MICRO LINEAR SERVO ACTUATOR ELECTRICAL USER MANUAL (STANDARD)

(Applicable to LA, LAS, LAF, LASF and LAXC Series)

Beijing Inspire-Robots Technology Co., Ltd. | January 2024

ID: PRJ-01-ETS-U-004 | Page Number: 24 pages | Version: V1.8.3

Table of Contents

User Manual for Micro Linear Servo Actuator

(Applicable to LA, LAS, LAF, LASF and LAXC Series)

1 Product Overview

1.1 Product Introduction

The Micro Linear Servo Actuator is a micro integrated linear servo system, which is integrated with a core-less motor, a planetary reducer, a screw structure, a sensor and a drive controller. It has the function of position closed-loop control with feed-forward compensation.

Technical Features:

- Drive and control integrated design
- Small size, high power density and high repeatability
- Communication and mechanical interfaces:

Electrical interfaces:

D: Type-D interface is used for LVTTL 3.3 V serial port communication. The Micro Linear Servo Actuator with Type-D interface has a configurable ID, and multiple Micro Linear Servo Actuators with different ID can be controlled via serial buses. The default ID is 1, and the communication baud rate is 921600bps, with 1 start bit, 8 data bits, and 1 stop bit, no parity.

P: The Micro Linear Servo Actuator with Type-P interface is compatible with the standard actuator interface and supports PWM control signals of 50 Hz and 333 Hz.

2: The Micro Linear Servo Actuator with the RS485 interface has a configurable ID, and multiple Micro Linear Servo Actuators with different ID can be controlled via serial buses. The default ID is 1, and the communication baud rate is 115200bps, with 1 start bit, 8 data bits, and 1 stop bit, no parity.

Mechanical interfaces: There are abundant optional mechanical interface modes, which is convenient for users to install.

- Wide power supply range: DC 7 V to 9 V power supply is available, and 8 V is recommended. **12 V power supply is also available to specific products. Communication with the technical engineer is required.**
- Overheating and overcurrent protection

1.2 Product Series

The Micro Linear Servo Actuator has five series for option:

LA Series: The center of rotation for the motor and the screw structure is in a straight line. It is featured by the slender overall configuration and a small cross-sectional area.

LAS Series: The center of rotation for the motor and the screw structure is not in a straight line and is arranged in parallel by gear transmission. It is featured by a shorter overall length and a slightly larger cross-sectional area.

LAXC Series: With the appearance identical to LA Series, the center of rotation for the motor and the screw structure is in a straight line; the screw has the planetary screw structure. It is featured by the slender overall configuration and a small cross-sectional area.

LAF Series: On the basis of LA series, a force sensor and corresponding signal acquisition and filtering algorithm are added to detect the force applied to the Micro Linear Servo Actuator. (The acquisition of the force sensor data is specifically described in Section 3.5.4 "Single Control Instruction".)

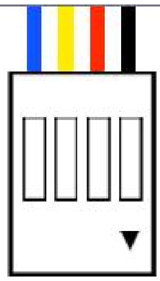
LASF Series: On the basis of LAS series, a force sensor and corresponding signal acquisition and filtering algorithm are added to detect the force applied to the Micro Linear Servo Actuator. (The acquisition of the force sensor data is specifically described in Section 3.5.4 "Single Control Instruction".)

Figure 1: Four Series of Micro Linear Servo Actuator (LAXC pictures to be added)

1.3 Electric connection

Type-D electric control interface of the actuator is a standard 4-pin DuPont female connector with a 2.54 mm pitch. The definition is shown as follows:

Pin NO.	Color	Signal
1	Black ■	GND
2	Red ■	VCC
3	Yellow ■	R X
4	Blue ■	T X

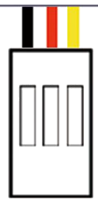


Pin NO	Color	Signal	Voltage
1	Black	GND	0 V
2	Red	VCC	7-9 V (maximum range: 7-10 V); damage due to overvoltage, low voltage without motion
3	Yellow	R X	0-3.3 V (risk of damage in case of 5 V)
4	Blue	T X	0-3.3 V (risk of damage in case of 5 V)

Figure 2: Electrical Interface Diagram of the Actuator with Type-D Control Interface

Type-P electric control interface of the actuator is a standard 3-pin DuPont female connector with a 2.54 mm pitch. The definition is shown as follows:

	Pin NO.	Color	Signal
PWM	1	Black ■	GND
	2	Red ■	VCC
	3	Yellow ■	PWM

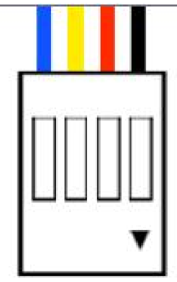


Pin NO	Color	Signal	Voltage
1	Black	GND	0 V
2	Red	VCC	7-9 V (maximum range: 7-10 V); damage due to overvoltage, low voltage without motion
3	Yellow	R X	0-3.3 V (risk of damage in case of 5 V)

Figure 3: Electrical Interface Diagram of the Actuator with Type-P Control Interface

Type 2 electric control interface of the actuator is a standard 4-pin DuPont female connector with a 2.54 mm pitch. The definition is shown as follows:

Pin NO.	Color	Signal
1	Black ■	GND
2	Red ■	VCC
3	Yellow ■	A+
4	Blue ■	B-



Pin NO	Color	Signal	Voltage
1	Black	GND	0 V
2	Red	VCC	7-9 V (maximum range: 7-10 V); damage due to overvoltage, low voltage without motion 12 V power supply is also available to specific models. Confirmation with the technical engineer is required.
3	Yellow	A+	0-3.3 V (positive terminal for the differential signal of RS485)
4	Blue	B-	0-3.3 V (negative terminal for the differential signal of RS485)

Figure 4: Electrical Interface Diagram of the Actuator with Type 2 Control Interface

2 PWM Control Interface

Definition of nouns：

PWM	Pulse Width Modulation
PWM frequency	The number of times a signal goes from high level to low level and back to high level in 1 second
PWM period	1 / PWM frequency
Pulse width time	The time of high level in 1 PWM cycle
duty ratio	Pulse width time / PWM period

The P-type interface is the PWM control interface, which adopts a fixed signal period (supporting PWM frequency of 50Hz or 333Hz), and achieves the purpose of displacement control by adjusting the pulse width time. The PWM reference waveform is as follows:

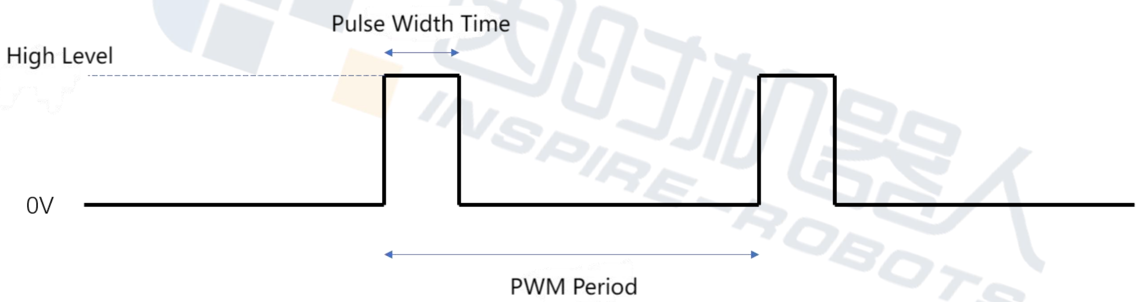


Figure 5: Periodic PWM Waveform Diagram

The linear relationship between pulse width time and stretching displacement is shown in the figure below:

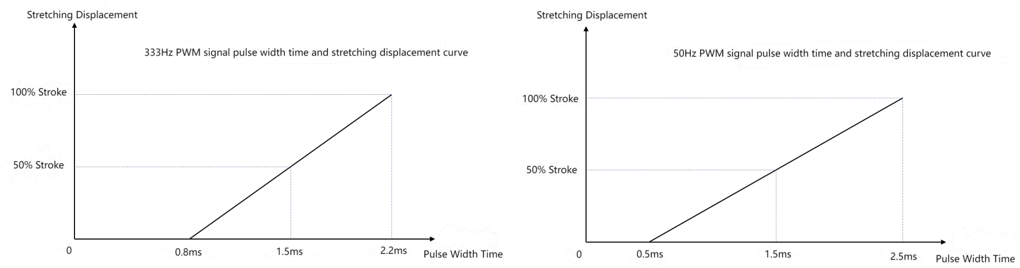


Figure 6: PWM signal pulse width time and stretching displacement curve

333Hz： Stretching displacement = (5/7 * Pulse width time – 4/7) * stroke

50Hz： Stretching displacement = (1/2 * Pulse width time – 1/4) * stroke

Note: Since the pulse width of the PWM signal is adjusted once every 1 period, the minimum time interval for adjusting the displacement must be greater than or equal to 1 PWM period.

The relationship between the high-level holding duration of PWM control signals for the Micro Linear Servo Actuator with this control interface and the actuator stroke is stated below:

333 Hz PWM control signal		
Pulse width	Stroke: 10 mm	Stroke: 16 mm
0.8 ms	0 mm	0 mm
1.52 ms	5 mm	8 mm
2.2 ms	10 mm	16 mm

50 Hz PWM control signal		
Pulse width	Stroke: 10 mm	Stroke: 16 mm
0.5 ms	0 mm	0 mm
1.5 ms	5 mm	8 mm
2.5 ms	10 mm	16 mm

3 UART Control Interface

3.1 UART communication mode

The Micro Linear Servo Actuator has a bus interface. Theoretically, it can support up to 254 actuators mounted on one bus; these actuators are under the uniform control of the full-duplex universal asynchronous receiver/transmitter (UART) interface with LVTTL 3.3 V level. The actuators mounted on the same bus need to be configured with different ID for communication control.

The communication instruction set of actuators is open to the product users. Actuators can be connected with users' PC (controller or general computer) via the UART interface with LVTTL 3.3 V level. Users can perform parameter configuration, condition monitoring, motion control, and other actions on actuators.

Any equipment with such UART interface with LVTTL 3.3 V level that complies with the communication protocol can communicate with such actuator, configure and control it. Both communication modes below can be adopted:

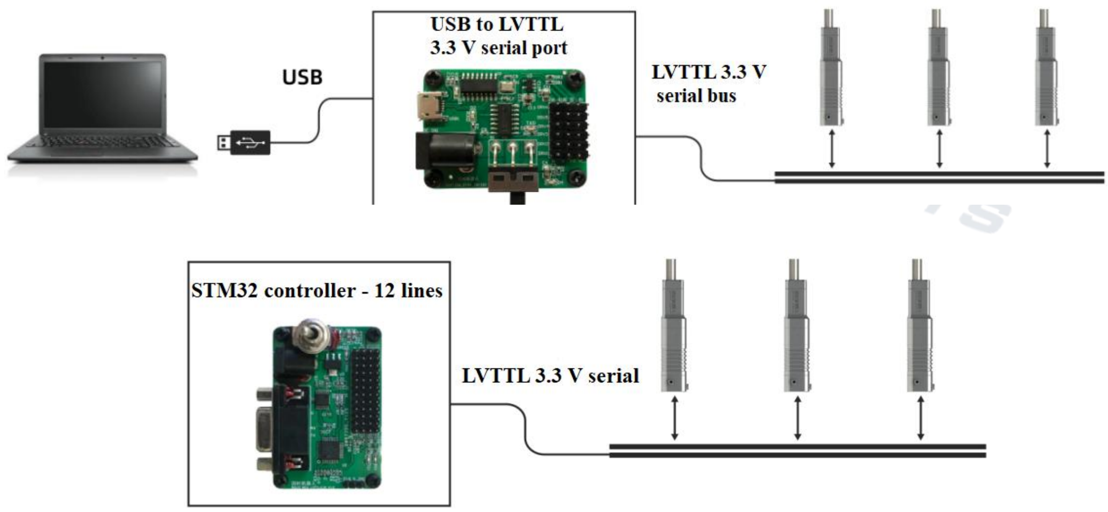


Figure 7: Communication Mode Diagram

Mode 1: Controlling via the PC control software

Insert the standard USB-LVTTL 3.3 V serial port module into the USB interface of the general computer; and then it can be identified as serial device. Operate the PC control software supplied with the Micro Linear Servo Actuator. This software can send the communication protocol-compliant packet to the Micro Linear Servo Actuator via the serial port. After receiving a correct instruction, the Micro Linear Servo Actuator can analyze it, complete the corresponding instruction requirement, and then return the response packet. In this way, the performance parameters of the Micro Linear Servo Actuator can be debugged conveniently and quickly, easily achieving the optimum operation effect.

Mode 2: Controlling via the special embedded controller

The Micro Linear Servo Actuator uses the full-duplex standard universal asynchronous receiver/transmitter (UART) with LVTTL 3.3 V (VCC: 3.3 V; VOH≥2.4 V; VOL≤0.4 V; VIH≥2V; VIL≤0.8V). Compared to the half-duplex mechanism, its receiver/transmitter port is independent. Users can control the communication with the Micro Linear Servo Actuator only by using the standard USB-LVTTL 3.3 V serial port module, with no need to design a half-duplex driver, which facilitates users' integrated debugging and testing. If it is connected with an embedded device, it should be ensured that the standard level of serial port signals is LVTTL 3.3 V.

3.2 Summary of UART Communication Protocol

Q&A communication is used between the control unit and actuators. The control unit automatically sends the instruction frame; after receiving the instruction frame, actuators will return the response frame after resolution.

In one control network, a control unit is allowed to connect and control multiple actuators, so each actuator needs to be configured by the user with a different ID as unique identifier. The data volume of the instruction frame sent by the control unit includes the ID information. The actuators can completely receive the instruction frame only if the ID matches, and will return the corresponding response frame after processing the instruction.

The communication mode is the universal asynchronous receiver/transmitter (UART) with LVTTL 3.3 V level. The unit of the instruction frame is byte. A single byte consists of 10 bits, including a start bit, 8 data bits and 1 stop bit, no parity.

3.3 Instruction frame

Format of basic instruction frame:

Frame header (FH) (2 B)		Frame length (1 B)	ID (1 B)	Instruction type (1 B)	Control table index (1 B)	Data segment (N B)	Checksum (1 B)
0x55	0xAA	Length	ID	CMD	Index	B1 - BN	Check Sum

Frame header (FH): Continuous receipt of 0x55 and 0xAA indicates arrival of the instruction frame.

Frame length: Length = N + 2; N is the length of the data segment to be sent (instruction type and control table index).

ID: Each actuator has an ID. The range of ID is from 0x01 to 0xFE (hexadecimal number), i.e., 1 to 254. The ID for broadcast is 255 (0xFF). If the ID sent by the controller is 255 (0xFF), all actuators will receive the instruction frame, without returning any response message.

Instruction type: This specifies the type of the instruction frame.

Control table index: If the instruction frame involves the control table, it indicates the starting index address of the control table to be operated.

Data segment: Data content sent with the instruction frame. The data segment of the read instruction has only one byte, which indicates the byte length of the memory control table to be read. The data segment of the write instruction is the content of the memory control table to be written.

Checksum: 8 low-order bytes of the sum of all data before checksum in the frame except the frame header (2 bytes)

3.4 Response frame

3.4.1 Format of response frame

The response frame of the Micro Linear Servo Actuator adopts the pitch-catch configuration in the normal communication control mode.

Format of response frame:

Frame header (FH) (2 B)		Frame length (1 B)	ID (1 B)	Instruction type (1 B)	Control table Index (1 B)	Data segment (N B)	Checksum (1 B)
0xAA	0x55	Length	ID	CMD	Index	B1 - BN	Check Sum

Frame header (FH): Continuous receipt of 0xAA and 0x55 indicates arrival of the instruction frame.

Frame length: Length = N + 2; N is the length of the data segment to be sent (instruction type and control table index).

ID: Each actuator has an ID. The range of ID is from 0x01 to 0xFE (hexadecimal number), i.e., 1 to 254. The ID for broadcast is 255 (0xFF). If the ID sent by the controller is 255 (0xFF), all actuators will receive the instruction frame, without returning any response message.

Instruction type: It specifies the type of the instruction frame corresponding to this response frame.

Control table index: If the response frame involves the control table, it indicates the starting index address of the control table to be operated.

Data segment: Data content sent with the response frame. The data segment of the read instruction is the data content to be read by the control unit; that of the write instruction is the preserved content of 1 byte.

Checksum: 8 low-order bytes of the sum of all data before checksum in the frame except the frame header (2 bytes)

3.4.2 Response time

The minimum response time corresponding to the response frame of the Micro Linear Servo Actuator is 120 us. As it may be interrupted by the control task (800 us), the maximum response time is 800 us. It is recommended to control the instruction interval above 1 ms during use.

3.5 Instruction type

The type of instruction frame is shown below:

Instruction type	**Function description**	**Values**	**Length of data segment**
CMD_RD (read instruction)	Data query in the control table	0x01	1
CMD_WR (write instruction)	Data writing into the control table	0x02	Not less than 2
CMD_WR_DRV (write instruction for motion control)	Positioning mode (feedback of status information)	0x21	2
	Positioning mode (no feedback)	0x03	2
	Follow-up mode (feedback of status information)	0x20	2

	Follow-up mode (no feedback)	0x19	2
	Positioning mode of broadcast (no feedback) containing N actuator position information	0xF2	3*N (N≤15)
	Follow-up mode of broadcast (no feedback) containing N actuator position information	0xF3	3*N (N≤15)
CMD_MC (single control instruction)	Realizing the function control of actuators	0x04	1

3.5.1 Read instruction

Function: The control unit reads the data message of the specified length starting from the index position in the actuator control table.

Length of instruction frame: 8

Instruction value: 0x01

Parameter 1: The first position of the index to be read in the control table;

Parameter 2: The number of bytes to be read in the control table

For example, when the control unit reads the information from the parameter configuration area of the control table of an actuator with the ID of 1, the instruction frame to be sent is shown below.

Frame header (FH) (2 B)		Frame length (1 B)	ID (1 B)	Instruction Type (1 B)	Control table Index (1 B)	Data segment (N B)	Checksum (1 B)
0x55	0xAA	0x03	0x01	0x01	0x62	0x02	0x69

The instruction frame sent is "55 AA 03 01 01 62 02 69", where "55 AA" is the frame header (FH); "03" is the length of frame data; "01" is the ID; another "01" is CMD_RD (read instruction); "62" is the first address (temperature value for over temperature protection *10) in the data segment of the control table already read; "02" is the number of bytes in the data segment already read; "69" is checksum, i.e., low-order bytes of the sum of all bytes before checksum in the instruction frame except the frame header. When this instruction frame is sent to an actuator, the response frame returned is shown below.

Frame header (FH)	Frame length	ID (1 B)	Instruction Type	Control table	Data segment (N B)	Checksum (1 B)

(2 B)		(1 B)		(1 B)	Index (1 B)		
0xAA	0x55	0x04	0x01	0x01	0x62	0x58 0x02	0xC2

The specific response frame received is "AA 55 04 01 01 62 58 02 C2", where "AA 55" is the response frame header; "04" is the data length; "01" is the ID; another "01" is the instruction type; "62" is the first address (temperature value for over temperature protection *10) in the data segment of the control table already read; the byte information of 0x0258 is the data segment information in the control table already read (in order of low-order bytes followed by high-order bytes, 0x0258=600, i.e., 60 ℃ indicates the temperature value for over temperature protection); "C2" is the last byte (i.e., checksum) and indicates low-order bytes of the sum of all data before checksum except the response frame header.

3.5.2 Write instruction

Function: The control unit writes the data message of the specified length starting from the index position into the actuator control table.

Length of instruction frame: varied

Instruction value: 0x02

Parameter 1: The first position of the index to be written into the control table;

Parameter 2: The data message to be written into the control table

For example, when the control unit writes the parameter information into the control table of an actuator with the ID of 1, the instruction frame to be sent is shown below.

Frame header (FH) (2 B)		Frame length (1 B)	ID (1 B)	Instruction Type (1 B)	Control table Index (1 B)	Data segment (N B)	Checksum (1 B)
0x55	0xAA	0x04	0x01	0x02	0x37	0x14 0x05	0x57

The specific instruction frame sent is "55 AA 04 01 02 37 14 05 57", where "55 AA" is the frame header (FH); "04" is the length of frame data; "01" is the ID; "02" is CMD_WR (write instruction); "37" is the first address (target position) written into the data segment of the control table; "14 05" is the content of the data segment (0x0514=1300; the target position is set to 1300) written into the control table; "57" is checksum, i.e., low-order bytes of the sum of all bytes before checksum in the instruction frame except the frame header.

When this instruction frame is sent to an actuator, it will move to the target position and return the response frame. For the details about the response frame, refer to the feedback of the actuator status information for query in the single control instruction.

3.5.3 Write instruction for motion control

For motion control of actuators, the following types of instruction frame can be divided by the control mode and status response.

a) Positioning mode (feedback of status information)

Function: Modify the target position in the control table; plan the actuator mounting path to ensure that it can arrive at the destination point in the shortest time and return the actuator status information (refer to the feedback of the actuator status information for query in the single control instruction).

Length of instruction frame: 4

Instruction value: 0x21

Parameter 1: 0x37 (first address of the target position)

Parameter 2: Target position

For example, when the control unit sends the target position in the positioning mode to an actuator with the ID of 1, the instruction frame to be sent is shown below.

Frame header (FH) (2 B)		Frame length (1 B)	ID (1 B)	Instruction Type (1 B)	Control table Index (1 B)	Data segment (N B)	Checksum (1 B)
0x55	0xAA	0x04	0x01	0x21	0x37	0x14 0x05	0x76

The specific instruction frame sent is "55 AA 04 01 21 37 14 05 76", where "55 AA" is the frame header (FH); "04" is the length of frame data; "01" is the ID; "21" is the write instruction for motion control in the positioning mode (feedback of status information); "37" is the first address of the target position written into the control table; "14 05" is the content of the data segment (0x0514=1300; the target position is set to 1300) written into the control table; "76" is checksum, i.e., low-order bytes of the sum of all bytes before checksum in the instruction frame except the frame header. When this instruction frame is sent to an actuator, it will move to the target position as per the path plan and return the response frame. For the details about the response frame, refer to the feedback of the actuator status information for query in the single control instruction.

b) Positioning mode (no feedback)

Function: Modify the target position in the control table; plan the actuator mounting path to ensure that it can arrive at the destination point in the shortest time, with no frame returned.

Length of instruction frame: 4

Instruction value: 0x03

Parameter 1: 0x37 (first address of the target position)

Parameter 2: Target position

For example, when the control unit sends the target position in the positioning mode to an actuator with the ID of 1, the instruction frame to be sent is shown below.

Frame header (FH) (2 B)		Frame length (1 B)	ID (1 B)	Instruction Type (1 B)	Control table Index (1 B)	Data segment (N B)	Checksum (1 B)
0x55	0xAA	0x04	0x01	0x03	0x37	0x14 0x05	0x58

The specific instruction frame sent is "55 AA 04 01 03 37 14 05 58", where "55 AA" is the frame header (FH); "04" is the length of frame data; "01" is the ID; "03" is the write instruction for motion control in the positioning mode (without feedback); "37" is the first address of the target position written into the control table; "14 05" is the content of the data segment (0x0514=1300; the target position is set to 1300) written into the control table; "58" is checksum, i.e., low-order bytes of the sum of all bytes before checksum in the instruction frame except the frame header. When this instruction frame is sent to an actuator, it will move to the target position as per the path plan, with no response frame returned.

c) Follow-up mode (feedback of status information)

Function: In the follow-up mode, the user is required to send the target position to the actuator at a fixed time interval (10 ms to 50 ms) for trajectory tracking; the actuator will return the status information for each control instruction.

Length of instruction frame: 4

Instruction value: 0x20

For other parts, refer to the details in Item b).

d) Follow-up mode (no feedback)

Function: In the follow-up mode, the user is required to send the target position to the actuator at a fixed time interval (10 ms to 50 ms) for trajectory tracking; the actuator will not return the response frame.

Length of instruction frame: 4

Instruction value: 0x19

For other parts, refer to the details in Item c).

e) Positioning mode of broadcast (no feedback)

Function: Send the target position simultaneously to N actuators with different ID; as a result, one instruction can control the motion of multiple actuators simultaneously.

Length of instruction frame: 1+3*N (1≤N≤15)

Instruction value: 0xF2

For example, when the control unit sends the target position in the positioning mode to N Micro Linear Servo Actuators, the instruction frame to be sent is shown below.

Frame header (FH) (2 B)		Frame length (1 B)	ID for broadcast (1 B)	Location mark (1 B)	Actuator 1 ID (1 B)	Actuator 1 Target Position (2 B)	...	Actuator N ID (1 B)	Actuator N Target Position (2 B)	Checksum (1 B)
0x55	0xAA	1+3*N	0xFF	0xF2	0x**	0x****	...	0x**	0x****	0x**

f) Follow-up mode of broadcast (no feedback)

Function: Send the target position simultaneously to N actuators with different ID; as a result, one instruction can control the motion of multiple actuators simultaneously. In the follow-up mode, the user is required to send the target position to the actuators at a fixed time interval (10 ms to 50 ms) for trajectory tracking.

Length of instruction frame: 1+3*N (1≤N≤15)

Instruction value: 0xF3

For example, when the control unit sends the target position in the positioning mode to N Micro Linear Servo Actuators, the instruction frame to be sent is shown below.

Frame header (FH) (2 B)		Frame length (1 B)	ID for broadcast (1 B)	Location mark (1 B)	Actuator 1 ID (1 B)	Actuator 1 Target Position (2 B)	...	Actuator N ID (1 B)	Actuator N Target Position (2 B)	Checksum (1 B)
0x55	0xAA	1+3*N	0xFF	0xF3	0x**	0x****	...	0x**	0x****	0x**

3.5.4 Single control instruction

Function: The control unit sends control commands to actuators.

Length of instruction frame: 8

Instruction value: 0x04

Parameter 1: Preserved

Parameter 2: Information on single control instructions; the user can use the following single control instructions.

0x04: Work, i.e., enabling the motor power drive output;

0x23: Emergency stop, i.e., disabling the motor power drive output (motion is possible only after a work start instruction is sent, followed by a position command);

0x14: Suspension, i.e., disabling the motor power drive output (motion is possible after a position command is sent directly);

0x20: Parameter binding, i.e., binding and writing current operating parameters into the internal Flash;

0x22: Query of the actuator status information (BIT), including target position, current position, temperature, motor drive current, and abnormal information;

0x1E: Fault clearance: In case of actuator overcurrent, locked-rotor, or abnormal operation of the motor, this instruction can be used to clear the error code and restore the actuator to normal operation.

a) When the control unit sends the emergency stop command to an actuator with the ID of 1, the instruction frame to be sent is shown below.

Frame header (FH) (2 B)		Frame length (1 B)	ID (1 B)	Single control Instruction (1 B)	Parameter 1 (1 B)	Parameter 2 (1 B)	Checksum (1 B)
0x55	0xAA	0x03	0x01	0x04	Preserved	0x23	0x2B

The specific instruction frame sent is "55 AA 03 01 04 00 23 2B", where "55 AA" is the frame header (FH); "03" is the length of frame data; "01" is the ID; "04" is CMD_MC (write instruction); "XX" is the preserved byte; "23" is the single control instruction value (23 = emergency stop); "2B" is checksum, i.e., low-order bytes of the sum of all bytes before checksum in the instruction frame except the frame header. After this instruction frame is sent to the Micro Linear Servo Actuator, for the response frame returned, refer to the feedback of the actuator status information for query in the single control instruction.

b) When the single control instruction frame is sent to the Micro Linear Servo Actuator ("query of actuator status information"), the format of the response frame returned is as follows:

Frame header (2B)		B 0	0xAA
		B 1	0x55
Length of data volume (1B)		B 2	0x11
ID (1B)		B 3	0x**
Instruction type (1B)		B 4	0x04
Parameter 1 (1B)		B 5	0x00
Parameter 2 (1B)		B 6	0x22
Target position (16 bits unsigned integer data): 0x03EB (1000 in the decimal system)	Low-order byte	B 7	0xEB
	High-order byte	B 8	0x03
Current position (16 bits signed integer data): 0x03DE (990 in the decimal system)	Low-order byte	B 9	0xDE
	High-order byte	B 10	0x03
Actuator temperature (1B signed byte data): 0x14 indicates 20 ℃.		B 11	0x14
Current (16 bits unsigned integer data): 0x0064 (100 in the decimal system)	Low-order byte	B 12	0x64
	High-order byte	B 13	0x00
Force sensor value - low-order bytes (16 bits signed integer data in g): 0x01F4 (500 g in the decimal system) Note: For a non-force controlled type actuator, this value is of no significance.	Low-order byte	B 14	0xF4
Error messages (1B): If Bit0 is 1, it means protection from locked-rotor; if Bit1 is 1, it means over temperature protection; if Bit2 is 1, it means overcurrent protection; and if Bit3 is 1, it means abnormal operation of the motor.		B 15	0x**
Force sensor value - high-order bytes (16 bits signed integer	High-order byte	B 16	0x01

data in g): 0x01F4 (500 g in the decimal system) Note: For a non-force controlled type actuator, this value is of no significance.			
Internal Data 1 (16 bits unsigned integer data): 0x0708 (1800 in the decimal system) Note: For a non-force controlled type actuator, this value is of no significance.	Low-order byte	B 17	0x08
	High-order byte	B 18	0x07
Internal Data 2 (16 bits unsigned integer data): 0x070A (1802 in the decimal system) Note: For a non-force controlled type actuator, this value is of no significance.	Low-order byte	B 19	0x0A
	High-order byte	B 20	0x07
Checksum: low-order bytes of the sum of all data before checksum except the response frame header (B2+B3+…+B20）&0xFF)		B 21	0x**

3.6 Memory control table

The master controller in the Micro Linear Servo Actuator has a control table containing the actuator information and control parameters. It is stored respectively in the RAM and Flash of the master controller chip. At the system power-on, the master controller chip reads the control table from the Flash to the RAM. During actuator operation, the user reads and writes the control table in the RAM to obtain the actuator status information and control and operate the actuator.

The user can use the "Parameter Binding" instruction in the "CMD_MC" single control command, so that the master controller chip will copy the content of the current RAM table to the Flash and save parameters without loss after power failure.

The content of the control table is as follows:

Offset address	Name	Remarks	Perm ission	Default value
0 - 1	Header	Preserved	--	0xAA 0x55
2	ID of the actuator	1 - 254 255 is the broadcast address.	R/W	0x01
3 - 11	Preserved	Preserved	--	--
12	Baud rate of the serial port	0 - 19200; 1 - 57600; 2 - 115200; 3 - 921600	R/W	3
13 - 25	Preserved	Preserved	--	--

Offset address	Name	Remarks	Permission	Default value
26 - 27	Current position	-20 - 2020	R	--
28 - 30	Preserved	Preserved	--	--
31	Reference point calibration setting of force sensor	Setting Range 1 When 1 is written, the current data of the force sensor will be set as reference point.	R/W	0
32 - 33	Overcurrent protection setting	Setting Range: 300 - 1500 mA	R/W	1500
34 - 54	Preserved	Preserved	--	--
55 - 56	Target position setting	0 - 2000	R/W	--
57 - 75	Preserved	Preserved	--	--
76 - 77	Force sensor data	Data range [-32767, +32768]; unit: g	R	--
78 - 79	Original value of force sensor	Data range [0, 65535]; 12bitADC	R	--
80 - 89	Preserved	Preserved	--	--
98 - 99	Over temperature protection setting	Setting range, [(recovery temperature + 5), 80]; the input value is temperature * 10.	R/W	800
100 - 101	Recovery temperature setting	Setting range, [20, temperature for over temperature protection - 5] The input value is temperature * 10.	R/W	600
102 - 254	Preserved	Preserved	--	--

Parameter addresses are described below:

2: Actuator ID; if multiple actuators are connected in parallel, set a different ID for each actuator. After the setting of ID modification is successful, the new ID will be enabled immediately. The actuator will communicate with its new ID. If you want to fix the ID, please perform the "Parameter Binding" operation.

12: The default baud rate of the communication interface is 921600bps. After the baud rate setting of the serial port is modified, the "Parameter Binding" operation should be performed, and such setting will become effective at the next power-on.

32-33: Overcurrent protection parameter; when the current of an actuator exceeds this set value, the actuator will stop working and enter the overcurrent protection state. After 5s, the actuator will automatically exit the overcurrent protection state, enter the initial state for normal power-on and wait for an instruction. After it has entered the overcurrent protection state for three consecutive times, the actuator will maintain the protection state until it receives the resetting failure command; in that case, the actuator will exit the overcurrent protection state.

55-56: Target position of an actuator; range: 0-2000; the larger the data is, the larger the actuator extension will be.

98-99: Temperature value for over temperature protection as a parameter; when the internal temperature of an actuator exceeds this set value, the actuator will stop working and enter the over temperature protection state. When the temperature falls below the recovery temperature value, the actuator will enter the initial state for normal power-on and wait for an instruction.

100-101: Recovery temperature value as a parameter; when an actuator enters the over temperature protection state, it will stop working and can restore to normal operation only after its temperature falls below this value; then it will enter the initial state for normal power-on and wait for an instruction. The recommended difference between the temperature for over temperature protection and the recovery temperature value is not less than 20 ℃.

3.7 Examples of common instructions

3.7.1 Example 1 (Modify ID)

Change the ID of an actuator from 3 to 2.

Instruction frame: 55 AA 03 03 02 02 02 0C

Response frame: Consistent with the response frame returned by the instruction "query of actuator status information"

The ID will become effective immediately after modification. The ID for subsequent communication is the new ID. If power-off is required to save this new ID, the "Parameter Binding" operation should also be performed.

3.7.2 Example 2 (Target position setting)

a) Positioning mode (feedback of status information)

Set the target address of an actuator with the ID of 3 to 1000, and return the response frame containing the actuator status.

Instruction frame: 55 AA 04 03 21 37 E8 03 4A

Response frame: Consistent with the response frame returned by the instruction "query of actuator status information"

b) Positioning mode (no feedback)

Set the target address of an actuator with the ID of 3 to 1000, with no response frame returned.

Instruction frame: 55 AA 04 03 03 37 E8 03 2C

c) Follow-up mode (feedback of status information)

Set the target address of an actuator with the ID of 3 to 1000, and return the response frame containing the actuator status.

Instruction frame: 55 AA 04 03 20 37 E8 03 49

Response frame: Consistent with the response frame returned by the instruction "query of push rod status information"

d) Follow-up mode (no feedback)

Set the target address of an actuator with the ID of 3 to 1000, with no response frame returned.

Instruction frame: 55 AA 04 03 19 37 E8 03 28

Note: When a follow-up mode command is sent, the time interval for sending should be fixed. The recommended time interval is 10 ms to 50 ms. The smaller this value is, the smaller the following error will be.

3.7.3 Example 3 (Stop setting)

Enable the stop action of an actuator with the ID of 3.

Instruction frame: 55 AA 03 03 04 00 23 2D

Response frame: Consistent with the response frame returned by the instruction "query of actuator status information"

3.7.4 Example 4 (Operation setting)

Enable the operation action of an actuator with the ID of 3.

Instruction frame: 55 AA 03 03 04 00 04 0E

Response frame: Consistent with the response frame returned by the instruction "query of actuator status information"

3.7.5 Example 5 (parameter setting for over temperature protection)

Set the temperature value for over temperature protection of an actuator with the ID of 3 to 70.5 ℃ (the actual input is 705, with the magnification of 10X; the hexadecimal number is 0x02C1).

Instruction frame: 55 AA 04 03 02 62 C1 02 2E

Response frame: Consistent with the response frame returned by the instruction "query of actuator status information"

Set the temperature value for recovery operation of an actuator with the ID of 3 to 60.5 ℃ (the actual input is 605, with the magnification of 10X; the hexadecimal number is 0x025D).

Instruction frame: 55 AA 04 03 02 64 5D 02 CC

Response frame: Consistent with the response frame returned by the instruction "query of actuator status information"

When the internal temperature of an actuator exceeds the temperature value for over temperature protection, the actuator will stop working and cannot continue to operate until the temperature value falls below the set value for the recovery temperature.

Note: Temperature input range for over temperature protection [recovery temperature + 5 ℃, 80 ℃]; Temperature setting range for recovery [20 ℃, temperature for over temperature protection - 5 ℃]

3.7.6 Example 6 (parameter setting for overcurrent protection)

Set the value for overcurrent protection of an actuator with the ID of 1 to 1000 mA (the actual input is 1000; the hexadecimal number is 0x03E8).

Instruction frame: 55 AA 04 01 02 20 E8 03 12

Response frame: Consistent with the response frame returned by the instruction "query of actuator status information"

3.7.7 Example 7 (parameter binding setting)

Bind and write current parameters of an actuator with the ID of 3 into the internal Flash to ensure no parameter loss after power failure.

Instruction frame: 55 AA 03 03 04 00 20 2A

Response frame: Consistent with the response frame returned by the instruction "query of actuator status information"

3.7.8 Example 8 (acquisition of actuator status information)

Acquire the status information of an actuator with the ID of 1.

Instruction frame: 55 AA 03 01 04 00 22 2A

Response frame: Consistent with the response frame returned by the instruction "query of actuator status information"

3.7.9 Example 9 (fault clearance)

Clear error codes of an actuator with the ID of 1. In case of actuator overcurrent or locked-rotor, the fault clearance command can be used to clear the error code and restore the actuator to normal operation.

Instruction frame: 55 AA 03 01 04 00 1E 26

Response frame: Consistent with the response frame returned by the instruction "query of actuator status information"

3.8 Exception handling mechanism

The status inquiry command (BIT) in the single control instruction can be used to obtain error codes of an actuator, including over current protection, overcurrent protection, protection from locked-rotor, abnormal operation of the motor, etc.

When the actuator experiences over temperature protection, it will stop operations and such error cannot be cleared; after its temperature decreases to the recovery temperature value, it can be automatically restored to the initial state after power-on and will wait for a new instruction.

When the actuator experiences an overcurrent fault, just wait for 5 seconds and then the error will be cleared automatically; or the fault clearance command in the single control instruction can be used, and the actuator will be restored to the initial state after power-on and will wait for a new instruction. If the two errors before driving are automatically cleared to resume work, the normal operation of the actuator can be restored by the fault clearance command after the third error occurs.

If the actuator has a locked-rotor error, it can be handled in the same way as overcurrent fault.

When the actuator experiences abnormal operation of the motor, it means that the internal output of the actuator reaches the maximum value, but the actual current value acquired is 0. When the current value acquired is larger than 30 mA, the error code regarding the abnormal operation of the motor will be cleared automatically. Such error code can also be cleared by the fault clearance command in the single control instruction. Generally, this error code indicates that the service life of the actuator motor is to expire.