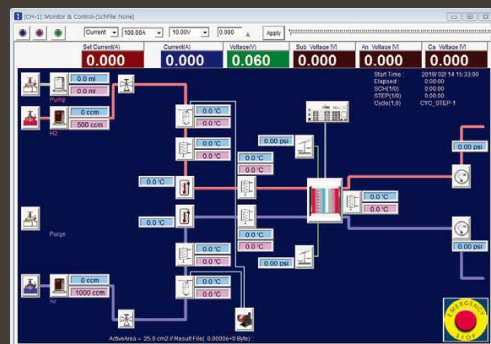


Product Catalog

Smart2™ Series Fuel Cell Test System

- Smart2™ DM
for DM Fuel Cell
- Smart2™ PEM
for PEM Fuel Cell
- Smart2™ PEM/DM
for PEM/DM Fuel Cell

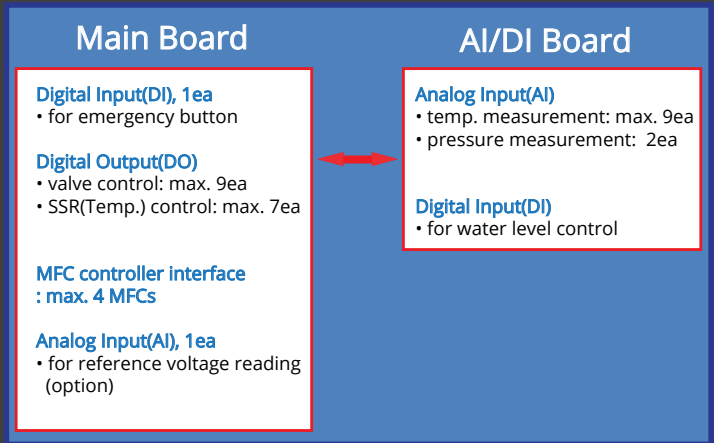


Fuel Cell Test System Smart2 Series

Fuel Cell Test System

- 100Watt fuel cell test system
- Fully integrated compact size
- Suitable for PEMFC and DMFC single cell
- Automatic purge gas control
- Temperature measurement and control external anode & cathode line and cell
- Full automatic by PC control
- Max. 3 channel control by one PC
- Accurate electronic load
- Stoichiometric control is available
- Nafion® membrane type humidifiers for fuel and oxidant gas
- Various safety functions
- Powerful software with independent data analysis software

The Smart2™ series controller is suitable for simple configuration of a single cell test system.



Smart2™ Series

- Smart2™ PEM/DM
PEM/DM Hybrid Fuel Cell Test System
- Smart2™ PEM
PEM Fuel Cell Test System
- Smart2™ DM
DM Fuel Cell Test System



Smart2™ DM



Smart2™ PEM/DM



Smart2™ PEM

The Smart controller supports the following features using AI(analog input), AO(analog output), DI(digital input) and DO(digital output).

- MFCs and/or liquid pump control
- Heating and cooling control
- Valve control (gas flow on/off, dry/wet gas selection etc.)
- Electronic load control
- Humidifier control
- Water supply control
- Measurement of temperature, voltage, pressure, humidity etc.

Most of fuel cell test system manufacturers use the 3rd party DAQ system for their fuel cell test system. This way might have limitations when expanding the system and/or cannot support specific requirements from users.

Safety Functions

The 100Watt Smart2™ series supports the following safety features.

- Watch dog function
If there is no communication between a control PC and the system, the system will stop automatically.
- Emergency button
Both hardware and software emergency button are provided.
- User can set safety limit value for each device.
- Water supply
Water supply can be controlled automatically by a level sensor (high & low).

Descriptions

The Smart2™ series fuel cell test system is a very compact fuel cell test system and it has three product lines - Smart2™ PEM for PEM FC, Smart2™ DM for DMFC, and Smart2™ PEM/DM for PEM/DM FC. Those systems are fully automated and integrated systems at a very attractive price.

The Smart2™ series is designed to test a 100Watt PEM or/and DM fuel cell and it includes a PC controlled electronic load, a gas/liquid controller, humidifiers and methanol pump¹⁾. The WFTS software with graphical user interface(GUI) makes you easy to operate the Smart2™ series system. With the exceptional features of the Smart2™ series, you can digitize your fuel cell system economically and evaluate your fuel

Humidification

Accurate and stable humidification is important for fuel cell test. The Smart2™ series uses Nafion® membrane tube for humidification and multiple line temperature sensors for humidify control.

Automation

The Smart2™ series fuel cell test system supports stoichiometric operation. User can plan an experiment not only by using schedule files but also by making batch files consisting of several schedule files. A manual operation is also available.

1) for Smart2 DM & Smart2 PEM/DM

Fuel Cell Test System Smart2 Series

Accurate Electronic Load

The **Smart2™ series** uses our own electronic load. This fuel cell electronic load is specially designed to meet fuel cell test including EIS measurement. This internal electronic load supports fast response time and EIS measurement. We are also supplying a single-channel EIS monitor(model: Zcon , respectively), which are designed to measure EIS of a single cell. The electrochemical reaction is time domain measurements. It means that sequential measurement may not produce accurate results. The **Smart2™ series** has an interface port for Zcon for future usage.

For DM fuel cell application, we supply a potentiostat/Galvanostat instead of electronic load for more accurate control. For more information, please contact us by sales@wonatech.com.

Standard Configuration - Smart2™ PEM/DM & Smart2™ PEM

- Solenoid valve : 5ea
 - fuel gas, oxidant gas, purge gas, water refill control for humidifiers
- MFC for anode and cathode: 2sets
- Check valve : 6ea
 - each MFC has two check valves on in- & out-line
 - purge gas for anode & cathode
- 3 Way valve : 2ea for wet gas or dry gas selection
- Methanol pump : 1set * (**Smart2 PEM/DM model only**)
- Humidifier : 2set & Automatic water feeding for humidifier : 1ea
- Manual back pressure regulator : 2ea & Pressure sensor: 2ea
- Pressure sensor : 2ea
- Temperature controller(with line heater & thermocouples) : 7set
 - humidifier temperature controller : 2sets
 - gas line temperature controller for inside the instrument : 2sets
 - gas line temperature controller for outside the instrument : 2sets
 - cell temperature controller : 1set
- Temperature monitor only : 2 points with thermocouples
 - inside the anode & cathode gas line
- Electronic load : 1set
- System controller including a DAQ system with emergency switch
- Control PC(option) with **WFTS Smart™** software
- Interface boards with LAN cables

Standard Configuration - Smart2™ DM

- Solenoid valve : 4ea
 - 2-way : Oxidant gas, purge gas, water supply for cathode humidifier
 - 3-way : Wet-Dry selection for cathode
- Piston pump for Anode : 1set
- MFC for Cathode : 1set
- Check valve : 2ea
- Temperature controller(with heater & thermocouples) : 4set
 - Cathode gas line temperature controller for outside the instrument : 1set
 - Cathode gas line temperature controller for inside the instrument : 1set
 - Humidifier&temperature controller for inside the instrument : 1set
 - Cell temperature controller : 1set
- Manual back pressure regulator : 1ea
- Electronic load : 1set
- System controller including DAQ system with emergency button
- Control PC(option) with Smart software
- Interface boards with LAN cables

Optional Equipment

- Impedance Monitor
- External potentiostat/galvanostat
- Zero voltage booster
- Fuel cell hardware fixture
- Conductivity Cell
- Conductivity Jig

Hardware Specification *1)

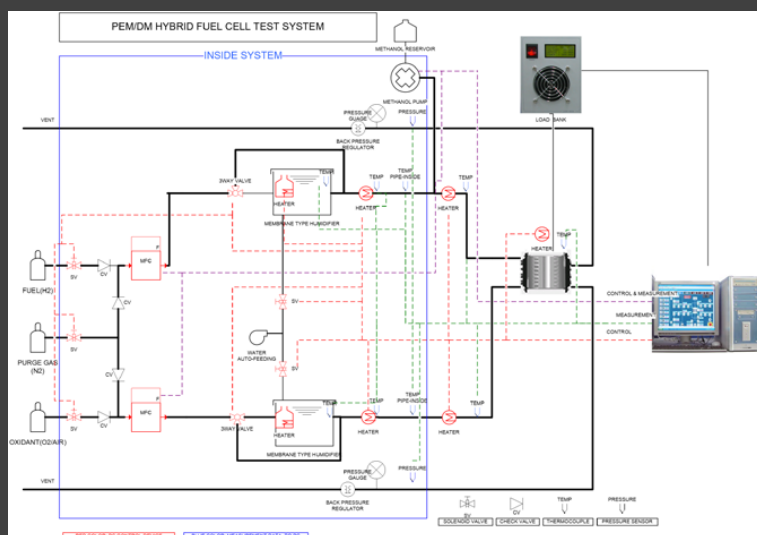
- MFC(Mass Flow Controller), 2ea
 - max. flow rate : H2(2 slpm), Air(5 slpm)
 - accuracy : 1% full scale
- 100Watt single cell application
 - anode gas flow rate : 0.02 ~ 1(or 2) slpm
 - cathode gas flow rate : 0.1 ~ 5 slpm
- Methanol pump, 1set
 - PC control type piston pump
 - 0.1 ~ 45cc/min flow rate control
- Humidifier, 2sets
 - membrane type(Nafion® membrane tube, 1m long)
 - automatic water feeding system(PC control)
- Built-in precision electronic load
 - 4 ranges(voltage & current)
 - max. 100Watt(max. 100A, max. 10V)
 - standard : 10V(1,2,5,10V), 50A(5,20,50,100A)
 - available control : CC, CV, CP, StepI, StepV, StepP
- Gas selectable : humidified or dry gas
 - with a PC controlled 3-way valve
- Manual back pressure regulator, 2ea
 - Max. 29 psi
- Temperature control system, 7 points
 - control & measurement: humidifier(2 points), cell temperature(1 point), and gas line(inside & outside, 4 points)
- Temperature measurement only, 2 points
 - temperature of inside pipe line
- Pressure measurement, 2 points
- Compact size : 430 x 430 x 504 mm(WxDxH) *2)

* 1) for Smart2 PEM/DM system

For more detailed information about Smart2 PEM, Smart2 DM, please contact us.

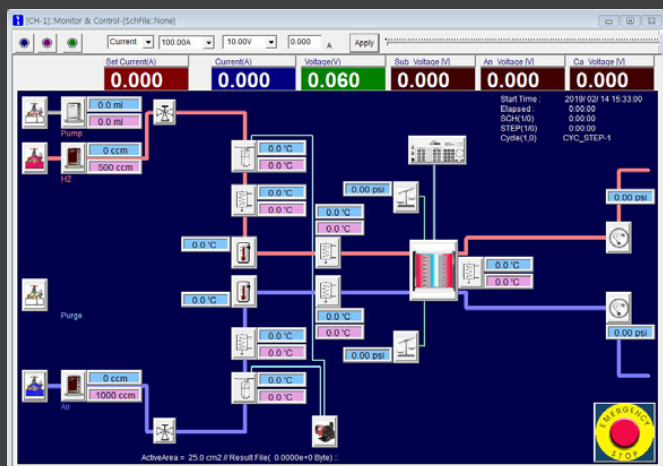
* 2) without pump head and back pressure regulator

Block Diagram of Smart2 PEM/DM System Standard Configuration Without Optional Devices



Fuel Cell Test System Smart2 Series

WFTS™ Software



Features

- Simple and easy operation
- Real-time graphic data output
- User friendly graphical user interface(GUI)
- Continuous data logging
- Background server program
- Independent data managing software
- Button click & play mode
- VOI(Value of Interest) displaying selection
- Colorful display of each module status

Descriptions

A dedicated WFTS™ software is used to operate the Smart2™ series system. This stable software consists of a server program to communicate with the system's main program for control & data acquisition and a data managing program for analysis. Also it can support maximum 4 channels even if they have different configurations. (For example, 1st channel: Smart2PEM/DM, 2nd & 3rd channel: Smart2PEM).

Automatic control and data acquisition is conducted through pre-programmed single or group schedule files in the software.

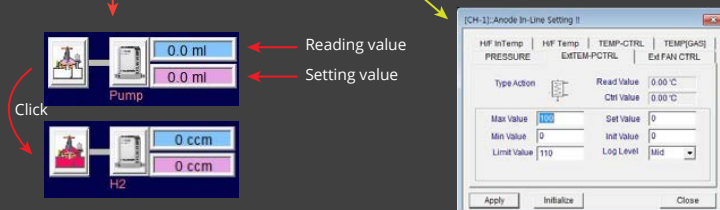
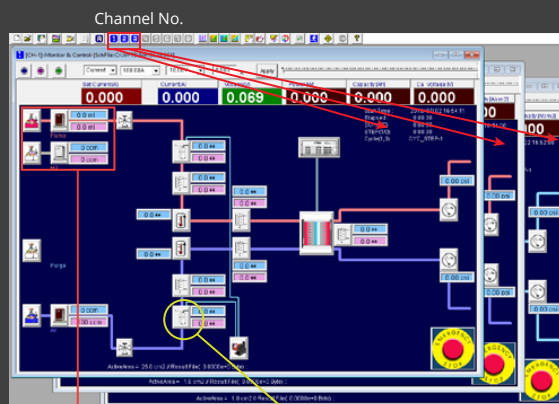
Safety limit setting for each device can assure users of safe operation with software emergency button.

Operators can interact with the system through graphical icons and visual indicators, which provides information about the operating status of the system and its setting/reading values. Graphical user interface(GUI) allows the users to use WFTS™ software in much simple and easy. And it is compatible with Microsoft Excel and Access for data collection and presentation.

Value of interest display helps operators monitor user selected three reading values and fixed three values(electronic load control value, reading current value and voltage value) with large display on the screen.

The real-time graph of WFTS™ software allows users to plot any number of variables versus any single variable or time. This feature is useful for developing real-time polarization curves or tracking cell performance across temperature ranges. Independent data managing software gives the various graphing, charting options and reporting.

Main Program



Control Panel

- Can control max. 8channels depending on PC specification
- Each channel's control panel has different background color to prevent channel wrong-operation.

Device Value Display

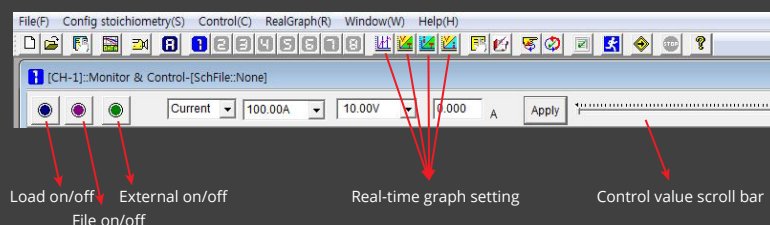
- Setting value & reading value or reading value only by each device's properties.

Button Click Operation

- User can operate each device just by clicking each icon button.
 - a) direct control: solenoid valve, 3-way valve, heater power on/off & emergency stop
e.g.) click solenoid valve → valve open(solenoid valve & MFC valve) → gas flow → color change(status display)
 - b) indirect control: each device to be controlled by setting parameters.
(temperature controller, MFC, pump, electronic load, humidifier)
e.g.) click anode input line temperature controller → parameter setting windows → apply
 - c) displaying related information : stack's temperature monitor, pressure monitor etc.
(safety limit setting available)

Device Icon Button Color Change By Status

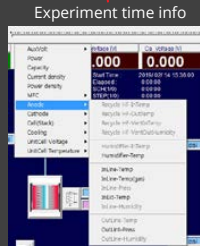
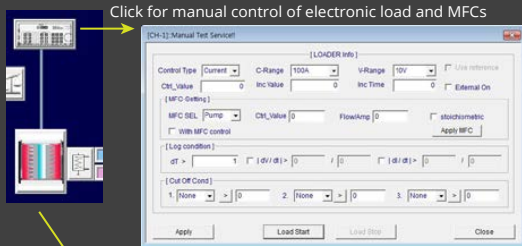
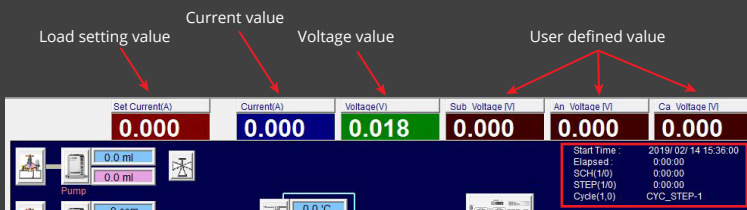
- Each device icon's color changes depending on the status
(running → colorful, idle → grey).
- This feature makes operators monitor each device's status at a glance.



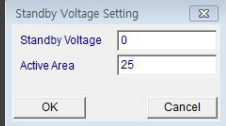
Fuel Cell Test System Smart2 Series

VOI(Value of Interest)

- Fixed value(3ea) and user defined value(3ea)



Cell standby voltage detection for safety operation



Select user defined value

Multichannel Control & Monitor

- Multichannel control panel
 - Assign schedule file for multiple channels & run channels simultaneously or independently.
 - Group control / monitor
 - Display test parameters using test monitor
 - Display device parameters using device monitor
 - back ground bar graph for each cell voltage & temperature with color



Multichannel Control



Fuel Cell Test System Smart2 Series

Stoichiometry

Set const stoichiometry

CH1 | Stoichio No.: 1

Index	Ampere	Stoi. Value
1	1 A	0.000000
2	2 A	0.000000
3	3 A	0.000000
4	4 A	0.000000
5	5 A	0.000000
6	6 A	0.000000
7	7 A	0.000000
8	8 A	0.000000
9	9 A	0.000000
10	10 A	0.000000

OK Cancel

Stoichiometry setting

Real-Time Graphic Data Presentation

- Predefined formats
 - voltage vs. time
 - current vs. time
 - voltage vs. current
- User defined X-Y-Y1 formats
 - user can select each axis parameter

Realtime Graph Setting

Channel: 1 OK

RefreshTime: 1 (sec) Cancel

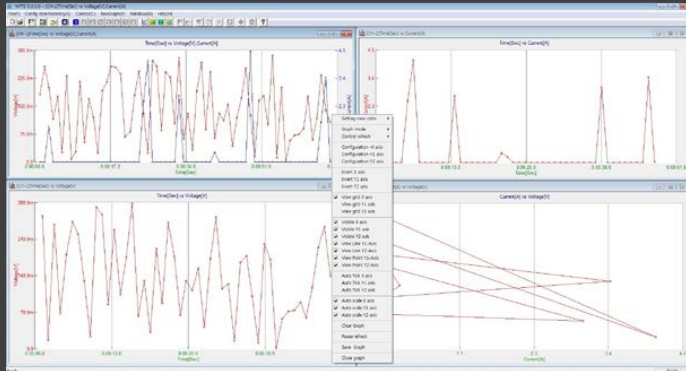
[View Item]

X Axis: Time

Y1 Axis: InChTemp[Ca], InTemp[Ca], InExtTemp[Ca], OutPress[Ca], DefPress[Ca], Cell-Temp, Time

Y2 Axis: Time

Real-time graph setting



- Memo
- During experiment using schedule file or batch file, operator can change each device's parameter and/or change load control strategies manually.

Operator can stop experiment by pressing stop button or emergency stop button or click purge gas' solenoid valve icon.

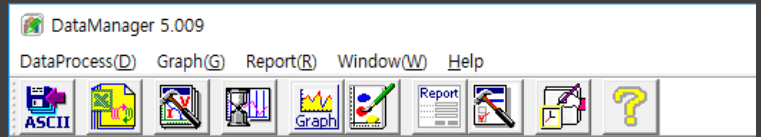
If a user loads schedule file or batch file for each channel and applies experiment condition by clicking 'apply' button, the **WFTS software** controls each device with the defined parameters on the first schedule file except load control. Load control is only activated when experiment is started and gas flow makes cell/stack voltage up. The **WFTS software** continuously monitors cell/stack voltage and if the voltage is higher than setting value(on view cond voltage), it makes the load in control.

Event Logging

- The **WFTS software** records each event for history review.
- Each logging file can be viewed on Data Manager Software.

Data Manager

- Independent data analysis program



Multi Y Axis Graph

- User selectable time base 4 Y axis graph
- Any of measured parameters can be selected for each axis.

Selecting item and files II

Select file: C:\Program Files\WonATech\WFTS5004\data\WCV test2_CH1.wrd

[Test Information]

Channel: 1 Test Duration: 2018/ 11/ 20 10:27 ~ 2018/ 11/ 20 17:56

Schedule file: Manual Test!!

Sch file count: 0 CellCount: 0 Area: 25.000

Memo:

[Item Selecting]

X axis: RunningTime

Y1 axis: Voltage

Y2 axis: Current Density

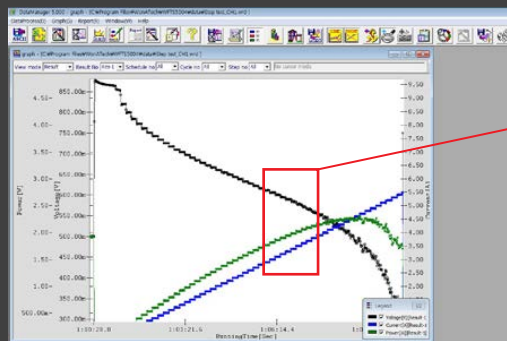
Y3 axis: Voltage

Y4 axis: Voltage

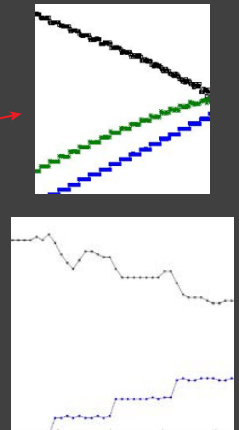
[Graph information]

Max. step count: 0 Max. cycle count: 0 Min. plot count: 1 Y axis count: 2

Total plot count(Min. plot count * Y axis count): 2 *** Max. plot count = 10



Step data sampling



Setting transfer condition

☒ Enable only step control data

begin point(End point - n) 2 Last point(End point - n) 1

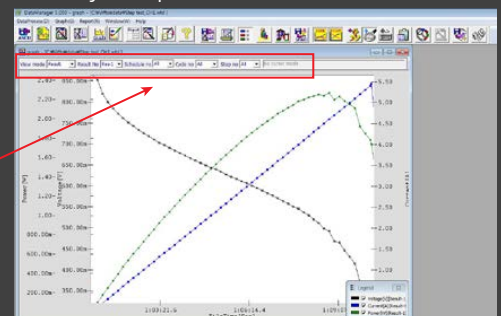
OK Cancel

Setting data transfer condition

Graph Parameter Selection

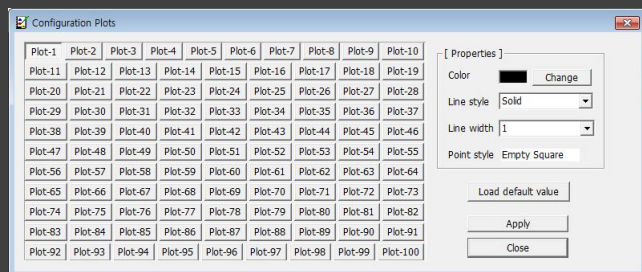
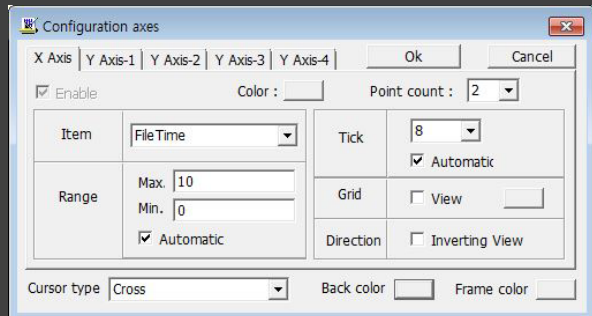
- View mode selection: result/schedule/cycle/step
- Result number selection
- Schedule number selection
- Cycle number selection
- Step number selection

Selection for:
View mode
Result No.
Schedule No.
Cycle No.
Step No.



Fuel Cell Test System Smart2 Series

Axis & Plot Configuration



Flow Cell Controller

- for building your own fuel cell test system
- MFCs and/or liquid pumps control
- heating and cooling control
- valve control (gas flowing on/off, dry/wet gas selection etc.)
- rotator control
- pressure regulator control
- measurement of temperature, voltage, pressure etc



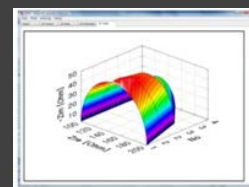
Impedance Monitoring System

- Single- channel system



EIS Data Analysis Software, ZMAN™

- Model simulation and fitting
- 2D- and 3D-Bode- and Nyquist plots
- Automatic equivalent circuit model search function
- KK plot, etc.



Related Products & Optional Accessories

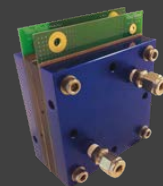
Electrochemical Workstation

- Zive Series Potentiostat/Galvanostat/Impedance Analyzer
- Single- and multichannel system



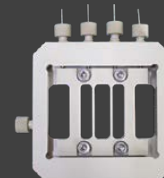
Single Cell Hardware Fixture

- For PEMFC and DMFC
- Max. temp.: 120 °C or 180 °C
- Active area : 5, 25 cm²
- MEA is not included.



Membrane Conductivity Cell

- For 5, 25cm² fuel cell hardware fixture
- Material : PEEK(cell body), platinum(wire)
- Operating temp. : up to 130 °C



Through-Plane Conductivity Test Jig

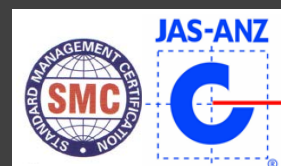
- For through plane conductivity measurement
- 2 probe type





WonATech Co., Ltd.
7, Neunganmal 1-gil, Seocho-gu,
Seoul, 06801, Korea
Phone: +82-2-578-6516
Fax: +82-576-2635
e-mail: sales@wonatech.com
website: www.wonatech.com

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