PG SwitchEZ™ Electric Rotary Valve Manual

Contents

PG SwitchEZ™ Electric Rotary Valve Manual

Chapter 1 – Product Introduction

1. Introduction

The SwitchEZ™ rotary valve is an electric multi-channel selection/switching valve designed for automated fluidic/microfluidic applications. Fast, reliable geared switching ensures long life, while the valve heads provide leak-free connections to 1/32", 1/16”, or smaller OD capillary tubing. SwitchEZ valves are constructed with PCTFE and sapphire crystal as wetted materials, suitable for use with a wide variety of chemicals.

2. System Features

Several design elements ensure high valve reliability and accuracy.

1. *Corrosion resistance* – Sapphire valve core and blended PCTFE/PPS valve head
2. *Spool structure* – Multi-directional self-adaptive plane fitting method
3. *Control* – RS232/RS485/CAN bus
4. *Power* – Gear motor
5. *Positioning* – Optical encoder positioning
6. *Drive* – Two-phase bipolar stepper motor driver
7. *Controller interface* – Standard terminals with 2.54mm pitch.
8. *Fluidic interface* – 1/4-28UNF female threads.

3. Applications

1. Microfluidic applications
2. Environmental testing
3. Experimental analysis
4. Medical analysis
5. Chromatography

4. Naming Convention

Model naming uses the following rule:

PG-ROTV - XXP-XXXX - X
① ② ③

1	Product type	PG-ROTV: SwithEZ™ electric rotary valve
2	Port Number	06P: 6 ports (6 to 1) selection valve 08P: 8 ports (8 to 1) selection valve 10P: 10 ports (10 to 1) selection valve 12P: 12 ports (12 to 1) selection valve 16P: 16 ports (16 to 1) selection valve 06P-3W2P: 6 ports, 3 ways 2 positions switching valve
3	Version	Blank: standard version X: custom version

Example: SwitchEZ 10 port selection valve – PG-ROTV-10P

5. Product Schematics

SwitchEZ selection valves may feature 6, 8, 10, 12, or 16 ports. Switching valves only come in 6 ports.

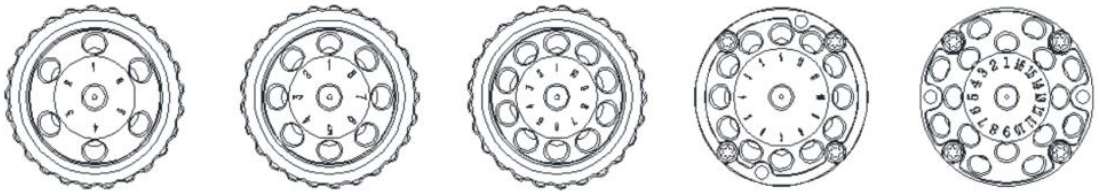

Figure 1-1. Overview of SwitchEZ selection valves

6/8/10 port valves may be installed interchangeably in a mounting plate as shown in **Figure 1-2** (unit: mm)

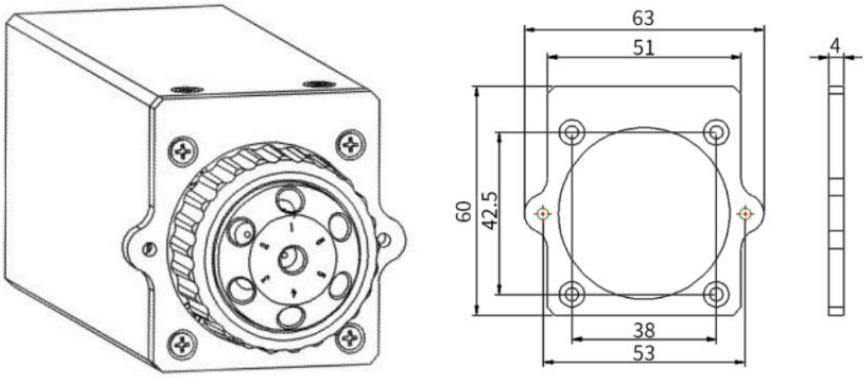

Figure 1-2. Mounting plate schematic

Individual valve schematics are shown in the following figures (unit: mm)

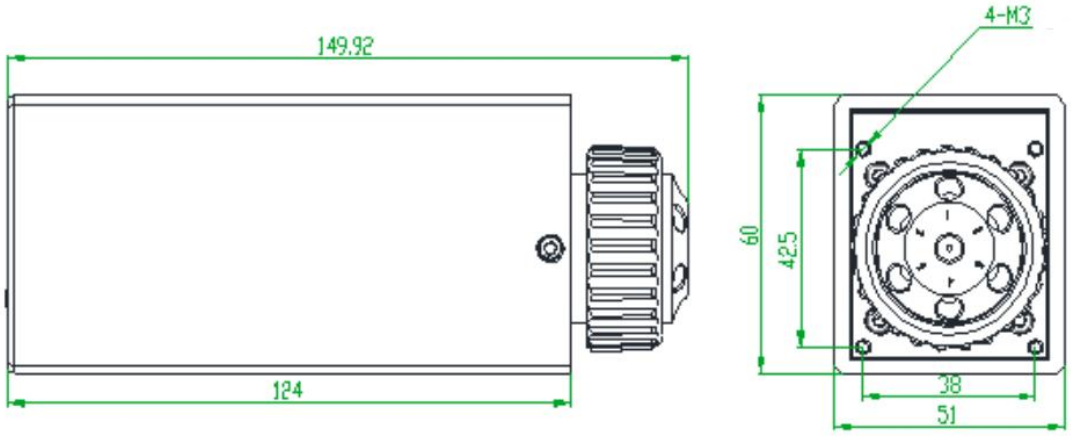

Figure 1-3. 6/8/10 port valve dimensions

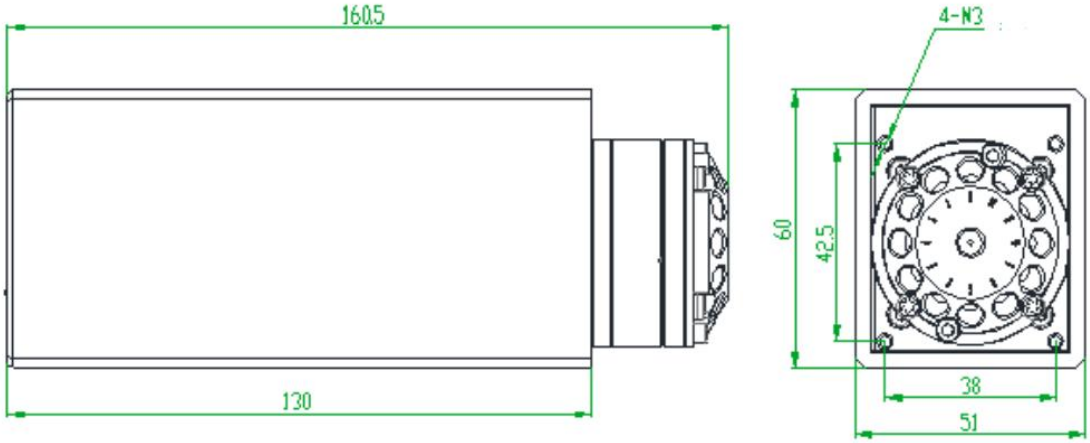

Figure 1-4. 12 port valve dimensions

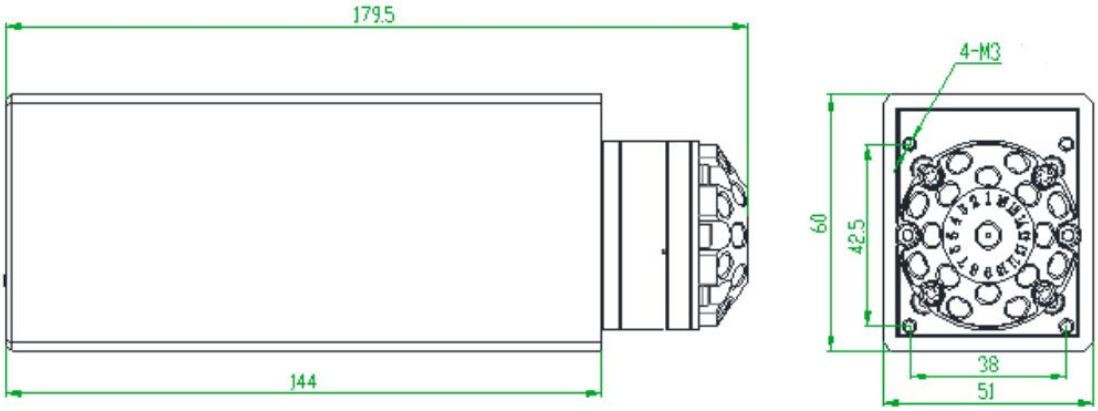

Figure 1-5. 16 port valve dimensions

For any given selection valve, the central port is the common channel position. The rotor switches between multiple ports to select one at a time.

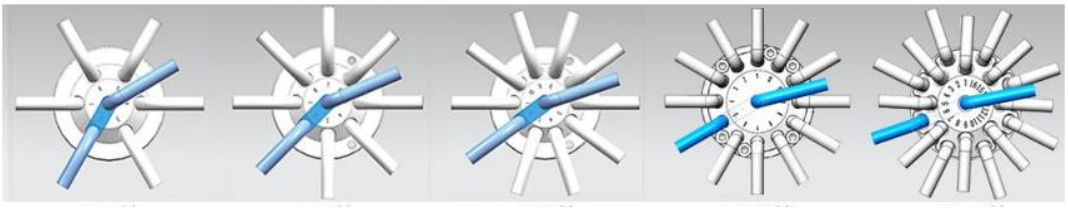

Figure 1-6. Selection valve mechanism

Additional volume diagrams are presented in **Figure 1-7**.

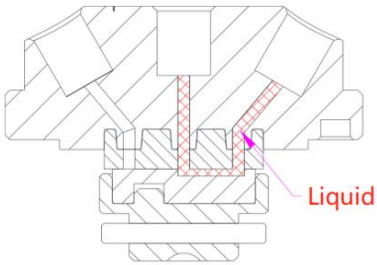

Figure 1-7-1. Port-o-port volume

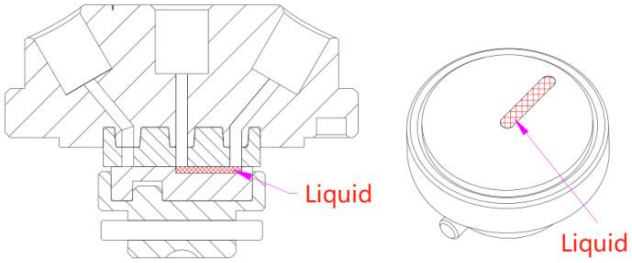

Figure 1-7-2. Rotor slot volume

The switching valve resets counterclockwise, after which the rotor slot is set between the 1st and largest numbered port. At this time, the central port and other ports are blocked, as shown in **Figure 1-8**.

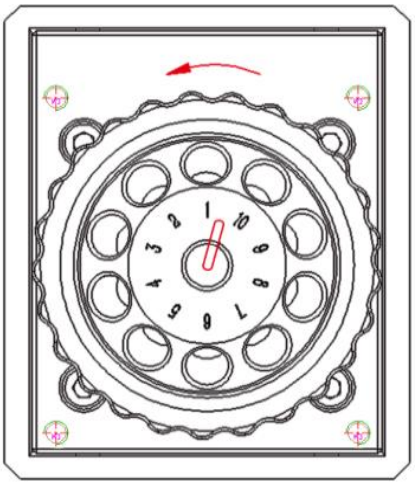

Figure 1-8. Rotary valve reset state

6. Product Specification

Name	Specifications		
Number of channels	6/8/10 ports	12 ports	16 ports
Channel diameter	1.2mm	1.0mm	1.0mm
Port to port volume (dead volume)	27.5μL	22.43μL	33.68μL
Rotor slot volume (dead volume)	5.41μL	6.08μL	10.4μL
Wetted material	PCTFE, Sapphire crystal		
Max pressure	Air pressure: 0 to1.0 MPa; Water pressure: 0 to 1.6 MPa		
Initial position detection	Set to automatically detect the initial position after powered-on (this function can be selectively turned on or off)		
Liquid temperature at valve head	0℃～150℃		
Tubing interface	1/4-28UNF internal thread		
Replaceable parts	the stator and rotor seals		
Transposition performance	Multiple locations, random start		
Optional driver board	No		
Switching time	≤2s/circle	≤2s/circle	≤3.3s/circle
Communication Interface	RS232/RS485/CAN bus		
Communication rate	RS232/ RS485 bus: 9600bps, 19200bps, 38400bps,57600bps, 115200bps CAN bus: 100kbps, 200kbps, 500kbps, 1Mpbs		
Device address and parameter setting	Communication Interface		
Applicable power supply	DC24V/3A		
Maximum power	60W		
Working ambient temperature	-10℃～50℃		
Working relative humidity	≤80% non-condensing state		
Dimensions (l*w*h)	60x51x150mm	60x51x160.5mm	60x51x179.5 mm
Weight	0.73kg	0.86kg	1.02kg

7. Electrical Port Definition

There are three electrical ports with various connectors as shown in **Figure 1-9**.

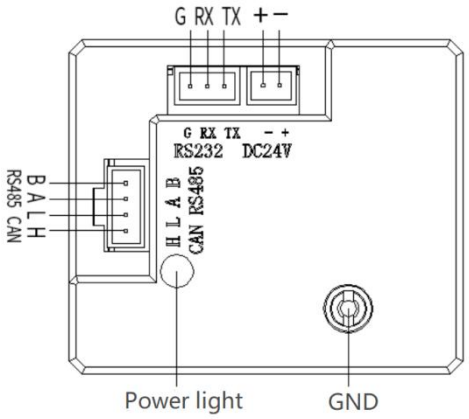

Figure 1-9. Electrical ports schematic

Pin name	Function
+	DC24V positive
-	DC24V negative
TX	RS232 data transit pin
RX	RS232 data receiving pin
GND	GND
H	CANH
L	CANL
A	RS485 A
B	RS485 B

Chapter 2 – Communication Protocol

1. Overview

The following describes the communication protocol:

1. Communication adopts asynchronous serial communication mode
2. Command and data frame adopt 2Byte checksum
3. Command and data in communication are hexadecimal numbers
4. Parameters are stored in little-endian mode

Other notes on instructions:

1. *Communication interface*: RS-232, RS-485
2. *Communication modes*: Two-way asynchronous and master-slave mode
3. *Baud rates (RS-232/RS-485)*: 9600, 19200, 38400, 57600, and 115200 bps
4. *Baud rates (CAN)*: 100 Kbps, 200 Kbps, 500 Kbps, 1 Mbps
5. *Data bits*: 8bit
6. *Parity check*: None
7. *Response time*: <1 second

2. Frame Format

There are three types of commands and one type of response message defined in the rotary valve communication protocol:

1. *General commands (two types)*
   2.1.1. *Query commands* – Query valve parameters
   2.1.2. *Control commands* – Control valve's position
2. *Factory commands – Set up rotary valve parameters*
3. *Response messages*

I. General Command Format

Query and control commands are 8 bytes and use the format described in **Table 2-1.**

Frame head	Address code	Function code	Parameter region		Frame end	Checksum	
B0	B1	B2	B3	B4	B5	B6	B7
STX	ADDR	FUNC	1-8bits	9-16bits	ETX	Low byte	High byte

Table 2-1. Format of general commands (query and control commands)

1. *1st byte* – Frame head (0xCC)
2. *2nd byte* – Addresses
   a) Normal address of slave (0x00~0x7F)
   b) Multicast address (0x80~0xFE)
   c) Broadcast address (0xFF)
3. *3rd byte* – Function code

4. *4th and 5th bytes* – Parameters of function code
5. *6th byte* – Frame end (0xDD)
6. *7th and 8th bytes* – Checksum code for bytes 1-6.

Note: 0x means hexadecimal. XX is a two-digit hexadecimal number which is entered in tool software.

II. Factory Command Format

Factory commands are 14 bytes and use the format described in **Table 2-2.**

Frame head	Address code	Function code	Password	Parameter region				Frame end	Checksum	
B0	B1	B2	B3, B4 B5, B6	B7	B8	B9	B10	B11	B12	B13
STX	ADDR	FUNC	PWD	1-8bits	9-16bits	17-24 bits	25-32 bits	ETX	Low byte	High byte

Table 2-2. Format of factory commands (setting commands)

Compared to general commands, factory commands have 4 password bytes. The parameter region is also changed from 2 to 4 bytes:

1. *1st byte* – Frame head (0xCC)
2. *2nd byte* – Addresses
   a) Normal address of slave (0x00~0x7F)
   b) Multicast address (0x80~0xFE)
   c) Broadcast address (0xFF)
3. *3rd byte* – Function code
4. *4th to 7th bytes* – Password code
5. *8th to 11th bytes* – Parameters of function doe
6. *12th byte* – Frame end (0xDD)
7. *13th and 14th bytes* – Checksum code for bytes 1-12.

III. Response Message Format

Response messages follow the same format as general commands (8 byte). Consult the previous section for an explanation of each byte.

Frame head	Address code	Status code	Parameter region		Frame end	Checksum	
B0	B1	B2	B3	B4	B5	B6	B7
STX	ADDR	STSTUS	1-8bits	9-16bits	ETX	Low byte	High byte

Table 2-3. Format of response messages

3. Command Description

The following section will further explain some of the code used in previously described frames.

I. Frame header and frame end

Name	Code	Comment
Frame header B0	0xCC	
Frame end B5 (B11)	0xDD	

Table 2-4. Definition of frame header and frame end

1. Frame header is defined at B0.
2. Frame end is defined at B5 for general commands and response frames.
3. Frame end is defined at B11 for factory commands.

II. Address Byte

Name	Abbreviation	Code	Comment
Address byte	Address	0xXX	

Table 2-5. Definition of address byte

1. General command is the same as response message frame.
2. The default value for code is 0x00, with a range of 0x00~0x7F.

III. Control Code (Factory Commands) (B2~B10)

Code B2	Command	Code B3 B4 B5 B6	Parameter description B7 B8 B9 B10
0x00	Set address	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0xXX (B8=0x00 B9=0x00 B10=0x00) where the value range of XX is 00～7F in and above V1.9 versions and 00～FF in versions below V1.9. The default is 00.
0x01	Set RS232 baud rate	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	5 baud rates: the factory default is 9600bps (B8=0x00 B9=0x00 B10=0x00) B7=0x00 corresponds to the baud rate of 9600bps B7=0x01 corresponds to the baud rate of 19200bps B7=0x02 corresponds to the baud rate of 38400bps B7=0x03 corresponds to the baud rate of 57600bps B7=0x04 corresponds to the baud rate of 115200bps
0x02	Set RS485 baud rate	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	
0x03	Set CAN wave baud rate	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	4 baud rates: the factory default is 100Kbps (B8=0x00 B9=0x00 B10=0x00) B7=0x00 corresponds to the baud rate of 100Kbps B7=0x01 corresponds to the baud rate of 200Kbps B7=0x02 corresponds to the baud rate of 500Kbps B7=0x03 corresponding to the baud rate of 1Mbps
0x0E	Set automatic reset when powered on	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0x00: non-automatic reset B7=0x01: automatic reset Automatically reset to the middle position between No. 1 port and the largest numbered port of the switching valve when powered on

0x10	Set the destination address of CAN	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	B7=0xXX (B8=0x00 B9=0x00 B10=0x00) The value range of XX is 00～FF. The default is 00.
0x50	Set up 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. The default is 00.
0x51	Set up 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. The default is 00.
0x52	Set up 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. The default is 00.
0x53	Set up 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. The default is 00.
0xFC	Lock valve parameters	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	The parameters are all 0x00.
0xFF	Restore factory settings	B3=0xFF B4=0xEE B5=0xBB B6=0xAA	The parameters are all 0x00.

Table 2-6. Control code description for factory commands

Example – Using 0x50/51/52 commands to set a multicast address

1. When using three rotary valves together, we can set their addresses to 00, 01, and 02. We can also mark them in RS485 communication mode.
2. *For rotary valve with address 00:*
   a) Use 0x50 to set 81 to address 0x81 for multicast channel 1
   b) Use 0x52 to set 83 to address 0x83 for multicast channel 3
3. *For rotary valve with address 01:*
   a) Use 0x50 to set 81 to address 0x81 for multicast channel 1
   b) Use 0x51 to set 82 to address 0x82 for multicast channel 2
4. *For rotary valve with address 02:*
   a) Use 0x51 to set 82 to address 0x82 for multicast channel 2
   b) Use 0x52 to set 83 to address 0x83 for multicast channel 3

Category\Device	Device 1(Address 00)	Device 2(Address 01)	Device 3(Address 02)
Multicast address	81	81	
		82	82
	83		83
Broadcast address	FF	FF	FF

Table 2-7. Summary of multicast address example

After setup, connect the three rotary valves in parallel to the serial port debugging tool. Use our API library to test the valves with the following messages:

1. *Address 0x81, command 0x44, parameter 0x01* – Port switching on device 1 and 2
2. *Address 0x82, command 0x44, parameter 0x03* – Port switching on device 2 and 3
3. *Address 0x83, command 0x44, parameter 0x05* – Port switching on device 1 and 3
4. *Address 0xFF, command 0x44, parameter 0x03* – Port switching on all devices

IV. Control Code (Query Commands) (B2~B4)

Code B2	Abbreviation	Parameter specification B3 B4
0x20	Query the address	B3=0x00 B4=0x00
Ox21	Query RS232 baud rate	B3=0x00 B4=0x00
0x22	Query RS485 baud rate	B3=0x00 B4=0x00
0x23	Query CAN baud rate	B3=0x00 B4=0x00
0x2E	Query automatic reset when powered 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 the current channel position	B3=0x00 B4=0x00
0x3F	Query the current version	B3=0x01 B4=0x09, The above is an example. If the query result shows the above parameters, that means the version is V1.9
0x4A	Query motor status	B3=0x00 B4=0x00

Table 2-8. Control code description for query commands (general command)

V. Control Code (Control Commands) (B2~B4)

Code B2	Abbreviation	Parameter specification B3 B4
0x44	The motor rotates through the code disc, and automatically chooses the best path	It depends on the actual number of channels of the switching valve. For example, for a 10-channel switching valve, B3=0xXX B4=0x00, where the value range of XX is 01～0A
0x45	Reset	B3=0x00 B4=0x00 The switching valve rotates to where the reset optical encoder is and stops
0xA4	Switch the port position according to the required direction	According to the actual number of ports of the switching valve, the parameter value cannot exceed the maximum number of channels of the current valve, and B3 and B4 must be two adjacent ports, see the following figure for details.
0xB4	Switch to the middle position of two adjacent ports according to the required direction	According to the actual number of ports of the switching valve, the parameter value cannot exceed the maximum number of ports of the valve, and B3 and B4 must be two adjacent port positions, see the figure below for details
0x49	Mandatory stop	B3=0x00 B4=0x00

Table 2-9. Control code description for control commands (general command)

Example – Using 0xA4 command to switch port position in desired direction

1. To switch the valve from port 1 to port 4 counterclockwise, use the following:
   a) *Command*: 0xA4
   b) *Parameter*: 0x0304
   The valve will then turn counterclockwise through port 3 to port 4.
2. To switch the valve from port 1 to port 4 clockwise, use the following instead:
   a) *Command*: 0xA4
   b) *Parameter*: 0x0504
   The valve will then turn clockwise through port 5 to port 4.

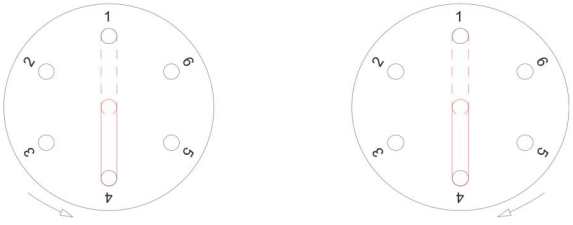

Figure 2-1. Overview of switching with 0xA4

Example – Using 0xB4 command to switch between two ports in desired direction

1. To switch the valve from port 1 to stop between ports 3 and 4 counterclockwise, use the following:
   a) *Command*: 0xB4
   b) *Parameter*: 0x0304

   The valve will then rotate counterclockwise, pass through port 3, and stop between ports 3 and 4.

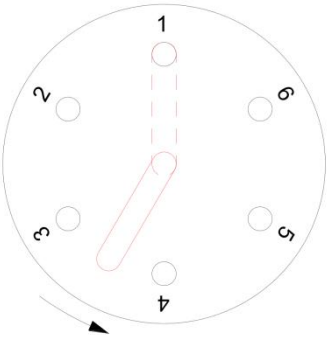

Figure 2-1. Overview of switching with 0xB4

VI. Checksum

Name	Abbreviation	Code B6, B7	Comment
Checksum	Checksum	0xXX 0xXX	The sum of the header to the end of the package

Table 2-10. Definition of checksum (general commands)

Note – Factory commands have checksum digits B12, B13 instead of B6, B7.

VII. Response Parameters B2, B3, B4

Code B2	Description	Other parameter description=B3 B4
0x00	Normal state	B3=0x00 B4=0x00 Example: When using the query command "0x3E", the parameters of B3 and B4 are returned to 0x01 0x00～0x0a 0x00 Indicates multi-channel number 1-10
0x01	Frame error	Parameter=0x00 0x00
0x02	Parameter error	Parameter=0x00 0x00
0x03	Optical encoder error	Parameter=0x00 0x00
0x04	Motor busy	Parameter=0x00 0x00
0x05	Motor stalled	Parameter=0x00 0x00
0x06	Unknown location	Parameter=0x00 0x00
0xFE	Task pending	Parameter=0x00 0x00
0xFF	Unknown mistake	Parameter=0x00 0x00

Table 2-11. Definition of response parameters (general commands)

1. Code B2 indicates current motor running status. All values besides 0x00 indicate various error states.
2. The command 0x4A (**Table 2-8**) should be sent to query motor status after the motor is running.
3. All listed code parameters are set in little-endian mode. Lower bits of data are stored in the lower address of memory, and higher bits in the higher address.

Chapter 3 – Troubleshooting and Frequently Asked Questions

1. Troubleshooting

Phenomena	Possible causes	Solutions
Not working when powered on	Applied voltage is not within the specified range	Check whether the voltage is within the specified range
	The power connection is loose or disconnected	Check the power connection and reconnect the power.
	Applied electric current is not within the specified range	Check whether the electric current is within the specified range
Switch but no liquid out	The channel is blocked by particles	Disconnect the tubing and check possible causes
Bubbles in liquid	The interface is not tight	Replace with the appropriate connectors
No communication	The TX and RX lines of RS232 are connected in reverse order OR RS485 phase A and B are reversed	Exchange RS232 TX and RX line , or exchange the A & B phase lines of RS485 port
RS232 communication sends and receives the same message	TX and RX are shorted	Check if there is any short circuit and replace the cable if yes

Table 3-1. Common hardware issues

2. Frequently Asked Questions

1. *How do I know if the valve is activated?*
   The LED on the back of the valve will flash green and red when connected to power.

2. *What cable is needed to control my rotary valve with a computer?*
   A USB/RS232 adapter is highly recommended for this application. We sell one on our website (PG-CBL-USB-ROTV). Third-party adapters may or may not work.

3. *What baud rate should the RS232 side be?*
   The baud rate should be 9600 by default.

4. *Is there an upper limit to the port number if the valve is controlled by RS232 port with API library?*
   Yes. Addresses above 20 will make the valve unresponsive.

5. *What API libraries are available for the rotary valves?*
   Python, C/C++ and LabView libraries with respective manuals are available for download.

6. *What is the checksum logic of the rotary valve?*
   The checksum is the sum of B0 to B5 in **Table 2-1** as shown below. If the checksum is wrong, the device will not respond.

Frame head	Address code	Function code	Parameter region		Frame end	Checksum	
B0	B1	B2	B3	B4	B5	B6	B7
STX	ADDR	FUNC	1-8bits	9-16bits	ETX	Low byte	High byte

7. *Do I need to send anything prior to sending a move command?*
   No. But you may retrieve the address with the following command:
   00 20 00 00 DD C9 01
   Example:
   2021-12-16 10:30:54 command: CC 00 20 00 00 DD C9 01
   2021-12-16 10:30:54 received message: CC 41 00 41 00 DD 2B 02

8. *How to move between ports on a valve in HEX?*
   You need the address of each port and the following command:
   CC XX XX 04 00 DD 32 02
   Example:
   Port 1 (0x41) to Port 4 (0x44)
   CC 41 44 04 00 DD 32 02

3. Safety Precautions

1. Please ensure that the voltage matches the voltage requirement of the valve.
2. Please use the original serial cable of this product to connect to the power supply.
3. The communication ports (RS232/RS485/CAN bus) are in **non-isolated** mode.
4. If any ports are NOT in use, use the included rubber plugs to plug them tightly to prevent contaminants or airflow from entering the valve body.
5. Do NOT disassemble the product parts. *Warranty is void for tamper-evident label tearing.*
6. Dispose of the device in accordance with the local regulations on the disposal of electronic waste.
7. When using RS485 and CAN to connect multiple valves, please refer to the connection diagram shown in **Figure 3-1** below.

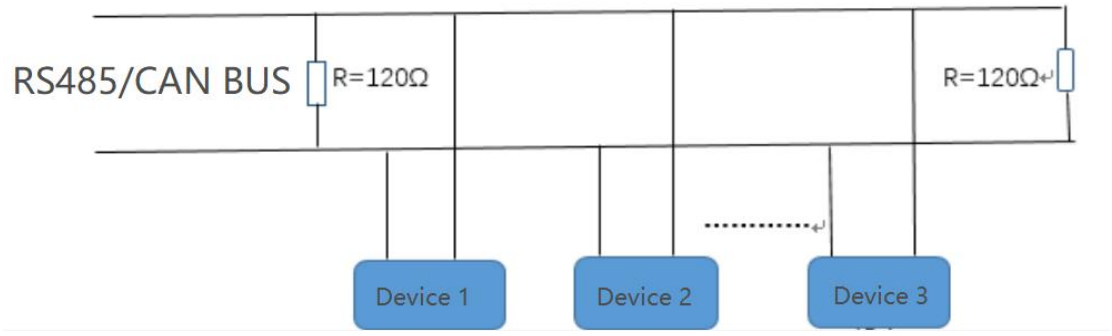

Figure 3-1. Connection Diagram for RS485 and CAN

For any additional issues or troubleshooting, please contact us by email:

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