Kewell

Stock Code: 688551

C100 FUEL CELL TEST SYSTEM

for Testing Single Cells

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KEWELL TECHNOLOGY CO., LTD.

www.kewelltest.com

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1. Product Overview

The C100-G fuel cell test system is developed to provide a test platform with high precision and high stability for fuel cells and related materials. It is applicable to testing proton exchange membranes, catalysts, binders and size formulas, screening diffusion layers and formulas and coating formulas, and verifying polar plate structure design; it also supports full cell test, lifetime test, dynamic condition test, catalyst poison resistance test (optional), etc. It can also conduct electrochemical tests including IV test (current sweep, voltage sweep), CV test (optional), LSV test (optional), and EIS (optional). In terms of hardware, the system is composed of a desktop host and an integrated accessory module. The host consists of a gas flow control module, a humidifying module, a gas heating module, a back pressure module, as well as some valves and sensors. The integrated accessory module consists of load, computer, and electrochemical module (optional). The system realizes basic test capabilities, automatic steps, 24h unattended operation and other functions through software and algorithm integration.

Product Appearance

2. Product Features

- Automatic wide range and high precision control and acquisition of gas flow (0.8%Rdg + 0.2%F.S.), temperature (RT+5~95℃, ±1℃), dew point (RT+5~90℃, ±1℃), and pressure (15kPa~300kPa, ±2kPa).

- Support sensitivity, performance (polarization curve, power curve), durability, and anti-reverse polarity tests.

- The electronic load is able to operate in Quadrant I and Quadrant IV, -2.5V@120A.

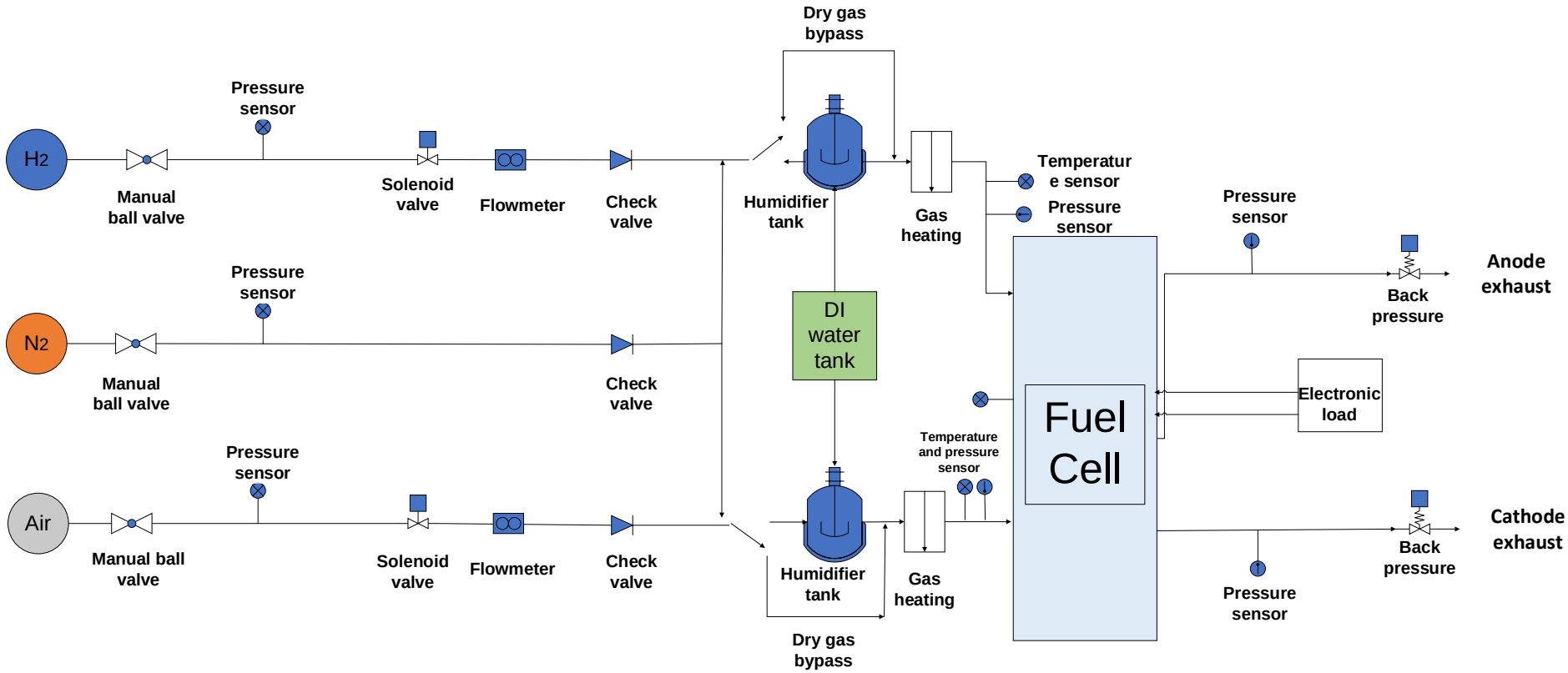
- Simultaneous data storage across 8 channels, multi-axis graphics and real-time tracking cursor (in curves only), custom script programming.

- Specialized fixtures for various specifications of fuel cells, such as 5cm² and 25cm².

- Support various electrochemical test methods, EIS/CV/LSV, etc.

3. System Composition

The schematic diagram of the fuel cell test system is shown below:



Schematic diagram (subject to actual design)

The system contains anode gas supply unit, cathode gas supply unit, nitrogen supply unit, sampling and control unit, HMI unit, safety protection unit, electronic load, etc. The anode/cathode gas supply unit consists of flow control, gas humidification, temperature control and back pressure control parts.

1) Anode/Cathode Gas Supply Unit

Pursuant to the electrochemical reaction of the fuel cell and parameters like flow, temperature, pressure, and humidity required for the anode and cathode reaction gases, the gas supply unit is correspondingly divided into the flow control, gas humidification, temperature control and back pressure control parts. The cathode/anode gas pressure tracking function is also available.

The reactant gases are then sent into the membrane electrode under test through the mass flow control unit, humidification unit, and heating unit. Among them, the humidification unit achieves fine humidity control by bubbling; the humidification unit can precisely control dew point temperature; and the heating unit can effectively control the temperature of the reactant gas that enters the membrane electrode.

The excess reactant gas is then discharged through the back pressure control unit. The back pressure control unit contains the back pressure regulating valve and solenoid valve, and it can control the flow and pressure through the back pressure regulating valve and the mass flow controller (MFC).

The hydrogen and air are vented separately.

A dry gas bypass is designed for the hydrogen and air supply circuits respectively, so as to meet the test requirements of various operating conditions.

2) Nitrogen Supply Unit

It is mainly used for testing the nitrogen purging of the cathode/anode before and after the test, and as the air source for pneumatic components inside the equipment.

3) Sampling and Control Unit

It collects each monitoring value of the system and controls the functional operation of the system. The unit contains the controller module, digital/signal acquisition module, digital/signal output control module, communication data exchange module, etc.

4) Sensing and Transducing Unit

To guarantee the high-precision control, stability and reliability of the entire test system, all sensors used are from internationally renowned brands, and a signal conditioning unit is introduced to the sensors, transmitters and the acquisition system. All sensors adopt two-wire current signal output, and the shielding layer is safely grounded at the signal source access to protect the sensing signal from external interference.

5) HMI Unit

The system is equipped with Kewell's self-developed software with functions such as parameter display and setting, automatic step, data storage, and graphical display. The system communication is realized through Ethernet and switch, allowing the test system to be operated remotely from the background. Moreover, Ethernet boasts excellent anti-interference performance.

6) Safety Protection Unit

The test system has an all-around safety protection logic. The software implements three-level fault protection control logic: level 1: alarm prompt; level 2: load shed and shutdown; when a level 3 fault occurs, it will stop immediately. Safety protection both ensures the safety of the test system and protects the DUT.

4. System Functions

4.1 Test Function

According to the requirements of GB/T20042.5-2009, T/CAAMTB 12-2020,US DOE, Japanese JIS C8832. and other standards, the system supports the following test items:

- Fuel cell polarization curve test
- Fuel cell sensitivity test
- Monitoring and analyzing the operating characteristics and consistency of each fuel cell
- Fuel cell start-up performance test
- Fuel cell steady-state operation test
- Fuel cell dynamic operation test
- Fuel cell activation test
- Fuel cell durability test
- Fuel cell system insulation test
- Real-time monitoring and alarm

4.2 Technical Parameters

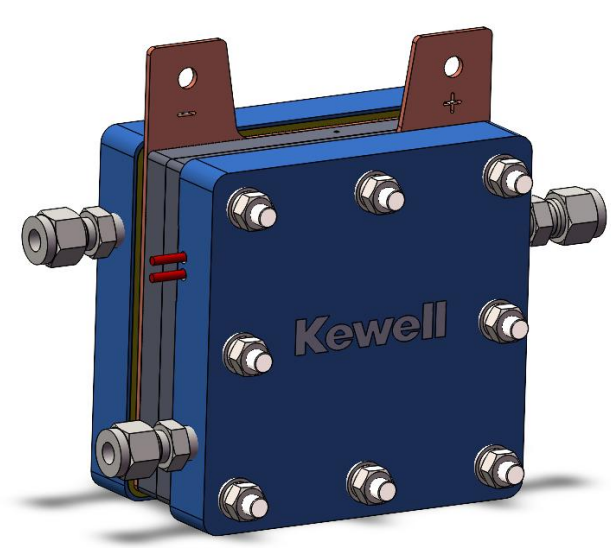
Type		Parameter
Applicable power range		5W-100W (For low power, the minimum air volume requirement must be met simultaneously)
Gas flow control	Anode flow measurement range	0.04-2 NLPM
	Cathode flow measurement range	0.1-5 NLPM
	Flow control accuracy	±(0.8%Rdg+0.2%F.S.)
	Nitrogen purging	Support nitrogen purging before and after testing, as well as nitrogen protection.
Gas pressure control	Back pressure control range	(Stack resistance + 15) kPa~300kPa.g
	Back pressure control accuracy	±2kPa (steady state)
Gas humidification control	Humidification method	Bubbling
	Dew point temperature range	RT+5℃~90℃
	Dew point temperature control accuracy	±1℃ (steady-state)

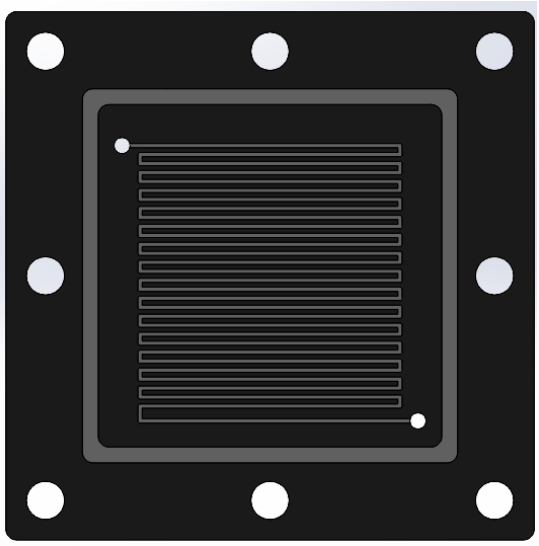
Dry gas bypass	Dry gas bypass	Available
Temperature control	Temperature control range	RT + 5℃~95℃
	Temperature control method	PID control
	Temperature control accuracy	±1℃ (steady-state)
Protection functions	Hardware protection	Emergency stop switch;
	Software protection	Over-temperature protection, over-voltage protection, under-voltage protection, electronic load fault protection, etc.
Electronic load	Max. power	600W
	Voltage range	-2.5V~12.5V
	Current range	0 ~ 120A
	Operating mode	Constant voltage, constant current, constant power, and programmable automatic operation
	Current accuracy	±(0.1%+0.1%F.S.)
	Voltage accuracy	0.05%+0.1%F.S.
	Anti-reverse polarity test	Available
Operating environment	Power distribution	220V, 50Hz, 0-45℃, 0-90%RH
Optional functions	Anode-cathode gas mixing function	Customizable according to type of gas
	Single-cell fixtures	Provide a set of fuel cell single-cell fixtures of certain specifications (such as 5cm2, 25cm2)
	Electrochemical workstation	Support software integration with the customer's electrochemical workstation (open communication protocol) or direct acquisition integration.

Optional:

1) Anode-cathode gas mixing function: The software enables switching between different gases to ensure uniform gas mixing. Equipped with MFC, it can achieve controllable mixing of hydrogen and nitrogen gases in any desired ratio. **The type of gases and the flow rates for the anode and cathode mixing need to be specified**.

2) Fuel cell fixtures: Currently, Kewell offers test fixtures in sizes of 5cm2 and 25cm2. The specific parameters and features are as follows:

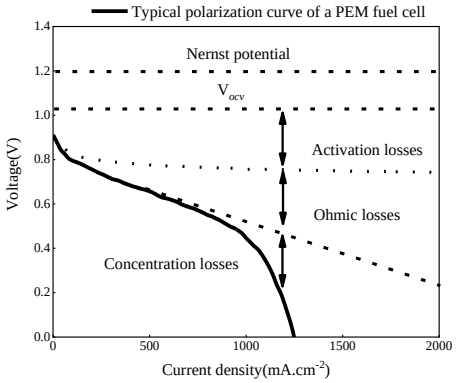




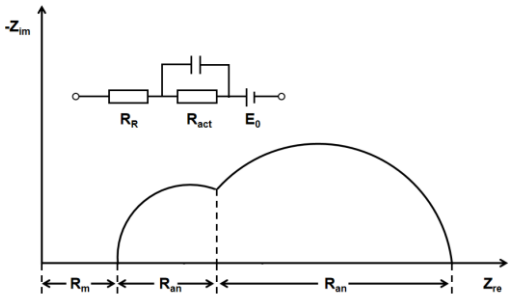
Advantages of the fuel cell fixtures: The conventional unidirectional serpentine fixture scheme can achieve higher single-cell performance through the optimization of the groove-ridge width ratio of the flow field. Besides, fixtures of 5cm2 and 25cm2 are completely the same except for the carbon plate. This is achieved by designing a reasonable sealing structure on the back of the carbon plate.

Type	Fuel cell fixtures	
Effective area/cm2	5	25
Flow field model	Single-channel serpentine flow field	
Flow field material	Both the cathode and anode: graphite, with sealing grooves around the flow field.	
Diffusion layer	None	
Current collector plate	Copper plate with gold plating	
End plate	Aluminum with anodized surface	
Internal seal	O-ring	
Water and gas inlet/outlet	End plate, cathode inlet and outlet, anode inlet and outlet, NPT 1/4" compression fitting	
Electric heating	220V electric heating rod, 4 x 20W/rod	
Pressure resistance	≤300kPa	
Voltage acquisition	At current collector plate wiring	

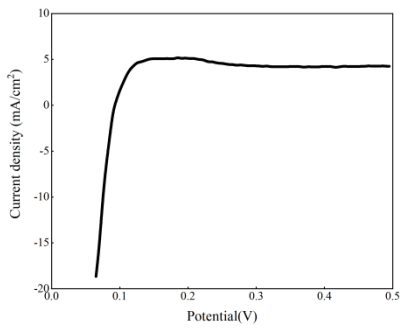
1) Electrochemical workstation: **The software can integrate customers' electrochemical workstations (with open communication protocols) or purchased one separately** to achieve electrochemical-related tests such as CV, EIS, LSV tests. The default brand is a domestic brand, but customer-specified brands are also acceptable.



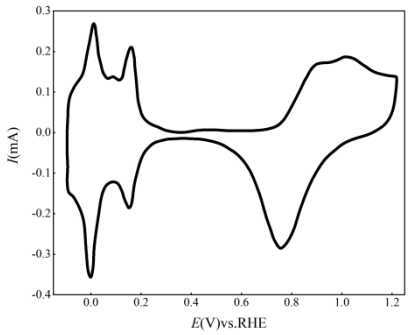
Polarization curve test



EIS test



Cyclic voltammetry measurement of fuel cell active area



Linear scanning of hydrogen permeation current density

4.3 Data Acquisition

During the testing process, the test bench supports background data logging and test data logging. The optimized data logging frequency is 1Hz, and the test data logging frequency is related to the test parameters. The test bench records include but are not limited to the following parameters (the parameter No. may be adjusted in the actual operation):

No.	Test point	No.	Test point
1	Time	15	Cathode humidification level
2	Current	16	Cathode inlet temperature
3	Current density	13	Anode inlet temperature
4	Voltage	14	Cathode humidifier tank temperature
5	Power	15	Anode source pressure

6	Power density	16	Anode inlet pressure
7	Anode gas volume	17	Anode outlet pressure
8	Anode stoichiometric ratio	18	Cathode source pressure
9	Cathode gas volume	19	Cathode inlet pressure
10	Cathode stoichiometric ratio	20	Cathode outlet pressure
11	Anode humidifier tank temperature	21	Cell temperature
12	Anode humidification level		

4.4 Design Accuracy

No.	Name	Accuracy
1	Gas flow controller	±(0.8%Rdg+0.2%F.S.)
2	Temperature sensor	≤±0.5℃
3	Pressure sensor	≤±0.5%F.S.*

*: Reference temperature is 25℃.

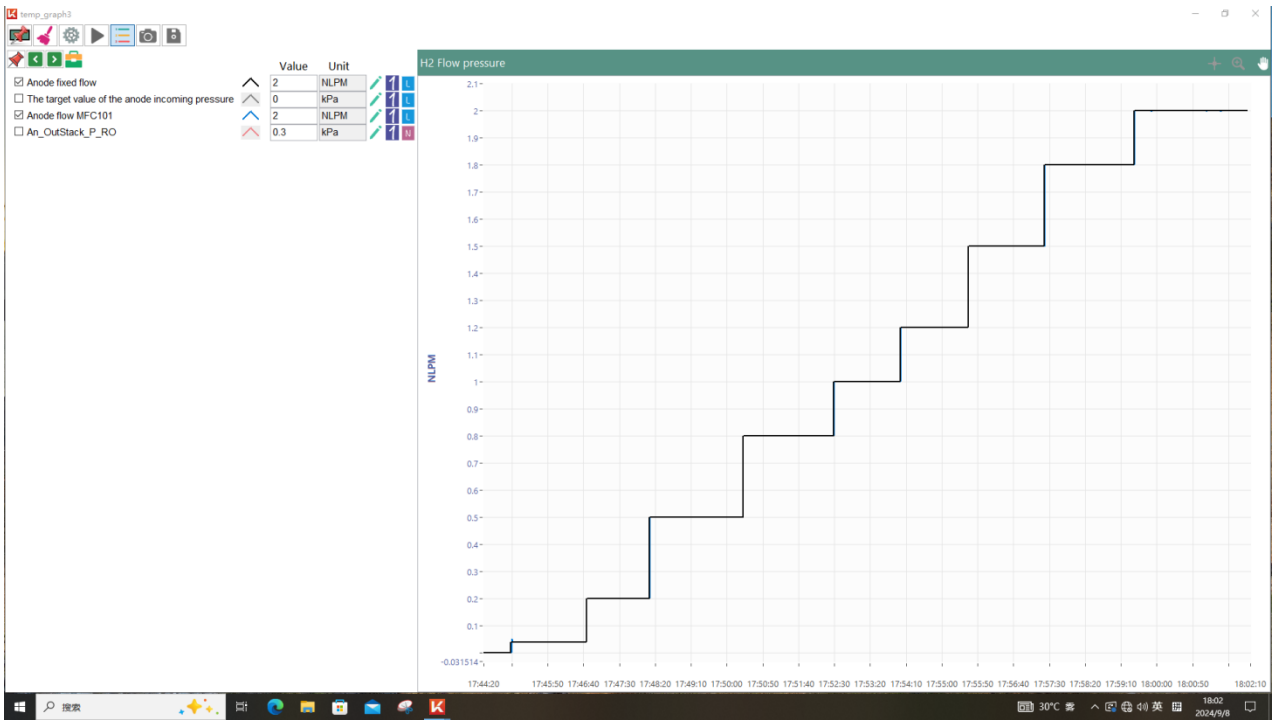
4.5 Brands of Key Components

Name	Description	Brands
Solenoid / Pneumatic valve	Control the output of hydrogen and air	ASCO, CKD or equivalent brands
Check valve	Control the one-way output of hydrogen, nitrogen and air	FITOK or equivalent brands
Flow controller	Detect the output flow of hydrogen and air	Alicat or equivalent brands
Pressure sensor	Test the pressure of hydrogen, nitrogen and air	Wika/Ashcroft, GEMS or equivalent brands
Temperature sensor	Detect the dew point temperature and inlet temperature of hydrogen and air	Wika/Ashcroft, GEMS or equivalent brands
Heating and humidification module	Control the temperature and humidity of air and hydrogen by bubbling	Kewell
Back pressure control module	Control the pressure of hydrogen and air circuits	Equilibar or equivalent brands

Note: If affected by uncontrolled factors, you may choose an equivalent brand upon agreement of the customer.

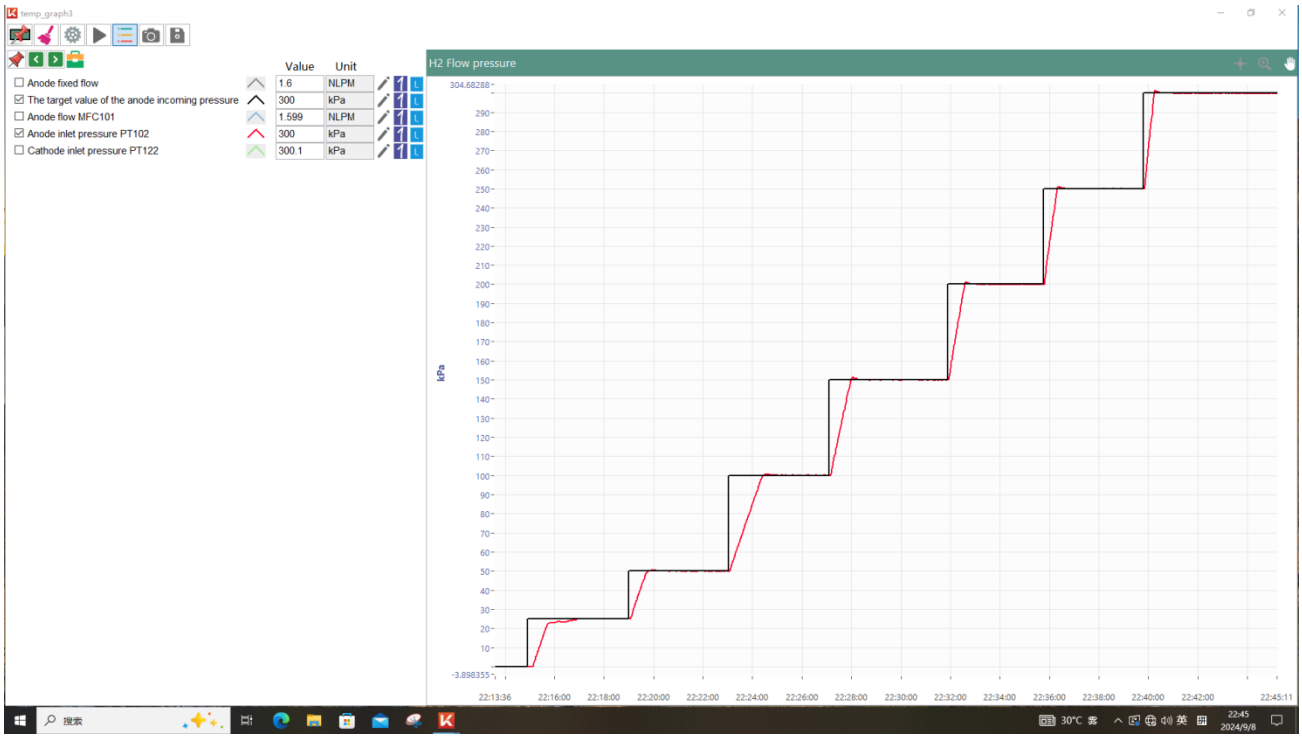
4.6 Measured Data

4.6.1 Cathode and Anode Flow Control



Cathode and anode flow control ±(0.8%Rdg+0.2%F.S.)

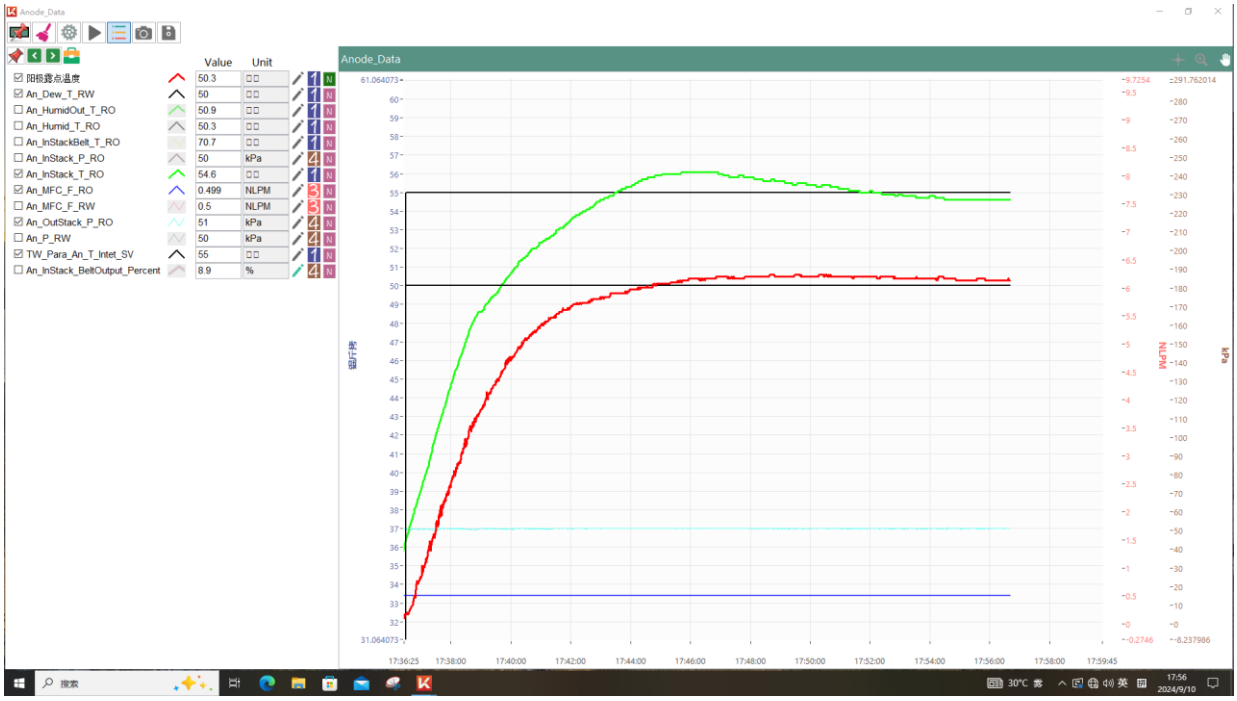
4.6.2 Cathode and Anode Gas Pressure Control



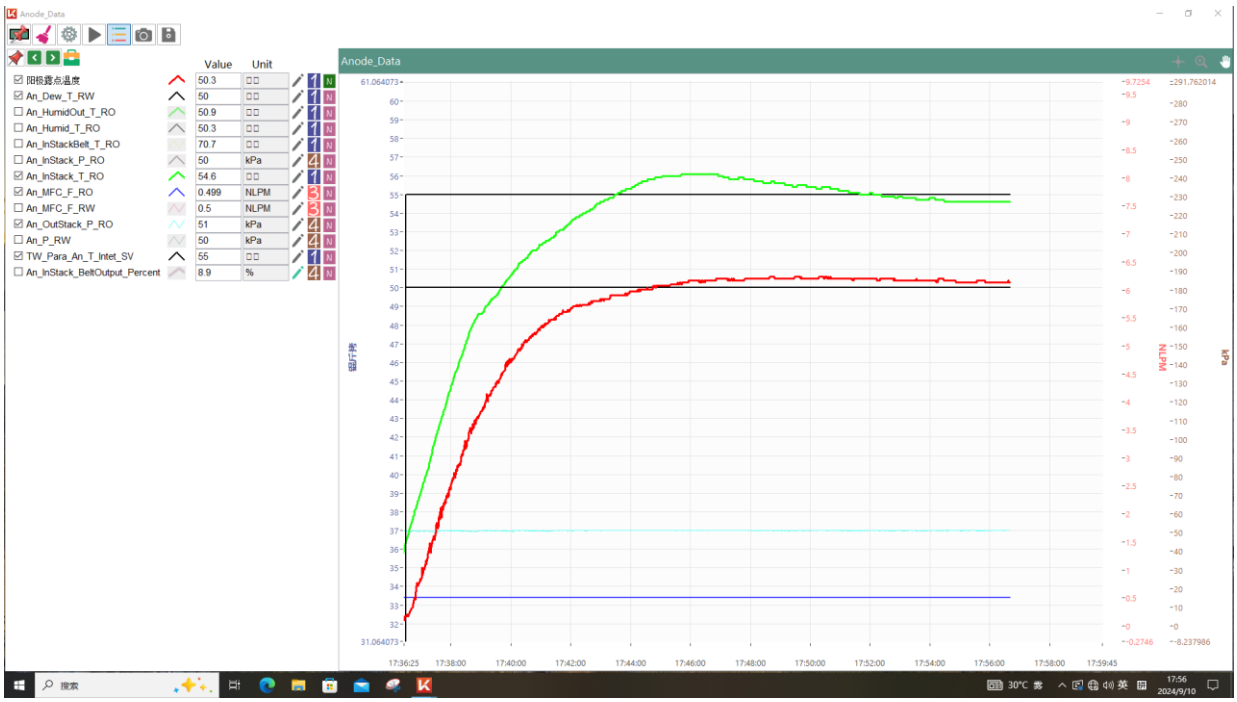
Cathode and anode pressure control 0~300kPa, ±2kPa

4.6.3 Variable Operating Condition Control

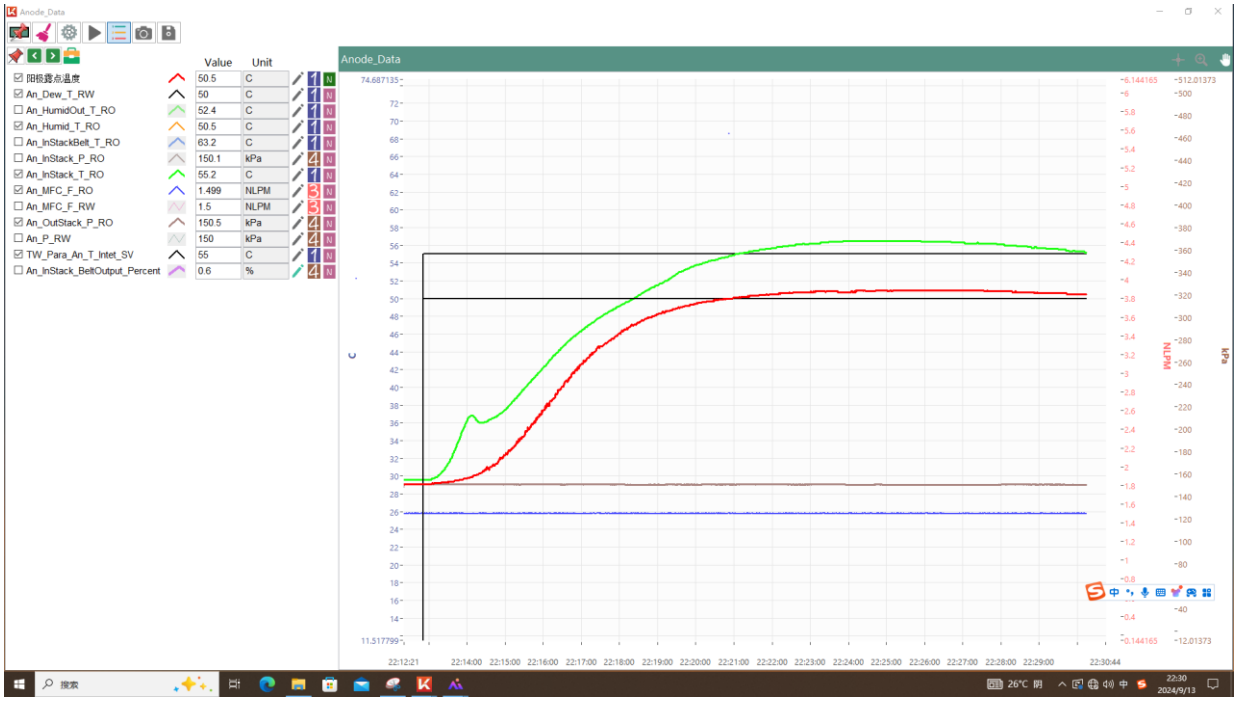
➢ Dew point temperature is 50℃, back pressure is 50Kpa, anode flow is 0.5NLPM, anode inlet temperature is 55℃



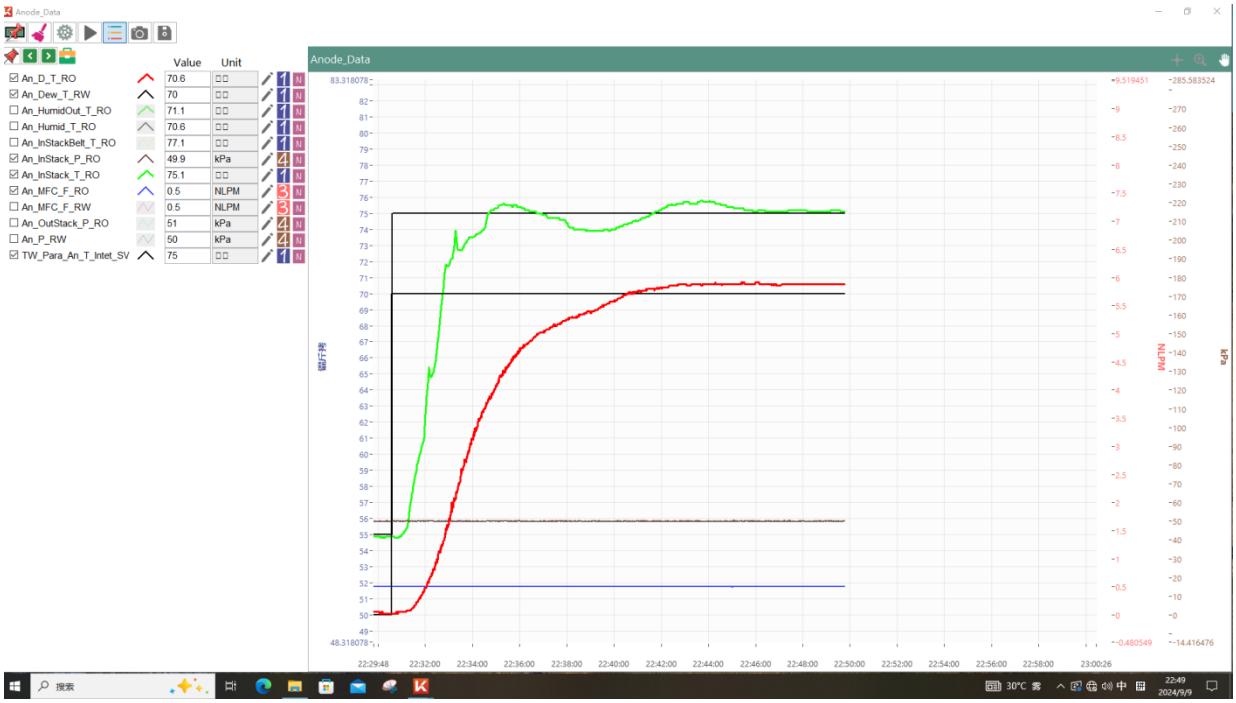
➢ Dew point temperature is 50℃, back pressure is 100Kpa, anode flow is 1NLPM, anode inlet temperature is 55℃



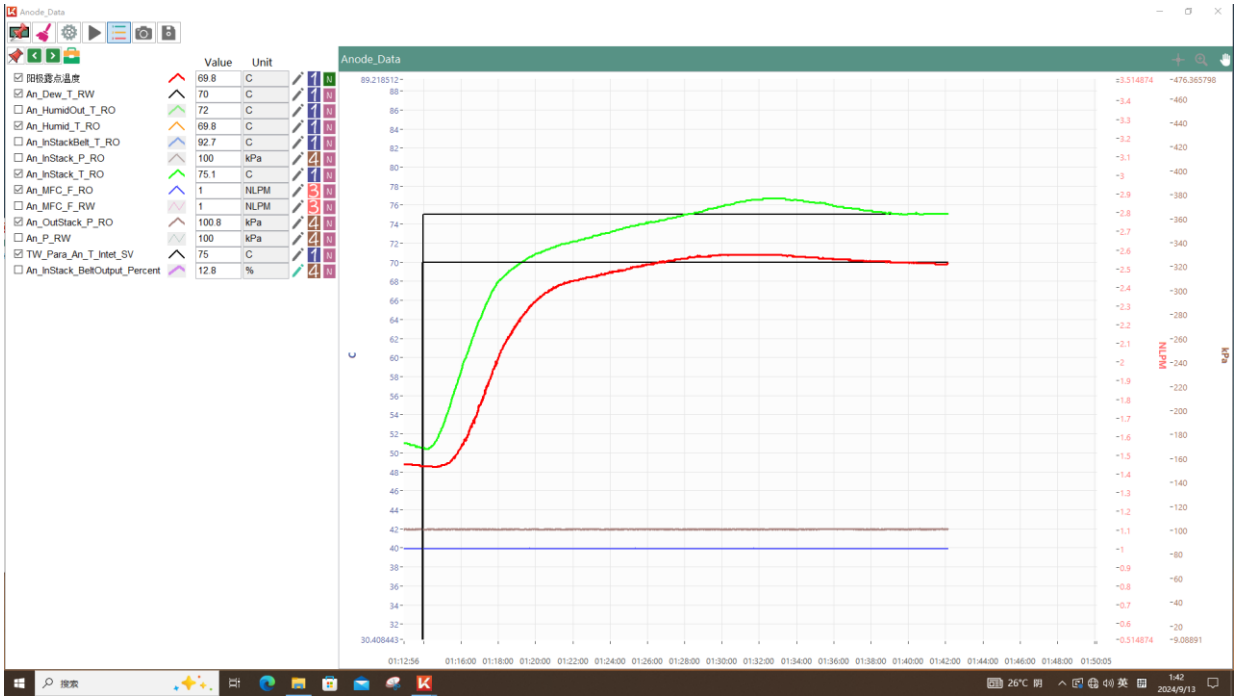
➢ Dew point temperature is 50℃, back pressure is 150Kpa, anode flow is 1.5NLPM, anode inlet temperature is 55℃



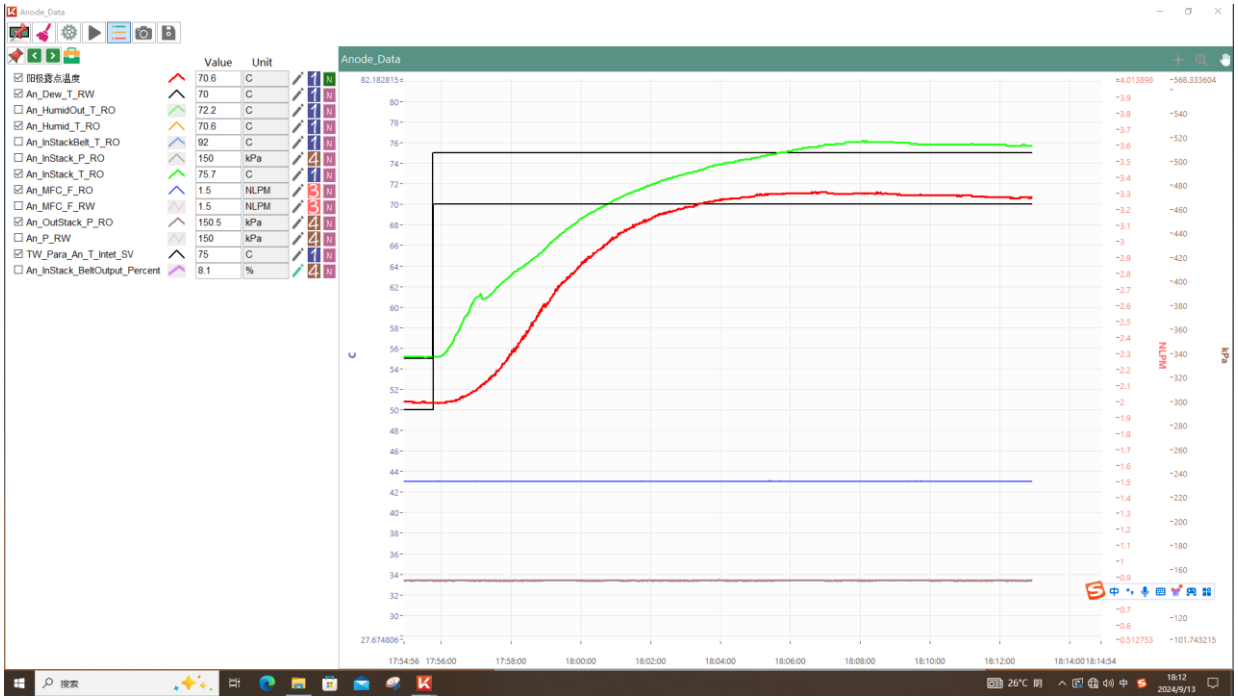
➢ Dew point temperature is 70℃, back pressure is 50Kpa, anode flow is 0.5NLPM, anode inlet temperature 75℃



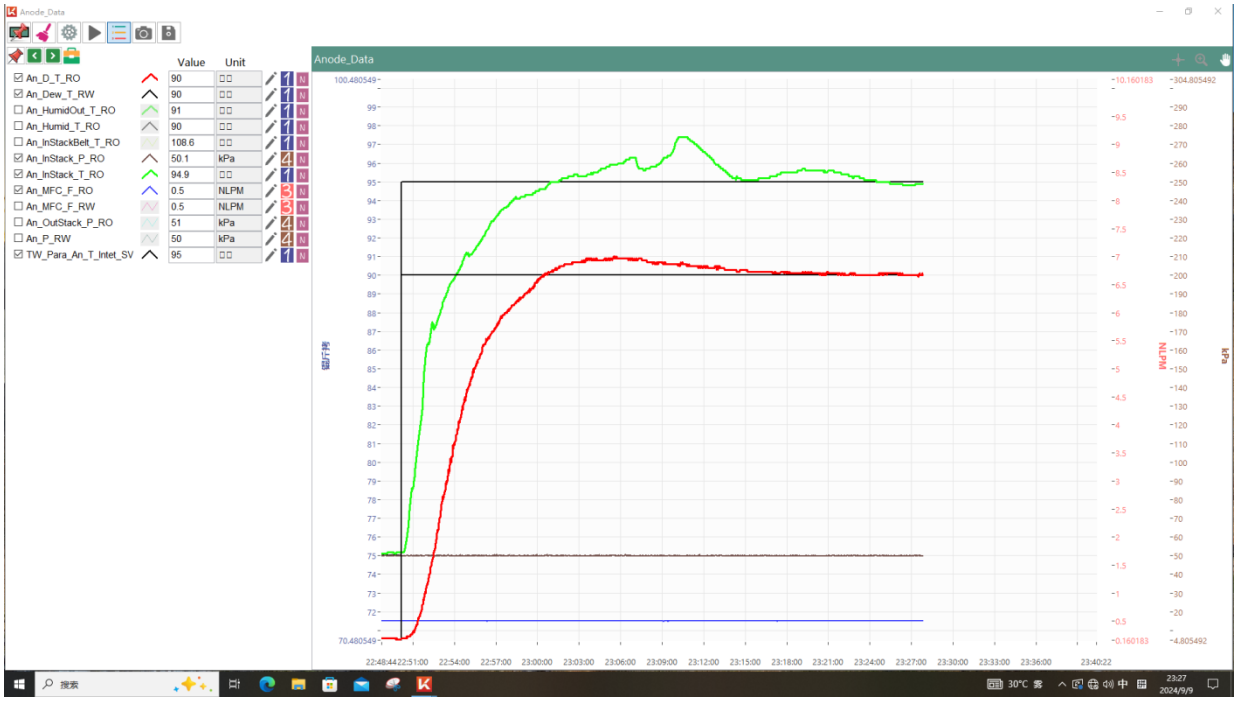
➢ Dew point is 70℃, back pressure is 100Kpa， anode flow is 1NLPM, anode inlet temperature 75℃



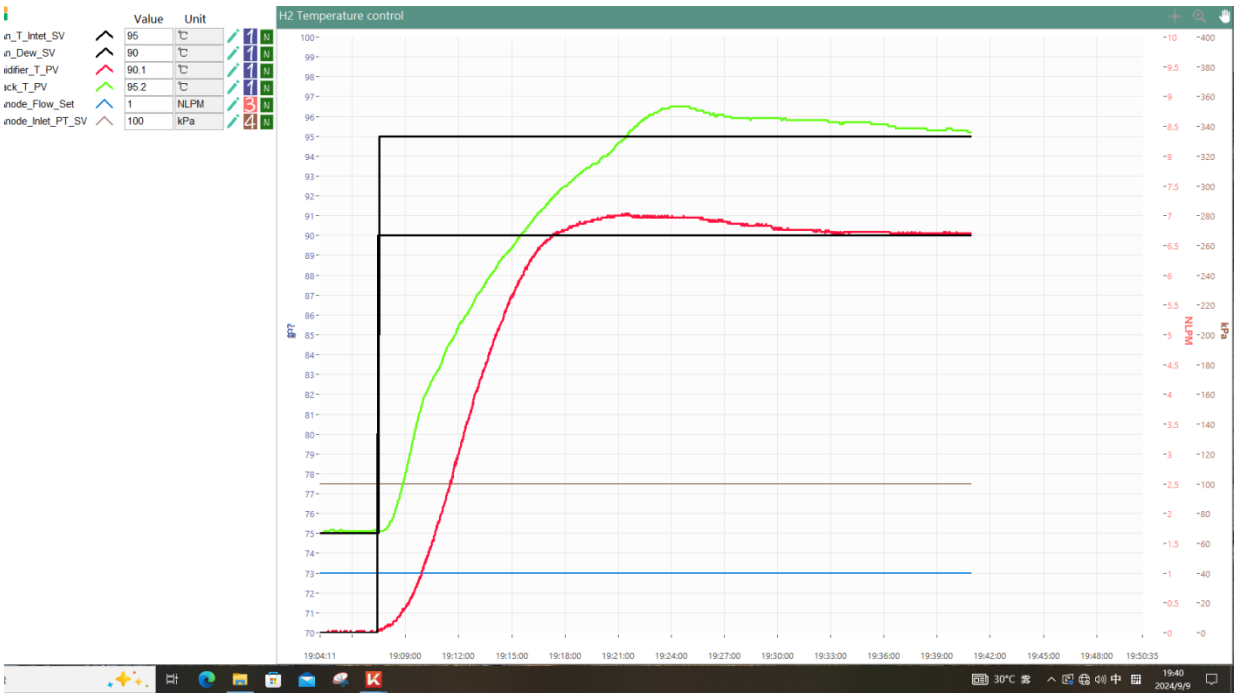
➢ Dew point temperature is 70℃, back pressure is 150Kpa, anode flow is 1.5NLPM, anode inlet temperature is 75℃



➢ Dew point temperature is 90℃, back pressure is 50Kpa, anode flow is 0.5NLPM, anode inlet temperature is 95℃

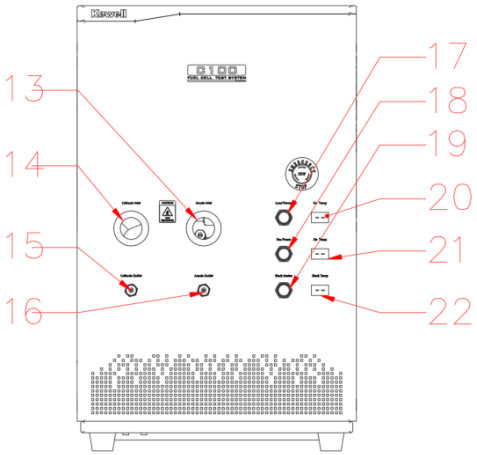


➢ Dew point temperature is 90℃, back pressure is 100Kpa, anode flow is 1NLPM, anode inlet temperature is 95℃

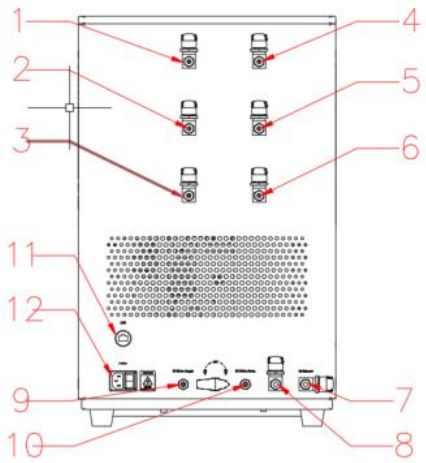


4.7 External Dimensions

The dimensions of the test bench are 385mm in length, 555mm in width, and 615mm in height. The electronic load and electrochemical workstation are both set up externally. The diagram below shows the test bench interfaces:



Front view of the test bench



Rear view of the test bench

Number	Interface Name	Instructions
1	O2 Supply	1-4 Tube Fittings
2	H2 Supply	1-4 Tube Fittings
3	N2 Supply	1-4 Tube Fittings
4	Air Supply	1-4 Tube Fittings
5	Cathode Mix	1-4 Tube Fittings
6	Anode Mix	1-4 Tube Fittings
7	Air Exhaust	1-4 Tube Fittings
8	H2 Exhaust	1-4 Tube Fittings
9	DI Water Supply	1-4 Tube Fittings
10	DI Water Drain	1-4 Tube Fittings
11	LAN	——
12	Power	——
13	Anode Inlet	1-4 Tube
14	Cathode Inlet	1-4 Tube
15	Cathode Outlet	1-4 Tube Fittings
16	Anode Outlet	1-4 Tube Fittings
17	Load Power	4-Pin Aviation Plug
18	Fan Power	4-Pin Aviation Plug
19	Cell Heater	4-Pin Aviation Plug
20	Anode Temp	2-Pin Plug
21	Cathode Temp	2-Pin Plug
22	Cell Temp	2-Pin Plug

5. Software

5.1 Software Introduction

1) Operating system

The software of this test system is applicable to platforms such as Microsoft Windows (Windows7, Windows8, Windows10, etc.). The standard configuration of the upper computer software is I5 processor, 8G RAM, 1T HDD, WIN10 system, dual-screen monitor and regular mouse and keyboard set. The software is equipped with Office operating software.

2) Registration

The first installation and use of this software requires registration, which is completed before leaving the factory. Provided that you need to install the software on other computers, please send the machine code of the computer to Kewell, and we will return the machine serial number.

3) User privileges

There are three levels of user privileges:

- Admin: it has all software operation permissions and can add or delete other users.
- Tester: it has battery test step editing and other operation permissions in the software but cannot modify software parameter settings.
- Guest: It has permissions to basic test operations in the software (such as importing step file), but cannot modify the content of step test.

5.2 Software Functions

Function/Mode	Description
User management	There are three levels of user permissions, defined as: 1-admin, 2-tester, 3-guest. Users of each permission level can make configurations to the extent of their current user permissions.
Tag system	TestWell adopts a "tag" system, which manages all parameters in the system, including measurements, controls, calculations, and user input values. Each parameter is assigned a unique tag name, and all tags are managed through a tag database. The tag system connects all functional modules and gives one module the ability to control another (for example, when running a script, the script can be used to initiate a device connection or bring up a user-defined interface).

Script compiler and script runner	The script compiler and runner are applied to multiple modules, including the real-time formula module, the safety alarm module, the test script module, and the test status module. Users can use it to customize control processes and respond to changes in the system in real-time and at high speed. Other modules achieve real-time formula calculation, safety alarms, and other functions through different operation mechanisms.
Custom interface	The user-defined interface module gives TestWell greater flexibility in use, enabling it to control and present the entire testing process through the reading and writing of tags.
Data graphics	The custom interface graphics supports user-defined curve content and curve formats, enabling real-time display of bar charts, time series charts, X-Y plots, etc. When paired with "real-time formulas," it allows for flexible definition of data presentation methods for various scenarios.
Alarm	Based on the alarm judgment of the process control system, alarm prompts and alarm content are displayed at relevant locations on the process screen.
Storage module	The storage module contains multiple test schemes, and users can also add their own storage schemes within it. It provides flexible support in response to variable data needs.
Real-time formula	Real-time formula supports calculation for real-time change of the tags. It can be triggered by the change of tags which are self-variables of the formula, to calculate their real-time change. It also supports multiple operational signs, achieving high-speed and accurate calculations.
Safety alarm module	The system has already included corresponding safety configuration files, which users can refer to and edit according to new needs, providing more detailed safety protection for the test system to be connected. The admin can set three-level alarm thresholds on the software to monitor hardware and take action/warn testers.
Component module	The component module provides PID control capability and can create multiple groups of PID for a single control variable, with each PID differentiated by conditions to achieve more flexible PID control.
Automatic step module	Support user-defined scripts as steps for testing, step execution supporting loops, branches, and feedback on the execution process during the process

The main functions of the software are as follows:

1) Tag system: Tags are the core of using this software. The I/O tag library contains all the available input/output tags in the system. It also includes system tags representing the start and stop of various operational modules. Users can control the start and stop of these modules using scripts (such as starting a device driver to establish a connection with the device). In the tag management interface, the tag sets visible with the current permission level of the user will be displayed (as shown in the following figure "full set of tags").

2) Customizable charts, allowing users to define numerous graphical combinations, where each combination can utilize multiple tags at the same time. The divisible graphics can be split into multiple graphs, and users can customize their position on the screen.

3) Script customization using a mature logic control language. The equipment comes with dedicated script editing software with complete programming capabilities.

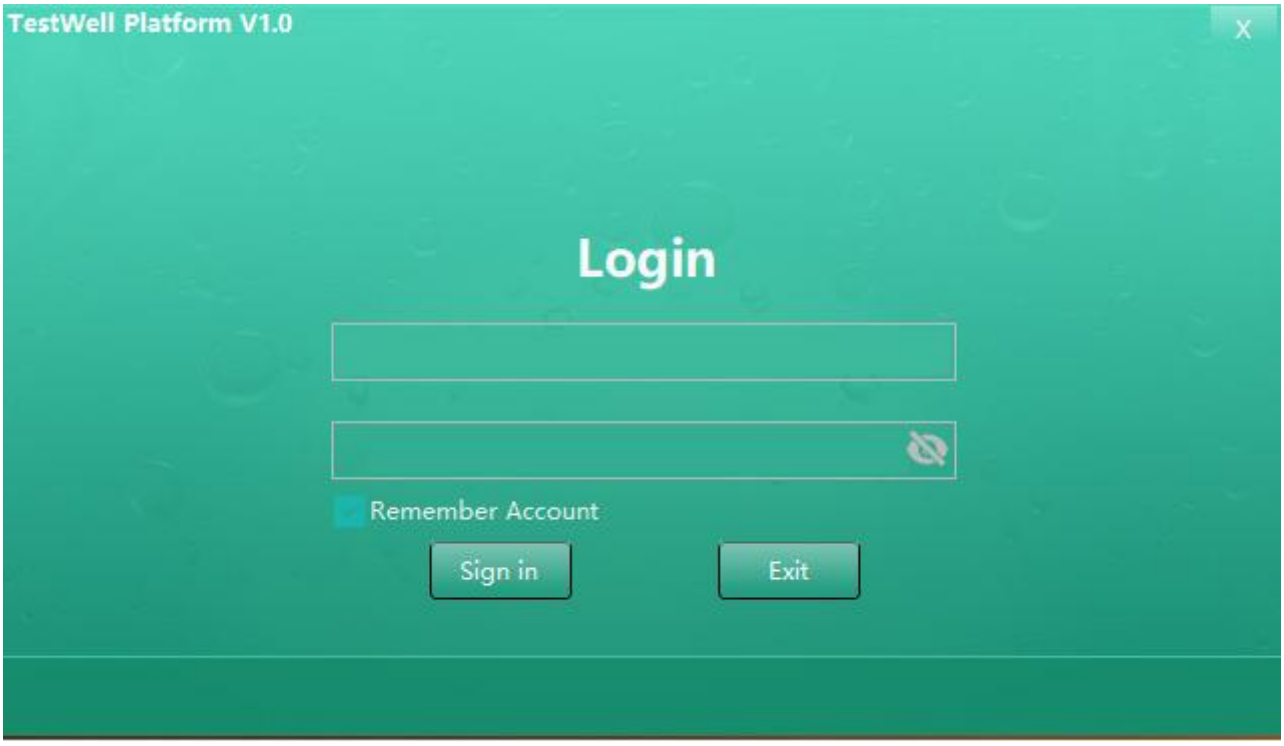
4) Function allows users to create mathematical equations and perform basic function operations. It supports user-defined equations and statistical calculations. Through customizable equations and automated scripts users can monitor the defined calculation variables in real-time and set alarm conditions based on these variables.

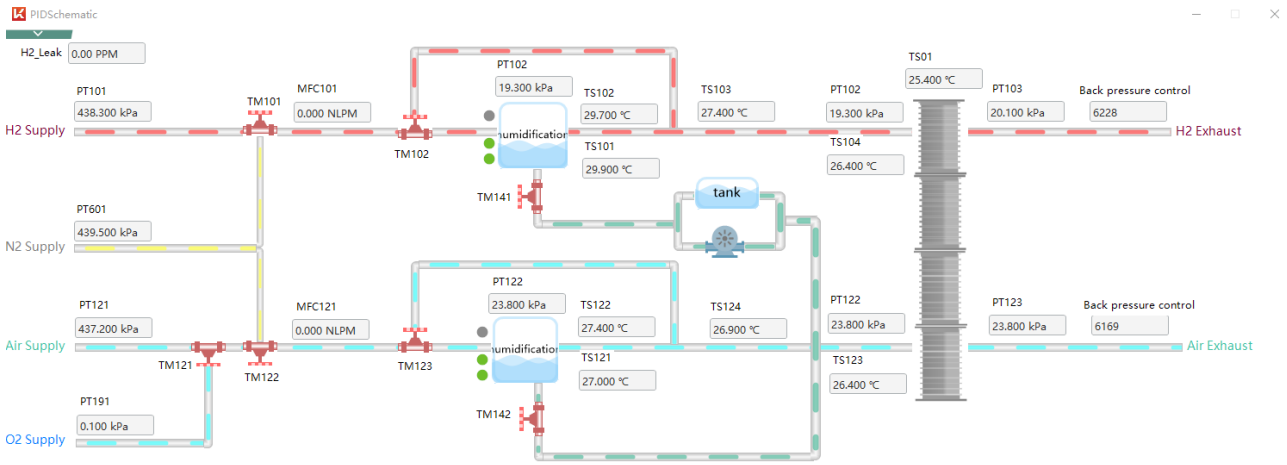
5) Independent data loggers, up to 8 separate sets of data logs can be executed simultaneously. Each data logger can log an unlimited amount of data and can be automatically turned ON/OFF through automated script files.

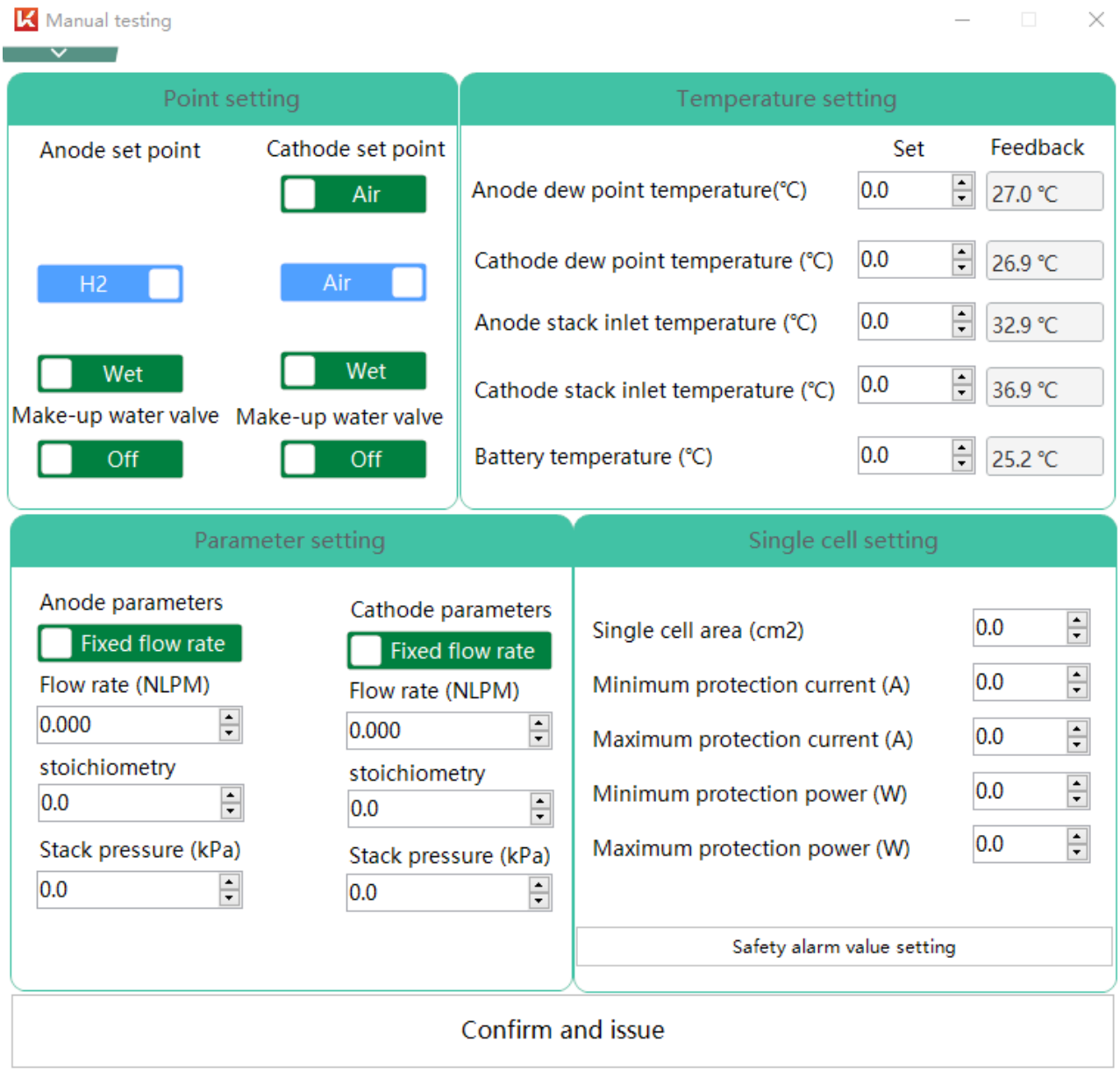
6) Custom interface, users can add and edit interface content, including but not limited to display content, position, size, and color.

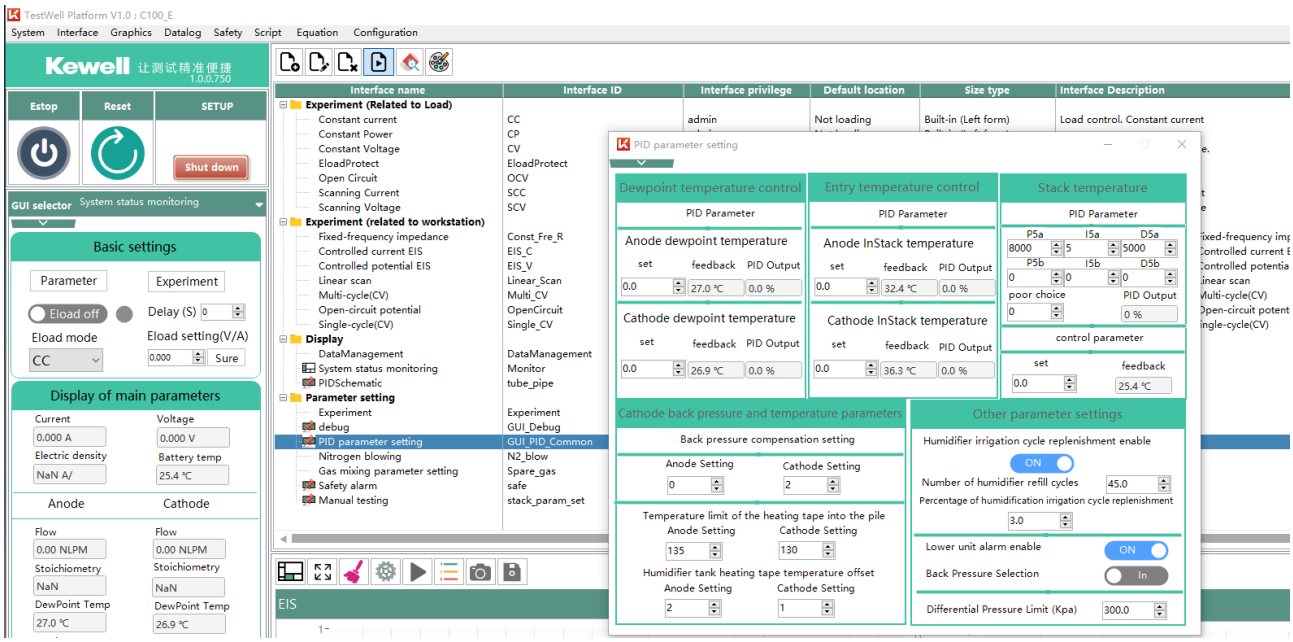
7) Curve editing, users can add curves to be displayed through tags, and set the curve format, such as point type, line type and width, and so on.

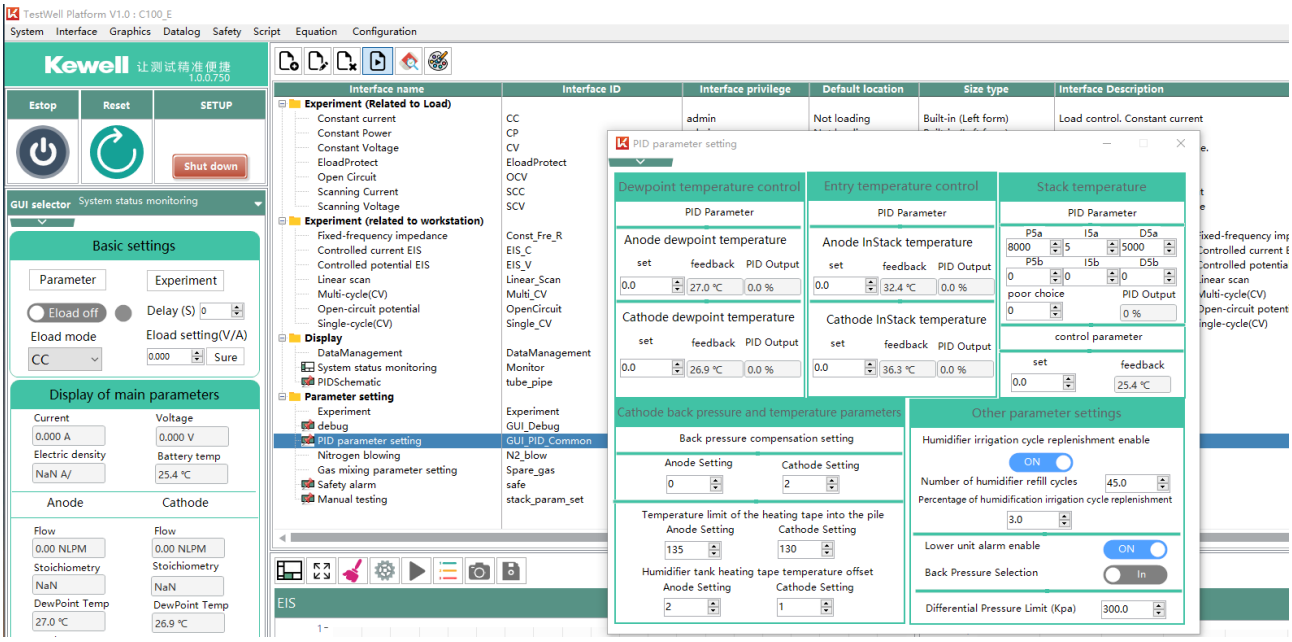
8) Sequence function, based on steps, i.e., edit the operating conditions for each step, such as nitrogen purging flow and purging time. Multiple steps constitute a complete test condition, which, like the script customization function, supports unattended operation.




PIDSchematic
H2_Leak
0.00 PPM
PT101
438.300 kPa
TM101
MFC101
0.000 NLPM
H2 Supply
TM102
PT102
19.300 kPa
TS102
29.700 ℃
TS103
27.400 ℃
PT102
19.300 kPa
TS01
25.400 ℃
PT103
20.100 kPa
Back pressure control
6228
H2 Exhaust
TS101
29.900 ℃
TS104
26.400 ℃
TM141
tank
PT601
439.500 kPa
N2 Supply
PT121
437.200 kPa
MFC121
0.000 NLPM
Air Supply
TM121
TM122
TM123
PT122
23.800 kPa
TS122
27.400 ℃
TS124
26.900 ℃
PT122
23.800 kPa
PT123
23.800 kPa
Back pressure control
6169
Air Exhaust
TS121
27.000 ℃
TS123
26.400 ℃
TM142
PT191
0.100 kPa
O2 Supply


Manual testing
Point setting
Anode set point
Cathode set point
Air
H2
Air
Wet
Wet
Make-up water valve
Make-up water valve
Off
Off
Temperature setting
Set
Feedback
Anode dew point temperature(℃)
0.0
27.0 ℃
Cathode dew point temperature (℃)
0.0
26.9 ℃
Anode stack inlet temperature (℃)
0.0
32.9 ℃
Cathode stack inlet temperature (℃)
0.0
36.9 ℃
Battery temperature (℃)
0.0
25.2 ℃
Parameter setting
Anode parameters
Fixed flow rate
Flow rate (NLPM)
0.000
stoichiometry
0.0
Stack pressure (kPa)
0.0
Cathode parameters
Fixed flow rate
Flow rate (NLPM)
0.000
stoichiometry
0.0
Stack pressure (kPa)
0.0
Single cell setting
Single cell area (cm2)
0.0
Minimum protection current (A)
0.0
Maximum protection current (A)
0.0
Minimum protection power (W)
0.0
Maximum protection power (W)
0.0
Safety alarm value setting
Confirm and issue


TestWell Platform V1.0 : C100_E
System Interface Graphics Datalog Safety Script Equation Configuration
Kewell 让测试精准便捷
1.0.0.750
Estop
Reset
SETUP
Shut down
GUI selector
System status monitoring
Basic settings
Parameter
Experiment
Eload off
Delay (S)
Eload mode
CC
Eload setting(V/A)
Sure
Display of main parameters
Current
Voltage
Electric density
Battery temp
Anode
Cathode
Flow
Stoichiometry
DewPoint Temp
Interface name
Interface ID
Interface privilege
Default location
Size type
Interface Description
Experiment (Related to Load)
Constant current
Constant Power
Constant Voltage
EloadProtect
Open Circuit
Scanning Current
Scanning Voltage
Experiment (related to workstation)
Fixed-frequency impedance
Controlled current EIS
Controlled potential EIS
Linear scan
Multi-cycle(CV)
Open-circuit potential
Single-cycle(CV)
Display
DataManagement
System status monitoring
PIDSchematic
Parameter setting
Experiment
debug
PID parameter setting
Nitrogen blowing
Gas mixing parameter setting
Safety alarm
Manual testing
EIS
PID parameter setting
Dewpoint temperature control
Entry temperature control
Stack temperature
PID Parameter
Anode dewpoint temperature
Cathode dewpoint temperature
Anode InStack temperature
Cathode InStack temperature
set
feedback
PID Output
control parameter
Cathode back pressure and temperature parameters
Back pressure compensation setting
Temperature limit of the heating tape into the pile
Humidifier tank heating tape temperature offset
Other parameter settings
Humidifier irrigation cycle replenishment enable
Number of humidifier refill cycles
Lower unit alarm enable
Back Pressure Selection
Differential Pressure Limit (Kpa)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Eload mode
CC
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Sure
Display of main parameters
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Lower unit alarm enable
Back Pressure Selection
Differential Pressure Limit (Kpa)

6. List of Equipment and Documents

6.1 Main Equipment Configuration List

No.	Name	Model	Qty.	Note
1	Fuel cell test system for testing single cells	C100-G	1	Includes cathode/anode gas supply unit, cathode/anode gas humidification unit, cathode/anode gas heating unit, cathode/anode gas back pressure unit, nitrogen supply unit, PLC sampling and control system, HMI unit, exhaust and gas venting circuit

6.2 List of Spare Parts

No.	Name	Specification	Qty.
1	Pipe fitting	NPT1/4	2
2	Two-way pneumatic connector	NPT1/4-NPT1/4	3
3	T-type pneumatic connector	NPT1/4-NPT1/4-NPT1/4	3
4	Pneumatic hose	NPT1/4	20m

6.3 List of Documents

No.	Print documents	Qty.	Note
1	Packing List	1	Come with the equipment
2	Product Manual	1	Come with the equipment
3	Product Maintenance Manual	1	Come with the equipment
4	List of Spare Parts	1	Come with the equipment
5	Product Factory Certificate	1	Come with the equipment

7. System Operating Conditions

C100 -G Fuel Cell Test Platform Operating Conditions			
No.	Parameter	Specific requirements C100-G	Note
1	Hydrogen source	0.5MPa~0.8Mpa, flow up to 5SLPM;	Complete the primary decompression at hydrogen source, specify in advance if the source pressure is too high
2	Nitrogen source	0.5MPa~0.8Mpa, flow up to 5SLPM	Complete the primary decompression at nitrogen source, specify in advance if the source pressure is too high
3	Air source	0.5MPa~0.8Mpa, flow up to 10SLPM;	Supplied by customer
4	Hydrogen exhaust	Reserve a hydrogen exhaust interface at the top of the lab to discharge the unreacted hydrogen;	Supplied by customer
5	DI water	Water consumption ≤2kg/h, conductivity <0.3us/cm	Supplied by customer
6	Air exhaust	Reserve an air exhaust interface at the top of the lab;	Supplied by customer
7	Power distribution	220V, supply power to the test bench (including the cooling circulation heating system, humidification unit heating, 24V unit)	Supplied by customer
		It's recommended to be ≥2KW	
8	External pipelines	Customer to reserve hydrogen, air, and nitrogen hoses (connected to the test bench), exhaust air, hydrogen, and water discharge hoses, and DI water tank (the test bench replenishes water from the tank)	Supplied by customer

8. Reference Standards

The development and design of this system refers to the following standards:

No.	Standard/Document No.	Standard/Document Name
1	T/CAAMTB 12—2020	Test methods of membrane electrode assemblies for PEMFC
2	GB/T 33979-2017	Test methods for proton exchange membrane fuel cell power system at subzero environment
3	GB/T 34872-2017	Technical requirement of hydrogen supply system for proton exchange membrane fuel cells
4	TCECA-G 0015-2017	Hydrogen specification for proton exchange membrane fuel cell vehicles
5	SAE J2617-2011	Recommended practice for testing performance of PEM fuel cell stack sub-system for automotive applications
6	SAE J2615-2011	Testing performance of fuel cell systems for automotive applications
7	GB/T 28183-2011	Test methods of fuel cell power system for bus
8	GB/T 24554-2022	Performance test methods for fuel cell engines
9	GB/T 27748.1-2017	Stationary fuel cell power system - Part 1： Safety
10	GB/Z 21742-2008	Portable proton exchange membrane fuel cell power systems
11	GB/Z 27753-2011	Test method for adaptability to operating conditions of membrane electrode assembly used in PEM fuel cells
12	GB/T 28816-2020	Fuel cell - Terminology
13	GB/T 20042.1-2017	Proton exchange membrane fuel cell - Part 1: Terminology
14	GB/T 20042.2-2023	Proton exchange membrane fuel cell - General technical specification of fuel cell stacks
15	GB/T 20042.3-2022	Proton exchange membrane fuel cell - Part 3: Test method for proton exchange membrane
16	GB/T 20042.4-2009	Proton exchange membrane fuel cell - Part 4: Test method for electrocatalysts
17	GB/T 20042.5-2009	Proton exchange membrane fuel cell - Part 5: Test method for membrane electrode assembly
18	GB/T 20042.6-2011	Proton exchange membrane fuel cell - Part 6: Test method of bipolar plate properties
19	GB/T 23645-2009	Test methods of fuel cell power system for passenger cars
20	GB/T 28817-2022	Single cell test methods for polymer electrolyte fuel cell (PEFC)
21	GB/T 23751.2-2017	Micro fuel cell power systems - Part 2: Performance test methods