Electrical Rotary Valve User Manual V1.0

Date: 03/02/2022

Contents

Chapter 1 Technology and Product Features

1.1 Product Key Features

1) Corrosion resistance: Sapphire valve core. The valve heads are made of PCTFE (polychlorotrifluoroethylene) and PPS.
2) Valve structure: The valve core adopts a multi-directional self-adaptive plane fitting method.
3) Motive power: The rotation of the valve body uses planetary gearbox motor.
4) Orientation: The valve hole is oriented by the optical encoder, which can effectively resolve the problem of inaccurate positioning after the gearbox is worn down.
5) Drive: The two-phase bipolar stepper drive module can control the motor current with high efficiency. It has a built-in error detection circuit and error detection (TSD/ISD) signal output function.
6) Control unit interface: XH terminal with 2.54mm pitch. Serial communication protocol supports RS-232/485/CAN bus
7) Fluidics Interface: ¼''-28UNF female thread
8) Typical applications: biological sample preparation and distribution, sample injection or selection, microfluidics system, automatic reagent delivery, high speed sample enrichment, column back flushing, flow cytometry, chemistry analyzer, mass spectrometers, element analyzers, analytical instruments etc.

Before using the selector valve, please read this user manual carefully and follow the instruction.

1.2 Valve Part Numbers

The electrical selector valves ASP-ERV-7 has different orifice sizes, port numbers, wetted materials, and maximum pressure resilience etc. The part numbers and specification are listed in Table 1.

Table 1 Electrical Rotary Valve Part Numbers and their Features

ASP-ERV-O1.2-06	Electrical Rotary Valve, 6 Ports, Orifice size 1.2mm, Max Pressure 1.5MPa, PCTFE/Sapphire
ASP-ERV-O1.2-08	Electrical Rotary Valve, 8 Ports, Orifice size 1.2mm, Max Pressure 1.5MPa, PCTFE/Sapphire
ASP-ERV-O1.2-10	Electrical Rotary Valve, 10 Ports, Orifice size 1.2mm, Max Pressure 1.5MPa, PCTFE/Sapphire
ASP-EVR-O1.0-12	Electrical Rotary Valve, 12 Ports, Orifice size 1.0mm, Max Pressure 1.5MPa, PCTFE/Sapphire
ASP-EVR-O1.0-16	Electrical Rotary Valve, 16 Ports, Orifice size 1.0mm, Max Pressure 1.5MPa, PCTFE/Sapphire

1.3 Product Specification

The port configuration of the ASP-EVR7 selector valve is shown in

Figure *1*: 6/8/10-port, 12-port, and 16-port. The dimension of the mounting holes and the mounting plate are shown in Figure 2 (unit: mm).

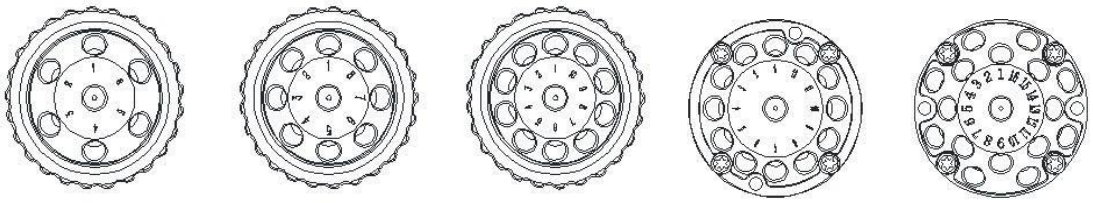


Figure 1 ASP-ERV7 Valve Port Options

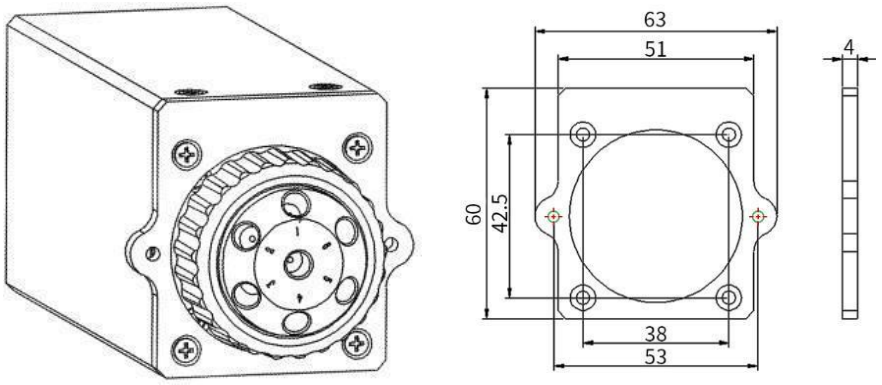


Figure 2 Valve Mounting Dimensions (Unit: mm)

1.4 Mechanical Dimensions (unit: mm)

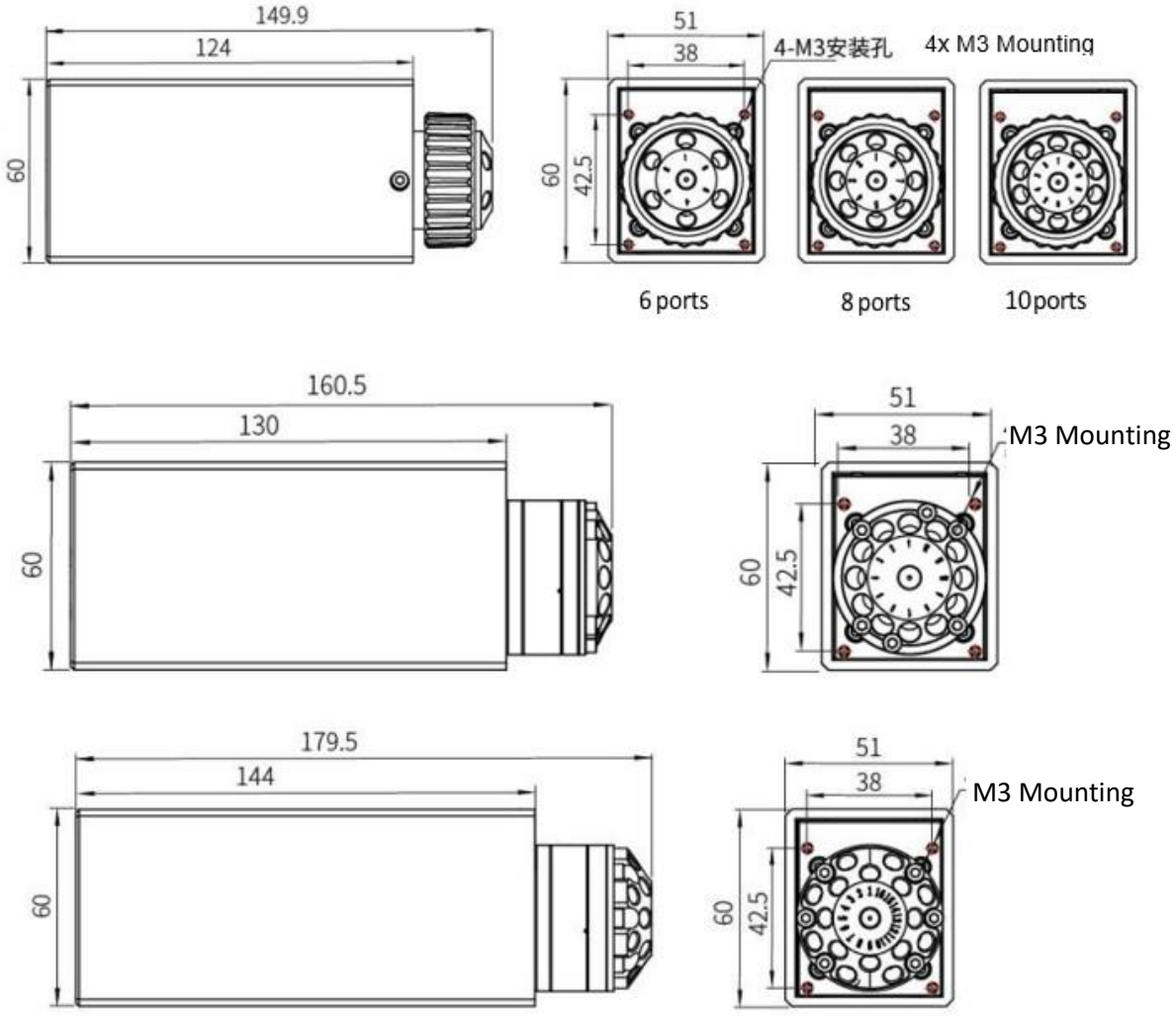


Figure 3 Structure Dimensions of 6/8/10-Ports Electrical Rotary Valves (Unit: mm)

1.5 Technical Parameters

Table 2 Technical specifications of the electrical rotary valves

Description	Parameter		
Configuration	6-/8-/10-Port	12-Port	16-Port
Orifice size (mm)	1.2	1.0	1.0
Internal volume (port-to-port)	27.5μL	22.43μL	33.68μL
Dead volume (sealed rotor)	5.41μL	6.08μL	10.4μL
Wetted material	PCTFE, Sapphire crystal		
Pressure rating	0-1.0MPa (air); 0-1.6MPa (DI water)		
Fluid temperature	0-150 °C		
Fluidics connection	¼''-28 UNF female thread		
Switching time	450ms	280ms	280ms
Communication	RS232/RS485/CAN bus		
Baud rate	RS232/ RS485: 9600bps, 19200bps, 38400bps, 57600bps, 115200bps; CAN: 100kbps, 200kbps, 500kbps, 1Mpbs		
Address& Parameter setting	Via communication		
Power supply	24VDC/3A		
Maximum power	60W		
Environment temperature	-10-50 °C		
Working humidity	≤80% (relative humidity, non-condensing)		
L x W x H mm^3	60x51x150	60x51x16	60x52x180
Net weight (Kg)	0.75	0.85	1.00

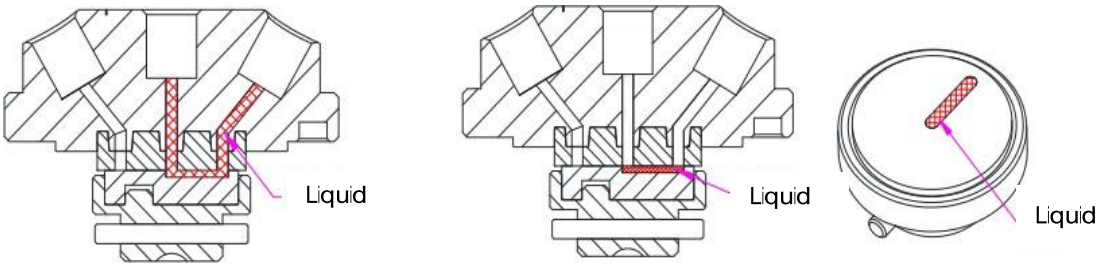


Figure 4 Schematic of Dead Volume from Port to Port & Dead Volume of the Sealed Rotor

1.6 Flow Configuration

The flow port configuration is shown in Figure 5. The central port of the valve is the common port. The valve can switch to any specific port by the rotor.

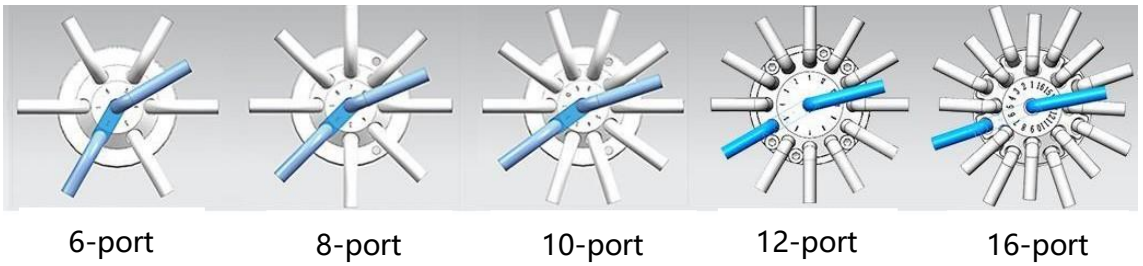


Figure 5 Flow Port Configuration of Electrical Rotary Valves

1.7 Reset Status

Reset direction is counterclockwise (unchangeable). After reset, the rotor slot is between the port 1 and the port of the maximum number. At this time, the center port and other ports are disconnected, as shown in Figure 6.

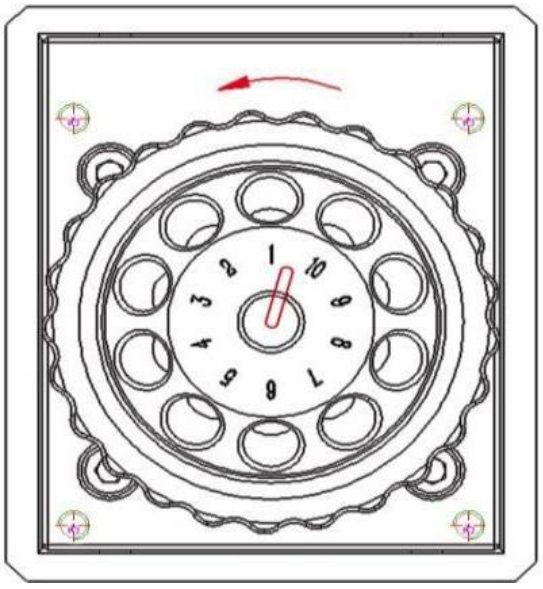
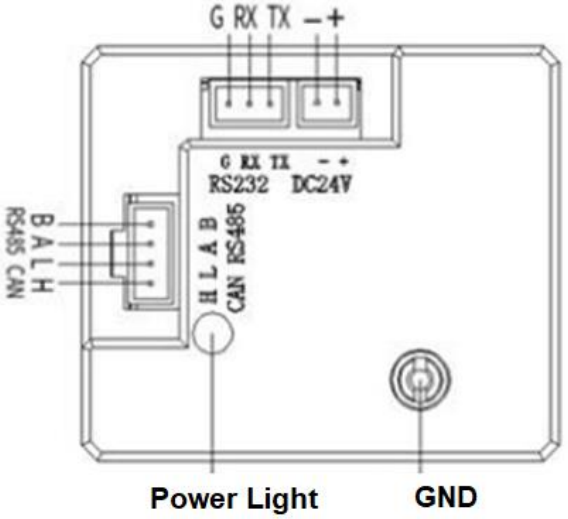


Figure 6 Rotor Slot Position After Valve Reset

1.8 Port Definition



Port	Description	Port	Description
+		H	
-		L	
TX		A	RS485A
RX		B	RS485B
GND	GND		

Figure 7 Port Diagram and Port Definition of Communication Ports

Chapter 2 Description of Control Code

2.1 Overview

The data transmission between the selector valve and the host device (computer, single-chip computer, PLC, etc.) adopts serial communication (e.g., RS-232/RS-485/CAN bus). The communication adopts asynchronous serial communication. Commands and data frames use sum check, and the sum check is two bytes (2Byte). Commands and data in communication are in hexadecimal, and parameters are stored in little-endian mode.

- Communication interface: RS-232, RS-485, CAN bus.
- Communication mode: two-way asynchronous, master-slave mode.
- Baud rate: RS232, RS485: 9600bps, 19200bps, 38400bps, 57600bps, 115200bps.
- CAN: 100Kbps, 200Kbps, 500Kbps, 1Mbps
- Data bit: 8-bit
- Parity: no check
- Response time: <1 second

2.2 Code Instructions

- Valve Parameter Setting Command (Factory Command)
- Valve Parameter Query Command (Common Command)
- Valve Action Command (Common Command)

Interpretation of 0xXX: 0x means hexadecimal, XX is a two-digit hexadecimal number. The value inputted into the software all should be XX.

Table 3 Send Command (Common Command)

FH (frame header)	Address code	Function code	Parameter		EOF (end of frame)	Sum check	
B0	B1	B2	B3	B4	B5	B6	B7
STX	ADDR	FUNC	1-8bit	9-16bit	ETX	Lowbyte	Highbyte

The message frame of "Send Command" is 8 bytes, and the complete format is as follows:

- The 1st byte STX: Frame header (0XCC)

- The 2nd byte ADDR: Address of slave device (0x00~0x7F) Multicast Address (0x80~0xFE) Broadcast Address (0xFF)
- The 3rd byte FUNC: Function code
- The 4th and 5th byte: Parameters corresponding to the function code
- The 6th byte ETX: End of frame (0xDD)
- The 7th and 8th byte: Cumulative sum check code from byte 1 to 6

Note: The above command format refers to the common command. If a password bit is added to the factory command and the parameter bit has also changed, from the original 2 bytes to 4 bytes, the command format is as follows:

The message frame of "Factory Command" is 14 bytes, and the format is as follows:

Table 4 Send Command (Factory Command)

FH (frame header)	Address code	Function code	Password	Parameter				EOF (end of frame)	Sum check	
B0	B1	B2	B3, B4, B5, B6	B7	B8	B9	B10	B11	B12	B13
STX	ADDR	FUNC	PWD	1-8 bit	9-16 bit	17-24 bits	25-32 bits	ETX	Low byte	High byte

Table 5 Response command

FH (frame header)	Address code	Status code	Parameter		EOF (end of frame)	Sum check	
B0	B1	B2	B3	B4	B5	B6	B7
STX	ADDR	STATUS	1-8 bit	9-16 bit	ETX	Low byte	High byte

Note: The send command and response command format of the common command are the same, and all the response command message frames are 8 bytes.

2.3 Command Format Instructions

Definition of frame header and end of frame B0, B5 (B11)

Name	Code	Remark
Frame header B0	0xCC	N/A
End of frame B5 (B11)	0xDD	N/A

Note: The send command and response command of the common command are the same. The frame header and end of frame are B0 and B5 respectively. Specially, the end of frame of factory command is B11.

Definition of address bit B1:

Name	Abbreviation	Code B1	Remark
Address bit	Addr	0xXX	N/A

Note:

- The send command and response command are the same.
- The XX in “0xXX” means that it can be set, the factory default is 0x00, and the parameter value range is 0x00～0x7F.

Table 6 Control command instructions (B2～B10)

A: Valve Parameter Setting Command (Factory Command) (B2~B10)

Code B2	Abbreviation	Password (B3 B4 B5 B6)	Parameter (B7 B8 B9 B10)
0x00	Set address	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0xXX (B8=0x00 B9=0x00 B10=0x00) The value range of XX is 00~7F in V1.9 & above version, 00~FF in version below V1.9, the default is 00.
0x01	Set RS232 baud rate	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	Totally 5 baud rates: the factory default is 9600bps (B8=0x00 B9=0x00 B10=0x00） B7=0x00 corresponding baud rate is 9600bps B7=0x01 corresponding baud rate is 19200bps B7=0x02 corresponding baud rate is 38400bps B7=0x03 corresponding baud rate is 57600bps B7=0x04 corresponding baud rate is 115200bps
0x02	Set RS485 baud rate	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	
0x03	Set CAN baud rate	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	Totally 4 baud rates: the factory default is 100K (B8=0x00 B9=0x00 B10=0x00） B7=0x00 corresponding baud rate is 100Kbps B7=0x01 corresponding baud rate is 200Kbps B7=0x02 corresponding baud rate is 500Kbps B7=0x03 corresponding baud rate is 1Mbps

Code B2	Abbreviation	Password (B3 B4 B5 B6)	Parameter (B7 B8 B9 B10)
0x0E	Set automatic reset when power on	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0x00 means non-automatic reset B7=0x01 means automatic reset Automatically reset to the position between port 1 and the port of the maximum number after power on (the factory default of selector valve is automatic reset).
0x10	Set CAN destination address	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0xXX (B8=0x00 B9=0x00 B10=0x00) The value range of XX is 00～FF, and the default is 00.
0x50	Set multicast channel 1 address	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0xXX (B8=0x00 B9=0x00 B10=0x00) The value range of XX is 80～FE, and the default is 00.
0x51	Set multicast channel 2 address	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0xXX (B8=0x00 B9=0x00 B10=0x00) The value range of XX is 80～FE, and the default is 00.
0x52	Set multicast channel 3 address	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0xXX (B8=0x00 B9=0x00 B10=0x00) The value range of XX is 80～FE, and the default is 00.
0x53	Set multicast channel 4 address	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0xXX (B8=0x00 B9=0x00 B10=0x00) The value range of XX is 80～FE, and the default is 00.
0xFC	Parameter lock	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	All the parameters are 0x00.
0xFF	Restore factory setting	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	All the parameters are 0x00.

Example: Use the 0x50/51/52/53 command to set the multicast address (only uses 0x50/51/52 commands in this example).

- In RS485 communication mode, set their addresses into 00, 01, 02 and make a mark. Firstly, for the multicast channel 1 address of ASP-ERV-7 whose address is 00, set the parameter 0x81 into 81 by command 0x50; for the multicast channel 3, the parameter 0x83 is set into 83 by the command 0x52.
- Secondly, for the multicast channel 1 address of ASP-ERV-7 whose address is 01, set the parameter 0x81 into 81 by command 0x50, for the multicast channel 2 address, the parameter 0x82 is set into 82 by the command 0x51; finally, for the multicast channel 2 address of ASP-ERV-7whose address is 02, set the parameter 0x82 into 82 by the command 0x51; for the multicast channel 3, the parameter 0x83 is set into 83 by the command 0x52. (See below table)

Table 7 Multicast Channel Address

Device Item	Device1 (Address 0)	Device2 (Address 1)	Device3 (Address 2)
Multicast address	81	81	
		82	82
	83		83
Broadcast address	FF	FF	FF

After the setting is completed, connect the three devices in parallel to the serial debugging tool, and use the debugging tool software MotorTest V0.8 to debug.

- Set the address into 0x81, the command into 0x44, and the parameter into 0x01. Click to send and then observe that the action of switching valve port is carried out on device 1 & device 2.
- Set the address into 0x82, the command into 0x44, and the parameter into 0x03. Click to send and then observe that the action of switching valve port is carried out on device 2 & device 3.
- Set the address into 0x83, the command into 0x44, and the parameter into 0x05. Click to send and then observe that the action of switching

valve port is carried out on device 1 & device 3.

- Set the address into 0xFF, the command into 0x44, and the parameter into 0x03. Click to send and then observe that the action of switching valve port is carried out on all the devices.

B: Valve Parameter Query Command (Common Command) (B2～B4)

Code B2	Abbreviation	Paramete r B3 B4
0x20	Query address	The address ranges from 0x0000 to 0x007F. The default value is 00
Ox21	Query RS232 baud rate	Totally 5 baud rates: the factory default is 9600bps B3B4=0X0000 corresponding baud rate is 9600bps B3B4=0X0001 corresponding baud rate is 19200bps B3B4=0X0002 corresponding baud rate is 38400bps B3B4=0X0003 corresponding baud rate is 57600bps B3B4=0X0004 corresponding baud rate is 115200bps
0x22	Query RS485 baud rate	
0x23	Query CAN baud rate	Totally 4 baud rates: B3B4=0X0000 corresponding baud rate is 100Kbps; B3B4=0X0001 corresponding baud rate is 200Kbps; B3B4=0X0002 corresponding baud rate is 500Kbps. B3B4=0X0003 corresponding baud rate is 1Mbps
0x2E	Query automatic reset when power on	B3=0x00 B4=0x00
0x30	Query CAN destination address	B3=0x00 B4=0x00
0x70	Query multicast channel 1 address	B3=0x00 B4=0x00
0x71	Query multicast channel 2 address	B3=0x00 B4=0x00
0x72	Query multicast channel 3 address	B3=0x00 B4=0x00
0x73	Query multicast channel 4 address	B3=0x00 B4=0x00
0x3E	Query current channel position	B3=0x00 B4=0x00
0x3F	Query current version	B3=0x01 B4=0x09, above is an example, if the response parameter is the same as above parameter, it means the current version is

		V1.9, see the version number on the label for details
0x4A	Query motor status	B3=0x00 B4=0x00

Note: After the V1.8 version, the software sub-version and the main version are merged into one command.

C: Valve Action Command (Common Command) (B2～B4)

Code B2	Abbreviation	Parameter B3 B4
0x44	The motor rotates through the code disc, and selects the best path automatically	It depends on the actual number of valve channels. For example, for the selector valve with 10 channels, B3=0xXX B4=0x00, where the value range of XX is 01～0A.
0x45	Reset	B3=0x00 B4=0x00 the selector valve runs to the reset optocoupler and stops.
0x4F	Origin reset	B3=0x00 B4=0x00 the selector valve runs to the encoder origin position, which overlaps with reset position of the 0x45 command.
0xA4	Switch the port according to the required direction	According to the actual number of ports of the selector valve, the parameter cannot exceed the maximum number of ports of the current valve, and B3, B4 must be two adjacent ones. see the figure below for details.
0xB4	Switch between ports according to the required direction	According to the actual number of ports of the selector valve, the parameter cannot exceed the maximum number of ports of the current valve, and B3, B4 must be two adjacent ones. see the figure below for details.
0x49	Stop forcibly	B3=0x00 B4=0x00

Example 1: 0x44: switch the port according to the required direction

- The current valve connected port is NO. 1 and the target: run counterclockwise to port 4: → Command: 0xA4 Parameter: 0x0304

  The valve will run counterclockwise through port 3 to port 4, as shown in Figure 8.

- The current valve connected port is NO. 1 and the target: run clockwise to port 4: → Command: 0xA4 Parameter: 0x0504

  The valve will run clockwise through port 5 to port 4 (B4 clockwise direction will not be repeated below), as shown in Figure 8.

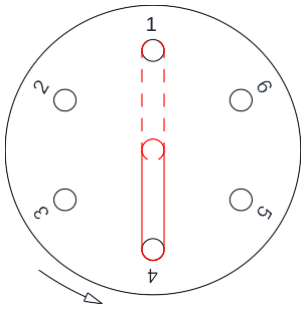


Figure 8 Valve Runs Counterclockwise

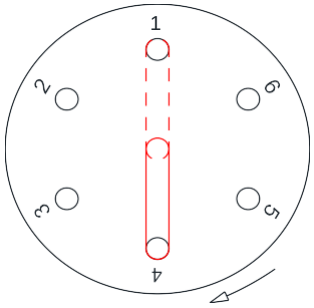


Figure 9 Valve Runs Clockwise

Example 2: 0xB4: Switch between ports according to the required direction

- The current valve connected port is NO. 1 and the target: run counterclockwise to between port 3 and port 4:→ Command: 0xB4, Parameter: 0x0304

  The valve will run counterclockwise through port 3 and stop between port 3 and port 4, as shown in Figure 10：

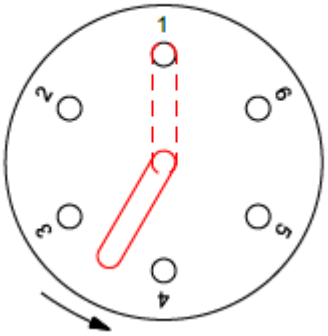


Figure 10 Example of Valve Switching Ports

Sum check (B6, B7)

Name	Abbreviation	Code B6 , B7	Remark
Sum check	Sum check	0xXX 0xXX	Sum of header and end

Note: The sum check bit of the factory command is B12, B13

Response parameter description B2 B3 B4

Table 8 Response Parameter

Code B2	Description	Parameter description=B3 B4
0x00	Normal status	B3=0x00 B4=0x00 Example: when using the query command “0x3E”, the parameter 0x01 0x00～0x0a 0x00 returned by B3, B4 means multi-channel 1-10 channels
0x01	Frame error	Parameter=0x00 0x00
0x02	Parameter error	Parameter =0x00 0x00
0x03	Optocoupler error	Parameter =0x00 0x00
0x04	Motor busy	Parameter =0x00 0x00
0x05	Motor stalled	Parameter =0x00 0x00
0x06	Unknown position	Parameter =0x00 0x00
0xFE	Task being executed	Parameter =0x00 0x00

0xFF	Unknown error	Parameter =0x00 0x00

Note:

- In RS485 communication, when sending an action command, the byte B2 in the response frame is FE, indicating that the command is received and being executed.
- The code B2 in the response command indicates the current running status of the motor. Only when B2=0x00, the motor is in normal operation, and other parameters are shown in the above table, corresponding to different abnormal status respectively.
- In principle, the motor should be sent the 0X4A command to query the motor status at the end of the motor operation. Only when the parameter B2 in the response command is 00, other commands can be executed correctly.

The code parameters of all the above commands are set in little-endian mode. Low data is stored in the low bit of the address and high data is stored in the high bit of the address.

Chapter 3 Common Problems & Solutions

Table 9 Troubleshooting on Common Problems

Phenomenon	Problem	Solution
Not working when power on	The working voltage is not in the acceptable range.	Check whether the voltage is within the acceptable range.
	The connection is loose or disconnected.	Check whether the connection is good.
	The working current is not in the acceptable range.	Check whether the current is within the acceptable range.
Not aspirate after switching	It is blocked by debris.	Remove the pump tube and clear the debris.
Liquid has bubbles.	The connection is not tight.	Replace suitable connectors.
No communication	The TX and RX lines of RS232 are connected reversely or phase A & B of RS485 are connected reversely.	Exchange the TX and RX line sequence of RS232 and exchange the phase A & B sequence of RS485.
The sent and received communications are consistent in RS232.	TX and RX are in short circuit.	Check whether there is short circuit, if yes, replace the cable.

Product Safety Precautions

- Please ensure that the voltage matches with the standard voltage of the instrument.
- Please use the original serial cable of this product to connect to the power supply.
- The three communication methods (RS232, RS485, CAN bus) of this product are in non-isolated mode.
- Please cover the unused ports with suitable coned plugs when laid aside to avoid impurity substance and air.
- Do not disassemble the product parts at will. No warranty for tamper-evident label tearing.
- When operating the software, please refer to the operating instructions of the software and the communication protocol, and data input is not allowed to be fabricated without authorization.

- Discarding the instrument should be in accordance with the regulations on the disposal of equipment. For the waste after using the machine, please follow the national environmental protection requirements.
- When using CAN bus protocol to connect multiple devices, please refer to the connection method shown in Figure 11 below.

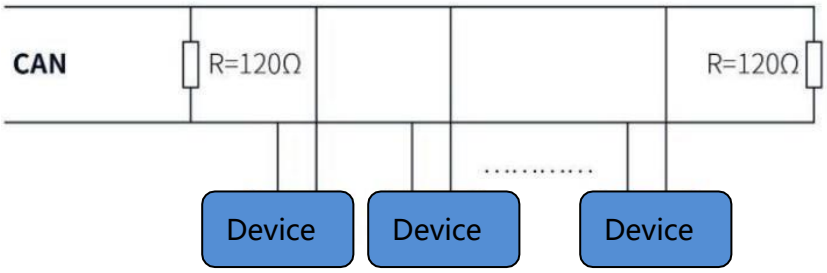


Figure 11 CAN Connection Method

- When using RS485 protocol to connect multiple devices, please refer to the connection method shown in Figure 12 below (CAN resistance is removed)

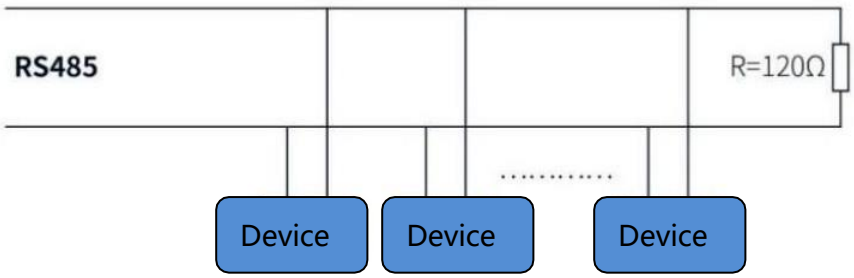


Figure 12 RS485 Connection Method

Chapter 4 Typical Fluidics Applications

Typical Applications of Electrical Rotary Valves

- Biological sample preparation and distribution
- Sample injection or selection
- Reagent recirculation system
- Microfluidics sample delivery or perfusion system
- Automatic reagent delivery
- High speed sample enrichment
- Column back flushing
- Flow cytometry or chemistry analyzer
- Mass spectrometers
- Elemental analyzers
- Analytical instruments

Example 1 Multi-Channel Reagent Distribution Circuit

Components and equipment are required as the follows. The schematic is shown in Figure 13.

- Valve reset position: it is located in between position 1 and 10
- Syringe pump home position
- Two-way solenoid valve: normally closed
- Syringe pump
- Glass syringes
- DI water reservoir
- Inline pressure transducer
- Waste container
- Reagent containers
- Tubing and fittings

Prime fluidic circuit steps:

- Electrical rotary valve reset, and the 2-way solenoid valve turned on

- Syringe pump withdraws DI water from water reservoir (aspirated water volume larger than liquid reservoir loop)
- 2-way solenoid valve turned off and rotary valve switches its position to port 2
- Syringe pump is homed and dispenses all DI water to waste container through port 2
- Rotary valve switches its position to port 3 and the syringe pump aspirates reagent 1 through port 3 to the liquid reservoir loop
- Rotary valve switches its position to port 2 and home the syringe pump
- Rotary valve switches its position to port 10. The syringe pump aspirate 1mL air through port 10
- Rotary valve switches its position to port 3 and dispense 100uL air
- Rotary valve switches back to port 2 and dispense all reagent

Reagent aspiration and dispense steps:

- Electrical rotary valve reset, and the 2-way solenoid valve turned on
- Syringe pump withdraws DI water from water reservoir (aspirated water volume larger than liquid reservoir loop)
- 2-way solenoid valve turned off and rotary valve switches its position to port 2
- Syringe pump is homed and dispenses all DI water to waste container through port 2
- Rotary valve switches its position to port 3 and the syringe pump aspirates reagent 1 through port 3 to the liquid reservoir loop (over aspiration and less dispense)
- Rotary valve switches its position to port 2 and dispense 200uL and switch to port 1 after 2 seconds' delay
- Syringe pump dispenses target volumes. Rotary valve switches its position to port 2 and home the syringe pump to dispense all reagent through port 2
- Rotary valve switches its position to port 10. The syringe pump aspirate 1mL air through port 10 and dispenses 0.5mL air
- Rotary valve switches its position to port 3 and dispense 100uL air
- Rotary valve switches back to port 2 and dispense all reagent

Example 2 Microfluidics Sample Selection and Delivery Recirculation System

Components and equipment are required as the follows. The schematic is shown in Figure 14.

- Sample/buffer solution reservoir
- Pressure controller (8- channel compressed air; 2-channel vacuum)

- Electrical rotary/select valves
- Microfluidic chips (droplet generator or cell sorter)
- Inline filter
- Liquid flow sensor
- Dino-lite microscope
- Waste container

The real-time flow rate is monitored by the liquid flow sensor (ranging from a few microliters to 5mL/min depending on the application requirements). The analog signal from the flow sensor via RS232 or RS485 or digital signal via I2C provides feedback to the pressure controller and forms a closed loop control to deliver desired flow rates of samples or reagents. The electrical rotary valve can switch to any ports and select different reagents or buffer solutions. The generated droplets in microfluidic chip can be imaged and analyzed through regular microscope, such as Dino-Lite microscope or fluorescence microscope. Vacuum pressure is applied to the waste collection container. Finally, the waste is collected to the waste container.

Example 3 Sample Injection and Recirculation

Example 1: Multi-Channel Reagent Distribution Circuit- Syringe Pump + Electrical Rotary Valve

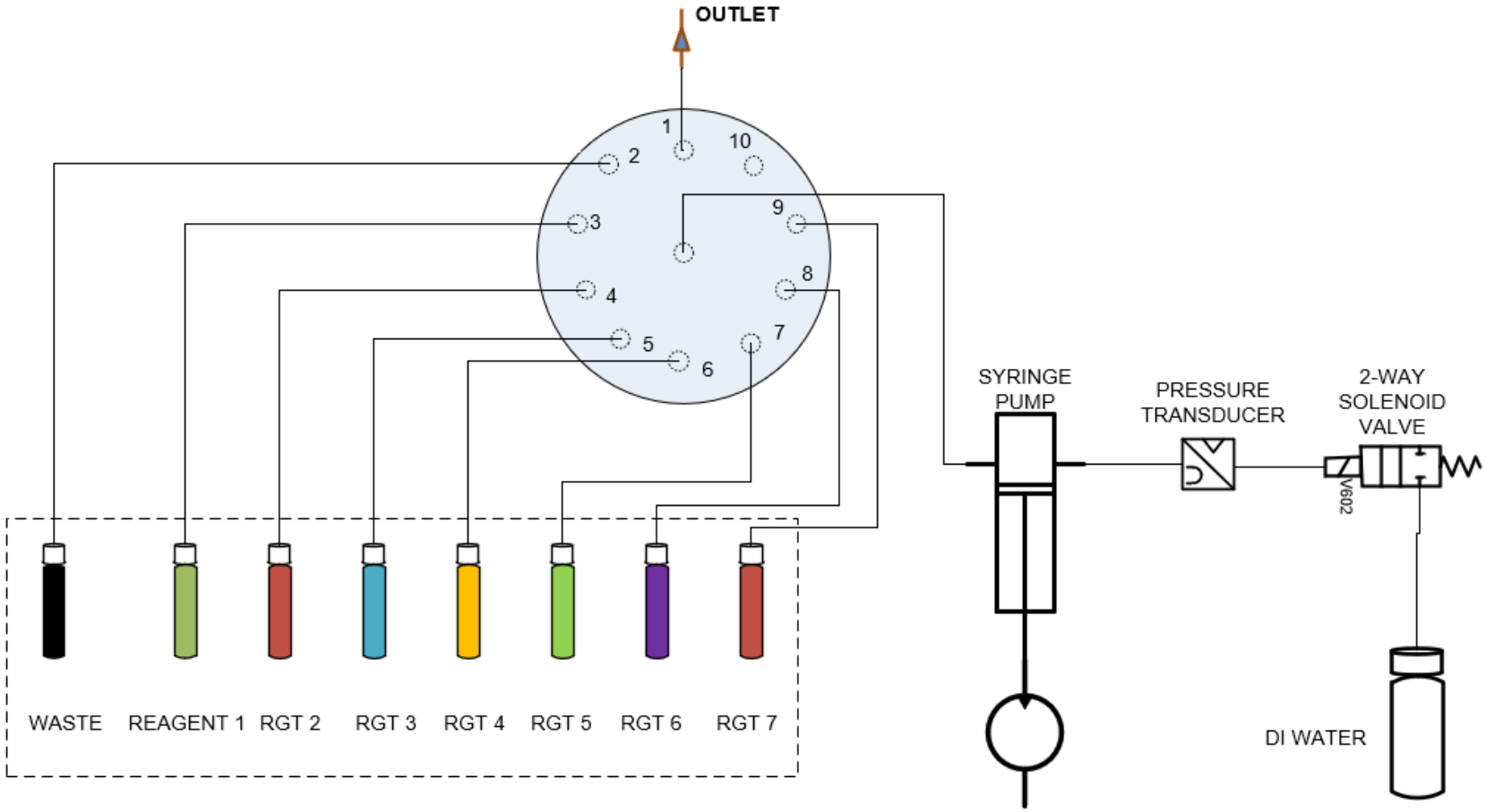


Figure 13 Schematic of Multi-Channel Reagent Distribution Circuit

Example 2: Microfluidics Sample Selection and Delivery: Pressure Controller + Electrical Rotary Valve

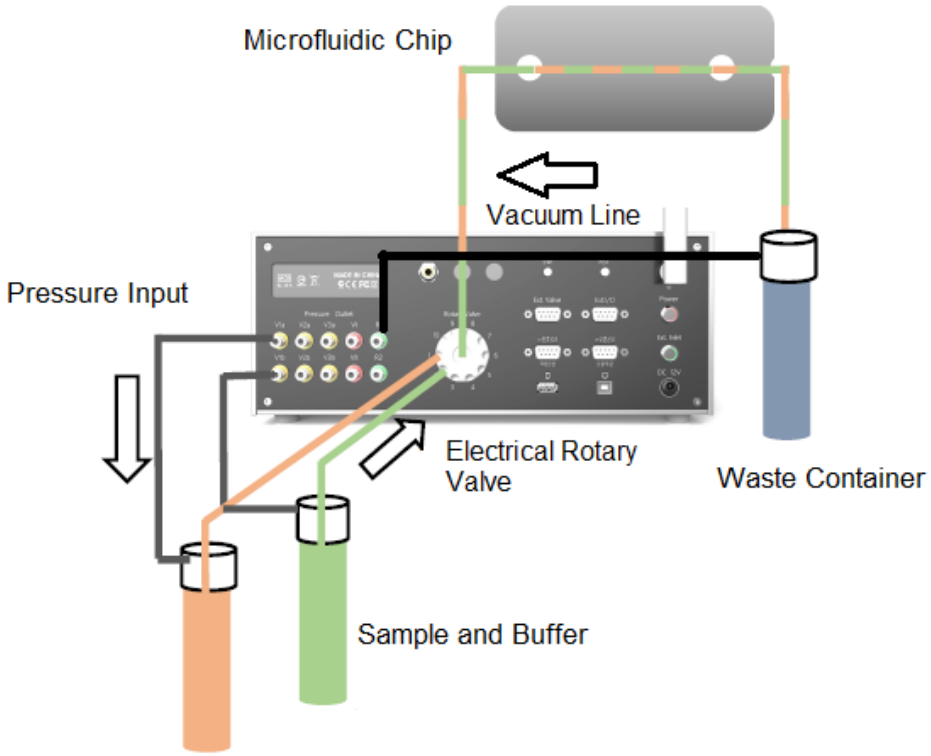


Figure 14 Schematic of Microfluidics Sample Selection and Delivery with Rotary Valve