Portable
Electrochemical Workstation
ZIVE PP1e

For Field Application
Including Internal FRA
10Volts/1Amp

For
Corrosion
Material Testing
Sensor/BioElectrochemistry
Battery/Fuel Cell
Super Capacitor/Solar Cell

WonATech

The ZIVE PP1e, a portable Potentiostat/Galvanostat/FRA, is for an electrochemical test such as DC corrosion measurement, EIS test, battery/super capacitor test, etc. and is suitable for outdoor use. The system is housed in a 5 meter water-proofed industrial plastic case. It weighs 7.7kg with an internal battery pack and a tablet computer and 5.4kg without a table computer. A multichannel system can be configured using multiple ZIVE PP1e units and an external PC. The internal potentiostat/galvanostat circuit is floating type to enable users to do a pipe corrosion measurement. Optional external battery pack can be used instead of AC/DC adapter. The ZIVE PP1e comes with a slim and light tablet computer as standard and you can also use your own laptop computer.

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

DAC Control
 : Two sets of high speed 16bit DAC(50MHz) for offset & scanning

ADC Reading
 : Two sets of 16 bit 500kHz ADC for reading voltage/current and
   16bit 250kHz ADCs for auxiliary data input. This can provide high
   frequency EIS, fast pulse techniques and high speed sampling time.

The ZIVE PP1e is a perfect choice for the complete DC and impedance characterization of various electrochemical applications. The system 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. 1 Amp in galvanic corrosion technique. Four(4) advanced software packages, which are catagorized by application field, are provided with the system as standard. Consequently, it widens ZIVE PP1e's flexibility.

Features

■ Portable high quality Potentiostat/Galvanostat/Impedance Analyzer
■ Light weight and compact size with full functions
■ Supplied in a 5 meter waterproof housing case
■ Wide current ranges(1nA~1A) for various applications
■ Built-in FRA : enables EIS tests by using software
■ 14 EIS techniques capability including multisine
■ Capable of multitude of applications
  - Corrosion, general electrochemistry, sensor, battery, fuel cell,
    supercapacitor, solar cell, etc.
■ Current interrupt IR measurement
  IR compensation(dynamic, positive feedback)
■ Bipolar pulse capability and auxiliary voltage measurement available
■ Voltage pulse or current pulse charge/discharge test(GSM,CDMA etc.),
  sine wave function for ripple simulation in battery test package
  & pulse plating available
■ High speed data sampling time
  - 50usec/sample in burst mode
  - 1msec/sample in normal mode
  - 2usec/sample in fast sweep mode
■ Fast sweep mode(5000V/sec with 10mV data sampling)
■ 3 measurement/control voltage ranges &
  10 measurement/control current ranges
■ Internal 295,000 data point storage & continuing experiment regardless
  of PC failure.
■ Full software package included as standard
  - Corrosion test software package (CORe)
  - EIS test software package (EISe)
  - Electrochemical analysis software package (EASe)
  - Energy software package (BATe)
■ Multichannel configuration available
■ Free software upgrade

○ **Front View**
  Control & Display - Embedded Tablet Computer

Built-in FRA
FPGA/DSP control
Plug-in type

Cell port:
working,
reference,
counter,
working sense
AuxV

○ **Internal Battery Pack(option)**

Safety and Maintenance

1. Even though the communication failure occurs between PC and ZIVE PP1e, the system continues its experiment on channel and saves the data into ZIVE memory up to 295,000 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.

Application

A portable electrochemical workstation, ZIVE PP1e, is ideal for field application. You can use this system for corrosion/coating evaluation, sensor test, electrode material, membrane, conducting polymer, power device research such as battery materials, fuel cells, super capacitors and solar cells.

■ Corrosion

The system is suitable for measuring low corrosion rates and EIS test to evaluate corrosion. ZRA function is supplied for galvanic corrosion measurement.
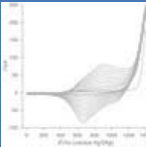
Sensors

The ZIVE PP1e can be used for sensor research using with DNA chips or screen printed electrodes. System's minimum current range is 1nA(with gain). Cyclic voltammetry, Chronoamperometry and EIS measurement can be used for this application.

General Electrochemistry

The ZIVE PP1e is also suitable for the development of bio-research, electron transfer kinetic studies or electrochemical analysis of compounds.

Batteries

The system is very well adapted for researches on the cycling behavior of battery. It supports 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 PP1e has fast potentiostat circuit with high speed data acquisition (50usec/point, burst mode). This function is well applicable to super capacitor testing. Charging/discharging capability is used for this application.

Fuel Cells

The ZIVE PP1e is ideal for characterizing the fuel cells and anodic/cathodic process mechanism at a development and research grade. This system can be directly used for PEMFC, DMFC, and DEFC etc. Automatic current ranging potentiostatic/ galvanostatic IV curve is available.

Main Software SM

The Smart Manager (SM) is to control ZIVE PP1e 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.
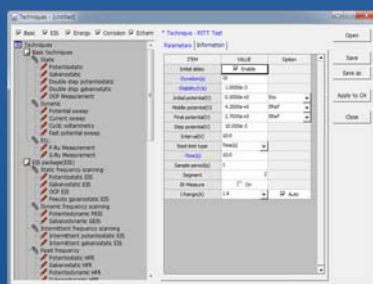
Technique list

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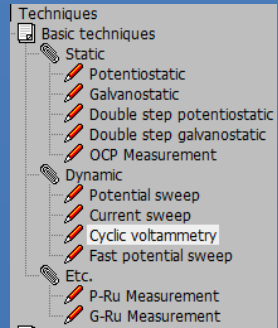
The above functions can be used sequentially by step control function.

Sequence editor

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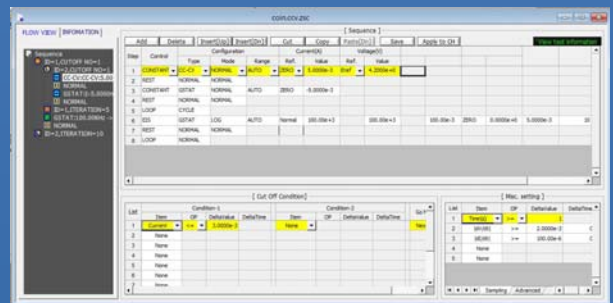
Sequence editor

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.

Sampling Condition

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

Flow View

- This displays sequence flow at a glance.
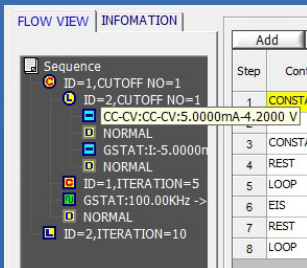
Flow view

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.
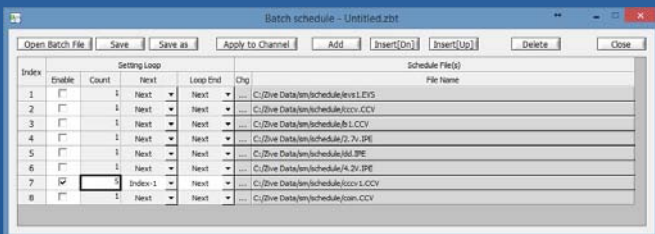
Advanced Software Packages

For a wide range of application, following software packages are provided as standard.

EIS Software Package(EISe)

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
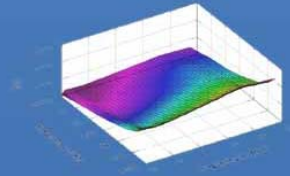
Coin cell intermittent PEIS 3D Nyquist plot by ZMAN

(*1) The system measures open circuit potential before for each frequency change and apply AC sine wave on this potential.
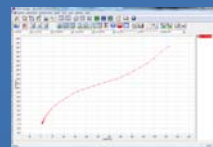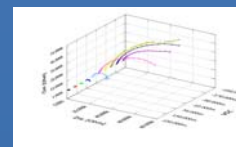
OCP EIS *Potentiodynamic PEIS* *Rs, Cp & Idc vs Vdc plot*
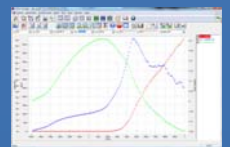
Corrosion Software Package(CORe)

Corrosion technique supports IR compensation.

1. Tafel(Tafel experiment)
2. Rp(Polarization resistance)
3. RpEc trend
4. PDYN(Potentiodynamic)
5. CYPOL(Cyclic polarization resistance)
6. GDYN(Galvanodynamic)
7. Reactivation
8. Galvanic corrosion
9. Potentiostatic ECN
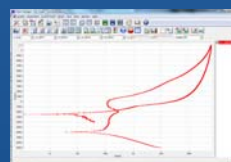10. Galvanostatic ECN
11. ZRA mode ECN
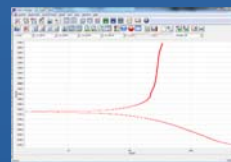
Tafel experiment
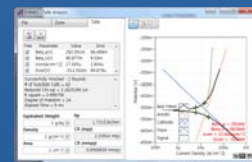
Rp (Polarization resistance)
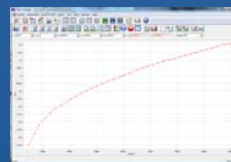
CYPOL(Cyclic polarization resistance)

## Electrochemical Analysis Software Package(EASe)

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)
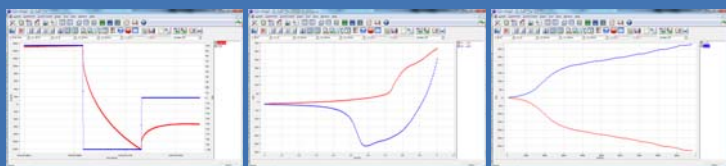
| *50usec sampling* | *Sampled DC voltammetry* | *NPV &RNPV overlay* |

Battery Software Package(BATe)

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
   • PITT
   • Pulse mode is available for GSM & CDMA profile. Pulse shape profile can
     be measured by user's demand.
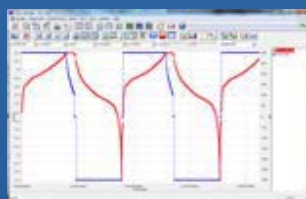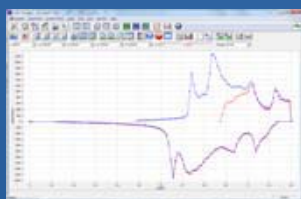
| *CC/CV test* | *EVS* |
| *Pulse shape profile monitor (micro sec order)* | *Current sine wave (charge ripple simulation)* |

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.

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

Control & Real Time Graph

Smart Manager Program provides virtual control panel for control & data acquisition with real time graph.

Multichannel real time graph

User can control and monitor in this control panel 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 technique. For experiment using sequence file or batch file, user can designate X,Y axis parameter on three different real time graph.

Each real time graph format can be also selected. Real time graph and VOI will be changed depending on DC test or impedance test automatically. 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.
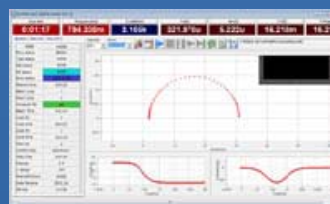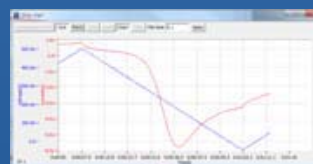

| *Single channel control panel* | *Multichannel real time graph* |

Strip Chart

Strip chart recorder function allows you to monitor DC curve in real time. You can monitor 2 Y axis data such as voltage, current, auxV, power, 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.
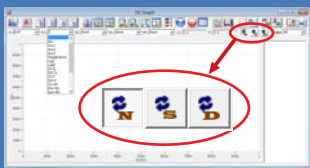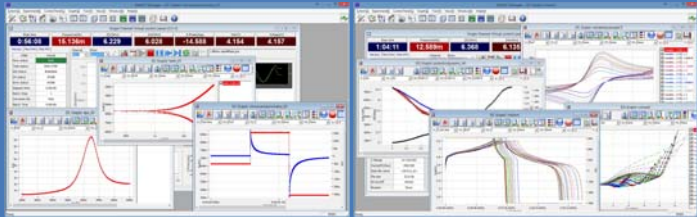
In DC and Cycle graph, whenever you click or , the parameters which are related to current such as current, capacity, energy, power, load, etc., are changed into calculated specific value or density value, respectively.

 : value divided by weight   : value divided by active area

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
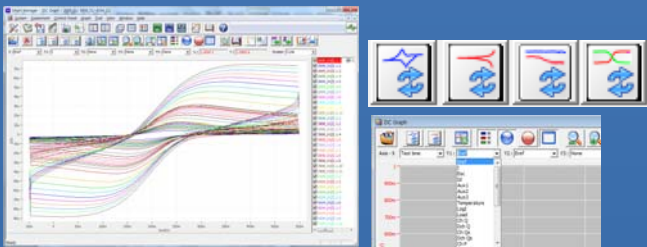
2) EIS Graph
- For EIS data display
- 3 shortcut buttons: Nyquist plot , Bode plot, Cs vs. frequency
- Graph parameters: Frequency, Zre, -Zim, Zmag, Zph, Y', Yimg, Y, |Y|, Yph, LogZ, LogY, Rs(R-C), Cs(R-C), Rp(R|C), Cp(R|C), Rs(R-L), Ls(R-L), Q(R-L), time, Vdc, Idc, temp, Aux(1,2,3)
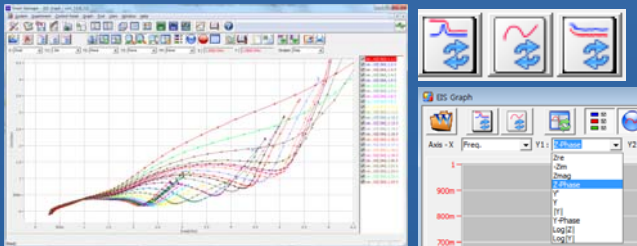
3) BAT Graph
- For battery cycle data display
- 3 shortcut buttons: cycle capacity, cycle average, Log(cycle No) vs. depth of discharge plot.
- Graph parameters: cycle number, Ch Q, Dch Q, Sum Q, Coulomb Eff, Ch-Wh, Dch-Wh, Sum Wh, Energy Eff, MinV, MaxV, ChQs, DchQ, ChVavg, DchVavg, Vavg
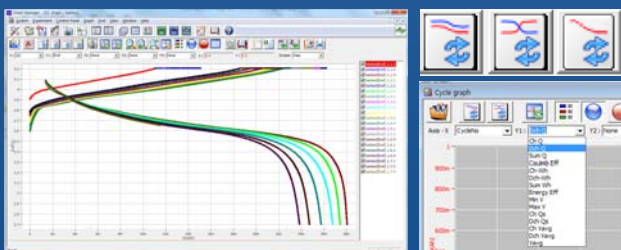
Data Export to ASCII & Excel File
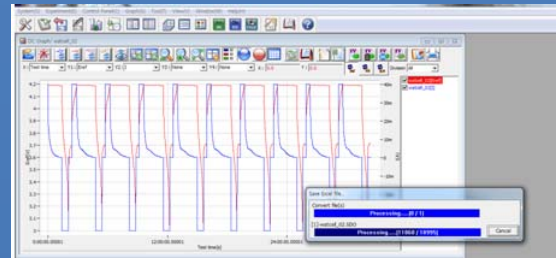
Selectable between 'Convert data on graph only' and 'Convert selected file(s)'

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
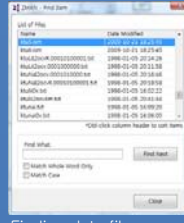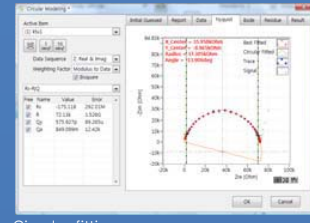- C vs. voltage graph
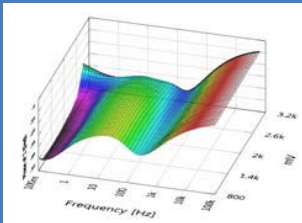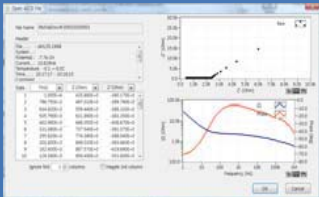
3D Bode plot for series measurement
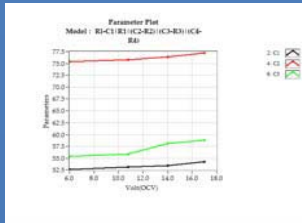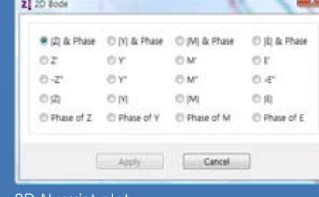
Parameter plot

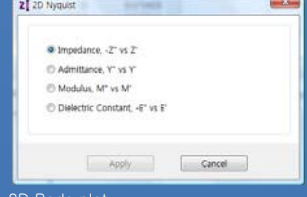Finding data file menu

Circular fitting
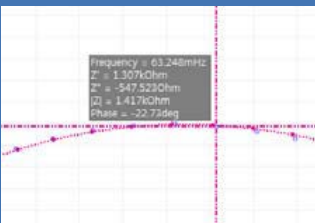
Importing 3rd parties ASCII data file
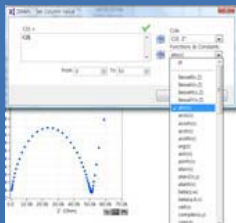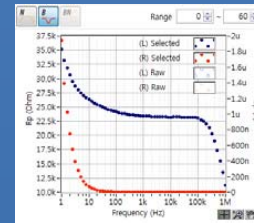
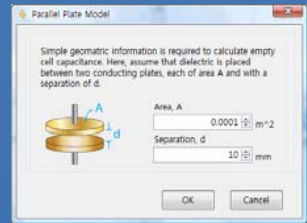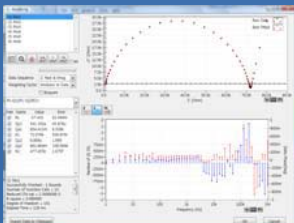Project manager with data preview

2D Nyquist plot

2D Bode plot
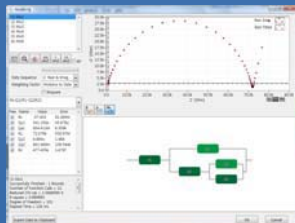
Cursor data display

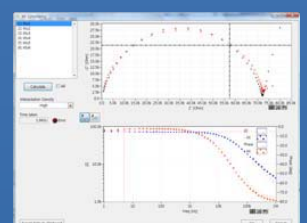Data replacement by formula function
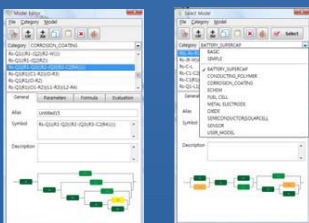
Rp,Cp vs frequency (R|C)

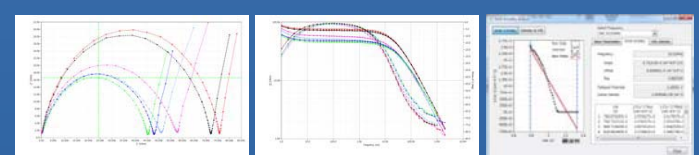Empty cell capacitance
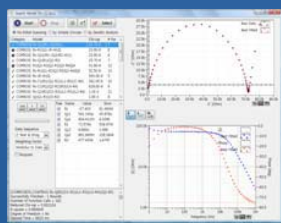
Fitting display
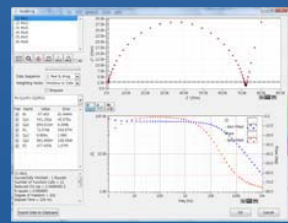
Donor density vs. Vfb graph and analysis

KK consistency
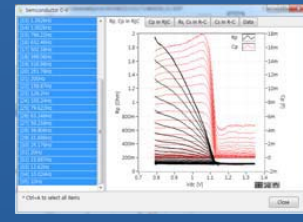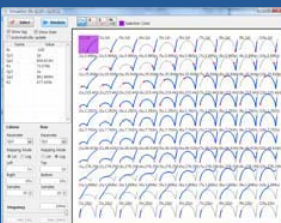
Model editor & model library

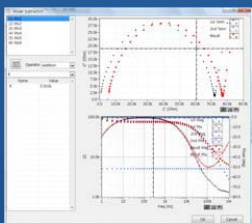Mott–Schottky analysis window

C/R–V graph

Automatic model searching

LEVM fitting

Parameter simulation

Element add/subtraction
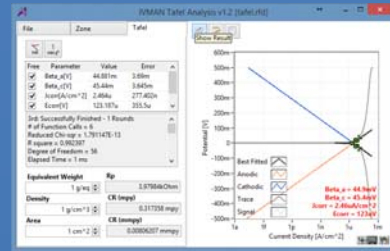
IVMAN™ DC Data Analysis Software

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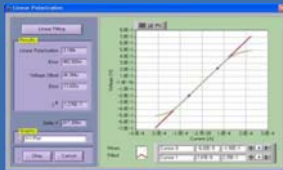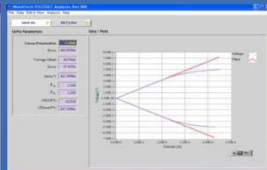 - IVMAN extractor
 - IVMAN peak find module

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.
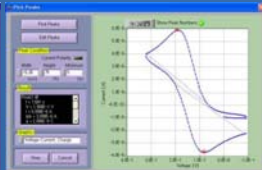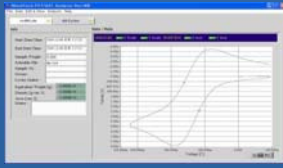- Reporting function

Polarization resistance fitting

Polarization analysis result
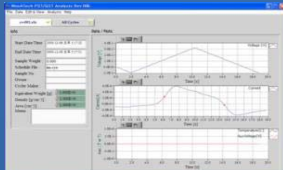
Time graph

Find peak menu

CV graph
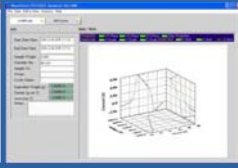
3D graph
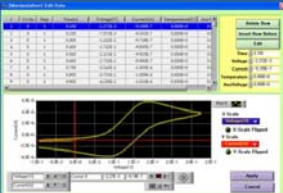
Edit data menu
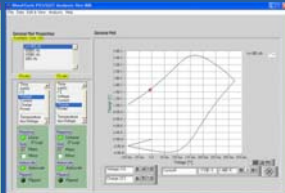
Universal graph

IVMAN TA™ Tafel Analysis

- Simple Tafel calculation

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)
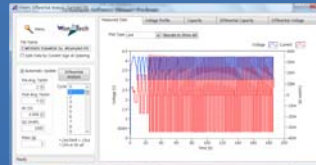
Measured data
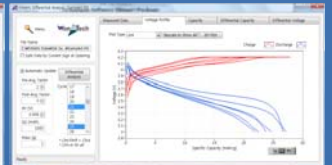
V vs. Q
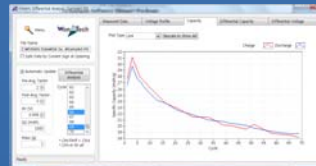
Cycle graph
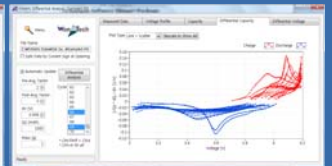
dQ/dV vs. V
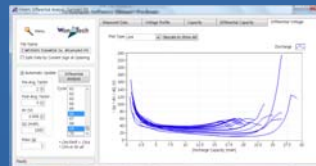
dV/dQ vs. Q
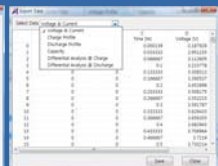
Export ASCII file

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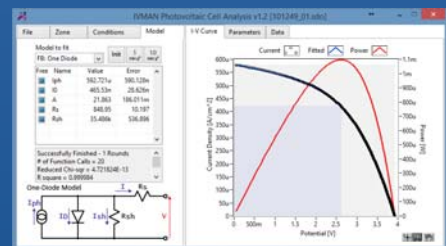
- Automatic analysis of parameters
  - open circuit voltage, open circuit current, max. power, efficiency photo induced current, diode quality factor, series resistance, etc.

IVMAN EX™ Extractor

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

IVMAN PF™ Peak Find Module

- Independent peak finding software

Optional Accessories

- Cell Kit

Corrosion Cell Kit

Flat Cell Kit

Plate Test Cell

Plate Test Cell

H-Type Cell

H-Type Cell
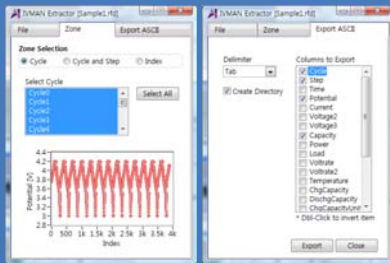
- Power Booster
  - for high voltage/high current application
  - modular type design
  - EIS capability
  - sine wave simulation available
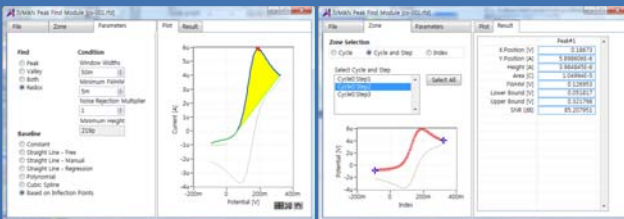
- Battery Test Cell
  - test cell for 2 or 3 electrode measurement
  - test cell for aqueous electrolyte
  - test cell for pressure monitoring
  - test cell for gas diffusion electrode
  - test cell for time-resolved gas analysis
  - test cell for optical and X-ray characterization
    in the reflective mode
 - test cell for high-throughput testing, etc.

ECC-Ref

ECC-Opto

ECC-Press

PAT-Single Stand

- Electrochemical Dilatometer
  - for the measurement of height changes in aprotic as well as
    aqueous electrolytes
  - ECD-3 : displacement resolution ≤50nm
  - ECD-3-nano : displacement resolution ≤5nm

• Battery Jig & Coin Cell Jig
  - for cylindrical cell or coin cell
  - 4 probe type

• Single Cell Hardware Fixture
  - for PEMFC and DMFC
  - max. temp. : 120˚C or 180˚C
  - active area : 5, 9, 25, 50, 100cm²
  - MEA is not included.

• 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)
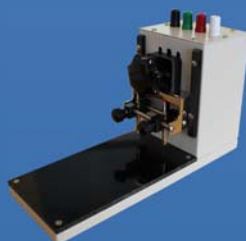
• Membrane Conductivity Cell
  - for 5, 9 and 25cm² fuel cell
    hardware fixture
  - material : PEEK(cell body), platinum(wire)
  - operating temp. : up to 130˚C
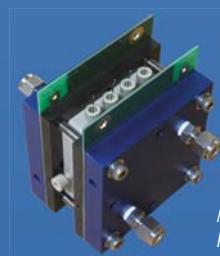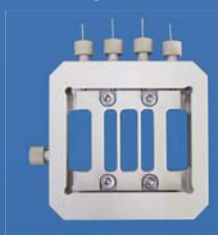
MCC with fuel cell hardware fixture

• Coin Cell Holder
  - D-SUB connector type

• Universal Electrode Holder
  - electrode and glass vial are not included.

• Through-Plane Conductivity Test Jig
  - for through plane conductivity measurement
  - 2 probe type

• Faraday Cage
  - size : 300 x 300 x 398mm(WxDxH)

Specification

Main System

PC communication	USB2.0 high speed
Line voltage	100~240VAC, 50/60Hz, 1Amp
Power adapter	24V@2.5Amp
Size/weight	411x321x165(WxDxH) / 4.4kg
Max. output power	15Watt

System

Cell cable	1 meter shielded type(standard) working, reference, counter, working sense, Auxiliary V
Control	DSP with FPGA
DAC	2x16bit DAC(50MHz) for bias & scan
Data acquisition	2x16bit ADCs(500kHz) for voltage, current
ADC	1x16bit ADCs(250kHz) for auxiliary reading
Calibration	Automatic
Filter selection	4ea(5Hz, 1kHz, 500kHz, 5MHz)
Scan rate	0~200V/sec in common mode 0~5000V/sec in fast mode
Tablet PC	Included
Internal data memory	295,000 points

Power Amplifier(CE)

Power	12Watt (12V@1A)
Compliance voltage	±12V
Max. current	±1A
Control speed selection	4ea
Bandwidth	2MHz
Slew rate	10V/usec

Potentiostat Mode (voltage control)

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

Galvanostat Mode (current control)

Current control	
Control current range	max. ±1A ± full scale depending on selected range
Current resolution	16 bit 30uA, 3uA, 300nA, 30nA, 3nA, 300pA, 30pA, 3pA, 300fA, 30fA
Current accuracy	±10pA ±0.1% f.s.(gain x1)>100nA f.s.
Voltage measurement	
Voltage range	10V, 1V, 100mV
Voltage resolution	16 bit 0.3mV, 30uV, 3uV
Voltage accuracy	±1mV ±0.05% of reading(gain x1)

Electrometer

Max. input voltage	±10V
Input impedance	$2\text{x}10^{13}$ 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	
Auxiliary voltage input	1 analog input: ±10V
Zero resistance ammeter	100nA~1A ranges
External booster interface	Via booster I/F cable
LED indicator	Cell On, Run LED

Internal Battery Pack (option)

Battery	Li ion battery
Weight	2.7kg
Capacity	300Whr
Size	270x180x140mm(WxDxH)
Charger	Included
Output voltage	24VDC, selectable
Charging guage	Included

Software

Max. step per experiment	1000
Shutdown safety limits	Voltage, current, power, AuxV etc.
Max. sampling rate	20kHz(50usec) in burst mode 500kHz(2usec) in fast sweep mode
Min. sampling time	Unlimited
Sampling condition	Time, dv/dt, dI/dt, etc.

PC Requirement

Operating system	WindowsXP SP3/7/8/10(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
Impedance analysis S/W	ZMAN™ software
DC data analysis S/W	IVMAN™ software package

The specifications are subject to change without notice.
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Designed by

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