7. FR-ZOR ORIENTATION CONTROL UNIT

7. 1 Features

The FR-ZOR orientation control unit is used with a position detector (pulse encoder) installed toa spindle of a machine tool (such as an automatic lathe) to allow the spipndle to stop at the predetermined position (orientation function).

- The position control loop formed by software processing using the position detections signal from the pulse encoder ensures orientation accuracy of within 1.5°.
- Allows the current position to be made from the parameter unit for ease of position.
- Allows setting and adjustment to be made from the parameter unit for ease of operation.

7. 2 Features

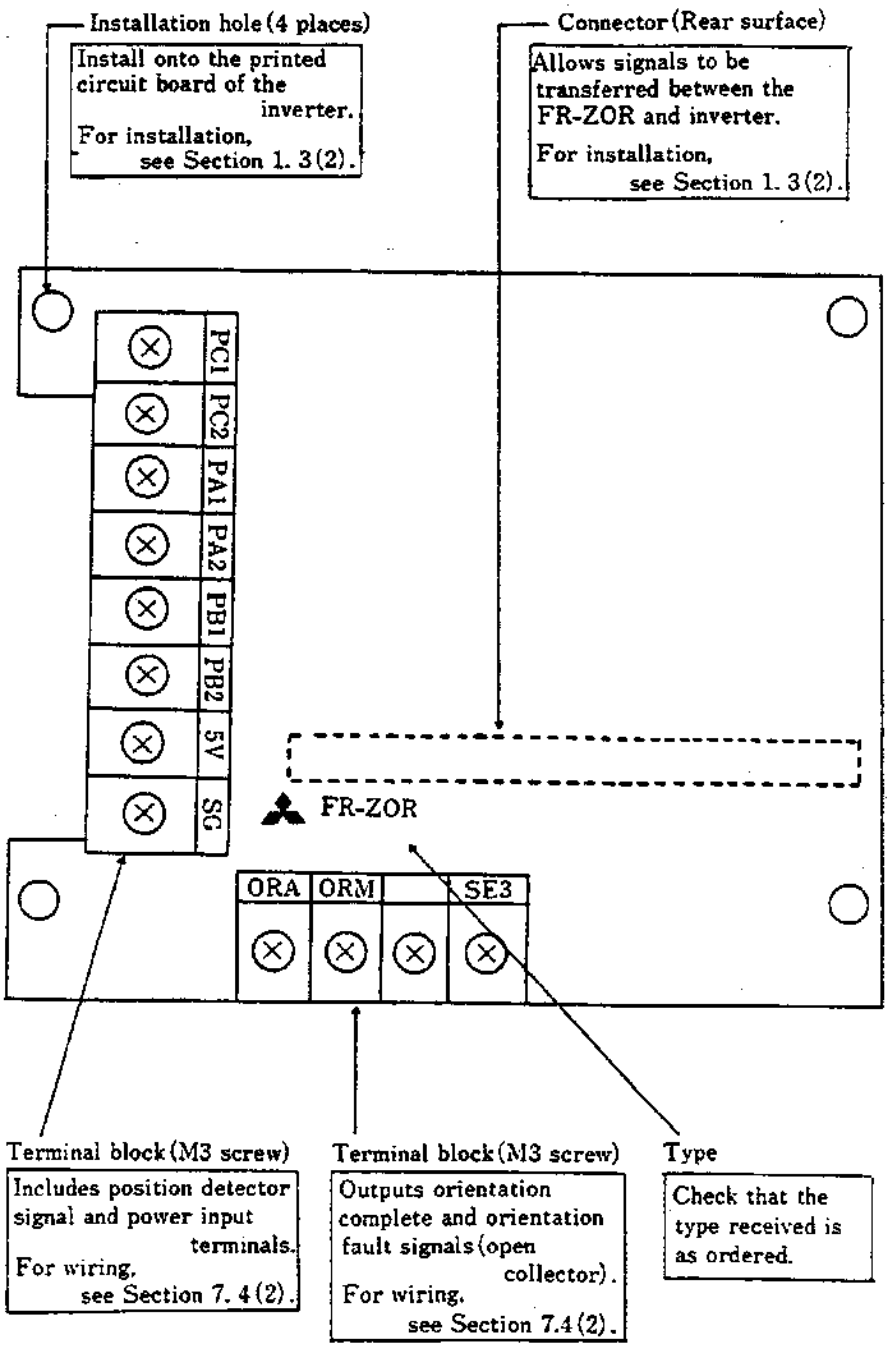


Fig. 7. 1 Structure

7. 3 Specifications

①Positioning repeatability
- 1.5 * Depends on load torque, load GD , orientation speed, creep speed, position loop select position, etc.

②Allowable speed
- Spindle speed 6000rpm max.
  * The motor and spindle must be coupled directly or via a belt to prevent a slip.
  A gear change type cannot be used.

③Position detector(pulse encoder)
- 1024 pulses/rotation(P/R). Line driver type LED pulse encoder
  - A, A signal : 1024 P/R
  - B, B signal : 1024 P/R
  - C, C signal : 1P/R

Recommended :
Tamagawa Seiki's TS1508N207 (connector coupled)

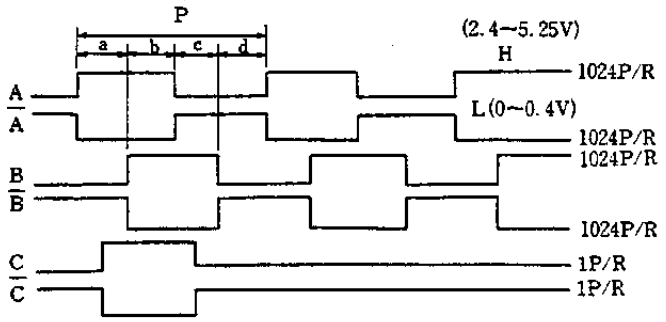


Fig. 7. 2 Output Pulse Specifications

*a, b, c and d must be (1/4 1/8) pulses at clockwise rotation as viewed at the encoder shaft end.

④Retention force after positioning
- Without servo lock function

⑤Power supply (for pulse encoder and option) :
- 5VDC (allowable range 4.75 to 6VDC)
  Use a power supply of 400mA or higher current capacity.
  Current consumption Pulse encoder……approx. 350mA
  Option unit……approx. 50mA

  Example : ES15-5 (5V, 3A)

7. 4 Wiring

(1) Wiring example

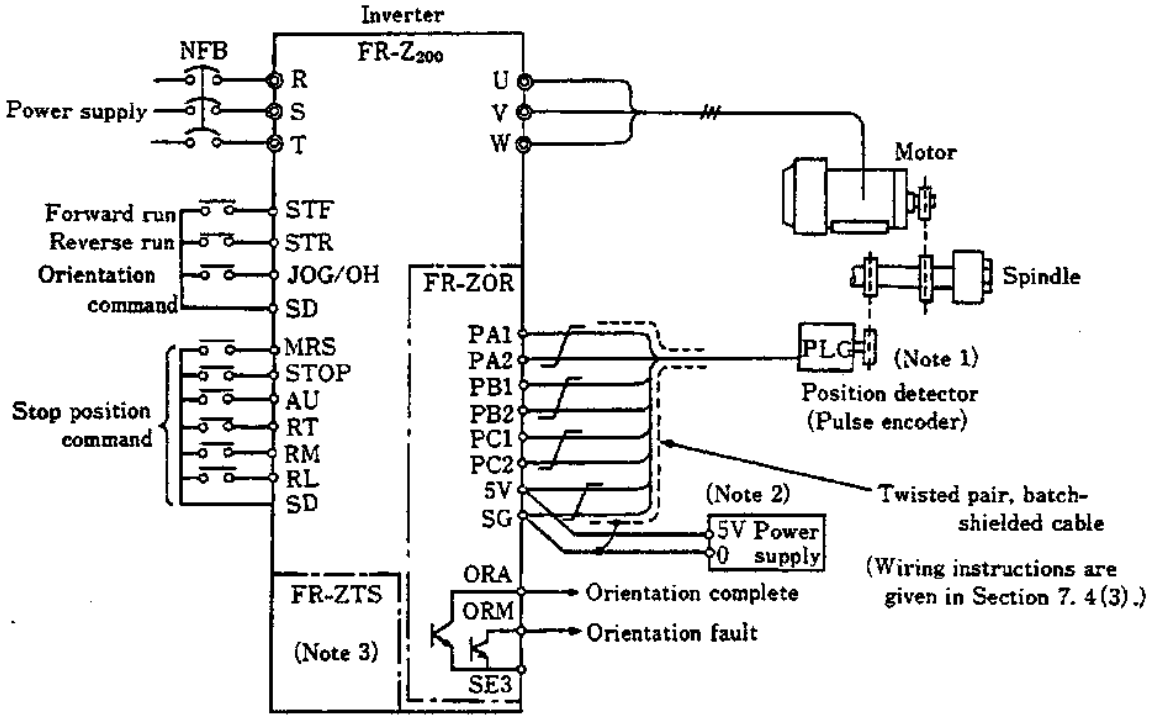


Fig. 7. 3 Wiring Example

Note 1 : Couple the position detector with the spindle directly or via a timing belt without looseness.
Note 2 : This power supply should be user-prepared.
Note 3 : The FR-ZOR must be used with the FR-ZTS (torque smoothing unit) with the exception of themodel which has a torque smoothing facility.

(2) Terminals

Table 7. 1 Terminals

Symbol	Terminal	Description
PAI	Encoder A-phase signal input terminal	Connect the A-phase signal wire from the encoder.
PA2	Encoder A-phase reverse signal input terminal (A-phase common)	Connect the A-phase reference signal wire from the encoder.
PB1	Encoder B-phase signal input terminal	Connect the B-phase reverse signal wiree from the encoder.
PB2	Encoder B-phase reverse signal input terminal (B-phase common)	Connect the B-phase reference signal wire from the encoder.
PC1	Encoder C-phase signal input terminal	Connect the C-phase signal wire from the encoder.
PC2	Encoder C-phase reverse signal input terminal (C-phase common)	Connect the C-phase reference signal wire from the encoder.
5V	Power (positive) input terminal	Connect the positive wire of the 5V power supply.
SG	Power supply ground terminal	Connect the ground wire of the 5V power supply and the shield of the shielded cable.

(3) Wiring instructions

①Use a twisted pair, batch-shielded cable (0.2mm or larger) between the FR–ZOR and encoder.

If a long cable is used, the voltage supplied to the encoder may be reduced due to voltage drop. To keep the encoder voltage within (SG) must allowed value, the cables to the power supply (5V) and ground (SG) must be connected as indicated in Table 7.2 or a twisted pair batch-shieled cable of largeer size must be used.

If the cable length is over 30m, use 6 or more cables in parellel or a 1.25mm cable and increase the 5V power supply slightly (about 5.5V). This allows the cable length to be increased up to 100m. In this case, the voltage applied across terminals 5V and SG must not exceed 6V to protect the option uni and encoder.

The cable length must not be exceed 100m to prevent malfunction.

Table 7. 2 Cable Sizes

Cable Length	Use of 0.2mmm Cable	Use of Larger-Size Cable
Within 10m	2 or more calbes in parallel	0.4mm or more
Within 20m	4 or more cables in parallel	0.75mm or more
Within 30m	6 or more cables in parallel	1.25mm or more
Within 100m	6 or more cables in parallel Power supply about 5.5V	1.25mm or more Power supply about 5.5V

②Terminal resistors

Terminal resistors (load resistors) of 100, 1/2W must be used at the output end of the pulse encoder.

The terminal resistors are not required when the pulse encoder is connected also to a numerical controller (NC) because the NC is equipped with the terminal resistors.

Connect terminal resistors R as shown in Fig. 7.4 when the pulse encoder is not connected with the NC.

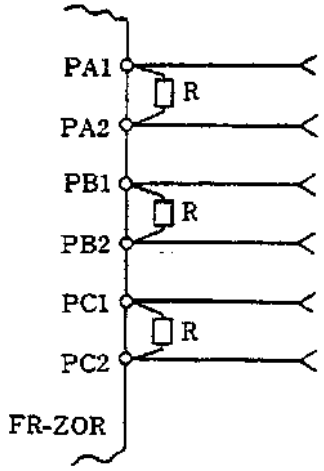


Fig. 7. 4 Connection of Terminal Resistors

③Connection of NC

When one pulse encoder is shared between the FR–ZOR and NC, connect the output signal of the pulse encoder as shown in Fig. 75.

In this case, the cable length between the FR–ZOR and NC must be as short as possible within 5m.

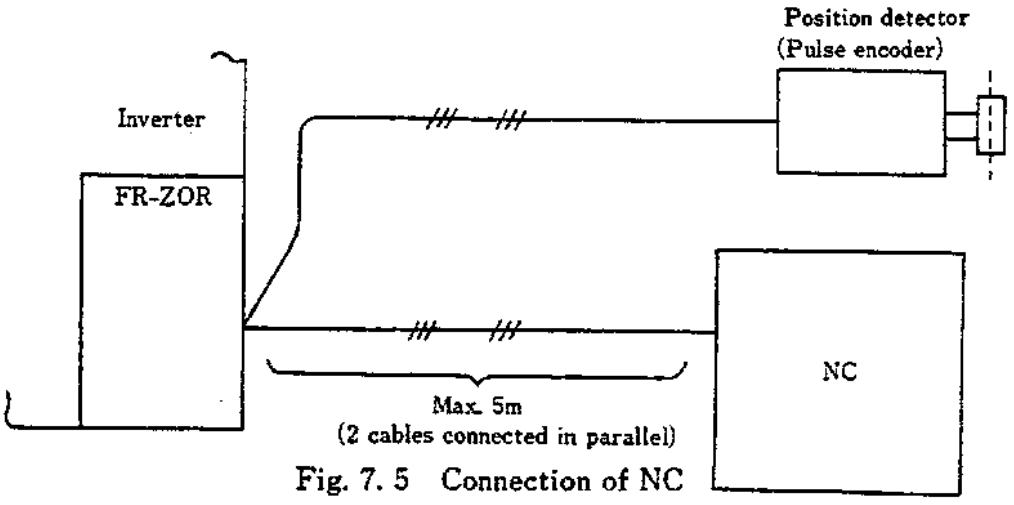


Fig. 7. 5 Connection of NC

④The cables connected between the FR–ZOR and encoder must be kept away from any source of noise (e.g. main circuit, high-voltage circuit) to prevent the influence of noise.

7. 5 Operation

(1) Principle (See Fig. 7.6)

①When the orientation command is provided, the motor decelerates to the orientation speed set in parameter 58.

②After the orientation speed is reached, the origin signal is detected, and as soon as the current position pulse has reached the creep select position set in parameter 60, the motor further decelerates to the creep set in parameter 59.

③As soon as the current position pulse has reached the position loop select position set in parameter 61, the position loop is selected.

④After the position loop has been selected, the motor further decelerates and DC dynamic braking is started as soon as the current position pulse reaches the DC dynamic braking start position set in parameter 62.

⑤About 0.5 seconds after the DC dynamic braking is started, the orientation complete signal is output if the current position pulse is within the orientation complete zone (set value) set in parameter 64 in reference to the stop position command.
(Once output, the orientation complete signal is not provided any more if the current position pulse is outside the complete zone due to external force, etc. Similarly, the position pulse value monitored remains unchanged.)

⑥The orientation is retried if the current position pulse is outside the orientation completezone about 0.5 seconds after the DC dynamic braking is started. At this time, neither the orientation complete signal nor the orientation fault signal is output.
Retry is made one more time if the position pulse is outside the complete zone after one retry. At this time, neither the orientation complete signal nor the orientation fault signal is output.
If the position pulse is outside the complete zone after the second retry, the motor remains stopped and no further retry is made. In this case, the orientation fault signal is output.

⑦Both the orientation complete signal and orientation fault signal are only output when the orientation command and start signal are input.

⑧After completion of the orientation, switch of the start signal and orientation signal in this order. The DC dynamic brake is released when tte start signal is switched off.

★The orientation command must be switched off after the start signal is switched off. If the orientation signal is switched off with the start signal on, the motor accelerates to the command speed.

(2) Orientation starting during rotation

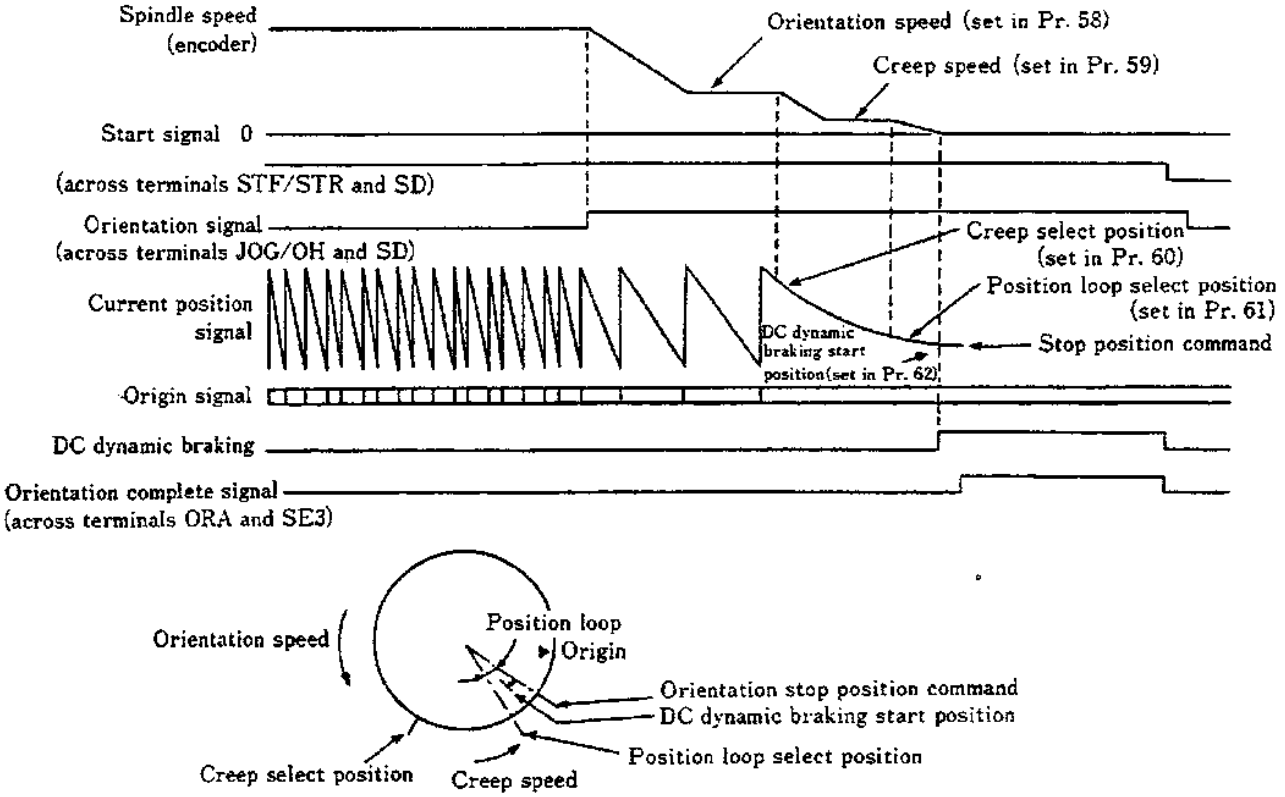


Fig. 7. 6 Timing Chart of Orientation Starting during Rotation

(3) Orientation starting during stop

After switching on the orientaton command (JOG/OH), switch on the start signal. The motor speed then rises to the orientation speed set in parameter 58 and starts the operation identical to "orientation starting during rotation."

Therefore, the speindle rotate more than one turn and stops at the predetermined position.

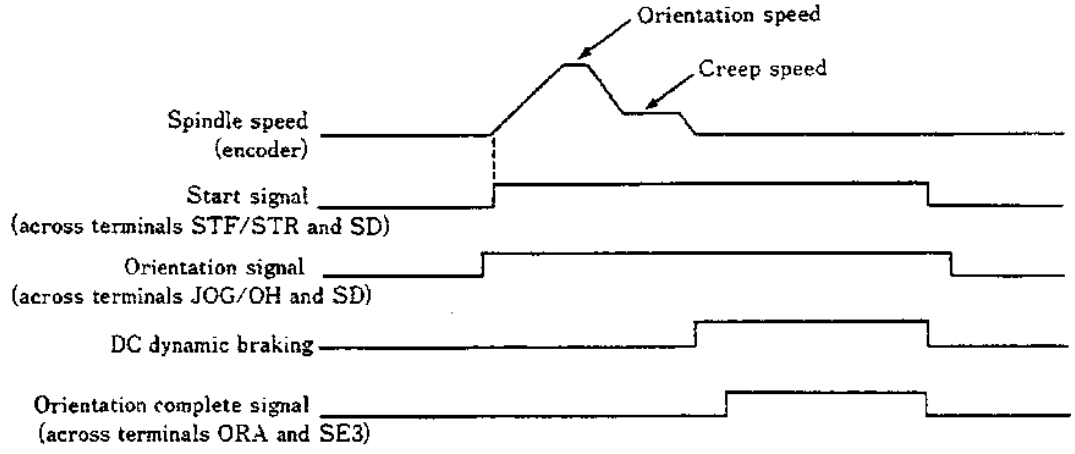


Fig. 7. 7 Timing Chart of Orientation Starting during Stop

(4) Continuous multi-point orientation is similar to "orientation starrting during stop."
The stop position command is changed in the areas shown in Fig. 7.8, where the stop position command is read when the orientation signal is switched on.
The stop position comman must be kept stable for 50msec after the orientation signal is switched on.

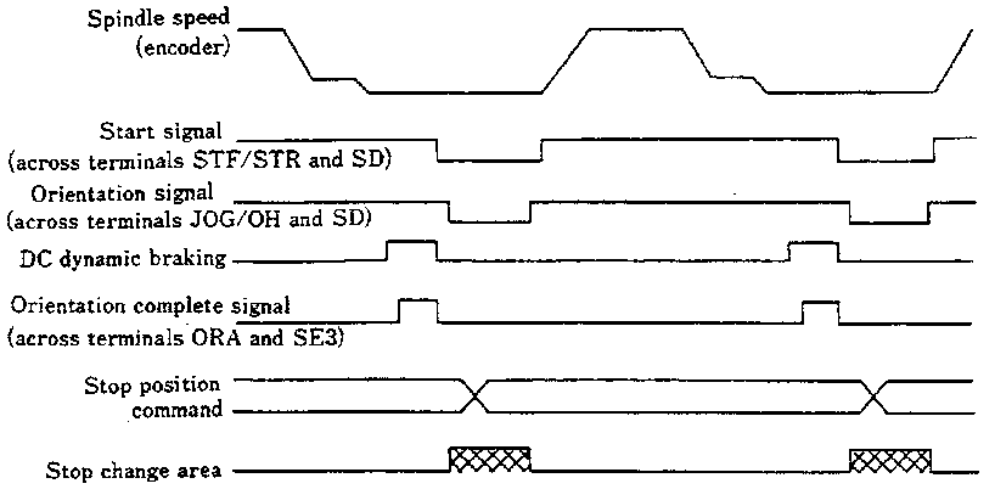


Fig. 7. 8 Timing Chart of Continuous Multi-Point Orientation

(5) Functions
The FR–ZOR orientation control unit has the following functions which are defined from the parameter unit. Each funciton is only valid when the FR–ZOR is installed. Any function cannot be read when the FR–ZOR is not installed.

Table 7. 3 Parameter List

Function No.	Function	Setting Range	Minimum Increment	Factory Setting	Description
57	Sto positon command selection	0 to 127 9999	1	9999	9999···Internal setting (position set in Pr. 63) 0 to 127···External setting
58	Orientatin speed	0 to 10Hz	0. 01Hz	2 Hz	Higher set value decreases orientation stop time but reduces stopping accuracy.
59	Creep speed	0 to 10Hz	0. 01Hz	0. 5Hz	
60	Creep select position	0 to 2047 pulses	1 pulse	511 pulses	Lower set value decreases orientatin stop time but reduces stopping accuracy.
61	Position loop select position	0 to 1023 pulses	1 pulse	96 pulses	
62	DC dynamic braking start position	0 to 31 pulses	1 pulse	0 pulses	Set in accordance with overrun pulses when the target position is overrun.
63	Internal stop position command	0 to 2047 pulses	1 pulse	0 pulses	Position 0.176° per pulse (i.e. 2048 pulses per rotation) from origin (forward direction of the encoder) Note : Position shift function is defined when any of 0 to 127 is set in Pr. 57.
64	Orientation complete zone (in-position)	0 to 31 pulses	1 pulse	9 pulses	Outputs the orientation complete signal when the spindle is oriented to a stop within the set value of the target position.
65	Position pulse monitoring	0, 1 9999	1	9999	0 ···Current position from origin 1 ···Externla stop position command 9999···Voltage monitoring

7. 6 Adjustment

(1) Stop position

Parameter 57 allows the stop positin command to be selected from between the "internal stop position command" set in parameter 63 from the parameter unit and the "external stop position command" using an external signal.

Set one of the abowe in parameter 57.

● Direction of encoder rotation

The forward rotation of the encoder is clockwise (CW) when viewed in the direction of arrow in Fig. 7.9. The forward rotation of the motor is counterclockwise (CCW) when viewed at the load shaft end.

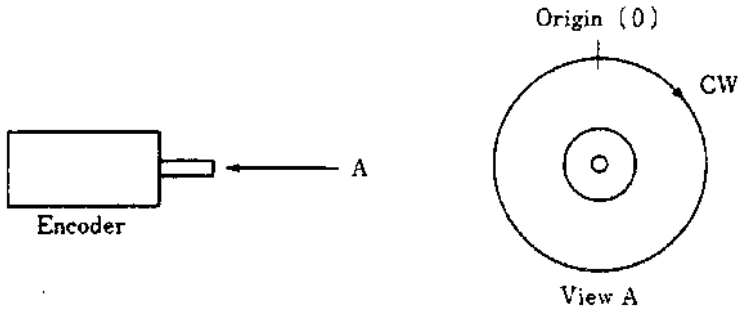


Fig. 7. 9 Direction of Encoder Rotation

①Internally-set stop position command

Set 9999 in parameter 57 (stop position command selection) to select internally-set stop position command mode.

In internal comman mode, the set value of parameter 63 is the stop position.

Since one rotation (360°) of the encoder is equally divided into 2048 positions, an angular value between two adjacent addresses is 0.176° (i.e. 360°/2048) as shown in Fig. 7. 10.

Numerals in parentheses indicate stop positions (addresses).

The encoder addresses start with 0 at the origin (C-phase signal output) and end with 2047.

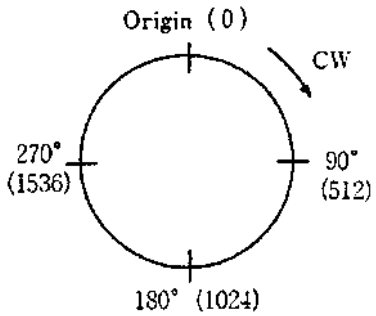
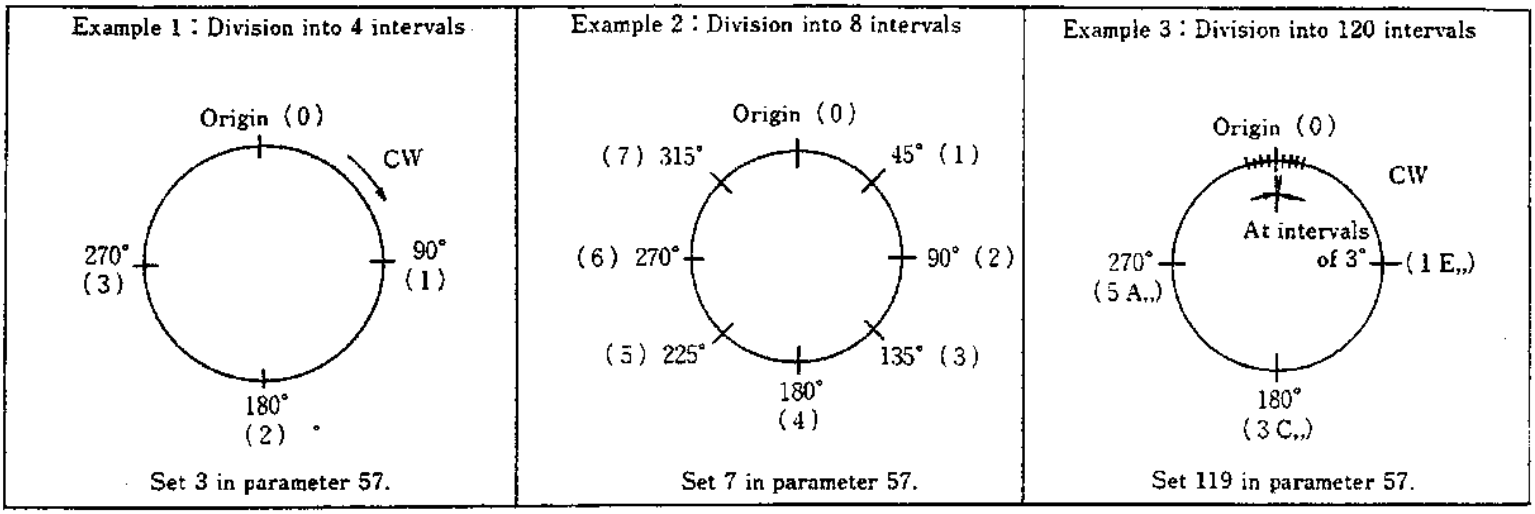


Fig. 7. 10 Encoder Address Allocation

②Externally-set sto position command

Setting of parameter 57 allows stop positions to be defined at up to 128 intervals.

The set value of parameter 57 is the required number minus 1, e.g. set 19 (=20−1) for 20 intervals (at intervals of 18°)



Note : Values in parentheses indicate input binary data from terminals.

Fig. 7. 11 Examples of Setting the External Stop Position Command in Parameter 57

Enter the external stop position command to the inverter terminals in binary. The inverter input terminals used depend on the set value of parameter 57. (See Table 7.4.)

Tabel 7. 4 Number of Intervals and Inverter Terminals Used

Max. Number of Intervals	Terminal / Set Value*	MRS	STOP	AU	RT	RH	RM	RL
8	0 to 7	○	○	○	○	MSB	←	LSB
16	0 to 15	○	○	○	MSB	←	←	LSB
32	0 to 31	○	○	MSB	←	←	←	LSB
64	0 to 63	○	MSB	←	←	←	←	LSB
128	0 to 127	MSB	←	←	←	←	←	LSB

LSB=Least Significant Bit

MSB=Most Significant Bit

Note : Terminals marked ○ perform their intrinsic functions.

*Indicates the value set in the parameter.

Table 7. 5 Index Angles, Parameter 57 Set Values and Externa Command Input Terminals

Index Angle (°)	Set Value of Parameter 57	Final Address (Hex.)	Position Command Input Terminal
360	0	0	
180	1	1	RH(MSB)
120	2	2	
90	3	3	RM
72	4	4	
60	5	5	RL(LSB
51.42	6	6	
45	7	7	
40	8	8	RT(MSB
36	9	9	
32.72	10	A	RH
30	11	B	
27.69	12	C	RM
25.71	13	C	
24	14	E	RL(LSB)
22.5	15	F	
21.17	16	1 0	
20	17	1 1	
18.94	18	1 2	AU(MSB)
18	19	1 3	
17.14	20	1 4	RT
16.36	21	1 5	
15.65	22	1 6	RH
15	23	1 7	
14.4	24	1 8	RM
13.84	25	1 9	
13.33	26	1 A	RL(LSB)
12.85	27	1 B	
12.41	28	1 C	
12	29	1 D	
11.61	30	1 E	
11.25	31	1 F	
10.9	31	2 0	
10.58	33	2 1	
10.28	34	2 2	
10	35	2 3	
9.72	36	2 4	
9.47	37	2 5	
9.23	38	2 6	
9	39	2 7	
8.78	40	2 8	
8.57	41	2 9	STOP(MSB)
8.37	42	2 A	
8.18	43	2 B	AU
8	44	2 C	
7.82	45	2 D	RT
7.65	46	2 E	
7.5	47	2 F	RH
7.34	48	3 0	
7.2	49	3 1	RM
7.05	50	3 2	
6.92	51	3 3	HL(LSB)
6.79	52	3 4	
6.66	53	3 5	
6.54	54	3 6	
6.42	55	3 7	
6.31	56	3 8	
6.2	57	3 9	
6.1	58	3 A	
6.	59	3 B	
5.9	60	3 C	
5.8	61	3 D	
5.71	62	3 E	
5.62	63	3 F	
5.53	64	4 0	
5.45	65	4 1	
5.37	66	4 2	
5.29	67	4 3	
5.21	68	4 4	
5.14	69	4 5	
5.07	70	4 6	
5	71	4 7	
4.93	72	4 8	
4.86	73	4 9	
4.8	74	4 A	
4.73	75	4 B	
4.67	76	4 C	
4.61	77	4 D	
4.55	78	4 E	
4.5	79	4 F	
4.44	80	5 0	
4.39	81	5 1	
4.33	82	5 2	
4.28	83	5 3	
4.23	84	5 4	
4.18	85	5 5	
4.13	86	5 6	
4.09	87	5 7	
4.04	88	5 8	MRS(MSB)
4	89	5 9	
3.95	90	5 A	STOP
3.91	91	5 B	
3.87	92	5 C	AU
3.82	93	5 D	
3.78	94	5 E	RT
3.75	95	5 F	
3.71	96	6 0	RH
3.67	97	6 1	
3.63	98	6 2	RM
3.6	99	6 3	
3.56	100	6 4	RL(LSB)
3.52	101	6 5	
3.49	102	6 6	
3.46	103	6 7	
3.42	104	6 8	
3.39	105	6 9	
3.36	106	6 A	
3.33	107	6 B	
3.3	108	6 C	
3.27	109	6 D	
3.24	110	6 E	
3.21	111	6 F	
3.18	112	7 0	
3.15	113	7 1	
3.13	114	7 2	
3.1	115	7 3	
3.07	116	7 4	
3.05	117	7 5	
3.02	118	7 6	
3.	119	7 7	
2.23	120	7 8	
2.23	121	7 9	
2.23	122	7 A	
2.23	123	7 B	
2.23	124	7 C	
2.23	125	7 D	
2.23	126	7 E	
2.23	127	7 F	

Note : The final address data is represented in hexadecimal (HEX).

(2) Position shift

In external position command mode, parameter 63 defines the position shift function.

The stop positions are those defined by the external position command plus the value set in parameter 63.

● Position shift

A function which electrically shifte the origin without changing the mechanical origin of the pulse encoder.

Example : When 100 is set in parameter 63, each stop position is shifted by the following angular value :

Shift of origin and stop position (°)=parameter 63 set value × 0.176

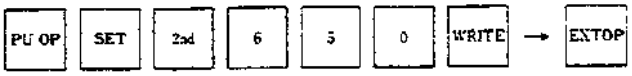
=100 × 0.176=17.6°

(3) Monitoring function

The "current position from the origin" and "stop position command value" can be monitored by selection "output voltage monitoring" from among the monitoring functions of the parameter unit.

①To monitor the current position from origin (set "0" in parameter 65)

Press the parameter unit keys as follows :



(Set to external oseration mode.)

Press  to display the current position from origin on the parameter unit in terms of address (0 to 4096··· same as pulse value).

②To monitor the external stop positioncommand value (set "1" in parameter 65)

Press the parameter unit keys as follows :

(Set to external oseration mode.)

Press  to display the current position command value on the parameter unit in decimal.

To know the positioning state by the monitoring function

Monitoring the above values ① and ② allows the position shift value to be checked.

Example : Assuming that the current position from origin is 1019 and the stop position command value is 1023;

(1023−1019) ×0.176°=0.7°

In forward run, the stop position is 0.7°ahead of the target position.

In forward run, the stop position is 0.7°past the target position.

7. 7 Precautions

(1) The FR–ZOR option unit may only be used in the FR–Z200 series inverters and must not be used in any other inverters, i.e. FR–Z300, Z120, Z020,Z123 and F400 series of inverters.

(2) The FR–ZOR must be used with the torque smoothing unit (FR–ZTS). If the FR–ZOR is used without the FR–ZTS, the stopping accuracy will be extremely decreased and orientation will not be complete.
The FR–ZTS need not be used in any of the FR–Z200 series inverters of 15K and up which contain the torque smoothing function.

(3) The pulse encoder must be coupled with the motor shaft or spindle to be stopped at a predetermined position, at the speed ratio of 1 to 1 without mechanical looseness.

(4) The DC dynamic brake operated to orient the spindle to a stop must be released within an extremely short period of time (several seconds) to protect the motor from heat which may cause burning.

(5) There is no servo lock function after positioning stop.
Hence, a holding mechanism such as a mechanical brake or a dowel pin should be used to secure the spindle.

(6) The spindle may be oriented to a stop if the direction of motor rotation is different from that of pulse encoder rotation or the A-phase and B-phase signal connections are reverse. However, the spindle cannot be positioned correctly if the pulse signal is not provided from the pulse encoder during orientation due to open wire, etc.

(7) Prepare a separate power supply if the 5VDC, 400mA power required for the pulse encoder and option unit cannot be supplied from the NC, etc.