MITSUBISHI ELECTRIC

TRANSISTORIZED INVERTER

-INSTRUCTION MANUAL-

ORIENTATION CONTROL / ENCODER FEEDBACK CONTROL / PULSE TRAIN INPUT

FR-A5AP

Thank you for choosing the Mitsubishi transistorized inverter option unit.
This instruction manual gives handling information and precautions for use of this equipment. Incorrect handling might cause an unexpected fault. Before using the equipment, please read this manual carefully to use the equipment to its optimum.
Please forward this manual to the end user.

This section is specifically about safety matters

Do not attempt to install, operate, maintain or inspect this 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	Assumes that incorrect handling may cause hazardous conditions, resulting in death or severe injury.
⚠ CAUTION	Assumes that incorrect handling may cause hazardous conditions, resulting in medium or slight injury, or may cause physical damage only.

Note that the ⚠ CAUTION level may lead to a serious consequence according to conditions. Please follow the instructions of both levels because they are important to personnel safety.

SAFETY INSTRUCTIONS

1. Electric Shock Prevention

⚠ WARNING

- **While power is on or when the inverter is running, do not open the front cover. You may get an electric shock.**
- **Do not run the inverter with the front cover removed. Otherwise, you may access the exposed high-voltage terminals and charging part and get an electric shock.**
- **Even if power is off, do not remove the front cover except for wiring or periodic inspection. You may access the charged inverter circuits and get an electric shock.**
- **Before starting wiring or inspection, check to make sure that the inverter power indicator lamp is off, wait for at least 10 minutes after the power supply has been switched off, and check that there are no residual voltage using a tester or the like. The capacitor is charged with high voltage for some time after power off and it is dangerous.**

⚠ WARNING

- Any person who is involved in the wiring or inspection of this equipment should be fully competent to do the work.
- Always install the option unit before wiring. Otherwise, you may get an electric shock or be injured.
- Handle this option unit with dry hands to prevent an electric shock.
- Do not subject the cables to scratches, excessive stress, heavy loads or pinching. Otherwise, you may get an electric shock.

2. Injury Prevention

⚠ CAUTION

- Apply only the voltage specified in the instruction manual to each terminal to prevent burst, damage, etc.
- Ensure that the cables are connected to the correct terminals. Otherwise, burst, damage, etc. may occur.
- Always make sure that polarity is correct to prevent burst, damage, etc.
- While power is on or for some time after power-off, do not touch the inverter as it is hot and you may get burnt.

3. Additional Instructions

Also note the following points to prevent an accidental failure, injury, electric shock, etc.:

(1) Transportation and mounting

⚠ CAUTION

- Do not install or operate the option unit if it is damaged or has parts missing.
- Do not stand or rest heavy objects on the product.
- Check that the mounting orientation is correct.
- Prevent screws, metal fragments or other conductive bodies or oil or other flammable substance from entering the inverter.

(2) Test operation and adjustment

⚠ CAUTION

- Before starting operation, confirm and adjust the parameters. A failure to do so may cause some machines to make unexpected motions.

(3) Usage

⚠ WARNING
● 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 inverter.

⚠ CAUTION
● When parameter clear or all parameter clear is performed, each parameter returns to the factory setting. Reset the required parameters before starting operation. ● For prevention of damage due to static electricity, touch nearby metal before touching this product to eliminate static electricity from your body.

(4) Maintenance, inspection and parts replacement

⚠ CAUTION
● Do not test the equipment with a megger (measure insulation resistance).

(5) Disposal

⚠ CAUTION
● Treat as industrial waste.

(6) General instruction

All illustrations given in this manual may have been drawn with covers or safety guards removed to provide indepth description. Before starting operation of the product, always return the covers and guards into original positions as specified and operate the equipment in accordance with the manual.

CONTENTS

1.PRE-OPERATION INSTRUCTIONS

1.1 Unpacking and Product Confirmation

Take the option unit out of the package, check the unit name, and confirm that the product is as you ordered and intact.
This product is a plug-in option unit designed for exclusive use in the Mitsubishi FR-A500(L)/V500 series transistorized inverter. Functions available differ between FR-A500(L)/F500(L) series and FR-V500 series, always check before using. This product can not be used with FR-F500(L) series.

● SERAL number check

- This product may be used with the FR-A500 series manufactured in and after February 1998. Any of the models may be used with this unit if its SERAL number indicated on the rating plate and package has the following version or later.
  SERIAL is made up of 1 version symbol, 1 alphabet letter or numeric character indicating month, and 7 numeric characters indicating the year and control number as shown below. (Only the first three digits of the control number are printed on the package.)

U	8	2	○○○○○○○
Symbol	Year	Month	Control number
SERIAL number			

Model	SERIAL Number	Model	SERIAL Number
FR-A520-0.4K, 0.75K	U82○○○○○○	FR-A540-0.4K to 3.7K	L82○○○○○○
FR-A520-1.5K to 11K	T82○○○○○○	FR-A540-5.5K, 7.5K	K82○○○○○○
FR-A520-15K to 22K	U82○○○○○○	FR-A540-11K to 22K	L82○○○○○○
FR-A520-30K to 55K	K82○○○○○○	FR-A540-30K to 55K	D82○○○○○○

PRE-OPERATION INSTRUCTIONS

- This product may be used with the FR-V520-1.5K to 7.5K, 30K and 37K manufactured in and after February 2002. Any of the models may be used with this unit if its SERAL number indicated on the rating plate and package has the following version or later.
  SERAL is made up of 1 version symbol, 1 alphabet letter or numeric character indicating month, and 7 numeric characters indicating the year and control number as shown below. (Only the first three digits of the control number are printed on the package.)

F 2 2 ○○○○○○
Symbol Year Month Control number
SERAL number

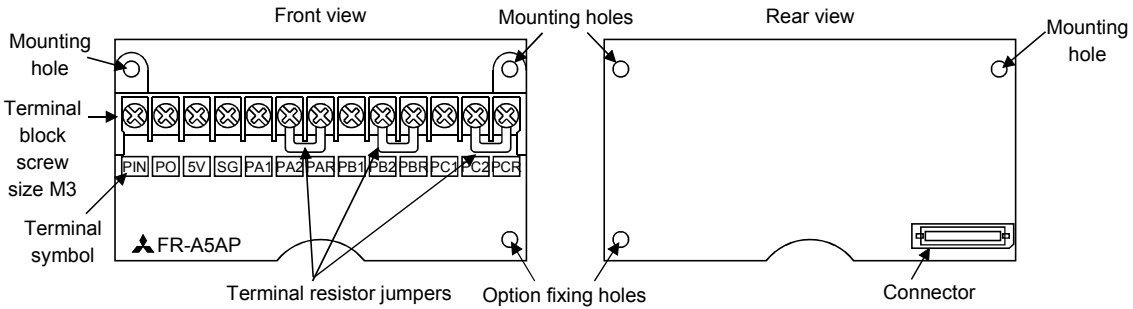
Model	SERIAL Number	Date Manufactured
FR-V520-1.5K to 7.5K	F22○○○○○○	in and after February 2002
FR-V520-30K	B22○○○○○○	
FR-V520-37K	C22○○○○○○	

1.2 Packing Confirmation

Make sure that the package includes the following

- Instruction manual.....1
- Mounting screws M3 × 10 2
- Terminal resistor jumpers (Jumpers fitted to the terminal block).....3

1.3 Structure



2.INSTALLATION

2.1 Pre-Installation Instructions

(1) Make sure that the input power of the inverter is off.

(2) When the FR-A5AP unit is used for encoder feedback control or orientation control, an encoder (motor with encoder) and external power supply are required.
When encoder feedback control and orientation control are used together, the encoder (motor with encoder) and external power supply are shared between these controls.

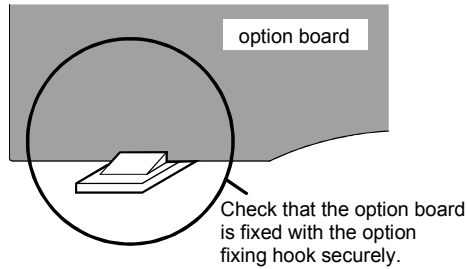
(3) When the FR-A5AP unit is fitted, the programmed operation function is made invalid.

⚠ CAUTION
⚠ **With input power on, do not install or remove the option unit. Otherwise, the inverter and option unit may be damaged.**

2.2 Installation Procedure

(1) Securely insert the connector of the option unit far into the connector of the inverter. At this time, fit the option fixing holes snugly. For the position of slot, refer to the next page. Also be sure to fit the unit into the option fixing hook (For the FR-A500(L) series, it is available in Aug., 2000).

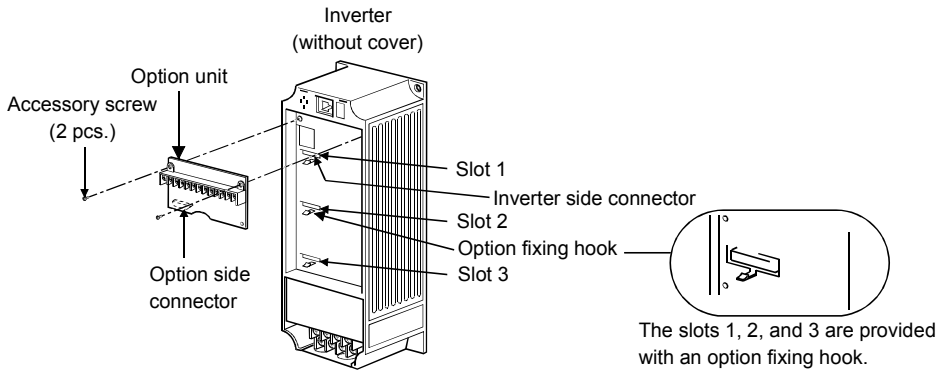
(2) Fit the option unit into the option fixing hook snuggly.
Check that the option board is fixed with the option fixing hook. (as shown on the below)



CAUTION

When the option unit is not securely plugged in the inverter, the inverter may operate improperly and an unexpected fault may occur.

(3) Securely fix the two right and left places of the option unit to the inverter with the accessory mounting screws. If the screw holes do not line up, the connector may not have been plugged snugly. Check for looseness.



CAUTION

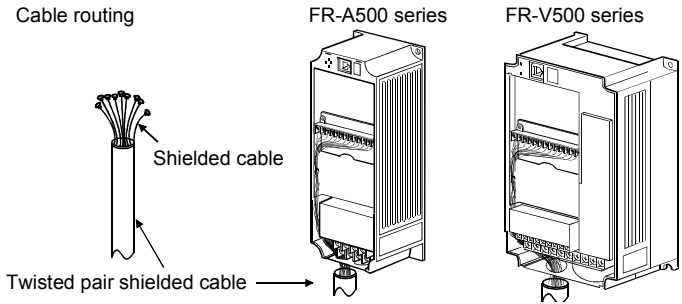
1. **Option fixing hooks are available for the FR-A500(L), F500(L) series inverter produced in and after Aug., 2000.**
2. **Only one type of option per inverter may be used. When two or more options are mounted, priority is in order of slots 1, 2 and 3, the options having lower priority are inoperative.**
3. **When the inverter cannot recognize that the option is mounted, it displays the option error. The errors shown differ according to the mounting slots 1, 2, 3.**

Mounting Position	Error Display
Slot 1	E.OP1
Slot 2	E.OP2
Slot 3	E.OP3

2.3 Wiring

Route the wires so that they do not take up a lot of space in the control circuit terminal block of the option unit. Wire the twisted pair shielded cable after stripping its sheath to make its cables loose. Also, protect the shielded cable of the twisted pair shielded cable to ensure that it will not make contact with the conductive area.

During wiring, do not leave wire off-cuts in the inverter. They may cause a fault, failure or malfunction.



REMARKS

The wires with large gaze may not be connected to the terminal block. When connected in parallel, all wires may not fit in the wiring space due to the increased number of wires. In such cases, perform wiring by using a junction terminal block.

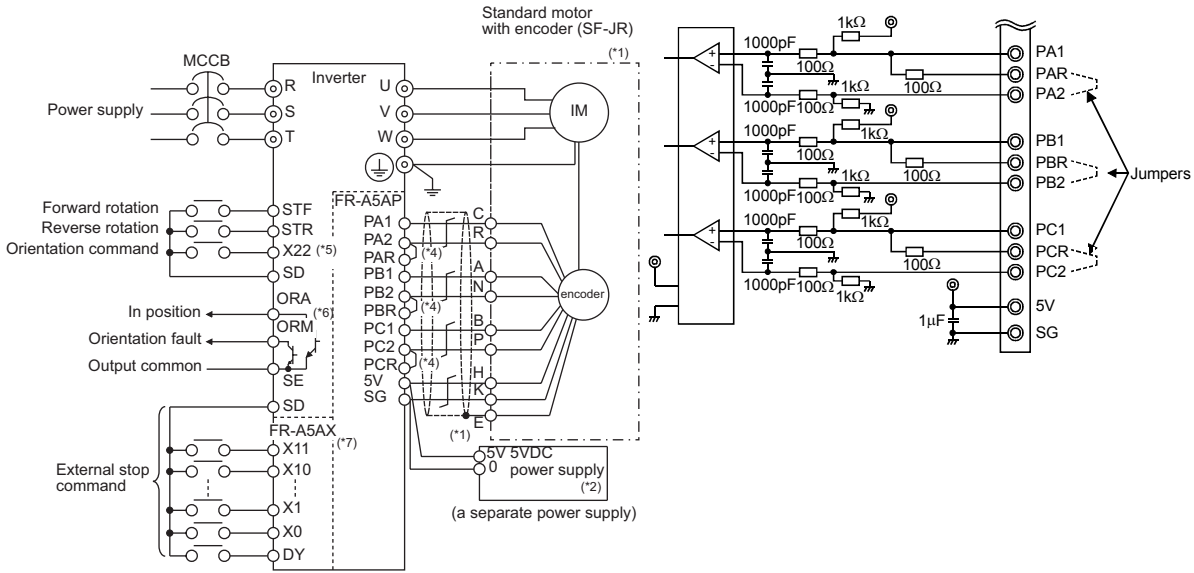
⚠ CAUTION

⚠ **When installing the inverter front cover, the cables to the inverter's control circuit terminals and option terminals should be routed properly in the wiring space to prevent them from being caught between the inverter and its cover.**

3. ORIENTATION CONTROL—A500(L)

This function is used with a position detector (encoder) installed to the spindle of a machine tool (or the motor) to allow a rotary shaft to be stopped at the specified position (oriented).
Pr. 350 "stop position command selection" is factory-set to "9999" to make the orientation control function invalid.
Refer to page 60 for orientation control by the FR-V500 series.

3.1 Wiring Example



*1 When the motor with encoder used is other than the standard motor with encoder (SF-JR), the pin numbers are different.
To reduce radiated noise, connect the shielded wires of the encoder cables to the case earth (ground) pin.
*2 When orientation control is used with encoder feedback control, the encoder and 5V power supply may be shared between these controls.
*3 Couple the encoder in line with the motor with a speed ratio of 1 to 1 without any mechanical looseness.
*4 Keep the accessory jumpers connected.
However, when the same encoder is shared between the FR-A5AP and another unit (e.g. NC) which is connected with a terminal resistor, the built-in terminal resistors are not required and should be removed. (Terminal resistors: 100Ω)
*5 Assign this function to any of the input terminals using Pr. 180 to Pr. 186 (input terminal function selection).
*6 Assign this function to any of the output terminals using Pr. 190 to Pr. 195 (output terminal function selection).
*7 When the stop position command is entered from outside the inverter (externally), the FR-A5AX plug-in option is required.

3.2 Terminals

Symbol	Terminal	Description
PA1	Encoder A-phase signal input terminal	A-, B- and Z-phase signals are input from the encoder. For information on the pulse signals, refer to page 14.
PA2	Encoder A-phase inverse signal input terminal	
PB1	Encoder B-phase signal input terminal	
PB2	Encoder B-phase inverse signal input terminal	
PC1	Encoder Z-phase signal input terminal	
PC2	Encoder Z-phase inverse signal input terminal	
PAR	A-phase terminal resistor terminal	Factory-connected with "PA2" by the jumper. Remove the jumper when the terminal resistor is not needed.
PBR	B-phase terminal resistor terminal	Factory-connected with "PB2" by the jumper. Remove the jumper when the terminal resistor is not needed.
PCR	Z-phase terminal resistor terminal	Factory-connected with "PC2" by the jumper. Remove the jumper when the terminal resistor is not needed.
5V	DC power (positive) input terminal	Encoder power supply common terminals. Input encoder power. Connect the positive side to 5V and the ground side to SG. Also, connect the shield of the shielded wire to SG. 4.75 to 6VDC (Current consumption 50mA)
SG	DC power ground terminal	

<Inverter I/O terminals>

Symbol	Terminal	Description
X22 (*1)	Orientation command input terminal	Used to enter an orientation signal.
SD	Common terminal	Common terminal for the orientation signal.
ORA (*2)	In-position signal output terminal	Switched low if the orientation has stopped within the in-position zone while the start and orientation signals are input. Open collector output. (Permissible load 24VDC, 0.1A)
ORM (*2)	Orientation fault signal output terminal	Switched low if the orientation has not stopped within the in-position zone while the start and orientation signals are input. Open collector output. (Permissible load 24VDC, 0.1A)
SE	Open collector output common terminal	Common terminal for the ORA and ORM open collector output terminals. Isolated from the common terminal of the control circuit.

*1 Assign the function of the X22 signal to any of the input terminals using "input terminal function selection" (Pr.180 to 186).
Refer to the inverter manual for details of input terminal function selection.

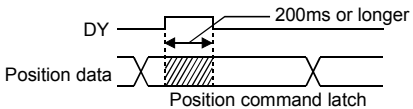
*2 Assign the functions of the ORA/ORM signal to any of the output terminals using "output terminal function selection" (Pr.190 to 195).
Refer to the inverter manual for details of output terminal function selection.

<FR-A5AX, inverter input terminals>

Symbol		Terminal	Remarks	Description
FR-A5AX input terminals	X0 to X11	Digital signal input terminals	Use a micro current switching contact relay for the relay contact. A transistor with the following specifications should be selected for the open collector signal: Electrical characteristics of the transistor used; • $I_C \geq 10mA$ • $V_{CE} \geq 30V$ • Leakage current 100μA max. • If IC $\geq$ 10mA, $V_{CE(sat)}$ voltage is 3V max.	Used to input digital signals through either relays or open collector transistors. As the command signals are entered, speed or position commands are selected using Pr. 360.
	DY*	Data read timing input signal		Used when a digital signal read timing signal is necessary. Data is only read while terminals DY-SD are shorted. By opening terminals DY-SD, the data before opening is retained.
Inverter input terminals	SD	Common terminal (sink)		Common terminal for digital signal input terminals and data read timing signals.
	PC	External transistor common terminal (source)		When connecting the transistor output (open collector output) of a programmable controller (PLC), etc., connect the external power common (positive) to this terminal to prevent a fault occurring due to leakage current.

* How to use terminal DY (when the stop position is specified from outside the inverter (externally)).

When terminals DY-SD are open, the inverter does not import data. Therefore, if the input status of the X0-X11 signals change, the stop position data before opening of terminals DY-SD is valid. Also, the position data is imported on the leading edge of the DY signal.



REMARKS

Pr.300 to Pr.305 settings for the FR-A5AX are made invalid when the stop position is set to be specified from outside the inverter (externally), with the FR-A5AP (orientation control option) fitted to the inverter and when orientation control is used.
Pr.300 to Pr.305 of the FR-A5AX are made valid when the stop position is not set from outside the inverter.

3.3 Wiring Instructions

(1) Connection with the position detector (encoder).

Use twisted pair shielded cables (0.2mm^2 or larger) to connect the FR-A5AP and position detector (encoder). Cables to terminals 5V and SG should be connected in parallel or be larger in size according to the cable length as indicated in the table below.
To protect the cables from noise, run them away from any source of noise (e.g. the main circuit and power supply voltage).

(2) Cable length.

1)Cable length within 30m.

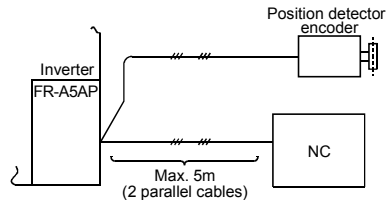
Cable Length	Number of Parallel Cables of 0.2mm^2 Required	Larger-Size Cable
Within 10m	At least 2 cables	0.4mm^2 or larger
Within 20m	At least 4 cables	0.75mm^2 or larger
Within 30m	At least 6 cables	1.25mm^2 or larger

2)Cable length of more than 30m.

Use a power supply slightly higher than 5V (approximately 5.5V) in addition to 6 or more parallel cables of 0.2mm^2 or cables of 1.25mm^2 or more. This allows the cable length to be increased up to 100m. Note that the voltage applied across terminals 5V-SG must not exceed 6V.

3)Connection with NC. (Or similar device)

When one position detector is shared between the FR-A5AP and NC (or another device), its output signals should be connected as shown below. In this case, the cable length between the FR-A5AP and NC should be as short as possible, within 5m.



(3) Connection of terminal resistors.
Use the jumpers across PA2-PAR, PB2-PBR and PC2-PCR to connect terminal resistors to the A, B and C-phases of the encoder. Normally, keep the jumpers fitted.
However, remove the jumpers when the same encoder is shared between the FR-A5AP and the other unit (e.g. NC) which is connected with a terminal resistor.

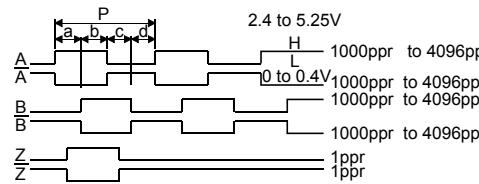
(4) Position detector (encoder).
Line driver LED type encoder

A. $\overline{A}$ signal 1000ppr to 4096ppr

B. $\overline{B}$ signal 1000ppr to 4096ppr

Z. $\overline{Z}$ signal 1ppr

Output pulse specifications



a, b, c and d should be (1/4 ± 1/8)P when rotation is clockwise as viewed from the shaft end of the encoder.

<Example of encoder available on the market>
Use an encoder which has an output circuit equivalent to AM26LS31 or 74LS113.
Pin Numbers of encoder Output Signals

Pin Number	Output Signal	Pin Number	Output Signal	Pin Number	Output Signal
C	A-phase signal	N	B-phase inverse signal	H	+5V power supply
R	A-phase inverse signal	B	Z-phase signal	K	Power supply common
A	B-phase signal	P	Z-phase inverse signal	E	Case earth (ground)

CAUTION

When encoder feedback control and orientation control are used together, the encoder is shared between these controls.
Use an encoder which has a pulse count of 1000 to 4096ppr (pulses per revolution).

3.4 Parameter List

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting	Remarks
350	Stop position command selection	0, 1, 9999	1	9999	9999: No orientation
351	Orientation speed	0 to 30Hz	0.01Hz	2Hz	
352	Creep speed	0 to 10Hz	0.01Hz	0.5Hz	
353	Creep select position	0 to 16383(*)	1	511	
354	Position loop select position	0 to 8191	1	96	Set using ± with respect to the stop position.
355	DC injection braking start position	0 to 255	1	5	Set using ± with respect to the stop position.
356	Internal stop position command	0 to 16383(*1)	1	0	
357	In-position zone	0 to 255	1	5	Set using ± with respect to the stop position.
358	Servo torque selection	0 to 13	1	1	
359	Encoder rotation direction	0, 1	1	1	
360	12-bit data selection	0, 1, 2 to 127	1	0	0: Speed command, 1: Position command, 2 to 127: Number of stop positions -1
361	Position shift	0 to 16383(*1)	1	0	
362	Position loop gain	1 to 10	1	1	
363	In-position signal output delay time	0 to 5 s	0.1 s	0.5 s	
364	Encoder stop check time	0 to 5 s	0.1s	0.5 s	

*1 When the FR-DU04 is used, up to 9999 may be set. When the FR-PU04 is used, up to maximum may be set.

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting	Remarks
365	Orientation time limit	0 to 60 s, 9999	1 s	9999	9999: 120 s setting
366	Recheck time	0 to 5 s 9999	0.1 s	9999	9999: No check
369	Encoder pulse count	0 to 4096	1	1024	Number of pulses before it is multiplied by 4
376 (*2)	Open cable detection enable/ disable selection	0, 1	1	0	0: Function disabled, 1: Function enabled

*2 Parameter available with an upgraded inverter. Refer to the inverter manual for the availability of the parameter.

3.5 Parameter Settings

3.5.1 Setting of stop position command

(1) Pr. 350 "stop position command selection" (factory setting: 9999)

- For the stop position command, either the internal stop position command or the external stop position command using external signals (12-bit data) may be selected.
- Set "9999" in Pr. 350 to make orientation control invalid.

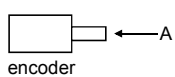
Pr. 350 Setting	Description
0	Internal stop position command
1	External stop position command
9999	Orientation control invalid (factory setting)

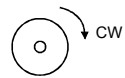
(2) Pr. 369 "number of encoder pulses" (factory setting: 1024)

Set the number of encoder pulses.
Set the number of pulses before it is multiplied by 4.
Example:
Set "1024" for 1024 pulses per revolution (ppr).

(3) Pr. 359 "encoder rotation direction" (factory setting: 1)

Indicates the direction in which the encoder rotates.



Pr. 359=0	Pr. 359=1 (factory setting)
 Forward rotation is clockwise rotation when viewed from A.	 Forward rotation is counterclockwise rotation when viewed from A.

(4) Pr. 361 "position shift" (factory setting: 0)

The stop positions are those defined by the position command plus the value set in Pr. 361.
<Position shift function>
Shifts the origin according to the compensation value without changing the origin of the position detector (encoder).

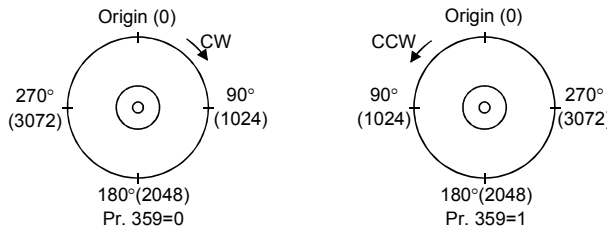
REMARKS

When the FR-A5AP is fitted and Pr. 350 "stop position command selection" is set to make orientation control valid, the PU (FR-DU04/FR-PU04) shows the rotation direction of the encoder.
Make setting so that FWD is displayed when the STF signal turns on or REV is displayed when the STR signal turns on.

3.5.2 Internal stop position command

(1) Pr. 356 "internal stop position command" (factory setting: 0)

Setting "0" in Pr. 350 "stop position command selection" chooses the internal position command mode. In the internal position command mode, the value set in Pr. 356 is the stop position. When the encoder pulse count is 1024prr, one revolution of the encoder (360 degrees) is divided into 4096 positions, i.e. 360 degrees/4096 pulses = 0.0879 degrees/pulses per address, as shown below. The stop positions (addresses) are indicated in parentheses.



3.5.3 External stop position command

(1) Pr. 360 "12-bit data selection" (factory setting: 0)

When "1" is set in Pr. 350 "stop position command selection" and the FR-A5AX option is used with the FR-A5AP, set stop positions using 12-bit data. The stop position command is a binary input regardless of the Pr. 304 setting.

•The value set in Pr. 360 "12-bit data selection" should be the number of stop positions less 1.

<Example>

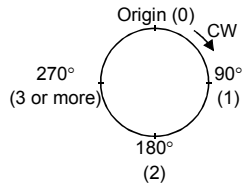
When the number of stop positions is 20 (divided at intervals of 18°), 20 - 1 = 19. Hence, set "19".

- The stop position command is entered in binary when using the FR-A5AX.

Pr. 360 Setting	Description
0	Speed command
1	Position command (*1)
2 to 127	The external stop position command may be used to set up to 128 stop positions at regular intervals. If the external stop command entered is greater than the setting, the stop positions are the same as those in the maximum external stop command value.

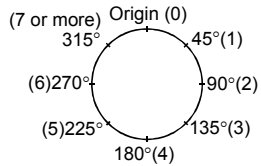
*1 When the value set in Pr. 369 "encoder pulse count" is 1024 or more, the 12-bit command is not a position command but the number of positions divided into 4096.

[Example 1]
4 stop positions



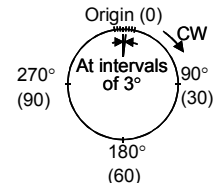
Pr. 360 = "3"

[Example 2]
8 stop positions



Pr. 360 = "7"

[Example 3]
120 stop positions



Pr. 360 = "119"

REMARKS

Values in parentheses indicate binary data entered from the input terminals of the FR-A5AX. If the position signal monitoring (Pr. 52 "DU/PU main display screen data selection" = 19) is selected, the data monitored is not the number of stop positions but is 0 to 4095 pulses.

- Relationships between stop position command and 12-bit data Pr. 350

Pr.350 "stop position command selection"	**Pr.360 "12-bit data selection"**	**Operating Status**		
		Stop position command	**12-bit data (FR-A5AX)**	**Speed command**
0: Internal	0: Speed command	Internal(Pr.356)	Speed command	12-bit data
	1, 2 to 127: Position command	Internal(Pr.356)	Invalid	External command (or PU)
1: External	0: Speed command	External(Pr.356)	Speed command	12-bit data
	1: External 1, 2 to 127: Position command	External (Internal when FR-A5AX is not fitted(Pr.356))	Position command	External command (or PU)

3.5.4 Time setting

(1) Pr. 363 "in-position signal output delay time" (factory setting: 0.5 s)
When the motor shaft enters the in-position zone, the in-position signal is output after a delay of the time set in Pr. 363. Also, when the motor shaft comes out of the in-position zone, the in-position signal is switched off after a delay of the time set in Pr. 363.

(2) Pr. 364 "encoder stop check time" (factory setting: 0.5 s)
When the in-position signal has not yet been output in orientation operation, the orientation fault signal is output if orientation cannot be completed and the encoder is stopped for the period of time set in Pr. 364. When the in-position signal has been output once, the orientation fault signal is output if the orientation cannot be completed again within the time set in Pr. 364.

(3) Pr. 365 "orientation time limit" (factory setting: 9999)
If orientation cannot be completed within the time set in Pr. 365, which is measured from when the current position signal has passed the creep select position, the orientation fault signal is output.

(4) Pr. 366 "recheck time" (factory setting: 9999)
If the start signal is switched off with the orientation command ON after the encoder is stopped under orientation control, the current position is checked again after the time set in Pr. 366 has elapsed and the in-position signal or orientation fault signal is output according to the check result.

3.5.5 Servo torque selection

(1) Pr. 358 "servo torque selection" (factory setting: 1)

Function \ Pr. 358 Setting	0	1	2	3	4	5	6	7	8	9	10	11	12	13	Remarks
1) Selection of servo torque function until output of in-position signal.	×	○	○	○	○	×	○	×	○	×	○	×	×	○	○ : Servo torque function valid × : Servo torque function invalid
2) Retry function selection.	×	×	×	×	×	×	×	○	×	×	×	○	×	×	○ : Retry function valid × : Retry function invalid
3) Output frequency is compensated for when motor shaft stops outside in-position zone.	×	×	○	○	×	○	○	×	×	×	×	×	○	○	○ : Frequency compensation valid × : Frequency compensation invalid
4) DC injection brake or servo torque is selected when the motor shaft comes out of the in-position zone after the in-position signal is output.	○	×	×	×	×	○	○	○	○	○	○	○	○	○	○ : DC injection brake selected × : Servo torque selected
5) Selection of DC injection brake or orientation termination timing.	○	○	○	×	×	○	○	○	○	×	×	×	×	×	○ : Start signal (STF, STR) or orientation command is switched off × : Orientation command is switched off
6) Selection of in-position signal OFF; when motor shaft comes out of in-position zone after in-position signal is output once.	○	○	○	○	○	×	×	×	×	×	×	×	×	×	○ : In-position signal is switched off when motor shaft comes out of in-position zone. × : In-position signal remains on if motor shaft comes out of in-position zone. (Orientation fault signal is not output.)

REMARKS

- If the orientation command is switched off with the start signal remaining on, the motor accelerates toward the command speed.
- If the motor shaft shifts to outside the stop position setting range, the servo torque function returns the motor shaft to the stop position (when sufficient torque can be developed). When orientation control is selected, servo torque is available for vector control, V/F control and all other controls.

1) Selection of servo torque function until the in-position signal is output

Set Pr. 358 "servo torque selection" to determine whether servo torque is required or not. When the current position signal is between the orientation stop position and DC injection brake start position, servo torque is not generated. The shaft is held by DC injection brake. If the current position signal comes out of this zone due to external force, etc., servo torque is generated to return the current position signal to within the zone.

Once the in-position signal is output, operation is performed in accordance with the setting in 4).

2) Retry function

Set Pr. 358 "servo torque selection" to determine whether the retry function is required or not. Note that this function cannot be used with the servo torque function. If the motor shaft is confirmed to have stopped but is not in the in-position zone, the retry function causes the shaft to be oriented again.

This retry is made three times, including the first orientation, but no more than three times. (The orientation fault signal is not output during retry operation.)

3) Frequency compensation function for use when the motor shaft has stopped outside the in-position zone

When the motor shaft has been stopped by external force, etc. before entering the in-position zone, the output frequency is increased to move the shaft to the orientation stop position. This output frequency rises gradually to the creep speed set in Pr. 352. This function cannot be used with the retry function.

4) Selection of whether DC injection brake or servo torque is started when the motor shaft comes out of the in-position zone after the in-position signal has been output once.
You can select whether to start DC injection brake to lock the shaft or to start servo torque to return the shaft to the orientation stop position if the motor shaft comes out of the in-position zone due to external force, etc. after the output of the in-position signal.

5) Selection of DC injection brake, servo torque or orientation termination timing
To terminate orientation, switch off the start signal (STF or STR) and then switch off the orientation command (X22). At this time, you can select the point of switching off the in-position signal between when the start signal is switched off or when the orientation command is switched off.

6) In-position signal OFF selection; for use when the motor shaft comes out of the in-position zone after the in-position signal is output once
You can select either the mode in which the in-position signal is switched off when the motor shaft comes out of the in-position zone or the mode in which the in-position signal remains on (orientation fault signal is not output) when the motor shaft comes out of the in-position zone.

(2) Pr. 362 "position loop gain" (factory setting: 1)
When Pr. 358 "servo torque selection" value has been set to choose the servo torque function, the output frequency provided to generate servo torque rises gradually up to the creep speed set in Pr. 352 according to the inclination set in Pr. 362 "position loop gain". Increasing the setting will increase the operation speed but may cause the machine to hunt.

3.5.6 Changing the monitor display

Monitoring	Description
Position signal monitoring	Set "19" in Pr. 52 to display the position signal on the PU instead of the output voltage. (Displayed only when the FR-A5AP is fitted.)
Orientation status	Set "22" in Pr. 52 to display the orientation status on the PU instead of the output voltage. (Displayed only when the FR-A5AP is fitted.) 0 - Orientation not selected (i.e. orientation mode has not been activated) or orientation speed has not been reached. 1 - Orientation speed reached. 2 - Creep speed reached. 3 - Position loop reached. 4 - In-position. 5 - Orientation fault (pulse stop). 6 - Orientation fault (orientation time limit elapsed). 7 - Orientation fault (recheck). 8 - Positioning orientation in progress.

3.5.7 Break in the cable detection enable/disable selection

This parameter is available with an upgraded inverter. Refer to the inverter manual for the availability of the parameter.

(1) Pr. 376 "break in the cable detection enable/disable selection" (factory setting: 0)

When the encoder signal turns off, it is judged as an inverter alarm (E.OSD) and the output is shut off.

Pr. 376 Setting	Description
0	Open cable detection disable
1	Open cable detection enable

3.6 Operation

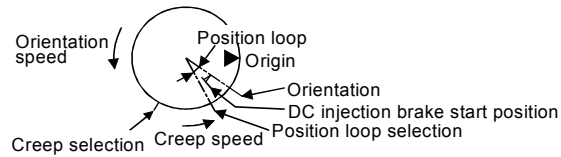
3.6.1 Orientation starting during rotation

1) The orientation command (X22) causes the motor to decelerate to the orientation speed set in Pr. 351 "orientation speed". (Pr. 351 factory setting: 2Hz)
2) After the orientation speed is reached, the motor decelerates to the creep speed set in Pr. 352 "creep speed" as soon as the current position signal reaches the creep select position set in Pr. 353 "creep select position". (Pr. 352 factory setting: 0.5Hz, Pr. 353 factory setting: 511)
3) Furthermore, the position loop begins to work as soon as the current position signal reaches the position loop select position set in Pr. 354 "position loop select position". (Pr. 354 factory setting: 96)
4) After the position loop is selected, the motor keeps decelerating until the current position signal reaches the DC injection brake start position set in Pr. 355 "DC injection brake start position", at which time DC injection brake is started to stop the motor. (Pr. 355 factory setting: 5)
5) When the motor has stopped within the in-position zone set in Pr. 357 "in-position zone", the in-position signal (ORA) is output with a delay of the in-position signal output delay time set in Pr. 363 "in-position signal output delay time". If the current position signal comes out of the in-position zone due to external force etc., the in-position signal is switched off with a delay of the in-position signal output delay time set in Pr. 363 "in-position signal output delay time". (Pr. 357 factory setting: 5)
6) The orientation fault signal (ORM) is output if the orientation cannot be completed within the time set in Pr. 365 "orientation time limit" after the current position signal has passed the creep select position.
7) If the orientation (once started) has been stopped by an external force etc. before the in-position zone is reached and the in-position signal (ORA) is not yet output, the orientation fault signal (ORM) is output after the encoder stop check time set in Pr. 364 "encoder stop check time" has elapsed. If the current position signal comes out of the in-position zone due to an external force etc. after the output of the in-position signal (ORA), the in-position signal (ORA) is switched off after a delay of the in-position signal output delay time set in Pr. 363 "in-position signal output delay time". If the orientation cannot be completed within the encoder stop check time set in Pr. 364 "encoder stop check time", the orientation fault signal (ORM) is output.

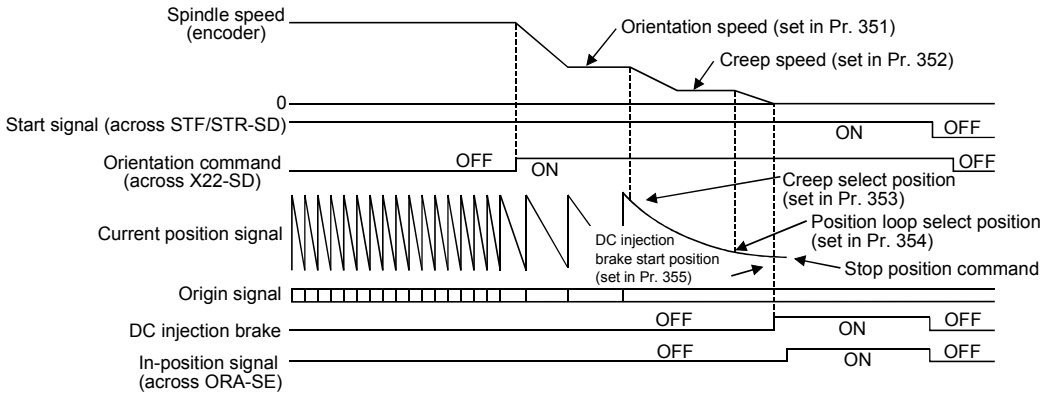
8) When the start signal (STF or STR) is switched off with the orientation command on after the in-position signal (ORA) or orientation fault signal (ORM) has been output once, the in-position signal (ORA) or orientation fault signal (ORM) is output again after the recheck time set in Pr. 366 "recheck time" has elapsed.
9) The in-position signal (ORA) and orientation fault signal (ORM) are not output if the orientation command is off.

REMARKS

If the orientation command is switched off with the start signal on, the motor accelerates to the command speed.



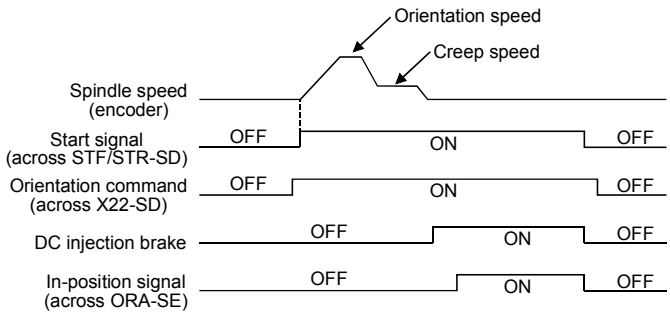
Operations timing chart



3.6.2 Orientation starting during stop

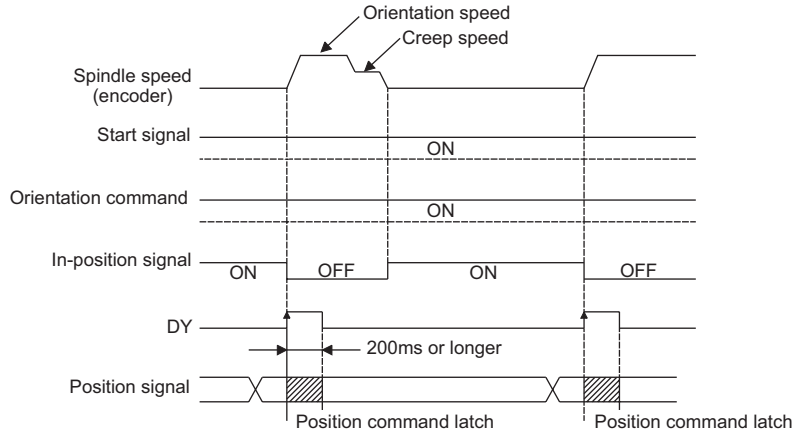
Switch on the orientation command (X22), then switch on the start signal to start and accelerate the motor to the orientation speed set in Pr. 351 "orientation speed" and perform orientation using the same procedure as in "orientation starting during rotation". Note that if the current position signal is within the DC injection brake start position, the spindle speed will not rise to the orientation speed and the DC injection brake is applied.

Operation timing chart



3.6.3 Multi-position orientation

Orientation starting with orientation command and STF/STR kept on
(Orientation starting in the orientation completion state)



- Position data is read on the leading edge of DY (refer to the FR-A5AX instruction manual).
- If the current position signal is within the creep select position, the spindle speed rises not to the orientation speed but to the creep speed.
- If the current position signal is outside the creep select position, the spindle speed rises to the orientation speed.
- If the current position signal is within the DC injection brake start position, the DC injection brake is applied.

3.7 Instructions

(1) The encoder should be coupled with the motor shaft or the spindle oriented with a speed ratio of 1 to 1 without any mechanical looseness.

(2) The DC injection brake operated for positioning must be released in the shortest time (within several seconds). Operating the brake continuously can cause the motor to generate heat and burn out.

(3) The servo lock function is not available after positioning stop. If the spindle must be held securely, prepare an appropriate holding means such as a mechanical brake or a dowel pin.

(4) To ensure correct positioning, the encoder must be set in the proper rotation direction and the A and B phases connected correctly.

(5) The orientation fault signal may be output if the pulse signal is not given from the encoder during orientation due to a signal loss or the like.

(6) When orientation control is exercised, orientation cannot be completed if "no DC injection brake operation" is set in the DC injection brake adjusting (voltage, frequency, speed, time) parameters. These parameters must be set to operate the DC injection brake.

(7) To terminate orientation, the start signal (STF or STR) must be first switched off and the orientation signal (X22) must be switched off. As soon as this orientation signal is switched off, orientation control ends. Depending on the Pr.358 "servo torque selection" settings, the orientation state remains if the orientation signal is on even after the DC injection brake is released at the switching off of the start signal. Therefore, the orientation status of the monitor function does not return to 0.)

(8) When the retry function of in Pr. 358 "servo torque selection" is selected, the retry operation is performed three times including the first orientation.
(Note: The first orientation counts as 1 retry.)

(9) For orientation control, set correct values in Pr. 350 "stop position command selection" and Pr. 360 "12-bit data selection" (external position command selection).
If the values set are incorrect, proper orientation control will not be performed.

(10) If "8888" (DC dynamic injection external selection) is set in Pr. 11 "DC injection brake operation time", the DC injection brake is not operated unless the X13 terminal signal is switched on. For orientation control, the DC injection brake is operated independently of the X13 signal.

(11) When orientation control is exercised, PID control is invalid.

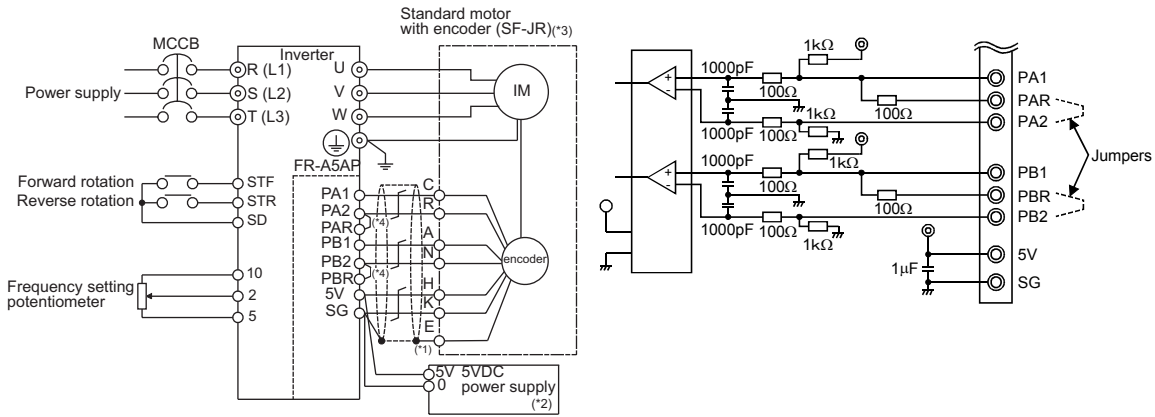
3.8 Specifications

Stop position accuracy	±1.5 degrees Depends on the load torque, load inertia moment, orientation speed, creep speed, position loop select position, etc.
Permissible rotation speed	Encoder-mounted shaft speed (6000r/min) The motor and encoder-mounted shaft must be coupled directly or via a belt without any slip. A gear change type cannot be used.
Functions	• Orientation and creep speed setting. • Stop position command selection. • DC injection brake start position setting. • Creep speed and position loop select position setting. • Position shift. • In-position zone. • Position signal monitoring, etc. Note: Set the above functions from the parameter unit.
Holding force after positioning	Without servo lock function (However, the servo lock function is valid when "2" is set in Pr. 370 to choose vector control.)
Input signals (contact input)	• Orientation command. • Forward and reverse rotation commands. • Stop position command (open collector signal may also be entered). Maximum 12-bit binary signal.
Output signals (open collector output)	• In-position signal. • Orientation fault signal.
DC power supply	Prepare a 5VDC power supply for the encoder. (Usually approximately 350mA) 5V, 50mA is also required for the option. Supply power from the NC or use a general power supply. Example:DENSEI-LAMBDA EWS15-5 (5V, 3A) *When encoder feedback control and orientation control are used together, the 5V power supply is shared between these controls.

4. ENCODER FEEDBACK CONTROL—A500(L)

The FR-A500(L) series fitted with the FR-A5AP can exercise encoder feedback control.
For the FR-V500 series, vector control can be exercised without the FR-A5AP and encoder feedback control is not exercised with the FR-A5AP.
This function is used with a speed detector (encoder) to allow the motor speed to be detected by the speed detector and fed back to the inverter so that the output frequency of the inverter is controlled to keep the motor speed constant to load variations.
Pr. 367 "speed feedback range" is factory-set to "9999" and Pr. 370 "control mode selection" to "0", making this function invalid.

4.1 Wiring Example



*1 When the motor with encoder used is other than the standard motor with encoder (SF-JR), the pin numbers are different.
To reduce radiation noise, connect the shielded wires of the encoder cables to the cable earth (ground) pin.

*2 When encoder feedback control is used with orientation control, the encoder and 5V power supply may be shared between these controls.

*3 Couple the encoder in line with the motor with a speed ratio of 1 to 1 without any mechanical looseness.

*4 Keep the accessory jumpers connected.
However, when the same encoder is shared between the FR-A5AP and the other unit (e.g. NC) which is connected with a terminal resistor, the built-in terminal resistors are not required and should be removed. (Terminal resistors; 100Ω)

4.2 Terminals

Symbol	Symbol Terminal	Description
PA1	Encoder A-phase signal input terminal	A and B-phase signals are input from the encoder. For information on the pulse signals, refer to page 37.
PA2	Encoder A-phase inverse signal input terminal	
PB1	Encoder B-phase signal input terminal	
PB2	Encoder B-phase inverse signal input terminal	
PAR	A-phase terminal resistor terminal	Factory-connected with "PA2" by the jumper. Remove the jumper when the terminal resistor is not needed.
PBR	B-phase terminal resistor terminal	Factory-connected with "PB2" by the jumper. Remove the jumper when the terminal resistor is not needed.
5V	DC power (positive) input terminal	Encoder power supply common terminals. Input encoder power. Connect the positive side to 5V and the ground side to SG. Also, connect the shield of the shielded wire to SG. 4.75 to 6VDC (Current consumption 50mA)
SG	DC power ground terminal	

4.3 Wiring Instructions

(1) Connection with the speed detector (encoder)

Use twisted pair shielded cables (0.2mm^2 or larger) to connect the FR-A5AP and speed detector (encoder). Cables to terminals 5V and SG should be connected in parallel or be larger in size according to the cable length table as indicated below.

To protect the cables from noise, run them (at least 10cm) away from any source of noise (e.g. the main circuit and power supply voltage).

(2) Cable length

1)Cable length within 30m

Cable Length	Number of Parallel Cables of 0.2mm^2	Larger-Size Cable
Within 10m	At least 2 cables	0.4mm^2 or larger
Within 20m	At least 4 cables	0.75mm^2 or larger
Within 30m	At least 6 cables	1.25mm^2 or larger

2)Cable length of more than 30m

Use a power supply slightly higher than 5V (approximately 5.5V) in addition to 6 or more parallel cables of 0.2mm^2 or cables of 1.25mm^2 or more. This allows the cable length to be increased up to 100m. Note that the voltage applied across terminals 5V-SG must not exceed 6V.

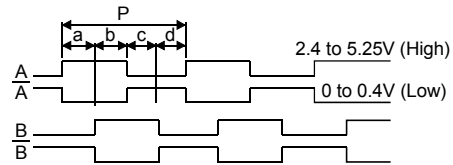
(3) Connection of terminal resistors

Use the jumpers across PA2-PAR and PB2-PBR to connect terminal resistors to the A and B-phases of the encoder. Normally, keep the jumpers fitted.

However, remove the jumpers when the same encoder is shared between the FR-A5AP and the other unit (e.g. NC) which is connected with a terminal resistor.

(4) Speed detector (encoder)
Line driver LED type encoder
A. $\overline{A}$ signal 1000ppr to 4096ppr
B. $\overline{B}$ signal 1000ppr to 4096ppr

Output pulse specifications



a, b, c and d should be (1/4 ± 1/8)P when rotation is clockwise as viewed from the shaft end of the encoder.

<Example of encoder available on the market>
<AM26L31, 74LS113 equivalent>

Pin Numbers of Encoder Output Signals

Pin Number	Output Signal	Pin Number	Output Signal
C	A-phase signal	H	+5V power supply
R	A-phase inverse signal	K	Power supply common
A	B-phase signal	E	Case earth (ground)
N	B-phase inverse signal		

REMARKS

When encoder feedback control and orientation control are used together, the encoder is shared between these controls.
Use the encoder with a pulse count of 1000 to 4096ppr.

4.4 Encoder Feedback Control and Vector Control Parameter List

Fitting this option unit adds the following parameters. Make setting as necessary.

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting	Control Mode	
					Encoder feedback control	Vector control
22	Torque restriction level (Stall prevention operation level) (*1)	0 to 300%, 9999	0.1%	150%	— (*3)	○
29	Acceleration/deceleration pattern	0, 1, 2, 3, 4	1	0	○ (*4)	○ (*4)
144	Number of motor poles (Speed setting switchover) (*1)	0, 2, 4, 6, 8, 10, 102, 104, 106, 108, 110	1	4	○	○
162	Automatic restart after instantaneous power failure selection	0, 1, 2	1	0	○	○
285	Overspeed detection frequency/excessive speed deviation detection frequency (*5)	0 to 30Hz, 9999	0.01Hz	9999	○ (*5)	○ (*5)
359	Encoder rotation direction	0, 1	1	1	○	○
367	Speed feedback range	0 to 400Hz, 9999	0.01Hz	9999	○	—
368	Feedback gain	0 to 100	0.1	1	○	—
369	Number of encoder pulses	0 to 4096	1	1024	○	○
370	Control mode selection	0, 1, 2	1	0	○	○
371	Torque characteristic selection	0, 1	1	1	—	○
372	Speed control P gain	0 to 200%	0.1%	100%	—	○

Parameter Number	Name	Setting Range	Minimum Setting Increments	Factory Setting	Control Mode	
					Encoder feedback control	Vector control
373	Speed control I gain	0 to 200%	0.1%	20%	—	○
374	Overspeed detection level	0 to 400Hz	0.01Hz	120Hz	○	○
375	Servo lock gain	0 to 150	1	20	—	○
376	Open cable detection enable/ disable selection	0, 1	1	0	○	○
380	Acceleration S pattern 1	0 to 50%	1%	0%	—	○
381	Deceleration S pattern 1	0 to 50%	1%	0%	—	○
382	Acceleration S pattern 2	0 to 50%	1%	0%	—	○
383	Deceleration S pattern 2	0 to 50%	1%	0%	—	○

*1 When the FR-A5AP is not fitted, the function names in parentheses are used.
*2 ○ in the Control Mode field indicates that the corresponding function is valid.
*3 Functions as the stall prevention operation level.
*4 The acceleration/deceleration pattern C setting (Pr. 29 = 4) is made valid when the FR-A5AP is fitted.
*5 Functions as an overspeed detection frequency under encoder feedback control and as an excessive speed deviation detection frequency under vector control. Excessive speed deviation detection frequency is a parameter available with an upgraded inverter. The parameter acts only as an overspeed detection frequency for a standard inverter. Refer to the inverter manual for the availability of the excessive speed deviation detection frequency.

4.5 Pre-Operation Settings

(1) Pr. 144 "number of motor poles (encoder)" (factory setting: 4)

The either of the following motors may be used. Set the number of motor poles according to the motor used:

- Standard motor (with encoder) : SF-JR 0.2kW to 55kW
- Constant-torque motor (with encoder) : SF-JRCA 0.4kW to 55kW

REMARKS

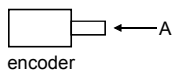
1. For vector control, this parameter value is made invalid and the setting of Pr. 81 "number of motor poles" is made valid.
2. If you set this parameter value to "0, 10 or 110" and operate the inverter, any of E.OP1 to E.OP3 occurs.
3. If you set "102, 104, 106 or 108", that value minus 100 is set as the number of poles.

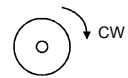
(2) Pr. 369 "number of encoder pulses" (factory setting: 1024)

Set the number of encoder pulses.
Set the number of pulses before it is multiplied by 4.
Example: Set "1024" for 1024 pulses per revolution (ppr).

(3) Pr. 359 "encoder rotation direction" (factory setting: 1)

(4) Indicates the direction in which the encoder rotates.



Pr. 359=0	Pr. 359=1 (factory setting)
 Forward rotation is clockwise rotation when viewed from A.	 Forward rotation is counterclockwise rotation when viewed from A.

REMARKS

When the FR-A5AP is fitted and encoder feedback control or vector control is selected, the PU (FR-DU04/FR-PU04) shows the rotation direction of the encoder.
Make the setting so that FWD is displayed when the STF signal switches on or REV displayed when the STR signal switches on.

4.6 Control Mode Setting

By setting the Pr. 370 "control mode selection" value, you can choose any of encoder feedback control (V/F control, advanced magnetic flux vector control) and vector control.
Torque control and position control are not performed. (However, torque limit can be done in the vector control mode.)
When holding torque is required during a stop, choose vector control (zero speed control or servo lock).

Control Mode		Motor	Pr. 80, Pr. 81 Setting	Pr. 370 Setting	Pr. 367 Setting	Zero Speed Control	Servo Lock	Torque Limit
Encoder feedback control	V/F control	Standard motor with encoder (same capacity)	9999	0 (1,2) (*2)	Other than 9999	×	×	×
	Advanced magnetic flux vector control	Standard motor with encoder (same capacity)	Other than 9999	0	Other than 9999			
Vector control (*1)		Standard motor with encoder (same capacity)	Other than 9999	1	—	○	×	○
			Other than 9999	2	—	×	○	○

(Pr. 370 factory setting: 0, Pr. 367 factory setting: 9999)

*1 When a speed control range of 1:1000 is required, choose vector control.
If vector control has been chosen, torque control and position control are not performed. The frequency response of vector control is 10 to 20rad/s.

*2 When Pr. 80 and Pr. 81 = "9999", encoder feedback control (V/F control) is valid if "1" or "2" is set in Pr. 370.

REMARKS

The X18 (RT) signal may be used to select between encoder feedback control + V/F control, encoder feedback control + advanced magnetic flux vector control and vector control during a stop only. Refer to the inverter manual for details of the X18 (RT) signal.

4.7 Encoder Feedback Control

Make sure that Pr. 80 "motor capacity", Pr. 81 "number of motor poles", Pr. 144 "speed setting change", Pr. 359 "encoder rotation direction", Pr. 369 "number of encoder pulses" and Pr. 370 "control mode" values are set properly. (Refer to page 40, 41.)

(1) Pr. 367 "speed feedback range" (factory setting: 9999)

This parameter is used to make the encoder feedback function valid.

Set the speed feedback control range.

(When Pr. 367 = 9999 (factory setting), the encoder feedback function is invalid.)

<Setting>

Define the upper and lower limits in reference to the set value (frequency at which the motor is to be rotated at constant speed). Normally, set the frequency converted from the rated motor speed (rated load) and slip (r/min). Too large setting will result in slow response.

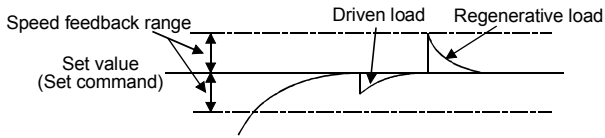
Example: Rated speed of a 4-pole motor is 1740r/min (60Hz)

Slip Nsp = synchronous speed - rated speed

= 1800 - 1740 = 60 (r/min)

Frequency equivalent to slip (fsp)

$$fsp = \frac{Nsp \times \text{number of poles}}{120} = \frac{60 \times 4}{120} = 2(Hz)$$



(2) Pr. 368 "feedback gain" (factory setting: 1)

This parameter is valid when encoder feedback control is valid. Set if rotation is instable or response is slow. When the setting is greater than 1, response is faster but overcurrent or rotational instability is more liable to occur. When the setting is less than 1, response is slower but rotation is more stable.

(3) Instructions for encoder feedback control

1) The number of motor poles used must be checked before starting operation. The number of poles set must be correct to ensure proper control of the motor.
2) The encoder should be coupled in line with the motor shaft without any mechanical looseness with a speed ratio of 1 to 1.
3) Make sure that the encoder has been set to the correct rotation direction on the rotation direction display of the parameter unit. If the rotation direction is not correct, encoder feedback control cannot be carried out (the inverter can be operated).
4) During acceleration or deceleration, encoder feedback control is not performed to prevent instability such as hunting. Encoder feedback control is started after the output frequency has once reached the [set speed] ± [speed feedback range].
5) If any of the following conditions occurs during encoder feedback control operation, the inverter is run at the output frequency of [set speed] ± [speed feedback range] without coming to an alarm stop and does not follow up the motor speed:
   - The pulse signal from the encoder is switched off due to an open cable, etc.
   - An accurate pulse signal cannot be detected due to induction noise, etc.
   - The motor is forced to accelerate (regenerative operation) or decelerate (e.g. motor lock) by large external force.
6) When opening the brake of the motor with brake, use the RUN (running) signal. (The brake may not be opened if the FU (output frequency detection) signal is used.)
7) During encoder feedback control, do not switch off the 5V power of the encoder. If the power is switched off, normal encoder feedback control cannot be exercised.
8) Programmed operation cannot be performed in the encoder feedback control mode (when the FR-A5AP is fitted).
9) Set Pr. 285 "overspeed detection frequency" to prevent misoperation caused if an accurate signal cannot be detected from the encoder. This shuts off the output and gives an inverter alarm (E.MB 1) when; (detection frequency) - (output frequency) > Pr. 285.

4.8 Vector Control (Zero Speed Control and Servo Lock)

Vector control can be performed when a standard motor with encoder is used.
Make sure that Pr. 80 "motor capacity", Pr. 81 "number of motor poles", Pr. 144 "number of motor poles", Pr. 359 "encoder rotation direction", Pr. 369 "number of encoder pulses" and Pr. 370 "control mode" values are set properly. (Refer to page 40, 41.)
Set "100%" in Pr. 89 "speed control gain" to perform vector control. For details of Pr. 89, refer to the inverter manual.
Servo lock will resist and attempts to move it from the stop position, the limitation is the amount of torque that can be provided.
Servo lock is only available in vector control mode (when using an encoder).

4.8.1 Zero speed control

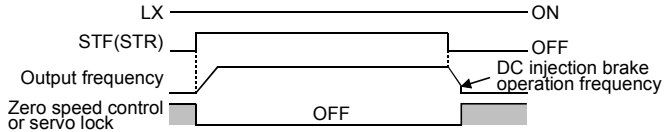
When the Pr. 370 value is "1" and Pr. 80 and Pr. 81 values are not "9999", zero speed control is made valid so that torque may be generated at zero speed.
Use Pr. 22 to set the torque limit level in the zero speed control mode. (150% torque (short duration) is possible.)

4.8.2 Servo lock

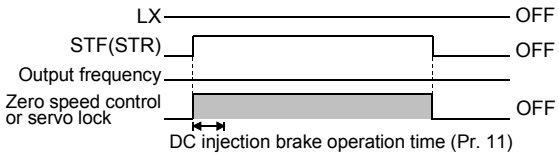
When the Pr. 370 value is "2" and Pr. 80 and Pr. 81 values are not "9999", servo lock is made valid.
Use Pr. 22 to set the torque limit level in the servo lock mode. (150% torque (short duration) is possible.)
Also, use Pr. 375 "servo lock gain" to set the servo lock gain. (Pr. 375 factory setting: 20)
A high setting will make response faster but increase the probability of instability.
When inertia moment is large, a high servo lock gain setting will increase the probability of instability.

<Zero speed control and servo lock timing charts>

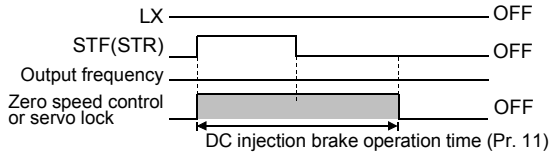
1) Zero speed control or servo lock is made valid when the pre-excitation terminal (LX) is ON without the start signal (STF, STR) being entered into the inverter (during a stop). Assign the function of the pre-excitation terminal (LX) to any of the terminals using Pr. 180 to Pr. 186.



2) Zero speed control or servo lock is made valid when the frequency command is 0Hz (not more than the starting frequency) with the start signal being entered.



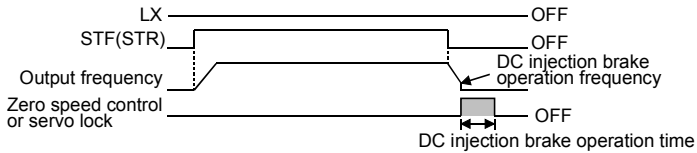
<Start signal turns OFF after the DC injection brake operation time has elapsed>



<Start signal turns OFF before the DC injection brake operation time has elapsed.>

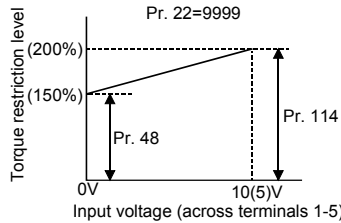
If a start is made during zero speed control or servo lock, online auto tuning is not activated.

3) Zero speed control or servo lock is made valid when the frequency command is not more than the DC injection brake frequency during deceleration of the inverter. The position at the DC injection brake operation frequency is held.



4.8.3 Pr. 22 "torque restriction level" (factory setting: 150%)

Torque limit may be activated only when vector control is selected. The second and third functions are Pr. 48 "second torque limit level" and Pr. 144 "third torque limit level".
When vector control is not selected, the stall prevention functions are activated. Use the same parameter numbers for setting. (Refer to the Inverter Instruction Manual.)
The Pr. 22 setting may be changed during operation.
When Pr. 22 = "9999", the torque limit level may be set by entering a signal into the No. 1 terminal. At this time, the auxiliary input override function of the No. 1 terminal is not activated.
The variable torque limit level analog signal can be limited.



4.8.4 Pr. 371 "torque characteristic selection" (factory setting: 1)

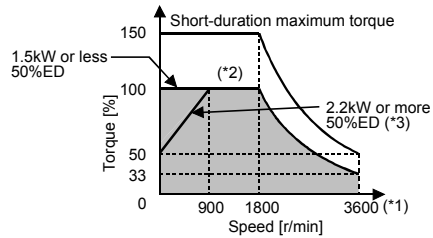
Used to change the torque characteristic according to the machine characteristics.

Pr. 371 Setting	Standard Motor with Encoder (e.g. SF-JR)
0	Cyclic operation mode
1 (factory setting)	Continuous operation mode

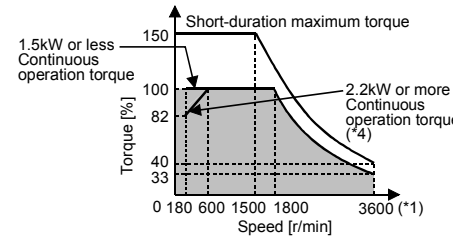
- Torque characteristic of the standard motor with encoder (Example: SF-JR standard motor with encoder (4 poles))

With Reference to 1800r/min (60Hz) Torque

Cyclic operation mode setting
When the inverter used has a capacity one rank higher than that of the motor and the rated voltage is input



Continuous operation mode setting
When the inverter used has the same capacity as that of the motor and the rated voltage is input



*1 The maximum speed is 1) 0.4kW to 7.5kW: 3600r/min, 2) 11kW to 30kW: 3000r/min, 3) 37kW to 55kW: 1950r/min.
*2 Continuous, repetitive operation of 50%ED can be performed in cycle time of 10 minutes. Note that the maximum continuous operation time is 5 minutes.
*3 Use the constant-torque motor (SF-JRCA with encoder) when 50%ED with 100% torque is required for 2.2kW or more at 900r/min or less.
*4 Use the constant-torque motor (SF-JRCA with encoder) when continuous 100% torque is required for 2.2kW or more at 600r/min or less.

CAUTION

1. **When using a motor and inverter which are the same in capacity in cycle operation mode, take caution that the current average value does not exceed the inverter rating. If the current average value exceeds, use an inverter whose capacity is one rank higher than the motor.**
2. **To provide 150% torque from 0Hz to the rated speed of the motor the inverter should be one rank higher than the motor.**
3. **Since the motor current increases when using an inverter and motor which are the same in capacity in cycle operation mode, use them with 80 % or less continuous torque.**
4. **Continuous operation when the inverter capacity is one rank higher than the motor will produce the same results as when the inverter and motor capacity are the same (as shown above).**
5. **If unusual noise from a motor (machine), hunting, or over current alarm occurs in continuous operation mode when satisfying two of the following conditions, change Pr. 37 "Torque characteristic selection" to cycle operation mode.**
   [Conditions]
   - **Running frequency is equal to or higher than the motor rated frequency.**
   - **Power supply voltage is less than 110% of the rated motor voltage.**

   When electronic thermal relay function or over current alarm functions in cycle operation mode, consider using an inverter and motor one rank higher in capacity.

4.8.5 Pr. 372 "speed control P gain" (factory setting: 100%)

Used to set the proportional gain of the speed loop.
A high setting will make the speed response faster but if the setting is too high this will cause vibrations and noise.

4.8.6 Pr. 373 "speed control I gain" (factory setting: 20%)

Used to set the integral gain of the speed loop.
A high setting will shorten restoration time at occurrence of speed variation but if the setting is too high this will cause speed overshooting.

4.8.7 Driving/regenerative status signal output (Y32)

When vector control is selected, the driving/regenerative status is output as a signal.
Assign the function of the output signal to any of the output terminals using Pr. 190 to Pr. 195 "output terminal function selection".

4.8.8 Operation ready 2 signal (RY2)

Output during operation (on completion of pre-excitation operation) under vector control. (switched on also during DC injection brake, 0 speed control or servo lock)
When opening the brake of a motor with brake, use the RY2 (operation ready 2) signal. (The brake may not be opened if the FU (output frequency detection) signal is used.)

4.8.9 Instructions for vector control

1) When using vector control, perform offline auto tuning in the motor rotation mode (while the motor is running). (Refer to the inverter manual.)
2) Before starting operation, always confirm that the correct number of poles of the motor is used. Proper speed control cannot be performed if the number of motor poles is incorrect.
3) Couple the encoder in line with the motor shaft with a speed ratio of 1 to 1 without any mechanical looseness.
4) Make sure that the encoder has been set to the correct rotation direction on the rotation direction display of the parameter unit. If the rotation direction is not correct, vector control cannot be carried out.
5) In the vector control mode, vector control is also exercised during acceleration/deceleration.
6) Do not switch off the 5V power of the encoder during vector control. Proper vector control cannot be performed if that power is switched off.
7) Proper vector control cannot be performed if the pulse signal from the encoder is lost due to an open cable, etc.
8) In the vector control mode, the carrier frequency is as follows:

● Carrier frequency of the FR-A500 series

Pr. 72 Setting	Carrier Frequency			
	V/F control, advanced magnetic flux vector control	Vector control		
		1 : 1 *1	One rank larger *2	
			18.5K or less	22K or more
0	0.7kHz	Approximately 1kHz	Approximately 1kHz	Approximately 1kHz
1	1kHz			
2	2kHz			
3	3kHz	Approximately 3kHz	Approximately 3kHz	Approximately 3kHz
4	4kHz			
5	5kHz			
6	6kHz		Approximately 6kHz	Approximately 6kHz
7	7kHz			
8	8kHz		Approximately 8kHz	
9	9kHz			
10	10kHz			
11	11kHz			
12	12kHz			
13	13kHz			
14	14kHz			
15	14.5kHz			

*1 This indicates the carrier frequency when the inverter capacity and the motor capacity are the same.
*2 This indicates the carrier frequency when the inverter capacity is one rank larger than the motor capacity. The capacities in the table indicate the inverter capacity.

CAUTION

In the vector control mode, set the Pr. 72 "PWM frequency selection" value during a stop.

● Carrier frequency of the FR-A500L series

Pr. 72 Setting	Carrier Frequency	
	V/F control, advanced magnetic flux vector control	Vector control
0	0.7kHz	Approximately 1kHz
1	1kHz	
2	2.5kHz	

4.9 Additional Functions

(1) Pr. 162 "selection of automatic restart after instantaneous power failure selection" (factory setting: 0)

By setting "2" in Pr. 162, automatic restart after instantaneous power failure can be made at the frequency detected from the encoder. In the vector control mode, automatic restart is made with the encoder detection frequency searched for, independently of the Pr. 162 setting.

Pr. 162 Setting	Description
0 (factory setting)	With frequency search
1	Without frequency search
2	Encoder detection frequency search

(2) Pr. 285 "overspeed detection frequency"/"excessive speed deviation detection frequency" (factory setting: 9999)

- When "0" is set in Pr. 370, Pr. 285 acts as an overspeed detection frequency. (Overspeed detection function)
  If (detection frequency (speed)) - (output frequency (speed)) > (Pr. 285 setting), E.MB1 occurs and the output is shut off.
  When Pr. 285 = 9999, overspeed detection is not performed.
- When "1" or "2" is set in Pr. 370, Pr. 285 acts as an excessive speed deviation detection frequency. (Speed deviation excess detection function)
  Excessive speed deviation detection frequency is a parameter available with an upgraded inverter. This parameter acts only as an over speed detection frequency for a standard inverter. Refer to the inverter manual for the availability of the excessive speed deviation detection frequency.
  If ((actual speed) - (speed command value)) > (Pr. 285 setting), E.OSD occurs and the output is shut off.

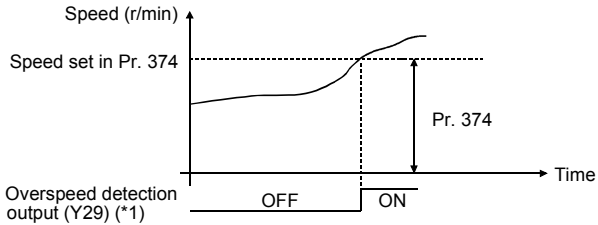
(3) Pr. 376 "break in the cable detection enable/disable selection" (factory setting: 0)

Parameter available with an upgraded inverter. Refer to the inverter manual for the availability of the parameter. (Refer to page 25)

(4) Pr. 374 "overspeed detection level" (factory setting: 120Hz)

Used to limit the maximum speed. (0 to 400Hz)

Any speed higher than the speed set in Pr. 374 is judged as overspeed and the corresponding signal is output. If overspeed is detected, the inverter will not come to an alarm stop.



*1 Assign overspeed detection (Y29) to any of Pr. 190 to Pr. 195 "output terminal function selection".

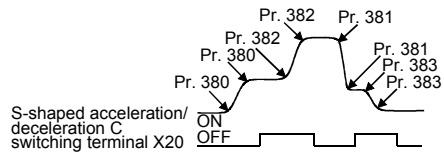
(5) Forward/reverse running signal output

Whether forward or reverse rotation is being made is output as a signal according to the actual speed. Assign the function of the output signal to any of the terminals using Pr. 190 to Pr. 195 "output terminal function selection".

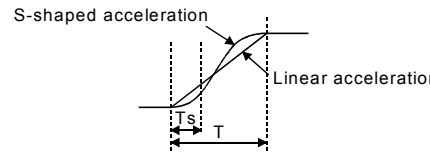
(6) S-shaped acceleration/deceleration C

When the FR-A5AP is fitted, S-shaped acceleration/deceleration C can be selected by setting "4" in Pr. 29 "acceleration/deceleration pattern". The S-shaped acceleration/deceleration C function allows the speeds of S-shaped acceleration/deceleration to be set in the corresponding parameters and the required parameter to be selected by the S-shaped acceleration/deceleration C switching terminal (X20).
Assign the function of the S-shaped acceleration/deceleration C switching terminal (X20) to any of the terminals using Pr. 180 to Pr. 186 "input terminal function selection".

Operation / S-Pattern Switching Terminal	During Acceleration	During Deceleration
OFF	Pr. 380 "S-shaped acceleration 1" (factory setting: 0%)	Pr. 381 "S-shaped deceleration 1" (factory setting: 0%)
ON	Pr. 382 "S-shaped acceleration 2" (factory setting: 0%)	Pr. 383 "S-shaped deceleration 2" (factory setting: 0%)



Also, Pr. 380 to Pr. 383 are used to set the ratio of the S-shaped acceleration/deceleration time (Ts) to the acceleration/deceleration time (T) in %.



CAUTION

During acceleration/deceleration, switching cannot be made using the S-shaped acceleration/ deceleration C switching terminal (X20). When X20 is switched either ON or OFF during either acceleration or deceleration, the effect of the switch (to select a different acceleration or deceleration shape) does not take effect until either the acceleration or deceleration has stopped (i.e. a stable speed has been reached).

4.10 Specifications

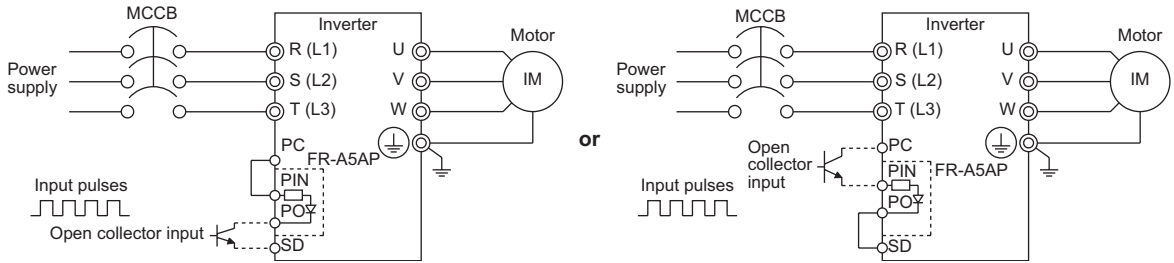
Speed variation ratio	±0.02% of the maximum speed (3600r/min) in vector control mode (load variation 0 to 100% at 6Hz or more). (*1)
Speed control range	1:1000 in vector control mode.
Functions	• Speed feedback range setting. • Feedback gain setting. • Encoder rotation direction setting.
DC power supply	A 5VDC power supply is required for the encoder and option unit. The 5V power supply can be shared between orientation control and encoder feedback control. This power supply is optional. Power supply 5VDC, current capacity 400mA or more. (Normally approximately 350mA for encoder and 50mA for option unit) <Power supply example> DENSEI LAMBDA EWS15-5 (5V 3A)
Maximum speed	3600r/min (120Hz)
Frequency response	10 to 20rad/s.

*1 Load variation 100% indicates the maximum continuous operation torque value of the motor output characteristic (refer to the relevent catalog or FR-A500 series technical information) to the running frequency.

5. PULSE TRAIN INPUT—A500(L)

A pulse train signal can be used to enter the speed setting of the inverter.
Pr. 384 is factory set to "0" to make this function invalid.
When the speed is input by the pulse train signal, the multi speed setting of the inverter becomes invalid.
Refer to page 56 for pulse train input with the FR-V500 series.

5.1 Wiring Example



CAUTION

This option unit must be wired using the open collector system to operate it properly.

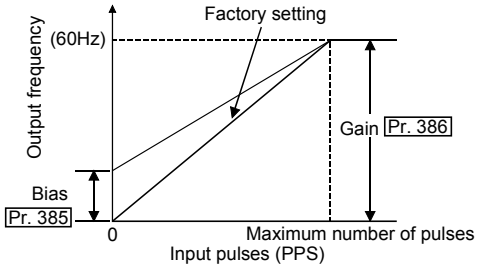
5.2 Terminals

Symbol	Terminal	Description
PIN	Pulse input terminal 1	Terminal used to enter a pulse train of 0 to 100kpps (*)
PO	Pulse input terminal 2	Terminal used to enter a pulse train of 0 to 100kpps (*)

REMARKS

*: Whether an input pulse is entered into PIN or PO depends on the wiring. Refer to page 56.

5.3 Adjustment



Note: Maximum number of input pulses: 100kpps

Note: Number of input pulses are multiplied by 2 internally.

5.4 Pulse Train Input Parameter List

Parameter Number	Name	Setting Range	Minimum Increments	Factory Setting
384 (*1)	Input pulse frequency division ratio	0 to 250	1	0
385	Zero-input pulse frequency	0 to 400Hz	0.01Hz	0
386	Maximum-input pulse frequency	0 to 400Hz	0.01Hz	60

*1 Indicates the frequency division ratio for the input pulses. The frequency resolution to the input pulses varies with the setting.

CAUTION

When the Pr. 384 value is "0" (factory setting), Pr. 385 and Pr. 386 do not function even if their values have been set.

⚠ CAUTION

⚠ Note that if you set any value other than 0Hz in Pr. 385, merely turning on the start signal will start the motor at the preset frequency without a pulse train input command.

5.5 Setting Example

How to calculate the input pulse frequency division ratio

Use the following formula to calculate the input pulse frequency division ratio in Pr. 384:

Maximum number of input pulses (pps) = Pr. 384 × 400

$$\text{Detectable frequency} > \frac{\text{Pr. 386}}{2 \times 16.6\text{ms} \times \text{Pr. 384} \times 400}$$

The detectable frequency changes with the maximum number of input pulses.

5.6 Specifications

Circuit System	Open Collector System
Input current	10mA
Max. permissible number of pulses	100kpps
Input pulse specifications	0f to 250f (f: variable frequency)
Response delay	16.6ms

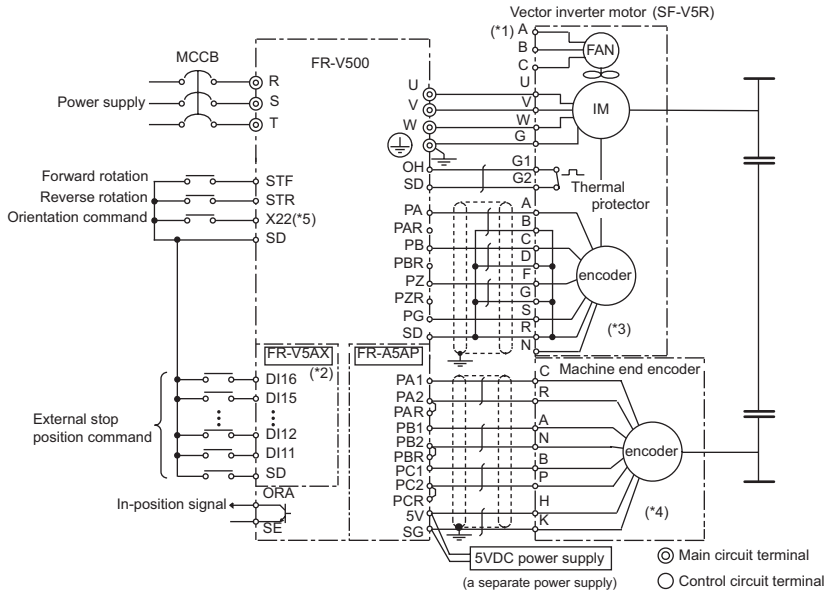
6. ORIENTATION CONTROL AT A MACHINE END—V500

This function is used with a position detector (encoder) installed to the spindle of a machine tool (or the motor) to allow a rotary shaft to be stopped at the specified position (oriented). Orientation control at a machine end is exercised.

Pr. 350 "stop position command selection" is factory-set to "9999" to make the orientation control function invalid.

Refer to page 8 for orientation control by the FR-A500(L) series.

6.1 Wiring Example



*1 The motor fan power supply is single-phase when the motor capacity is 7.5kW or less.

*2 When the stop position command is entered from outside the inverter (externally), the FR-V5AX, FR-V5AH or FR-A5AX plug-in option is required.

*3 For the terminal specifications, refer to the inverter manual.

*4 For the terminal specifications, refer to page 66

*5 Assign any of terminals functions in input terminal function selection (Pr.180 to Pr.183 and Pr.187).

6.2 Terminals

Symbol	Terminal	Description
PA1	Encoder A-phase signal input terminal	A-, B- and Z-phase signals are input from the encoder. For information on the pulse signals, refer to page 66.
PA2	Encoder A-phase inverse signal input terminal	
PB1	Encoder B-phase signal input terminal	
PB2	Encoder B-phase inverse signal input terminal	
PC1	Encoder Z-phase signal input terminal	
PC2	Encoder Z-phase inverse signal input terminal	
PAR	A-phase terminal resistor terminal	Factory-connected with "PA2" by the jumper. Remove the jumper when the terminal resistor is not needed.
PBR	B-phase terminal resistor terminal	Factory-connected with "PB2" by the jumper. Remove the jumper when the terminal resistor is not needed.
PCR	Z-phase terminal resistor terminal	Factory-connected with "PC2" by the jumper. Remove the jumper when the terminal resistor is not needed.
5V	DC power (positive) input terminal	Encoder power supply common terminals. Input encoder power. Connect the positive side to 5V and the ground side to SG. Also, connect the shield of the shielded wire to SG. 4.75 to 6VDC (Current consumption 50mA)
SG	DC power ground terminal	

<Inverter I/O terminals>

Symbol	Terminal	Description
X22 (*1)	Orientation command input terminal	Used to enter an orientation signal.
SD	Common terminal	Common terminal for the orientation signal.
ORA (*2)	In-position signal output terminal	Switched low if the orientation has stopped within the in-position zone while the start and orientation signals are input. Open collector output. (Permissible load 24VDC, 0.1A)
SE	Open collector output common terminal	Common terminal for the ORA and ORM open collector output terminals. Isolated from the common terminal of the control circuit.

*1 Assign the function of the X22 signal to any of the input terminals using "input terminal function selection" (Pr.180 to Pr. 183, Pr. 187).
Refer to the inverter manual for details of input terminal function selection.

*2 Assign the functions of the ORA signal to any of the output terminals using "output terminal function selection" (Pr.190 to Pr. 192, Pr. 195).
Refer to the inverter manual for details of output terminal function selection.

<FR-V5AX, FR-V5AH, FR-A5AX, inverter input terminals>

Symbol		Terminal	Remarks	Description
FR-V5AX input terminals	DI11 to DI16	Extra contact input terminals	Use a micro current switching contact relay for the relay contact. A transistor with the following specifications should be selected for the open collector signal: Electrical characteristics of the transistor used; • $I_C \geq 10$mA • $V_{CE} \geq 30$V • Leakage current 100μA max. • If IC $\geq$ 10mA, $V_{CE(sat)}$ voltage is 3V max.	Used to input digital signals through either relays. The command signal entered is position command.
FR-V5AH input terminals	X0 to X15	Digital signal input terminals		Used to input digital signals through either relays or open collector transistors. As the command signals entered, speed/torque or position commands are selected using Pr. 360.
	DY	Data read timing input signal		Not used for orientation control.
	SD	Common terminal (sink)		Common terminal for digital signal input terminals and data read timing signals. Common terminal for the SD terminal on the inverter side.
FR-A5AX input terminals	X0 to X11	Digital signal input terminals		Used to input digital signals through either relays or open collector transistors. As the command signals entered, speed or position commands are selected using Pr. 360.
	DY	Data read timing input signal		Not used with the FR-V500 series.
Inverter input terminals	SD	Common terminal (sink)		Common terminal for digital signal input terminals and data read timing signals.
	PC	External transistor common terminal (source)		When connecting the transistor output (open collector output) of a programmable controller (PC), etc., connect the external power common (positive) to this terminal to prevent a fault occurring due to leakage current.

REMARKS

Pr.300 to Pr.305 settings for the FR-A5AX/FR-V5AH, Pr.400 to Pr.405 settings for the FR-V5AX are made invalid when the stop position is set to be specified from outside the inverter (externally), with the FR-A5AP (orientation control option) fitted to the inverter and when orientation control is used.
Pr.300 to Pr.305 of the FR-A5AX/FR-V5AH, Pr.400 to Pr.405 of the FR-V5AX are made valid when the stop position is not set from outside the inverter.

6.3 Wiring Instructions

(1) Connection with the position detector (encoder)

Use twisted pair shielded cables (0.2mm^2 or larger) to connect the FR-A5AP and position detector (encoder). Cables to terminals 5V and SG should be connected in parallel or be larger in size according to the cable length table as indicated below.
To protect the cables from noise, run them away from any source of noise (e.g. the main circuit and power supply voltage).

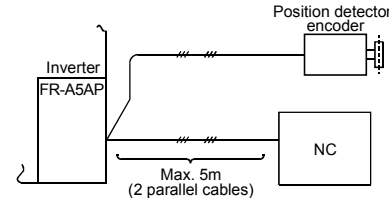
(2) Cable length

1)Cable length within 30m

Cable Length	Number of Parallel Cables of 0.2mm^2 Required	Larger-Size Cable
Within 10m	At least 2 cables	0.4mm^2 or larger
Within 20m	At least 4 cables	0.75mm^2 or larger
Within 30m	At least 6 cables	1.25mm^2 or larger

2)Cable length of more than 30m
Use a power supply slightly higher than 5V (approximately 5.5V) in addition to 6 or more parallel cables of 0.2mm^2 or cables of 1.25mm^2 or more. This allows the cable length to be increased up to 100m. Note that the voltage applied across terminals 5V-SG must not exceed 6V.

3)Connection with NC (Or similar device)
When one position detector is shared between the FR-A5AP and NC (or another device), its output signals should be connected as shown below. In this case, the cable length between the FR-A5AP and NC should be as short as possible, within 5m.



(3) Connection of terminal resistors
Use the jumpers across PA2-PAR, PB2-PBR and PC2-PCR to connect terminal resistors to the A, B and C-phases of the encoder. Normally, keep the jumpers fitted.
However, remove the jumpers when the same encoder is shared between the FR-A5AP and the other unit (e.g. NC) which is connected with a terminal resistor.

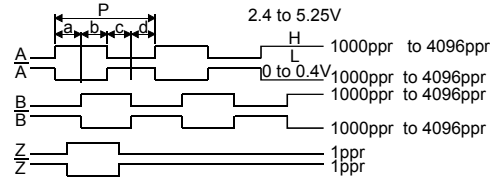
(4) Position detector (encoder)
Line driver LED type encoder

A. $\overline{A}$ signal 1000ppr to 4096ppr

B. $\overline{B}$ signal 1000ppr to 4096ppr

Z. $\overline{Z}$ signal 1ppr

Output pulse specifications



a, b, c and d should be (1/4 ± 1/8)P when rotation is clockwise as viewed from the shaft end of the encoder.

<Example of encoder available on the market>
Use an encoder which has an output circuit equivalent to AM26LS31 or 74LS113.

Pin Numbers of Encoder Output Signals

Pin Number	Output Signal	Pin Number	Output Signal
C	A-phase signal	H	+5V power supply
R	A-phase inverse signal	K	Power supply common
A	B-phase signal	E	Case earth (ground)
N	B-phase inverse signal		
B	Z-phase signal		
P	Z-phase inverse signal		

6.4 Parameter List

For orientation control at a machine end, the parameter values are the same as those used when orientation control is exercised at a motor end by the inverter. However, the encoder rotation direction and the number of encoder pulses used are not those set in Pr. 852 "encoder rotation direction" and Pr. 851 "number of encoder pulses" but those in Pr. 359 "encoder rotation direction for orientation" and Pr. 369 "number of encoder pulses for orientation".
For setting orientation control at the machine end, set Pr.393 "orientation selection" to "10, 11 or 12".

Parameter No.	Name	Setting Range	Minimum Setting Increments	Factory Setting
350	Stop position command selection	0, 1, 2, 9999	1	9999
351	Orientation switchover speed	0 to 1000r/min	1r/min	200r/min
356	Internal stop position command	0 to 16383 (*1)	1	0
357	Orientation in-position zone	0 to 8192	1	11
359 (*2)	Encoder rotation direction for orientation	0, 1	1	1
360	External position command selection	0, 1, 2 to 127	1	0
361	Position shift	0 to 16383 (*1)	1	0
362	Orientation position loop gain	0.1 to 100	0.1	10
369 (*2)	Encoder pulse count for orientation	0 to 4096	1	1024
393	Orientation selection	0, 1, 2, 10, 11, 12	1	0
394 (*2)	Number of machine side gear teeth	0 to 32767 (*1)	1	1
395 (*2)	No. of motor side gear theeth	0 to 32767 (*1)	1	1
396	Orientation speed gain (P term)	0 to 1000	1	60
397	Orientation speed integral time	0 to 20.0s	0.001	0.333
398	Orientation speed gain (D term)	0 to 100.0%	0.1	1
399	Orientation deceleration ratio	0 to 1000	1	20

*1 When the FR-DU04-1 is used, up to 9999 may be set. When the FR-PU04V is used, up to the maximum value may be set.
*2 Setting is enabled when the FR-A5AP is fitted

6.5 Parameter Setting

If the orientation command signal (X22) is turned on during operation after the various parameters have been set, the speed will decelerate to the "orientation switchover speed". After the "orientation stop distance" is calculated, the speed will further decelerate, and the "orientation state" (servo lock) will be entered. The "orientation complete signal" (ORA) will be output when the "orientation complete width" is entered.

6.5.1 Selecting stop position command

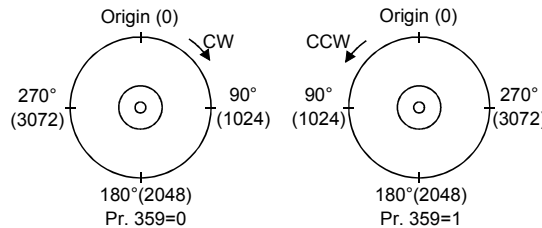
(1) Pr.350 "Stop position command selection"

Select either the internal stop position command (Pr. 356) or the external stop position command (6/12/16-bit data).

Pr. 350 Setting	Type of Command
0	Internal stop position command (Pr. 356:0 to 16383)
1	External stop position command (FR-V5AX) 6 bit data
2	External stop position command (FR-A5AX) 12 bit data
3	External stop position command (FR-V5AH) 16 bit data
9999 (factory setting)	Orientation control invalid

1) Internal stop position command (Pr. 350="0")

The value set in Pr. 356 is the stop position. When the number of encoder pulses is 1024p/r, one revolution of the encoder (360 degrees) is divided into 4096 positions, i.e. 360 degrees/4096 pulses = 0.0879 degrees/pulses per address, as shown on the right. The stop positions (addresses) are indicated in parentheses.



2) External stop position command (Pr. 350="1")

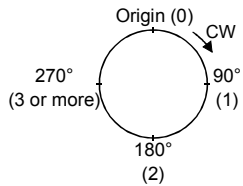
(Pr. 360 "external position command selection" (factory setting: 0))

Mount the option FR-V5AX and set a stop position using 6-bit data (binary input).

•The value set in Pr. 360 "external position command selection" should be the number of stop positions less 1.

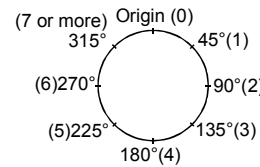
Pr. 360 Setting	Description
0	External stop position command is made invalid (multi-function input with the FR-V5AX)
1	Set 64 stop positions at regular intervals
2 to 127	Set the stop position command dividing up to 128 stop positions at regular intervals. If the external stop command entered is greater than the setting, the stop positions are the same as those in the maximum external stop command value. Note that the stop command greater than the 64 stop positions can not be entered if the number of stop positions are 65 to 128. <Example> When the number of stop positions is 20 (divided at intervals of 18 degrees), 20 - 1 = 19. Hence, set "19".

[Example 1] 4 stop positions



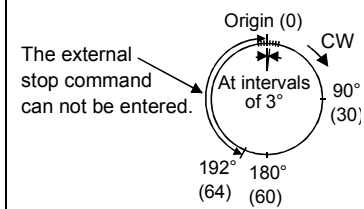
Pr. 360 = "3"

[Example 2] 8 stop positions



Pr. 360 = "7"

[Example 3] 120 stop positions



Pr. 360 = "119"

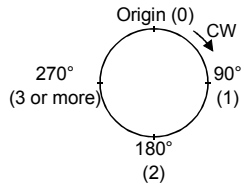
3) External stop position command (Pr. 350="2")

Mount the option FR-A5AX and set a stop position using 12-bit data (binary input).

•The value set in Pr. 360 "external position command selection" should be the number of stop positions less 1.

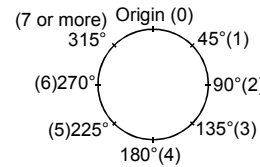
Pr. 360 Setting	Description
0	Speed command is made invalid (speed command with the FR-A5AX)
1	Set 4096 stop positions at regular intervals
2 to 127	Set the stop position command dividing up to 128 stop positions at regular intervals. If the external stop command entered is greater than the setting, the stop positions are the same as those in the maximum external stop command value. <Example> When the number of stop positions is 90 (divided at intervals of 4 degrees), 90 - 1 = 89. Hence, set "89".

[Example 1] 4 stop positions



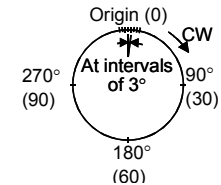
Pr. 360 = "3"

[Example 2] 8 stop positions



Pr. 360 = "7"

[Example 3] 120 stop positions



Pr. 360 = "119"

CAUTION

- **Values in parentheses indicate binary data entered from the input terminals of the FR-A5AX. If the position pulse monitoring (Pr. 52 "DU/PU main display screen data selection" = 19) is selected, the data monitored is not the number of stop positions but is 0 to 4095 pulses.**
- **When any of "1 to 127" is set in Pr. 360, parameters (Pr. 300 to Pr. 305) of the FR-A5AX are made invalid. (Parameters are valid when Pr. 360="0".)**
- **Terminal DY (Data read timing input signal) is made invalid. (The position data import is performed at the start of orientation.)**
- **When the option is not fitted or Pr. 360="0", the stop position is 0 even if the external stop position command is selected with the Pr. 350 setting.**

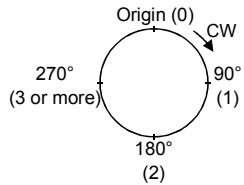
4) External stop position command (Pr. 350="3")

Mount the option FR-V5AH and set a stop position using 16-bit data (binary input).

•The value set in Pr. 360 "external position command selection" should be the number of stop positions less 1.

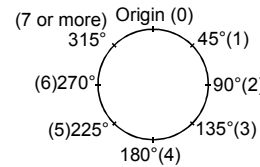
Pr. 360 Setting	Description
0	Speed command is made invalid (speed command or torque command with the FR-V5AH)
1	Set 65536 stop positions at regular intervals
2 to 127	Set the stop position command dividing up to 128 stop positions at regular intervals. If the external stop command entered is greater than the setting, the stop positions are the same as those in the maximum external stop command value. <Example> When the number of stop positions is 90 (divided at intervals of 4 degrees), 90 - 1 = 89. Hence, set "89".

[Example 1] 4 stop positions



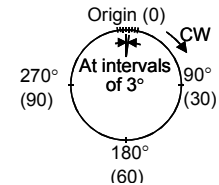
Pr. 360 = "3"

[Example 2] 8 stop positions



Pr. 360 = "7"

[Example 3] 120 stop positions



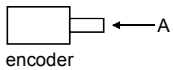
Pr. 360 = "119"

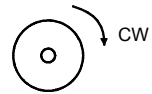
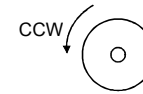
CAUTION

- **Values in parentheses indicate binary data entered from the input terminals of the FR-A5AX. If the position pulse monitoring (Pr. 52 "DU/PU main display screen data selection" = 19) is selected, the data monitored is not the number of stop positions but is 0 to 65535 pulses. (For the FR-DU04-1, 0 to 9999 are displayed.)**
- **When any of "1 to 127" is set in Pr. 360, parameters (Pr. 300 to Pr. 305) of the FR-V5AH are made invalid. (Parameters are valid when Pr. 360="0".)**
- **Terminal DY (Data read timing input signal) is made invalid. (The position data import is performed at the start of orientation.)**
- **When the option is not fitted or Pr. 360="0", the stop position is 0 even if the external stop position command is selected with the Pr. 350 setting.**

(2) Pr. 369 "encoder pulse count for orientation" (factory setting: 1024)
Set the number of encoder pulses output.
(Set the number of pulses before it is multiplied by 4.)
Example: Set "1024" for 1024 pulses per revolution (ppr).

(3) Pr. 359 "encoder rotation direction for orientation" (factory setting: "1")
Indicates the direction in which the encoder rotates.



Pr. 359=0	Pr. 359=1
 Forward rotation is clockwise rotation when viewed from A.	 Forward rotation is counterclockwise rotation when viewed from A.

REMARKS

When Pr. 350 "stop position command selection" is set to make orientation control valid, the PU (FR-DU04-1/ FR-PU04V) shows the rotation direction of the encoder.
Make setting so that FWD is displayed when the STF signal turns on or REV is displayed when the STR signal turns on.

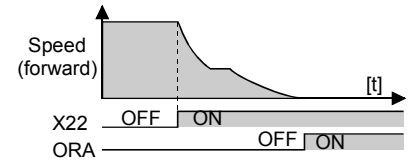
6.5.2 Setting the rotation direction

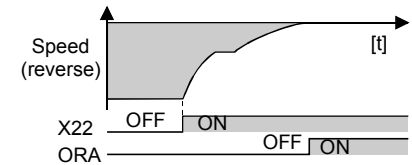
(1) Pr. 393 "orientation selection"

Pr. 393 setting	Rotation Direction	Type	Remarks
0 (factory setting)	Pre-orientation	Motor end orientation	Refer to the instruction manual (detailed) of the inverter for details.
1	Forward rotation orientation		
2	Reverse rotation orientation		
10	Pre-orientation	Machine end orientation	Orientation is executed from the current rotation direction.
11	Forward rotation orientation		Orientation is executed from the forward rotation direction. (If the motor is running in reverse, orientation is executed from the forward rotation direction after deceleration.)
12	Reverse rotation orientation		Orientation is executed from the reverse rotation direction. (If the motor is running in forward, orientation is executed from the reverse rotation direction after deceleration.)

1) Orientation from the current rotation direction (Pr.393="10")

- When the orientation command (terminal X22) is input, the motor speed will decelerate from the runnig speed to Pr. 351 "orientation switchover speed". At the same time, the orientation stop position command will be read in. (The stop position command is determined by Pr.350 and Pr.360.)
- When the orientation switchover speed is reached, the encoder Z phase pulse will be confirmed, and the mode will change from speed control to position control (orientation position loop gain parameter (Pr. 362)).
- When the control is changed, the distance to the orientation stop position will be calculated. The motor will decelerate and stop with a set deceleration pattern (Pr. 399), and the orientation (servo lock) state will be entered.
- When entered in the Pr. 357 in-position zone is entered, the orientation complete signal (terminal ORA) will be output.
- The zero point position (origin) can be moved using position shift (Pr. 361).



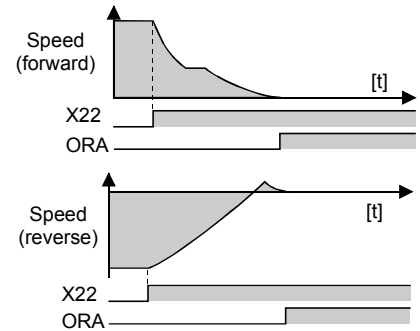


⚠ WARNING

⚠ **If the orientation command (terminal X22) is turned off while the start signal is input, the motor will accelerate toward the speed of the current speed command. Thus, to stop, turn the forward rotation (reverse rotation) signal off.**

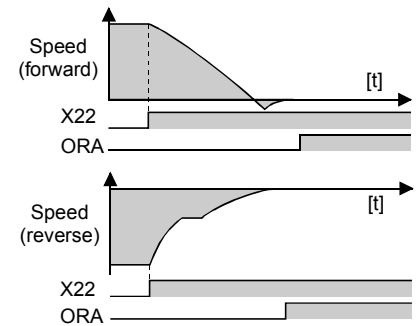
2) Orientation from the forward rotation direction (Pr.393=11)

- This method is used to improve the stopping precision and maintain the mechanical precision when the backlash is large.
- If the motor is running in the forward rotation direction, it will orientation stop with the same method as "orientation from the current rotation direction". If the motor is running in reverse, it will decelerate, the rotation direction will be changed to forward run, and then orientation stop will be executed.



3) Orientation from the reverse rotation direction (Pr.393=12)

- If the motor is running in the reverse rotation direction, it will orientation stop with the same method as "orientation from the current rotation direction".
- If the motor is running in forward, it will decelerate, the rotation direction will be changed to reverse run, and then orientation stop will be executed.



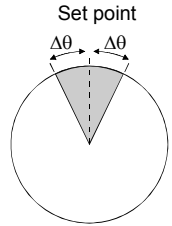
REMARKS

If "E.ECT" (no encoder signal) is displayed causing the inverter to trip when the orient signal (X22) is ON, check for an open cable of the Z phase of the encoder.

(2) Pr. 357 "orientation in-position zone"(factory setting:11)

- The positioning width for orientation stop can be set.
- The factory setting of Pr. 357 is "11". To change the $\Delta\theta$ value, finely adjust with $\pm$10 increments, and make fine adjustment.
- If the position detection value from the encoder enters $\pm\Delta\theta$ during orientation stop, the orientation complete signal (ORA) will be output.

Example of operation



$$\Delta\theta = \frac{360^\circ}{\text{Pr.851 number of encoder pulses} \times 4} \times \text{Pr.357}$$

CAUTION

This setting is used to judge the ON/OFF of the orientation complete signal, and does not determine the orientation stop precision.

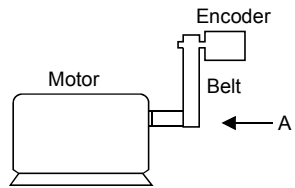
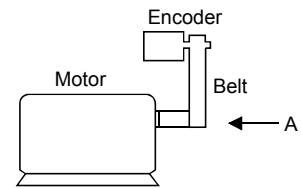
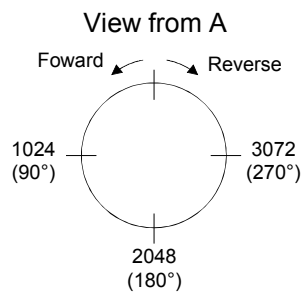
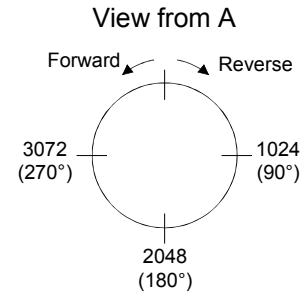
6.5.3 Fine adjustment of the orientation stop position

(1) Pr. 361 "position shift" (factory setting: 0)

The orientation stop position will deviate by the value set × 360 degrees / Pr.369 "encoder pulse count for orientation" × 4.

Finely adjust the position by changing this setting value in increments of 10.

The orientation stop position will differ according to the direction that the encoder is installed in. Refer to the drawings below.

	Case 1	Case 2
Installation direction		
Normal orientation		

6.5.4 Encoder orientation gear ratio setting

Use the following parameters to set the encoder orientation gear ratio.

- **Pr. 394 "number of machine side gear teeth" (factory setting: 1)**
- **Pr. 395 "number of motor side gear teeth" (factory setting: 1)**

Make sure that the above parameter values are factory settings.

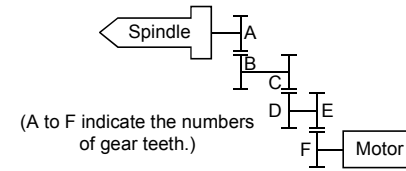
An accurate gear ratio (or pulley ratio) from the motor shaft to the spindle is necessary.

Confirm that the numbers of gear teeth set in Pr. 394 and Pr. 395 are correct.

Pr.394 = A x C x E

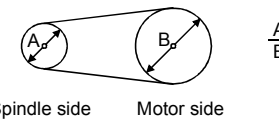
Pr.395 = B x D x F

Exercise care so that the A x C x E and B x D x F settings do not exceed 32767. If either or both of them exceed that value, make approximations.



REMARKS

Pulley ratio ..... Ratio of vector-driven motor side pulley diameter to spindle side pulley diameter



$\frac{A}{B}$

Setting example (When the numbers of gear teeth are as follows)

A : 15, C : 43, E : 60, B : 10, D : 28, F : 55

Pr.394 = 15 x 43 x 60 = 38700

Pr.395 = 10 x 28 x 55 = 15400

Since the Pr. 394 setting exceeds 32767 at this time, make approximations as follows.

$$\frac{Pr.391}{Pr.392} = \frac{38700}{15400} = \frac{3870}{1540}$$

6.5.5 Adjustment of the servo rigidity

Pr. 396 "orientation speed gain (P term)" (factory setting: 60)
Pr. 397 "orientation speed integral time" (factory setting: 0.333)
Pr. 398 "orientation speed gain (D term)" (factory setting: 1)
Pr. 362 "orientation position loop gain" (factory setting: 10)

To increase the servo rigidity[*1] during orientation stop in Pr. 396 or Pr. 397, adjust with the following procedures.

1)Increase the Pr. 362 "orientation position loop gain" value to the extent that rocking does not occur during orientation stop.

2)Increase Pr. 396 and Pr. 397 at the same rate.
Generally adjust Pr. 396 in the range from 10 to 100, and Pr. 397 from 0.1 to 1.0s. (Note that these do not need to be set to the same rate.)
<Example>
When the Pr. 396 value is multiplied by 1.2, divide the Pr. 397 value by 1.2.
If vibration occurs during orientation stop, the scale cannot be raised any higher.

3)Pr. 398 is the lag/advance compensation gain.[*2]
The limit cycle can be provided by increasing the value, and the running can be stopped stably.
However, the torque in regard to the position deviation will drop, and the motor will stop with deviation.

POINT

Application of lag/advance control and PI control
PI control can be applied by setting Pr. 398 to 0. Normally, the lag/advance control is selected. Use PI control in the following cases.
When using a machine with a high spindle stationary friction torque and requires a stopping position precision.

REMARKS

*1. Servo rigidity: This is the response when a position control loop is configured.
When the servo rigidity is raised, the holding force will increase, the running will stabilize, but vibration will occur easily.
When the servo rigidity is lowered, the holding force will drop, and the setting time will increase.
*2. Limit cycle: This is a phenomenon that generates ± continuous vibration centering on the target position.

6.5.6 Orientation deceleration ratio

(1) Pr. 399 "orientation deceleration ratio" (factory setting: 20)

Make adjustments as shown below according to the orientation status.
(Refer to the Pr. 396 and Pr. 397 details also.)
Generally adjust Pr. 362 in the range from 5 to 20 and Pr. 399 from 5 to 50.

Phenomenon	Adjustment Procedure			
	Pr.396	Pr.397	Pr.362	Pr.399
Rocking occurs during stopping	3) ↗	3) ↗	2) ↘	1) ↘
The orientation time is long	→	→	2) ↗	1) ↗
Hunting occurs when stopping	2) ↘	2) ↗	1) ↘	→
The servo rigidity during stopping is low	1) ↗	1) ↘	2) ↗	→

REMARKS

1. ↗: Increase the parameter setting value.
→: Do not change the parameter setting value.
↘: Decrease the parameter setting value.
2. The numbers 1) 2) and 3) in the table show the order of priority for changing the parameters setting value.

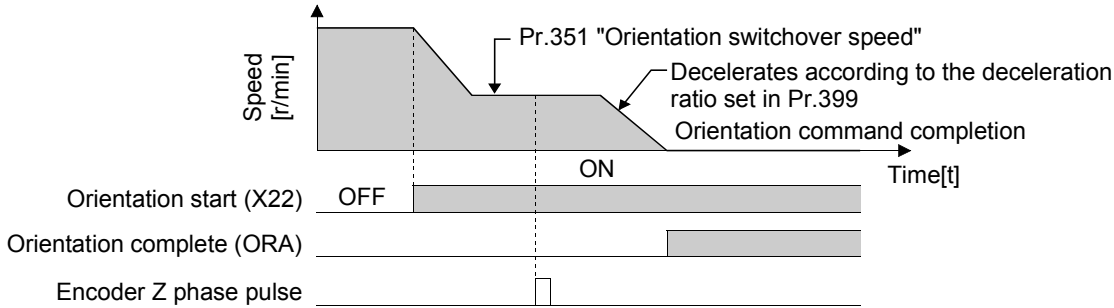
CAUTION

If orientation stop is not possible and the excessive position error alarm occurs, or if the motor does forward/reverse reciprocation operation (↻), the parameter setting value for the orientation detector installation direction may be incorrect. Review Pr. 393 "orientation selection".

6.5.7 Orientation switchover speed

(1) Pr. 351 "orientation switchover speed" (factory setting: 200)

•Set the speed when switching beween the speed control mode and the position control mode is performed under orientation operation. Decreasing the set speed enables stable orientation stop. Note that the orientation time will increase.



REMARKS

When " 19" is set in Pr. 52 "DU/PU main display data selection", position pulse monitor is displayed instead of PU output voltage monitor.

6.6 Instructions

(1) The encoder should be coupled with the spindle oriented without any mechanical looseness.
(2) The DC injection brake operated for positioning must be released in the shortest time (within several seconds). Operating the brake continuously can cause the motor to generate heat and burn out.
(3) To ensure correct positioning, the encoder must be set in the proper rotation direction and the A and B phases connected correctly.
(4) Orientation may not be completed if the pulse signals are not received from the encoder during orientation due to a signal loss or the like.
(5) When orientation control is exercised, orientation cannot be completed if "no DC injection brake operation" is set in the DC injection brake adjusting (voltage, frequency, speed, time) parameters. These parameters must be set to operate the DC injection brake.
(6) To terminate orientation, the start signal (STF or STR) must be first switched off and the orientation signal (X22) must be switched off. As soon as this orientation signal is switched off, orientation control ends.
(7) For orientation control, set correct values in Pr. 350 "stop position command selection" and Pr. 360 "12-bit data selection" (external position command selection).
If the values set are incorrect, proper orientation control will not be performed.
(8) If "8888" (DC injection external selection) is set in Pr. 11 "DC injection brake operation time", the DC injection brake is not operated unless the X13 terminal signal is switched on. For orientation control, the DC injection brake is operated independently of the X13 signal.
(9) When orientation control is exercised, PID control is invalid.

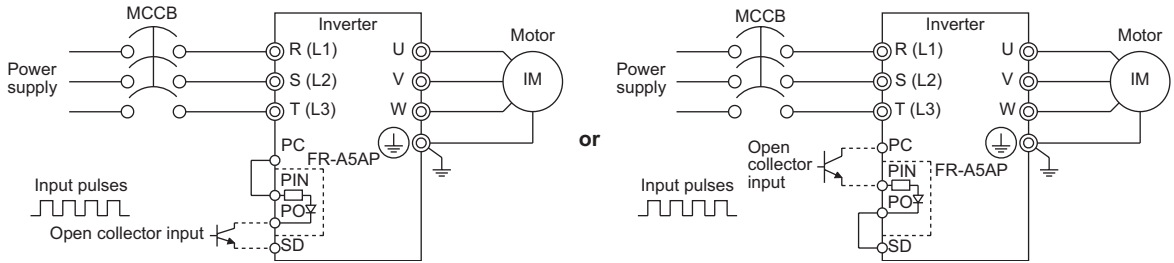
6.7 Specifications

Stop position accuracy	±1.5 degrees (When used with the SF-VR) Depends on the load torque, load inertia moment, orientation speed, creep speed, position loop select position, etc.
Permissible rotation speed	Encoder-mounted shaft speed (6000r/min) The motor and encoder-mounted shaft must be coupled directly or via a belt without any slip. A gear change type cannot be used.
Functions	• Orientation and creep speed setting. • Stop position command selection. • DC injection brake start position setting. • Creep speed and position loop select position setting. • Position shift. • In-position zone. • Position signal monitoring, etc. Note: Set the above functions from the parameter unit.
Holding force after positioning	Without servo lock function (However, the servo lock function is valid when "1" is set in Pr. 802.)
Input signals (contact input)	• Orientation command. • Forward and reverse rotation commands. • Stop position command (open collector signal may also be entered). Maximum 12-bit binary signal.
Output signals (open collector output)	• In-position signal.
DC power supply	Prepare a 5VDC power supply for the encoder. (Usually approximately 350mA) 5V, 50mA is also required for the option. Supply power from the NC or use a general power supply. Example:DENSEI-LAMBDA EWS15-5 (5V, 3A) *When encoder feedback control and orientation control are used together, the 5V power supply is shared between these controls.

7. PULSE TRAIN INPUT—V500

A pulse train signal can be used to enter the speed setting of the inverter.
Pr. 384 is factory set to "0" to make this function invalid.
When the speed is input by the pulse train signal, the multi speed setting of the inverter becomes invalid.
Refer to page 56 for pulse train input with the FR-A500(L) series.

7.1 Wiring Example



CAUTION

This option unit functions properly only when an open collector connection is configured.

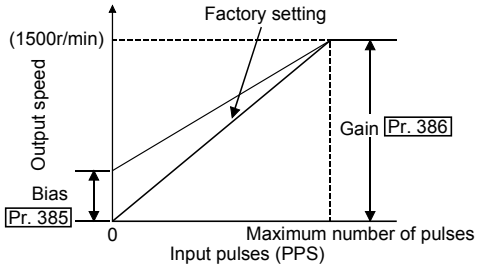
7.2 Terminals

Symbol	Terminal	Description
PIN	Pulse input terminal 1	Terminal used to enter a pulse train of 0 to 100kpps (*)
PO	Pulse input terminal 2	Terminal used to enter a pulse train of 0 to 100kpps (*)

REMARKS

*: Whether an input pulse is entered into PIN or PO depends on the wiring. Refer to page 86.

7.3 Adjustment



Note: Maximum number of input pulses: 100kpps

Note: Number of input pulses are multiplied by 2 internally.

7.4 Pulse Train Input Parameter List

Parameter No.	Name	Setting Range	Minimum Increments	Factory Setting
384 (*1)	Input pulse frequency division ratio	0 to 250	1	0
385	Zero-input pulse frequency	0 to 3600r/min	0.1r/min	0
386	Maximum-input puler frequency	0 to 3600r/min	1r/min	1500 (NA version: 1800r/min)

*1 Indicates the frequency division ratio for the input pulses. The speed resolution to the input pulses varies with the setting.

CAUTION

When the Pr. 384 value is "0" (factory setting), Pr. 385 and Pr. 386 do not function even if their values have been set.

⚠ CAUTION

⚠ Note that if you set any value other than 0r/min in Pr. 385, merely turning on the start signal will start the motor at the set speed without a pulse train input command.

7.5 Setting Example

How to calculate the input pulse frequency division ratio

Use the following formula to calculate the input pulse frequency division ratio in Pr. 384:

Maximum number of input pulses (pps) = Pr. 384 × 400

$$\text{Detectable frequency} > \frac{\text{Pr. 386}}{2 \times 16.6\text{ms} \times \text{Pr. 384} \times 400}$$

The detectable frequency changes with the maximum number of input pulses.

7.6 Specifications

Circuit System	Open Collector System
Input current	10mA
Max. permissible number of pulses	100kpps
Input pulse specifications	0f to 250f (f: variable frequency)
Response delay	16.6ms

REVISIONS

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

Print Date	*Manual Number	Revision
Mar., 1998	IB(NA)-66848-A	First edition
Jan., 2002	IB(NA)-66848-B	Additions Applicable inverters Pr. 285 "excessive speed deviation detection frequency" (FR-A500 series only) Pr. 376 "break in the cable detection enable/disable selection" (FR-A500 series only) Partial changes Wiring handling method
Feb., 2003	IB(NA)-66848-C	Additions Factory setting values for the NA version of the FR-V500 series Orientation with external input by the FR-V5AH
Feb., 2006	IB(NA)-66848-D	Partial changes Installation procedure Precautions about Pr. 371 "torque characteristic selection" Carrier frequency under vector control