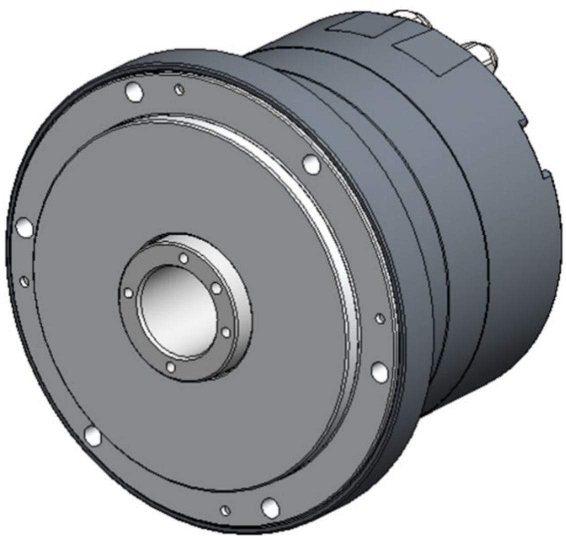
HarmonicDrive®

MECHATRONICS

Flat Hollow Shaft AC Servo Motors
compatible with Panasonic Corporation
MINAS A6 series

PMA series manual



ISO14001
ISO9001

Introduction

Thank you for purchasing our PMA 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.
Company names and product names in this document are generally registered trademarks or trademarks of their respective companies.
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 servo amplifier 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 SERVO AMPLIFIER

- **Read the related manuals to ensure safe operation. For details on the related manuals, refer to the [Related manual] (P6).**

- **Before usage, ensure you read the "Safety Guide AC Servo Motor & Amplifier MINAS A6 Series" operation manual.**
  Please download the operation manual from the Panasonic Corporation website.
  http://industrial.panasonic.com/jp/products/motors-compressors/fa-motors

- **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 15 minutes after turning OFF the power supply.

- Even after the power supply is turned OFF, electric charge remains in the servo amplifier. In order to prevent electric shock, perform inspections 15 minutes or more after the power supply is turned OFF.
- When installing, make sure that the inner electronic components are hard to reach.

DISPOSAL

CAUTION

The motor and servo amplifier must be disposed of as industrial waste.
When disposing of the motor or servo amplifier, 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 motor

Chapter 4 Options

Appendix

Related manual

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

Title	Document No.	Description	Obtaining method
Modbus communication and Block operation Specification	No.SX-DSV03033	MINAS A6/A6L Modbus communication specifications and block operation function specifications are explained.	Can be downloaded from the Panasonic Corporation website.
Functional Specification	No.SX-DSV02910	Servo amplifier MINAS A6 series functions are explained.	
Realtime Express（RTEX） Functional Specification	No.SX-DSV03027	Servo amplifier MINAS A6N series functions are explained.	
Realtime Express（RTEX） Communication Specification	No.SX-DSV03028	The specifications of the network interface "Realtime Express" RTEX, which connects the servo amplifier MINAS A6N series to the host device, are explained.	
EtherCAT Functional Specification	No.SX-DSV03215	Servo amplifier MINAS A6B series functions are explained.	
EtherCAT Communication Specification	No.SX-DSV03216	The specifications of the network interface EtherCAT, which connects the servo amplifier MINAS A6B series (slave) to the host device (master), are explained.	

Conformance to overseas standards

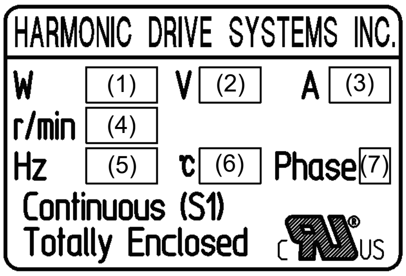
The PMA series motors are compliant with the following overseas standards.

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

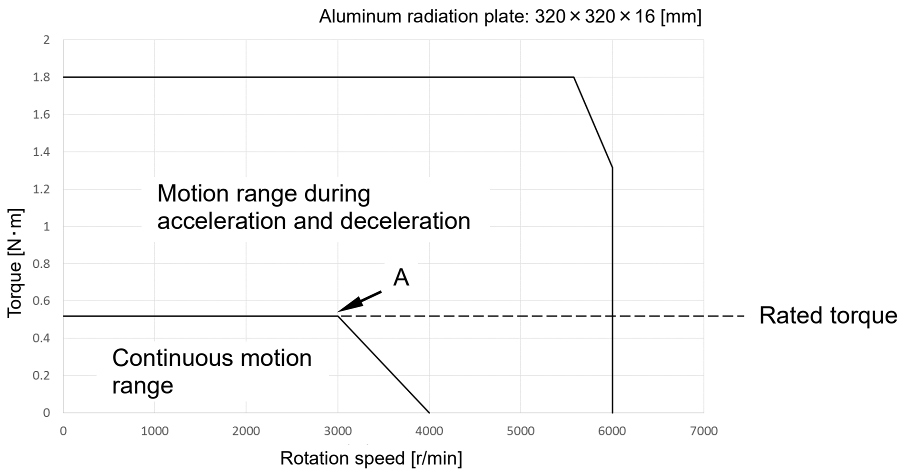
UL nameplate sticker

According to the UL1004-1, UL1004-6 (File No. E243316) standards, the following specifications are indicated on the PMA 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		PMAC08
(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	r/min	3000
(5) Frequency at point A	Hz	250
(6) Allowable ambient temperature	℃	40
(7) Number of phases	-	3

Item \ Model		PMAB09
(1) Output at point A	W	251
(2) Voltage at point A	V	136
(3) Allowable continuous current	A	2.5
(4) Speed at point A	r/min	3000
(5) Frequency at point A	Hz	250
(6) Allowable ambient temperature	℃	40
(7) Number of phases	-	3

Item \ Model		PMAB12
(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	r/min	2500
(5) Frequency at point A	Hz	208
(6) Allowable ambient temperature	℃	40
(7) Number of phases	-	3

Item \ Model		PMAB15
(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	r/min	2000
(5) Frequency at point A	Hz	167
(6) Allowable ambient temperature	℃	40
(7) Number of phases	-	3

Item \ Model		PMAA21A
(1) Output at point A	W	1320
(2) Voltage at point A	V	100
(3) Allowable continuous current	A	20.0
(4) Speed at point A	r/min	1000
(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 PMA series AC servo motor models feature a hollow bore structure and compact design, and they can be controlled by Modbus, RTEX, or EtherCAT when combined with the Panasonic AC servo amplifier MINAS A6 series. Wires, pipes, ball screws, or laser beams go through the hollow bore depending on the mechanism design required for your applications.
PMA 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 PMA series AC servo motors are equipped with a highly reliable 17-bit magnetic absolute encoder* with safety function. The serial communication requires fewer cables.
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.
* Model No. 08 is equipped with an optical encoder.

◆ Supporting a combination with MINAS A6 amplifiers

Combination with Pnasonic MINAS A6 / A6N / A6B amplifiers is now available. It can be controlled using the RTEX or EtherCAT high-speed motion network.

1-2 Combinations with servo amplifier and extension cables

The combinations of PMA motors, MINAS A6 servo amplifiers, and extension cables are as follows:

Motor model		PMAC08	PMAB09	PMAB12	PMAB15	PMAA21A
Servo amplifier model	A6 I/O communication compatible	MBDL□25■	MCDL□35■	MDDL□55■	MEDL□83■	MFDL□B3■
	A6N RTEX compatible	MBDL□25■	MCDL□35■	MDDL□55■	MEDL□83■	MFDL□B3■
	A6B EtherCAT compatible	MBDL□25■	MCDL□35■	MDDL□55■	MEDL□83■	MFDL□B3■
Extension cables (option)	Motor wire	EWD-MB**-A06-TN-P				EWD-MB**-D09 -TMC-P
	Encoder wire	MFECA0◇◇0EAE (With battery box)				MFECA0◇◇ 0ETE (With battery box)

"□" and "■" in the servo amplifier model are the function classifications for safety functions and interface specifications. See below for details.

	Symbol	Specification
□	N	Without safety function
	T	With safety function

	Symbol	Interface specification	Function classification
■	SE	Analog/Pulse	Position control type
	SG		General purpose communication type
	SF		Multi-function type
	NE	RTEX	Standard type
	NF		Multi-function type
	BE	EtherCAT	Standard type
	BF		Multi-function type

** and ◇◇ in the extension cable model indicate the cable length. See below for details.

Motor wire : 03 = 3 m, 05 = 5 m, 10 = 10 m, 20 = 20 m
Encoder wire : 03 = 3 m, 05 = 5 m, 10 = 10 m, 20 = 20 m

For details on encoder wires, contact Panasonic Corporation customer support.

1-3 Model

The model names for the PMA series motors and how to read the symbols are explained below.
Model example:

PMA	B	09	A	200	−	14	S	17b	B	−	C	Y	−	A6	−	SP
(1)	(2)	(3)	(4)	(5)	−	(6)	(7)	(8)	(9)	−	(10)	(11)	−	(12)	−	(13)

(1) Model: PMA series AC servo motor

(2) Motor version symbol

A	Model No. 21A
B	Model Nos. 09, 12, 15
C	Model No. 08

(3) Model Nos.: 08, 09, 12, 15, 21A

(4) Brake

A	Without brake
B	With brake

(5) Applicable servo amplifier input voltage

200	200 V

(6) Encoder format

14	MINAS-supported format compliant, transmission rate: 2.5 Mbps, 1-on-1 connection, with backup capacitor
34	MINAS-supported format compliant, transmission rate: 2.5 Mbps, 1-on-1 connection, without backup capacitor

(7) Encoder type

S	Multi-turn absolute type

(8) Encoder resolution

17b	17 bit (131072 pulses/revolution)

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

B	30 degree

(10) Connector specification

C	With standard connector
N	Without connector

(11) Option symbol

Y	Cable taken out from the side

(It is not available for model Nos. 08, 21A.)

(12) Combined amplifier symbol

A6	MINAS A6 series

(13) Special specification

No description	Standard product
SP	Special specification product

1-4 Specifications

The specifications of the PMA series motors are shown below.

Item		Model: PMAC08	PMAB09	PMAB12	PMAB15	PMAA21A
Combined servo amplifier	A6 (I/O communication compatible)	MBDL□25■	MCDL□35■	MDDL□55■	MEDL□83■	MFDL□B3■
	A6N (RTEX compatible)	MBDL□25■	MCDL□35■	MDDL□55■	MEDL□83■	MFDL□B3■
	A6B (EtherCAT compatible)	MBDL□25■	MCDL□35■	MDDL□55■	MEDL□83■	MFDL□B3■
Drive input voltage *1	V	200	200	200	200	200
Rated output *2*3	W	163	251	406	754	1320
Maximum momentary torque *2	N·m	1.8	3.0	7.0	13	45
	kgf·m	0.18	0.31	0.71	1.33	4.59
Rated torque *2*3	N·m	0.52	0.8	1.55	3.6	12.6
	kgf·m	0.053	0.082	0.158	0.367	1.29
Max. rotational speed *2	r/min	6000	5600	4800	4000	3000
Rated rotational speed	r/min	3000	3000	2500	2000	1000
Instantaneous max. current *2	A	6.5	8.9	19	29	75
Rated current *2*3	A	2.1	2.5	4.2	7.8	20
Torque constant *2	N·m/A	0.35	0.41	0.44	0.54	0.72
	kgf·m/A	0.036	0.042	0.045	0.055	0.073
EMF constant *4	V/(r/min)	0.037	0.043	0.046	0.057	0.075
Phase resistance (20 ℃)	Ω	1.43	1.2	0.33	0.19	0.028
Phase inductance	mH	2.5	3	1.4	1.2	0.29
Inertia moment Values in parentheses are for models with a brake.	$GD^2/4$ $\times 10^{-4}$ 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)	1280 (1444)
Allowable radial load (when stationary)	N	800	800	1200	2400	4500
	kgf	81.6	81.6	122	245	459
Allowable axial load (when stationary)	N	1900	2400	3600	5000	14000
	kgf	194	245	367	510	1429
Rated radial load (at rated rotational speed)	N	175	185	233	530	1040
	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} (131072)				
	Multi-turn detector *5	2^{16} (65536)				
Mass Values in parentheses are for models with a brake.	kg	1.4 (1.5)	2 (2.1)	3.4 (3.8)	5.5 (6.2)	17.5 (19.7)

Environmental conditions[*7]	Operating temperature: 0 to 40 ℃/Storage temperature: -20 to 60 ℃ Service/storage humidity: 20 to 80 % RH (no condensation) Resistance to vibration: 25 m/s^2 (frequency: 10 to 400 Hz) Resistance to impact: 300 m/s^2 [*6] No dust, metal powder, corrosive gas, inflammable gas, or oil mist. To be used indoors, no direct sunlight. Altitude: less than 1000 m above sea level
Motor insulation	Insulation resistance: 100 MΩ or more (500 VDC insulation tester) Dielectric strength: 1500 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: Single-phase 200 VAC is compatible with PMAC08, PMAB09, and PMAB12. (Specifications are the same as in the table above)

*2: This displays representative characteristics for when combined with a dedicated amplifier (driven using an ideal sine wave).

*3: Values after the temperature has risen and saturated when installed on the following aluminum radiation plates.

PMAC08 : 320×320×16 [mm]
PMAB09 : 350×350×18 [mm]
PMAB12 : 400×400×20 [mm]
PMAB15 : 500×500×25 [mm]
PMAA21A : 600×600×30 [mm]

*4: Value of the phase-induced voltage constant multiplied by 3.

*5: The multi-turn detector range is -32768 to 32767.

*6: For testing conditions, refer to [1-10 Shock resistance] (P1-16) and [1-11 Resistance to vibration] (P1-17). Motor operation is not guaranteed in applications where vibrations and impacts are continuously applied for a long period of time.

*7: For details, refer to [3-3 Location and installation] (P3-5).

1-5 Holding brake

The brakes equipped on PMA series motors are used to hold the motor shaft in place when the power is cut off. With some models (PMAB09, 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		PMAC08	PMAB09	PMAB12	PMAB15	PMAA21A
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	**N·m**	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		100000 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 24 VDC ± 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 3000 r/min, provided that the inertia moment of load is 3 times or less than that of the motor.
*5: Motor with holding brake may generate mechanical noise from the brake rotating body during acceleration/stopping/low speed driving, but it does not affect the performance or functionality.

WARNING

The holding brake cannot be used for deceleration.
Do not use the holding brake more than the allowable number of normal brakings (100000 times at the rotational speed of 150 r/min or less) or allowable number of emergency stops (200 times at the rotational speed of 3000 r/min, provided that the inertia moment of load is 3 times or less than that of the motor).

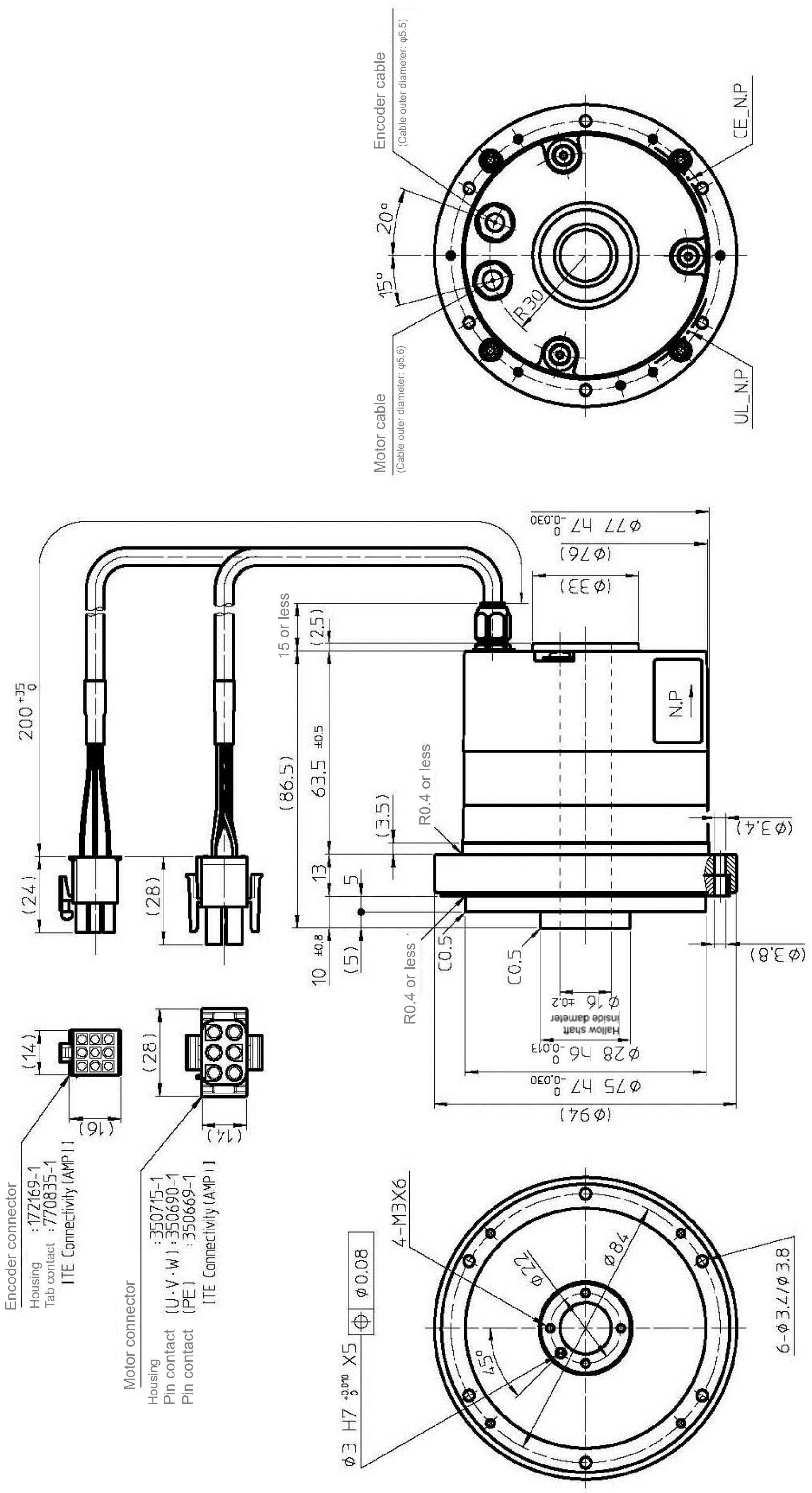
Exceeding the allowable number of normal brakings and allowable number of emergency stops may cause the holding torque to decrease and consequently become unusable as a brake.

1-6 External dimensions

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

- **PMAC08 (with/without brake)**

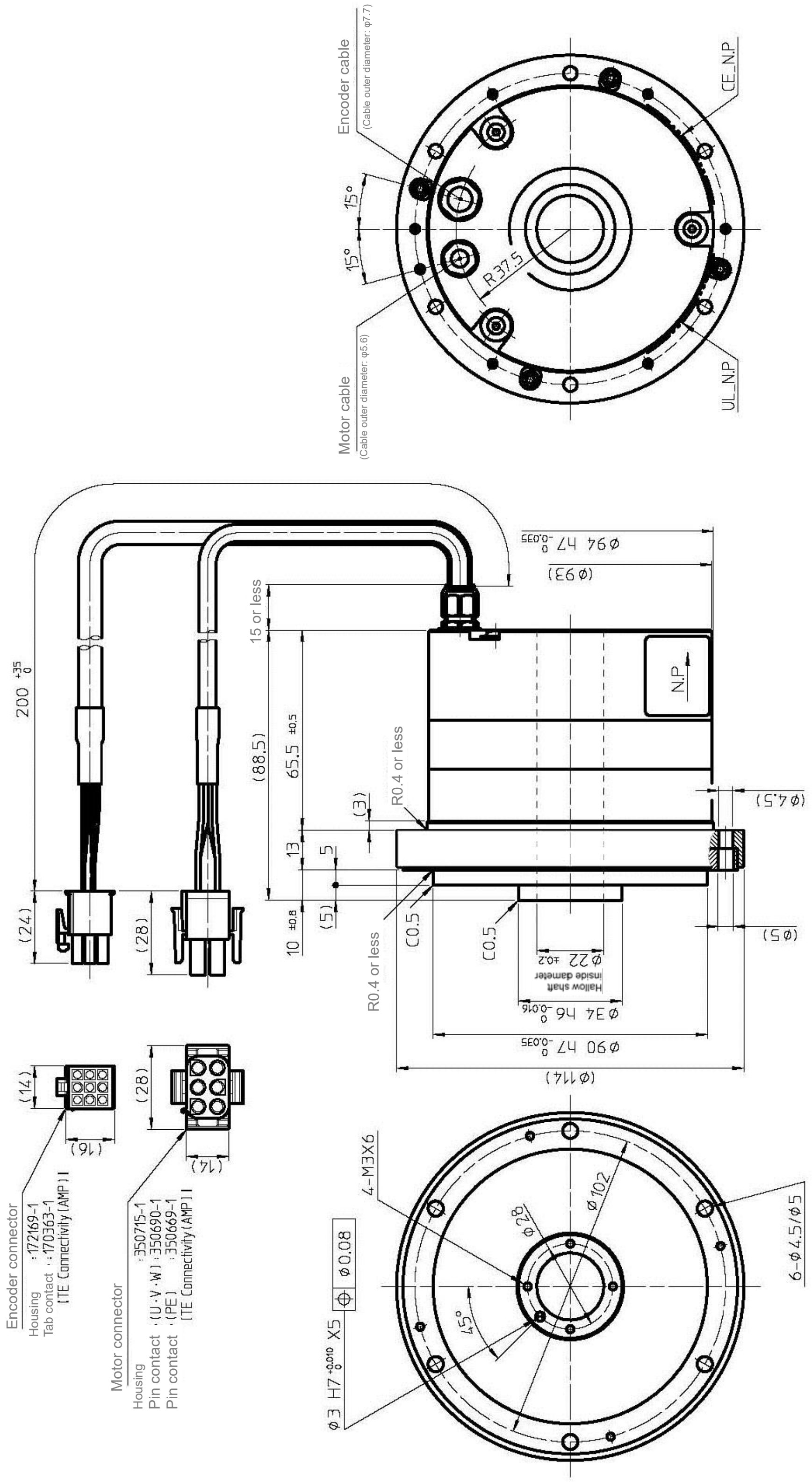
Unit [mm] (third angle projection)



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.

- **PMAB09 (with/without brake)**

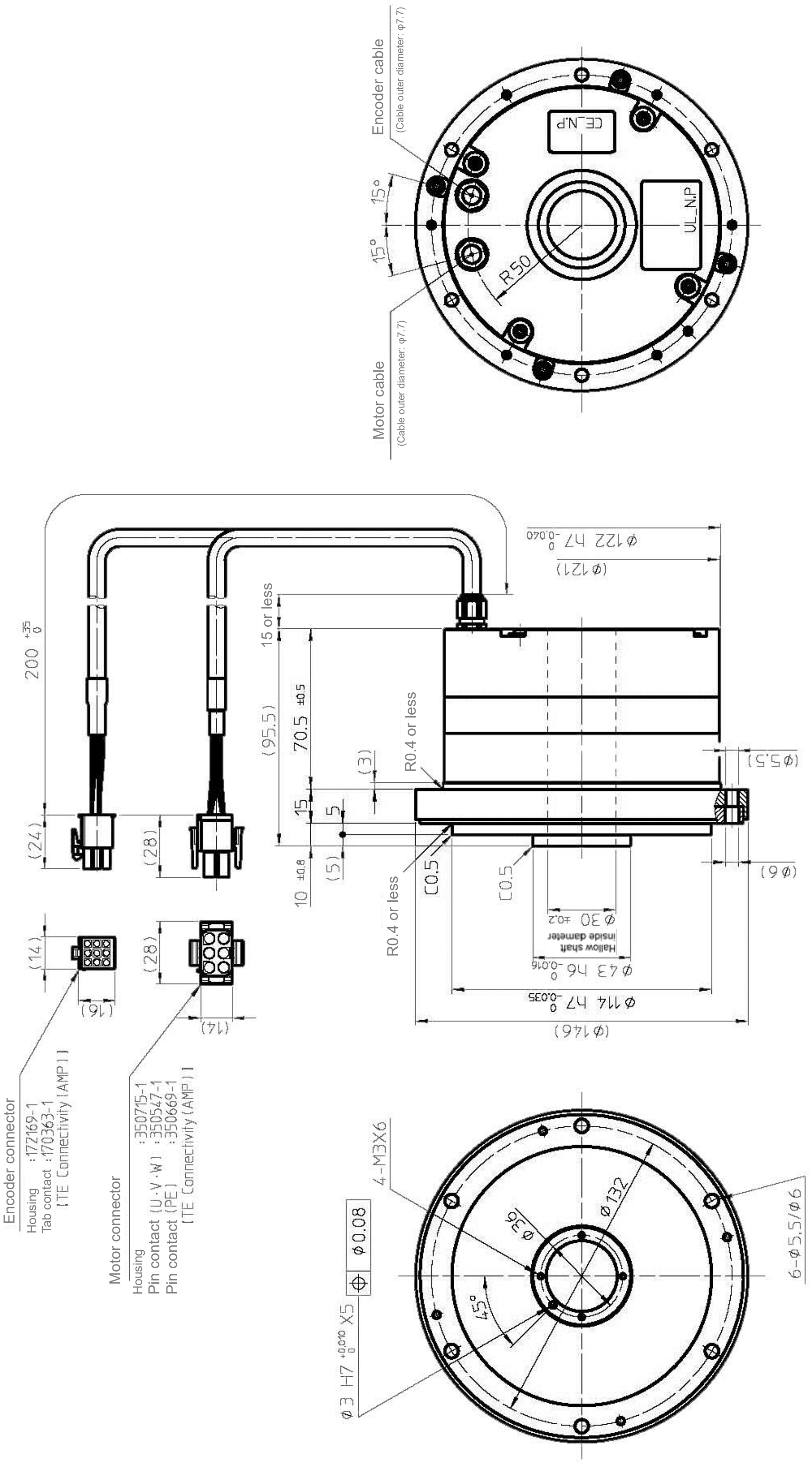
Unit [mm] (third angle projection)



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.

- **PMAB12 (with/without brake)**

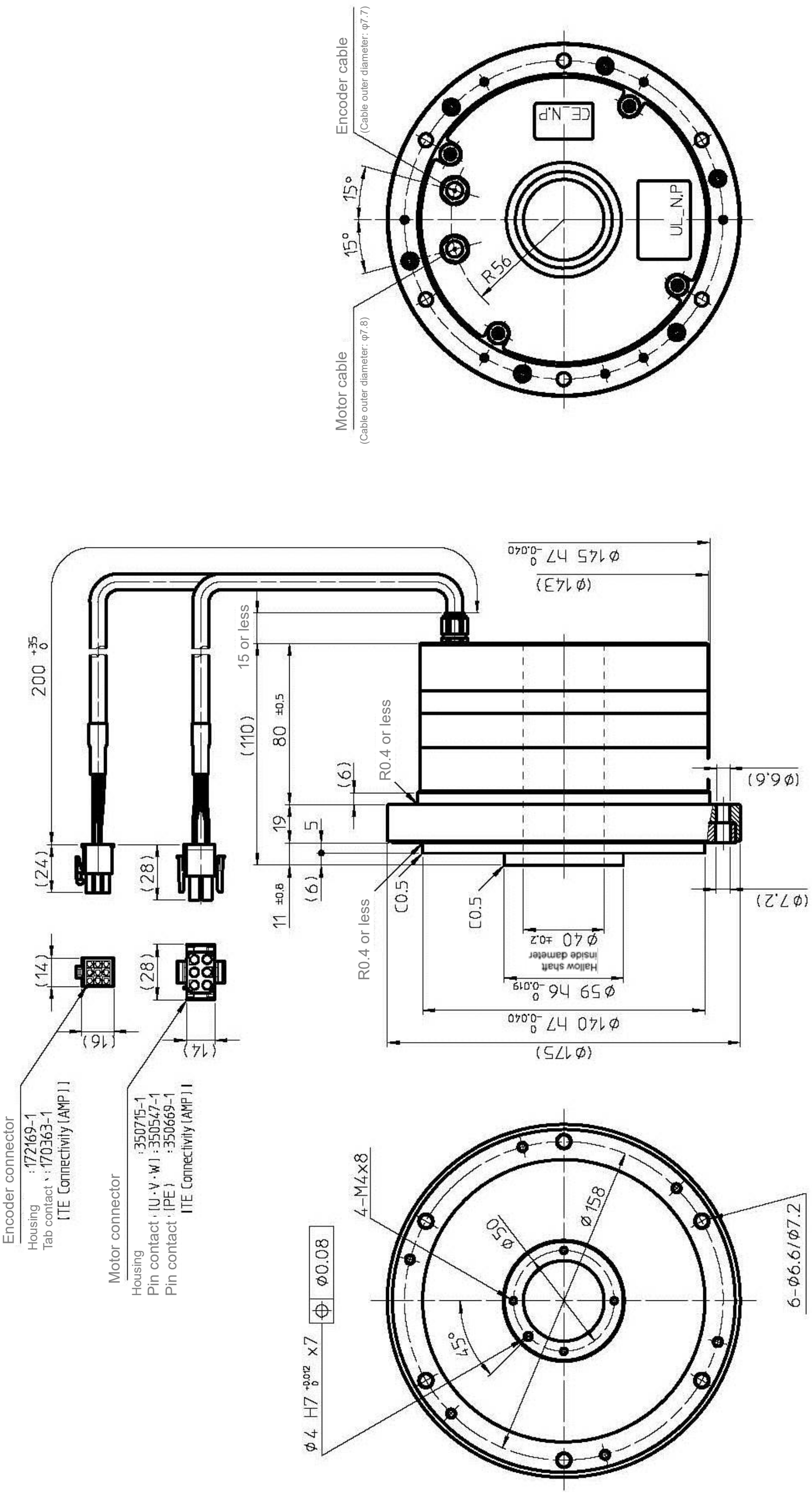
Unit [mm] (third angle projection)



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.

- **PMAB15 (with/without brake)**

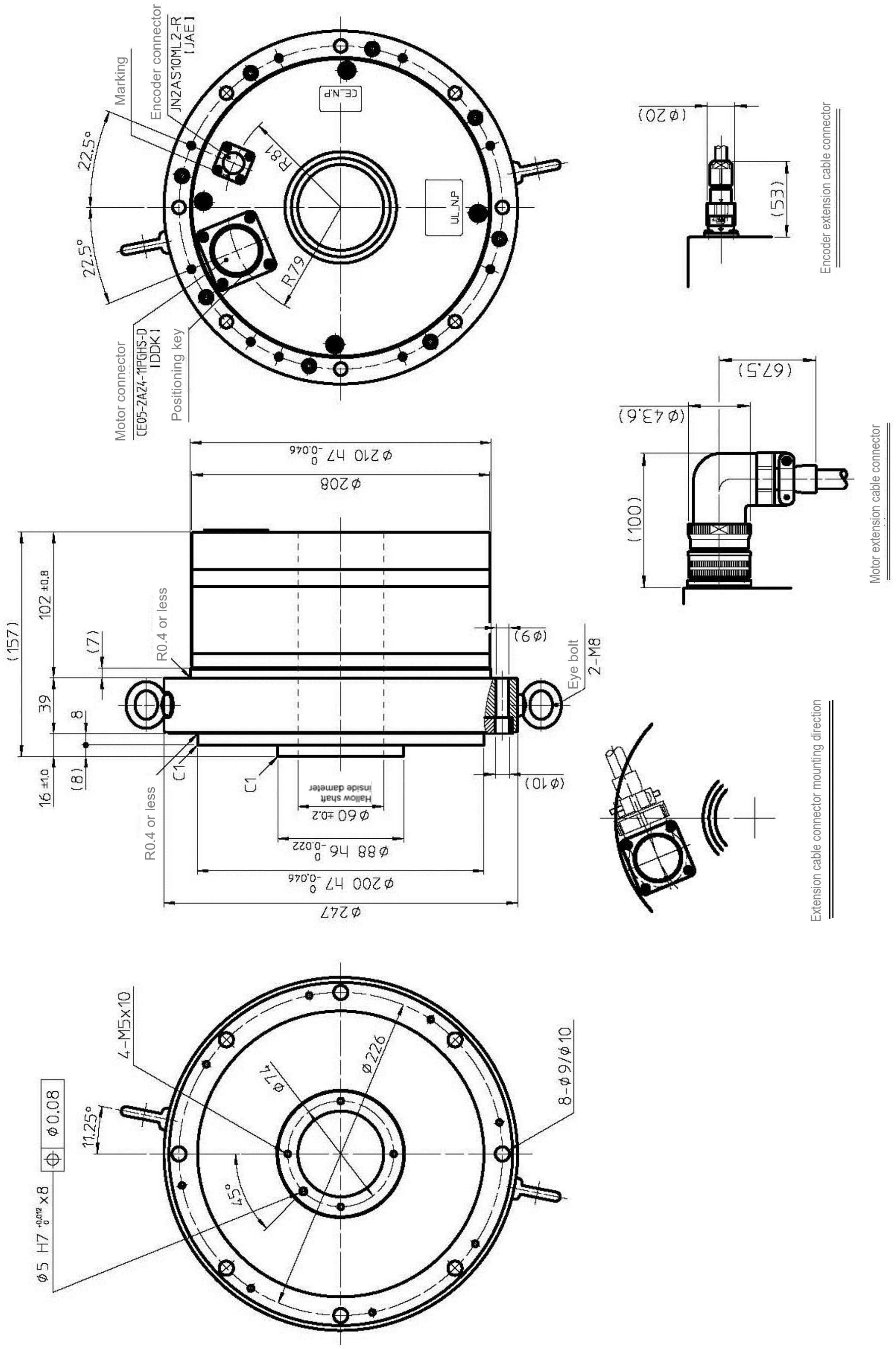
Unit [mm] (third angle projection)



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.

● PMAA21A (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.

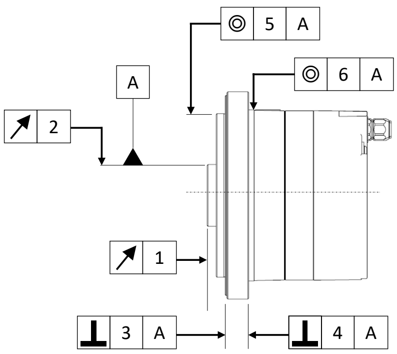
1-7 Mechanical accuracy

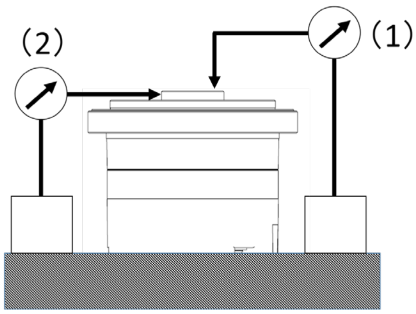
The mechanical accuracies of the output shaft and mounting flange for PMA series motors are shown below:

Unit [mm]

Accuracy items	PMAC08	PMAB09	PMAB12	PMAB15	PMAA21A
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

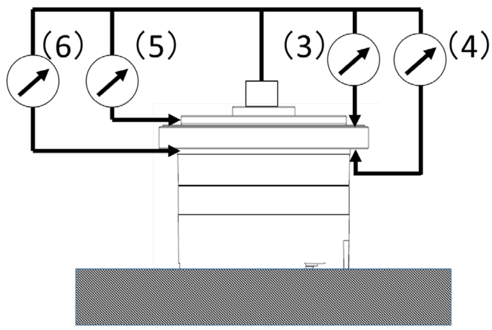
The indicator on the fixed part measures the axial runout (maximum runout width) of the end surface of the output shaft per revolution.

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 PMA 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 servo amplifier 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.
It is recommended that you replace the battery while the driver is receiving power. If the battery is replaced with the control circuit power ON, the absolute position data is not lost.
Note that if servo amplifier (A6) parameter setting Pr.0.15 is set to "1", the encoder can be operated as an incremental system.

Specifications

Type *1		Magnetic sensor/electronic battery backup type (Single rotation optic, multiple revolution magnetic sensor/electronic battery backup type)
Resolution	**Single-turn detector**	2^{17}: 131072 pulses
	Multi-turn detector	2^{16}: 65536 (-32768 to 32767)
Maximum allowable rotational speed		7000 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 *3 (when power is not supplied)
Backup time by internal battery *4		30 minutes (after 3 hours of charge, ambient temperature of 25 ℃, axis stopped) (For backup while the servo amplifier and encoder are disconnected briefly)

*1: Model No. 08 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.
*3: The value is obtained with the axis stopped. Frequent movement of the axis with no power supply would cause the external battery to drain quickly.
*4: This function is only available for PMAC08. Other models do not have this function.

Transfer of encoder data

Data is transferred via bi-directional communication in a normal condition while power is supplied. When the servo amplifier control power supply is turned OFF and the driver enters the battery backup mode, communication stops.

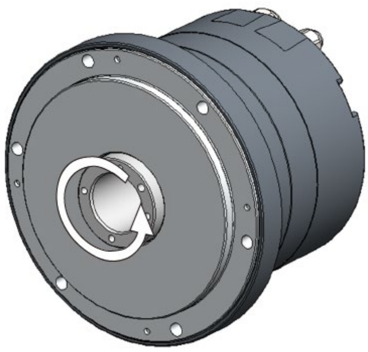
Differences in specifications with the MINAS A6 series 17bit absolute encoder

The encoder installed in the PMA series uses a different format, meaning that its specifications are slightly different. Differences and points of note are shown in the table below.

Item			Specifications			Notices
			PMA series		MINAS A6S series MINAS A6N series MINAS A6B series	
			Model No. 08	Model No. 09 and later		
Battery alarm voltage		V	3.07 to 3.33	3.05 to 3.25	3.0 to 3.2	None
Power-on stand-by time		s	0.5 or less	5 or less	1.5 or less	It is necessary to change amplifier parameter Pr 6.18 [Power ON wait time]. **If this is not changed, then at power supply ON, error 21.0 will be generated**. Change the wait time, with (1.5 + set value), from the amplifier factory set value of "0" (default value) to "3.5". However, this change is not necessary when model No. 08 is used.
Current consumption during normal operation	**TYP**	mA	65	105	80	No problem up to 20 m with the standard encoder cable. Separate examination required for special specifications.
	MAX		100	180	110	
Current consumption during backup (when axis stopped)	**TYP**	μA	30	25	60	Careful consideration required when calculating battery life.
	MAX		35	70	80	
Current consumption during backup (when axis rotating)	**TYP**	μA	30	285	180	
	MAX		35	350	—	
Overspeed detection		—	In normal operation At backup		At backup	Careful consideration required for responses during abnormal operation.

1-9 Rotation direction

The rotation direction of the motor can be switched with respect to the position command/speed command/torque command directions.
The method of changing the rotation direction varies depending on the servo amplifier communication I/F.
A6S "Analog/Pulse" and A6N "RTEX" can be changed with Pr0.00 of PANATERM.
For A6B "EtherCAT", change the set value of EtherCAT Object Index 607Eh-00h (Polarity) on the host device.
For details, refer to the Functional Specification of the servo amplifier technical documentation from Panasonic Corporation.



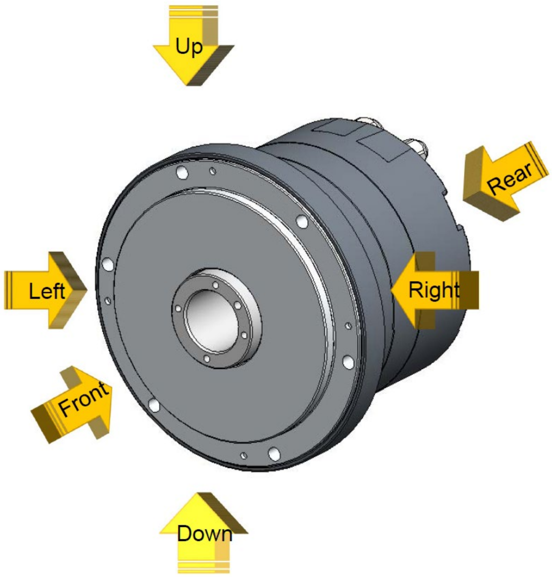
CCW (counterclockwise) rotation direction

Rotation direction setting

Pr0.00 set value (A6S, A6N)	607Eh (Polarity) set value (A6B)	Motor rotation direction	
		During forward direction command	During reverse direction command
0	224	CW direction (clockwise)	CCW direction (counterclockwise)
1	0	CCW direction (counterclockwise)	CW direction (clockwise)

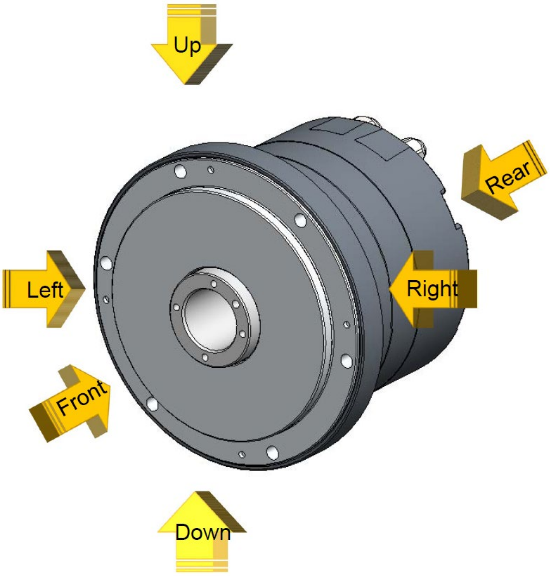
1-10 Shock resistance

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 below indicate the operable ranges of PMA series motors when combined with a MINAS A6 servo amplifier. For details, refer to [2-1 PMA series selection].

1. Continuous motion range

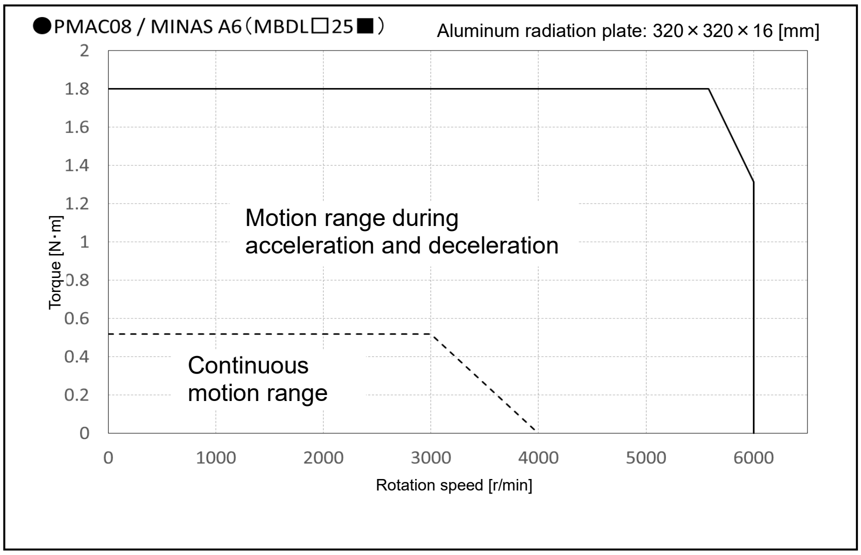
This indicates a range in which the motor can be operated continuously as shown by the relationship between the torque and rotational speed. Note that values are measured with the radiation plate listed on the graphs installed.

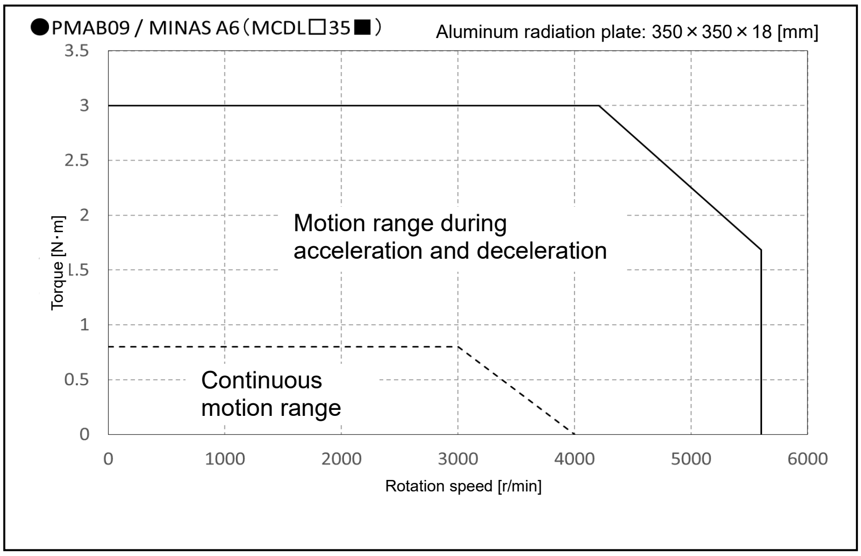
2. Motion range during acceleration and deceleration

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.

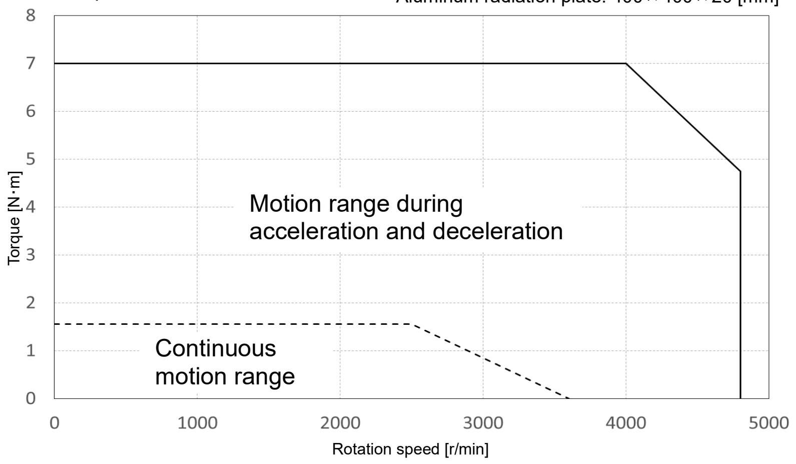
Caution

- The 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.

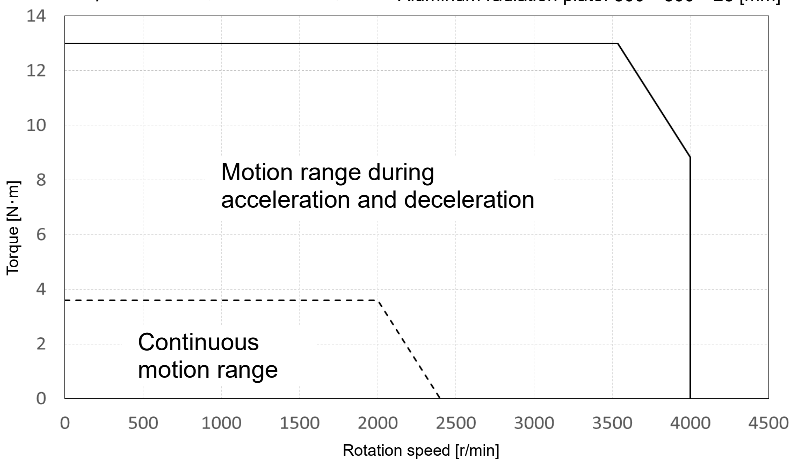




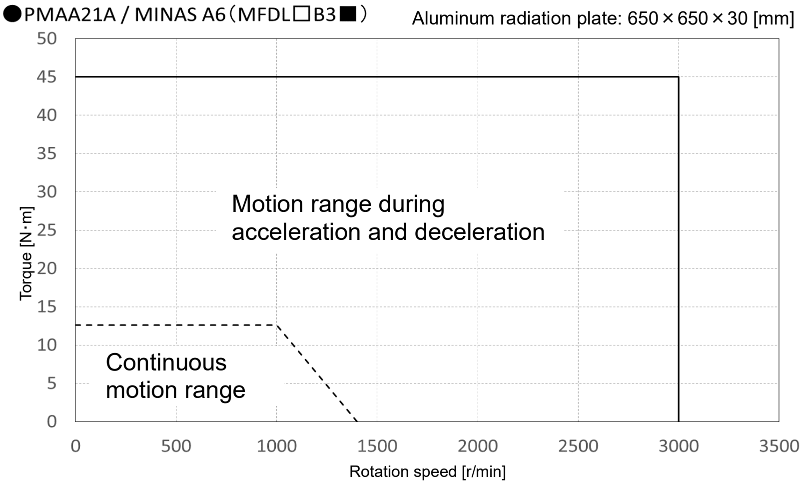
●PMAB12 / MINAS A6（MDDL☐55■） Aluminum radiation plate: 400×400×20 [mm]



●PMAB15 / MINAS A6（MEDL☐83■） Aluminum radiation plate: 500×500×25 [mm]



●PMAA21A / MINAS A6（MFDL☐B3■） Aluminum radiation plate: 650×650×30 [mm]



1-13 Cable specifications

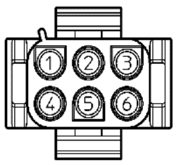
The following tables show the specifications of the motor and encoder cables for the PMA series motors.

Motor cable specifications

- Model Nos. 08, 09, 12, 15

Pin No.	Color	Name	
		Without brake	With brake
1	Red	Motor phase-U	Motor phase-U
2	Black	Motor phase-V	Motor phase-V
3	White	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:

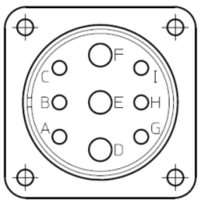
	Model Nos. 08, 09	Model Nos. 12, 15
Motor UVW	350690-1	350547-1
Brake	350690-1	350690-1
Motor PE	350669-1	350669-1

TE Connectivity (by AMP)

- Model No. 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



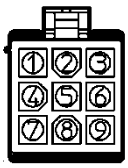
Connector model: CE05-2A24-11PGHS-D (by DDK)

Encoder cable specifications

- Model Nos. 08, 09, 12, 15

Pin No.	Color	Signal name	Remarks
1	Orange	BAT+	Battery +
2	Gray	BAT-	Battery - (GND)
3	Shield	FG	
4	Yellow	PS	Serial signal differential output (+)
5	Blue	$\overline{PS}$	Serial signal differential output (-)
6	—	No connection	
7	Red	E5 V	Power supply input +5 V
8	Black	E0 V	Power supply input 0 V (GND)
9	—	No connection	

- Connector pin layout

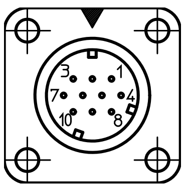


Connector model: 172169-1
Pin model (Model No. 08) : 770835-1 or 794059-1
Pin model (Model Nos. 09, 12, 15) : 170363-1
TE Connectivity (by AMP)

- Model No. 21A

Pin No.	Signal name	Remarks
1	E0 V	Power supply input 0 V (GND)
2	No connection	-
3	PS	Serial signal differential output (+)
4	E5 V	Power supply input +5 V
5	BAT–	Battery - (GND)
6	BAT+	Battery +
7	$\overline{PS}$	Serial signal differential output (-)
8	No connection	-
9	FG	
10	No connection	-

- Connector pin layout



Connector model: JN2AS10ML2-R (by JAE)

Chapter 2

Selection guidelines

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

2-1 PMA series selection

Allowable load inertia moment

To maximize the performance of the PMA series, make a tentative selection of a motor so that the rotational speed and load inertia moment ratio are equal to or lower than the allowable 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.

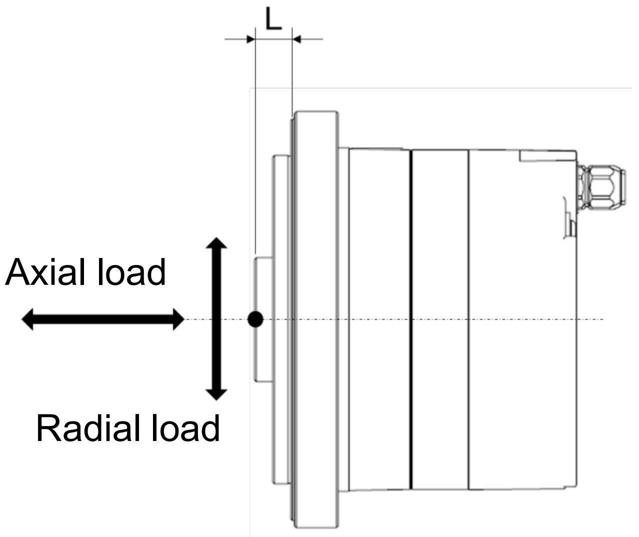
Model		PMAC08	PMAB09	PMAB12	PMAB15	PMAA21A
Allowable rotational speed	r/min	6000	5600	4800	4000	3000
Inertia moment (without brake)	$\times 10^{-4}$ kg·m^2	0.734	1.78	6.45	15.8	125
	$\times 10^{-4}$ kgf·cm·s^2	7.49	18.2	65.8	161	1280
Inertia moment (with brake)	$\times 10^{-4}$ kg·m^2	0.828	2.16	6.83	19.8	141
	$\times 10^{-4}$ kgf·cm·s^2	8.45	22.1	69.7	202	1444
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				

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 amplifier, an additional regenerative resistor must be connected externally to the servo amplifier. For details, refer to [Related manual] (P6).

2-2 Verifying and examining load weights

For PMA series motors, ensure that the load applied to the center of rotation and the end of the output shaft does not exceed the permissible load in the table below. Values shown in the table are permissible loads when applied individually.



Permissible output shaft load

Item / Model	L	When operated at the rated speed		When stationary	
		Radial load	Axial load	Radial load	Axial load
	mm	N	N	N	N
PMAC08	10	175	100	800	1900
PMAB09	10	185	105	800	2400
PMAB12	10	233	130	1200	3600
PMAB15	11	530	180	2400	5000
PMAA21A	16	1040	880	4500	14000

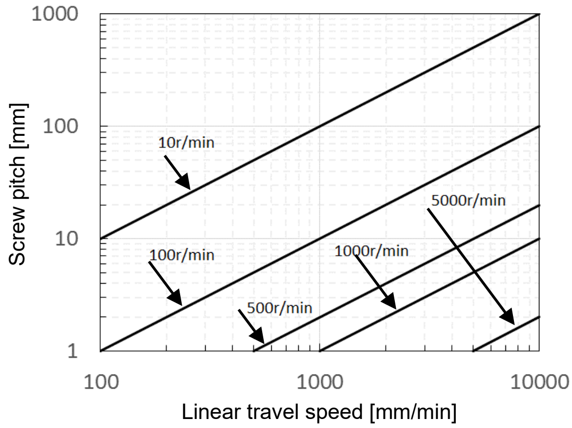
2-3 Examining the operating status

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 motor rotational speed r/min of the load driven by a PMA series motor.
For linear operation, use the rotational speed conversion formula below:

$$\text{Motor rotational speed [r/min]} = \frac{\text{Linear travel speed [mm/min]}}{\text{Screw feed pitch [mm]}}$$



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

Calculating and examining load inertia moment

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

Load torque calculation

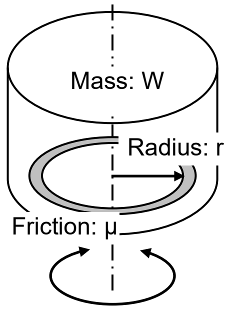
Calculate the load torque as follows:

- 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 [N･m]
μ : Friction coefficient
W : Mass [kg]
r : Average radius of friction side [m]

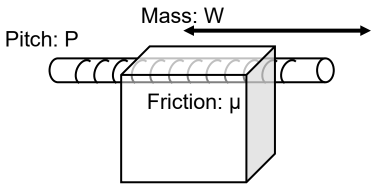


- Linear operation (horizontal operation)

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 [N･m]
μ : Friction coefficient
W : Mass [kg]
P : Screw feed pitch [m]

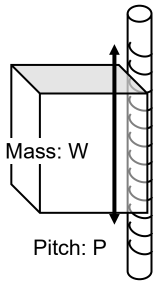


- Linear operation (vertical operation)

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

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

T : Rotary torque [N･m]
W : Mass [kg]
P : Screw feed pitch [m]



2

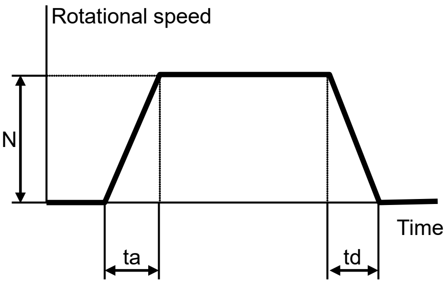
Selection guidelines

Acceleration time and deceleration time

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

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

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



ta : Acceleration time [s]

td : 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·m^2]

J_L : Inertia moment of load [kg·m^2]

N : Rotational speed of motor [r/min]

T_M : Maximum momentary torque [N·m]

T_F : Motor friction torque [N·m]

$T_F = K_T \times I_R - T_R$

K_T : Torque constant [N·m/A]

T_R : Rated torque [N·m]

I_R : Rated current [A]

T_L : Load torque [N·m]

The polarity is positive [+] when the torque is applied in the rotation direction, or negative [-] when it is applied in the opposite direction.

- **Calculation example 1**

Select a motor that best suits the following operating conditions:

・ Rotational speed: 4000 [r/min]

・ Inertia moment of load: 3.0×10^{-4} [kg·m^2]

・ Since the load mechanism is mainly inertia, the load torque is negligibly small.

(1) According to the conditions above, tentatively select PMAB09 from the table in section 2-1.

(2) From the rating table, the following values are obtained:
$J_M = 1.78 \times 10^{-4}$ [kg·m^2], $T_M = 3.0$ [N·m], $T_R = 0.80$ [N·m], $K_T = 0.41$ [N·m/A], $I_R = 2.5$ A

(3) Based on the above formula, the motor's friction torque T_F is calculated as
0.41 × 2.5 - 0.80 = 0.225 [N·m].

(4) If k = 1.3, the acceleration time and deceleration time can be obtained as follows from the above formulas:
$t_a = 1.3 \times (1.78 + 3.0) \times 10^{-4} \times 2 \times \pi / 60 \times 4000 / 3.0 ≒ 0.087$ [s]
$t_d = 1.3 \times (1.78 + 3.0) \times 10^{-4} \times 2 \times \pi / 60 \times 4000 / (3.0 + 2 \times 0.225) ≒ 0.075$ [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

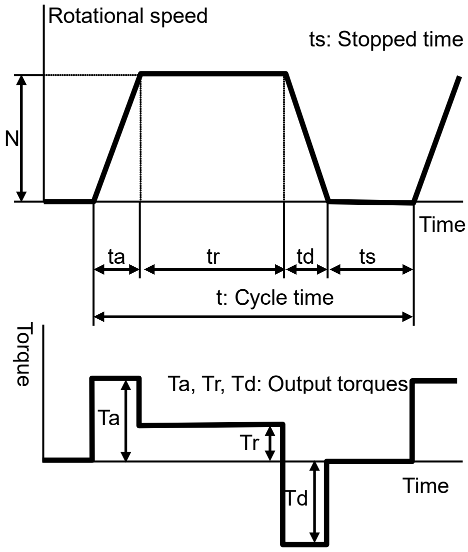
Evaluating effective torque and average rotational speed

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 [1-12 Operable range].
Using the following formula, calculate the effective torque Tm and average rotational speed Nav 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	[N・m]
Ta	: Torque during acceleration	[N・m]
Tr	: Torque at constant speed	[N・m]
Td	: Torque during deceleration	[N・m]
Nav	: Average rotational speed	[r/min]
N	: Rotational speed at constant speed	[r/min]



- **Calculation example 2**

The calculation method is explained below using PMAB09 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 3600° 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 θ is calculated as follows:

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

Accordingly, $t_r = \theta / (6 \times N) - (t_a + t_d) / 2$

When θ = 3600° and ta = 0.087 [s], td = 0.075 [s], N = 4000 [r/min] in calculation example 1, are applied to this formula, tr is calculated as 0.069 seconds.

(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,
Ta = 2.30 [N・m] and Td = 2.53 [N・m] are obtained.

(3) Calculate the effective torque. Apply the values in (1) and (2), Tr = 0 [N・m], and t = 0.8 seconds to the above formulas.

$$T_m = \sqrt{\frac{2.30^2 \times 0.087 + 0^2 \times 0.069 + 2.53^2 \times 0.075}{0.8}} = 1.08\ [\mathrm{N \cdot m}]$$

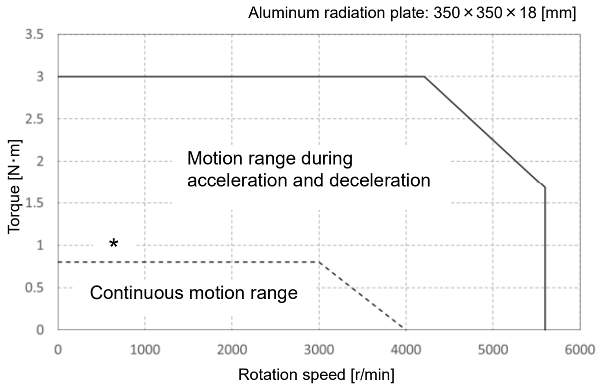
(4) Calculate the average rotational speed. Apply the values in (1), N = 4000 r/min, and t = 0.8 seconds to the above formulas.

$$N_{av} = \frac{4000/2 \times 0.087 + 4000 \times 0.069 + 4000/2 \times 0.075}{0.8} = 750\ [\mathrm{r/min}]$$

(5) The * mark in 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 PMAB09, 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 PMAB09

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 = 2.30 [N・m]
T_r = 0 [N・m]
T_d = 2.53 [N・m]
T_m = 0.80 [N・m]
t_a = 0.087 [s]
t_r = 0.069 [s]
t_d = 0.075 [s]

Then, the following equation is obtained:

$t = (2.30^2 \times 0.087 + 2.53^2 \times 0.075) / 0.80^2 = 1.46$ [s]

Based on the result, setting the cycle time to 1.5 seconds or more to provide a longer stop time gives T_m = 0.80 [N・m] 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 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 PMA 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 [1-3 Model] (P1-3) in this manual for details of the model codes.

3 **Check if the servo amplifier combinations are correct.**

Check that this is the model combination given in this document in Chapter 1 Section 2 "Combinations with servo amplifier and extension cables" column.

4 **Check if the power voltages being input are correct.**

The value of the power voltage input is shown in the servo amplifier nameplate “INPUT” column. 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 servo amplifier with a motor that is not specified on the name plate.
The characteristics of the servo amplifier have been adjusted according to the motor. Wrong combinations of servo amplifiers 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 servo amplifier's nameplate.
Connecting a power supply with an input voltage that is not specified on the nameplate may result in damage to the servo amplifier, injury or fire.

3-2 Notices on handling

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

CAUTION

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

(2) Do not place PMA 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 ℃. 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.

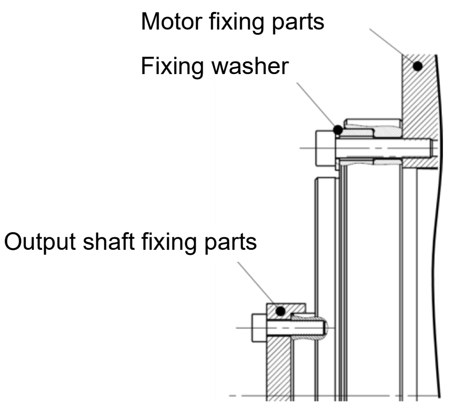
(6) Do not use or store the motor in locations subject to flammable or corrosive gases or dust particles.

(7) The large model (PMAA21A) 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.

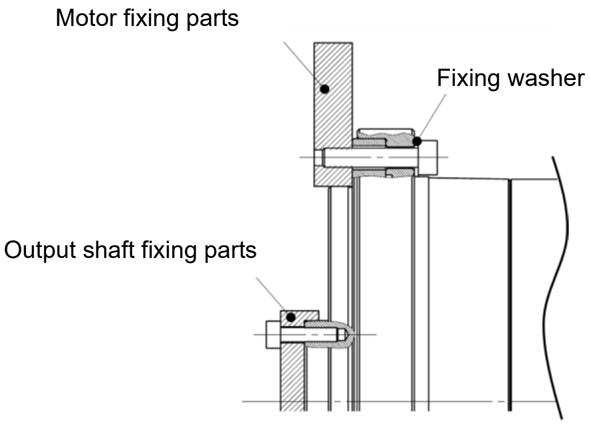
Installation and transmission torque

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

3

Installing the motor

● Recommended tightening torque and transmission torque

Item \ Model		PMAC08		PMAB09		PMAB12	
		Output shaft	Motor	Output shaft	Motor	Output shaft	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	N·m	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	N·m	18	103	23	215	30	446
	kgf·m	1.8	10.5	2.4	22.0	3.1	45.5

Item \ Model		PMAB15		PMAA21A	
		Output shaft	Motor	Output shaft	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	N·m	4.5	15.3	9.0	37.0
	kgf·m	0.46	1.56	0.92	3.8
Transmission torque	N·m	70	755	167	2630
	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

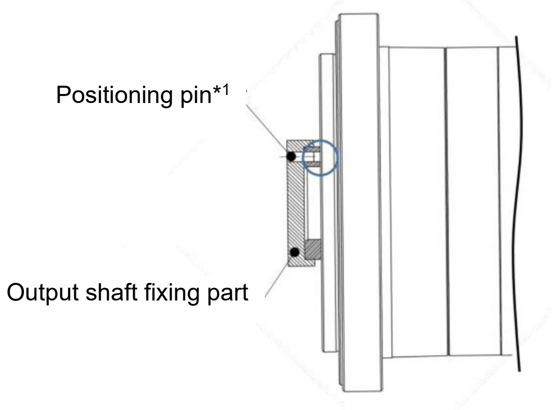
Precautions on installation

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 PMA 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 PMA 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 material

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

Location	Material
Housing	Aluminum material is exposed (no treatment)
Hollow shaft (output shaft)	SUS 420J2
Bolt	SCM435 (black oxide coating treatment)

3-3 Location and installation

Environment of location

The environmental conditions of the installation location for PMA 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 400 Hz) or less (Refer to [1-11 Resistance to vibration] (P1-17))
- ◆ Impact: 300 m/s^2 or less (Refer to [1-10 Shock resistance] (P1-16))
- ◆ 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-5 4 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 (PMAC08, PMAB09, PMAB12, PMAB15) are not IP-54-compliant. Also, when a PMAA21A encoder connector converter cable is used, the motor side is warrantied as installed, but this does not apply to the connector on the servo amplifier side. Connectors of PMAA21A motor are warrantied as installed.
- ◆ Use the motor indoors or within an enclosure. Do not expose it to direct sunlight.
- ◆ Altitude: less than 1000 m above sea level

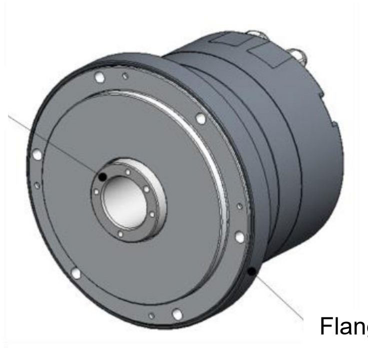
Installation

When installing a PMA 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 servo amplifier and wiring.

An extension cable is provided. Use it when wiring the servo amplifier. For details on wiring, refer to [1-13 Cable specifications] (P1-20) and [Related manual] (P6)

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 requires an external battery to retain absolute positions.

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.

Chapter 4

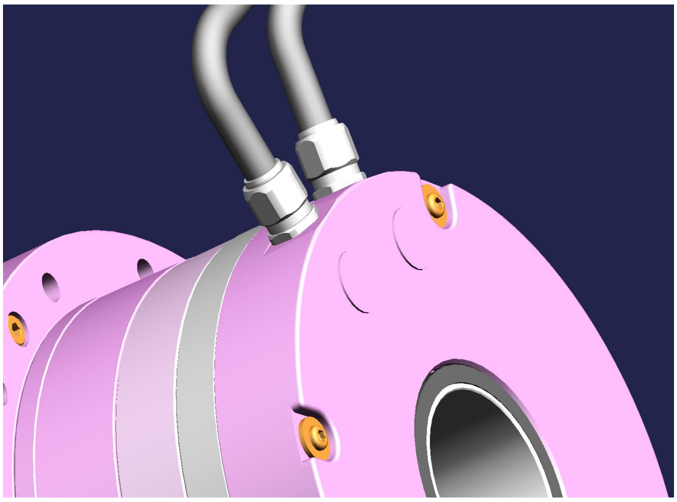
Options

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.
This option is not available for model Nos. 08, 21A.
For details on the option where cables can be taken out from the side, contact our sales office.



Extension cables

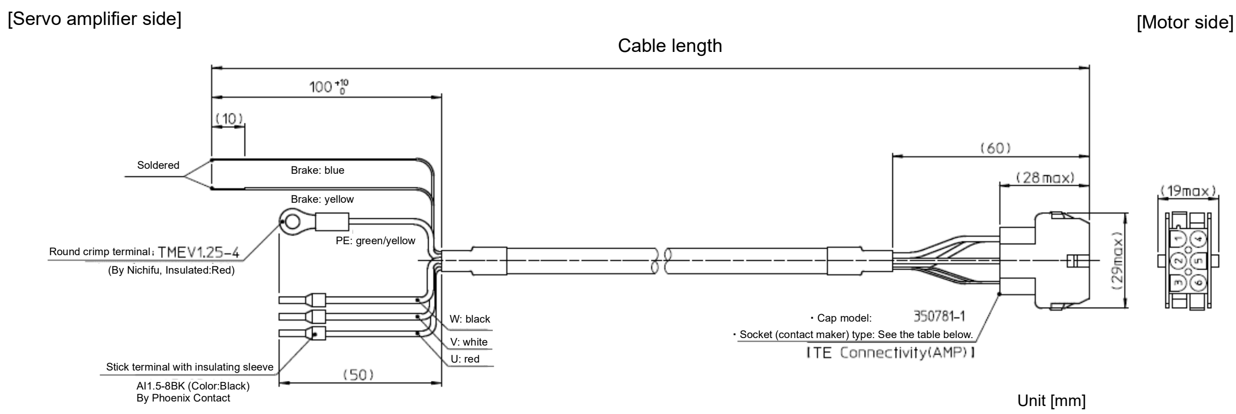
These extension cables are used to connect PMA series motors and MINAS A6 servo amplifiers.
Two types of extension cables are available for motor (including brake wire) and encoder.
You must use an extension cable to connect your PMA series motor and MINAS A6 servo amplifier.

Motor extension cable:

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

EWD-MB**-A06-TN-P

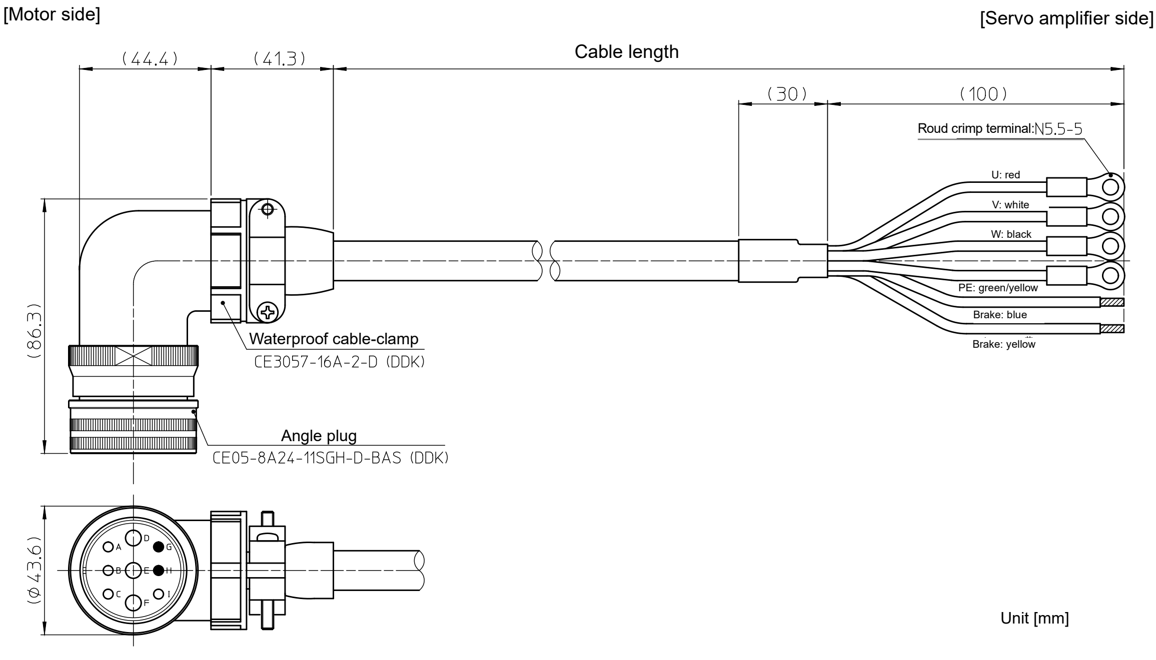
└ Indicate the cable length (03 = 3 m, 05 = 5 m, 10 = 10 m, 20 = 20 m).



- **Motor model No. 21A**

EWD-MB**-D09-TMC-P

└ Indicate the cable length (03 = 3 m, 05 = 5 m, 10 = 10 m, 20 = 20 m).



Encoder extension cable:

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

MFECA0**0EAE (With battery box)

└ Indicate the cable length (03 = 3 m, 05 = 5 m, 10 = 10 m, 20 = 20 m).

- **Motor model No. 21A**

MFECA0**0ETE (With battery box)

└ Indicate the cable length (03 = 3 m, 05 = 5 m, 10 = 10 m, 20 = 20 m).

For details on encoder extension cable, contact Panasonic Corporation customer support.

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	3600	1.18×10^4	3.281	39.37

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

(4) Force

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

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

(5) Mass

SI system	kg	
Unit	lb.	oz.
Factor	2.205	35.27

Unit	lb.	oz.
Factor	0.4535	0.02835
SI system	kg	

(6) Angle

SI system	rad		
Unit	Degree	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							

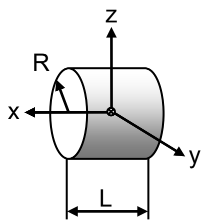
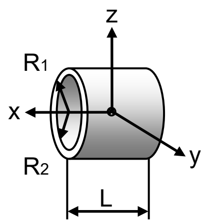
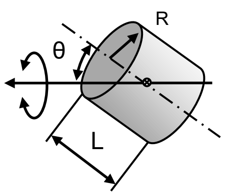
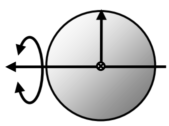
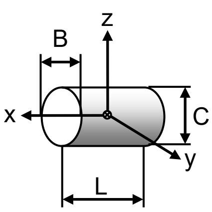
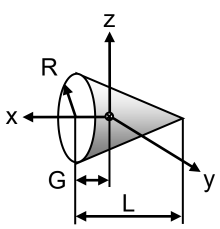
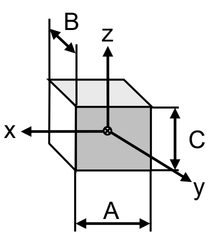
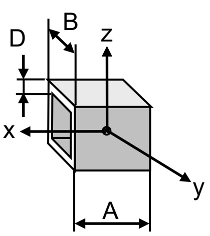
A -2 Calculating inertia moment

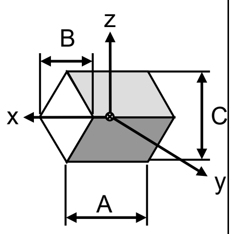
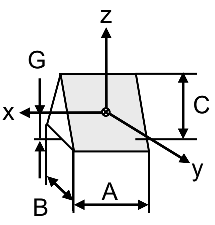
Formulas of mass and inertia moment

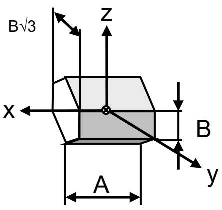
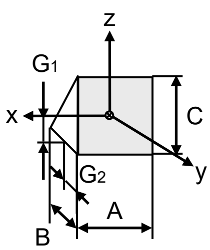
(1) The center of rotation matches the centroidal line

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 [×10^{3}kg / m^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	$m = \pi\left(R_1^2 - R_2^2\right)L\rho \times 10^3$ $Ix = \frac{1}{2} m\left(R_1^2 + R_2^2\right)$ $Iy = \frac{1}{4} m\left\{\left(R_1^2 + R_2^2\right) + \frac{L^2}{3}\right\}$ $Iz = \frac{1}{4} m\left\{\left(R_1^2 + R_2^2\right) + \frac{L^2}{3}\right\}$
Slanted cylinder 	$m = \pi R^2 L\rho \times 10^3$ $I_\theta = \frac{1}{12} m \times \left\{3R^2\left(1 + \cos^2\theta\right) + L^2\sin^2\theta\right\}$	Ball 	$m = \frac{4}{3}\pi R^3 \rho \times 10^3$ $I = \frac{2}{5} m R^2$
Ellipsoidal cylinder 	$m = \frac{1}{4} BCL\rho \times 10^3$ $Ix = \frac{1}{16} m\left(B^2 + C^2\right)$ $Iy = \frac{1}{4} m\left(\frac{C^2}{4} + \frac{L^2}{3}\right)$ $Iz = \frac{1}{4} m\left(\frac{B^2}{4} + \frac{L^2}{3}\right)$	Cone 	$m = \frac{1}{3}\pi R^2 L\rho \times 10^3$ $Ix = \frac{3}{10} m R^2$ $Iy = \frac{3}{80} m\left(4R^2 + L^2\right)$ $Iz = \frac{3}{80} m\left(4R^2 + L^2\right)$ $G = \frac{L}{4}$
Rectangular pillar 	$m = ABC\rho \times 10^3$ $Ix = \frac{1}{12} m\left(B^2 + C^2\right)$ $Iy = \frac{1}{12} m\left(C^2 + A^2\right)$ $Iz = \frac{1}{12} m\left(A^2 + B^2\right)$	Square pipe 	$m = 4AD(B - D)\rho \times 10^3$ $Ix = \frac{1}{3} m\left\{(B - D)^2 + D^2\right\}$ $Iy = \frac{1}{6} m\left\{\frac{A^2}{2} + (B - D)^2 + D^2\right\}$ $Iz = \frac{1}{6} m\left\{\frac{A^2}{2} + (B - D)^2 + D^2\right\}$

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 	$m=\frac{1}{2}ABC\rho\times10^3$ $Ix=\frac{1}{36}m\left(B^2+C^2\right)$ $Iy=\frac{1}{12}m\left(A^2+\frac{2}{3}C^2\right)$ $Iz=\frac{1}{12}m\left(A^2+\frac{2}{3}B^2\right)$ $G_1=\frac{C}{3}$ $G_2=\frac{B}{3}$

- **Example of specific gravity**

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

Material	Specific gravity [×10³kg / m³]
SUS304	7.93
S45C	7.86
SS400	7.85
Cast iron	7.19
Copper	8.92
Brass	8.50

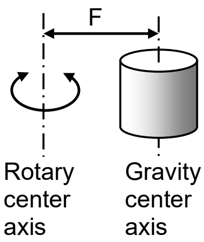
Material	Specific gravity [×10³kg / m³]
Aluminum	2.70
Duralumin	2.80
Silicon	2.30
Quartz glass	2.20
Teflon	2.20
Fluorocarbon resin	2.20

Material	Specific gravity [×10³kg / m³]
Epoxy resin	1.90
ABS	1.10
Silicon resin	1.80
Polyurethane rubber	1.25

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

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

$$I=Ig+mF^2$$



I : Inertia moment when the gravity center axis does not match the rotational axis [kg·m²]

I_g : Inertia moment when the gravity center axis matches the rotational axis [kg·m²]
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.

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

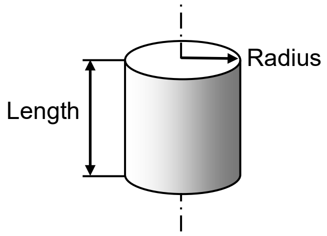
I : Inertia moment of a linear operation object converted to motor axis [kg·m²]

m : mass [kg]

P : Linear travel per motor one revolution [m/rev]

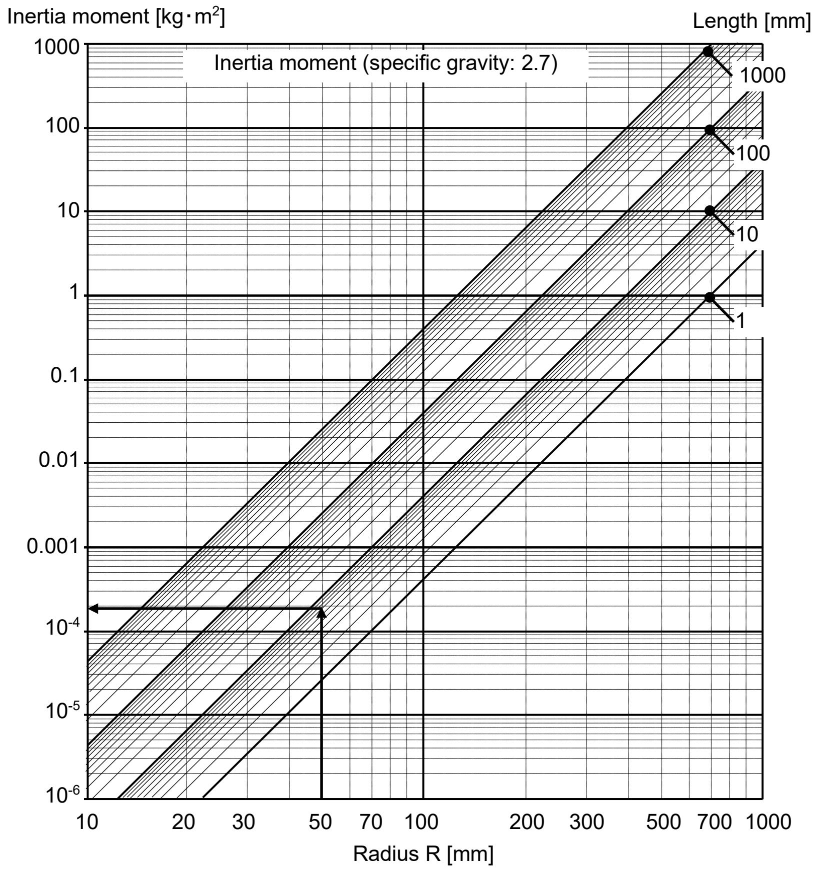
Inertia moment of cylinder

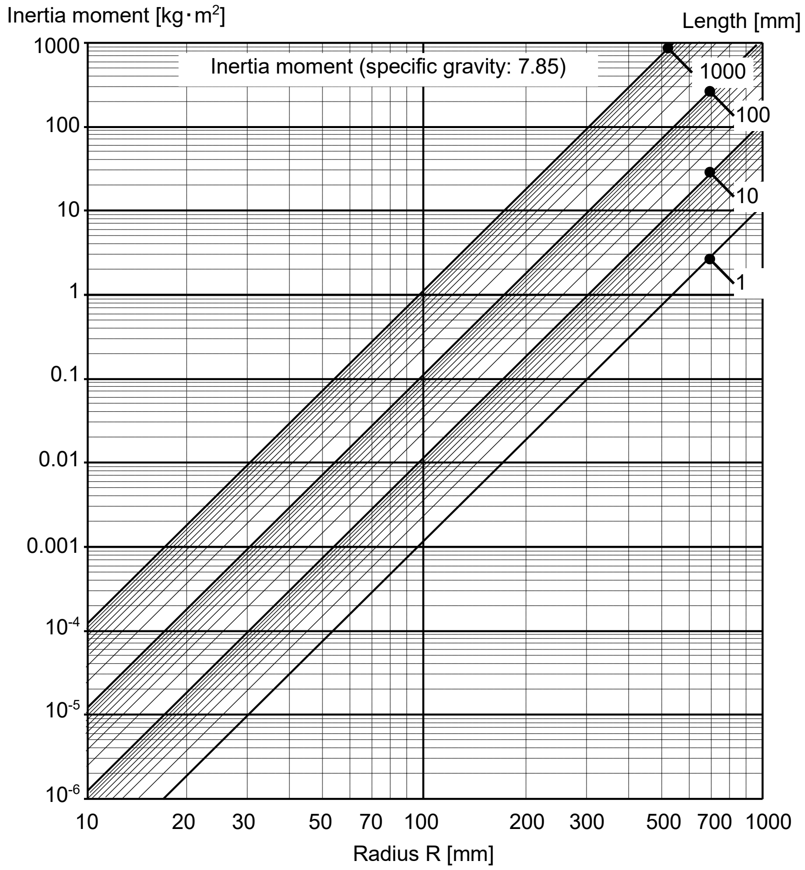
The inertia moment of a cylinder can be obtained from the graphs to the right.



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
Outer diameter: 100 [mm]
Inner diameter: 50 [mm]
Inertia moment:
Approx. 1.9×10^{-4} [kg・m²] (by the graph on the right)
(Calculated value: 0.000186 m²)





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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