SP18 Pipettor Manual

——18-02 Pipettor Series

Product Model:

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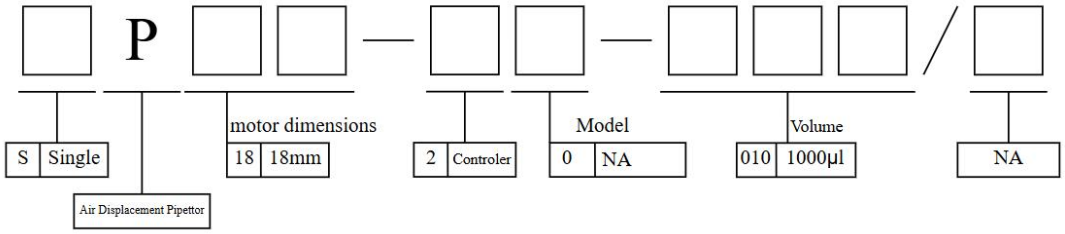
1 Product Overview

The SP18 Pipettor series is a module that Keyto uses air displacement to achieve aspiration and dispense, and works with disposable TIP for pipetting. The SP18 can achieve automatic aspiration and dispense in the range of 5 to 1000uL with TIP of different specifications. The pipettor provides a fast and reliable mechanical adapter module and a common communication interface. It is suitable for integration in pipetting platforms that are sensitive to cross contamination and pipetting units of inspection instruments, providing high-performance and reliable pipetting functions for various instruments.

1.1 Ordering information



Notes:

1. The naming rule includes the pipettor only, and the ADP-Z is not included.
2. For ADP-Z, please contact us.

1.2 Main Features

◆ This pipettor has a unique mechanical structure that allows multiple SP18 to be used in conjunction with each other as 18mm nozzle to nozzle center spacing, which greatly increases the pipetting velocity.

◆ The pipettor is equipped with a excellent-performance drive control unit and provides CAN, RS232 and RS485 communication interface and the corresponding protocol, allowing SP18 achieve multiple functional applications easily and quickly by the host controller.

◆ Equipped with advanced pressure sensors and algorithms for rapid liquid level detection, aspiration of empty detection, and aspiration of foam detection in various reagents and high-humidity environments.

◆ This pipettor allows for automatic TIP pick-ups and ejection, as well as TIP drop detection.

◆ Advanced pipetting barrel processing technology, strict inspection procedures, and unique sealing solutions, which ensure that the pipetting barrel's service life can reach more than 1 million cycles without maintenance.

◆ The excellent chemical and wear resistance of the nozzle materials in contact with the disposable TIP ensure that the nozzle does not need to be replaced during its life cycle.

◆ The pipette has a maximum weight of 400 g, ensuring portability and ease of use.

1.3 Glossary

- **PLLD**: Pressure-based liquid level detection
- **ADP**: Air Displacement Pipettor
- **Host**: Customer Controller
- **Device**: SP18
- **Tx/Send/Transmit**: From the Host to the Device
- **Rx/Receive/Response**: From the Device to the Host

2 Products Specifications

2.1 Specifications

Table 2-1 Specifications

Product	SP18-20-010/C11
Dispense range	5 ～ 1000uL
Liquid level detection	PLLD
Weight	350g
TIP compatibility	50,200,1000ul TIP
Dimensions	251mm*74.3mm*17mm
Center distance of multiple nozzles	18mm
Communication	RS232、RS485、CAN
Baud Rate	RS232/RS485: 9600,19200,38400(default),115200 CAN:100K,125K,250K,500K(default),1000K.
Operating Temperature	+15 ～ +35℃
Power Input	24V DC ±5%
Pipetting life	One million cycles

Table 2-2 Pipetting Performance

TIP	Dispense Volume(uL)	Single / Aliquot dispensing	Accuracy(A)	CV
50(filter)	5	single	5.0%	3.0%
50	10	single	3.0%	2.0%
200(filter)	10	single	6.0%	3.0%
200	50	single	2.0%	0.75%
1000	10	single	10.0%	5.0%
1000(filter)	20	aliquot	7.5%	3.0%
1000	50	aliquot	5.0%	2.0%
200	10	aliquot	5.0%	3.0%

1. Test environment: still air environment at 21～25℃.

2. The test method is non-contact dispense method(Suspended dispensing liquid).

3. You need replace the new TIP after each test, Testing with deionized water.

4. When the dispense liquid volume is not good, you need to increase the compensation value, need do aspirating compensation when single aspirate single dispense. in generally practice, single aspirate aliquot dispense does not need to do compensation.

5. Single aspiration and single dispensing: For example, use a TIP to aspirate 10ul of reagent once, and then dispense 10ul of reagent at one time. Replace the new TIP after each dispense of the reagent, and repeat the measurement ten times to calculate the accuracy and precision of the data.

6. Single aspiration and aliquot dispensing: For example, use one TIP to aspirate 1000ul of reagent at one time, and dispense 20ul each time for 50 times. Replace the TIP after all dispensing done. Calculate the accuracy and precision after discarding the head and tail data (48 times).

TIP is a disposable product, please do not reuse TIP.

Accuracy: refers to the degree of deviation of the measurement result from the true value of the measured value.

$$A = \frac{\left|\overline{V} - V\right|}{V} * 100\%$$

CV(Coefficient of Variation): Expressed by precision, its value can objectively and accurately reflect the degree of discreteness of a set of data.

$$CV = \frac{\sqrt{\frac{1}{n-1}\left(\sum_{i=1}^{n} V_i^2 - n\overline{V}^2\right)}}{\overline{V}} * 100\%$$

Note: The relationship between volume (μL) and measurement value (mg)

$$V = \frac{X}{Sg}$$

Sg : Pure water is 0.99707;

n : Number of liquid dispense times;

V : Volume corresponding to a single measurement value;

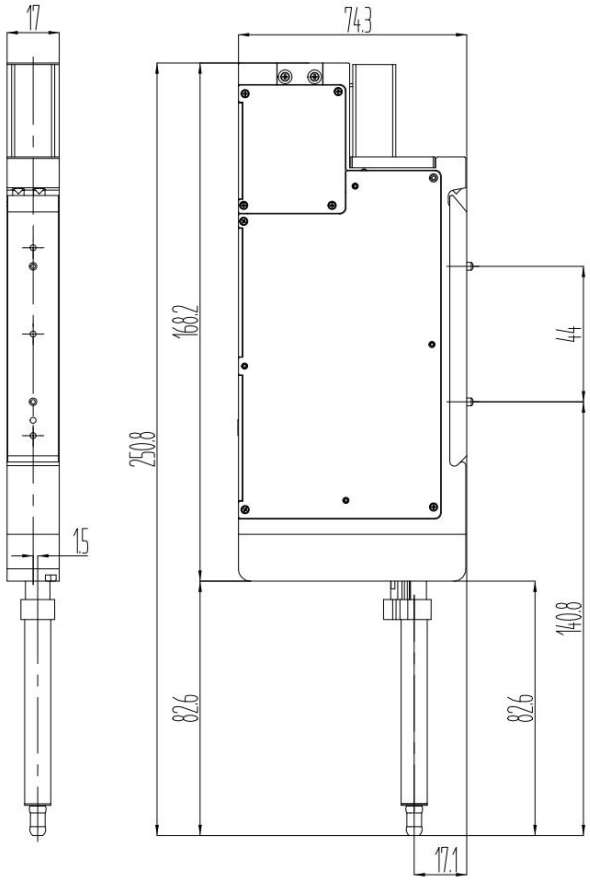
$\overline{V}$: Volume corresponding to the average of all measurement values.

2.2 SP18 Series Pipettor Dimension

2.2.1 Product Figure

Figure 2-1 Product Figure

2.2.2 Dimensional and Mounting Drawings



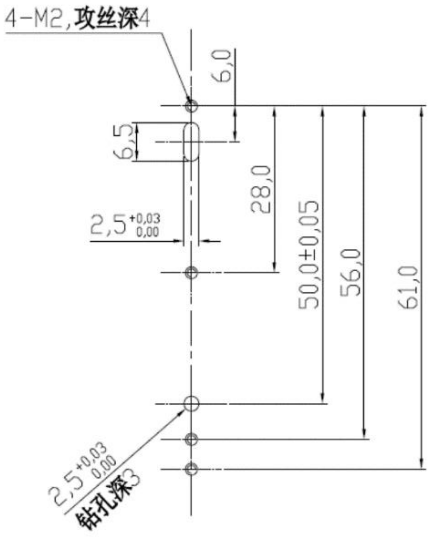


Figure 2-2 Dimensional Drawing

3 Electrical Interface

3.1 Definition of DIP Switch

This DIP switch is located under the debugging port cover. To set the SP18 address and enable the terminal resistor operation, you need to first remove the debugging port cover using a Cross-head screwdriver. The SP18 has an 8-bit DIP switch, which is used to set the ID, enable the 120-ohm RS485 terminal resistor, and enable the 120-ohm CAN terminal resistor.

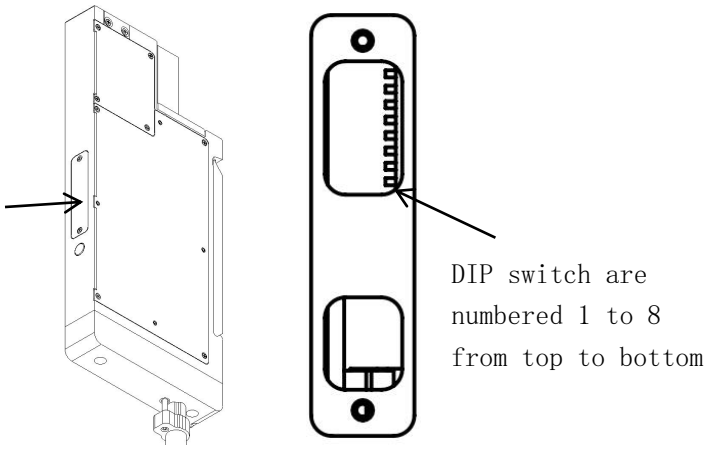


Table 3-1 DIP Switch description

SW	Function	Description
1	120 ohm CAN termination resisto	ON: Enabled OFF: Disabled
2	120 ohm RS485 termination resistor	ON: Enabled OFF: Disabled
3	Reserve	
4	Address bit4	The DIP switch address is expressed in 5-bit binary, bit0 being the lowest bit. The binary value +1 is the ID (address value) and the ID range is: 1～32. DIP switches each set to ON for 1 and OFF for 0. For example,if the address value is configured as 6, the corresponding binary value is 5(0b00101), and the4～8 bit is as follows:OFF, OFF, ON, OFF, ON.
5	Address bit3	
6	Address bit2	
7	Address bit1	
8	Address bit0	

Reduce the RS485/CAN transmission distance when using the product. If communication is unstable, ensure the 120Ω termination resistors are properly enabled at both end and begin of the bus to maintain a total impedance of 60Ω.

3.2 Hardware Interface Definition

The power supply of SP18 is 24V DC ±5%, the peak RMS value of the current does not exceed 500mA, and the RMS value of the current does not exceed 400mA.

Please insulate unused cores!

The cables must be connected or disconnected when the power is off!

The SP18 connects to external control systems via a highly flexible towline cable with AWG26 cores. Select a communication method and connect according to the Table below:

Table 3-2 Definition of Towline cable

Function	Core Color	Description
DC 24V+	Red	Power input 24V±5% ≥1A
GND	Black	Grounding
RS232-RX	Green	Communication interface
RS232-TX	Blue	Communication interface
RS485A	Orange	Communication interface
RS485B	White	Communication interface
CAN L	Yellow	Communication interface
CAN H	Yellow-green	Communication interface
GPO1	Purple	pLLD digital output, 5V level
GPO	Brown	Reserved

The GPO1 interface schematic circuit is shown below:

Additional TVS protection is required in customer PCBA when using the GPO1.

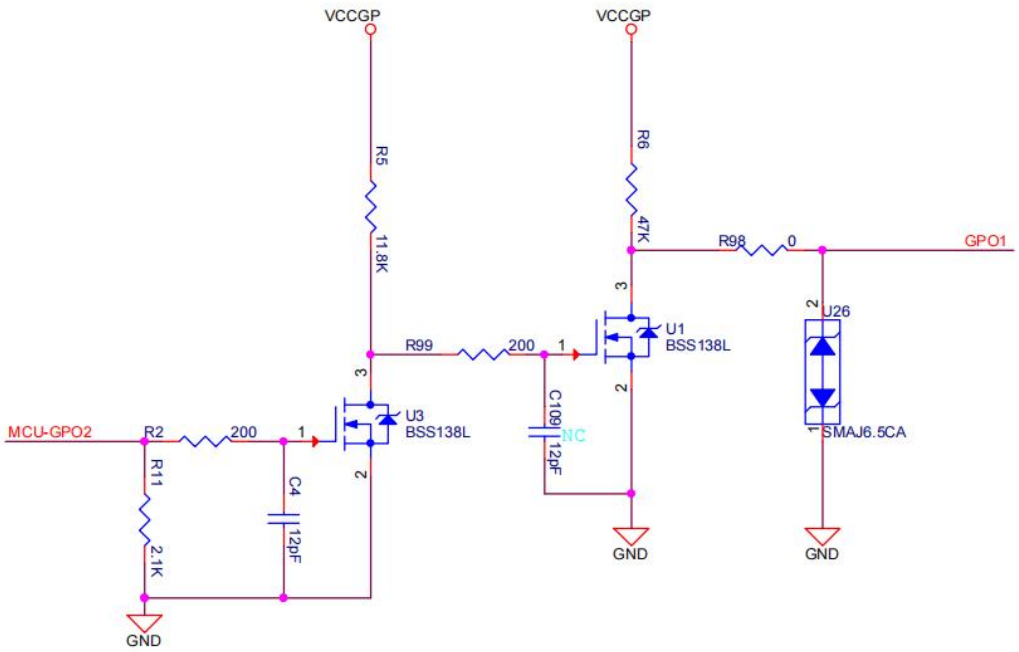


Figure 3-1 GPO Circuit Diagram

3.3 RS485/CAN Connection Topology Diagram

For RS485 communication, minimize the number of devices on the bus. A one-to-one communication setup is recommended to improve efficiency and reliability.

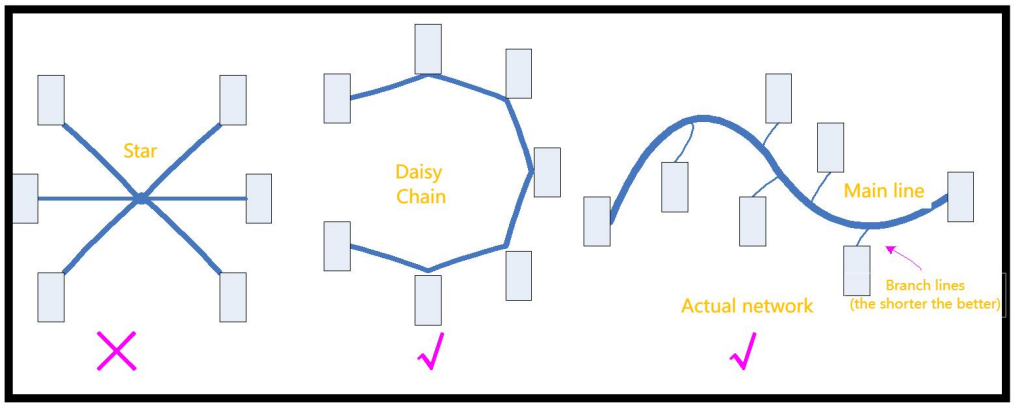


Figure 3-2 RS485/CAN Connection Topology Diagram

4 Installation and Debugging

4.1 Installing the pipettor

Install the pipettor on the ADP-Z or vertical plane as shown in Figure 4-1 Pipettor Installation Diagram. For standalone SP18 use, connect using the 10-core highly flexible towline cable as Table 3-2 Definition of Towline cable. When used with the Keyto ADP-Z, insert the ADP-Z 10-core cable into the pipettor and connect the ADP-Z 8-core cable as Table 4-1 Quick Debugging cable connecting. The relevant accessories are already configured at the factory.

Ensure the system is powered off when connecting or disconnecting cables!

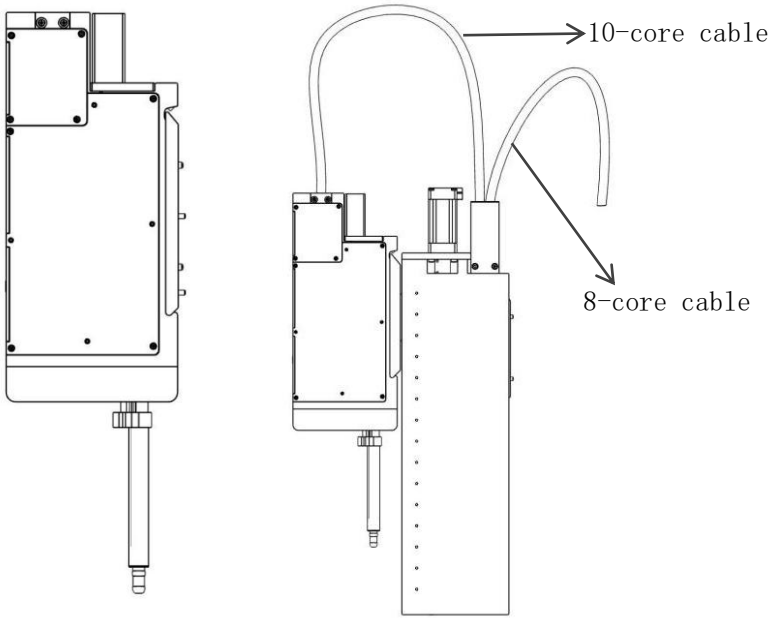


Figure 4-1 Pipettor Installation Diagram

4.2 Connecting Power and Communication Cables

When SP18 is used in combination with ADPZ, See Table 4-1 Quick Debugging cable connectingrefer to the diagram below for wiring.

The cables must be connected or disconnected when the power is off!

Table 4-1 Quick Debugging cable connecting

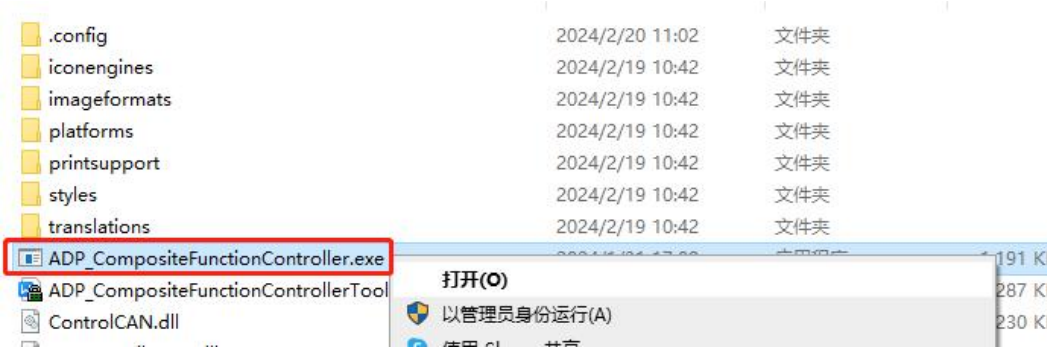
Function	Core Color	Description
DC 24V+	Red	Power input 24V±5%, ≥1A
GND	Black	Grounding
RS485A	Orange	Communication interface
RS485B	White	Communication interface

5 Host Computer Test Software

The host computer software enables combined control of the pipettor and ADPZ-axis of Keyto.

5.1 Opening the ADP Host Computer Test Software

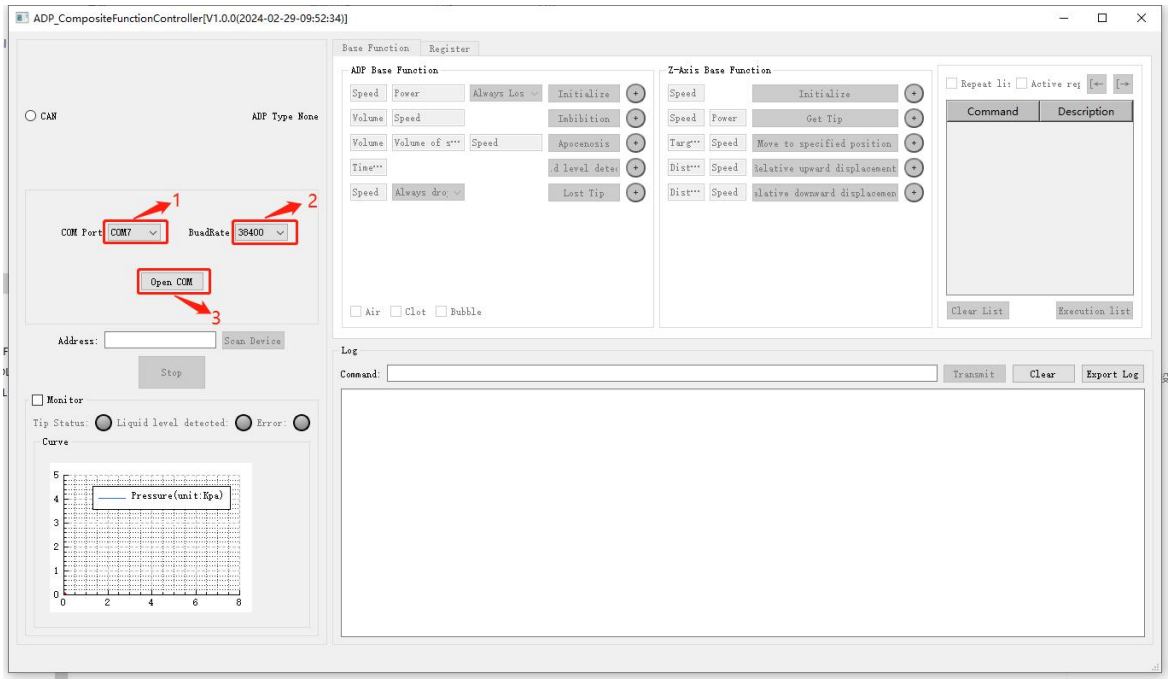
1. Connect the cable and power up the device.
2. Open the ADP_CompositeFunctionController.exe testing software.



5.2 Serial Port and Baud Rate Selection

1. Select the corresponding serial port number and the baud rate of 38400 (factory default 38400).

2. Click "Open COM" button.

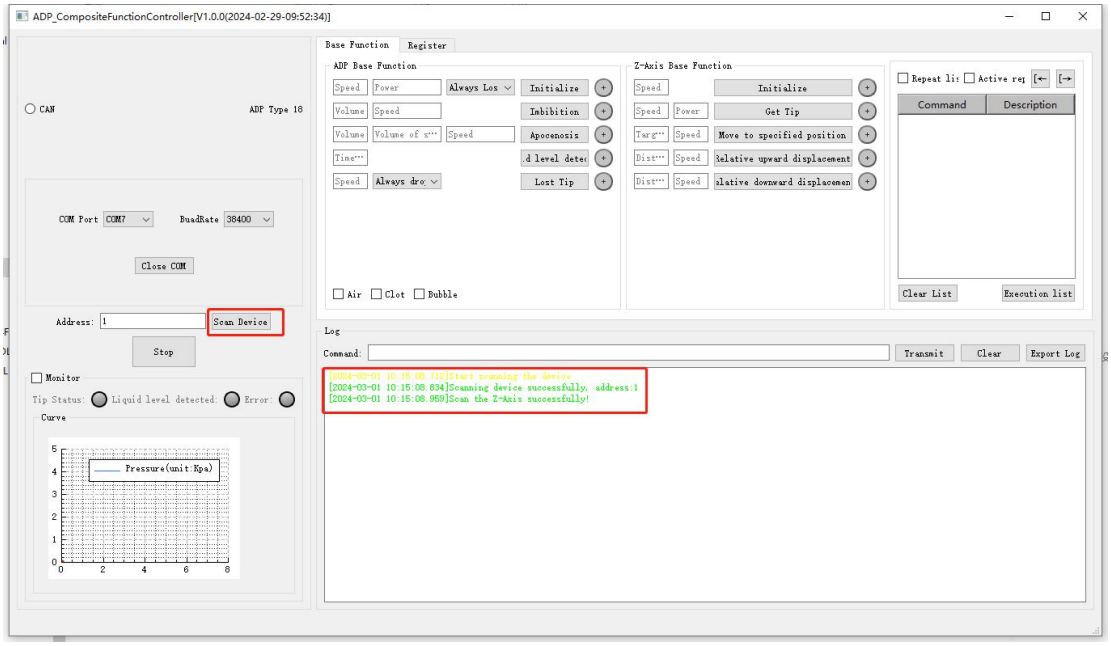


5.3 Scanning Device Address

1. Click the "Scan" button, the default address is 1, the address bar will be automatically populated with the scanned address when the scan is

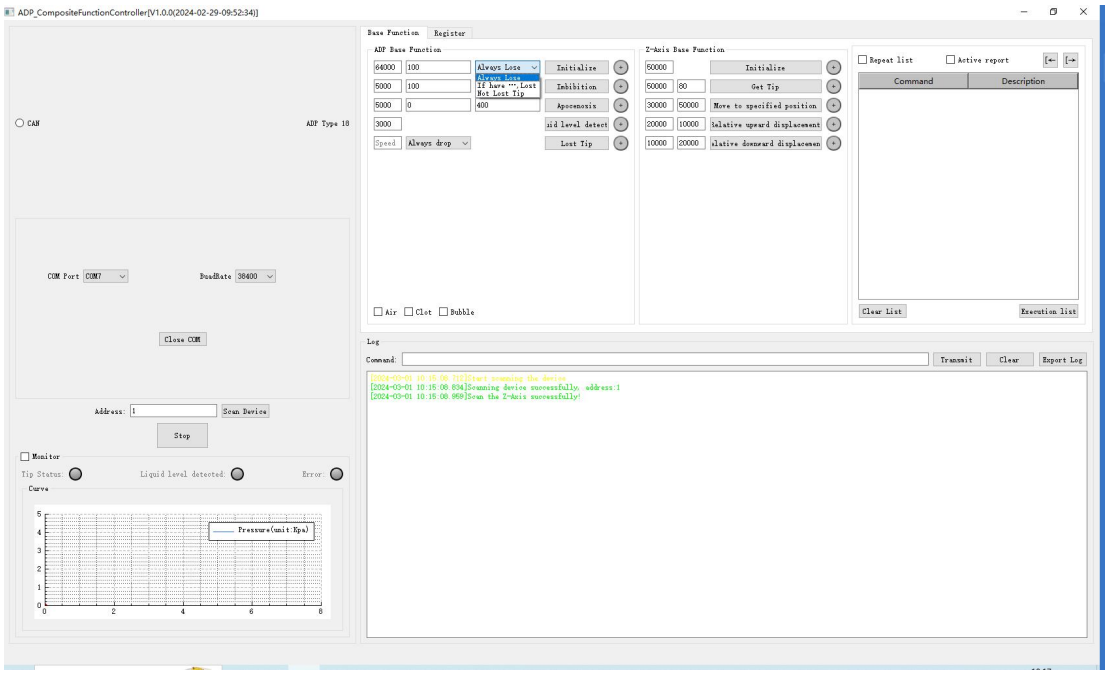
complete. Note that other device operations will only execute after addresses are scanned.

2. The log area will display the successful scanning of the device address..
3. “Device” will show current device model.



5.4 Single-step Command

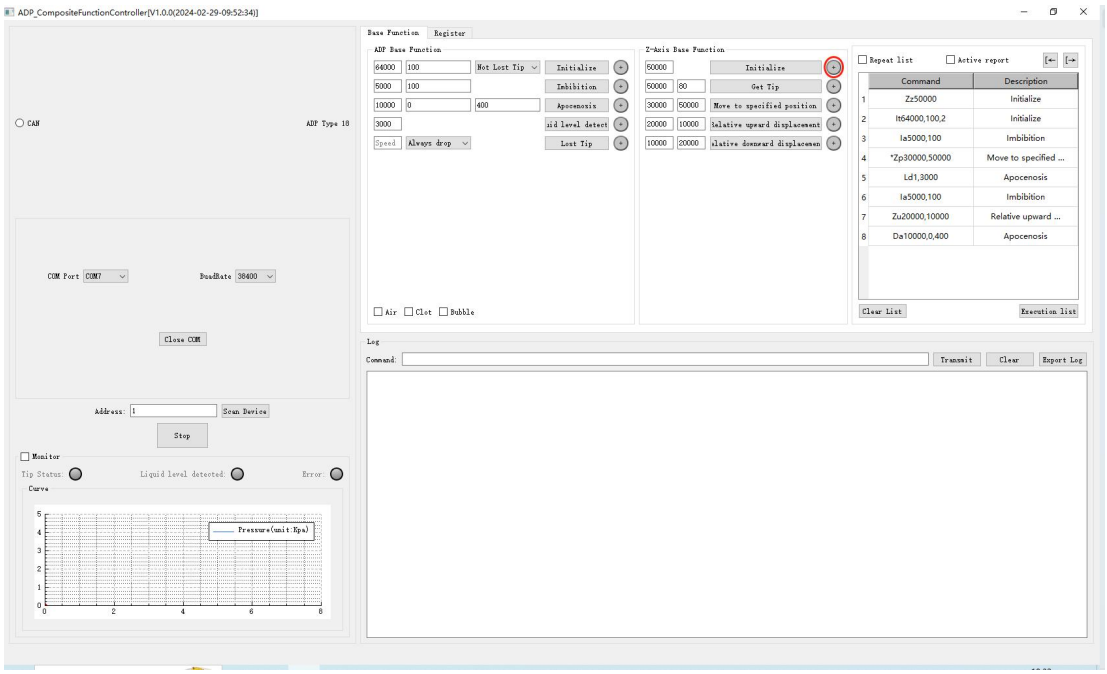
1. Enter the required initialization parameters and click the ’Init’ button..



5.5 Combined Execution Command

Configure the parameters for both the ADP and the ADP-Z. Click ″+″ to add the commands to the combined command list. The command list will display the added

commands; double-click to modify them if necessary. Click "Run List", and the host computer will sequentially send the commands. It will execute the next command after confirming the current one has completed.



Fill in the parameters in sequence and click the "+" sign to add the following content:

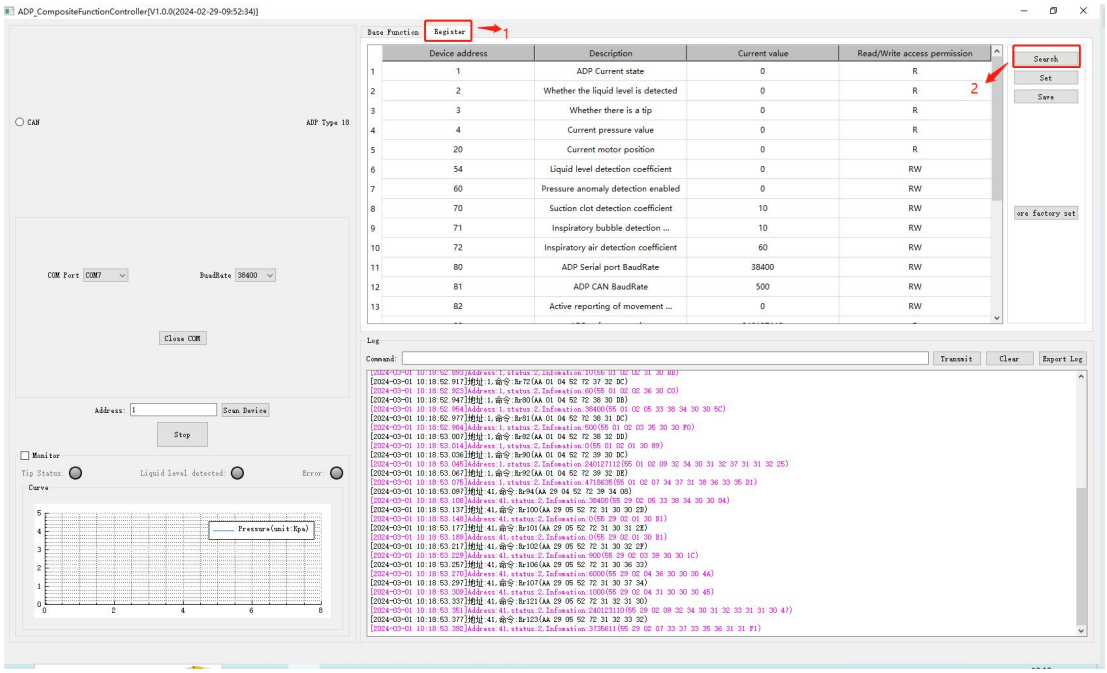
1. Zero the HSZ axis at a speed of 50,000 μm/s.
2. Zero the pipettor at a speed of 64000 μstep/s, with 100% power and in a way that the TIP is not ejected.
3. The pipettor aspirates 50 μL of air at an aspiration speed of 100 μL/s.
4. The HSZ axis moves downward to the position of 30,000 μm at a speed of 50,000 μm/s. (Adding a "*" before the command indicates that this command does not need to wait for the movement to complete, and the next command will be sent directly.)
5. The pipettor activates the Aspiration-based PLLD. The detection times out after 3s. Once the liquid level is detected, the HSZ axis will automatically stop moving.
6. The pipettor aspirates 50 μL of liquid at an aspiration speed of 100 μL/s.
7. The HSZ axis moves upward by 20,000 μm at a speed of 10,000 μm/s.
8. The pipettor dispenses the liquid at a speed of 400 μL/s.

After adding, as shown in the figure below, you can click "Execute list" to execute the current command set, and the device will execute the contents in the list in sequence.

Running scripts(command set) supports import and export, click the "[←" button to import, and click the "[→" button to export.

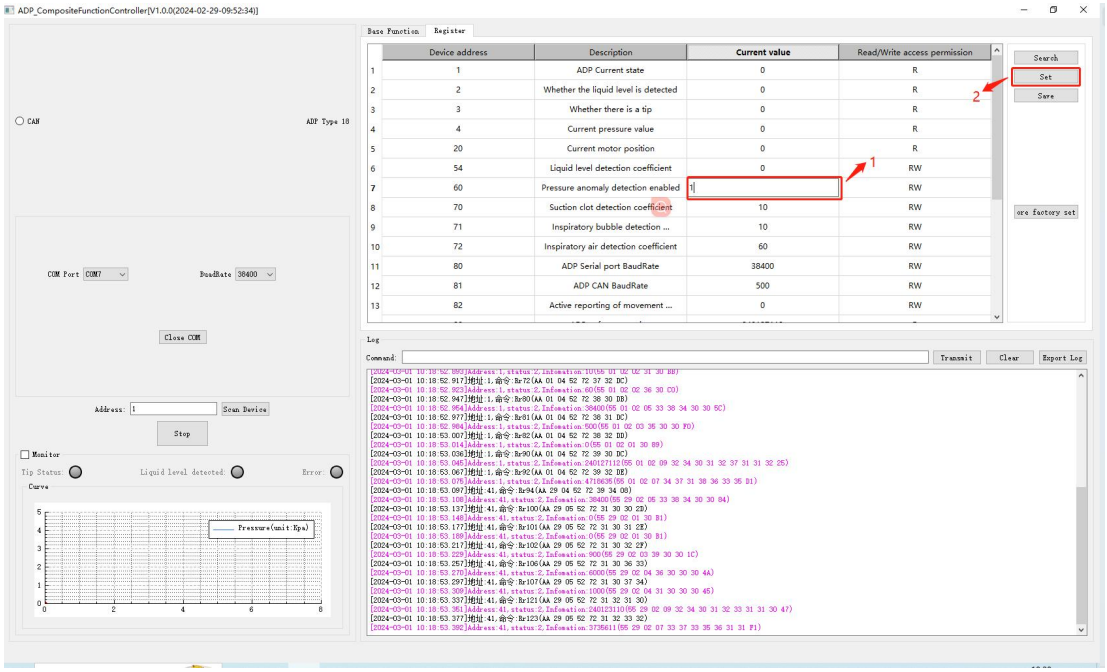
5.6 Register Query

1. Click the 'Register' button to switch to the registration interface.
2. Click the 'Query' button to have the host computer query the device registers sequentially.
3. The value of the device register will be displayed in the 'Current Value' field.



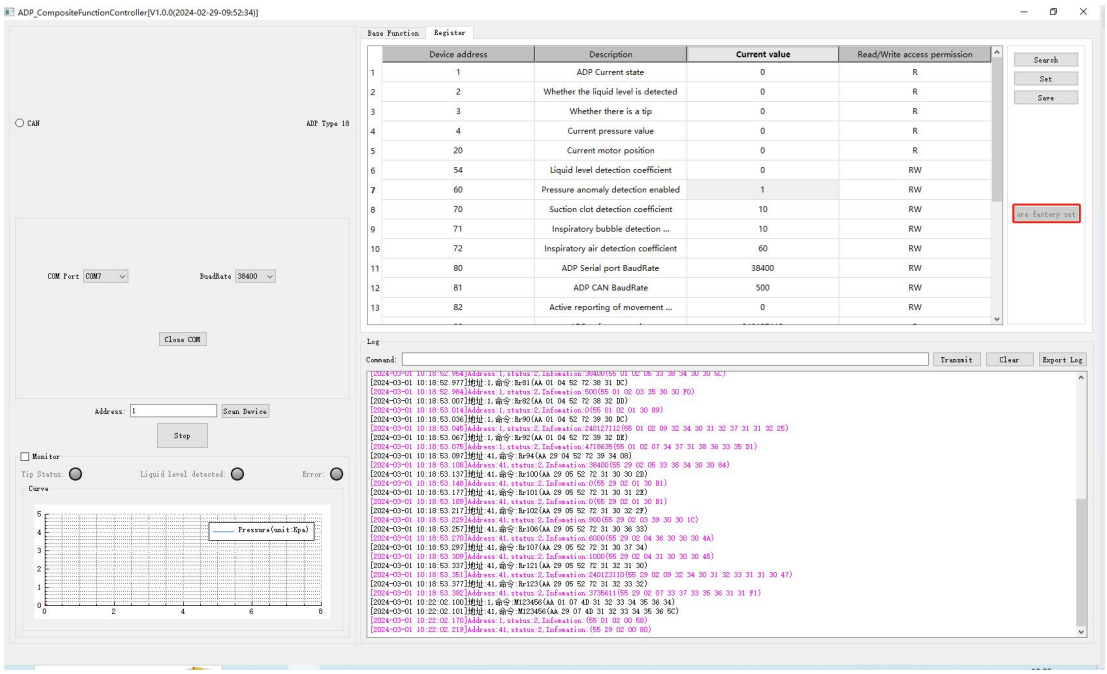
5.7 Register Parameter Settings

1. Double-click the 'Current Value' field in the register parameter line that needs modification (only values with RW permissions can be modified). Enter the new value, then press 'Enter' or click a blank area to confirm.
2. Click 'Setup' to modify the register value.
3. Click 'Save' to store the register value, which will persist after power-off..
4. Power off and restart the device. After restarting, the host computer software will need to reselect the serial port.



5.8 Restore to Factory Settingss

1. Click the 'Restore Default Settings' button to reset all register settings to their factory defaults.
2. Power off and restart the device. After restarting, the host computer software must reselect the serial port.



6 Applications

6.1 Application Process

The basic liquid aspiration and dispense application typically includes single aspiration with single dispense or single aspiration with aliquot-dispense. Figure 6-1 Aspiration and Dispense processillustrates a common single aspiration and single dispense workflow. Recommended communication framework and sample data are provided in chapter 8 Communication Process.

Note:

1. By default, both single aspirate single dispense and single aspirate aliquot dispense are no-contact dispense.
2. TIP detection: Enable this feature via Register 43. Aspiration commands cannot be executed without a TIP.
3. Clot detection: Reference Register 60 for pressure anomaly detection.
4. Liquid level detection delay: Delay liquid level detection by 500ms after the ADP-Z descends to avoid disturbances from ADP-Z moving.
5. Liquid level detection velocity: Maintain a speed of 20mm/s of ADP-Z to ensure the TIP does not submerge more than 3mm.
6. Aspiration delay: 100ms delay before leaving the reagent after aspirating, can improve liquid handling accuracy and CV in the application of micro-dispense.
7. Leading air gap: reduce the reagent residue in the TIP after dispense.
8. Trailing Air Gap: avoiding liquid spillage or dropping.
9. Leading Air Gap/Trailing Air Gap: For a nominal volume of 1000uL, allow an additional 50uL for aspiration of air. Total aspiration volume must not exceed 1050uL. Adjust volumes as needed within this limit.
10. aliquot-dispense data: Avoid using the first and last dispense results for accuracy; dispense these to the original reagent container or waste bin.
11. aliquot-dispense parameters: Adjust re-aspiration volume and cut-off velocity for better performance (see section 3.6.8 Aspiration and Dispense Parameters).
12. Single dispense data: Default values for re-aspiration volume and cut-off velocity are recommended.
13. Dispense: When dispensing, make sure the end of the TIP is inside the container to prevent splashing.

When performing aspiration of liquid, the aspiration volume must not exceed the picked up TIP volume. Do not exceed the volume capacity of the picked up TIP during aspiration. For example, a 200uL TIP can not aspirate more than 200uL.

14. Error handling:
    - If TIP pickup fails, send a "eject TIP" command to prevent a stuck TIP

before retrying at another TIP position.

- During liquid level detection, set a lower limit to avoid bottoming out. For multi-channel applications,if the same liquid level for all channel, ensure consistent liquid levels for all channels to avoid premature detection triggers.

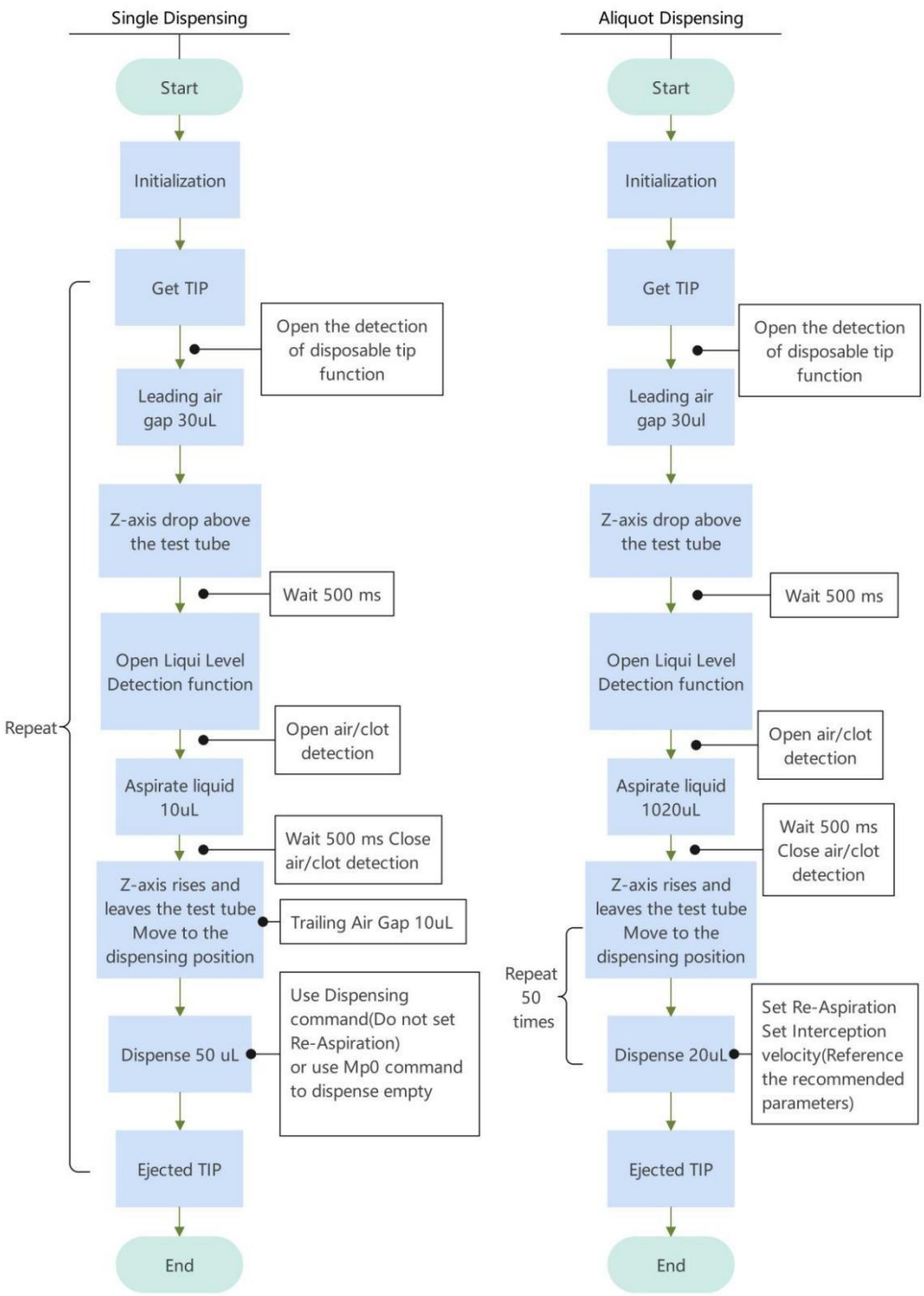


Figure 6-1 Aspiration and Dispense process

6.2 Pick up TIP

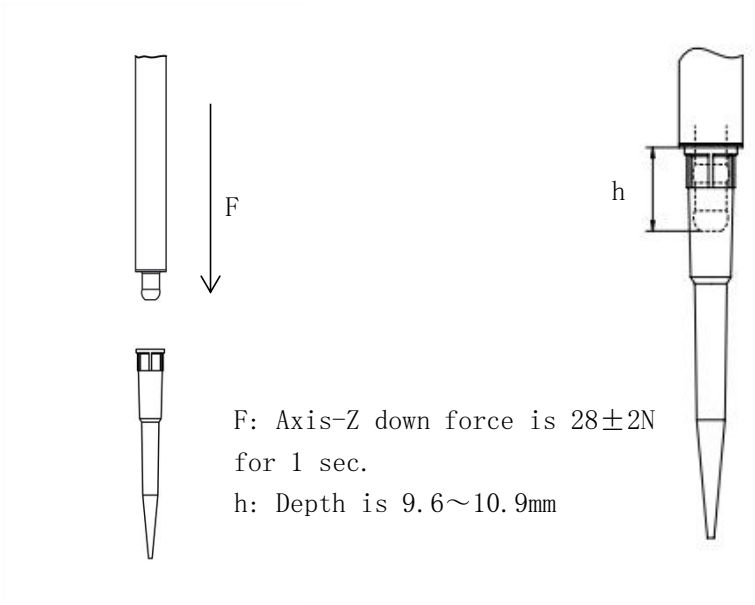


Figure 6-2 TIP Pickup Diagram

When the SP18 pipettor probe is positioned directly above the TIP, use Keyto ADP-Z TIP Pickup command to automatically apply the appropriate down force. When controlling the SP18 and customer ADP-Z for TIP pickup, we recommend starting with a inserting depth of 9.6 mm. Ensure the TIP is securely picked up after lifting and meets leakage requirements. The maximum inserting depth should not exceed 10.9 mm. The recommended down force is 28±2N for 1 second.

Convenient Leakage Testing Method: At room temperature, in the SP18 standby state, pick up a non-conductive, clean, 1000uL TIP with filter. Aspirate 1000uL of pure water, lift the TIP above the liquid level, and leave it static for one minute. If liquid leaks from the TIP, increase the inserting depth appropriately.

Ensure correct TIP installation by applying a down force of 28±2 N for 1 second.

Insufficient down force may cause the TIP to fall off during moving, while excessive down force may result in TIP ejection failure or permanent damage to the SP18.

6.3 Liquid Level Detection

Move down the SP18 rapidly until the end of TIP is located 15～20mm above the mouth of the test tube, then setting the speed becomes ≤20mm/s. The liquid level detection is started after 500 ms, and the liquid level detection status is obtained by query the GP01 signal or register 2. See Table 10-2 Register.

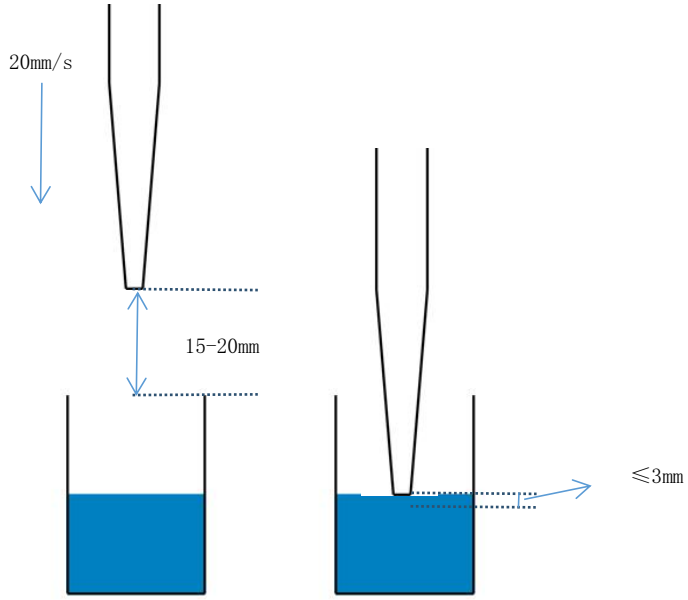


Figure 6-3 Liquid Level Detection Diagram

Start the liquid detection function by sending the Ld command through the serial port or using the KT_CAN_DIC protocol (Index 0x4007). Once activated, the SP18 will monitor pressure changes in real-time. Upon detecting a change, it will alert the customer controller through multiple signals.

Recommended process for liquid level detection: Position the SP18 with the loaded TIP 15～20 mm above the reagent container’s top surface. Delay 500ms and send the liquid detection command while continuing to lower. Stop the ADP-Z upon receiving a triggered liquid detection signal that lasts 1 ms (to filter interference) or a liquid detection command. See chapter 8.4 Development Process Practice

Notes:

1. The liquid detection response time is approximately 20ms. Keep the ADP-Z descent speed below 20mm/s during detection.
2. Ensure the TIP is free of debris (including residual reagents), as debris may cause abnormal detection.
3. Factory parameters are preset for specific TIP models. If the liquid level detection is triggered before contacting the liquid level, the liquid level detection coefficient will be increased appropriately, and if the detection is deeper, the liquid level detection coefficient will be reduced appropriately, and the liquid level detection coefficients can be found in Table 10-2 Register.

6.4 Mixing Process

Perform mixing using SP18 by executing aspiration and dispense cycles:

1. Cycle:Aspiration→Mp0 Dispense→Aspiration→Mp0 Dispense→...
2. Use the Mp0 absolute position move command for consistent dispense positions.
3. Do not reuse the TIP for mixing, otherwise the accumulated liquid film

may be sucked into the pipetting barrel and maybe damage the SP18. For practical examples, See 8.4 Development Process Practice

6.5 Aspiration and Dispense Liquid Following

The SP18 used with Keyto ADP-Z, supports liquid following, See Table 10-2 Register. For practical applications, see section 8.4 Development Process Practice

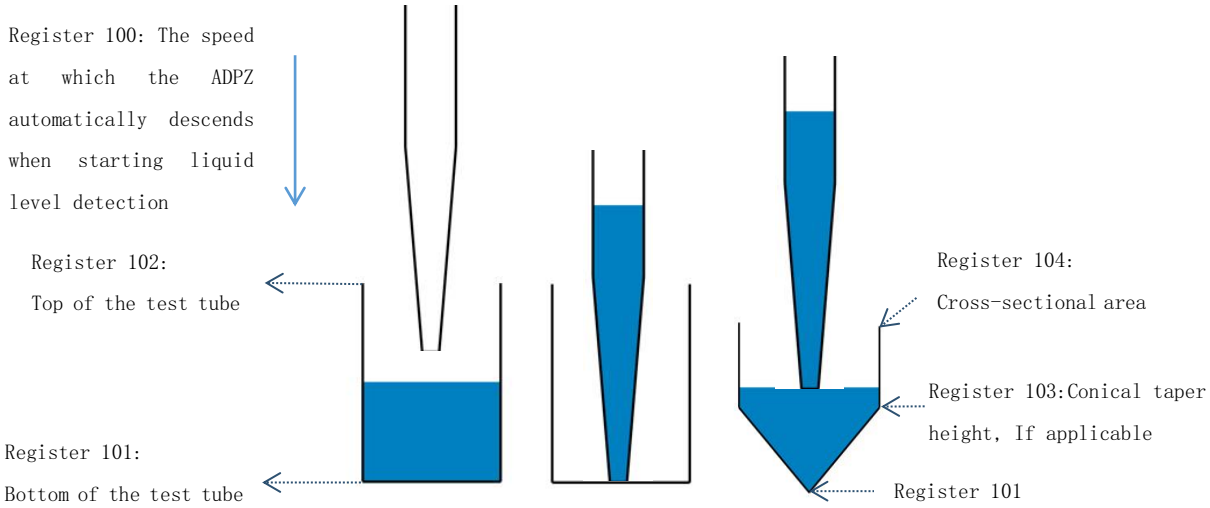


Figure 6-4 Aspiration and Dispense Liquid Level Following Diagram

6.6 Anti-droplet Control

The anti-droplet control prevents reagent leakage during the handling of organic solvents. Consider the following:

- Activate the anti-droplet control only after the end of TIP leaves the liquid surface. Any aspiration or dispense command stops the function. If reagent remains in the TIP after dispense, the anti-droplet control needs to be reactivated.
- **This function affects pipetting accuracy and is not recommended if the reagent is not prone to dripping (e.g., water-like).**
- During the execution of this command (means that enabling anti-droplet control without a subsequent disable command or without completing actions like aspiration or dispense that stop the anti-droplet execution), the pipettor will monitor pressure fluctuations. Therefore, the TIP must not be manually removed during this period. If a second reagent needs to be aspirated after aspirating the first reagent and enabling anti-droplet control, please disable the anti-droplet control before aspirating the second reagent.
- For reagents with excessively strong polarity, it is recommended to aspirate an additional 2～10uL of air after leaving the liquid surface, and then enable the anti-droplet control.

6.7 Pipetting Abnormality Detection

The SP18 uses a pressure sensor to monitor internal pipetting barrel pressure, enabling real-time detection of anomalies such as clots, foam, or aspiration of empty. By default, this feature is disabled. Enable it by configuring Register 60, each bit corresponds to a function, the corresponding bit to write 1 to enable, write 0 to disable. Ensure proper conversion from hexadecimal to decimal when configuring values. For example, to enable foam and clot detection, write 3 (0x03) to Register 60.

Register Address	Description
60	Pressure Abnormality Detection Enable,HEX code, the corresponding bit is 1 to enable the function: Bit 0: Clot detection (minimum volume: 10uL) Bit 1: foam detection (minimum volume: 20uL) Bit 2: empty detection (minimum volume: 10uL)

Note: The pipettor will only detect pipetting anomalies if the pipettor volume is not less than the specified volume, because the pipettor volume is too small for the air pressure to change significantly. If there is a reagent in the TIP to aspirate the liquid, the aspiration of empty/foam detection are unreliable at this time. If users need to perform aspiration of air before normal aspiration and dispense of liquid, please set register 60 to turn off the pressure abnormal detection to prevent error reporting, and then turn on the pressure abnormal detection during normal aspiration and dispense of liquid, See section 8.4.

6.8 Aspiration and Dispense Parameters

6.8.1 Aspiration and dispense velocity

Follow the basic principle of "slow aspiration, fast dispense" during liquid handling. The viscosity of the reagent and the TIP type may affect the velocity. The reference relationship between aspiration volume and aspiration velocity is shown in:

Table 6-1 Recommended aspirate velocity

When performing single aspiration and single dispense, set a reasonable dispense velocity to ensure complete dispense of the reagent and to avoid splashing. Recommended dispense volumes and speeds are shown in Table 6-2. For single aspiration and single dispense, you can set the same cut-off velocity:

Table 6-2 Recommended Dispense velocity

TIP Type	50ul TIP		200ul TIP		1000ul TIP	
Dispensing Volume (uL)	5	10	50	100	500	1000

re-aspiration Volume(uL)	0					
Dispense velocity(uL/s)	100	200	300	400	500	500
cut-off velocity(uL/s)	25	25	25	25	25	25

6.8.2 re-aspiration volume

In single aspiration and aliquot-dispense, the re-aspiration volume can be adjusted according to Table 6-3:

Table 6-3 Re-aspirate parameter reference for aliquot dispense

Dispense volume / TIP / re-aspiration	5～10ul	10～20ul	20～100ul
50ul	≥5ul	/	/
200ul	≥2ul	≥4ul	/
1000ul	/	≥2ul	≥4ul
Dispense cut-off velocity	60～100ul/s(less than dispense velocity)		

6.8.3 Recommended aspiration and dispense parameters

The following data is based on pure water. When the dispensing accuracy and CV meet the SP18 series pipettor's performance requirements, the recommended parameters for each test are shown below.

Table 6-4 Recommended Parameters for Pure Water

TIP Type (F: Filter)	Single/aliquot dispense	dispense Volume (uL)	Leading Air Gap (0.01uL)	Aspiration Volume (0.01uL)	Aspiration velocity (uL/s)	Dispense Volume (0.01uL)	re-aspiration Volume (0.01uL)	Dispense velocity (uL/s)
50F	Single dispense	5	3500	0	400	25	3000	500
50	Single dispense	10	4000	0	400	25	3000	1000
200F	Single dispense	10	4000	0	400	25	3000	1000
200	Single dispense	50	8000	0	300	25	3000	5000
1000	Single dispense	10	4000	0	300	25	3000	1000
200	aliquot-dispense	10	1000	450	300	80	2000	20000

1000	aliquot-dispense	50	5000	300	400	80	2000	102000
1000F	aliquot-dispense	20	2000	300	400	80	2500	102000

Other reagent parameter descriptions:

Table 6-5 Other Reagent parameters

Reagents	TIP	Dispense type	测量体积	排液体积(0.01ul)	排液回吸体积(0.01ul)	排液速度(ul/s)	排液截流速度(ul/s)	吸空体积(0.01ul)	吸液体积(0.01ul)
5%甘油溶液	50F	Aliquot dispense	5	500	400	450	30	2000	5000
缓存液	1000F	单排	10	11000	0	400	25	10000	1000
缓存液	1000F	单排	100	20000	0	400	25	10000	10000
缓存液	1000F	单排	200	30000	0	400	25	10000	20000

其他类型试剂测试平均值和 CV 结果

Table 6-6 CV of Other Reagents

Reagent	TIP Type	Aspirate ul	Aspirate velocity ul/s	Dispense Velocity ul/s	Dispense Ave mg	CV(%)
Transparent liquid Sodium silicate	50	10	50	500	11.84	0.75
	200	10	50	500	11.7	0.64
	200	50	100	500	63.34	0.60
Liquid paraffin	200	10	20	50	7.84	2.93
	200	50	20	50	37.2	2.04
Ethanol absolute	50	10	50	200		
	200	10	50	200		
	200	50	100	500	32.554	0.74

DMSO	50	10	100	100	10.94	1.38
	200	10	100	200	11.34	1.18
	200	50	100	500	53.92	0.27
BSA	50	10	100	300	9.537	0.89
	200	10	100	500	9.109	1.21
	200	50	200	500	46.27	0.38

6.9 Accuracy and CV testing and compensation

6.9.1 Accuracy and CV testing

1. Preparation Before Testing

When performing the accuracy and CV tests, please note the following preparations:

Avoid placing the balance or performing accuracy and CV tests in the following environments: The environment with direct sunlight, severe temperature fluctuations, strong air convection, or vibration.

Preparation materials: 0.1mg or 0.01mg scale interval balance, TIP, 1mL plastic centrifuge tubes, rubber gloves, pure water.

2. Single Dispensing Process

During testing, operators are required to wear a lab coat and rubber gloves to maintain a stable environment.

3. Balance Leveling and Zeroing

Follow the balance manual to level and zero the balance.

4. Weighing Empty Centrifuge Tubes

Prepare 10 centrifuge tubes and record the weight and serial port number of each empty tube.

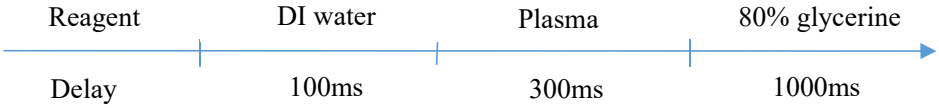
5. Initialization the Pipettor, TIP Installation, and Aspiration of Air

Before each test, initialize the pipettor and replace with a new TIP. Discard data if the TIP is deformed or contaminated. Perform aspiration of 30uL air before aspirating liquid to ensure complete dispensing of the reagent inside the TIP.

6. Single Dispensing Operation

Lower the pipettor until the TIP is ≤ 3mm below the liquid level.

Send an aspiration command; after aspiration, wait (refer to viscosity-related delays) before raising the pipettor.



Dispense the liquid with the volume: 30uL (air) + liquid volume. Keep the TIP edge near the centrifuge tube to prevent splashing.

7. Weighing the Reagent in Centrifuge Tubes

Repeat steps 5～6 ten times. Record the weight of each filled tube and calculate the reagent weight by subtracting the empty tube weight.

8. Factors Affecting Accuracy and CV

Accuracy and CV testing are affected by a number of factors, the main ones being:

- For aspiration and dispense parameters, See section 6.8.
- Reagent temperature, which affects the aspiration volume.
- Reagent density, which affects the dispense volume.
- TIP submerge depth, causing liquid to hang on the outer wall of the TIP affects the accuracy and CV of the dispense.
- Aspiration volume, which affects dispense accuracy and CV.
- Whether or not to use the liquid level detection function, which affects the TIP submerge depth.
- The delay time after aspiration and the speed when leaving the liquid level.

6.9.2 Accuracy compensation

For higher precision, perform aspiration calibration for single aspiration and single dispensing operations. Aliquot-dispensing operations typically do not require calibration. Segmental calibration is recommended for different aspiration volumes and TIP types.

1. Determine calibration points. For small volumes, use more points; for large volumes, fewer points are sufficient, we recommend no less than 5 calibration points, you can use different volumes of TIP to calibrate 5 or more points, or you can calibrate 5 or more points per each of the different volumes of TIP separately. Here we use 50uL and 1000uL TIP to calibrate the full stroke.

	50uL TIP	1000uL TIP
Calibration point/uL	5	50
	8	200
	10	500
	20	700
	50	1000

2. Measure dispensing accuracy at each point ten times and calculate the average. Compensate based on the deviation. For example, if the average at the 1000uL point is 990uL, adjust the aspiration volume to 1010uL.

3. Adjust linearly for precise compensation, as theoretical and measured values follow a linear trend.

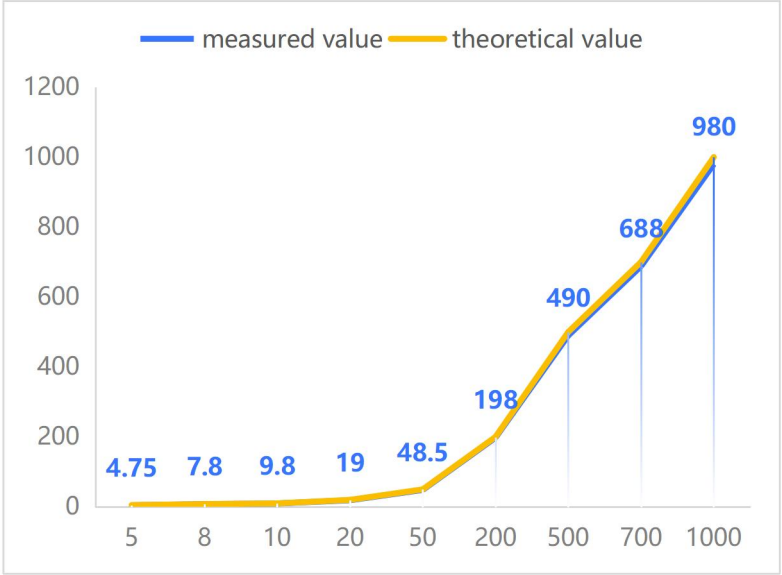


Figure 6-5 Comparison of Theoretical and Measured Aspiration Values

7 Communication Protocol

7.1 Communication Method

7.1.1 Communication interface

The following methods are supported for communicating with the SP18:

- RS232
- RS485
- CAN

Baud rate:

Serial Port: 9600,19200,38400(default),115200.**8 data bits,no parity,1 stop bit.**

CAN:100K,125K,250K,500K(default),1000K.

7.1.2 Protocols

SP18 supports serial port and CAN communication. The serial port communication includes RS232 and RS485, which share the same protocol.

- KT_CAN_DIC Protocol (Recommended)
- KT_OEM Protocol (Recommended)
- KT_DT Protocol

KT_CAN_DIC Protocol (Recommended)

This communication protocol is used for LAN-based CAN communication. It operates by reading and writing the CAN dictionary to control and configure SP18. The SP18 automatically uploads its status upon changes, eliminating the need for polling. See chapter 9.

KT_OEM Protocol (Recommended)

This protocol is based on RS232 and RS485 communication. It includes a communication sequence number and a checksum byte, effectively preventing data loss. Users can poll SP18’s status during operation and parse responses to determine if a command was successfully executed or if errors occurred. See chapter 10.

KT_DT Protocol

This protocol is also based on RS232 and RS485 communication but does not include a checksum. ASCII strings are used for data transfer, making it easier to debug via serial port debugging tools. However, the lack of checksum increases the risk of data loss. See chapter 10.

7.2 KT_CAN_DIC Protocol Format

KT_CAN_DIC message type is an Extended frame, comprising a frame ID and a Data Area.

Frame Type: Data frame

Message Identifier Type: Extended frame

Frame ID: Uses extended ID

DLC: Fixed data length of 8

Data Area: Fixed 8 bytes, including communication sequence number and register address (see Table 7-3 Data Area Format).

Frame ID Data Format:

Table 7-1 CAN Message ID Area Format

	Bit28～16	bit15～8	bit7～0
Send	Command	Source address	Destination address
Response	0x0000	Destination address	Source address

Source address: The address of the Host.

Destination address: The address of the SP18.

Frame ID Command:

Table 7-2 CAN ID Command

Command	Function	Description
0x0000	Response	Response for reading and writing
0x0001	Write	Write object dictionary Return value: status, See Table 10-2 Register
0x0002	Read	Read object dictionary; if there is no corresponding object dictionary, no data is returned.
0x0003	Process Data	Used for uploading real time data which does not require an answer, e.g. status change active uploading send should via this commands
0x0004	Heartbeat	Timely uploaded heartbeat data; can be used to check device online status. The data uploaded in the heartbeat is node status; status information can be found in the Status Table
0x0080	Warning	The device will automatically report the commands if error occurs, See Table 10-1 Status

Data Area Format:

Table 7-3 Data Area Format

	byte0	byte1～2	byte3	byte4～7
Send/response	Sequence number	Object Index	Object sub-index	4 bytes of data

Data Field Components:

1. Sequence Number: Distinguishes each frame of sent and received data. The sequence number of sent and received frames must match. Increment the sequence number by 1 for each frame.
2. Object Index: A 16-bit index defining the KT_CAN_DIC dictionary Table. See chapter 9 KT_CAN_DIC Object Dictionary.
3. Object Sub Index: An 8-bit sub-index used with the index to define the KT_CAN_DIC dictionary.
4. Data: A data length of 32 bits represents the communication data, which is a signed integer, see chapter 9 KT_CAN_DIC Object Dictionary.

7.3 KT_OEM Protocol Format

KT_OEM protocol is based on RS232 or RS485 communication, and the Fields are consistent with KT_DT protocol. the protocol contains a checksum field, which is able to effectively identify abnormal commands, and the protocol fields contain

sequence number, which can simplify the handling of communication exceptions, so when using serial port communication, it is recommended to use the KT_OEM protocol to communicate with the SP18. the SP18 parses the string in real time, verifies whether the address matches the checksum and the protocol format is correct, and immediately returns the status of executing the command. During working, the SP18 status can be obtained by sending the query status command to confirm whether the execution of the command is completed or there is an error.

Table 7-4 OEM Protocol Sending Format

Field	Type	Number of bytes	Description
Frame Header	Uint8	1	Fixed value 0xAA, indicating start of command.
Sequence number	Uint8	1	Command sequence number (0x80～0xFF),if the sequence number of the current command is the same as the sequence number of the previous command, the current command will not executed, but will respond with the same response as the previous command.
Address	Uint8	1	Target communication address, each pipettor on the bus should be set to a unique address number in the range 1～32. Communication will only occur when the address matches, otherwise, the received command will be ignored.
Data Length	Uint8	1	Length of the Data area Field.
Data area	Byte	n	ASCII command strings, see chapter 10 for details.
Checksum	Uint8	1	An 8-bit checksum is calculated from the frame header to the end byte of the data area. The value obtained takes the last 8 bits of data.

Table 7-5 OEM Protocol Response Format

Field	Type	Number of Bytes	Description
Frame Header	Uint8	1	Fixed value 0x55, indicates the start of response.
Sequence number	Uint8	1	Consistent with the received command sequence number. If the send command sequence number is omitted, this sequence number is also omitted.
Address	Uint8	1	Communication address, each pipettor on each bus should be set to a unique address number, which is the original address of the device when returning data.
Status	Uint8	1	Current pipettor status, see Table 10-1 Status.
Data Length	Uint8	1	Data area length, when the data length is 0 , the data field data is empty.
Data Area	Byte	n	ASCII code return data, if data length is 0, there is no this field.

Checksum	Uint8	1	An 8-bit checksum is calculated from the frame header to the end byte of the data area. The value obtained takes the last 8 bits of data.

7.4 KT_DT Protocol Format

The KT_DT protocol processes ASCII strings for commands and verifies address and syntax. Status of the first command in the string is returned.

Table 7-6 DT Protocol Sending Format

Field	Type	Number of bytes	Description
Address	Byte	1～2	The target communication address, each SP18 on each bus should be set to a unique address number, taking values from 1 to 32. It will communicate properly when the addresses match, otherwise it will ignore the received commands
Direction	Byte	1	Fixed to the character ’ > ’ (0x3E), means from Host to Device
Data area	Byte	n	ASCII command strings, see chapter 10 for details.
End character	Byte	1	Fixed to Carriage Return(0x0D), indicates the end.

Table 7-7 DT Protocol Response Format

Field	Type	Number of bytes	Description
Address	Byte	1～2	The device address that response to the command, with a value range of 1～32 in ASCII character format, must match the command address
Direction	Byte	1	‘<’ (0x3C), means from the Device to Host
Status	Byte	2	See Table 10-1 Status
‘:’	Byte	1	’:’ if no return data this symbol is not displayed
Data area	Byte	n	Response string, see the corresponding return data in chapter 10.
End character	Byte	1	Fixed to Carriage Return(0x0D), indicates the end.

8 Communication Process

Note that when using serial port communication, KT_DT protocol has no data verification, so it is recommended to be used only for debugging. For the machine integrating SP18, please use KT_OEM protocol. The data format of KT_OEM protocol and KT_DT protocol data area is the same, but the data format of frame header and frame tail is different. When using KT_OEM protocol, the status should be queried for each step of operation to ensure that the command is executed before executing the next step. In the following example, the SP18 address is 1.

8.1 Examples of KT_CAN_DIC Protocol

See chapter 9 KT_CAN_DIC Object Dictionary. where each control command has a unique index and multiple sub-index. Non-zero sub-index frames are sent first, followed by the zero sub-index frame. The SP18 begins operating once receiving the zero sub-index frame.

Table 8-1 Examples of KT_CAN_DIC Protocol

Function	Direction	ID(HEX)	Data(HEX)	Description
Initialization	Tx	0001 00 01	01 40 00 01 00 00 00 64	0001 write command;00 source address;01 device address; 01 sequence number;40 00 index (Initialization);01 sub-index(power setting);00 00 00 64 data(setting 100%)
	Rx	0000 01 00	01 40 00 01 00 00 00 02	0000 Response;01 device address;00 source address; 01 sequence number(ame as send command sequence number, The same below);40 00 index ;01 sub-index;00 00 00 02 status(executed successfully, other see Table 10-1 Status, The same below)
	Tx	0001 00 01	02 40 00 02 00 00 00 00	0001 write command;00 source address;01 device address; 02 sequence number;40 00 index (Initialization);02 sub-index(TIP mode settin);00 00 00 00 data(eject TIP whether TIP is detected or not)
	Rx	0000 01 00	02 40 00 02 00 00 00 02	0000 Response;01 device address;00 source address;02 sequence number;40 00 index ;02 sub-index;00 00 00 02 status
	Tx	0001 00 01	03 40 00 00 00 00 3E 80	0001 write command;00 source address;01 device address; 03 sequence number;40 00 index (initialization);00 sub-index(velocity);00 00 3E 80 data(velocity setting to 16000ustep/s)
	Rx	0000 01 00	03 40 00 00 00 00 00 02	0000 Response;01 device address;00 source address;03 sequence number;40 00 index ;00 sub-index;00 00 00 02 status
Liquid Level Detectio	Tx	0001 00 01	04 40 07 01 00 00 13 88	0001 write command;00 source address;01 device address; 04 sequence number;40 07 index (liquid level detection);01 sub-index(time setting);00 00 13 88

Function	Direction	ID(HEX)	Data(HEX)	Description
n				data(timeout setting to 5000ms)
	Rx	0000 01 00	04 40 07 01 00 00 00 02	0000 Response;01 device address;00 source address; 04 sequence number;40 07 index ;01 sub-index;00 00 00 02 status
	Tx	0001 00 01	05 40 07 00 00 00 00 01	0001 write command;00 source address;01 device address; 05 sequence number;40 07 index (liquid level detection);00 sub-index(reporting type setting);00 00 00 01data (liquid level detected and automatically reported)
	Rx	0000 01 00	05 40 07 00 00 00 00 02	0000 Response;01 device address;00 source address;05 sequence number;40 07 index ;00 sub-index;00 00 00 02 status
	Liquid level detected	0003 01 00	E2 70 00 00 00 00 00 04	0003 process data;01 device address;00 source address; E2 sequence number(Consistent with the heartbeat sequence, it increments by one each time it is received.);70 00 index (liquid level detected);00 sub-index;00 00 00 04 status(liquid level detected)
	Timeout	0080 01 00	E9 00 00 00 00 00 00 16	0080 warning data;01 device address;00 source address;E9 sequence number;00 00 index ;00 sub-index;00 00 00 16 status(timeout error)
Aspiration	Tx	0001 00 01	06 40 01 01 00 00 00 C8	0001 write command;00 source address;01 device address;06 sequence number;40 01 index (aspiration);01 sub-index(velocity);00 00 00 C8 data(200ul/s)
	Rx	0000 01 00	06 40 01 01 00 00 00 02	0000 Response;01 device address;00 source address;06 sequence number;40 01 index ;01 sub-index;00 00 00 02 status
	Tx	0001 00 01	07 40 01 02 00 00 00 0A	0001 write command;00 source address;01 device address;07 sequence number;40 01 index (aspiration);02 sub-index(cut-off velocity setting);00 00 00 0A data(10ul/s)
	Rx	0000 01 00	07 40 01 02 00 00 00 02	0000 Response;01 device address;00 source address;07 sequence number;40 01 index ;02 sub-index;00 00 00 02 status
	Tx	0001 00 01	08 40 01 00 00 00 27 10	0001 write command;00 source address;01 device address;08 sequence number;40 01 index (aspiration);00 sub-index(volume);00 00 27 10 data(100ul)
	Rx	0000 01 00	08 40 01 00 00 00 00 02	0000 Response;01 device address;00 source address;08 sequence number;40 01 index ;00 sub-index;00 00 00 02 status
Dispense	Tx	0001 00 01	09 40 02 01 00 00 01 F4	0001 write command;00 source address;01 device address;09 sequence number;40 02 index (dispense);01

Function	Direction	ID(HEX)	Data(HEX)	Description
				sub-index(re-aspirate volume);00 00 01 F4 data(5.00ul)
	Rx	0000 01 00	09 40 02 01 00 00 00 02	0000 Response;01 device address;00 source address;09 sequence number;40 02 index ;01 sub-index;00 00 00 02 status
	Tx	0001 00 01	0A 40 02 02 00 00 00 C8	0001 write command;00 source address;01 device address;0A sequence number;40 02 index (dispense);02 sub-index(velocity);00 00 00 C8 data(200ul/s)
	Rx	0000 01 00	0A 40 02 02 00 00 00 02	0000 Response;01 device address;00 source address;0A sequence number;40 01 index ;02 sub-index;00 00 00 02 status
	Tx	0001 00 01	0B 40 02 03 00 00 00 64	0001 write command;00 source address;01 device address;0B sequence number;40 02 index (dispense);03 sub-index(cut-off velocity);00 00 00 64 data(100ul/s)
	Rx	0000 01 00	0B 40 02 03 00 00 00 02	0000 Response;01 device address;00 source address;0B sequence number;4002 index ;03 sub-index;00 00 00 02 status
	Tx	0001 00 01	0C 40 02 00 00 00 03 E8	0001 write command;00 source address;01 device address;0C sequence number;40 02 index (dispense);00 sub-index(volume);00 00 03 E8 data(10.00ul)
	Rx	0000 01 00	0C 40 02 00 00 00 00 02	0000 Response;01 device address;00 source address;0C sequence number;40 02 index ;00 sub-index;00 00 00 02 status
Read register	Tx	0002 00 01	0D 20 00 01 00 00 00 00	0002 read command;00 source address;01 device address;0D sequence number;20 00 index (Point to the register);01 sub-index(current status register, see Table 10-2 Register);00 00 00 00 data;
	Rx	0000 01 00	0D 20 00 01 00 00 00 00	0000 Response;01 device address;00 source address;0D sequence number;20 00 index ;01 sub-index;00 00 00 00 data
Read register	Tx	0002 00 01	0E 20 00 02 00 00 00 00	0002 read command;00 source address;01 device address;0E sequence number;20 00 index (Point to the register);02 sub-index(Liquid Level Detection status register);00 00 00 00 data
	Rx	0000 01 00	0E 20 00 02 00 00 00 01	0000 Response;01 device address;00 source address;0E sequence number;20 00 index ;02 sub-index;00 00 00 01 data(liquid level is detected, if 00000000 then liquid level is not detected)
Write register	Tx	0001 00 01	0F 20 00 36 00 00 00 0A	0001 write command;00 source address;01 device address;0F sequence number;20 00 index (Point to the register);36 sub-index(liquid level detection coefficient);00 00 00 0A data(set to 10)

Function	Direction	ID(HEX)	Data(HEX)	Description
	Rx	0000 01 00	0F 20 00 36 00 00 00 02	0000 Response;01 device address;00 source address;0F sequence number;20 00 index ;36 sub-index;00 00 00 02 data

8.2 Example of KT_OEM Protocol(HEX Mode)

Note: KT_OEM protocol is a encapsulation of KT_DT protocol. For the description of command string and return string, see chapter 10.

Table 8-2 Example of a single command of OEM protocol

Function	Direction	Data(HEX)	Description
Initialization	Tx	AA80010D497431363030302C3130302C3005	AA frame header;80 index;01 device address;0D command string length; 49 74 31 36 30 30 30 2C 31 30 30 2C 30 string command “It16000,100,0”;05 frame end checksum
	Rx	5580010200d8	55 frame header;80 index;01 device address;02 command execution success status(other see Table 10-1 Status, The same below.);00 return string length;d8 frame end checksum
Liquid Level Detection	Tx	AA8101084C64312C3530303006	AA frame header;81 index;01 device address;08 command string length;4C 64 31 2C 35 30 30 30 string command “Ld1,5000”;06 frame end checksum
	Rx	5581010200d9	55 frame header;80 index;01 device address;02 command execution success status;00 return string length;d9 frame end checksum
Aspiration	Tx	AA82010E496131303030302C3230302C313021	AA frame header;82 index;01 device address;0E command string length;49 61 31 30 30 30 30 2C 32 30 30 2C 31 30 string command “Ia10000,200,10”;21 frame end checksum
	Rx	5582010200da	55 frame header;82 index;01 device address;02 command execution success status;00 return string length;da frame end checksum
Dispense	Tx	AA8301124461313030302C3530302C3230302C313030E2	AA frame header;83 index;01 device address;12 command string length;44 61 31 30 30 30 2C 35 30 30 2C 32 30 30 2C 31 30 30 string command“Da1000,500,200,100”;e2 frame end checksum
	Rx	5583010200db	55 frame header;83 index;01 device address;02 command execution success status;00 return string length;db frame end checksum
Read Status	Tx	AA8401013F6F	AA frame header;84 index;01 device address;01 command string length;3F string command“? ”;6f frame end checksum
	Rx	5584010000da	55 frame header;84 index;01 device address;00 idle state;00 return string length;da frame end checksum
Read register	Tx	AA8501035272332A	AA frame header;85 index;01 device address;03 command string length;52 72 33 string command“Rr3”;2A frame end checksum
	Rx	5585010201300e	55 frame header;85 index;01 device address;02

Function	Direction	Data(HEX)	Description
			successful execution of the command;01 return string length;30 return string “0” ;0e frame end checksum
Write register	Tx	AA860107577235342C3130F7	AA frame header;86 index;01 device address;07 command string length;57 72 35 34 2C 31 30 string command “Wr54,10” ;F7 frame end checksum
	Rx	5586010200de	55 frame header;86 index;01 device address;00 idle state;00 return string length;de frame end checksum

8.3 Example of KT_DT Protocol(String Mode)

Table 8-3 DT Protocol Single Command

Function	Direction	Data(HEX)	Description
Initialization	Tx	1>It16000,100,0	1 device address 16000 initialization velocity is 16000ustep/s 100 initialization power is 100% 0 TIP will be ejected during initialization regardless of whether the TIP is detected or not
	Rx	1<2	1 device address;2 command execution success status(See Table 10-1 Status)
Liquid Level Detection	Tx	1>Ld1,5000	1 device address;1 automatic reporting status after detecting the liquid level;5000 detection timeout time of 5000 milliseconds
	Rx	1<2	1 device address;2 command execution success status
	Rx	1<4	1 device address;4 Liquid level status detected; at the same time the yellow LED is always on
Aspiration	Tx	1>Ia10000,200,10	1 device address 10000 aspiration 100.00uL 200 velocity of 200uL/s 10 cut-off velocity 10uL/s
	Rx	1<2	1 device address;2 command execution success status
Dispense	Tx	1>Da1000,500,200,100	1 device address; 1000 dispense volume is 10.00ul 500 re-aspiration volume is 5.00ul 200 velocity is 200ul/s 100 cut-off velocity is 100uL/s.
	Rx	1<2	1 device address;2 command execution success status
Read Status	Tx	1>?	1 device address; ? used to query the current status of SP16, equivalent to reading the register 1
	Rx	1<0	1 device address;0 idle state

Read register	Tx	1>Rr3	1 device address;3 check for TIP status
	Rx	1<2:0	1 device address;2 successful execution of the command; 0: no TIP
Write register	Tx	1>Wr54,10	1 device address;54 liquid level detection coefficient;10 set to 10
	Rx	1<2	1 device address;2 successful execution of the command

8.4 Development Process Practice

8.4.1 CAN communication flow

It is recommended to use CAN Event-Triggered Communication mode. The pipettor will automatically report its completion status after finishing the operation.

Configure automatically reporting via Index 0x9F00 sub-index 0x05 to enable the event-triggered communication mode.

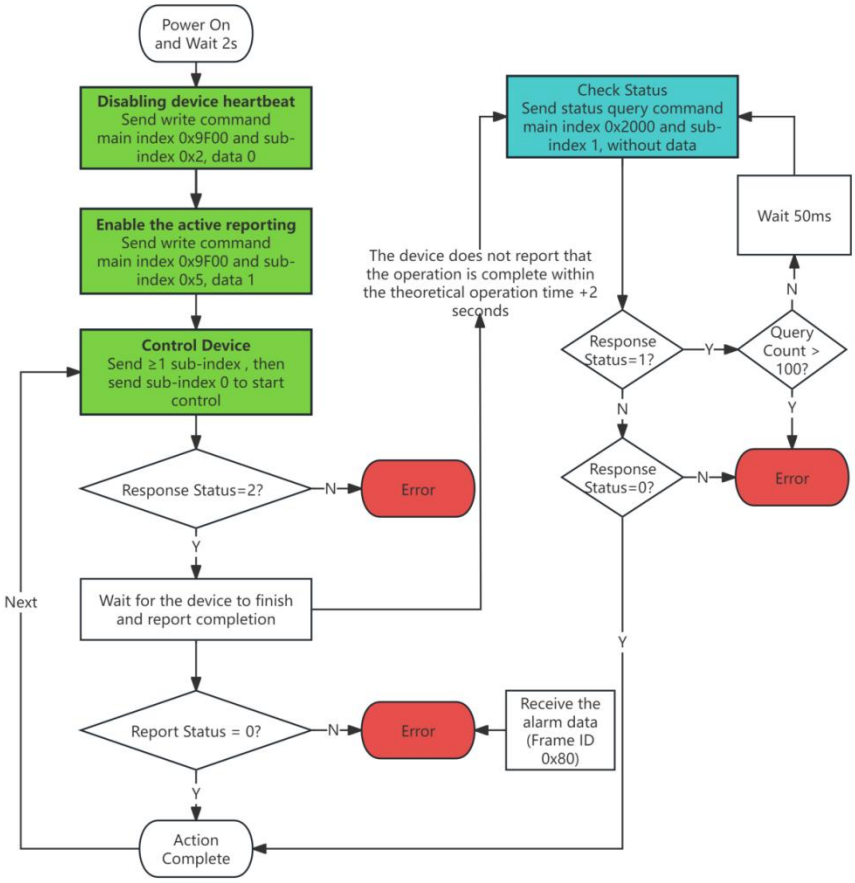


Figure 8-1 KT_CAN_DIC Protocol Communication Framework

Green Box: Write registers and control SP18 action operations (right side of the flowchart).

Blue Box: Query SP18 status and read registers (left side of the flowchart)

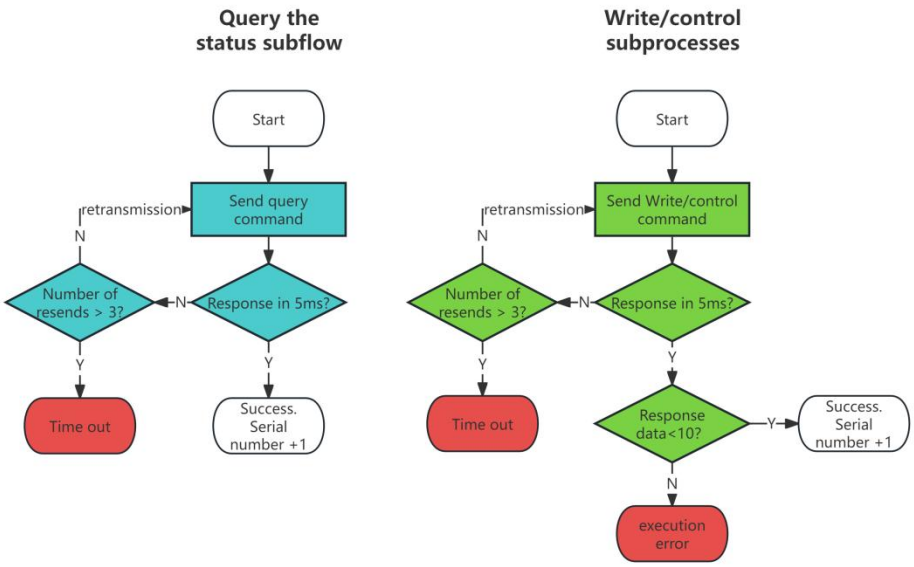


Figure 8-2 KT_CAN_DIC Protocol Communication Sub-flow Framework

8.4.2 Serial Port communication flow

When using serial port communication, wait ⩾10ms after receiving a response before sending the next command to avoid bus interference.

Use a one command-one response mode: each command must wait for acknowledgment before sending the next command.

The one command-one response mode is available at Figure 8-3 KT_OEM Protocol Communication Framework

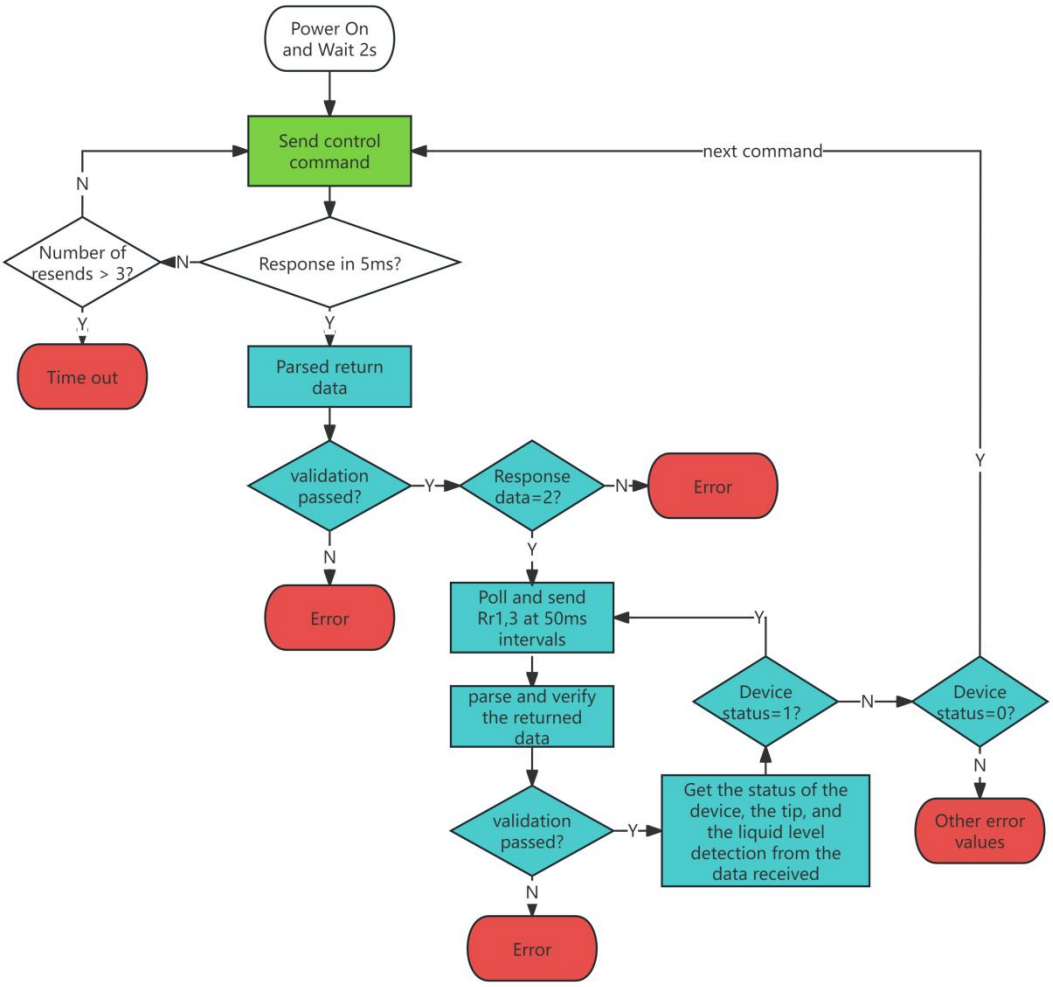


Figure 8-3 KT_OEM Protocol Communication Framework

8.4.3 CAN development process practice

Table 8-4 CAN Development Process

No.	direction	Description	Frame ID	Format	Type	DLC	Data(HEX)
0	Rx	Power-on default heartbeat upload	0x00040100	Data frame	Extended frame	0x08	00 00 00 00 00 00 00 00
1	Rx	Power-on default heartbeat upload	0x00040100	Data frame	Extended frame	0x08	00 00 00 00 00 00 00 00
2	Rx	Power-on default heartbeat upload	0x00042900	Data frame	Extended frame	0x08	01 00 00 00 00 00 00 00
3	Rx	Power-on default heartbeat upload	0x00040100	Data frame	Extended	0x08	01 00 00 00 00 00 00 00

No.	direction	Description	Frame ID	Format	Type	DLC	Data(HEX)
					frame		
4	Rx	Power-on default heartbeat upload	0x00042900	Data frame	Extended frame	0x08	02 00 00 00 00 00 00 00
5	Tx	Disable ADP-Z heartbeat	0x00010029	Data frame	Extended frame	0x08	01 20 00 6B 00 00 00 00
6	Rx		0x00002900	Data frame	Extended frame	0x08	01 20 00 6B 00 00 00 02
7	Tx	Disable pipettor heartbeat	0x00010001	Data frame	Extended frame	0x08	01 20 00 53 00 00 00 00
8	Rx		0x00000100	Data frame	Extended frame	0x08	01 20 00 53 00 00 00 02
9	Tx	Enable Pipettor Movement Completion automatically Reporting	0x00010001	Data frame	Extended frame	0x08	02 20 00 52 00 00 00 01
10	Rx		0x00000100	Data frame	Extended frame	0x08	02 20 00 52 00 00 00 02
11	Tx	Enable ADP-Z Movement Completion automatically Reporting	0x00010029	Data frame	Extended frame	0x08	02 20 00 52 00 00 00 01
12	Rx		0x00002900	Data frame	Extended frame	0x08	02 20 00 52 00 00 00 02
13	Tx	Set pipettor initialization power to 100%	0x00010001	Data frame	Extended frame	0x08	03 40 00 01 00 00 00 64
14	Rx		0x00000100	Data frame	Extended frame	0x08	03 40 00 01 00 00 00 02
15	Tx	Configure pipettor initialization with TIP ejection	0x00010001	Data frame	Extended frame	0x08	04 40 00 02 00 00 00 00
16	Rx		0x00000100	Data frame	Extended	0x08	04 40 00 02 00 00 00 02

No.	direction	Description	Frame ID	Format	Type	DLC	Data(HEX)
					frame		
17	Tx	Execute pipettor initialization	0x00010001	Data frame	Extended frame	0x08	05 40 00 00 00 00 FA 00
18	Rx		0x00000100	Data frame	Extended frame	0x08	05 40 00 00 00 00 00 02
19	Rx	Pipettor motion completion frame	0x00030100	Data frame	Extended frame	0x08	** 70 02 00 00 00 00 00
20	Tx	ADP-Z initialization	0x00010029	Data frame	Extended frame	0x08	** 41 00 00 00 00 C3 50
21	Rx		0x00002900	Data frame	Extended frame	0x08	** 41 00 00 00 00 00 02
22	Rx	ADP-Z action completion frame	0x00032900	Data frame	Extended frame	0x08	** 70 02 00 00 00 00 00
23	Tx	Configure the pipettor aspiration velocity to 100uL/s	0x00010001	Data frame	Extended frame	0x08	** 40 01 01 00 00 00 64
24	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 01 01 00 00 00 02
25	Tx	Configure pipettor aspiration cut-off velocity to 0uL/s	0x00010001	Data frame	Extended frame	0x08	** 40 01 02 00 00 00 00
26	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 01 02 00 00 00 02
27	Tx	Execute pipettor aspiration of 30uL air	0x00010001	Data frame	Extended frame	0x08	** 40 01 00 00 00 0B B8
28	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 01 00 00 00 00 02
29	Rx		0x00030100	Data frame	Extended frame	0x08	** 70 02 00 00 00 00 00
30	Tx	Set the power of ADP-Z	0x00010029	Data	Extend	0x08	** 41 04 01 00 00 00 50

No.	direction	Description	Frame ID	Format	Type	DLC	Data(HEX)
		pickup TIP to 80%		frame	ed frame		
31	Rx		0x00002900	Data frame	Extended frame	0x08	** 41 04 01 00 00 00 02
32	Tx	Execute ADP-Z to pickup TIP	0x00010029	Data frame	Extended frame	0x08	** 41 04 00 00 00 4E 20
33	Rx		0x00002900	Data frame	Extended frame	0x08	** 41 04 00 00 00 00 02
34	Rx	Pipettor has pickup TIP	0x00030100	Data frame	Extended frame	0x08	** 70 01 00 00 00 00 01
35	Rx	ADP-Z motion completion frame	0x00032900	Data frame	Extended frame	0x08	** 70 02 00 00 00 00 00
36	Tx	Configure ADP-Z velocity 30000um/s	0x00010029	Data frame	Extended frame	0x08	** 41 01 01 00 00 75 30
37	Rx		0x00002900	Data frame	Extended frame	0x08	** 41 01 01 00 00 00 02
38	Tx	Execute ADP-Z moving to position 0um	0x00010029	Data frame	Extended frame	0x08	** 41 01 00 00 00 00 00
39	Rx		0x00002900	Data frame	Extended frame	0x08	** 41 01 00 00 00 00 02
40	Rx	ADP-Z action completion frame	0x00032900	Data frame	Extended frame	0x08	** 70 02 00 00 00 00 00
41	Tx	Configure ADP-Z velocity 30000um/s	0x00010029	Data frame	Extended frame	0x08	** 41 01 01 00 00 75 30
42	Rx		0x00002900	Data frame	Extended frame	0x08	** 41 01 01 00 00 00 02
43	Tx	Execute ADP-Z moving to position 180000um	0x00010029	Data frame	Extended frame	0x08	** 41 01 00 00 02 BF 20

No.	direction	Description	Frame ID	Format	Type	DLC	Data(HEX)
44	Rx		0x00002900	Data frame	Extended frame	0x08	** 41 01 00 00 00 00 02
45	Tx	Configure liquid level detection without detecting timeout	0x00010001	Data frame	Extended frame	0x08	** 40 07 01 00 00 00 00
46	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 07 01 00 00 00 02
47	Tx	Execute liquid level detection	0x00010001	Data frame	Extended frame	0x08	** 40 07 00 00 00 00 00
48	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 07 00 00 00 00 02
49	Rx	ADP-Z action completion frame	0x00032900	Data frame	Extended frame	0x08	** 70 02 00 00 00 00 00
50	Rx	Pipettor motion completion frame	0x00030100	Data frame	Extended frame	0x08	** 70 02 00 00 00 00 00
51	Tx	Query whether the liquid level is detected in register 2	0x00020001	Data frame	Extended frame	0x08	** 20 00 02 00 00 00 00
52	Rx	Return that the liquid level is detected	0x00000100	Data frame	Extended frame	0x08	** 20 00 02 00 00 00 01
		...mixing					
53	Tx	Execute pipettor aspiration of 100.00ul	0x00010001	Data frame	Extended frame	0x08	** 40 01 00 00 00 27 10
54	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 01 01 00 00 00 02
55	Rx	Pipettor motion completion frame	0x00030100	Data frame	Extended frame	0x08	** 70 02 00 00 00 00 00
56	Tx	Configure pipettor velocity to 76800ustep/s	0x00010001	Data frame	Extended frame	0x08	** 40 03 01 00 01 2C 00

No.	direction	Description	Frame ID	Format	Type	DLC	Data(HEX)
57	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 00 00 00 00 00 02
58	Tx	Perform pipettor dispensing and emptying	0x00010001	Data frame	Extended frame	0x08	** 40 03 00 00 00 00 00
59	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 00 00 00 00 00 02
60	Rx	Pipettor motion completion frame	0x00030100	Data frame	Extended frame	0x08	** 70 02 00 00 00 00 00
		...Cycle 53-60 for mixing					
56	Tx	Configuration of pipettor aspiration anomaly detection	0x00010001	Data frame	Extended frame	0x08	** 20 00 3C 00 00 00 05
57	Rx		0x00000100	Data frame	Extended frame	0x08	** 20 00 3C 00 00 00 02
58	Tx	Configure the pipettor liquid following surface area of 90mm^2	0x00010001	Data frame	Extended frame	0x08	** 20 00 68 00 00 00 5A
59	Rx		0x00000100	Data frame	Extended frame	0x08	** 20 00 68 00 00 00 02
60	Tx	Configure the pipettor aspiration velocity to 100uL/s	0x00010001	Data frame	Extended frame	0x08	** 40 01 01 00 00 00 64
61	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 01 01 00 00 00 02
62	Tx	Configure the pipettor aspiration cut-off velocity to 0uL/s	0x00010001	Data frame	Extended frame	0x08	** 40 01 02 00 00 00 00
63	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 01 02 00 00 00 02
64	Tx	Execute pipetting of	0x00010001	Data	Extend	0x08	** 40 01 00 00 00 27 10

No.	direction	Description	Frame ID	Format	Type	DLC	Data(HEX)
		100uL of liquid		frame	ed frame		
65	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 01 00 00 00 00 02
66	Rx	ADP-Z action completion frame	0x00032900	Data frame	Extended frame	0x08	** 70 02 00 00 00 00 00
67	Rx	Pipettor motion completion frame	0x00030100	Data frame	Extended frame	0x08	** 70 02 00 00 00 00 00
68	Tx	Close the liquid suction following function	0x00010001	Data frame	Extended frame	0x08	** 20 00 68 00 00 00 00
69	Rx		0x00000100	Data frame	Extended frame	0x08	** 20 00 68 00 00 00 02
70	Tx	Configure ADP-Z velocity 40000um/s	0x00010029	Data frame	Extended frame	0x08	** 41 01 01 00 00 9C 40
71	Rx		0x00002900	Data frame	Extended frame	0x08	** 41 01 01 00 00 00 02
72	Tx	Execute ADP-Z moving to position 0um	0x00010029	Data frame	Extended frame	0x08	** 41 01 00 00 00 00 00
73	Rx		0x00002900	Data frame	Extended frame	0x08	** 41 01 00 00 00 00 02
74	Rx	ADP-Z action completion frame	0x00032900	Data frame	Extended frame	0x08	** 70 02 00 00 00 00 00
75	Tx	Configure pipettor re-aspiration volume 0.00ul	0x00010001	Data frame	Extended frame	0x08	** 40 02 01 00 00 00 00
76	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 02 01 00 00 00 02
77	Tx	Configure the pipettor to dispense at a velocity of	0x00010001	Data frame	Extended frame	0x08	** 40 02 02 00 00 01 90

No.	direction	Description	Frame ID	Format	Type	DLC	Data(HEX)
		400ul/s					
78	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 02 02 00 00 00 02
79	Tx	Configure pipettor dispense up to velocity 0ul/s	0x00010001	Data frame	Extended frame	0x08	** 40 02 03 00 00 00 00
80	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 02 03 00 00 00 02
81	Tx	Execute pipettor dispense 130.00ul	0x00010001	Data frame	Extended frame	0x08	** 40 02 00 00 00 32 C8
82	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 02 00 00 00 00 02
83	Rx	Pipettor motion completion frame	0x00030100	Data frame	Extended frame	0x08	** 70 02 00 00 00 00 00
84	Tx	Close pipettor aspiration abnormality detection	0x00010001	Data frame	Extended frame	0x08	** 20 00 3C 00 00 00 00
85	Rx		0x00000100	Data frame	Extended frame	0x08	** 20 00 3C 00 00 00 02
86	Tx	Configure the pipettor to always eject TIP	0x00010001	Data frame	Extended frame	0x08	** 40 00 02 00 00 00 00
87	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 00 02 00 00 00 02
88	Tx	Execute Pipettor eject TIP	0x00010001	Data frame	Extended frame	0x08	** 40 00 00 00 00 7D 00
89	Rx		0x00000100	Data frame	Extended frame	0x08	** 40 00 00 00 00 00 02
90	Rx	Pipettor motion completion frame	0x00030100	Data frame	Extended frame	0x08	** 70 02 00 00 00 00 00

**: It is recommended that the user increment the communication sequence number

by 1 before sending each frame of data to ensure that each frame of data is different. The device will reply with the same sequence number as the frame in each response.

8.4.4 Serial Port Development Process practic

Table 8-5 Serial Port Development Process

Direction	Command(HEX)	Function	Command String ASCII
Tx	AA8029075A7A353030303023	ADP-Z initialization	Zz50000
Rx	558029020000		
Tx	AA8129013F94	Polling ADP-Z status	
Rx	558129010000	ADP-Z status 01 busy	
	.....	Omit (continue polling status until idle)	
Tx	AA8329013F96	Query ADP-Z status	
Rx	558329000001	ADP-Z state 0 idle	
Tx	AA84010D4974363430303302C3130302C300C	Pipettor initialization	It64000,100,0
Rx	5584010200dc		
Tx	AA8501013F70	Polling Pipettor Status	
Rx	5585010100dc	Pipettor Status 01 Busy	
	.....	Omit (continue polling status until idle)	
Tx	AA8701013F72	Query Pipettor Status	
Rx	5587010000dd	Pipettor status 0 idle	
Tx	AA88290A5A6735303030302C3830AF	ADP-Z downward action pickup TIP	Zg50000,80
Rx	558829020008		
	.....		
Tx	AA8A29013F9D	Query ADP-Z status	
Rx	558a29000008	ADP-Z state 0 idle	
Tx	AA8B290E5A7532303030302C31383030303082	Move the Z-axis upward by 2 cm	Zu20000,180000
Rx	558b2902000b		
	.....		
Tx	AA8D29013FA0	Query ADP-Z status	
Rx	558d2900000b	ADP-Z state 0 idle	
Tx	AA8E010352723333	Query TIP status	Rr3
Rx	558e0102013118	return 0x31, Tip detected	
Tx	AA8F010B57723130302C3130303030BC	Configure the liquid level detection follow-up function	Wr100,10000
Rx	558f010200e7		
Tx	AA90010C4961333030302C3130302C30CD	Pipettor aspirate 30.00uL air	Ia3000,100,0
Rx	5590010200e8		

Direction	Command(HEX)	Function	Command String ASCII
	.....		
Tx	AA9201013F7D	Query Pipettor Status	
Rx	5592010000e8	idle	
Tx	AA9301054C64302C307F	liquid level detection	Ld0,0
Rx	5593010200eb		
	.....		
Tx	AA9501013F80	Query Pipettor Status	
Rx	5595010000eb	idle	
Tx	AA9601035272323A	Query whether the liquid level is detected	Rr2
Rx	55960102013120	return 0x31, liquid level is detected	
Tx	AA97011E7B496131303030302C3130302C304D70302C39363030302C333230307D354A	The pipette aspirates 100.00 μl of liquid, then empties it. Repeat this process 5 times for mixing	{Ia10000,100,0Mp0,96000,3200}5
Rx	5597010200ef		
	.....		
Tx	AA9901013F84	Query Pipettor Status	
Rx	5599010000ef	idle	
Tx	AA9A0106577236302C35DB	Set up abnormal liquid suction detection	Wr60,5
Rx	559a010200f2		
Tx	AA9B010D4961313030303302C3130302C3007	Pipettor aspiration 100.00ul	Ia10000,100,0
Rx	559b010200f3		
	.....		
Tx	AA9D01013F88	Query Pipettor Status	
Rx	559d010000f3	idle	
Tx	AA9E290A5A70302C313830303030CA	ADP-Z rises to position 0	Zp0,180000
Rx	559e2902001e		
	.....		
Tx	AAA029013FB3	Query ADP-Z status	
Rx	55a02900001e	idle	
Tx	AAA1010F4461313330303302C302C3130302C3069	Pipettor dispense 130.00uL	Da13000,0,100,0
Rx	55a1010200f9		
	.....		
Tx	AAA301013F8E	Query Pipettor Status	
Rx	55a3010000f9	idle	
Tx	AAA40106577236302C30E0	Turn off aspiration anomaly detection	Wr60,0
Rx	55a4010200fc		
Tx	AAA5010D4974363430303302C3130302C30	Pipettes perform a TIP ejection	It64000,100,0

Direction	Command(HEX)	Function	Command String ASCII
	2D		
Rx	55a5010200fd		
	.....		
Tx	AAA701013F92	Query Pipettor Status	
Rx	55a7010000fd	idle	

9 KT_CAN_DIC Object Dictionary

The object dictionary includes a 16-bit index and an 8-bit sub-index. Different operations are indicated by ordered index numbers. All data include read and write permissions. Control command include initialization, aspirate liquid, and dispense liquid. Different indexes represent different command. Sub-indexes are different parameters. The number of parameters is the same as that of serial port command. For example, the serial port command <It>n1,[n2],[n3], It corresponds to the index 0x4000, and n1[n2][n3] corresponds to the sub-index 0～2.

Note: Each control command has a unique index and multiple sub-indexes. The frame data with non-zero sub-index is sent first, and the frame data with zero sub-index is sent last. The pipettor starts moving when it receives a command with zero sub-index.

9.1 Control Command

Table 9-1 KT_CAN_DIC Control Command

Function	Index	Sub-index	R/W	Data range	Default	Description
Initialization	0x4000	0	W	200～64000 (ustep/s)	/	**Mandatory parameter** Initialization, Initialization Speed
		1	RW	0～100(%)	100	Power
		2	RW	0～2	0	TIP ejection mode: 0: Eject TIP regardless of whether there is a TIP 1: Eject TIP if detected 2: Do not eject TIP
Aspiration	0x4001	0	W	1～105000 (0.01ul)	/	**Mandatory parameter** Aspiration volume (0.01uL)
		1	RW	1～520	200	Aspiration velocity (uL/s)
		2	RW	0～200	25	cut-off velocity (uL/s)
Dispense	0x4002	0	W	1～105000 (0.01ul)	/	**Mandatory parameter** Dispense volume (0.01uL)
		1	RW	0～10000 (0.01ul)	0	re-aspiration volume (0.01uL)
		2	RW	1～520	200	Dispense velocity (uL/s)
		3	RW	0～200	25	cut-off velocity (uL/s)
Absolute Positioning	0x4003	0	W	0～197520	/	**Mandatory parameter** Position value, 197520ustep=1050ul
		1	RW	200～96000	32000	Running velocity(ustep/s)

Function	Index	Sub-index	R/W	Data range	Default	Description
		2	RW	0～32000	3200	Stop velocity(ustep/s)
Liquid Level Detection	0x4007	0	W	0～1	/	**Mandatory parameter** 0: No automatic report after liquid level is detected; 1: Automatically report after liquid level detection
		1	RW	0～20000 (ms)	0	Detection timeout duration: 0: No timeout detection; Other values: Timeout duration in milliseconds. A timeout error will be reported if liquid level is not detected within this period.
Stop	0x4008	0	W	0	0	Stop motion and liquid level detection.
Anti-Droplet Control	0x4010	0	W	0～1	0	0: Disable anti-droplet; 1: Enable anti-droplet.
	0x4010	1	RW	0～1000	200	Anti-droplet velocity(ul/s)
	0x4010	2	RW	0～1000	50	Maximum adjustment range(ul)
	0x4010	3	RW	0～20000	500	The function shall be activated after the air pressure has stabilized for the specified time.
Factory reset	0x5000	1	W	/	/	**Mandatory parameter** The parameter must be filled in with 123456 to take effect.

9.2 General Commands

Table 9-2 KT_CAN_DIC General Command

Function	Index	Sub-index	R/W	Data Range	Default Value	Description
Status Query	0x2000	1	RW	/	/	Status: 0 = Idle; 1 = Busy. Other values: Error code.
Device type	0x9F00	0	R	/	/	Device type: each device shall have a unique device ID.
Stop	0x9F00	1	W	/	/	Stop Device
Heartbeat Interval	0x9F00	2	RW	/	/	CAN Active Upload Heartbeat Interval (ms) 0: Disable Heartbeat

Function	Index	Sub-index	R/W	Data Range	Default Value	Description
						Other values: Periodic Upload Interval/(ms)
Reboot	0x9F00	3	W	/	/	Reboot
SW Version	0x9F00	4	R	/	/	Version
Active Reporting	0x9F00	5	RW	/	/	0: Disable Active Reporting 1: Enable Active Reporting CAN Active Reporting for movement completion: upload data 0 via CAN command 03, Main Index 0x7002 Sub-index 0 to indicate movement completion. Other values indicate error statuses
Save	0x9F10	0	W	/	123456	save the parameters during power loss
Factory reset	0x9F10	1	W	/	123456	Factory reset

9.3 Read and Write Register

Read/write the SP18 registers through the index 0x2000, and the sub-index corresponds to the Register Address, which is shown in Table 10-2 Register. The read/write function commands can be found at 8.1 Examples of KT_CAN_DIC Protocol

9.4 Process Data

The SP18 device automatically reports process data through Command 0x0003. The process data dictionary is shown in the table below

Table 9-3 KT_CAN_DIC Process Data

Function	Index	Sub-index	R/W	Data Range	Default Value	Description
Liquid level detected	0x7000	0	/	4	4	0:The liquid level is not detected 1: The liquid level is detected.
TIP Detection status	0x7001	0	/	0～1	0	TIP detection status Automatically reporting of the disposable TIP status when it is picked up or ejected 0: No disposable TIP 1: With disposable TIP
Motion Completed	0x7002	0	/	0～255	0	After moving done then automatically report the status 0: normal

	Other data:Error status, see Table 10-1 Status

9.5 Heartbeat Data

The pipettor sends heartbeat data via command 0x0004, which the Host can use it to detect whether the device is online.

9.6 Warning Data

The SP18 device sends warning information using Command 0x0080 of the KT_CAN_DIC protocol. The warning data format is identical to the error information format used for status query command. For detailed warning information, See Table 10-1 Status.

10 Serial Port Commands

This chapter describes the data format for operation commands in the KT_OEM and KT_DT protocols, specifically the data block of the command string. The data is formatted as ASCII strings, and multiple command sets can be sent simultaneously. The SP18 will parse and execute the commands sequentially. The command types are categorized as follows:

- Initialization command
- Control commands
- Parameter read/write commands
- System control commands

10.1 Command Syntax

Send multiple commands to pipettor, and the format is as follows:

<CMD><n1,n2,n3><CMD><n1,n2,n3><CMD><n1,n2,n3>

The pipettor responds data in the following ASCII format:

<n1,n2,n3>

Among them:

<CMD>: command, consists of the letters a～z and A～Z, up to two letters, See section 10.3.

<n1,n2,n3>: command parameters, commands parameters are separated by ',' sign, and the command without parameters can be empty. If some of the parameters need to be by default, you can fill in the parameters as empty. For example, the second parameter will be empty command: It64000,,2. If the next part of the parameters are empty, it can be omitted. For example, the last two parameters are empty command: It64000 means that the last two parameters are empty.

1) <> is used to differentiate data blocks and does not need to be sent.

2) The commands are case-sensitive.

3) It is agreed that the instruction letters are at most two letters long, with two-letter instructions consisting of an uppercase letter followed by a lowercase letter. Single-letter instructions are represented by uppercase letters. The special character '?' denotes a query instruction, and '{}' denotes a loop control instruction. A single uppercase letter instruction is for system control, while an uppercase letter followed by a lowercase letter is for operation control.

10.2 Status

Each command has a return status to indicate whether it was successfully executed, if an error occurred, or if the device is idle or busy. Status codes are represented as a single byte in hexadecimal format.

Rules:

0～9: Working status.

10～19: Command execution error code.

>=20: Error code.

Table 10-1 Status

Value	Function	Description
0	Idle	The idle state of the device
1	Busy	The device is in a busy state.
2	Execution Success	The instruction is executed successfully.
3	Execution Completed	It is closed by default. This status will be reported after the execution of the action instruction is completed. Refer to register 82.
4	Liquid level detected	It is closed by default. In the serial communication mode, when the instruction to detect the liquid level [n1] = 1 is used to enable the active reporting function for liquid - level detection, the status will be actively uploaded once the liquid level is detected. In other modes, check whether the liquid level is detected by querying register 2.
…		
10	Parameter exceeded limit	The instruction parameter exceeds the range.
11	Parameter error	The instruction parameter is incorrect.
12	Syntax error	The instruction has a syntax error.
13	Invalid commands	This instruction is not supported.
14	Address error	The read - write parameter address is incorrect.
15	Prohibit writing	Writing is prohibited.
16	Prohibit reading	Reading is prohibited.
17	Pipettor uninitialized	It has not been initialized.
18	ADP-Z uninitialized	ADPZ has not been initialized.
19	ADP-Z unconnected	The Z-axis is not connected.
20	No TIP warning	Liquid suction and discharge are allowed after an alarm is triggered.
21	Eject disposable TIP failure warning	Liquid suction and discharge are allowed after an alarm is triggered.
22	Timeout warning	Liquid suction and discharge are allowed after an alarm is triggered.
23	Aspiration clot detection warning	Liquid suction and discharge are allowed after an alarm is triggered.
24	Aspiration foam detection warning	Liquid suction and discharge are allowed after an alarm is triggered.
25	Aspiration air detection warning	Liquid suction and discharge are allowed after an alarm is triggered.

28	Anti-droplet range exceeds the limit	Aspiration and dispense of liquid is prohibited and needs to be re-initialized and troubleshot.
50	Motor stall error	Prohibit aspirate and dispense of liquid, require re-initialization and troubleshoot
51	Drive failure	Prohibit aspirate and dispense of liquid, require re-initialization and troubleshoot
52	error with the zero - position optocoupler	Prohibit aspirate and dispense of liquid, require re-initialization and troubleshoot
53	error with the TIP optocoupler	Prohibit aspirate and dispense of liquid, require re-initialization and troubleshoot
54	Pressure Sensor error	Prohibit aspirate and dispense of liquid, require re-initialization and troubleshoot
55	EEPROMerror	Prohibit aspirate and dispense of liquid, require re-initialization and troubleshoot

10.3 Command Details

This section provides detailed explanations for each command.

[] indicates optional parameters. If the optional parameters are empty, the default parameters in the protocol will be used. No [] indicates a mandatory parameter.

<> contains command. The symbol <> does not need to be sent. It is only used to distinguish letters from command.

10.3.1 Initialization Command

10.3.1.1 <It>n1,[n2],[n3] Initialization

Used to initialize the SP18 by automatically moving the plunger to position 0. The command parameters determine whether the TIP is ejected.

Command	Parameter	Data Range	Unit	Default	Description
It	n1	200～64000	ustep/s	16000	Initialization velocity.
	[n2]	1～100	%	100	Power during Initialization.
	[n3]	0～2	/	0	0: TIP will be ejected Regardless of whether there is a TIP 1: If a TIP is detected, the TIP will be ejected 2: Don’t eject the TIP

Ensure correct TIP installation by applying a down force of 28±2 N for 1 second.

Insufficient down force may cause the TIP to fall off during moving, while excessive down force may result in TIP ejection failure or

permanent damage to the SP18.

10.3.2 Control Command

10.3.2.1 <Ia>n1,[n2],[n3] Aspiration

Used for aspirating liquid, it automatically converts the parameters corresponding to the volume into the piston movement distance, and controls the piston to move upward to aspirate liquid.

Command	Parameter	Data Range	Unit	Default	Description
Ia	n1	1～105000	0.01ul	0	Aspiration volume.
	[n2]	1～520	1ul/s	200	Aspiration velocity.
	[n3]	0～200	1ul/s	25	Cut-off velocity.

[n1] Aspiration Volume: This parameter is mandatory. The aspiration volume refers to the theoretical volume aspirated into the TIP. However, due to various physical factors, the aspirated volume and target volume may differ. For high-precision aspirations, it is necessary to calibrate based on the aspiration velocity, liquid viscosity, aspiration volume, and TIP type to create an appropriate calibration curve.

[n2] Aspiration velocity: The flow rate should be set according to the physical properties of the liquid, such as viscosity and surface tension. For certain liquids, an excessively fast flow rate may result in low pipetting barrel pressure in the SP18, causing the liquid to continue flowing into the TIP after the plunger stops, leading to over-aspiration. The recommended approach is to match the liquid flow rate with the aspiration velocity.

[n3] Cut-off Velocity: This parameter controls the final stopping velocity of the fluid, which should be adjusted based on the specific physical properties of the liquid.

[n4] TIP Compensation: This compensation mode is based on single aspiration and single dispense cycles using Keyto's TIP and pure water, ensuring precision within the range of pipettor performance.

10.3.2.2 <Da>n1,[n2],[n3],[n4] Dispense

Used for dispense liquid, it automatically converts the parameters corresponding to the volume into the piston movement distance, controls the piston movement to dispense the liquid, and chooses whether to re-aspirate according to the parameters to prevent liquid hanging.

Command	Parameter	Data Range	Unit	Default	Description
Da	n1	1～105000	0.01ul	0	Dispense volume.
	[n2]	0～10000	0.01ul	0	re-aspiration volume.
	[n3]	1～520	1ul/s	200	Dispense velocity.
	[n4]	0～200	1ul/s	25	Cut-off velocity.

[n1] Dispense Volume: This parameter refers to the theoretical volume dispensed from the TIP. Due to various physical factors, the dispensed volume and target volume may differ. For high-precision dispensing, calibration should consider dispensing velocity, liquid viscosity, dispensing volume, and TIP type.

[n2] re-aspiration Volume: To prevent liquid droplet formation at the TIP end, which can impact accuracy and cause cross-contamination, a re-aspiration function is designed to retract a specified volume of liquid after dispensing. The re-aspiration volume depends on the dispense volume, TIP type, and reagent viscosity. It may also affect dispensing precision. Users should optimize settings to avoid droplet formation and achieve desired precision.

[n3] Dispense velocity: This parameter should be set according to the liquid's physical properties. For certain liquids, excessively fast flow rates can cause high pipetting barrel pressure in the SP18. A reasonable approach is to match the liquid flow rate with the dispense velocity.

[n4] Cut-off Velocity: This parameter determines the velocity at the end of dispensing. The piston decelerates to the stop velocity before coming to a complete stop. The cut-off velocity must be lower than the dispensing velocity. A higher cut-off velocity can improve droplet detachment at the needle TIP.

Parameter n1 is the target volume of liquid dispensed, [n2] does not affect the target volume of liquid dispensed, but only affects the effect of aliquot-dispense of hanging droplet; single aspiration single dispense should be kept [n2] is 0;

The cut-off velocity must be less than the dispense velocity.

10.3.2.3 <Mp>n1,[n2],[n3] Absolute Positioning

The control plunger moves to an absolute position within the entire stroke from 0～197520 ustep corresponding to 0～1050uL.

Command	Parameter	Data Range	Unit	Default	Description
Mp	n1	0~197520	ustep	0	Position value.
	[n2]	200~96000	ustep	32000	Running velocity.
	[n3]	0~32000	ustep	3200	Stop velocity.

10.3.2.4 <Ld>n1,[n2] Liquid Level Detection

This command is used to detect the surface of the reagent. When the liquid level is detected, SP18 sends a liquid level detection signal. Users can monitor this signal in three ways: by checking the SP18 automatically reporting message, monitoring the GPO1 output, or querying the status.

Command	Parameter	Data Range	Unit	Default	Description
Ld	n1	0～1	/	1	0: No automatic reporting after liquid level detection; users should query Register 2 to confirm. 1: Automatically reporting of status after

					liquid level is detected.
	[n2]	0～20000	ms	10000	0: No timeout. Other values: Timeout duration. If no pressure change is detected within the timeout period, an error is reported.

10.3.2.5 <Pc>n1,[n2],[n3],[n4] Anti-Droplet Control

This command enables anti-droplet functionality after completing aspiration. Set parameter n1 to 1 to enable the feature. Note: For products supporting this function, users must resend this command to reactivate anti-droplet control after executing other commands.

Command	Parameter	Data Range	Unit	Default	Description
Pc	n1	0～1	/	0	0: Disable anti-droplet control 1: Enable anti-droplet control
	[n2]	0～1000	ul/s	200	Anti-droplet velocity
	[n3]	0～1000	ul	50	Maximum adjustment range
	[n4]	0～20000	ms	500	The function shall be activated after the air pressure has stabilized for the specified time

10.3.3 Parameter Read/Write commands

10.3.3.1 Registers

Registers are used by users to configure and view the parameters of the SP18, which is convenient for users to use flexibly.

Table 10-2 Register

Register Address	R/W	Data Range	Unit	Default	Description
1	R/W	/	/	0	Current status, write 0 to clear error, return value is same as “?” command.
2	R	0～1	/	0	Whether the liquid level is detected: 0: Liquid level not detected. 1: Liquid level detected.
3	R	0～1	/	0	The TIP is picked up? 0:No, no TIP 1:Yes, with TIP (after executing the eject TIP command, this register cannot replace register 1 to determine if the device enters the idle state.)
4	R	/	/	/	Current pressure sensor ADC value.
10	R/W	/	/	0	GPO1 output configuration: 0: Outputs a 10ms high-level pulse.

Register Address	R/W	Data Range	Unit	Default	Description
					1: Outputs high level after detecting the liquid level. 2: Outputs low level after detecting the liquid level.
29	R	1050	ul	1050	Maximum volume.
43	R/W	0～1	/	0	0: Does not check TIP picked-up status; no error when performing aspiration or dispensing even no TIP. 1: Checks TIP picked-up status; reports an error if performing aspiration or dispensing if no TIP.
54	R/W	1～100	/	0	Liquid level detection coefficient. The default value is suitable for most applications.
60	R/W	0～0x07	/	0	Abnormal pressure detection enable (HEX, enables corresponding functions when the bit is set to 1): Bit 0: Enables clot detection during aspiration. Bit 1: Enables foam detection during aspiration. Bit 2: Enables aspiration of empty detection.
70	R/W	0～100	/	10	Aspiration of clot detection coefficient.The smaller the value is, the more sensitive it is.
71	R/W	0～1000	/	10	Aspiration of foam detection coefficient.The smaller the value is, the more sensitive it is.
72	R/W	0～100	/	60	Aspiration of empty detection coefficient. The larger the value is, the more sensitive it is.
80	R/W	9600/19200/38400	bps	38400	Serial Port port baud rate.
81	R/W	100/125/250/500/1000	Khz	500	CAN baud rate.
82	R/W	0～1	/	0	If the movement is completed,whether reported automatically the status or not: 0: Disable automatically reporting 1: Enable automatically reporting
83	R/W	0～10000	ms	1000	CAN heartbeat interval: 0: No heartbeat data.

Register Address	R/W	Data Range	Unit	Default	Description
					Other values: Heartbeat interval, in ms.
90	R	/	/	/	Firmware version.
91	R	/	/	0x00200003	Device type.
92	R	/	/	/	Device sequence number.
100	R/W	0～50000	um	0	Z-axis speed for liquid level detection: automatic Z-axis control is enabled during liquid level detection. When set to 0, the Z-axis shall not move.
101	R/W	0～180000	um	/	The Z-axis position when the Tip moves to the test tube bottom, shall define the stroke limit for liquid level detection or liquid level tracking during aspiration and ejection.
102	R/W	0～180000	um	/	The Z-axis position when the Tip moves to the test tube opening, shall define the stroke limit for liquid level tracking during ejection.
103	R/W	0～180000	um	/	Conical taper height
104	R/W	0～180000	mm^2	/	The cross-sectional area of the inner cavity at the test tube opening is designed for liquid level tracking during aspiration and ejection. When set to 0, the Z-axis for aspiration and ejection shall default to no movement

Registers 100 to 104 are only available when used in conjunction with our company's Z-axis (ADPZ).

10.3.3.2 <Wr>n1,n2 Write Register

Command	Parameter	Data Range	Unit	Default	Description
Wr	n1	1～100	/	/	Register address.
	n2	/	/	/	Data to be written.

10.3.3.3 <Rr>n1,[n2] Read Register

This command reads the values of registers, starting from the specified address and reading a specified number of registers.

Command	Parameter	Data Range	Unit	Default	Description

Rr	n1	1～100	/	/	Starting address.
	n2	/	/	1	Number of registers to read.

The return data of multiple addresses are separated by ','.

10.3.4 System Operation Command

10.3.4.1 <?> Query Status

This ? command queries the current status of the device.

10.3.4.2 {} Loop

The loop control command is used to control the loop execution of the command string. The loop can be nested. A maximum of 20 loops including nested loops are supported in one command string.

Command	Parameter	Data Range	Unit	Default	Description
{	/	/	/	/	Start of the loop.
}	[n1]	/	/	0	0: infinite loop. other values: number of loops

10.3.4.3 <L>n1 Delay

The delay is used for internal system delays and is mainly used as a delay between the execution of two commands.

Command	Parameter	Data Range	Unit	Default	Description
L	n1	0～20000	ms	/	**Mandatory parameter** Delay time

返回数据: 见状态表

10.3.4.4 <T> Stop

Stop the command currently being executed by the device.

Command	Parameter	Data Range	Unit	Default	Description
T	/	/	/	/	Stop

10.3.4.5 <U> Reset

This command is used to restart and reset the device.

Command	Parameter	Data Range	Unit	Default	Description
U	n1	/	/	123456	**Mandatory parameter** The parameter should be 123456.

10.3.4.6 <M>n1 Restore Factory Settings Command

After executing this command, you need to restart the device.

Command	Parameter	Data Range	Unit	Default	Description
M	n1	/	/	123456	**Mandatory parameter** The parameter should be 123456.

10.3.4.7 <S> Save

After executing this command, the modified register parameters will be saved after power off.

Command	Parameter	Data Range	Unit	Default	Description
S	/	/	/	/	The modified register parameters will be saved after power off

11 LED Indication

The different colors of the tri-color LED represent various states of the device. The LED states are shown in the Table below.

Table 11-1 LED Status 1

LED	Description
Off	Idle, no TIP
green	Idle, TIP picked up
blue	Busy
yellow	Liquid level detected
purple	During liquid level detecting
Red light flashing	Warning / Error

Table 11-2 LED Status 2

The number of flashes	Description
1	No TIP alarm has been detected
2	Failed to eject the TIP.
3	Timeout alarm
4	Aspiration clot detection warning
5	Aspiration foam detection warning
6	Aspiration air detection warning
9	Motor stall error
10	Drive failure
11	error with the zero - position optocoupler
12	error with the TIP optocoupler
13	Pressure Sensor error
14	EEPROM error

12 Troubleshooting and Q&A

12.1 Common problems and solutions

Note: The following descriptions are troubleshooting methods for issue arisen when performed in a compliant operating environment and under rated operating conditions.

Here are four types of common issue:

- Communication issues (See Table 12-1 Communication Issues)
- TIP related issues (See Table 12-2 TIP related issues)
- Liquid level detection issues (See Table 12-3 Liquid level detection issues)
- Accuracy and CV issues(See Table 12-4 Accuracy and CV issues)

Table 12-1 Communication Issues

Issue	Possible causes	Recommended Solutions
The pipettor indicator light does not light up after power on	The plug cable is not fixed, and the pipettor moves up and down, causing the cable to bend and break at the terminal connection.	If the cable is not in good contact when shaking, consider replacing the cable and make sure it is properly installed. See chapter 3
	Short circuit between power lines	Use a multimeter to check if the pipettor power supply is short-circuited. If so, please send it back for repair.
	The cable connector is not plugged in tightly/is loose	Disconnect the power supply and reconnect it as described in chapter 3
	Incorrect cable connection	See chapter 3
Unable to Pipettor communication	The baud rate is set incorrectly	The default baud rate of the pipettor is 38400
	The wiring sequence is incorrect	Confirm the RS485/CAN line sequence, see section 3.2
	Serial port tool is not compatible	Replace the USB to serial cable or RS485 adapter of different brands.
	command format is incorrect	Check the command format.
Unstable communication	Communication line is disturbed	1. Make sure the communication cable is as short as possible. 2. If necessary, turn the termination resistor switch to ON. 3. Separate the communication cable from the high current cable. 4. Keep the resistance between the two phases of

		CAN\RS485 at 60Ω.
	Data is sent too frequently	1. Use a slower baud rate for communication. 2. Use a one command-one response communication method with an interval of more than 10ms between serial port commands. 3. Use re-transmission mechanism to ensure communication reliability.

Table 12-2 TIP related issues

Issue	Possible Cause	Recommended Solution
After aspiration, the device lifts up the TIP and reagent drips out	TIP is not tied tight	You can rotate the TIP by hand to confirm whether it is properly installed. If it is not properly installed, See section 6.2
	Normal gravity causes	1. Our leakage tester can test air pressure leakage with an accuracy of up to pa level. Each pipettor will be tested before leaving the factory. 2. Recommended test method: Put the pipettor in standby mode at room temperature, install a (non-conductive) clean 1000ul TIP without filter, aspirate 1000ul of pure water and let it stand for 30s to check if there is no leakage at the TIP, which is normal. 3. Please note: During the test process, the TIP must be tied tightly. During the aspirate liquid process, avoid inserting the TIP too deeply into the liquid surface, which may cause liquid to hang on the outer wall of the TIP and cause the test to fail.
	Reagent type reason	Organic reagents or some solvents with certain substances added will leak faster than ordinary reagents. You can use the tail end to suck out the air to prevent liquid from hanging.
	Reagent temperature	If the reagent temperature is high, it will leak faster due to heat. This can be solved by sucking out the liquid and then sucking out some air.
LED indicator light does not turn on after picking up the TIP.	TIP dimensions are inconsistent or incompatible.	If it is a batch issue, it is recommended to change the TIP brand or install the TIP using a greater down force, but not more than 30N. If it is occasional, the TIP consistency may be poor and it is recommended to change the TIP brand.
When the TIP is reused, the accuracy and precision are poor, and there is residue on the inner wall.	TIP can only be used once	Reusing the TIP will affect the accuracy and precision of liquid aspirate and dispense and the success rate of liquid level detection. Reusing the TIP is not recommended.
Failed to withdraw TIP	After executing TIP eject, the TIP is still hanging at the end of the	1. If it is a batch problem, the TIP size is not suitable. It is recommended to change the TIP brand. 2. If it happens occasionally, it may be due to poor TIP consistency. It is recommended to change the

	nozzle	TIP brand.
	TIP cannot be ejected.	Follow Section 6.2, apply a down force of 28±2 N to install the TIP. Excessive down force may cause TIP ejecting failure.

Table 12-3 Liquid level detection issues

Issue	Possible Cause	Recommended Solution
Liquid level detection is too deep	Water in the pipettor pipetting barrel	After dispensing the water, wait for 48 hours for natural air drying and then test whether the liquid level detection function can be used normally. If there is still a problem, return it to the factory for repair.
	The pipettor is falling down too fast	See 6.3 and control the Z-axis moving down velocity for the pipettor to detect the liquid level at about 20mm/s.
Liquid level detection is triggered in advance\the liquid level detection is detected as soon as it is started	Water in the pipettor pipetting barrel	After dispensing the water, wait for 48 hours for natural air drying and then test. If there are still problems, return it to the factory for repair.
	TIP Reuse	Reusing the TIP will affect the accuracy and precision of liquid aspirate and dispense and the success rate of liquid level detection. Reusing the TIP is not recommended.
	TIP filter element quality is unqualified, low air permeability	Replace the TIP of another brand or use a TIP without a filter element for testing. If it is related to the filter element, modify the liquid level detection coefficient to adapt or replace the TIP of another brand.
	Start the liquid level detection function below liquid level	The liquid level detection must be started on above the liquid surface.
GPO1 signal cannot drive external devices	GPO1 provides a signal only, without high driving capability.	GPO1 output signal current is only a few microamps. It cannot be used to drive high load external devices.

Table 12-4 Accuracy and CV issues

Issue	Possible Cause	Recommended Solution
Good CV but poor accuracy	Requires accuracy compensation.	Configure aspiration compensation parameters as described in section 6.9.2.
	Incorrect parameter settings.	Set appropriate aspiration and dispensing parameters according to section 6.8.
	Incorrect testing method.	See 6.9 to follow the recommended test procedure for accuracy and CV.
Residue left in the TIP after dispensing.	No leading air gap or insufficient air gap.	A leading air gap of 30uL is sufficient for most scenarios. Adjust based on the reagent type and remaining volume in the pipette.
	Reagent properties.	1. Viscous reagents may not be fully dispensed in one attempt. Use slow, multiple dispensing method.

		2. Organic reagents may adhere to the TIP inner wall. Residual liquid may drop slowly after dispensing.
	Poor-quality TIP.	Compare with other TIP brands. If residue is caused by the TIP, replace the TIP brand.
Poor CV and accuracy.	Liquid level detection was not used during aspiration.	1. Use liquid level detection to ensure the TIP reaches the liquid level, or keep the end of the TIP≤3mm below the liquid surface. Avoid immersing too deeply. 2. For higher aspiration accuracy, consider using aspiration liquid following instead of using aspiration trailing air gap.
	No leading air gap or insufficient leading air gap.	A leading air gap of 30uL is sufficient for most scenarios. Adjust based on the reagent type and remaining volume in the pipette.
	Incorrect testing method.	See 6.9 to follow the recommended test procedure for accuracy and CV.

12.2 Q & A

Q1: **Why did the pipettor work yesterday but suddenly stop working today? / Why can’ t I communicate with the device after connecting?**

1. Check the wiring, power, voltage.
2. Power off and measure the resistance between the 24V (red) and GND (black) terminals. If there’ s a short circuit, the board is likely damaged. Contact us for repair.
3. Verify wiring sequence, serial port, or CAN configuration.
4. Use the default address (1) for sending commands, as described in Section 5.
5. Ensure a resistance of 60 Ω between CAN/RS485 phases and minimize transmission distances.
6. Confirm the RS232 three-wire connections: Rx → Tx, Tx → Rx, GND → GND.

Q2: **What should I do if water/reagent is drawn into the pipettor?**

1. Immediately stop using the pipettor. Dry the device and let it air-dry for 48 hours before testing the liquid level detection function.
2. If the liquid level detection function fails or returns errors, send the device back to the manufacturer for repair.

Q3: **How can I use the ADP-Z with the SP18? / How is liquid level detection achieved?**

1. Use the ADP_CompositeFunctionController.exe software to control both the pipettor and ADP-Z together, as detailed in Section 5.
2. Special symbols like "*" can enable simultaneous ADP-Z descent and ADP

liquid level detection.

Q4: **How do I use TIP presence detection, aspiration of air and clot TIP detection features?**

1. See Table 10-2 Registerfor details on Register 43 and Register 60.
2. When TIP presence detection is enabled, executing aspiration/dispense or liquid level detection commands without a TIP will trigger an error (state 20).

Q5: **Liquid Level Detection is not sensitive? / Unable to detect liquid level? / Liquid level detection failure?**

1. It is recommended to execute the liquid level detection command after a 500ms ADP-Z descent in the workflow.
2. Water ingress during debugging can cause function failure.
3. Do NOT reuse TIPS.
4. For filtered TIPS, poor filter quality may affect liquid level detection performance.

Q6: **What ' s the difference between single dispense and aliquot-dispense? How should aspiration parameters be set?**

1. Single Aspiration-Single Dispense: Aspirate 100uL and dispense the entire 100uL into one tube. Use the recommended flow: leading air gap → aspiration → dispensing. Leave aspiration cut-off velocity, dispensing re-aspiration volume, and dispensing cut-off velocity at default values to maintain accuracy and CV.
2. Single Aspiration-Multi Dispense: Aspirate 1000uL and dispense 20uL into different tubes up to 50 times. Configure re-aspiration volume and cut-off velocity specifically for this case, referring to Table 6-4 for guidance.

Q7: **How can I fully dispense or empty the reagent?**

1. Recommended flow: Leading air gap of 30uL → aspirate 20uL → dispense 50uL. The leading air gap volume is flexible within the maximum volume of 1040uL.
2. Use the Mp command to achieve full dispensing or reset position.

Q8: **Why won' t the TIP eject or certain commands execute?**

1. Verify that the command was sent successfully and that the device acknowledged it.
2. Check the device's return information and status for errors or LED indications.
3. For reliable communication, use a query-response model and send subsequent commands only after receiving responses.

Q9: **Is there a DEMO library?**

1. We provide STM32 microcontroller demo code and C/C# host software reference code.

Q10: **Which communication method is recommended?**

1. Recommended: KT_CAN_DIC protocol with automatically reporting for action completion or error codes.
2. For serial port communication, use the KT_OEM protocol with response-based

transmissions. Ensure a minimum 10 ms delay between frames.

Q11: **How can I ensure every command is received successfully?**

1. Use KT_CAN_DIC commands with sequence number for one-to-one mapping of responses and transmissions.
2. Wait for a response before sending the next command. If a response times out, resend the command.

Q12: **How do I confirm action completion? / Can action completion trigger a flag?**

1. During action execution, query the device's state: "busy." The device returns to "idle" upon completion.
2. KT_CAN_DIC heartbeat status changes from 1 ("busy") to 0 ("idle").
3. See Register 82 for action completion reporting.

Q13: **Why aren't modified parameters retained after restarting?**

1. Follow Section 5.6 for proper parameter setup (do not modify system parameters unnecessarily).
2. Ensure a complete power cycle if using a switch power supply.
3. Note that some parameters are not saved during power-down.

Q14: **How can I verify successful reagent aspiration?**

1. Enable ADP-Z following during aspiration to ensure the TIP reaches the reagent.
2. Set Register 60 to enable air-gap detection. If the air-gap volume reaches the detection standard, the device returns an error (state 25).

Q15: **What if the device reports an error?**

Record the status of the device feedback and the current execution process when the error is reported. If the following solution measures do not provide effective help, please contact us. Some of the status trigger scenarios and solution measures:

1. Error status 10～ 16 (DEC below): check parameter case, parameter writable range.
2. Error Condition 17～ 18: Initialization the unit before controlling aspiration and dispense or action.
3. Error state 20: Register 43 enables this warning function, which sends a aspiration/dispense/level detection command to feed back this error when no TIP is detected, and suggests stopping the operation to prevent the reagent from being sucked into the device cavity.
4. Error status 21: Detecting TIP in place at the end of the execution of the push TIP command feeds back this error, checking whether the TIP is installed too tightly, avoiding repeated use of the TIP, etc.
5. Error Condition 22: Liquid level not detected within the specified time of performing liquid level detection Feedback on this error ensures that the TIP has access to the reagent during pipettor descent.
6. Error Status 23-25: Register 60 enables this warning function, which feeds back such error when abnormal air pressure is detected during liquid aspiration, adjusts according to the user's process, and allows the device

to continue to be controlled when the error is reported.

7. Error status 50～ 55: We recommend contacting our company for assistance.

Q16: How can I test the gas tightness of a pipettor?

1. Our leakage testing equipment can measure pressure leakage with a precision of up to the Pa level.
2. Convenient Method:

In standby mode, at room temperature, install a clean, non-conductive, non-filter 1000uL TIP.

Aspirate 1000uL of pure water, then let the system stand for 30 seconds.

Verify no leakage from the TIP TIP.

3. Important Notes:

Ensure the TIP is securely attached. During aspiration, avoid inserting the TIP too deeply into the liquid to prevent droplet.

Leakage from organic reagents like ethanol is normal.

Q17: How should Register 60 be configured for detecting aspiration abnormalities?

1. For example, writing Wr60,5 enables detection for air-gap and clot detection only.

Table 12-5 Register 60 Function Configuration

DEC	Bit2	Aspiration of Empty Detection	Bit1	Aspiration of Foam Detection	Bit0	Aspiration of Clot Detection
0 (default)	0	Off	0	Off	0	Off
1	0	Off	0	Off	1	On
2	0	Off	1	On	0	Off
3	0	Off	1	On	1	On
4	1	On	0	Off	0	Off
5	1	On	0	Off	1	On
6	1	On	1	On	0	Off
7	1	On	1	On	1	On

Q18: What is the role of RS485/CAN termination resistors?

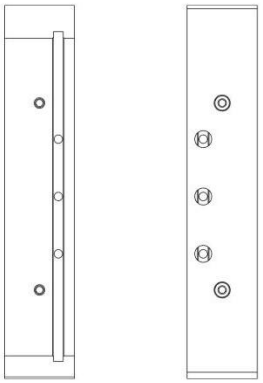
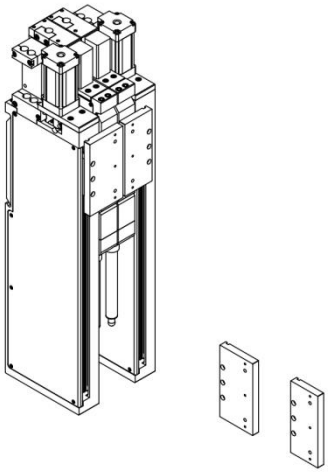
Without termination resistors, self-oscillation may occur on the communication bus. Adding termination resistors improves communication reliability and stability.

13 Accessory Ordering information

Table 13-1 Ordering information 1

Name	Remarks
Single Adapter Board	Exclusively for Assembly on ADPZ
Dual-Unit Adapter Board	Exclusively for Assembly on ADPZ
Quadruple-Unit Adapter Board	Exclusively for Assembly on ADPZ
Dual-Unit Side-Mounted Adapter Board (Left/Right)	Exclusively for Assembly on ADPZ
FFC Two-Wire Socket	Customize
FFC Single-Wire Socket	Customize
Screw	M1.6*3*2.5 Small Countersunk Head Cross Recess Screw
50/200/1000ul TIP	Length 57.85/58.45/95.75mm

Table 13-2 Ordering information 2

Single Adapter Board	
Dual-Unit Side-Mounted Adapter Board (Left/Right)	

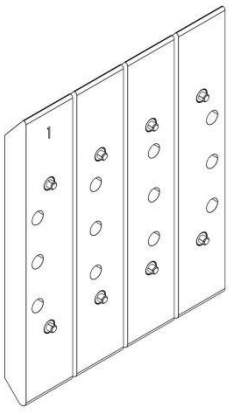
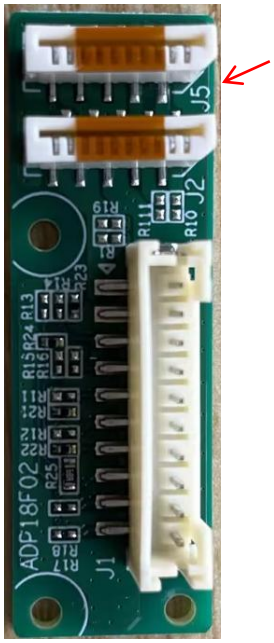
Quadruple-Unit Adapter Board	

Table 13-3 Ordering information 3

FFC Two-Wire Socket,J2 is on the left side and J5 is on the right side.					
	J2 PIN	function	J5 PIN	function	Remarks
	1	empty	1	empty	
	2	empty	2	empty	
	3	empty	3	empty	
	4	empty	4	empty	
	5	GND	5	empty	
	6	GND	6	empty	
	7	GND	7	GND	GND
	8	DC 24V+	8	CAN L	communication interface
	9	DC 24V+	9	GND	GND
	10	DC 24V+	10	CAN H	communication interface

FFC Single-Wire Socket, The red arrow indicates Pin 1.			
	J5 PIN	function	Remarks
	1	DC 24V+	24V±2%, ≥1A
	2	GND	GND
	3	DC 24V+	24V±2%, ≥1A
	4	GND	GND
	5	GPO	spare
	6	GPO1	pLLD digital output, with a level of 5V
	7	RS485A	communication interface
	8	RS485B	communication interface
	9	CAN H	communication interface
	10	CAN L	communication interface

14 Environmental Conditions

Item	Unit	Value
Operating environmental temperature	℃	+15℃～+35℃
Operating environmental humidity	RH%	40%～80% non-condensing
Storage temperature	℃	-20℃～+70℃
Storage humidity	RH%	40%～80% non-condensing

15 Safety Precautions

For your and other users' safety, please read the safety precautions carefully.

This manual uses the following marks. Please fully understand what they mean before reading on.

WARNING	Any content with this mark, related to the safe use of the product and the user's safety, must strictly follow the requirements of the operation, otherwise, it may cause damage to the product or endanger the user's safety.
CAUTION	Any content with this mark is a part of the user must pay attention to, otherwise, it will cause damage to the product or other losses due to improper operation.

	Must operate as warned, with specific warnings or caution messages described within the triangle.		Actions that must be prohibited, with specific prohibitions described in circles.
	Important commands or actions must be performed.		
CAUTION			
	Please turn off the power when it is idle for a long time or when the whole machine is repaired, otherwise, it will cause fire or electric shock.		Do not put it in wet, dusty, greasy environment or close to heat generating equipment, otherwise, it will cause product failure, even malfunction, fire or electric shock.
	Prohibit hot-swapping any serial port interface cable, motor cable, optocoupler cable or valve power cable, otherwise, it will cause communication or other parts to fail.		
WARNING			
	Do not disassemble Do not disassemble, repair or modify the product by		Avoid use in wet environments Moisture may cause electric shock.

	yourself, otherwise, it may cause fire or electric shock.		
	Cut off the power when abnormal If there is an abnormal situation, immediately cut off the power. Otherwise, it may cause fire or electric shock.		Protection when using corrosive fluids Strictly follow the applicability medium of the specification book to use, when using corrosive fluids must pay attention to protection.

Contact Information

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16 Appendix of Figures and Tables