AC Servo Actuator

RSF supermini Series

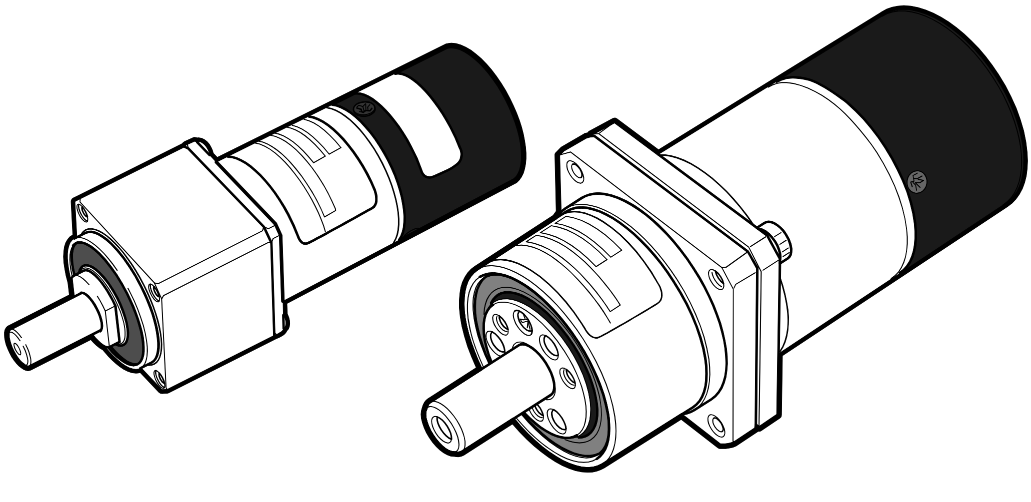
+

Mitsubishi Electric AC servo amplifier

"MELSERVO-J4" SSCNETⅢ/H communication compatible

Manual

(With RSF-3C and RSF-5B)



ISO14001

ISO9001

Introduction

Thank you very much for your purchasing our RSF supermini 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.

SAFETY GUIDE

To use the servo system safely, 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.

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

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

CAUTION **If this product is utilized in any facility in which human life is at stake or that may incur material losses, install safety devices so that accidents will not occur even when the output control is disabled due to damage.**

SAFETY NOTE

ITEMS YOU SHOULD NOTE WHEN USING THE ACTUATOR

- **NOTICES ON DESIGN**

BE SURE TO READ THE MANUAL FOR 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: 49 m/s^2 or less
- No contamination by water, oil
- No metal powder, dust, oil mist, corrosive gas, or explosive gases

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.
- Electrostatic discharge may destroy encoder elements, therefore, we recommend that installation be performed under the environment where the relative humidity is 40 to 70 % RH.

- **OPERATIONAL PRECAUTIONS**

BE SURE TO READ THE MANUAL BEFORE OPERATING THE PRODUCT.

WARNING

Never connect cables directly to a power supply socket.

- Each actuator must be operated with a proper driver.
- Do not directly apply a commercial power supply. Failure to observe this caution may lead to fire or damage to the actuator.

Do not subject the actuator to impacts and shocks.

- Do not use a hammer during installation as an encoder is directly connected to the actuator.
- Hitting the actuator may damage the encoder, causing uncontrollable or faulty operation.

Do not pull 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 directly attached to the output shaft are hit, the output shaft may become non-controllable.

OPERATIONAL PRECAUTIONS

BE SURE TO READ THE MANUAL BEFORE OPERATING THE PRODUCT.

CAUTION

Do not make a voltage resistance test.

- Do not perform a megger test or voltage resistance test. Failure to observe this caution may result in damage to the control circuit of the driver.
  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.

- Frequent power ON/OFF may result in deterioration of internal circuit elements.
- Start/stop operation should be performed via input signals.

- **DISPOSAL**

DISPOSAL OF ACTUATOR

CAUTION

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

Dispose of these items as industrial waste.

ITEMS YOU SHOULD NOTE WHEN USING THE SERVO AMPLIFIER

- **Read the "MR-J4-_B Servo Amp Technical Manuals" (No. SH-030105) and ensure safe operation.**
- **Before using this product, be sure to read the "MELSERVO-J4 SERIES AC SERVO SAFETY GUIDE" which comes together with the servo amplifier.**
- **OPERATIONAL PRECAUTIONS**

WARNING	**Before performing operations, set and check the parameters.** - Be sure to set correct values for the parameters listed in Chapter 3 of this manual. - Setting incorrect values for the parameters may cause insufficient torque or overcurrent that may lead to actuator burnout, resulting in injury or fire.

CAUTION	**Use a reinforced insulated or double insulated power supply for the 24V DC power supply to the servo amplifier.**

Contents

Chapter 1

Overview of the RSF supermini Series

Outlines of servo actuator models, specifications, external dimensions, etc., are explained in this chapter.

1-1 Overview of RSF supermini Series

The RSF supermini series are ultra-compact AC servo actuators that combine a speed reducer HarmonicDrive® for ultra-precision control with a ultra-compact AC servo motor developed to maximize the performance of a speed reducer.

Actuators with an electromagnetic brake are also included in the lineup. They can meet the fail-safe requirements of equipment to prevent accidents upon power supply failure.

Actuators, whose combined servo amplifier option code is J, are combined with Mitsubishi Electric "MR-J4W2-0303B6-MX940J" series servo amplifiers. The SSCNETⅢ/H network controls operation of the RSF supermini series actuators correctly and precisely.

The RSF supermini series actuators contribute to downsizing robot joint drive mechanisms, semiconductor/LCD panel manufacturing devices, machine tools, and other FA equipment. By utilizing its compact and high-torque characteristics, it can also be used in compact equipment and researches.

1-2 Major characteristics

Small, lightweight, and high-torque

The RSF supermini series with the precision-control deceleration device HarmonicDrive® realizes a 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.
Also, combination with the dedicated AC servo motor realizes size and weight reduction that are never possible before.

Standard lineup of actuators with a brake (only RSF-5B)

The standard lineup of AC servo actuators includes the deenergisation operation type actuators with an electromagnetic brake for the first time for this size of actuators.
Fail-safe requirements of equipment can be met to prevent accidents upon power failure without providing any external brake or changing the equipment structure to install a brake.

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.

1-3 Ordering information

Model codes for the RSF supermini series actuators are as follows:

Actuator Model

RSF-5 B-50-E 050-C-SP

- **RSF**: Model: AC servo actuator
Series: RSF series
- **5**: Frame size: 3 or 5
- **B**: Design version
- **50**: Reduction ratio of HarmonicDrive®
  - 30: 1/30
  - 50: 1/50
  - 100: 1/100
- **E**: Encoder specifications
  - E: Incremental encoder
- **050**: Encoder pulses on motor shaft
  - 020: 200p/rev (Model 3)
  - 050: 500p/rev (Model 5)
- **C**: Option
  - C: With connector (Standard product)
  - BC: (model 5 only): with brake and connector
  - J: Combined with Mitsubishi Electric servo amplifier
  - No code: No option
- **SP**: Special specification
  - No symbol: Standard product

1-4 Actuator - Amplifier Combinations

When the combined amplifier option is J, the actuator is used in combination with a Mitsubishi Electric servo amplifier.

Actuator series name	Model No.	Input voltage (V)	Encoder type	Combined amplifier SSCNETⅢ/H compatible	Relay cable
RSF supermini	3	DC24	Incremental	MR-J4W2-0303B6-MX940J	For encoders: FWA-E**JST09-3M14 For motors: EWA-M**-JST04-TN2 For brakes: EWA-B**-JST03-TMC
	5	DC24			

When the actuator is used for the first time, it is necessary to setup the combined actuator in the servo amplifier. For details, refer to "3-1 Receiving inspection" (P3-1).
For details on J4 amplifiers, refer to MR-J4W2-0303B6-MX940J Product Specifications (No.BCN-B72000-227).

1-5 Specifications of RSF supermini actuators

Specifications of actuators are as follows:

Time rating:	Continuous	Structure:	Totally enclosed self cooling type
Excitation method:	Permanent magnet type	Lubricant:	Grease (Harmonic Grease)

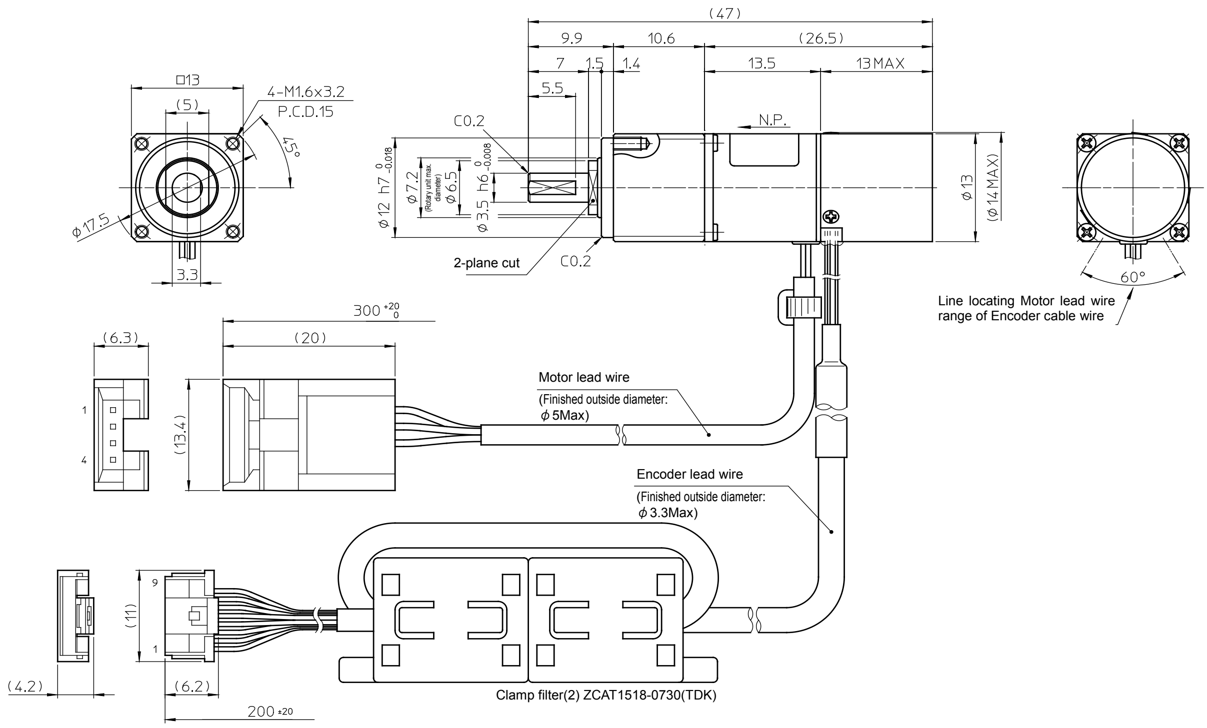
Item \ Model		RSF-3C			RSF-5B		
		30	50	100	30	50	100
Maximum torque	Nm	0.13	0.21	0.30	0.5	0.9	1.4
	kgfcm	1.27	2.05	2.94	5.1	9.17	14.3
Allowable continuous torque [*7] (when operated at permissible continuous rotational speed)	Nm	0.03	0.07	0.11	0.18	0.29	0.44
	kgfcm	0.31	0.68	1.08	1.83	2.95	4.48
Allowable continuous stall torque	Nm	0.04	0.08	0.12	0.28	0.44	0.65
	kgfcm	0.41	0.82	1.22	2.85	4.48	6.62
Maximum rotational speed	r/min	243	146	73	243	146	73
Allowable continuous rotational speed	r/min	150	90	45	150	90	45
Torque constant	Nm/A	0.11	0.18	0.40	0.3	0.54	1.1
	kgfcm/A	1.12	1.84	4.08	3.06	5.51	11.22
Maximum current	A	1.5	1.4	1.1	2.3	2.2	1.7
Allowable continuous current	A	0.65	0.66	0.56	1.11	0.92	0.76
Input power supply (amplifier)	V	DC24±10%					
EMF constant	V/(r/min)	0.015	0.025	0.05	0.04	0.07	0.13
Phase resistance (at 20°C)	Ω	1.34			0.82		
Phase inductance	mH	0.18			0.27		
Inertia moment [*4] $GD^2/4$	kgm^2	0.11×10^{-4}	0.29×10^{-4}	1.17×10^{-4}	0.66×10^{-4} (1.11×10^{-4})	1.83×10^{-4} (3.15×10^{-4})	7.31×10^{-4} (12.6×10^{-4})
Inertia moment [*4] J	$kgfcms^2$	1.07×10^{-4}	2.98×10^{-4}	11.90×10^{-4}	0.67×10^{-3} (1.13×10^{-3})	1.87×10^{-3} (3.15×10^{-3})	7.45×10^{-3} (12.6×10^{-3})
Reduction ratio		30	50	100	30	50	100
Allowable radial load (output shaft median)	N	36			90		
	kgf	3.6			9.1		
Allowable thrust load	N	130			270		
	kgf	13.2			27.5		
Encoding format		Incremental encoder					
Encoder resolution [*5]	pls/rev	200 [800]			500 [2000]		
Actuator resolution [*5]	pls/rev	[24,000]	[40,000]	[80,000]	[60,000]	[100,000]	[200,000]
Mass [*4*6]	g	31			66 (86)		
Brake holding torque [*4]	Nm	—			(0.18)	(0.29)	(0.44)
	kgfcm	—			(1.83)	(2.95)	(4.48)
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: 49 m/s^2 (frequency 10 to 400 Hz) Shock resistance: 300 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: 1,500VAC/1 min Insulation class: B					

Note 1:The table shows typical output values of actuators.
Note 2:The values in the table above are obtained when combined with a MR-J4W2-0303B6-MX940J amplifier.
Note 3:All values shown are typical values.
Note 4:The values in parentheses are for models with a brake.
Note 5:The values in brackets are resolution obtained when combined with an amplifier and multiplied by 4.
Note 6:The mass values do not include clamp filters. The mass of a clamp filter is 6 g.
Note 7:Values with saturated temperature rise when installed on an aluminum radiation plate
(RSF-3: 85×85×3 (mm), RSF-5: 150×150×3 (mm)).

1-6 External dimensions of actuators

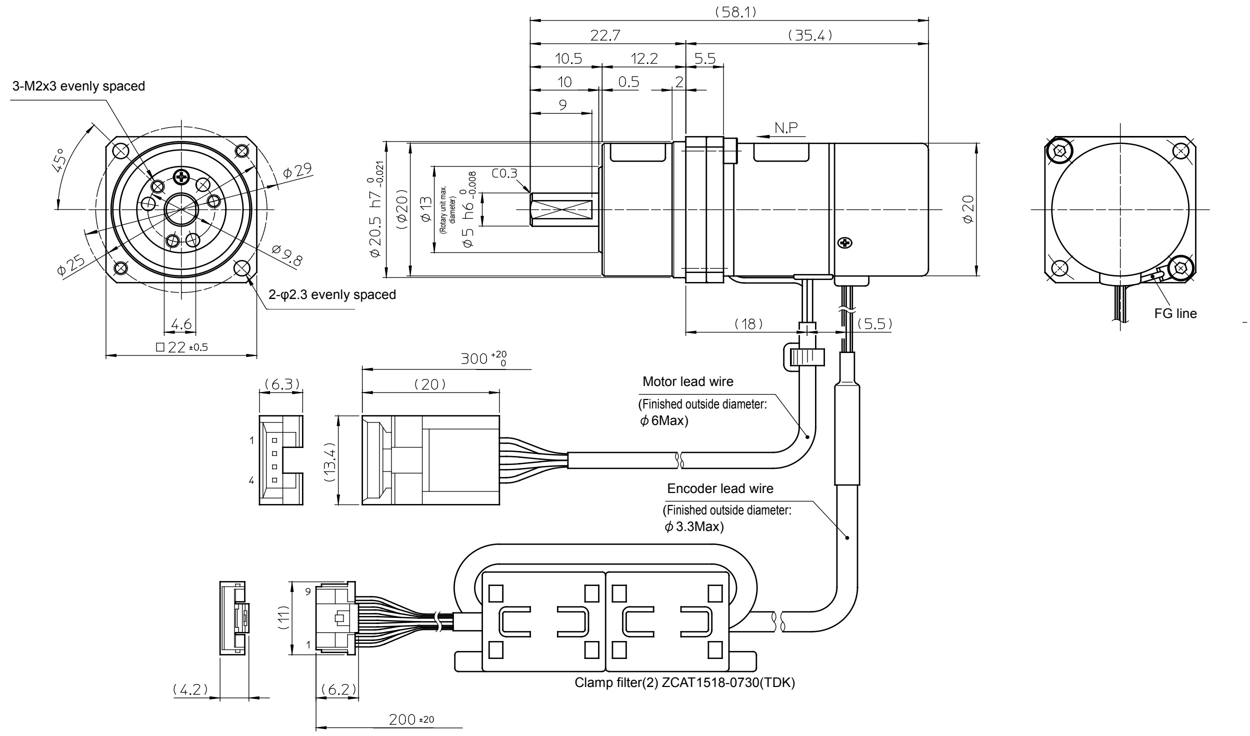
The external drawings are shown as follows:

RSF-3C-XXX-E020-CJ

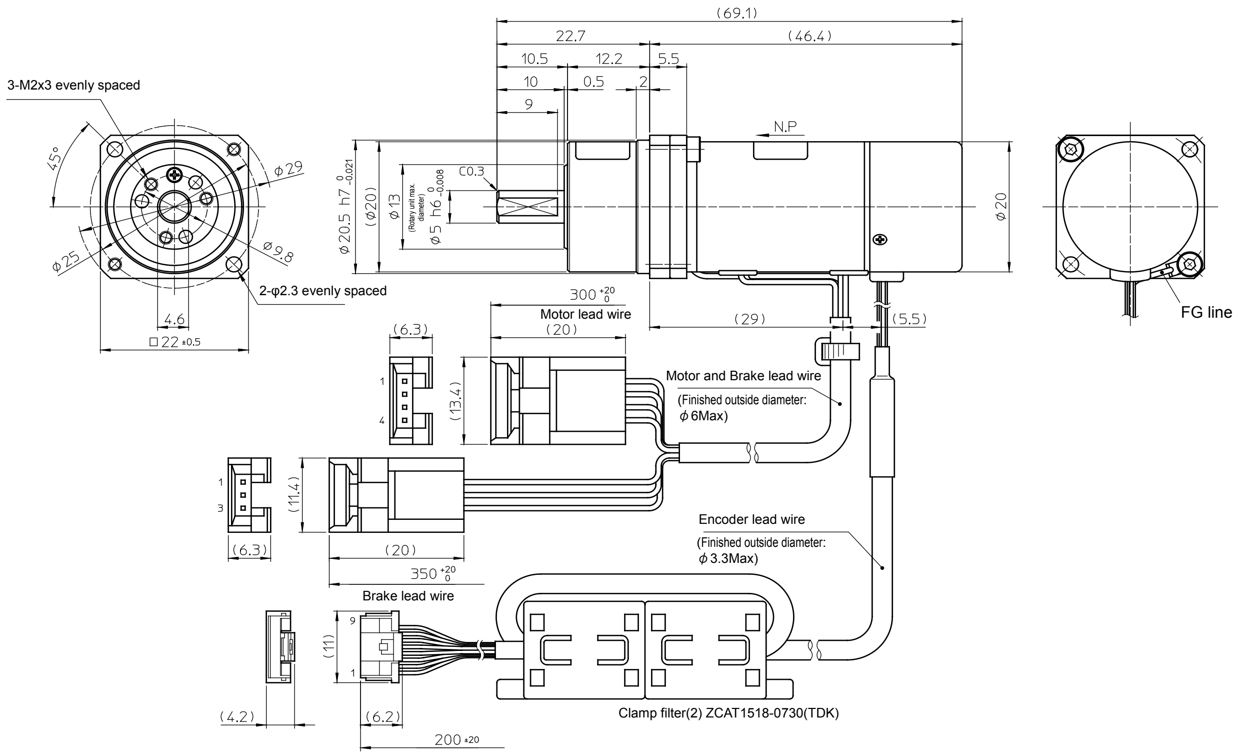


Note) For detailed external dimensions, check the delivery specification drawing issued by us.
Tolerances may vary due to product manufacturing method (foundry piece, machine-finished good).
If necessary, please contact us for the tolerance when it is not indicated in the dimensions.

RSF-5B-XXX-E050-CJ



RSF-5B-XXX-E050-BCJ(with brake)



Note) For detailed external 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.

1-7 One-way positioning accuracy

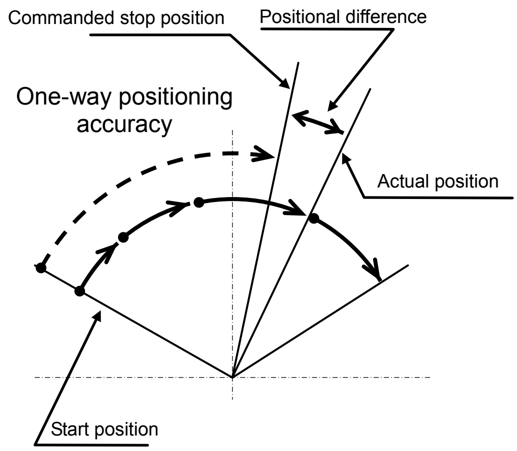
The following table shows the "one-way positioning accuracy."
The following table contains representing values.
RSF supermini series actuators house the speed reducer HarmonicDrive® for precision control, positioning errors of the motor shaft are compressed by reduction ratio to 30, 50 or 100. Actually, the angle transmission error of the speed reducer determines the positional accuracy. As a result, the measured angle transmission error of the speed reducer is indicated as the positional accuracy of the RSF supermini series.
The accuracy for each gear ratio is shown below.

Model		RSF-3C			RSF-5B		
Item \ Gear ratio		30	50	100	30	50	100
One-way positioning accuracy	arc min	10			4	3	3
	rad	2.9×10^{-3}			1.20×10^{-3}	0.87×10^{-3}	0.87×10^{-3}

Reference

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

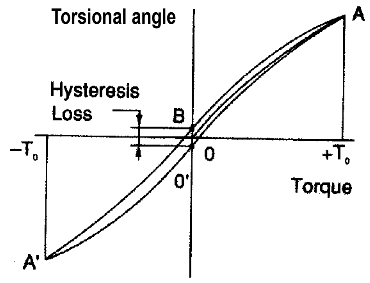
- **One-way positioning of rotation shaft motion**
  First, perform positioning at any one position in a fixed direction. This position is the reference position. Next, perform positioning in succession in the same direction, and measure the difference between the angle actually rotated from the reference 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 supermini actuator is expressed by the slope of the curve that is a spring rate (wind-up) (unit:N･m/rad).

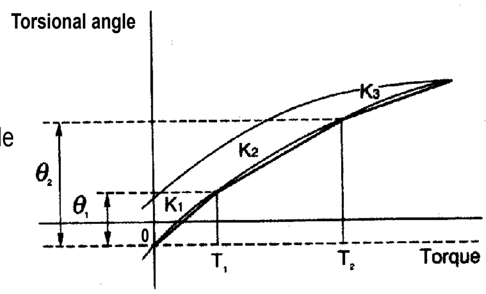


The torsional stiffness may be evaluated by dividing torque-torsion characteristics curve into three major regions. The spring rate of each region is expressed K_1, K_2, and K_3 respectively.

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: $\varphi = \frac{T}{K_1}$ *φ : Torsional angle
- 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-3C			RSF-5B		
Symbol \ Gear ratio		30	50	100	30	50	100
T_1	Nm	0.016	0.016	0.016	0.075	0.075	0.075
	kgfm	0.0016	0.0016	0.0016	0.0077	0.0077	0.0077
K_1	Nm/rad	27	30	34	90	110	150
	kgfm/arc min	0.0008	0.0009	0.0010	0.003	0.003	0.004
θ_1	$\times 10^{-4}$ rad	5.9	5.3	4.7	8.7	6.9	5
	arc min	2.0	1.8	1.6	3	2.4	1.7
T_2	Nm	0.05	0.05	0.05	0.22	0.22	0.22
	kgfm	0.005	0.005	0.005	0.022	0.022	0.022
K_2	Nm/rad	40	47	54	110	140	180
	kgf m/arc min	0.0012	0.0014	0.0016	0.003	0.004	0.005
θ_2	$\times 10^{-4}$ rad	12.5	10.6	9.3	22	18	13
	arc min	4.2	3.6	3.1	7.5	6	4.4
K_3	Nm/rad	51	57	67	120	170	200
	kgfm/arc min	0.0015	0.0017	0.0020	0.004	0.005	0.006

1-9 Actuator resolution

RSF supermini series actuators are equipped with a 200-pulse (Model No. 3) or a 500-pulse (Model No. 5) encoder, and the speed is reduced to 1/30, 1/50 or 1/100 using the speed reducer HarmonicDrive® for precision control. Accordingly, the actuator resolution is 30, 50 or 100 times the encoder resolution. In addition, the resolution is electrically multiplied by 4 when an actuator is combined with a dedicated servo amplifier.
The actuator resolution at each reduction ratio is shown in the table below.

Model		**RSF-3C**			**RSF-5B**		
Item / Gear ratio		30	50	100	30	50	100
Actuator resolution	Pulse/Rotation	24,000	40,000	80,000	60,000	100,000	200,000
Angle per one pulse *1	Angle second (arc sec)	54	32.4	16.2	21.6	12.96	6.48

* 1: When combined with a J4 servo amplifier, the RSF-3C moves every 8 command pulses only by the angle listed.
The RSF-5B moves every 4 command pulses only by the angle listed. Therefore, the displacement and number of command pulses, and rotation speed and command pulse frequencies are as follows:

Command pulse frequency and number of pulses required for the actuator output shaft to move 360 degrees per 30 r/min:

Model	**Reduction ratio**	**Pulse frequency (when moving at 30r/min)**	**No. of pulses (when moving 360°)**
RSF-3C(*2)	30	96000(pls/sec)	192000(pls)
	50	160000(pls/sec)	320000(pls)
	100	320000(pls/sec)	640000(pls)
RSF-5B(*3)	30	120000(pls/sec)	240000(pls)
	50	200000(pls/sec)	400000(pls)
	100	400000(pls/sec)	800000(pls)

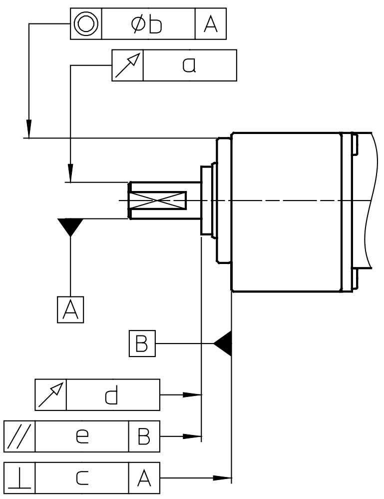
* 2: Pulse frequency (pls/sec) ＝ Rotational speed ÷ 60 × (Actuator resolution × 8)
No. of pulses (pls/) ＝ Displacement (deg) ÷ 360 × (Actuator resolution × 8):
* 3: Pulse frequency (pls/sec) ＝ Rotational speed ÷ 60 × (Actuator resolution × 4)
No. of pulses (pls/) ＝ Displacement (deg) ÷ 360 × (Actuator resolution × 4)

For details, see "MR-J4-_B Servo Amplifier Technical Manuals" (No. SH (name) 030101) or contact Mitsubishi Electric.

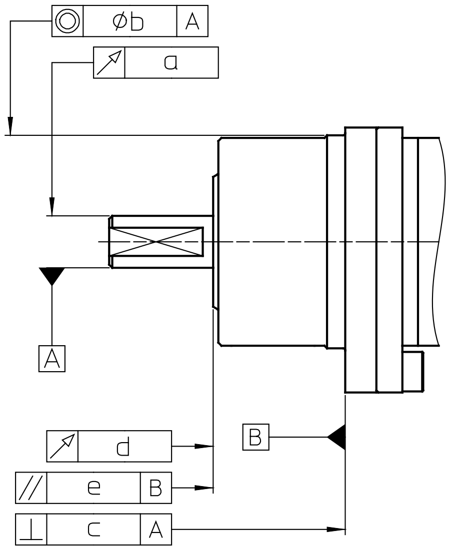
1-10 Mechanical accuracy

The mechanical accuracies of the output shaft and mounting flange for RSF supermini series actuators are shown below:

RSF-3C



RSF-5B



Mechanical accuracy *** T.I.R. unit: mm**

Symbol	Subject Dimension	Accuracy value	
Model		RSF-3C	RSF-5B
a	Runout of the tip of the output shaft	0.03	0.03
b	Concentricity of installed spigot joint	0.02	0.04
c	Squareness of installation surface	0.02	0.02
d	Output flange surface contact	0.005	0.005
e	Parallelism of installation surface and output flange	0.015	0.015

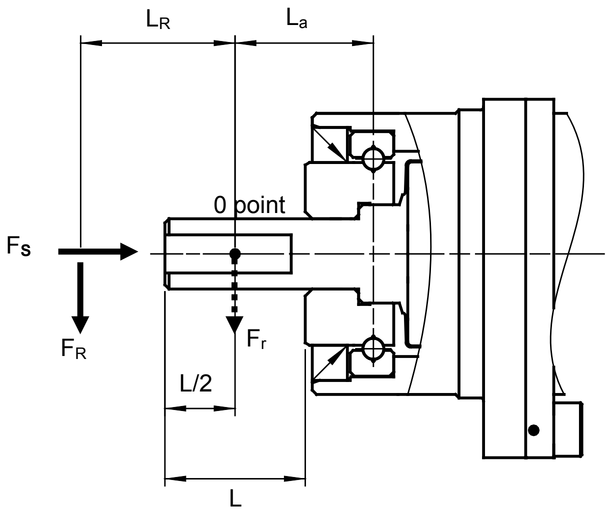
*: T.I.R(Total Indicator Reading): Indicates the total amount of dial gage reading when the measurement unit is rotated once.

1-11 Allowable load

Allowable radial load and allowable thrust load

The gear head used in the RSF supermini series incorporates the high-precision 4-point contact ball bearing for direct support of external load (output part).

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.



Model	Unit	RSF-3C	RSF-5B
Allowable radial load (F_r)	N	36	90
	kgf	3.6	9.1
Allowable thrust load (F_S)	N	130	270
	kgf	13	27

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]

Model		RSF-3C	RSF-5B
Allowable radial load (F_r)	N	36	90
	kgf	3.6	9.1
L_a	mm	8.6	9.85
L	mm	7	10

1-12 Rotary direction

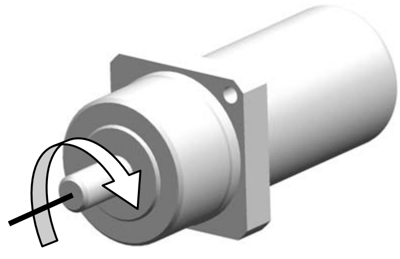
The rotation direction of the actuator is defined as a clockwise (CW) rotation as viewed from the output shaft when a FWD rotation command is given to a RSF supermini series actuator from a Mitsubishi Electric J4 amplifier.

The rotation direction of the Mitsubishi Electric J4 amplifier can be switched with the parameter "PA14: Rotation direction selection/Moving direction selection" setting.

"PA14: Rotation direction selection/Moving direction selection" setting

Setting value	FWD input	REV input	Setting
0	FWD rotation	REV rotation	Default
1	REV rotation	FWD rotation	

* The model shown is RSF-5B. The same setting is applied to RSF-3C.
* For details on the amplifier, refer to "MR-J4W2-0303B6-MX940J" Product Specifications (No. BCN-B72000-227).



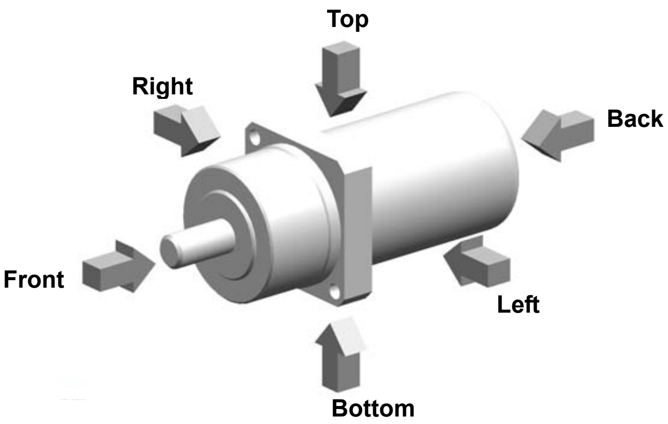
FWD: CW rotation

1-13 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.



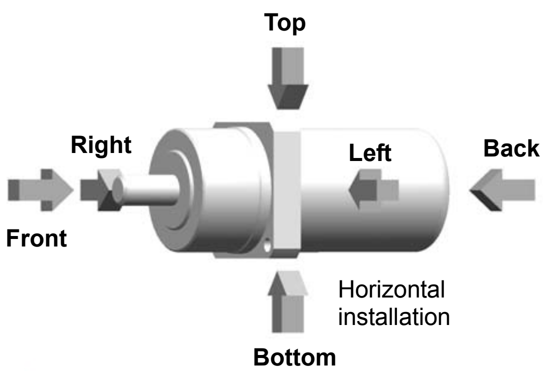
Impact resistance

1-14 Vibration resistance

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

Vibration acceleration: 49m/s^2 (5G)
Frequency: 10 to 400Hz

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



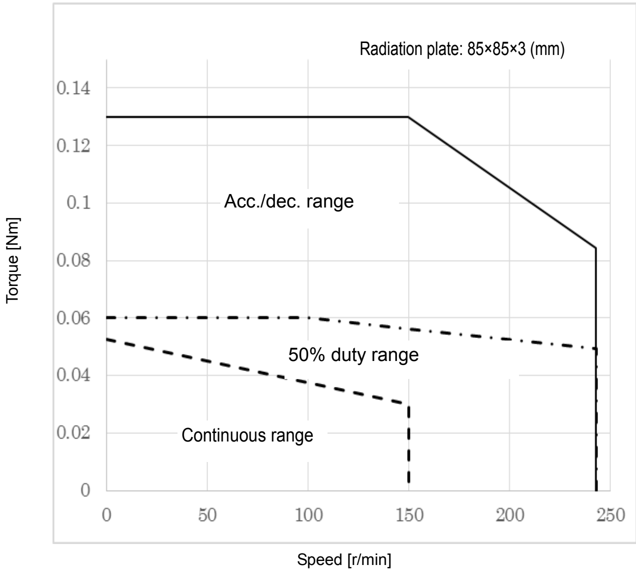
Vibration resistance

1-15 Operable range

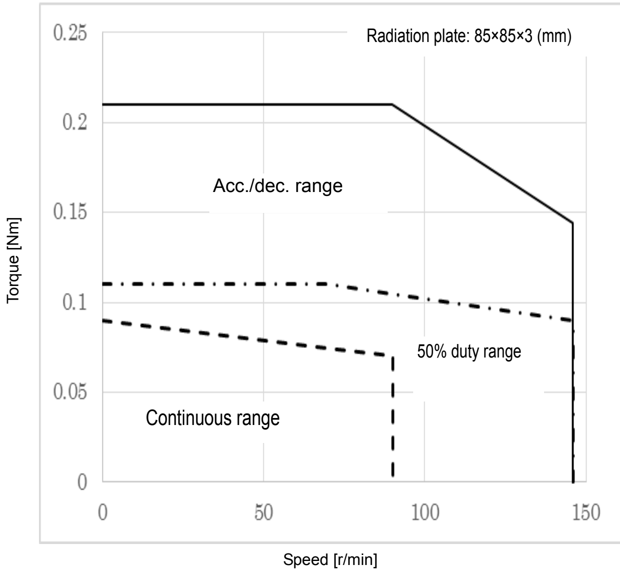
The following graphs show the usable ranges of the RSF supermini series actuators.

- Acceleration and deceleration range:
  This range indicates the torque rotation speed at which the product can be operated at this instant. The range is typically used for acceleration or deceleration.
- Continuous duty range:
  This range indicates the torque rotation speed at which the actuator can be operated continuously.
- 50% duty range:
  This range indicates the torque rotation speed at which the actuator can be operated at 50% duty operation (the ratio of operating time and delay time is 50:50).

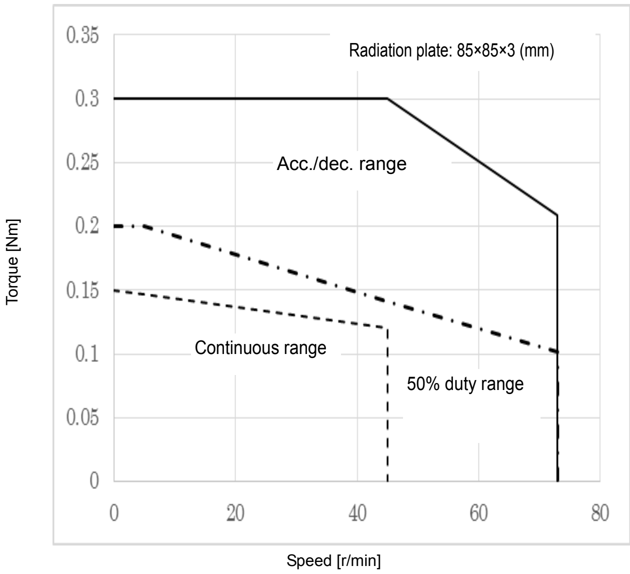
RSF-3C-30-E020-CJ



RSF-3C-50-E020-CJ

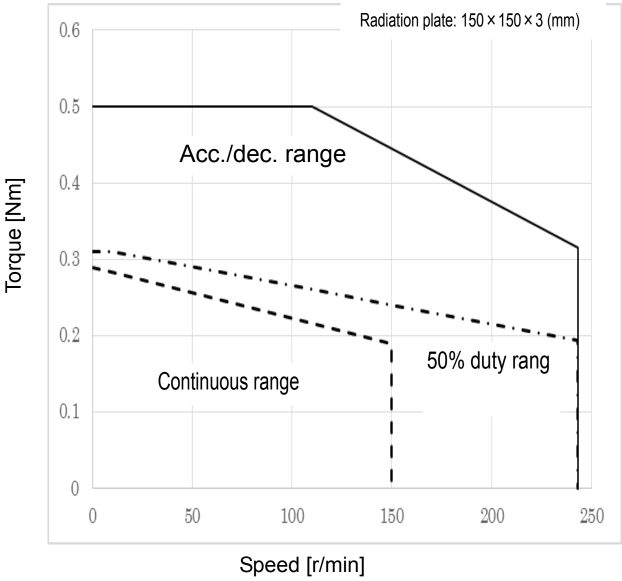


RSF-3C-100-E020-CJ

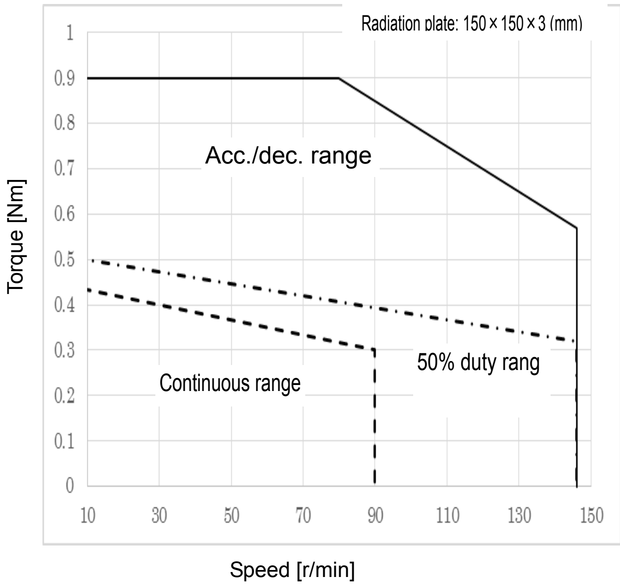


Note: The values of the graph are obtained when the aluminum radiation plate shown at the upper right of the graph is installed.
Note: If it is used continuously in one direction in the continuous range, please consult with us.

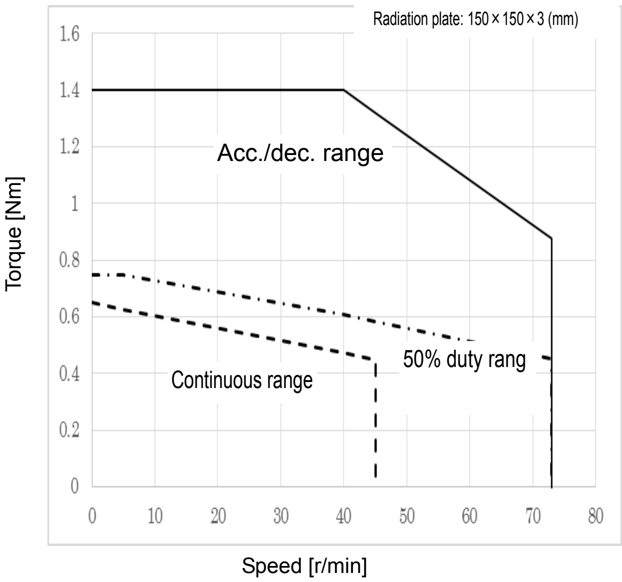
RSF-5B-30-E050-CJ
RSF-5B-30-E050-BCJ



RSF-5B-50-E050-CJ
RSF-5B-50-E050-BCJ



RSF-5B-100-E050-CJ
RSF-5B-100-E050-BCJ



Note: The values of the graph are obtained when the aluminum radiation plate shown at the upper right of the graph is installed.
Note: If it is used continuously in one direction in the continuous range, please consult with us.

1-16 Cable specifications

The following tables show specifications of motor lead wires, brake lead wires and encoder lead wires of the RSF supermini actuators.

Motor lead wire

Pin No.	Color	Signal name	Remark
1	Red (RED)	U	Motor phase-U
2	White (WHT)	V	Motor phase-V
3	Black (BLK)	W	Motor phase-W
4	Green[Note] (GRN)	FG	Grounding *RSF-5B only

Note: Green/yellow tubes are attached in the vicinity of the connector.

Connector used	Housing:	PALR-04VF (with retainer)
	Contact:	S(B)PAL-001T-P0.5
Recommended connector	Housing:	PARP-04V (with retainer)
	Contact:	S(B)PA-001T-P0.5

Manufactured by J.S.T. Mfg Co., Ltd

Brake lead wire (RSF-5B only)

Pin No.	Line color
1	Blue (BLU)
2	Yellow (YEL)
3	Gray (GRY)

Connector used	Housing:	PALR-03VF (with retainer)
	Contact:	S(B)PAL-001T-P0.5
Recommended connector	Housing:	PARP-03V (with retainer)
	Contact:	S(B)PA-001T-P0.5

Manufactured by J.S.T. Mfg Co., Ltd

Encoder lead wire

Pin No.	Color	Signal name	Remark
1	White (WHT)	A	A phase output
2	Green (GRN)	B	B phase output
3	Yellow (YEL)	Z	Z phase output
4*	Brown (BRW)	U	U phase output
5*	Blue (BLU)	V	V phase output
6*	Orange (ORG)	W	W phase output
7	Red (RED)	+5V	Power supply input
8	Black (BLK)	GND	Power supply input
9			

* The U.V.W signal is not used when combined with a J4 servo amplifier.

Connector used	Housing:	NSHR-09V-S
	Contact:	SSHL-003T-P0.2

Manufactured by J.S.T. Mfg Co., Ltd

CAUTION

Use some reinforced insulated or double insulated power supplies for the 24V DC power supply to the servo amplifier and brake.

Chapter 2

Selection of the RSF supermini Series

This chapter explains how to select a proper RSF supermini series actuator.

2-1 Allowable load moment of inertia

To make full use of high precision and high performance of the RSF supermini series actuator, perform temporary selection by considering the load moment of inertia and rotation speed.
As a guideline, the load moment of inertia should be 3 to 5 times the moment of inertia of the actuator.
For the moment of inertia of the actuator, refer to [1-5 Specifications of RSF supermini actuators] (P1-3).
For the method of calculating inertia moment, refer to [Appendix 2 Moment of inertia] (Page A-3).
The rotation speed cannot exceed the maximum rotation speed of the actuator. For the maximum rotation speed, refer to [1-5 Specifications of RSF supermini actuators] (P1-3).

2-2 Variable load inertia

RSF supermini series actuators include HarmonicDrive® gearing that has a high reduction ratio. Because of this there are minimal effects of variable load moment of inertias to the servo drive system. In comparison to direct servo systems this benefit will drive the load with a better servo response.
For example, assume that the load moment of inertia increases to N-times during its motion (for example, robot arms). The effect of the variable load moment of inertia to the [total inertia converted into motor shaft] is as follows:
The symbols in the formulas are:

J_S:	total moment of inertia converted into motor shaft	**L:**	Ratio of load moment of inertia to motor inertia
J_M:	moment inertia of motor		
R:	reduction ratio of RSF supermini series	**N:**	variation ratio of load moment of inertia

- Direct drive

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

- RSF supermini actuator drive

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

In the case of the RSF supermini series, this is an extremely large number, such as R = 30, R = 50 or R = 100, that is $R^2 = 900$, $R^2 = 2500$, or $R^2 = 10000$. Then the ratio is $J_S'/J_S \fallingdotseq 1$. This means that the system is hardly affected by the load variation.

2-3 Verifying loads

The RSF supermini series incorporates a precision 4-point contact ball bearing for direct support of external load. To make full use of the performance of the RSF supermini series, check the maximum load moment, life of the 4-point contact ball bearing, and static safety factor.
For detailed calculation methods for the maximum load moment, life of the 4-point contact ball bearing, and static safety factor, refer to the "HarmonicDrive® Reducer for precision control General catalog".

2-4 Examining operating status

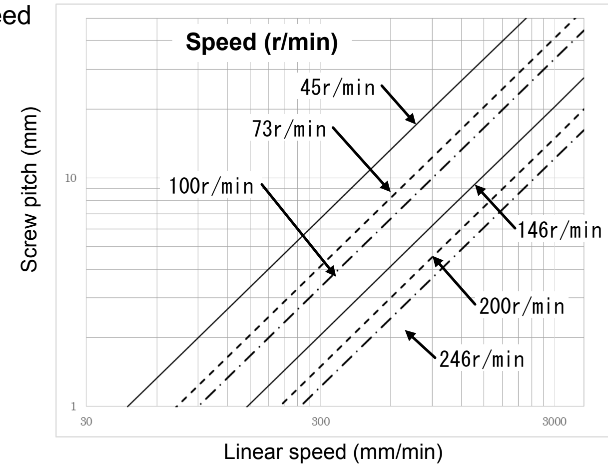
When the operation pattern (duty cycle) is such that the actuator starts and stops repeatedly, starting current and braking current flow through the motor at high frequency and the actuator generates heat. Accordingly, examine whether or not the generated heat can be accommodated.
The study is as follows:

Examining actuator rotation speed

Calculate the required RSF supermini actuator speed (r/min) to drive the load.
For linear motion, convert with the formula below:

$$\text{Rotary speed (r/min)} = \frac{\text{Liner speed (mm/min)}}{\text{Pitch of screw(mm)}}$$

Select a reduction ratio from [30], [50] and [100] of an RSF supermini actuator of which the maximum speed is more than the required speed.



Calculating and examining load inertia moment

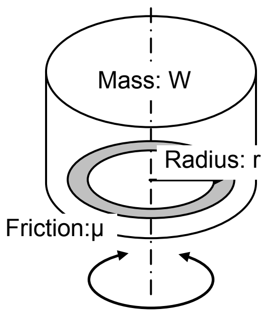
Calculate the load moment of inertia driven by the RSF supermini series actuator.
For the calculation methods, refer to [Appendix 1 Conversion of unit] (Page A-1).
Tentatively select an RSF supermini actuator referring to section [2-1 Allowable load moment of inertia] (P2-1) with the calculated value.

Calculating load torque

Calculate the load torque as follows:

- Rotary motion

The rotary torque for the mass W rotating on the ring of radius r from the center of rotation as shown in the figure to the right can be obtained as follows:



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

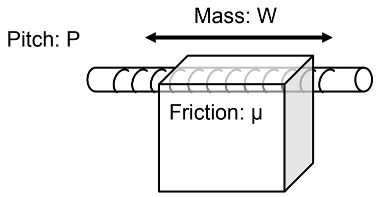
T: torque (N·m)
μ: coefficient of friction
W: mass (kg)
r: radius of friction face (m)

- Horizontal linear motion

The following formula calculates the torque for horizontal linear motion of mass [W] fed by the screw of pitch [P].

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

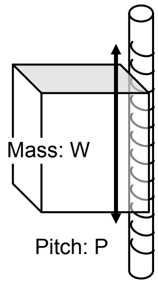
T: torque (N·m)
μ: coefficient of friction
W: mass (kg)
P: screw pitch (m)



- Vertical linear motion

The following formula calculates the torque for vertical linear motion of mass [W] fed by the screw of pitch [P].

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

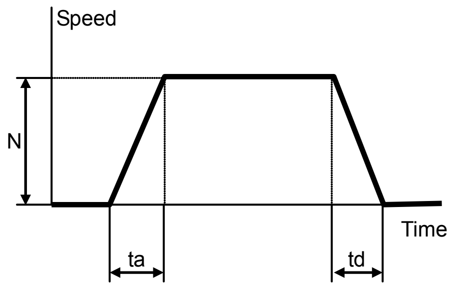


Acceleration time and deceleration time

The fastest acceleration and deceleration times with the selected actuator can be calculated using the following formula.

Acceleration: $$t_a = (J_A + J_L) \times \frac{2 \times \pi}{60} \times \frac{N}{T_M - T_L} \qquad (1)$$

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



ta:	acceleration time	(sec)
td:	deceleration time	(sec)
J_A:	actuator inertia	(kg·m^2)
J_L:	load moment of inertia	(kg·m^2)
N:	actuator speed	(r/min)
T_M:	maximum torque of actuator	(N·m)
T_L:	load torque	(N·m)

For polarity, the rotation direction is set to positive (+), and the opposite direction is set to negative (-).

The friction torque of the actuator T_F (N·m) can also be obtained from the following formula:

$$T_F = K_T \times I_M - T_M \qquad (3)$$

K_T : Torque constant [N·m/A]
I_M : Maximum current [A]

Example: 1

Select an actuator that best suits the following operating conditions:

Rotary speed: 140r/min
Load moment of inertia: 0.9×10^{-3} kg·m^2

Since the load mechanism is mainly inertia, the load torque is negligibly small.
Acceleration/deceleration time is 0.03sec (30msec) or less.

(1) Compare these conditions with the [1-5 Specifications of RSF supermini actuators] (P1-3) and temporarily select RSF-5B-50.

(2) Obtain $J_A=1.83\times10^{-4}$kg·m^2, T_M =0.9 N·m, K_T=0.54 N·m/A, and I_M =2.2A from [1-5 Specifications of RSF supermini actuators] (P1-3).

(3) The friction torque of the actuator is T_F = 0.54×2.2-0.9 = 0.29 N·m from Formula (3) on the previous page.

(4) Therefore, the shortest acceleration/deceleration time can be obtained from Formula (1) and Formula (2), as follows:

$$t_a = (0.183\times10^{-3}+0.9\times10^{-3})\times2\times\pi/60\times140/0.9 = 0.018 \text{ sec (18msec)}$$
$$t_d = (0.183\times10^{-3}+0.9\times10^{-3})\times2\times\pi/60\times140/(0.9+2\times0.29) = 0.011 \text{ sec (11msec)}$$

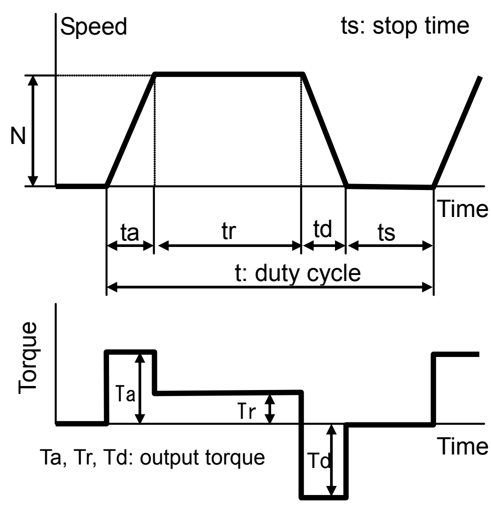
(5) Because the assumed acceleration/deceleration time is 0.03sec (30msec) or less, the temporarily selected actuator can be used for acceleration/deceleration, based on the result of (4).

(6) If the calculation results of the acceleration/deceleration time do not fall within the desired time range, examine them again as follows.
- Try to reduce the load moment of inertia.
- Review the reduction ratio and actuator model number.

Examining duty

During the selecting process of the RSF supermini series, the temporal variability of torque and rotation speed need to be taken into account. During acceleration or deceleration in particular, a large amount of electricity flows to generate a large amount of torque, resulting in a greater amount of heat.

Using the following formula, calculate the duty: %ED when the actuator is operated repeatedly in the drive pattern shown to the right.



$$\%ED = \frac{K_{La}\times t_a + K_{Lr}\times t_r + K_{Ld}\times t_d}{t}\times100 \qquad (4)$$

ta:	Acceleration time from speed 0 to N	[s]
td:	Deceleration time from speed N to 0	[s]
tr:	Operating time at a constant speed of N	[s]
t:	Single cycle time in second	[s]
K_{La}:	Duty factor for acceleration time	
K_{Lr}:	Duty coefficient during constant speed operation time	
K_{Ld}:	Duty factor for deceleration time	

Example: 2

How to obtain K_{La}, K_{Lr} and K_{Ld} and example of duty calculation

As a result of Calculation Example 1 shown below, the selected actuator RSF-5B-50 works fine, so RSF-5B-50 can be used for duty factor graphs.

Operation conditions:

- The inertial load is accelecated at the maximum torque of the actuator, and decelerated at the maximum torque after operation at a fixed speed.
- The movement angle θ of one cycle is 120°.
- The duration of one cycle is 0.4 (s).
- The other conditions are the same as Calculation Example 1.

(1) K_{La} and K_{Ld}: The average speed during the rotation speed change from 0 to 140r/min is 70r/min. From the duty factor graphs, $K_{La}=K_{Ld}≒1.5$ can be obtained.

(2) K_{Lr}: Tr≒0 for the inertial load. Similarly, from the duty factor graphs, $K_{Lr}≒0.29$ can be read.

(3) The movement angle can be obtained from the area in the “Rotation speed-Time” diagram above. In other words, the movement angle θ can be expressed as follows:

θ = (N / 60) x {tr + (ta + td) / 2} x 360

Solving the formula above for tr (operation time at a fixed speed of N), the following can be obtained.

tr = θ/ (6 x N) – (ta + td) / 2

Substituting θ= 120° and ta= 0.03(s), td= 0.03(s), and N= 140r/min from Example 1, tr=0.113(s).

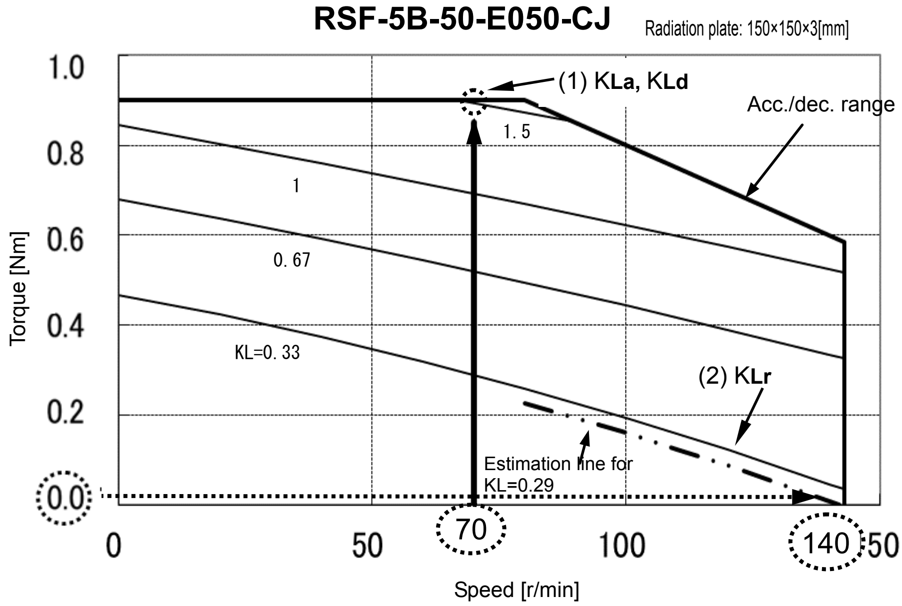
(4) Because the cycle time is 0.4(s), the %ED is obtained as follows:

%ED = (1.5x 0.03 + 0.29 x 0.113 + 1.5 x 0.03) / 0.4 x 100 = 30.7%

Because the value of %ED obtained is below 100, continuous repeated operation of this cycle can be done.

If this value is 100 or above,
- Operation pattern
- Load reduction

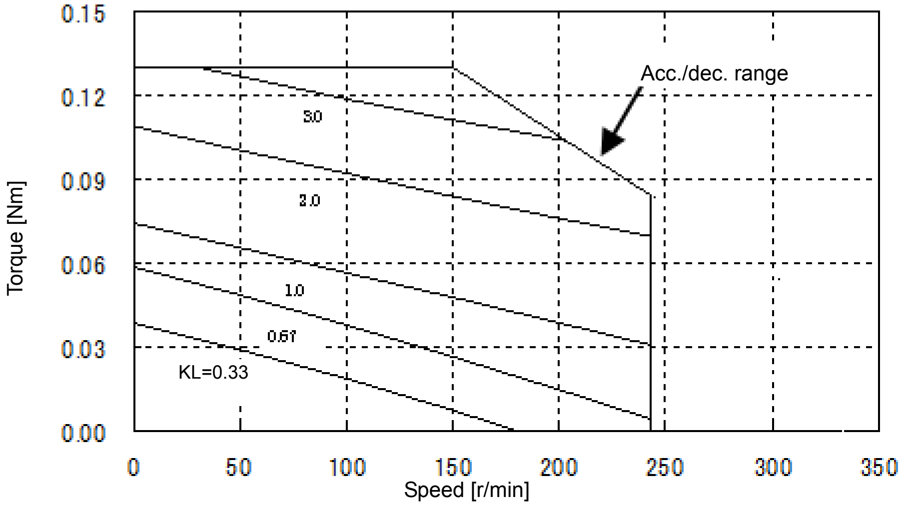
must be reexamined.



Graphs of duty factor

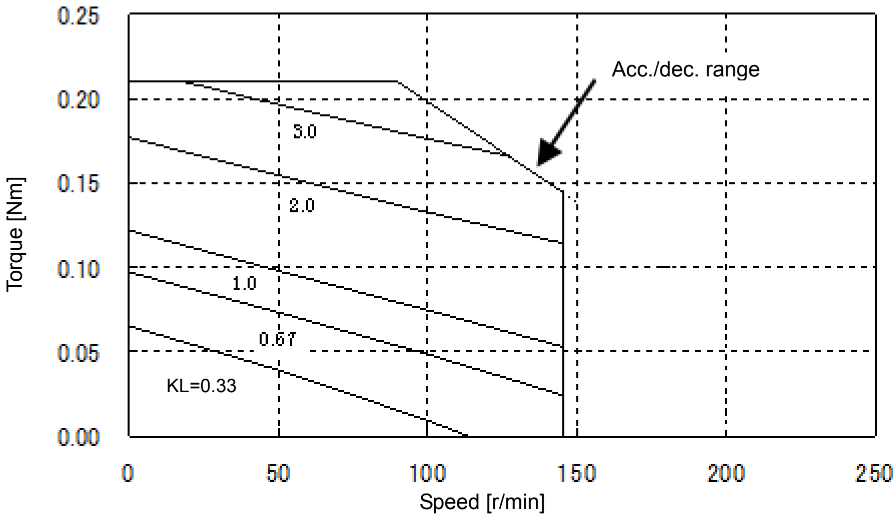
- **RSF-3C-30-E020-CJ**

Radiation plate: 85×85×3[mm]



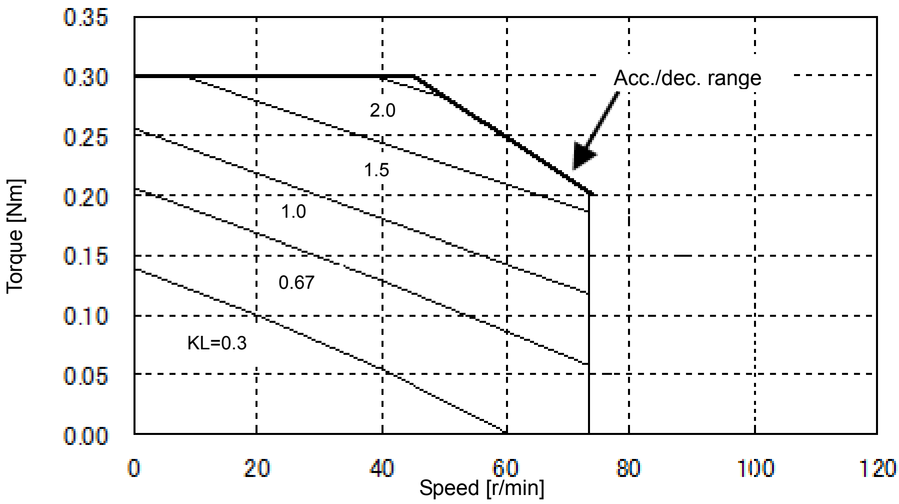
- **RSF-3C-50-E020-CJ**

Radiation plate: 85×85×3[mm]

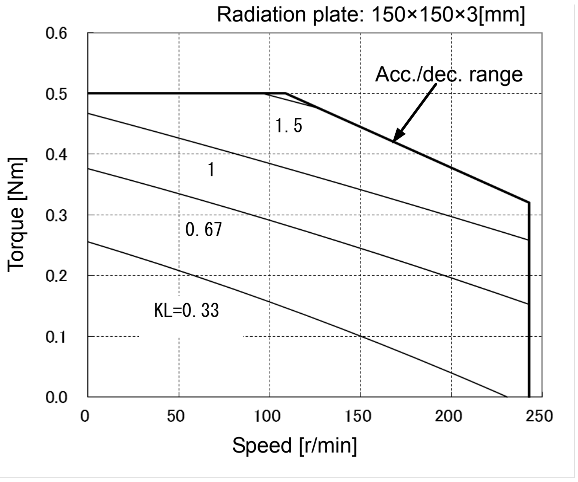


- **RSF-3C-100-E020-CJ**

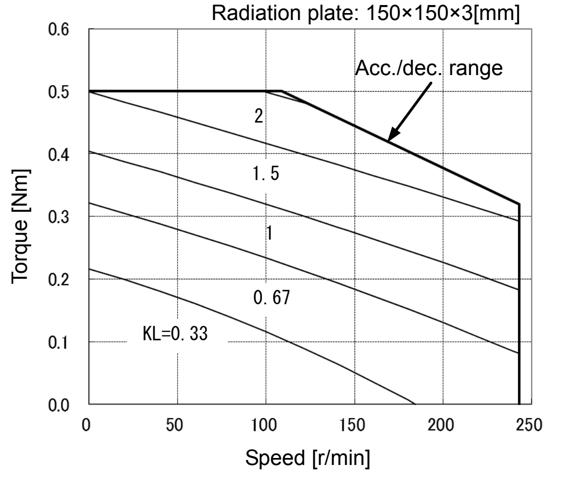
Radiation plate: 85×85×3[mm]



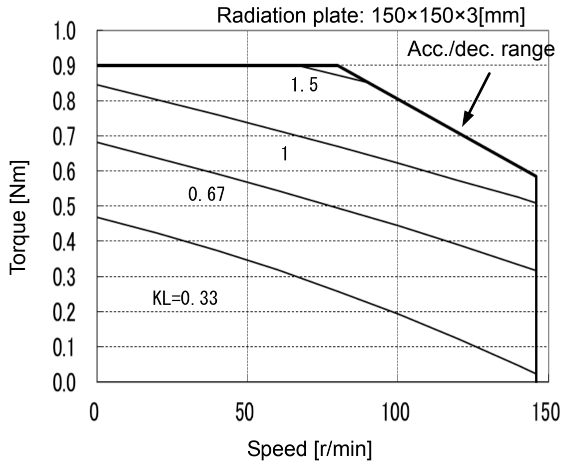
● **RSF-5B-30-E050-CJ**



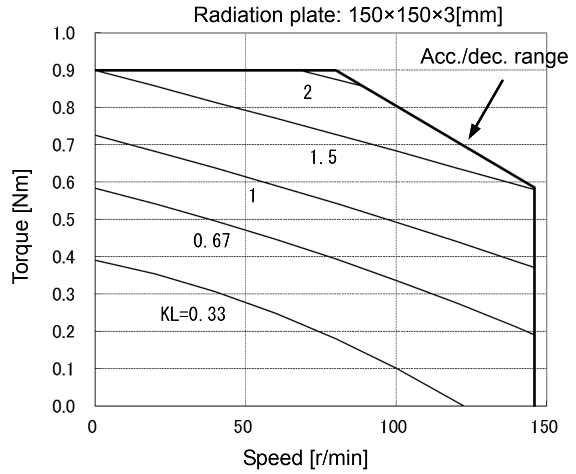
● **RSF-5B-30-E050-BCJ**



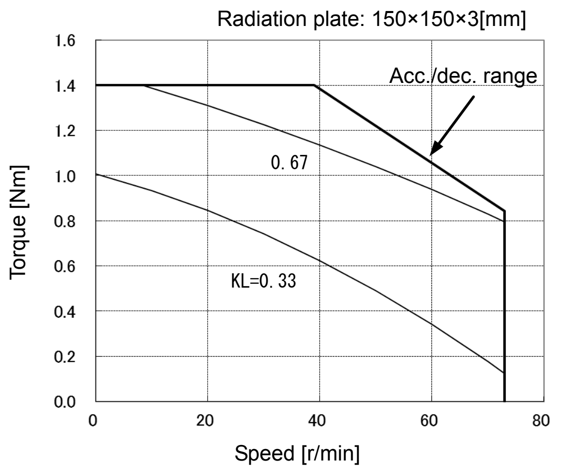
● **RSF-5B-50-E050-CJ**



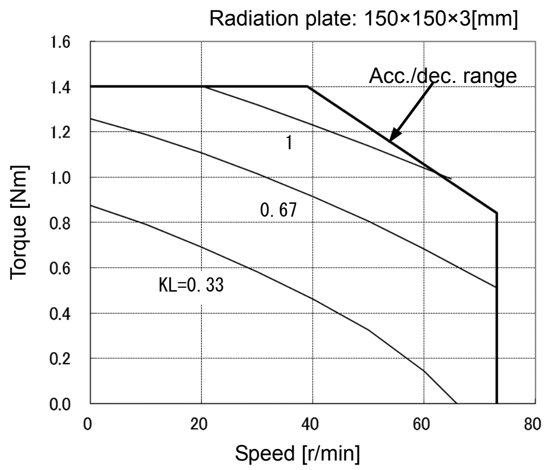
● **RSF-5B-50-E050-BCJ**



● **RSF-5B-100-E050-CJ**



● **RSF-5B-100-E050-BCJ**



Examining effective torque and average rotational speed

Addionally to the former studies, the effective torque and the average speed should be studied.

(1) The effective torque should be less than allowable continuous torque specified by the driver.
(2) The average speed should be less than allowable continuous speed of the actuator.

Calculate the effective torque (Tm) and the average speed (Nav) of an operating cycle as shown in [Examining duty] (P2-4).

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

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

Tm:	effective torque	(N・m)			
Ta:	maximum torque	(N・m)			
Tr:	load torque	(N・m)			
ta:	acceleration time	(s)	**td:**	deceleration time	(s)
tr:	running time at constant speed	(s)	**t:**	time for one duty cycle	(s)
Nav:	average speed	(r/min)			
N:	Rotation speed at constant speed	(r/min)			

If the calculation results for the effective torque and average rotation speed are not within the range of continuous usage in the graph shown in [1-15 Operable range] (P1-13), take measures to reduce the duty.

Example 3: Getting effective torque and average speed

Effective torque and average speed are studied by using the operation conditions of Examples 1 and 2.

1) Effective torque

From the parameters of T_a = 8.3 N・m, T_r = 0 N・m, t_a = 0.113 s, t_r = t_d = 0.03 s, t=0.4 s,

$$T_m = \sqrt{\frac{0.9^2 \times (0.03 + 0.03)}{0.4}} = 0.349 \quad N \cdot m$$

The value exceeds the allowable continuous torque (0.29 N・m) of RSF-5B-50 temporarily selected in Example 1, so continuous operation cannot be done using the cycle set in Example 2. The following formula is the formula for effective torque solved for t. By substituting the value of allowable continuous torque in T_m of this formula, the allowable value for one cycle time can be obtained.

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

Substituting 0.9 N・m for T_a, 0 N・m for T_r , 0.349 N・m for T_m , 0.03 s for t_a , 0.113 s for t_r, and 0.03 s for t_d :

$$t = \frac{0.9^2 \times (0.03 + 0.03)}{0.29^2} = 0.578 \quad [s]$$

Namely, when the time for one duty cycle is set more than 0.578 s, the effective torque [T_m] becomes less than 0.29 N・m, and the actuator can drive the load with lower torque than the allowable continuous torque continuously.

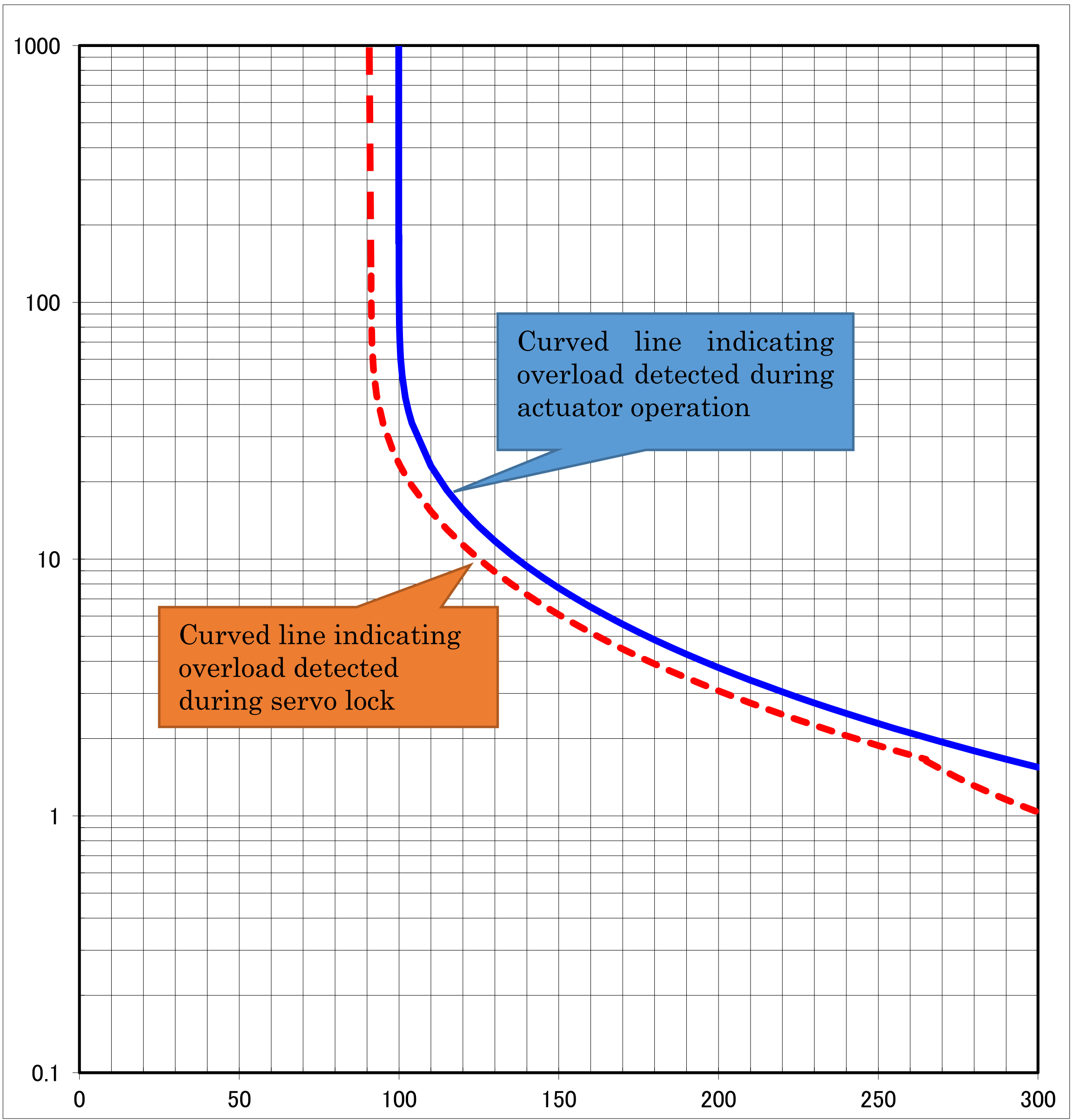
2) Average speed
From the parameters of N = 140 r/min, ta = 0.03 s, tr = 0.113 s, td = 0.03 s, t = 0.4 s

$$N_{av} = \frac{{}^{140}\!/_{2} \times 0.03 + 140 \times 0.113 + {}^{140}\!/_{2} \times 0.03}{0.578} = 34.64 \quad [\text{r/min}]$$

This value is within the allowable continuous rotational speed (90 r/min) of RSF-5B-50, so it can be used.

Permissible overloaded time

When a RSF supermini series actuator is intermittently operated in allowable continuous torque or more, the time the torque can be output continuously is limited by the overload detection function of the servo amplifier even within the allowable duty range. This overload detection time is shown in the figure below.



Output torque coefficient (%)
(Output torque = Output torque coefficient x Continuous allowable torque)

Chapter 3

Installing the actuator

The following explains the installation procedures of the actuators.

3-1 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 side of the RSF supermini 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.
For details of model symbols, refer to [1-3 Ordering information] (P1-2).

3-2 Notice on handling

Handle the RSF supermini series actuator carefully by observing the notices specified below.

WARNING

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.

CAUTION

(1) Do not apply impact or unnecessary excessive force to output shaft 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 less than 80%. 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 use or store the actuator in locations subject to corrosive gases or dust particles.
(6) Electrostatic discharge may destroy encoder elements, therefore, we recommend that installation be performed under the environment where the relative humidity is 40 to 70 % RH.

3-3 Location and installation

Environment of location

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

- Service 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. Design the closed space size, ventilation system, and device locations so the ambient temperature near the actuator is always less than 40°C.
- 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:less than $49m/sec^2$ (10Hz~400Hz)
- Impact:less than 300 m/sec^2
- 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.

Considerations into External Noise

Pay sufficient attention when installing the actuator: The actuator may malfunction by external noise depending on the conditions of installation.

- Make sure that the FG line of RSF-5B is securely grounded.
- Because RSF-3C does not have any FG line from the motor enclosure. Thus, when using it, make sure that that enclosure is securely grounded to the body of the equipment through the gear head house. In addition, make sure that the body of the equipment is securely grounded.
- Do not bind the motor line and encoder signal line together.
- Do not draw any external power line (i.e., servo amplifier power supply line, 100/200 VAC line.), actuator signal line, and motor line through the same pipe or duct or bind them together.

The noise tolerance values of RSF supermini equipment are listed below.
They are guide values from a measurement that were performed using a standard relay cable in a noise test environment while the clamp filter included with the product was installed to the equipment.
Note that the noise tolerance values in your actual environment of use may differ from them.

Model	RSF-3C	RSF-5B
Noise tolerance (encoder signal line)	1.5kV	2.0kV

Installation

Since the RSF supermini 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 an 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 attaching a coupling, be sure not to apply force to the actuator output shaft.

(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:

Model		RSF-3C	RSF-5B
Number of bolts		4	2
Bolt size		M1.6	M2
Installation PCD	mm	15	25
Wrenching torque	N･m	0.26	0.25
	kgf･m	0.03	0.03
Transfer torque	N･m	3.0	2.0
	kgf･m	0.3	0.2

Recommended bolt: JIS B 1176 bolt with hexagonal hole; Strength category: JIS B 1051 12.9 or greater

(3) For correct wiring operation, refer to MR-J4W2-0303B6 ― MX940J Product Specifications (No.BCN-B72000-227).

(4) Motor cable and encoder 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.
The actuator uses many precision parts. 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.

3-4 Initial settings for amplifier

In order to control your actuator with a J4 amplifier, the following parameters must be set.

Parameter	Actuator	Setting value RSF-3C	Setting value RSF-5B
PA01	Operation mode	1060	
PA17	Servo motor series setting	(*1)	
PA18	Servo motor type setting		
PC05	Voltage selection	0100	
PC27	Rotation direction selection	0000	
PL08	Linear servo motor/DD motor function selection 3	0X10 (*4)	
PL09	Magnetic pole detection level	3 (*2)	
PL13	Resolution multiplying factor setting (*3)	0013	0012
PL25	Resolution setting	1900	1F40
PL26	Resolution setting	0000	0000

(*1) In order to control your actuator with a J4 amplifier, the J4 amplifier parameters PA17: Servo motor series setting and PA18: Servo motor type setting must be set. Refer to the table below to set the parameters. (For details on how to set the J4 amplifier parameters, refer to MR-J4W2-0303B6-MX940J Product Specifications (No. BCN-B72000-227).)

Actuator model	Setting value PA17	Setting value PA18	Amplifier Model No.
RSF-3C-30-E020-CJ	00E7	1E1E	MR-J4W2-0303B6-MX940J
RSF-3C-50-E020-CJ		1E32	
RSF-3C-100-E020-CJ		1E64	
RSF-5B-30-E050-CJ		1F1E	
RSF-5B-50-E050-CJ		1F32	
RSF-5B-100-E050-CJ		1F64	
RSF-5B-30-E050-BCJ		201E	
RSF-5B-50-E050-BCJ		2032	
RSF-5B-100-E050-BCJ		2064	

WARNING

Make sure that the parameters are set for the correct actuator to be combined. Failure to do so may cause low torque problems or overcurrent that may lead to actuator burnout, resulting in injury or fire.

(*2) Refer to "3-5 Excitation of actuators" (P3-5).
(*3) Refer to "3-6 MR-Configurator 2 operation to set PL13" (P3-6).
(*4) X=0: Pole detection stroke limit enabled / X=1: Pole detection stroke limit disabled

3-5 Excitation of actuators

The "MR-J4W2-0303B6-MX940J" servo amplifier, which is compatible with this actuator, detects the magnetic pole at the first excitation after the power is turned on. At that time, the actuator output shaft rotates about ±0.5 degree max.
Precautions for using this method are described below.

◆The magnetic pole cannot be detected under the following conditions:
(1) The actuator output shaft is locked from outside and cannot be moved.
(2) The actuator output shaft is driven by an external force.

◆ The magnetic pole may not be detected under the following conditions:
(3) A force higher than the torque values listed below is applied inhibiting the actuator from rotating.

Actuator Model No.	Force to inhibit rotation (Nm)
RSF-3C-30	0.04
RSF-3C-50	0.08
RSF-3C-100	0.15
RSF-5B-30	0.14
RSF-5B-50	0.39
RSF-5B-100	0.73

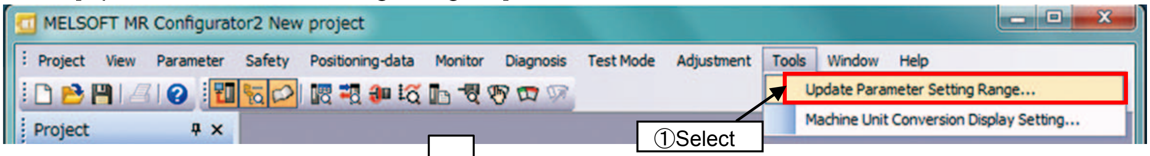
If the servo amplifier outputs the AL27.1: Initial magnetic pole detection error even when neither (1) or (2) condition is present, a force higher than the torque values listed above may be applied inhibiting the rotation.
In this case, the magnetic pole may be detected by changing the servo amplifier configuration parameter PL09: Magnetic pole detection voltage level.
However, if a force higher than the torque values listed below is applied inhibiting the rotation, the magnetic pole cannot be detected. Reduce the force inhibiting the rotation.

Actuator Model No.	PL09 Default value	PL09 Maximum settable value	PL09 Force that inhibits the excitable rotation when the maximum value is set (Nm)
RSF-3C-30	3	4	0.07
RSF-3C-50	3	4	0.12
RSF-3C-100	3	4	0.24
RSF-5B-30	3	4	0.24
RSF-5B-50	3	4	0.59
RSF-5B-100	3	3	0.73

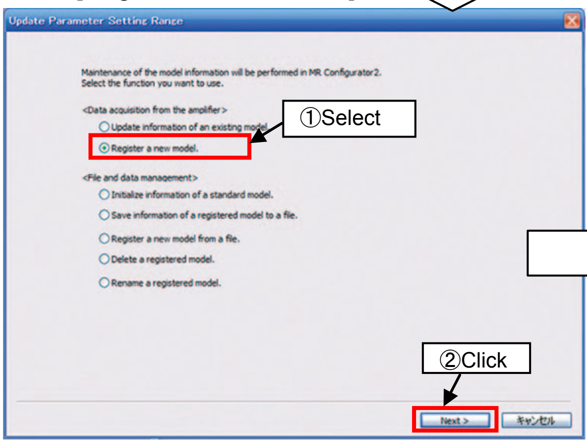
3-6 MR-Configurator 2 operation to set PL13

Follow the following procedure to set PL13: Resolution multiplying factor.

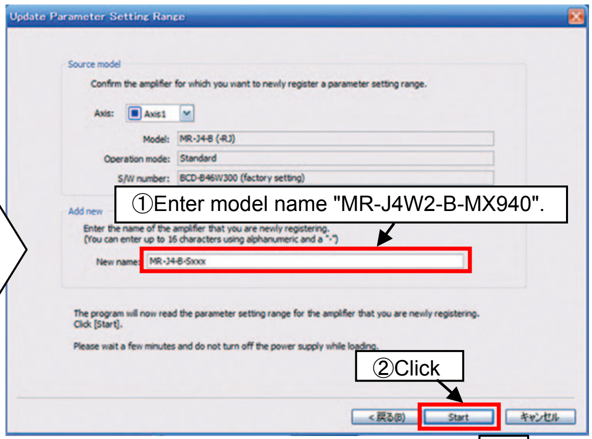
(1) Connect the servo amplifier to a PC with a USB cable and start MR Configurator 2.
(2) Select [Update Parameter Setting Range…].



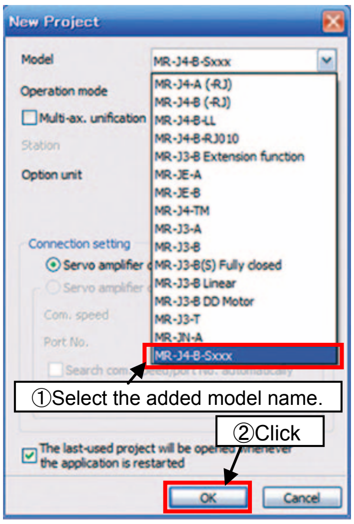
(3) Select [Register a new model.].



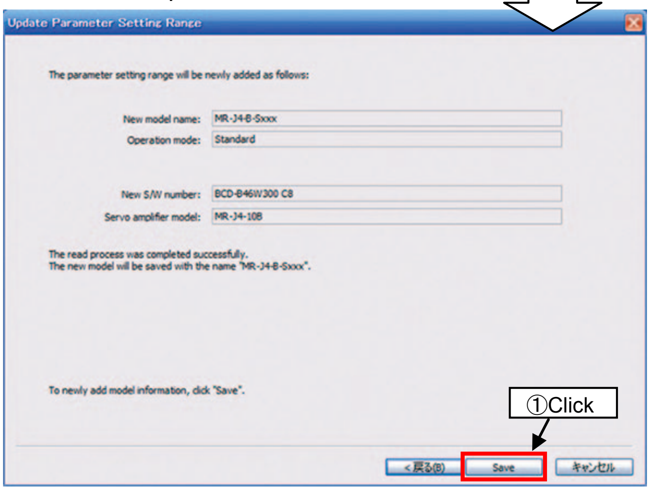
(4) Enter the amplifier name.



(6) Select the added model.



(5) Select the amplifier model name.



Chapter 4

Motor shaft retention brake(RSF-5B)

RSF-5B actuator is standard-equipped with a motor shaft holding brake. (Option symbol: B) An external brake is not required to meet the fail safe and other requirements.
The brake has 2 coils; one for releasing brake, and another for retaining the released state. By controlling the currents through the coils, power consumption during retention of brake release can be reduced.

4-1 Motor shaft retention brake specifications

Item \ Gear ratio		30	50	100
Method		Single disc dry type deenergisation operation type (Separate attraction coil and retention coil)		
Brake operating voltage Note 4	V	24VDC±10%		
Current consumption during release (at 20°C)	A	0.8		
Current consumption during retention of release (at 20°C)	A	0.05		
Retention torque Note 1	N·m	0.18	0.29	0.44
	kgf·cm	1.84	2.96	4.49
Moment of inertia Note 1	($GD^2/4$) $kg·cm^2$	1.11×10^{-4}	3.15×10^{-4}	12.6×10^{-4}
	(J) $kgf·cm·s^2$	1.13×10^{-3}	3.15×10^{-3}	12.6×10^{-3}
Weight Note 2	g	86 (excluding the clamp filters)		
Number of allowable brake operations Note 3		100,000 times		

Note 1:This is a value at the output shaft of the actuator.
Note 2:This is a value for the entire actuator.
Note 3:The motor shaft rotation speed is controlled as shown in the following table.
Note 4:Use a reinforced insulated or double insulated power supply for the 24V DC power supply to the brake.

Reduction ratio	Output shaft rotation speed [r/min]	Motor shaft rotation speed [r/min]
30	5.0	150
50	3.0	
100	1.5	

4-2 Controlling the brake power supply

Using a relay cable (Recommended method)

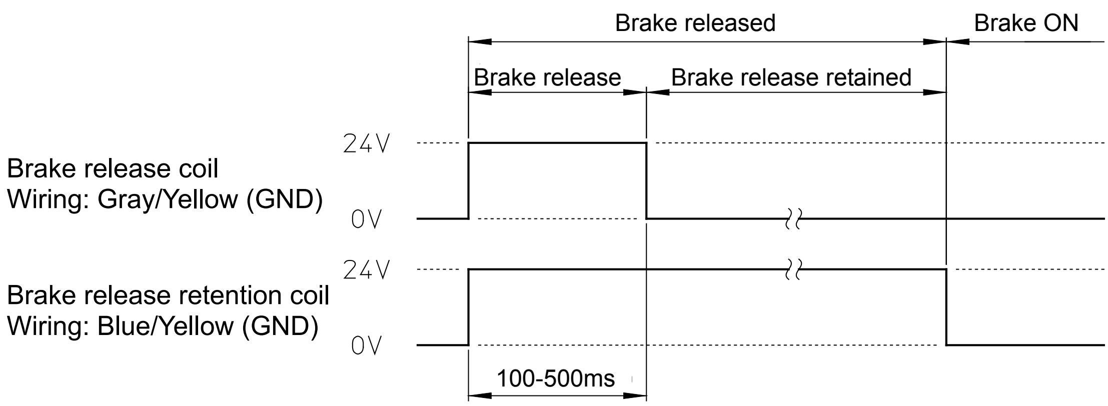
The optional relay cables for brakes (EWA-B××-JST03-TMC) incorporate a circuit that controls the brake current.
You don’t have to control the brake current, so it is recommended to use the actuator with a brake in combination with a relay cable for brakes.
If the relay cable for brakes is used, brake can be operated by turning on/off the brake power supply.
The power supply for the brake (that can output 24VDC±10%) shall be provided by the customer. Use a power supply unit that can output the current during release as described in [4-1 Motor shaft retention brake specifications] (P4-1).
The supply duration of the current consumption during release is 0.5 sec or less at 24VDC±10%.

Not using a relay cable

If the optional relay cable for brakes (EWA-B××-JST03-TMC) is not used, the customer must control the brake power supply to the brake release coil and release retention coil.
Supply the power upon brake release and during brake release retention, as shown below.

	Lead wire color	Applied voltage
Upon brake release	Gray/Yellow	24VDC±10%
	Blue/Yellow	
During release retention	Gray/Yellow	0VDC
	Blue/Yellow	24VDC±10%
During brake use	Gray/Yellow	0VDC
	Blue/Yellow	

Supply the power to the coils according to the following time chart.



Control the power supply so that the duration in which the power is supplied to the brake release coil (gray/yellow) is 100 to 500 ms. The brake will not be released only by the power supply to the brake release retention coil. To release the brake, also supply the power to the brake release coil.

WARNING

The power supply to the brake must be controlled.
Control the power supply to the brake as described in [4-2 Controlling the brake power supply] (P4-2). If the current flows continuously to the attraction coil, the actuator burns due to temperature rise, causing fire or electric shock.

WARNING

Be careful not to exceed the number of allowable brake operations (Refer to [4-1 Motor shaft retention brake specifications] (P4-1)).
If the number is exceeded, the retention torque drops and it cannot be used as a brake.

Chapter 5

Options

Options you can purchase as necessary are explained in this chapter.

5-1 Relay cables

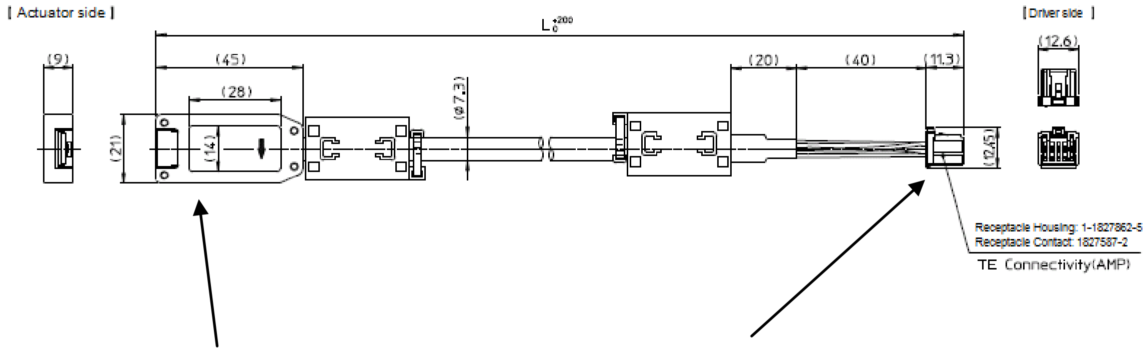
A relay cable is used to connect an RSF supermini series actuator with an amplifier.
There are 3 types of relay cables for encoders, motors, and brakes. Select an appropriate type according to the model of the actuator you ordered.

- **Relay cable model** (xx indicates the cable length 3m, 5m, or 10m.)

(1) For encoders

EWA-E××-JST09-A10-M

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



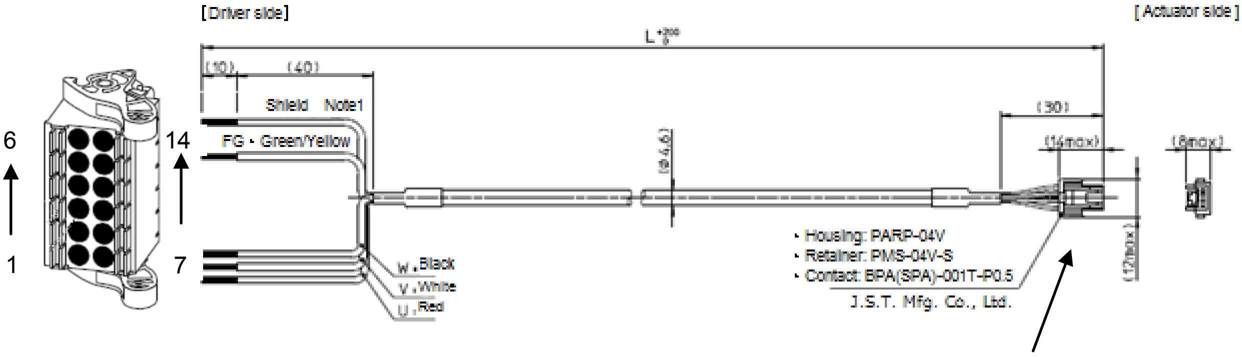
Pin No.	Signal name	Pin No.	Signal name
1	A phase	6	W phase
2	B phase	7	+5V
3	Z phase	8	GND
4	U phase	9	N.C.
5	V phase		

Pin No.	Signal name	Pin No.	Signal name
1A	A+ phase	**1B**	A- phase
2A	B+ phase	**2B**	B- phase
3A	Z+ phase	**3B**	Z- phase
4A	+5V	**4B**	GND
5A	Shield	**5B**	――

(2) For motors

EWA-M××-JST04-NC-M

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

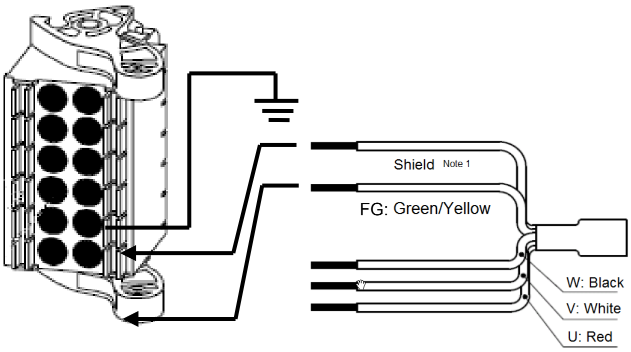


Pin No.	Signal name
1	U phase
2	V phase
3	W phase
4	FG

【Shield line/FG line connections for connector installation】

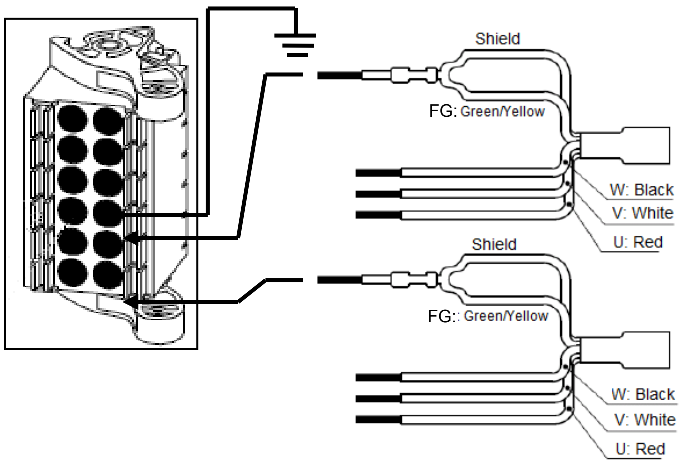
When installing the connector supplied with the MR-J4W2-0303B6-MX940J amplifier, connect the shield line and FG line as follows:

◆ When the actuator connected to the MR-J4W2-0303B6-MX940J amplifier has 1 shaft



Connect the shield line and FG line to pin 7 (E2) and pin 9 (E1) on the CNP1 connector, and ground pin 11 (FG).

◆ When the actuator connected to the MR-J4W2-0303B6-MX940J amplifier has 2 shafts



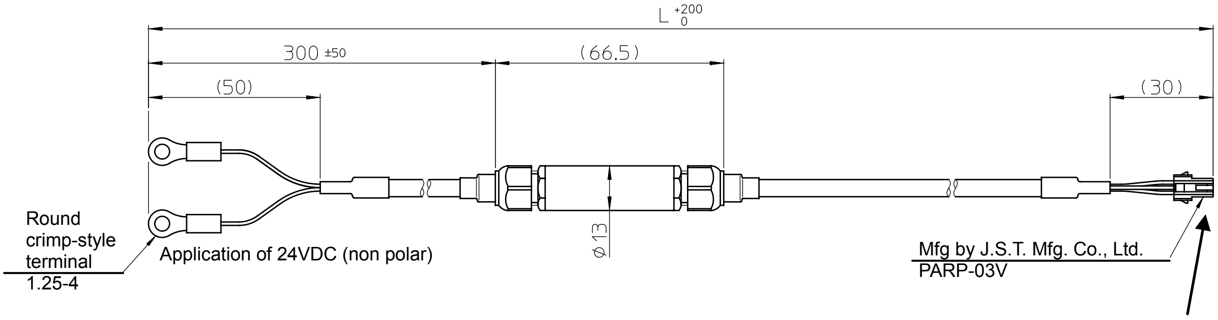
Shape the shield line and FG line as shown in the figure on the left, and connect them to pin 7 (E2) and pin 9 (E1) on the CNP1 respectively. Ground pin 11 (FG) on the CNP1.

5 Options

(3) For brakes (RSF-5B only)

EWA-B××-JST03-TMC

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



Pin No.	Signal name
1	Red
2	White
3	Black

Appendix

This chapter explains the conversion of unit and the moment of inertia.

A-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				

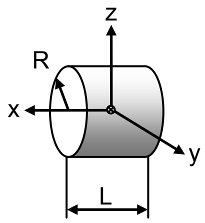
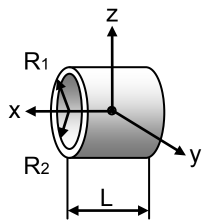
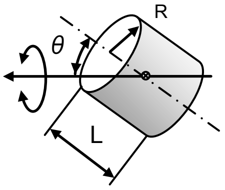
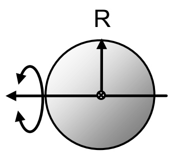
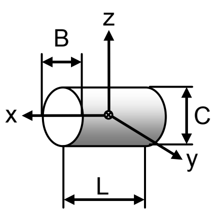
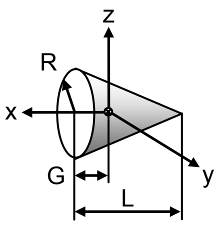
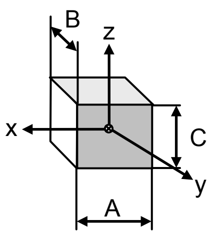
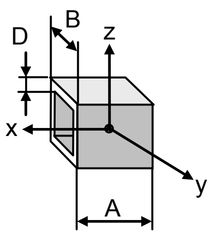
A-2 Moment of inertia

1. Calculation formulas for mass and moment of inertia

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

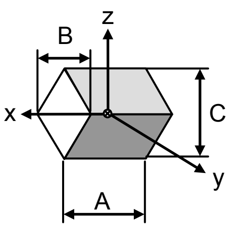
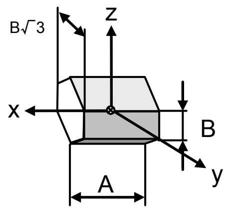
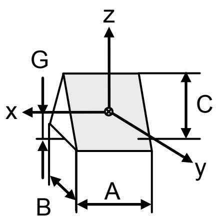
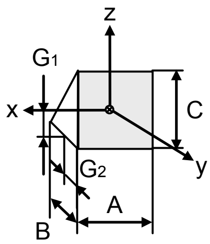
Calculation formulas for mass and moment of inertia are shown below.
m:Mass (kg), Ix, Iy, Iz: moment of inertia (kgm^2) making Axes x, y and z as centers of revolution
G : Distance from edge surface of center of gravity (m)
ρ : Density (kg/m^3)

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 	$m=\pi BCL\rho$ $Ix=\frac{1}{16}m\left(B^2+C^2\right)$ $Iy=\frac{1}{4}m\left(\frac{C^2}{4}+\frac{L^2}{3}\right)$ $Iz=\frac{1}{4}m\left(\frac{B^2}{4}+\frac{L^2}{3}\right)$	Cone 	$m=\frac{\pi}{3}\pi R^2 L\rho$ $Ix=\frac{3}{10}mR^2$ $Iy=\frac{3}{80}m\left(4R^2+L^2\right)$ $Iz=\frac{3}{80}m\left(4R^2+L^2\right)$ $G=\frac{L}{4}$
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 	$m=4AD(B-D)\rho$ $Ix=\frac{1}{3}m\left\{(B-D)^2+D^2\right\}$ $Iy=\frac{1}{6}m\left\{\frac{A^2}{2}+(B-D)^2+D^2\right\}$ $Iz=\frac{1}{6}m\left\{\frac{A^2}{2}+(B-D)^2+D^2\right\}$

App

Appendix

Shape of object	Mass, inertia, position of center of gravity	Shape of object	Mass, inertia, position of center of gravity
Rhombic prism 	$m=\frac{1}{2}ABC\rho$ $Ix=\frac{1}{24}m\left(B^2+C^2\right)$ $Iy=\frac{1}{24}m\left(C^2+2A^2\right)$ $Iz=\frac{1}{24}m\left(B^2+2A^2\right)$	Regular hexagon prism 	$m=\frac{3\sqrt{3}}{2}AB^2\rho$ $Ix=\frac{5}{12}mB^2$ $Iy=\frac{1}{12}m\left(A^2+\frac{5}{2}B^2\right)$ $Iz=\frac{1}{12}m\left(A^2+\frac{5}{2}B^2\right)$
Equilateral triangular prism 	$m=\frac{1}{2}ABC\rho$ $Ix=\frac{1}{12}m\left(\frac{B^2}{2}+\frac{2}{3}C^2\right)$ $Iy=\frac{1}{12}m\left(A^2+\frac{2}{3}C^2\right)$ $Iz=\frac{1}{12}m\left(A^2+\frac{B^2}{2}\right)$ $G=\frac{C}{3}$	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 density

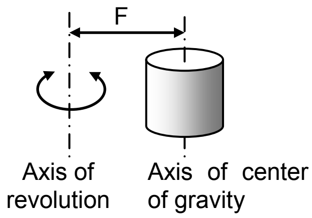
The following table shows informative values of density. Please check actual specific gravities of materials individually.

Material	**Density**	**Material**	**Density**	**Material**	**Density**
SUS304	7930	Aluminum	2700	Epoxy resin	1900
S45C	7860	Duralumin	2800	ABS	1100
SS400	7850	Silicon	2300	Silicon resin	1800
Cast iron	7190	Quartz glass	2200	Polyurethane rubber	1250
Copper	8920	Teflon	2200		
Brass	8500	Fluorocarbon resin	2200		

(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 actuator axis of a linear motion object driven by a screw is calculated by the following formula.

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

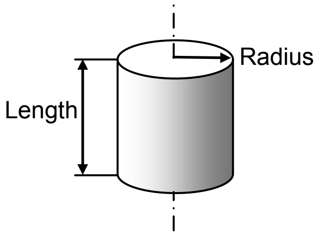
I: Moment of inertia converted into actuator axis of a linear motion object (kgm^2)

m: Mass (kg)

P: Amount of linear movement per revolution of actuator (m/rev)

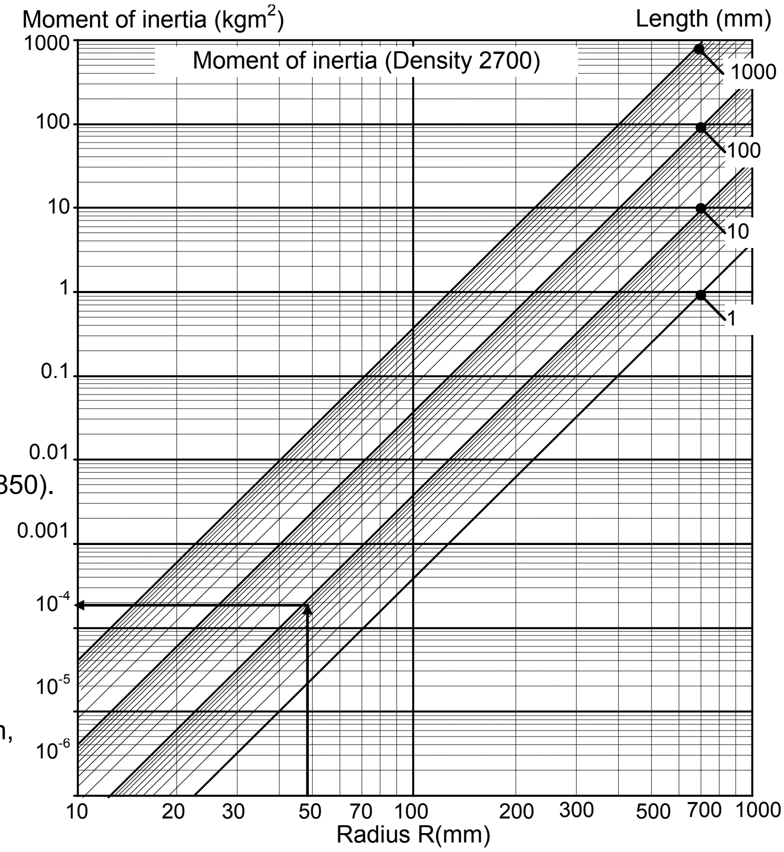
2. Moment of inertia of circular cylinder

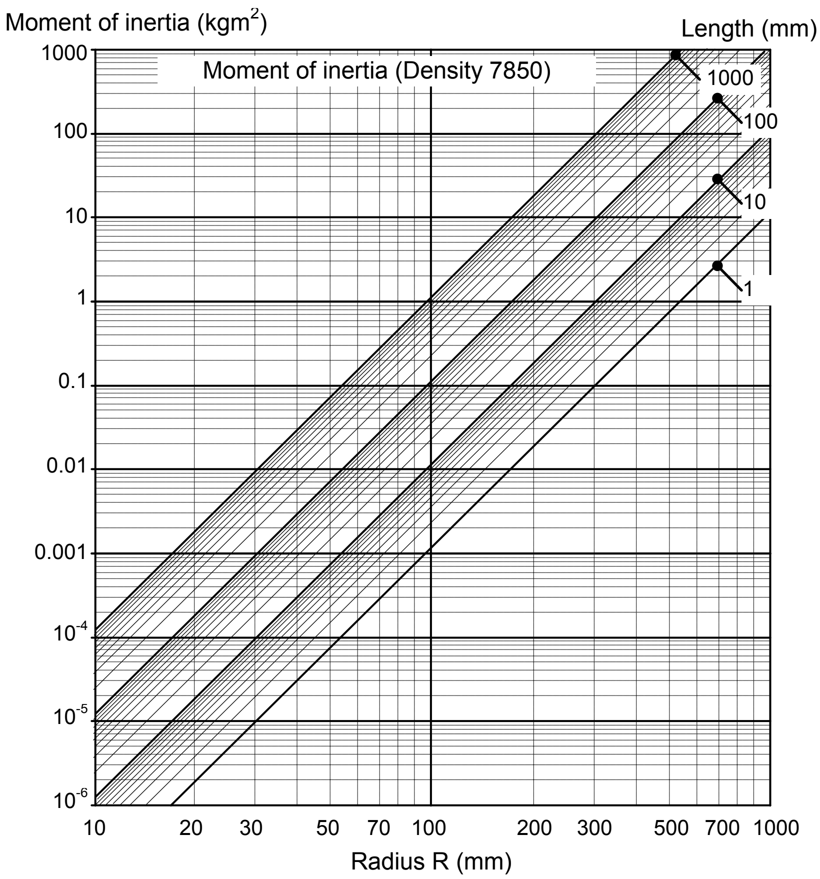
Approximate values of moment of inertia of circular cylinder can be calculated from the graph on the right.



The top graph is applied to aluminum (density 2700) and the bottom graph, to steel (density 7850).

(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 1.9×10^{-4} kgm^2.
(Calculated value: 0.000186kgm^2)





Warranty Period and Terms

The RSF supermini series actuators are 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 RSF supermini 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 supermini 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 supermini series actuator and the HA-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.

HarmonicDrive® HarmonicPlanetary® HarmonicGrease® HarmonicGearhead® HarmonicLinear® BEAM SERVO® Harmonicsyn®

Registered Trademark in Japan

Certified to ISO14001／ISO9001 (TÜV Management Service GmbH)
All specifications and dimensions in this manual subject to change without notice.
This manual is correct as of July 2023.

https://www.hds.co.jp/

Head Office:	Ichigo Omori Building, 6-25-3 Minami-Ohi, Shinagawa-ku, Tokyo, Japan, 140-0013 TEL: +81(0)3-5471-7800 FAX: +81(0)3-5471-7811
Overseas Division:	5103-1 Hotakaariake, Azumino-shi, Nagano, Japan, 399-8301 TEL: +81(0)263-81-5950 FAX: +81(0)263-50-5010
HOTAKA Plant:	1856-1 Hotakamaki, Azumino-shi, Nagano, Japan, 399-8305 TEL: +81(0)263-83-6800 FAX: +81(0)263-83-6901
Harmonic Drive SE:	Hoenbergstrasse 14 D-65555 Limburg a.d. Lahn, Germany TEL: +49-6431-5008-0 FAX: +49-6431-5008-119
Harmonic Drive L.L.C.:	42 Dunham Ridge, Beverly, Massachusetts 01915 U.S.A. TEL: +1-978-532-1800 FAX: +1-978-532-9406

No. 2307-3R-TRSFmM-E