

FACTORY AUTOMATION

Mitsubishi Electric Sensorless Servo Global PM Motors EM-A Series



Mitsubishi Electric Sensorless Servo Global PM Motors

EM-Aseries

For the EM-A Series, Mitsubishi Electric has developed a unique salient-pole core* to realize high-performance magnetic motors that can ensure positioning and speed control without a sensor.

*Patent No.: 5646119

Downsizing and energy saving



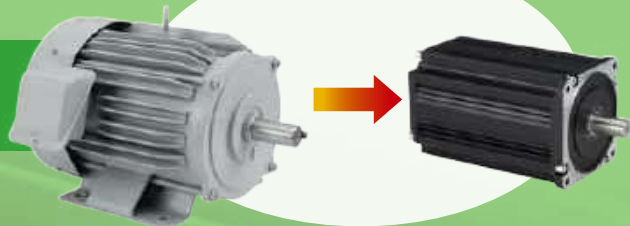
Globalization

High performance

Downsizing and energy saving

Problems

- Downsizing of equipment
- Energy saving



Solutions

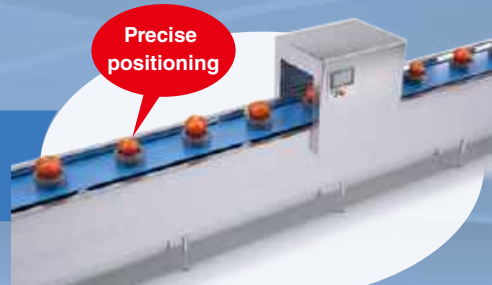
- The motors use cores with optimum shapes for sensorless control, and the motor frame numbers are lower by 1 or 2 compared to induction motors. Then, the equipment can be downsized.
- The use of the magnetic motors meeting the efficiency class* IE5 for variable speed motors can promote energy saving.

* According to the efficiency reference values (%) for variable speed motors (rated speed 1801 to 6000 r/min) based on IEC60034-30-2.

High performance

Problems

- Improvement of equipment performance and cost reduction



Solutions

- Mitsubishi Electric's unique sensorless control realizes precise speed control comparable to that of servo motors.
- Positioning control can be achieved without a sensor (encoder).

Globalization

Problems

- Use of the same motor in the equipment exported to various countries



Solutions

- Since the magnetic motors do not require*1 the high efficiency certification in each country, they can be easily used in the equipment to be exported.
- Conformance to international safety standards (UL/cUL, CE/UKCA) is also available.

*1: As of July 2023 (with partial compliance with China Energy Label Law (CEL 038-2020))

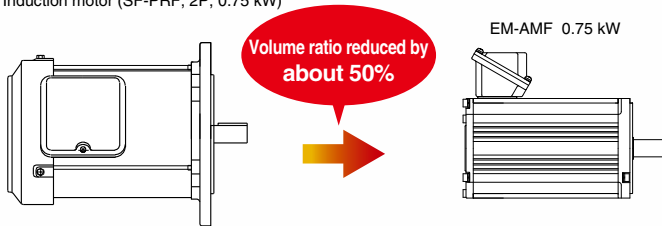
Downsizing and energy saving

Downsizing

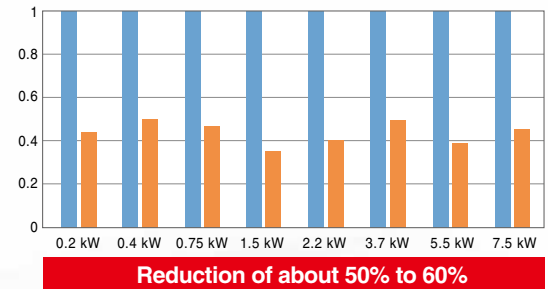
- The motor core shape optimum for sensorless control realizes 50 to 60% reduction of volume and 30 to 50% reduction of mass compared to induction motors.

[Comparison of volume]

Induction motor (SF-PRF, 2P, 0.75 kW)

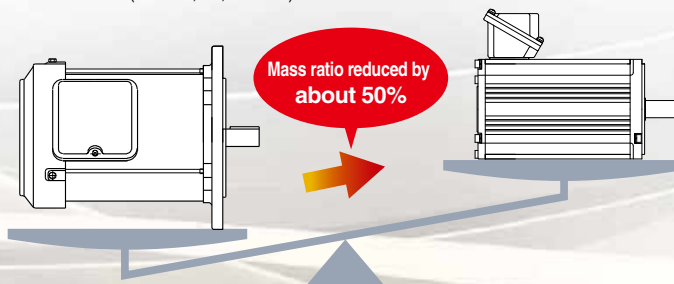


[Volume] When the volume of induction motors is 1

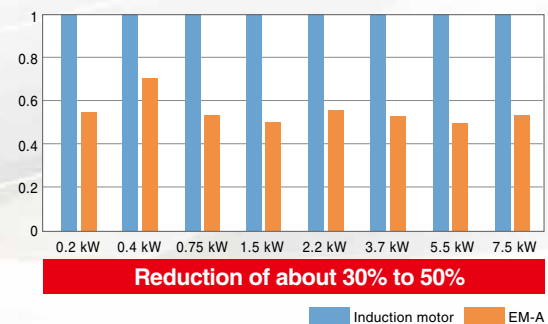


[Comparison of mass]

Induction motor (SF-PRF, 2P, 0.75 kW)



[Mass] When the mass of induction motors is 1



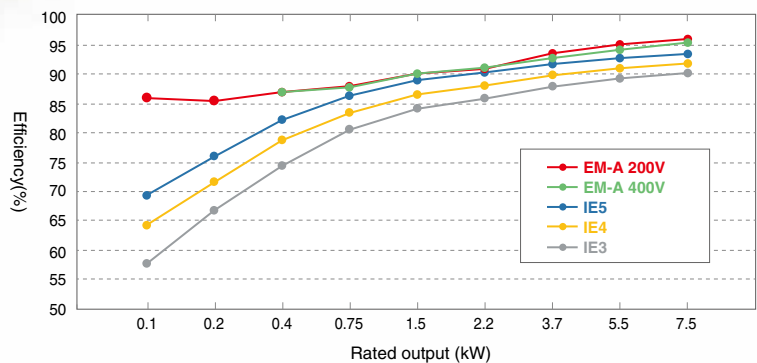
Energy saving

- Energy-saving motors meeting the efficiency class* IE5 for variable speed motors.

* According to the efficiency reference values (%) of variable speed motors based on IEC60034-30-2 (at the rated speed of 1801 to 6000 r/min).

* Representative data; values are not guaranteed.

Meeting the IE5 efficiency standard



- The motors consume lower electric power and contribute to the reduction of energy charge, which reduces the CO₂ emission and contributes to the prevention of global warming.

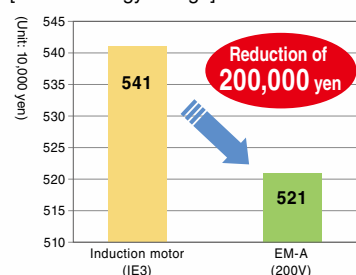
<Estimation conditions>

Efficiency value when 10 motors are operated at the rated load for 8760 hr/year (= 24 hr/day × 365 days/year) with an electricity rate of 15 yen/kWh and CO₂ emissions of 0.42 kg/kWh

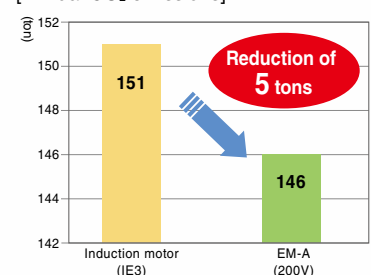
* This data is for reference only.

Energy-saving efficiency when using ten 3.7 kW motors

[Annual energy charge]



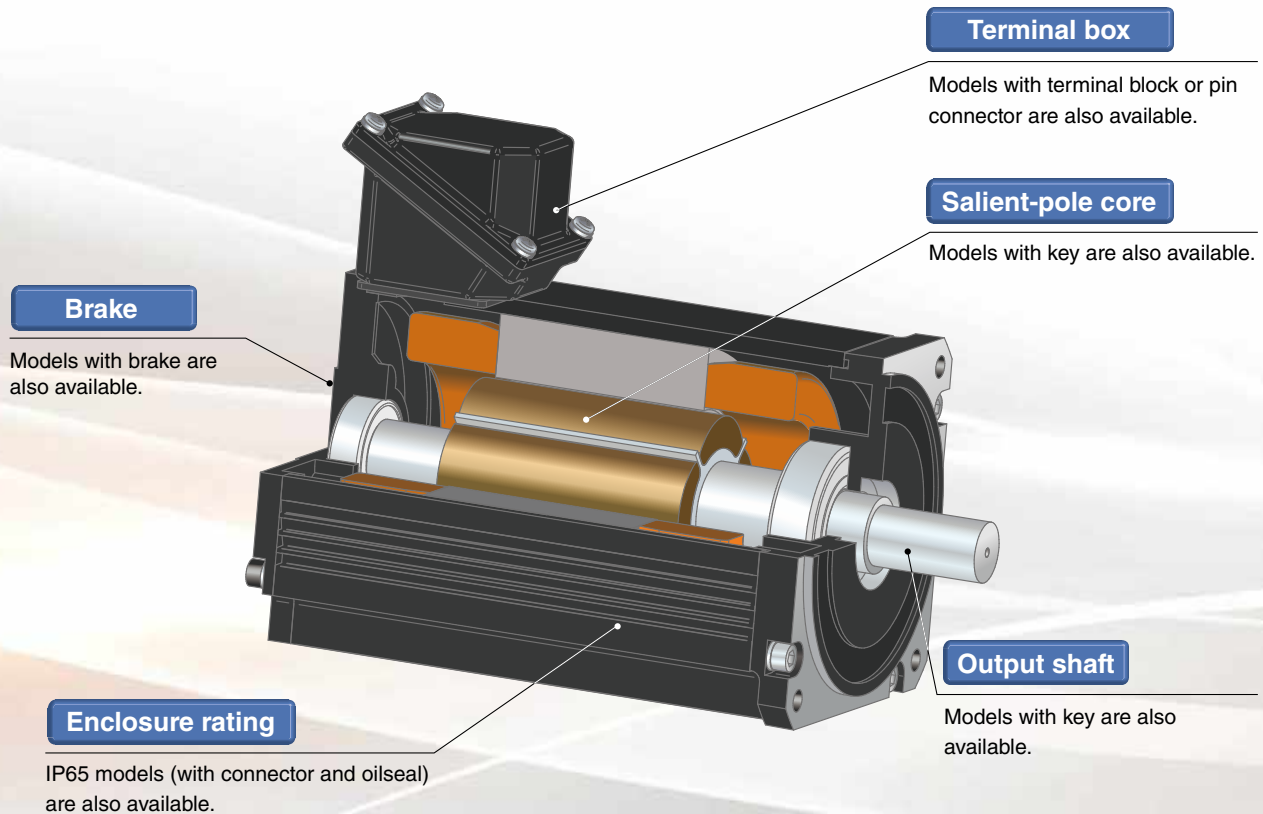
[Annual CO₂ emissions]



High performance

Mitsubishi Electric has developed a unique salient-pole core to achieve high-performance magnetic motors that can be controlled position and speed without a sensor.

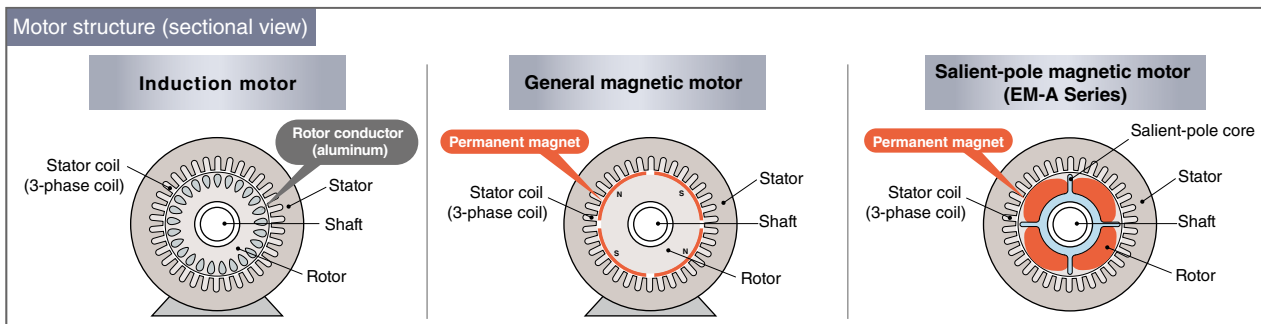
1 Concepts: Downsizing and energy savings; High performance; Globalization (International standard specifications)



Newly developed salient-pole magnetic motors

EM-A series include newly developed magnetic motors using the patented salient-pole core^{*1}. The rotor consists of the salient-pole core and surface-mounted permanent magnet, and therefore the motor inductance changes depending on the rotational position. This change in inductance is applied to the sensorless control.

The combination of the newly developed salient-pole magnetic motor and Mitsubishi Electric's unique high-performance sensorless control technique enables high-accuracy speed control and position control without a sensor (encoder). ^{*1} Patent No. 5646119



Speed control

Speed control comparable to servo motors is achieved without a sensor.

Speed variation ratio:
±0.05%
* In the case of digital input

Max. torque:
200%

- EM-A series realizes high-accuracy speed control by using Mitsubishi Electric's unique PM sensorless vector control that does not cause significant speed variations even under changing loads.
- EM-A series can be applied to high precision transfer systems of semiconductor and liquid crystal manufacturing lines.
- EM-A series can drive at stable speed ever when load fluctuates.

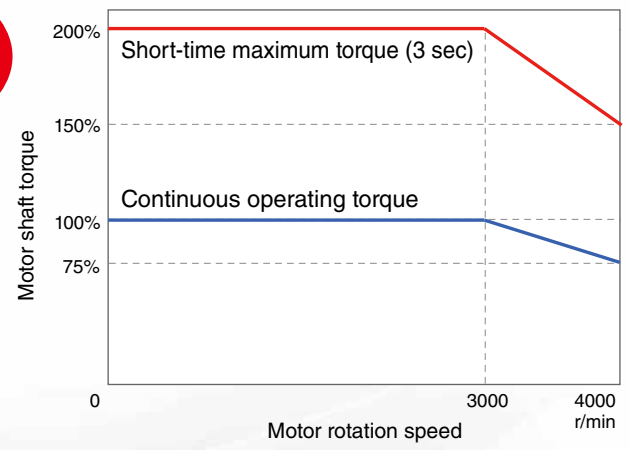
Speed variation ratio: ±0.05% *1
Speed control range: 1:1000

*1: When load changes between 0 and 100%

$$\text{Speed variation ratio} = \frac{\text{Actual rotation speed} - \text{command rotation speed}}{\text{Rated speed}} \times 100(\%)$$

- The servo lock function generates holding torque when the motor stops and can prevent movement by external force.

[Operating torque characteristics]



* Torque characteristics may decline when the input voltage is low.
 * The continuous operating torque is 90% at 10 r/min or less (1.5 kW or more).
 * When high-load operation is performed in low-speed areas (in particular at 15 r/min or less (0.75 kW or less) or 10 r/min or less (1.5 kW or more)), the electronic thermal protector (E.THT or ETHM) may activate and it may not be possible to produce torque in the short-time operating area.
 * At low speeds (approx. 100 r/min or less), speed may be uneven due to torque ripples caused by magnetic attraction/repulsion forces of the motor.
 * The indicated maximum torque (200%) is for 3-phase inverter power specifications.

Positioning control

Positioning can be performed without a sensor.

- The combination of the newly developed salient-pole magnetic motor and Mitsubishi Electric's unique high-performance sensorless control technique enables high-precision speed control and positioning control without a sensor (encoder).
- The positioning function (point table method) using a contact signal and CC-Link communication (optional) can be used.*1
 The use of the pulse-train input option*2 enables positioning by using a programmable controller positioning module.

Positioning accuracy:
200p/rev

Positioning accuracy: 200 p/rev *3
Inverter position command resolution: 4096 p/rev

*1: The function is not applicable to absolute position detection systems.
 *2: FR-A7AP-EX kit (Only compatible with the FR-E700EX Series)
 *3: See the inverter instruction manual for wiring length requirements.

International standards compliance

○: Compliant x: Not compliant —: Not applicable

Model	EM-AMF(K)(W)			EM-AMF(K)T			EM-AMFB(K)(W)			EM-AMFB(K)T		
	UL/cUL	CE/UKCA	CEL	UL/cUL	CE/UKCA	CEL	UL/cUL	CE/UKCA	CEL	UL/cUL	CE/UKCA	CEL
0.1kW	○	○	—	○	○	—	○	○	—	○	○	—
0.2kW	○	○	—	○	○	—	○	○	—	○	○	—
0.4kW	○	○	—	○	○	—	○	○	—	○	○	—
0.75kW	○	○	○	○	○	○	○	○	—	○	○	—
1.5kW	○	○	○	○	○	○	○	○	—	○	○	—
2.2kW	○	○	○	○	○	○	○	○	—	○	○	—
3.7kW	○	○	○	x	x	x	○	○	—	x	x	—
5.5kW	○	○	○	x	x	x	○	○	—	x	x	—
7.5kW	○	○	○	x	x	x	○	○	—	x	x	—

* 400 V class models available only as 0.4 kW or higher.

* CEL compliance available only with 200 V class models. (Compliance planned for 400 V class.)

Compatible with wide range of voltages!

Compatibility with a wide range of voltages, one motor can be used in various regions around the world.

Motor voltage class	Inverter power supply specification	Inverter input voltage/frequency
200V	3-phase 200 V	3-phase 200 to 240 V, 50/60 Hz
	Single-phase 200 V	Single-phase 200 to 240 V, 50/60 Hz
	Single-phase 100 V	Single-phase 100 to 120 V, 50/60 Hz
400V	3-phase 400 V	3-phase 380 to 480 V, 50/60 Hz

Special specifications also available!

Waterproof specifications (IP65) and terminal block* models and models with terminal box socket directionality are also separately available.

* Terminal block models are limited to 2.2 kW or less.

Mitsubishi Electric Global FA Centers

Mitsubishi Electric offers full-fledged global factory automation services through dedicated staff with extensive experience and advanced technical skills across the globe. Customers can enjoy top-of-the-line service and support from any of our numerous support locations.

EMEA

- MITSUBISHI ELECTRIC EUROPE B.V. Polish Branch
- MITSUBISHI ELECTRIC EUROPE B.V. German Branch
- MITSUBISHI ELECTRIC EUROPE B.V. UK Branch
- MITSUBISHI ELECTRIC EUROPE B.V. Czech Branch
- MITSUBISHI ELECTRIC EUROPE B.V. Italian Branch
- MITSUBISHI ELECTRIC TURKEY ELEKTRIK URUNLERI A.S.

Asia-Pacific

China

- MITSUBISHI ELECTRIC AUTOMATION (CHINA) LTD. Beijing FA Center
- MITSUBISHI ELECTRIC AUTOMATION (CHINA) LTD. Guangzhou FA Center
- MITSUBISHI ELECTRIC AUTOMATION (CHINA) LTD. Shanghai FA Center
- MITSUBISHI ELECTRIC AUTOMATION (CHINA) LTD. Tianjin FA Center
- SETSUYO ENTERPRISE CO., LTD.

Korea

- MITSUBISHI ELECTRIC AUTOMATION KOREA CO., LTD.

Thailand

- MITSUBISHI ELECTRIC FACTORY AUTOMATION (THAILAND) CO., LTD.

ASEAN

- MITSUBISHI ELECTRIC ASIA PTE. LTD.

Malaysia

- Malaysia FA Center

Indonesia

- PT. MITSUBISHI ELECTRIC INDONESIA Cikarang Office

Vietnam

- MITSUBISHI ELECTRIC VIETNAM COMPANY LIMITED Hanoi Branch Office
- MITSUBISHI ELECTRIC VIETNAM COMPANY LIMITED

Philippines

- MELCO Factory Automation Philippines Inc.

India

- MITSUBISHI ELECTRIC INDIA PVT. LTD. Ahmedabad Branch
- MITSUBISHI ELECTRIC INDIA PVT. LTD. Bangalore Branch
- MITSUBISHI ELECTRIC INDIA PVT. LTD. Chennai Branch
- MITSUBISHI ELECTRIC INDIA PVT. LTD. Coimbatore Branch
- MITSUBISHI ELECTRIC INDIA PVT. LTD. Gurgaon Head Office
- MITSUBISHI ELECTRIC INDIA PVT. LTD. Pune Branch

Americas

USA

- MITSUBISHI ELECTRIC AUTOMATION, INC.

Mexico

- MITSUBISHI ELECTRIC AUTOMATION, INC. Mexico Branch
- MITSUBISHI ELECTRIC AUTOMATION, INC. Queretaro Office
- MITSUBISHI ELECTRIC AUTOMATION, INC. Monterrey Office

Brazil

- MITSUBISHI ELECTRIC DO BRASIL COMERCIO E SERVICOS LTDA.

Lineup/Specifications

Lineup

● Motor only

EM EM: Global PM motor	A A: A series	M M: Motor only	F F: Flange type	B None: Without brake B: With brake	K None: Without key K: With key	None: IP44 W: IP65 T: With terminal block ¹	
				Output 0.1 to 7.5kW ²	Rotation Speed 3000 r/min	Voltage 200 V class 400 V class	Special specification Terminal box socket direction International standards specification ³

*1: For details, see p. 13.

*2: 400 V class models available only as 0.4 kW or higher.

*3: For details, see p. 8 and 9.

Specifications

● Common EM-A motor specifications

Output (kW)	0.1 ⁴	0.2 ⁴	0.4	0.75	1.5	2.2	3.7	5.5	7.5		
Motor frame number	50Fr		63Fr		71Fr		100Fr				
Flange angle size	□90		□110		□125		□176				
Number of poles	4				6						
Rated frequency (Hz)	100				150						
Rated motor rotation speed(r/min)					3000						
Max. motor rotation speed(r/min)					4000						
Motor rated torque(Nm)	0.32	0.64	1.27	2.39	4.78	7.0	11.8	17.5	23.9		
Motor max. torque(%)	200 ⁵										
Positioning accuracy(p/rev)	200 ⁶										
Rating	Continuous										
Allowable output shaft overhang load (N) ⁷	392		490		686		1470				
Allowable output shaft thrust load (N)	196		294		490		980				
Heat resistance class	130(B)						155(F)				
Moment of inertia J (×10 ⁻⁴ kg·m ²)	Without brake		1.51	1.51	3.72	5.43	11.4	16.5	62.0	85.5	109
	With brake		1.53	1.53	4.03	5.74	12.2	17.3	66.5	90.0	113.5
Recommended moment of load inertia ratio	10 times or less										
Enclosure rating	Indoor type (IP44) ⁸ , Dust and waterproof type (IP65) ^{8,9}										
Enclosure structure	Totally-enclosed self-cooling type										
Ambient temperature/relative humidity	0 to +40°C / RH 90% or less										
Altitude	Up to 1000 m above sea level										
Vibration	Constant 4.9 m/s ² , instantaneous 9.8 m/s ² or less										
Brake specifications	DC spring holding type (24 V DC) (Brake torque 150% or more/allowable number of braking operations 1000 times/ mechanical life 1,000,000 times)										
Paint color	Black (equivalent to Munsell N1.5)										
Weight(kg)	Without brake		2.9	2.9	4.9	6.4	9.5	11.7	22	28	34
	With brake		3.9	3.9	6.7	8.2	12.2	14.4	28	34	40

*4: 200 V class only.

*5: Excluding single-phase input.

*6: See the inverter instruction manual for wiring length requirements.

*7: With load position at the center of the output shaft.

*8: Excluding the part where the shaft passes through.

*9: With EM-AMF□□V

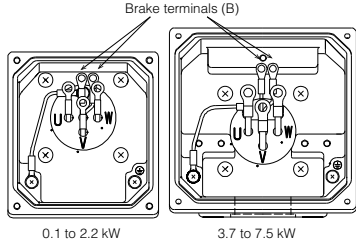
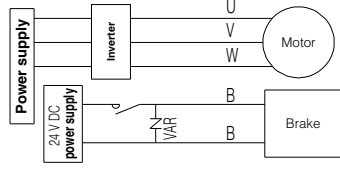
○: Supported —: Not applicable

200 V class	Output (kW)		0.1	0.2	0.4	0.75	1.5	2.2	3.7	5.5	7.5
	Supported inverter	Capacity (□K)		0.1	0.2	0.4	0.75	1.5	2.2	3.7	5.5
FR-E720EX-□K ¹⁰			○	○	○	○	○	○	○	—	—
R-E820-□K ¹⁰			○	○	○	○	○	○	○	○	○
FR-E820S-□K ¹⁰			○	○	○	○	○	○	—	—	—
	FR-E810W-□K ¹⁰		○	○	○	○	—	—	—	—	—
	Motor rated voltage(V)		130	135	160	165	170	165	160	170	165
	Motor rated current(A)		0.55	1.1	1.8	3.3	6.1	9.3	16.5	22	31
400 V class	Output (kW)		0.4	0.75	1.5	2.2	3.7	5.5	7.5		
	Supported inverter	Capacity (□K)	0.4	0.75	1.5	2.2	3.7	5.5	7.5		
		FR-E840-□K ¹⁰		○	○	○	○	○	○		
		Motor rated voltage(V)	320	330	340	330	320	340	330		
	Motor rated current(A)	0.9	1.7	3.1	4.7	8.3	11	15.5			

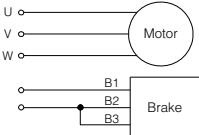
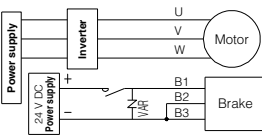
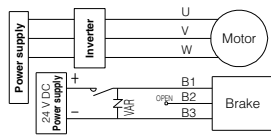
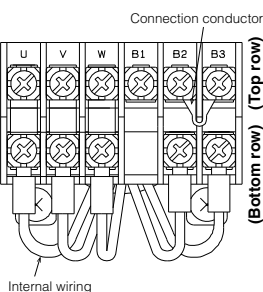
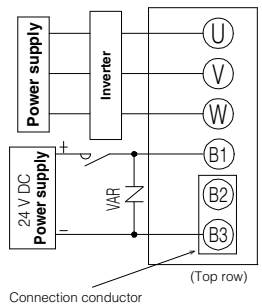
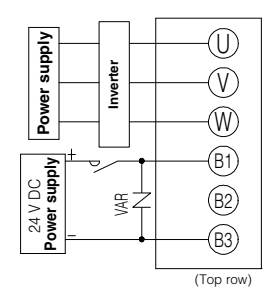
*10: Be sure to perform initial setup of PM parameters (Pr.998) when using an EM-A motor for operation. See the inverter instruction manual for details.

Brake wiring

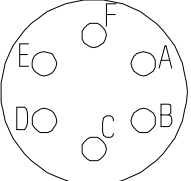
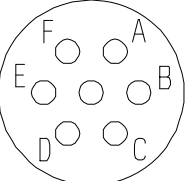
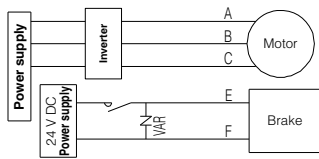
● Lug model

Terminal drawer structure	Connection diagram		
 <p>0.1 to 2.2 kW 3.7 to 7.5 kW</p>			
	<table border="1"> <tr> <td>Motion delay time</td> <td>0.01 to 0.04 s</td> </tr> </table>	Motion delay time	0.01 to 0.04 s
Motion delay time	0.01 to 0.04 s		

● Terminal block model

Shipped	Separation switching	DC switching (fast switching)			
 <p>Circuit</p>					
 <p>Connection diagram</p>					
<table border="1"> <tr> <td>Motion delay time</td> <td>0.1 to 0.3 s</td> <td>0.01 to 0.04 s</td> </tr> </table>	Motion delay time	0.1 to 0.3 s	0.01 to 0.04 s		
Motion delay time	0.1 to 0.3 s	0.01 to 0.04 s			

● Connector model

Connector pin assignment		Connection diagram		
0.1 to 0.75 kW	1.5 kW, 2.2 kW			
				
<p>A: Power supply (U) B: Power supply (V) C: Power supply (W) D: Ground E, F: Brake power supply (24 V DC)</p>		<table border="1"> <tr> <td>Motion delay time</td> <td>0.01 to 0.04 s</td> </tr> </table>	Motion delay time	0.01 to 0.04 s
Motion delay time	0.01 to 0.04 s			

Precautions

- (1) For terminal block models, connect the positive (+) side of the 24 V DC power supply to B1, and the negative (-) side to B3.
- (2) When using DC switching (fast switching), remove the connection conductor from the terminal block as shown in the figure above.
- (3) The terminal block has a top and bottom row. Be sure to connect the motor and brake power supply wiring to the terminal screws on the top row shown in the figure above.
- (4) No manual release mechanism is included. Electrically release the electromagnetic brake by supplying 24 V DC power.
- (5) Note that power factor correction capacitors cannot be used in the motor circuit.
- (6) When applying the brake, set the brake to operate after rotation of the motor has stopped.
- (7) See the instruction manual for surge absorber (varistor) selection examples.

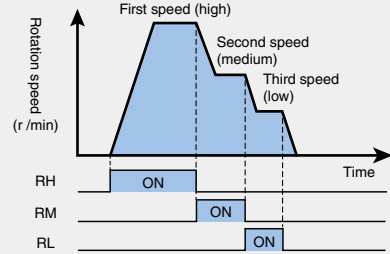
1

Operating in the speed control mode

The motor can be operated at a specified speed with an external operation switch.

3-speed operation can be performed with an external operation switch.

* Setting multiple speeds (up to 15) is also possible.



Operation procedure

1	Screen displayed when power is turned on	The monitor screen appears.
2	Speed setting	Turn on the high speed switch (RH).
3	Start → Acceleration → Constant speed	Turn on the start switch (STF or STR). The speed indicated on the display area will increase with the acceleration time Pr.7 and reach "3000" (3000 r/min). The [RUN] lamp is on during normal rotation and flashing during reverse rotation. ● When RM has been turned on, 1500 r/min is displayed. When RL has been turned on, 300 r/min is displayed.
4	Deceleration → Stop	Turn off the start switch (STF or STR). The speed indicated on the display area will decrease with the deceleration time Pr.8 and reach "0" (0 r/min), and the motor will stop. The [RUN] lamp will go out.
5	Speed setting (OFF)	Turn off the high speed switch (RH).

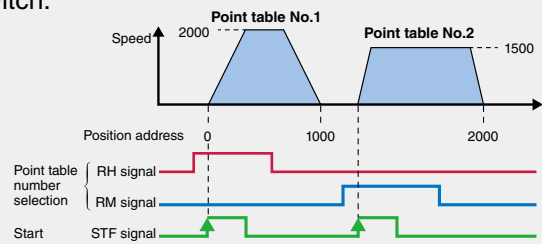
2

Operating in the position control mode

Position control can be performed without a sensor, and the motor can be operated for movement to a specified position with an external operation switch.

Operation example

Positioning operation can be performed with an external operation switch.



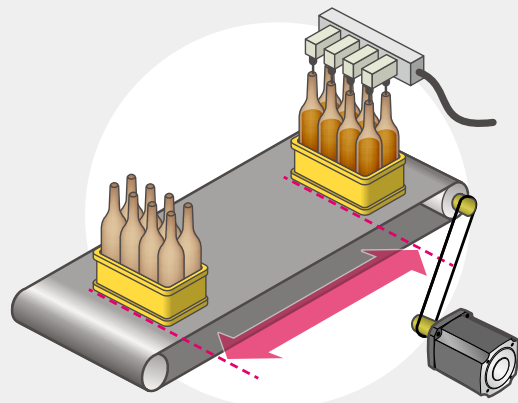
Operation procedure

1	Screen displayed when power is turned on	The monitor screen appears.
2	Target position setting	Turn on the high speed switch (RH).
3	Servo on (origin point return)	Turn on the low speed switch (SON).
4	Positioning	Turn on the start switch (STF). The motor will run until the position specified in the point table is reached.
5	Stop	Turn off the start switch (STF).
6	Servo off	Turn off the low speed switch (SON).
7	Target position setting (OFF)	Turn off the high speed switch (RH).

For position control, the speed command is calculated in the way the difference between commanded position and present position is reaching to zero, and then the motor is started.

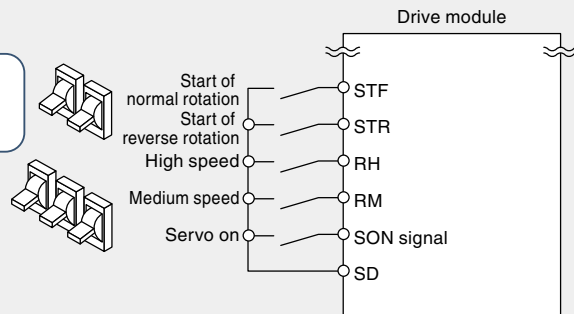
The position command can be set by the point table method.

The positioning operation can be performed by selecting a position command in the point table with an external operation switch.



Connection example

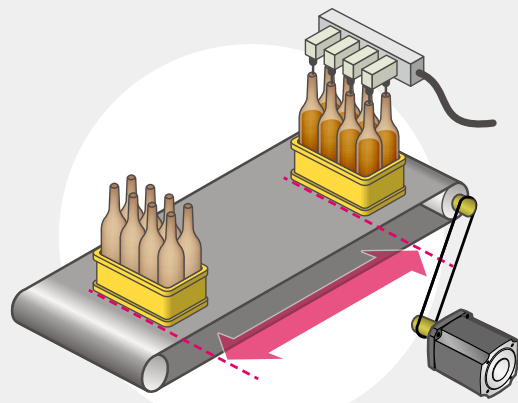
Assign the external operation switch functions for position control.



Create the point table.

Item	First positioning	Second positioning
Operating speed	2000r/min(Pr.4)	1500r/min(Pr.5)
Acceleration time	1.0s(Pr.578)	0.5s(Pr.580)
Deceleration time	1.0s(Pr.579)	0.5s(Pr.581)
Target position	1000(Pr.465)	2000(Pr.467)
Auxiliary function for positioning	10: Forward direction Incremental value command Independent (Pr.525)	11: Backward direction Incremental value command Independent (Pr.526)

Item	Setting
Pr.800 Control method selection	13: Position control
Pr.532 Home position return method	2: Data set method
Pr.537 Roll feed mode selection	1



* The parameter numbers are for the FR-E700EX. For details, see the instruction manual for the drive module.

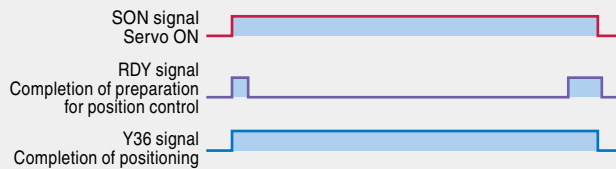
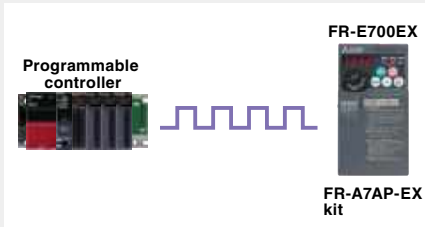
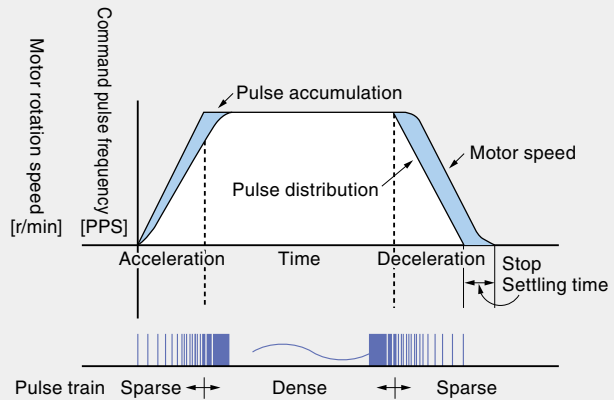
3

Introduction of positioning modules

An example of combination with a positioning module is introduced.

Operation example

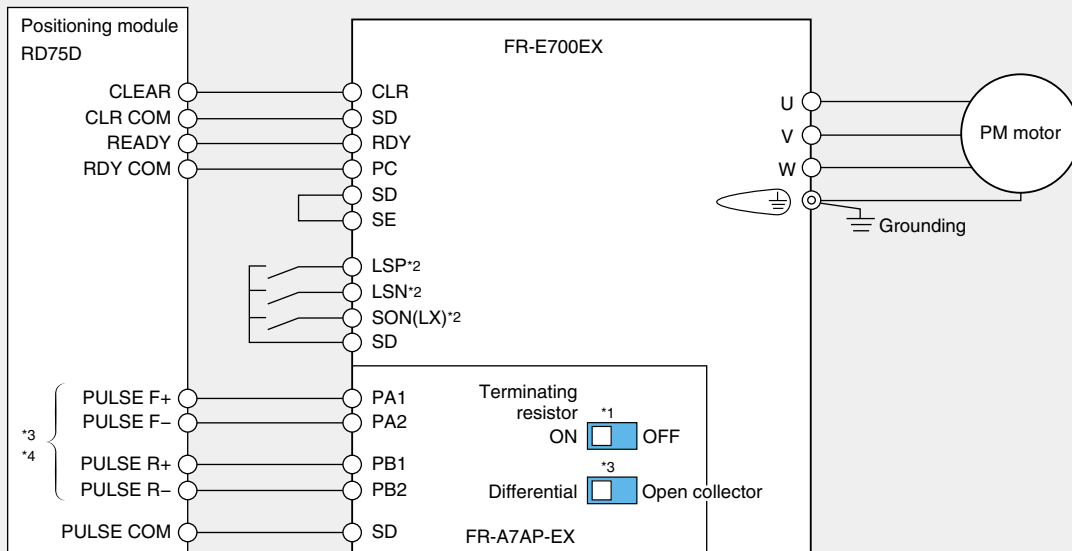
Positioning by pulse-train input can be performed by combining FR-A7AP-EX (built-in option) and a programmable controller positioning module.



Wiring example

Example of wiring of FR-A7AP-EX (built-in option) and positioning module

Connection with MELSEC iQ-R Series RD75D positioning module



*1 When an open collector is used, set the terminating resistor selector switch to OFF (default).

*2 Assign the functions with Pr.178 to Pr.184 (input terminal function selection).

*3 The connection varies depending on the specifications for the pulse signals input from the positioning module. (This figure gives an example of connection with a differential line driver.)

*4 When Pr.428 (command selection) is not set to "1,4," connect the positioning module terminals (PULSE F+, PULSE F-, PULSE R+ and PULSE R-) and the terminals of FR-A7AP-EX (PA1, PA2, PB1 and PB2) as shown in the wiring example.

When Pr.428 is set to "1,4," connect the terminals PULSE R+ and PA1, PULSE R- and PA2, PULSE F+ and PB1, and PULSE F- and PB2.

Application examples

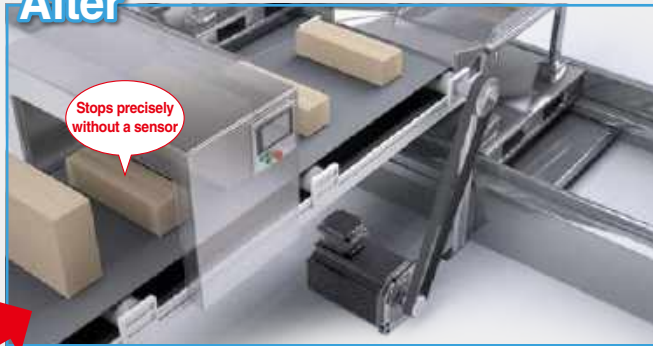
1 Transport application

Positioning is possible without a sensor (encoder)

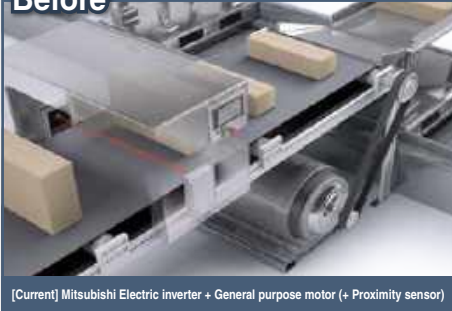
Other features

- Improved work speed and stopping accuracy.
- Not subject to high-efficiency laws and regulations of various countries, and can be used safely for overseas projects.

After

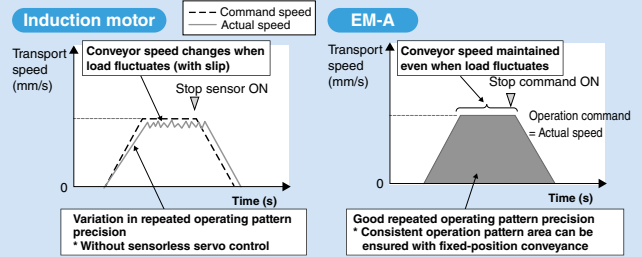


Before



[Current] Mitsubishi Electric inverter + General purpose motor (+ Proximity sensor)

[Suggested] FR-E800 + EM-A



2 Pump application

Torque in the low speed range

Maximum torque is*
200%

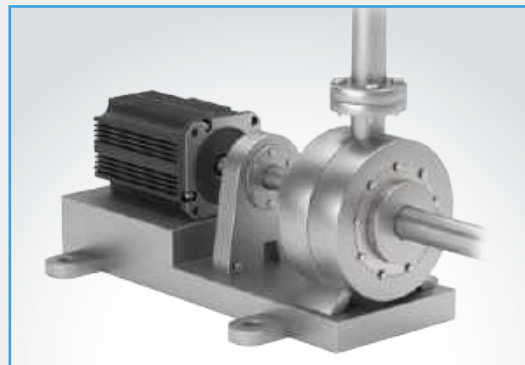
- The speed control range is wide and the torque is good even at low speeds. (Speed control range 1000)

*1: The indicated maximum torque (200%) is for 3-phase inverter power specifications.

High precision speed control

Speed fluctuation rate is
±0.05%
*For digital input

- Compared to induction motors, these new motors provide high precision speed control with less speed fluctuation.



- The EM-A Series realizes high-precision speed control by using Mitsubishi Electric's unique PM sensorless vector control that does not cause significant speed variations even under changing loads.
- These motors can operate at stable speeds that are resistant to load fluctuations.

[Operating torque characteristics]

