

A3T Series
AC Spindle Drive
Commissioning Manual
(V2.0 version)

● **Product Profile**

A3T Series Digital AC servo spindle driver adopts advanced all-digital control and AC motor vector control theory, excellent system performance, high reliability, widely used in CNC machine tools, textile machinery and other related industrial machinery spindle drive.

● **Product Features**

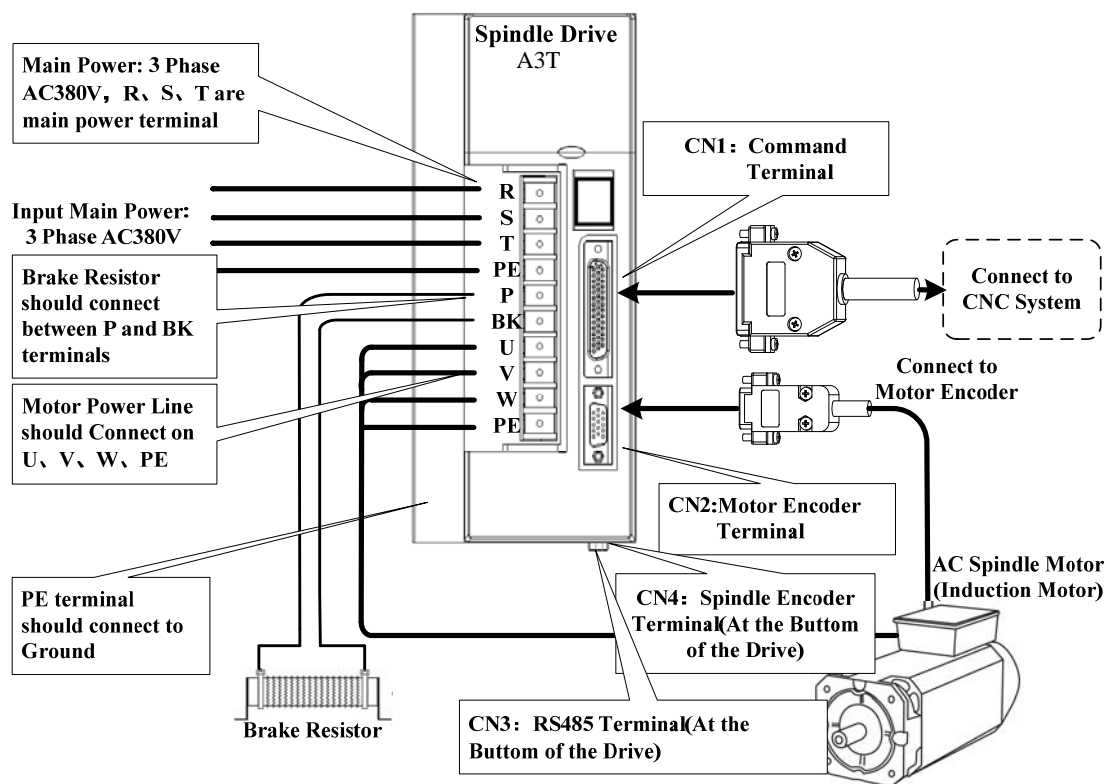
- The use of high-performance DSC chip and large-scale programmable logic control chip, excellent control performance.
- Choosing a new industrial-grade IPM module with strong overload drive capability.
- Set speed control, position control, torque control in one.
- Can drive various types of spindle motors, and can be used to control the internal electric spindle.
- Supports incremental photoelectric encoders, rotary transformers, positive cosine encoders and many other position feedback components.
- Supports dual encoder control for full closed-loop high-precision control of machine tool spindle.
- Spindle quasi-stop, rigid tapping, threaded cutting and other functions.
- Excellent low speed characteristics and industry-leading dynamic acceleration and deceleration performance.

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1、Wiring Instructions

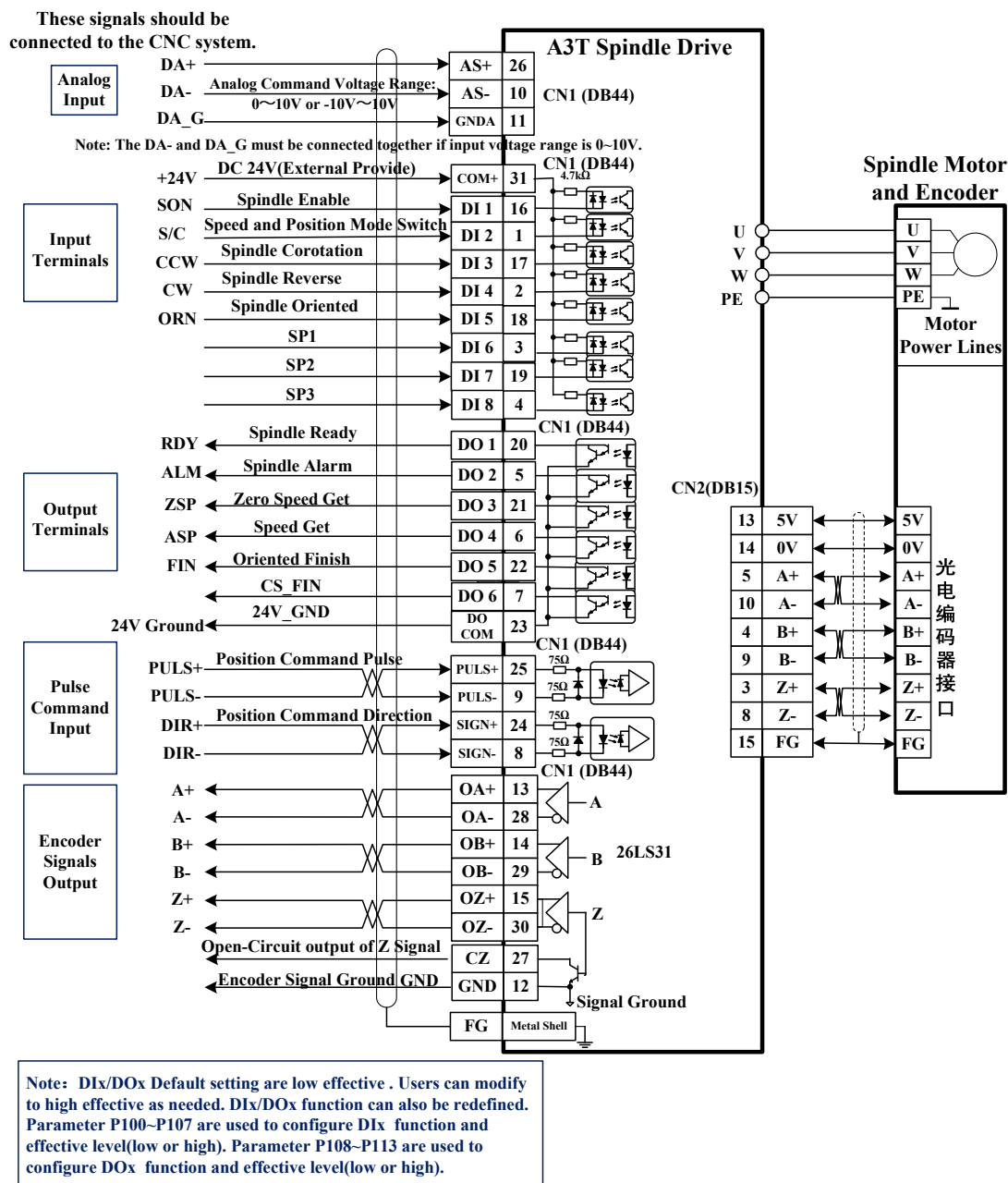
1.1 Front panel terminal wiring diagram



1.2 Brake resistance specification

Drive Model Type	Drive model Brake resistance	Drive model Brake Power
A3T-H37	$\geq 50\Omega$	$\geq 1500W$
A3T-H55	$\geq 50\Omega$	$\geq 1500W$
A3T-H75	$\geq 30\Omega$	$\geq 2000W$
A3T-H150	$\geq 27\Omega$	$\geq 2500W$
A3T-H220	$\geq 15\Omega$	$\geq 3000W$

1.3 Control port CN1 and Motor encoder port CN2 Connection diagram

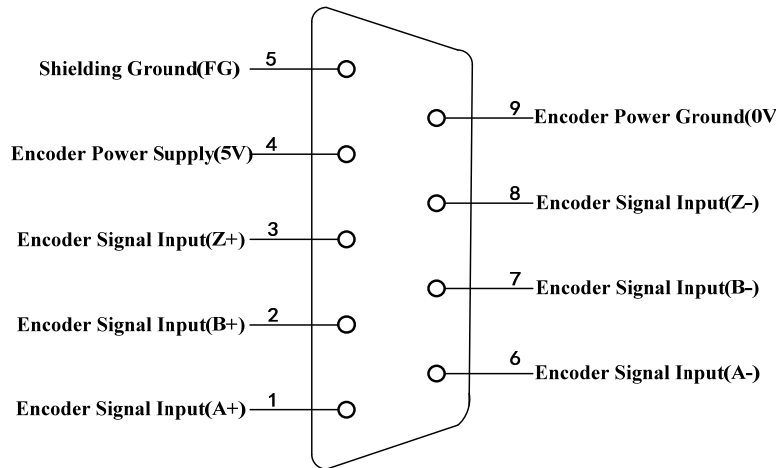


Special Note:

If the pulse command signal is a 24V power supply, the resistor must be concatenated at puls-, sign-2K, 5%, 0.25W, otherwise it may damage the pulse command port.

1.4 Spindle Encoder Port CN4 Connection diagram

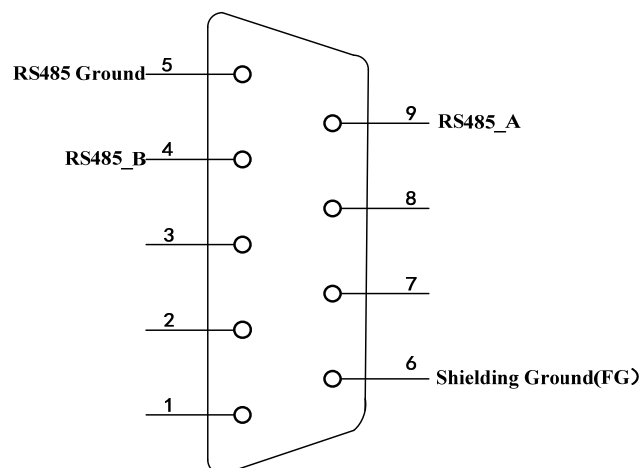
The Spindle encoder port uses a double-row DB9 socket, and the shape and pins are distributed:



Spindle encoder Port DB9 plug (incremental photoelectric encoder)

1.5 Communication Port CN3 Connection diagram

The communication port uses a double-row DB9 socket, and the shape and pins are distributed:

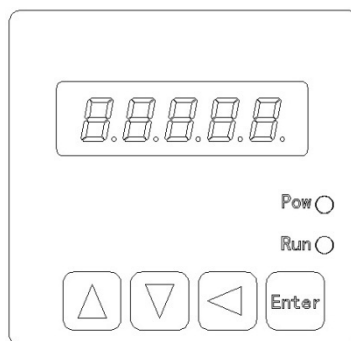


Communication Port DB9 Plug

2、Panel operation

2.1 Operator Panel Introduction

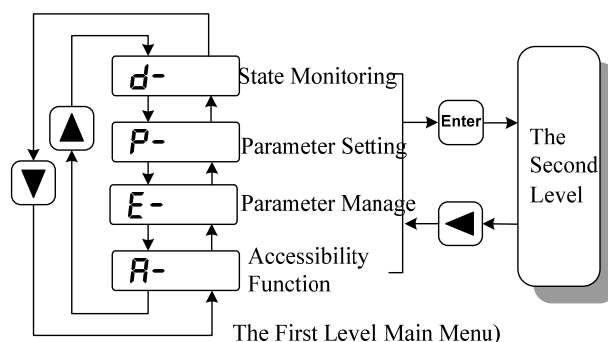
Panel by 5 LED digital tube display, 4 keys ▲, ▼, ◀, Enter, used to display the system of various state settings parameters. The operation is a hierarchical operation, expanded by the main menu layers by layer.



Symbol	Name	Function
Pow	Main Power lamp	Light: The main power supply has been powered on. Extinguished: The main power supply is not powered on.
Run	Running lamp.	Light: The motor is powered on and running. Extinguished: The motor is not powered on.
▲	The up key	Increases the ordinal number or the numeric value, long press has the repetitive effect.
▼	The down key	Decreases the ordinal number or the numeric value, long press has the repetitive effect.
◀	The Esc key	Menu Escape; Operation Cancel

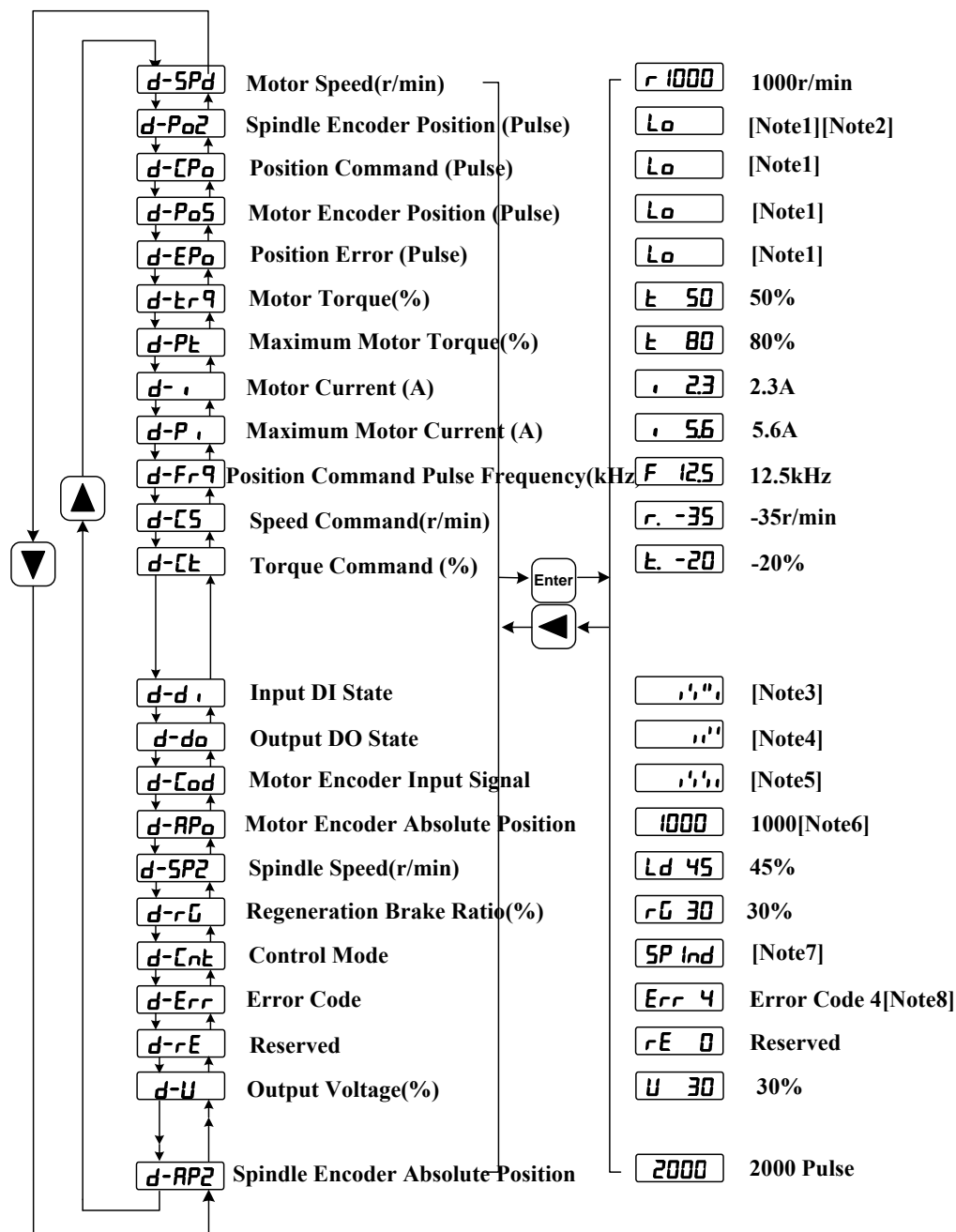
2.2 Main Menu

The first layer is the main menu, a total of 4 modes of operation, with ▲ and ▼ key to change the menu mode, press ENTER to enter the second layer, perform specific actions, press ◀ key to return the main menu from the second layer.



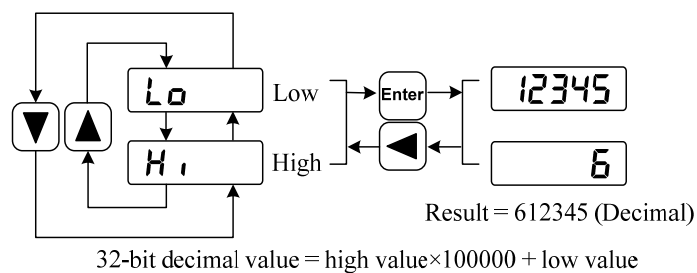
2.3 Status monitoring

Under the main menu, select Status Monitoring menu “d-” press ENTER to enter the monitoring mode. There are various monitoring items, users can press ▲ and ▼ key to select the required display item, and then press ENTER to enter the specific display state. The Status monitoring display item has the following specific meanings:



1. 32-Bit binary numeric display [Note 1]

The 32-bit binary range is -2147483648~2147483647, which is represented by a combination of low and high, and low and high position is selected through the menu, and the complete value is synthesized with the formula in the graph.



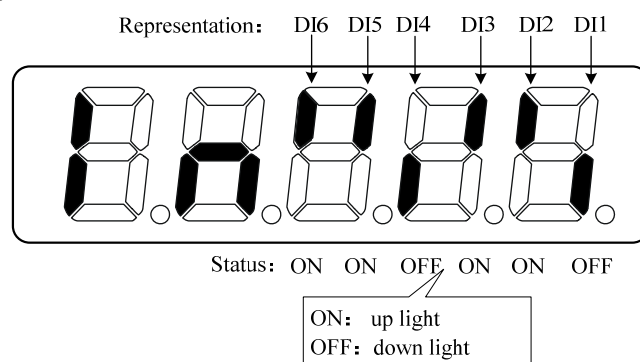
2. Pulse unit [Note 2]

The pulse unit is the encoder pulse unit. Take the use of the 2500-wire encoder as an example:

$$\begin{aligned}
 \text{Encoder Pulse UNIT} &= \text{Encoder resolution} \\
 &= 4 \times \text{encoder lines} \\
 &= 4 \times 2500 \text{ (pulse/rev)} \\
 &= 10000 \text{ (pulse/rev)}
 \end{aligned}$$

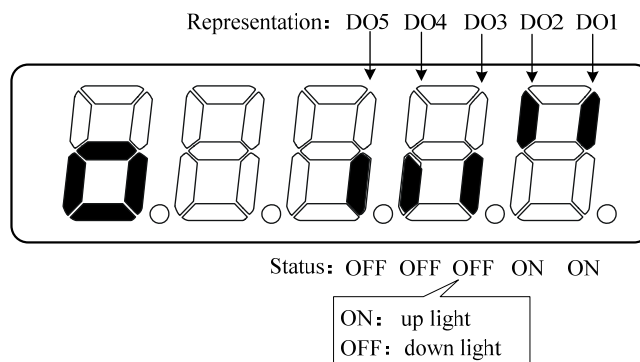
3. Input terminal DI [Note 3]

The vertical line of the digital tube represents the state of a bit, the up stroke on the vertical line is lit to indicate on, and the down stroke is lit to indicate off.



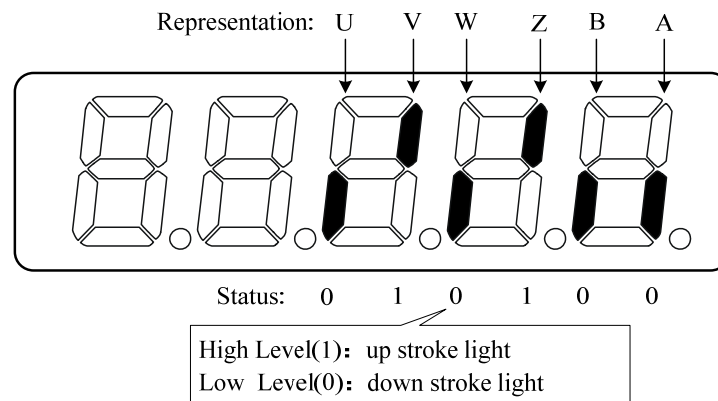
4. Output terminal DO [Note 4]

The vertical line of the digital tube represents the state of a bit, the up stroke on the vertical line is lit to indicate on, and the down stroke is lit to indicate off.



5. Encoder input signal [Note 5]

The vertical line of the digital tube represents the state of a bit, the up stroke on the vertical line is lit to indicate a high level, and down stroke is lit to indicate a low level. (Note: Absolute position encoder, this display is meaningless)



6. Rotor single-ring position [Note 6]

Represents the position of the rotor relative to the stator in a turn, with one conversion to a period, the minimum resolution of the encoder is in units, and the Encoder Z pulse as the origin point.

2500-Wire Encoder: The range is 0~9999 (10 binary), and the z pulse appears with a value of 0.

Absolute POSITION encoder: its range is 0~1ffff (16 decimal), which is represented by high and low bits.

Rotary Transformer Encoder: Its range is 0~65535 (10 binary), and the z pulse appears with a value of 0.

7. Control mode [Note 7]

Display characters represent the current control mode of the spindle drive.

SP ind	Spindle Speed Mode
Co in	Orientation Mode
StoC1	C-Axis Position Mode (Semi-closed Loop Control: Motor Encoder)
StoC2	C-Axis Position Mode (Full-closed Loop Control: Spindle Encoder)

8. Error code [note 8]

No error display two minus sign. There is an error to display the alarm number and blink. When the alarm appears, the monitor automatically enters the status monitoring and displays the alarm number, but can do other operations through the keyboard. When it is not in the monitoring state, the rightmost digital tube of the decimal point flicker indicates that there is an alarm presence.

2.4 Parameter setting and parameter management

(1) Parameter setting

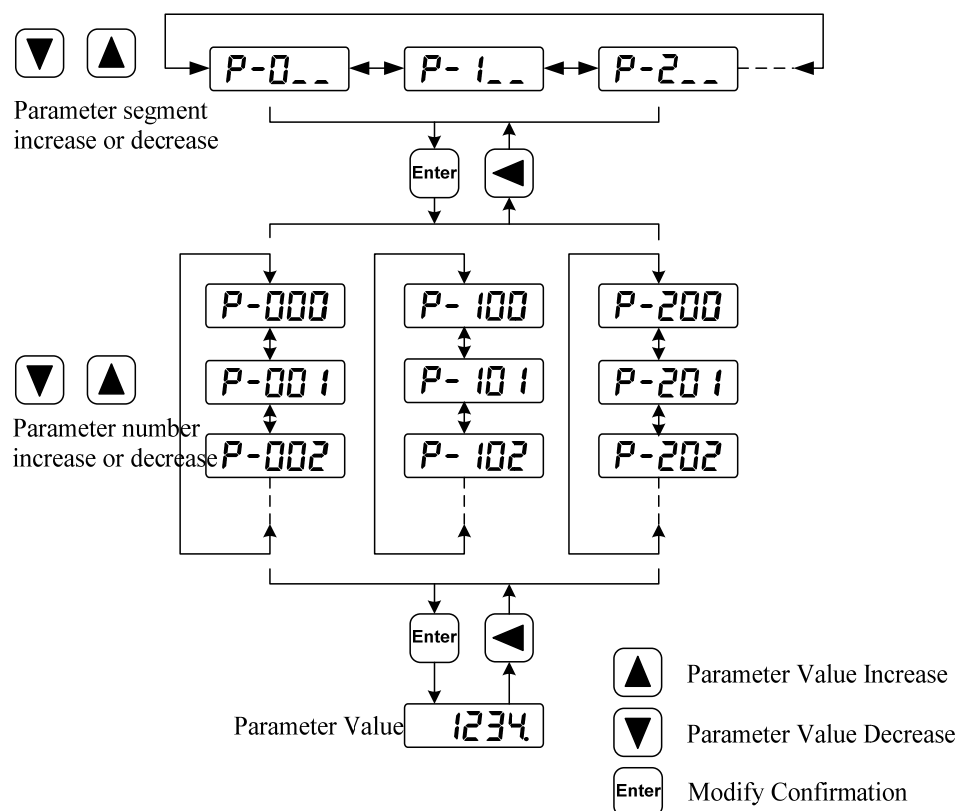
The parameters are represented by parameter segment + parameter number, the hundred digits are the segment number, and the ten digits and one digit are the parameter numbers. For example, parameter P-102, the segment number is '1', the parameter number is '02', and the digital tube is displayed as 'P- 102'.

In the main menu, select parameter setting 'P- ' and press **Enter** to enter the parameter setting mode. First use the **▲**, **▼** keys to select the parameter segment. After selecting it, press the Enter key to enter the parameter number selection. Then use the **▲**, **▼** keys to select the parameter number. When selected, press Enter to display the parameter value.

Use the **▲**, **▼** keys to modify the parameter value. Press the **▲** or **▼** key once to increase or decrease the parameter by 1. Press and hold the **▲** or **▼** key to increase or decrease the parameter continuously. When the parameter value is modified, the decimal point of the rightmost LED digital tube is lit. Press Enter to confirm that the modified value is valid. At this time, the decimal point of the LED digital tube on the right is off, and the modified value will be immediately reflected in the control (some parameters need to be saved and re-power on to work).

After that, you can continue to modify the parameters. After the modification is completed, press the **◀** key to return to the parameter number selection state. If you are not satisfied with the value being modified, do not press Enter to confirm. Press **◀** to cancel and the parameter will return to the original value.

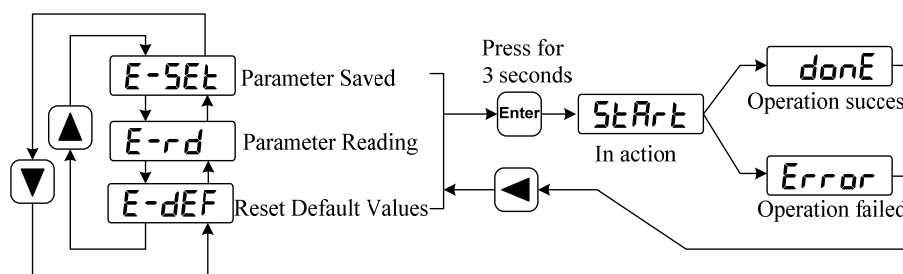
The modified parameters are not saved to the EEPROM. If you need to save them permanently, use the parameter write operation in the parameter management.



(2) Parameter management

Parameter management mainly deals with the operation between the parameter table and the EEPROM. In the main menu, select parameter management 'E-' and press Enter to enter the parameter management mode.

Select the operation mode, there are 3 modes, use ▲, ▼ to select. Press the Enter key after selecting the operation mode and hold it for more than 3 seconds to activate the operation. After the completion, press the ◀ key to return to the operation mode selection state.

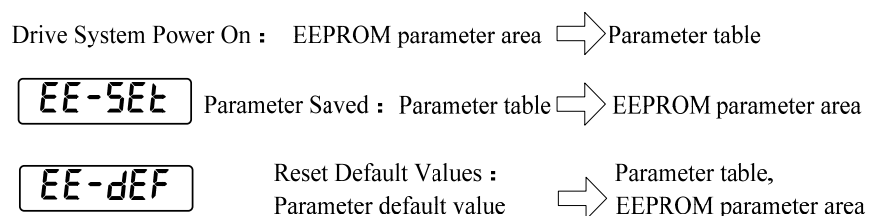


- Parameter Saved

This operation represents writing parameters from a parameter table to EEPROM. If user modifies the parameter, only the parameter value in the parameter table are changed, the parameter will maintain the original value when you power up again. If user wants to permanently change the parameter value, you need to perform a parameter saving operation, write the parameters in the parameter table to the EEPROM, so that the parameter is modified when you power up again.

- Reset default values

This operation indicates that the default value (factory value) for all parameters is read into the parameter table and written to EEPROM, and the default parameter will be used the next time you power up. Use this action to reset all parameters to the factory state when the user has messed up the parameters and the drive not working properly. Because the default values of parameters for different drive models and motor models are different, the correctness of the motor code (parameter P-002) must be guaranteed when doing this operation firstly.



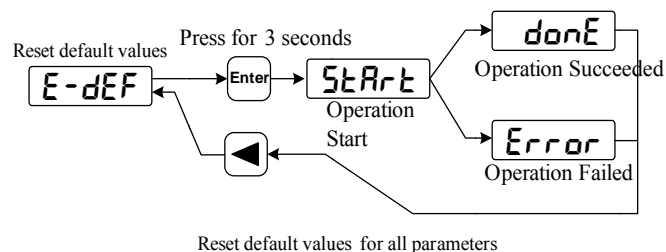
3、Parameter setting and function debugging

- When the user uses the drive unit at the first time, it is recommended to perform a test running (keyboard speed regulation or JOG Running) without connecting the load. Ensure that the drive unit and servo motor work properly after handling and installation, and ensure that the default parameters of the drive unit adapter are valid.
- After the drive unit and the motor are working properly, connect the CN1 control terminal without connecting the load, and cooperate with the CNC device of the upper computer to debug and run the speed mode, position mode or other working mode that the user needs.
- After the signal connection, parameter setting, motor operation are debugged normally, then connect the load and run with load.

3.1 Set Motor Code

Switch on the main circuit power supply, the drive's POW light is lit, the display panel is lit, if there is an alarm appears, please check the connection. Set the motor code parameters according to the following steps:

1. modify the operation password (parameter P-000) is 385;
2. according to the motor model to modify the motor Code (parameter P-002), the motor model code is detailed in the 6th chapter of the Motor adapter table;
3. Enter parameter management and perform reset default values action as shown in the following figure:

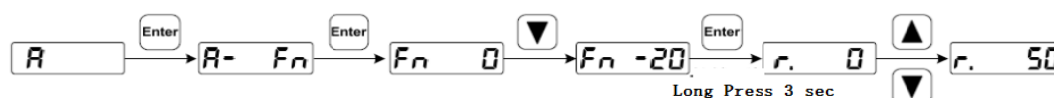


4. when the panel display operation succeeded, turn off the power supply, waiting for the drive panel extinguishing, and then turn on the power supply again, user can do the next operation (keyboard speed test running or JOG running)

3.2 Trial run

3.2.1 Keyboard Speed regulation test run

After switching on the drive power to confirm that there are no alarms and any exceptions, user can operate as the following figure:



The panel prompt is 'r.', the value unit is r/min, and the speed command is provided by the

button. Use the ▲, ▼ keys to change the speed command and the motor will run at the given speed. A positive number indicates forward rotation (CCW), a negative number indicates reverse rotation (CW), and the minimum given speed is 0.1 r/min. **If the motor is running normally, you can enter the spindle control parameter settings.**

3.2.2 Jog spot test run

Turn on the main circuit power, the Pow indicator of the drive lights up, the display panel lights up, if there is an alarm, please check the connection.

After confirming that there is no alarm or any abnormal condition, set P-098 to 1, the servo enable (SON) is ON, and the RUN indicator is lit. At this time, the motor is energized and is at zero speed.

In the auxiliary function menu 'F-' , select 'F-JOG' and press Enter to enter jog (JOG) operation mode. The jog prompt is 'J', the value unit is r/min, and the speed command is provided by the button:

Press ▲ key and hold, the motor will run at JOG speed (CCW), release the button, the motor will stop and keep zero speed; press ▼ and hold, the motor will run according to JOG speed reverse (CW), release the button the motor will stop and keep zero speed.

The JOG speed is set by parameter P-076 and the default speed is 100r/min.. **If the motor is running normally, you can proceed to the next step (coupling with the CNC system).**

The meanings of the test run related parameters are as follows:

Parameter Num	name	setting value	default value	parameter description
P060	Speed command acceleration time	Suitable value	200	Unit: ms 0-1000r/min acceleration time, increase this parameter to reduce acceleration impact
P061	Speed command deceleration time	Suitable value	200	Unit: ms 1000r/min-0 deceleration time, increase this parameter can reduce deceleration impact
P069	Commissioning torque limit	100~200	100	Unit: Rated torque *1%
P075	Maximum speed limit	Set as needed	6000	Unit: r/min Setting this parameter can play the role of speeding safety protection
P076	JOG running speed	Suitable value	100	Unit: r/min JOG speed
P098	Forced enable (Internal Servo On)	1 or 0	0	Forced enabling: set to 1 the motor is energized, set to 0 the motor is not energized if no external servo on signal.

Note: When the keyboard speed test run or jog point test run, if the motor appears vibration, noise

and other anomalies, it is necessary to modify P005, P006, P007, P019 and other speed loop parameters for debugging.

3.3 Spindle control parameter setting

The spindle control mode is applied to the occasion that the spindle needs to output power in a rotating manner, and the spindle needs to participate in the feed axis interpolation in a position mode (C-axis mode or indexing mode), such as CNC lathe, milling machine, machining center, and etc. The speed command is the analog voltage (0~10V or -10V~10V), which come from AS+, AS- of the command terminal CN1. The position command is the pulse command, which come from the PULS+, PULS- and SIGN+, SIGN of the command terminal CN1.

In the initial state, the spindle drive operates in the speed control mode, and receives the analog speed command to run in speed mode as the power output shaft of the machine tool. If the spindle is required to participate in the linkage interpolation of the feed axis (for example: rigid tapping), the master CNC system switches the spindle drive to position control mode via the IO control signal (speed/position switching).

(1) Control mode settings

After confirming that the command Port CN1 wiring is correct, keep all input signals as off, turn on the power supply, and then set the necessary parameters.

(2) DI/DO function Settings

The digital input and output port related functions are configured as follows:

Parameter	name	default value	Parameter Note
P108	Digital output DO1 Function	2	2: The spindle is ready
P109	Digital output DO2 Function	3	3: Alarm output
P110	Digital output DO3 Function	4	4: Arrival at zero speed
P111	Digital output DO4 Function	6	6: Speed arrive
P112	Digital output DO5 Function	13	13: Spindle orientation completed
P113	Digital output DO6 Function	14	14: S/C (speed/position) switching completed

Note: DO1~DO6 default settings are low active. If user wants to change to high active, please take the corresponding parameters in the table above to reverse.

For example: P109 set to 3, alarm output low active, P109 set to -3, alarm output high active.

(3) Speed control parameter settings (Speed mode)

The speed command related parameters are described in the following table:

Parameter	name	setting value	default value	Parameter Note
P025	Speed command Source	0	0	0: Set to analog input, input analog voltage by port AS+ and AS-; 3: Pulse speed mode
P046	Analog speed command gain	Set as needed	600	Unit: r/min/V, set the command speed corresponding to 1V voltage. The input voltage and the speed are linear. The default setting is 600: it means that 10V corresponds to 6000r/min, and 5V corresponds to 3000r/min.
P047	Analog speed instruction zero offset compensation	Set as needed	0	Unit: 0.1mv, used to adjust the zero offset value of the analog voltage input channel. The analog zero adjustment function automatically sets this parameter, or can be set manually (the NC system outputs the zero speed command, adjust this parameter to make the motor speed near 0)
P048	Speed instruction Direction	Set as needed	0	Used to set whether the speed command is reversed: set to 0 is not reversed, set to 1 is inverted.
P049	Speed instruction Filter Time constant	Set as needed	100	Unit: 0.1ms, set the low-pass filter coefficient of the analog speed command, smooth the analog command, the larger the value, the smoother the command.
P-050	Analog Speed Instruction Polarity	Set up as needed	0	0: Bipolar. 1: Single positive polarity. The input positive polarity is valid, and the negative polarity is forced to 0. 2: Single negative polarity. The input negative polarity is valid, and the positive polarity is forced to 0.

P-051	Analog Speed Command Dead Zone 1 (mV)	Set up as needed	0	The command is forced to 0 when the input voltage is between dead zone 2 (parameter P052) to dead zone 1 (parameter P051).
P-052	Analog Speed Command Dead Zone 2 (mV)	Set up as needed	0	
P058	Speed instruction electronic gear molecules	Set up as needed	1	Set the electronic gear ratio of the speed command to match various speed commands; when the input analog voltage is less than 10V, set this parameter to achieve the maximum speed corresponding to the 10V voltage input.
P059	Speed instruction Electronic gear denominator	Set up as needed	1	
P060	Speed instruction Acceleration Time	Set up as needed	200	Unit: ms 0-1000r/min acceleration time, increase this parameter to reduce acceleration impact
P061	Speed instruction Deceleration time	Set up as needed	200	Unit: ms 1000r/min-0 deceleration time, increase this parameter can reduce deceleration impact
P075	Maximum speed limit	Set up as needed	6000	Unit: r/min

(4) Position control parameter settings (c-axis position mode)

Parameters related to position instructions are set as described in the following table:

Parameter	name	setting value	default value	parameter description
P029	Position command electronic gear molecule	Set as needed	1	Set the electronic gear ratio of the position command to match the various pulse commands.
P030	Position command electronic gear denominator	Set as needed	1	
P035	Position command pulse mode	Set as needed	0	0: pulse + direction; 1: CCW/CW pulse; 2: Quadrature pulse(A/B).

P036	Position command input direction	Set as needed	0	Set the count direction of the position command pulse: set to 0 position command is not reversed, set to 1 position command is reversed.
P024	Encoder pulse output polarity	Set as needed	0	Set the polarity of the Encoder output pulse: set to 0 output pulse is not reversed, set to 1 output pulse is reversed.
P040	Position command exponential smoothing filter time	Set as needed	0	Unit: 0.1ms, set the exponential smoothing filter time of the position command, smooth the position command, the larger the value, the smoother the command.

3.4 Spindle function debugging

1. As needed, after the above-mentioned necessary parameters are set, perform the parameter writing operation (refer to the **E-5E** operation described in parameter management in Section 2.4). After parameters are saved, user should turn off the spindle driver and restarted.
2. Give a small analog voltage command and make the servo input signal SON ON, the spindle forward rotation signal CCW (or the spindle reversal signal CW) ON, the motor should follow the command to run. At this time, the “Run” indicator on the panel lights up and you can check if the motor is running normally by monitoring the following variables:
 - (1) Observe the motor current by monitoring '**d- i**' (unit: A). When the motor is running at normal steady speed, the displayed current value will not exceed the rated current of the motor.
 - (2) Observe the analog command by monitoring '**d-LS**' (unit: r/min), the normal display value is equal to the speed indicated by '**d-SPd**';
 - (3) Observe the original analog quantity command (in voltage, unit: mv) by monitoring '**rE- iQ**' under the '**d-rE**' menu. Normally, the display value is equal to the command voltage given by the master controller. (Note: '**rE- iQ**' is the instruction after zero offset compensation.)
3. After confirming the normal, slowly increase the analog voltage command, gradually increase the speed of the motor running, and monitor whether the motor runs with vibration, noise, whether the speed is stable, and whether the motor current will exceed the rated value.
4. When the motor runs from zero speed to positive maximum speed, or from zero speed to negative maximum speed, the user can perform other functions debugging.

During the operation of the analog command speed mode, common anomalies and processing methods are as follows:

Serial number	Abnormal phenomena frequently encountered during the operation	Processing methods
1	After a given analog command, the monitor window 'rE-3' shows that the data does not correspond to the instruction voltage	Check if the master controller command system and command cable are connected correctly.
2	After enabling, the monitor window rE-10 has the corresponding instruction voltage value, but the d-55 does not have the corresponding instruction speed, that is, the voltage instruction and the motor does not run	1. Check the settings of the "required parameters"; 2. Check the input I/O signal line. It is convenient to check the contents of d-d1 for I/O state check.
3	The positive direction of motor rotation is inconsistent with the requirements of the master controller	Modify parameter P048 to set whether the speed command is reversed: set to 0 without inversion, set to 1 for inversion (immediately effective)
4	Motor vibration, noise and other abnormal conditions, when spindle orientation, motor shaft jitter;	1. Check if the shielded cable is properly wired. 2. Refer to Chapter 4, Section 4.2, Basic Performance Parameter Debugging Instructions.
5	Give the 0V instruction, the motor will also move slightly	Perform automatic analog zero-calibration operation, or manually modify parameter P047, for details see section 3.8.

5. After the speed mode is running normally, the drive unit can directly switch to the position mode when the motor is enabled. The input signal CSMODE (speed/position mode switching) is turned ON, and the drive unit is switched to the position mode.
6. Make the servo enable input signal SON ON. Give a low frequency position pulse command, the motor should run. By monitoring d-1, observe the motor current (unit: A). Normally, the displayed current value will not exceed the rated current of the motor. By monitoring d-Fr9, the frequency of the command pulse can be displayed in real time.
7. Slowly increase the frequency of the position command, gradually increase the speed of the motor running, and monitor whether the motor runs with vibration, noise, whether the speed is stable, and whether the motor current will exceed the rated value.
8. When the motor is running at the rated speed, it can follow the command, and when the d-CP0 display position command pulse number is equal to the number of pulses displayed by d-P05, the user can perform other function debugging.

During the operation of the position control mode, common anomalies and treatment methods are as follows:

Serial number	Abnormal phenomena frequently encountered in debugging runs	Processing method
1	After enabling the position pulse instruction, the α -P α display does not change and the motor does not run	Check if the master controller command system and command cable are connected correctly.
2	α -P α shows a change, the motor does not run	1. Check the settings of the related parameters; 2. Check the input I/O signal line. It is convenient to check the contents of α - α for I/O check.
3	The positive direction of motor rotation is inconsistent with the requirements of the master controller.	Modify the parameter P036 to set whether the position command is reversed: set to 0 to not reverse, set to 1 to reverse (immediately effective)
4	The rotation direction of the spindle is consistent with the desired direction, but the position of the master controller shows the opposite direction of expectation	Modify parameter P024 to set whether the encoder output polarity is reversed: set to 0, not reversed, set to 1 to reverse (restart is valid)
5	Abnormal conditions such as vibration and noise in the motor	1. Check if the shielded cable is properly wired. 2. Refer to Chapter 4, Section 4.2, Basic Performance Parameter Debugging Instructions.
6	Motor can only run in one Direction	1. Check if the command line is properly connected. 2. Check if parameter P035/P036 is set properly.

3.5 Spindle Orientation Function

(1) Feature description

In order to replace or measure the knife tool, the function of quickly and accurately rotating the spindle to a set position and maintaining the position at that location (the stop position of the motor shaft or the stop position of the spindle) is called the spindle orientation function, which based on the position feedback signal of the motor encoder or the spindle encoder. The related parameters are described below:

Parameter	name	Parameter range	Default Value	Unit
P184	Spindle orientation speed	10~1000	300	r/min
P185	Spindle orientation position	0~32767	0	Pulse
P191	Selection of spindle orientation direction	0~2	1	
P192	Spindle orientation position reference source	0~2	0	
P009	Position loop servo gain (spindle orientation mode)	1~1000	25	1/s

P191: Selection of spindle orientation direction

0: The spindle orientation direction is automatically determined by the spindle rotation direction. When the motor CCW rotates, the orientation speed is CCW direction, and the orientation speed is the CW direction when the motor CW rotates.

1: Regardless of the rotation direction of the motor, the spindle oriented in the CCW direction;

2: Regardless of the rotation direction of the motor, the spindle oriented in the CW direction

P192: Spindle orientation position reference source

0: Select the Z signal of the motor shaft encoder ENC1 as the reference source of the spindle orientation position; (suitable for applications where the motor shaft and spindle ratio are 1:1).

1: Select the Z signal of the external zero-index switch as the reference source of the spindle orientation position; (suitable for applications where the motor shaft and spindle ratio are not 1:1 and external zero-index switch is assembled on the spindle shaft).

2: Select the Z signal of the spindle encoder ENC2 as the reference source of the spindle orientation position; (suitable for applications where the spindle shaft is fitted with spindle encoder ENC2).

(2) Operation process

The operation process of spindle orientation which choose the motor encoder ENC1 as the reference source describes as follows: < P192 is set to 0 >

1. After power-on, call up the monitoring menu **d-PP0**, press E(Enter) to display the absolute position of the motor shaft. If **|||||** is displayed, the motor shaft is in an indeterminate position (Z pulse signal is not detected), its value cannot be used as the default orientation position.

Reference;

2. Rotate the motor shaft at least one turn. After the drive detects the Z pulse signal of the motor encoder, it displays the correct absolute position of the shaft.

Note: Let the motor rotate one turn, you can manually revolve the spindle when the motor is not enabled, or you can give a low speed command to rotate the spindle when the motor is enabled.

3. Slowly adjust the motor shaft or the connected spindle to the orientation point, then record the rotor position displayed by **d-RP0**, write the recorded value to parameter P185 and save it. This parameter value is the orientation position.

4. Make the SON signal ON (the CCW or CW signal is ON in the analog speed command mode), and keep the spindle orientation start signal SPTO always ON regardless of the motor running or not. The motor will run at the speed set by parameter P184 until finding the position of the orientation point, and then maintain in the orientation position, at the same time the spindle orientation completion signal FIN will be active.

5. After the CNC device receives orientation completion signal FIN, it performs the tool change operation. The orientation start signal must be ON during the tool change process. After the operation is completed, the orientation start signal can be canceled to perform other operations.

Note: The accuracy of the spindle orientation depends on the encoder's feedback accuracy.

The accuracy of the orientation position control is ± 1 pulse.

The operation process of spindle orientation which choose the spindle encoder ENC2 as the reference source describes as follows: < P192 is set to 2 >

(Note: The resolution parameters of the spindle encoder (P028 and P027) must be set correctly and saved into EEPROM(see details in **section 3.6**). And then, restart the power supply of the driver.)

1. After power-on, call up the monitoring menu **d-RP2**, press E to display the absolute position of the spindle. If **R I I I** is displayed, the spindle is in an indeterminate position (Z pulse signal is not detected), its value cannot be used as the reference position value;

2. Rotate the spindle shaft at least one turn. After the drive detects the Z pulse signal of the spindle encoder, it displays the correct absolute position of the shaft.

Note: Let the spindle rotate one turn, you can manually revolve the spindle when the motor is not enabled, or you can give a low speed command to rotate the spindle when the motor is enabled.

3. Slowly adjust the motor shaft or the connected spindle to the orientation point, then record the rotor position displayed by **d-RP2**, and write the recorded value to parameter P185 and save it. This parameter value is the orientation position. The subsequent operation process is the same as above section.

3.6 Full closed-loop control (dual encoder debugging)

(1) Feature description

In order to overcome the influence of the gap and error of spindle transmission on the control performance and improve the precision of the spindle position control, the function of position control or degree control is called full closed-loop control according to the real-time position feedback signal of the spindle encoder (the second position Encoder). The relevant parameters are described below:

Parameter	Name	Parameter range	default Value	Unit
P023	Position Feedback Encoder selection	0~1	0	

- setting position feedback signal source of the spindle position control mode (c axis);
- parameter meaning: 0: Motor encoder (first encoder) 1: Spindle encoder (second encoder);
- This parameter setting requires a power outage restart to take effect.

P085	Second encoder control parameters	Parameter range	default Value	Unit
		0~11111	0	

- Set the polarity of A/B signal of the spindle encoder (the second encoder);
- parameter meaning: 0: A/B non-inverted phase 1:A/B inverted phase
- This parameter setting requires a power outage restart to take effect.

Parameter	Name	Parameter range	default Value	Unit
P027	Second encoder resolution L (4)	0~9999	0	Pulse
P028	Second encoder resolution H (4)	0~9999	1	Pulse

- Set the resolution of the spindle encoder (second encoder) (the number of pulses rotated one turn for 4 times the frequency);
- parameter meaning: **Resolution = (P028 * 10000) + P027;**
- **For example:**
The number of spindle encoder lines is 1024 lines, the number of pulses rotated one turn of the spindle is 4096, then set P028 = 0, P027 = 4096;
The number of spindle encoder lines is 2500 lines, the number of pulses rotated one turn of the spindle is 10000, then set P028 = 1, P027 = 0;
- This parameter setting requires a power outage restart to take effect.

(2) Operation Process

Firstly, debug the semi-closed-loop position control (with the motor encoder as the position signal feedback source), to make sure whether the motor encoder and spindle encoder position

signal is normal and **the polarity is consistent**. Then, user can start the full closed-loop debugging (the spindle encoder as the position signal feedback source). The debugging process is described as follows:

- 1, Set the parameter P023 to 0 select motor encoder as the source of position feedback signal. Set the correct value of the spindle encoder resolution (parameters P028 and P-027), save parameters and then let the power outage restart;
- 2, After the power-on again, the spindle is in a semi-closed-loop way. Rotate the spindle to a fixed direction in a low speed (the CNC device giving a low-speed position rotation instructions or manual rotate spindle). User can observe $d-PP0$ (the absolute position of the motor encoder) and $d-PP2$ (absolute position of the spindle encoder), check that whether the change direction of them are consistent (i.e., they both changed from small to large or from large to small). If inconsistent, the P085 needs to be modified (spindle encoder A/B inverted phase);
- 3, Then, set the parameter P-023 to 1 open the full closed-loop control switch, select the spindle encoder as the position feedback signal source, save the parameters and the turn off the power of the spindle driver and restart;
- 4, When the above process is completed, turn on the power again, the spindle driver is working in the full closed-loop control mode, the CNC device output servo on signal and speed/position switching signal, the spindle will running in the position control mode.

3.7 Rigid tapping (position control/C-axis score function)

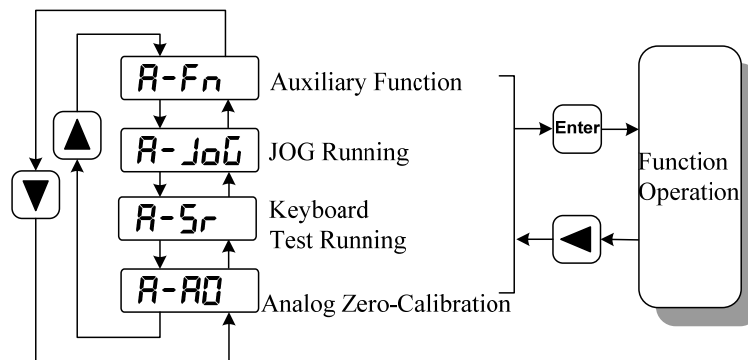
In machine tool machining, rigid tapping is a thread machining under the position closed loop, which requires the drive unit to have high servo rigidity. Requires quick response to position commands and minimizes position following errors. Therefore the driver needs to be set a higher position loop gain and speed loop gain. For the spindle servo drive, as a general spindle machining (speed control mode) and rigid tapping machining (position control mode), two different speed loop gains and position loop gains are required, so the speed loop second gain parameters P010, P011 are added. Increase position loop second gain parameters are P013, P021, P022. When the upper computer numerical control device gives the DI signal CSMODE (speed/position mode switching) to ON, the driving unit switches to the position mode, and the speed loop and the position loop gain parameter are automatically switched to the second group gain, and the relevant parameters are as follows:

Parameter	Name	Parameter range	default Value	Unit
P010	Speed loop gain (C-axis mode)	1~3000	50	Hz
P011	Speed loop integration Time (C-axis mode)	1~1000	20	ms
P013	Position loop gain(C-axis mode)	1~1000	40	1/s
P021	Position loop Feed-forward gain (C-axis mode)	0~100	0	%
P022	Position loop Feedforward Filter Time (C-axis mode)	2~500	10	0.1ms

3.8 Analog command zero-calibration function

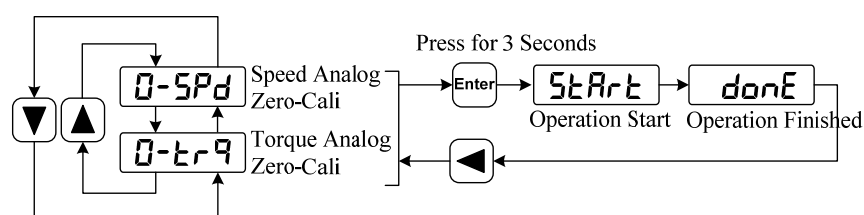
(1) Analog zero-calibration operation

Select the auxiliary function ' **A-AD** ' in the main menu and press Enter to enter the auxiliary function mode. Use the ▲, ▼ keys to select the operating mode. Press the Enter key after selecting the operation to enter the corresponding function. Press the ◀ key to return to the operation mode selection state.



When using this operation, the drive automatically detects the analog zero offset and writes the zero offset value to parameter P047. This operation has saved the zero offset parameter to the EEPROM, so there is no need to perform a parameter write operation.

The operation process is as follows: (1) The CNC device outputs the 0V analog command to the servo drive (G code: M3 S0), then user can select the analog zero-calibration menu ' **A-AD** ', press the Enter key to choose the operation; (2) If the drive control mode is analog speed mode, select the ' **0-SPd** ' menu; (3) Press the Enter key after selecting the operation and keep it for more than 3 seconds to activate the operation. After the operation done, press the ◀ key to return to the menu selection state, operation details are shown below:



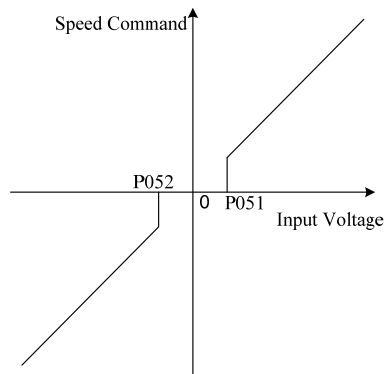
(2) Set parameter for analog dead zone

After the analog zero-calibration, user can compensate the analog zero-offset value. If the CNC device outputs zero-speed instruction, the spindle still rotates in a very low speed close to zero, in order to solve the above problems, it is necessary to set the analog dead zone parameter.

The parameters are described as follows:

P051	Analog Speed command Dead Zone 1	Parameter range	default Value	Unit
		0~13000	0	mv
P052	Analog Speed command Dead Zone 2	-13000~0	0	mv

If the input voltage is located between Dead Zone 2 (parameter P052) ~ Dead Zone 1 (parameter P051), the instruction is forced to 0.



By monitoring the $rE-9$ under the $d-rE$ menu, user can observe the analog command after zero offset compensation (indicated by voltage, unit: mv), and the dead zone parameter can be set according to the display value. For example, when the CNC device gives a zero speed command, the $rE-9$ display fluctuates within -50~50. You can set P051 to 60 and P052 to -60. When the analog voltage changes within -60mv~60mv, the drive speed command is forced to 0.

4、Performance optimization Tuning

4.1 Control Loop Gain parameters

The gain parameters for Speed mode and spindle orientation mode are as follows:

Parameter	Name	Default value	Unit	Parameter description
P005	Speed Loop Gain	50	Hz	To improve rigidity, the parameter value should be increased, but too large value will cause vibration and noise, the amount of each adjustment is 5
P006	Speed Loop Integration Time (Speed Mode)	30	ms	The larger the load inertia, the appropriate increase in the parameter value, but too large value will reduce the speed response rigidity, the amount of each adjustment is 5
P009	Position Loop Gain (Orientation Mode)	25	1/s	To improve the spindle rigidity in orientation mode, the parameter value should be increased, but too large value will cause vibration and noise, the amount of each adjustment is 5.
P007	Torque Command Filter Time	50	0.1ms	In order to eliminate the vibration and noise when the motor is running, the two parameter values should be increased appropriately, and the smaller the parameter value without obvious vibration and noise, the better, the amount of each adjustment is 10; <u>priority should be given to the adjustment of P019, in the case of the inability to completely eliminate the noise vibration, and then consider the adjustment of the P007</u>
P019	Speed Feedback Filter Time	100	0.1ms	

The gain parameters for position mode are as follows:

Parameter	Name	Default value	Unit	Parameter description
P010	Speed Loop Gain(Position Mode)	50	Hz	To improve rigidity, the parameter value should be increased, but too large value will cause vibration and noise, the amount of each adjustment is 5.
P011	Speed Loop Integration time (Position Mode)	30	ms	The larger the load inertia, the appropriate increase in the parameter value, but too large value will reduce the speed response rigidity, the amount of each adjustment is 5

P013	Position Loop Gain (Position Mode)	40	1/s	To improve the rigidity of the spindle in position mode, the parameter value should be increased, but too large value is easy to cause vibration and noise, the amount of each adjustment is 5.
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4.2 Performance optimization

① Gain parameter adjustment steps:

The choice of position and speed bandwidth must be determined by the rigidity of the machine and the application. The conveying mechanism connected by the belt is low in rigidity and can be set to a lower bandwidth (P009/P013: 10~40); The driven gearbox has medium mechanical rigidity and can be set to medium bandwidth (P009/P013: 30~50); the direct drive spindle or the electric spindle has high rigidity and can be set to high frequency width (P-009/P-013) > 50). If the mechanical properties are unknown, user can gradually increase the gain to increase the bandwidth until resonance, and then lower the gain.

In the servo gain, if one parameter is changed, other parameters also need to be readjusted. Please do not make large changes to only one parameter. For the steps to change the servo parameters, generally follow the following principles:

Improve response	Reduces response, suppresses vibration and overshoot
1. Increase the speed loop gain K_v (P005/P010), the amount of each adjustment is 5. 2. Reduce the speed loop integral time constant T_i (P006/P011), the amount of each adjustment is 5; 3. Increase position loop gain K_p (P009/P013) the amount of each adjustment is 5.	1. Reduce the position loop gain K_p (P009/P013), the amount of each adjustment is 5. 2. Increase the speed loop integral time constant T_i (P006/P011), each adjustment is 5; 3. Reduce the speed loop gain K_v (P005/P010), each adjustment is 5.

② Noise and resonance suppression methods:

If the control loop gain can't be set larger value because of the mechanical system resonance and other reasons, desired responsiveness can't achieve, user can increase the speed detection filter time appropriately (P019: per adjustment of 10). If there is no obvious effect, user can increase the torque low-pass filter time appropriately (P007: per adjustment of 10) to suppress resonance.

5、 Debug problems and processing method

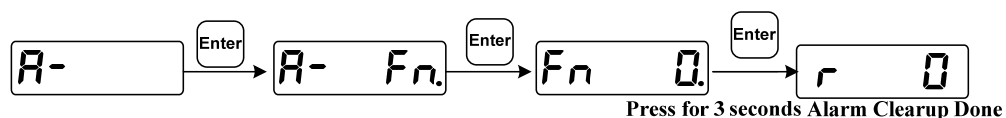
5.1 Alarm Code

Alarm Code	Alarm name	Alarm content	Alarm Clear
Err--	No alarm	Working normally	
Err 1	Speeding	Motor speed exceeds maximum limit	YES
Err 2	Power main circuit over voltage	Main circuit power supply voltage exceeds the specified maximum value	NO
Err 3	Power main circuit under voltage	Main circuit power supply voltage is lower than the specified minimum value	NO
Err 4	Position following-deviation too large	The value of the position deviation counter exceeds the set value	YES
Err 5	Position command over clocking	Position command frequency exceeds the highest frequency	YES
Err 6	Motor stall	The motor shaft is blocked, or the wiring is incorrect, or the pole pair setting is incorrect, or the encoder line number is set incorrectly.	YES
Err 8	Speed response failure	Excessive spindle load makes the speed deviation too large, or the pole pair setting is incorrect, or the encoder line number is set incorrectly.	YES
Err 9	Incremental encoder AB signal error	Motor encoder AB signal has interference or disconnection	NO
Err11	IPM module over current	Main power circuit IPM inverter module over current or over heat.	NO
Err12	Over current	Servo driver instantaneous current is too large.	NO
Err13	Over load	Motor average load current is too large	NO
Err14	Brake peak power overload	Brake instantaneous load is too large	NO
Err16	Motor thermal overload	Motor heating value exceeds the set value (I ² t detection)	NO
Err17	Brake average power overload	Brake long-term average load is too large	NO
Err18	Power module overload	Power module output average load is too large.	NO
Err20	EEPROM error	EEPROM read and write error	NO
Err21	Logic circuit error	Processor peripheral logic circuit error	NO
Err23	AD conversion reference voltage error	AD sampling circuit voltage reference is not a standard value	NO

Err24	AD conversion channel is asymmetrical or zero drift too large	AD sampling amplification conditioning circuit is abnormal.	NO
Err25	Motor code error	Motor code setting is not suitable	NO
Err29	User torque overload alarm	Motor load exceeds user-set value and duration	YES
Err30	Encoder Z signal loss	Encoder Z signal does not appear	NO
Err31	Encoder Z signal detection is abnormal	Encoder Z signal has interference or signal instability	NO
Err32	Encoder UVW signal illegal coding	The motor encoder UVW signal is missing, and the Z signal can be manually turned off to cancel the alarm.	YES
Err34	Spindle orientation failure	Spindle orientation function is running incorrectly	YES
Err35	Spindle encoder (second encoder) error	Spindle encoder AB polarity error	NO
Err36	Spindle encoder (second encoder) line is broken	Spindle encoder line is broken or there is interference	NO

5.2 Alarm Cleanup method

When the spindle drive has a fault alarm occurred, after troubleshooting the cause, in the case of continuous power, alarm removal can be achieved through the drive operating panel, the specific operation method is as follows:



Note: Some hardware failure alarms can't be cleared, as detailed in the section 5.1.

5.3 Frequently debug problems and countermeasures

① There is no display or power on the upper power Err-20

The panel is not displaying when power-on:

- Use multimeter to detect whether the power input AC380V is normal;
- The 3.7kw drive checks whether the braking resistance between P and BK terminals is well connected and whether the braking resistance is damaged;
- After the above reasons are excluded, it can be determined that the drive is damaged.

Err-20 present when power on: if the first power is not a fault phenomenon, there are two possible reasons: first, in the process of saving parameters, the drive unexpectedly power outage, this situation needs to perform the recovery of the default parameter operation **E-dEF**, power outage restart can eliminate this failure, the second is the drive memory chip damage, need to

repair and replace the storage chip.

② **The motor is rotating at a low fixed speed in uncontrolled state.**

Check that the motor power line UVW phase sequence is correct.

③ **ERR-6/ERR-8/ERR-12 failure alarm during power-on or runtime**

Firstly check whether the spindle drive and motor wiring is correct, and then determine whether there is plugging phenomenon in the motor shaft or the mechanical resistance of the motor shaft is too large, and then check whether the customer code P096 or motor code P002 is set correctly;

Then check whether the encoder signal cable is reliable connection or whether there is a problem with the encoder cable, the encoder cable may appear disconnected, the shielding layer is not well grounded at both ends, the joint appears water or impurities and other faults.

④ **The motor rotates not smoothly, oscillating and so on phenomenon**

Check that the customer code P096 and the motor code P002 are set correctly, check that the motor power cord connection is reliable or not, and that the UVW phase sequence is correct, and check that the encoder cable is connected reliably.

⑤ **The drive appears Err-2 or Err-11 alarm**

Alarm happens when the drive is on power, or large inertia, frequent acceleration and deceleration.:

- If the alarm appears when power on, it can be determined that the hardware circuit of the drive is faulty;
- If the alarm appears when the motor braking from a high speed to a low speed, firstly user can check he monitoring menu '**d- I**' and '**d-P I**', to see whether the instantaneous value and maximum value of the current is beyond the spindle drive allowable range, if out of range, the corresponding reduction of inertia acceleration (that is, increasing acceleration time P060 and deceleration time P061). Keep the current within the spindle drive and motor allowable range to see if the failure disappears.

⑥ **Noise or vibration in motor operation (high frequency)**

- a, the first appropriate adjustment of the filter coefficient of P019, and then adjust the filter coefficient P007, the amount of each adjustment is 5;
- b, if the effect of the larger filter coefficient is not obvious, it is necessary to reduce the speed loop proportional gain and position loop proportional gain, that is, reduce P005/P010 and P009/P013, the amount of each adjustment is 5;
- c, if there is no significant improvement in the above measures, please check the encoder cable interference, check whether the shielding layer is well grounded at both ends.

⑦ **Jitter (Low frequency) in motor operation**

- a, check whether the servo motor with the load and inertia within the allowable range of the motor, if the load and inertia beyond the motor rated multiples too much (load torque greater than twice times, inertia greater than 5 times), please re-select a larger size motor;

- b, appropriate adjustment of the speed loop proportional gain P005/P010, the amount of each adjustment is 5;
 - c, if the effect of larger P005/P010 is not obvious, user can reduce the filter coefficient P007/P019 appropriately, the amount of each adjustment is 5;
 - d, if the effect of smaller filter coefficient is not obvious, user can reduce position loop gain P009/P013, the amount of each adjustment is 5;
 - e, if there is no significant improvement in the above measures, please check the encoder cable and instruction cable, check whether the shielding layer is well grounded at both ends.
- ⑧ **The motor shaft is not rigid enough or crawls during low speed operation (walk and stop)**
- In speed mode, the above phenomenon occurs, increase the parameter P005 (10 per adjustment);
 - The above behavior occurs in position mode (c axis), increase the parameter P010 (10 per adjustment).

6、 Drive specifications and motor adapter table

6.1 Model Specifications and Performance parameters

Table 6.1 Drive Model specifications

Model: S3a		S3a-H37	S3a-H55	S3a-H75	S3a-H150	S3a-H220	S3a-H370
Input power supply		Three phase AC380V (85%~110%) 50 Hz/60Hz±1Hz					
Maximum output current root mean square value (A)		20	30	42	60	84	113
Rated power of the standard motor (kW)		3.7	5.5	7.5	15	22	37
Basic Specifications	Main Circuit Mode	Three-phase full-wave rectifier, IPM svpwm inverter bridge					
	Feedback Encoder	Incremental photoelectric encoders, rotary transformers, sine/cosine encoders					
	Control Mode	Manual Mode, JOG, Speed Mode, Position Mode, Speed/Position Mode.					
Speed Control Mode	Performance	Speed Range	1~30000r/min Maximum output frequency 1kHz (Speed closed-loop control)				
		Adjusting speed ratio	1:30000 Constant power speed regulation range > 4:1 (corresponding to the standard motor speed range 1500r/min~6000r/min)				
		Steady speed accuracy	When the load change rate is 0 to 100%, the speed change rate < (rated speed x 0.1%)				
	Speed Command Input	Voltage Range	1 DC 0~10V + forward and reverse signal + enable signal; 2 DC-10V~-+10V + enable signal;				
		Pulse Speed Mode	1: pulse + direction; 2: CCW pulse / CW pulse; 3: A / B two-phase orthogonal pulse;				
		Speed Command Electronic Gear Function	Speed Command Multiplication Coefficient: -32767~32767; Speed Command Frequency Division Coefficient: 1~32767;				
Position Control Mode	Position Command PulseType	① pulse + direction; ② CCW pulse/CW pulse; ③ A/B two-phase orthogonal pulse;					
	Position Command Electronic Gear Function	Position Position	Command Command	Multiplication Coefficient : 1~32767; Frequency Division Coefficient: 1~32767;			

Input and Output Signals	Position Feedback Signal Output	Motor encoder or spindle encoder signal 1:1 output, A/B/Z differential signal, line driver output
	Status Signal Output	Spindle ready, zero speed output, position/speed arrival, alarm output, orientation completion, and etc.
	Control Signal Input	Spindle enable, CCW forward signal, CW reverse signal, alarm clear, spindle orientation, speed/position mode switching, and etc.
Basic Function	Regenerative Energy Processing Function	Drive built-in regenerative energy processing circuit and external regenerative braking resistor
	Operation Function	4 buttons, selectable status display, parameter setting, parameter management, auxiliary function operation, and etc.
	Monitoring Function	5-digit LED digital tube, which can display speed, torque, speed command, feedback position, position deviation, load current, output voltage, IO status, control mode, command pulse frequency, alarm code, and etc.
	Protection Features	Overvoltage, under voltage, over current, overload, over speed, position error, orientation alarm, position error alarm, brake abnormality, encoder abnormality, and etc.
	Internal Speed Command Function	Can choose internal preset multi-speed command
	Spindle Orientation Function	Support high-speed operation, direct orientation , orientation direction and position can be flexibly set
	Rigid Tapping Function	Can participate in the interpolation control of the coordinate axis to complete functions such as rigid tapping and thread cutting
	Feed Servo Function	Optimized control algorithms enable the spindle to have all the functions of the servo axis

6.2 Spindle Motor Adapter Table

Table 6.2 MiGE spindle motor model code table

Motor Code (P-002)	Suitable Drive Models	Spindle Motor Models	Rated Power (kW)	Rated Current (A)	Rated Torque (Nm)	Rated speed/Max Speed (r/min)	Overload Multi ples
0	S3-H37F (20A 3.7kW) (380V)	MY165-070C	1.1	2.6	7.0	1500/8000	2
1		MY165-096C	1.5	3.4	9.6	1500/8000	2
2		MY165-140C	2.2	4.9	14.0	1500/8000	2
3		MY165-235C	3.7	7.8	23.5	1500/8000	2
6		MY204-235C	3.7	9.1	23.5	1500/8000	2
7		MY204-350C	5.5	13.0	35.0	1500/8000	1.6
10	S3-H55F (30A 5.5kW) (380V)	MY204-235C	3.7	9.1	23.5	1500/8000	2
11		MY204-350C	5.5	13.0	35.0	1500/8000	2
12		MY204-478C	7.5	17.8	47.8	1500/8000	1.7
13	S3-H75F (42A 7.5kW) (380V)	MY204-235C	3.7	9.1	23.5	1500/8000	4
14		MY204-350C	5.5	13.0	35.0	1500/8000	3
15		MY204-478C	7.5	17.8	47.8	1500/8000	2
16		MY204-605C	9.5	23.8	60.5	1500/8000	1.7
17		MY265-700C	11	21.5	70	1500/8000	2
19	S3-H150F (60A 15kW) (380V)	MY204-605C	9.5	23.8	60.5	1500/8000	2
20		MY265-700C	11	21.5	70	1500/8000	2
21		MY265-960C	15	29.0	96	1500/8000	2
22		MY265-A18C	18.5	35.2	118	1500/8000	1.6
23	S3-H220F (84A 22kW) (380V)	MY265-A18C	18.5	35.2	118	1500/8000	2
24		MY265-A40C	22	42.3	140	1500/8000	2

Note: The spindle motors listed in the above table are normally assembled with 2500-wire photoelectric encoder. If the encoder is 1024-wire photoelectric encoder, user needs to perform the recovery of the default parameters (see 3.1 section, 'E-dEF' operation) and then manually set the parameter P082 to 1024, if for other types of encoders please consult our customer service.