Terms

The RSF-B mini series actuators are warranted as follows:

■ Warranty period

Under the condition that the actuator is handled, used and maintained properly followed each item of the documents and the manuals, all the RSF B mini series actuators 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 RSF B mini series actuators 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 the other than the RSF B mini series actuator and the HA-655/675/680 servo driver.

(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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