MITSUBISHI ELECTRIC

800 series

# INVERTER

Plug-in option

# FR-A8APS

# INSTRUCTION MANUAL

*EnDat interface*

*Orientation control*

*Encoder feedback control*

*Vector control*

*Position control*

**Thank you for choosing this Mitsubishi inverter plug-in option.**
**This Instruction Manual provides handling information and precautions for use of this product. Incorrect handling might cause an unexpected fault. Before using this product, always read this Instruction Manual carefully to use this product correctly.**
**Please forward this Instruction Manual to the end user.**

## Safety instructions

**Do not attempt to install, operate, maintain or inspect the product until you have read through this Instruction Manual and appended documents carefully and can use the equipment correctly. Do not use this product until you have a full knowledge of the equipment, safety information and instructions. In this Instruction Manual, the safety instruction levels are classified into "Warning" and "Caution".**

**⚠Warning** **Incorrect handling may cause hazardous conditions, resulting in death or severe injury.**

**⚠Caution** **Incorrect handling may cause hazardous conditions, resulting in medium or slight injury, or may cause only material damage.**

**The ⚠Caution level may even lead to a serious consequence according to conditions. Both instruction levels must be followed because these are important to personal safety.**

◆ **Electric shock prevention**

### ⚠Warning

- While the inverter power is ON, do not remove the front cover or the wiring cover. Do not run the inverter with the front cover or the wiring cover removed. Otherwise you may access the exposed high voltage terminals or the charging part of the circuitry and get an electric shock.
- Do not remove the inverter front cover even if the power supply is disconnected. The only exception for this would be when performing wiring and periodic inspection. You may accidentally touch the charged inverter circuits and get an electric shock.
- Before wiring or inspection, LED indication of the inverter unit operation panel must be switched OFF. Any person who is involved in wiring or inspection shall wait for at least 10 minutes after the power supply has been switched OFF and check that there is no residual voltage using a tester or the like. For some time after the power-OFF, a high voltage remains in the smoothing capacitor, and it is dangerous.
- Any person who is involved in wiring or inspection of this equipment shall be fully competent to do the work.
- The plug-in option must be installed before wiring. Otherwise you may get an electric shock or be injured.
- Do not touch the plug-in option or handle the cables with wet hands. Otherwise you may get an electric shock.
- Do not subject the cables to scratches, excessive stress, heavy loads or pinching. Otherwise you may get an electric shock.

◆ **Injury prevention**

### ⚠Caution

- The voltage applied to each terminal must be the ones specified in the Instruction Manual. Otherwise a burst, damage, etc. may occur.
- The cables must be connected to the correct terminals. Otherwise a burst, damage, etc. may occur.
- The polarity (+ and -) must be correct. Otherwise a burst or damage may occur.
- While power is ON or for some time after power OFF, do not touch the inverter as it will be extremely hot. Touching these devices may cause a burn.

◆ **Additional instructions**

**The following instructions must be also followed. If the product is handled incorrectly, it may cause unexpected fault, an injury, or an electric shock.**

## ⚠ Caution

**Transportation and mounting**

- Do not install or operate the plug-in option if it is damaged or has parts missing.
- Do not stand or rest heavy objects on the product.
- The mounting orientation must be correct.
- Foreign conductive objects must be prevented from entering the inverter. That includes screws and metal fragments or other flammable substance such as oil.
- If halogen-based materials (fluorine, chlorine, bromine, iodine, etc.) infiltrate into a Mitsubishi product, the product will be damaged. Halogen-based materials are often included in fumigant, which is used to sterilize or disinfest wooden packages. When packaging, prevent residual fumigant components from being infiltrated into Mitsubishi products, or use an alternative sterilization or disinfection method (heat disinfection, etc.) for packaging. Sterilization of disinfection of wooden package should also be performed before packaging the product.

**Trial run**

- Before starting operation, each parameter must be confirmed and adjusted. A failure to do so may cause some machines to make unexpected motions.

## ⚠ Warning

**Usage**

- Do not modify the equipment.
- Do not perform parts removal which is not instructed in this manual. Doing so may lead to fault or damage of the product.

## ⚠ Caution

**Usage**

- When parameter clear or all parameter clear is performed, the required parameters must be set again before starting operations. Because all parameters return to their initial values.
- To avoid damage due to static electricity, static electricity in your body must be discharged before you touch the product.

**Maintenance, inspection and parts replacement**

- Do not carry out a megger (insulation resistance) test.

**Disposal**

- The product must be treated as industrial waste.

## General instruction

- Many of the diagrams and drawings in this Instruction Manual show the inverter without a cover or partially open for explanation. Never operate the inverter in this manner. The cover must be reinstalled and the instructions in the Instruction Manual must be followed when operating the inverter.

## — CONTENTS —

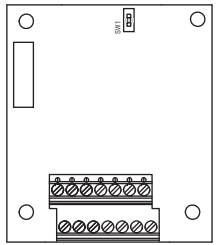
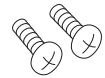
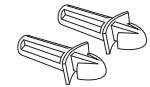
# 1 PRE-OPERATION INSTRUCTIONS

## 1.1 Unpacking and product confirmation

Take the plug-in option out of the package, check the product name, and confirm that the product is as you ordered and intact.
This product is a plug-in option dedicated for the FR-A800 series inverter.

### 1.1.1 Product confirmation

Check the enclosed items.

| | | |
|---|---|---|
| Plug-in option ..... 1  | Mounting screw (M3 × 8 mm) ..... 2 (Refer to page 9)  | Spacer .....2 (Refer to page 9)  |

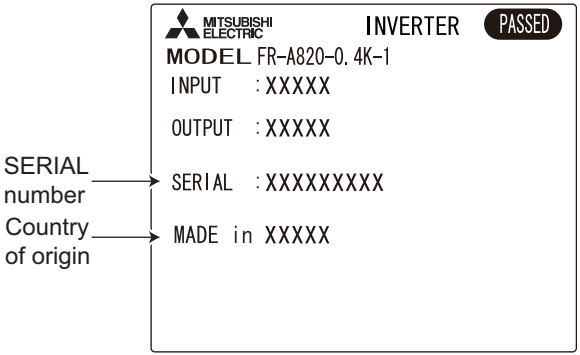
**NOTE**

- Connection diagrams in this Instruction Manual appear with the control logic of the input terminals as sink logic, unless otherwise specified. (For the control logic, refer to the Instruction Manual of the inverter.)

## 1.1.2 SERIAL number check

The FR-A8APS can be used for the inverter models listed below with the following SERIAL number or later. Check the SERIAL number indicated on the inverter rating plate or package.

Rating plate example



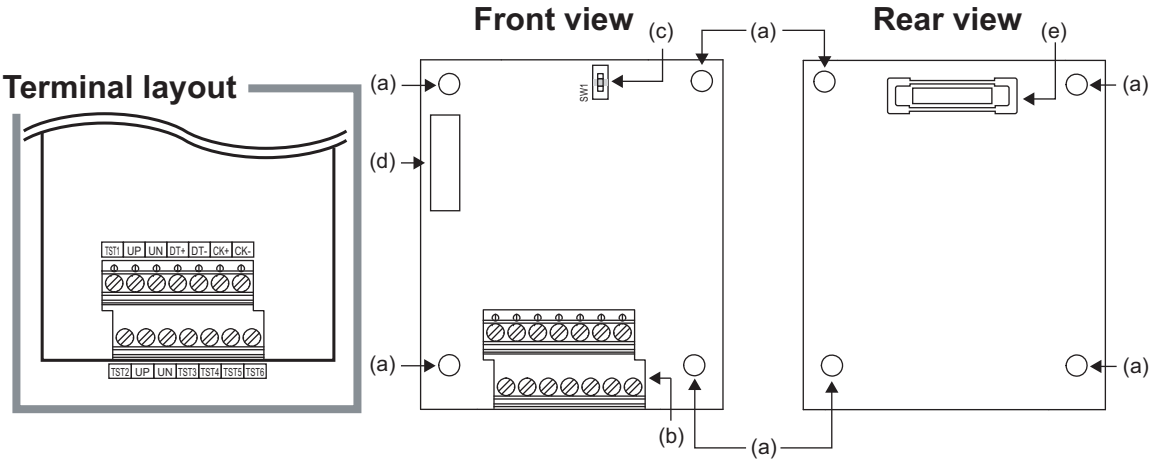

□ ○ ○ ○○○○○○
Symbol Year Month Control number
SERIAL

The SERIAL consists of one symbol, two characters indicating the production year and month, and six characters indicating the control number.
The last digit of the production year is indicated as the Year, and the Month is indicated by 1 to 9, X (October), Y (November), or Z (December).

FR-A800 series

| Model | Country of origin indication | SERIAL number |
|---|---|---|
| FR-A820-00046(0.4K) to 04750(90K)<br>FR-A840-00023(0.4K) to 06830(280K)<br>FR-A842-07700(315K) to 12120(500K)<br>FR-A846-00023(0.4K) to 03610(132K) | MADE in Japan | □65○○○○○○ or later |
| | MADE in China | □66○○○○○○ or later |

## 1.2 Component names




| Symbol | Name | Description | Refer to page |
|---|---|---|---|
| a | Mounting hole | Fixes the option to the inverter with screws, or installs spacers. | 9 |
| b | Terminal block | Connected with an encoder. | 13 |
| c | Switch for manufacturer setting (SW1) | Do not change the initially-set status.<br>(OFF (setting position marked with the white line)) | — |
| d | CON2 connector | Not used. | — |
| e | Connector | Connects to the option connector of the inverter. | 9 |

# 2 INSTALLATION AND WIRING

## 2.1 Pre-installation instructions

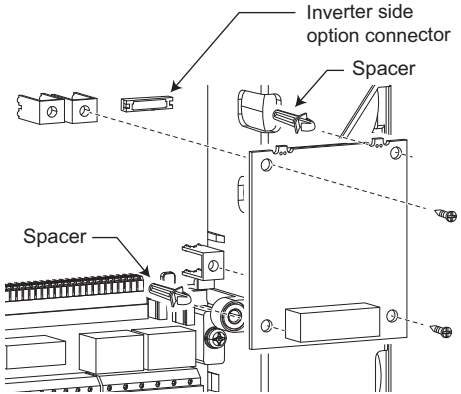
Check that the inverter's input power and the control circuit power are both OFF.

**⚠ Caution**

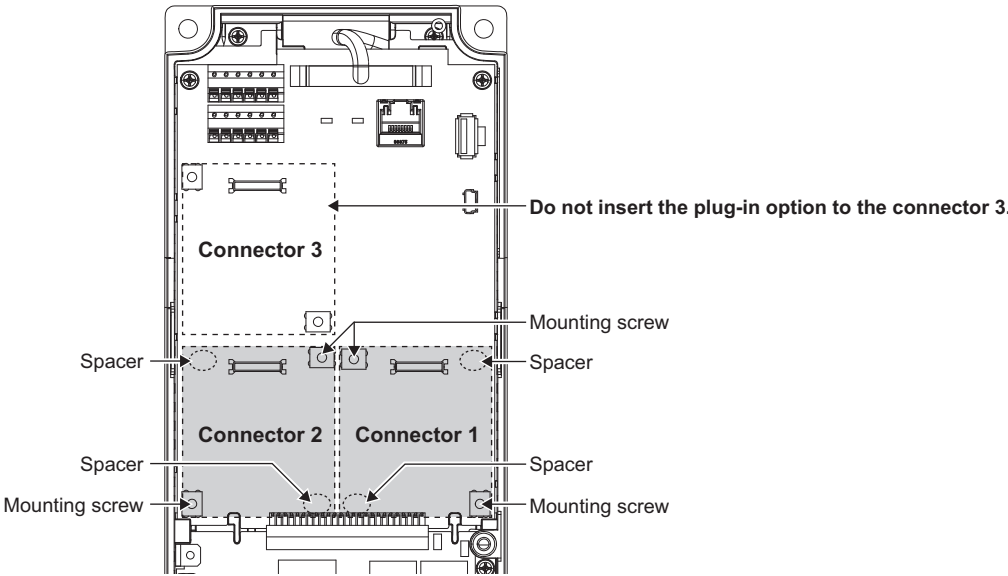
- **With input power ON, do not install or remove the plug-in option. Otherwise, the inverter and plug-in option may be damaged.**
- **To avoid damage due to static electricity, static electricity in your body must be discharged before you touch the product.**

## 2.2 Installation procedure

(1) Remove the inverter front cover. (Refer to Chapter 2 of the Instruction Manual (Detailed) of the inverter for details on how to remove the front cover.)
(2) For the two mounting holes (as shown in the next page) that will not be tightened with mounting screws, insert spacers.
(3) Fit the connector of the plug-in option to the guide of the connector on the inverter unit side, and insert the plug-in option as far as it goes.
(4) Fit the two locations, the left and right, of the plug-in option securely to the inverter unit by screwing in the supplied mounting screws. (tightening torque 0.33 N·m to 0.40 N·m) If the screw holes do not line up, the connector may not be inserted deep enough. Check the connector.



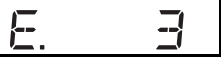

**Example of installation to connector 1**




**Insertion positions for screws and spacers**

NOTE

- When mounting/removing the plug-in option, hold the sides of the option. Do not press on the parts on the option circuit board. Stress applied to the parts by pressing, etc. may cause a failure.
- Caution must be applied to mounting screws falling off when removing and mounting the plug-in option.
- The priorities of vector control compatible plug-in options are defined as follows: FR-A8AL > FR-A8APS > FR-A8APR > FR-A8AP. The vector control compatible plug-in options with lower priority do not function.
- Two or more of the same options cannot be connected. When multiple options are mounted, priority is given to option connectors 1, 2 and 3 on the inverter in this order, and options having a lower priority do not function.
- When the inverter cannot recognize the option unit due to improper installation, etc., or when a fault occurs in the option or encoder, the protective function (E.1 to E.3 or E.OP1 to E.OP3) is activated and the inverter cannot be operated. A different indication will appear according to the mounted position (option connector 1 to 3).

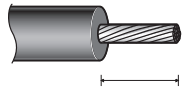
| Mounted position | Fault indication | |
|---|---|---|
| Option connector 1 |  |  |
| Option connector 2 |  |  |
| Option connector 3 |  |  |

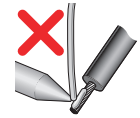
- When removing the plug-in option, remove the two screws on the left and right, then pull it straight out. Pressure applied to the connector and to the option board may break the option.

## 2.3 Wiring

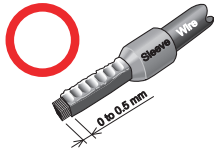
(1) Strip off the sheath of the signal cable from the encoder for the below length. If the length of the sheath peeled is too long, a short circuit may occur with neighboring wires. If the length is too short, wires might come off.
Wire the stripped signal cable after twisting it to prevent it from becoming loose. In addition, do not solder it.

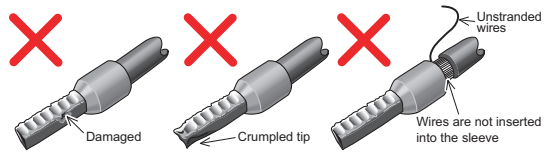
Cable stripping length



For connecting the FR-A8APS, use a blade terminal as necessary.
When using the blade terminal, use care so that the twisted wires do not come out.




**NOTE**

- Blade terminals commercially available (as of February 2016. The product may be changed without notice.)

| Terminal screw size | Wire size ($mm^2$) | Ferrule terminal model | | Manufacturer | Crimping tool name |
|---|---|---|---|---|---|
| | | With insulation sleeve | Without insulation sleeve | | |
| M2 | 0.3 to 0.5 | AI 0,5-6WH | A 0,5-6 | Phoenix Contact Co., Ltd. | CRIMPFOX 6 |

(2) Loosen the terminal screw and insert the cable into the terminal.

| Screw size | Tightening torque | Cable size | Screwdriver |
|---|---|---|---|
| M2 | 0.22 N·m to 0.25 N·m | 0.3 $mm^2$ to 0.75 $mm^2$ | Small ⊖ flat-blade screwdriver<br>(Tip thickness: 0.4 mm/tip width: 2.5 mm) |

**NOTE**

- Undertightening can cause cable disconnection or malfunction. Overtightening can cause a short circuit or malfunction due to damage to the screw or unit.
- When wiring cables to the inverter's RS-485 terminals while a plug-in option is mounted, take caution not to let the cables touch the circuit board of the option or of the inverter. Otherwise, electromagnetic noises may cause malfunctions.

**⚠ CAUTION**

- **After wiring, wire offcuts must not be left in the inverter. They may cause a fault, failure or malfunction.**

## 2.4 Terminals



| Terminal symbol | Terminal name | Description |
|---|---|---|
| UP | Power supply (positive side) terminal | For the power supply (5 V) for the encoder |
| UN | Power grounding terminal | |
| DT+ | Communication data signal (DATA) | For serial communication data of the EnDat interface encoder |
| DT- | Communication data inversion signal ($\overline{DATA}$) | |
| CK+ | Clock signal (CLOCK) | For clock data output to the EnDat interface encoder |
| CK- | Clock inversion signal ($\overline{CLOCK}$) | |
| TST1 to TST6 | Terminals for manufacturer setting. Keep them open. | |

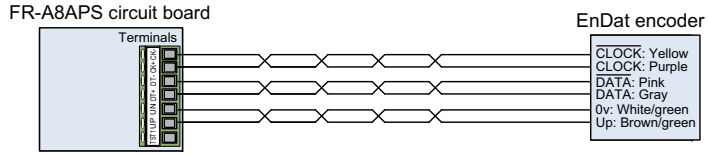
## 2.5 Encoder

### ◆ Specifications

| | |
|---|---|
| **Type** | EnDat 01/EnDat 21/EnDat 02/EnDat 22 |
| **Command set** | EnDat 2.1/2.2 |
| **Bit length** | 8192 (13 bits)/33554432 (25 bits) |
| **Measurement method** | Absolute measurement method only (Incremental signals are not supported.) |
| **Input power** | 4.5 to 5.5 V 300 mA |

The following table shows recommended encoders and cables.
(as of April 2016. The product may be changed without notice.)

| | |
|---|---|
| **Recommended encoder** | ECN1313, ECN1325, EQN1325 or equivalent<br>Select a high resolution encoder for a multiple-pole motor. |
| **Recommended cable** | Cables (manufactured by HEIDENHAIN) compatible with the encoders above |
| **Manufacturer** | HEIDENHAIN |




**NOTE**

- EnDat is a registered trademark of DR.JOHANNES HEIDENHAIN GmbH.
- The wiring length differs according to combination of the encoder and the cable. For details of the selection, contact HEIDENHAIN.

### ◆ Parameter for detector

| Item | FR-A8APS parameter |
|---|---|
| Encoder rotation direction | **Pr.359** |
| Number of detector pulses | — (Obtained via communication from the encoder) |
| Encoder signal loss detection enable/disable selection | **Pr.376** |

### ◆ Parameters related to the encoder pulse (Pr.353 to Pr.357, Pr.361, Pr.465 to Pr.494, Pr.1285 to Pr.1288)

When the EnDat interface encoder with the encoder pulse number larger than 16384 is used, convert the pulse number using the following formula to find the value to be set in **Pr.353 to Pr.357, Pr.361, Pr.465 to Pr.494, Pr.1285 to Pr.1288.**
Parameter setting = Pulse number before conversion × (16384 / Encoder pulse number)

Example) Encoder pulse number = 33554432, pulse number at the creep switchover position = 32768
**Pr.353** setting = 32768 × (16384/33554432) = 16

### ◆ Control method

| Control method | IM | PM |
|---|---|---|
| V/F control (orientation control, encoder feedback control) | ○ | × |
| Advanced magnetic flux vector control (orientation control, encoder feedback control) | ○ | × |
| Vector control | ○ | ○ |

○: Supported, ×: Not supported

## ◆ Major functions list

| Function | IM | PM |
|---|---|---|
| Vector control (speed control) | ○ | ○ |
| Vector control (torque control) | ○ | × |
| Vector control (position control) | ○ | ○ |
| Servo lock (pre-excitation selection) | ○ | ○ |
| Droop control | ○ | ○ |
| Brake sequence | ○ | ○ |
| Encoder signal loss detection (E.ECT) | ○ | ○ |
| Notch filter | ○ | ○ |
| Anti-sway control | ○ | ○ |
| Magnetic flux command | ○ | × |
| Overspeed detection (E.OS) | ○ | ○ |
| Speed deviation excess (E.OSD) | ○ | ○ |
| Speed limit | ○ | × |

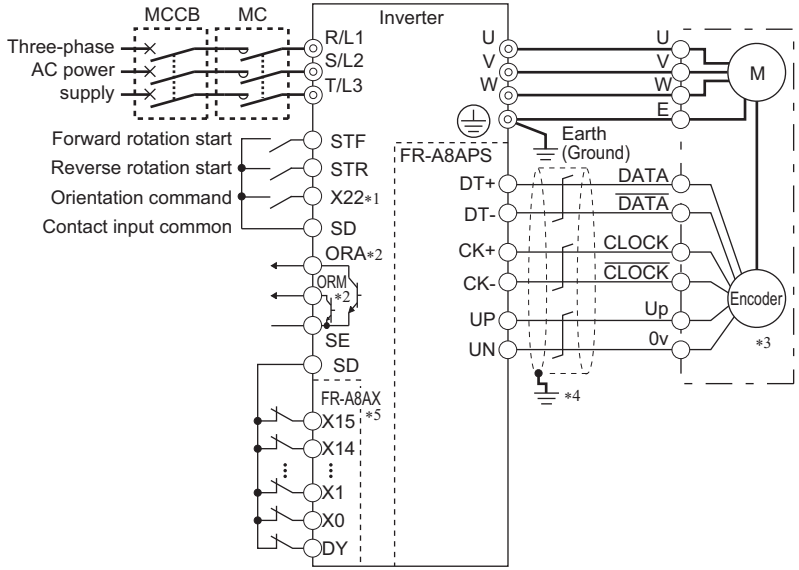
| Function | IM | PM |
|---|---|---|
| Deceleration check | ○ | ○ |
| Forward rotation output (Y30) signal/ Reverse rotation output (Y31) signal/ Regenerative status output (Y32) signal | ○ | ○ |
| Encoder position tuning | × | ○ |
| Absolute position control | ○ | ○ |
| Encoder pulse dividing output | × | × |
| Model adaptive / Speed feed forward control | ○ | ○ |
| Easy gain tuning | ○ | ○*1 |
| Torque bias | ○ | × |
| Encoder feedback control | ○ | × |
| Orientation control | ○ | ○ |
| Machine end orientation control | × | × |
| X18 signal switchover | ○ | × |

○: Supported, ×: Not supported

*1 Available only when **Pr.819** = "2" (load inertia ratio manual input)

This function is used with an encoder installed to the spindle of a machine tool, etc. to allow a rotary shaft to be stopped at the specified position (oriented).
For the details of the parameters used for orientation control, refer to the Instruction Manual (Detailed) of the inverter.

## 4.1 Wiring example




*1 Use **Pr.178 to Pr.189 (input terminal function selection)** to assign the function to any of terminal.
Refer to the Instruction Manual (Detailed) for details of **Pr.178 to Pr.189 (input terminal function selection)**.

*2 Use **Pr.190 to Pr.196 (output terminal function selection)** to assign the function to any of terminal.
Refer to the Instruction Manual (Detailed) for details of **Pr.190 to Pr.196 (output terminal function selection)**.

*3 Connect the encoder so that there is no looseness between the motor and motor shaft. Speed ratio should be 1:1.

*4 Earth (ground) the shield of the encoder cable to the enclosure using a tool such as a P-clip.

*5 When a stop position command is input from outside, a plug-in option FR-A8AX is necessary. Refer to the Instruction Manual (Detailed) for details of external stop position command.

## 4.2 Terminals

### ◆ Option FR-A8AX terminal

| Terminal symbol | Terminal name | Description |
|---|---|---|
| X0 to X15 | Digital signal input terminal | Input the digital signal at the relay contact or open collector terminal.<br>Using **Pr.360**, speed or position command is selected as the command signal entered. |
| DY | Data read timing input signal terminal | Used when a digital signal read timing signal is necessary. Data is read only during the DY signal is on.<br>By switching the DY signal off, the X0 to X15 data before signal-off is retained. |

### ◆ Inverter terminal

| Terminal (signal) | | Terminal (signal) name | Application explanation |
|---|---|---|---|
| Input | X22 | Orientation command | Used to enter an orientation signal for orientation.<br>For the terminal used for X22 signal input, set "22" in any of **Pr.178 to Pr.189** to assign the function. *1 |
| Output | ORA | Orientation complete | Switched LOW if the orientation has stopped within the in-position zone while the start and X22 signals are input.<br>For the terminal used for the ORA signal output, assign the function by setting "27 (positive logic) or 127 (negative logic)" in any of **Pr.190 to Pr.196**. *1 |
| | ORM | Orientation fault | Switched LOW if the orientation has not completed within the in-position zone while the start and X22 signals are input.<br>For the terminal used for the ORM signal output, assign the function by setting "28 (positive logic) or 128 (negative logic)" in any of **Pr.190 to Pr.196**. *1 |

*1 Refer to the Instruction Manual (Detailed) for details of **Pr.178 to Pr.189 (input terminal function selection)** and **Pr.190 to Pr.196 (output terminal function selection)**.

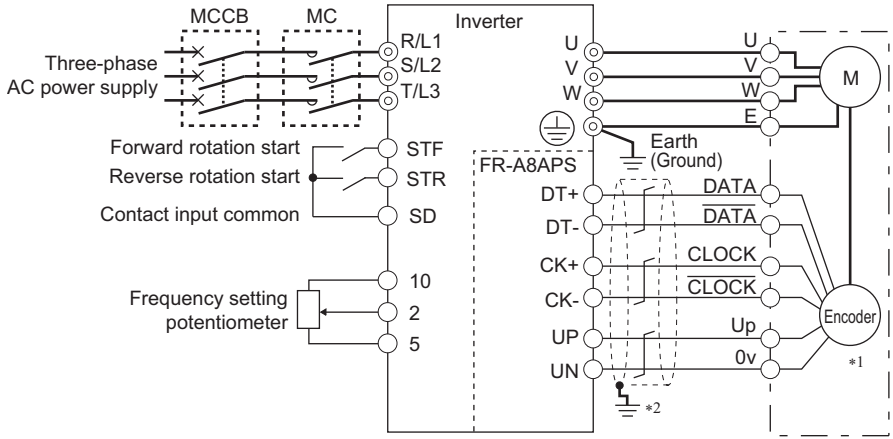
## 4.3 Specifications

| | |
|---|---|
| **Repeated positioning accuracy** | ±1.5°<br>Depends on the load torque, moment of inertia of the load or orientaion, creep speed, position loop switching position, etc. |
| **Permissible speed** | Rotation speed of the EnDat interface encoder-mounted shaft<br>The drive shaft and encoder-mounted shaft must be coupled directly or via a belt (with the speed ratio of 1:1) without any mechanical looseness or slip. Gear changing shafts cannot be applied. |
| **Functions** | Orientation, creep speed setting, stop position command selection, DC injection brake start position setting, creep speed and position loop switch position setting, position shift, orientation in-position, position pulse monitor, etc. |
| **Holding force after positioning** | Under V/F control, Advanced magnetic flux vector control...without servo lock function<br>Under vector control...with servo lock function |
| **Input signal (contact input)** | Orientation command, forward and reverse rotation commands, stop position command<br>Binary signal of maximum 16 bits (when used with the FR-A8AX) |
| **Output signal (open collector output)** | Orientation completion signal, orientation fault signal |

# 5 ENCODER FEEDBACK CONTROL V/F Magnetic flux

Mount FR-A8APS to an FR-A800 series inverter to perform encoder feedback control under V/F control or Advanced magnetic flux vector control.
This controls the inverter output frequency so that the motor speed is constant to the load variation by detecting the motor speed with the encoder to feed back to the inverter.
For the details of the parameters used for encoder feedback control, refer to the Instruction Manual (Detailed) of the inverter.

## 5.1 Wiring examples




*1 Connect the encoder so that there is no looseness between the motor and motor shaft. Speed ratio should be 1:1.
*2 Earth (ground) the shield of the encoder cable to the enclosure using a tool such as a P-clip.

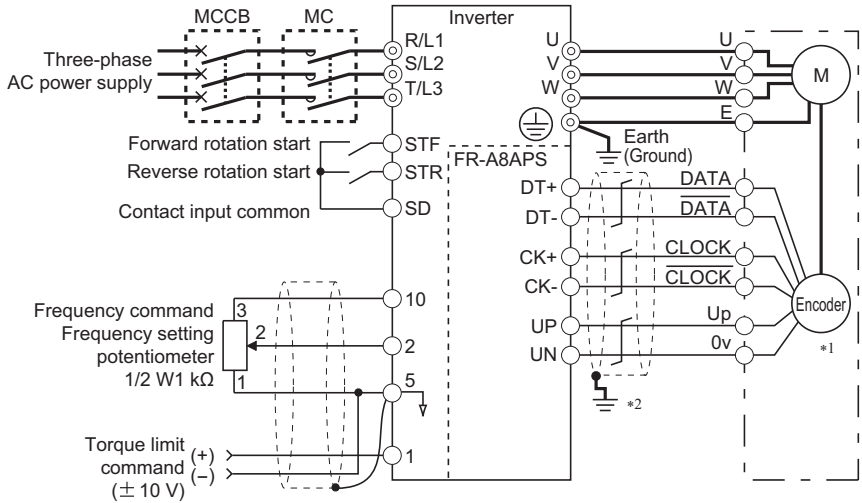
## 5.2 Specifications

| | |
|---|---|
| **Speed variation ratio** | ±0.1% (100% means 3600 r/min) |
| **Function** | • Setting of speed feedback range<br>• Setting of feedback gain<br>• Setting of encoder rotation direction |
| **Maximum speed** | V/F control: 590 Hz, Advanced magnetic flux vector control: 400 Hz |

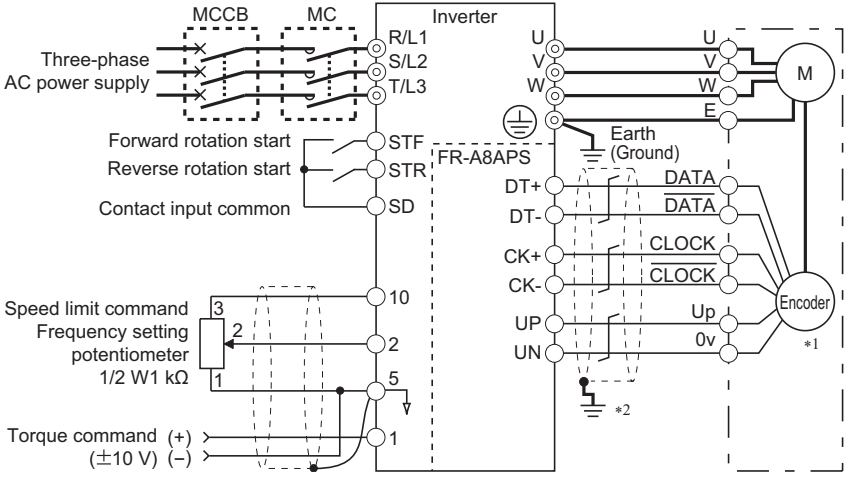
When the FR-A8APS is installed on the FR-A800 series inverter, full-scale vector control operation can be performed using a motor with encoder. (For the details of vector control, refer to the Instruction Manual (Detailed) of the inverter.)
Speed control, torque control, and position control are enabled under vector control for the induction motor.
Speed control and position control are enabled under vector control for the PM motor.

## 6.1 Wiring examples

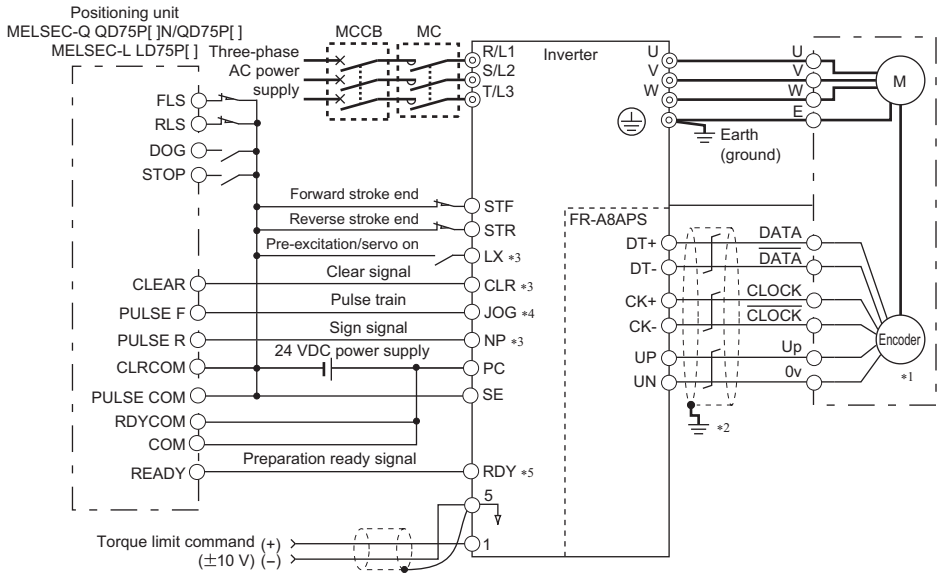
### ◆ Speed control



## ◆ Torque control (With induction motor only)



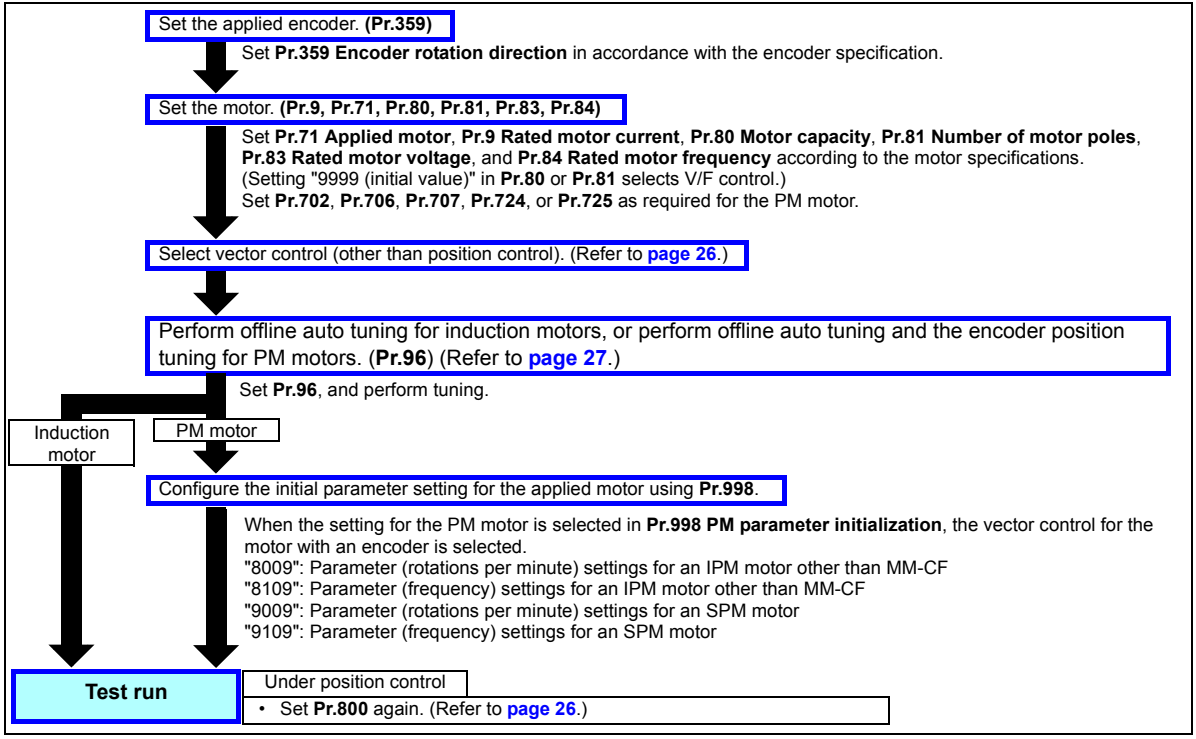
## ◆ Position control




*1 Connect the encoder so that there is no looseness between the motor and motor shaft. Speed ratio must be 1:1.
*2 Earth (ground) the shield of the encoder cable to the enclosure using a tool such as a P-clip.
*3 Assign the function using **Pr.178 to Pr.184, Pr.187 to Pr.189 (input terminal function selection)**.
*4 When position control is selected, terminal JOG function is invalid and simple position pulse train input terminal becomes valid.
*5 Assign the function using **Pr.190 to Pr.194 (output terminal function selection)**.

## 6.2 Setting procedure of vector control for motor with encoder

Follow the following procedure to change the setting for the vector control for the motor with an encoder.



NOTE

- For PM motors, after performing offline auto tuning and encoder position tuning, first perform PM parameter initialization. If parameter initialization is performed after setting other parameters, some of those parameters will be initialized too. (For the parameters to be initialized, refer to the Instruction Manual (Detailed) of the inverter.)

## 6.3 Vector control for PM motor with encoder

- With the FR-A8APS, PM motors with an encoder can be driven under vector control. (For the setting of vector control for an induction motor, refer to the Instruction Manual (Detailed) of the inverter.)

<table>
<tr><th>Pr.80 (Pr.453), Pr.81 (Pr.454)</th><th>Pr.71 (Pr.450)</th><th>Pr.800 setting *1</th><th>Pr.451 setting *1</th><th>Control method</th><th>Control mode</th><th>Remarks</th></tr>
<tr><td rowspan="7">Other than 9999</td><td rowspan="7">IPM/SPM motor (other than MM-CF)</td><td colspan="2">0, 100*2</td><td rowspan="4">Vector control*4</td><td>Speed control</td><td>—</td></tr>
<tr><td colspan="2">3, 103</td><td>Position control</td><td>—</td></tr>
<tr><td colspan="2">4, 104*3</td><td>Speed control/position control switchover</td><td>MC signal: ON Position control<br>MC signal: OFF Speed control</td></tr>
<tr><td colspan="2">6, 106</td><td>Torque control by variable-current limiter control</td><td>—</td></tr>
<tr><td>9, 109</td><td>—</td><td colspan="3">PM sensorless vector control test operation</td></tr>
<tr><td>20 (initial value), 110*5</td><td>20, 110*5</td><td>PM sensorless vector control</td><td>Speed control</td><td>—</td></tr>
<tr><td>—</td><td>9999 (initial value)</td><td colspan="3">The setting value of Pr.800 is used for the second motor.<br>(PM sensorless vector control (speed control) when Pr.800="9 or 109")</td></tr>
<tr><td>9999*6</td><td>—</td><td colspan="2">—</td><td colspan="3">—</td></tr>
</table>

*1 The setting values of 100 and above are used when the fast-response operation is selected.
*2 The operation for the setting of "0 or 100" is performed when "1, 2, 101, or 102" is set.
*3 The operation for the setting of "4 or 104" is performed when "5 or 105" is set.
*4 Speed control under PM sensorless vector control when the FR-A8APS is not installed.
*5 The operation for the setting of "20 or 110" is performed when "10 to 14, or 111 to 114" is set.
*6 When a PM motor is used, set **Pr.80** and **Pr.81** according to the motor. Setting "9999" disrupts proper operation.

## 6.4 Offline auto tuning Vector

- The offline auto tuning enables the optimal operation of a motor with encoder.

| Pr. | Name | Initial value | Setting range | Description | |
|---|---|---|---|---|---|
| | | | | PM motor | Induction motor |
| 96<br>C110 | Auto tuning setting/status | 0 | 0 | No offline auto tuning | |
| | | | 1 | Performs offline auto tuning (without motor rotation) | |
| | | | 11 | Performs offline auto tuning only for motor constant R1 (without motor rotation) | |
| | | | 101 | Performs encoder position tuning and offline auto tuning (with motor slight rotation) | Performs offline auto tuning (with motor rotation) |
| 463<br>C210 | Second motor auto tuning setting/status | 0 | 0, 1, 11, 101 | Performs offline auto tuning for the second motor (Refer to **Pr.96** for the setting.) | |

**POINT**

- Refer to the Instruction Manual (Detailed) of the inverter to perform the offline auto tuning.
- This section explains the specific information of the motor with an encoder.

### ◆ Parameters in which the tuning results are set to after tuning (PM motor)

| Pr. | Name | Tuning items by Pr.96 (Pr.463) settings | | | Description |
|---|---|---|---|---|---|
| | | 101 | 1 | 11 | |
| 90 (458) | Motor constant (R1) | ○ | ○ | ○ | Resistance per phase |
| 92 (460) | Motor constant (L1)/d-axis inductance (Ld) | ○ | ○ | — | d-axis inductance |
| 93 (461) | Motor constant (L2)/q-axis inductance (Lq) | ○ | ○ | — | q-axis inductance |
| 711 (739) | Motor Ld decay ratio | ○ | ○ | — | d-axis inductance decay ratio |
| 712 (740) | Motor Lq decay ratio | ○ | ○ | — | q-axis inductance decay ratio |
| 859 (860) | Torque current/Rated PM motor current | ○ | ○ | — | |
| 96 (463) | Auto tuning setting/status | ○ | ○ | ○ | |
| 373 | Encoder position tuning setting/status | ○ | — | — | Encoder position tuning performing status |
| 1105 | Encoder magnetic pole position offset | ○ | ○ | — | Turning data of encoder position tuning |

○: Perform turning, —: No turning

**NOTE**

- If the offline auto tuning is started before the encoder position tuning is finished (**Pr.1105**="9999") for a PM motor, the protective function (E.MP) is activated.

## 6.5 Encoder position tuning Vector

- Encoder position tuning is required when a PM motor with an encoder is driven. The measured offset value between the motor home magnetic pole position and the encoder home position is stored. Only the encoder position tuning can be performed when offline auto tuning is not required, such as when the parameters for motor constant are set manually, or when offline auto tuning is already performed.

| Pr. | Name | Initial value | Setting range | Description |
|---|---|---|---|---|
| 373<br>C142 | Encoder position tuning setting/status | 0 | 0 | Encoder position tuning is disabled. |
| | | | 1 | Encoder position tuning is enabled. |
| 1105<br>C143 | Encoder magnetic pole position offset | 9999 | 0 to 4095 | Encoder position tuning result is set. |
| | | | 9999 | Encoder position tuning is not performed. |

### ◆ Before performing encoder position tuning

- Check that the FR-A8APS, a motor, and an encoder are properly connected.
- Check that a motor (single, stop status) is connected. (Check that the motor is not rotated by an external force during tuning.)
- Check that the mechanical brake is released.
- Check that the vector control (speed control) for the PM motor with an encoder is selected (refer to page 26).

NOTE

- The encoder position tuning is required when a PM motor is used. (It is disabled when an induction motor is used.)
- When auto tuning is performed at the setting of **Pr.96**="101", offline auto tuning and the encoder position tuning can be performed at the same time (refer to page 27).

### ◆ Setting

- To perform tuning, set **Pr.373**="1".

## ◆ Performing tuning

**POINT**

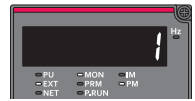
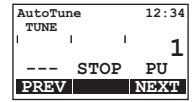
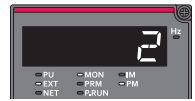
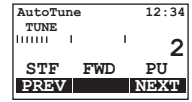
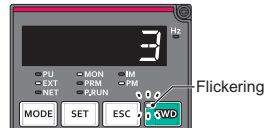
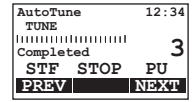
- Before performing tuning, check the monitor display of the operation panel or parameter unit if the inverter is in the state ready for tuning. Turning ON the start command while tuning is unavailable starts the motor.

- In the PU operation mode, press FWD / REV on the operation panel.
  For External operation, turn ON the start command (STF signal or STR signal). Tuning will start.

**NOTE**

- The motor shaft is rotated about 180 degrees during tuning.

- The following shows the monitor display/indicator on the operation panel (FR-DU08), the parameter unit (FR-PU07), and the LCD operation panel (FR-LU08) during tuning.

| Status | Parameter unit (FR-PU07) display | Operation panel (FR-DU08) display/indicator | LCD operation panel (FR-LU08) display |
|---|---|---|---|
| Setting | READ:List<br>TUNE 1<br>--- STOP PU |  |  |
| During tuning | TUNE 2<br>STF FWD PU |  |  |
| Normal completion | TUNE 3<br>COMPLETION<br>STF STOP PU |  |  |

- When encoder position tuning ends, press STOP RESET on the operation panel during PU operation. For External operation, turn OFF the start signal (STF signal or STR signal).
  This operation resets the encoder position tuning, and the PU's monitor display returns to the normal indication. (Without this operation, next operation cannot be started.)

**NOTE**

- The data measured once in the encoder position tuning is stored in **Pr.1105**, and is held until the encoder position tuning is performed again. However, performing all parameter clear resets the tuning data.

- If the encoder position tuning has ended in error (see the table below), tuning data is not set. Perform an inverter reset and restart tuning.

| Pr.373 setting | Error cause | Countermeasures |
|---|---|---|
| 8 | Forced end | Set **Pr.373**="1" and try again. |
| 9 | Inverter protective function operation | Identify and remove the cause of the protective function activation, and make the setting again. |
| 93 | The motor or the encoder is not connected. | Check the wiring of the motor and the encoder, the brake opening, and make the setting again. |

- When tuning is ended forcibly by pressing STOP RESET or turning OFF the start signal (STF or STR) during tuning, the tuning does not end properly. (The tuning data have not been set.)
  Perform an inverter reset and restart tuning.
- When the protective function (E.EP) is activated during tuning, check the wiring of the motor and the encoder, **Pr.359** setting, and then perform tuning again.
- When the tuning ends properly, the counter value of the offset between the motor home magnetic pole position and the encoder home position is written in **Pr.1105**.

## 6.6 Specifications

| | | |
|---|---|---|
| Speed control | Speed control range | 1:1500 (both driving/regeneration *1) |
| | Speed variation ratio | ±0.01% (100% means 3000 r/min) |
| | Speed response | 20 Hz (40 Hz during fast-response operation) |
| | Maximum speed | 400 Hz |
| Torque control | Torque control range | 1:50 |
| | Absolute torque accuracy | ±10% *2 |
| | Repeated torque accuracy | ±5% *2 |
| Position control | Repeated positioning accuracy | ±1.5° (at motor shaft end) |
| | Maximum input pulse frequency | 100 kpps (Terminal JOG) |
| | Positioning feedback pulse | Different depending on the encoder resolution |
| | Electronic gear setting | 1/50 to 20 |
| | In-position width | 0 to 32767 pulses |
| | Error excess | 0 to 400k pulses |
| Function | | • Setting of speed feedback range<br>• Setting of feedback gain |

*1 Regeneration unit (option) is necessary for regeneration
*2 With online auto tuning (adaptive magnetic flux observer), dedicated motor, rated load

# 7 POSITION CONTROL FUNCTION

## 7.1 About position control

- In position control, speed commands, which are calculated to eliminate the difference between the command pulse (parameter setting) and the feedback pulse number, are output to rotate the motor.

**NOTE**

- For the details of the setting procedure and operations, refer to the Instruction Manual (Detailed) of the inverter.

## 7.2 Absolute position control

When the FR-A8APS is used, setting "1110" in **Pr.419 Position command source selection** enables storing of the position after the first home position return is completed for the point table positioning during position control by point tables. The home position return operation is not required at every power-ON.

(1) Parameter setting

To perform absolute position control, install the FR-A8APS and set "1110" in **Pr.419**.

Also, connect an encoder with EnDat interface such as the EQN1325 or equivalent (with a multi-turn counter).

When an encoder other than mentioned above is connected or the PM sensorless vector control (position control) is set, the operation is the same as the one under the setting of **Pr.419** = "110".

- Position command source selection (**Pr.419**)

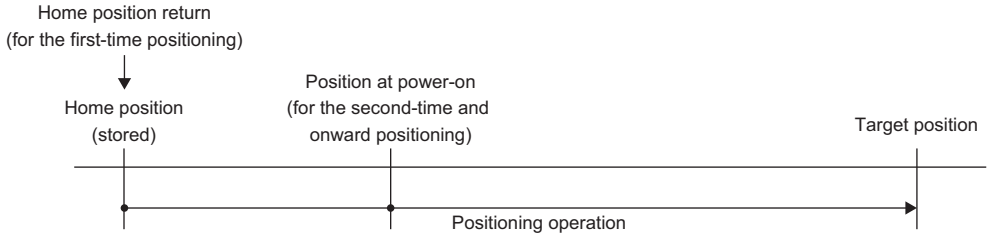
| Pr.419 | Description |
|---|---|
| 0 (initial value) | Simple position control by point tables (position command by setting parameters) |
| 1*1 | Position command by the pulse train input (when the FR-A8AL is installed) |
| 2 | Simple pulse train position command by the pulse train input to the inverter |
| 10 | Simple position control by point tables (position command by setting parameters)<br>(The home position data is retained at servo-OFF (LX signal: OFF).) |
| 100/110 | Simple position control by point tables (position command by setting parameters)<br>(The monitor value of the current position 2 is cleared when the home position return is completed.) |
| 1110*2 | Simple position control by point tables (position command by setting parameters)<br>(absolute position control) |

*1 During position control under vector control, if "1" is set in **Pr.419** while the FR-A8AL is not installed or is disabled, a protective function (E.OPT) is activated.

*2 During position control under vector control, if "1110" is set in **Pr.419** while the FR-A8APS is not installed or is disabled, a protective function (E.OPT) is activated.

(2) Operation

Example) Operation at power-ON




| Positioning | Operation |
|---|---|
| First time | After the home position return operation is performed (the home position data is retained), positioning starts. |
| Second time and onward | The home position return operation is not required regardless of the ON/OFF of the power supply.<br>To change the home position, perform the home position return operation again. |

- When the amount of shift from the home position to one direction exceeds the maximum possible position shift amount, LHP (multi-turn count excess) warning is generated. As the home position data is lost, perform the home position return again.
- When any of the following operations is performed, the home position data is lost. Perform the home position return again.
  1) The absolute position control is disabled (**Pr.419** ≠ "1110") and then enabled again.
  2) The electronic gear (**Pr.420** and **Pr.421**) is changed.
  3) The encoder rotation direction is changed.
  4) The LHP warning is generated.
- When the home position return is performed while **Pr.1282** = "4" (ignoring the home position), set a value other than "4" in **Pr.1282** after the home position return is completed.
- While the absolute position control is valid, the roll feed mode is invalid regardless of the **Pr.1293** setting.
- When the absolute position control is valid and the home position return is not completed, the position shift distance after power-ON or inverter reset is monitored and the value is displayed in the position command, current position, and current position 2. When the home position return is completed, the value indication is reset to "0".

NOTE

- Maximum possible position shift amount = ±(Encoder pulse number × (Maximum count of the multi-turn counter / 2) - 1)
  Example) Encoder pulse number = 8192, multi-turn counter count = 4096
  Maximum possible position shift amount = ±16777215

(3) Warning

Output is not shut off when a protective function is activated.

| Operation panel indication | LHP |  | FR-LU08 indication | — |
|---|---|---|---|---|
| **Name** | Multi-turn count excess | | | |
| **Description** | Appears when the home position data is lost due to overflow of the multi-turn counter. | | | |
| **Check point** | Check if the amount of shift from the home position to one direction exceeds the maximum possible position shift amount. | | | |
| **Corrective action** | • Check the operation range.<br>• Perform the home position return again. | | | |

MEMO

MEMO

REVISIONS

*The manual number is given on the bottom left of the back cover.

| Print Date | *Manual Number | Revision |
|---|---|---|
| May 2016 | IB(NA)-0600661ENG-A | First edition |
| | | |

INVERTER

**MITSUBISHI ELECTRIC CORPORATION**
HEAD OFFICE: TOKYO BUILDING 2-7-3, MARUNOUCHI, CHIYODA-KU, TOKYO 100-8310, JAPAN

IB(NA)-0600661ENG-A(1605) MEE Printed in Japan 