

## Compact Type Electrochemical Workstation ZIVE SP1

Including Internal FRA  
10Volts/1Amp  
Full Software Package Included

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

# Electrochemical Workstation ZIVE SP1

The **ZIVE SP1** is an outstanding Potentiostat/Galvanostat/FRA offered at affordable price. This powerful model is a perfect choice for the complete DC and impedance characterization of various electrochemical applications.

The **ZIVE SP1** 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 categorized by application field, are provided with the system as standard. Consequently, it widens **ZIVE SP1**'s flexibility.

## Features

- Economical high quality Potentiostat/Galvanostat/Impedance Analyzer
- Compact size with full functions
- Smart LCD display
- 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
- 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
  - 2usec or 3usec depending on data point number
- Fast sweep mode(5000V/sec with 10mV data sampling)
- 3 measurement/control voltage ranges & 10 measurement/control current ranges
- Internal 542,000 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



ZIVE SP1 front view



DC Mode

EIS Mode

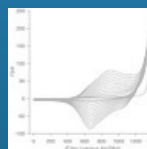


ZIVE SP1 rear view

## Application

The **ZIVE SP1** electrochemical workstation is ideal for fundamental research in electrochemistry, development and quality assurance of new sensors, corrosion/coatings, electrode material, membrane, conducting polymer, evaluation power device research such as battery materials, fuel cells, super capacitors and solar cells.

### ■ General Electrochemistry



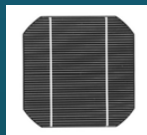
The **ZIVE SP1** is also suitable for the development of bio-research, electron transfer kinetic studies or electrochemical analysis of compounds.

### ■ 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.

### ■ Solar Cells



Solar cell development and production require extensive material and device testing to improve efficiency and match individual cells for panel construction. The **ZIVE SP1** is the best solution for photovoltaic cell characterization.

### ■ 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 SP1** 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.

### ■ Super Capacitors



The **ZIVE SP1** has fast potentiostat circuit with high speed data acquisition. This function is well applicable to super capacitors testing. Charging/discharging capability is used for this application.

# Electrochemical Workstation ZIVE SP1

## Fuel Cells



The ZIVE SP1 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. Automatic current ranging potentiostatic/galvanostatic IV curve is available.

## Smart Manager(SM) Software



The Smart Manager(SM) 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.

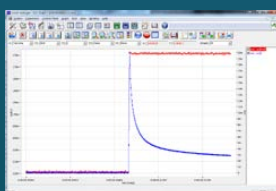
The SM software is easy to use and supports various electrochemical experiments including functions of system control, schedule file editor, real time graph, analysis graph, user calibration, and data file treatment etc.

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

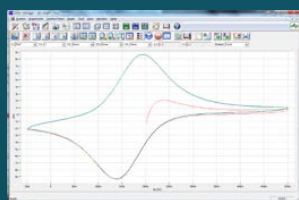
## Basic Techniques

### Basic Technique with Standard Functions

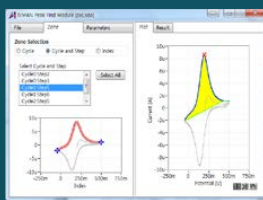
- 1) Potentiostatic
- 2) Galvanostatic
- 3) Double step potentiostatic
- 4) Double step galvanostatic
- 5) OCP measurement
- 6) Potential sweep
- 7) Current sweep
- 8) Cyclic voltammetry
- 9) Fast potential sweep
- 10) Potentiostatic Ru measurement
- 11) Galvanostatic Ru measurement



50 usec data sampling



DC graph

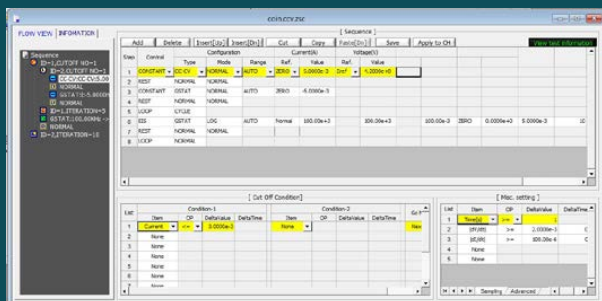


Peak find module

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

### Sequence Editor

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



### 1) Control Task Parameter

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

### 2) Cut-off(Vertex) condition

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

Condition-1		
Item	OP	DeltaValue
Step Time	>=	30
None		
Step End		
Step Time		
Current		
I Density		
Voltage		
Capacity		
-dV		
dV/dt		
dI/dt		
Temp. (C)		
AUX1		
AUX2		
AUX3		
Test Time		
Loop Time		
Cycle Time		
Eoc		
[Whr]		
LCC(%)		
LCD(%)		
FCC(%)		
FCD(%)		
Power (W)		
SumQ(Ahr)		
SumE(Whr)		
Loop Next		
DI Ch.		
Crate		

Cutoff Condition

### 3) Sampling Condition

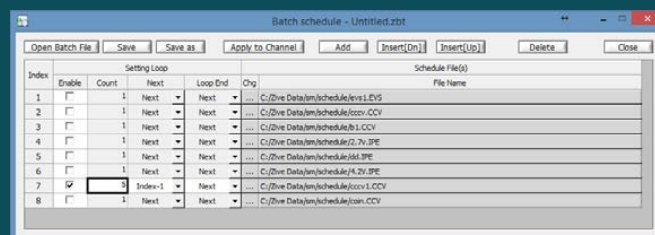
- time, |dI/dt|, |dV/dt|, |dA1/dt|, burst time

### 4) Flow View

This displays sequence flow at a glance.

### 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.





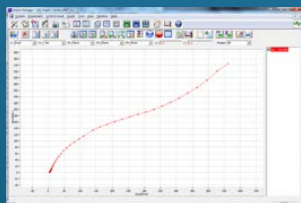
## Advanced Software Packages

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

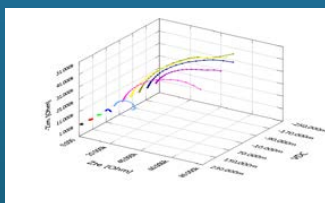
### ■ EIS Software Package (EISe)

- 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

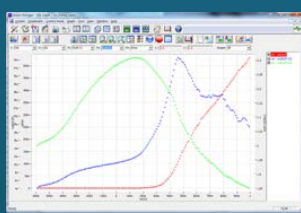
(\*1) The system measures open circuit potential before each frequency change and applies AC sine wave on this potential.



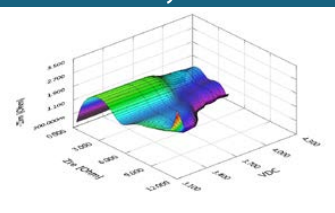
OCVEIS



Potentiodynamic PEIS



Rs, Cp & Idc vs Vdc plot

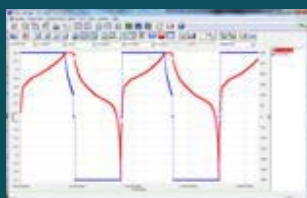


Coin Cell Intermittent PEIS  
3D Nyquist Plot By ZMAN

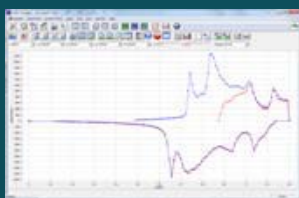
### ■ Energy Software Package (BATE)

BATE software supports IR measurement.

- 1) Battery Test Technique
    - CC/CV test for cycle life test of lithium battery
    - CC/CC test for cycle life test of NiCd & NiMH battery
    - Discharging test
    - EVS (Electrochemical voltage spectroscopy)
    - Variable scan rate CV
    - Potentiostatic IV curve
    - Galvanostatic IV curve
    - Steady state 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

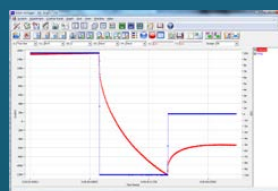
### 3) Cutoff Condition

- Time, voltage, current, power, auxV etc.

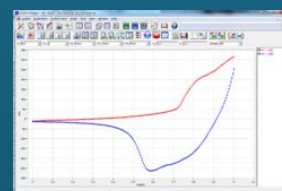
Various battery charge/discharge test is available including pulse discharge for GSM, CDMA application.

### ■ Electrochemical Analysis Software Package (EASe)

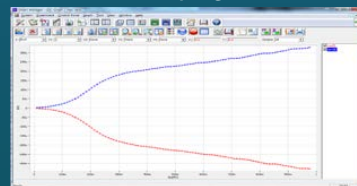
- 1) Step Techniques
  - CA (Chronoamperometry)
  - CC (Chronocoulometry)
  - CP (Chronopotentiometry)
- 2) Sweep Techniques
  - LSV (Linear Sweep Voltammetry)
  - SDV (Sampled DC Voltammetry)
  - Fast CV
  - Fast LSV
- 3) Pulsed Techniques
  - DPV (Differential Pulse Voltammetry)
  - SWV (Square Wave Voltammetry)
  - DPA (Differential Pulse Amperometry)
  - NPV (Normal Pulsed Voltammetry)
  - RNPV (Reverse Normal Pulse Voltammetry)
  - DNPV (Differential Normal Pulse Voltammetry)



50 usec sampling



sdv\_charging/sdv\_discharging

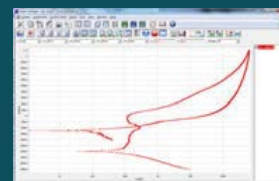


NPV & RNPV overlay

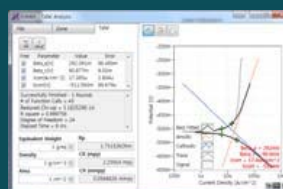
### ■ Corrosion Software Package (CORE)

Corrosion technique supports IR compensation.

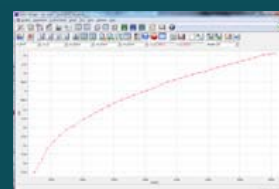
1. Tafel(Tafel experiment)
2. Rp(Polarization resistance)
3. Potentiodynamic
4. Galvanodynamic
5. Cyclic polarization
6. Ecorr vs. time
7. Galvanic corrosion
8. RpEc trend
9. Reactivation potential
10. Critical pitting potential
11. Potentiostatic ECN
12. Galvanostatic ECN
13. ZRA mode ECN



Cyclic polarization resistance



Tafel plot



Polarization resistance

## Control & Real Time Graph

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

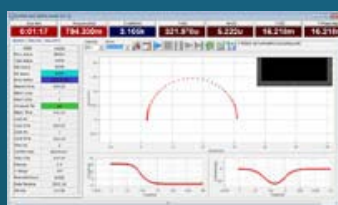


Multichannel real time graph

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.

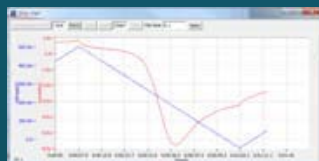


Single channel control panel



Multichannel real time graph

## Strip Chart

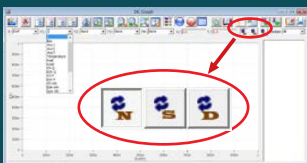
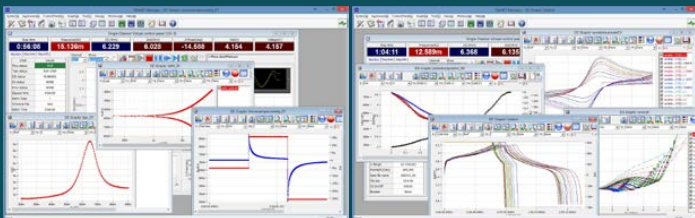


Strip chart recorder function allows you to monitor DC curve in real time. You can monitor 2 Y axis data such as voltage, current, auxV, power, capacity etc. in real time

## 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.



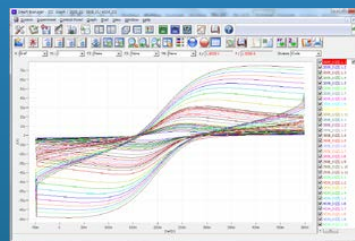
In DC and Cycle graph, whenever you click or , the parameters which are related to current such as current, capacity, energy, power, load, etc., are changed into calculated specific value or density value, respectively.

: value divided by weight

: value divided by active area

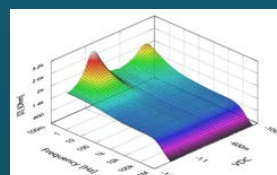
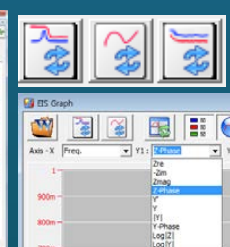
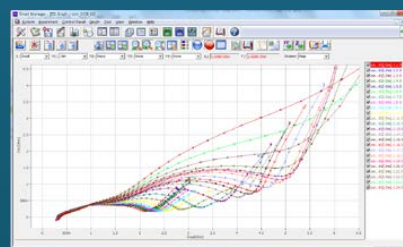
## 1) DC Graph

- 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, 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

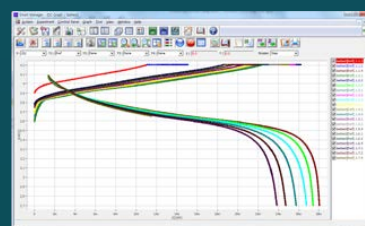
- For EIS data display
- 3 shortcut buttons: Nyquist plot, Bode plot, Cs vs. frequency
- Graph parameters: Frequency, Zre, -Zim, Zmag, Zph, Y', Yimg, Y, |Y|, Yph, LogZ, LogY, Rs(R-C), Cs(R-C), Rp(R|C), Cp(R|C), Rs(R-L), Ls(R-L), Q(R-L), time, Vdc, Idc, Aux1



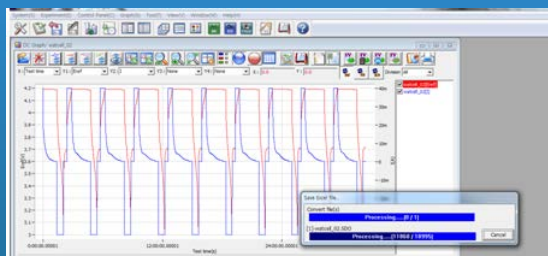
3D Bode Plot by ZMAN  
Technique used: Potentiodynamic Impedance Measurement By Using A Corrosion Cell

## 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



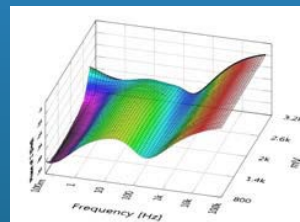
Selectable between 'Convert data on graph only' and 'Convert selected file(s)'

## Data Analysis Software

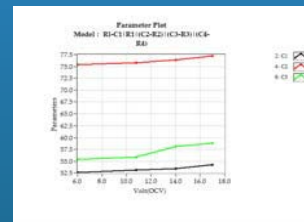
ZIVE data file can be used for analysis by using external IVMAN™ software for DC analysis, IVMAN DA™ software for battery data analysis, IVMAN PA™ software for photo-voltaic cell data analysis and ZMAN™ software for EIS data analysis without license.

## ZMAN™ EIS Data Analysis Software

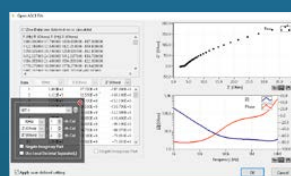
- Model simulation and fitting
- 2D- and 3D-Bode- and Nyquist plots
- Automatic equivalent circuit model search function
- Project concept to handle multiple EIS data analysis
- Parameter plot from fitted elements value
- Compatible with data format from Zahner, Gamry, Ametek etc. (License code is needed.)
- 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



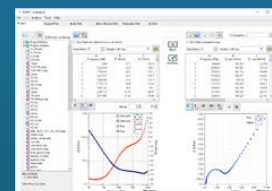
3D Bode plot for series measurement



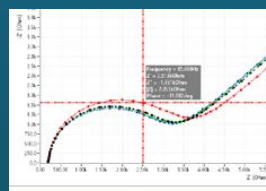
Parameter plot



Importing 3rd parties ASCII data file



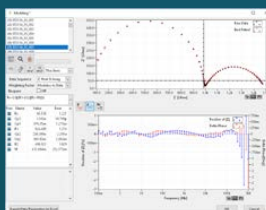
Project manager with data preview



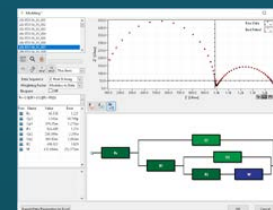
Cursor data display



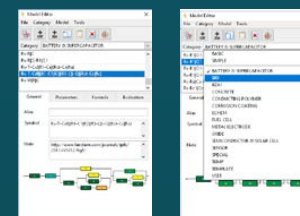
Data replacement by formula function



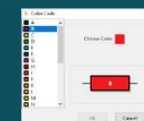
Fitting display



Model editor & model library



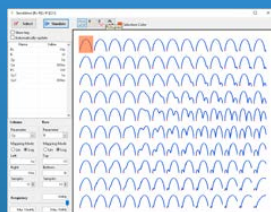
Automatic model searching



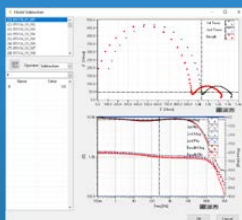
LEVM fitting



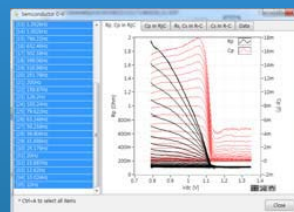
# Electrochemical Workstation ZIVE SP1



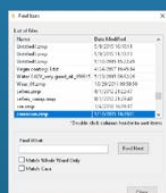
Parameter simulation



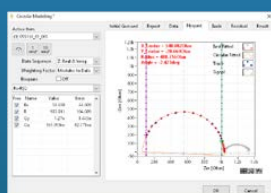
Element add/subtraction



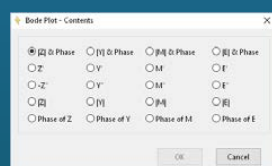
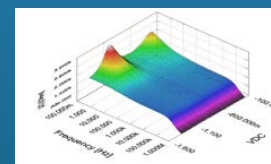
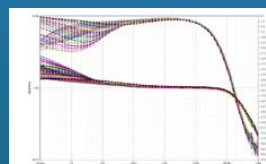
C/R-V graph



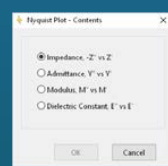
Finding data file menu



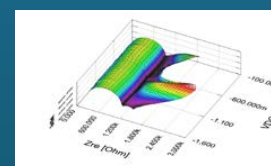
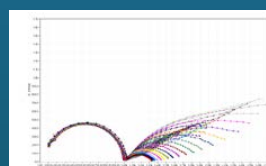
Circular fitting



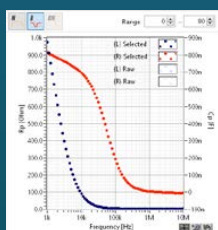
2D Nyquist plot



2D Bode plot



Bode & Nyquist overlay & 3D plots



Rp,Cp vs frequency (R|C)



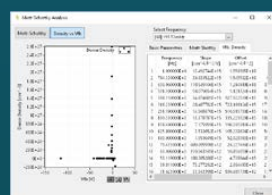
Empty cell capacitance

## IVMAN™ DC Data Analysis Software

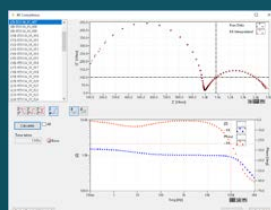


IVMAN™ software package consists of

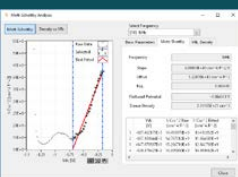
- IVMAN software
- IVMAN utilities
  - IVMAN differential analysis software
  - IVMAN photo voltaic cell analysis.
  - IVMAN Tafel analysis
  - IVMAN extractor
  - IVMAN peak find module



Donor density vs. Vfb graph and analysis



KK consistency

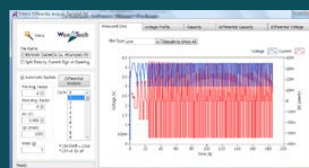


Mott-Schottky analysis window

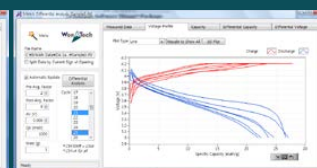


## IVMAN DA™ Battery Test Data Analysis Software

- 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)

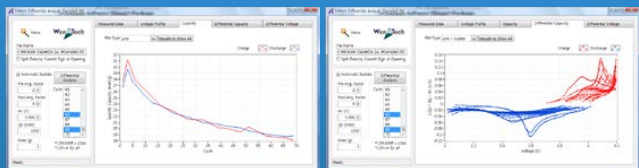


Measured data



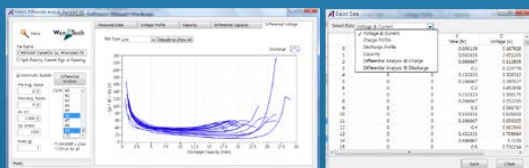
V vs. Q

# Electrochemical Workstation ZIVE SP1



Cycle graph

$dQ/dV$  vs.  $V$

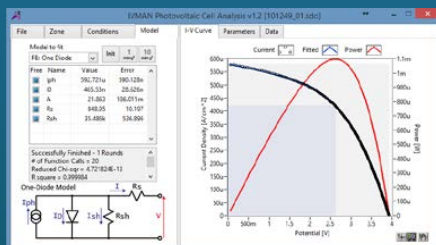


$dV/dQ$  vs.  $Q$

Export ASCII file



## IVMAN™ Photovoltaic Cell Analysis

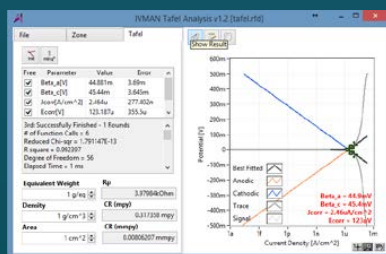


- Automatic analysis of parameters
- open circuit voltage, open circuit current, max. power, efficiency
- photo induced current, diode quality factor, series resistance, etc.



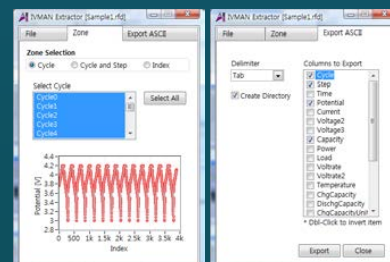
## IVMAN TA™ Tafel Analysis

- Simple Tafel calculation



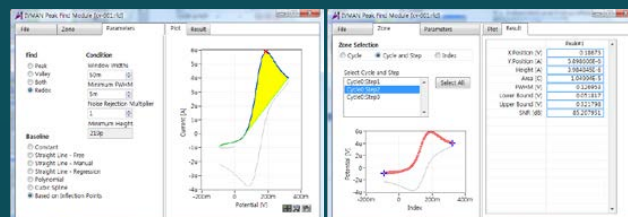
## IVMAN EX™ Extractor

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



## IVMAN PF™ Peak Find Module

- Independent peak finding software



## 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

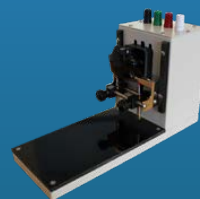


## Optional Accessories

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



- Battery Jig & Pouch Jig



Corrosion Cell Kit



Flat Cell Kit



Permission Cell Kit



Plate Test Cell



Plate Test Cell



Universal electrode holder



Black Box for photo-electrochemistry



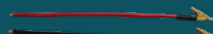
Faradaic cage



Flat specimen holder



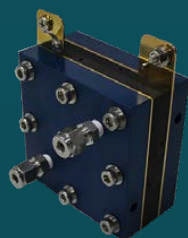
Through-Plane Conductivity Test Jig



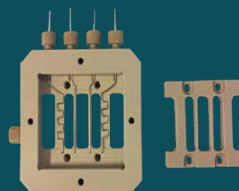
Copper Alligator electrode holder



Pt plug electrode



- Single Cell Hardware Fixture
  - for PEMFC and DMFC
  - max. temp. : 120°C or 180°C
  - active area : 5, 9, 25, 50, 100cm<sup>2</sup>
  - MEA is not included.



membrane conductivity cell

## Specification

Main System	
PC communication	USB2.0 high speed
Line voltage	100~240VAC, 50/60Hz, 1Amp
Power adapter	24V 2.5Amp
Size/weight	160x330x81mm(WxDxH) / 2.05Kg
Max. output power	12Watt

System	
Cell cable	1 meter shielded type(standard) working, reference, counter, working sense, Auxiliary V
Control DAC	DSP with FPGA 2x16bit DAC(50MHz) for bias & scan
Data acquisition ADC	2x16bit ADCs(500kHz) for voltage, current 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
Max. channel No.	8 channels via USB connection
Internal data memory	542,000 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 with gain)
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 with gain)
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	2x10 <sup>13</sup> 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~5V rms (Potentiostatic) 0.1~70% f.s. (Galvanostatic)
Mode	<b>Static EIS:</b> Potentiostatic, Galvanostatic, Pseudogalvanostatic, OCP <b>Dynamic EIS:</b> Potentiodynamic, Galvanodynamic <b>Fixed frequency impedance:</b> Potentiostatic, Galvanostatic, Potentiodynamic, Galvanodynamic <b>Multisine EIS:</b> Potentiostatic, Galvanostatic <b>Intermittent PEIS/GEIS</b>

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
Sync terminal	For channel synchronizing

Smart LCD Display	
DC mode	Control value, E value, I value E range, I range
EIS mode	Frequency, Magnitude, Phase E range, I range
Operation status	Mode: PST, GST, ZRA, EIS, CC, CV, CP, CR Status: Cell On, Run, Error

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