HamonicDrive®

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 sufficient safety measures when installing and operating the equipment so as to prevent an accident resulting in a serious physical injury damaged by a malfunction or improper operation.
- 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.

ISO14001

ISO9001

SAFETY GUIDE

For RSF-B mini series, HA series
manufactured by Harmonic Drive Systems Inc

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

Precautions when using a direct drive motor

CAUTIONS FOR DIRECT DRIVE MOTOR AT APPLICATION DESIGNING

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 以下
- 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 DIRECT DRIVE MOTOR IN OPERATIONS

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 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.
- 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 intent 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 or megger 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.

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 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.

Contents

Memo

Chapter 1 Overview of the RSF-B mini series

RSF-B mini series are AC servo actuators combined with a precision control reduction gear HarmonicDrive® that provides high-torque and accurate rotation operation and a high-speed and high-response AC servo motor.

Use RSF-B mini series for robot joint drive, semi-conductor, liquid crystal panel manufacturer, machine tools and other various types of FA devices.

1-1 Major characteristics

◆ Small, lightweight, and high-torque

The RSF-B mini series with the precision-control deceleration device HarmonicDrive® realizes a small, lightweight, high torque and has a very high output torque for the outer dimensions compared to the direct driving method with a high-capacity motor alone.

◆ Superior positioning precision

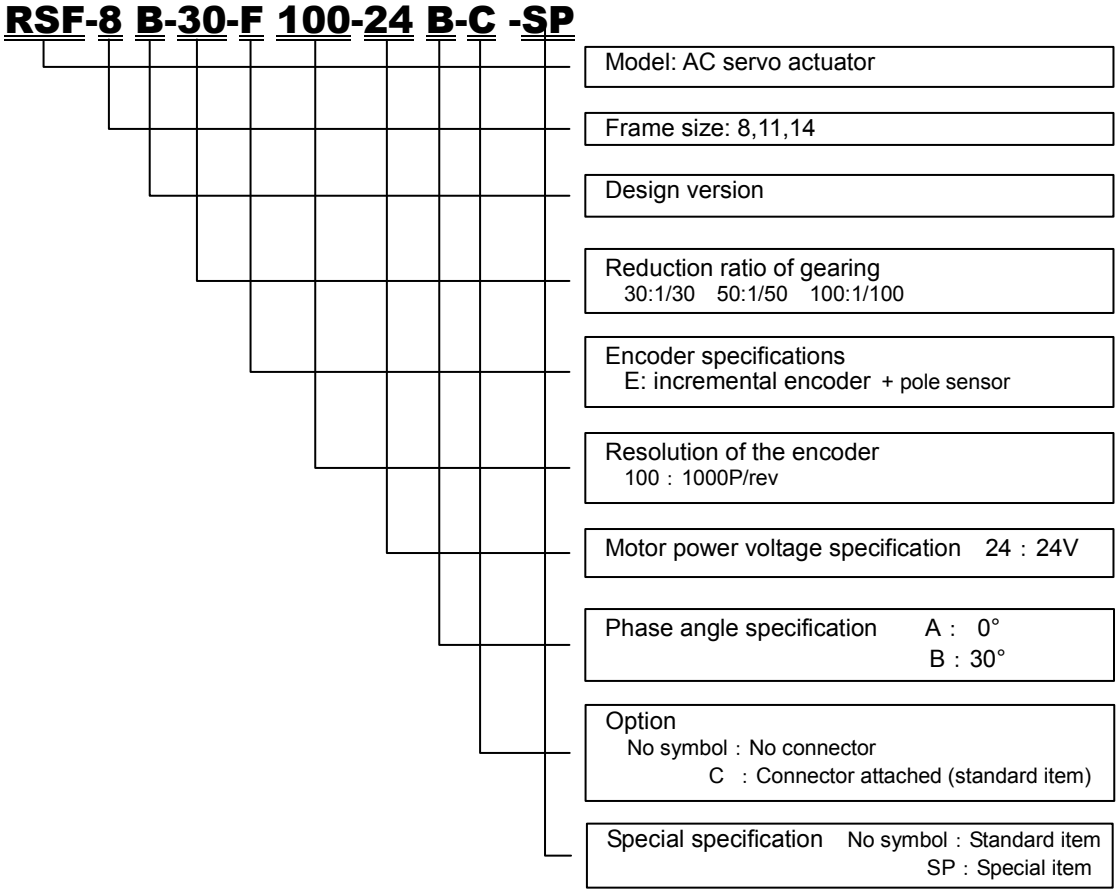
The characteristics of the control deceleration device HarmonicDrive® such as non-backlash and superior positioning precision realize high-precision mechanisms.

◆ Stable controllability

The high deceleration gear ratio of the control deceleration device HarmonicDrive® provides stable controllability for large variations of load moment of inertia.

1-2 Ordering information

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



1-3 Combinations with drivers

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

Actuator model name	Combined driver model name
RSF-8B	HA-680-4B-24
RSF-11B	HA-680-6B-24
RSF-14B	HA-680-6B-24

WARNING

Do not combine an actuator that is different from that described on the nameplate of the driver.

Characteristics of the driver have been adjusted with the actuator. A combination of a different “driver” and an “actuator” may cause burnout of the actuator due to insufficient torque and overcurrent, injury and a fire.

1-4 Specifications of RSF-B mini actuators

Specifications of actuators are as follows:

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 Note6
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	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
		kgfcm	8.2	14	29	11	20	41	17	31	61
Rated rotating speed *		r/min	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
		kgfcm	9.3	17	36	17	31	58	26	46	92
Instantaneous maximum current *		A	3.8	3.9	2.9	14.4	15.8	9.4	14.4	17.2	12.3
Instantaneous maximumtorque *		Nm	1.8	3.3	4.8	4.5	8.3	11	9.0	18	28
		kgfcm	18	34	49	46	85	112	92	184	286
Max. speed *		r/min	200	120	60	200	120	60	200	120	60
Torque constant		Nm/A	0.62	1.1	2.1	0.40	0.66	1.5	0.76	1.3	2.6
		kgfcm/A	6.3	11	21	4.1	6.7	15	7.8	13	27
EMF constant		V/(r/min)	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	$GD^2/4$	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}
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		
		kgf	20			25			40		
Allowable thrust load		N	98			196			392		
		kgf	10			20			40		
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			HA-680-4B-24			HA-680-6B-24					

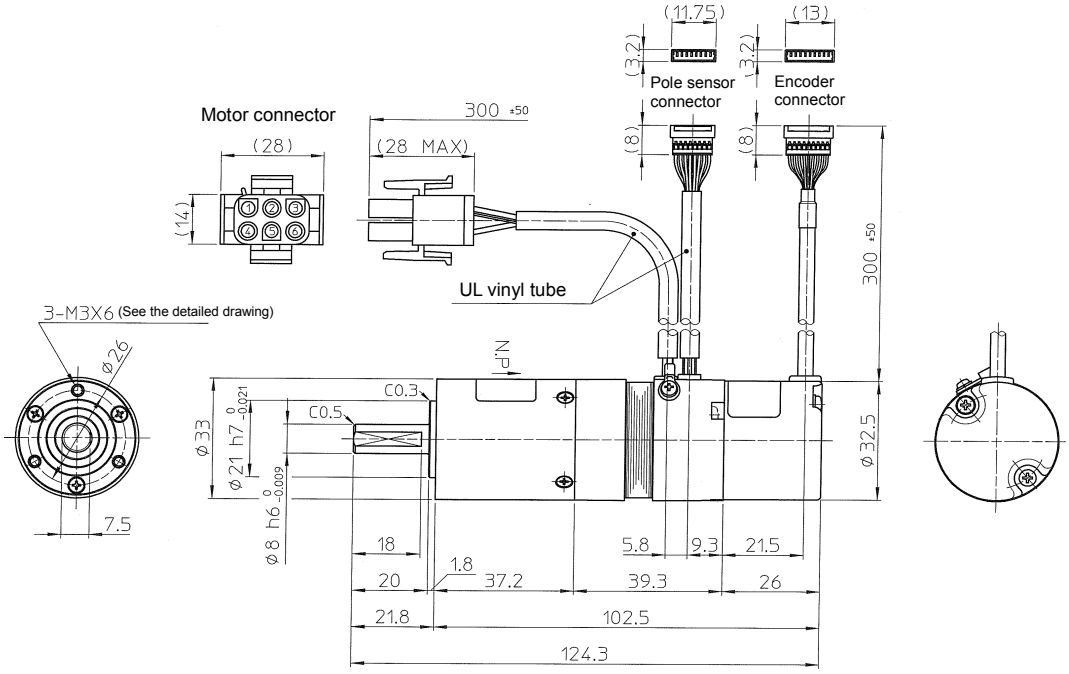
Note 1: The table shows typical output values of actuators including the efficiency of HarmonicDrive®.
Note 2: The values in the table above are obtained when it is combined with the combined driver (HA-680-4B-24) and the actuator is mounted on the aluminum radiator plate (150 x 150 x 6(mm)).
Note 3: Values indicated by an asterisk (*) are those for the saturated temperature rise. Other values indicate the temperature at 20°C. All values are typical.
Note 4: The moment of inertia is the total value of the motor shaft and HarmonicDrive® moment of inertia values converted to the output side.
Note 5: The encoder resolution is (motor shaft encoder resolution when multiplied by 4) x (gear ratio).
Note 6: Refer to "1-13 Vibration resistance" on page 11 for the test conditions.

1-5 External dimensions of actuators

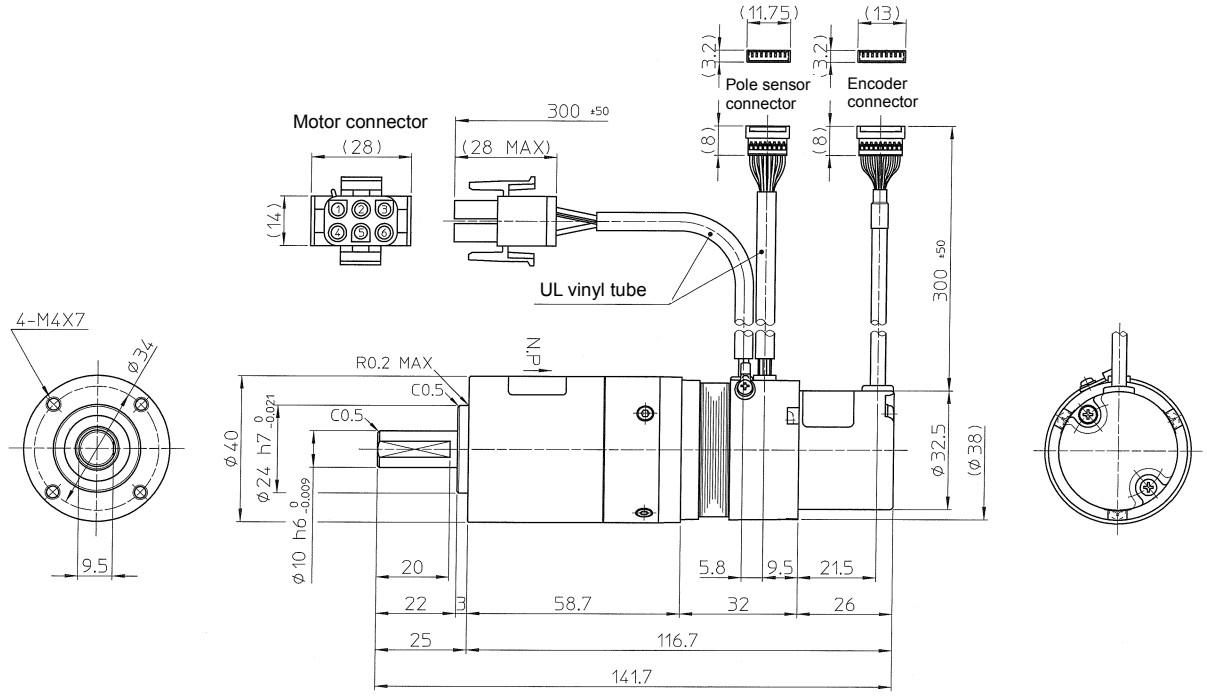
Unit : mm (third angle projection method)

The external drawings are shown as follows:

■ RSF-8B

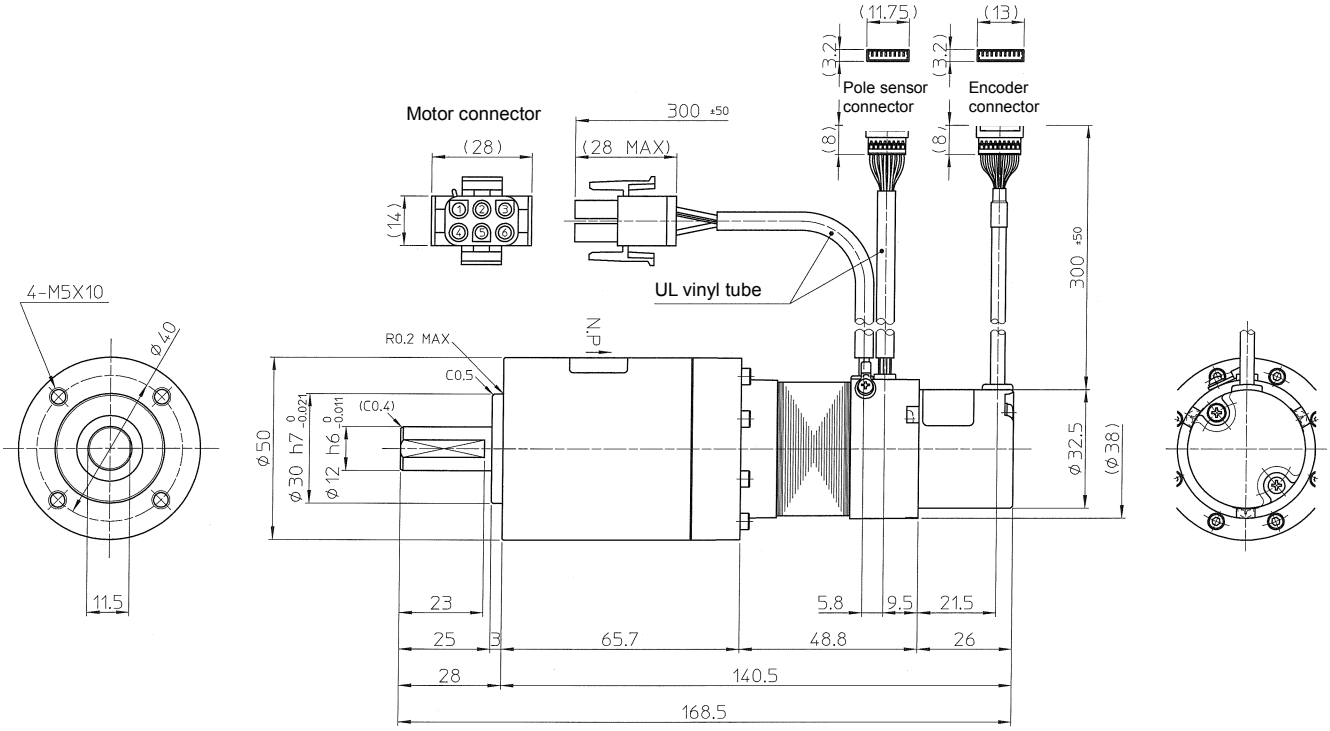


■ RSF-11B



Note) For detailed outside dimensions, check the delivery specification drawing issued by us. Tolerances may vary due to product manufacturing method (foundry piece, machine-finished good). If necessary, please contact us for the tolerance when it is not indicated in the dimensions.

■RSF-14B



Note) For detailed outside dimensions, check the delivery specification drawing issued by us. Tolerances may vary due to product manufacturing method (foundry piece, machine-finished good). If necessary, please contact us for the tolerance when it is not indicated in the dimensions.

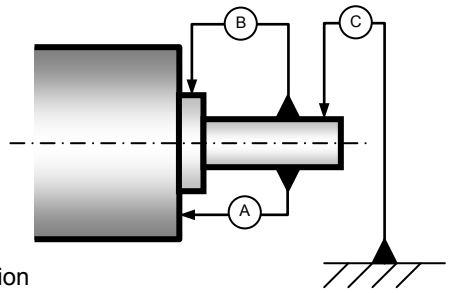
1-6 Machine accuracy

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 following table shows the “one-way positioning accuracy”.
The following table contains representing values. (JIS B 6201:1987)

The one-way positioning accuracy of RSF-B mini actuators is almost equal to the angular positioning accuracy of the HarmonicDrive® gearing, because the effect on the positioning error of the built-in motor is reducted by the gearing.

The accuracy for each gear ratio is shown below.

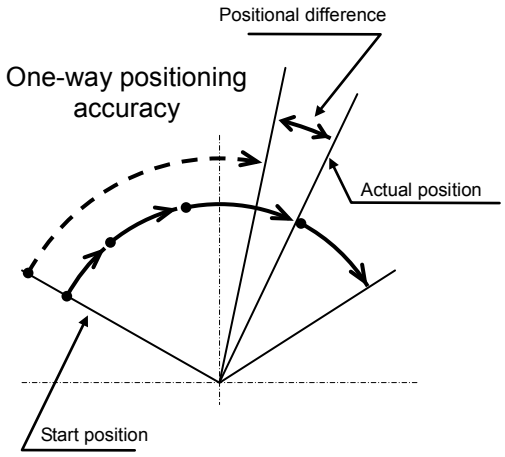
Item \ Mode		RSF-8B			RSF-11B			RSF-14B		
		30	50	100	30	50	100	30	50	100
One-way positioning accuracy	arc min	3	2.5		2.5	2		2.5	2	
	rad	8.73×10^{-4}	7.27×10^{-4}		7.27×10^{-4}	5.82×10^{-4}		7.27×10^{-4}	5.82×10^{-4}	

■ Reference

(Accuracy display and measurement method according to JIS B 6201: 1987)

● One-way positioning of rotation shaft motion

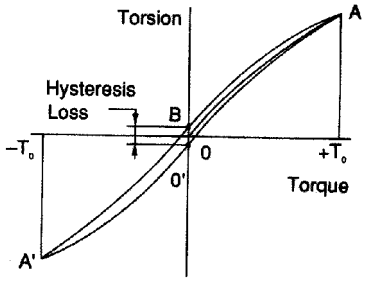
First, perform positioning at any one position in a fixed direction. This position is the reference position. Next, perform positioning in succession in the same direction, and measure the difference between the angle actually rotated from the reference position and the desired angle at each position. The maximum difference in one rotation among these values is taken as the measurement value. Measurement of equipment with the continuous positioning function for rotational motion shall be done once per 30 degrees or 12 positions throughout the entire rotation range as a rule.



1-8 Torsional stiffness

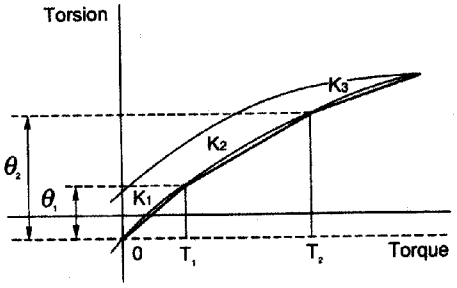
When a torque is applied to the output flange of the actuator with the motor locked, the resulting torsional wind up is near proportional to the torque.

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

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	N·m	0.29			0.80			2.0		
	kgfm	0.03			0.082			0.2		
K_1	x10^4 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	0.1	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	N·m	0.75			2.0			6.9		
	kgf·m	0.077			0.20			0.7		
K_2	x10^4 N·m/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 N·m/rad	0.054	0.084	0.12	0.16	0.32	0.44	0.34	0.57	0.71
	kgfm/arc-min	0.016	0.025	0.036	0.047	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 control decelerator HarmonicDrive®. 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		1 : 30	1 : 50	1 : 100
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

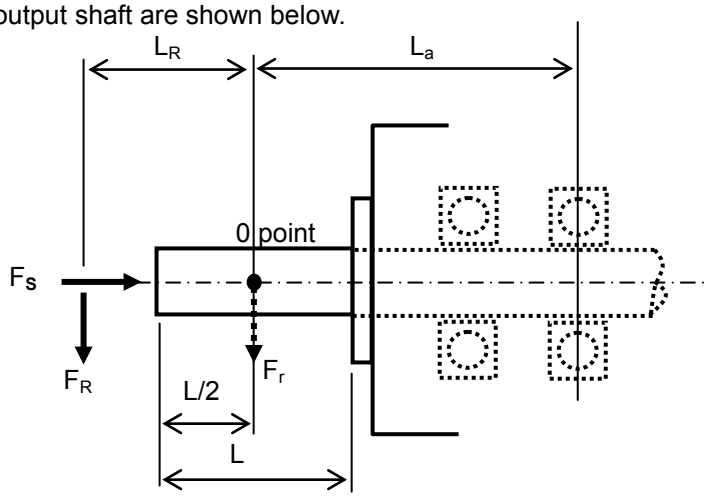
1-10-1 Allowable radial load and allowable thrust load

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

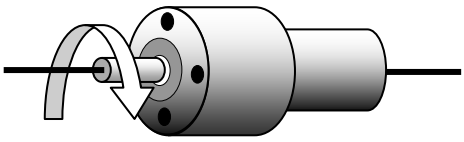
1-11 Rotary direction

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

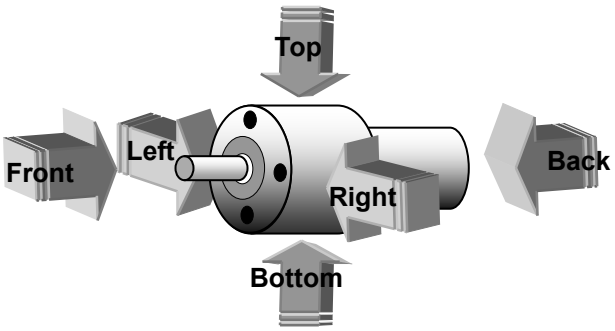
The impact resistance of the actuators is as follows.

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

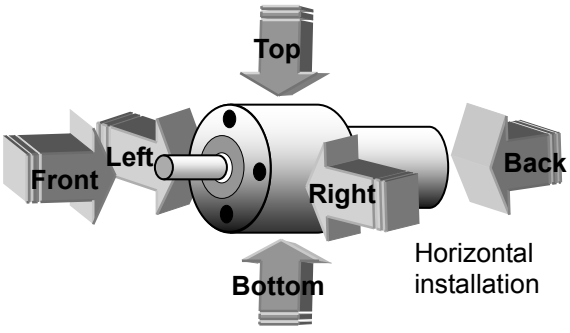
1-13 Vibration resistance

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.

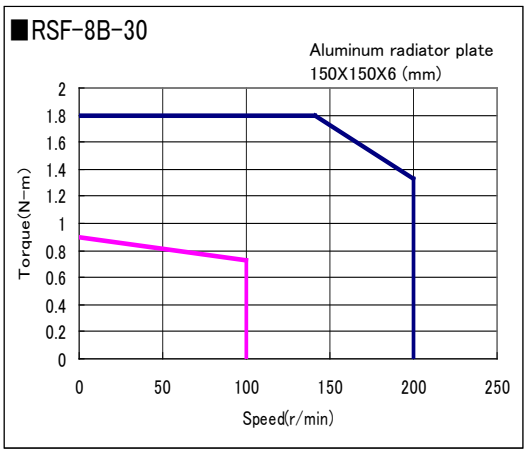


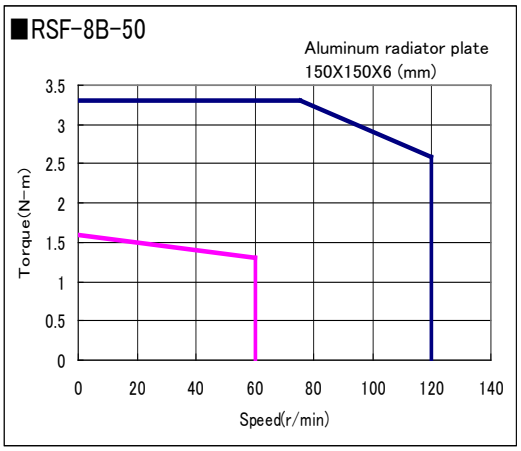
Vibration resistance

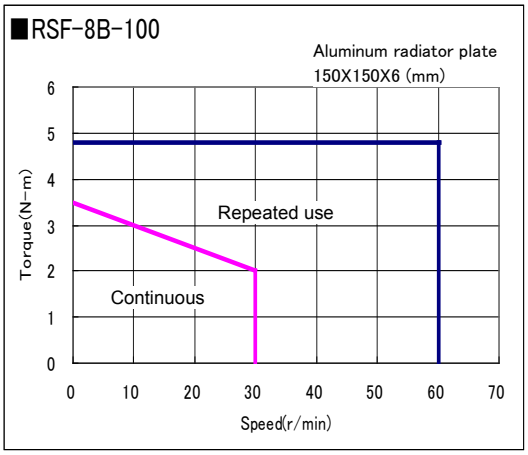
1-14 Torque-speed characteristics

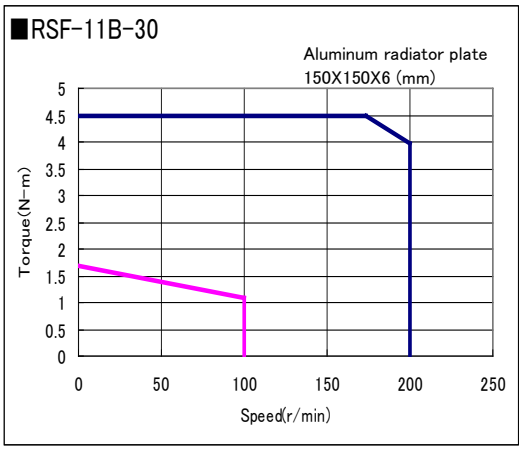
The following graphs show the usable ranges of the RSF-B mini series actuators combined with the dedicated AC servo driver HA-680 by the power voltage 24VDC input.

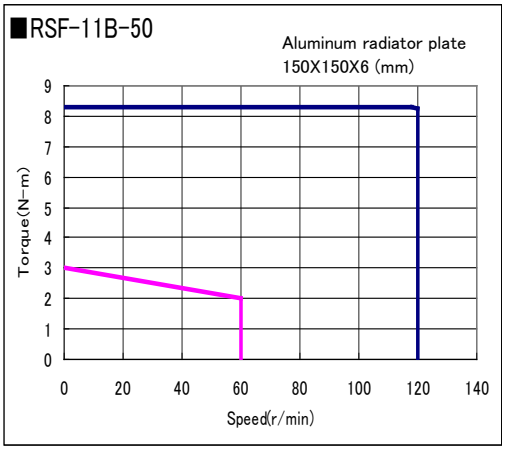
1) Continuous duty range:
   The range allows continuous operation for the actuator.
2) Repeated use range:
   The range allows repeated operation for the actuator. This range is used for acceleration and deceleration.

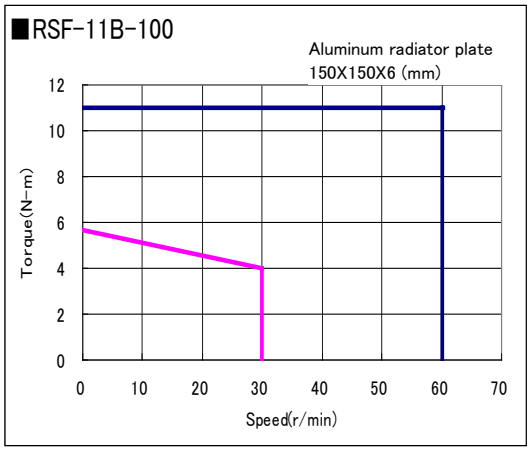


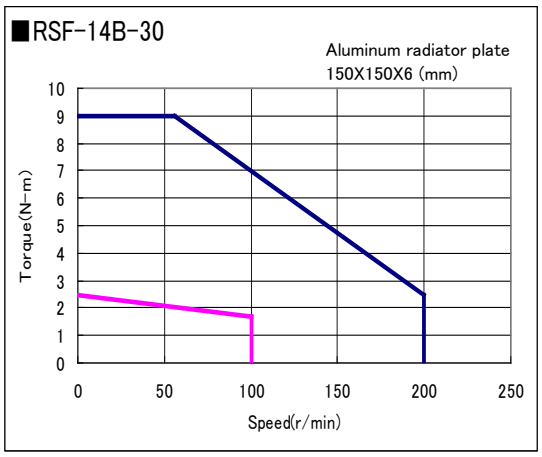


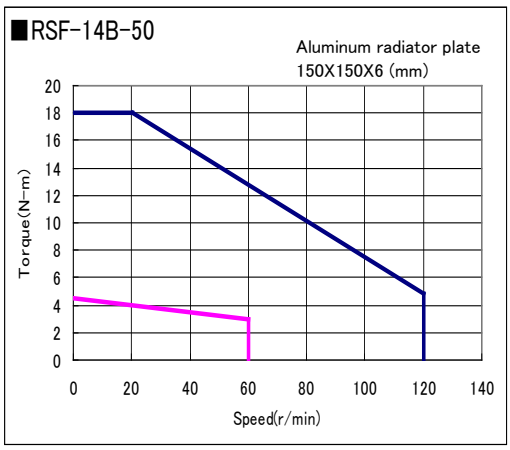


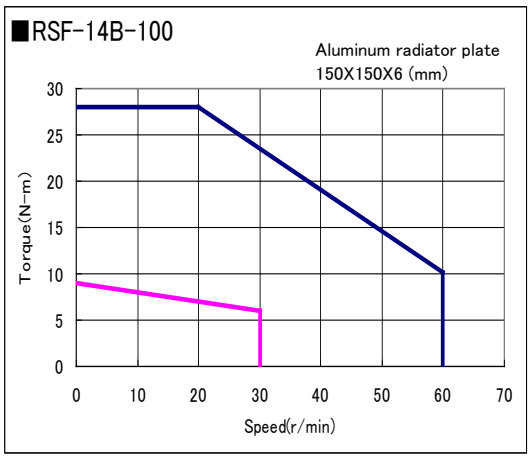












Note: Even in the continuous range, if it is used continuously in one direction, please consult with us.

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/Yellow	(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

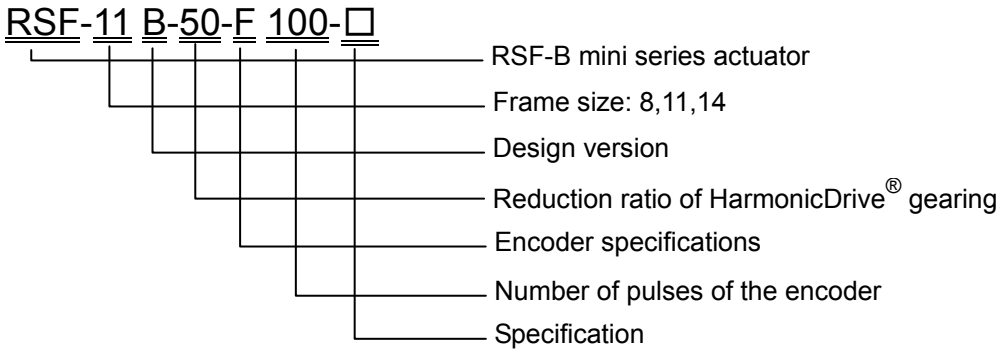
Check the following when products are received.

- Inspection procedure

(1) Check the shipping container and item for any damage that may have been caused during transportation. If the item is damaged, immediately report the damage to the dealer it was purchased from.

(2) A label is attached on the right side of the RSF-B mini series actuator. Confirm the products you ordered by comparing with the model on the [TYPE] line of the label. If it is different, immediately contact the dealer it was purchased from.

The model code is interpreted as follows:



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

(3) The model code of the RSF-B mini series actuator to be driven is indicated on the [ADJUSTED FOR USE WITH] line of the driver label. Match the actuator with its driver so as not to confuse the item with the other actuators.

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.

(4) The [INPUT VOL.] line of the driver label indicates the power supply voltage value to be input to the driver.

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.

CAUTION

Use a reinforced insulated or double insulated power supply for the 24V DC power supply to the driver.

2-2 Notice on handling

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

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

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

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

(2) Do not put actuators on in 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 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

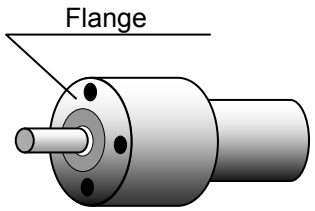
Since the RSF-B mini series actuator is a high precision servo mechanism, great care is required for proper installation.

Install the actuator taking care not to damage accurately machined surfaces. Do not hit the actuator with a hammer. 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: When installing the actuator to a coupling, use a plastic hammer to avoid excessive physical shocks.



(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 cable. Do not hang the actuator with the cable. If you do, the connection part may be damaged. Install the cable with slack not to apply tension to the actuator. Especially, do not use the actuator under any condition where the cable is bent repeatedly.

CAUTION

Do not disassemble and re-assemble the actuator.

As many precision components are used, the Harmonic Drive Systems, Inc. does not guarantee the actuator that has been reassembled by others than the authorized persons by the Harmonic Drive Systems, Inc.

Chapter 3 Options

3-1 Relay cables

There are relay cables that connect the RSF-B mini series actuator and driver.

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

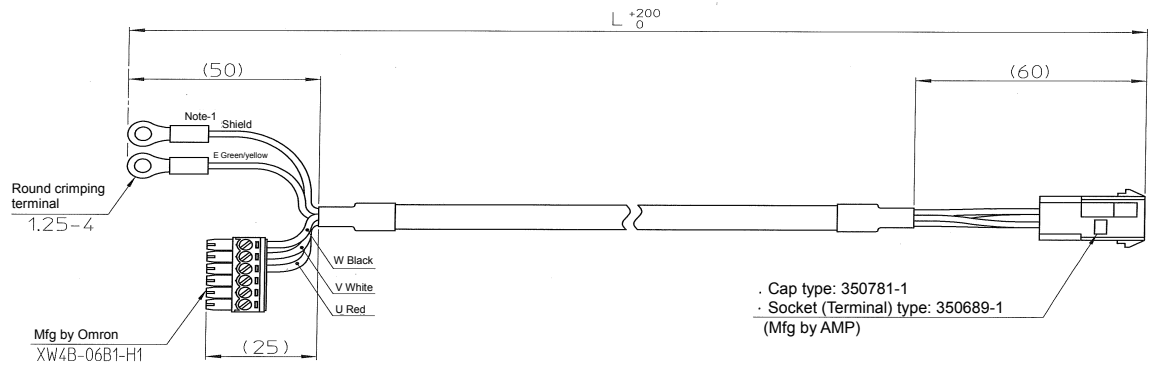
● **Relay cable type** (XX indicates the cable length 3m, 5m, or 10m.)

■Connecting driver: HA-680 series

①For motors:

EWC－MB**－A06－TN2

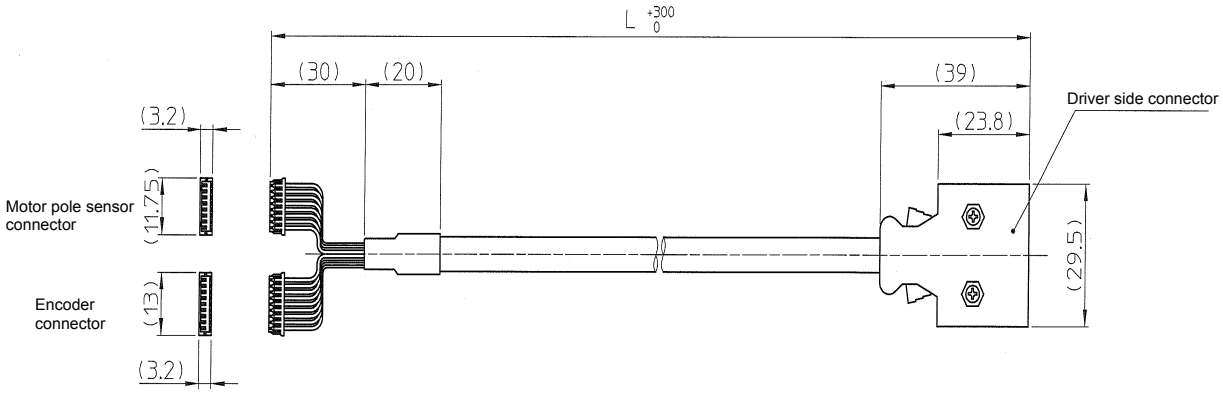
Cable length (03=3m, 05=5m, 10=10m)



②For an incremental encoder + pole sensor:

EWB－F**－M0809－3M14

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

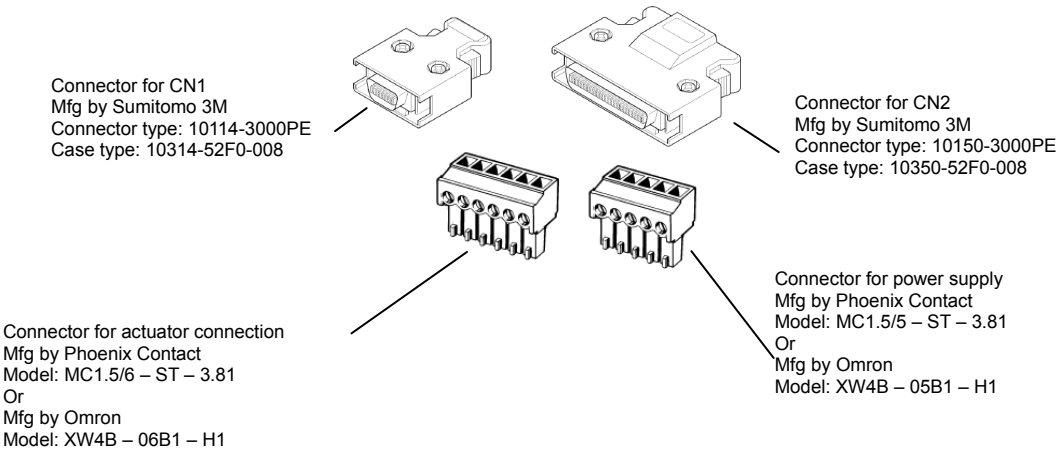


3-2 Connectors

■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 Conversion of unit

This technical manual basically uses the SI unit system. The conversion coefficients between the SI unit system and other unit systems are shown below.

(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

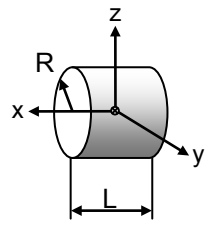
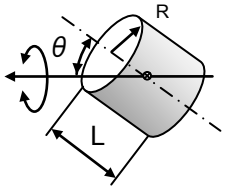
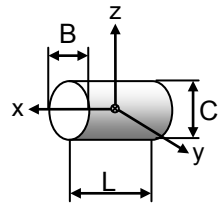
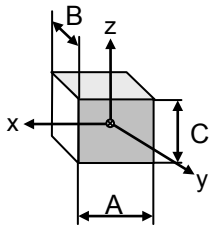
1. Calculation formulas for mass and moment of inertia

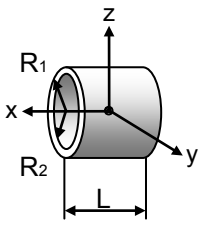
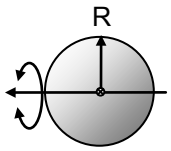
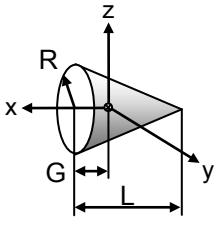
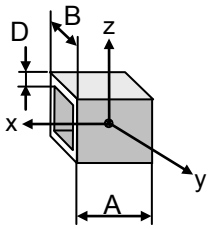
(1) When center of revolution and line of center of gravity match

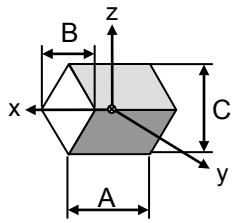
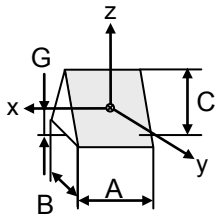
Calculation formulas for mass and moment of inertia are shown below.

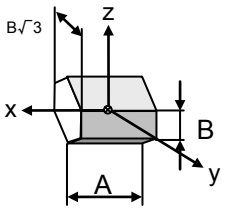
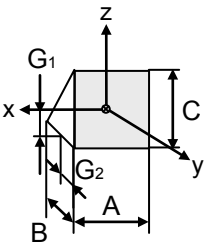
m: Mass (kg)
Ix, Iy, Iz: moment of inertia (kgm^2) making Axes x, y and z as centers of revolution
G: Distance from edge surface of center of gravity
ρ: Specific gravity

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

Shape of object	Mass, inertia, position of center of gravity
Circular cylinder 	$m = \pi R^2 L \rho$ $Ix = \frac{1}{2} m R^2$ $Iy = \frac{1}{4} m \left(R^2 + \frac{L^2}{3} \right)$ $Iz = \frac{1}{4} m \left(R^2 + \frac{L^2}{3} \right)$
Tilted circular cylinder 	$m = \pi R^2 L \rho$ $I_\theta = \frac{1}{12} m$ $\times \left\{ 3R^2 \left(1 + \cos^2\theta \right) + L^2 \sin^2\theta \right\}$
Elliptic circular cylinder 	$m = \frac{1}{4} \pi BC L \rho$ $Ix = \frac{1}{16} m \left(B^2 + C^2 \right)$ $Iy = \frac{1}{4} m \left(\frac{C^2}{4} + \frac{L^2}{3} \right)$ $Iz = \frac{1}{4} m \left(\frac{B^2}{4} + \frac{L^2}{3} \right)$
Prism 	$m = A BC \rho$ $Ix = \frac{1}{12} m \left(B^2 + C^2 \right)$ $Iy = \frac{1}{12} m \left(C^2 + A^2 \right)$ $Iz = \frac{1}{12} m \left(A^2 + B^2 \right)$

Shape of object	Mass, inertia, position of center of gravity
Round pipe  R1: Outside diameter R2: Inside diameter	$m = \pi \left(R_1^2 - R_2^2 \right) L \rho$ $Ix = \frac{1}{2} m \left(R_1^2 + R_2^2 \right)$ $Iy = \frac{1}{4} m \left\{ \left(R_1^2 + R_2^2 \right) + \frac{L^2}{3} \right\}$ $Iz = \frac{1}{4} m \left\{ \left(R_1^2 + R_2^2 \right) + \frac{L^2}{3} \right\}$
Sphere 	$m = \frac{4}{3} \pi R^3 \rho$ $I = \frac{2}{5} m R^2$
Cone 	$m = \frac{1}{3} \pi R^2 L \rho$ $Ix = \frac{3}{10} m R^2$ $Iy = \frac{3}{80} m \left(4R^2 + L^2 \right)$ $Iz = \frac{3}{80} m \left(4R^2 + L^2 \right)$ $G = \frac{L}{4}$
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 	$m=\frac{1}{2}ABC\rho$ $Ix=\frac{1}{36}m\left(B^2+C^2\right)$ $Iy=\frac{1}{12}m\left(A^2+\frac{2}{3}C^2\right)$ $Iz=\frac{1}{12}m\left(A^2+\frac{2}{3}B^2\right)$ $G_1=\frac{C}{3}\qquad G_2=\frac{B}{3}$

◆ 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

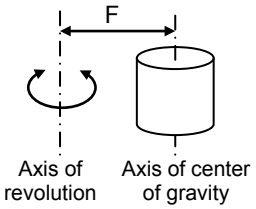
Material	Specific gravity
Aluminum	2.70
Duralumin	2.80
Silicone	2.30
Quartz glass	2.20
Teflon	2.20
Fluorine resin	2.20

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

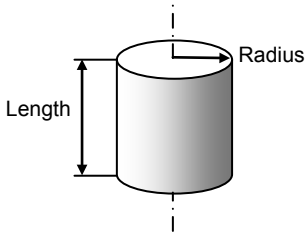
The moment of inertia converted into an FHA-C actuator axis of a linear motion object driven by a screw is calculated by the following formula.

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

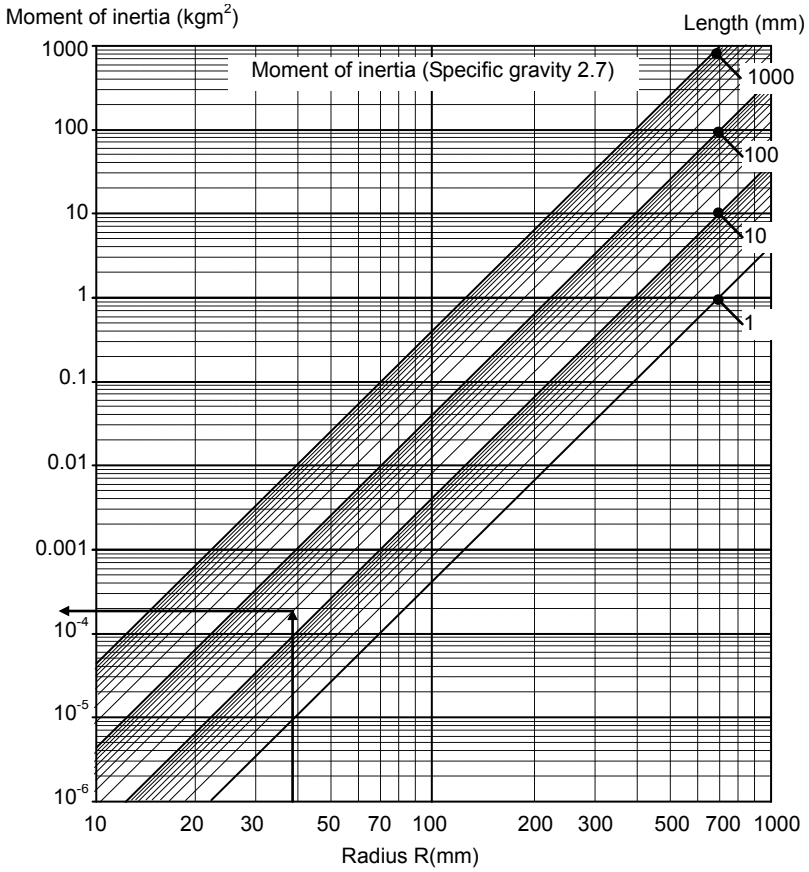
I: Moment of inertia converted into actuator axis of a linear motion object (kgm^2)
m: Mass (kg)
P: Amount of linear movement per revolution of actuator (m/rev)

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).

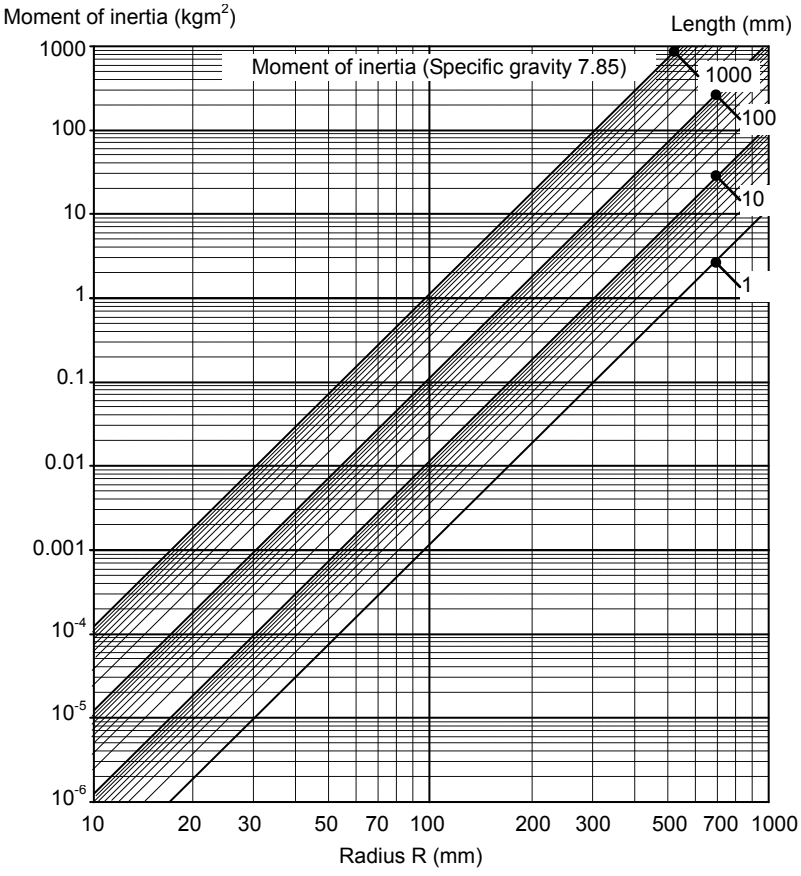


(Example)

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 equipment listed in this document is warranted as follows:

■Warranty period

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

■Warranty terms

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

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

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

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HarmonicGearhead® HarmonicLinear® BEAM SERVO® Harmonicsyn®

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All specifications and dimensions in this manual subject to change without notice.
This manual is correct as of February 2023.

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