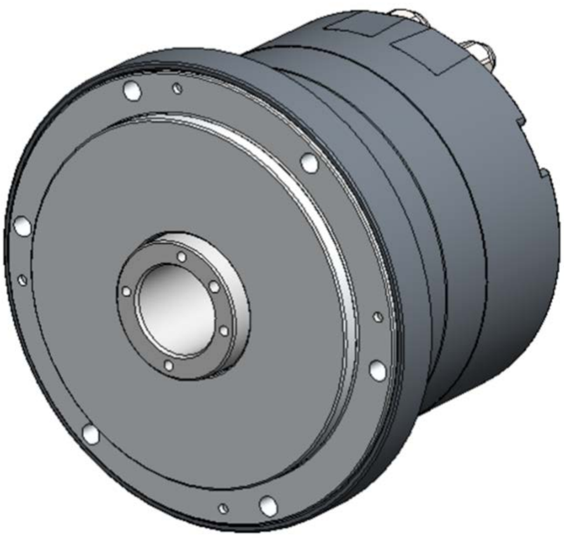
HarmonicDrive®

Flat Hollow Shaft AC Servo Motors

HMA series manual



ISO14001

ISO9001

Introduction

Thank you for purchasing our HMA series AC servo motor.
Incorrect handling or improper use of this product may result in unexpected accidents or a shorter product life. Read this manual carefully and use the product correctly so that the product can be used safely for many years.
The information contained in this manual is subject to change without notice.
Keep this manual in a convenient location and refer to it whenever necessary in operating or maintaining the product.
The end user of the product should have a copy of this manual.

SAFETY GUIDE

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

NOTATION

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

WARNING	Indicates a potentially hazardous situation, which, if not avoided, could result in death or serious personal injury.
CAUTION	Indicates a potentially hazardous situation, which, if not avoided, may result in minor or moderate personal injury and/or damage to the equipment.
Caution	Indicates what should be performed or avoided to prevent non-operation or malfunction of the product or negative effects on its performance or function.

LIMITATION OF APPLICATIONS

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

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

If the above list includes your intended 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 do not occur even when the output control is disabled due to damage.

SAFETY NOTE

ITEMS YOU SHOULD NOTE WHEN USING THE MOTOR

- **CAUTIONS RELATED TO THE DESIGN**

CAUTION

Always use the motor under the specified conditions:
The motor is designed to be used indoors. Observe the following conditions:
- Ambient temperature: 0 to 40℃
- Ambient humidity: 20 to 80% RH (no condensation)
- Vibration: Max. 25 m/s^2
- No contamination by water or oil
- No corrosive or explosive gas

Always follow the instructions in the related manuals to install the motor in the equipment.
- Follow the instructions in the manual to ensure that the center of the motor is aligned with the center of the paired unit.
- Improper alignment may cause vibration or damage to the output shaft.

- **OPERATIONAL PRECAUTIONS**

WARNING

Do not exceed the allowable torque.
- Do not apply a torque exceeding the maximum torque.
- Be aware that, if arms directly attached to the output shaft are hit, the output shaft may become uncontrollable.

Never connect cables directly to a power supply socket.
- Motors must be connected to the proper driver to operate.
- Do not connect a commercial power supply directly to the motor. Failure to observe this caution may damage the motor, possibly resulting in a fire.

Do not apply impacts and shocks to the motor.
- Do not tap the motor with a hammer or other tool because an encoder is connected directly to the motor.
- If the encoder is damaged, the motor may become uncontrollable.

Do not pull the cables.
- Pulling the cables can damage connectors, causing the motor to become uncontrollable.

ITEMS YOU SHOULD NOTE WHEN USING THE DRIVER

● CAUTIONS RELATED TO THE DESIGN

CAUTION

Always use the motor under the specified conditions:
The driver generates heat. Take extra caution for radiation and use it under the following conditions.

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

Use sufficient noise suppressing means and safe grounding.
Any noise generated on a signal wire causes vibration or improper motion. Be sure to observe the following precautions.

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

Pay attention to negative torque caused by inverse load.

- An inverse load may cause damage to the driver.
- Please consult our sales office if you intent to use the motor in such applications.

Use a fast-response type ground-fault detector designed for PWM inverters.
When using a fast-response type ground-fault detector, use one that is designed for PWM inverters. Do not use a time-delay-type ground-fault detector.

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 do not occur even when the output control is disabled due to damage.

● OPERATIONAL PRECAUTIONS

WARNING

Never change any wiring while the power is active.
Make sure that the power is not active before servicing the products. Failure to observe this caution may result in an electric shock or uncontrollable operation.

Do not touch the terminals for at least 5 minutes after turning OFF the power supply.

- Even after the power supply is turned OFF, electric charge remains in the driver. In order to prevent electric shock, perform inspections 5 minutes or more after the power supply is turned OFF.
- When installing, make sure that the inner electronic components are hard to reach.

CAUTION

Do not perform 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 perform such tests.

Do not operate the driver by switching the power ON/OFF.

- Frequent power ON/OFF operations may cause deterioration of circuit elements inside the driver.
- Use command signals to start or stop the motor.

DISPOSAL

CAUTION

The motor and driver must be disposed of as industrial waste.

When disposing of the motor or driver, disassemble it as much as possible, separate parts according to the material description (if indicated), and dispose of them as industrial waste.

Contents

Chapter 1 Outlines

Chapter 2 Selection guidelines

Chapter 3 Installing the HMA motor

Chapter 4 Options

Appendix

Related manual

The related manual is listed below. Use it as a reference as necessary.

Title	Description
AC Servo Driver HA-800 series manual	The specifications and characteristics of HA-800 series drivers are explained.

Conformance to overseas standards

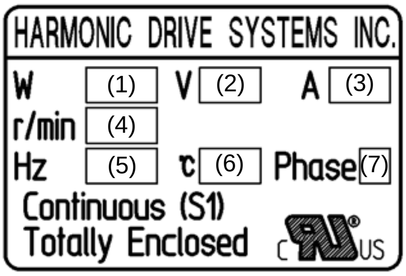
The HMA series motors are compliant with the following overseas standards.

UL standards	UL1004-1, UL1004-6 (File No. E243316)
CSA standards	C22.2 No.100
European Low Voltage EC Directives	EN60034-1, EN60034-5

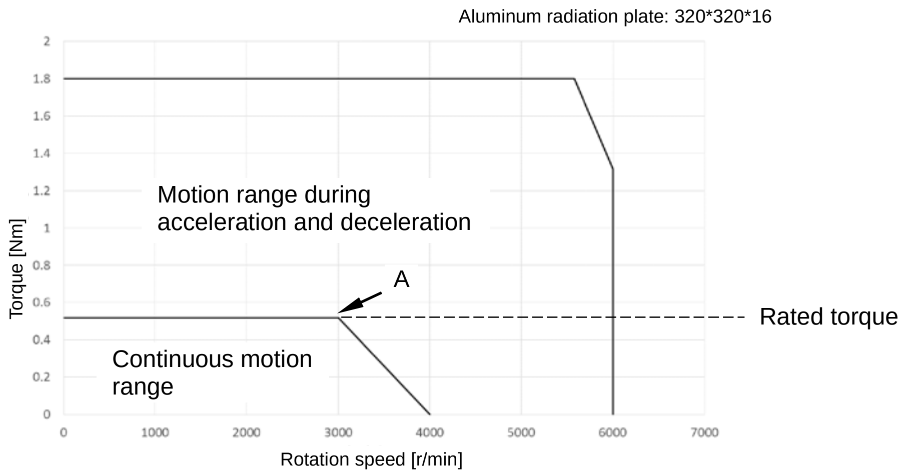
UL nameplate sticker

According to the UL1004-1, UL1004-6 (File No. E243316) standards, the following specifications are indicated on the HMA series motors.

Nameplate field	Description
(1)	Output [W] at point A on the graph below
(2)	Voltage [V] between motor wires at point A on the graph below
(3)	Allowable continuous current [A]
(4)	Rotational speed at point A on the graph below [r/min]
(5)	Current fundamental frequency [Hz] at point A on the graph below
(6)	Allowable ambient temperature [℃]
(7)	Number of phases



UL nameplate sticker



The values displayed on the name plate for each model are shown below.

Item \ Model		HMAC08
(1) Output at point A	W	163
(2) Voltage at point A	V	130
(3) Allowable continuous current	A	2.1
(4) Speed at point A	rpm	3,000
(5) Frequency at point A	Hz	250
(6) Allowable ambient temperature	℃	40
(7) Number of phases	-	3

Item \ Model		HMAB09 (Motor input voltage 200 V)	HMAB09 (Motor input voltage 100 V)
(1) Output at point A	W	251	251
(2) Voltage at point A	V	136	71
(3) Allowable continuous current	A	2.5	4.3
(4) Speed at point A	rpm	3,000	3,000
(5) Frequency at point A	Hz	250	250
(6) Allowable ambient temperature	℃	40	
(7) Number of phases	-	3	

Item \ Model		HMAB12
(1) Output at point A	W	406
(2) Voltage at point A	V	129
(3) Allowable continuous current	A	4.2
(4) Speed at point A	rpm	2,500
(5) Frequency at point A	Hz	208
(6) Allowable ambient temperature	℃	40
(7) Number of phases	-	3

Item \ Model		HMAB15
(1) Output at point A	W	754
(2) Voltage at point A	V	125
(3) Allowable continuous current	A	7.8
(4) Speed at point A	rpm	2,000
(5) Frequency at point A	Hz	167
(6) Allowable ambient temperature	℃	40
(7) Number of phases	-	3

Item \ Model		HMAA21A
(1) Output at point A	W	1,320
(2) Voltage at point A	V	100
(3) Allowable continuous current	A	20.0
(4) Speed at point A	rpm	1,000
(5) Frequency at point A	Hz	133
(6) Allowable ambient temperature	℃	40
(7) Number of phases	-	3

Chapter 1

Outlines

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

1-1 Outlines

All HMA series AC servo motor models feature a hollow bore structure and compact design. Wires, pipes, ball screws, or laser beams go through the hollow bore depending on the mechanism design required for your applications.
HMA series AC servo motors play an important role in driving various factory automation (FA) equipment, such as robot joints, alignment mechanisms for semi-conductors and LCD devices, ATC of metal-cutting machines, printing machine roller drives, etc.

◆ Comes standard with a 17-bit magnetic absolute encoder

The HMA series AC servo motors are equipped with a highly reliable 17-bit magnetic absolute encoder* with safety function. The serial communication requires fewer cables and provides not only a multi revolution counting function which is a must-have feature of motors, but it also has an internal backup battery to retain absolute positions even when the encoder cable is disconnected briefly.
The encoder also constantly compares two sets of detected angles. If any abnormality is found, the encoder's built-in failsafe function outputs a signal to the host system. This helps you build a safe system.
* Size 08 is equipped with an optical encoder.

◆ Supporting a more compact control board and open network control with a dedicated drive

The dedicated HA-800 series drives feature a thin design, contributing to the reduction in the control board size. It also allows you to control your motor on a MECHATROLINK-II or CC-Link network.

1-2 Model

The order code for the HMA series motors and how to read the symbols are explained below.
Model example:

HMA	B	09	A	200	−	10	S17b	A	−	C	Y	−	SP
(1)	(2)	(3)	(4)	(5)	−	(6)	(7)	(8)	−	(9)	(10)	−	(11)

(1) Model: HMA series AC servo motor

(2) Motor version symbol

A	Size 21A
B	Size 09, 12, 15
C	Size 08

(3) Size: 08, 09, 12, 15, 21A

(4) Brake

A	Without brake
B	With brake

(5) Applicable servo driver input voltage

100	100 V
200	200 V

(100 V is compatible with size 09 only.)

(6) Encoder format

10	Compliant with format A, transmission rate: 2.5 Mbps, 1-on-1 connection

(7) Encoder type, resolution

S17b	17-bit multi-turn absolute encoder, 131,072 pulses/revolution

(8) Encoder phase angle: Phase difference between the voltage induced in motor phase U and absolute origin

A	0 degree

(9) Connector specification

C	With standard connector
N	Without connector

(10) Option symbol

Y	Cable taken out from the side

(Please contact us for size 08. This option is not available for size 21A.)

(11) Special specification

No description	Standard product
SP	Special specification product

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Outlines

1-3 Combinations with drives and extension cables

The combinations of HMA motors, HA-800 drivers and extension cables are as follows:

		HMAC08	HMAB09	HMAB12	HMAB15	HMAA21A
I/O command		HA-800A -3D/E-200	HA-800A -3D/E-200 (HA-800A -6D/E -100)	HA-800A -6D/E-200	HA-800A -24D/E-200	HA-800A -24D/E -200
MECHATROLINK-II		HA-800B -3D/E-200	HA-800B -3D/E -200 (HA-800B -6D/E -100)	HA-800B -6D/E-200	HA-800B -24D/E-200	HA-800B -24D/E -200
CC-Link		HA-800C -3D/E-200	HA-800C -3D/E -200 (HA-800C -6D/E -100)	HA-800C -6D/E-200	HA-800C -24D/E-200	HA-800C -24D/E -200
Extension cables (option)	For motors	EWD-MB**-A06-TN3			EWD-MB** -A06-TMC	EWD-MB** -D09-TMC
	For encoders	EWD-S**-A08-3M14				EWD-S** -D10-3M14

*1: ** in the extension cable model indicates the cable length: 03 = 3m, 05 = 5m, 10 = 10m
*2: The driver models shown in parentheses are used when combined with motors whose applicable servo drive input voltage is 100 V.

1-4 Specifications

The specifications of the HMA series motors are shown below.

Item		Model	HMAC08	HMAB09		HMAB12	HMAB15	HMAA21A
Compatible drivers			HA-800□-3 D/E-200	HA-800□-3 D/E-200	HA-800□-6 D/E-100	HA-800□-6 D/E-200	HA-800□-2 4D/E-200	HA-800□-2 4D/E-200
Input power supply		V	200	200	100	200	200	200
Rated output		W	163	251		406	754	1,320
Maximum momentary torque*1		Nm	1.8	3.0		6.6	13	33
		kgf·m	0.18	0.31		0.67	1.33	3.37
Rated torque*1*2		Nm	0.52	0.80		1.55	3.60	12.6
		kgf·m	0.053	0.082		0.158	0.367	1.29
Max. rotational speed*1		r/min	6,000	5,600	4,800	4,800	4,000	3,000
Rated rotational speed		r/min	3,000	3,000		2,500	2,000	1,000
Instantaneous max. current*1		Arms	6.5	8.9	15.4	18	29	55
Rated current*1*2		Arms	2.1	2.5	4.3	4.2	7.8	20.0
Torque constant*1		Nm/A	0.35	0.41	0.24	0.44	0.54	0.72
		kgf·m/A	0.036	0.042	0.024	0.045	0.055	0.073
MEF constant*3		V/(r/min)	0.037	0.043	0.025	0.046	0.057	0.075
Phase resistance (20℃)		Ω	1.43	1.2	0.4	0.33	0.19	0.028
Phase inductance		mH	2.5	3.0	1.0	1.4	1.2	0.29
Inertia moment Values in parentheses are for models with a brake.	GD2/4	$\times 10^{-4}$ kg·m^2	0.734 (0.828)	1.78 (2.16)		6.45 (6.83)	15.8 (19.8)	125 (141)
	J	$\times 10^{-4}$kgf·cm·s^2	7.49 (8.45)	18.2 (22.1)		65.8 (69.7)	161 (202)	1,280 (1,444)
Allowable radial load (when stationary)		N	800	800		1,200	2,400	4,500
		kgf	81.6	81.6		122	245	459
Allowable axial load (when stationary)		N	1,900	2,400		3,600	5,000	14,000
		kgf	194	245		367	510	1,429
Rated radial load (at rated rotational speed)		N	175	185		233	530	1,040
		kgf	17.9	18.9		23.8	54.1	106.1
Rated axial load (at rated rotational speed)		N	100	105		130	180	880
		kgf	10.2	10.7		13.3	18.4	89.8
Encoder type			Absolute encoder					
Encoder resolution		Single-turn detector	2^{17} (131,072)					
		Multi-turn detector*4	2^{16} (65,536)					
Mass Values in parentheses are for models with a brake.		kg	1.4 (1.5)	2.0 (2.1)		3.4 (3.8)	5.5 (6.2)	17.5 (19.7)

Environmental conditions	Operating temperature: 0 to 40℃/Storage temperature: -20 to 60℃ Service/storage humidity: 20 to 80% RH (no condensation) Resistance to vibration: 25m/s^2 (frequency: 10 to 400Hz) Resistance to impact: 300 m/s^2 *5 No dust, metal powder, corrosive gas, inflammable gas, or oil mist. To be used indoors, no direct sunlight. Altitude: less than1,000 m above sea level
Motor insulation	Insulation resistance: 100 MΩ or more (500 VDC insulation tester) Dielectric strength: 1,500 VAC/1 min Insulation class: A
Mounting direction	Can be installed in any direction.
Protection structure	Totally enclosed self-cooled type (IP54)

The table above shows the typical values.
*1: Indicates typical characteristics when combined with our driver (driven using an ideal sine wave).
*2: Values after the temperature has risen and saturated when installed on the following aluminum radiation plates.
HMAC08: 320×320×16 [mm]
HMAB09: 350×350×18 [mm]
HMAB12: 400×400×20 [mm]
HMAB15: 500×500×25 [mm]
HMAA21A: 650×650×30 [mm]
*3: Value of the phase-induced voltage constant multiplied by 3.
*4: The multi-turn detector range is -32,768 to 32,767.
*5: For testing conditions, refer to [1-10 Shock resistance] (P1-15) and [1-11 Resistance to vibration] (P1-16).
Motor operation is not guaranteed in applications where vibrations and impacts are continuously applied for a long period of time.

1-5 Holding brake

The brakes equipped on HMA series motors are used to hold the motor shaft in place when the power is cut off. With some models (HMAB09, 12), the motor's built-in circuit controls the voltage supplied to the brake in order to reduce the power consumption while the brake is actuated.
Always use a DC power supply that has a proper brake excitation voltage and is capable of outputting enough current during suction.

Specifications

Item \ Model		HMAC08	HMAB09	HMAB12	HMAB15	HMAA21A
Type		Dry non-excitation actuation type				
Power-saving control		No	Yes		No	
Brake excitation voltage	**V**	24 VDC ± 10% (no polarity) *1				
Current consumption during suction	**A**	0.37	0.8*2	0.8*2	0.7	0.9
Current consumption during holding	**A**	0.37	0.3	0.3	0.7	0.9
Holding torque	**Nm**	0.6	1.0	2.0	4.0	15
	kgf·m	0.06	0.102	0.204	0.408	1.53
Allowable number of normal brakings*3		100,000 times				
Allowable number of emergency stops *4		200 times				

*1: The power supply for the brake is not included in the product. Use a power supply that is capable of outputting enough current during brake suction.
*2: The duration the current is supplied during suction is 0.5 second or less for the power supply of 24VDC ± 10%.
*3: When the brake is activated at the rotational speed of 150 r/min or less.
*4: When the brake is activated at the rotational speed of 3,000 r/min, provided that the inertia moment of load is 3 times or less than that of the motor.

WARNING

The holding brake cannot be used for deceleration.
Do not use the holding brake more than the allowable number of normal brakings (100,000 times at the rotational speed of 150 rpm or less) or allowable number of emergency stops (200 times at the rotational speed of 3,000 rpm, provided that the inertia moment load is 3 times or less than that of the motor).

Exceeding the allowable number of normal brakings and allowable number of emergency stops may cause the holding torque to decrease and consequently become unusable as a brake.

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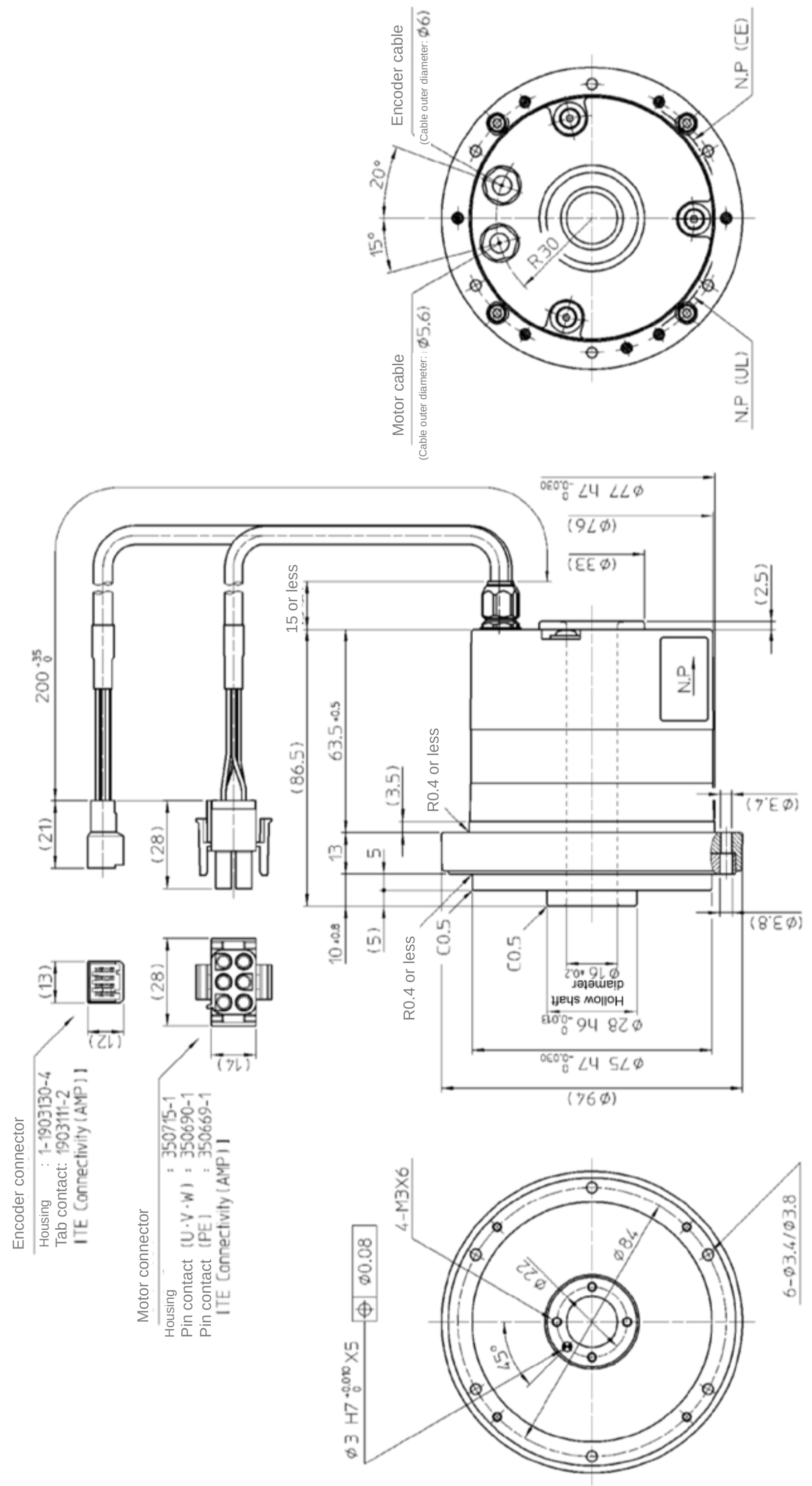
Outlines

1-6 External dimensions

The external dimensions of the HMA series motors are shown below.

- **HMAC08 (with/without brake)**

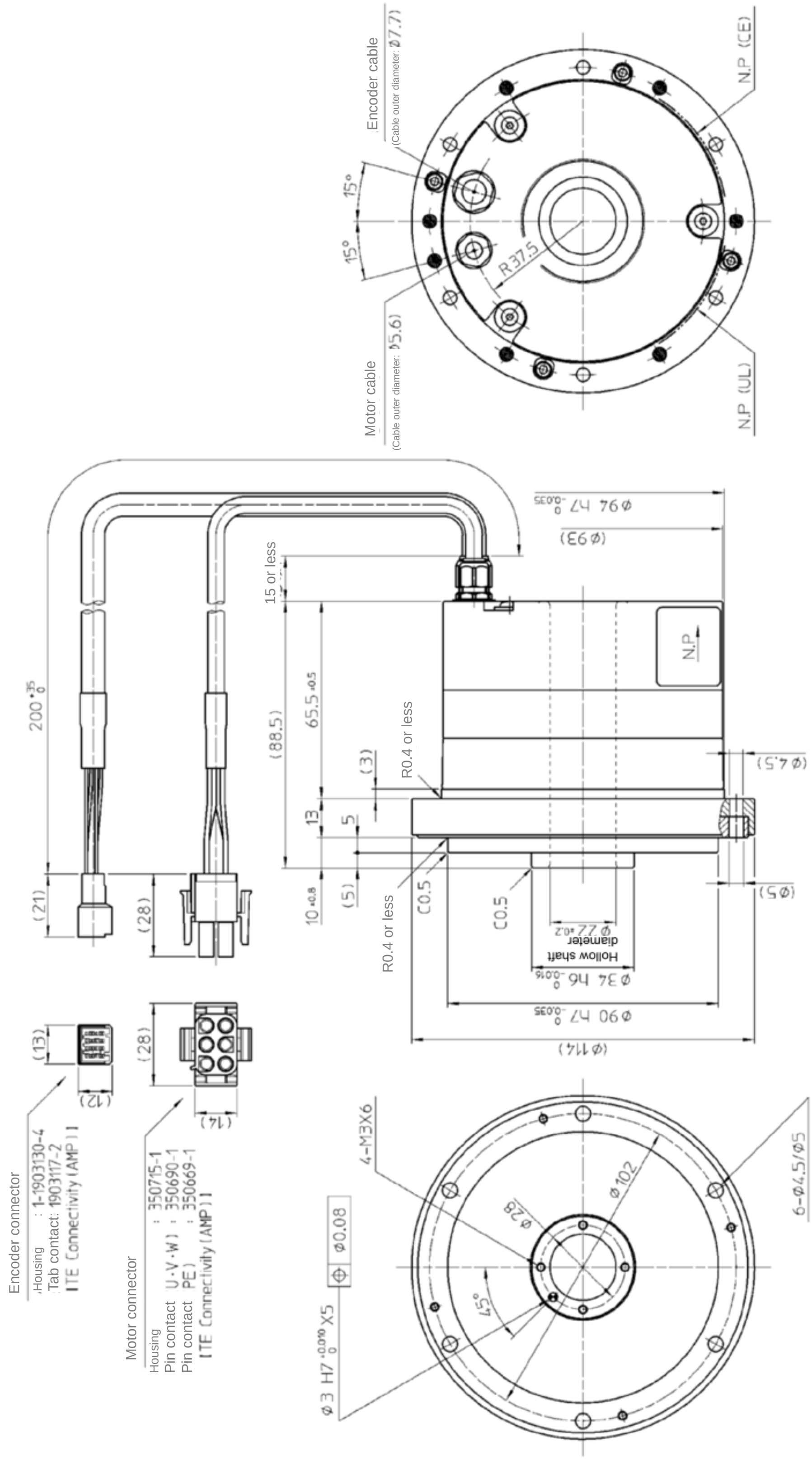
Unit: mm (third angle projection)



Note: For details on external dimensions, see our illustrated specifications.
Tolerances may vary with the product manufacturing method (foundry piece, machine-finished good).
Contact us for the differential range of the size that is not described.

- **HMAB09 (with/without brake)**

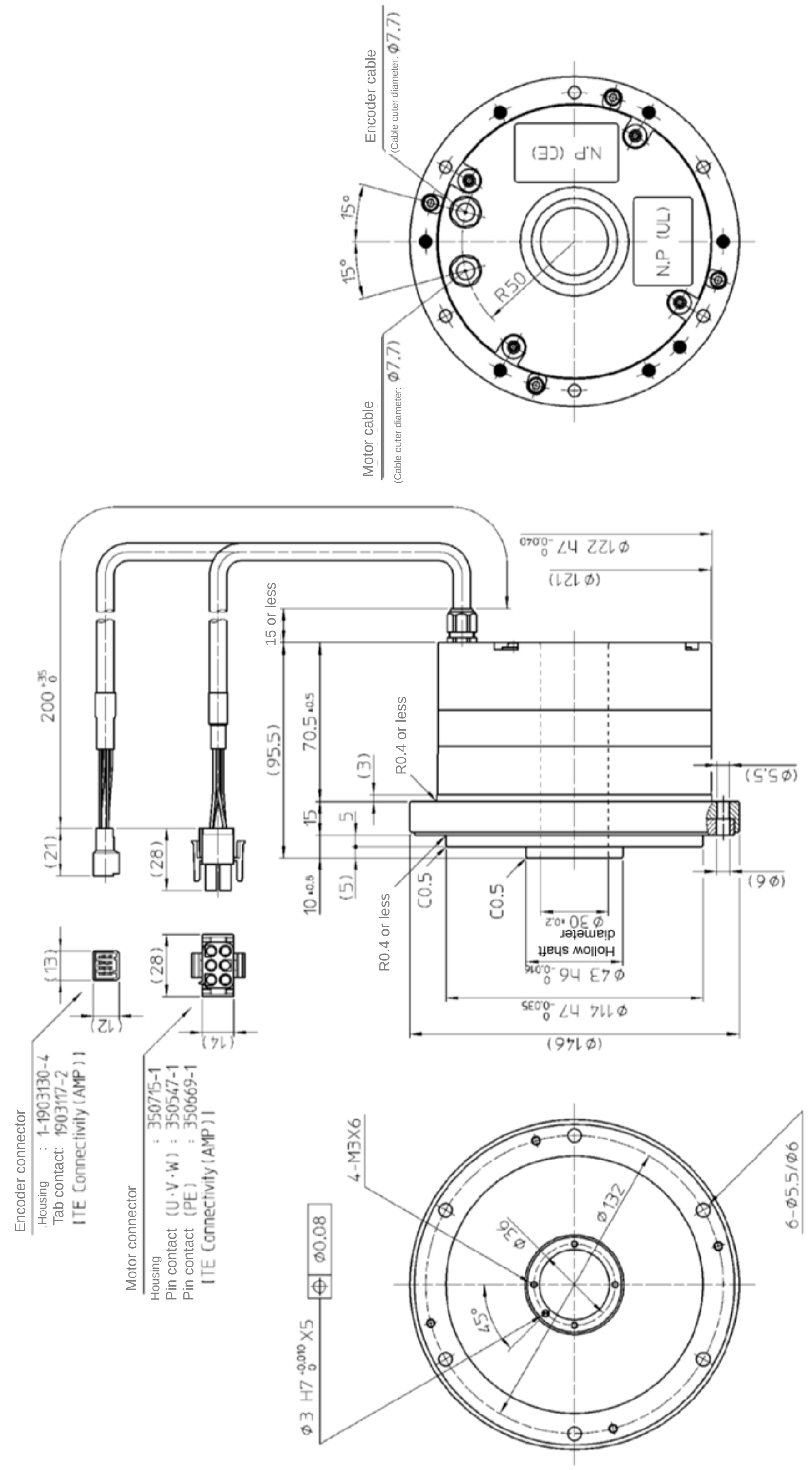
Unit: mm (third angle projection)



Note: For details on external dimensions, see our illustrated specifications.
Tolerances may vary with the product manufacturing method (foundry piece, machine-finished good).
Contact us for the differential range of the size that is not described.

● HMAB12 (with/without brake)

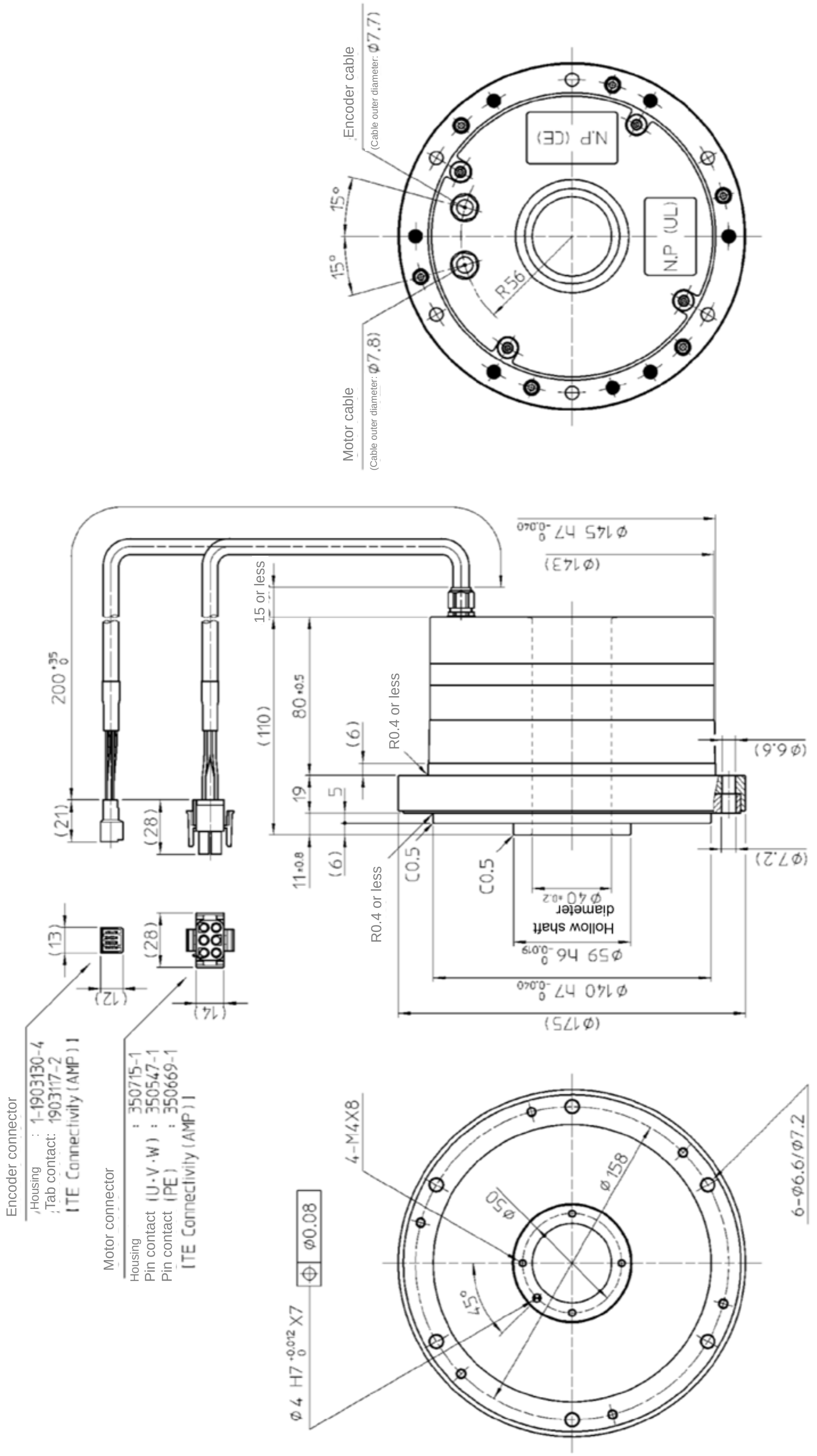
Unit: mm (third angle projection)



Note: For details on external dimensions, see our illustrated specifications.
Tolerances may vary with the product manufacturing method (foundry piece, machine-finished good).
Contact us for the differential range of the size that is not described.

- **HMAB15 (with/without brake)**

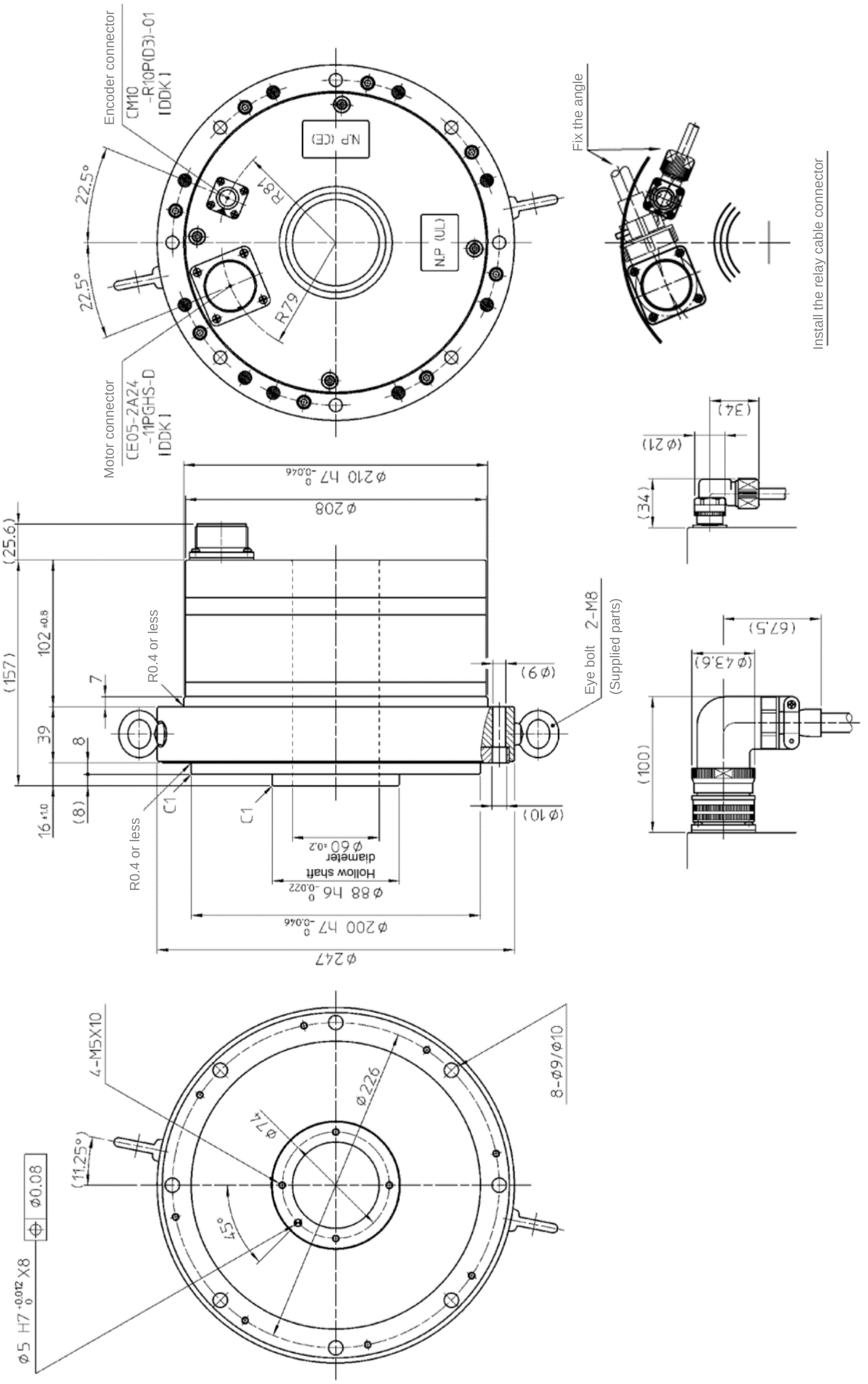
Unit: mm (third angle projection)



Note: For details on external dimensions, see our illustrated specifications.
Tolerances may vary with the product manufacturing method (foundry piece, machine-finished good).
Contact us for the differential range of the size that is not described.

- **HMAA21A (with/without brake)**

Unit: mm (third angle projection)



Note: For details on external dimensions, see our illustrated specifications.
Tolerances may vary with the product manufacturing method (foundry piece, machine-finished good).
Contact us for the differential range of the size that is not described.

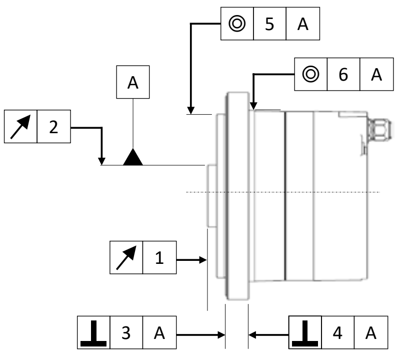
1-7 Mechanical accuracy

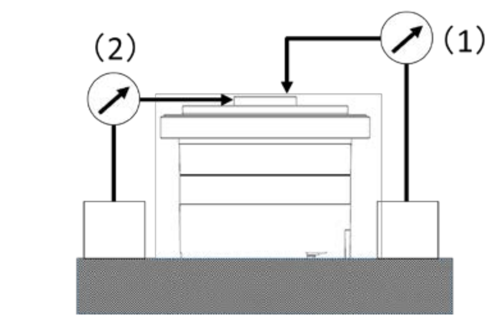
The mechanical accuracies of the output shaft and mounting flange for HMA series motors are shown below:

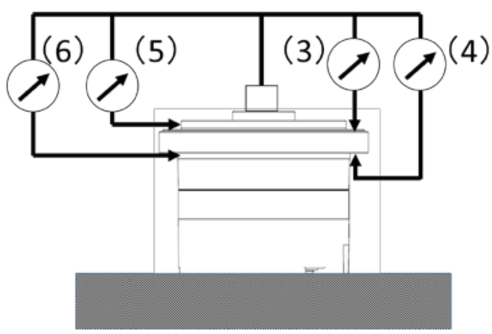
Unit: mm

Accuracy items	HMAC08	HMAB09	HMAB12	HMAB15	HMAA21A
1. Output shaft surface runout	0.020	0.020	0.020	0.040	0.040
2. Deflection of output shaft	0.020	0.020	0.020	0.040	0.040
3. Squareness of the mounting surface to the output shaft	0.080	0.080	0.080	0.090	0.100
4. Squareness of the mounting surface to the output shaft	0.060	0.065	0.065	0.085	0.090
5. Concentricity of the mounting surface to the output shaft	0.050	0.050	0.050	0.050	0.060
6. Concentricity of the mounting surface to the output shaft	0.045	0.045	0.045	0.055	0.065

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







The methods for measurement are as follows:

1 **Output shaft surface runout**

The indicator on the fixed part measures the axial runout (maximum runout width) of the end surface of the output shaft per revolution.

2 **Deflection of output shaft**

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

3,4 **Squareness of the mounting surface to the output shaft**

The indicator on the output shaft reference position measures the axial runout (maximum runout width) of the outermost circumference of the mounting surface (both on the output shaft side and opposite side) per revolution.

5,6 **Concentricity of the mounting surface to the output shaft**

The indicator on the output shaft reference position measures the radial runout (maximum runout width) of the fitting part (both on the output shaft side and opposite side) per revolution.

1-8 Detector specifications (Absolute encoder)

Absolute encoders installed in the HMA series are multi-turn absolute encoders. The encoder consists of a single-turn detector for detecting the motor shaft position, and a multi-turn detector for detecting the number of revolutions.
The encoder constantly detects the absolute position of the machine and stores it by means of the battery backup, regardless of whether the driver or external controller power is turned ON or OFF. Accordingly, once the origin is detected when the machine is installed, originating is not required for subsequent power ON operations. This facilitates the recovery operation after a power failure or breakdown.
The single-turn absolute position detector and the accumulation counter that detects the number of revolutions are both made dual-redundant, where data is constantly checked between two identical devices while the power is ON to ensure a highly reliable design that allows self-detection of encoder errors should they occur.
In addition, a backup capacitor is installed in the encoder to retain absolute positions even when the driver-encoder extension cable is disconnected for initial startup of the device, etc. (internal backup). However, the backup capacitor has a limited life and its performance deteriorates. Therefore, it is recommended that you replace the battery in the battery backup built in the HA-800 driver while the driver is receiving power.

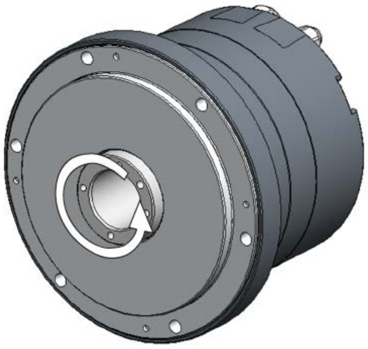
Specifications

Type[*1]		Magnetic sensor/electronic battery backup type (Single-turn optical sensor, multi-turn magnetic sensor/electronic battery backup type)
Resolution	**Single-turn detector**	2^{17}: 131,072 pulses
	Multi-turn detector	2^{16}: 65,536 (-32,768 to 32,767)
Maximum allowable motor shaft rotational speed		7,000 r/min[*2]
Safety/redundancy		・ Check method in which two identical single-turn detectors are compared ・ Check method in which two identical cumulative revolution counters that detect the number of revolutions are compared
Backup time by external battery		1 year (when power is not supplied)
Backup time by internal battery		30 minutes (after 3 hours of charge, ambient temperature of 25℃, axis stopped) (For backup while the driver and encoder are disconnected briefly)

*1: HMAC08 is equipped with an optical encoder; other models are equipped with a magnetic encoder.
*2: This is the rotational speed limit of the encoder and is different from the rotational speed that the motor can drive.

1-9 Rotation direction

As a default, the rotation direction is defined as counterclockwise (CCW) rotation as viewed from the output shaft when a FWD command pulse is given from an HA-800 driver.
This rotation direction can be changed on the HA-800 driver by selecting [SP50: Command polarity setting] under [System parameter mode 3].



Counterclockwise rotation direction

"SP50: Command polarity" setting

Set value	FWD command pulse	REV command pulse	Setting
0	CCW (counterclockwise) direction	CW (clockwise) direction	Default
1	CW (clockwise) direction	CCW (counterclockwise) direction	

1

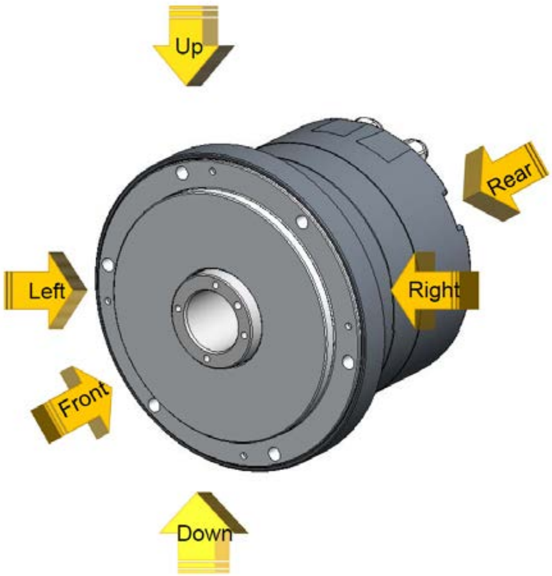
Outlines

1-10 Shock resistance

The shock resistance of the motor is as follows, and this value is the same in up/down, left/right and front/rear directions:

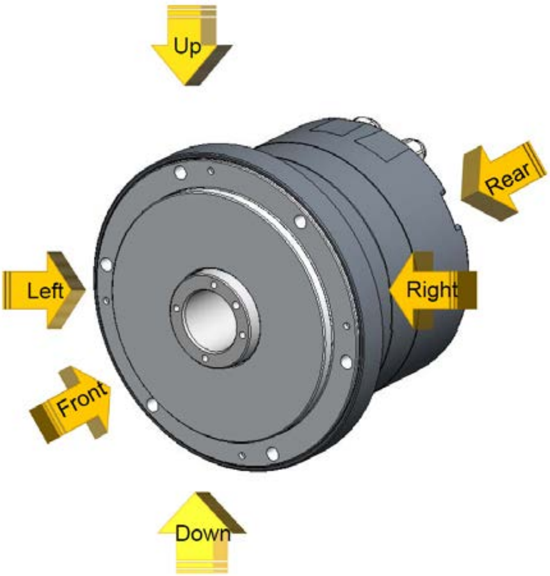
Shock acceleration: 300 m/s^2

In our shock resistance test, the motor is tested three times in each direction. Motor operation is not guaranteed in applications where impacts exceeding the above value are constantly applied.



1-11 Resistance to vibration

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



1-12 Operable range

The graphs on the following pages indicate the operable ranges of HMA series motors when combined with an HA-800 driver. For details, refer to [2-1 HMA series selection].

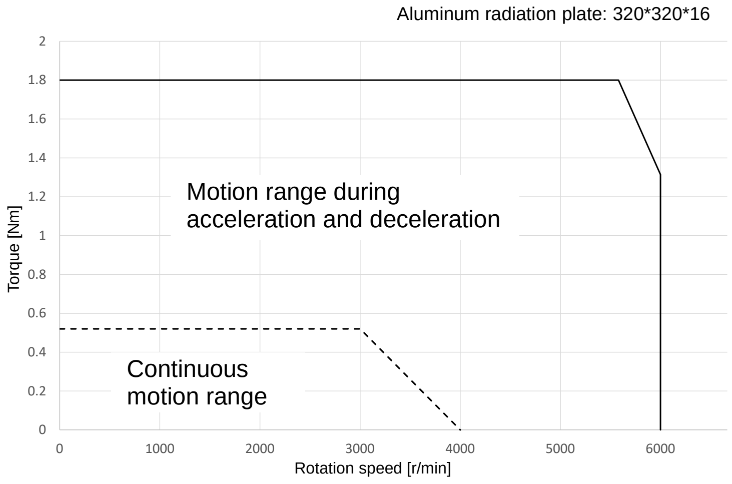
1. Continuous motion range

This indicates a range in which the motor can be operated continuously as shown by the relationship between the torque and rotational speed. Note that values are measured with the radiation plate listed on the graphs installed.

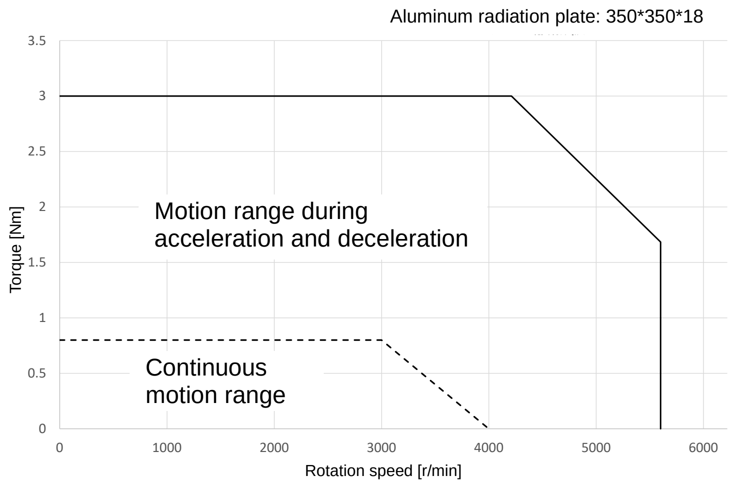
2. Motion range during acceleration and deceleration

This indicates a range in which the motor can be operated instantaneously as shown by the relationship between the torque and rotational speed. This range is normally used for acceleration or deceleration.

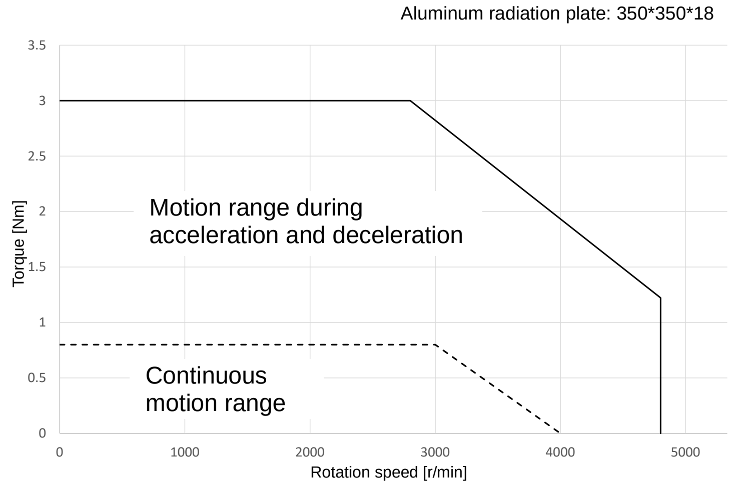
■HMAC08



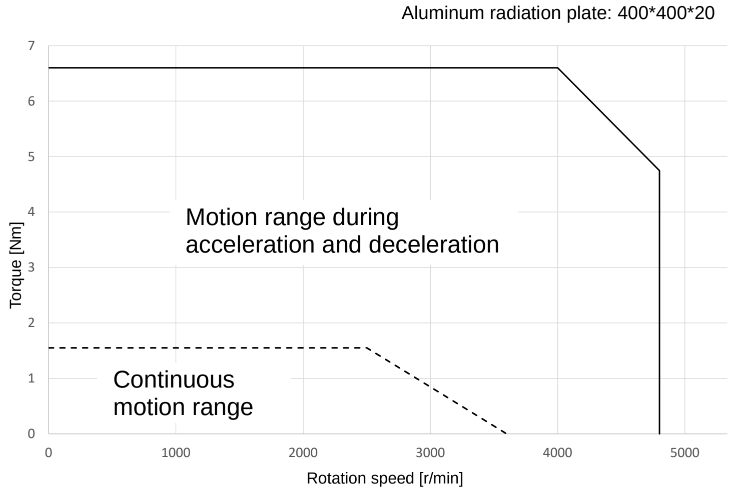
■HMAB09 *200 VAC type



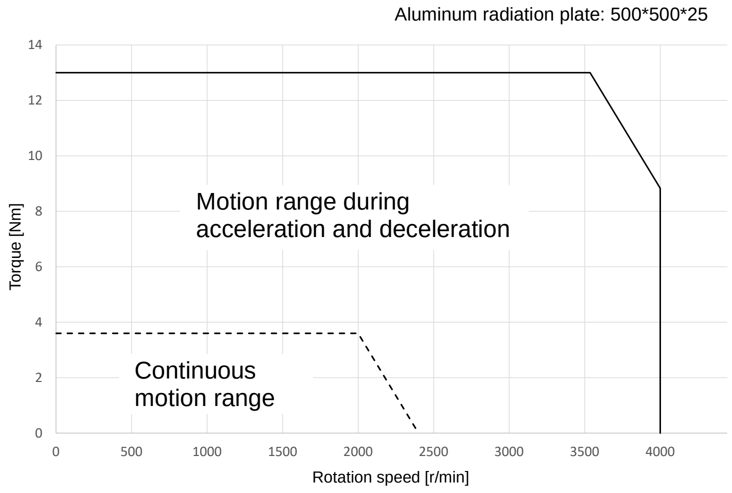
■HMAB09 *100 VAC type



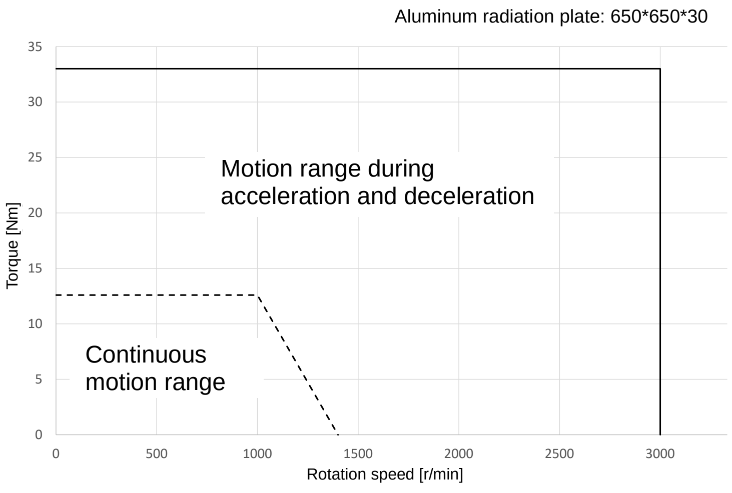
■HMAB12



■HMAB15



■HMAA21A



1-13 Cable specifications

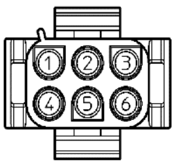
The following tables show the specifications of the motor and encoder cables for the HMA series motors.

Motor cable specifications

- Size 08, 09, 12, 15

Pin No.	Color	Name	
		Without brake	With brake
1	Red	Motor phase-U	Motor phase-U
2	White	Motor phase-V	Motor phase-V
3	Black	Motor phase-W	Motor phase-W
4	Green/Yellow	PE	PE
5	Blue	No connection	Brake
6	Yellow	No connection	Brake

- Connector pin layout



Connector model: 350715-1
Pin model:

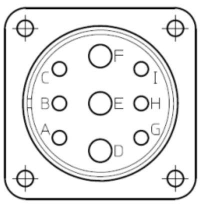
	Size 08, 09	Size 12, 15
Motor UVW	350690-1	350547-1
Brake	350690-1	350690-1
Motor PE	350669-1	350669-1

by AMP

- Size 21A

Pin No.	Color (extension cable)	Name	
		Without brake	With brake
A	Blue	No connection	Brake
B	Yellow	No connection	Brake
C	-	No connection	No connection
D	Red	Motor phase-U	Motor phase-U
E	White	Motor phase-V	Motor phase-V
F	Black	Motor phase-W	Motor phase-W
G	Green/Yellow	PE	PE
H	-	PE	PE
I	-	No connection	No connection

- Connector pin layout



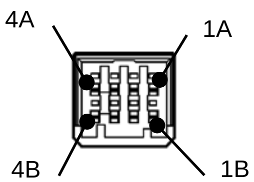
Connector model: CE05-2A24-11PGHS-D (by DDK)

Encoder cable specifications

- Size 08, 09, 12, 15

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

- Connector pin layout

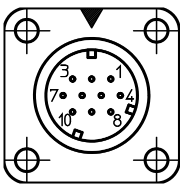


Connector model: 1-1903130-4
Pin model: 1903111-2, 1903116-2, or 1903117-2
by AMP

- Size 21A

Pin No.	Color	Signal name	Remarks
1	Orange	Vbat	Battery +
2	Gray	GND (bat)	Battery - (GND)
3	NC	No connection	
4	Red	Vcc	Power supply input +5V
5	Black	GND (Vcc)	Power supply input 0V (GND)
6	NC	No connection	
7	NC	No connection	
8	Yellow	SD+	Serial signal differential output (+)
9	Blue	SD-	Serial signal differential output (-)
10	-	FG	

- Connector pin layout



Connector model: CM10-R10P (D3)-01 (by DDK)

Chapter 2

Selection guidelines

This chapter explains how to select a proper HMA series motor.

2-1 HMA series selection

Allowable load inertia moment

To maximize the performance of the HMA series, make a tentative selection of a motor so that the max. rotational speed and allowable load inertia moment ratio are equal to or lower than the values shown in the table below.
The allowable load inertia moment ratios in the table below are reference values for the following cases:

(1) Controllable range: where the motor is accelerated/decelerated gradually or high responsiveness is not required.
(2) Stable control range: where higher responsiveness is required to shorten the transient vibration period during positioning or stable operation at a constant speed is required.

Model No.		HMAC08	HMAB09	HMAB12	HMAB15	HMAA21A
Allowable rotational speed	(r/min)	6,000	5,600 (4,800)*	4,800	4,000	3,000
Inertia moment (without brake)	$\times10^{-4}$ kg·m^2	0.734	1.78	6.45	15.8	125
	$\times10^{-4}$ kgf·cm·s^2	7.49	18.2	65.8	161	1,280
Inertia moment (with brake)	$\times10^{-4}$ kg·m^2	0.828	2.16	6.83	19.8	141
	$\times10^{-4}$ kgf·cm·s^2	8.45	22.1	69.7	202	1,444
Allowable load inertia moment ratio	(1) Controllable range	10 times or less than inertia moment				
	(2) Stable control range	3 times or less than inertia moment				

*: The values in parentheses are values for motors with 100 V input voltage.

Refer to [A-2 Calculating inertia moment] (P5-3) for the calculation of inertia moment.

When a load with a large inertia moment is operated frequently, a greater regenerative energy is produced during braking. If the produced regenerative energy exceeds the absorption capacity of the built-in regenerative resistor of the servo driver, an additional regenerative resistor must be connected externally to the driver. For details, refer to the manual of your driver.

2-2 Verifying and examining load weights

Ensure that the load applied to the output shaft of the HMA series motor does not exceed the max. radial load and max. axial load when stationary and also that the load does not exceed the rated radial load and rated axial load at the rated rotational speed.

Refer to the following formulas (1) and (2) to calculate the radial load and axial load.

◆ **Formula (1): Max. radial load, max. axial load**

$$Fr_{max} \geqq Fr \times (Lr + R) \quad (Fa=0)$$

$$Fa_{max} \geqq Fa \times La \quad (Fr=0)$$

Symbols in calculation formula

Fr_{max}	Max. radial load	N	Refer to Fig.1.
Fa_{max}	Max. axial load	N	Refer to Fig.1.
Fr	Radial load	N	Refer to Fig.1.
Fa	Axial load	N	Refer to Fig.1.
Lr, La	————	mm	Refer to Fig.1.
R	Offset amount	mm	Refer to Fig.1 and Table 1.

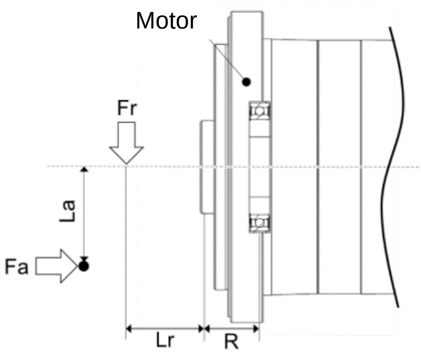


Fig. 1: External load action diagram

◆ **Formula (2): Rated radial load, rated axial load**

$$Fr_{ave} \geqq Fr \times (Lr + R) \quad (Fa=0)$$

$$Fa_{ave} \geqq Fa \times La \quad (Fr=0)$$

Symbols in calculation formula

Fr_{ave}	Rated radial load	N	Refer to Fig.1.
Fa_{ave}	Rated axial load	N	Refer to Fig.1.
Fr	Radial load	N	Refer to Fig.1.
Fa	Axial load	N	Refer to Fig.1.
Lr, La	————	mm	Refer to Fig.1.
R	Offset amount	mm	Refer to Fig.1 and Table 1.

Specifications of the support bearings

The following table shows the specifications of the support bearings.
Table 1: Specifications of the main roller bearings

Item / Model	Offset amount (R)	Rated radial load	Rated axial load	Allowable radialload (when stationary)	Allowable axial load (when stationary)
	mm	N	N	N	N
HMAC08	17.8	175	100	800	1,900
HMAB09	21.7	185	105	800	2,400
HMAB12	25.0	233	130	1,200	3,600
HMAB15	27.3	530	180	2,400	5,000
HMAA21A	39.5	1,040	880	4,500	14,000

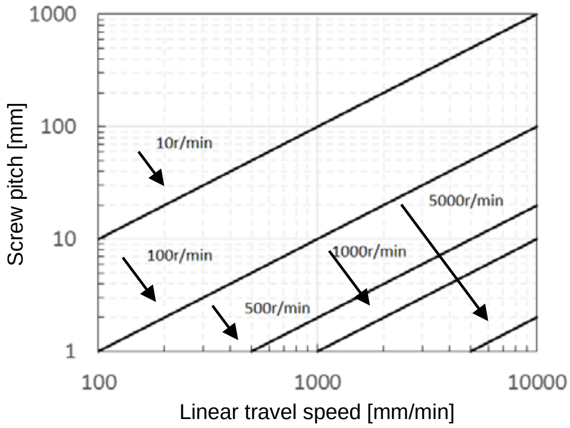
2-3 Examining the operating status

The motor generates heat if started/stopped repeatedly or operated continuously at high speed. Accordingly, evaluate whether or not the generated heat can be accommodated.
Evaluate as follows:

Examining motor rotational speed

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

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



Check that this rotational speed is less than the max. rotational speed of the HMA series motor.

Calculating and examining load inertia moment

Calculate the inertia moment of the load driven by an HMA series motor.
Refer to [A-2 Calculating inertia moment] (P5-3) for the calculation.
Based on the calculation result, make a tentative selection of an HMA series motor referring to [Allowable load inertia moment] (P2-1).

Load torque calculation

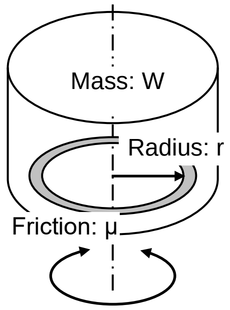
Calculate the load torque as follows:

- Rotary motion

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

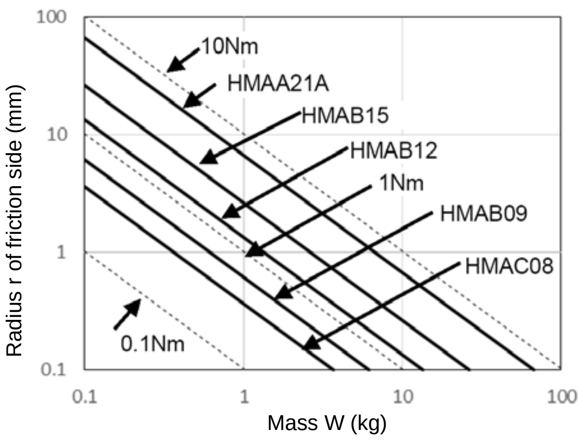
$T = 9.8 \times \mu \times W \times r$

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



Example of rotary torque calculation (friction coefficient = 0.1)
HMA: torque of maximum torque is shown.

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

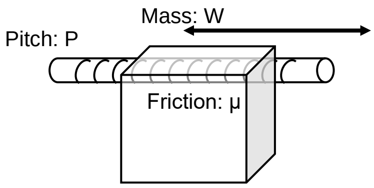


- Linear operation (horizontal operation)

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

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

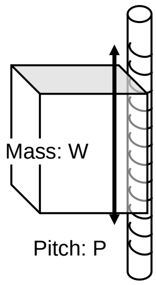
T: Rotary torque (Nm)
μ: Friction coefficient
W: Mass (kg)
P: Screw feed pitch (m)



- Linear operation (vertical operation)

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

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

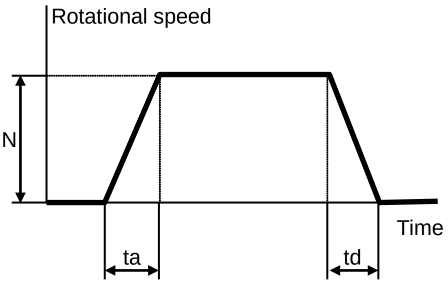


Acceleration time and deceleration time

Calculate the acceleration and deceleration times for the motor tentatively selected using the following formula.

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

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



t_a: Acceleration time (s)
t_d: Deceleration time (s)
k: Acceleration reduction coefficient 1 to 1.5
The total positioning time may become shorter if the acceleration is lowered for the purpose of reducing the settling time after positioning.
J_M: Inertia moment of motor ($kg \cdot m^2$)
J_L: Inertia moment of load ($kg \cdot m^2$)
N: Rotational speed of motor (r/min)
T_M: Maximum momentary torque (Nm)
T_F: Motor friction torque (Nm)

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

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

- **Calculation example 1**

Select a motor that best suits the following operating conditions:
- Rotational speed: 4800 r/min
- Inertia moment of load: 2.0×10^{-4} $kg \cdot m^2$
- Since the load mechanism is mainly inertia, the load torque is negligibly small.

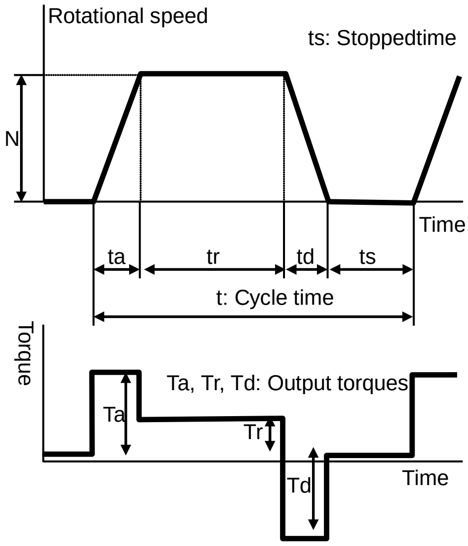
(1) According to the conditions above, tentatively select an HMAC08 from the table in section 2-1.
(2) From the rating table, the following values are obtained: $J_M = 0.734 \times 10^{-4}$ $kg \cdot m^2$, $T_M = 1.8$ Nm, $T_R = 0.52$ Nm, $K_T = 0.35$ Nm/A, $I_R = 2.1$ A
(3) Based on the above formula, the motor's friction torque T_F is calculated as 0.35 × 2.1 - 0.52 = 0.215 Nm.
(4) If k = 1.3, the acceleration time and deceleration time can be obtained as follows from the above formulas:
$t_a = 1.3 \times (0.734 + 2.0) \times 10^{-4} \times 2 \times \pi / 60 \times 4{,}800 / 1.8 \fallingdotseq 0.099$ s
$t_d = 1.3 \times (0.734 + 2.0) \times 10^{-4} \times 2 \times \pi / 60 \times 4{,}800 / (1.8 + 2 \times 0.215) \fallingdotseq 0.080$ s
(5) If the calculated acceleration/deceleration times are too long, correct the situation by:
- Reducing the inertia moment of load
- Selecting a motor with a larger frame size

Evaluating effective torque and average rotational speed

One way to check if the heat generated from the motor during operation would present a problem is to determine if the point of operation, determined by the effective torque and average rotational speed, is inside the continuous motion range explained in [1-12Operable range].
Using the following formula, calculate the effective torque Tm and average rotational speed N_{av} when the motor is operated repeatedly in the drive pattern shown to the right.

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

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



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

- **Calculation example 2**

The calculation method is explained below using HMAC08 as an example.
Operating conditions: Accelerate an inertia load and then let it move at a constant speed, followed by deceleration, based on conditions similar to those used in calculation example 1. The travel angle per cycle is 3,600° and the cycle time is 0.8 seconds.

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

$\theta = (N / 60) \times \{t_r + (t_a + t_d) / 2\} \times 360$

Accordingly, tr = θ/ (6 x N) – (ta + td) / 2

When θ = 3,600° and ta = 0.099 (s), td = 0.080 (s), N = 4,800 (r/min) in calculation example 1, are applied to this formula, tr is calculated as 0.035 (s).

(2) Next, calculate the torque during acceleration and torque during deceleration. Based on the acceleration/deceleration time formulas in the preceding section, the relational expressions for torque during acceleration and torque during deceleration if k = 1 are as follows:

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

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

When the values in calculation example 1 are applied to this formula, T_a = 1.38 (Nm) and T_d = 1.29 (Nm) are obtained.

(3) Calculate the effective torque. Apply the values in (1) and (2), T_r = 0 (Nm), and t = 0.8 (s) to the above formulas.

$$T_m = \sqrt{\frac{1.38^2 \times 0.099 + 0^2 \times 0.035 + 1.29^2 \times 0.080}{0.8}} = 0.64 \text{Nm}$$

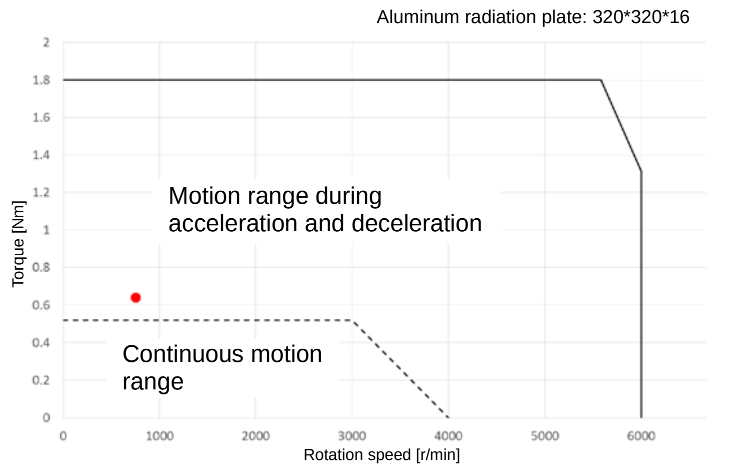
(4) Calculate the average rotational speed. Apply the values in (1), N = 4,800 (r/min), and t = 0.8 (s) to the above formulas.

$$N_{av} = \frac{4,800/2 \times 0.099 + 4,800 \times 0.035 + 4,800/2 \times 0.080}{0.8} = 750 \text{ r/min}$$

(5) The figure on the right shows the points of operation determined by the effective torque and average rotational speed calculated above, plotted on the graph of operable range of HMAC08, exceeding the continuous motion range. The conclusion is that this motor cannot be operated continuously under these conditions. Accordingly,

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

etc., must be reevaluated.



Operable range of HMAC08

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

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

Apply the following: T_a = 1.38 Nm, T_r= 0 Nm, T_d = 1.29 Nm, T_m = 0.52 Nm, t_a = 0.099 s, t_r= 0.035 s, t_d = 0.080 s. Then, the following equation is obtained:

$t = (1.38^2 \text{ x } 0.099 + 1.29^2 \text{ x } 0.080)/ 0.52^2 = 1.19$ s

Based on the result, setting the cycle time to 1.2 seconds or more to provide a longer stop time gives T_m = 0.52 Nm or less, thereby permitting continuous operation within the rated torque.

Caution

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

Chapter 3

Installing the HMA motor

This chapter explains how to install the motor.

3-1 Receiving inspection

Check the following items after unpacking the box.

Inspection procedure

1 Check the items thoroughly for damage sustained during transportation.

If any item is damaged, immediately contact the dealer.

2 Check if the motor is what you ordered.

The nameplate is found on the end face or the side of the HMA series motor. Check the TYPE field on the nameplate to confirm that it is the model you have ordered. If any item is different from what you ordered, immediately contact the dealer.
Refer to section [1-2 Model] (P1-2) in this manual for details of the model codes.

3 Check if the driver combinations are correct.

The compatible HMA series motor models are shown in the ADJUSTED FOR USE WITH field of the nameplate on the HA-800 driver.

4 Check if the driver input voltages being input are correct.

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

100: Single-phase 100 V power supply
200: 3-phase/single-phase 200 VAC power supply

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

WARNING

Do not combine the driver with a motor that is not specified on the name plate.
The characteristics of the driver have been adjusted according to the motor. Wrong combinations of drivers and motors may cause insufficient torque or overcurrent that may cause motor burnout, injury or fire.

Do not connect a power supply with a voltage that is not specified on the driver's nameplate.
Connecting a power supply with an input voltage that is not specified on the nameplate may result in damage to the driver, injury or fire.

3-2 Notices on handling

Practice caution and observe the following notices when handling HMA series motors.

CAUTION

(1) Do not apply any excessive force or impact, especially to the motor's output shaft.

(2) Do not place HMA series motors on a table, shelf, etc., where the motor could easily fall.

(3) Do not connect the motor terminals directly to the power supply. The motor may burn out and cause a fire or electric shock.

(4) The allowable storage temperature is -20 to +60°C. Do not expose the motor to direct sunlight for long periods of time or store it in areas at low or high temperatures.

(5) The allowable relative storage humidity is 80% or less. In particular, do not store the motor in a very humid place or in areas where there are large temperature changes between day and night.

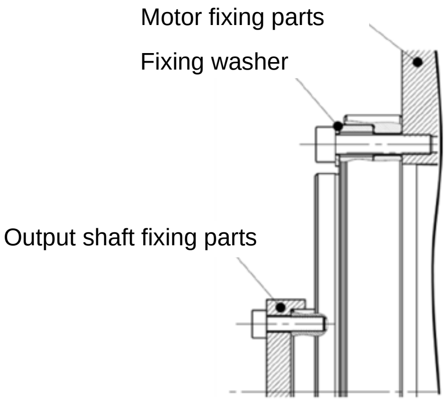
(6) Do not use or store the motor in locations subject to flammable or corrosive gases or dust particles.

(7) The large model (HMAA21A) is heavy. Handling these models may cause lower back pain, or injury if the motor drops or topples and you are pinned underneath. Handle your motor with due care by wearing safety shoes, take other proper precautions, and also use supporting jigs.

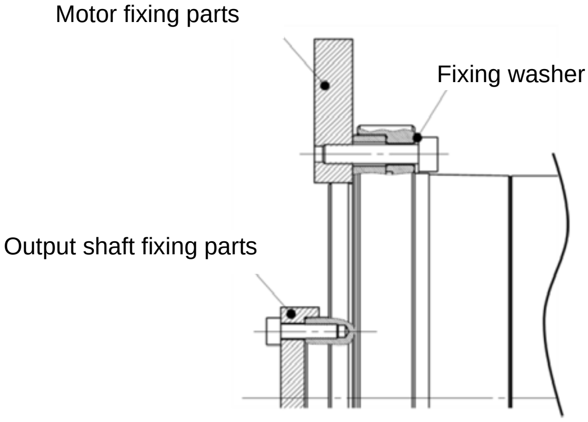
Installation and transmission torque

Examples of motor assembly are shown below. Use high-tension bolts and tighten them with a torque wrench to control the tightening torque. Use flat washers because the tightening torque is high and the motor flange is made of aluminum.

Motor assembly example



Assembly example 1



Assembly example 2

- Recommended tightening torque and transmission torque

Item \ Model		HMAC08 Output shaft	HMAC08 motor	HMAB09 Output shaft	HMAB09 motor	HMAB12 Output shaft	HMAB12 motor
Number of bolts, size		4-M3	6-M3	4-M3	6-M4	4-M3	6-M5
Bolt installation P.C.D.	mm	22	84	28	102	36	132
Tightening torque	Nm	2.0	2.0	2.0	4.5	2.0	9.0
	kgf·m	0.20	0.20	0.20	0.46	0.20	0.92
Transmission torque	Nm	18	103	23	215	30	446
	kgf·m	1.8	10.5	2.4	22.0	3.1	45.5

Item \ Model		HMAB15 Output shaft	HMAB15 Motor	HMAA21A Output shaft	HMAA21A Motor
Number of bolts, size		4-M4	6-M6	4-M5	8-M8
Bolt installation P.C.D.	mm	50	158	74	226
Tightening torque	Nm	4.5	15.3	9.0	37.0
	kgf·m	0.46	1.56	0.92	3.8
Transmission torque	Nm	70	755	167	2,630
	kgf·m	7.2	77.1	17.0	268.2

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

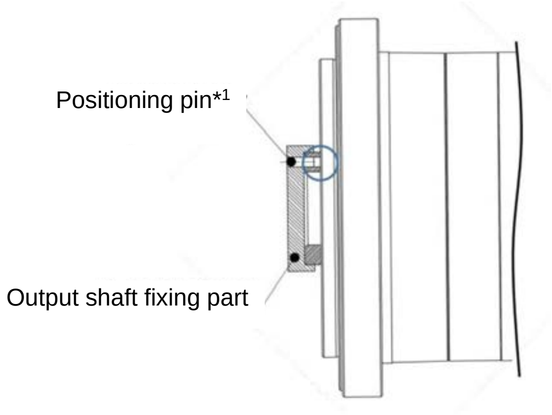
Precautions on installation

When designing the assembly, note that application of any abnormal or excessive force that causes deformation of the installation surface may result in performance drop. To deliver optimal performance of the HMA series motors, pay attention to the following points:

- Warping and deformation on the mounting surface
- Blockage caused by foreign matter
- Burrs, rising and abnormal position accuracy around tapped mounting holes
- Insufficient chamfering of mounting faucet joint
- Abnormal circularity of mounting faucet joint

Use of positioning pins

The HMA series motors have positioning pin holes in the output shaft. Use these pin holes as necessary. For details, refer to [1-6 External dimensions] (P1-7) or the illustrated specifications.



Example of use of positioning pins

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

Motor shaft material

The HMA series motors use the following materials, however, they are not completely rust-proof.

Location	Material
Housing	No treatment (aluminum material is exposed)
Hollow shaft (output shaft)	SUS
Bolt	Chrome plating

3-3 Location and installation

Environment of location

The environmental conditions of the installation location for HMA series motors are as follows. Always observe these conditions to determine an appropriate installation location.

◆ Operating temperature: 0 to 40℃
The temperature in the cabinet may be higher than the atmosphere depending on the power loss of housed devices and size of the cabinet. Plan the cabinet size, cooling system, and device locations so the ambient temperature of the motor is kept 40℃ or below.

◆ Operating humidity: Relative humidity of 20 to 80%. Make sure no condensation occurs.
Take note that condensation is likely to occur in a place where there is a large temperature change between day and night or when the motor is started/stopped frequently.

◆ Vibration: 25 m/s^2 (10 to 400Hz) or less (Refer to [1-11 Resistance to vibration] (P1-16))

◆ Impact: 300 m/s^2 or less (Refer to [1-10 Shock resistance] (P1-15))

◆ Use environment: Free from condensation, metal powder, corrosive gases, water, oil mist, flammable gases, etc.

◆ Protection class: Standard products are structurally designed to meet the IP-54 requirements.

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

The protection class against contact and entry of foreign matter is as follows:
5: Protected against entry of dust/dirt. Entry of foreign matter caused by incomplete protection must not affect the operation of the system.

However, rotating and sliding areas (oil seal areas, all models) and connectors (HMAC08, HMAB09, HMAB12, HMAB15) are not IP-54-compliant. Connectors of HMAA21A are warrantied as installed.

◆ Use the motor indoors or within an enclosure. Do not expose it to direct sunlight.

◆ Altitude: less than1,000 m above sea level

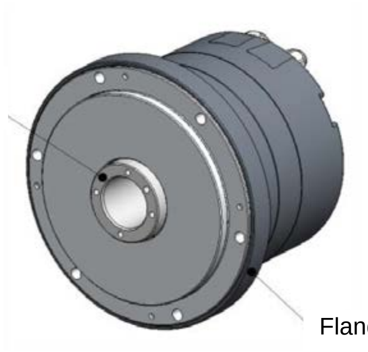
Installation

When installing an HMA series motor, ensure that it is installed accurately and do not tap with a hammer, etc. The motor houses an encoder. Excessive impact may damage the encoder.

Installation procedure

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

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



2 Connect the driver and wiring.

An extension cable is provided. Use it when wiring the driver. For details on wiring, refer to [1-13 Cable specifications] (P1-20) and the manual of your HA-800 driver.

3 Wire the motor cable and encoder cable.

Do not pull the cables with a strong force. Doing so may damage the connectors. Install the cable with slack and do not to apply any tension to the motor. Provide a sufficient bending radius (at least six times the cable diameter), especially when the cable flexes.

Caution

- Do not bring strong magnetic bodies (magnet chucks, permanent magnets, etc.) near the rear cover of the motor. Encoder abnormality may result.
- This encoder retains absolute positions when the power is turned OFF by means of the driver's battery or its own built-in capacitor. If the encoder cable is disconnected for maintenance, etc., turn ON the driver power and charge the backup capacitor first. After 3 hours of charge, the encoder cable can be disconnected for 30 minutes, provided that the axis is stopped and ambient temperature is 25℃. However, when the backup capacitor is deteriorated, the absolute positions may not be retained.

WARNING

Do not disassemble/reassemble the motor.

The motor uses many precision parts. If the motor is disassembled/reassembled by the customer, it may cause motor burnout or uncontrollable operation, resulting in a fire or injury.

3 Installing the HMA motor

Chapter 4

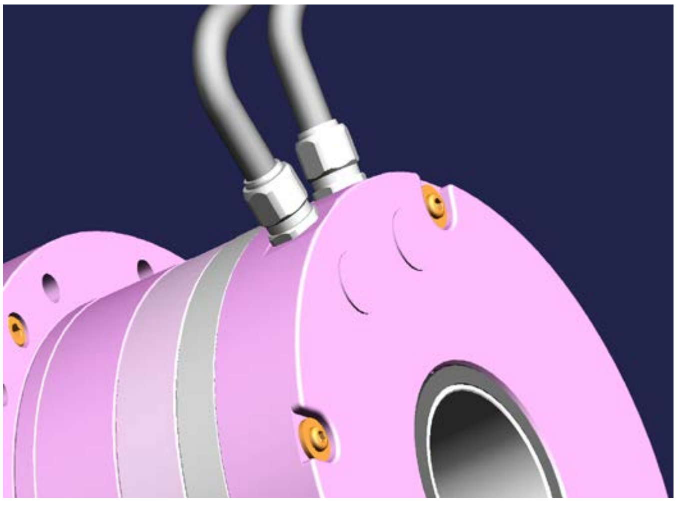
Options

This chapter provides information on the options.

4-1 Options

Cable taken out from side face (option code: Y)

The cables (motor and encoder wires) are taken out from the side face of the motor.
Use this option if the motor is housed in a system and there is not enough space at the rear of the housing.
Please contact us for model No. 08. This option is not available for size 21A.
For details on the option where cables can be taken out from the side, contact our sales office.



Extension cables

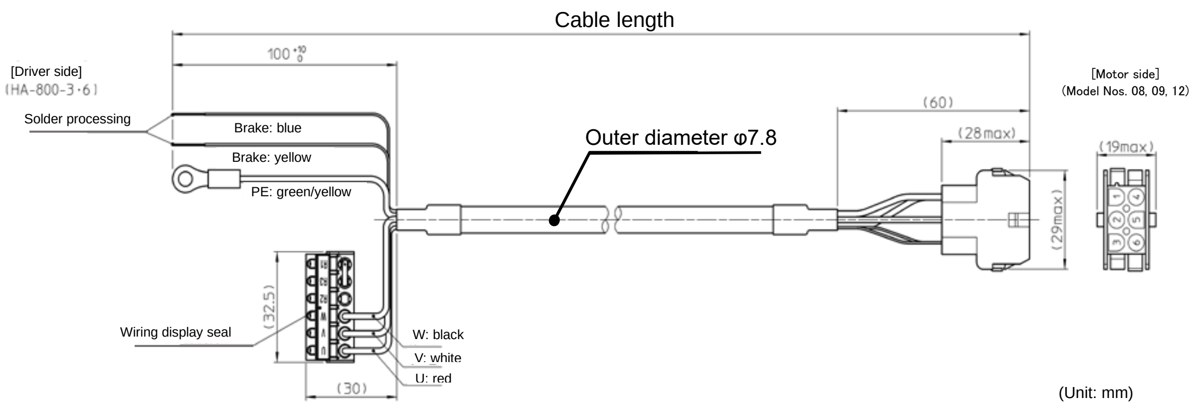
These extension cables are used to connect the HMA series motors and HA-800 drivers.
Two types of extension cables are available for motors (including brake wire) and absolute encoders.
You must use an extension cable to connect your HMA series motor and HA-800 driver.

For motors

- **Motor model Nos. 08, 09, 12**

EWD-MB**−A06-TN3

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

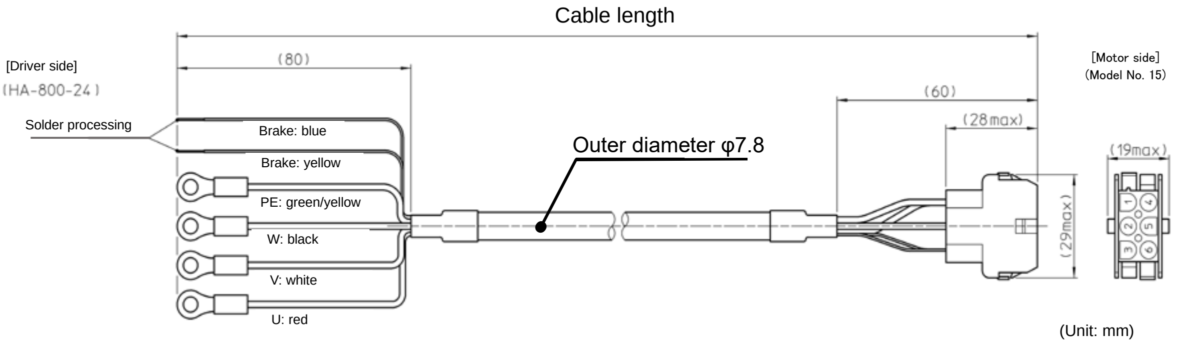


(Unit: mm)

- **Motor model No. 15**

EWD-MB**-A06-TMC

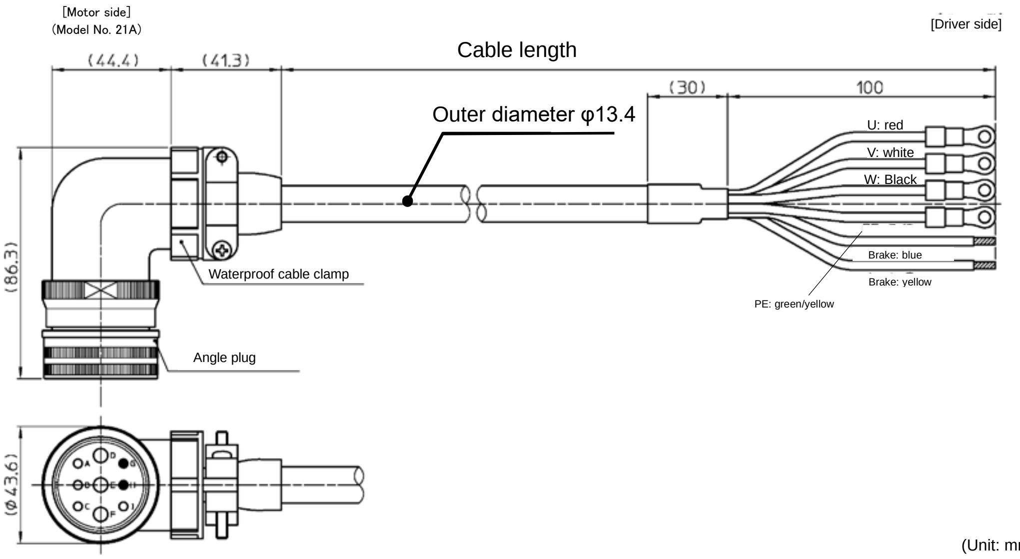
Cable length (03 = 3m, 05 = 5m, 10 = 10m)



(Unit: mm)

- **Motor model No. 21A**
EWD-MB**-D09-TMC

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



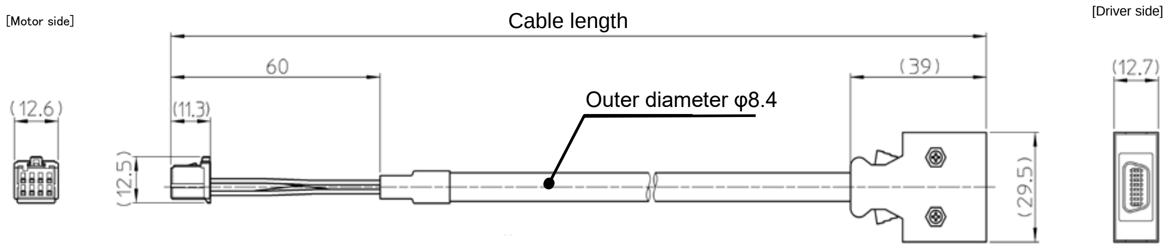
(Unit: mm)

For absolute encoder

- **Motor model Nos. 08, 09, 12, 15**

EWD-S**-A08-3M14

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

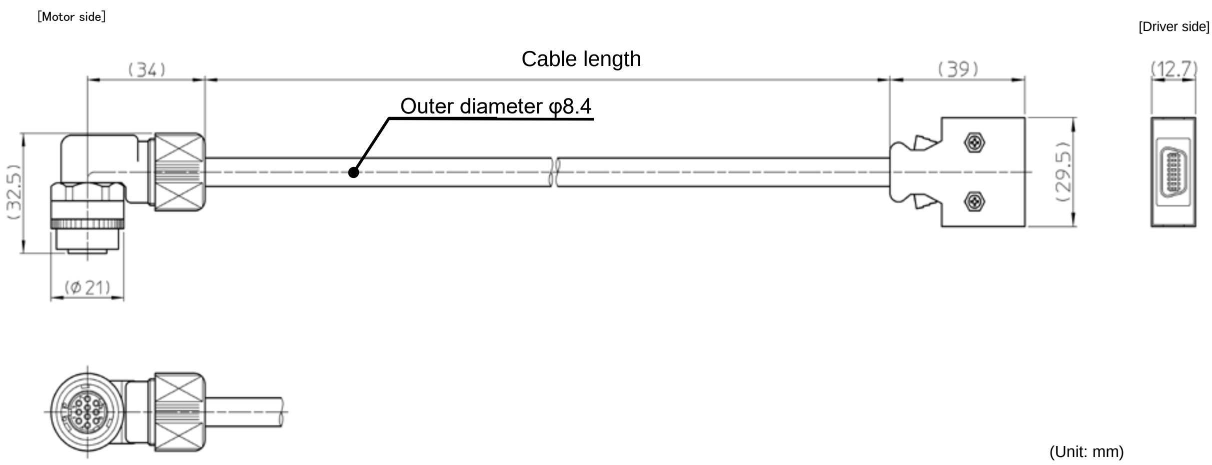


(Unit: mm)

- **Motor model No. 21A**

EWD-S**-D10-3M14

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



(Unit: mm)

Appendix

A-1 Unit conversion

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

(1) Length

SI system	m	
Unit	ft.	in.
Factor	3.281	39.37

Unit	ft.	in.
Factor	0.3048	0.0254
SI system	m	

(2) Linear speed

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

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

(3) Linear acceleration

SI system	m/s^2			
Unit	m/min^2	$ft./min^2$	$ft./s^2$	in/s^2
Factor	3,600	1.18×10^4	3.281	39.37

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

(4) Force

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

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

(5) Mass

SI system	kg	
Unit	lb.	oz.
Factor	2.205	35.27

Unit	lb.	oz.
Factor	0.4535	0.02835
SI system	kg	

(6) Angle

SI system	rad		
Unit	Degree	Minute	Sec.
Factor	57.3	3.44×10^3	2.06×10^5

Unit	Degree	Minute	Sec.
Factor	0.01755	2.93×10^{-4}	4.88×10^{-6}
SI system	rad		

(7) Angular speed

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

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

(8) Angular acceleration

SI system	rad/s^2	
↓		
Unit	deg/s^2	deg/min^2
Factor	57.3	3.44 x 10^3

Unit	deg/s^2	deg/min^2
Factor	0.01755	2.93 x 10^{-4}
↓		
SI system	rad/s^2	

(9) Torque

SI system	N·m			
↓				
Unit	kgf·m	lb·ft	lb·in	oz·in
Factor	0.102	0.738	8.85	141.6

Unit	kgf·m	lb·ft	lb·in	oz·in
Factor	9.81	1.356	0.1130	7.06 x 10^{-3}
↓				
SI system	N·m			

(10) Inertia moment

SI system	kg·m^2							
↓								
Unit	kgf·m·s^2	kgf·cm·s^2	lb·ft^2	lb·ft·s^2	lb·in^2	lb·in·s^2	oz·in^2	oz·in·s^2
Factor	0.102	10.2	23.73	0.7376	3.42 x 10^3	8.85	5.47 x 10^4	141.6

Unit	kgf·m·s^2	kgf·cm·s^2	lb·ft^2	lb·ft·s^2	lb·in^2	lb·in·s^2	oz·in^2	oz·in·s^2
Factor	9.81	0.0981	0.0421	1.356	2.93 x 10^{-4}	0.113	1.829 x 10^{-5}	7.06 x 10^{-3}
↓								
SI system	kg·m^2							

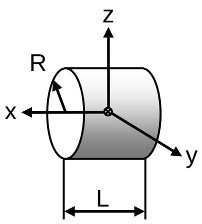
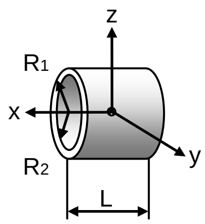
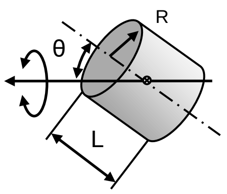
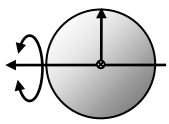
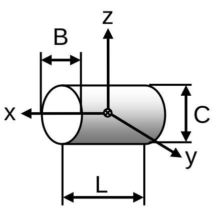
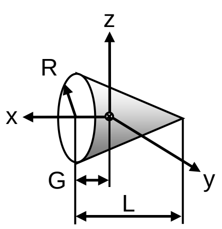
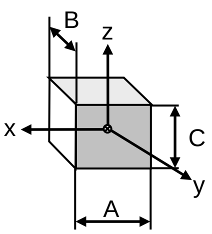
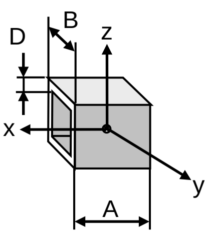
A -2 Calculating inertia moment

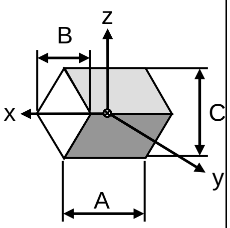
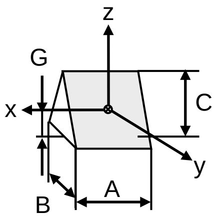
Formulas of mass and inertia moment

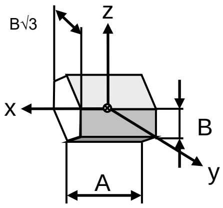
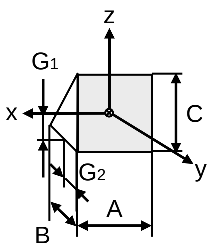
(1) The center of rotation matches the centroidal line

The following table includes formulas to calculate mass and inertia moment.
m: Mass (kg), Ix, Iy, Iz: inertia moments which rotate around x-, y-, z-axes respectively (kg･m^2)
G: Distance from the end face to the center of gravity (m)
ρ: Specific gravity (g/cm^3)

Units　Length: m, Mass: kg, Inertia moment: kg･m^2

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

Object form	Mass, inertia, gravity center
Rhombus pillar 	$m=\frac{1}{2}ABC\rho\times10^3$ $Ix=\frac{1}{24}m\left(B^2+C^2\right)$ $Iy=\frac{1}{24}m\left(C^2+2A^2\right)$ $Iz=\frac{1}{24}m\left(B^2+2A^2\right)$
Isosceles triangle pillar 	$m=\frac{1}{2}ABC\rho\times10^3$ $Ix=\frac{1}{12}m\left(\frac{B^2}{2}+\frac{2}{3}C^2\right)$ $Iy=\frac{1}{12}m\left(A^2+\frac{2}{3}C^2\right)$ $Iz=\frac{1}{12}m\left(A^2+\frac{B^2}{2}\right)$ $G=\frac{C}{3}$

Object form	Mass, inertia, gravity center
Hexagonal pillar 	$m=\frac{3\sqrt{3}}{2}AB^2\rho\times10^3$ $Ix=\frac{5}{12}mB^2$ $Iy=\frac{1}{12}m\left(A^2+\frac{5}{2}B^2\right)$ $Iz=\frac{1}{12}m\left(A^2+\frac{5}{2}B^2\right)$
Right triangle pillar 	$m=\frac{1}{2}ABC\rho\times10^3$ $Ix=\frac{1}{36}m\left(B^2+C^2\right)$ $Iy=\frac{1}{12}m\left(A^2+\frac{2}{3}C^2\right)$ $Iz=\frac{1}{12}m\left(A^2+\frac{2}{3}B^2\right)$ $G_1=\frac{C}{3}$ $G_2=\frac{B}{3}$

Appe

Appendix

- **Example of specific gravity**

The following tables show reference values for specific gravity. Check the specific gravity for each material.

Material	Specific gravity
SUS304	7.93 [g/cm^3]
S45C	7.86 [g/cm^3]
SS400	7.85 [g/cm^3]
Cast iron	7.19 [g/cm^3]
Copper	8.92 [g/cm^3]
Brass	8.50 [g/cm^3]

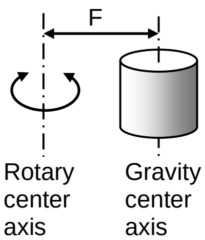
Material	Specific gravity
Aluminum	2.70 [g/cm^3]
Duralumin	2.80 [g/cm^3]
Silicon	2.30 [g/cm^3]
Quartz glass	2.20 [g/cm^3]
Teflon	2.20 [g/cm^3]
Fluorocarbon resin	2.20 [g/cm^3]

Material	Specific gravity
Epoxy resin	1.90 [g/cm^3]
ABS	1.10 [g/cm^3]
Silicon resin	1.80 [g/cm^3]
Polyurethane rubber	1.25 [g/cm^3]

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

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

$$I=Ig+mF^2$$



I: Inertia moment when the gravity center axis does not match the rotational axis (kg・m^2)
I_g: Inertia moment when the gravity center axis matches the rotational axis (kg・m^2)
Calculate according to the shape by using formula (1).
m: mass (kg)
F: Distance between rotary center and gravity center (m)

(3) Inertia moment of linear operation objects

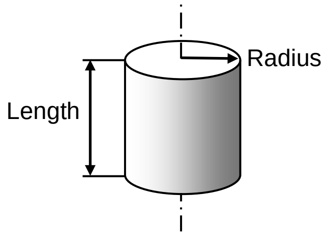
The inertia moment, converted to output shaft, of a linear motion object driven by a screw, etc., is calculated using the formula below.

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

I: Inertia moment of a linear operation object converted to motor axis (kg・m^2)
m: mass (kg)
P: Linear travel per motor one revolution (m/rev)

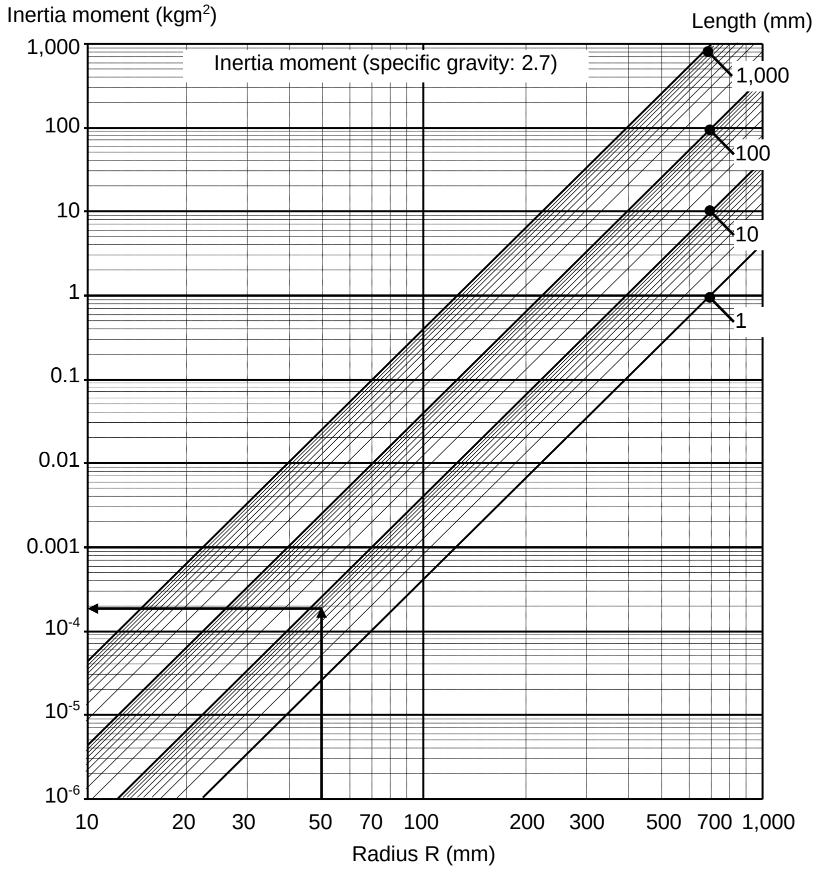
Inertia moment of cylinder

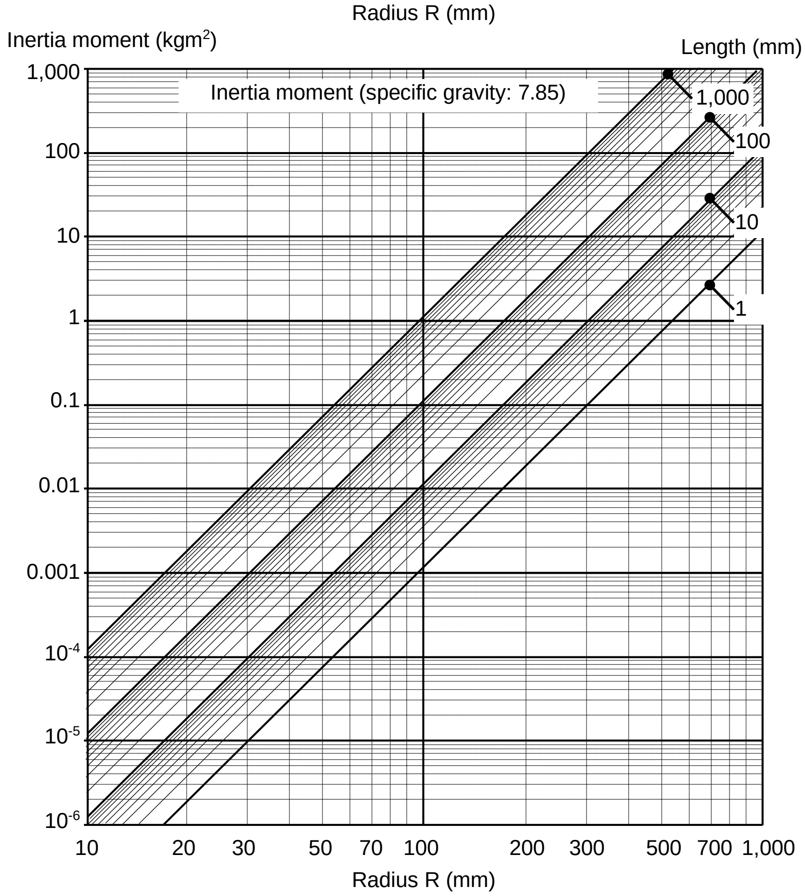
The inertia moment of a cylinder can be obtained from the graphs to the right.



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

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





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Warranty Period and Terms

The equipment listed in this document is warranted as follows:

■Warranty period

Under the condition that the motor is 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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Certified to ISO14001／ISO9001 (TÜV SÜD Management Service GmbH)

All specifications and dimensions in this manual subject to change without notice.

This manual is correct as of October 2018.

http://www.hds.co.jp/english/

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