MICRO LINEAR SERVO ACTUATOR USER MANUAL FOR BLA SERIES (ELECTRICAL)

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Micro Linear Servo Actuator
User Manual for BLA Series (Electrical)

1 Product Overview

1.1 Product Introduction

The Micro Linear Servo Actuator (hereinafter referred to as the "Actuator") is a micro servo electric brushless push rod, which is integrated with a micro motor, a reducer, a screw structure, a high-precision absolute position sensor (no loss of position information after power failure; no need to return to zero position) and a drive control system (include the FOC control algorithm and the three closed-loop control of current, speed and position). It can realize the high-precision servo control of any position within the stroke range.

Features:

- Drive and control integrated design
- Small size, high power density, and high repeatability
- Diversified interfaces:
  Electrical interface: RS485 (compatible with Modbus RTU)
  Mechanical interfaces: There are abundant optional mechanical interface modes, which is convenient for users to install.
- Overheating and overcurrent protection

1.2 Electrical Interface

The interface uses the XH2.54 socket with plastic housing, with the pin pitch of 2.54 mm. The definition is shown as follows:

	Pin	Color	RS485 definition
	1	Red ■	VCC
	2	Black ■	GND
	3	Yellow ■	A+
	4	Blue ■	B-

Figure 2: Interface Definition

2 Interface and Communication

2.1 UART Serial Bus

This driver series adopts the RS485 communication mode and supports the Modbus RTU protocol and the Inspire communication protocol.

The default ID is 0x01. The default communication baud rate is 115200. See 3.5.7 for ID configuration. See 2.5.8 for baud rate configuration.

2.2 Summary of Inspire Communication Protocol

2.2.1 Communication mechanism

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

A controller is allowed to connect and control multiple actuators, so each actuator needs to be configured with a different ID as unique identifier. The data volume of the instruction frame sent by the controller 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 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.

2.2.2 Format of basic frame

Frame type	Frame header (FH) (2 bytes)		Data length (1 bytes)	ID (1 byte)	Data segment			Checksum (1 bytes)
					Instruction type (1 bytes)	Register address (2 bytes)	Data (N bytes)	
Instruction frame	0x55	0xAA	L	ID	CMD	RegisterAddr	Data	Check Sum
Response frame	0xAA	0x55						

Frame header (FH): 0x55 0xAA for the instruction frame; 0xAA 0x55 for the response

frame

Data length: number of bytes in the data segment, L = N + 3

ID: The ID range is from 0x01 to 0xFE, i.e., 1 to 254. The default ID is 0x01. 0xFF is the broadcast address. If the controller sends the instruction frame with ID of 0xFF, all actuators on the bus will receive it, without returning the response frame. The ID of the response frame is the ID of actuators that send it.

Data segment: Little endian is used for instruction type, register address, number of registers, data, etc. When the data length is larger than one byte, low-order bytes appear at the front of the data segment, while high-order bytes are kept behind the data segment. There are three instruction types.

Instruction type	Function description	Values	Length of data segment (unit: byte)
CMD_RD_STATUS	Read the actuator status information.	0x30	3
CMD_WR_REGISTER	Write the register (with the status information returned).	0x31	3+n*2 Where "n" is the number of registered to be written
CMD_RD_REGISTER	Register reading	0x32	4

Note: Each register occupies 2 bytes; little endian is used; low-order bytes appear at the front of the data segment, while high-order bytes are kept behind the data segment.

Checksum: 8 low-order bytes of the sum of all data before checksum in the frame except the frame head

2.2.3 Interval between instructions

Due to control task interruption, the response time of the response frame is from 120 us to 800 us. The recommended interval between two adjacent instruction frames sent is not less than 5 ms.

2.2.4 Read the actuator status information.

The format of the instruction frame is listed below:

Frame header (FH) (2 bytes)	Data length (1 bytes)	ID (1 byte)	Data segment			Checksum (1 bytes)
			Instruction type (1 bytes)	Register address (2 bytes)	Data (0 bytes)	

0x55	0xAA	0x03	ID	0x30	0x0000	Null	Check Sum

The format of the response frame is listed below:

Frame header (FH) (2 bytes)			Low-order byte	0xAA
			High-order byte	0x55
Data length (1 byte)				0x0F
ID (1 byte)				ID
Data segment	Instruction type (1 byte)			0x30
	Preserved (1 byte)			0x00
	Preserved (1 byte)			0x00
	Actuator status information②	Actual position (per-unit system) (16 bits signed integer data)	Low-order byte	CurrentPosition_L
			High-order byte	CurrentPosition_H
		Actual current (per-unit system) (16 bits signed integer data)	Low-order byte	CurrentCurrent_L
			High-order byte	CurrentCurrent_H
		Actual force① (per-unit system) (16 bits signed integer data)	Low-order byte	ForceSensor_L
			High-order byte	ForceSensor_H
		Actual speed (per-unit system) (16 bits unsigned integer data)	Low-order byte	Speed_L
			High-order byte	Speed_H
		Error code (16 bits unsigned integer data)	Low-order byte	ErrorCode_L
			High-order byte	ErrorCode _H
		Temperature (16 bits signed integer data)	Low-order byte	Temperature _L
			High-order byte	Temperature _H
Checksum (1 byte)				Check Sum

Note 1: The data content of the electric cylinder status information frame can be set in the debugging software.

Note 2: If the electric cylinder is not equipped with a force sensor, this data is meaningless.

2.2.5 Register reading

The format of the instruction frame is listed below:

Frame header (FH) (2 bytes)		Data length (1 bytes)	ID (1 bytes)	Data segment				Checksum (1 bytes)
				Instruction type (1 bytes)	Register address (2 bytes)		Number of registers (1 bytes)	
					Low-order byte	High-order byte		
0x55	0xAA	0x04	ID	0x32	RegisterAddr_L	RegisterAddr_H	n	Check Sum

The format of the response frame is listed below:

Frame header (FH) (2 bytes)			Low-order byte	0xAA
			High-order byte	0x55
Data length (1 byte)				3+2*n
ID (1 byte)				ID
Data segment	Instruction type (1 byte)			0x32
	Register address (2 bytes)		Low-order byte	RegisterAddr_L
			High-order byte	RegisterAddr_H
	N register data (2 * n bytes)	1st register	Low-order byte	0x**
			High-order byte	0x**
		...	Low-order byte	0x**
			High-order byte	0x**
		nth register	Low-order byte	0x**
			High-order byte	0x**
Checksum (1 byte)				Check Sum

2.2.6 Register writing

The format of the instruction frame is listed below:

Frame header (FH) (2 bytes)			Low-order byte	0x55
			High-order byte	0xAA
Data length (1 byte)				3+2*n
ID (1 byte)				ID
	Instruction type (1 byte)			0x31
	Register address (2 bytes)		Low-order byte	RegisterAddr_L
			High-order byte	RegisterAddr_H
	N register data (2 * n bytes)	1st register	Low-order byte	0x**
			High-order byte	0x**
		...	Low-order byte	0x**
			High-order byte	0x**
		nth register	Low-order byte	0x**
			High-order byte	0x**
Checksum (1 byte)				Check Sum

The format of the response frame is listed below:

Note 2: The data content of the actuator status information frame can be set in the debugging software.

Frame header (FH) (2 bytes)			Low-order byte	0xAA
			High-order byte	0x55
Data length (1 byte)				0x0F
ID (1 byte)				ID
	Instruction type (1 byte)			0x31
	Register address (2 bytes)		Low-order byte	RegisterAddr_L
			High-order byte	RegisterAddr_H
	Actuator status information①	Actual position (per-unit system) (16 bits signed integer data)	Low-order byte	CurrentPosition_L
			High-order byte	CurrentPosition_H
		Actual current (per-unit system) (16 bits signed integer data)	Low-order byte	CurrentCurrent_L
			High-order byte	CurrentCurrent_H
		Actual force① (per-unit system)	Low-order byte	ForceSensor_L
			High-order byte	ForceSensor_H

		(16 bits signed integer data)		
		Actual speed (per-unit system) (16 bits unsigned integer data)	Low-order byte	Speed_L
			High-order byte	Speed_H
		Error code (16 bits unsigned integer data)	Low-order byte	ErrorCode_L
			High-order byte	ErrorCode _H
		Temperature (16 bits signed integer data)	Low-order byte	Temperature _L
			High-order byte	Temperature _H
Checksum (1 byte)				Check Sum

Note 1: The data content of the electric cylinder status information frame can be set in the debugging software.

Note 2: If the electric cylinder is not equipped with a force sensor, this data is meaningless.

2.3 Summary of Modbus RTU protocol

The Modbus RTU protocol adopts the master-slave request/response communication mode. The protocol frame contains function codes, data fields, and cyclic redundancy check (CRC). This actuator series supports reading holding register (function code: 0x03), preset single register (function code: 0x06), and preset multiple registers (function code: 0x10).

When transmission of 16 bits integer data is based on the Modbus protocol, the big endian will be adopted; that is, if the data length is larger than 1 byte, high-order byte or bytes will be followed by low-order byte or bytes.

2.3.1 Read the holding register (function code: 0x03).

Query frame format of master station	Slave station address	Function code	Starting register (high-order bytes)	Starting register (low-order bytes)	Number of registers (high-order bytes)	Number of registers (low-order bytes)	CRC
	0x01	0x03	0x00	0x06	0x00	0x02	24 0A

Explanation: Read No.1 (0x01) slave holding register, starting address = 0x0006; The number of registers is =0x0002, and the ending address is =0x0006+2-1=0x0007, that is, slave station No.1 holds registers 0x0006-0x0007, and there are two registers in total.

Response frame format of slave station	Slave station address	Function code	Byte count	0x006B register (high-order bytes)	0x006B register (low-order bytes)	0x006C register (high-order bytes)	0x006C register (low-order bytes)	CRC
	0x01	0x03	0x04	0x00	0x01	0x00	0x02	2A 32

Explanation:Returns the slave holding register 0x0006-0x0007 (No.1(0x01)), which consists of two registers. The value of 0x0006 register is 0x0001 and the value of 0x0007 register is 0x0002.

2.3.2 Preset single register (function code: 0x06)

Query frame format of master station	Slave station address	Function code	Starting register (high-order bytes)	Starting register (low-order bytes)	Data content (high-order bytes)	Data content (low-order bytes)	CRC
	0x01	0x06	0x00	0x06	0x00	0x02	E8 0A

Explanation: SSet slave holding register No.1 (0x01) with register address 0x0006 and data content 0x0002.

Response frame format of slave station	Slave station address	Function code	Starting register (high-order bytes)	Starting register (low-order bytes)	Data content (high-order bytes)	Data content (low-order bytes)	CRC
	0x01	0x06	0x00	0x06	0x00	0x02	E8 0A

2.3.3 Preset multiple registers (function code: 0x10)

Query frame format of master station	Slave station address	Function code	Starting register (high-order bytes)	Starting register (low-order bytes)	Number of registers (high-order bytes)	Number of registers (low-order bytes)	Byte count	Data (high-order bytes)	Data (low-order bytes)	Data (high-order bytes)	Data (low-order bytes)	CRC
	0x01	0x10	0x00	0x06	0x00	0x02	0x04	0x00	0x02	0x00	0x01	13 85

Explanation: Set the slave holding register No.1 (0x01), the starting address of the register is 0x0006, the number of registers is 0x0002, the byte count of data content is 0x04, and the data content is 0x0002 and 0x0001 respectively.

Response frame format of slave station	Slave station address	Function code	Starting register (high-order bytes)	Starting register (low-order bytes)	Number of registers (high-order bytes)	Number of registers (low-order bytes)	CRC
	0x01	0x10	0x00	0x06	0x00	0x02	A1 C9

2.4 Register description

Address	Name	User permission	Debug mode
0x01	Equipment type	Read only	Read only
0x02	Firmware version	Read only	Read only
0x03 0x04 0x05	Serial number	Read only	Read and write
0x06	ID; range: 1-254	Read and write	Read and write
0x07	Baud rate: 3-921600; 2-115200; 1-57600; 0-19200	Read and write	Read and write
0x08	1 - Fault clearance command	Read and write	Read and write
0x09	1 - Emergency stop command	Read and write	Read and write
0x0A	1 - Dwell motion command	Read and write	Read and write
0x0B	1 - Parameter recovery command	Read and write	Read and write
0x0C	1 - Hold-over command	Read and write	Read and write
0x0E	Over temperature protection (unit: ℃)	Read and write	Read and write
0x0F	Recovery temperature value (unit: ℃)	Read and write	Read and write
0x10	Overcurrent protection value, per-unit system (16384: 100%), default value = 16384	Read and write	Read and write
0x11	Maximum forward output value of motor, per-unit system (16384: 100%), default value = 16384	Read and write	Read and write
0x12	Maximum reverse output value of motor, per-unit system (16384: 100%), default value = -16384	Read and write	Read and write
0x13	Upper limit of stroke, per-unit system (16384: 100%), default value = 16384	Read and write	Read and write
0x14	Lower limit of stroke, per-unit system (16384: 100%), default value = 0	Read and write	Read and write
0x15	Setting of force control direction, 0 - extrusion as forward	Read and	Read and

Address	Name	User permission	Debug mode
	direction, 1 - extension as forward direction	write	write
0x20	Operating mode: 0 - position mode; 1 - servo mode; 4 - force control mode; 5 = quick positioning + soft contact mode	Read and write	Read and write
0x22	Target value setting of force control, per-unit system (16384: 100%), default value = 0	Read and write	Read and write
0x23	Target speed (valid in the speed mode), per-unit system (16384: 100%), default value = 0	Read and write	Read and write
0x24	Target position (valid in the speed, positioning and servo modes), per-unit system (16384: 100%), default value = 0	Read and write	Read and write
0x25	Soft contact speed (valid in the quick positioning + soft contact mode), per-unit system (16384: 100%), default value = 0	Read and write	Read and write
0x26	Actual position, per-unit system (16384: 100%)	Read only	Read only
0x27	Current value, per-unit system (16384: 100%)	Read only	Read only
0x28	Actual speed value, per-unit system (16384: 100%)	Read only	Read only
0x29	Actual force value, per-unit system (16384: 100%)	Read only	Read only
0x2A	Error code Bit0-stall fault; Trigger conditions: the motor current is greater than the set current, and the speed is less than 0.1mm/s for 3 s; Cleaning method: the first two times the current is lower than the set current, it will be cleared automatically, and the third time it needs to be cleared manually; Bit1-overtemperature; Trigger condition: the temperature of the electric cylinder is greater than the set temperature for 10s； ; Clearing method: automatically clear when the temperature is lower than the return temperature value; Bit2: overcurrent; Trigger condition: the electric cylinder current is greater than the set current for 3s; Cleaning method: the first two times the current is lower than the set current, it will be cleared automatically, and the third time it needs to be cleared manually; Bit3- the motor is abnormal; Trigger condition: the motor is damaged; Cleaning method: manual cleaning; Bit 4- Flash parameter is wrong or not saved; Trigger condition: parameter loss; Cleaning method: manual cleaning; Bit5--drive system failure; Trigger condition: the electric cylinder drive chip is abnormal; Cleaning method: manual cleaning; Bit6- the encoder signal is abnormal; Trigger condition: the encoder chip is abnormal; Cleaning method: manual cleaning; Bit7- the current sampling circuit is abnormal; Trigger condition: the current sampling circuit is abnormal; Cleaning method: manual cleaning;	Read only	Read only

Address	Name	User permission	Debug mode
	Bit8-10-reserved; Bit11- the position sensor is abnormal; Trigger condition: the linear magnetic grating sensor is abnormal; Cleaning method: manual cleaning; Bit12-14-reserved; Bit15-high temperature alarm; Trigger condition: the temperature of the electric cylinder is higher than the temperature set by the user, and the alarm will be given after 10s; Clearing method: automatically clear if the temperature is lower than the return temperature value		
0x2B	Actual temperature value (unit: ℃)	Read only	Read only

Physical quantity	Per-unit reference value (the value corresponding to 16384)	
Stroke	10 mm	30 mm
Current	1800mA③	
Speed	10 mm/s①	39 mm/s②
Acceleration	500 mm/s^2	
Force	200N	

Note 1: It is 12.2 mm/s for the firmware before 2. 14, 2023.

Note 2: It is 44.034 mm/s for the firmware before 2. 14, 2023.

Note 3: It is 3000mA for the firmware before 10. 31, 2023.

3 Examples of common instructions

3.1 Read the actuator status information.

The frame format of the Inspire protocol is as follows:

Instruction frame		Response frame	
Values	**Description**	**Values**	**Description**
0x55	Frame header (FH)	0xAA	Frame header (FH)
0xAA	Frame header (FH)	0x55	Frame header (FH)
0x03	Data length	0x0F	Data length
0x01	ID	0x01	ID
0x30	CMD_RD_STATUS	0x30	CMD_RD_STATUS
0x00		0x00	
0x00		0x00	
0x34	Checksum	0x00	Actual position, per-unit value; 16384 (0x4000) corresponding to 100% of the per-unit reference stroke
		0x40	
		0x00	Actual current, per-unit value; 8192 (0x2000) corresponding to 50% of the per-unit reference current
		0x20	
		0x00	Actual force, per-unit value; 4096 (0x1000) corresponding to 25% of the per-unit reference force
		0x10	
		0x00	Actual speed, per-unit value; 0 (0x0000) corresponding to 0% of the per-unit reference speed
		0x00	
		0x00	Error code
		0x00	
		0x20	Temperature (32 ℃)
		0x00	
		0xD0	Checksum

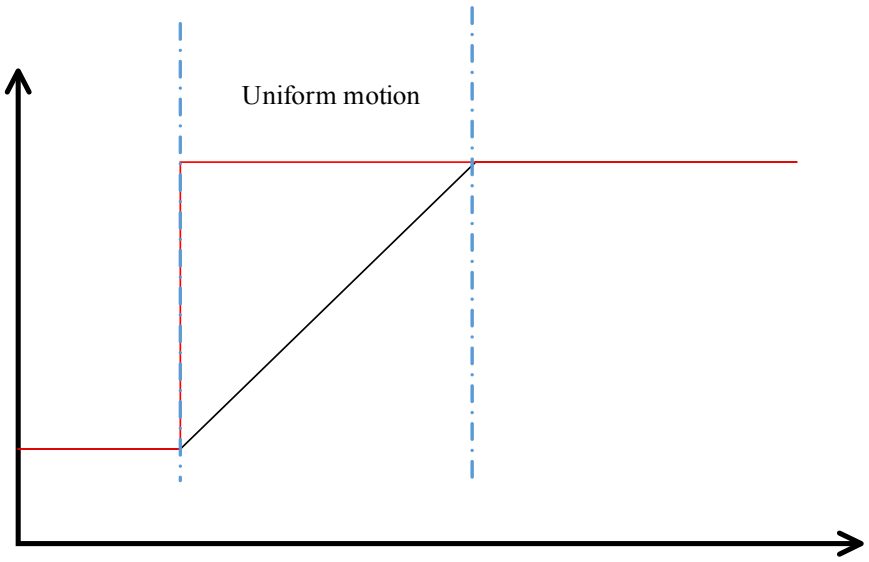
The frame format of Modbus RTU protocol is as follows:

Instruction frame		Response frame	
Values	**Description**	**Values**	**Description**
0x01	Address	0x01	Address

0x03	Function code	0x03	Function code
0x00	Register address	0x0A	Byte
0x26		0x00	Actual position, per-unit value; 2 (0x0002) corresponding to 0.012% of the per-unit reference stroke
0x00	Number of registers	0x02	
0x05		0x00	Actual current, per-unit value; 0 (0x0000) corresponding to 50% of the per-unit reference current
0x64	Cyclic redundancy check (CRC)	0x00	
0x02		0x00	Actual speed, per-unit value; 0 (0x0000) corresponding to 0% of the per-unit reference speed
		0x00	
		0x01	Actual force, per-unit value; 282 (0x011A) corresponding to 25% of the per-unit reference force
		0x1A	
		0x00	Error code
		0x00	
		0x1D	Cyclic redundancy check (CRC)
		0xED	

3.2 Positioning motion

First of all, set the 0x20 (operating mode) register to 0, and enter the position control mode. If operation occurs in the position control mode, there is no need to set the 0x20 (operating mode) register. Next, set the values of the 0x23 (set speed) and 0x24 (target position) registers. Control the actuator to ensure that it moves to the target position at the set speed.



Red: target position; Black: actual position

For example, control the BLAS10 actuator to ensure that it moves to the target position of 10 mm (100% of the per-unit reference position) at 10 mm/s (100% of the per-unit reference speed). It is necessary to set the 0x23 (set speed) register to 16384 and the 0x24 (target position) register to 16384. First of all, set the 0x20 register to 0x00 (if the content of the 0x20 register is 0x00, there is no need to set it again); next, set the values of the 0x23 and 0x24 registers.

The frame format of the Inspire protocol is as follows.

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x55	Frame header (FH)	0xAA	Frame header (FH)
0xAA	Frame header (FH)	0x55	Frame header (FH)
0x05	Data length	0x0F	Data length
0x01	ID	0x01	ID
0x31	CMD_WR_REGISTER	0x31	CMD_WR_REGISTER
0x20	Setting the address of the operating mode register	0x20	
0x00		0x00	
0x00	0: Position mode	0x00	Actual position, per-unit value; 16384 (0x4000) corresponding to 100% of the per-unit reference stroke
0x00		0x40	
0x57	Checksum	0x00	Actual current, per-unit value; 8192 (0x2000) corresponding to 50% of the per-unit reference current
		0x20	
		0x00	Actual force, per-unit value; 4096 (0x1000) corresponding to 25% of the per-unit reference force
		0x10	
		0x00	Actual speed, per-unit value; 0 (0x0000) corresponding to 0% of the per-unit reference speed
		0x00	
		0x00	Error code
		0x00	
		0x20	Temperature (32 ℃)
		0x00	
		0xD0	Checksum

Instruction frame		Response frame	
Values	**Description**	**Values**	**Description**
0x55	Frame header (FH)	0xAA	Frame header (FH)
0xAA	Frame header (FH)	0x55	Frame header (FH)
0x07	Data length	0x0F	Data length
0x01	ID	0x01	ID
0x31	CMD_WR_REGISTER	0x31	CMD_WR_REGISTER
0x23	Setting the address of the speed register	0x00	
0x00		0x00	
0x00	Setting the speed to 16384 (0x4000), i.e., 100% of the maximum speed	0x00	Actual position, per-unit value; 16384 (0x4000) corresponding to 100% of the per-unit reference stroke
0x40		0x40	
0x00	Setting the target position to 16384 (0x4000), i.e., 100% of the per-unit reference position	0x00	Actual current, per-unit value; 8192 (0x2000) corresponding to 50% of the per-unit reference current
0x40		0x20	
0xDC	Checksum	0x00	Actual force, per-unit value; 4096 (0x1000) corresponding to 25% of the per-unit reference force
		0x10	
		0x00	Actual speed, per-unit value; 0 (0x0000) corresponding to 0% of the per-unit reference speed
		0x00	
		0x00	Error code
		0x00	
		0x20	Temperature (32 ℃)
		0x00	
		0xD0	Checksum

The frame format of Modbus RTU protocol is as follows.

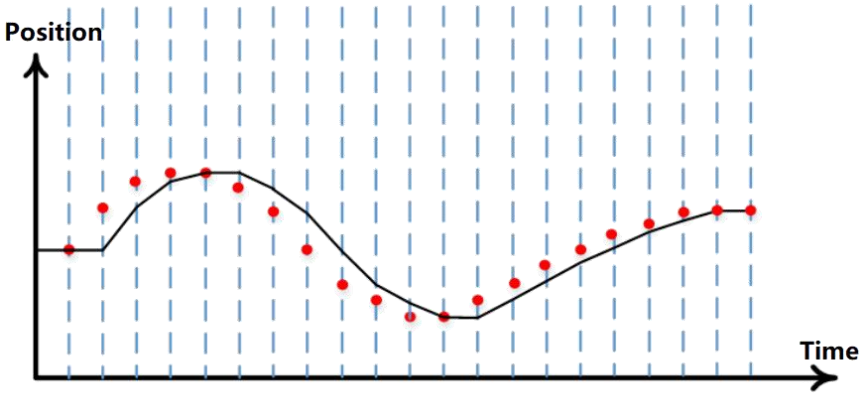
Instruction frame		Response frame	
Values	**Description**	**Values**	**Description**
0x01	Address	0x01	Address
0x06	Function code	0x06	Function code
0x00	Register address	0x00	Register address
0x20		0x20	

0x00	Data content	0x00	Data content
0x00		0x00	
0x88	Cyclic redundancy check (CRC)	0x88	Cyclic redundancy check (CRC)
0x00		0x00	

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x01	Address	0x01	Address
0x10	Function code	0x10	Function code
0x00	Register address	0x00	Register address
0x23		23	
0x00	Number of registers	0x00	Number of registers
0x02		0x02	
0x04	Byte	0x95	Cyclic redundancy check (CRC)
0x40	Setting the speed to 16384 (0x4000), i.e., 100% of the maximum speed	0xB5	
0x00			
0x40	Setting the target position to 16384 (0x4000), i.e., 100% of the per-unit reference position		
0x00			
0x95	Cyclic redundancy check (CRC)		
0xA2			

3.3 Servo mode

In the servo mode, the actuator will follow the preset position trajectory (PC sends position set values to the 0x24 register at a constant time interval not more than 50 ms). As shown below, a shorter time interval for sending position set values indicates better following performance.



Red: target position; Black: actual position

For example, control the actuator to ensure that it moves to the target position of 10 mm (100% of the per-unit reference position). It is necessary to set the 0x24 (target position) register to 16384. First of all, set the 0x20 register to 0x01 (if the content of the 0x20 register is 0x01, there is no need to set it again); next, set the value of the 0x24 register.

The frame format of the Inspire protocol is as follows.

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x55	Frame header (FH)	0xAA	Frame header (FH)
0xAA	Frame header (FH)	0x55	Frame header (FH)
0x05	Data length	0x0F	Data length
0x01	ID	0x01	ID
0x31	CMD_WR_REGISTER	0x31	CMD_WR_REGISTER
0x20	Setting the address of the operating mode register	0x20	
0x00		0x00	
0x00	1: Servo mode	0x00	Actual position, per-unit value; 16384 (0x4000) corresponding to 100% of the per-unit reference stroke
0x01		0x40	
0x58	Checksum	0x00	Actual current, per-unit value; 8192 (0x2000) corresponding to 50% of the per-unit reference current
		0x20	
		0x00	Actual force, per-unit value; 4096 (0x1000) corresponding to 25% of the per-unit reference force
		0x10	
		0x00	Actual speed, per-unit value; 0 (0x0000)

		0x00	corresponding to 0% of the per-unit reference speed
		0x00	Error code
		0x00	
		0x20	Temperature (32 ℃)
		0x00	
		0xD0	Checksum

Instruction frame		Response frame	
Values	**Description**	**Values**	**Description**
0x55	Frame header (FH)	0xAA	Frame header (FH)
0xAA	Frame header (FH)	0x55	Frame header (FH)
0x05	Data length	0x0F	Data length
0x01	ID	0x01	ID
0x31	CMD_WR_REGISTER	0x31	CMD_WR_REGISTER
0x24	Setting the address of the position register	0x24	
0x00		0x00	
0x00	Setting the target position to 8192 (0x2000), i.e., 50% of the per-unit reference position	0x00	Actual position, per-unit value; 16384 (0x4000) corresponding to 100% of the per-unit reference stroke
0x20		0x40	
0x7B	Checksum	0x00	Actual current, per-unit value; 8192 (0x2000) corresponding to 50% of the per-unit reference current
		0x20	
		0x00	Actual force, per-unit value; 4096 (0x1000) corresponding to 25% of the per-unit reference force
		0x10	
		0x00	Actual speed, per-unit value; 0 (0x0000) corresponding to 0% of the per-unit reference speed
		0x00	
		0x00	Error code
		0x00	
		0x20	Temperature (32 ℃)
		0x00	
		0xD0	Checksum

The frame format of Modbus RTU protocol is as follows.

Instruction frame		Response frame	
Values	**Description**	**Values**	**Description**
0x01	Address	0x01	Address
0x06	Function code	0x06	Function code
0x00	Register address	0x00	Register address
0x20		0x20	
0x00	Data content	0x00	Data content
0x01		0x01	
0x49	Cyclic redundancy check (CRC)	0x49	Cyclic redundancy check (CRC)
0xC0		0xC0	

Instruction frame		Response frame	
Values	**Description**	**Values**	**Description**
0x01	Address	0x01	Address
0x06	Function code	0x06	Function code
0x00	Register address	0x00	Register address
0x24		0x24	
0x20	Data content	0x20	Data content
0x00		0x00	
0xD0	Cyclic redundancy check (CRC)	0xD0	Cyclic redundancy check (CRC)
0x01		0x01	

3.4 Force control mode

First of all, set the 0x20 (operating mode) register to 4, and enter the force control mode. If operation occurs in the force control mode, there is no need to set the 0x20 (operating mode) register. Next, set the value of the 0x22 (set force control) register. The actuator will be subjected to closed-loop regulation to ensure that the force value is the set value for force control.

For example, control the actuator force value at 50 N (25% of the per-unit reference

force). First of all, set the 0x20 register to 0x04 (if the content of the 0x20 register is 0x04, there is no need to set it again); next, set the value of the 0x22 register.

The frame format of the Inspire protocol is as follows.

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x55	Frame header (FH)	0xAA	Frame header (FH)
0xAA	Frame header (FH)	0x55	Frame header (FH)
0x05	Data length	0x0F	Data length
0x01	ID	0x01	ID
0x31	CMD_WR_REGISTER	0x31	CMD_WR_REGISTER
0x20	Setting the address of the operating mode register	0x20	
0x00		0x00	
0x04	4: Force control mode	0x00	Actual position, per-unit value; 16384 (0x4000) corresponding to 100% of the per-unit reference stroke
0x00		0x40	
0x5B	Checksum	0x00	Actual current, per-unit value; 8192 (0x2000) corresponding to 50% of the per-unit reference current
		0x20	
		0x00	Actual force, per-unit value; 4096 (0x1000) corresponding to 25% of the per-unit reference force
		0x10	
		0x00	Actual speed, per-unit value; 0 (0x0000) corresponding to 0% of the per-unit reference speed
		0x00	
		0x00	Error code
		0x00	
		0x20	Temperature (32 ℃)
		0x00	
		0xD0	Checksum

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x55	Frame header (FH)	0xAA	Frame header (FH)
0xAA	Frame header (FH)	0x55	Frame header (FH)

0x05	Data length	0x0F	Data length
0x01	ID	0x01	ID
0x31	CMD_WR_REGISTER	0x31	CMD_WR_REGISTER
0x22	Setting the address of the force control register	0x22	
0x00		0x00	
0x00	Setting the force control value to 4096 (0x4000), i.e., 25% of the per-unit force control value	0x00	Actual position, per-unit value; 16384 (0x4000) corresponding to 100% of the per-unit reference stroke
0x10		0x40	
0x69	Checksum	0x00	Actual current, per-unit value; 8192 (0x2000) corresponding to 50% of the per-unit reference current
		0x20	
		0x00	Actual force, per-unit value; 4096 (0x1000) corresponding to 25% of the per-unit reference force
		0x10	
		0x00	Actual speed, per-unit value; 0 (0x0000) corresponding to 0% of the per-unit reference speed
		0x00	
		0x00	Error code
		0x00	
		0x20	Temperature (32 ℃)
		0x00	
		0xD0	Checksum

The frame format of Modbus RTU protocol is as follows.

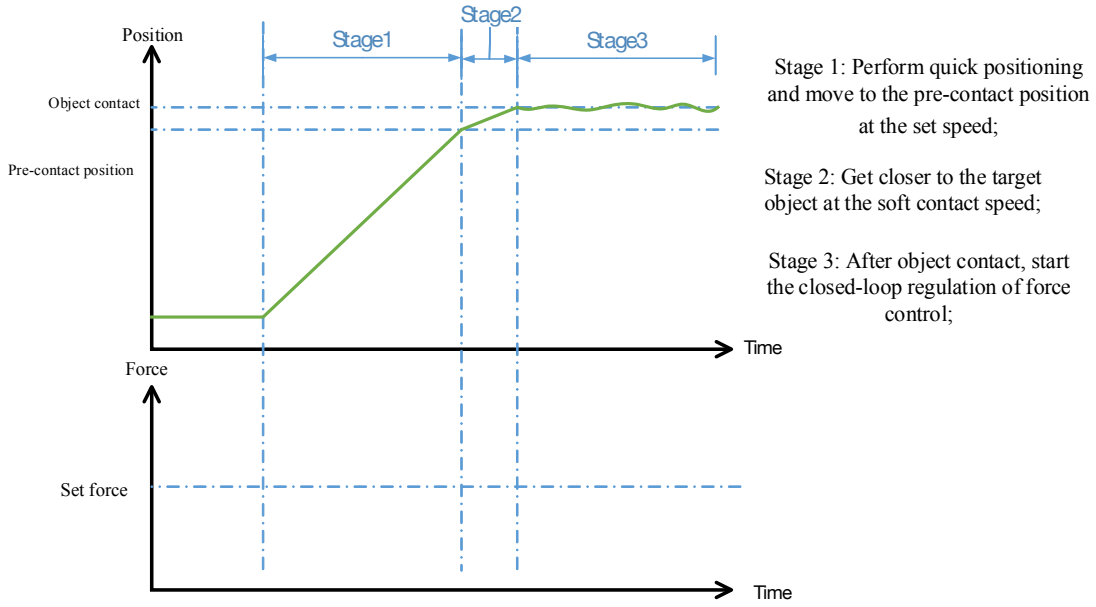
Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x01	Address	0x01	Address
0x06	Function code	0x06	Function code
0x00	Register address	0x00	Register address
0x20		0x20	
0x00	Data content	0x00	Data content
0x04		0x04	
0x89	Cyclic redundancy check (CRC)	0x89	Cyclic redundancy check (CRC)
0xC3		0xC3	

Instruction frame		Response frame	
Values	**Description**	**Values**	**Description**
0x01	Address	0x01	Address
0x06	Function code	0x06	Function code
0x00	Register address	0x00	Register address
0x22		0x22	
0x10	Data content	0x10	Data content
0x00		0x00	
0x24	Cyclic redundancy check (CRC)	0x24	Cyclic redundancy check (CRC)
0x00		0x00	

3.5 Quick positioning + soft contact mode

In the quick positioning + soft contact mode, the actuator will move to the pre-contact position (0x24 register) at the set speed (0x23 register). After it is in place, the actuator will move, get closer to and contact the object at the soft contact speed (0x25 register). Once the actual force is close to the set value for force control (0x22 register), the actuator will enter the force control and regulation stage and will maintain its force output at the set value for force control (0x22 register).

First of all, set the 0x20 (operating mode) register to 5, and enter the quick positioning + soft contact control mode. If operation occurs in the quick positioning + soft contact mode, there is no need to set the 0x20 (operating mode) register. Next, set the values of the 0x22 (set force), 0x23 (set speed), 0x24 (target position), and 0x25 (soft contact speed) registers.



Quick Positioning + Soft Contact Mode Diagram

For example, control the BLAS10 actuator to ensure that it moves to the pre-contact position of 5 mm (50% of the per-unit reference position) at 10 mm/s (100% of the per-unit reference speed). Next, contact the target object at the soft contact speed of 0.1 mm/s (1% of the per-unit reference speed). Finally, maintain the pushing force of 50 N (25% of the per-unit force control value). It is necessary to set the 0x23 (set speed) register to 16384, the 0x24 (target position) register to 8192, the 0x25 (soft contact speed) register to 163, and the 0x22 (set force control) register to 4096. First of all, set the 0x20 register to 0x05 (if the content of the 0x20 register is 0x05, there is no need to set it again); next, set the values of the 0x22, 0x23, 0x24 and 0x25 registers.

The frame format of the Inspire protocol is as follows.

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x55	Frame header (FH)	0xAA	Frame header (FH)
0xAA	Frame header (FH)	0x55	Frame header (FH)
0x05	Data length	0x0F	Data length
0x01	ID	0x01	ID
0x31	CMD_WR_REGISTER	0x31	CMD_WR_REGISTER
0x20	Setting the address of the operating mode register	0x20	
0x00		0x00	

0x05	5: Quick positioning + soft contact mode	0x00	Actual position, per-unit value; 16384 (0x4000) corresponding to 100% of the per-unit reference stroke
0x00		0x40	
0x5C	Checksum	0x00	Actual current, per-unit value; 8192 (0x2000) corresponding to 50% of the per-unit reference current
		0x20	
		0x00	Actual force, per-unit value; 4096 (0x1000) corresponding to 25% of the per-unit reference force
		0x10	
		0x00	Actual speed, per-unit value; 0 (0x0000) corresponding to 0% of the per-unit reference speed
		0x00	
		0x00	Error code
		0x00	
		0x20	Temperature (32 ℃)
		0x00	
		0xF1	Checksum

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x55	Frame header (FH)	0xAA	Frame header (FH)
0xAA	Frame header (FH)	0x55	Frame header (FH)
0x0B	Data length	0x0F	Data length
0x01	ID	0x01	ID
0x31	CMD_WR_REGISTER	0x31	CMD_WR_REGISTER
0x22	Setting the address of the force control register	0x22	
0x00		0x00	
0x00	Setting the force control value to 4096 (0x1000), i.e., 25% of the per-unit force control value	0x00	Actual position, per-unit value; 16384 (0x4000) corresponding to 100% of the per-unit reference stroke
0x10		0x40	
0x00	Setting the speed to 16384 (0x4000), i.e., 100% of the maximum speed	0x00	Actual current, per-unit value; 8192 (0x2000) corresponding to 50% of the per-unit reference current
0x40		0x20	
0x00	Setting the pre-contact position to 8192 (0x2000), i.e., 50% of the per-unit reference position	0x00	Actual force, per-unit value; 4096 (0x1000) corresponding to 25% of the per-unit reference force
0x20		0x10	
0xA3	Setting the soft contact speed to 163	0x00	Actual speed, per-unit value; 0

0x00	(0x00A3), i.e., 1% of the per-unit reference speed	0x00	(0x0000) corresponding to 0% of the per-unit reference speed
0x72	Checksum	0x00	Error code
		0x00	
		0x20	Temperature (32 ℃)
		0x00	
		0xF	Checksum

The frame format of Modbus RTU protocol is as follows.

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x01	Address	0x01	Address
0x06	Function code	0x06	Function code
0x00	Register address	0x00	Register address
0x20		0x20	
0x00	Data content	0x00	Data content
0x05		0x05	
0x48	Cyclic redundancy check (CRC)	0x48	Cyclic redundancy check (CRC)
0x03		0x03	

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x01	Address	0x01	Address
0x10	Function code	0x10	Function code
0x00	Register address	0x00	Register address
0x22		0x22	
0x00	Number of registers	0x00	Number of registers
0x04		0x04	
0x08	Byte	0x61	Cyclic redundancy check (CRC)
0x10	Setting the force control value to 4096 (0x1000), i.e., 25% of the per-unit force control value	0xCC	
0x00			

0x40	Setting the speed to 16384 (0x4000), i.e., 100% of the maximum speed		
0x00			
0x20	Setting the target position to 8192 (0x2000), i.e., 50% of the per-unit reference position		
0x00			
0x00	Setting the pre-contact position to 163 (0x00A3), i.e., 1% of the per-unit reference speed		
0xA3			
0x8A	Cyclic redundancy check (CRC)		
0x77	Cyclic redundancy check (CRC)		

3.6 Fault clearance

Set the 0x08 register to 1 to clear faults that can be cleared.

The frame format of the Inspire protocol is as follows.

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x55	Frame header (FH)	0xAA	Frame header (FH)
0xAA	Frame header (FH)	0x55	Frame header (FH)
0x05	Data length	0x0F	Data length
0x01	ID	0x01	ID
0x31	CMD_WR_REGISTER	0x31	CMD_WR_REGISTER
0x08	Register address	0x08	Register address
0x00		0x00	
0x01	1	0x00	Actual position, per-unit value; 16384 (0x4000) corresponding to 100% of the per-unit reference stroke
0x00		0x40	
0x40	Checksum	0x00	Actual current, per-unit value; 8192 (0x2000) corresponding to 50% of the per-unit reference current
		0x20	
		0x00	Actual force, per-unit value; 4096 (0x1000) corresponding to 25% of the per-unit reference force
		0x10	

		0x00	Actual speed, per-unit value; 0 (0x0000) corresponding to 0% of the per-unit reference speed
		0x00	
		0x00	Error code
		0x00	
		0x20	Temperature (32 ℃)
		0x00	
		0xD9	Checksum

The frame format of Modbus RTU protocol is as follows.

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x01	Address	0x01	Address
0x06	Function code	0x06	Function code
0x00	Register address	0x00	Register address
0x08		0x08	
0x00	Data content	0x00	Data content
0x01		0x01	
0xC9	Cyclic redundancy check (CRC)	0xC9	Cyclic redundancy check (CRC)
0xC8		0xC3	

3.7 Parameter saving

When the parameters in a register are modified and expected to remain valid after power-off and restart, a parameter saving command can be sent by setting the 0x0C register to 1 to fix such parameters in the Flash.

The frame format of the Inspire protocol is as follows.

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x55	Frame header (FH)	0xAA	Frame header (FH)
0xAA	Frame header (FH)	0x55	Frame header (FH)
0x05	Data length	0x0F	Data length

0x01	ID	0x01	ID
0x31	CMD_WR_REGISTER	0x31	CMD_WR_REGISTER
0x0C	Register address	0x0C	Register address
0x00		0x00	
0x01	1	0x00	Actual position, per-unit value; 16384 (0x4000) corresponding to 100% of the per-unit reference stroke
0x00		0x40	
0x44	Checksum	0x00	Actual current, per-unit value; 8192 (0x2000) corresponding to 50% of the per-unit reference current
		0x20	
		0x00	Actual force, per-unit value; 4096 (0x1000) corresponding to 25% of the per-unit reference force
		0x10	
		0x00	Actual speed, per-unit value; 0 (0x0000) corresponding to 0% of the per-unit reference speed
		0x00	
		0x00	Error code
		0x00	
		0x20	Temperature (32 ℃)
		0x00	
		0xDD	Checksum

The frame format of Modbus RTU protocol is as follows.

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x01	Address	0x01	Address
0x06	Function code	0x06	Function code
0x00	Register address	0x00	Register address
0x0C		0x0C	
0x00	Data content	0x00	Data content
0x01		0x01	
0x88	Cyclic redundancy check (CRC)	0x88	Cyclic redundancy check (CRC)
0x09		0x09	

3.8 Dwell motion

If the register 0x0A is set to 1, the current motion of an actuator can be suspended.

The frame format of the Inspire protocol is as follows.

Instruction frame		Response frame	
Values	**Description**	**Values**	**Description**
0x55	Frame header (FH)	0xAA	Frame header (FH)
0xAA	Frame header (FH)	0x55	Frame header (FH)
0x05	Data length	0x0F	Data length
0x01	ID	0x01	ID
0x31	CMD_WR_REGISTER	0x31	CMD_WR_REGISTER
0x0A	Register address	0x0A	Register address
0x00		0x00	
0x01	1	0x00	Actual position, per-unit value; 16384 (0x4000) corresponding to 100% of the per-unit reference stroke
0x00		0x40	
0x42	Checksum	0x00	Actual current, per-unit value; 8192 (0x2000) corresponding to 50% of the per-unit reference current
		0x20	
		0x00	Actual force, per-unit value; 4096 (0x1000) corresponding to 25% of the per-unit reference force
		0x10	
		0x00	Actual speed, per-unit value; 0 (0x0000) corresponding to 0% of the per-unit reference speed
		0x00	
		0x00	Error code
		0x00	
		0x20	Temperature (32 ℃)
		0x00	
		0xDB	Checksum

The frame format of Modbus RTU protocol is as follows.

Instruction frame		Response frame	
Values	**Description**	**Values**	**Description**

0x01	Address	0x01	Address
0x06	Function code	0x06	Function code
0x00	Register address	0x00	Register address
0x0A		0x0A	
0x00	Data content	0x00	Data content
0x01		0x01	
0x68	Cyclic redundancy check (CRC)	0x68	Cyclic redundancy check (CRC)
0x08		0x08	

3.9 Modify the ID of an actuator.

Modify the ID of an actuator to 2. After the register 0x06 is set to 0x02, the new ID will become effective immediately. Next, send the parameter saving command (see 2.5.5) to fix the ID in the Flash.

The frame format of the Inspire protocol is as follows.

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x55	Frame header (FH)	0xAA	Frame header (FH)
0xAA	Frame header (FH)	0x55	Frame header (FH)
0x05	Length of data segment	0x0F	Data length
0x01	ID	0x01	ID
0x31	CMD_WR_REGISTER	0x31	CMD_WR_REGISTER
0x06	ID register address	0x06	ID register address
0x00		0x00	
0x02	The new ID is 2.	0x00	Actual position, per-unit value; 16384 (0x4000) corresponding to 100% of the per-unit reference stroke
0x00		0x40	
0x3F	Checksum	0x00	Actual current, per-unit value; 8192 (0x2000) corresponding to 50% of the per-unit reference current
		0x20	
		0x00	Actual force, per-unit value; 4096

		0x10	(0x1000) corresponding to 25% of the per-unit reference force
		0x00	Actual speed, per-unit value; 0 (0x0000) corresponding to 0% of the per-unit reference speed
		0x00	
		0x00	Error code
		0x00	
		0x20	Temperature (32 ℃)
		0x00	
		0xD0	Checksum

The frame format of Modbus RTU protocol is as follows.

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x01	Address	0x01	Address
0x06	Function code	0x06	Function code
0x00	Register address	0x00	Register address
0x06		0x06	
0x00	Data content	0x00	Data content
0x02		0x02	
0xE8	Cyclic redundancy check (CRC)	0xE8	Cyclic redundancy check (CRC)
0x0A		0x0A	

3.10 Modify the baud rate.

Modify the baud rate of the actuator to 115200. Set the register 0x07 to 0x02 ("2" corresponds to the baud rate of 115200). Then send the parameter saving command (see 3.5.10). After power-off and restart, the new baud rate will become effective.

The frame format of the Inspire protocol is as follows.

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x55	Frame header (FH)	0xAA	Frame header (FH)
0xAA	Frame header (FH)	0x55	Frame header (FH)
0x05	Data length	0x0F	Data length

0x01	ID	0x01	ID
0x31	CMD_WR_REGISTER	0x31	CMD_WR_REGISTER
0x07	Register address for baud rate	0x07	Register address for baud rate
0x00		0x00	
0x02	2 The baud rate is 115200.	0x00	Actual position, per-unit value; 16384 (0x4000) corresponding to 100% of the per-unit reference stroke
0x00		0x40	
0x40	Checksum	0x00	Actual current, per-unit value; 8192 (0x2000) corresponding to 50% of the per-unit reference current
		0x20	
		0x00	Actual force, per-unit value; 4096 (0x1000) corresponding to 25% of the per-unit reference force
		0x10	
		0x00	Actual speed, per-unit value; 0 (0x0000) corresponding to 0% of the per-unit reference speed
		0x00	
		0x00	Error code
		0x00	
		0x20	Temperature (32 ℃)
		0x00	
		0xA7	Checksum

The frame format of Modbus RTU protocol is as follows.

Instruction frame		**Response frame**	
Values	**Description**	**Values**	**Description**
0x01	Address	0x01	Address
0x06	Function code	0x06	Function code
0x00	Register address	0x00	Register address
0x07		0x07	
0x00	Data content	0x00	Data content
0x02		0x02	
0xB9	Cyclic redundancy check (CRC)	0xB9	Cyclic redundancy check (CRC)
0xCA		0xCA	

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