Ai-M Series

2-Phase Closed-Loop Stepper Motor

▣ Features

- Minimal heat generating, high torque motor (control voltage 55V)
- Higher cost-efficiency compared to conventional servo motors
- Available in motor frame size 20mm, 28mm, 35mm, 42mm, 56mm, 60mm

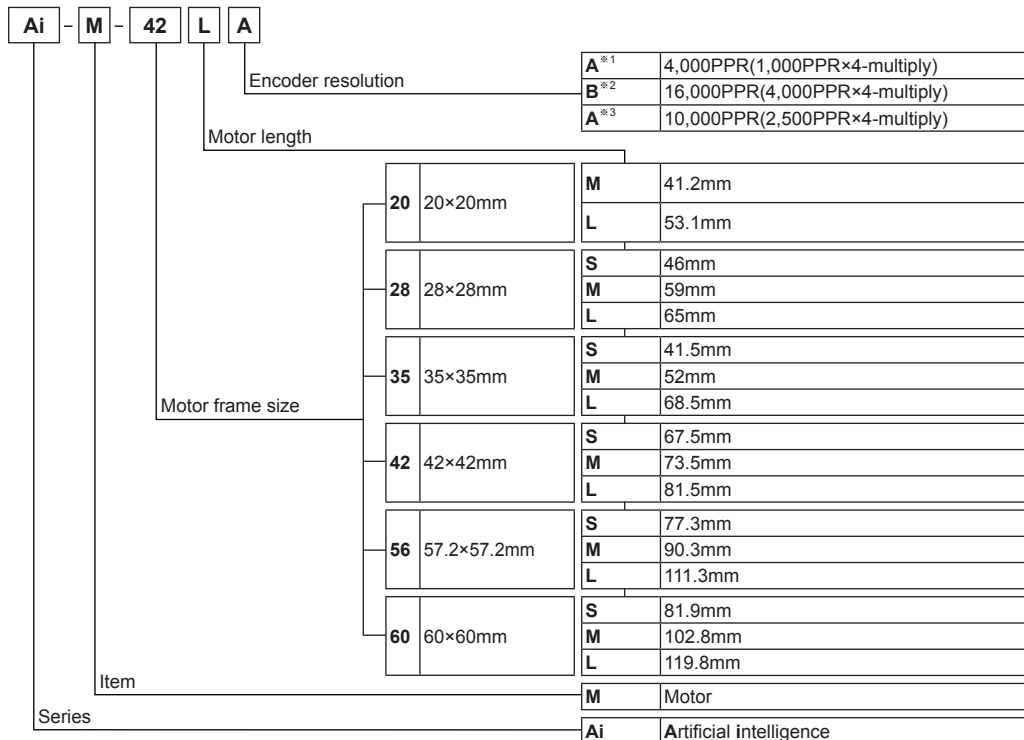[Frame size 20mm] [Frame size 28mm] [Frame size 35mm]

[Frame size 42mm] [Frame size 56mm] [Frame size 60mm]

⚠ Please read "Safety Considerations" in operation manual before using.

CE

▣ Ordering Information

| Ai | – | M | – | 42 | L | A |

Encoder resolution	A[※1]	4,000PPR(1,000PPR×4-multiply)	
	B[※2]	16,000PPR(4,000PPR×4-multiply)	
	A[※3]	10,000PPR(2,500PPR×4-multiply)	

Motor length

20	20×20mm	M	41.2mm
		L	53.1mm
28	28×28mm	S	46mm
		M	59mm
		L	65mm
35	35×35mm	S	41.5mm
		M	52mm
		L	68.5mm
42	42×42mm	S	67.5mm
		M	73.5mm
		L	81.5mm
56	57.2×57.2mm	S	77.3mm
		M	90.3mm
		L	111.3mm
60	60×60mm	S	81.9mm
		M	102.8mm
		L	119.8mm

Motor frame size

M	Motor
Ai	**A**rtificial **i**ntelligence

Item

Series

※1: Encoder resolution for frame size 20mm motors.
　　Microstep control for AiS driver, it controls up to 10,000PPR.
※2: Encoder resolution for frame size 28, 35mm motors.
※3: Encoder resolution for frame size 42, 56, 60mm motors.

Autonics

2-Phase Closed-Loop Stepper Motor

◼ Specifications

◎ Motor

● Frame size 20mm

Model	Ai-M-20MA	Ai-M-20LA
Max. holding torque[※1]	0.183kgf·cm (0.018N·m)	0.357kgf·cm (0.035N·m)
Rotor moment of inertia	$2g·cm^2$ ($2×10^{-7}kg·m^2$)	
Rated current	10.6A/Phase	
Resistance	6.6Ω/Phase ±10%	10.5Ω/Phase ±10%
Inductance	2.1mH/Phase ±20%	4.0mH/Phase ±20%
Weight[※2]	Approx. 0.192kg (approx. 0.092kg)	Approx. 0.219kg (approx. 0.120kg)

● Frame size 28mm

Model	Ai-M-28SB	Ai-M-28MB	Ai-M-28LB
Max. holding torque[※1]	0.51kgf·cm (0.05N·m)	1.42kgf·cm (0.14N·m)	1.63kgf·cm (0.16N·m)
Rotor moment of inertia	$9g·cm^2$ ($9×10^{-7}kg·m^2$)	$12g·cm^2$ ($12×10^{-7}kg·m^2$)	$18g·cm^2$ ($18×10^{-7}kg·m^2$)
Rated current	1.0A/Phase		
Resistance	5.78Ω/Phase ±10%	8.8Ω/Phase ±10%	10.1Ω/Phase ±10%
Inductance	3.2mH/Phase ±20%	6.0mH/Phase ±20%	6.2mH/Phase ±20%
Weight[※2]	Approx. 0.260kg (approx. 0.162kg)	Approx. 0.318kg (approx. 0.222kg)	Approx. 0.342kg (approx. 0.248kg)

● Frame size 35mm

Model	Ai-M-35SB	Ai-M-35MB	Ai-M-35LB
Max. holding torque[※1]	0.714kgf·cm (0.07N·m)	1.326kgf·cm (0.13N·m)	3.162kgf·cm (0.31N·m)
Rotor moment of inertia	$8g·cm^2$ ($8×10^{-7}kg·m^2$)	$14g·cm^2$ ($14×10^{-7}kg·m^2$)	$22g·cm^2$ ($22×10^{-7}kg·m^2$)
Rated current	1.2A/Phase		
Resistance	2.1Ω/Phase ±10%	3.25Ω/Phase ±10%	5.0Ω/Phase ±10%
Inductance	1.25mH/Phase ±20%	2.85mH/Phase ±20%	5.6mH/Phase ±20%
Weight[※2]	Approx. 0.278g (approx. 0.180kg)	Approx. 0.347kg (approx. 0.250kg)	Approx. 0.456kg (approx. 0.366kg)

● Frame size 42mm

Model	Ai-M-42SA	Ai-M-42MA	Ai-M-42LA
Max. holding torque[※1]	2.55kgf·cm (0.25N·m)	4.08kgf·cm (0.4N·m)	4.89kgf·cm (0.48N·m)
Rotor moment of inertia	$35g·cm^2$ ($35×10^{-7}kg·m^2$)	$54g·cm^2$ ($54×10^{-7}kg·m^2$)	$77g·cm^2$ ($77×10^{-7}kg·m^2$)
Rated current	1.7A/Phase		
Resistance	1.7Ω/Phase ±10%	1.85Ω/Phase ±10%	2.1Ω/Phase ±10%
Inductance	1.9mH/Phase ±20%	3.5mH/Phase ±20%	4.4mH/Phase ±20%
Weight[※2]	Approx. 0.45kg (approx. 0.34kg)	Approx. 0.52kg (approx. 0.41kg)	Approx. 0.59kg (approx. 0.48kg)

● Frame size 56mm

Model	Ai-M-56SA	Ai-M-56MA	Ai-M-56LA
Max. holding torque[※1]	6.12kgf·cm (0.6N·m)	12.24kgf·cm (1.2N·m)	20.39kgf·cm (2.0N·m)
Rotor moment of inertia	$140g·cm^2$ ($140×10^{-7}kg·m^2$)	$280g·cm^2$ ($280×10^{-7}kg·m^2$)	$480g·cm^2$ ($480×10^{-7}kg·m^2$)
Rated current	3.5A/Phase		
Resistance	0.55Ω/Phase ±10%	0.57Ω/Phase ±10%	0.93Ω/Phase ±10%
Inductance	1.05mH/Phase ±20%	1.8mH/Phase ±20%	3.7mH/Phase ±20%
Weight[※2]	Approx. 0.76kg (approx. 0.62kg)	Approx. 0.99kg (approx. 0.85kg)	Approx. 1.36kg (approx. 1.22kg)

● Frame size 60mm

Model	Ai-M-60SA	Ai-M-60MA	Ai-M-60LA
Max. holding torque[※1]	11.22kgf·cm (1.1N·m)	22.43kgf·cm (2.2N·m)	29.57kgf·cm (2.9N·m)
Rotor moment of inertia	$240g·cm^2$ ($240×10^{-7}kg·m^2$)	$490g·cm^2$ ($490×10^{-7}kg·m^2$)	$690g·cm^2$ ($690×10^{-7}kg·m^2$)
Rated current	3.5A/Phase		
Resistance	1.0Ω/Phase ±10%	1.23Ω/Phase ±10%	1.3Ω/Phase ±10%
Inductance	1.5mH/Phase ±20%	2.6mH/Phase ±20%	3.8mH/Phase ±20%
Weight[※2]	Approx. 0.89kg (approx. 0.75kg)	Approx. 1.27kg (approx. 1.13kg)	Approx. 1.58kg (approx. 1.44kg)

※1: Max. holding torque is maintenance torque of stopping the motor when supplying the rated current (2-phase excitation) and is the standard for comparing the performance of motors.
※2: The weight includes packaging. The weight in parenthesis is for unit only.

Ai-M Series

▣ Specifications

• Common specifications

Standard step angle		1.8°/0.9° (Full/Half step)
Motor phase		2-phase
Run method		Bipolar
Insulation class		B type (130℃)
Insulation resistance		Over 100MΩ (at 500VDC megger), between motor coil-case
Dielectric strength		500VAC 50/60Hz for 1 min between motor coil-case
Vibration		1.5mm amplitude at frequency 10 to 55Hz (for 1 min) in each X, Y, Z direction for 2 hours
Shock		Approx. max. 50G
Environment	Ambient temperature	0 to 50℃, storage: -20 to 70℃
	Ambient humidity	20 to 85%RH, storage: 15 to 90%RH
Approval		C E
Protection structure		IP30 (IEC34-5 standard)
Stop angle error[1]		±0.09°
Shaft vibration[2]		0.03mm T.I.R.
Radial Movement[3]	Frame size 20, 28, 35mm	Max. 0.025mm (load 450g)
	Frame size 42, 56, 60mm	Max. 0.025mm (load 25N)
Axial Movement[4]	Frame size 20, 28, 35mm	Max. 0.05mm (load 920g)
	Frame size 42, 56, 60mm	Max. 0.01mm (load 50N)
Concentricity for shaft of setup in-low		0.05mm T.I.R.
Perpendicularity of set-up plate shaft		0.075mm T.I.R.

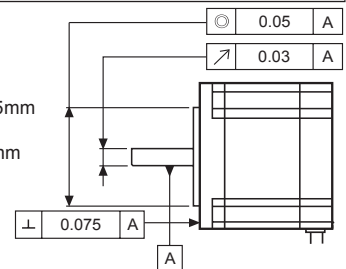[1]: Specifications are for full-step angle, without load. (values may vary by load size)
[2]: T.I.R. (Total Indicator Reading)
   - Indicates total quantity of dial gauge in case of 1 rotation of measuring part around the reference point.
[3]: Amount of radial shaft displacement when adding a radial load (450g for frame size 20, 28, 35mm and 25N for frame size 42, 56, 60mm) to the tip of the motor shaft.
[4]: Amount of axial shaft displacement when adding a axial load (920g for frame size 20, 28, 35mm and 50N for frame size 42, 56, 60mm) to the shaft.
※Environment resistance is rated at no freezing or condensation.

◎ Encoder

• Frame size 20, 28, 35mm

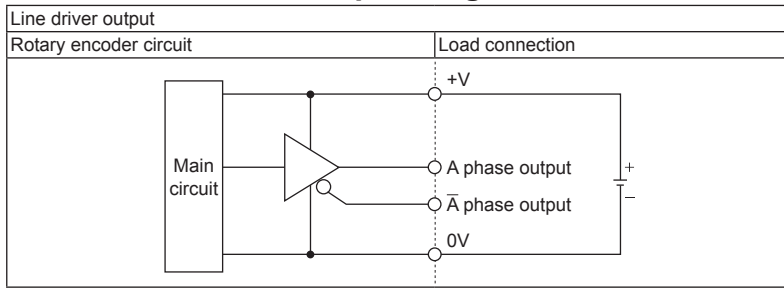| Item		Magnetic incremental rotary encoder
Resolution	Frame size 20mm[1]	4,000PPR (1,000PPR×4-multiply)
	Frame size 28, 35mm	16,000PPR (4,000PPR×4-multiply)
Electrical specification	Output phase	A, $\overline{A}$, B, $\overline{B}$, Z, $\overline{Z}$ phase
	Output duty rate	$\frac{T}{2} \pm \frac{T}{3}$ (T=1 cycle of A phase)
	Phase difference of output	Output between A and B phase: $\frac{T}{4} \pm \frac{T}{4}$ (T=1 cycle of A phase)
	Control output	Line driver output	• [Low] - Load current: max. 20mA, residual voltage: max. 0.5VDC⎓ • [High] - Load current: max. -20mA, output voltage: min. 2.5VDC⎓
	Response time (rise, fall)	Frame size 20mm	Max. 1.5µs (cable length: 2m, I sink = 20mA)
		Frame size 28, 35mm	Max. 1µs (cable length: 2m, I sink = 20mA)
	Max. response frequency	Frame size 20mm	200kHz
		Frame size 28, 35mm	1,000kHz
	Power supply	5VDC⎓ ±5% (ripple P-P: max. 5%)
	Current consumption	Max. 50mA (disconnection of the load)

[1]: Microstep control for AiS driver, it controls up to 10,000PPR.

• Frame size 42, 56, 60mm

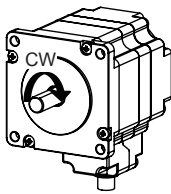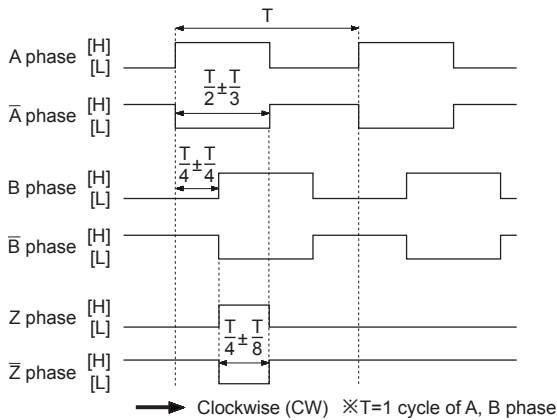| Item		Incremental rotary encoder
Resolution		10,000PPR (2,500PPR×4-multiply)
Electrical specification	Output phase	A, $\overline{A}$, B, $\overline{B}$, Z, $\overline{Z}$ phase
	Output duty rate	$\frac{T}{2} \pm \frac{T}{4}$ (T=1 cycle of A phase)
	Phase difference of output	Output between A and B phase: $\frac{T}{4} \pm \frac{T}{8}$ (T=1 cycle of A phase)
	Control output	Line driver output	• [Low] - Load current: max. 20mA, residual voltage: max. 0.5VDC⎓ • [High] - Load current: max. -20mA, output voltage: min. 2.5VDC⎓
	Response time (rise, fall)	Max. 0.5µs (cable length: 2m, I sink = 20mA)
	Max. response frequency	300kHz
	Power supply	5VDC⎓ ±5% (ripple P-P: max. 5%)
	Current consumption	Max. 50mA (disconnection of the load)

2-Phase Closed-Loop Stepper Motor
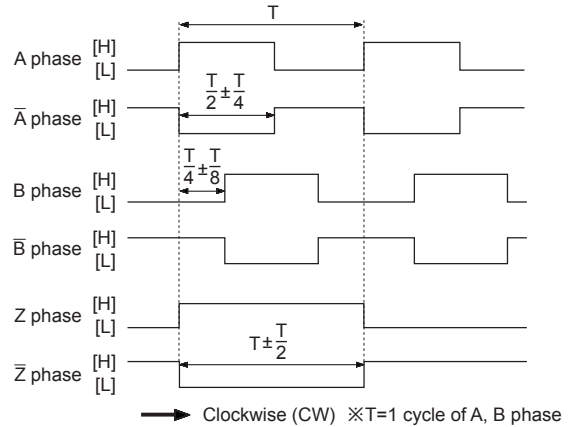
■ Encoder Control Output Diagram

Line driver output

Rotary encoder circuit	Load connection

+V

Main circuit

A phase output

$\overline{A}$ phase output

0V

$+$

$-$

※All output circuits of A, $\overline{A}$, B, $\overline{B}$, Z, $\overline{Z}$ phase are the same.

■ Encoder Output Waveforms

◎ **Frame size 20, 28, 35mm**

A phase [H] [L]

$\overline{A}$ phase [H] [L]

$\frac{T}{2} \pm \frac{T}{3}$

B phase [H] [L]

$\overline{B}$ phase [H] [L]

$\frac{T}{4} \pm \frac{T}{4}$

Z phase [H] [L]

$\overline{Z}$ phase [H] [L]

$\frac{T}{4} \pm \frac{T}{8}$

Clockwise (CW) ※T=1 cycle of A, B phase

◎ **Frame size 42, 56, 60mm**

A phase [H] [L]

$\overline{A}$ phase [H] [L]

$\frac{T}{2} \pm \frac{T}{4}$

B phase [H] [L]

$\overline{B}$ phase [H] [L]

$\frac{T}{4} \pm \frac{T}{8}$

Z phase [H] [L]

$\overline{Z}$ phase [H] [L]

$T \pm \frac{T}{2}$

Clockwise (CW) ※T=1 cycle of A, B phase

CW

■ Connection Diagram

Autonics 2 phase closed-loop stepper motors take bipolar wiring methods.
The wiring colors for each phase and lead-wire are as the followings:

Red/Black(A)

Yellow/Black(B)

Motor

Blue/Black($\overline{A}$)

White/Black($\overline{B}$)

Ai-M Series

■ Dimensions

◎ Frame size 20mm
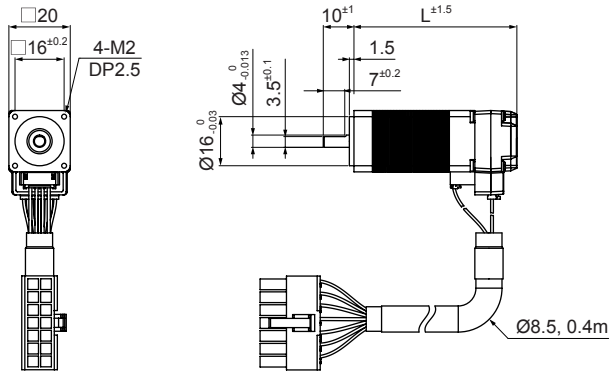
Model	L
Ai-M-20MA	41.2
Ai-M-20LA	53.1

◎ Frame size 28mm
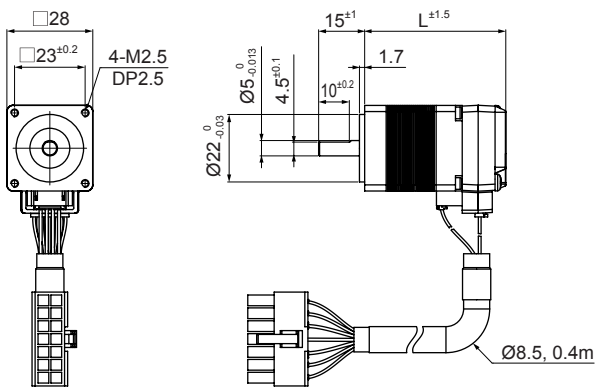
Model	L
Ai-M-28SB	46
Ai-M-28MB	59
Ai-M-28LB	65

◎ Frame size 35mm
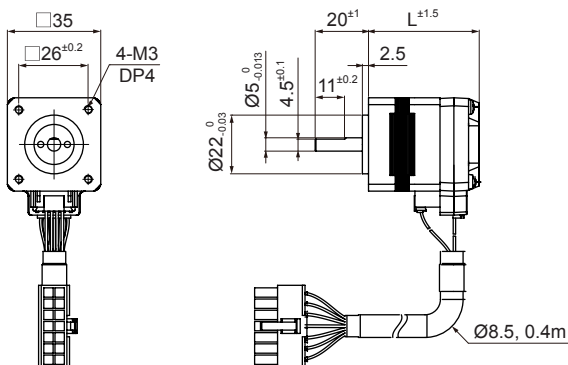
Model	L
Ai-M-35SB	41.5
Ai-M-35MB	52
Ai-M-35LB	68.5

Autonics

2-Phase Closed-Loop Stepper Motor

■ Dimensions

(unit: mm)
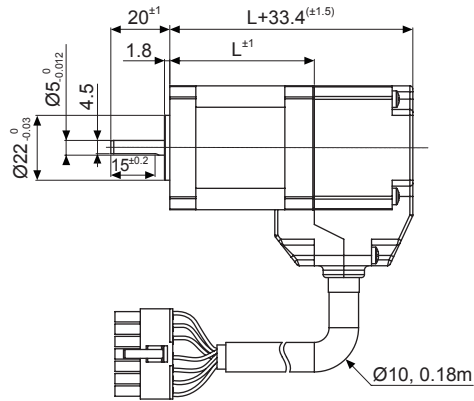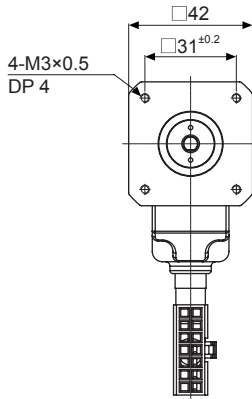
◎ Frame size 42mm

Model	L
Ai-M-42SA	34.1
Ai-M-42MA	40.1
Ai-M-42LA	48.1

◎ Frame size 56mm
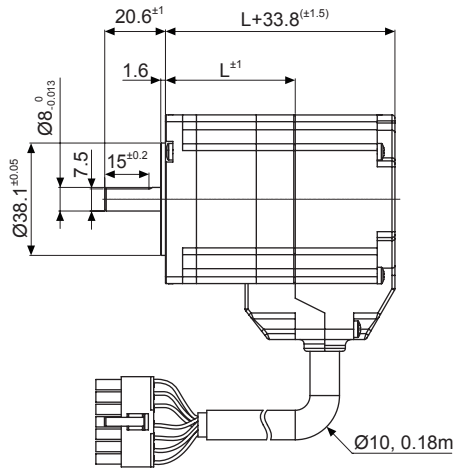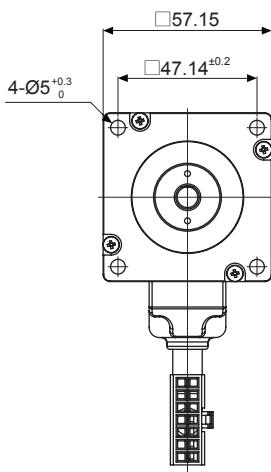
Model	L
Ai-M-56SA	43.5
Ai-M-56MA	56.5
Ai-M-56LA	77.5

◎ Frame size 60mm
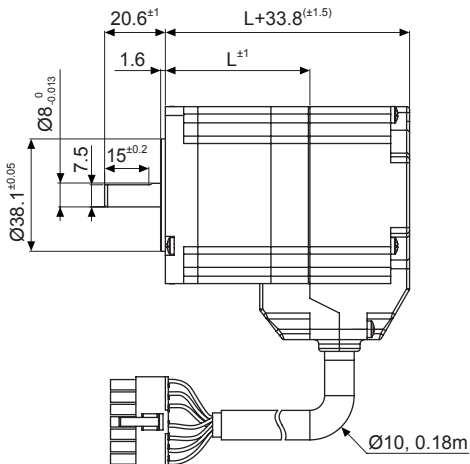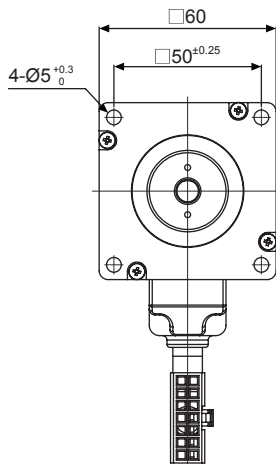
Model	L
Ai-M-60SA	48.1
Ai-M-60MA	69
Ai-M-60LA	86

(A)
Photoelectric
Sensors

(B)
Fiber
Optic
Sensors

(C)
Door/Area
Sensors

(D)
Proximity
Sensors

(E)
Pressure
Sensors

(F)
Rotary
Encoders

(G)
Connectors/
Connector Cables/
Sensor Distribution
Boxes/Sockets

(H)
Temperature
Controllers

(I)
SSRs / Power
Controllers

(J)
Counters

(K)
Timers

(L)
Panel
Meters

(M)
Tacho /
Speed / Pulse
Meters

(N)
Display
Units

(O)
Sensor
Controllers

(P)
Switching
Mode Power
Supplies

(Q)
Stepper Motors
& Drivers
& Controllers

(R)
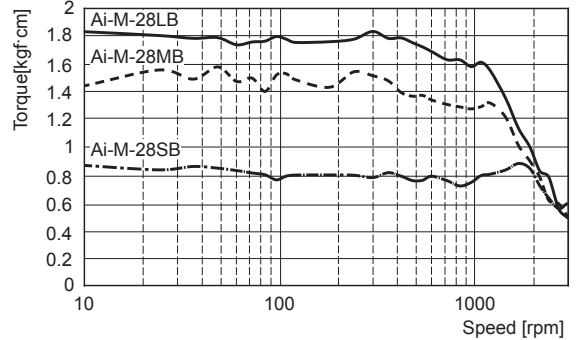Graphic/
Logic
Panels

(S)
Field
Network
Devices
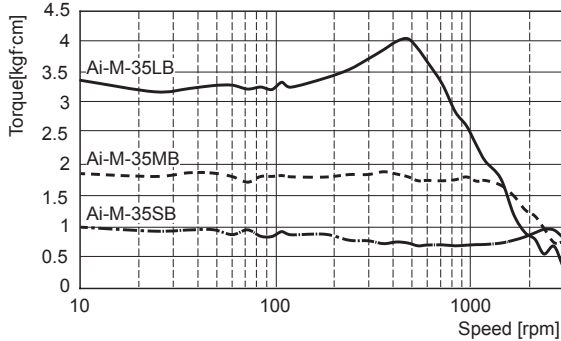
(T)
Software

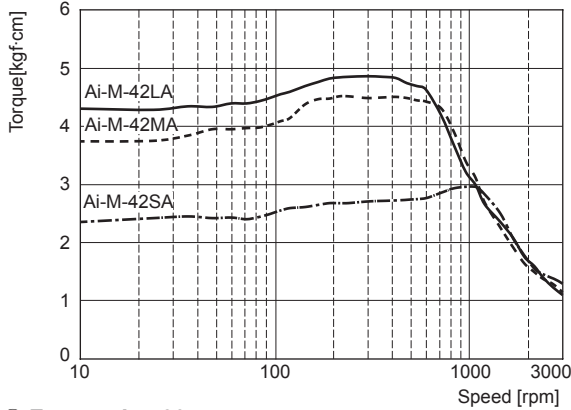# Ai-M Series

▣ Motor Characteristics

◎ Frame size 20mm
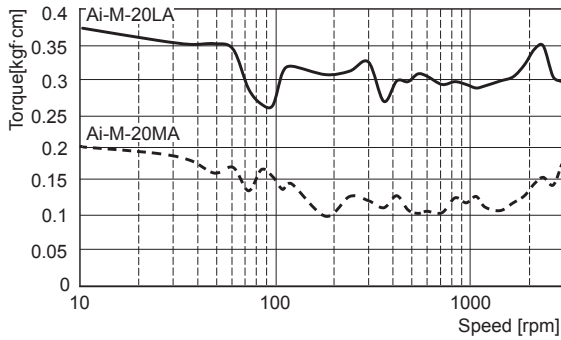
Torque[kgf·cm] vs Speed [rpm]
Ai-M-20LA
Ai-M-20MA

◎ Frame size 28mm

Torque[kgf·cm] vs Speed [rpm]
Ai-M-28LB
Ai-M-28MB
Ai-M-28SB

◎ Frame size 35mm

Torque[kgf·cm] vs Speed [rpm]
Ai-M-35LB
Ai-M-35MB
Ai-M-35SB

◎ Frame size 42mm

Torque[kgf·cm] vs Speed [rpm]
Ai-M-42LA
Ai-M-42MA
Ai-M-42SA

◎ Frame size 56mm

Torque[kgf·cm] vs Speed [rpm]
Ai-M-56LA
Ai-M-56MA
Ai-M-56SA

◎ Frame size 60mm

Torque[kgf·cm] vs Speed [rpm]
Ai-M-60LA
Ai-M-60MA
Ai-M-60SA

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■ Connection Connectors of Motor

◎ CN2: Motor+Encoder Connector

Pin arrangement	Pin no.	Function	Pin no.	Function
	1	GND	8	+5VDC
	2	ENCODER A	9	ENCODER $\overline{A}$
	3	ENCODER B	10	ENCODER $\overline{B}$
	4	ENCODER Z	11	ENCODER $\overline{Z}$
	5	GND EARTH	12	N·C
	6	MOTOR A	13	MOTOR B
	7	MOTOR $\overline{A}$	14	MOTOR $\overline{B}$

Type			Specifications			Manufacture
			Connector	Connector terminal	Housing	
CN2	Motor+ Encoder	Frame size 20, 28, 35mm	5557-14R	5556T2	—	Molex
		Frame size 42, 56, 60mm		5556T		

※Above connectors are suitable for Ai-M Series. You can use equivalent or substitute connectors.

◎ Cable (sold separately)

| Type	Model	
Motor+Encoder cable	Normal	Moving
	C1D14M-□※1	C1DF14M-□※1

※1: □ indicates cable length (1, 2, 3, 5, 7, 10).
    E.g.) C1DF14M-10: 10m moving type motor+encoder cable.

■ Motor Installation

1. Mounting direction

Motor can be mounted in any directions-facing up, facing down and side ways.
No matter which direction motors to be mounted, make sure not to apply overhung or thrust load on the shaft.
Refer to the table below for allowable shaft overhung load / thrust load.

Side ways
Overhung load
D※1

Facing up, down
Thrust load
Thrust load
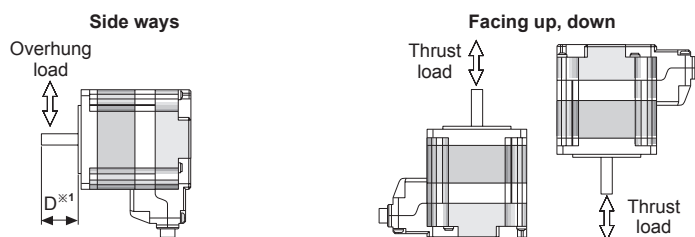
※1: The distance from the shaft in front (mm)

Motor size	The distance from the shaft in front (mm), Allowable overhung load [kgf (N)]				Allowable thrust load
	D=0	D=5	D=10	D=15	
Frame size 20mm	1.22 (12)	1.53 (15)	—	—	
Frame size 28mm	2.55 (25)	3.46 (34)	5.3 (52)	—	
Frame size 35mm	2 (20)	2.55 (25)	3.46 (34)	5.3 (52)	
Frame size 42mm	2 (20)	2.6 (25)	3.5 (34)	5.3 (52)	Under the load of motor
Frame size 56mm	5.5 (54)	6.8 (67)	9.1 (89)	13.3 (130)	
Frame size 60mm					

Do not apply excessive force to motor cable when mounting motors.
Do not forcibly pull or insert the cable. It may cause poor connection or disconnection of the cable by force.
In case of frequent cable movement required application, proper safety countermeasures must be ensured.
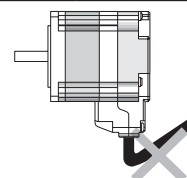
Ai-M Series

▣ Motor Installation

2. Mounting method

With considering heat radiation and vibration isolation, mount the motor as tight as possible against a metal panel having high thermal conductivity such as iron or aluminum.
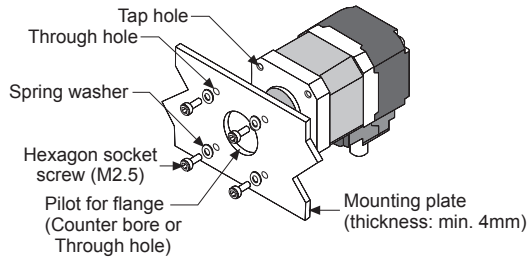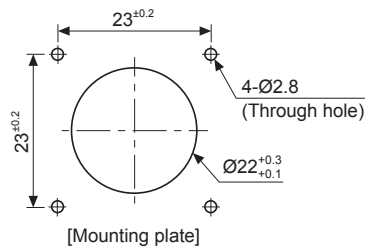When mounting motors, use hexagon socket screws, hexagon nuts, spring washers and flat washers.
Refer to the table below for allowable thickness of mounting plate and using bolt.

◎ **Frame size 20mm**
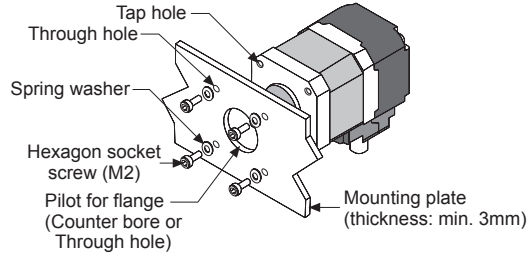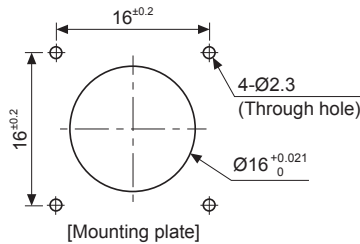
※Do not draw the wire with over strength 5N after wiring the encoder.

◎ **Frame size 28mm**

※Do not draw the wire with over strength 5N after wiring the encoder.

◎ **Frame size 35mm**
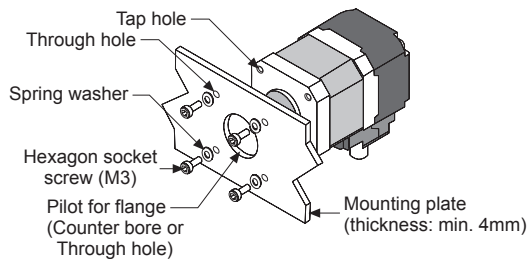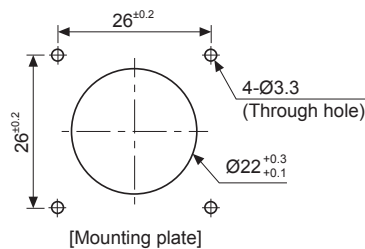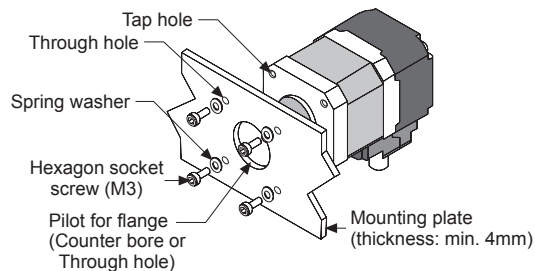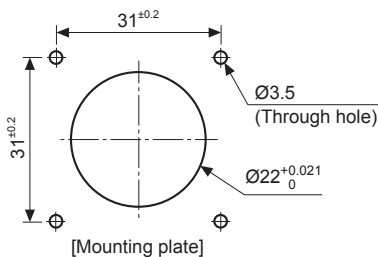

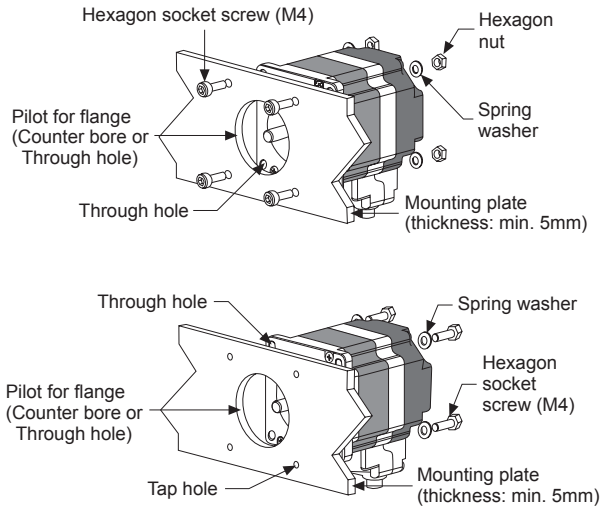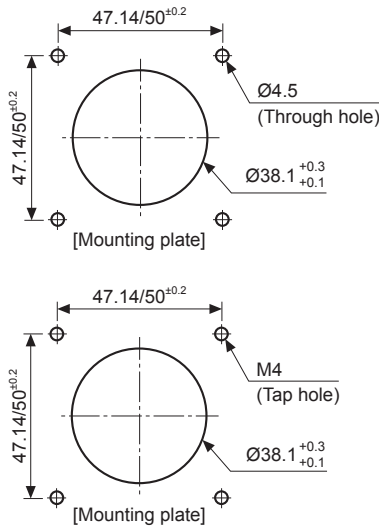※Do not draw the wire with over strength 5N after wiring the encoder.

◎ **Frame size 42mm**

※Do not draw the wire with over strength 30N after wiring the encoder.

Autonics

2-Phase Closed-Loop Stepper Motor

◎ **Frame size 56mm/60mm**

47.14/50$^{±0.2}$

47.14/50$^{±0.2}$

Ø4.5
(Through hole)

Ø38.1 $^{+0.3}_{+0.1}$

[Mounting plate]

Hexagon socket screw (M4)

Hexagon nut

Pilot for flange
(Counter bore or
Through hole)

Spring washer

Through hole

Mounting plate
(thickness: min. 5mm)

47.14/50$^{±0.2}$

47.14/50$^{±0.2}$

M4
(Tap hole)

Ø38.1 $^{+0.3}_{+0.1}$

[Mounting plate]

Through hole

Spring washer

Pilot for flange
(Counter bore or
Through hole)

Hexagon
socket
screw (M4)

Tap hole

Mounting plate
(thickness: min. 5mm)

※Do not draw the wire with over strength 30N after wiring the encoder.

3. Connection with load

When connecting the load, be sure of the center, tension of the belt, and parallel of the pulley.
When connecting the load such as a pulley, a belt, be sure of the allowable thrust load, radial load, and shock.
Tighten the screw for a coupling or a pulley not to be unscrewed.
When connecting a coupling or a pulley on the motor shaft, be sure of damage of the motor shaft and the motor shaft bearing.
Do not disassemble or modify the motor shaft to connect with the load.

Direct load connection with coupling	Load connection with pulley, belt, and wire	Load connection with gear
Flexible coupling Ball screw or TM screw ※Use Autonics flexible coupling (ERB Series).		
When connecting the load directly (ball screw, TM screw, etc) to the motor shaft, use a flexible coupling as shown in the above figure. If the center of the load is not aligned with that of shaft, it may cause severe vibration, shaft damage or shorten life cycle of the shaft bearing.	The motor shaft and the load shaft should be parallel. Connect the motor shaft and the line which connects the center of two pulleys to a right angle.	The motor shaft and the load shaft should be parallel. Connect the motor shaft to the center of gear teeth side to be interlocked.

4. Installation condition

Install the motor in a place that meets certain conditions specified below.
It may cause product damage if it is used out of following conditions.
①Inside of the housing which is installed indoors
  (This unit is manufactured for the purpose of attaching to equipment. Install a ventilation device.)
②Within 0 to 50℃ (at non-freezing status) of ambient temperature
③Within 20 to 85%RH (at non-dew status) of ambient humidity
④The place without explosive, flammable and corrosive gas
⑤The place without direct ray of light
⑥The place where dust or metal scrap does not enter into the unit
⑦The place without contact with water, oil, or other liquid
⑧The place without contact with strong alkali or acidity
⑨The place where easy heat dissipation could be made
⑩The place without continuous vibration or severe shock
⑪The place with less salt content
⑫The place with less electronic noise occurs by welding machine, motor, etc.
⑬The place where no radioactive substances and magnetic fields exist. It shall be no vacuum status as well.

(A)
Photoelectric
Sensors

(B)
Fiber
Optic
Sensors

(C)
Door/Area
Sensors

(D)
Proximity
Sensors

(E)
Pressure
Sensors

(F)
Rotary
Encoders

(G)
Connectors/
Connector Cables/
Sensor Distribution
Boxes/Sockets

(H)
Temperature
Controllers

(I)
SSRs / Power
Controllers

(J)
Counters

(K)
Timers

(L)
Panel
Meters

(M)
Tacho /
Speed / Pulse
Meters

(N)
Display
Units

(O)
Sensor
Controllers

(P)
Switching
Mode Power
Supplies

(Q)
Stepper Motors
& Drivers
& Controllers

(R)
Graphic/
Logic
Panels

(S)
Field
Network
Devices

(T)
Software

Ai-M Series

◙ Troubleshooting

1. When motor does not rotate
　①Check the connection status between controller and driver, and pulse input specifications (voltage, width).
　②Check the pulse and direction signal are connected correctly.
2. When motor rotates to the opposite direction of the designated direction
　①When RUN mode is 1-pulse input method, CCW input [H] is for forward, [L] is for backward.
　②When RUN mode is 2-pulse input method, check CW and CCW pulse input are changed or not.
3. When motor drive is unstable
　①Check that driver and motor are connected correctly.
　②Check the driver pulse input specifications (voltage, width).

◙ Proper Usage

1. Follow instructions in 'Proper Usage'.
　Otherwise, it may cause unexpected accidents.
2. Using motors at low temperature may cause reducing ball bearing's grease consistency and friction torque is increased.
　Start the motor in a steady manner since motor's torque is not to be influenced.
3. If wiring encoder cable, separate it from high voltage line or power cable for preventing surge and inductive noise.
　The cable length should be as short as possible.
　Failure to follow this instruction may result in raised cable resistance, residual voltage, and output waveform noise
4. Must connect the encoder shield cable to the F.G. terminal.
5. For using motor, it is recommended to maintenance and inspection regularly.
　①Unwinding bolts and connection parts for the unit installation and load connection
　②Strange sound from ball bearing of the unit
　③Damage and stress of lead cable of the unit
　④Connection error with driver
　⑤Inconsistency between the axis of motor output and the center, concentric (eccentric, declination) of the load, etc.
6. This unit may be used in the following environments.
　①Indoors (in the environment condition rated in 'Specifications')
　②Altitude max. 2,000m
　③Pollution degree 2
　④Installation category II

Autonics