Catalogue

Dear users:

Welcome to using LST series of online dynamic outer diameter measuring & control instrument. If you use it for the first time, please do carefully read "Operating Manual".

I. Introduction of Instrument

1.1 Overview

LST laser diameter measuring instrument, professional non-contact dynamic diameter measuring instrument, is suitable for online diameter measurement of round workpieces such as: optical fiber and cable, electric wire & cable, glass tube, plastic tube and bearing. It not only measure display diameter and deviation value but also could control diameter automatically according to user requirement to keep consistency of wire diameter.

- Suitable for online measurement of any round wires and workpieces.
- Non-contact measurement, high-speed inspection, high precision and stable performance.
- With Fθ optical lens, there is small influence of shaking on measured wire.
- With inbuilt PID control module, wire diameter can be automatically controlled.
- With all-dimensional revolving operating panel, long-distance displays of various dimensions are equipped.
- With multi-address RS232/485 communication interface.
- With semiconductor laser of long service life.
- With Switzerland brushless DC motor, it could be adapted to working under severe environment.

LST series of diameter measuring instrument could be classified into two types such as one-dimension and two-dimension according to the measurement pattern. One-dimension diameter measuring instrument only measures the diameter value of workpiece in one direction while two-dimension diameter measuring instrument measures the diameter value in two directions of X and Y. One and two-dimension measuring instruments features compact structure, same operation function and output interfaces.

Basic LST series of diameter measuring instrument is comprised of laser measuring head, operation panel and remote controller, and can be connected with long-distance displays of various dimensions as shown by the Fig. 1.

The measuring instrument is equipped with high-precision laser scanning system and embedded digital processing circuit. The diameter signal produced by the scanning system is firstly converted into digital signal to obtain practical diameter value and related data through series of calculations and processing. The output interface of diameter measuring instrument contains 1 485 communication interface and 2 synchronic serial ports. The data of diameter measuring instrument could be transmitted to PC or remote controller through 485 communication interface. It can be connected with operation panel and remote controllers and displays of various dimensions through synchronic serial port to realize remote control and display.

Operational panel is installed above measuring head. It is used for setting parameters of data display. There are two rows of nixie tube, which could display two groups of data and adjust angle at random.

Remote controller is mainly used for automatic control. It receives data including the diameter and deviation value of diameter measuring instrument through synchronic serial port and 485 communication interface. Remote controller generates PID regulatory signal through data it receives to control the rotating speed of tractor so as to finally control wire diameter.

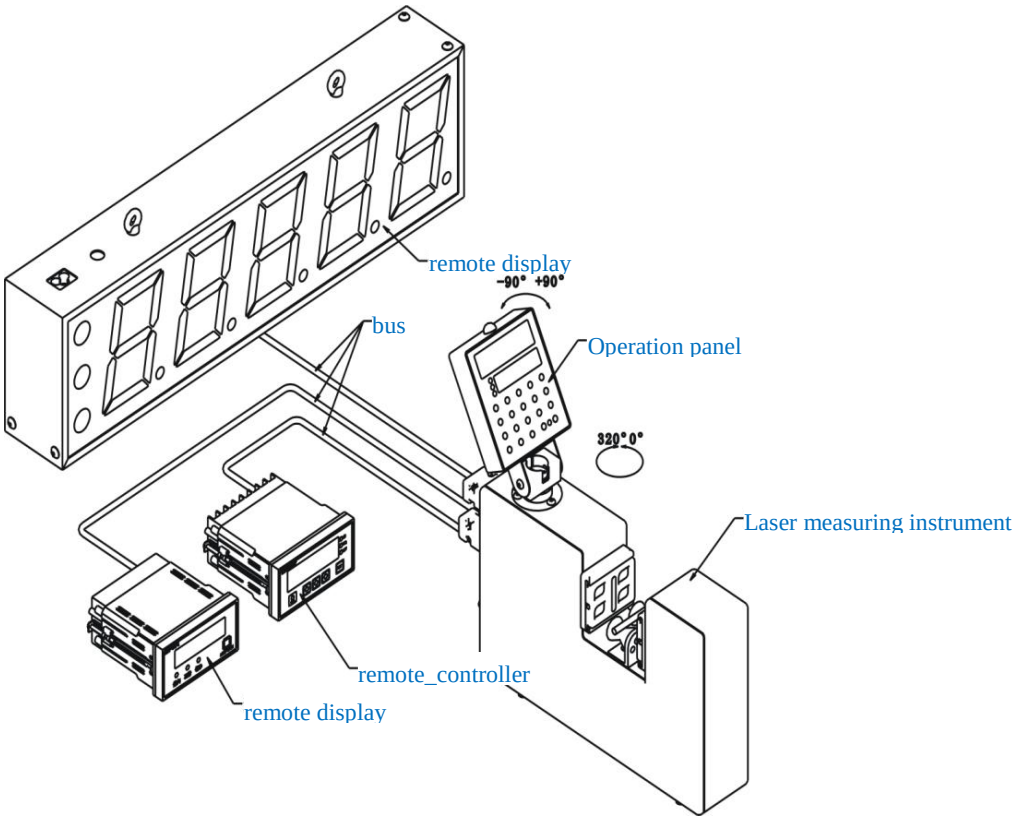


Fig. 1 (a) One-dimension

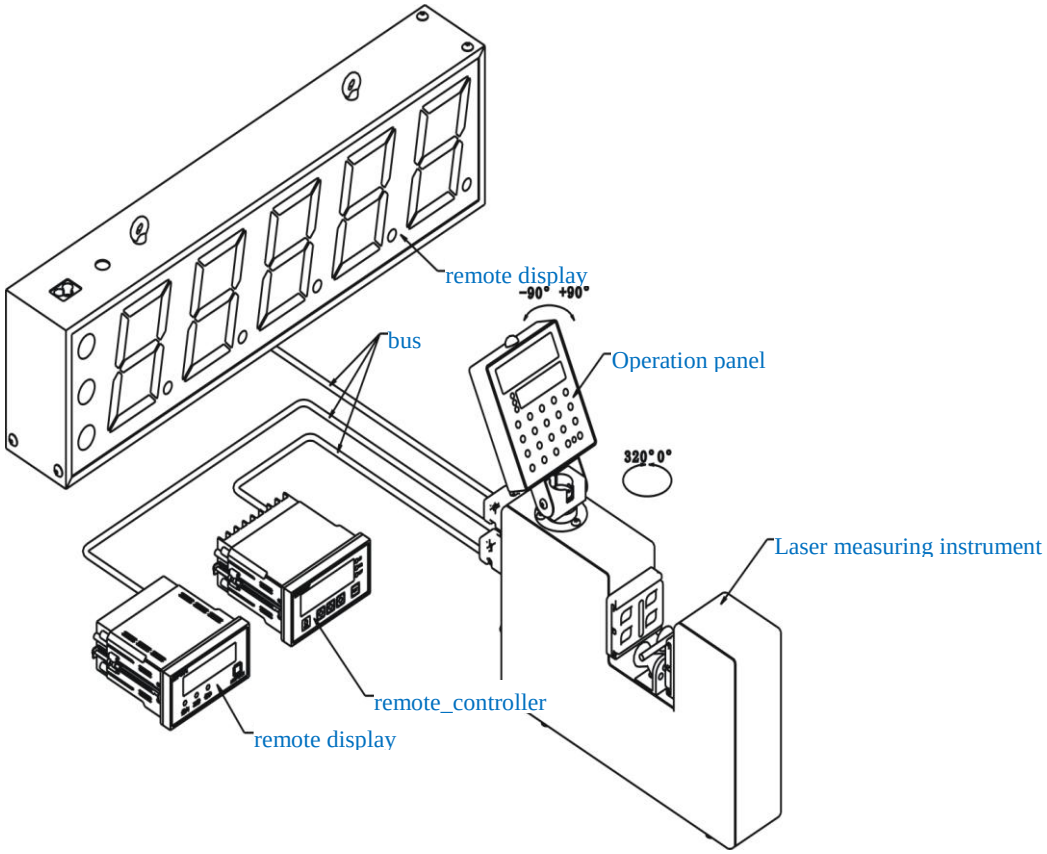
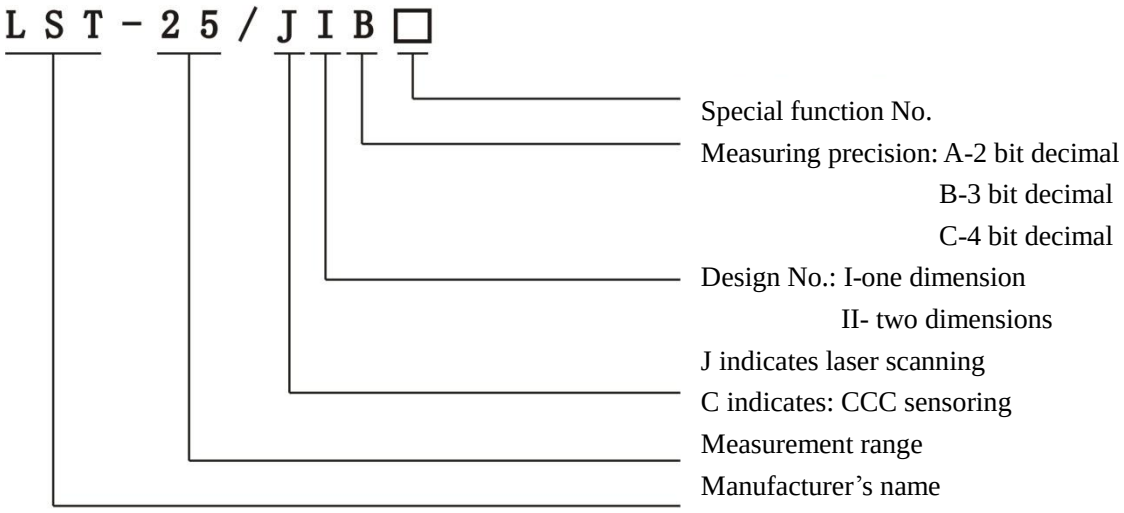


Fig. 1 (b) Two-dimension

1.2 Type & technical indicator

1.2.1 Type & specification



Example; LST-25/JIB indicates the diameter measuring instrument with measurement range of 25mm, one dimension and measuring precision of 3 small decimal points.

1.2.2 Technical parameters

Equivalent scanning speed: 600 times/sec (1400 times/ sec at fastest speed)
Control interface output: -10V～+10V
Maximum output current: 5mA
Center-height adjustable range: 850～1100mm

Type Specification	Measuring Range	Measuring Precision	Resolution Ratio	External Dimension of Measuring Head	Weight
LST-25/JIB	0.1～25mm	±2μm	1μm	290×60×170mm	
LST-25/JIIB	0.1～25mm	±2μm	1μm	320×60×256mm	
LST-40/JIB	0.2～40mm	±2μm	1μm	400×80×175mm	
LST-40/JIIB	0.2～40mm	±2μm	1μm	365×80×311mm	
LST-70/JIA	1～70mm	±5μm	3μm	668×120×160mm	
LST-100/JIA	1～100mm	±5μm	3μm	480×80×367mm	
LST-200/JIA	1～200mm	±5μm	3μm	660×120×437mm	

Table 1

1.2.3 Working conditions

Power: AC 180～260V 50Hz
Working temperature: -5～+50℃
Air humidity: ≤90% (no condensate water)
Power consumption: ≤15W

II. Laser Measuring Head

2.1 Principle of measurement

The light beam generated by laser is irradiated on the revolving prism. The light beam irradiated by the prism becomes the one in parallel motion through lens 1 while the parallel light beam will be converged on the receiving element. Please refer to the Fig. 2. When the tested object on the focal plane of lens 1, part of light ray is shield, thus the shadow is generated. As a result, the corresponding electric signal is generated on receiving element. The diameter value and a series of related signals are obtained after the signal is processed with diameter measuring instrument.

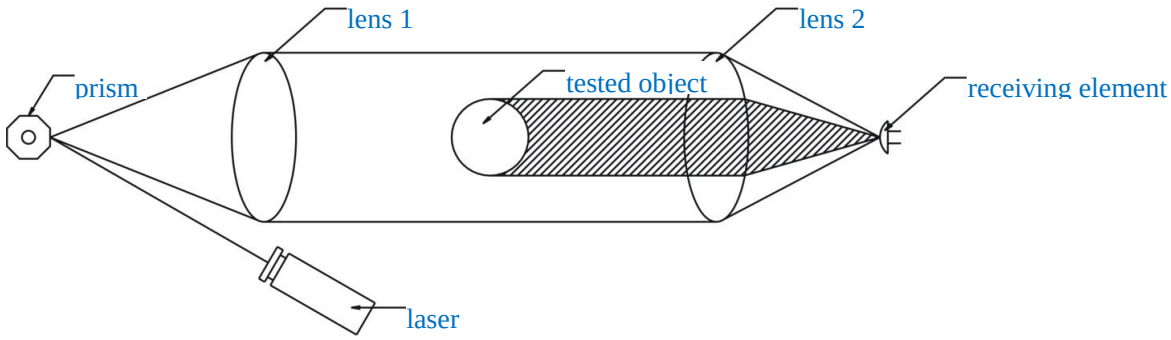


Fig. 2 (a) One-dimension Measurement Principle

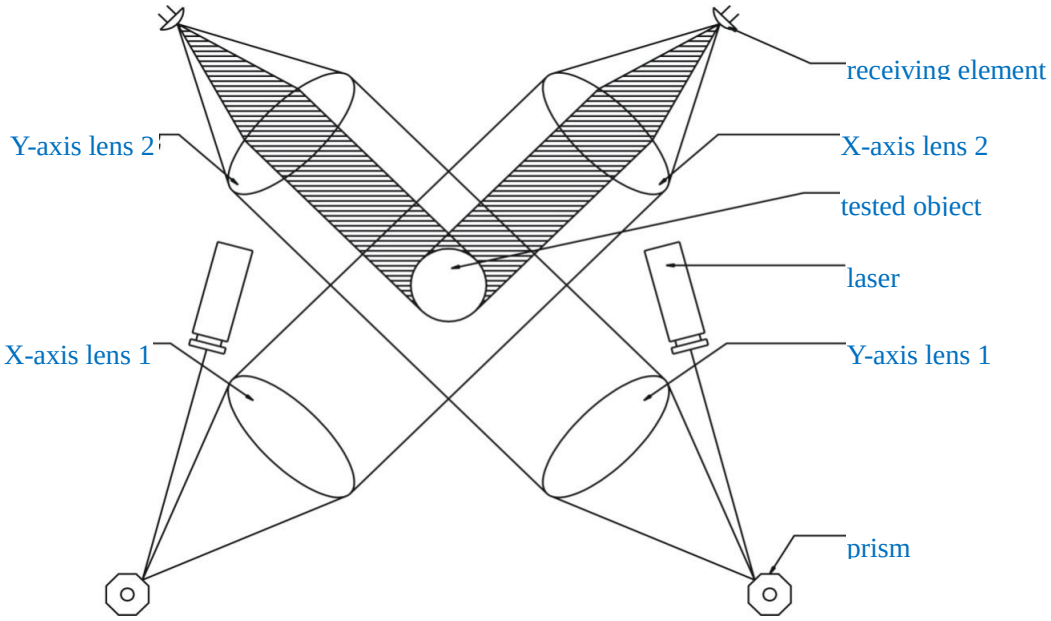
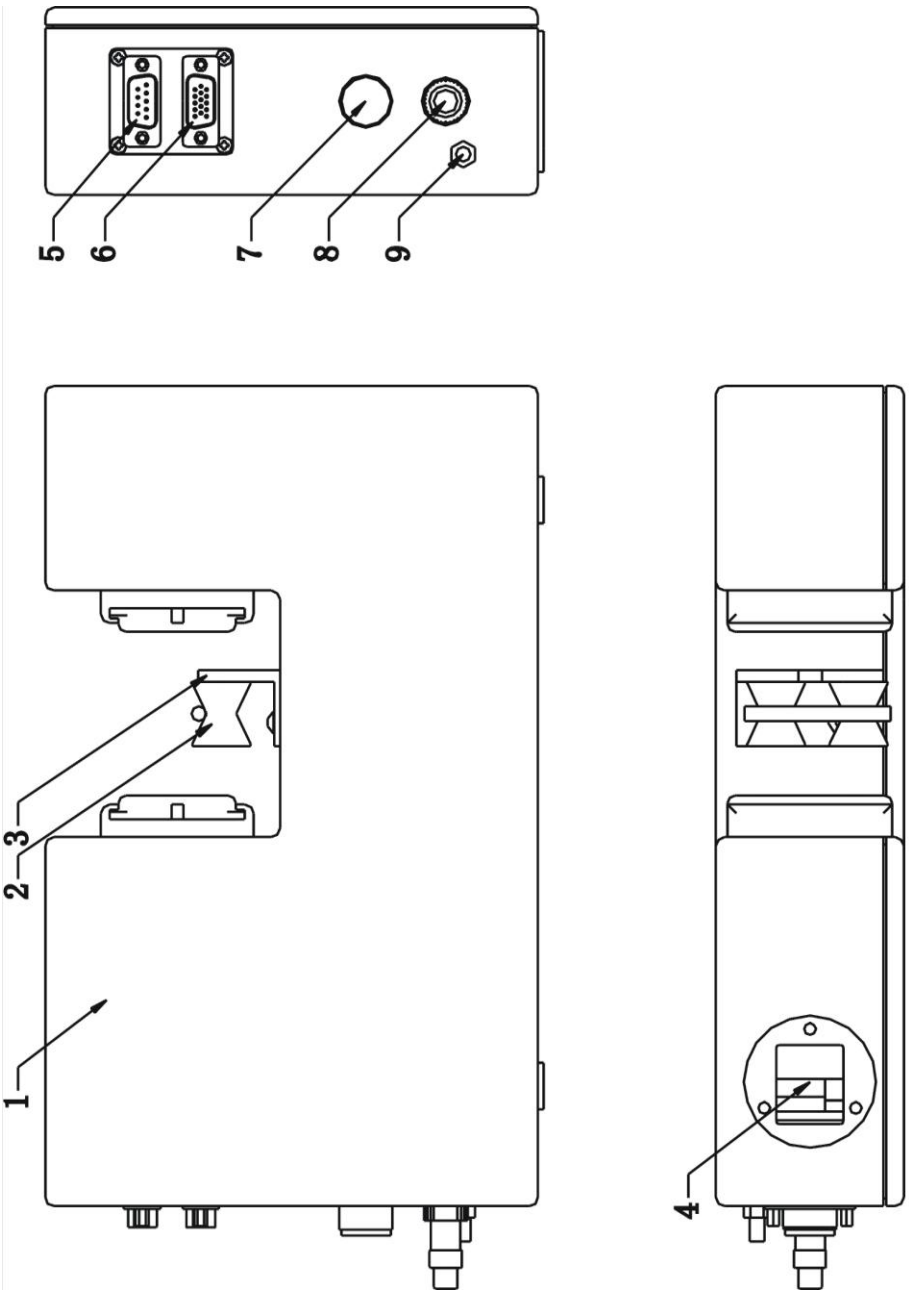


Fig. 2 (b) Two-dimension Measurement Principle

2.2 Function and Layout

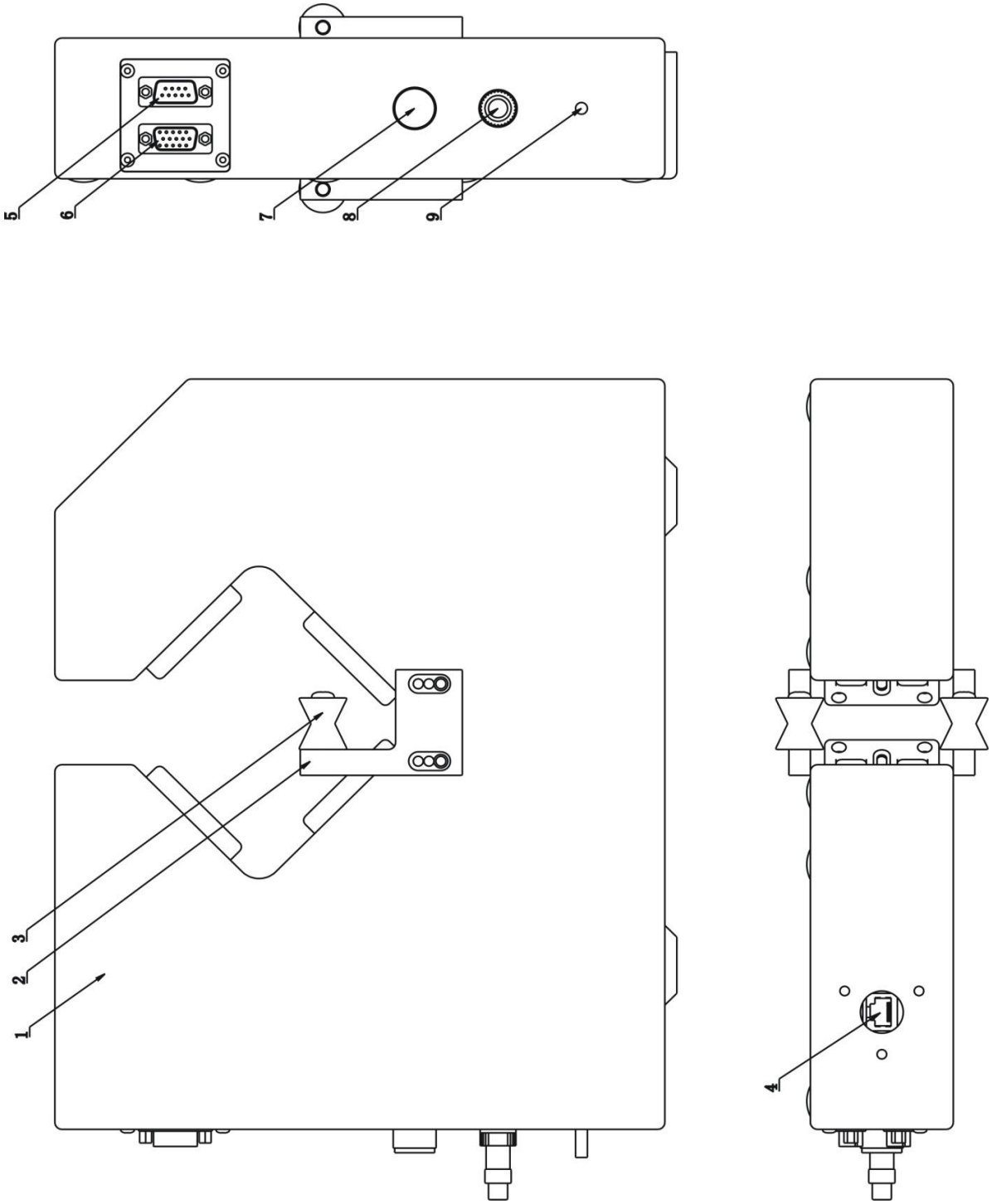
For one-dimension, taking LST-25/JIB for example:



1: laser measuring instrument；2: guide roller；3:guide roller holder；4: synchronized serial port 1；
5: 485 communication interface；6: synchronized serial port 2；7: power switch；8: outlet；9: grounding screw

Fig. 2 (c) One-dimension

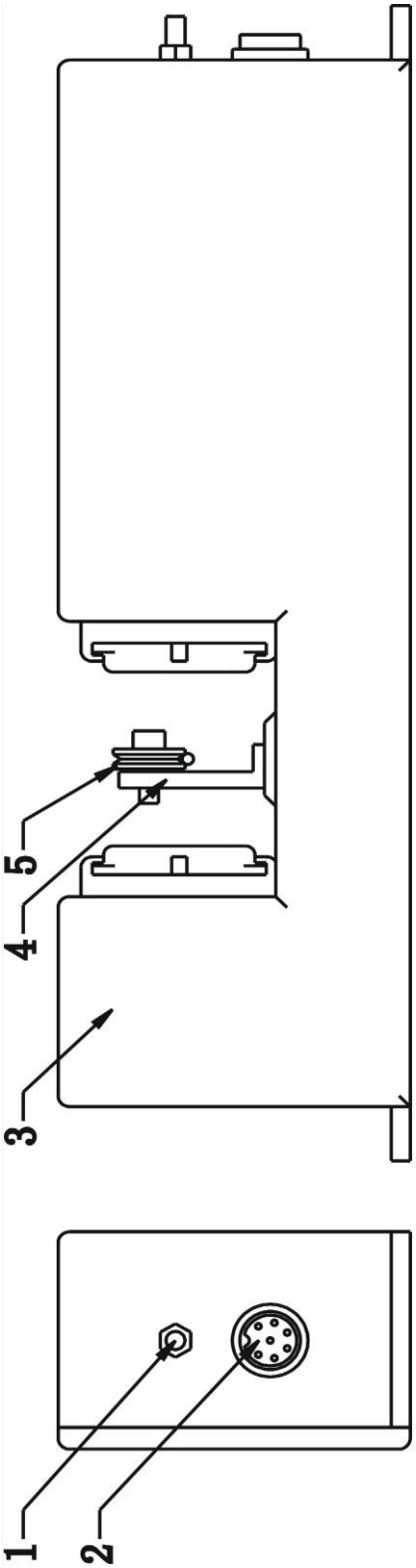
For two-dimension, taking LST-25/JIIB for example:



1: laser measuring instrument；2:guide roller holder；3: guide roller；4: synchronized serial port 1；
5: 485 communication interface；6: synchronized serial port 2；7: power switch；8: outlet；9: grounding screw

Fig. 2 (d) Two-dimension

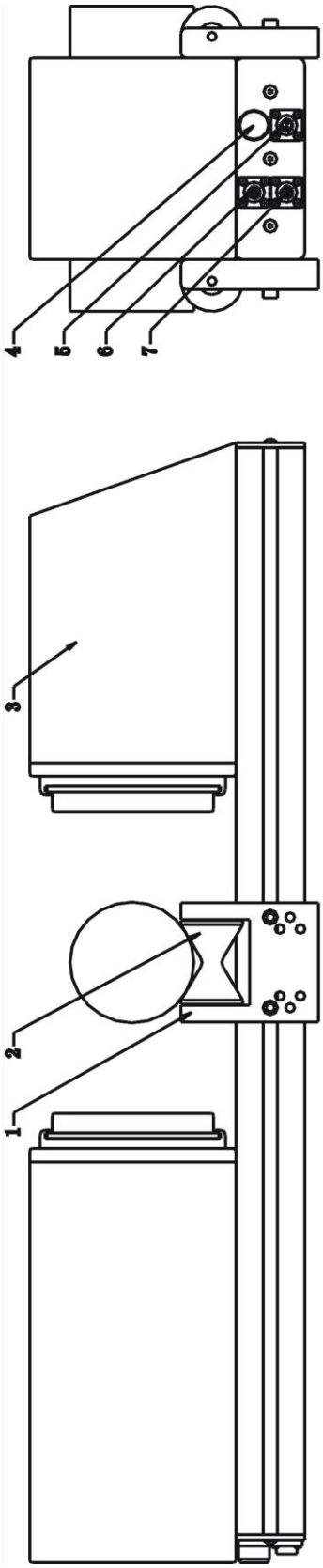
LST-25/JIB-2 one-dimension measuring head:



1:grounding screw; 2: synchronized serial port 3; 4: laser diameter measuring instrument; 5: guide roller

Fig. 2 (e) LST-25/JIB Measuring Head

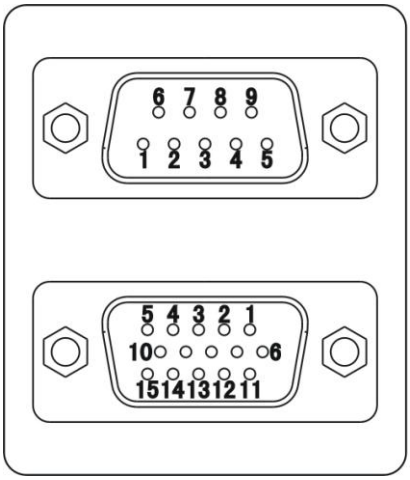
LST-70/JIA one-dimension measuring head:



1:guide roller holder; 2: guide roller; 3: laser diameter measuring instrument; 4: power switch; 5: outlet; 6: 485 communication output; 7: synchronized serial port 2.

Fig. 2 (f) LST-70/JIA Measuring Head

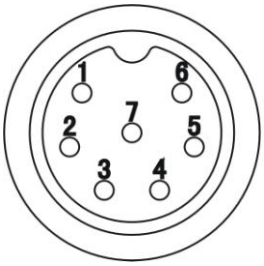
2.3 Interface description



485 communication interface:
2-pin: 485-A
3-pin: 485-B
5-pin: ground wire

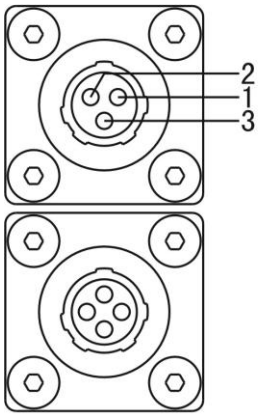
Synchronized serial port 2 interface:
1 and 2-pin: first pair of synchronized serial ports output
4 and 5-pin: second pair of synchronized serial ports output
14 and 15-pin: third pair of synchronized serial port output
Any pair of synchronized serial port output can be used as the input of displays or controllers such as: LST-02X or LST-03T or LST-04X or LST-05X

Fig. 2 (g) Schematic Diagram of LST-25/J and LST-40/J Interface



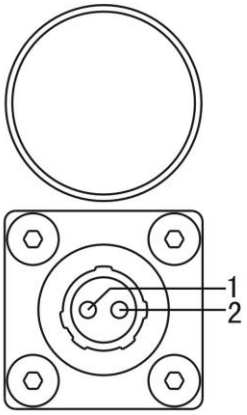
Synchronized serial port 3:
1-pin: 19V input; 2-pin: X positive signal
3-pin: X negative signal; 4-pin: Y positive signal
5-pin: Y negative signal; 6-pin: ground wire

Fig. 2 (h) Schematic Diagram of LST-25/JIB-2



485 communication interface
1-pin: 485-A
2-pin: 485-B
3-pin: ground wire

Synchronized serial port 2 interface
1 and 2-pin: first pair of synchronized serial port output
3 and 4-pin: second pair of synchronized serial port output
Any pair of synchronized serial port output can be used as the input of displays or controllers such as: LST-02X or LST-03X or LST-04X or LST-05X



Power switch and indicator lamp

Power input terminal:
1-pin: 19V input
2-pin: ground wire

Fig. 2 (i) Schematic Diagram of Interfaces such as: LST-70/JIA, LST-100/JIA and LST-200/JIA

2.4 Grounding screw

In most cases, grounding (connected to earth) can reduce interference and avoid accidental burnout

III. LST Operation Panel

3.1 Function layout of operation panel

Operation panel is installed above measuring head and connected with it through synchronized serial port 1 as shown by the Fig. 3 (a). It is used for data display, parameter setting, over-deviation indication and alarm. It is suitable for LST series of products. For the function layout of panel, please refer to the Fig. 3 (b).

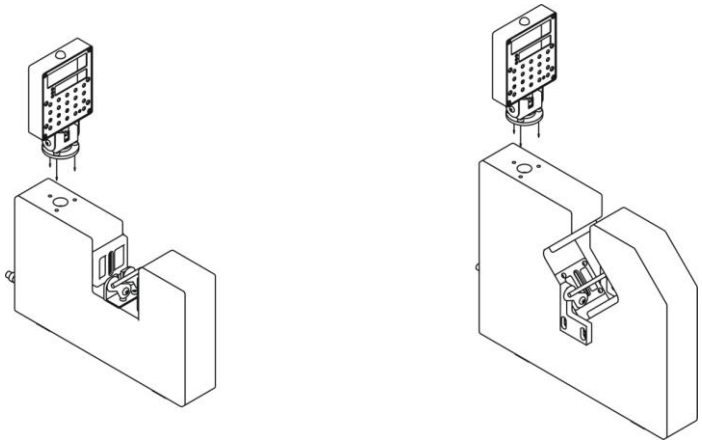
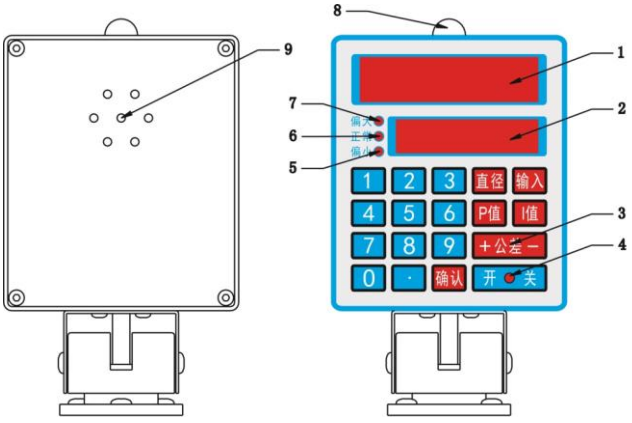


Fig. 3 (a) LST-CB Panel Installation



1. Main display screen
2. Sub display screen
3. Operation key
4. Input indicator lamp
5. Lower-deviation indicator lamp
6. Non-deviation indicator lamp
7. Upper-deviation indicator lamp
8. Alarm indicator lamp
9. Over-deviation alarm

Fig. 3 (b) Function of LST-CB Panel

Notes:

1: When setting X and Y alarms separately, upper-deviation indicator lamp indicates X measurement value alarm while lower-deviation indicator lamp indicates Y measurement value alarm.

2. When measuring the jitter value, the upper-deviation indicator lamp indicates measurement value alarm of outer diameter while lower-deviation indicator lamp indicates measurement value alarm of jitter.

3: When measuring ovality, the upper-deviation indicator lamp indicates measurement value alarm of outer diameter while lower-deviation indicator lamp indicates measurement value alarm of ovality.

4: When measuring inner diameter of glass, upper-deviation indicator lamp indicates measurement value alarm of outer diameter while lower-deviation indicator lamp indicates measurement alarm of inner diameter of glass.

5: When measuring maximum and minimum size or length and width, the main display screen displays maximum size or length while the sub display screen displays the minimum size or width.

3.2 Set parameter definition

Key Value	Parameter Functions	Code	Type	Setting Range	Factory Default
First-level Parameter					
Diameter	1. Diameter value presetting 2. X diameter setting value on the occasion when X and Y diameters are separated.	10	LST-25	0.100～27.000	5.000
			LST-40	0.200～42.000	10.000
			LST-70	1.00～72.00	50.00
			LST-100	1.00～100.00	70.00
			LST-200	1.00～200.00	100.00
+ Tolerance	1. Presetting of plus tolerance value 2. X plus tolerance setting value on the occasion when X and Y diameters are separated. 3. Plus and minus tolerance setting value on the occasion when jittering is measured. 4 Plus and minus tolerance setting value on the occasion when ovality is measured.	11	LST-25	0.100～27.000	5.000
			LST-40	0.200～42.000	10.000
			LST-70	1.00～72.00	50.00
			LST-100	1.00～100.00	70.00
			LST-200	1.00～200.00	100.00
- Tolerance	1. Minus tolerance presetting 2. X minus tolerance setting value on the occasion when X and Y diameters are separated 3. Jitter alarm setting value on the occasion when the jittering is measured 4. Ovality alarm setting value on the occasion when ovality is measured	12	LST-25	0.100～27.000	5.000
			LST-40	0.200～42.000	10.000
			LST-70	1.00～72.00	50.00
			LST-100	1.00～100.00	70.00
			LST-200	1.00～200.00	100.00
Second-level Parameter					
P	P value proportionality coefficient presetting	13	All	0～200	24
I	I value integral coefficient presetting	14	All	0～200	16
0	D value differential coefficient presetting	15	All	0～200	0
1	Average times presetting	1	All	1～1000	20
2	Correspondence address presetting	2	All	0～127	1
3	Correspondence baud rate presetting	3	All	2400、4800、9600，19200	9600
4	Alarm enable option	4	All	0-closed.1-open	0
5	Contraction ratio	5	Below 40	0.100～2.000	1.000

6	Sub display item selection	6	One-dimension	0-deviation value	0
				1-location value	
				2-jitter value	
				3-maximum and minimum value	
				4-measuring length & width	
			Two-dimension	0-average diameter	1
				1-average deviation	
				2-ovality	
				3- X diameter	
				4-Y diameter	
				5-X deviation	
				6-Y deviation	
				7-X location	
				8-Y location	
7	PID output polarity selection	7	All	0-positive, 1-negative	0
8	Refresh time for beating detection	8	One-dimension	0.10～5.00S	3.00
	Delay time for ovality detection		Two-dimension	0.05～600.00S	
	Third-level parameter				
INPUT+3	Communication format setting	18	All	0- default communication format	0
				1- default communication format, odd parity check	
				2- default communication format, even parity check	
				3-MODBUS RTU, no check	
				4-MODBUS RTU, odd parity check	
				5-MODBUS RTU, even-parity check	
INPUT+4	Shut down by pressing any alarm key	19	All	0-open, 1-closed	0
INPUT+6	Main display selection	21	Two-dimension	0- average diameter	0
				1-average deviation	
				2-ovality	
				3-X diameter	
				4-Y diameter	
				5-X deviation	
				6-Y deviation	
				7-X location	
				8-Y location	

INPUT+7	Analog quantity output selection	22	All	0- PID, 1- 1-deviation value output	0
INPUT+8*	Qualification rate of ovality	23	All	0～100	80
INPUT+9*	Measurement type	24	All	0-standard measurement 1-location measurement 2-maximum value with scanning range 3-measure inner diameter of glass	0
INPUT +Diameter*	Setting value of Y diameter on the occasion when X and Y diameters are separated	25	LST-25	0.100～27.000	5.000
			LST-40	0.200～42.000	10.000
			LST-70	1.00～72.00	50.00
			LST-100	1.00～100.00	70.00
			LST-200	1.00～200.00	100.00
INPUT+ +Tolerance*	Setting value of Y plus tolerance on the occasion when X and Y diameters are separated	26	LST-25	0.100～27.000	5.000
			LST-40	0.200～42.000	10.000
			LST-70	1.00～72.00	50.00
			LST-100	1.00～100.00	70.00
			LST-200	1.00～200.00	100.00
INPUT+ -tolerance*	Setting value of Y minus tolerance on the occasion when X and Y diameters are separated	27	LST-25	0.100～27.000	5.000
			LST-40	0.200～42.000	10.000
			LST-70	1.00～72.00	50.00
			LST-100	1.00～100.00	70.00
			LST-200	1.00～200.00	100.00
INPUT+P*	Decimal point selection	28	All	0-3 bit, 1-4 bit	0
INPUT+I*	Separate setting selection for X and Y	29	All	0-X & Y not separated, 1-X & Y separated	0
INPUT+0*	05 controller selection	30	All	0-new version, 1- old version	0
INPUT+ INPUT+ +tolerance*	Fine adjustment of X diameter	41	All	0.000～0.200	0.100
INPUT+ INPUT+ -tolerance*	Fine adjustment of Y diameter	42	All	0.000～0.200	0.100
INPUT+ ON+ OFF	Reset factory default	99	All	0-unchanged, 1-default value	0
	Function key				
.	Display value switching	Diameter display value is switched and displayed between the real one according to the value after contraction ratio			
INPUT	Parameter input/backspace key	Confirm to enter parameter input state, LSB bit nixie tube flashes after confirmation.			
ENTER	Data modification confirmation	Save or exit parameter modification, when measuring beating, it is to measure beating start key.			
ON+OFF	Input switch	When pressing ON, indicator lamp will be on to open for input, or off. Shut down			
INPUT+ INPUT	Display software version No.	Automatically shut down after displaying for 2sec			

Notes:

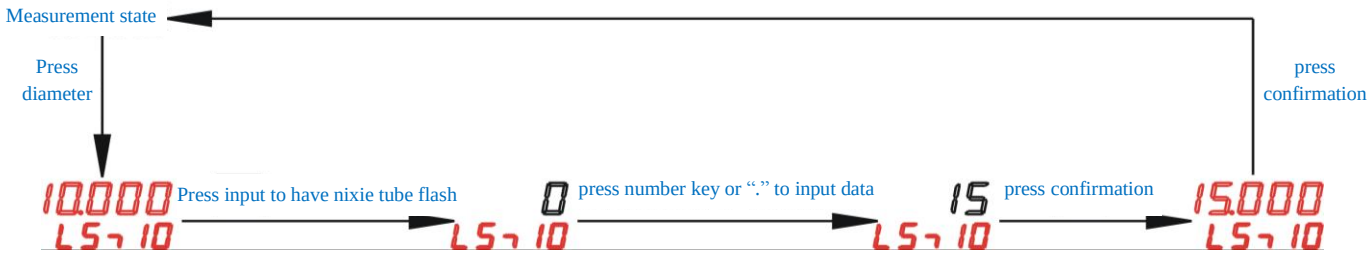
1. There is no function of parameter with the number of "*" on operation panel of LST-08X.

2. For communication baud rate selection, firstly press 3, and then input password 88888 and press tolerance "+" or "-" keys to choose. After confirming baud rate, exit by pressing enter key for twice.

3.4 Flow chart of menu setting

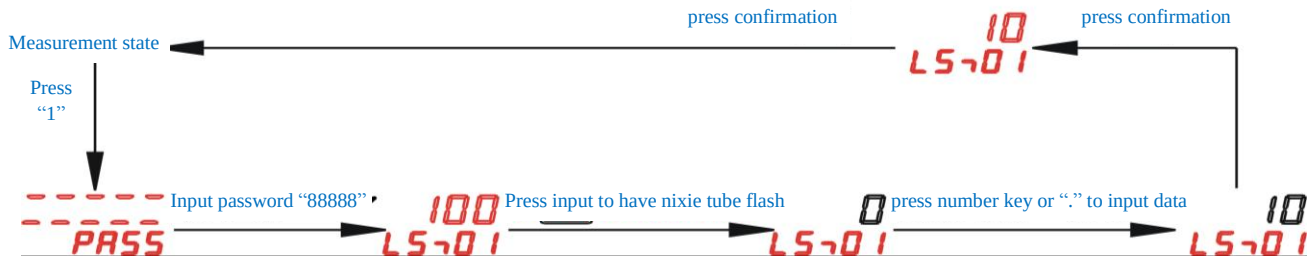
3.4.1 Operation process for setting parameter

First-level Parameter



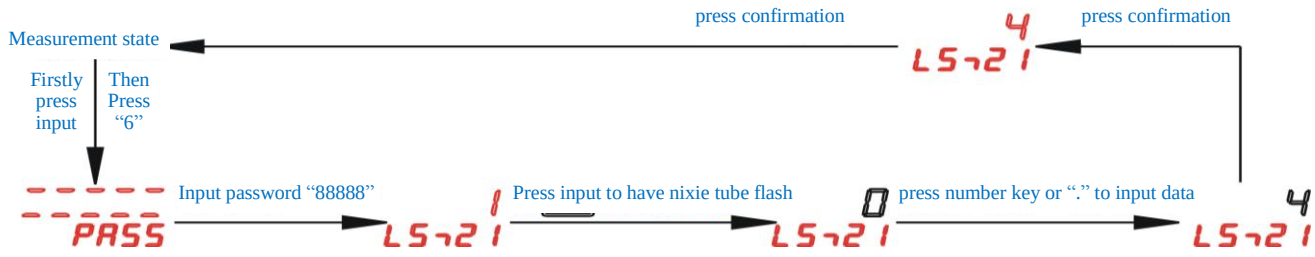
a. Setting example of diameter parameter

Second-level Parameter



b. Setting example of average times parameter

Third-level parameter

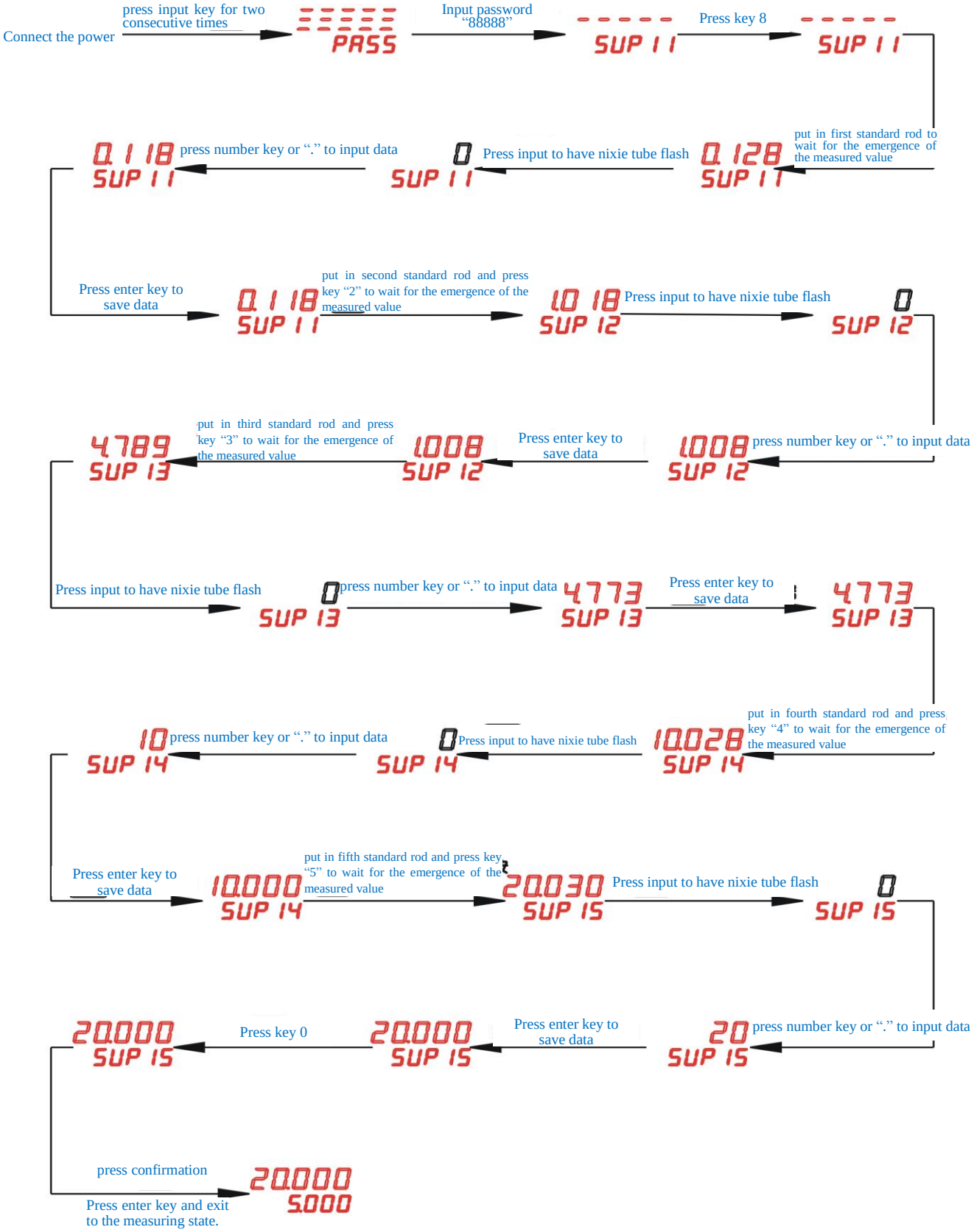


c. Setting example of main display selection parameter

3.4.2 Operation process of calibration parameter

Calibration process of X axis diameter of one or two dimensions:

Calibration process for two-dimension Y axis diameter:

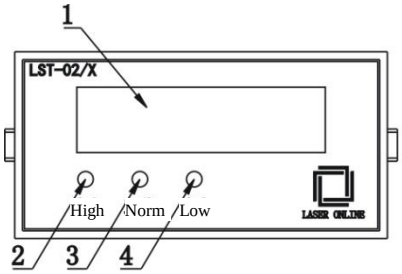


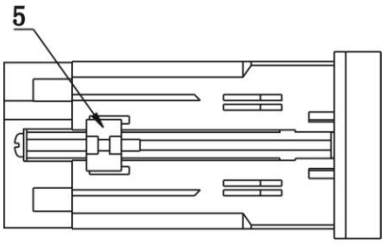
Twin-lens diameter calibration process:

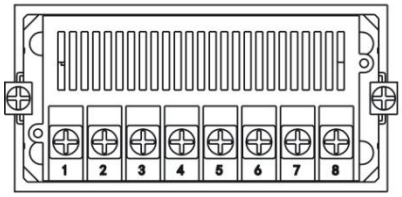
IV. LST Remote Display

Remote display is used for long-distance displaying. The user can choose two models such as: LST-02/X or LST-03/X. Remote display is connected with diameter measuring instrument through wiring terminal (LST-02/X) or aviation plug (LST-03/X). The transmission distance could reach 200m. The connecting line is provided by the user.

Connection type: according to the table 2



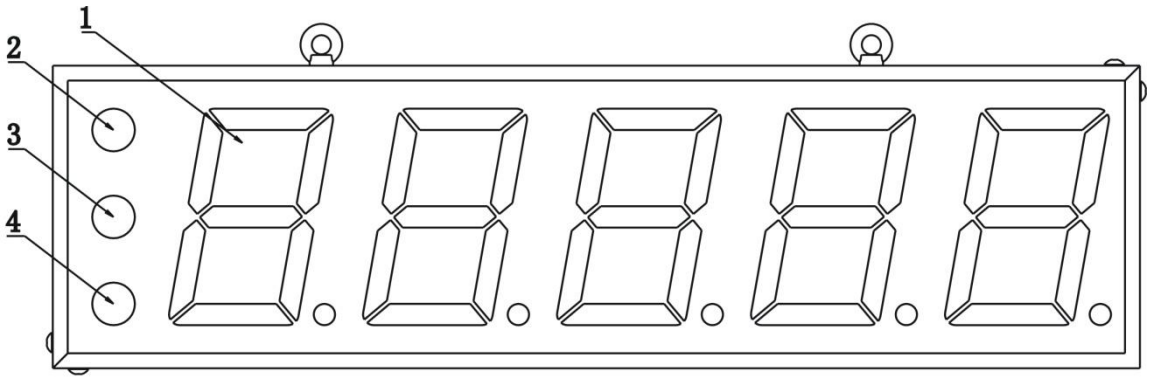


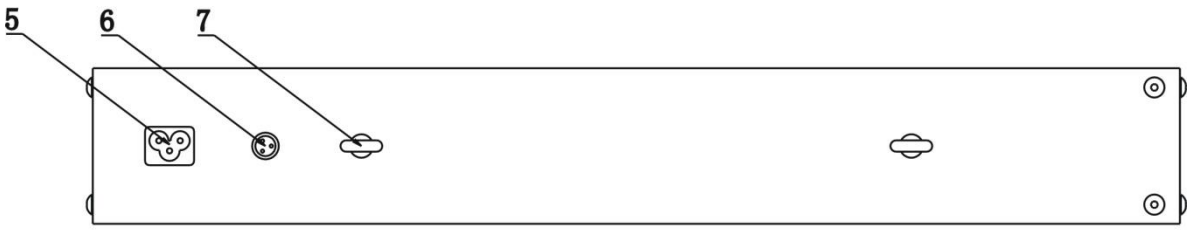


TI 1	RI 2	3	4	5	6	L 7	N 8
Synchronized serial port 2						220VAC	

1. Display screen; 2. Upper-deviation indicator lamp; 3. Non-deviation indicator lamp; 4. Lower-deviation indicator lamp; 5. Mounting bracket

Fig. 4 (a) LST-02/X





1. Display screen; 2. Upper-deviation indicator lamp; 3. None-deviation indicator lamp; 4. Lower-deviation indicator lamp; 5. 220V power; 6. Synchronized serial port 2 (connecting and measuring head); 7. Display hook

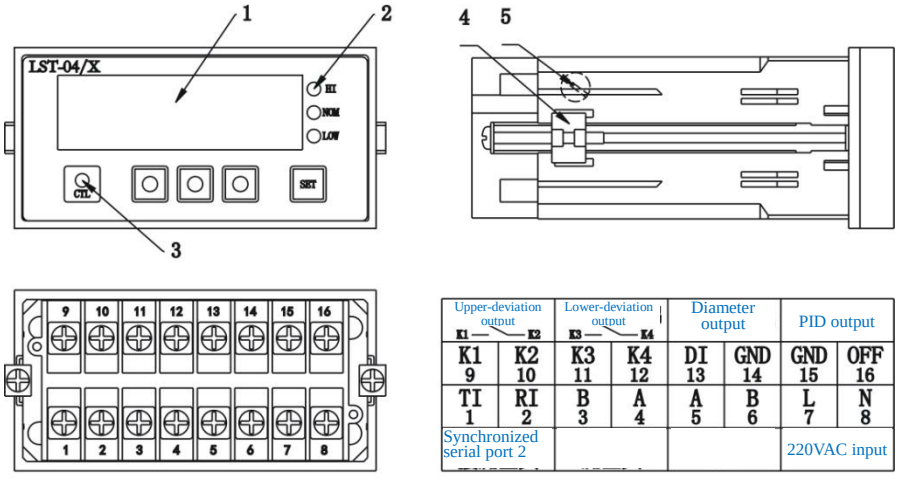
Fig. 4 (b) LST-03/X

V. LST Remote Controller

LST series of remote controller is connected with diameter measuring instrument through synchronized serial port 2. The crew speed of plastic extruding machine revolving speed is controlled according to the measured wire and nominal value, so that the actual wire diameter may approach nominal value. That is, outer diameter automatic control is realized to keep consistency of wire diameter. The user can choose two models such as: LST-04/X or LST-05/X according to different hole sizes.

5.1 LST-04/X

5.1.1 Function layout



Upper-deviation output K1 — K2		Lower-deviation output K3 — K4		Diameter output		PID output	
K1 9	K2 10	K3 11	K4 12	DI 13	GND 14	GND 15	OFF 16
TI 1	RI 2	B 3	A 4	A 5	B 6	L 7	N 8
Synchronized serial port 2						220VAC input	

1. Display screen; 2. Alarm indicator lamp; 3. Input indicator lamp;
4. Mounting bracket; 5 Output setting

Fig. 5 (a) LST-04/X

Analogue output: two independent 12-bit D/A output (photoelectric isolation), output impedance is 100Ω.

1. Diameter output: 0~10V (10V corresponds to full scale)

2. Deviation/ PID controlled quantity: ±0.2V~2.3V, which is adjustable and can be regulated to ±2 V when leaving the factory.

Over-deviation alarm: relay output.

Synchronized port 2: remote controller should be connected according to the table 2.

485 communication interface (connected to the measuring head): according to the table 3. 1-A □ and 2-B □, it is necessary to connect 485 communication link.

485 communication interface (connected to PC): 16-A □, 15-B □.

5.1.2Parameter setting

1) Power on: pr s the shift key and enter designated modified parameter. By taking for example, only by pressing the shift key for once, the display screen can display Similarly, for the parameter “ ”, it is necessary to press the shift key for twice.

2) Enter parameter revision status: finish the last step, press the set key and enter parameter revision status. At this time, the LSB nixie tube of display window will flash; under this state, by pressing the shift key, the flashing nixie tube will move one bit forward.

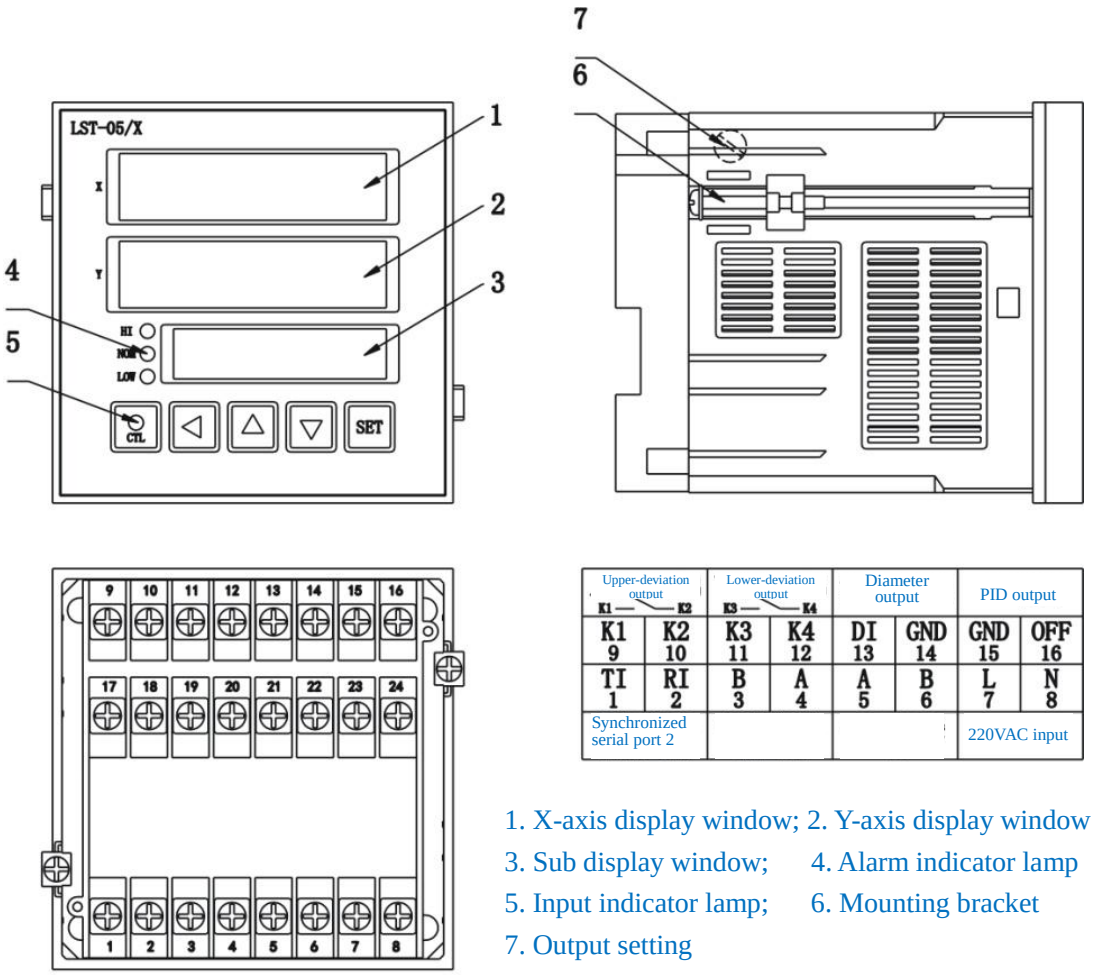
3) Parameter setting: By pressing addend key or subtracted key, the size of parameter can be modified. By pressing addend key once when LSB nixie tube flashes, the parameter can be added and subtracted by 1. If it moves forward, the parameter can be added and subtracted by 10 and 100.

4) Store parameter: press the set key for 2sec, and store the parameters and exit parameter revision status.

Parameter code	Parameter function	Model	Set range	Factory default
A	Display window option	One-dimension	0: Nixie tube displays diameter value 1: Nixie tube displays deviation value 2: Nixie tube displays beating value	0
b	PID output selection		0: PID output 1: deviation output	0
C	Export ratio of diameter analogue		0~2.000	1.000
d	Zero set of PID output		-999~999	0

5.2 LST-05/X

5.2.1 Function layout



Upper-deviation output K1 — K2		Lower-deviation output K3 — K4		Diameter output		PID output	
K1 9	K2 10	K3 11	K4 12	DI 13	GND 14	GND 15	OFF 16
TI 1	RI 2	B 3	A 4	A 5	B 6	L 7	N 8
Synchronized serial port 2						220VAC input	

1. X-axis display window; 2. Y-axis display window
3. Sub display window; 4. Alarm indicator lamp
5. Input indicator lamp; 6. Mounting bracket
7. Output setting

Fig. 5 (b) LST-05/X

Analog output: two independent 12-bit D/A output (photoelectric isolation). Output impedance is 100Ω.

1. Diameter output: 0~10V (10V corresponds to full scale).

2. Deviation/ PID controlled quantity: adjustable, ranging from ±0.2V to 2.3V. it is adjusted to ±2 V when leaving the factory.

Over-deviation alarm: relay output

Synchronized serial port 2: press the table 2, remote controller must be connected.

485 communication interface (connected with measuring head): by pressing the table 3.1-A □ and 2-B □, it is necessary to connect 485 communication.

485 communication interface (connected with PC): press 16-A □ and 15-B □.

5.2.2 Parameter setting

1) Power on: press the shift key and enter designated modified parameter. By taking  for example, only by pressing the shift key for once, the display screen can display  . Similarly, for the parameter "  ", it is necessary to press the shift key for twice.

2) Enter parameter revision status: finish the last step, press the set key and enter parameter revision status. At this time, the LSB nixie tube of display window will flash; under this state, by pressing the shift key, the flashing nixie tube will move one bit forward.

3) Parameter setting: By pressing addend key or subtracted key, the size of parameter can be modified. By pressing addend key once when LSB nixie tube flashes, the parameter can be added and subtracted by 1. If it moves forward, the parameter can be added and subtracted by 10 and 100.

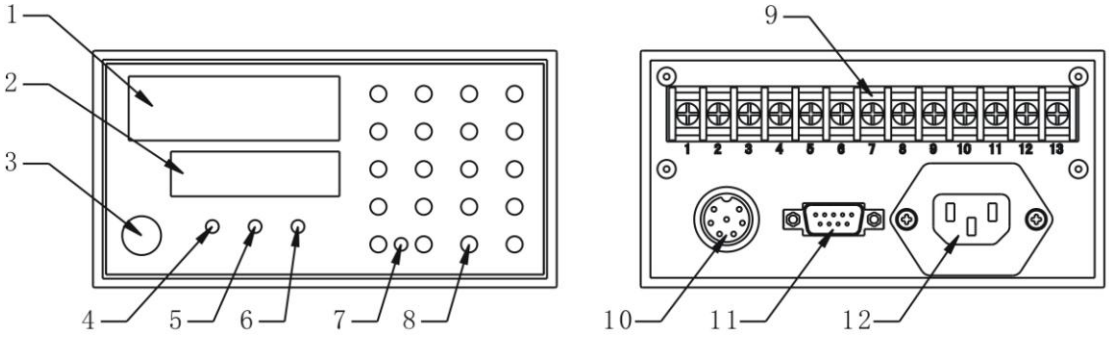
4) Store parameter: press the set key for 2sec, and store the parameters and exit parameter revision status.

Parameter code	Parameter function	Model	Set range	Factory default
	Sub display selection	Two-dimension	0: display average diameter value 1: display average deviation value 2: display ovality 3: display X-axis deviation 4: display Y-axis deviation	0
	PID output selection		0: PID output 1: deviation output	0
	Analog quantity export ratio of diameter		0~2.000	1.000
	Zero set of PID output		-999~999	0
LST-E	Version selection		0: corresponding to the measuring head lower than the version 3.00 1: corresponding to the measuring head larger than the version 3.00.	1

Controller Parameter List (three groups of nixie tube display)

5.3 LST-08/X

5.3.1 Function layout



1. Main display window; 2. Sub display window; 3. Power switch; 4. Upper-deviation indication; 5. Normal indication; 6. Lower-deviation indication; 7. Input indicator lamp; 8. Operation key; 9. Output wiring terminal; 10. Synchronized serial port 3

Output wiring terminal:

1. Wiring termina; 2 & 3. Synchronized serial port 2; 4. Analog ground. 5. Diameter analog output; 6. Analog ground; 7. PID or deviatio analog output; 8 & 9: Standardby contact outputq

Fig. 5 (c) Function Diagram of LST-X-08

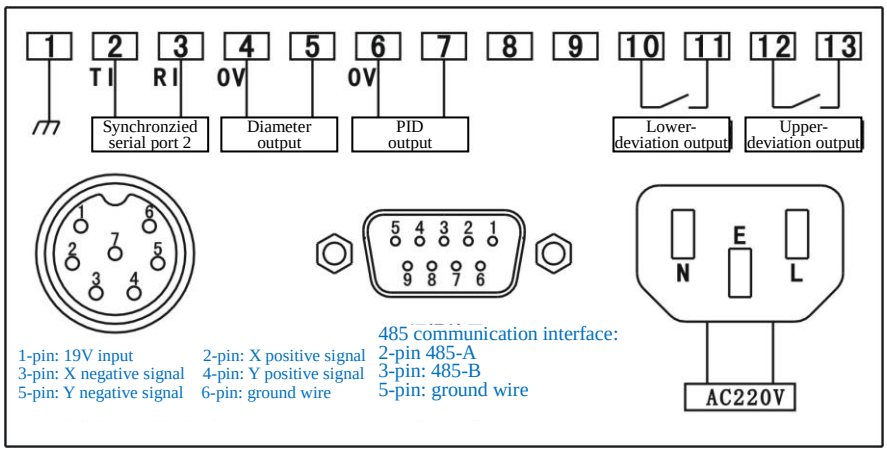


Fig. 5 (d) Wiring Diagram of LST-08

Output analog quantity: two independent 12-bit D/A output (photoelectric isolation). Output impedance is 100Ω.

1. Diameter: 0~10V (corresponding to full scale).

2. Deviation/PID controlled quantity: adjustable, ranging from ±0.2V to 10V. It is adjusted to ±10 V when leaving the factory.

Example: deviation voltage: standard value: 1.0MM tolerance setting: ±0.1MM

Measured value: 1.200MM For the measured value exceeds tolerance, it is 10V.

Measured value: 1.050MM For the measured value only exceeds half of tolerance, the voltage is 5V.

Upper-deviation alarm: relay output (contact 12 and 13)

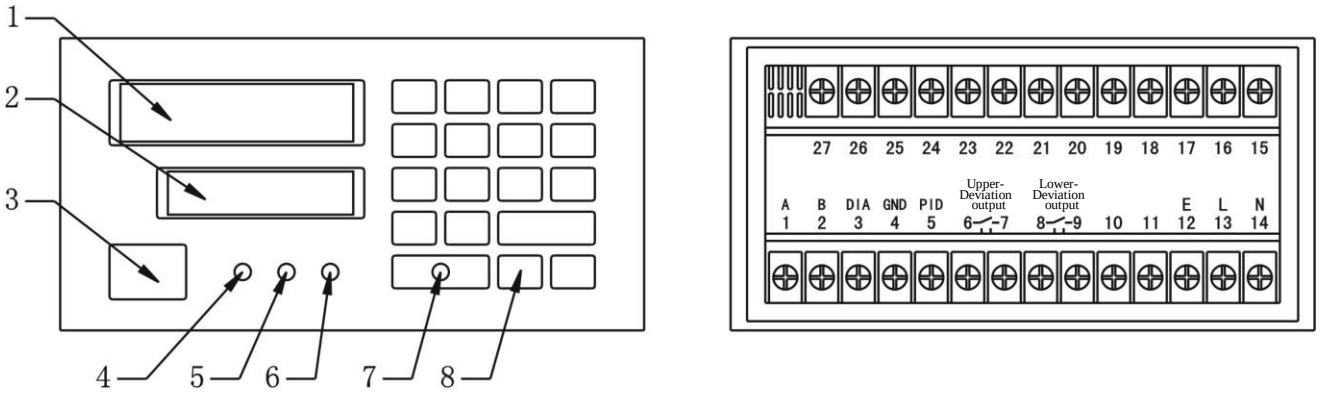
Lower-deviation alarm: relay output (contact 10 and 11)

DB9-2: communication interface

485 communication interface: DB9-2-A □ and DB9-3-B □

5.4 LST-09/X

5.4.1 Function layout



1. Main display window; 2. Sub display window; 3. Power switch; 4. Upper-deviation indication; 5. Normal indication; 6. Lower-deviation indication; 7. Input indicator lamp; 8. Operation key; Output wiring terminal: 1. 485 □-A; 2. 485 □-B; 3. Diameter analog quantity output; 4. Analog ground; 5. PID or deviation analog quantity output; 6. Upper-deviation contact output; 8 & 9: lower-deviation contact output; 12. Grounding terminal; 13. L; 14. N

Fig. 5 (d) Wiring Terminal of LST-X-08

Output analog quantity: two independent 12-bit D/A output (photoelectric isolation). Output impedance is 100Ω.

1. Diameter: 0~10V (corresponding to full scale).

2. Deviation/PID controlled quantity: adjustable, ranging from ±0.2V to 10V. It is adjusted to ±10 V when leaving the factory.

Example: deviation voltage: standard value: 1.0MM tolerance setting: ±0.1MM

Measured value: 1.200MM For the measured value exceeds tolerance, it is 10V.

Measured value: 1.050MM For the measured value only exceeds half of tolerance, the voltage is 5V.

Upper-deviation alarm: relay output (contact 12 and 13)

Lower-deviation alarm: relay output (contact 10 and 11)

485 communication connected with: A; B: connected with communication input.

VI. Use of Caliper

6.1 Installation

(1) Open the package, and check whether the instruments and accessories are complete according to the packing list.

(2) Install the measuring head on the bracket and tighten and fasten the screw.

(3) Put the measuring head in proper location on production line, move the bracket to have the tested cable aligned to the center of groove of guide roller, prepare foot screw and fasten the measuring head on production line.

(4) Relax and fasten screw, and lift measuring head to have the cable touch the bottom of groove of guide roller and have little pressure when working normally, and then tighten the screw.

(5) Insert power cable into power socket and tighten it and connect the power, and then the instrument will begin to work.

6.2 Feedback control

Laser measuring head and remote controller can constitute feedback control system, which can adjust the speed of tractor and extruder according to the deviation of diameter and dynamically adjust wire diameter. Now, the explanation is given by taking the control of production line of electric wire and cable for example, follow this one to finish other applications.

6.2.1 Installation position

LST laser diameter measuring instrument can be installed in front of cooling water tank. The feedback on change in wire diameter is immediately given and it is favorable for controlling. However, the measured diameter is the thermal state value of the wire. There is certain error between it and cooled actual value. Additionally, due to high outlet temperature, soft sheath of wire, the guide roller cannot be installed and the wire can jitter easily. After the diameter measuring instrument is installed after cooling water tank and dryer, the measured value is actual value after cooled and molding. However, the delayed feedback on change in wire diameter will influence the precision. The remote controller is generally installed on electric cabinet and connected with diameter measuring instrument through power cable.

6.2.2 Control wiring

1) Firstly, cut off the power of diameter measuring instrument, remote controller, tractor and plastic extruding machine.

2) Open controller of tractor or plastic extruding machine (DC adjustable-speed motor or transducer).

3) Weld off the wire on high-end tap of controller regulator potentiometer, and connect the wire OFF of PID (OFF) output of remote controller to the upper-end tap of potentiometer and ground wire with that welded off from the potentiometer. Please refer to the following diagram.

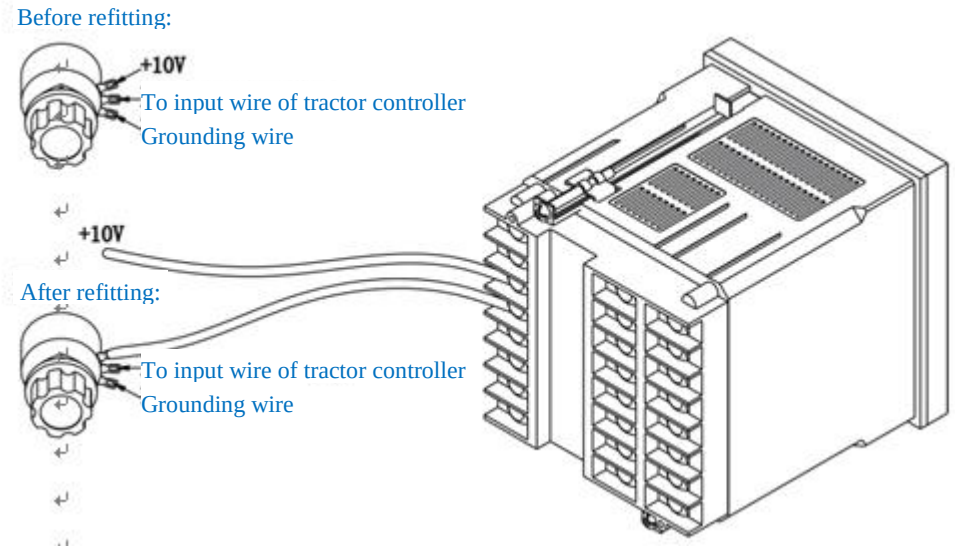


Fig. 6 (a) 6

6.2.3 Control parameters

The P值 and I值 parameters of remote controller decide the stability of control. The defaulted parameters could work well under most situations. When the control is too slow or non-stable with defaulted parameters, user should adjust these parameters:

P值roportionality coefficient indicates the proportional action of regulator; the value is 00-99. the larger the P值 value the faster the regulating effect. However, it is not stable. The oscillation could be easily caused. Contrarily, the smaller the P值 proportionality coefficient the slower the regulating effect but stable.

I值 integration coefficient decides the ability of the system to eliminate error in outer diameter. The value is also 00—99. The larger the integration coefficient I值 the stronger the ability to eliminate the error. However, if it is large excessively, the system will not be stable. The wire diameter will greatly fluctuate. The smaller the integration coefficient I值 the weaker the ability to eliminate the error. If the integration coefficient is 0, the feedback control will doesn't work.

For the input of control parameters P值 and I值, the modification method is as below (default standard: P=24 I=16)

1) Press key P值 or I值, the display will display the original P or I value;

2) Enter password input status , input password: "88888".

3) Press key 输入, the main display displays "0" and flashes. Press number keys "0" and "9", set parameter P值 or I值 one by one.

4) Press enter key, then the main display will display the P value or I value to be set.

5) Press enter key again, then the instrument will substitute new P value of I value for the original one. In the meantime, it automatically returns to the normal measuring status , then P value of I value will be set.

6.2.4 Control debugging

After the feedback control line is connected, debug according to the following steps

1) Set nominal value
2) Set control parameter as P value: 24; I value: 16.
3) Prepare two wires, in which one is thinner than the one with nominal value set and the other is thicker than the one with nominal value set. For example. The nominal value is 00.720mm, the one is 0.5mm and the other is 1mm.
4) Don't pass through copper core, but start revolving of the motor at low speed correspondingly (control extruder is screw motor. It is traction motor when the wire speed is controlled.)
5) Press 开 关 key and connect outer diameter control, then place thick and thin wires on guide roller of outer diameter measuring and control instrument to observe the change in revolving speed of motor and see whether it is consistent with requirement. For example, when plastic extruder screw speed is controlled, if the thin wire is put, the motor speed will be reduced. When thick wire is put, the motor speed is increased. Then, the requirement will be met. If contrarily, when the thin wire is put, the motor speed will be reduced. However, when the thick wire is put, the motor speed will be increased. Then, the requirement will not be met. If it is found that the motor speed doesn't meet requirements, the two wires of control voltage output can be exchanged.
6) Press 开 关 key, cut off outer diameter control and then start up and implement trial run.
7) Regulate the production line stably and observe the change process of outer diameter. After it is stable, press 开 关 key and connect outer diameter control, then three kinds of circumstances will emerge possibly.

   Situation 1: The wire diameter will approach the set nominal value (error is within 1%) (about 20 seconds), and there is no obvious fluctuation phenomenon. Then, the adjustment will be completed.

   Situation 2: The wire diameter will approach the set nominal value slowly. However, the time is long (more than 2min). Then, it is necessary to increase the proportionality coefficient P值 and integration coefficient I值 at this time.

   Situation 3 outer diameter fluctuates drastically and cannot reach stable status. At this time, it is necessary to reduce the proportionality coefficient P值 and integration coefficient I值. Repeatedly modify proportionality coefficient and integration coefficient until the situation 1 occurs. Then, the adjustment will be finished.

6.2.5 Notes for control

1) when outer diameter feedback control is used, its feedback control effect is only to provide "fine tuning" to the outer diameter. Therefore, it is necessary to adjust the coarse tuning of wire diameter to be near to the set value and stable, then press the key 

of controller and connect outer diameter control.

2) The effect of outer diameter feedback is to control the average value of outer diameter of wire on the set value. It cannot eliminate the fast change of outer diameter of wire, which is guaranteed by the stability on the production line.

3) If there is water in tested wire, the measured result includes the outer diameter value including water film on the surface. It is larger than the outer diameter of dry wire (about one wire). At this time, it is necessary to slightly increase the nominal value according to the practical experience.

6.2.6 Instrument state

* Normal state

1) Main display displays the outer diameter of tested object. The display range is: 00.000 mm～25.000mm;

2) Sub display displays deviation value (by modifying the parameter, the position value and jitter value can be displayed);

3) When the outer diameter value is within allowed tolerance range, the indicator lamp 

is on, which indicates the wire is normal.

4) When the outer diameter value exceeds the upper tolerance, the indicator lamp 

is on, which indicates the wire is too thick.

5) When the outer diameter value exceeds the lower tolerance, the indicator lamp 

is on, which indicates the wire is too thin.

6) When automatic feedback control is opened, the indicator lamp 

will be on, which indicates the feedback is opened.

7) When automatic feedback control is closed, the indicator lamp 

will be on, which indicates the feedback is opened.

* Abnormal state

1) When main display displays 

, it indicates the password is wrong (check the password is correct or not;
2) When main display displays 

, it indicates the communication is wrong (check whether the communication wire is normal);
3) When main display displays 

, it indicates the communication is wrong (check whether the communication wire is normal);
4) When main display displays 

, it indicates the motor fault (report to the after-sale service personnel).

VII. Communication

Standard asynchronous serial interface is adopted for bus of controller and RS232485 of remote controller. The real-time diameter value can be obtained and internal parameter can be modified through this interface (please refer to the following table).

Data format: 1 start bit, 8 data bits and 1 stop bit. Odd-even check can be selected according to ^3 parameter.

7.1 LST communication format

Standard asynchronous serial interface is adopted for bus of controller and RS232485 of remote controller. The real-time diameter value can be obtained and internal parameter can be modified through this interface (please refer to the following table).

R e a d p a r a m e t e r : address parameter

Diameter measuring instrument output: address & parameter two bits data and the high-order comes first, CRC is check code.

W r i t e p a r a m e t e r : address & parameter two bits data and the high-order comes first, CRC is check code.

CRC check code is the result value (1 bit) of all bits. 8-bit CRC code of CCITT will be adopted for CRC. Its generator polynomial is $G(x)=X_8+ X_5+ X_4+ 1$.

Example 2: read diameter value

Assuming the address of diameter measuring instrument is 1 (01 H). When the current diameter is 6.234 (185aH), then:

Input: 01H41H

Diameter measuring instrument output is: 01 H 4 1 H 1 8 H 5 a H C R C code

Example 2: read position value

Assuming the address of diameter measuring instrument is 1 (01 H). when the current position value is -05, then:

Input: 01H44H

Diameter measuring instrument output is: 01 H 4 4 H F F H F B H C R C code

Example 3: write reference diameter value

Assuming the address of diameter measuring instrument is 1 (01 H), the reference diameter value will be changed into 60.00 (1770H), then:

Input: 01H 66H 17H 70H CRC code

CRC calculation example: CRC code

Sending address: sci_txt[0]=01H; sending parameter: sci_txt[1]=41H

Sending data is higher than 8 bits: sci_txt[2]=18H; sending data is lower than 8 bits: sci_txt[3]=5AH. CRC value to be calculated: sci_txt[4]=2AH

Subroutine of Verify_CRC8 is as below:

n: indicates number of bit calculating CRC; crc: indicates initial CRC value; *p: indicates the data address of CRC.

```
unsigned char Verify_Crc8(unsigned char n,unsigned char crc,unsigned char *p){
unsigned char i,j,crc_buf;
    for(j=0;j<n;j++){
        crc_buf=*p++;
        for(i=0;i<8;i++){
            if (((crc^crc_buf)&0x01)==0){//Lowest bit is the same
                crc>>=1;
            }else{//Lowest bit is not the same
                crc^=0x18;
                crc>>=1;
                crc|=0x80;
            }
            crc_buf>>=1;
        }
    }
    return(crc);
}
```

For reading of other parameters, please observe the table

Read parameters		Write parameters		One-dimension	Two-dimension
ASCII	Hexadecimal	ASCII	Hexadecimal		
A	0X41	---------	---------	Read diameter	Read average diameter
B	0x42	---------	---------	---------	Read X-axis diameter
C	0X43	---------	---------	---------	Read Y-axis diameter
D	0X44	---------	---------	Read position	Read X-axis position
E	0X45	---------	---------	---------	Read X-axis position
F	0X46	f	0X66	Reference diameter	Reference diameter
G	0X47	g	0X67	Upper-deviation	Upper-deviation

H	0X48	h	0X68	Lower-deviation	Lower-deviation
K	0X4B	k	0X6B	Average times	Average times
L	0X4C	l	0X6C	P parameter	P parameter
M	0X4D	m	0X6D	I parameter	I parameter
N	0X4E	n	0X6E	D parameter	D parameter
S	0X53	---------	---------	Jitter value	Jitter value

Table 5

7.2 MODBUS RTU communication format

Asynchronous serial port is adopted for bus of controller and RS232/485 of remote controller. For communication, the master device on the bus of RS-485 firstly sends out order. When the communication order is sent to the instrument, the equipment meeting corresponding address code will receive the communication order. If there is no error, it will execute the corresponding task and send the execution result to the sender. The returned information includes: address code, function codes of execution action, the data and wrong check code (CRC) after execution action. If there is no error, it will not send any information.

7.2.1 Information frame format

START	initial structure	delay (transmission time with ≥3.5 bit)
ADDR	address code	1 byte (8 bits)
CS	function code	1 byte (8 bits)
DATA	data area	N byte (N×8 bits)
CRC	Wrong check	2 bytes (16 bits)
END	end structure	delay (transmission time with ≥3.5 bit)

7.2.2 Initial and end structure

Initial structure symbolizes the beginning of a data frame while the end structure symbolizes the ending of a data frame, generated by the sender of data frame. The method: reduce the bus of RS-485 to the transmission time with 3.5 bytes. All data bytes of a data frame should be sent continuously. If the interval with transmission time of 1.5 bytes emerges in certain data frame, it will be abandoned as invalid frame.

At receiving terminal, once the bus idle of 3.5-byte transmission time is detected, it assumes that a new data frame begins. However, during receiving data frame, once the bus idle of 3.5-byte

transmission time is detected, it assumes that the data frame is received. If the bus idle of transmission time with byte larger than 1.5 and smaller than 3.5 during receiving the data frame is detected, the data frame will be abandoned as invalid frame. Then, the next initial structure will restart.

7.2.3 Address code

Address code is the first data byte in information frame sent by the communication every time. Standard Modbus RTU protocol supports slave address code 1-247. Allowable address code range of LST-XXJ outer diameter measuring instrument is 01-6F. It can be set through panel of instrument. For setting methods, please refer to the section 3.4.

7.2.4 Function code

Function code is the first data byte in information frame sent by communication every time. The function code defined by Modbus RTU communication protocol is 1-127 (0x01-0x7F). The following function codes are used for LST-XXJ outer diameter measuring instrument:

03 read holding register read register content with one or many continuous address

06 write single register write first 16-bit data into register

7.2.5 Data area

(1) 03 function (read holding register) data area of request frame includes four bytes:

Byte 3: initial address of register (high byte)

Byte 4: initial address of register (low byte)

Byte 5: quantity of register (high byte)

Byte 6: quantity of register (low byte)

After request order is normally executed, the returned response frame data area includes 2N+1 bytes (N: quantity of register)

Byte 3: number of bytes of follow-up data (=2N)

Byte 4～3+2N: N registers' value (high byte comes first, followed by the low byte)

（2）06 function (write single register) data area of request frame includes four bytes

Byte 3: register address (high byte)

Byte 4: register address (low byte)

Byte 5: Register value to write (high byte)

Byte 6: Register value to write (low byte)

After the request order is normally executed, the returned response frame data area is completely the same with the request frame.

7.2.6 Exceptional response frame

If the abnormality occurs to the slave when executing request order, an exceptional response frame will be returned. Its structure is:

START	initial structure	delay (transmission time with ≥3.5 bytes)
ADDR	address code	1 byte, the address of slave
ES	poor & error code	1 byte, = original function code +128 (decimal system) or +80h (hexadecimal)
EC	exception code	1 byte
CRC	error checkout	2 bytes (16 bits)
END	end structure	delay (transmission time with ≥3.5 bytes)

In which poor & error code=original function code = original function code +128 (decimal system) or +80h (hexadecimal). For example, for function request 03, its poor & error code= 83h (hexadecimal). The definition of exception code: 01= function code that is not supported; 02=wrong address of register; 03=data error; 04=execution failure

7.2.7 CRC check

Modbus RTU communication protocol, CRC is used to control transmission error. Sender calculate CRC codes including address code, function code and data area and sent them by attaching them to the data (CRC code contains two bytes. The low byte shall be firstly sent). The receiver shall recalculate CRC check code after receiving the data frame, and compare it with the received one. If equivalent, the data frame is valid. Conversely, if not equivalent, it assumes that the data frame is invalid.

Calculation method of CRC: preset 1 16-bit register, and then calculate continuous 8 bytes in the message. Note: only 8 data bits in character participates in calculation of generated CRC. Start bit, stop bit and odd-even check bit don't participate in calculation of CRC. During generation of CRC, every 8-bit character is different from the value in register, then move the result to the direction of LSB by one bit while MSB position is zeroed. Then, extract and check LSB: if LSB=1, conduct exclusive-or calculation of value in register with a fixed prevalue (binary system 1010 0000 0000 0001 or hexadecimal: A001h). If LSB=0, don't conduct it. This process will be repeated until 8 times' shift is executed (one byte). After last times' (8^{th} times) shift and related operations are completed, the next exclusive-or calculation of 8-bit byte with the current value of register will be implemented. Then, repeat it for 8 consecutive times like the abovementioned content. When bytes in message are calculated, the final value in register is obtained, namely CRC code. That is, the process of CRC generation is:

(1) Load 1 16-bit register into hexadecimal FFFFh (1), called CRC register.

(2) Conduct exclusive-or calculation of the first 8-bit byte of the message with low byte of

16-bit CRC register. The result shall be put into CRC register.

(3) Shift CRC register towards right (towards direction of LSB), MSB shall be zeroed. Extract and detect LSB.

(4) If LSB=0: repeat step (3) and begin shift for another times.

If LSB=1, conduct exclusive-or calculation of CRC register and constant value A001h (1010 0000 0000 0001)

(5) Repeat step 3 and 4, until 8th times' shift is finished. By then, the operation of the byte is finished.

(6) Repeat step 2-5 for the next byte in message; continue the operation until all messages are processed.

(7) Final content in CRC register is CRC check code.

7.2.8 Examples of information frame

Assuming the address of outer diameter measuring instrument (slave) is 01, all data shall be indicated with hexadecimal.

(1) Read measured outer diameter value

Request frame: 01 03 00 61 00 01 d5 d4

Response frame: 01 03 02 XX YY RR RR

In which, XX and YY are high and low bytes of measured outer diameter. RR RR are CRC check codes of 2 bytes. Thereupon concluded: measured outer diameter value= 256×(XX) + (YY). Unit is micronmeter (um).

(2) Read nominal value of outer diameter

Request frame: 01 03 00 65 00 01 94 15

Response frame: 01 03 02 XX YY RR RR

In which, XX and YY are high and low bytes of measured outer diameter. RR RR are CRC check codes of 2 bytes. Thereupon concluded: measured outer diameter value= 256×(XX) + (YY). Unit is micronmeter (um).

(3) Wire nominal value of outer diameter

Requirement: write nominal value of outer diameter=6.000 mm = 6000 um (hexadecimal=1770h) into the instrument

Request frame: 01 06 00 65 17 70 97 c1

Response frame: 01 06 00 65 17 70 97 c1

7.2.9 Register address distribution

Only read parameter		One-dimension	Two-dimension	Only read parameter		One-dimension	Two-dimension
Address	Combined address			Address	Combined address		
0x01	40002	Instrument specification code		0x5E	40095	Feedback control status	
0x02	40003	Software version		0x5F	40096	Tested wire location	
0x03	40004	Instrument configuration		0X61	40098	Measured outer diameter value	Read average outer diameter
0x5A	40091	Instrument status		0X62	40099	Working condition of instrument	
0x5B	40092	alarm		0X63	40100	X-axis measured outer diameter value	
0x5D	40094	Feedback control output		0X64	40101	Y-axis measured outer diameter value	
Read parameter		One-dimension	Two-dimension	Read parameter		One-dimension	Two-dimension
Address	Combined address			Address	Combined address		
0X65	40102	Reference diameter		0x6D	40110	Y-axis deviation	
0X66	40103	Upper deviation		0X78	40121	Feedback work mode	
0X67	40104	Lower deviation		0X79	40122	P parameter	
0X6B	40108	Y-axis reference diameter		0X7A	40123	I parameter	
0X6C	40109	Y-axis deviation		0X92	40147	Alarm output setting	

Table 6

VIII. Overall Dimensions

Appearance and installation dimension of all parts of laser diameter measuring instrument is as shown by the following diagram:

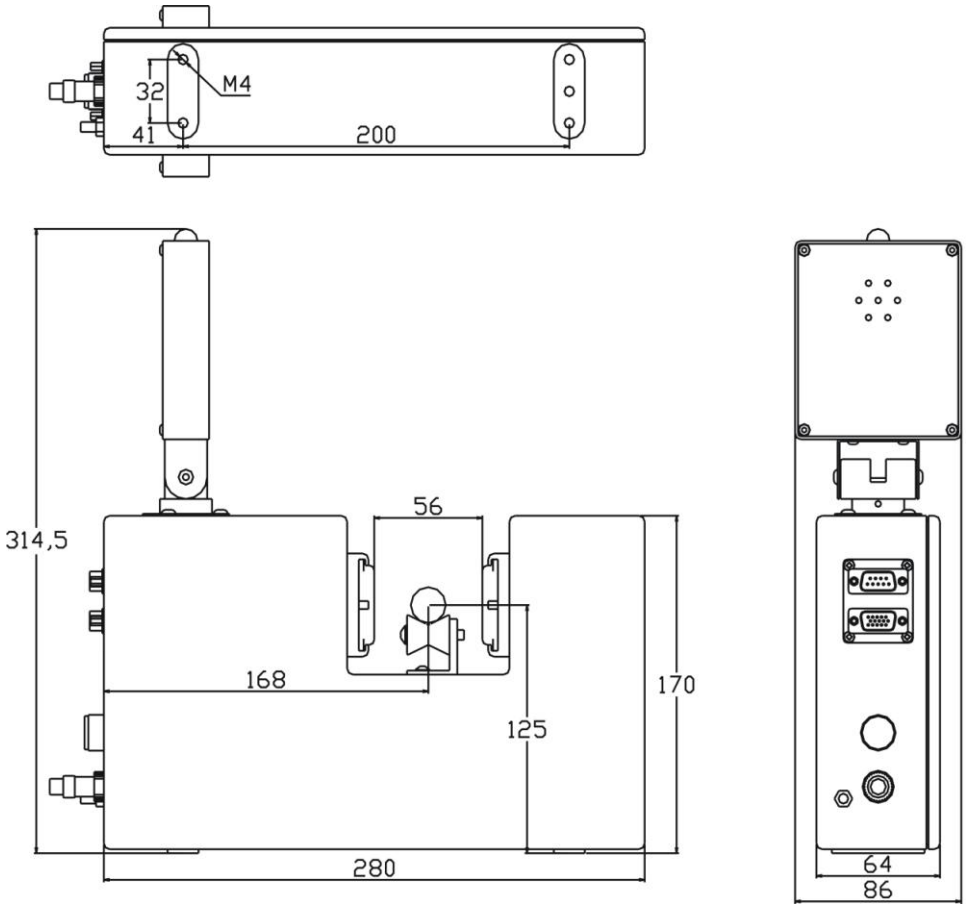


Fig. 8 (a) LST-25/JIB

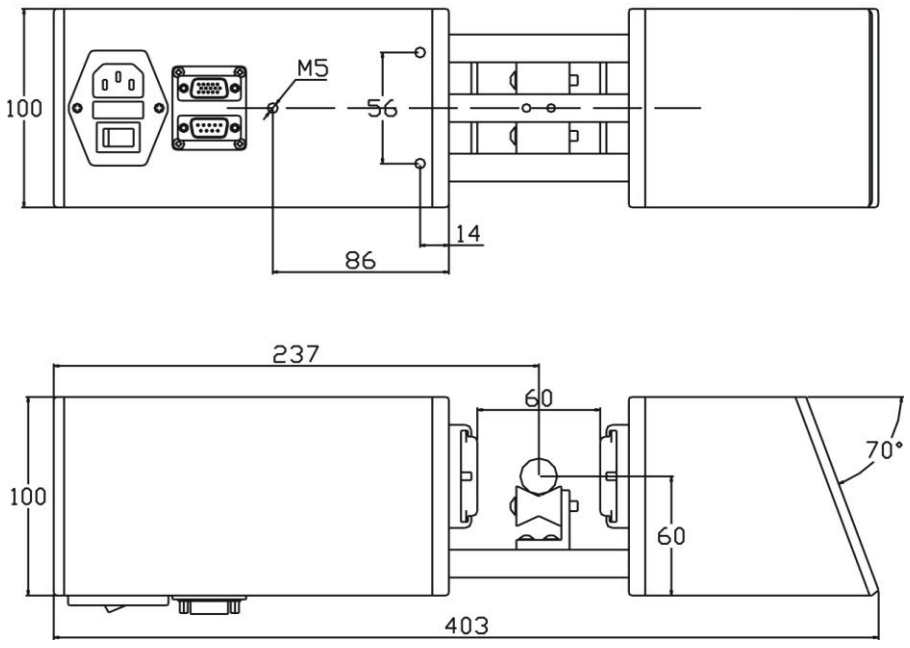


Fig. 8 (b) LST-25JIBN

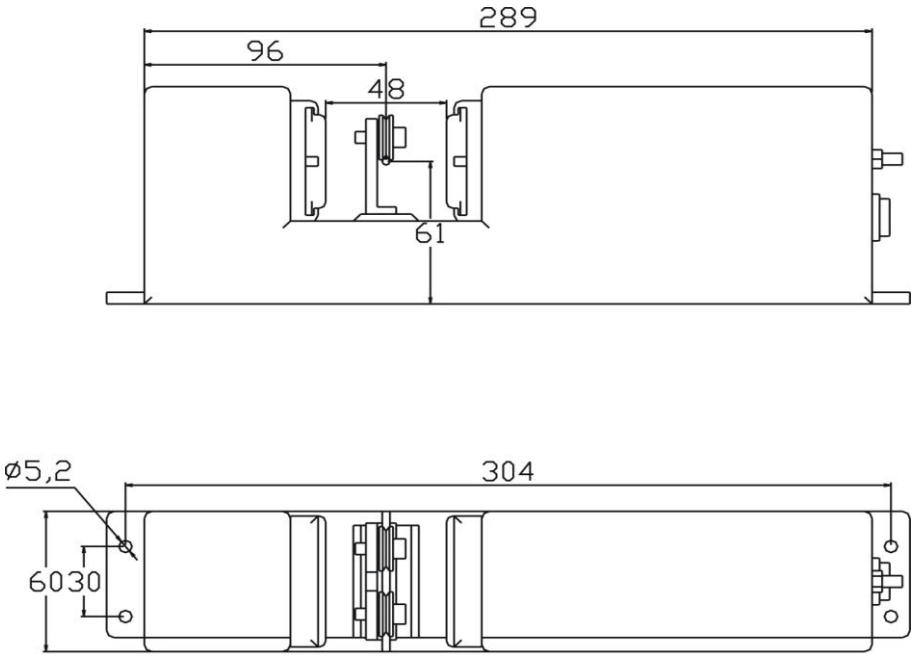


Fig. 8 (c) LST-25JIB-2

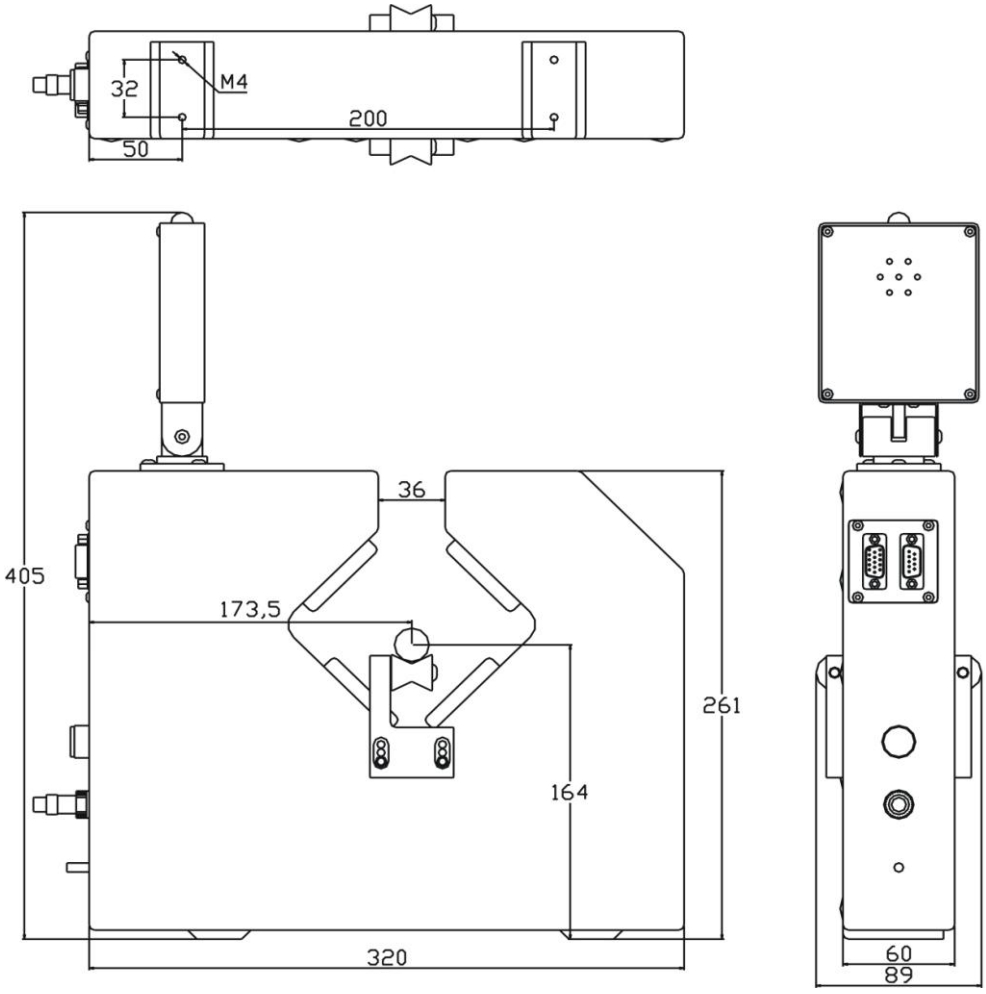


Fig. 8 (d) LST-25JIIB

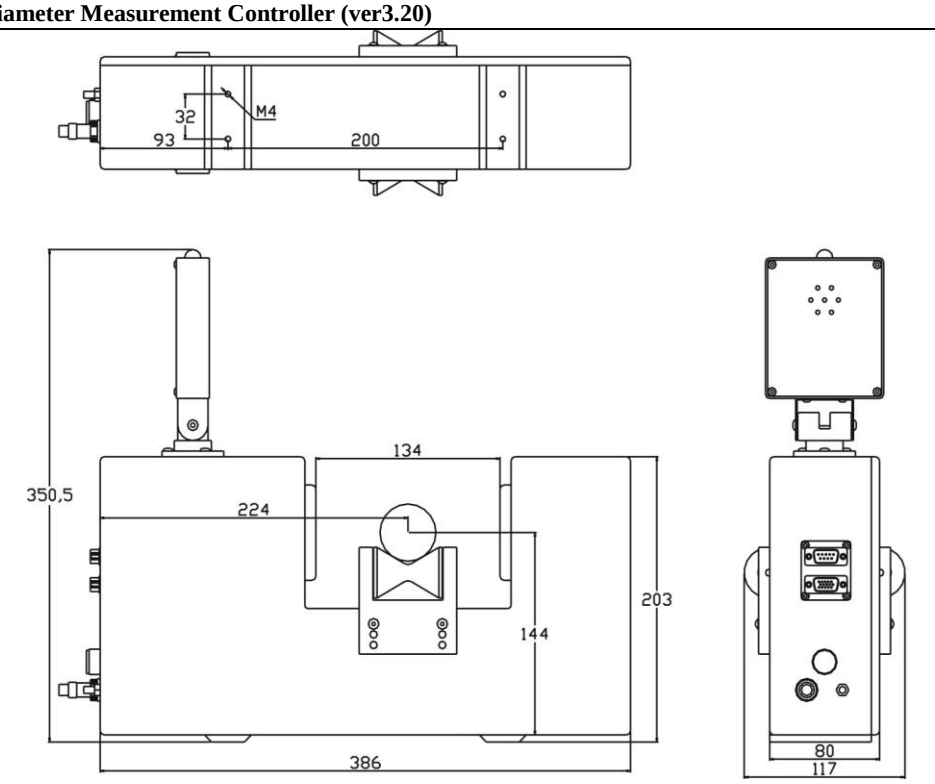


Fig. 8 (e) LST-40JIB

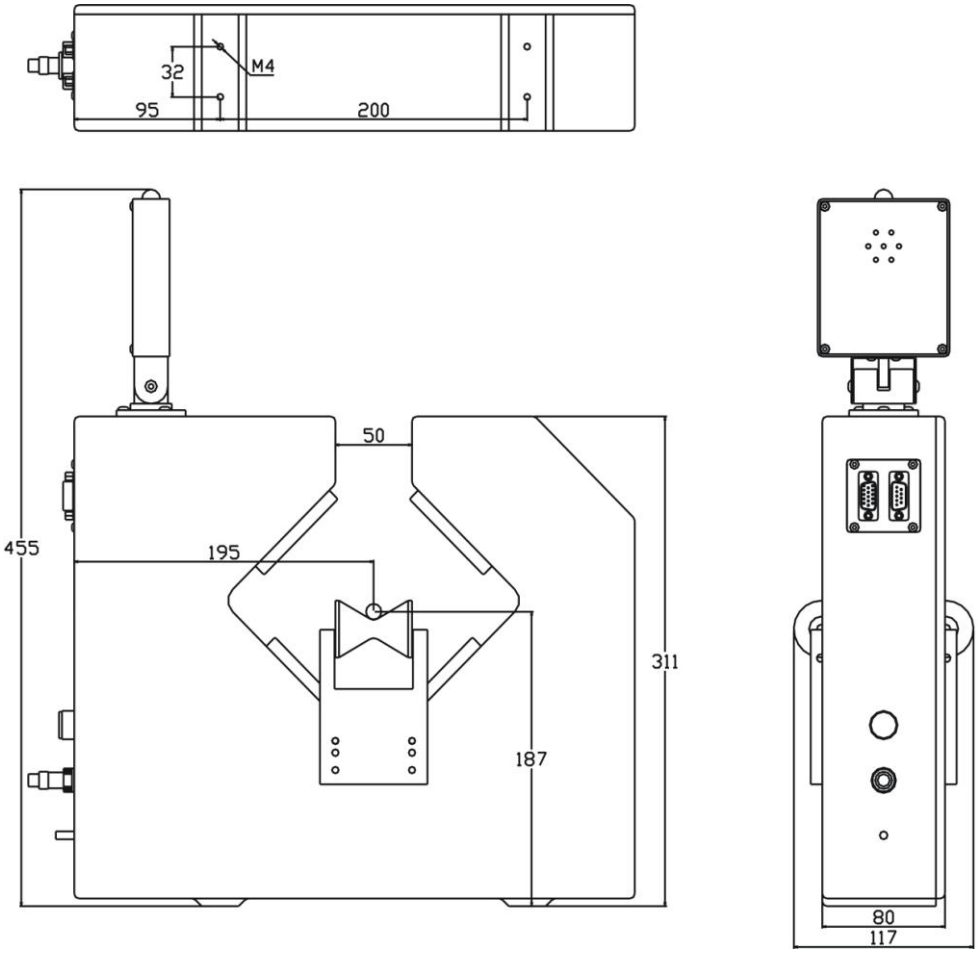


Fig. 8 (f) LST-40JIIB

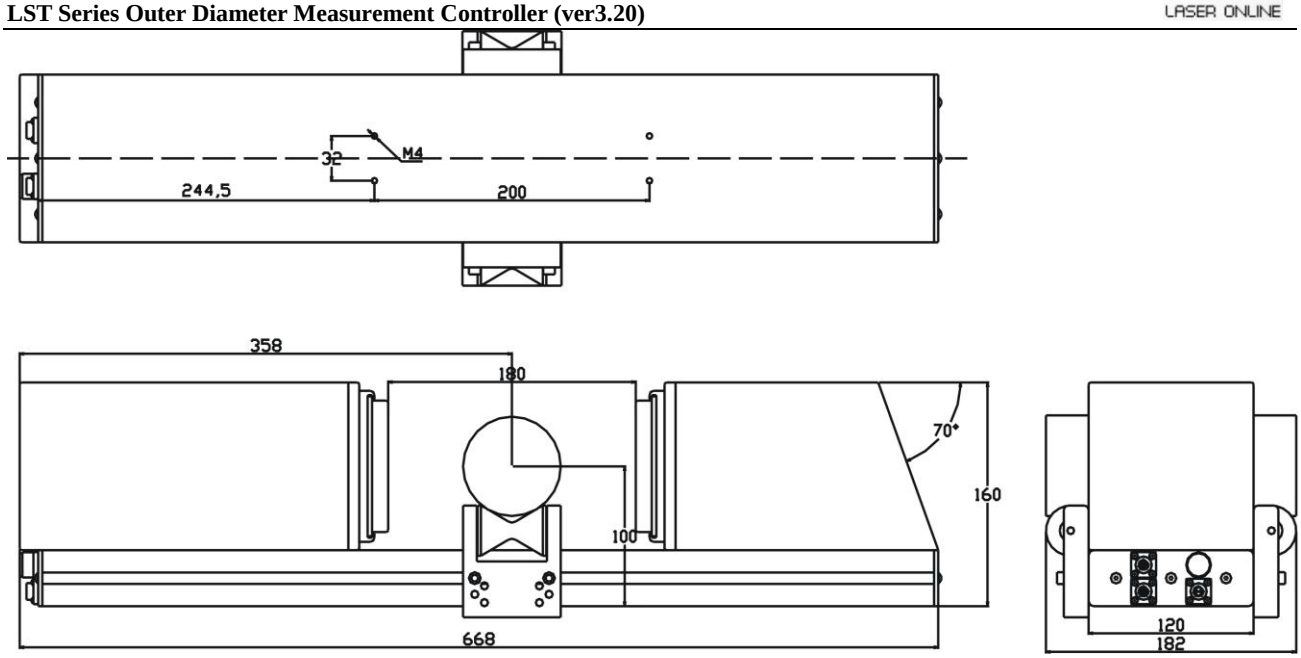


Fig. 8 (g) LST-70JIA

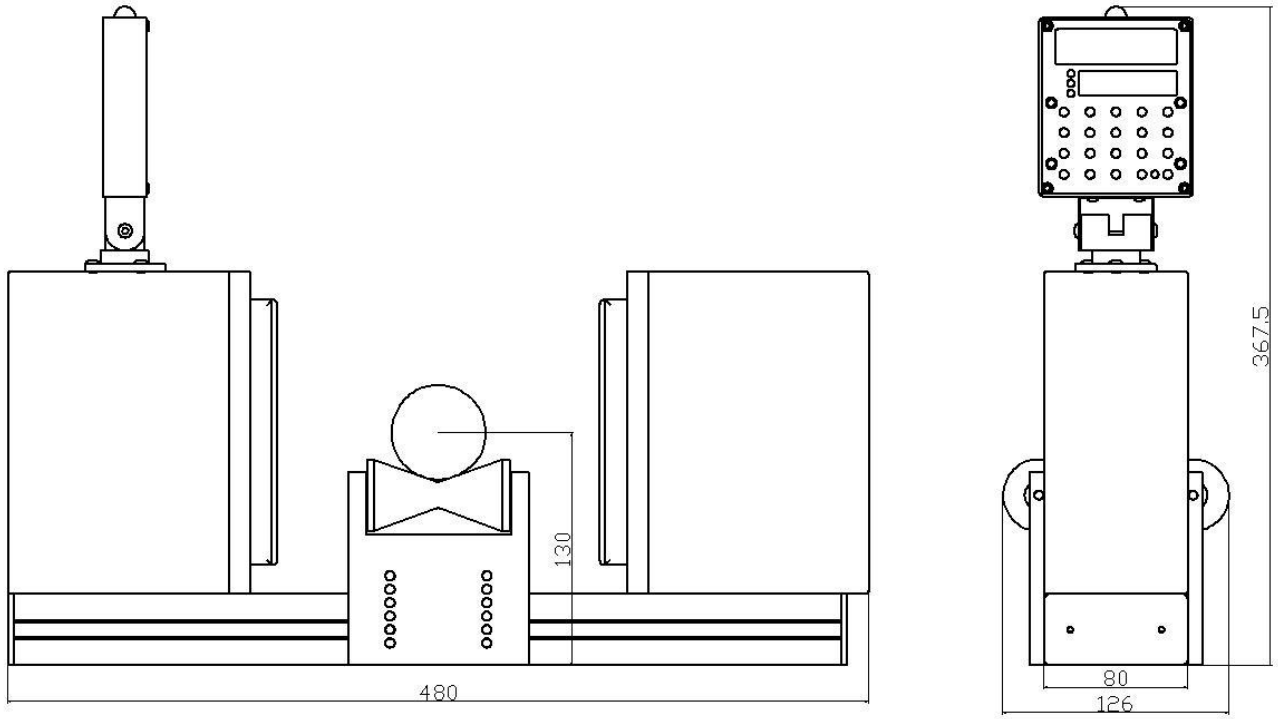


Fig. 8 (h) LST-100JIA

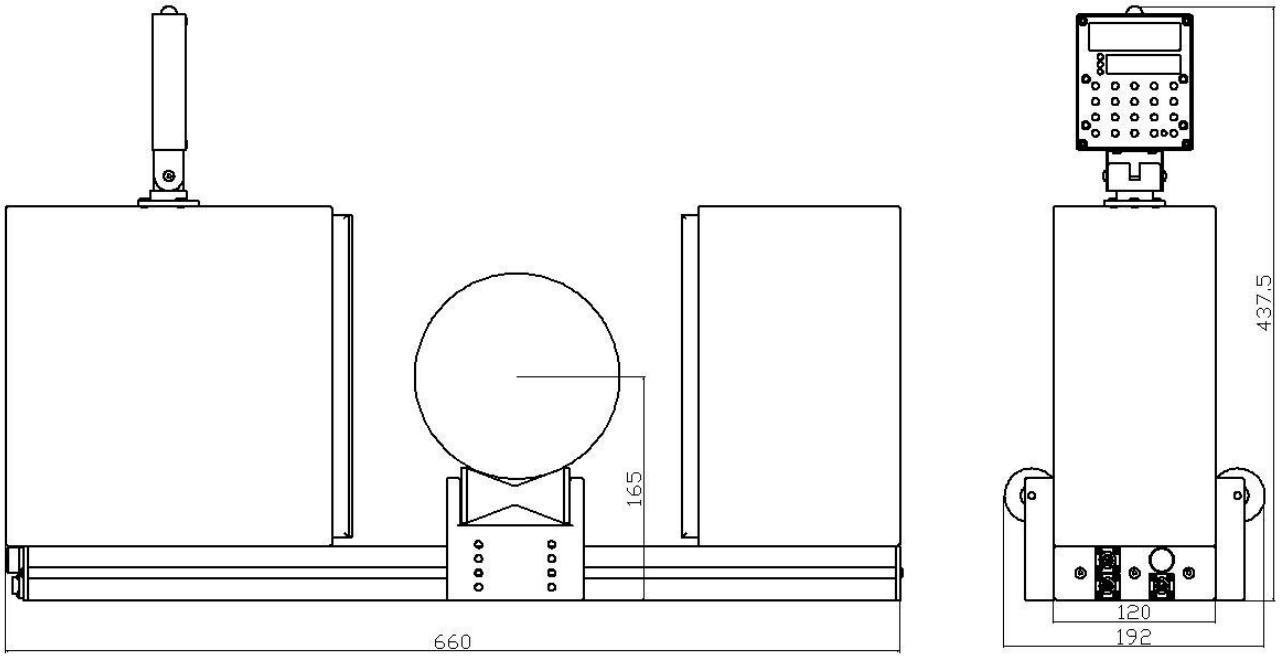


Fig. 8 (i) LST-200JIA

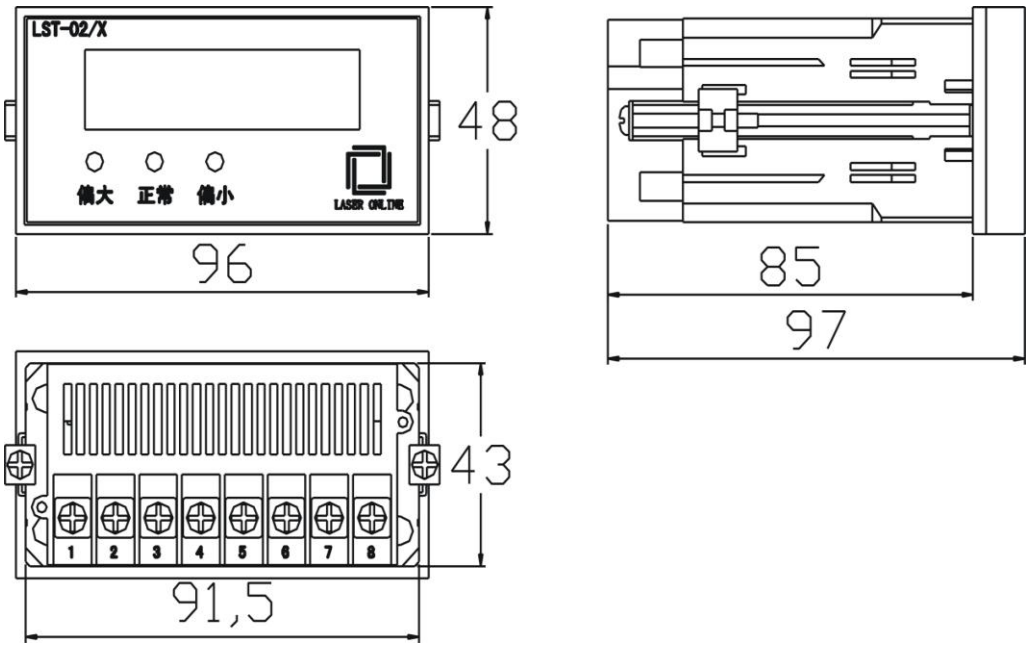


Fig. 8 (j) LST-02X

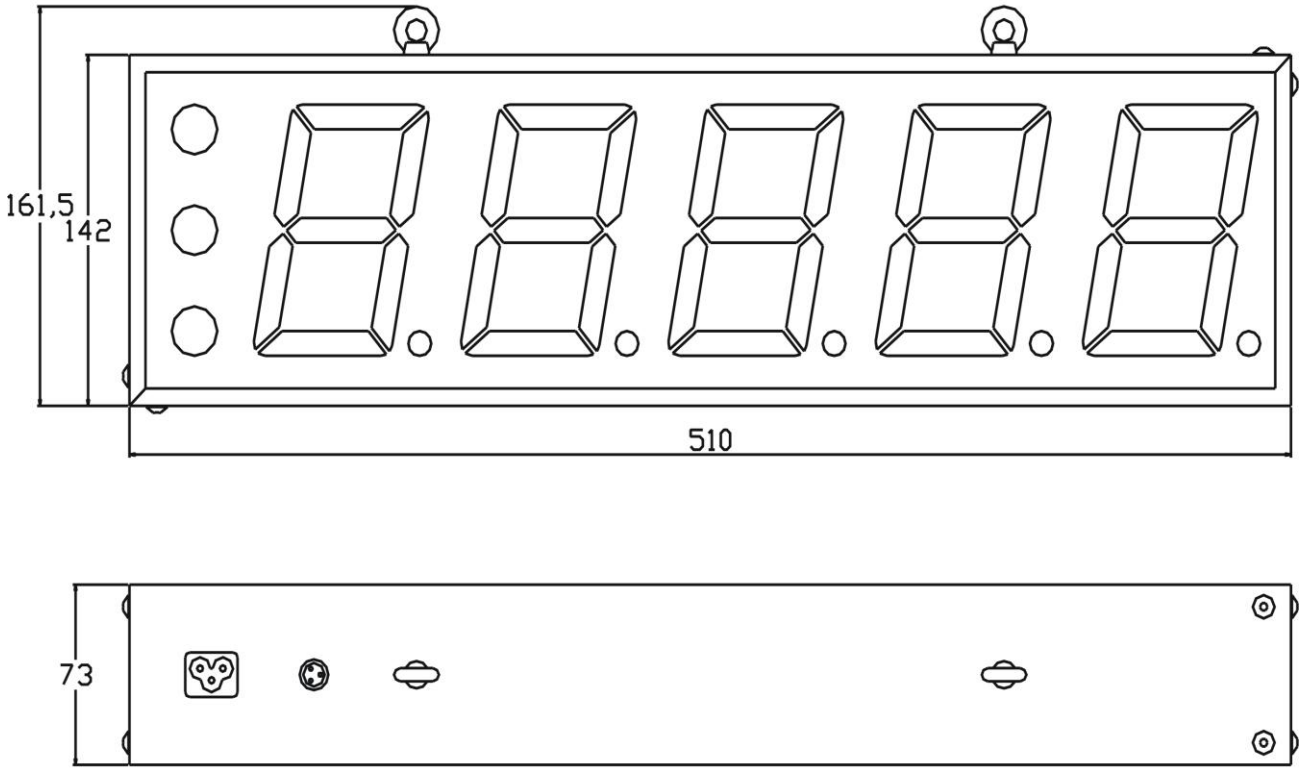


Fig. 8 (k) LST-03X

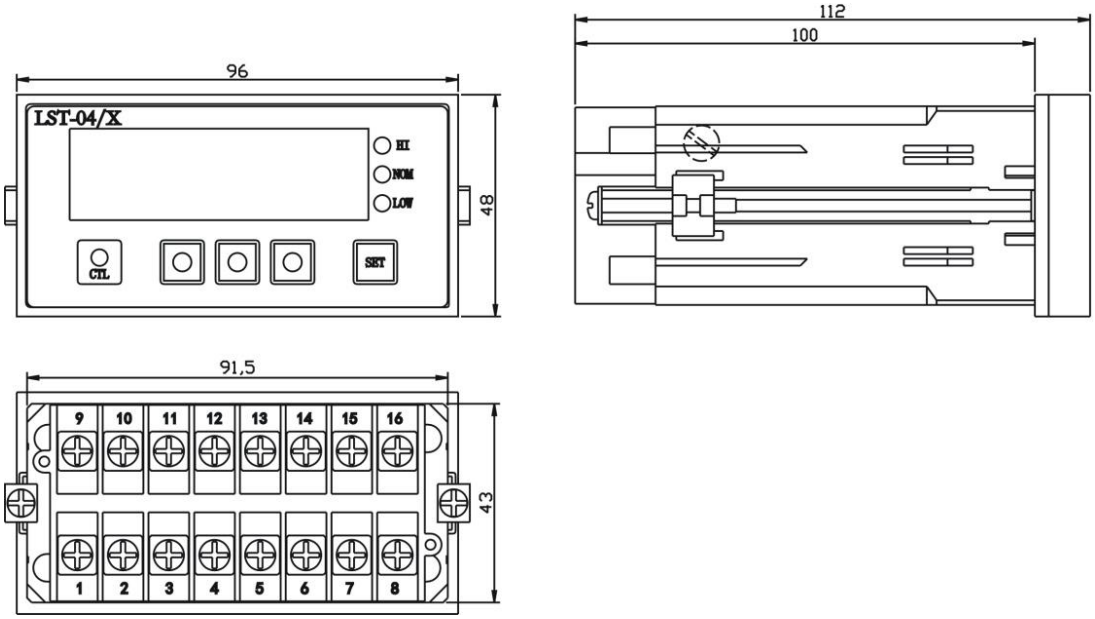


Fig. 8 (l) LST-04X

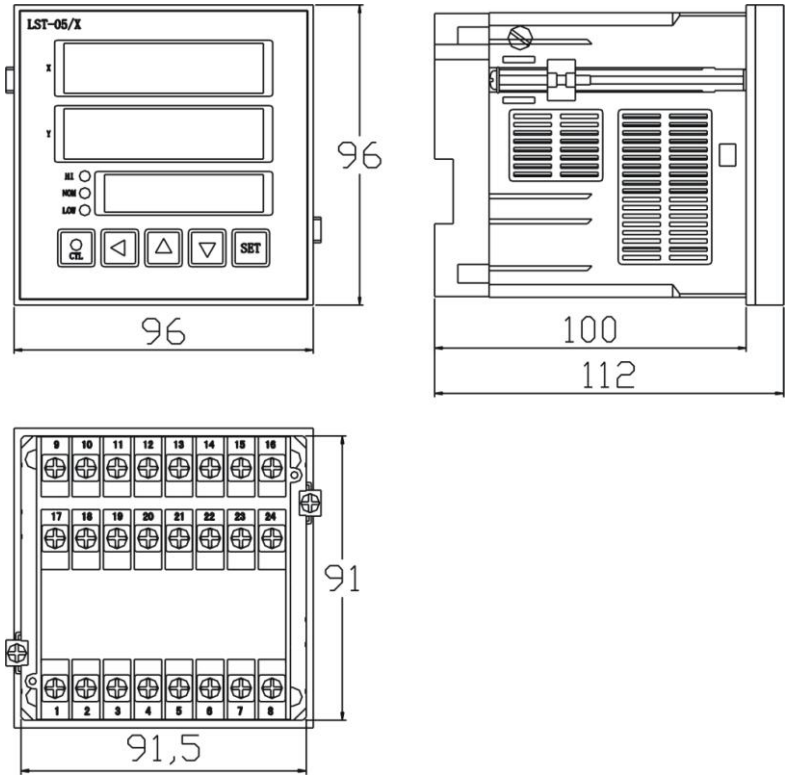


Fig. 8 (m) LST-05X

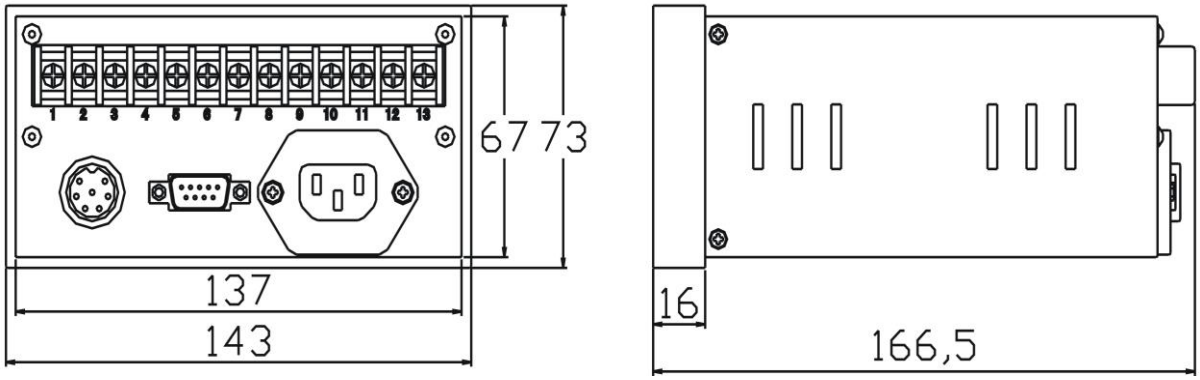


Fig. 8 (n) LST-08X

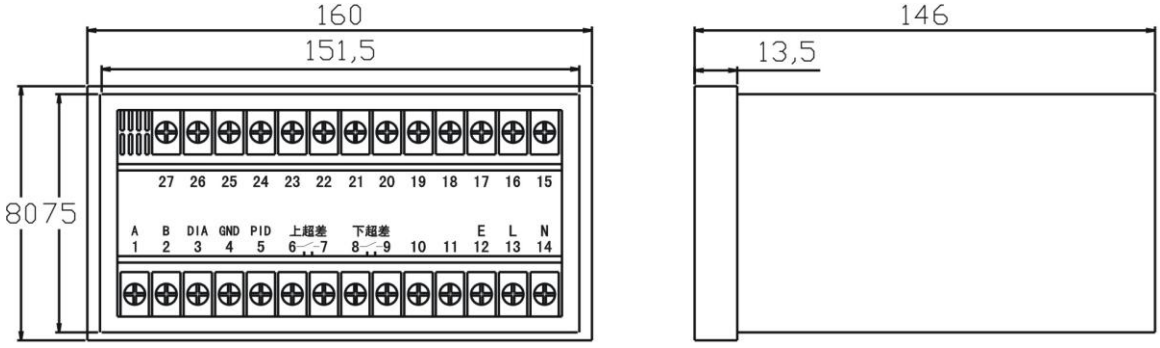


Fig. 8 (o) LST-09X

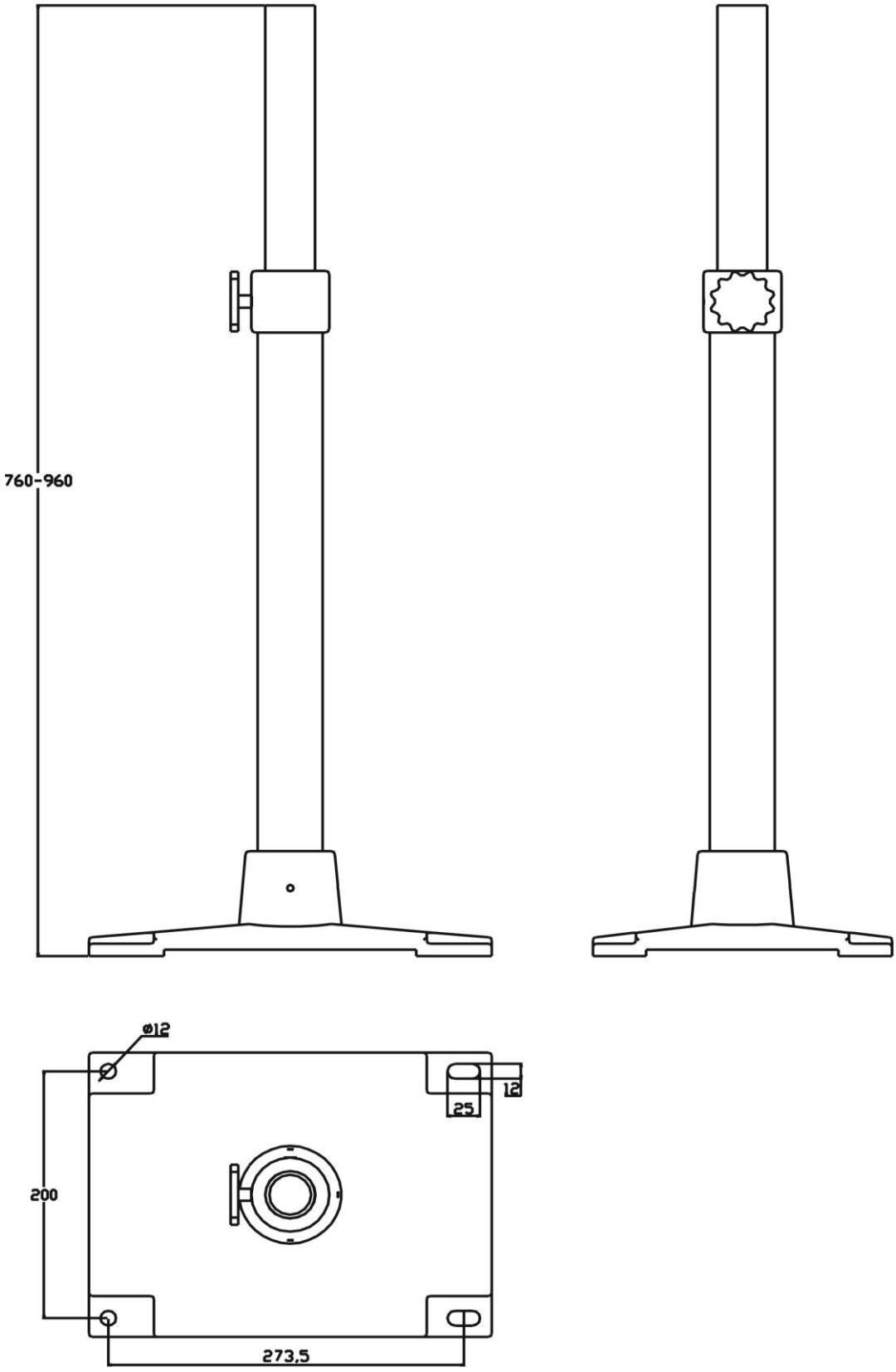


Fig. 8 (p) LST-ZJ

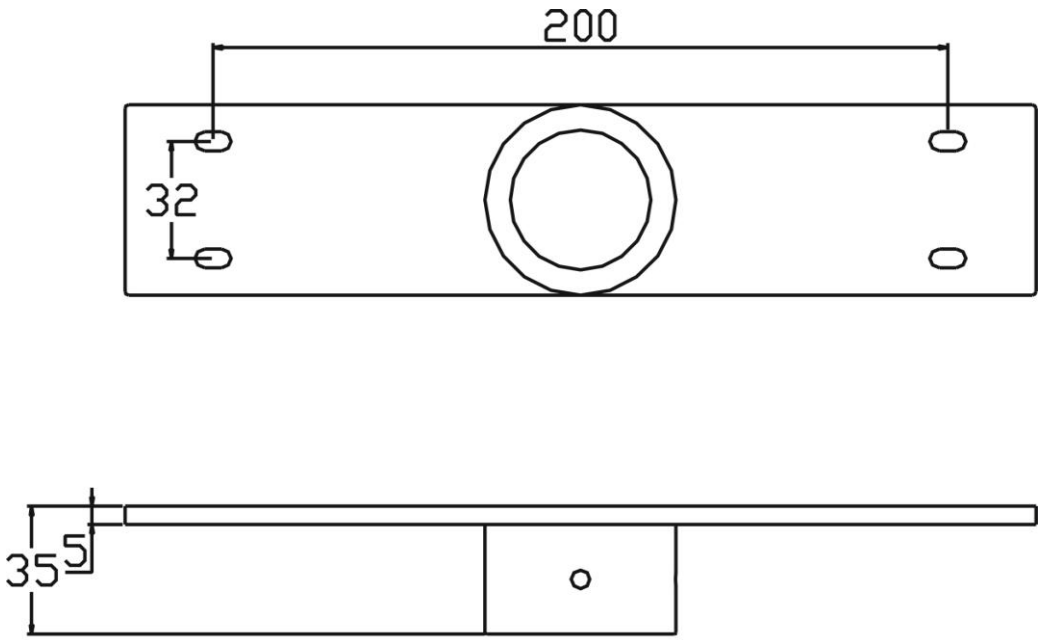


Fig. 8 (q) LST-TB1

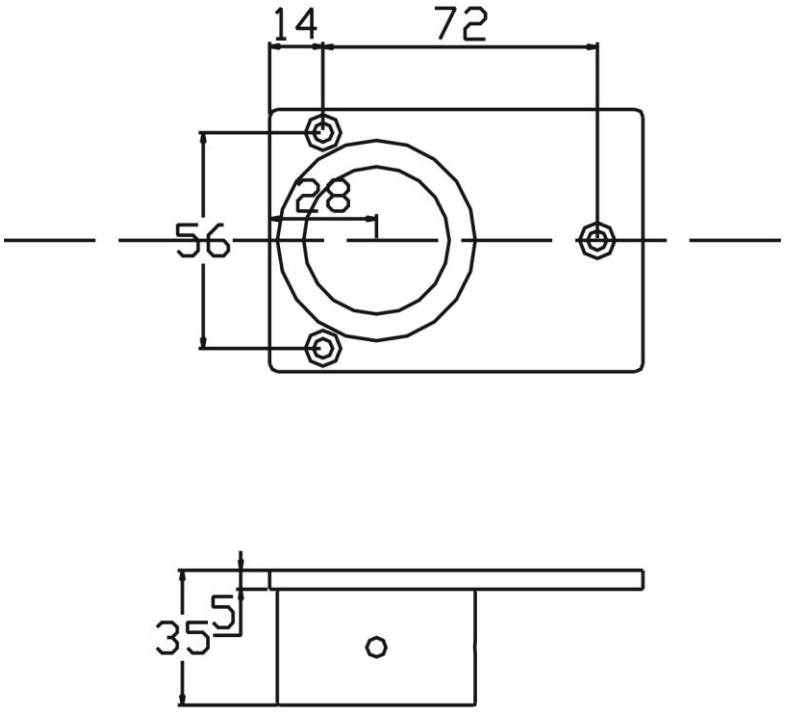


Fig. 8 (i) LST-TB2

IX. Maintenance

1) When using diameter measuring instrument, it is necessary to pay attentions and keep protective lens of light inlet clean. In case of oil stain and dirt, it shall be wiped out with lens paper.

2) When the diameter measuring instrument is used for wire production line, drying treatment shall be done after the wire comes out of the water thank to prevent the precision from being influenced due to the water or water drop on the surface of wire in the measurement zone.

3) The standard rod shall be degreased with gasoline or alcohol and wiped out with lens paper or absorbent cotton before use every time and it shall be coated with rust protection after use.

4) Input voltage of diameter measuring instrument shall be kept within 180～260V.

X. Accessories

Power line ----------1

Standard rod ----------1 piece

Cleaning ball ----------1

Lens paper ----------1 piece

Connecting cable (the length is configured according to the user requirement) ----------1 piece

Specification ----------1

Certificate of qualification ----------1

XI. After-sale Service

As of the date of shipment, in case of any faults in controller under the circumstance of rational storage and use within one year, our company will provide repair and exchange services. The right to interpret shall be reserved by our company.

In case of alteration of specification, the real object will prevail.