Designed by ZIVE LAB

Power Electrochemical Workstation ZIVE SP10

Including Internal FRA/ZRA
5Volts/10Amp

For
Battery/Fuel Cell
Super Capacitor/Solar Cell
Electrolysis/Electrosynthesis
Material Testing

WonATech

Electrochemical Workstation ZIVE SP10

The ZIVE SP10, the outstanding Potentiostat/Galvanostat/FRA, is the best choice for the complete DC and impedance characterization of various energy source and storage such as fuel cell, battery, solar cell, supercapacitor and electrolysis, electrosynthesis .

The system is designed under FPGA and DSP control with high speed capability.

DAC Control
: Two sets of high speed 16 bit DAC(50MHz) for offset & scanning & one set of 16 bit DAC(1MHz) for auxiliary analog output control

ADC Reading
: Two sets of 16 bit 500kHz ADC for reading voltage/current and 4 channel 16 bit 250kHz ADCs for auxiliary data input such as temperature, auxiliary voltage etc. It provides high frequency EIS, fast pulse techniques and high speed sampling time.

The ZIVE SP10 is equipped with a Frequency Response Analyzer(FRA) for system as standard and it provides high performance impedance measurements over the frequency range 10uHz to 1MHz. The ZRA(zero resistance ammeter) function can measure max. 10Amp in galvanic corrosion technique. The system is supplied with four(4) advanced software packages, which are catagorized by application fields. With this advanced software packages, user can widen ZIVE SP10's flexibility

Hardware Features

- ±5V@10Amp control range
- Wide current ranges(10A to 100pA) for various applications (100pA and 1nA ranges are with gain)
- Independent operation by FPGA with DSP
- Built-in FRA for impedance measurement
- Smart LCD display
- Simultaneous 3 auxiliary voltage measurements
- K-type thermocouple input for temperature measurement as standard
- 1 auxiliary analog output
- 3 digital outputs & 2 digital inputs
- External booster(ZB series) interface for high current application

Smart LCD Display

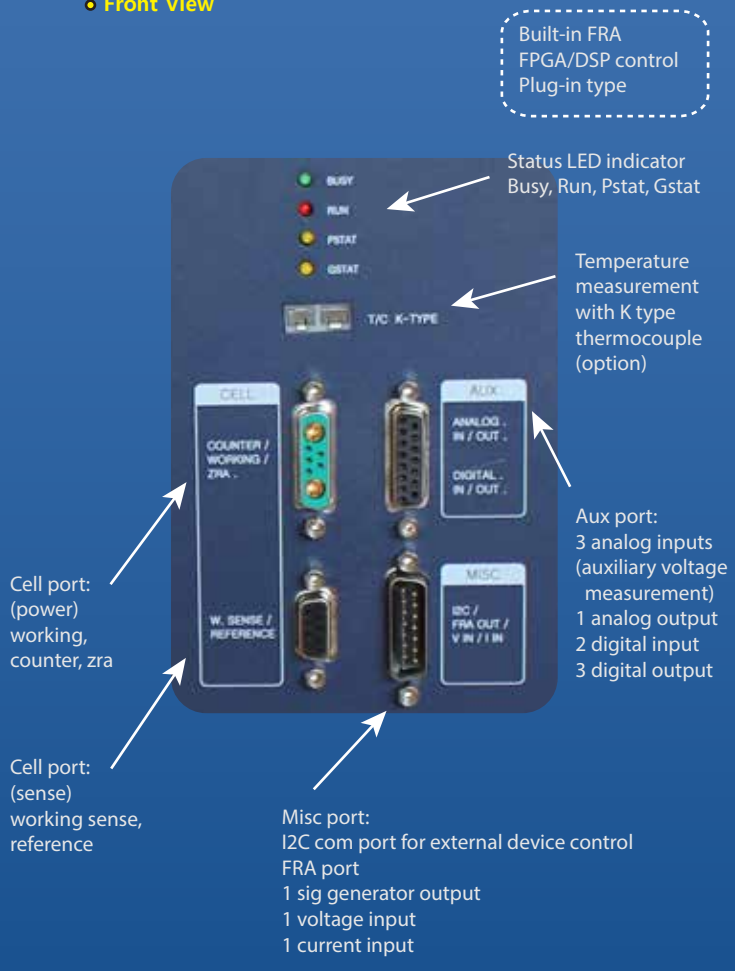
DC Mode

EIS Mode

System Features

- Versatile high quality Potentiostat/Galvanostat/Impedance Analyzer
- Compact size with full functions
- FRA function to control an external electronic load or 3rd party potentiostat/galvanostat is available as standard
- 14 EIS techniques capability including multisine
- Current interrupt IR measurement/IR compensation (Dynamic, Positive feedback)
- Bipolar pulse capability
- Voltage pulse or current pulse charge/discharge test(GSM,CDMA etc.), sine wave function for ripple simulation in battery test package and pulse plating available
- High speed data sampling time
  - 2usec or 3usec depending on data point number
- Fast sweep mode(5000V/sec with 10mV data sampling)
- 3 measurement/control voltage ranges & 12 measurement/control current ranges
- Internal 542,000 data point storage and continuing experiment regardless of PC failure
- Full software packages are included as standard
  - Corrosion test software package(COR)
  - EIS test software package(EIS)
  - Electrochemical analysis software package(EAS)
  - Energy software package(BAT)
- Multichannel configuration available
- Free software upgrade

Front View



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Versatility

The ZIVE SP10's system comes with additional three analog inputs (auxiliary voltage input) and 1 analog output along with 3 digital outputs and 2 digital inputs, and one temperature input for K type thermocouple. It will help user expand the usage of the instrument.

For example,

1. User can measure the voltage between working and reference electrode and, by using 2 additional analog inputs(auxiliary voltage input), user can also measure the voltage between reference and counter electrode and between working and counter electrode as well.

2. With analog output, the system can control rotating speed of the rotator, MFC flow rate etc. by ±10V full scale.

3. User can control on/off of an external device by 3 DO(digital ouput) signal and 2 DI(digital input) signal from an external device can be used for cutoff condition.

Safety and Maintenance

1. Even though the communication failure occurs between PC and ZIVE SP10, the system continues its experiment on channel and saves the data into ZIVE memory up to 542,000 data point set. After the communication is restored, ZIVE will transfer saved data to PC automatically or user can transfer data when he/she wants. This function will be highly efficient for long time experiment.

2. User can define a safety condition setting by inputting his/her own safety levels for voltage, current, temperature etc. If the measurement value exceeds this setting value, the system will automatically stop to protect the system and cell.

3. If the control value of voltage or current is different from measured value, the experiment will stop automatically to protect the cell.

4. Automatic calibration function is available for user calibration.

5. The hardware parameters and calibration data are stored in the device.

6. The system is controlled from a PC via USB.

Application

The ZIVE SP10 electrochemical workstation is ideal for evaluation power device research such as battery material, fuel cell, supercapacitor and solar cell and electrolysis, electrosynthesis etc. This system can be used for high current fundamental research in electrochemistry or QC/QA for power devices.

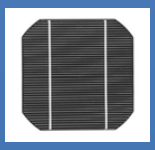
Batteries

The system is very well adapted for researches on the cycling behavior of battery. It provides various control modes for battery cycling. It can support EVS (electrochemical voltage spectroscopy)/GITT/PITT test. Fast pulse capability for GSM, CDMA test is included in battery test software package. Pulse profile measurement function to check pulse shape is available. For ripple simulation test, sine wave charging/discharging is available.

Super Capacitors

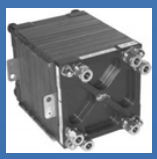
The ZIVE SP10 has fast potentiostat circuit with high speed data acquisition. This function is well applicable to super capacitor testing. Charging/discharging capability is used for this application.

Solar Cells



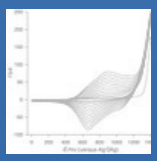
Solar cell development and production requires extensive material and device testing to improve efficiency and match individual cells for panel construction. The ZIVE SP10 is the best solution for photovoltaic cell characterization. With system's AI, AO, DI, and DO, the system can monitor other device's signal and also control them.

Fuel Cells



The ZIVE SP10 is ideal for characterizing the fuel cells and anodic/cathodic process mechanism at development and research grade. This system can be directly used for PEMFC, DMFC, and DEFC etc. The FRA can control an external electronic load for EIS measurement of fuel cell. I-V curve measurements in a full range of available current(autorange option is active during the I-V scan in order to ensure measurement with continuously high resolution).

General Electrochemistry



The ZIVE SP10 is also suitable for the development of high current electrochemical materials where multichannel DC and impedance analysis is beneficial in providing high throughput of results.

Impedance(ESR) measurement for QC/QA

The ZIVE SP10 is also suitable for impedance measurement at fixed frequency using independent software.

Main Software SM

The Smart Manager (SM) is to control ZIVE SP10 model and it provides user defined sequential test by using sequence file, technique menu and batch file. The batch file allows the users to do a serial test by combining sequence files and/or technique files.
The SM software is easy to use and supports various electrochemical experiments including functions of system control, schedule file editor, real time graph, analysis graph, user calibration, and data file treatment etc.

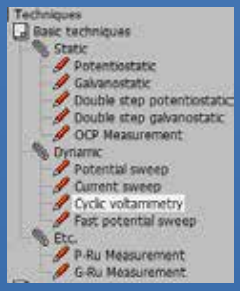
Technique list

Sequence editor

Basic Techniques

■ Basic techniques with standard functions

1) Potentiostatic
2) Galvanostatic
3) Double step potentiostatic
4) Double step galvanostatic
5) OCP measurement
6) Potential sweep
7) Current sweep
8) Cyclic voltammetry
9) Fast potential sweep
10) Potentiostatic Ru measurement
11) Galvanostatic Ru measurement



The above functions can be used sequentially by step control function.

■ Sequence editor

User can design his/her experiment procedure by using TASK sequential routine editor.

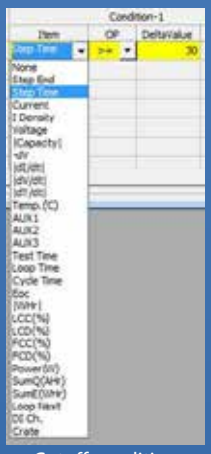
● Control Task Parameters

Control Mode		
constant	GSTAT	constant current control
	Crate	constant Crate control
	PSTAT	constant voltage control
	POWER	constant power control
	LOAD	constant load control
	CC-CV	constant current constant voltage control
	Crate-CV	Crate constant voltage control
	CP-CV	constant power constant voltage control
	CL-CV	constant load constant voltage control
	Id	Id control
	Is	Is control
	OCP	OCP control
Step	GSTAT	current step control
	PSTAT	potential step control
Sweep	GSTAT	current sweep control
	FAST-G	fast current sweep control
	PSTAT	potential sweep control
	FAST-P	fast potential sweep control
EIS	GSTAT	galvanostatic EIS
	PSTAT	potentiostatic EIS
	OCP	OCP EIS
	PSUEDO	pseudo galvanostatic EIS
	HFR G	galvanostatic HFR
	HFR P	potentiostatic HFR
	MsineG	galvanostatic multisine EIS
	MsineP	potentiostatic multisine EIS
Rest		rest control
ZRA		ZRA control
Loop		loop control
Pulse	Vpulse	voltage pulse control
	Ipulse	current pulse control
	GSINE	current sine wave control
	PSINE	potential sine wave control

- Constant potential, current, C-rate, power, load, OCP
- Sweep potential, current
- Fast sweep potential, current
- Staircase potential, current
- CC-CV, CP-CV, CL-CV, Crate-CV control
- Id, Is control
- EIS control
- Pulse or sinewave control
- Rest(voltage monitoring only)
- Loop(cycle) control

● Cut-off(Vertex) Condition

- Time(step, test, loop, cycle)
- Current, current density
- Voltage
- Capacity
- C-rate
- -dV
- |dV/dt|
- |dI/dt|
- Aux1
- Eoc
- etc.



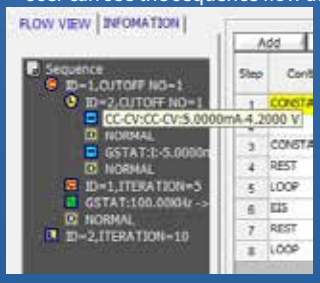
Cutoff condition

● Sampling Condition

- time, |dI/dt|, |dV/dt|, |dT/dt|, |dA1/dt|, burst time

● Flow View

- User can see the sequence flow at a glance.



Flow view

■ Batch function

User can design batch file including multiple technique files and/or sequence files. With this batch file, user can experiment several techniques/sequence in series automatically.

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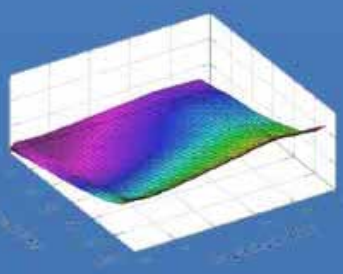
Smart Manager Advanced Software Package

For a wide range of application, advanced software packages for specific experimental techniques are available as standard.

■ EIS Software Package(EIS)

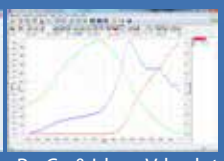
1. Potentiostatic EIS
2. Galvanostatic EIS
3. Pseudo galvanostatic EIS
4. OCP(*1) EIS
5. Potentiodynamic PEIS
6. Galvanodynamic GEIS
7. Potentiodynamic HFR
8. Galvanodynamic HFR
9. Potentiostatic HFR monitor
10. Galvanostatic HFR monitor
11. Multisine potentiostatic EIS
12. Multisine galvanostatic EIS
13. Intermittent potentiostatic EIS
14. Intermittent galvanostatic EIS



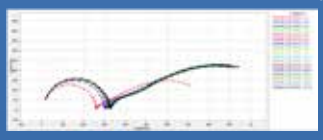
Coin cell intermittent PEIS
3D Nyquist plot by ZMAN

(*1) The system measures open circuit potential before each frequency change and applies AC sine wave on this potential.

Galvanostatic EIS



Rs, Cp & Idc vs Vdc plot

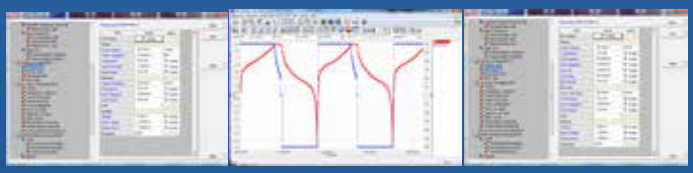


Intermittent Poteniostatic EIS

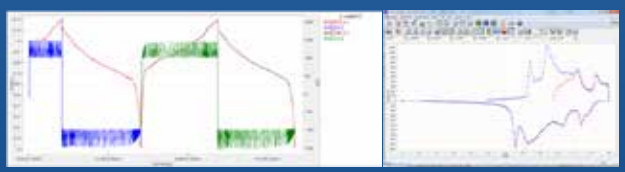
■ Energy Software Package(BAT)

BAT software supports IR measurement.

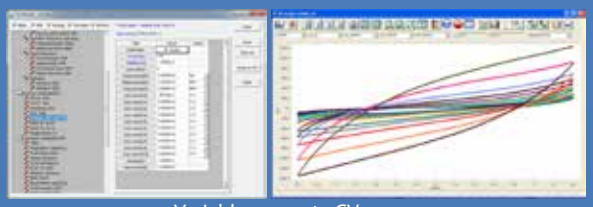
1. Battery test techniques
   - CC/CV test for cycle life test of lithium battery
   - CC/CC test for cycle life test of NiCd or NiMH battery
   - Discharging test
   - EVS(Electrochemical voltage spectroscopy)
   - Variable scan rate CV
   - Potentiostatic IV curve
   - Galvanostatic IV curve
   - Steadystate CV
     - GITT(Galvanostatic intermittent titration technique) test
   - PITT(Potentiostatic intermittent titration technique) test



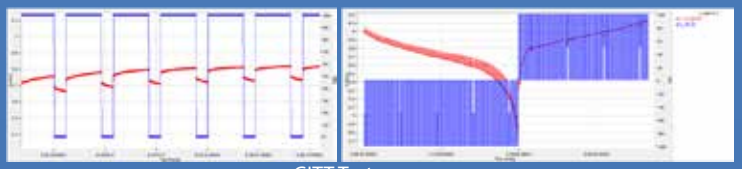
CC/CV test　　CC/CC test



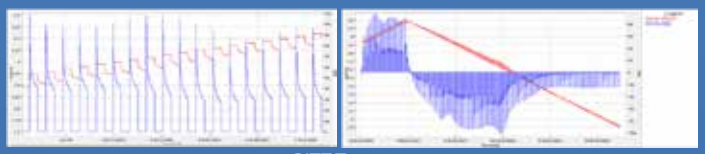
EVS test raw data　　EVS graph format (dQ/dV vs. V)



Variable scan rate CV



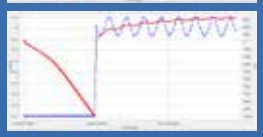
GITT Test



PITT Test

- Pulse mode is available for GSM & CDMA profile. Pulse shape profile can be measured by user's demand.

Pulse shape profile monitor (micro seconds order)



Current sine wave (charge ripple simulation)

2. Control mode
   - Charge: CC, CC-CV, pulse, sine wave
   - Discharge: CC, CP, CR, pulse, sine wave

3. Cutoff condition
   - time, voltage, current, power, temperature, auxV etc.

Various battery charge/discharge test is available including pulse discharge for GSM and CDMA application.

■ Corrosion Software Package(COR)

Corrosion technique supports IR compensation.

1. Tafel(Tafel experiment)
2. Rp(Polarization resistance)
3. Potentiodynamic
4. Galvanodynamic
5. Cyclic polarization
6. Ecorr vs. time
7. Galvanic corrosion
8. RpEc trend
9. Reactivation potential
10. Critical pitting potential
11. Potentiostatic ECN
12. Galvanostatic ECN
13. ZRA mode ECN

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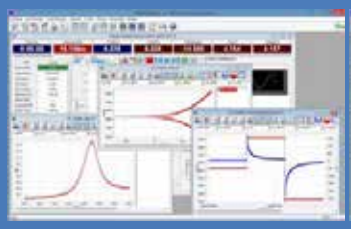
■ Electrochemical Analysis Software Package(EAS)

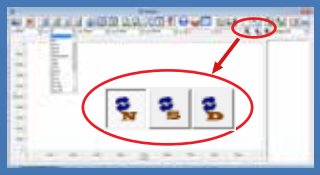
1. Step techniques
   CA(Chronoamperometry), CC(Chronocoulometry), CP(Chronopotentiometry)

2. Sweep techniques
   LSV(Linear sweep voltammetry), SDV(Sampled DC voltammetry),
   Fast CV, Fast LSV

3. Pulsed techniques
   DPV(Differential pulse voltammetry), SWV(Square wave voltammetry),
   DPA(Diff. pulse amperometry), NPV(Normal pulsed voltammetry),
   RNPV(Reverse normal pulse voltammetry), DNPV(Differential normal pulse voltammetry)

Each software package's upgrade will be provided at free of charge.





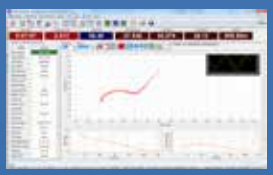
In DC and Cycle graph, whenever you click  or , the parameters which are related to current such as current, capacity, energy, power, load, etc., are changed into calculated specific value or density value, respectively.

 : value divided by weight

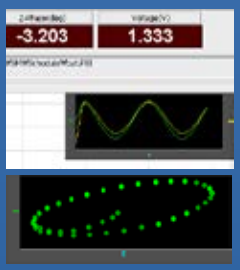
 : value divided by active area

Control & Real Time Graph

Smart Manager provides 2 kinds of control & data acquisition with real time graph.

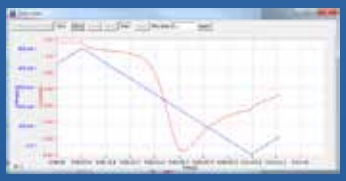


User can control and monitor for specific channel in details and he/she can monitor data in VOI(value of interest) window and channel status in one window. Real time graph's X, Y axis format will be changed per technique automatically. It can be defined by user's demand per techniques.
For experiment using sequence file or batch file, user can designate X,Y parameter on three different real time graph. The real time graph's format can be also selected.



The real time graph and VOI will be changed depending on DC test or impedance test automatically. The virtual control panel always displays the graph for recent test result. For impedance measurement, wave monitor will be displayed on real time graph to check wave's quality. This monitor can be switched to Lissajous(I vs. E) plot.

■ Strip Chart

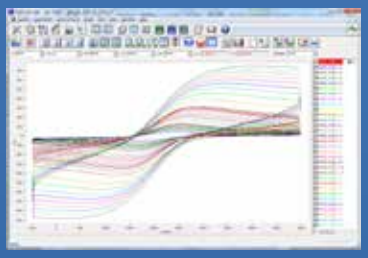


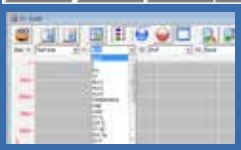
Strip chart recorder function provides real graph function independently. You can monitor 2 Y axis data such as voltage, current, auxV1,2,3, temperature, power, and capacity etc. in real time.

Graph

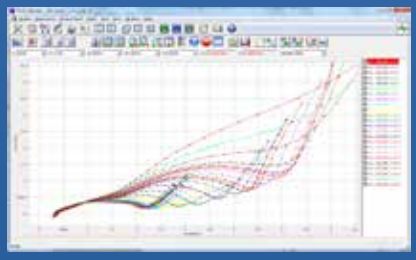
Smart Manager's graph function is to simplify the operation. There are 3 kinds of graph per each experiment. You can change X, Y1, Y2, Y3, Y4 axis parameter as you want. Each graph provides shortcut buttons. When you click these buttons, the format of the graph will be changed accordingly.

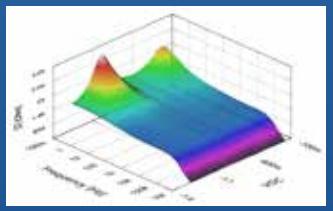
1) DC Graph
- For general data display
- 4 shortcut buttons: I vs. V, E vs. LogI, V, I vs. time, V vs. Q
- Graph parameters: time, Eref, I, Eoc, Id, Aux1, Aux2, Aux3, temp, LogI, Load, ChQ, DchQ, ChQs, DchQs, Ch P, Dch P, Ch-Wh, Dch-Wh, Sum Wh, Sum Q, Sum |Q|, |Q|, Rp, dQ/dV





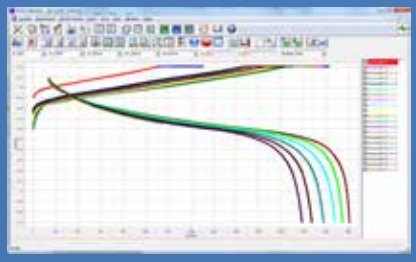
2) EIS Graph
- For EIS data display
- 3 shortcut buttons: Nyquist plot , Bode plot, Cs vs. frequency
- Graph parameters: Frequency, Zre, -Zim, Zmag, Zph, Y', Yimg, Y, |Y|, Yph, LogZ, LogY, Rs(R-C), Cs(R-C), Rp(R|C), Cp(R|C), Rs(R-L), Ls(R-L), Q(R-L), time, Vdc, Idc, temp, Aux(1,2,3)



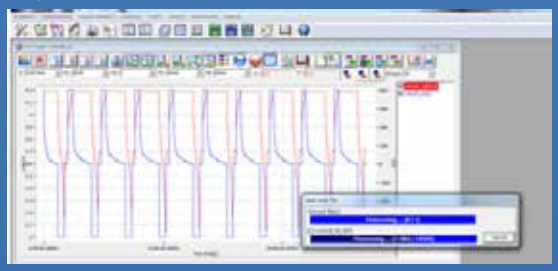


3D Bode plot by ZMAN
Technique used: Potentiodynamic impedance measurement by using a corrosion cell

3) Cycle Graph
- For battery cycle data display
- 3 shortcut buttons: cycle capacity, cycle average, Log(cycle No) vs. depth of discharge plot.
- Graph parameters: cycle number, Ch Q, Dch Q, Sum Q, Coulomb Eff, Ch-Wh, Dch-Wh, Sum Wh, Energy Eff, MinV, MaxV, ChQs, DchQ, ChVavg, DchVavg, Vavg



■ Data Export to ASCII & Excel File 



Selectable between 'Convert data on graph only' and 'Convert selected file(s)'.

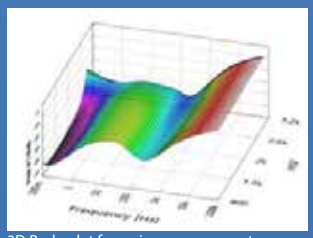
Data Analysis Software

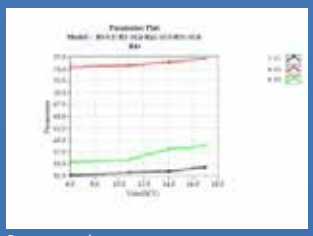
ZIVE data file can be used for analysis by using external IVMAN™ software for DC analysis, IVMAN DA™ software for battery data analysis, IVMAN PA™ software for photo-voltaic cell data analysis and ZMAN™ software for EIS data analysis without license.

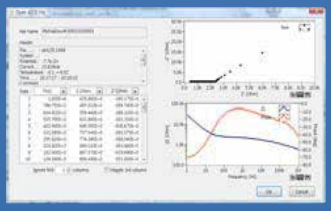
ZMAN™ EIS Data Analysis Software

- Model simulation and fitting
- 2D- and 3D-Bode- and Nyquist plots
- Automatic equivalent circuit model search function
- Project concept to handle multiple EIS data analysis
- Parameter plot from fitted elements value
- Compatible with data format from Zahner, Gamry, Ametek etc. (License code is needed.)
- Various weighting algorithm
- Model library and user model
- KK plot
- Batch fitting for project data
- Impedance parameter simulation
- Interpolate bad data
- Black-Nichols plot
- 3D graph setting option
- Improved model editor
- Application model library for automatic searching
- Parameter simulation of model
- Genetic algorithm option for initial guessing
- Automatic initial guessing
- Trace movie function on fitting
- Free for ZIVE's data format(*.seo, *.wis) analysis (No license code required.)
- Circle fitting
- Data editing available (insert, delete, edit)

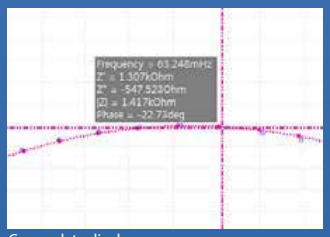
- Add/subtract element parameters
- Add/subtract model parameters
- Impedance, Z in polar, admittance, Y in Polar, modulus, M in polar, dielectric constant, E in polar. data display
- Empty cell capacitance calculation
- Find file function
- Data replacement by formula function
- Cursor data display
- Model finding result automatic sorting by Chi square value
- R, C R, L R, Q preview & graphic
- ZHIT function
- Mott-Schottky analysis
- Donor density vs. Vfb graph
- C vs. voltage graph


3D Bode plot for series measurement

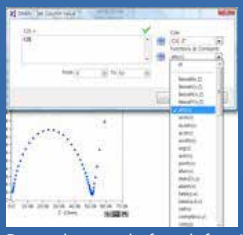

Parameter plot

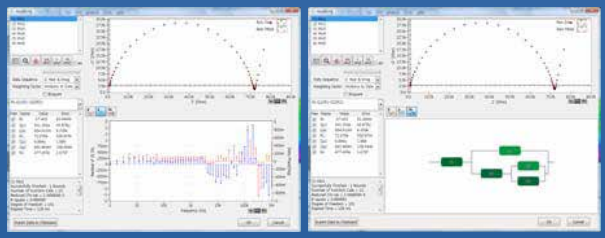

Importing 3rd parties ASCII data file

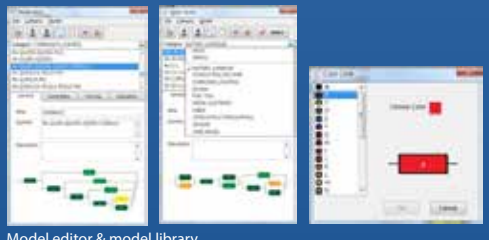

Project manager with data preview

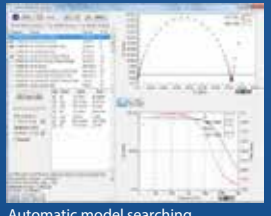


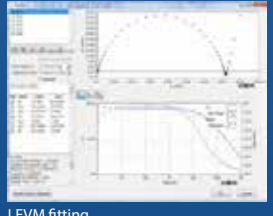
Cursor data display


Data replacement by formula function


Fitting display


Model editor & model library


Automatic model searching


LEVM fitting

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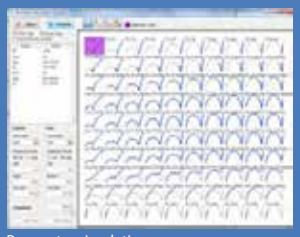
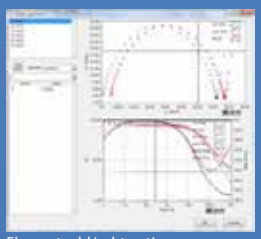
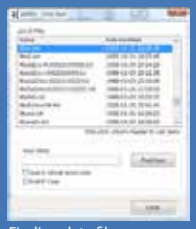
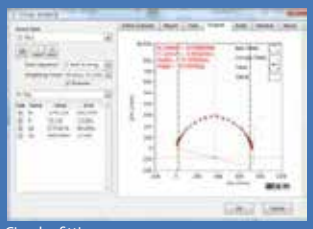
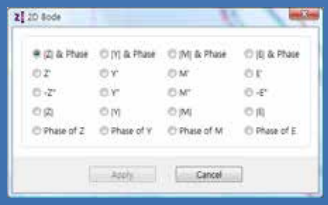

Parameter simulation


Element add/subtraction

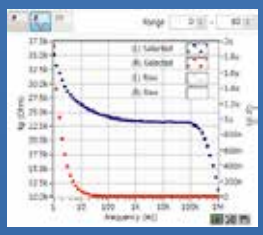

Finding data file menu

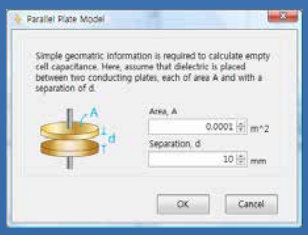

Circular fitting



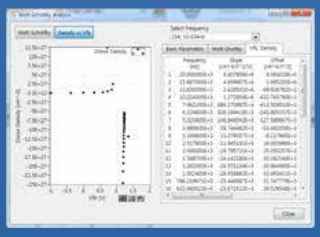
2D Nyquist plot

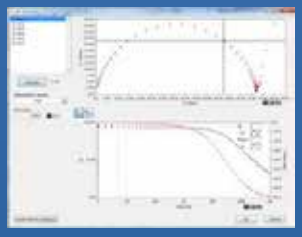
2D Bode plot

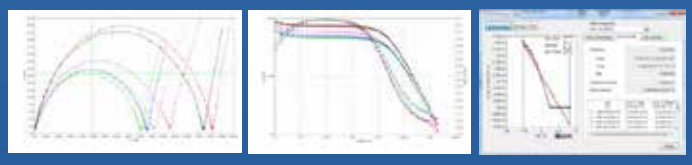

Rp,Cp vs frequency (R|C)

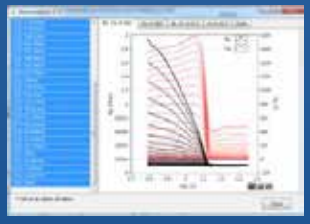


Empty cell capacitance


Donor density vs. Vfb graph and analysis


KK consistency


Mott-Schottky analysis window

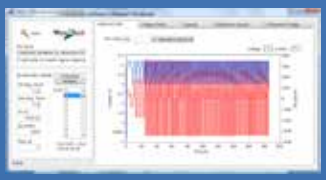

C/R-V graph

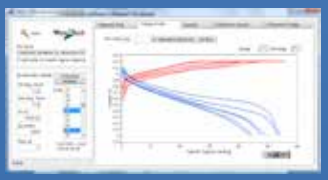
IVMAN™ DC Data Analysis Software

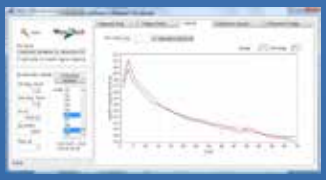
IVMAN™ software package consists of
- IVMAN software
- IVMAN utilities
  - IVMAN differential analysis software
  - IVMAN photo voltaic cell analysis.
  - IVMAN Tafel analysis
  - IVMAN extractor
  - IVMAN peak find module

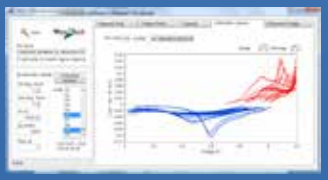
IVMAN DA™ Battery Test Data Analysis Software

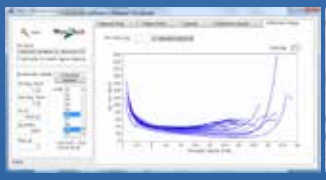
- Battery test data analysis
- Electrochemical voltage spectroscopy (dQ/dV vs. V)
- Voltage vs. Capacity analysis (V vs. Q)
- Cycle graph (Q vs. cycle)
- Differential voltage graph (dV/dQ vs. Q)


Measured data


V vs. Q

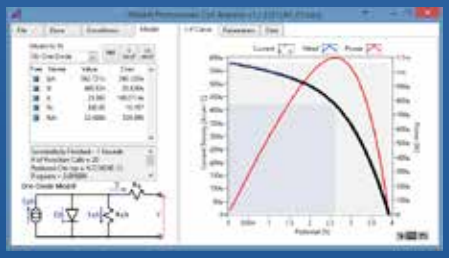

Cycle graph


dQ/dV vs. V


dV/dQ vs. Q


Export ASCII file

IVMAN™ Photovoltaic Cell Analysis

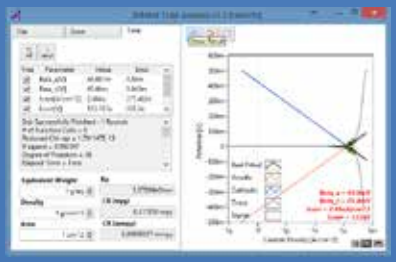


- Automatic analysis of parameters
  - open circuit voltage, open circuit current, max. power, efficiency photo induced current, diode quality factor, series resistance, etc.

Electrochemical Workstation ZIVE SP10

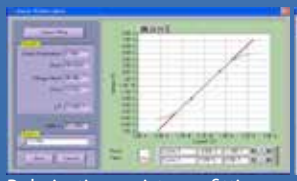
IVMAN TA™ Tafel Analysis

- Simple Tafel calculation

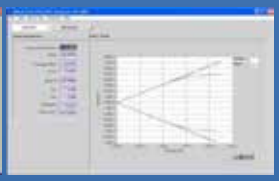


IVMAN™ Main Software

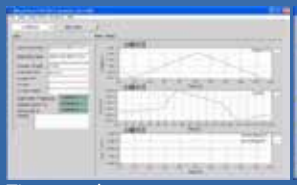
- Ideal for DC corrosion data analysis and electro-analytical data analysis
- Initial guessing function on Tafel analysis
- Polarization resistance fitting
- 3D graph
- Find peak function
- Interpolation, differentiation, integration etc.
- Reporting function



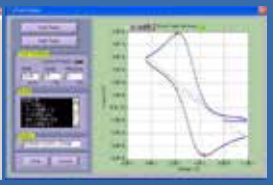
Polarization resistance fitting



Polarization analysis result



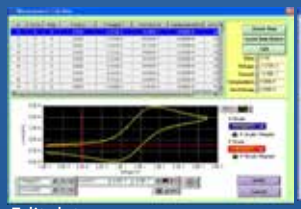
Time graph



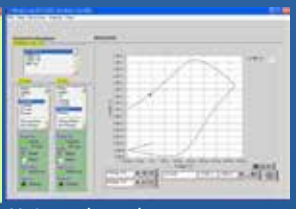
Find peak menu

CV graph

3D graph



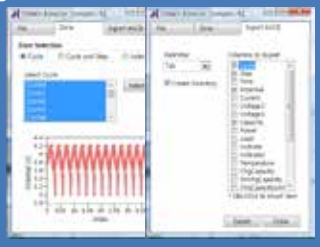
Edit data menu



Universal graph

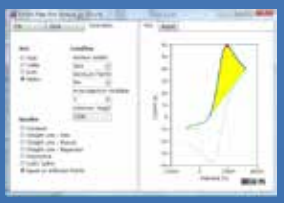
IVMAN EX™ Extractor

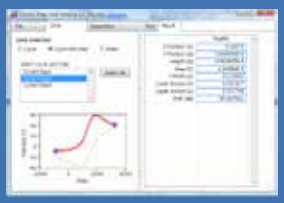
- Extracting data by cycle number or step
- Exporting ASCII file



IVMAN PF™ Peak Find Module

- Independent peak finding software





Optional Accessories

- Redox Flow Battery Test System
  - for charge/discharge test of a single cell
  - impedance measurement available
  - temperature control and measurement
  - electrolyte flow control with a dual channel peristaltic pump
  - max. 4 channel control with a PC
  - support various safety functions
  - system configuration :
    ZIVE SP5 Electrochemical workstation + RFC1 flow cell controller

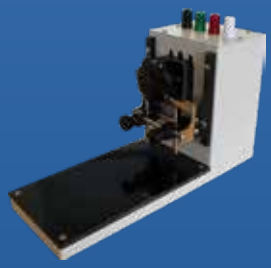
- Flow Cell Controller
  - MFCs and/or liquid pumps control
  - heating and cooling control
  - valve control
    (gas flowing on/off, dry/wet gas selection etc.)
  - rotator control
  - pressure regulator control
  - measurement of temperature, voltage, pressure,humidity etc.

Electrochemical Workstation ZIVE SP10

• Power Booster
- for high voltage/high current application
- modular type design
- EIS capability
- sine wave simulation available

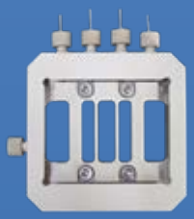
• Battery Jig & Coin Cell Jig
- for cylindrical cell or coin cell
- 4 or 2 contact pin depending on models
- rack type is available.

• Pouch Cell Jig
- contact type
a) pull-down contact type with adjustable contact probe's width
b) banana connector for cell cable connection
- 4 contact point type(Kelvin probe)



• Single Cell Hardware Fixture
- for PEMFC and DMFC
- max. temp. : 120˚C or 180˚C
- active area :
5, 9, 25, 50, 100cm^2
- MEA is not included.

• Membrane Conductivity Cell
- for 5, 9 and 25cm^2 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

Specification

Main System	
PC communication	USB2.0 high speed
Line voltage	100~240VAC, 50/60Hz
Max. output power	60Watt
Size	240x372x241mm(WxDxH)
LED indicator	Run, Busy, Potentiostat, Galvanostat

System	
Cell cable	1 meter shielded type(standard) Power terminal: working, counter Sense terminal: reference, working sense
Control DAC	DSP with FPGA 2x16bit DAC(50MHz) for bias & scan 1X16bit DAC(1MHz) for analog output
Data acquisition ADC	2x16bit ADCs(500kHz) for voltage, current 4x16bit ADCs(250kHz) for auxiliary voltage and temperature reading
Calibration	Automatic
Filter selection	4ea(5Hz, 1kHz, 500kHz, 5MHz)
Scan rate	0~200V/sec in common mode 0~5000V/sec in fast mode
Max. channel No.	16 channels via USB connection
Internal data memory	542,000 points
LCD display	DC & EIS mode automatically

Power Amplifier(CE)	
Power	60Watt (6V@10A)
Compliance voltage	±6V
Max. current	±10A
Control speed selection	8ea
Bandwidth	1MHz
Slew rate	10V/usec

Potentiostat Mode (voltage control)	
Voltage control	
Control voltage range	±5V, ±500mV, ±50mV
Voltage resolution	16 bit per each range
Voltage accuracy	±1mV ±0.05% of setting(gain x1)
Max. scan range	±5V vs. ref. E
Current measurement	
Current range	12 ranges(auto/manual setting) 10nA~10A 100pA & 1nA with gain
Current resolution	16 bit 300uA, 30uA, 13uA, 300nA, 30nA, 13nA 300pA, 30pA, 3pA, 300fA, 30fA, 3fA
Current accuracy	±20pA ±0.1% f.s.(gain x1)>1uA

Galvanostat Mode (current control)	
Current control	
Control current range	max. ±10A ± full scale depending on selected range
Current resolution	16 bit 300uA, 30uA, 13uA, 300nA, 30nA, 13nA 300pA, 30pA, 3pA, 300fA, 30fA, 3fA
Current accuracy	±20pA ±0.1% f.s.(gain x1)>1uA
Voltage measurement	
Voltage range	±5V, ±500mV, ±50mV
Voltage resolution	16 bit 150uV, 15uV, 1.5uV
Voltage accuracy	±1mV ±0.05% of reading(gain x1)

Electrometer	
Max. input voltage	±5V
Input impedance	$2x10^{13}$ Ω||4.5pF
Bandwidth	>22MHz
CMRR	>114dB

EIS(Internal FRA) for System	
Frequency range	10uHz~1MHz
Frequency accuracy	0.01%
Frequency resolution	5000/decade
Amplitude	0.1mV~5Vrms(Potentiostatic) 0.1~70% f.s.(Galvanostatic)
Mode	**Static EIS:** Potentiostatic, Galvanostatic, Pseudogalvanostatic, OCP **Dynamic EIS:** Potentiodynamic, Galvanodynamic **Fixed frequency impedance:** Potentiostatic, Galvanostatic, Potentiodynamic, Galvanodynamic **Multisine EIS:** Potentiostatic, Galvanostatic **Intermittent PEIS/GEIS**

Interfaces for System	
Auxiliary port	
Digital output	3(open collector)
Digital input	2(photo coupler)
Auxiliary voltage inputs	3 analog inputs: ±10V For measurement of WE vs. CE CE vs. RE or other signal
Analog output	1 analog output: ±10V For stirrer, MFC, RDE, etc.
Misc. port	
Sig generator output	1 analog output for FRA output or waveform generation output
Peripheral communication	I2C to control external devices
Temp. measurement	1 K-type thermocouple input
Zero Resistance Ammeter	10nA ~ 10A ranges

Software	
Max. step per experiment	1000
Shutdown safety limits	Voltage, current, temperature, etc.
Max. sampling rate	2usec or 3usec depending on data point number
Min. sampling time	Unlimited
Sampling condition	Time, dV/dt, dI/dt, temperature, etc.

PC Requirement	
Operating system	Windows 7/8/10(32bit/64bit OS)
PC specification	Pentium4, RAM 1GB or higher
Display	1600x900 high color or higher
USB	High speed 2.0

General	
Dummy cell	One external dummy cell included
Thermocouple	K-type, 1.5 meter long(option)
Aux. & Misc. cable	Option
Impedance analysis S/W	ZMAN™ software
DC data analysis S/W	IVMAN™ software package

The specifications are subject to change without notice.

Designing the Solution for Electrochemistry

Designed by

ZIVE LAB

www.zivelab.com

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

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