NT-100

Capacitive Height Controller User Manual

V1.3

PREFACE

Thank you for choosing our product!

This manual introduces the use of NT-100 Independent Capacitive Height Controller in detail, including system characteristics, operation, installation instructions and so on.

Please read this manual carefully before using this controller and related equipment. This will help you use it better.

We apologize for the fact that the products you receive may differ in some respects from what is stated in this manual due to the continual updating of product functions.

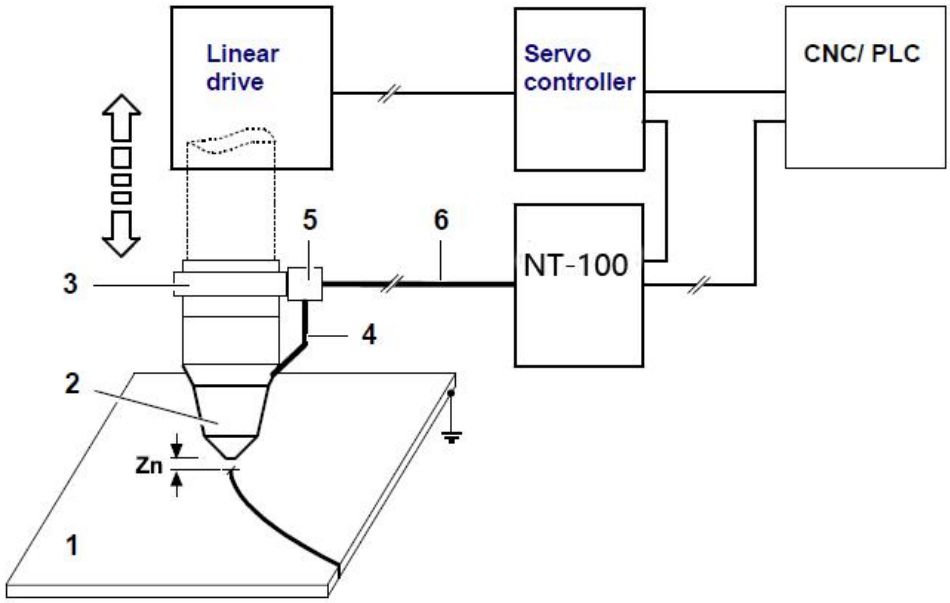
Chapter 1. Product introduction

1.1 Brief Introduction

NT-100 Capacitive Height Controller (hereinafter referred to as NT-100). In the process of laser cutting, the distance between the nozzle and the surface of the workpiece is not constant because of the uneven workpiece and cutting high pressure gas injection, which will have a negative effect on the cutting performance or even crashing nozzle. NT-100 Height Controller can keep the distance between nozzle and workpiece constant when cutting in high speed, protect nozzle from colliding with workpiece, and improve cutting effect greatly. The capacitance sensor on the cutting head can detect

the distance between the nozzle and the workpiece surface, send the signal through preamplifier to the adjustment box for processing, and send output signal to the servo controller to control the Z axis.

The NT-100 height adjusting box can be used as a controller to output the control voltage or as a distance measurement system to output the distance signal. This depends on the selected mode, sensor control mode or distance measurement system mode.



1-1 System Wiring Diagram

1 Workpiece
2 Sensor
3 Cutting head
4 Electrode cable
5 Preamplifier
6 Sensor cable

1.2 Function Specification

- Capacitance sampling rate: 1,000 times per second.
- Static measurement accuracy: 0.001mm.
- Height measurement range: 0 ~ 25mm.

- The signal will not decay with strong capacity of resisting when the length of signal transmission cable is up to 100m.
- Support network communications and U disk online upgrade.
- Support the jitter suppression function; can effectively suppress the jitter caused by blowing air and dross, etc.
- Adapt to any cutting head and nozzle; capacitance parameter adaptive.
- Support panel collision alarm, nozzle electrode lost detection alarm, sensor wire breakage alarm.
- Support one point, two point and sixteen point capacitance calibration, support displaying the calibrated curve.
- Support real-time capacitance calibration, can effectively solve the influence of temperature and other factors on capacitance sensor.
- The 16 bit DA output, the output voltage (±10 V) signal in the sensor control mode, or the linear height signal of the signal output voltage (0-10 V) in the distance measurement mode, have an update cycle of 1000 times per second.
- The 14 bit AD input detects the external analog voltage signal (0V-10V) and adjusts the stationary distance in real time.
- Support oscilloscope function, can detect the capacitance and height changes in real time.
- Support oscilloscope function, can detect AD changes in real time.
- Support EtherCAT bus communication.

Chapter 2. Wiring Instruction

2.1 System Composition

The capacitive control system is composed of NT-100 controller, preamplifier, laser cutting head, cable and so on as shown below.

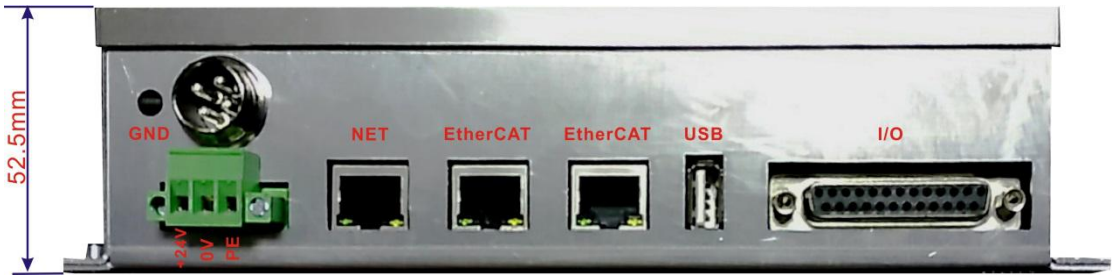
Accessories	Quantity	Standard Configuration	Optional Configuration
Height Controller Host	1	NT-100	
Preamplifier	1	CHC_AMP	
Radio-frequency Cable	1	SPC-140(140mm)	SPC-180(180mm)
Sensor Cable	1	STC-10 (10m)	STC-15 (15m)
Plug	1	DB25 (M)	
Manual	1		

2.2 Installation Dimension

2.2.1 Master Controller

The Master Controller boundary dimension as shown in the below figure.

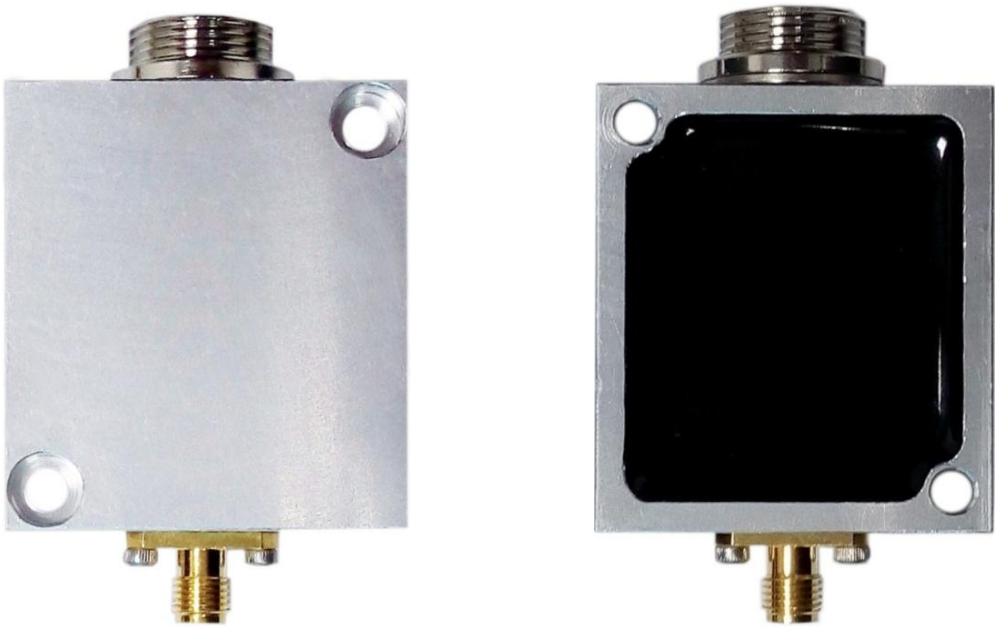
Front view



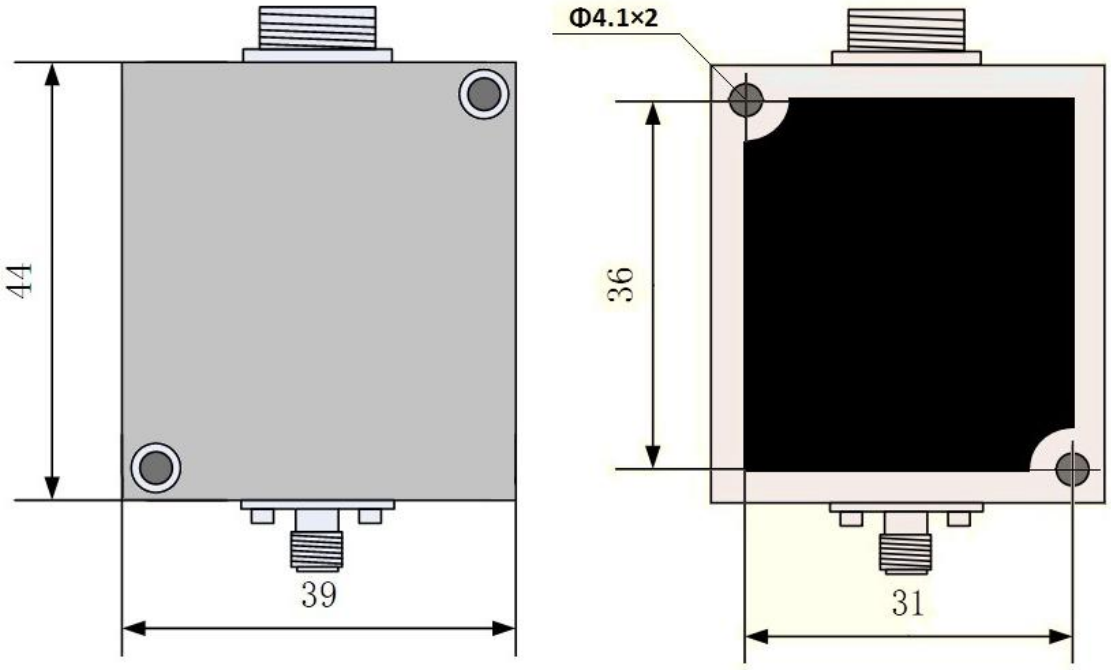
Side view

2.2.2 Preamplifier

The appearance and dimensions of the preamplifier are shown in the figure below.



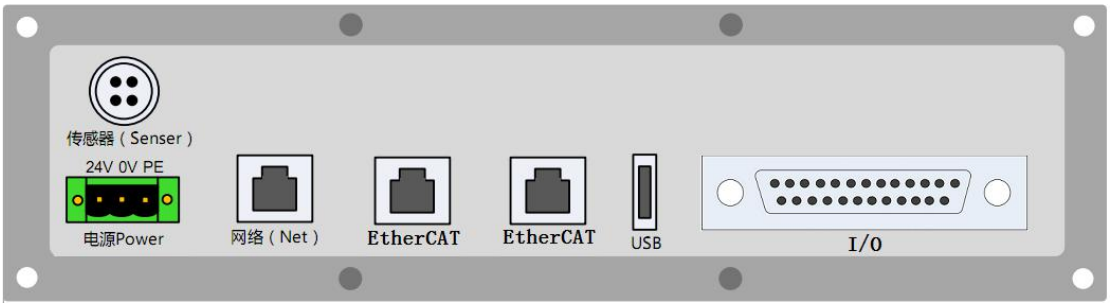
Appearance



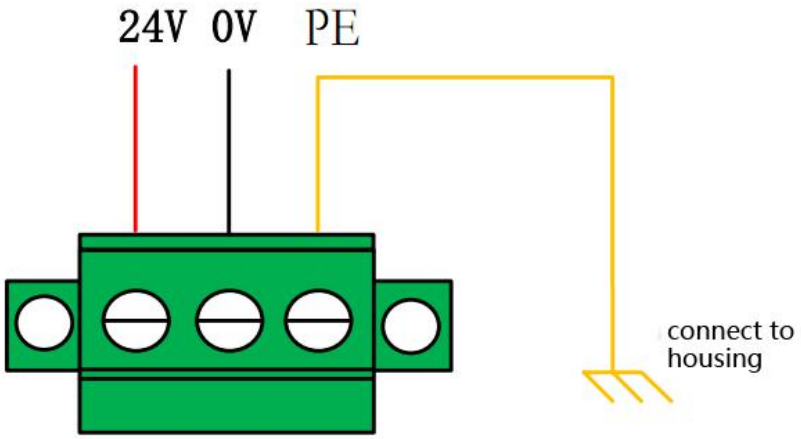
Installation dimension

2.3 Interface Specification

2.3.1 Interface Layout

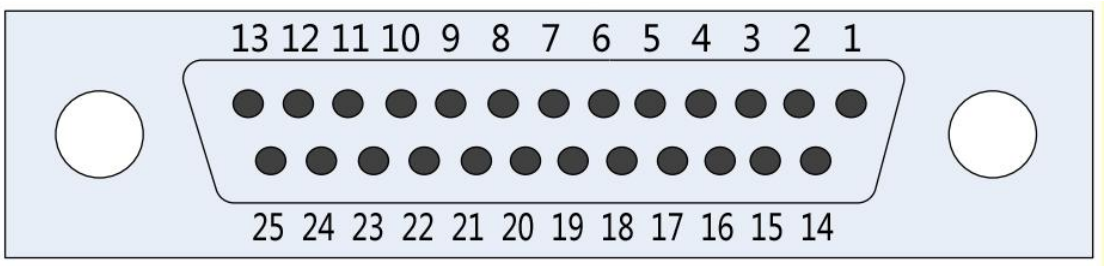


2.3.2 Power Supply Interface



The housing of the machine is the negative pole of the measured capacitance. In order to ensure the stable operation of the measuring circuit, The "PE pin" of the power supply interface must be reliably connected to the machine housing (that is, with the machine housing well on), and the preamplifier housing must also be well connected to the machine housing. The specific index is that the DC impedance is always less than 10 ohms, otherwise the actual follow effect may not be good.

2.3.3 Input / Output Interface



25 core head (pin) input and output interface

Pin	Signal Definition	Pin	Signal Definition
1	24V (Power Input)	14	0V (Power Ground)
2	OUT1(Signal Output)	15	IN1 (Signal Input)
3	OUT2(Signal Output)	16	IN2 (Signal Input)
4	OUT3(Signal Output)	17	IN3 (Signal Input)
5	OUT4(Signal Output)	18	IN4 (Signal Input)
6	OUT5 (Signal Output)	19	IN5 (Signal Input)
7	OUT6 (Signal Output)	20	IN6 (Signal Input)
8	(Reserved Interface)	21	IN7 (Signal Input)
9	(Reserved Interface)	22	IN8 (Signal Input)
10	CAN-H (CAN Bus Communication Interface)	23	CAN-L (CAN Bus Communication Interface)
11	AD+ (0-10V Positive Input Interface)	24	AD- (0-10V Negative Output Interface)
12	DA+ (±10V Positive Input Interface)	25	DA- (±10V Negative Output Interface)
13	0V (Power Ground)		

	Interface	Definition	I/O	Signal	Voltage	Note
Digital Quantity	**IN1**	**A3**	I	CAL.REQUEST/ SET RANGE/ SET RANGE		Reference point calibration; Two point calibration, 100%MBEW; 1 point calibration, 100%MBEW; Calibration start signal
	IN2	**A4**	I	SELECT CHAR.BIT0		Two point calibration 10%MBEW; Selective calibration characteristic curve
	IN3	**A5**		SELECT CHAR.BIT1		
	IN4	**A6**		SELECT CHAR.BIT2		
	IN5	**A7**		STROBE		Calibration signal (Teach mode)
	IN6	**A8**	I	Zn1-4 BIT0		Common operation mode; Selection interval (Zn1-4)
	IN7	**A9**		Zn1-4 BIT1		
	IN8	**B1**	I	CHECK		Real-time calibration signal
	OUT1	**A10**	O	FAR		Indicator sensor is outside the range of measurement
	OUT2	**A11**	O	COLLISION (+NOZZLE LOST)		Meaning depends on A14 & A15 as table below
	OUT3	**A12**	O	CABLE CUT		Indication sensor break
	OUT4	**A13**	O	READY		Height adjusting box is ready
	OUT5	**A14**	O	BODY TOUCH		Sensor and workpiece short circuit
	OUT6	**A15**	O	POS.REACHED/ NOZZLE LOST		Reaching the setting point or calibration complete; Nozzle electrode lost
Analog	**AD+**	**A16**	A	EXT.NOZZLE(+)	0-10V	Distance between nozzle and workpiece 0.3V-9.7V, Outer Interval (3%-97%MBEW)
	AD-	**A17**		EXT.NOZZLE(-)		
	DA-	**A18**		GND	±10V	Control voltage

	DA+	**A19**	A	OUT	0-10V	Linear distance

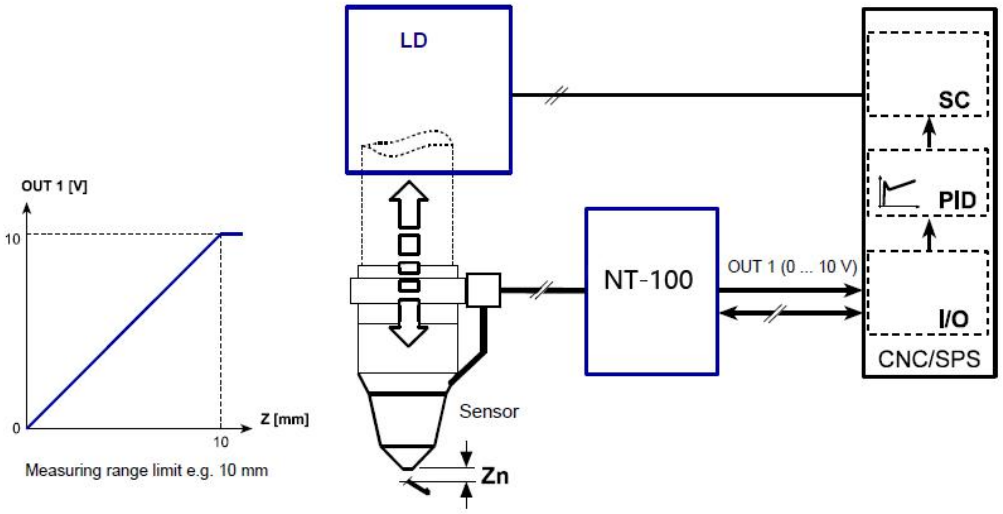
Error	Output			Note
	A11	A14	A15	
TIP TOUCH	High	---	---	Sensor and workpiece short circuit
BODY TOUCH	High	High	---	Sensor body and workpiece short circuit
NOZZLE LOST	High	---	High	Nozzle electrode lost

2.3.5 Sensor Interface

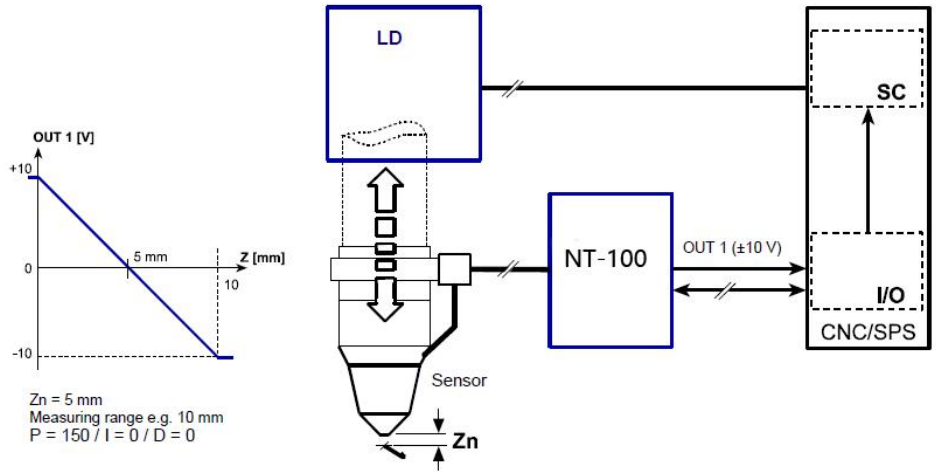
1:Connect with pin 1 of the cable
2:Connect with pin 2 of the cable
3:Connect with pin 3 of the cable
4:Connect with shield of the cable

4-core sensor signal transmission cable can be made by 3-core shielded cable and 2 pcs of 4-core aviation plugs.Core 1, 2, 3 should be connected to corresponding core, core 4 should be connected to shielded.

2.3.4 Application Case



Control box as distance measuring system; Measuring range: 10mm; Output voltage: OUT = 0-10V。

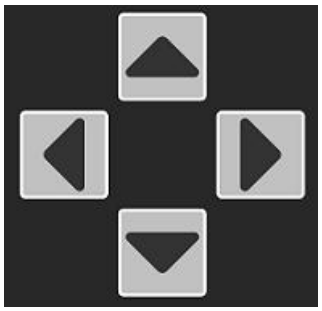


Control box as controller; Measuring range: 10mm; Zn=5mm; Proportional control, P=150、I=0、D=0.

Range from -5mm to 5mm, corresponding output voltage -10V to 10V

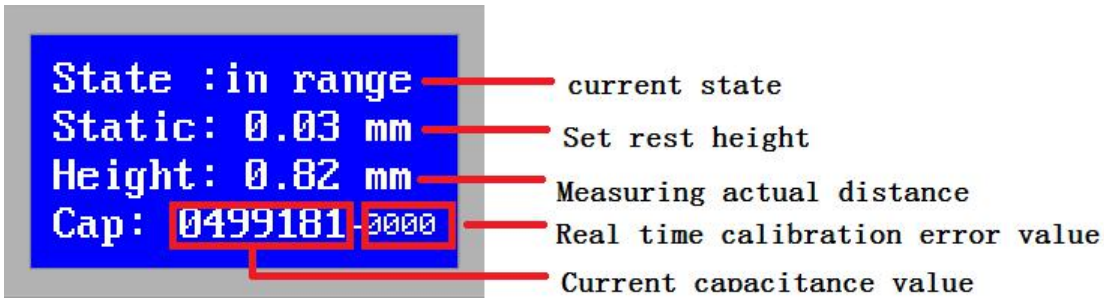
Chapter 3. Operating Instruction

3.1 Button Instruction

Shortcut Button	 : For selection of main menu
Direction Button	 : Adjust the selection items. And the increase decrease of the data
Control Button	 : "ENTER" confirm current operation; "ESC" exit current operation

3.2 Main Interface

After electrified initialization, system enter "Main Interface" automatically. As shown below:



The display features on the main interface include:

State:

Displaying the state of the current control box. There are several states:

A. **Nozzle collision:** Sensor and workpiece short circuit

B. **In range:** Measuring distance of sensor is within effective measuring range.

C. **Beyond measuring range:** Measuring distance of sensor exceeds effective measuring range.

Static:

Displaying static distance of system. Static distance is acquired by control box measuring input signal of (A16 - A17). This data is only valid in sensor control mode.

Height:

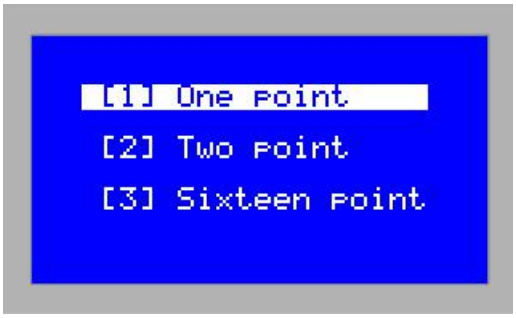
In capacitive measuring range, displaying distance between cutting head and plate surface.

Cap:

The principle of system sampling is to measure the capacitance between the cutting head and the plate to get the distance. The closer the cutting head is to the plate, the greater the capacitance. When the cutting head touches the plate, the capacitance changes to 0.

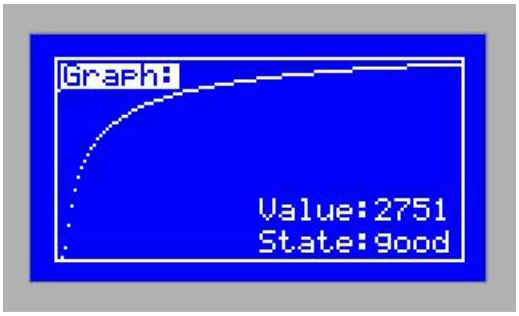
3.3 Calibration Interface

In the main interface, press "F1" button to enter the "Manual Calibration Interface". As shown below:



Before the first time of using NT-100, capacitance calibration must be done first. In subsequent use, if the capacitance changes due to temperature drift and other reasons, it is only necessary to calibrate the capacitance. It is recommended to use sixteen point calibration.

During manual calibration, follow the instructions on the interface to move the cutting head to the corresponding height from the plate. In the calibration process, the user can press the "ESC" button to end the calibration.



When the calibration is finished, there are two indexes, the first is to show the range of capacitance after calibration, the second is the state of this calibration: “excellent”, “good” or “bad”.

The floating head calibration process consists of the following steps:

(1).Operate the floating head move down slowly to detect touching plate.

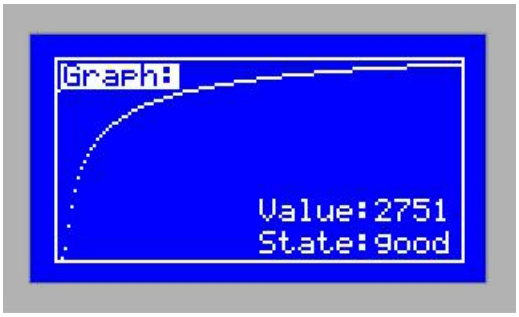
(2).After touching plate, move the floating head up, operate according to the distance of calibrated point indicated on the screen. Press “ENTER” button to enter the next operation, or press “ESC” to end the calibration.

The meaning of the calibration results is as follows:

Stability: reflecting the static characteristics of the capacitance. If this calibrated index is not ideal, it may due to plate vibration or strong external disturbance. Meanwhile it reflects dynamic characteristics of capacitance change in calibration process. The ideal condition for this index is "excellent" or "good".

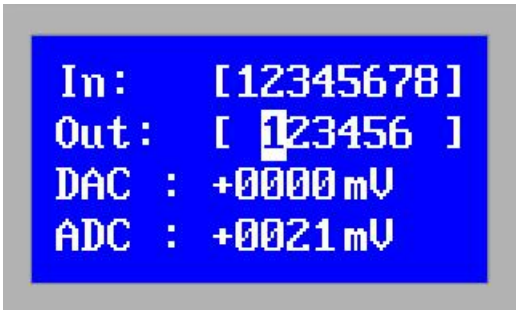
Effective value: Conversion value of capacitance from 0.5mm to the plate to infinity. It reflects measuring range of nozzle sensor. The larger the measuring range, the better the tracking accuracy and stability. Press “ENTER” to save calibration value.

Display height - capacitance graph. The normal graph should be smooth, as shown below:



3.4 Test Interface

In the main interface, Press “F2” Button to enter “Test Interface”. As shown below:



Direction Button Left & Right are used to select the object to operate on. Direction Button Up & Down are used to change the status value of operation object.

3.5 Parameter Interface

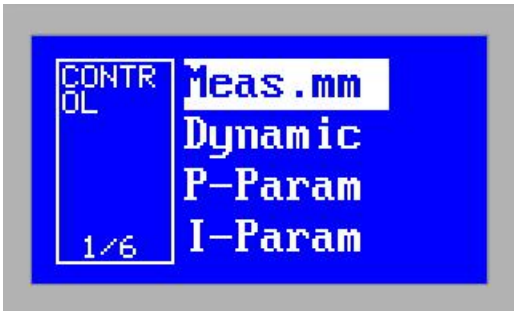
In the main interface, Press "F3" Button to enter "Parameter Interface". As shown below:

When using NT-100 for the first time, the user must set the above parameters correctly. The control parameters must be set correctly or the system will not work properly.

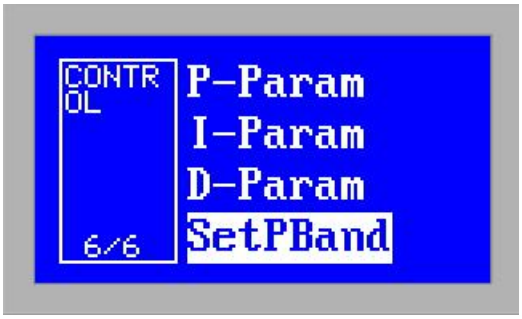
3.5.1Control Parameter

Press "Up" or "Down" to select the target menu item and press "ENTER" to enter the "Control Parameter Interface".

Page 1 is shown below:



Page 2 is shown below:



The meaning of each parameter is shown in the following table:

Parameter	Meaning
Meas. mm	Setting the maximum measuring rang; the default range is 10mm; user can select range of 10mm, 15mm, 20mm, 25mm.
Dynamic	Setting the dynamic response of the system, unit is mV/ms; the larger parameter, the faster the response. This parameter is valid only in sensor mode (control mode).
P-Param	Setting the PID parameters of the system. This parameter is valid only in sensor mode (control mode).
I-Param	Setting the PID parameters of the system. This parameter is valid only in sensor mode (control mode).
D-Param	Setting the PID parameters of the system. This parameter is valid only in sensor mode (control mode).

3.5.2 Senior Parameter

Press “Up” or “Down” to select the target menu item and press “ENTER” to enter the “Senior Parameter Interface”. As shown below:

The meaning of each parameter is shown in the following table:

3.5.3 Restoration Parameter

Parameter	Meaning
Cap Filter	Real-time suppression of environmental interference to capacitance value by software processing
Real-time Ca	When the real-time calibration function is on, the height controller automatically calibrates the body capacitance of the cutting head after each machining to reduce the number of manual calibration of the height controller. When using this function, make sure that the cutting head at the docking point is above the plate 30mm to trigger the IN8 input signal, and that the signal should remain above 100ms.
Vibration Su	When the vibration suppression function is on, this function can suppress the vibration caused by cutting the plate with less rigid structure and reduce the cross section wave ripple.
Vibration Ti	This parameter is the intensity of the vibration suppression function, and the larger the value, the more obvious the effect of the vibration suppression function. But it will reduce the response of the height controller. The default value is 20 ms, and the recommended range is 5 ~ 50 ms.

Press "Up" or "Down" to select the target menu item and press "ENTER" to enter the "Alarm Parameter Interface". As shown below:

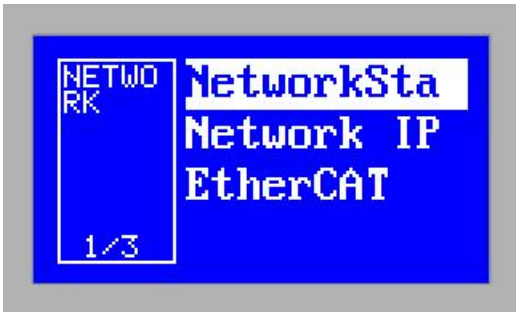
The meaning of each parameter is shown in the following table:

Parameter	Meaning
TT Level	Set a threshold for collision prevention. If the position reaches the threshold range, the "TIP TOUCH" signal will be set. Setting range: 0.00-1.00mm

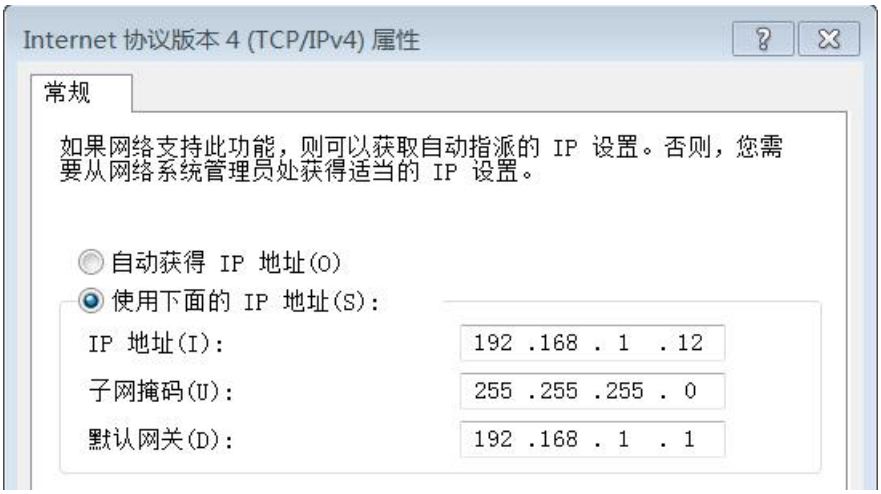
Col Delay	The parameters can delay the output of “TIP TOUCH” or “COLLISION”(A11 pin) signal, filter the short pulse interference, and improve the stability of the system. Only if the interference or touch of the workpiece is longer than the delay time will the signal be sent to the CNC / PLC. If the evasive action of the driver is fast enough or the interference pulse is very short, then the “TIP TOUCH” signal will not be triggered and the stability of the system will be improved. Setting range: 0-1000ms
Nozz Lost	When the electrode loss function is to, the copper nozzle electrode is detected. When the copper nozzle is beyond the surface of 30mm, the signal output is obtained from the “NOZZLE LOST” (A15 pin).
SmallerCap	When the system detects that the body capacitance is smaller than a certain range, the alarm will be generated. Set the threshold for generating "body capacitance small alarm", when the real-time calibration is turned on, the threshold value will be added to the later capacitance compensation value, which can reduce the triggering frequency of the alarm.

3.5.4 Network Parameter

Press “Up” or “Down” to select the target menu item and press “ENTER” to enter the “Network Parameter Interface”. As shown below:



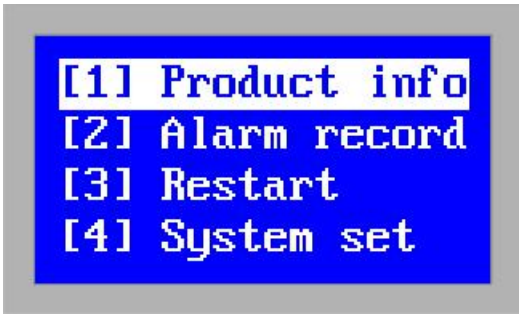
When connecting to a network, it is recommended that the PC and NT-100 be connected by the network cable. The IP address on the PC side should be set in the same segment as the NT-100 (192.168.1.xxx, not duplicated with NT-100). The gateway also needs to be set on that segment, and the last number is 1, such as 192.168.1.1. As shown below:



Note: after resetting IP of the network card of the computer, network card must be banned-enable again. Make sure the IP settings of the network card to take effect.

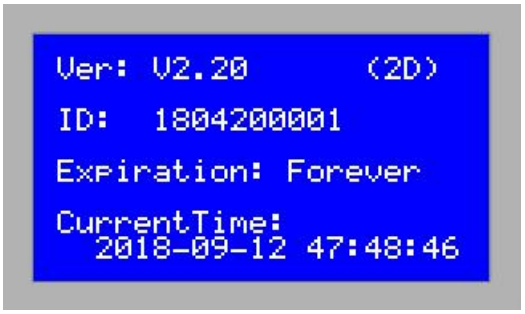
3.6 Senior Parameter

In the main interface, Press "F4" Button to enter "Senior Interface". As shown below:



3.6.1 Version Information

Press "Up" or "Down" to select the target menu item and press "ENTER" to enter the "Version Information Interface". As shown below:



The user can view in this interface:

Information	Meaning
Ver	NT-100 program version number, such as V2.01. (Plate) for plate cutting applications. (Three-dimensional) for three-dimensional robotic arm cutting applications.
ID	Global unique serial number of NT-100, such as 1804200001
Expiration	Expiry date of using NT-100 service
Current Time	Current internal date of NT-100

Note:

When the NT-100 service expires, the main interface displays alert information (authorization expires), and main functions will not be available. Users can press "F1" in this interface, to enter the registration interface, then enter the correct registration code to return to normal use.

3.6.2 Alarm Information

Press "Up" or "Down" to select the target menu item and press "ENTER" to enter the "Alarm Information Interface".

In this interface, the alarm events that occurred earlier will be displayed in a list.The system records up to 20 recent alarm events. Pressing "F1" can clear the alarm list. When multiple alarms are generated at the same time, the main interface will display multiple alarms in a scroll form. The specific meaning of alarms, refer to the alarm explanation table.

3.6.3 Reboot

Press "Up" or "Down" to select the target menu item and press "ENTER" to enter the "Reboot". This operation can restart the NT-100 controller, it is equivalent to power off and power on again.

3.6.4 System Setting

Press “Up” or “Down” to select the target menu item and press “ENTER” to enter the “System Setting Interface”. As shown below:

The user can view in this interface:

Information	Meaning
SensCon	Control: sensor working mode, output ±10V Distance: distance measuring system, output 0V --10V
Scene	0：Plate cutting application 1：Three dimensional cutting application
Language	0：Chinese 1：English
Control	0：I/O Control 1： EtherCAT Bus communication control

Chapter 4. Alarm Instruction

4.1 Warning Instructions and Possible Causes

Alarm	Instruction	Possible Cause
Capacitance Zero	When the system fails to measure the capacitance correctly, the capacitance value becomes 0.	➢ The cutting head touches the plate. ➢ Water enter into the cutting head. ➢ The body capacitance of the cutting head is too large and exceeds the detection range. ➢ Amplifier damage. ➢ Bad connection of amplifier / cutting head. ➢ Inside of cutting head, short circuit of positive pole (nozzle) and negative pole (housing) of

		inductive capacitance.
Body capacitance reduced	The alarm is generated when the system detects that the body capacitance is smaller than a certain range.	➢ The alarm can also be caused by the replacement of parts, or by re-connections, or by random changes in the characteristics of their own analog components. User only need to re-calibrate. ➢ The laser scattering onto the nozzle causes the temperature of the nozzle to rise sharply, resulting in temperature drift. ➢ The gap between the positive pole (nozzle) and negative pole (cutting head housing) is changed by gas blowing. ➢ Bad connection of amplifier / cutting head. ➢ Calibration distance setting is too small (three dimension less than 10mm， two dimension less than 15mm)，it is also possible to cause the alarm of body capacitance becoming small. ➢ For plasma cloud impact capacitance amplifier, during cutting of stainless steel plate, especially coated stainless steel plate, do not set the follow height below 0.5mm, increase the follow height properly, increase the gas blowing pressure properly.
Capacitance Abnormal Increase	The alarm is generated when the system detects that the capacitance exceeds the calibrated maximum capacitance or the set touching plate capacitance.	➢ The cutting head touches the plate. ➢ Water enter into the cutting head. ➢ The laser scattering onto the nozzle causes the temperature of the nozzle to rise sharply, resulting in temperature drift.。 ➢ The gap between the positive pole (nozzle) and negative pole (cutting head housing) is changed by gas blowing.
Authorization Expiry	System setup service time is up.	Please contact the supplier to solve the problem.
Capacitance	Capacitance changes or	User only need to re-calibrate capacitance.

Calibration	system parameters have been modified.	

Chapter 5. Debugging Specification

5.1 Manual Reference Point (sixteen point) Calibration

1、Change or confirm measurement range limits (Maximum 25mm).

2、In the main interface, press “F1” to enter “Calibration” interface, then enter “sixteen point Calibration” menu.

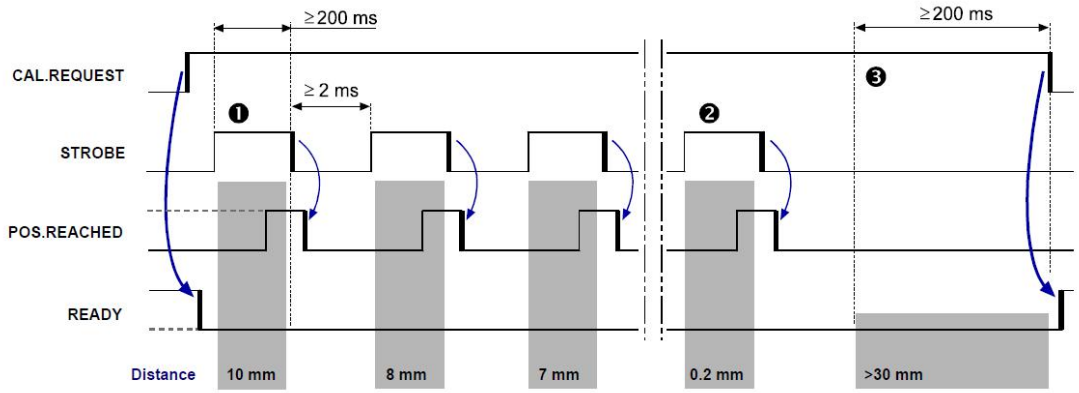
3、Start calibration, move the cutting head to the first point, and press “Enter” to confirm.

4、Move in turn and confirm the remaining fifteen points.

5、Confirm or cancel to exit; calibration ends.

5.2 Automatic Reference Point (sixteen point) Calibration

Automatic calibration control sequence diagram is as below:



1、Change or confirm measurement range limits (Maximum 25mm).

2、Set CAL.REQUEST signal (PIN A3, High).

3、Move the sensor to the workpiece until the COLLISION signal is set (PIN A11, High), that is , touching the workpiece and finding the zero point needed for calibration.

4、 Move to the first reference point (measurement range limit).

5、 Set STROBE signal (PIN A7, High); confirm that the reference point has been reached.

6、 Before POS.REACHED signal is read, STROBE must be maintained above 200ms. POS.REACHED (PIN A15, High) signal confirmed measuring value is received by CNC/PLC.

7、 Handle the remaining fifteen reference points separately.

For example:

Reference Point	Measuring Range 10mm	Measuring Range 15mm	Measuring Range 20mm	Measuring Range 25mm
Reference point 1	10.00mm	15.00mm	20.00mm	25.00mm
Reference point 2	8.00mm	12.00mm	16.00mm	20.00mm
Reference point 3	7.00mm	10.50mm	14.00mm	17.50mm
Reference point 4	6.00mm	9.00mm	12.00mm	15.00mm
Reference point 5	5.00mm	7.50mm	10.00mm	12.50mm
Reference point 6	4.00mm	6.00mm	8.00mm	10.00mm
Reference point 7	3.00mm	4.50mm	6.00mm	7.50mm
Reference point 8	2.50mm	3.75mm	5.00mm	6.25mm
Reference point 9	2.00mm	3.00mm	4.00mm	5.00mm
Reference point 10	1.80mm	2.70mm	3.60mm	4.50mm
Reference point 11	1.50mm	2.25mm	3.00mm	3.75mm
Reference point 12	1.20mm	1.80mm	2.40mm	3.00mm
Reference point 13	1.00mm	1.50mm	2.00mm	2.50mm
Reference point 14	0.70mm	1.05mm	1.40mm	1.75mm
Reference point 15	0.50mm	0.75mm	1.00mm	1.25mm
Reference point 16	0.20mm	0.30mm	0.40mm	0.50mm
Nozzle Lost	>30.00mm	>30.00mm	>30.00mm	>30.00mm

Nozzle lost detection function “NOZZLE LOST”

The following steps are mandatory, otherwise the entire calibration process will not be valid.

1、Set CAL.REQUEST signal (PIN A3, High）.

2、Move the sensor away from the workpiece, the distance should be longer than 30mm.

3、Maintain the entire position at least 200ms to calibrate the NOZZLE LOST.

4、Reset CAL.REQUEST signal (PIN A3, Low).

If an error occurs during the calibration of the reference point, COLLISION (PIN A11, High) signal will be set.

If calibration fails, repeat the above steps.

5.3 Adjusting System and Controlling Parameters to Optimize PID

Parameters

1、Set the current static distance to (1mm).

2、Set the default PID parameter, P=20, I=0, D=0.

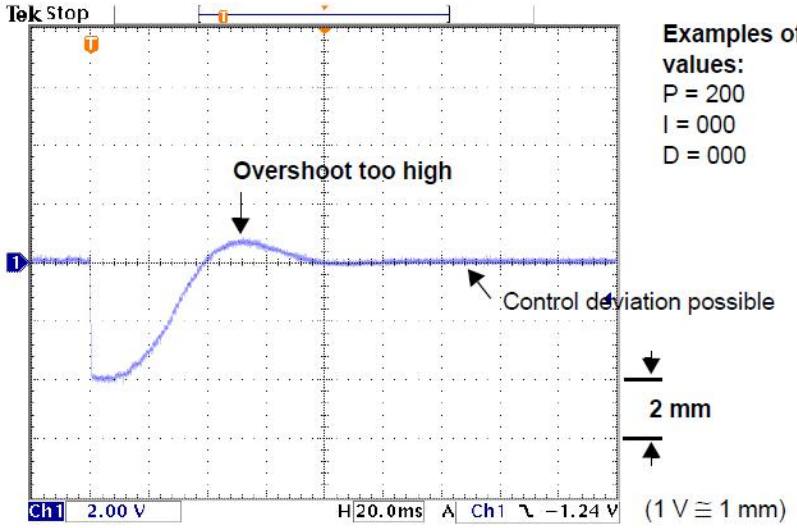
3、Switch the system to automation.

4、Monitor A19 signal on oscilloscope.

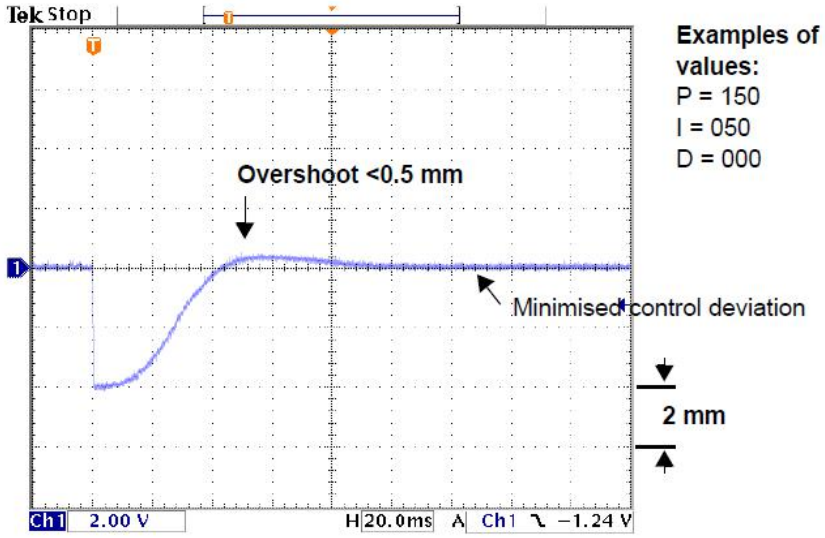
5、Increase P until oscillations (*P-Param*). When changing P, repeat the second to fifth steps.

6、Set P to 75% of the oscillating value.

7、Set I to 30% of P.



P-Param



I-Param

Chapter. Wiring Connection Instruction

For example: