SP13 Pipettor Manual

—— 13 Series

Product Model:

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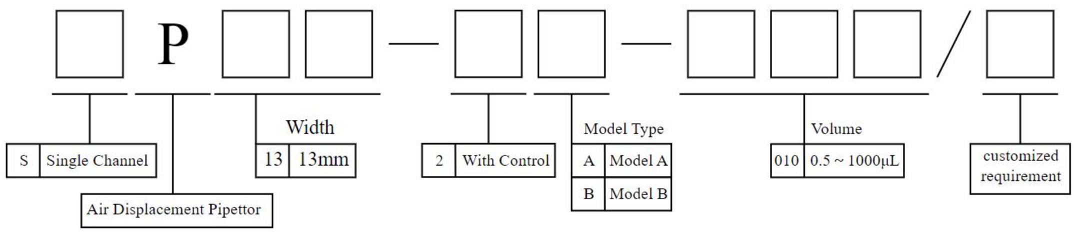
1 Product Overview

The Single Air Displacement pipettor SP13 is a Keyto module based on pneumatic aspiration and dispensing technology with TIP for pipetting. The SP13 supports automated pipetting in the range of 0.5～1,000μL with TIPs of various volume. SP13 provides a fast and reliable mechanical transfer module and a common communication interface. It is suitable for integration into pipetting platforms and pipetting units of diagnostic instruments that are sensitive to cross-contamination, providing reliable and high-performance pipetting functions for various types of instrument.

1.1 Ordering Information



Note:

1. The products specified in the ordering information include only the pipettor itself and exclude the HSZ-axis;
2. If you need to purchase HSZ-axis, please contact us.

1.2 Main Features

◆ The pipettor features a unique mechanical structure that is compatible with 8-units assembly SP13 while being expandable to 12-units assembly. When picked up TIPs, it achieves a 9mm center distance between nozzles and enables independent vertical movement for each channel, significantly enhancing pipetting speed and efficiency.

◆ This pipettor has a high-performance drive control unit integrated inside. The various functional applications of SP13 can be realized quickly and conveniently through the controller.

◆ The pipettor is equipped with powerful sensors and algorithms, which can be applied to high-speed liquid level detection of various reagents, and also supports functions such as sample clot detection.

◆ The pipettor features automatic TIP ejection with integrated TIP loading detection and TIP detachment detection functions.

◆ The pipettor incorporates advanced barrel machining technology, rigorous inspection procedures, and a unique sealing solution, ensuring that the pipetting barrel's service life exceeds 1 million cycles without maintenance.

◆ The TIP-contact nozzle components are constructed from chemically resistant and highly wear-resistant materials, ensuring nozzle replacement is not required throughout the entire product lifecycle.

◆ This pipettor weighs no more than 270g per unit model A and model B, making it lightweight and convenient.

1.3 Glossary

- **PLLD**: Pressure Liquid Level Detection
- **CLLD**: Capacitive Liquid Level Detection
- **Host**: Customer Controller
- **Send**: From the Host to the Device
- **Response**: From the Device to the Host
- **Device**: SP13
- **Reversed:** Currently non-functional, but may be assigned new functionalities in the future. Users must adhere to specified protocols when handling these parameters.

2 Product Specifications

2.1 Specifications

Table 2-1 Specifications

Device	SP13
Pipetting range	0.5～1000μL
Liquid level detection	PLLD, CLLD
Disposable TIP compatibility	10,50,200,1000μL TIP
Multiple device spacing	9mm
Communication interface	CAN
Selectable baud rate	CAN: 100k, 125k, 250k, 500k (default), 1000k
Operating temperature	+15 to +35° C
Power requirements	24V DC ±5%
Pipetting barrel life	1 million times
Dimensions	265.7*74.5*8.5mm
Weight	≤270g

Table 2-2 Pipetting Performance

TIP specificationgs /uL	Dispensing volume/ul	Dispensing type	Accuracy（A）	CV
10F	0.5	Single	15.0%	10.0%
10F	1	Single	5.0%	4.0%
50F	2	Single	5.0%	5.0%
50F	5	Single	5.0%	2.0%
50F	10	Single	3.0%	1.0%
50F	50	Single	2.0%	0.75%
200F	10	Single	5.0%	2.0%
200F	50	Single	2.0%	0.75%
200F	200	Single	1.0%	0.75%
1000F	100	Single	2.0%	0.75%
1000F	1000	Single	1.0%	0.75%
1000F	20	Aliquot	3.0%	3.0%
1000F	50	Aliquot	3.0%	2.0%

1. Test reagent: Pure water;
2. Test environment: 21～25℃ in a still air environment;
3. Test method: Non-contact dispensing(suspended dispensing);
4. Use a new TIP for each pipetting operation;
5. Single aspiration and single dispensing: For example, aspirate 10μL reagent with a new TIP, then fully dispense the 10μL in one action. Replace the TIP after each complete dispense, repeat for 10 measurement cycles to calculate accuracy and precision;
6. Single aspiration and aliquot dispensing: For example, aspirate 1000μL reagent with a single TIP, then perform 50 dispenses of 20μL each. Replace the TIP after complete ejection, discard the first and last dispenses (retain 48 valid data points) for accuracy and precision calculations.

Note: TIP is a disposable product, please do not reuse TIP.
It is recommended that users use a TIP with a filter to aspirate and dispense liquid.

A(Accuracy): The deviation of measured results from the expected value.

$$A = \frac{\left|\overline{V} - V_0\right|}{V_0} * 100\%$$

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

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

The relationship between volume V (μL) and measured value X (mg) is expressed as:

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

Sg: The specific gravity of purified water at 25° C, with a defined value of 0.99707.

n: Dispensing Cycles

V: The corresponding volume per measurement

V_0: The target dispensing volume

$\overline{V}$: The average volume corresponding to all measured values

2.2 SP13 Series ADP Physical Dimensions

2.2.1 Physical Outline Diagram

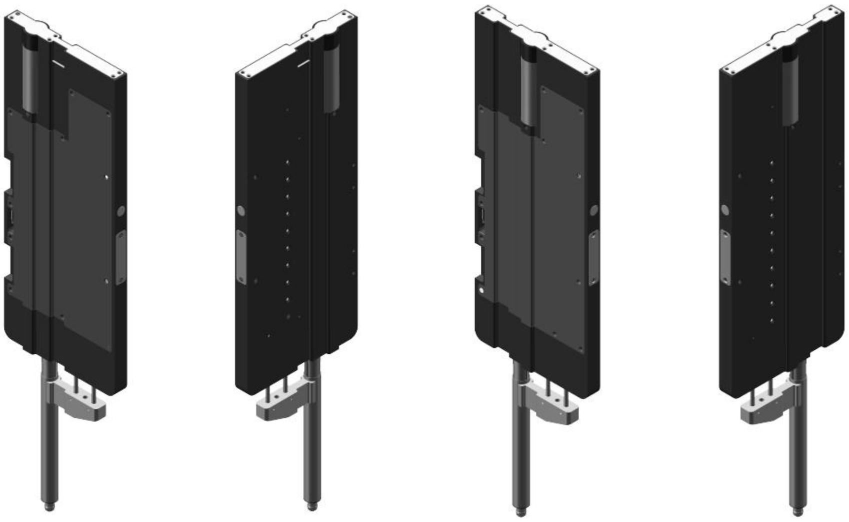


Figure 2-1 Physical Diagram Illustration(Left:model A;Right:model B)

2.2.2 Dimensions and Mounting Drawing

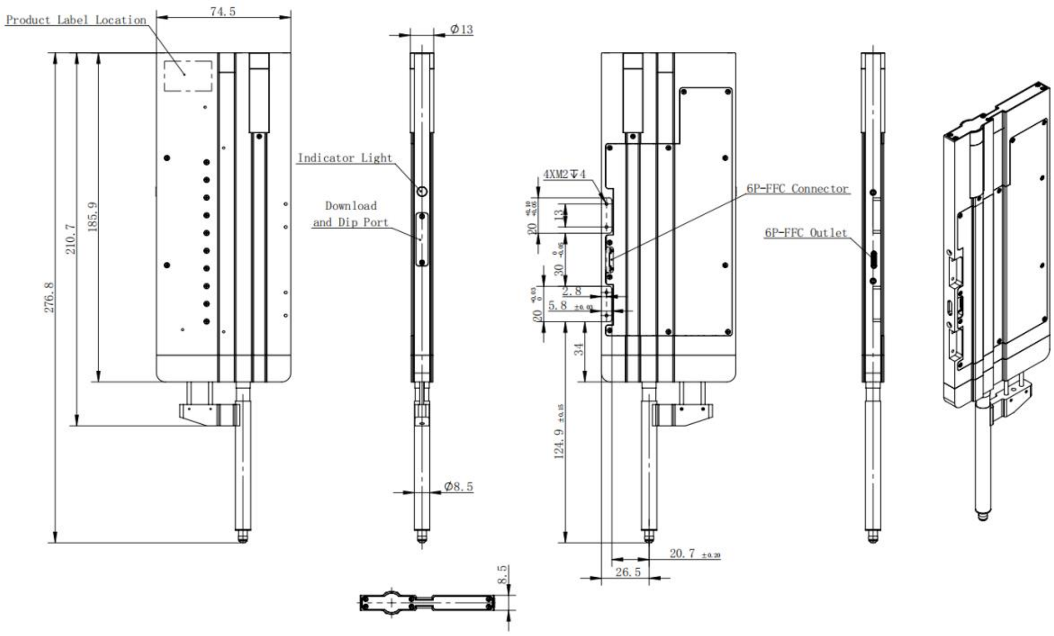


Figure 2-2 model A of SP13 Dimensional Drawings & Mounting Specifications

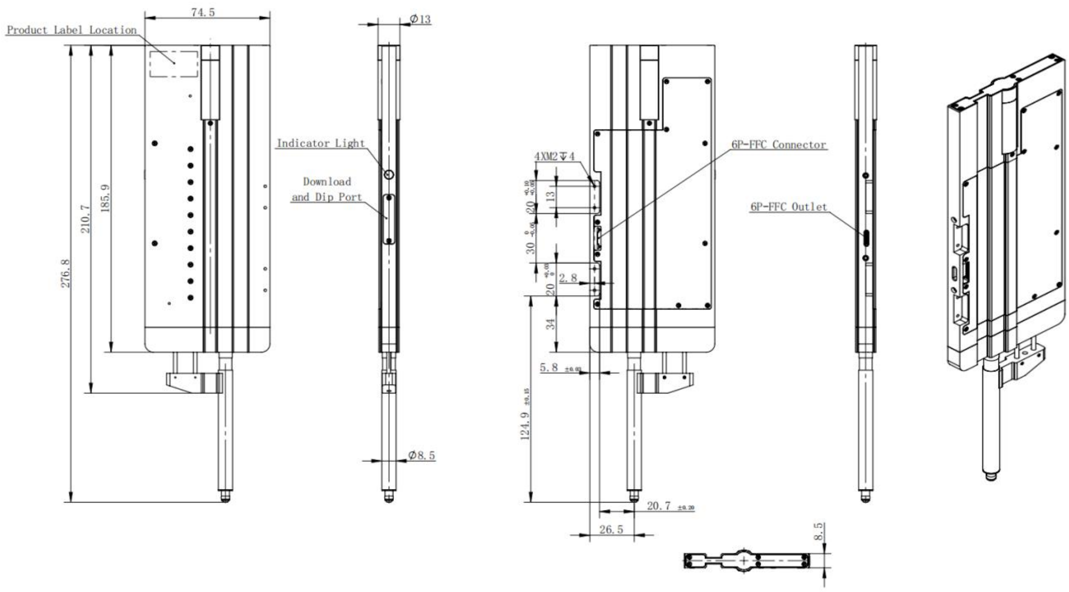


Figure 2-3 model B of SP13 Dimensional Drawings & Mounting Specifications

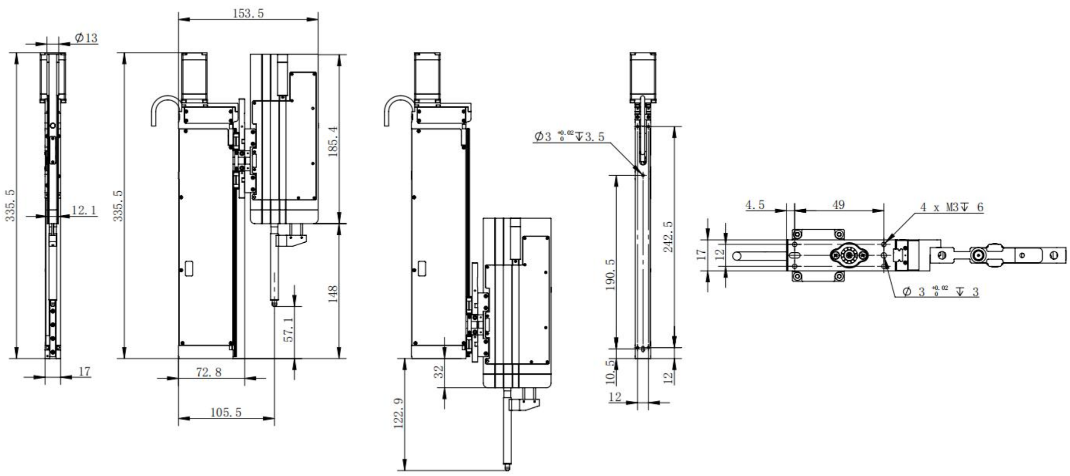


Figure 2-4 SP13-HSZ Assembly Dimensional Drawing

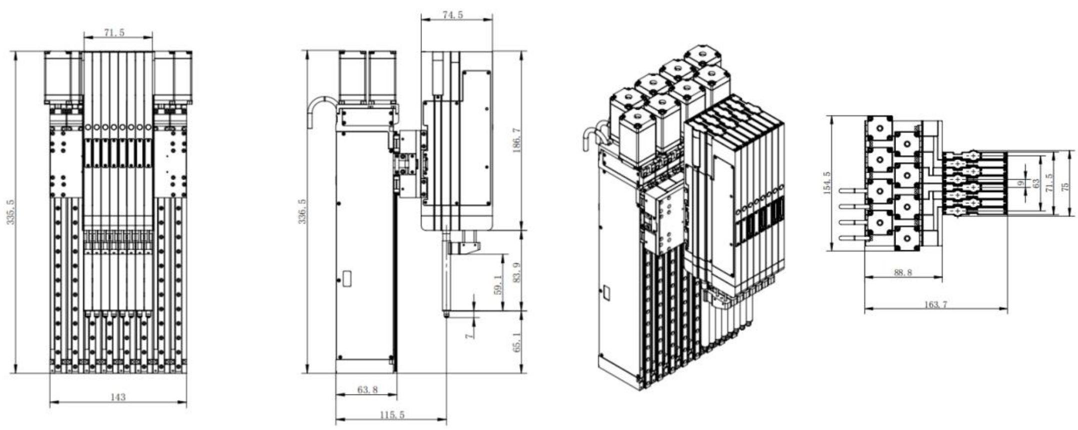


Figure 2-5 SP13-HSZ 8-Unit Assembly Dimensional Drawing

3 Electrical Interface Specifications

3.1 ※DIP Switch Configuration Guidance

The DIP switch is positioned beneath the debug port cover plate. To perform Dip operations such as address modification, the cover plate must be removed using a Phillips screwdriver . The SP13 features an 8-bit DIP switch used for: Device ID configuration, Enabling 120 ohm CAN termination resistor. As shown in Figure 3-1, the rightward position indicates the ON status.

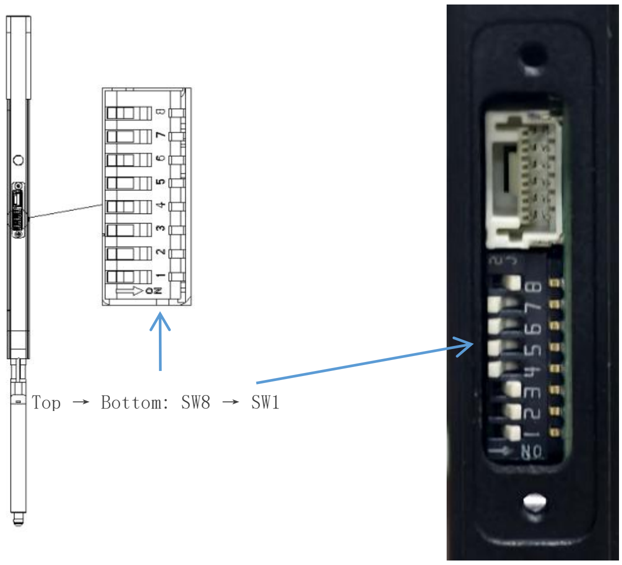


Figure 3-1 DIP Switch

Table 3-1 DIP Switch Specifications

SW	Function	Specifications
8	120 ohm CAN termination resistor	ON: Enabled OFF: Disabled
7	Reserved	Keep OFF at all times
6	Reserved	Keep OFF at all times
5	Reserved	Keep OFF at all times
4	Address bit3	The DIP switch address is configured using a 4-bit binary format, with bit0 representing the least significant bit (LSB). Each switch position corresponds to a binary digit-ON state indicates "1" while OFF indicates "0", and the combined binary value forms the DIP ID. The communication address for all protocols is determined by the Protocol ID, which is calculated as: Protocol ID = DIP ID + Offset ID + 1. The valid Protocol ID range is 1 to 127 (the Offset ID can be found in Table 12-1. For example, when using the default Offset ID of
3	Address bit2	
2	Address bit1	
1	Address bit0	

	0, to set Protocol ID to 8, the corresponding DIP ID binary value should be 7 (0b0111), requiring switches 4 through 1 to be set to OFF, ON, ON, and ON respectively. As shown in Figure 3-1, the DIP ID is 7 (0b0111).

During product operation, minimize the transmission distance of CAN signals as much as possible. If communication instability occurs, verify that the 120 ohm termination resistors are properly enabled at both the first and last devices on the bus. The measured resistance between the two signal lines should be 60 ohm to ensure proper impedance matching.

3.2 ※Hardware Interface Specifications

The SP13 power supply is 24VDC±5%, the peak RMS current per device shall not exceed 450mA, and the RMS current shall not exceed 300mA. The FFC pin distance is 1mm.

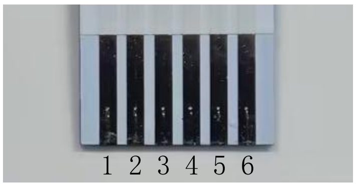


Figure 3-2 FFC Pin Number

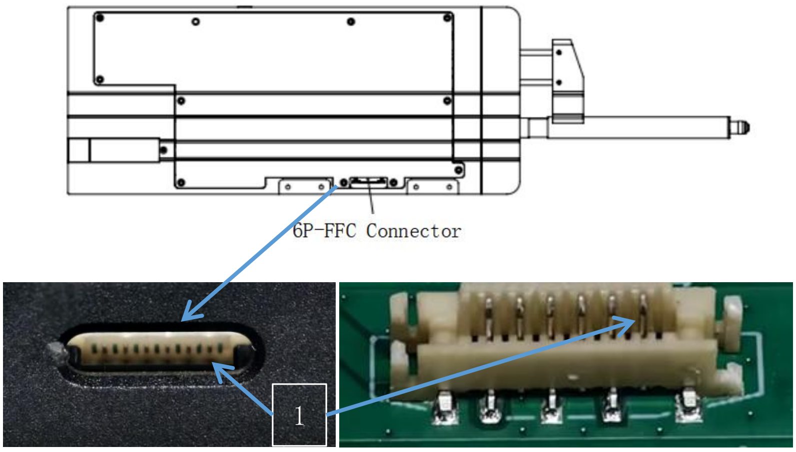


Figure 3-3 Power & Communication Sockets Specifications

Warning:

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

The SP13 connects to external control systems via a 6P-FFC cable, supporting CAN communication interface. The below is the pin-out description:

Table 3-2 Power Supply & CAN Communication Socket Interface Specifications

Pin	Function	Description
1	CANH	Communication interface
2	CANL	Communication interface
3	GND	Grounding

4	VCC	Power input 24V DC ±5%, ≥1A
5	GNDS	Chassis Ground
6	GNDS	

3.3 CAN connection Topology Diagram

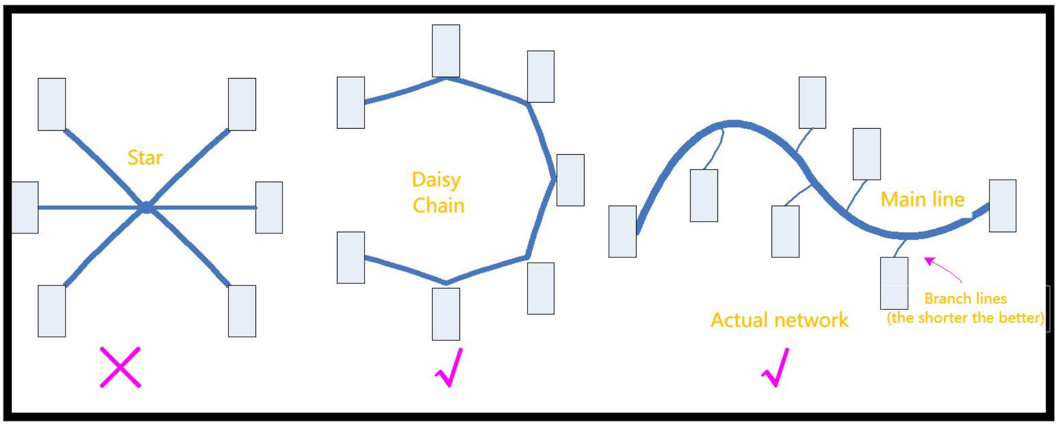


Figure 3-4 CAN Connection Topology Diagram

Note:

When using the SP13 with Keyto's HSZ-axis, the CAN termination resistor DIP switch on each SP13 must be set to the ON position to ensure proper signal integrity in the motion control network.

For applications where the SP13 is connected to third-party devices, the following rules apply:

1. Only the first and last devices on the CAN bus should have their 120Ω termination resistors enabled.

2. The measured resistance between the CAN_H-CAN_L lines must be 60Ω (parallel equivalent of two 120Ω resistors).

4 Mounting and Commissioning

4.1 Mounting the SP13

As shown in Figure 4-1, mount the pipettor on the HSZ-axis or within the vertical plane. If used in conjunction with the , please refer to Section 2.2 and Figure 4-1 for mounting guidance.

Warning:

Connection or disconnection of cables must be performed with the power turned off!

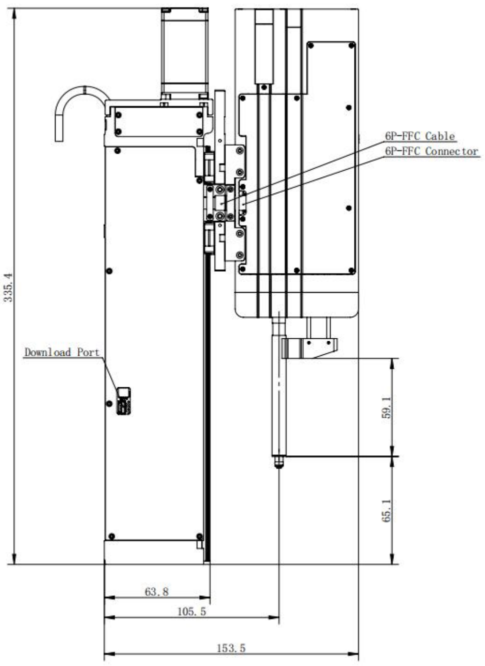


Figure 4-1 Mounting Dimensions

4.2 Connecting Power and Communication Cable

When connecting the cables, refer to Table 3-2 for proper wiring. If used with the Keyto's HSZ-axis, the 6Pin-FFC provided with the HSZ axis must be inserted into the power supply and CAN communication socket on the SP13, and the cable clamp must be secured. Before powering on, set the CAN termination resistor DIP switch on the SP13 to the ON position.

When the SP13 is used with the Keyto's HSZ-axis, the chassis ground wire from the HSZ-axis grounding hole must be properly grounded. Refer to Figure 4-2 for the location of the grounding hole (reserved). If the SP13 is used with other devices, ensure that the chassis ground wire from the SP13 power supply and communication socket is securely grounded.

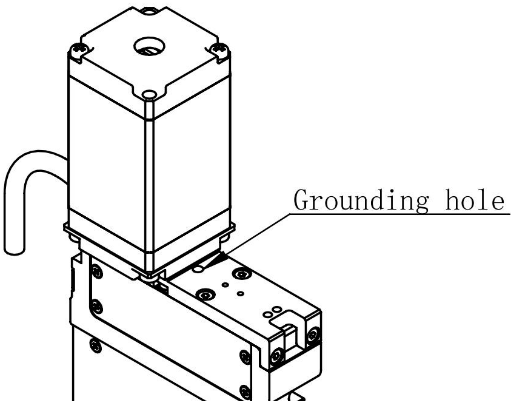


Figure 4-2 Grounding Terminal Diagram

Note:

When connecting the FFC cable to the SP13 power and communication socket, the exposed wire core should be inserted horizontally upwards into the FFC flexible flat cable (refer to Figure 3-3), and then the crimping board should be pressed on. If used with HSZ-axis, the included 6-pin FFC must be plugged into the SP13 power supply and CAN communication socket.

After wiring, secure the cable clamp and close the cover plate.

The chassis ground wire must not be directly connected to the power ground!

All cable connections or disconnections must be performed with the power turned off!

5 Host Computer Debugging Software

The host computer software enables combined control of the pipettor and the Keyto's HSZ-axis. Details about the electrical connection are described in Chapter 4.

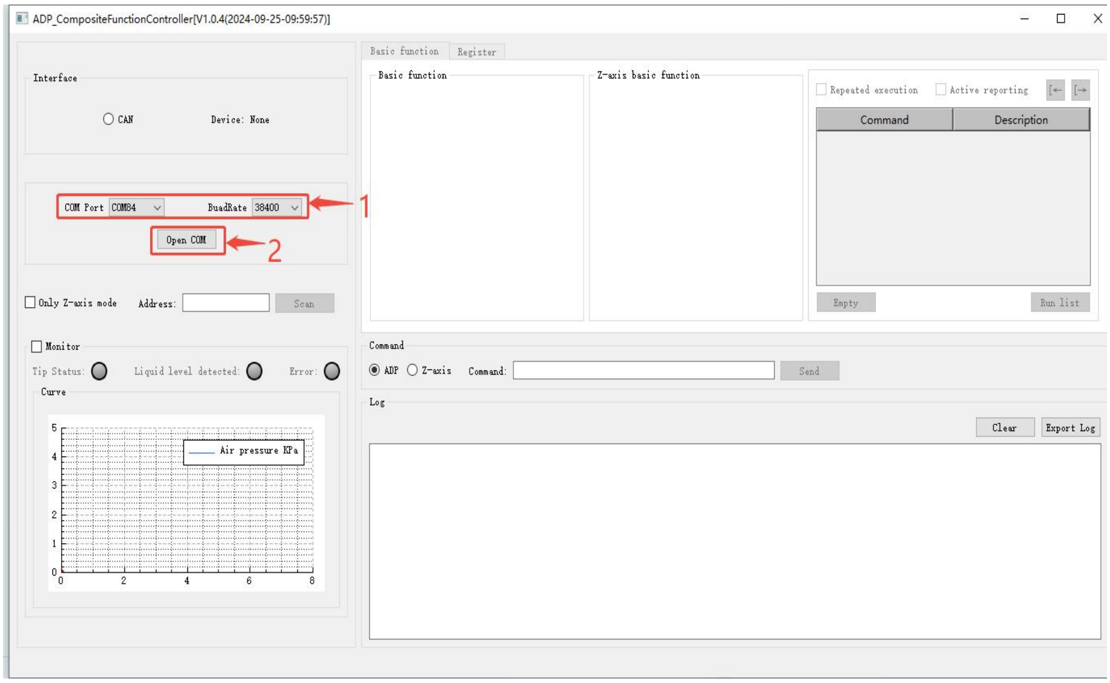
5.1 Opening the Host Computer Debugging Software

After cable being connected and powered up the device, then open the ADP_CompositeFunctionController.exe test software:

名称	修改日期	类型	大小
.config	2024/5/24 13:44	文件夹	
iconengines	2024/5/24 13:44	文件夹	
imageformats	2024/5/24 13:44	文件夹	
platforms	2024/5/24 13:44	文件夹	
printsupport	2024/5/24 13:44	文件夹	
styles	2024/5/24 13:44	文件夹	
translations	2024/5/24 13:44	文件夹	
ADP_CompositeFunctionController	2024/2/29 9:00	应用程序	1,195 KB

5.2 Serial Port and Baud Rate Selection

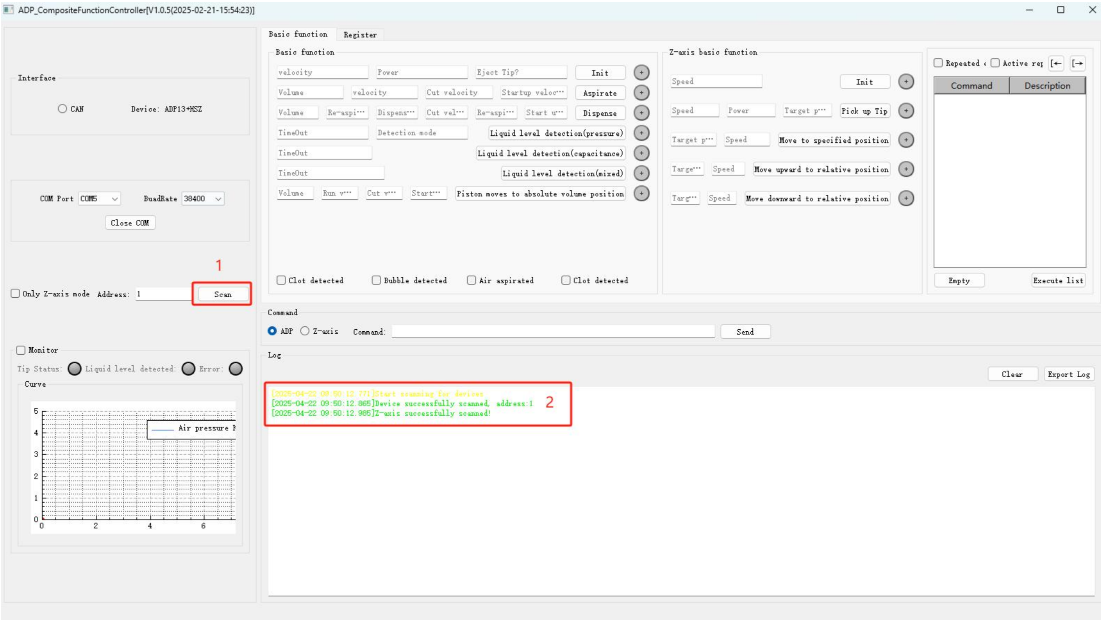
Select the corresponding device ID and port number, choose 500 baud rate (the factory default is 500), and click "Open CAN" button to open the CAN port.



Note: Only when the SP13 is connected to the HSZ axis can the software be used via the serial port (RS485).

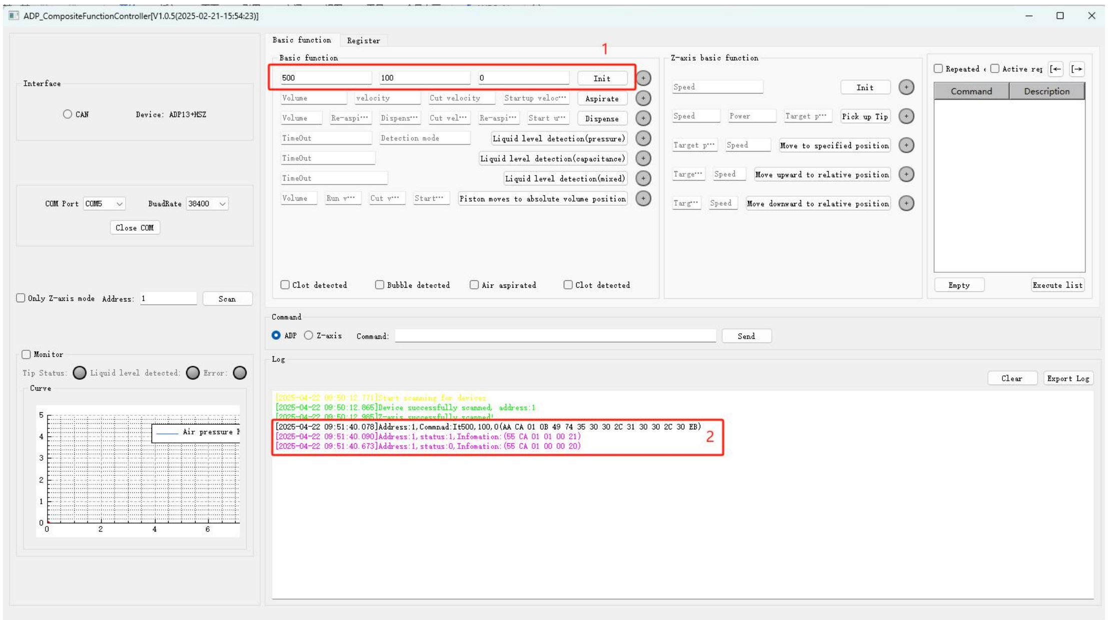
5.3 Scanning Devices

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.



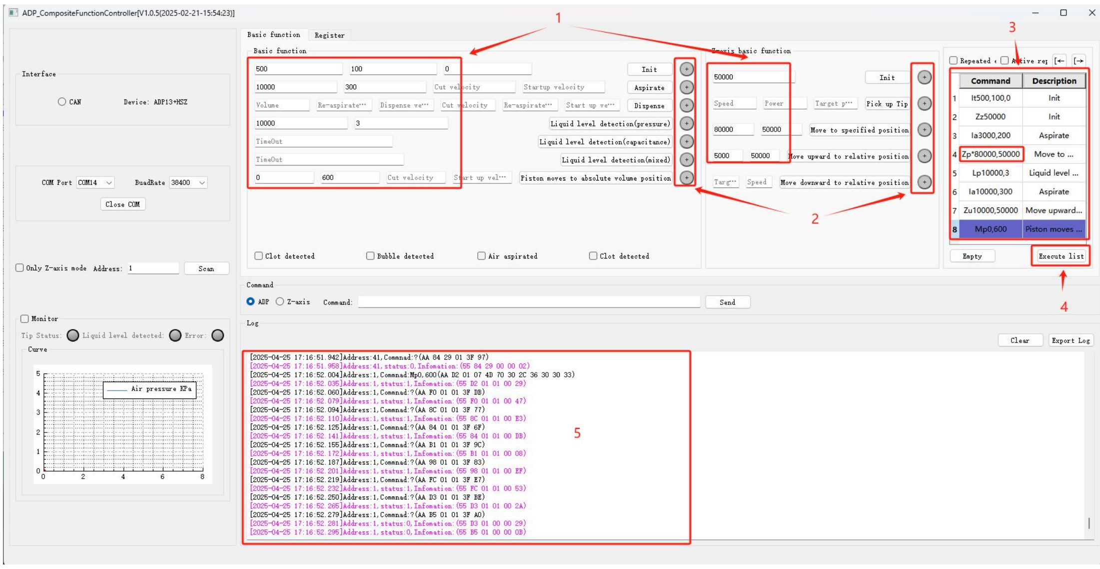
5.5 Combined Execution Command

In Section 5.4, it is introduced how to control the device with a single button.

If you want to achieve continuous actions, you can refer to this section. As shown in the figure, click the "+" sign in sequence to add commands to the command set.

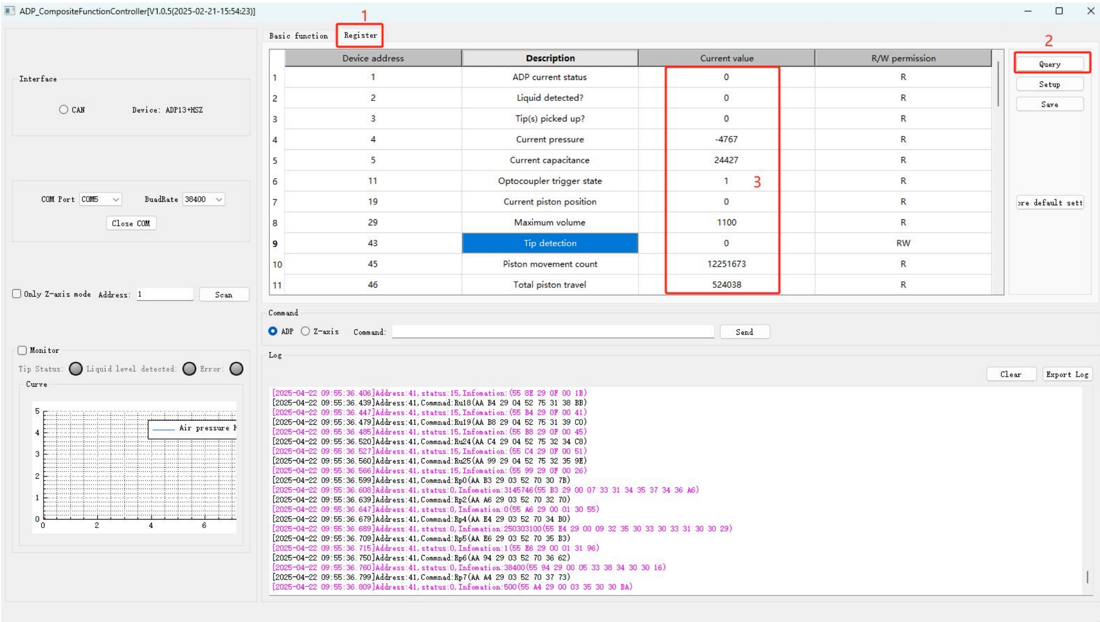
Fill in the parameters in sequence and click the "+" sign to add the following content:

1. Zero the pipettor at a speed of 500μL/s, with 100% power and in a way that the TIP is always ejected.
2. Zero the HSZ axis at a speed of 50,000μm/s.
3. The pipettor aspirates 30μL of air at an aspiration speed of 200μL/s.
4. The HSZ axis moves downward to the position of 80,000 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 at a speed of 3μL/s. The detection times out after 10s. Once the liquid level is detected, the HSZ axis will automatically stop moving.
6. The pipettor aspirates 100μL of liquid at an aspiration speed of 300μL/s.
7. The HSZ axis moves upward by 5,000μm at a speed of 50,000μm/s.
8. The pipettor dispenses the liquid at a speed of 600μL/s.
9. 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.



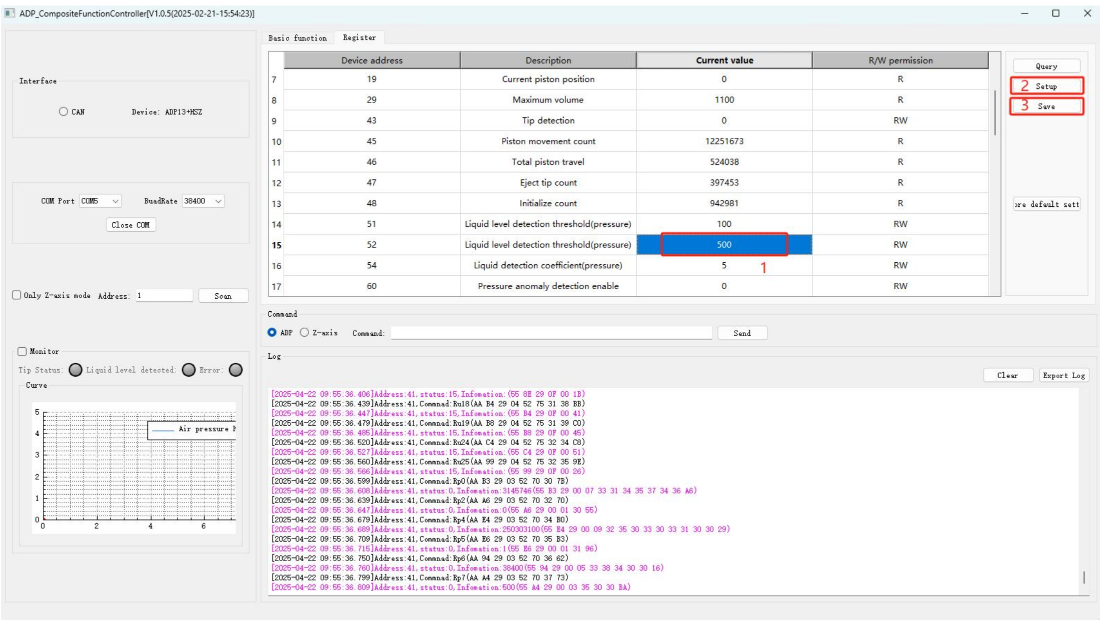
5.6 Register Query

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

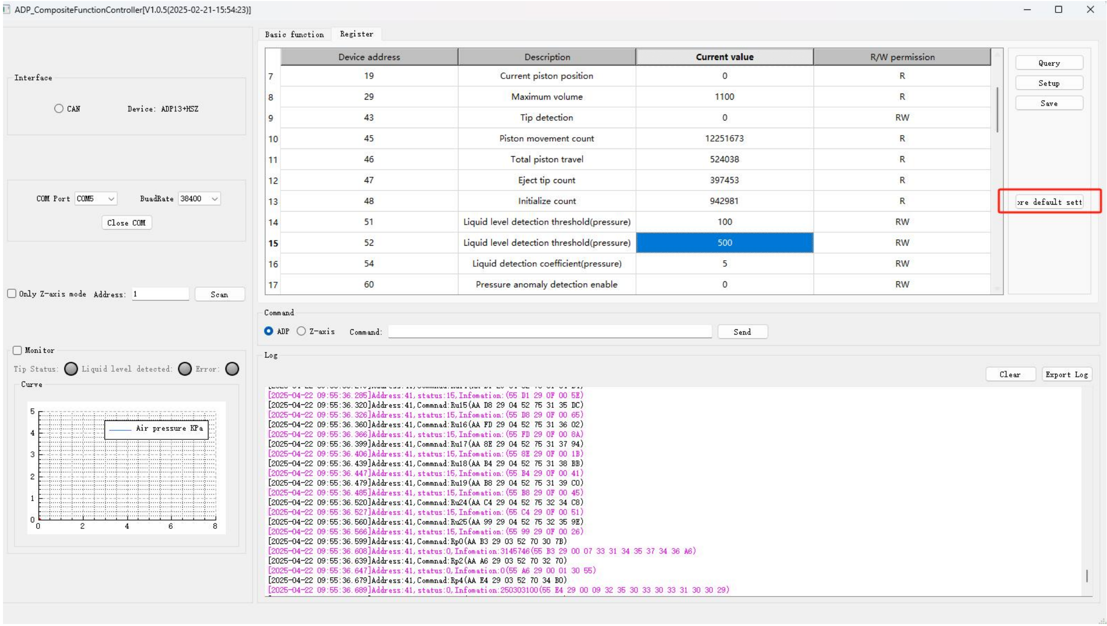
1. Double-click the "Current Value" field in the register parameter line that needs modification (only values with RW permissions can be modified). Enter the new value, then press "Enter" or click a blank area to confirm.
2. Click "Setup" to modify the register value.
3. Click "Save" to store the register 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 Restoring to Factory Settings

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 application processes for liquid aspiration and dispensing generally include single aspiration and single dispensing, as well as single aspiration and aliquot dispensing. provides the recommended usage procedures for single aspiration and single dispensing, as well as single aspiration and aliquot dispensing (applicable only to pure water reagents).

Note:

1. By default, both single aspirating single dispensing and single aspirating aliquot dispensing both perform no-contact dispensing.
2. Liquid aspiration and dispensing TIP detection: Enabled by configuring user register 43, the pipettor will not execute the aspiration command when it detects no TIP attached.
3. Liquid level detection delay: The SP13 pressure liquid level detection function includes a built-in step to wait for air pressure stabilization after enabling the detection. When using this function, ensure that the TIP does not come into contact with the reagent within 500ms after the pressure liquid level detection is activated.
4. Liquid level detection speed: It is recommended to control the HSZ-axis liquid level detection speed at around 50mm/s to ensure that the TIP is inserted into the liquid by no more than 1mm.
5. Aspiration delay: After aspiration is completed, a 100ms delay before withdrawing from the reagent can improve the pipetting accuracy and CV (coefficient of variation) for micro-volume dispensing.
6. Leading Air Gap: Reduce the reagent residue in the TIP after dispensing.
7. Trailing Air Gap: Prevents reagent overflow or droplet formation.
8. Leading Air Gap&Trailing Air Gap: When the aspiration volume does not exceed the maximum capacity: Leading Air Gap should not be less than 20μL to ensure complete reagent expulsion from the TIP. Trailing Air Gap volume should be adjusted based on operational requirements.
9. Single aspiration and aliquot dispensing data: The first and last dispensing have poorer accuracy; it is recommended not to use the first and last data, and dispense them back to the original reagent or into the waste tank.
10. Single aspiration and aliquot dispensing command parameters: It is necessary for optimal dispensing performance to set the re-aspirating volume and cut-off velocity, please refer to section 0;
11. Single aspiration and single dispensing command parameters: It is recommended to keep the default values of re-aspirating volume and cut-off velocity parameters.

12. Dispensing: During dispensing, maintain the TIP within the container opening to prevent reagent splashing.

    ⚠ *Warning: When aspirating reagents, the aspirated volume must not exceed the capacity of the installed TIP. For example, when a 200μL TIP is installed, it is prohibited to control the pipettor to aspirate reagents with a volume greater than 200μL!*

13. The system shall implement additional exception handling measures beyond alarm status, as detailed below:
    - TIP Pickup Failure Recovery: Automatically retry failed TIP pickup 1～2 times. If retries fail, execute TIP ejection command to clear potential partial TIP attachment. Attempt pickup from alternate rack position to compensate for TIP manufacturing tolerances.
    - Liquid Level Detection Safeguards: Configure absolute Z-axis lower limit to prevent TIP-bottom contact. For multi-unit applications with shared liquid surfaces: Implement liquid height synchronization , apply TIP-length compensation to to prevent liquid level detection failure caused by TIP variations.

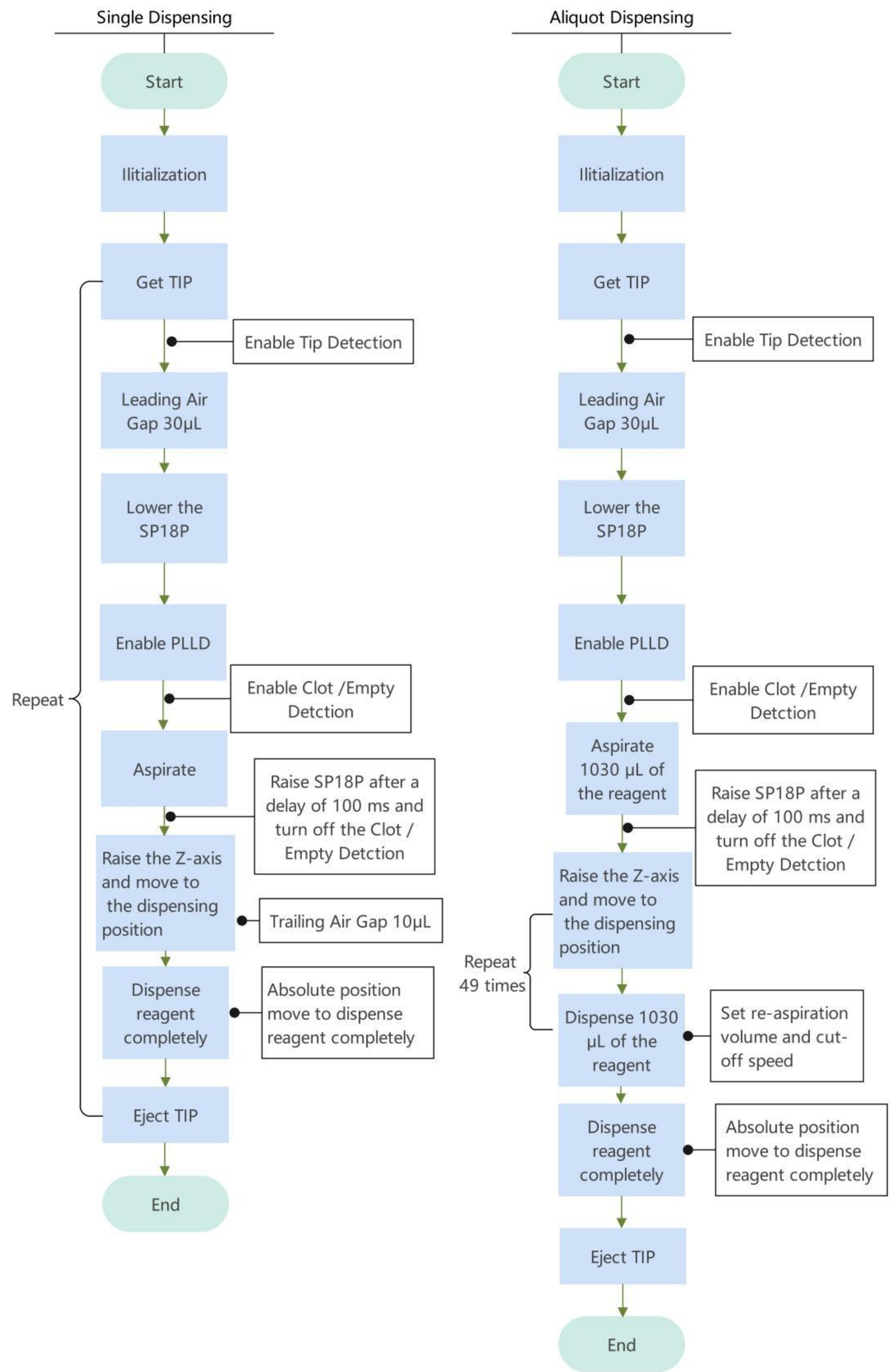


Figure 6-1 Pipetting Process

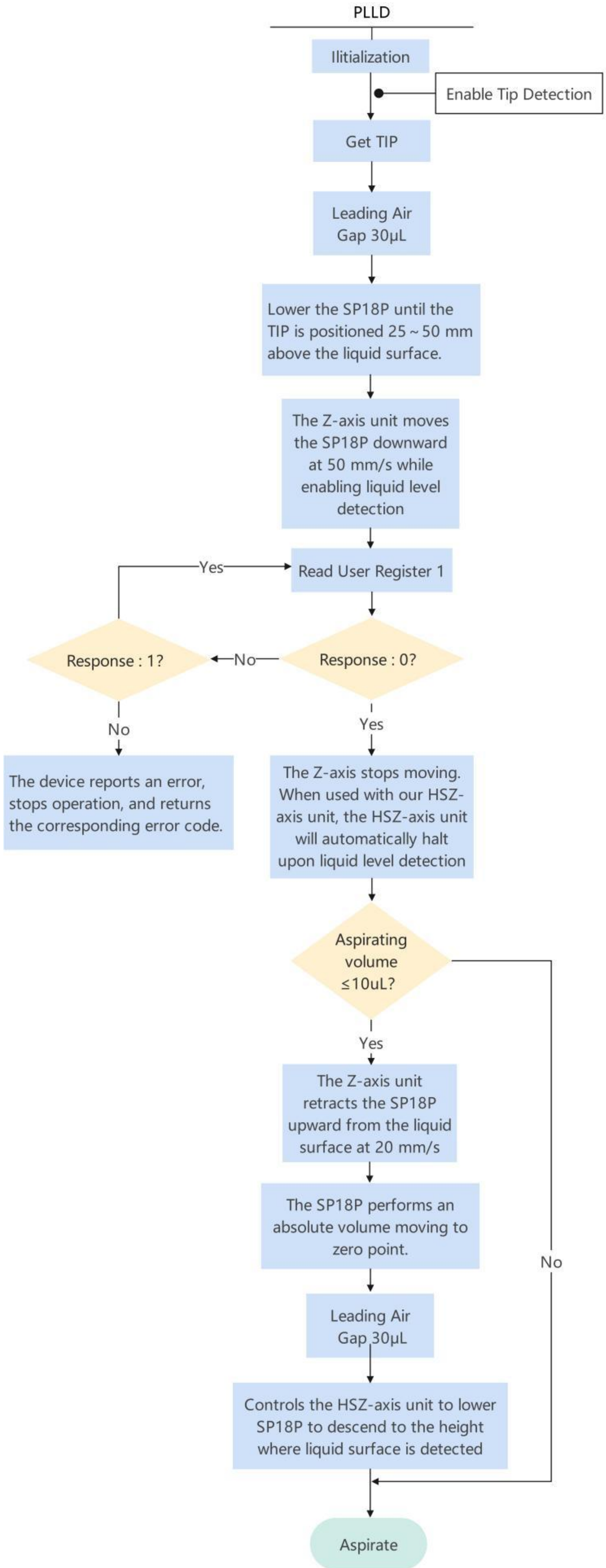


Figure 6-2 The Aspiration Process With PLLD

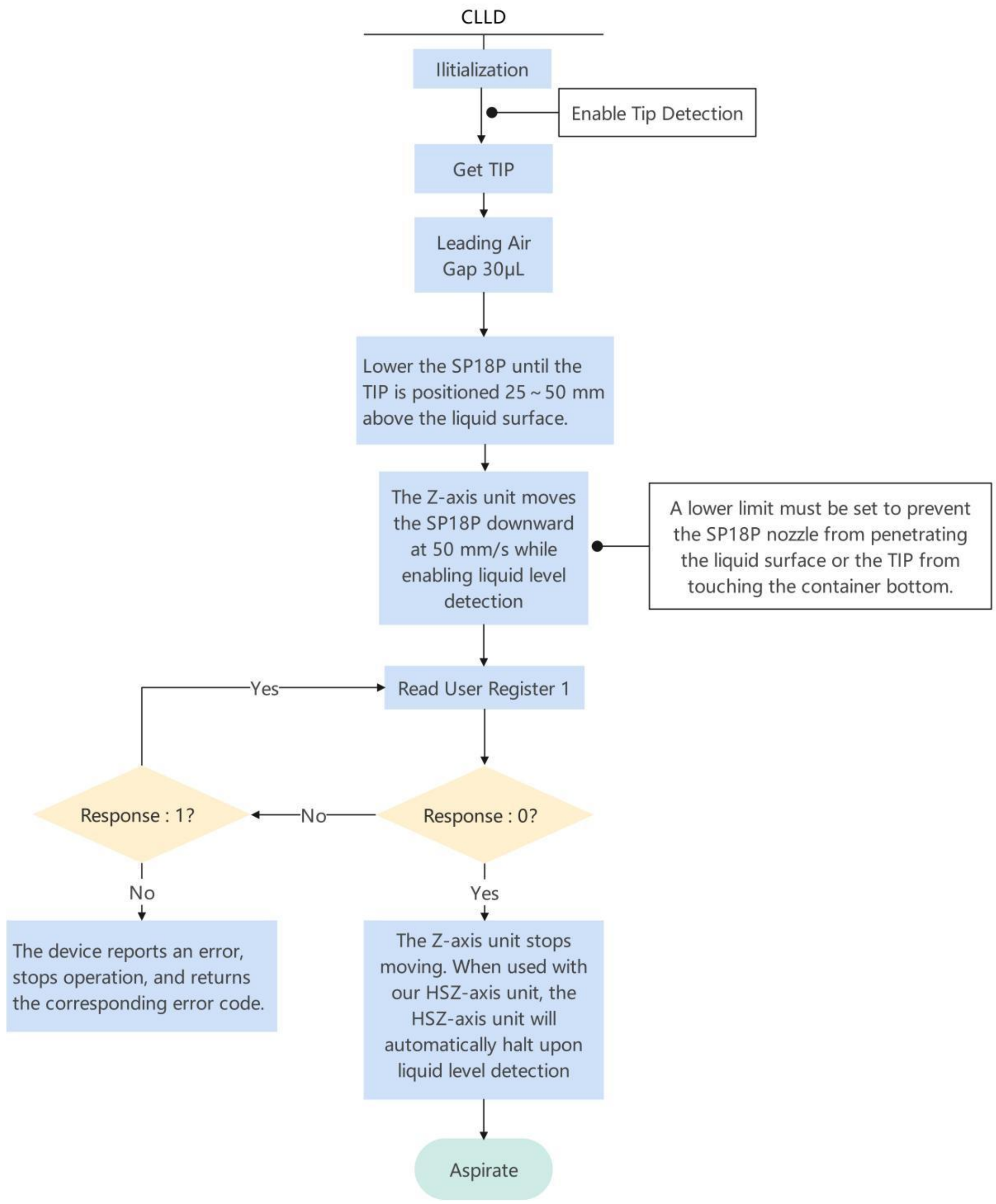


Figure 6-3 The Aspiration Process With CLLD

6.2 Picking up TIP

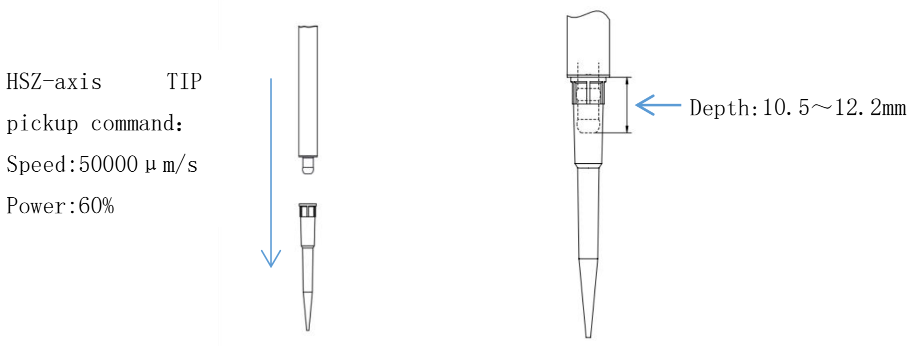


Figure 6-4 TIP Pickup Diagram

When positioning the SP13 nozzle above TIP, utilize our proprietary HSZ-axis TIP pickup command to automatically apply optimized downforce. For implementation examples, refer to Section 8.4.

Excessive downforce may lead to TIP ejection failure and even cause permanent damage to both the SP13 and HSZ-axis!

6.3 Liquid Level Detection

The HSZ-axis rapidly lower the SP13 until the TIP reaches 25～50 mm above the tube, then switches to a slow approach speed of 50 mm/s. Upon liquid level detection, the HSZ axis automatically stops. Users can monitor the detection status through: CAN bus auto-reporting (real-time), Register polling:user register 2 , user register 1 (operation completion flag).Reference: Table 12-1.

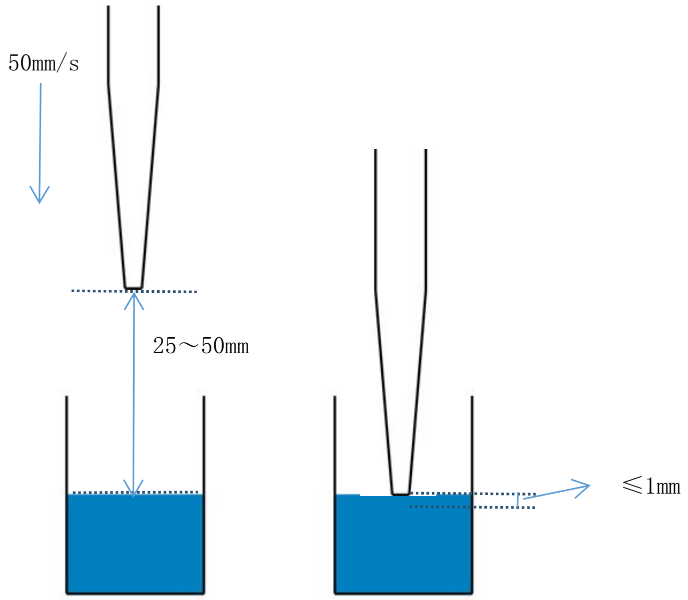


Figure 6-5 Liquid Level Detection Diagram

The liquid level detection function can be activated either by sending Lp/Lc commands via serial port or by writing to KT_CAN_DIC 0x4032/ 0x4033. Once enabled, the SP13 will continuously monitor real-time variations in the pressure/capacitive sensor outputs. When the pipettor detects the liquid level, it will prompt the user that the liquid level has been detected through the LED indicator light and communication information.

Recommended Liquid Level Detection Procedure:

During liquid level detection, first lower the SP13 (equipped with a TIP) until the TIP is positioned 25～50 mm above the anticipated liquid surface. Then, execute the LLD command and continue the descent. Upon detecting the liquid surface, the HSZ-axis will automatically halt the downward movement.

Note:

1. *During liquid level detection, the recommended descending speed of the HSZ axis is 50mm/s (not exceeding 100mm/s) to prevent the TIP from being inserted too deeply into the liquid surface due to excessive speed.*
2. *the tip of the TIP must be free of foreign objects (including residual reagents); otherwise, the pipettor may fail to accurately detect the liquid level.*
3. *When using PLLD (Pneumatic Liquid Level Detection), due to significant differences in filter elements between TIP of different brands, the default parameters for SP13 liquid level detection are only suitable for most TIP. If the pipettor triggers liquid level detection before the TIP contacts the liquid surface, appropriately increase the PLLD coefficient or decrease the absolute value of the liquid level detection command n2. If the TIP is inserted deeply into the liquid surface when detection is triggered, appropriately decrease the PLLD coefficient or increase the absolute value of the liquid level detection command n2. The PLLD coefficient is listed in Register 54 of Table 12-1.*
4. *When using PLLD, for reagents with a pipetting volume not exceeding 10μL, it is recommended to first obtain the liquid level height and then aspirate the liquid to reduce the impact of pneumatic liquid level detection on pipetting accuracy. For reagents with a pipetting volume exceeding 10μL, the liquid can be directly aspirated after the liquid level is detected.*
5. *When using CLLD, refer to Point 3 to appropriately adjust the CLLD coefficient (see Register 121 of Table 12-1).*

6.4 Mixing

Note:

When performing mixing operations using the SP13's aspiration/dispensing cycles, observe the following critical guidelines.

1. Example of Mixing 20μL Reagent: Above the liquid surface, perform absolute volume movement to 30μL (leading air gap) → then below the liquid surface, perform absolute volume movement to 50μL → below the liquid surface, perform absolute volume movement to 30μL → repeat the previous two steps n times → below the liquid surface, perform absolute volume movement to 30μL → lift TIP away from the reagent and perform absolute volume movement to 0 to empty (lifting to empty prevents bubble formation in the reagent)
2. The leading air gap and terminal absolute volume movement are essential for ensuring complete fluid expulsion;
3. Do not reuse the TIP for mixing, otherwise, the accumulated liquid film may be aspirated into the pipetting barrel, potentially damaging the pipette.

6.5 Pipetting Command Parameters

6.5.1 Pipetting Velocity

When aspirating and dispensing reagents, follow the basic principle of"slow aspiration and fast dispensing". The viscosity of the reagent and the TIP model may affect the velocity. When aspirating, the reference relationship between the aspiration volume and the aspiration velocity is shown in Table 6-1:

Table 6-1 Recommended Aspirating Velocity

volume	1μL→	100μL→	500μL→
velocity	100μL/s	200μL/s	500μL/s

When single aspirating and single dispensing, set a reasonable dispensing velocity to ensure that the reagent is dispensed completely and avoid splashing. For the recommended relationship between dispensing volume and velocity, refer to Table 6-2. single aspirating and single dispensing can set the same cut-off velocity parameters.

Table 6-2 Recommended Dispensing Velocity

TIP Type	10μLF TIP		50μLF TIP		200μLF TIP		1000μLF TIP	
Dispensing volume(μL)	0.5	1	2	5	50	100	500	1000
Re-aspiration volume(μL)	0	0	0	0	0	0	0	0

Dispensing velocity(μL/s)	100	100	200	200	200	200	500	1000
Cut-off velocity(μL/s)	25	25	25	25	25	25	25	25

6.5.2 Re-aspirating Volume

In single aspiration and single dispensing, the re-aspirate volume should be set to 0. In single aspirating and aliquot dispensing, the re-aspirate volume setting can be changed by referring to Table 6-4 and adjusted by users.

Table 6-3 Re-aspirate Parameter Reference For Aliquot Dispensing

TIP / Dispensing volume / Re-aspirating volume	5～10μL	10～20μL	20～100μL
50μL	≥2μL	/	/
200μL	≥3μL	≥3μL	/
1000μL	/	≥3μL	≥3μL
Cut-off velocity(μL/s)	25～200μL/s (lower than dispensing velocity)		

6.5.3 Recommended Parameters for Pipetting

The following operational parameters are optimized to ensure both accuracy and precision meet SP13 performance specifications when testing with pure water.

Table 6-4 Recommended Parameters for Pipetting Commands

TIP Type (F: with filter)	Dispensing type	Dispensi-ng volume (μL)	Leading Air Gap(0.01μL)	Aspiration volume (0.01μL)	Dispensing volume (0.01μL)	Re-aspiration volume (0.01μL)	Dispensing velocity (μL/s)	Dispensing cut-off velocity (μL/s)
10F	Single	0.5	2000	0.5	100	0	200	25
50F	Single	5	2000	500	100	0	200	25
200F	Single	10	2000	1000	100	0	200	25
1000F	Single	10	2000	1000	100	0	200	25
200F	Aliquot	10	2000	21000	500	0	200	25
1000F	Aliquot	50	2000	102000	1000	0	500	25
1000F	Aliquot	20	2000	102000	1000	0	500	25

6.6 ※Accuracy and CV Testing and Calibration

6.6.1 Accuracy and CV Testing

1. Pre-Test Preparation

To ensure reliable accuracy and precision testing:

To ensure accurate pipetting performance validation, all testing must be conducted in a controlled environment free from direct sunlight, significant temperature fluctuations, strong air currents, or mechanical vibrations. Required materials include: an analytical balance with 0.1 mg or 0.01 mg resolution, compatible pipettor TIPs, 1mL plastic centrifuge tubes, rubber gloves, and 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 Procedure:

Prior to operation, the analytical balance must be properly leveled and zeroed according to the manufacturer instructions in the user manual. .

4. Weighing Empty Centrifuge Tubes

Prepare 10 centrifuge tubes and record both their empty weights and corresponding identification numbers.

5. SP13 initialization, TIP installation and aspirate the air

Perform SP13 initialization before each test.

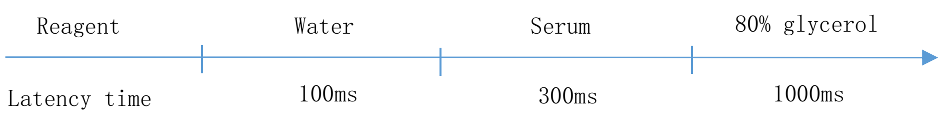
Replace and use a new TIP. If the TIP is deformed or contaminated, discard the current data.

To ensure that all reagents are dispensed from the TIP, aspirate 30μL of air before aspirating the liquid.

6. Single aspirating process

Control the HSZ-axis unit to descend TIP until the end of TIP is ≤1mm below the liquid surface.

Send the SP13 aspirating command, and after the aspiration is completed, raise the SP13 according to the reagent viscosity with the recommended latency time as shown in the figure below::



Send a dispensing command with the volume: 30μL of leading air gap volume + required reagent volume. Keep the end of the TIP moved to the edge of the centrifuge tube calibre to prevent reagent splashing..

7. Weighing Centrifuge Tubes with Reagent

Repeat step 5 to 6 ten times and weigh the ten centrifuge tubes in sequence. The weight of the reagent is the centrifuge tube with reagent data minus the weight of the empty centrifuge tube.

8. Factors Affecting Accuracy and CV

Accuracy and CV test results are affected by lots of factors, the main ones being:

- Pipetting parameters, please refer to section 0.
- Reagent temperature will affect the aspirated liquid volume.
- Reagent density will affect the aspirated liquid volume.
- After TIP is tied into the reagent, the hanging liquid on the outer wall affects the dispenseing accuracy and CV.
- Leading Air Gap volume, which affects dispense accuracy and CV.
- Latency time after aspiration and velocity when leaving the liquid level.

6.6.2 Accuracy Calibration

For higher accuracy performance practice, we can perform the aspiration volume calibration for single aspiration and single dispensing, generally, the aspiration volume for single aspiration and aliquot dispensing do not need to be calibrated. For different aspiration volume and TIP, segmented calibration is recommended. Below is how to perform a segmented calibration for aspiration volume of 1～1000 μL:

1. To ensure accurate pipetting across a range of volumes, especially when dealing with both small and large volumes, it is important to calibrate at multiple points. For small volumes pipetting, more calibration points are necessary due to the critical nature of precision at these low volumes. Larger volumes may require fewer calibration points but should still be adequately covered to ensure accuracy.

Table 6-5 Calibration

	50μL TIP	1000μL TIP
Calibration point(uL)	1	100
	5	200
	10	500
	20	700
	50	1000

2. For each calibration point, measure the dispensing accuracy 10 times and calculate the average value. Based on the difference between the target volume and the measured average, apply a adjustment.As an example, if the average delivered volume at the 1000μL test point measures 980μL (indicating a 20μL negative deviation), we should increase the nominal 1000μL aspiration volume to 1020 μL.

3. Given that the measured values and theoretical values in practical tests show a near-linear relationship, you can apply linear calibration based on the dispensed volume. This approach simplifies the adjustment process by applying a consistent correction factor across the range of volumes used.

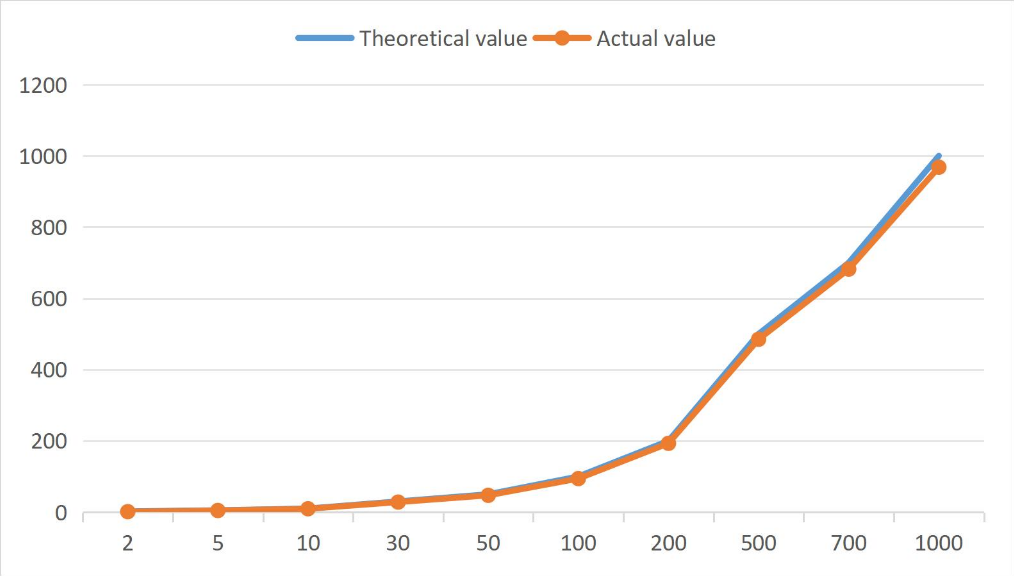


Figure 6-6 Calibration of Theoretical and Measured Values of Aspiration

7 Communication Protocol

7.1 Communication Interface

The SP13 communication supports the CAN communication interface and three communication protocols.

The supported CAN baud rates are 100k, 125k, 250k, 500k (default), and 1000k.

Note: Upon detection of any communication protocol, all other protocols will be disabled until system reboot or reset

KT_CAN_DIC Protocol (recommended)

The communication protocol is used for CAN communication in the local area network. It controls the SP13 and configuration parameters by reading and writing the KT_CAN_DIC object dictionary. During the execution of the action, there is no need to poll the device execution status, just wait for the device to automatically report the completion of the execution. The device execution completion may also be abnormally stopped, so it is necessary to monitor the automatically reporting status of the execution completion. If it is an error state, error handling is required.

KT_OEM Protocol (supported only when paired with the Keyto's HSZ axis)

The protocol is based on RS485 communication. The communication protocol contains sequence number and checksum byte, which can effectively prevent data loss. During operation, the main control polls the status of the SP13 to determine whether the SP13 has completed the action or an error has occurred.

KT_DT Protocol(supported only when paired with the Keyto's HSZ axis)

The protocol is based on RS485 communication. The KT_DT protocol is composed entirely of ASCII characters, which makes it easy to use the serial port debugging assistant to send commands and receive feedback. This protocol has no verification. When communication is disturbed, it is impossible to determine whether the command data is abnormal. The processing of abnormal command loss is also complicated. Therefore, this protocol is only used for quick start and should be avoided for formal use on customer instrument.

Note: When SP13 is used in conjunction with the HSZ axis, CAN1 and RS485 of the HSZ axis are unified as external interfaces, which receive commands sent by the Host unit and feedback the execution status of the HSZ axis and SP13. CAN2 of the HSZ axis is connected to CAN of SP13 for communication. When the Host unit uses the RS485 communication mode, SP13 also supports serial port commands, which are forwarded through CAN2 of the HSZ axis.

7.2 ※KT_CAN_DIC Protocol Format

The KT_CAN_DIC message type utilizes extended frames, consisting of an ID and a Data Field.

Frame Type: Data Frame

ID: Extended ID format (refer to Table 7-1)

DLC: Fixed data length of 8 bytes

Data Field: Fixed 8-byte structure containing Sequence Number, Index, and Data (refer to Table 7-1).

ID Format

Table 7-1 KT_CAN_DIC Message ID Field Format

	bit28～16	bit15～8	bit7～0
Send	Command	Host address	Device address
Response	Command	Device address	Host address

ID Field Contents:

1. Host address.
2. Device address.
3. Command: Indicates the operation type of the frame (refer to Table 7-1).

Table 7-2 KT_CAN_DIC ID Command List

命令	功能	说明
0x0000	Response	Response for reading and writing
0x0001	Write	Write Dictionary Return Value: Status (refer to Table 11-1)
0x0002	Read	Read Dictionary Returns no data if the specified dictionary entry does not exist
0x0003	Process data	Used for unsolicited data reporting (e.g., status change notifications) No acknowledgment required
0x0004	Heartbeat	Heartbeat packets for online status monitoring (contains node status per Table 11-1)
0x0080	Alarm	Device autonomously reports errors via this command Error codes defined in Table 11-1

Data field

Table 7-3 KT_CAN_DIC Data Field Format

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

Data Field Contents:

1. Sequence Number: Used to distinguish each frame during sending/responding. It is recommended to increment the sequence number by 1 before sending each frame to ensure uniqueness.
2. Index: A 16-bit index address that defines the dictionary table. Sub-Index: An 8-bit sub-index address used in conjunction with the Index to define the dictionary table.

Note: Each control command has a unique index and may have multiple sub-indexes. Frame data with non-zero sub-indexes should be sent first, and then frame data with a zero sub-index should be sent last. The SP13 starts moving when it receives a command with a zero sub-index.

3. Data: A 32-bit signed integer for communication (details in Table 9-1).

7.3 ※KT_OEM Protocol Format

The KT_OEM protocol operates on RS485 communication with data fields identical to the KT_DT protocol, featuring a checksum field for effective abnormal command detection and a sequence number field to simplify communication error handling, making it the recommended protocol for SP13 communication via RS485. The SP13 performs real-time string parsing to verify address matching, checksum accuracy, and protocol format correctness, while immediately returning device status. During operation, the status of SP13 can be obtained by sending status query commands to confirm whether instructions have been successfully executed or if errors have occurred.

Table 7-4 Message Sending Format Of KT_OEM Protocol

Field	Type	Length	Description
Frame header	Uint8	1	Value 0xAA, indicating the start of command
Sequence number	Uint8	1	Command Sequence Number, valid range: 0x80～0xFE. If the current command sequence number matches that of the previous command, it is identified as a retransmitted command. The device does not execute retransmitted commands but instead replies with the same response as the previous command.
Address	Uint8	1	Communication address: Each device on a bus should be set to a unique address number, with a range of 0 to 0x7F and 0xFF. Communication will only occur when the address matches, otherwise, the received command will be ignored. 0xFF is a broadcast address, which all devices can receive and execute without responding to the message.
Data length	Uint8	1	Data field length, with a value range of 0x01 to 0xFF.
Data field	Byte	n	Command string in ASCII character format, refer to Section 10.2.
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 Message Responding Format Of KT_OEM Protocol

Field	Type	Length	Description
Frame header	Uint8	1	Value 0x55, indicating the start of response
Sequence number	Uint8	1	Corresponds to the sequence number of the received command
Address	Uint8	1	Address of the device
Status	Uint8	1	Response device status or command execution Status, refer to Table 11-1: Status Codes.
Data length	Uint8	1	Response data field length; when the response data is 0, this field shall be 0 and cannot be omitted, with a value range of 0x00 to 0xFF.
Data field	Byte	n	Response string in ASCII character format; if there is no response, this field is omitted. Refer to the response data corresponding to the operation command in section 10.2.
Checksum	Uint8	1	The 8-bit checksum is calculated from the header of the frame 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_OEM protocol is based on RS485 communication, while the KT_DT protocol consists entirely of ASCII characters, making it convenient to send and receive commands using a serial port debugging assistant. Upon receiving a string of characters, the SP13 will parse the string, verify if the address matches and check if the syntax is correct, then return the status of the execution of the first command.

Table 7-6 Message Sending Format Of KT_DT Protocol

Field	Type	Length	Description
Address	Byte	1～3	The address of the Device that receives the message. Each device on the bus should be set to a unique address number, ranging from 1 to 127 and 255, represented by ASCII characters. 255 is a broadcast address, which all devices can receive and execute without responding to the message.
Direction	Byte	1	Character " > " (0x3E), means from Host to Device
Data field	Byte	n	Command string in ASCII character format, with the length of the command string being less than 256. Refer to section 10.2 for details.
End character	Byte	1	Carriage return (0x0D); each frame of the KT_DT protocol message should end with a carriage return.

Table 7-7 Message Responding Format Of KT_DT Protocol

Field	Type	Length	Description
Address	Byte	1～3	The address of the device responding to this message has a value range of 1 to 127, which must match the address sent, and is represented using ASCII characters.
Direction	Byte	1	"<"(0x3C), means from the Device to Host.
Status	Byte	1～3	Response device status or the execution status of the protocol send operation, refer to Table 11-1 for the status codes.
":"	Byte	1	":"(0x3A), it will be empty if there is no response data.
Data field	Byte	n	Response data string, with a length less than 256. Refer to section 10.2.
End character	Byte	1	Carriage return (0x0D); each frame of the KT_DT protocol message should end with a carriage return.

8 Communication Process

Note: When using serial communication, the KT_DT protocol, due to the lack of data verification, is recommended for debugging purposes only. For the complete system, the KT_OEM protocol should be used. The data format of the data field in the KT_OEM protocol is identical to that of the KT_DT protocol; only the header and trailer formats differ. When applying the KT_OEM protocol, the status should be queried after each operation to ensure that the current instruction has been executed before proceeding to the next step. In the following examples, the address of SP13 is 1.

Note: Upon detection of any communication protocol, all other protocols will be disabled until system reboot or reset

8.1 Examples of KT_CAN_DIC Protocol

Note: Refer to section 9.1.

Note:Each control command has a unique index and may have multiple sub-indexes. Frame data with non-zero sub-indexes should be sent first, and then frame data with a zero sub-index should be sent last. The SP13 starts moving when it receives a command with a zero sub-index.

Table 8-1 Examples Of KT_CAN_DIC Protocol

Function	Direc-tion	ID (HEX)	Data (HEX)	Description
Initialization	Tx	0001 00 01	00 40 00 00 00 00 01 F4	0001 Write; 00 Host Address; 01 Device Address; 00 Sequence number; 40 00 Index (Initialization); 00 Sub-index (Initialization velocity setting); 00 00 01 F4 Data (500μL/s)
	Rx	0000 01 00	00 40 00 00 00 00 00 01	0000 Response; 01 Device Address; 00 Host Address; 00 Sequence number; 40 00 Index; 00 Sub-index; 00 00 00 01 Device Status
	Rx	0003 01 00	00 70 02 00 00 00 00 00	0003 Process Data; 01 Device Address; 00 Host Address; 00 Sequence number, 70 02 Index
Aspiration (Leading Air gap)	Tx	0001 00 01	01 40 01 00 00 00 0B B8	0001 Write; 00 Host Address; 01 Device Address; 01 Sequence number; 40 01 Index; 00 Sub-index; 00 00 0B B8 Data (30.00μL)
	Rx	0000 01 00	01 40 01 00 00 00 00 01	0000 Response; 01 Device Address; 00 Host Address; 01 Sequence number; 40 01 Index; 00 Sub-index; 00 00 00 01 Device Status
	Rx	0003 01 00	01 70 02 00 00 00 00 00	0003 Process Data; 01 Device Address; 00 Host Address; 01 Sequence number, 70 02 Index

Function	Direc-tion	ID (HEX)	Data (HEX)	Description
PLLD	Tx	0001 00 01	02 40 32 01 FF FF FF F6	0001 Write; 00 Host Address; 01 Device Address; 02 Sequence number; 40 32 Index; 01 Sub-index; FF FF FF F6 Data (-10μL/s)
	Rx	0000 01 00	02 40 32 01 00 00 00 00	0000 Response; 01 Device Address; 00 Host Address; 02 Sequence number; 40 32 Index; 01 Sub-index; 00 00 00 00 Data (0)
	Tx	0001 00 01	03 40 32 00 00 00 13 88	0001 Write; 00 Host Address; 01 Device Address; 03 Sequence number; 40 32 Index; 00 Sub-index; 00 00 13 88 Data (5000ms)
	Rx	0000 01 00	03 40 32 00 00 00 00 01	0000 Response; 01 Device Address; 00 Host Address; 03 Sequence number; 40 32 Index; 00 Sub-index; 00 00 00 01 Data (1)
	Rx	0003 01 00	02 70 02 00 00 00 00 00	0003 Process Data; 01 Device Address; 00 Host Address; 02 Sequence number, Index
Aspiration	Tx	0001 00 01	04 40 01 03 00 00 00 19	0001 Write; 00 Host Address; 01 Device Address; 04 Sequence number; 40 01 Index; 03 Sub-index; 00 00 00 19 Data (25μL/s)
	Rx	0000 01 00	04 40 01 03 00 00 00 00	0000 Response; 01 Device Address; 00 Host Address; 04 Sequence number; 40 01 Index; 03 Sub-index; 00 00 00 00 Data (0)
	Tx	0001 00 01	05 40 01 02 00 00 00 19	0001 Write; 00 Host Address; 01 Device Address; 05 Sequence number; 40 01 Index; 02 Sub-index; 00 00 00 19 Data (25μL/s)
	Rx	0000 01 00	05 40 01 02 00 00 00 00	0000 Response; 01 Device Address; 00 Host Address; 05 Sequence number; 40 01 Index; 02 Sub-index; 00 00 00 00 Data (0)
	Tx	0001 00 01	06 40 01 01 00 00 02 58	0001 Write; 00 Host Address; 01 Device Address; 06 Sequence number; 40 01 Index; 01 Sub-index; 00 00 02 58 Data (600μL/s)
	Rx	0000 01 00	06 40 01 01 00 00 00 00	0000 Response; 01 Device Address; 00 Host Address; 06 Sequence number; 40 01 Index; 02 Sub-index; 00 00 00 00 Data (0)
	Tx	0001 00 01	07 40 01 00 00 01 86 A0	0001 Write; 00 Host Address; 01 Device Address; 07 Sequence number; 40 01 Index; 00 Sub-index; 00 01 86 A0 Data (1000μL)
	Rx	0000 01 00	07 40 01 00 00 00 00 01	0000 Response; 01 Device Address; 00 Host Address; 07 Sequence number; 40 01 Index; 00 Sub-index; 00 00 00 01 Data (1)
	Rx	0003 01 00	03 70 02 00 00 00 00 00	0003 Process Data; 01 Device Address; 00 Host Address; 03 Sequence number, 70 02 Index

Function	Direc-tion	ID (HEX)	Data (HEX)	Description
Absolute volume movement	Tx	0001 00 01	08 40 03 03 00 00 00 19	0001 Write; 00 Host Address; 01 Device Address; 08 Sequence number; 40 03 Index; 03 Sub-index; 00 00 00 19 Data (25μL/s)
	Rx	0000 01 00	08 40 03 03 00 00 00 00	0000 Response; 01 Device Address; 00 Host Address; 08 Sequence number; 40 03 Index; 03 Sub-index; 00 00 00 00 Device Data (0)
	Tx	0001 00 01	09 40 03 02 00 00 00 19	0001 Write; 00 Host Address; 01 Device Address; 09 Sequence number; 40 03 Index; 02 Sub-index; 00 00 00 19 Data (25μL/s)
	Rx	0000 01 00	09 40 03 02 00 00 00 00	0000 Response; 01 Device Address; 00 Host Address; 09 Sequence number; 40 03 Index; 02 Sub-index; 00 00 00 00 Data (0)
	Tx	0001 00 01	0A 40 03 01 00 00 03 20	0001 Write; 00 Host Address; 01 Device Address; 0A Sequence number; 40 03 Index; 01 Sub-index; 00 00 03 20 Data (800μL/s)
	Rx	0000 01 00	0A 40 03 01 00 00 00 00	0000 Response; 01 Device Address; 00 Host Address; 0A Sequence number; 4003 Index; 01 Sub-index; 00 00 00 00 Data (0)
	Tx	0001 00 01	0B 40 03 00 00 00 00 00	0001 Write; 00 Host Address; 01 Device Address; 00 Sequence number; 40 03 Index; 00 Sub-index; 00 00 00 00 Data (0)
	Rx	0000 01 00	0B 40 03 00 00 00 00 01	0000 Response; 01 Device Address; 00 Host Address; 0B Sequence number; 40 03 Index; 00 Sub-index; 00 00 00 01 Data (1)
	Rx	0003 01 00	04 70 02 00 00 00 00 00	0003 Process Data; 01 Device Address; 00 Host Address; 04 Sequence number, 70 02 Index
Reading user register	Tx	0002 00 01	0C 20 00 01 00 00 00 00	0002 Read; 00 Host Address; 01 Device Address; 0C Sequence number; 20 00 Index; 01 Sub-index; 00 00 00 00 Data (0)
	Rx	0000 01 00	0C 20 00 01 00 00 00 00	0000 Response; 01 Device Address; 00 Host Address; 0C Sequence number; 20 00 Index; 01 Sub-index; 00 00 00 00 Data (0)
Reading user register	Tx	0002 00 01	0D 20 00 02 00 00 00 00	0002 Read; 00 Host Address; 01 Device Address; 0D Sequence number; 20 00 Index; 02 Sub-index; 00 00 00 00 Data (0)
	Rx	0000 01 00	0D 20 00 02 00 00 00 00	0000 Response; 01 Device Address; 00 Host Address; 0D Sequence number; 20 00 Index; 02 Sub-index; 00 00 00 00 Data (0)
Writing user register	Tx	0001 00 01	0E 20 00 36 00 00 00 05	0001 Write; 00 Host Address; 01 Device Address; 0E Sequence number; 20 00 Index; 36 Sub-index; 00 00 00 05 Data (5)

Function	Direc-tion	ID (HEX)	Data (HEX)	Description
	Rx	0000 01 00	0E 20 00 36 00 00 00 00	0000 Response; 01 Device Address; 00 Host Address; 0E Sequence number; 20 00 Index; 36 Sub-index; 00 00 00 00 Data (0)

8.2 Example of KT_OEM Protocol (HEX)

Note: The KT_OEM protocol encapsulates the KT_DT protocol. For detailed specifications of command strings and response strings, refer to Section 10.2.

Table 8-2 Example of a Single Command of KT_OEM Protocol

Function	Direction	Instance (HEX)	Description
Initialization	Tx	AA 80 01 0B 49 74 35 30 30 2C 31 30 30 2C 32 A3	AA Frame header; 80 Sequence number; 01 Device address; 0B Data field length; 49 74 35 30 30 2C 31 30 30 2C 32 Command string"It500,100,2"; A3 checksum
	Rx	55 80 01 01 00 D7	55 Frame header; 80 Sequence number; 01 Device address; The device is executing command; 00 Data field length; D7 checksum
PLLD	Tx	AA 85 01 07 4C 70 31 30 30 30 30 E4	AA Frame header; 85 Sequence number; 01 Device address; 07 Data field length; 4C 70 31 30 30 30 30 Command string"Lp10000"; E4 checksum
	Rx	55 85 01 01 00 DC	55 Frame header; 85 Sequence number; 01 Device address; The device is executing command; 00 Data field length; DC checksum
Aspiration	Tx	AA 80 01 12 49 61 31 30 30 30 30 2C 36 30 30 2C 32 35 2C 32 35 F0	AA Frame header; 80 Sequence number; 01 Device address; 12 Data field length; 49 61 31 30 30 30 30 2C 36 30 30 2C 32 35 2C 32 35 Command string"Ia10000,200,25,25"; F0 checksum
	Rx	55 80 01 01 00 D7	55 Frame header; 80 Sequence number; 01 Device address; The device is executing command; 00 Data field length; D7 checksum
Dispensing	Tx	AA 81 01 15 44 61 35 30 30 30 30 2C 30 2C 35 30 30 2C 35 30 2C 30 2C 35 30 76	AA Frame header; 81 Sequence number; 01 Device address; 12 Data field length; 15 44 61 35 30 30 30 30 2C 30 2C 35 30 30 2C 35 30 2C 30 2C 35 30 Command string"Da50000,0,500,50,0,50"; 76 checksum
	Rx	55 81 01 01 00 D8	55 Frame header; 81 Sequence number; 01 Device address; The device is executing command; 00 Data field length; D8 checksum
Reading user register	Tx	AA 83 01 01 3F 6E	AA Frame header; 83 Sequence number; 01 Device address; 01 Data field length; 3F Command string"? "; 6E checksum
	Rx	55 83 01 00 00 D9	55 Frame header; 83 Sequence number; 01 Device address; 00 Data; 00 Data field length; D9 checksum
Reading user register	Tx	AA 84 01 03 52 72 33 29	AA Frame header; 84 Sequence number; 01 Device address; 03 Data field length; 52 72 33 Command string"Rr3"; 29 checksum
	Rx	55 84 01 00 01 30 0B	55 Frame header; 84 Sequence number; 01 Device address; 00 Data; 01 Data field length; 30 Data field length; 0B checksum
Writing user register	Tx	AA 85 01 07 57 72 35 34 2C 31 30 F6	AA Frame header; 85 Sequence number; 01 Device address; 07 Data field length; 57 72 35 34 2C 31 30 Command string"Wr54,10"; F6 checksum
	Rx	55 85 01 00 00 DB	55 Frame header; 85 Sequence number; 01 Device address; 00 Data; 00 Data field length; DB checksum

8.3 Example of KT_DT Protocol (String)

Table 8-3 Example of a Single Command of KT_DT Protocol

Function	Direction	Instance (ASCII)	Description
Initialization	Tx	1>It500,100,0	1 Device address; 500: Initializing velocity 500μL/s, 100: Initializing power 100%,0: Eject TIP
	Rx	1<1	1 Device address; The device is executing the command.
PLLD	Tx	1>Lp5000	1 Device address; 5000: detection timeout 5000 ms
	Rx	1<1	1 Device address; The device is executing the command.
Aspiration	Tx	1>Ia10000,200	1 Device address; 10000:Aspirating volume100.00 μ L; 200: Aspirating velocity 200μL/s
	Rx	1<1	1 Device address; The device is executing the command.
Dispensing	Tx	1>Da1000,500,200,100,0,25	1 Device address; 100:Dispensing volume 10.00μL; 500: Re-aspirating volume 5.00μL; 200: Dispensing velocity 200μL/s; 100: Cut-off velocity 100μL/s,0: Re-aspiration delay 0, 25: Startup velocity 25μL/s
	Rx	1<1	1 Device address; The device is executing the command.
Reading user register	Tx	1>?	1 Device address
	Rx	1<0	1 Device address; The device is idle.
Reading user register	Tx	1>Rr3	1 Device address
	Rx	1<0:0	1 Device address; 0: The device is idle.
Writing user register	Tx	1>Wr54,5	1 Device address
	Rx	1<0	1 Device address; The device is idle.

8.4 Development Process Example

8.4.1 CAN Communication Example

Note: A query-response communication mode is recommended, where each new command is sent only after receiving the response to the previous command.

The CAN communication enables the automatic reporting function by default (see Table 12-2, Public Register 5), where the device automatically reports status changes after they occur. This includes TIP status monitoring (disabled by default, see Table 12-1, User Register 43), movement completion reporting, and error message reporting.

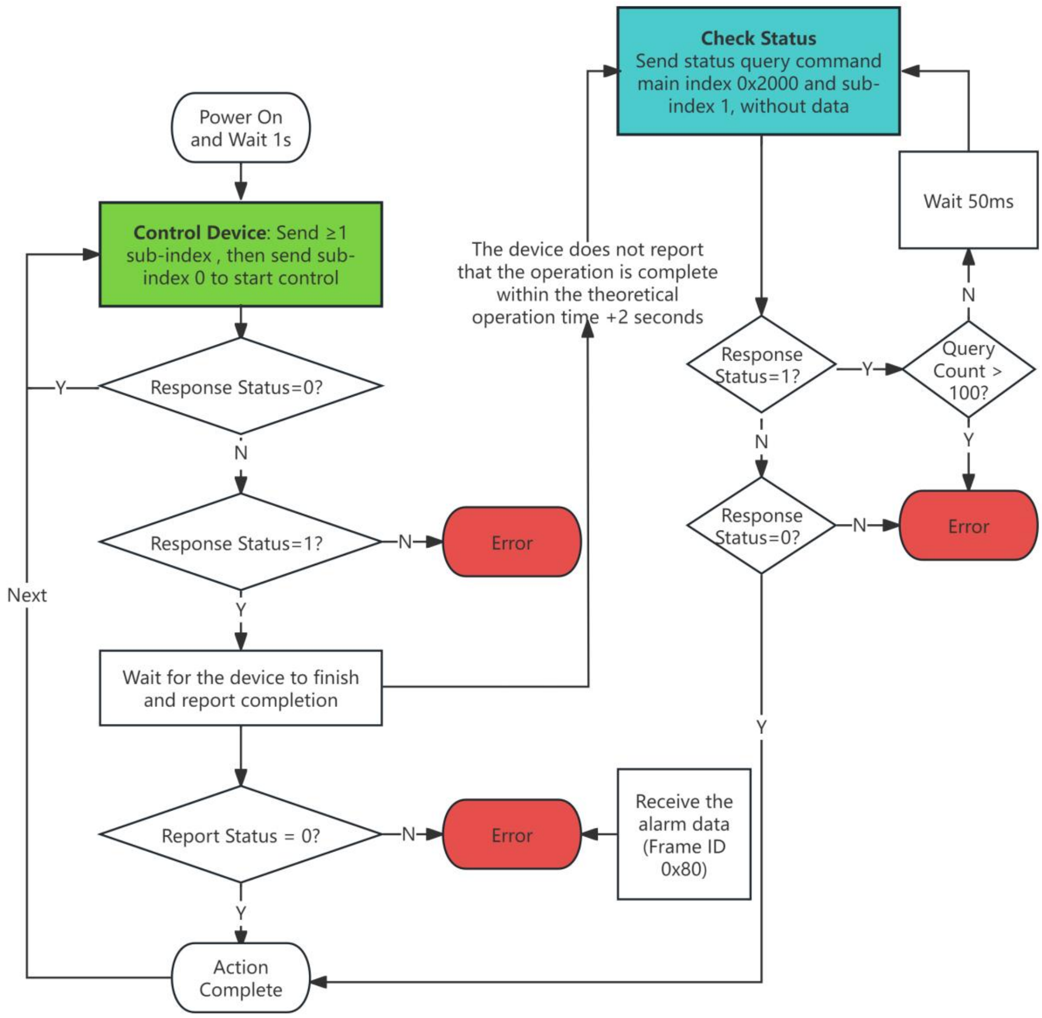


Figure 8-1 CAN Protocol Communication Framework

The green box indicates the operations of writing to registers and controlling SP13 movement, as detailed in the right side of Figure 8-2, CAN Protocol Communication Sub-process Framework. The blue box indicates querying the SP13 status and reading registers, as detailed in the left side of Figure 8-2, CAN Protocol Communication Sub-process Framework.

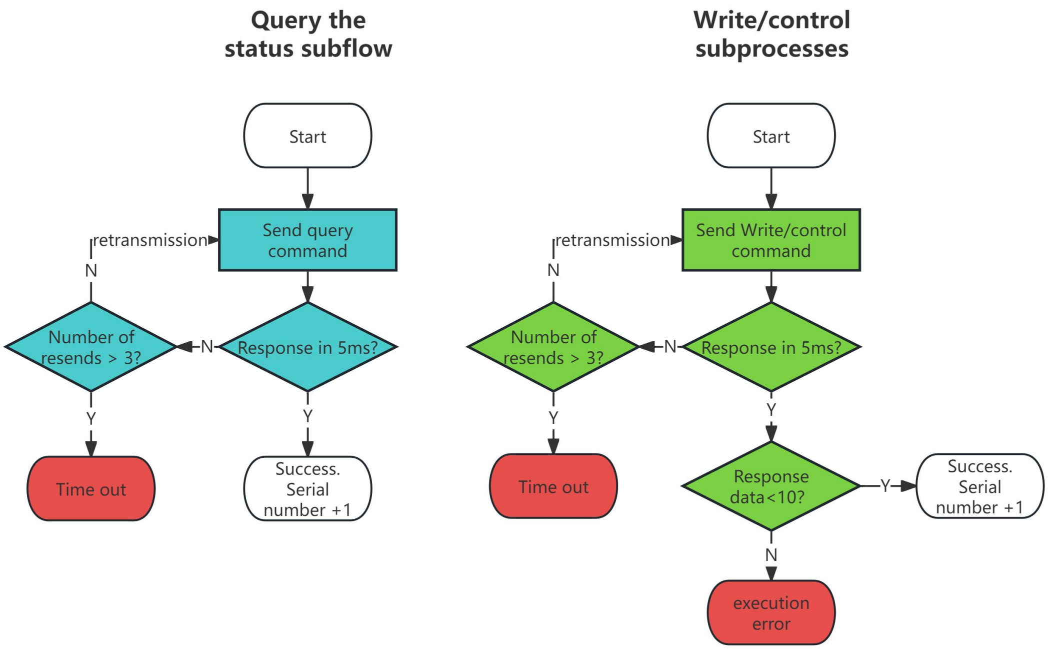


Figure 8-2 CAN Protocol Communication Sub-Process Framework

8.4.2 Serial Port Communication

Note: When using serial communication with the Keyto's HSZ axis, it is recommended to wait for an interval of more than 10 ms after the command response before sending the next frame of data to avoid bus interference. The communication shall adopt a question-and-answer mode, That is, after sending a command each time, you should wait for the response before sending a new command..

The query-response mode is shown in Figure 8-3.

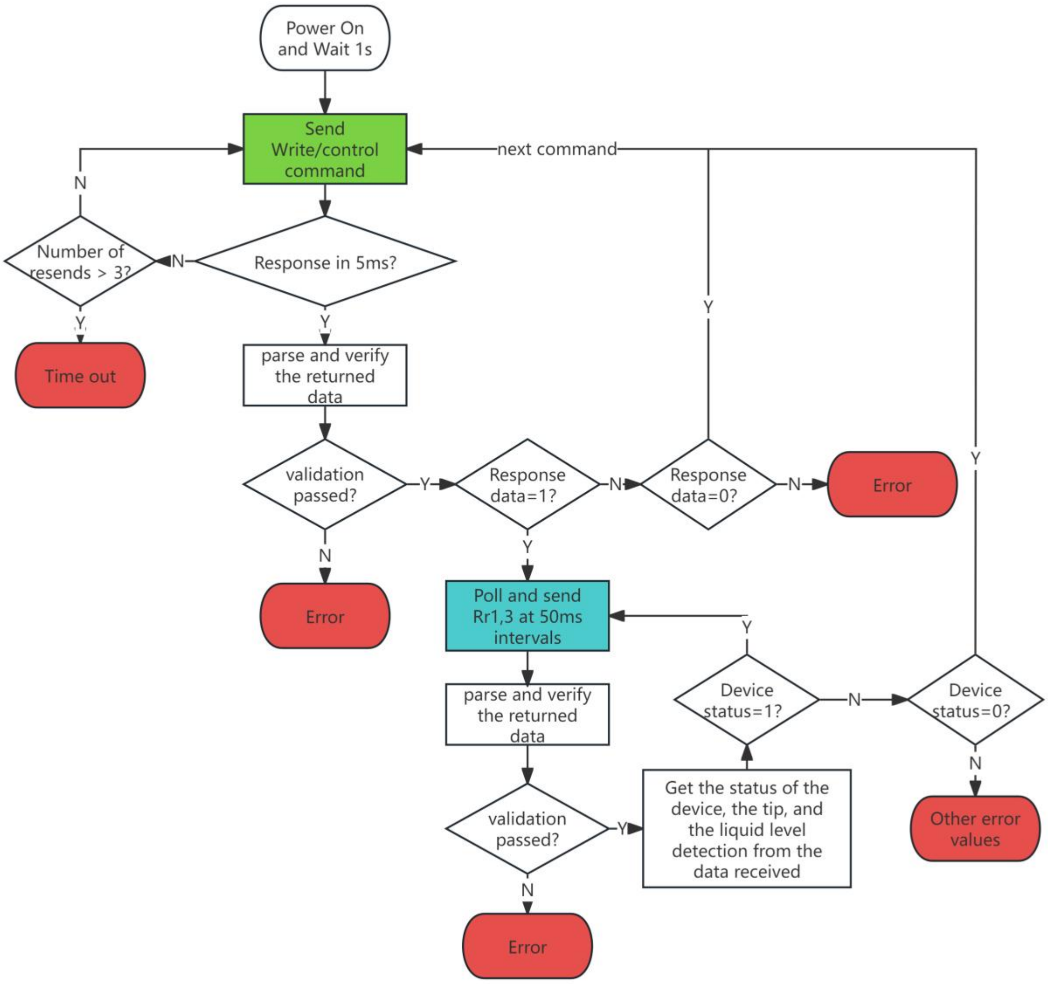


Figure 8-3 OEM Protocol Communication Framework

The green boxes indicate writing register operations and SP13 motion control commands, with detailed implementation shown in the right-side workflow of Figure 8-4. The blue boxes represent SP13 status queries and read register operations, as illustrated in the left-side workflow of Figure 8-4.

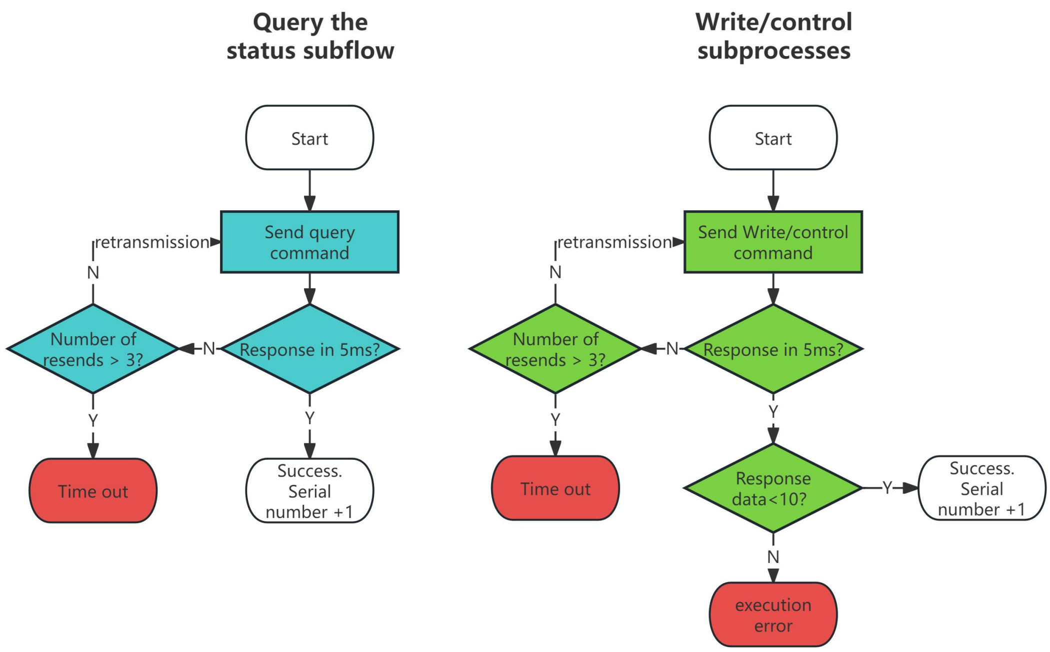


Figure 8-4 OEM Protocol Communication Sub-Process Framework

8.4.3 CAN Development Process Monitoring Example

Table 8-4 CAN Development Process

No.	Direc-tion	Description	Frame ID	Format	Type	DLC	Data(HEX)
0	Tx	Initialization	0x00010001	Data Frame	Extended Frame	0x08	01 40 00 00 00 00 01 F4
1	Rx		0x00000100	Data Frame	Extended Frame	0x08	01 40 00 00 00 00 00 01
2	Rx	Action completion status	0x00030100	Data Frame	Extended Frame	0x08	** 70 02 00 00 00 00 00
3	Tx	HSZ-axis initialization	0x00010029	Data Frame	Extended Frame	0x08	** 41 00 00 00 00 C3 50
4	Rx		0x00002900	Data Frame	Extended Frame	0x08	** 41 00 00 00 00 00 01
5	Rx	Action completion status	0x00032900	Data Frame	Extended Frame	0x08	** 70 02 00 00 00 00 00
6	Tx	Aspiration velocity 100μL/s	0x00010001	Data Frame	Extended	0x08	** 40 01 01 00 00 00 64

No.	Direc-tion	Description	Frame ID	Format	Type	DLC	Data(HEX)
					Frame		
7	Rx		0x00000100	Data Frame	Extended Frame	0x08	** 40 01 01 00 00 00 00
8	Tx	Cut-off velocity 25μL/s	0x00010001	Data Frame	Extended Frame	0x08	** 40 01 02 00 00 00 19
9	Rx		0x00000100	Data Frame	Extended Frame	0x08	** 40 01 02 00 00 00 00
10	Tx	Leading air gap 30.00μL	0x00010001	Data Frame	Extended Frame	0x08	** 40 01 00 00 00 0B B8
11	Rx		0x00000100	Data Frame	Extended Frame	0x08	** 40 01 00 00 00 00 01
12	Rx	Action completion status	0x00030100	Data Frame	Extended Frame	0x08	** 70 02 00 00 00 00 00
17	Tx	Getting TIP power 50%	0x00010029	Data Frame	Extended Frame	0x08	** 41 04 01 00 00 00 32
18	Rx		0x00002900	Data Frame	Extended Frame	0x08	** 41 04 01 00 00 00 00
19	Tx	Getting TIP velocity 50mm/s	0x00010029	Data Frame	Extended Frame	0x08	** 41 04 00 00 00 C3 50
20	Rx		0x00002900	Data Frame	Extended Frame	0x08	** 41 04 00 00 00 00 01
21	Rx	Action completion status	0x00032900	Data Frame	Extended Frame	0x08	** 70 02 00 00 00 00 00
22	Tx	HSZ-axis velocity 200mm/s	0x00010029	Data Frame	Extended Frame	0x08	** 41 01 01 00 03 0D 40
23	Rx		0x00002900	Data Frame	Extended Frame	0x08	** 41 01 01 00 00 00 00
24	Tx	HSZ-axis moving to	0x00010	Data	Extend	0x08	** 41 01 00 00 00 00

No.	Direc-tion	Description	Frame ID	Format	Type	DLC	Data(HEX)
		position 0	029	Frame	ed Frame		00
25	Rx		0x00002900	Data Frame	Extended Frame	0x08	** 41 01 00 00 00 00 01
26	Rx	Action completion status	0x00032900	Data Frame	Extended Frame	0x08	** 70 02 00 00 00 00 00
27	Tx	HSZ-axis velocity 50mm/s	0x00010029	Data Frame	Extended Frame	0x08	** 41 01 01 00 00 C3 50
28	Rx		0x00002900	Data Frame	Extended Frame	0x08	** 41 01 01 00 00 00 00
29	Tx	HSZ-axis moving to position 180mm	0x00010029	Data Frame	Extended Frame	0x08	** 41 01 00 00 02 BF 20
30	Rx		0x00002900	Data Frame	Extended Frame	0x08	** 41 01 00 00 00 00 01
31	Rx	Action completion status	0x00032900	Data Frame	Extended Frame	0x08	** 70 02 00 00 00 00 00
32	Tx	PLLD aspiration mode 10μL/s	0x00010001	Data Frame	Extended Frame	0x08	** 40 32 01 00 00 00 0A
33	Rx		0x00000100	Data Frame	Extended Frame	0x08	** 40 32 01 00 00 00 00
35	Tx	PLLD without timeout monitoring	0x00010001	Data Frame	Extended Frame	0x08	** 40 32 00 00 00 00 00
36	Rx		0x00000100	Data Frame	Extended Frame	0x08	** 40 32 00 00 00 00 01
37	Rx	Action completion status	0x00032900	Data Frame	Extended Frame	0x08	** 70 02 00 00 00 00 00
38	Rx	Action completion status	0x00030100	Data Frame	Extended Frame	0x08	** 70 02 00 00 00 00 00

No.	Direc-tion	Description	Frame ID	Format	Type	DLC	Data(HEX)
39		...Prepare for mixing					
40	Tx	SP13 moves to an absolute volume of 130.00μL	0x00010001	Data Frame	Extended Frame	0x08	** 40 03 00 00 00 32 C8
41	Rx		0x00000100	Data Frame	Extended Frame	0x08	** 40 03 01 00 00 00 01
42	Rx	Action completion status	0x00030100	Data Frame	Extended Frame	0x08	** 70 02 00 00 00 00 00
43	Tx	SP13 moving to an absolute volume of 30.00μL	0x00010001	Data Frame	Extended Frame	0x08	** 40 03 00 00 00 0B B8
44	Rx		0x00000100	Data Frame	Extended Frame	0x08	** 40 00 00 00 00 00 01
45	Rx	Action completion status	0x00030100	Data Frame	Extended Frame	0x08	** 70 02 00 00 00 00 00
46		...Mixing by cycling between 40 and 45					
47	Tx	Enabling the pipettor abnormality detection during pipetting	0x00010001	Data Frame	Extended Frame	0x08	** (reversed)
48	Rx		0x00000100	Data Frame	Extended Frame	0x08	** (reversed)
49	Tx	Configuring the SP13 to adjust its aspiration based on the tube area	0x00010001	Data Frame	Extended Frame	0x08	** (reversed)
50	Rx		0x00000100	Data Frame	Extended Frame	0x08	** (reversed)
51	Tx	Aspiration velocity 100μL/s	0x00010001	Data Frame	Extended Frame	0x08	** 40 01 01 00 00 00 64

No.	Direc-tion	Description	Frame ID	Format	Type	DLC	Data(HEX)
52	Rx		0x00000100	Data Frame	Extended Frame	0x08	** 40 01 01 00 00 00 00
53	Tx	Cut-off velocity 25μL/s	0x00010001	Data Frame	Extended Frame	0x08	** 40 01 02 00 00 00 19
54	Rx		0x00000100	Data Frame	Extended Frame	0x08	** 40 01 02 00 00 00 00
55	Tx	Aspiration volume: 100.00μL	0x00010001	Data Frame	Extended Frame	0x08	** 40 01 00 00 00 27 10
56	Rx		0x00000100	Data Frame	Extended Frame	0x08	** 40 01 00 00 00 00 01
57	Rx	Action completion status	0x00032900	Data Frame	Extended Frame	0x08	** 70 02 00 00 00 00 00
58	Rx	Action completion status	0x00030100	Data Frame	Extended Frame	0x08	** 70 02 00 00 00 00 00
59	Tx	Disabling aspiration following	0x00010001	Data Frame	Extended Frame	0x08	(reversed)
60	Rx		0x00000100	Data Frame	Extended Frame	0x08	(reversed)
61	Tx	HSZ-axis velocity 200mm/s	0x00010029	Data Frame	Extended Frame	0x08	** 41 01 01 00 03 0D 40
62	Rx		0x00002900	Data Frame	Extended Frame	0x08	** 41 01 01 00 00 00 00
63	Tx	HSZ-axis moving to position 0	0x00010029	Data Frame	Extended Frame	0x08	** 41 01 00 00 00 00 00
64	Rx		0x00002900	Data Frame	Extended Frame	0x08	** 41 01 00 00 00 00 01
65	Rx	Action completion status	0x00032900	Data Frame	Extended	0x08	** 70 02 00 00 00 00 00

No.	Direc-tion	Description	Frame ID	Format	Type	DLC	Data(HEX)
					Frame		
66	Tx	SP13 moving to an absolute volume of 0	0x00010001	Data Frame	Extended Frame	0x08	** 40 03 00 00 00 00 00
67	Rx	SP13 initialization and TIP ejection	0x00000100	Data Frame	Extended Frame	0x08	** 40 03 00 00 00 00 01
68	Rx	Action completion status	0x00030100	Data Frame	Extended Frame	0x08	** 70 02 00 00 00 00 00
69	Tx	disabling the pipettor abnormality detection during pipetting	0x00010001	Data Frame	Extended Frame	0x08	** (reversed)
70	Rx		0x00000100	Data Frame	Extended Frame	0x08	** 20 00 3C 00 00 00 00
71	Tx		0x00010001	Data Frame	Extended Frame	0x08	** 40 00 00 00 00 01 F4
72	Rx		0x00000100	Data Frame	Extended Frame	0x08	** 40 00 00 00 00 00 01
73	Rx	Action completion status	0x00030100	Data Frame	Extended Frame	0x08	** 70 02 00 00 00 00 00

**: It is recommended that the Host add 1 to the sequence number before sending each frame of data, so that each frame of data is different, and the device will respond with the same sequence number of the frame each time.

9 KT_CAN_DIC Command

The object dictionary includes a 16-bit index and an 8-bit sub-index, which are used to indicate different operations in an organized manner. All data entries include read or write permissions, allowing for precise control over access and modification. Control commands such as initialization, aspiration, and dispensing are represented by specific indices, while the sub-indices correspond to the parameters associated with each command.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.

9.1 Control Command

Note:

Each control command has a unique index and may have multiple sub-indexes. Frame data with non-zero sub-indexes should be sent first, and then frame data with a zero sub-index should be sent last. The SP13 starts moving when it receives a command with a zero sub-index.

Table 9-1 KT_CAN_DIC Control Command

Function	Index	Sub-index	R/W	Data range	Unit	Default	Description
Initialization	0x4000	0	RW	3~1500	μL/s	/	**Mandatory parameter,** Initialization velocity
		1	RW	0~100	%	100	Power (reversed)
		2	RW	0~2	/	0	TIP ejection mode during Initialization process: 0: Eject TIP always 1: Eject only if TIP detected 2: No ejection
Aspiration	0x4001	0	W	1~110000	0.01 μL	/	**Mandatory parameter,** Aspiration volume
		1	RW	1~1500	μL/s	200	Aspiration velocity
		2	RW	0~1500	μL/s	25	Cut-off velocity (reversed)
		3	RW	0~200	μL/s	25	Startup velocity (reversed)
Dispensing	0x4002	0	W	1~110000	0.01 μL	/	**Mandatory parameter,** Dispensing volume
		1	RW	0~10000	0.01 μL	0	Re-aspiration volume
		2	RW	1~1500	μL/s	200	Dispensing velocity

		3	RW	0～1500	μL/s	25	Cut-off velocity(reversed)
		4	RW	0～20000	ms	0	Delay before Re-aspiration
		5	RW	0～200	μL/s	25	Startup velocity (reversed)
Absolute volume pipetting	0x4003	0	W	0～110000	0.01 μL	/	**Mandatory parameter,** Absolute volume position
		1	RW	1～1500	μL/s	200	Velocity
		2	RW	0～1500	μL/s	25	Cut-off velocity(reversed)
		3	RW	0～200	μL/s	25	Startup velocity (reversed)
PLLD	0x4032	0	RW	0～20000	ms	/	**Mandatory parameter,** Timeout 0: Does not check whether a timeout occurs. Other values: During the timeout duration, if no pressure change is detected, a timeout error will be reported.
		1	RW	-200～200	μL/s	-10	Detection Mode: 0: Piston stationary PLLD (reserved); > 0: Aspiration-based PLLD < 0: Dispensing-based PLLD
CLLD	0x4033	0	RW	0～20000	ms	/	**Mandatory parameter,** Timeout
MLLD (reversed)	0x4034	0	W	0～20000	ms	/	**Mandatory parameter,** Timeout (reserved)
Anti-droplet control (reversed)	0x4035	0	W	0～20000	ms	/	**Mandatory parameter** Timeout (reserved)
Reading the pressure sensor data	0x4036	0	RW	0～4999	/	/	**Mandatory parameter,** The starting index for reading pressure sensor data
		1	RW	1～40	/	40	Number of data items to read

Reading the capacitive sensor data	0x4037	0	RW	0～4999	/	/	**Mandatory parameter,** The starting index for reading capacitive sensor data
		1	RW	1～40	/	40	Number of data items to read
Emergency Stop	0x9F00	1	W	0	/	/	**Mandatory parameter**
Firmware Restarting	0x9F00	3	W	123456	/	/	**Mandatory parameter**
Saving	0x9F10	0	W	0	/	/	**Mandatory parameter**
Restoring factory settings	0x9F10	1	W	123456	/	/	**Mandatory parameter**

Note: When the index of the cached data read via the sub-index parameter in the 0x4036 and 0x4037 commands exceeds 4999, only the cached data up to index 4999 will be returned. For example, in the 0x4036 command, if the sub-index "1" is first set to 30 and the main index "0" is set to 4990, it will actually only return the cached data for indexes 4990 to 4999。

9.2 Reading and Writing User Registers

Read and write the SP13 user register through the index 0x2000. The sub-index corresponds to the user register address, refer to Table 12-1.

9.3 Reading and Writing Common Register

Read and write the SP13 common register through the index 0x9F00, and the sub-index corresponds to the common register address. The common register address can be found in Table 12-2 Common Register.

9.4 Process Data

The pipettor automatically reports process data through the command 0x0003, and the sequence number of all Process data is add 1 each time in the range of 0 to 255.

Table 9-2 KT_CAN_DIC Process Data

Function	Index	Sub-index	R/W	Data range	Default	Description
TIP detection status	0x7001	0	R	0～1	/	TIP detection status Automatically reporting of the TIP status when it is picked up or ejected 0: No TIP 1: With TIP
Movement completion	0x7002	0	R	0	0	After moving done then automatically report the status

9.5 Heartbeat Data

SP13 sends heartbeat data via command 0x0004, which the Host can use to detect whether the device is online. By default, the heartbeat function is turned off but can be enabled as needed. For details on the corresponding register,refer to Table 12-2.

9.6 Error Data

SP13 sends error information via command 0x0080. For details on the error information, refer to Table 11-1.

10 Serial Port Commands

This chapter describes the data format of the data field in the KT_OEM and KT_DT protocols, specifically the format of operational commands. The data consists of ASCII strings, allowing multiple command sets to be sent simultaneously. The SP13 will parse and execute each command set sequentially. These commands are categorized by function into the following types:

- Initialization command
- Control commands
- Register reading and writing commands
- Query commands
- System control commands

10.1 Command Syntax

Send multiple commands to SP13, and the format is as follows:

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

The SP13 responds data in the following ASCII format:

<n1,n2,n3>

Among them:

<CMD>: Commands, which consists of the letters a～z and A～Z, up to two letters, please refer to section 10.2.

<n1,n2,n3>: Command parameters, which are separated by a comma (,), and the command without parameters can be empty. To retain default values for specific parameters while explicitly setting others, leave the corresponding field empty before the comma (e.g., It500,,2 sets the second parameter as default while specifying the first and third). Trailing empty parameters may be omitted entirely (e.g., Ia1000,200 is equivalent to Ia1000,200,, with the last two parameters defaulted).

Note:

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 commands consisting of an uppercase letter followed by a lowercase letter. Single-letter commands are represented by uppercase letters. The special character "?" denotes a query command, and "{}" denotes a loop control instruction. A single uppercase letter command is for system control, while an uppercase letter followed by a lowercase letter is for operation control.

10.2 Command Details

Note:

[] 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.

10.2.1 Control Commands

10.2.1.1 <It>n1,[n2],[n3] Initialization Command

Used to initialize SP13 by automatically controlling the SP13 piston to position 0, and optionally executing or not executing the TIP ejection action based on the parameter.

Table 10-1 It Command

Command	Parameters	Data range	Unit	Default	Description
It	n1	3～1500	μL/s	/	**Mandatory parameter**, Initializing velocity
	[n2]	0～100	%	100	Power (reversed)
	[n3]	0	/	0	Eject TIP always
		1			Eject only if TIP detected
		2			No ejection

Response: Immediately return data indicating that the device status is 1 (busy), which means the device has received the command and started to execute it. If the automatic reporting function is enabled, the device will automatically report data indicating that the device status is 0 (idle) after the movement is completed. If the automatic reporting function is not enabled, the device will not return data after the movement is completed. The host should actively query the device status until the device is idle and then send a new command. See Table 11-1 for the device status.

Warning: To ensure the correct pickup of the TIP, please apply a downforce of 28±2N not exceeding 1 second when getting the TIP. Insufficient downforce may cause the TIP to fall off during movement, while excessive downforce may damage the SP13 and HSZ-axis.

10.2.1.2 <Ia>n1,[n2],[n3],[n4] Aspiration

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

Table 10-2 Ia Command

Command	Parameters	Data range	Unit	Default	Description

Ia	n1	1～110000	0.01μL	/	**Mandatory parameter,** Aspirating volume
	[n2]	1～1500	μL/s	200	Aspirating velocity
	[n3]	0～1500	μL/s	25	Cut-off velocity (Reversed)
	[n4]	0～200	μL/s	25	Startup velocity (Reversed)

n1 Aspiration volume:

The parameter is Mandatory.The aspiration volume refers to the theoretical volume of reagent drawn into the TIP. However, due to various physical factors, the actual aspirated volume may differ from the target volume. For high-precision aspiration requirements, it is necessary to create corresponding calibration curves by taking into account physical characteristics such as aspiration velocity, liquid viscosity, aspiration volume, and TIP type.

[n2] Aspiration velocity:

The aspiration velocity should be set according to the physical properties of the liquid, such as viscosity and surface tension. For different liquids, an excessively fast flow rate may lead to excessively low pressure in the SP13 chamber, or it may cause the liquid to continue flowing into the TIP after the piston stops, resulting in over-aspiration. A reasonable approach is to match the liquid flow rate with the aspiration velocity.

[n3] Cut-off velocity:

This parameter is used to control the final stopping speed of the fluid, and should be set according to the different physical properties of the reagent.

[n4] Startup velocity:

This parameter is used to control the start-up flow rate of the fluid, with a default value equal to the cutoff speed, and it has a maximum limit of 200μL/s.

Response: Immediately return data indicating that the device status is 1 (busy), which means the device has received the command and started to execute it. If the automatic reporting function is enabled, the device will automatically report data indicating that the device status is 0 (idle) after the movement is completed. If the automatic reporting function is not enabled, the device will not return data after the movement is completed. The host should actively query the device status until the device is idle and then send a new command. See Table 11-1 for the device status.

10.2.1.3 <Da>n1,[n2],[n3],[n4],[n5],[n6] Dispensing

This parameter is used for dispensing command.The SP13 automatically converts the volume-specific parameters into piston movement distance to control the piston motion during dispensing. Additionally, based on the selected parameters, it determines whether to perform a re-aspiration to prevent droplets from remaining at the TIP, ensuring accurate dispensing.

Table 10-3 Da Command

Command	Parameters	Data range	Unit	Default	Description

Da	n1	1～115000	0.01μL	/	**Mandatory parameter,** Dispensing volume
	[n2]	0～10000	0.01μL	0	Re-aspiration volume
	[n3]	1～1000	μL/s	200	Dispensing velocity
	[n4]	0～1000	μL/s	25	Cut-off velocity
	[n5]	0～20000	ms	0	Delay before Re-aspiration
	[n6]	0～200	μL/s	25	Startup velocity (Reversed)

n1 Dispensing volume:

The parameter is Mandatory. The dispensing volume refers to the theoretical volume of liquid expelled from the TIP. However, due to various physical factors, the actual dispensed volume may differ from the target volume. For high-precision dispensing requirements, it is necessary to create corresponding calibration curves by taking into account physical characteristics such as dispense speed, liquid viscosity, dispense volume, and TIP type.

[n2] Re-aspiration volume:

When performing single aspiration and aliquot dispensing, if there is no re-aspiration step during the dispensing actions, it can easily lead to droplets remaining at the tip of the TIP after completing the dispense action. To avoid the issue of droplets hanging from the TIP, which can affect accuracy and precision and cause cross-contamination, we have designed an automatic re-aspiration function in the dispensing command. This function automatically re-aspirate a specified volume of liquid after completing the dispensing action.

[n3] Dispensing velocity:

The dispensing velocity should be set according to the physical properties of the liquid, such as viscosity and surface tension. For different reagent, an excessively fast flow rate may lead to excessively high pressure in the SP13 chamber. A reasonable approach is to match the liquid flow rate with the dispensing velocity.

[n4] Cut-off velocity:

This parameter is used to set the velocity at which the dispensing process ends. Specifically, it controls how the system decelerates to a stop after the final stage of dispensing is completed. The cut-off velocity must be less than or equal to the dispensing velocity. A higher cut-off velocity can quickly terminate the liquid flow, which helps reduce droplet formation on the TIP, improving accuracy and cleanliness.

[n5] Re-aspiration delay:

The parameter can be used to set the delay time for the re-aspiration after dispensing.

[n6] Startup velocity:

This parameter is used to control the start-up flow rate of the fluid, with a default value equal to the cutoff speed, and it has a maximum limit of 200μL/s.

Response: Immediately return data indicating that the device status is 1 (busy), which means the device has received the command and started to execute it. If the automatic reporting function is enabled, the device will automatically report data indicating that the device status is 0 (idle) after the movement is completed. If the automatic reporting function is not enabled, the device will not return data after the movement is completed. The host should actively query the device status until the device is idle and then send a new command. See Table 11-1 for the device status.

Note:

Parameter <n1> represents the target dispensing volume.

<n2> does not affect the target dispense volume but only influences the dispense performance in the case of single aspiration followed by aliquot dispensing.

For single aspiration and single dispensing, it is recommended to keep <n2> at 0 and <n4> at 25.

During aliquot dispensing, the cut-off velocity <n4> must be less than or equal to the dispensing velocity <n3>.

10.2.1.4 <Lp>n1,[n2] Pressure Liquid Level Detection

It is used to detect the surface of the reagent. During liquid level detection, the host first controls the HSZ axis to lower the SP13 with a TIP loaded on it, so that the tip of the TIP is 25～50 mm above the reagent liquid surface. Then, the host sends a command to control the HSZ axis to continue lowering the SP13 at a slow speed. Meanwhile, it activates the PLLD function of the SP13. The SP13 will monitor the changes in the data of the pressure sensor in real-time. When the TIP touches the liquid surface, the SP13 will send a signal indicating that the liquid level has been detected. Users can check the liquid level detection signal in three ways: monitoring communication data, observing the LED indicator, or actively querying the status of User Register 2.

Table 10-4 Lp Command

Command	Parameters	Data range	Unit	Default	Description
Lp	n1	0～20000	ms	/	**Mandatory parameter,** Timeout 0: Does not check whether a timeout occurs. Other values: During the timeout duration, if no pressure change is detected, a timeout error will be reported.
	[n2]	-200～200	μL/s	-10	Pressure-Based Liquid Surface Detection Method: 0: Piston stationary PLLD (reserved); > 0: Aspiration-based PLLD < 0: Dispensing-based PLLD

Response: Immediately return data indicating that the device status is 1 (busy), which means the device has received the command and started to execute it. If the automatic reporting function is enabled, the device will automatically report data indicating that the device status is 0 (idle) after the movement is completed. If the automatic reporting function is not enabled, the device will not return data after the movement is completed. The host should actively query the device status until the device is idle and then send a new command. See Table 11-1 for the device status.

10.2.1.5 <Lc>n1 Capacitive Liquid Level Detection

It is used to detect the surface of the reagent. During liquid level detection, the host first controls the HSZ axis to lower the SP13 with a TIP loaded on it, so that the tip of the TIP is 25～50 mm above the reagent liquid surface. Then, the host sends a command to control the HSZ axis to continue lowering the SP13 at a slow speed. Meanwhile, it activates the CLLD function of the SP13. The SP13 will monitor the changes in the data of the capacitive sensor in real-time. When the TIP touches the liquid surface, the SP13 will send a signal indicating that the liquid level has been detected. Users can check the liquid level detection signal in three ways: monitoring communication data, observing the LED indicator, or actively querying the status of User Register 2.

Table 10-5 Lc Command

Command	Parameters	Data range	Unit	Default	Description
Lc	n1	0～20000	ms	/	**Mandatory parameter,** Timeout 0： Does not check whether a timeout occurs. Other values： During the timeout duration, if no pressure change is detected, a timeout error will be reported.

Response: Immediately return data indicating that the device status is 1 (busy), which means the device has received the command and started to execute it. If the automatic reporting function is enabled, the device will automatically report data indicating that the device status is 0 (idle) after the movement is completed. If the automatic reporting function is not enabled, the device will not return data after the movement is completed. The host should actively query the device status until the device is idle and then send a new command. See Table 11-1 for the device status.

10.2.1.6 <Lm>n1 Mixed Liquid Level Detection (reversed)

10.2.1.7 <Pc>n1 Anti-droplet Control (reversed)

10.2.1.8 <Mp>n1,[n2],[n3][n4] Absolute Volume Movement Command

Control the piston to move to the absolute volume position.

Table 10-6 Mp Command

Command	Parameters	Data range	Unit	Default	Description
Mp	n1	0～115000	0.01μL	/	**Mandatory parameter,** Absolute volume position
	[n2]	1～1000	μL/s	200	Velocity
	[n3]	0～1000	μL/s	25	Cut-off velocity (Reversed)
	[n4]	0～200	μL/s	25	Startup velocity (Reversed)

Response: Immediately return data indicating that the device status is 1 (busy), which means the device has received the command and started to execute it. If the automatic reporting function is enabled, the device will automatically report data indicating that the device status is 0 (idle) after the movement is completed. If the automatic reporting function is not enabled, the device will not return data after the movement is completed. The host should actively query the device status until the device is idle and then send a new command. See Table 11-1 for the device status.

10.2.2 Parameters Reading and Writing Commands

10.2.2.1 <Qp>n1,[n2] Reading the Pressure Sensor Data

Table 10-7 Qp Command

Command	Parameters	Data range	Unit	Default	Description
Qp	n1	0～4999	/	/	**Mandatory parameter,** The starting index for reading pressure sensor data
	[n2]	1～40	/	40	The number of cached data read

Response: Pressure sensor data.

Each time an aspiration, dispensing, or liquid level detection command is executed, the sensor data cache will be cleared and data caching will restart. The caching will stop when the cache is full or the action has been completed.

10.2.2.2 <Qc>n1,[n2] Reading the Capacitive Sensor Data

Table 10-8 Qc Command

Command	Parameters	Data range	Unit	Default	Description
Qc	n1	0～4999	/	/	**Mandatory parameter,** The starting index for reading capacitive sensor data
	[n2]	1～40	/	40	The number of cached data read

Response: Capacitive sensor data.

Each time an aspiration, dispensing, or liquid level detection command is executed, the sensor data cache will be cleared and data caching will restart. The caching will stop when the cache is full or the action has been completed.

Note: When the index of the cached data read by the n2 parameter in the Qp and Qc commands exceeds 4999, only the cached data up to index 4999 will be returned. For example, if the user sends 1>Qp4990,30, it will actually only return the cached data for indexes 4990 to 4999.

10.2.2.3 <Wr>n1,n2,[n3] Writing User Register

This command can be used to perform writing operations on the writable registers in Table 12-1.

Table 10-9 Wr Command

Command	Parameters	Data range	Unit	Default	Description
Wr	n1	1～200	/	/	**Mandatory parameter,** User register address
	[n2]	/	/	/	Data

Response: Immediately return the device status. See Table 11-1 for the device status.

10.2.2.4 <Rr>n1,[n2] Reading User Register

This command allows users to perform read operations on the readable registers listed Table 12-1, reading the specified number of register values starting from the start address.

Table 10-10 Rr Command

Command	Parameters	Data range	Unit	Default	Description

Rr	n1	1～200	/	/	Mandatory parameter, Start register address
	[n2]	/	/	1	The number of registers

Response: For the status section, refer to Table 11-1. The data section contains the read data, and the returned data from multiple addresses is separated by a comma",".

10.2.2.5 <Wp>n1,n2,[n3] Writing Common Registers

This command can be used to perform writing operations on the writable registers in Table 12-2.

Table 10-11 Wp Command

Command	Parameters	Data range	Unit	Default	Description
Wp	n1	0～10	/	/	Mandatory parameter, User register address
	[n2]	/	/	/	Data

Response: Immediately return the device status. See Table 11-1 for the device status.

10.2.2.6 <Rp>n1,[n2] Reading Common Registers

This command allows users to perform read operations on the readable registers listed Table 12-2, reading the specified number of register values starting from the start address.

Table 10-12 Rp Command

Command	Parameters	Data range	Unit	Default	Description
Rp	n1	0～10	/	/	Mandatory parameter, Start register address
	[n2]	/	/	1	The number of registers

Response: For the status section, Table 11-1. The data section contains the read data, and the returned data from multiple addresses is separated by a comma",".

Note:

When using the Rr and Rp commands to read registers: If an invalid register is encountered during the read operation, the reading will stop, discard any data already read, and return device status 14 (Wrong address). If a register prohibited from being read is encountered, the reading will stop, discard any data already read, and return device status 15 (Prohibit reading and writing). Device status details are shown in Table 11-1.

Examples:

- *Sending "1>Rr4,3" will return device status 14 (User register 6 does not exist, as the read range is 4～6, and 6 is wrong.*
- *Sending "1>Rp1,2" will return device status 15 (Common register 2 is prohibited from being read).*
- *Sending "1>Rr130" will return device status 14 (User register 130 does not exist).*

- *Sending "1>Rr117,8" will return device status 14 (User registers 121～124 do not exist, as the read range is 117～124, and some registers in this range are wrong).*

When using the Wr and Wp commands to write to registers:if an invalid register is written to, the device will return status 14 (Wrong address).If a register prohibited from being written is encountered, the operation will return status 15 (Read or write operation prohibited).Device status details are shown in Table 11-1.

Examples:

- *Sending "1>Wr2,1 or 1>Wr5,10" will return device status 15 (User registers 2 and 5 are prohibited from being written).*
- *Sending "1>Wr130,2" will return device status 14 (User register 130 does not exist).*
- *Sending "1>Wp9,3" will return device status 15 (Common register 9 is prohibited from being written).*
- *Sending "1>Wp12,1" will return device status 14 (Common register 12 does not exist).*

10.2.3 System Operation Commands

10.2.3.1 <?> Query Status Command

Response: Immediately return the device status. See Table 11-1 for the device status.

10.2.3.2 <{}> Loop Control Command

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.

Table 10-13 {} Command

Command	Parameters	Data range	Unit	Default	Description
{	/	/	/	/	Loop Start
}	[n1]	0～2147483647	/	0	0: infinite loop. other values: number of loops

Note: Loops can only be nested up to 20 layers deep

Response: /

10.2.3.3 <L>n1 Delay

The delay command is used for internal system delays, mainly to introduce a delay between the execution of two commands.

Table 10-14 L Command

Command	Parameters	Data range	Unit	Default	Description
L	n1	0～20000	ms	/	**Mandatory parameter,** Delay time

Response: Immediately return the device status. See Table 11-1 for the device status.. Regardless of whether the automatic reporting function is enabled, there will be no additional returned data after the delay is completed. See Table 11-1 for the device status.

10.2.3.4 <T> Stop Command

Stop the command currently being executed by the device.

Table 10-15 T Command

Command	Parameters	Data range	Unit	Default	Description
T	/	/	/	/	/

Response: Immediately return the device status. See Table 11-1 for the device status.

10.2.3.5 <U>n1 Resetting Command

This command is used to restart the device.

Table 10-16 U Command

Command	Parameters	Data range	Unit	Default	Description
U	n1	123456	/	/	**Mandatory parameter,** The parameter is valid when it is 123456.

Response: Return the device status within 500ms. See Table 11-1 for the device status.

10.2.3.6 <M>n1 Restoring Factory Settings Command

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

Table 10-17 M Command

Command	Parameters	Data range	Unit	Default	Description
M	n1	123456	/	/	**Mandatory parameter,** The parameter is valid when it is 123456.

Response: Return the device status within 500ms. See Table 11-1 for the device status.

10.2.3.7 <S> Saving

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

Table 10-18 S Command

Command	Parameters	Data range	Unit	Default	Description
S	/	/	/	/	The modified register parameters will be saved after rebooting.

Response: Immediately return the device status. See Table 11-1 for the device status.

11 Device Status and LED

11.1 Device Status

Each command has a return status, indicating whether the command is executed successfully, whether the device has an error, is busy, idle, etc. The status is 1 byte of hexadecimal data.

Rules:

0～9: Working status.

10～19: Commands execution error code.

>=20: Device failures error code.

Table 11-1 Device Status

Value	Status	Description
0	Idle	The device is idle and there are no abnormalities.
1	Busy	The device is executing the command.
10	Parameter over range	The command parameter is out of range. For example, "1>Ia150000".
11	Parameter abnormality	Reversed.
12	Syntax Error	In the command string, the number of loop starts is greater than the number of loop ends. For example, "1>{{It500,100,0}1". There are invalid characters in the command string. For example, "1>%".
13	Invalid command	This instruction is not supported. For example, "1>QT".
14	Wrong address	The read or write register address is incorrect. For example, "1>Rr300".
15	Prohibit reading and writing	This register cannot be read or written. For example, "1>Wr2,1".
16	Command overflow	There is currently an command being executed.
17	Uninitialized	The device has not been initialized.
20	TIP abnormal drop error	TIP falling off, loosening, or abnormal detection of TIP presence.
21	Eject TIP abnormal error	After executing the TIP ejection command, the TIP is still attached to the nozzle.
22	Liquid level detection failure error	The liquid level was not detected within the timeout period.
50	Motor stall error	
51	Motor driver error	
52	Optocoupler error	
54	Pressure sensor	

	error	Pipetting is prohibited; faults must be resolved before initializing the SP13.
55	Storage Error	
60	Uncalibrated error	
61	capacitive sensor error	
62	Storage verification error	
64	CAN Error	

11.2 LED

The status of the SP13 is indicated by LED, as shown in table below:

Table 11-2 LED Specification 1

LED Status	Description
500ms Blue light→Off	Power on
Off	Idle, TIP undetected
Green	Idle, TIP detected
Blue	Busy status
Yellow	Liquid level detected
Purple	Liquid level detecting
Red Flashing	Error
Blue Flashing	Unencrypted
Red	In the process of upgrading the program

Table 11-3 LED Specification 2

Number of red flashes	Description
1	TIP ejection failed
2	Liquid level detection failed
3	Pipetting anomaly
4	Uncalibrated
5	Motor stall
6	Hardware error

12 Register

12.1 User Register

This register enables configuration and monitoring of SP13 parameters for operational control.

Table 12-1 User Register

Register address	R/W	Data range	Unit	Default	Description
1	R/W	/	/	0	Current status, and write 0 to clear error
2	R	0～1	/	0	0: No liquid level detected; 1: Liquid level detected The register value changes from 1 to 0 when executing the next operation after successful liquid level detection.
3	R	0～1	/	0	0: No TIP; 1: TIP present During the execution of the TIP ejection command (initialization), this register cannot be used instead of user register 1 to determine whether the device enters the idle state.
4	R	/	/	0	Current pressure sensor value
5	R	/	/	0	Current capacitive sensor value
11	R	0～1	/	0	Zero-position photoelectric sensor status 0:Not Triggered 1:Triggered
19	R	-4197～110000	0.01μL	0	Current piston position
22	R	0～1500	μL/s	0	Current piston velocity
29	R	1100	μL	1100	Maximum aspiration volume
43	R/W	0～7	/	0	Read and write (16-bit) register with valid low-order 3 bits (bit0～bit2). Data range 0～7 corresponds to binary values 0b000～0b111. Each bit independently controls one function: bit0: TIP detection during aspiration,dispensing and liquid level detection;

					bit1: Active reporting of TIP status changes; bit2: Active reporting of accidental TIP drop; Writing 0 disables TIP detection (overwrites current settings). Example: Writing 6 (0b110) = Only enables: bit1 and bit2
45	R	0～0xFFFFFFFF	/	0	Piston movement count
46	R	0～0xFFFFFFFF	/	0	Total piston travel distance (Multiples of the full stroke)
47	R	0～0xFFFFFFFF	/	0	Total TIP ejection count
48	R	0～0xFFFFFFFF	/	0	Total Initialization Count
54	R/W	0～1000	/	5	PLLD coefficient Lower values indicate higher sensitivity for liquid level detection via pressure sensing
60	R/W	0～31	/	0	Pipetting anomaly detection (Reserve)
70	R/W	0～2000	/	10	Aspiration clot detection coefficient. The smaller this value is, the more sensitive the detection will be (Reserve)
71	R/W	0～2000	/	10	Aspiration foam detection coefficient. The smaller this value is, the more sensitive the detection will be (Reserve)
72	R/W	0～2000	/	10	Aspiration empty detection coefficient. The smaller this value is, the more sensitive the detection will be (Reserve)
73	R/W	0～2000	/	10	Dispensing clot detection coefficient. The smaller this value is, the more sensitive the detection will be (Reserve)
74	R/W	0～2000	/	10	Dispensing foam detection coefficient. The smaller this value is, the more sensitive the detection will be (Reserve)

85	R/W	0-111	/	0	Offset ID
110	R/W	1～1000	ms	5	Pressure sensor data buffering interval
111	R	0～5000	/	0	Buffered pressure sensor data count
112	R/W	0～1000	ms	100	Post-operation pressure data buffering duration
115	R/W	1～1000	ms	5	capacitive sensor data buffering interval
116	R	0～5000	/	0	Buffered capacitive sensor data count
117	R/W	0～1000	ms	100	Post-operation capacitive data buffering duration
120	R/W	0～1000	/	100	CLLD coefficient (Higher values increase sensitivity for CLLD)

12.2 Common Register

Table 12-2 Common Register

Register address	R/W	Data range	Unit	Default	Description
0	R	/	/	2097160	Device model information
1	W	0	/	/	Emergency stop
2	R/W	0～10000	ms	0	CAN heartbeat interval 0: Stop heartbeat; Other values: scheduled upload interval
3	W	123456	/	/	Firmware restart
4	R	/	/	/	Firmware version
5	R/W	0～1	/	1	CAN automatic reporting function 0: Disable automatic reporting function; 1: Enable automatic reporting function
7	R/W	100,125,250,500,1000	kbps	500	CAN baud rate
9	R	/	/	/	Device serial number, it is unique for each SP13 and serves as a distinct identifier

13 ※Troubleshooting

13.1 Common Problems and Solutions

Note: The following describes troubleshooting methods performed under required working environments and rated conditions. The fault classification retrieval table is as follows:

- Communication-related faults (Table 13-1)
- TIP-related faults (Table 13-2)
- Liquid level detection-related faults (Table 13-3)
- Pipetting accuracy and CV-related fault (Table 13-4)

Table 13-1 Communication Issues

Issues	Possible causes	Recommended solutions
The pipettor indicator light does not light up after power on	The FFC (Flexible Flat Cable) was not properly secured, leading to bending and eventual breakage at the connection point due to the pipettor vertical movements.	When shaking the FFC results in poor contact, consider replacing the FFC and ensure that the pressure plate is correctly securing the FFC soft ribbon cable. Refer to section 4.1.
	A short circuit between power lines	Use a multimeter to confirm whether the pipettor power supply is short-circuited. If a short circuit is detected, please send it back for repair.
	FFC connection incorrect	Refer to Section 3.2.
pipettor communication failure	Incorrect baud rate setting	The default CAN baud rate of the pipette is 500K. Please refer to Chapter 5 to test communication using the upper computer.
	The wiring sequence is incorrect.	Connect CAN_H and CAN_L of CAN correctly.
	Incompatible communication tool	Replace the CAN analyzer.
	Incorrect command format	Check the command format.
Unstable communication	Communication line noise	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 at 60 ohm.

Table 13-2 TIP Issues

Faults	Possible causes	Recommended solutions
Reagent dripping from TIP after aspiration	TIP is not securely attached	Rotate the TIP by hand to confirm whether it is properly installed. If it is not properly installed, please refer to Section 6.2.
	Gravity	1. Our air-tightness testing instrument can detect pressure leaks with a precision of up to the Pascal (Pa) level, and every pipettor undergoes strict testing before leaving the factory. 2. For air-tightness verification, we recommend conducting the test at room temperature by installing a clean, non-conductive 1000μL TIP without a filter. Aspirate 1000μL of pure water, let it sit for 30 seconds, and check that no liquid leakage occurs at the TIP to confirm normal operation. 3. During the process, ensure the TIP is securely attached and avoid inserting it too deeply into the liquid surface to prevent liquid from clinging to the outer wall of the TIP, which could lead to a failed test.
	Reagent type	Organic reagents or some solvents with certain substances added will leak faster than ordinary reagents. Trailing air gap improves reagent dripping fault to some extent.
	Reagent temperature	Higher temperature reagents may tend to drip or leak due to their own heat. Trailing air gap improves reagent dripping fault to some extent.
SP13 LED Indicator does not turn on after getting TIP	The TIP size is incompatible with the SP13 nozzle or shows inconsistent fit	For batch faults, it is recommended to change the TIP brand or use higher installation force (not exceeding 30N). For sporadic faults, possible TIP inconsistency may be addressed by switching to alternative TIP brands or applying increased insertion force during TIP pickup.
Repeated use of TIPs leads to poor accuracy and CV performance, with residual liquid observed on	TIPs are not reusable	TIP should not be reused as it negatively impacts aspiration and dispensing accuracy, CV, and liquid-level detection success rates.

the inner walls of the TIP		
TIP ejection failure	After executing the TIP ejection command, the TIP remains stuck on the nozzle	If it is a batch fault (TIP size mismatch), it is recommended to change the TIP brand. If it is an occasional fault (poor TIP consistency), it is also recommended to change the TIP brand.
	TIP ejection incomplete after executing eject command	Please refer to the section 6.2 and Install the TIP with a downforce of 28±2N not exceeding 1 second, and remove the TIP within the recommended downforce range.

Table 13-3 LLD Issues

Faults	Possible causes	Recommended solutions
Excessive TIP immersion depth after liquid level detection	Pipetting barrel flooded with water	After water intrusion, allow the device to air-dry naturally for 48 hours before testing if the liquid level detection function has resumed normal operation. If the fault persist, the device must be returned to the manufacturer for repair.
	The pipettor descends too rapidly when executing liquid level detection commands	Refer to Section 6.3"Liquid Level Detection" which specifies that the pipettor descent speed during liquid level detection should be controlled at ≤ 100mm/s, with 50mm/s recommended as the optimal rate.
The pipettor liquid level detection command completes execution before the TIP actually contacts the liquid surface	Pipetting barrel flooded with water	After water intrusion, allow the device to air-dry naturally for 48 hours before testing if the liquid level detection function has resumed normal operation. If the fault persist, the device must be returned to the manufacturer for repair.
	Reusing the TIP	Reusing TIP negatively impacts aspiration and dispensing accuracy, precision, and liquid level detection success rates, therefore TIP reusing is not recommended.
	The TIP filter quality is substandard with insufficient air permeability	To troubleshoot, try using TIP from a different brand or filter-free TIP for testing. If the fault is confirmed to be filter-related, either adjust the liquid level detection coefficient or switch to an alternative brand of TIP.
	The pipettor executes liquid level detection command after the TIP penetrates the liquid surface	The pipettor must execute the liquid level detection command while the TIP is in the air.

Table 13-4 Accuracy and CV Issues

Faults	Possible causes	Recommended solutions
The system shows CV values but fails to meet accuracy specificatio-ns	The system requires aspiration volume calibration	Refer to Section 6.6.2 to perform the corresponding aspiration calibration.
	incorrect aspiration/dispensing command parameter settings	refer to Section 0 to configure the appropriate aspiration/dispensing command parameter.
	Incorrect testing method	Refer to Section 6.6.1 and follow the recommended testing procedures to perform accuracy and CV measurements.
Incomplete dispensing with residual reagent in TIP	Insufficient or missing leading air gap	Under normal circumstances, a leading air gap of 30μL can be suitable for most scenarios. However, depending on the type of reagent and the remaining capacity of the pipettor, you may need to appropriately increase the leading air gap volume.
	Specific performance of the reagent	1. Some types of reagents have high viscosity and cannot be fully dispensed in one attempt. In such cases, the liquid can be emptied by dispensing slowly and repeatedly. 2. Some organic reagents may adhere to the inner walls of the TIP, and residual reagent inside the TIP may slowly flow out after dispensing.
	Unqualified TIP	Compare with TIP from other brands to observe if there is any residue. If the fault is determined to be caused by the TIP, consider replacing the TIP with one from a different brand.
both the CV and accuracy are not meeting the required standards	Aspiration without PLLD/CLLD	1. Perform liquid level detection before aspiration, or ensure the TIP penetration depth is ≤1mm below the liquid surface to avoid excessive immersion. 2. Implement aspiration following based on the actual liquid volume to prevent leading air gap during the process.
	Insufficient or missing leading air gap	Under normal circumstances, a leading air gap of 30μL can be suitable for most scenarios. However, depending on the type of reagent and the remaining capacity of the pipettor, you may need to appropriately increase the leading air gap volume.

	Incorrect testing method	Refer to Section 6.6.1 and follow the recommended testing procedures to perform accuracy and CV measurements.

13.2 Q & A

Q1: Why did SP13 work yesterday but suddenly stop working today? / Why can't SP13 communicate after connecting?

1. Check wiring and power supply.
2. Power off and measure the resistance between 24V and GND of this product. If the two poles are short-circuited, the device can be judged as a board damage. Contact us for further repairs.
3. Check the cable connection, serial port or CAN configuration
4. Refer to Chapter 5 and send commands to the correct address (default address: 1)
5. Please keep the resistance between CAN phases at 60 ohm and reduce the transmission distance as much as possible.

Q2: What should I do if the pipettor is flooded with water?

1. Stop using the pipettor immediately, dispense the water or reagents, let it air dry for 48 hours, then test the liquid level detection function.
2. Test whether the liquid level detection function is normal. If it is abnormal or an error occurs, send it back to the manufacturer for repair.

Q3: How to coordinate HSZ-axis with SP13 and implement liquid level detection?

1. When controlling the SP13 and HSZ-axis combination via host computer, the system can automatically detect HSZ-axis connection status upon device scanning.
2. To perform the operation, sequentially send the following commands with corresponding parameters: first execute the pipettor initialization command, then the HSZ-axis initialization command, followed by the HSZ-axis descent command, and finally the liquid level detection command.
3. HSZ-axis will auto-stop upon liquid surface detected.

Q4: How to Use the TIP Presence Detection Function?

1. Refer to Register 43 in Table 12-1 for detailed specifications.
2. When the TIP presence detection is enabled, attempting to execute aspiration,dispensing or liquid level detection commands without a properly attached TIP will trigger Error State 20.

Q5: Liquid level detection is not sensitive? / Liquid level detection is not possible? / Liquid level detection fails?

1. Water entering the device during debugging may cause functional failure.
2. Reusing TIP.
3. TIP with filter. Poor quality of filter element may affect the liquid level detection effect.

Q6: What is the difference between single dispensing and aliquot dispensing? / How to set the aspiration parameters?

1. For example, if the user intends to aspirate 100μL and then dispense the full 100μL into the target tube in a single aspiration and single dispensing operation, it is recommended to follow the suggested procedure:

aspirate air → aspirate reagent → dispense reagent. During this process, it is advised to use the default settings for the aspiration cut-off velocity, dispensing re-aspiration volume and dispensing cut-off velocity.

2. The user purpose is to aspirate 1000 μL of liquid and dispense 20 μL each time into different test tubes (up to 50 times) for single aspiration and aliquot dispensing. In this case, the aspiration volume and cut-off velocity must be set separately for the dispensing.

Q7: How to dispense the reagents completely?

1. Recommended process: Leading Air Gap 30 μL → aspirate 20 μL → dispense 50 μL (There is no fixed value for this aspirate volume, it is just a recommended process, and the user can adjust it within the maximum stroke range).
2. The 0x4003 command can be used to achieve emptying.
3. Increasing the dispensing velocity appropriately can indeed help in fully emptying the TIP.

Q8: Why can't the TIP be ejected, or why is a specific command not being executed??

1. Confirm whether the command is sent successfully and whether the device receives it successfully.
2. Confirm the device return information and status, whether it reports an error or the LED flashes.
3. Communication is recommended to be one question and one response. After receiving the command response, the next frame is sent.

Q9: Is there a DEMO library?

1. Currently, reference source code for STM32 microcontrollers and C/C# upper computer (host software) can be provided.

Q10: How to ensure that every command is received successfully?

1. KT_CAN_DIC command serial number response and sending one-to-one correspondence.
2. Each command can only send the next frame after waiting for a response. If there is no response after a timeout, the command will be resent.

Q11: How to judge whether the action is completed? / Can the flag be reported when the action is completed?

1. The status of the device in action is 1 (busy), and the device action completion status is 0 (idle)
2. The KT_CAN_DIC heartbeat return status switches from 1 (busy) to 0 (idle)
3. Active reporting of action completion.

Q12: Why do parameters revert to original values after reboot when set via host computer software?

1.
2. 1. Steps for setting parameters refer to Section 5.6 Register Description (system parameters should not be modified casually).
3. If using a switched-mode power supply, ensure complete power disconnection before reboot.

4. Some parameters do not support being saved after a power loss.

Q13: What to do when the device reports an error?

Record the status and current execution process reported by the device when the error occurs. If the following solutions do not provide effective assistance, please contact us. Here are some common fault scenarios and their corresponding resolution measures::

1. Error status 10-15 (DEC): Check parameter case and parameter writable range.
2. Error status 17: Initialize the device before controlling its movements.
3. Error status 20: Enable the alarm function via user register 43. When an aspiration,dispensing or liquid level detection command is sent without a TIP being detected, this error will be reported..
4. Error Status 22: When performing liquid level detection, if the pipettor fails to detect the liquid surface within the specified time, this error will be reported. Ensure that the pipettor descending movement allows the TIP to make contact with the reagent.
5. Error Status 50-64: It is recommended to contact us for assistance in resolving these issues.

Q14: How to test the leakage of the pipettor?

1. Our air-tightness testing instrument can detect gas leaks with a precision down to the pascal (Pa) level.
2. Convenient test method: At room temperature, with the pipettor in standby mode, install a clean, non-conductive 1000 μL TIP without a filter. Aspirate 1000 μL of pure water, then let it sit undisturbed for 30 seconds. After this period, check if there is any liquid leaking from the tip of the TIP.
3. Note: During the testing process, ensure that the TIP is securely attached to the pipettor to guarantee a proper seal and prevent leaks. Additionally, when aspirating liquid, avoid inserting the TIP too deeply into the liquid surface. Inserting the TIP too deeply can cause liquid to cling to the outer wall of the TIP, which may lead to a detection failure..
4. Note: Leakage of organic reagents such as ethanol is considered a normal phenomenon.

Q15: What is the function of CAN termination resistor?

1. Without termination resistors, the bus is prone to self-oscillation, which can lead to unreliable communication and potential data corruption. Adding termination resistors can significantly improve the reliability and stability of communication by preventing signal reflections that cause such oscillations.

14 Environmental Conditions

Item	Unit	Value
Operating environmental temperature	℃	+15℃～+35℃
Operating environmental humidity	RH%	40%～80%
Storage temperature	℃	-20℃～+55℃
Storage humidity	RH%	40%～80%

15 Safety Precautions

For the personal safety of you and other users, please read the safety precautions carefully.

This user manual uses the following symbols. Please fully understand their meanings before continuing to read.

WARNING	Any content with this mark, related to the safe use of the product and the user safety, must strictly follow the requirements of the operation, otherwise, it may cause damage to the product or endanger the user 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 cable, motor cable, optocoupler cable or valve power cable, otherwise, it will cause communication or other parts to fail.		If there is a long-term non-use of the hole please use the matching plug, otherwise, may cause impurities and airflow into the valve body and affect normal use.
	It is forbidden to disassemble the valve or adjust any parameters by yourself, otherwise, the valve may not work properly.		

WARNING			
	Do not disassemble Do not disassemble, repair or modify the product by yourself, otherwise, it may cause fire or electric shock.		Avoid use in wet environments Moisture may cause 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.

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