Designed by ZIVE LAB

# Multichannel Power Electrochemical Workstation

# ZIVE MP5

Including Internal FRA/ZRA
10Volts/5Amp(40Watt/ch)

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

WonATech

# Electrochemical Workstation ZIVE MP5

The ZIVE MP5, the outstanding multichannel Potentiostate/ Galvanostat/FRA, is the best choice for the complete DC and impedance characterization of corrosion, coating, sensor and other fundamental electrochemical analysis. And also, its versatile functions make it suitabe to other application including various energy sources and storage such as fuel cells, batteries, solar cells, and super capacitors.

Each channel is designed under FPGA and DSP control with high speed capability.

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

ADC Reading
: Two sets of 16 bit 500kHz ADC for reading voltage/current and 4 channel 16bit 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.

Each channel of ZIVE MP5 is equipped with a Frequency Response Analyzer(FRA) 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. 5Amp 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 MP5's flexibility.

## System Features

- Versatile high quality multichannel potentiostat/galvanostat/impedance analyzer
- 8 fully independent channels with 14 EIS techniques capability including multisine
- Multichannel FRA function to control an external electronic load or 3rd party potentiostat/galvanostat is available as standard
- Current interrupt IR measurement
  IR compensation available(dynamic, positive feedback)
- 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 & 11 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)
- Channel expandable up to 32 channels
- Free software upgrade

## Hardware Features

- ±10V@5Amp control range per channel
- Wide current ranges(5A to 50pA) for various applications (500pA with gain)
- Min. number of channels : 2 channels
- Independent operation by FPGA with DSP
- Built-in FRA per channel for impedance measurement
- Bipolar pulse capability
- K-type thermocouple input for temperature measurement as standard
- Simultaneous 3 auxiliary voltage measurements
- 1 auxiliary analog output
- 3 digital outputs & 2 digital inputs
- External booster(ZB series) interface for high current application
- External multiplexer(MUX series) interface for a sequential measurements on multiple electrochemical cells

- *Front View*

- *Channel View*

## Versatility

The ZIVE MP5'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 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 MP5, 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.

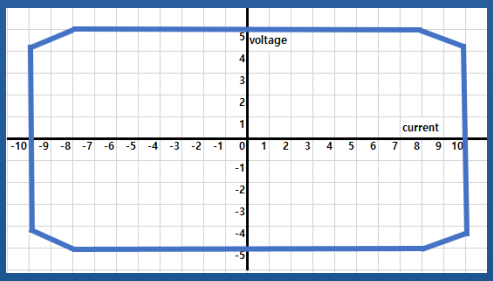
5. The system has its own hardware parameters and calibration data.

6. The channels feature plug-n-play setup for easy installation and removal.

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

8. An 8 channel system can be expanded to a 16ch-, a 24ch-system etc. by using an USB hub.

## Operation power range




The ZIVE MP5's Max power is 40Watt per channel. You can operate Max 5Amp @ 8V and 4Amp@10V.
If your application require higher current for higher voltage, you can choose MP10 model for those application.

## Application

The ZIVE MP5 multichannel electrochemical workstation is ideal for evaluation power devices such as battery materials, fuel cells, super capacitors, solar cells, etc. With low current capability, the system can be used for fundamental research in electrochemistry, development and quality assurance of new sensors, corrosion/coatings, etc.

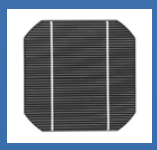
- ***Batteries***

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***

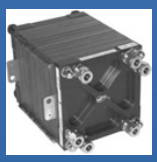
The ZIVE MP5 has fast potentiostat circuit with high speed data acquisition. This function is well applicable to super capacitor testing. Charging/discharging capability is used for this application.

- ***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 MP5 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 MP5 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).

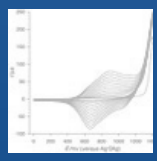
- ***Corrosion***

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

- ***Sensors***

The ZIVE MP5 can be used for sensor research using with DNA chips or screen printed electrodes. System's minimum current range is 500pA(with gain).
Cyclic voltammetry, Chronoamperometry and EIS measurement can be used for this application.

- ***General Electrochemistry***

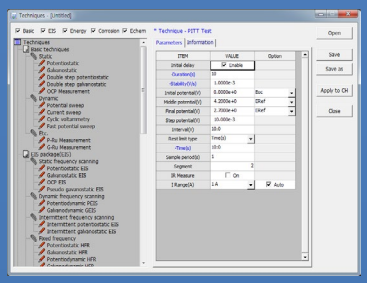


The ZIVE MP5 is also suitable for the development of bio-research, electron transfer kinetic studies and electrochemical analysis of compounds at low trace levels, where multichannel DC and impedance analysis is beneficial in providing high throughput of results.

## Main Software

SM

The Smart Manager (SM) is to control ZIVE MP5 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.



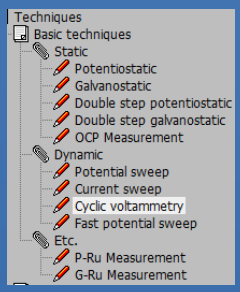
Technique list

## 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.

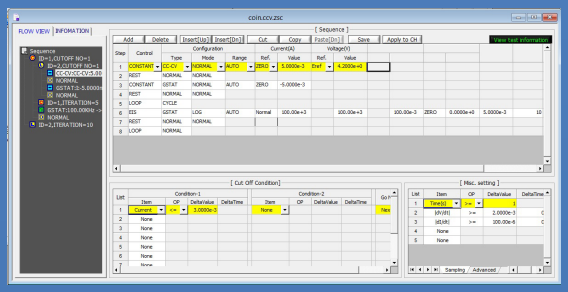



### *Sequence editor*

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

#### 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 |

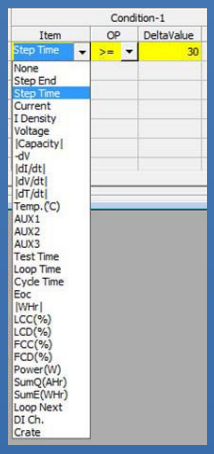


Sequence editor

- 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.



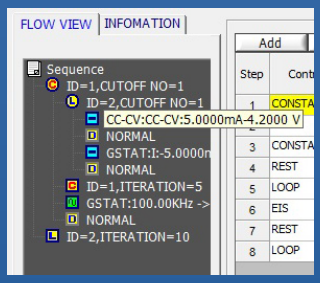

Cutoff condition

#### Sampling Condition

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

#### Flow View

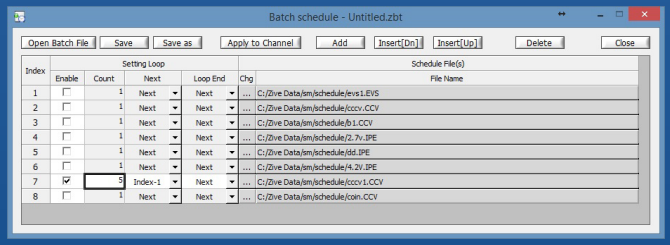
- User can see the sequence flow at a glance.




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.



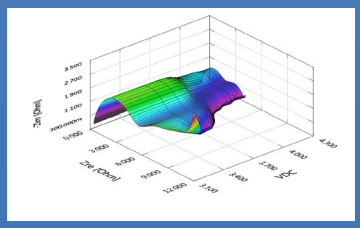
## Smart Manager Advanced Software Package

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

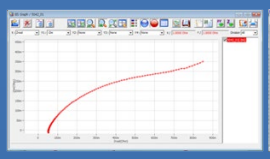
### *EIS Software Package(EIS)*

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

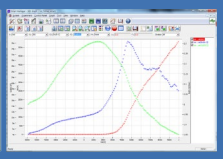
(*1) The system measures open circuit potential before each frequency change and applies AC sine wave on this potential.



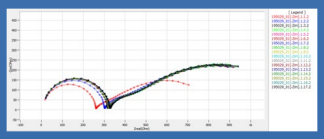
Coin cell intermittent PEIS
3D Nyquist plot by ZMAN



Galvanostatic EIS



Rs, Cp & Idc vs Vdc plot

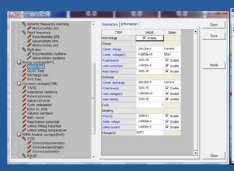


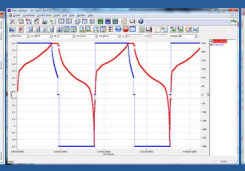
Intermittent Poteniostatic EIS

### *Energy Software Package(BAT)*

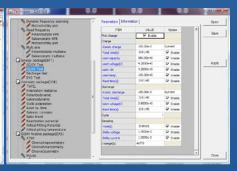
BAT software supports IR measurement.

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

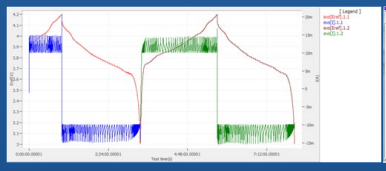




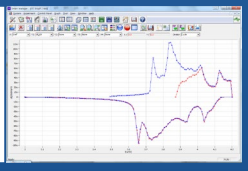
CC/CV test



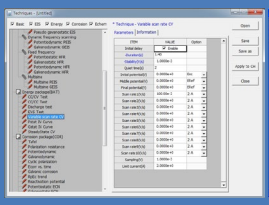
CC/CC test

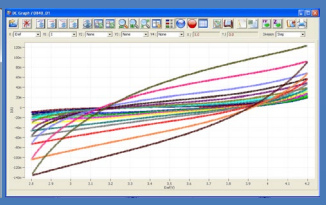


EVS test raw data

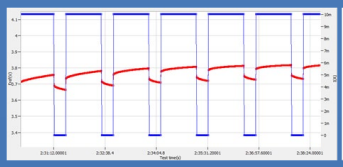


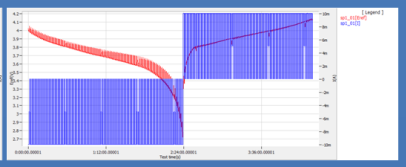
EVS graph format
(dQ/dV vs. V)



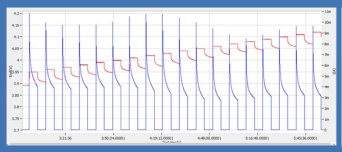


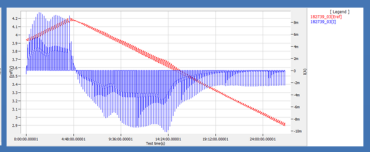
Variable scan rate CV





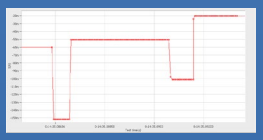
GITT test



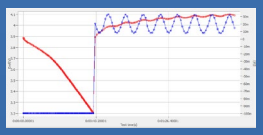


PITT test

- 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

### *Electrochemical Analysis Software Package(EAS)*

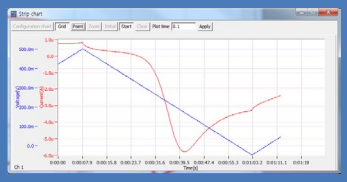
1. Step techniques
   CA(Chronoamperometry), CC(Chronocoulometry), CP(Chronopotentiometry)

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.

### *Strip Chart*



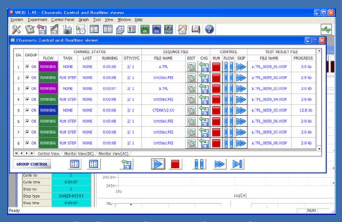
Strip chart recorder function provides real graph function independently. You can monitor 2 Y axis data such as voltage, current, AuxV1,2,3, temperature, power, capacity etc. in real time and can select channel(s) which you want to monitor. You can also set max. data point for showing strip chart length.

### *Simple Monitor*

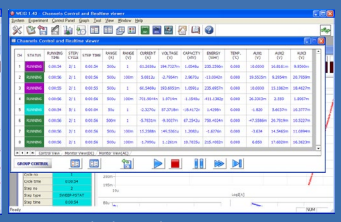
This display window is for monitor the major data values and channel status for multiple channel operation.

## Control & Real Time Graph

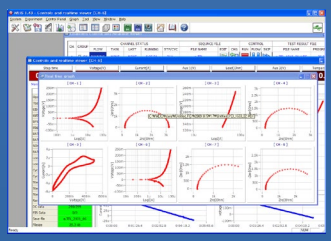
Smart Manager provides 2 kinds of control & data acquisition with real time graph.



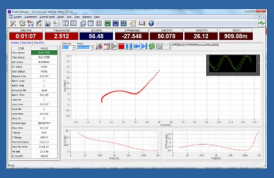
Multichannel Control Panel



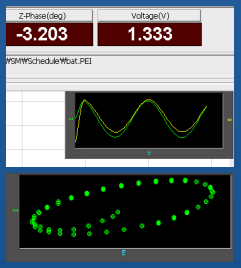
Multichannel Data Monitor
(EIS data/DC data selectable)



Multichannel Real Time Graph



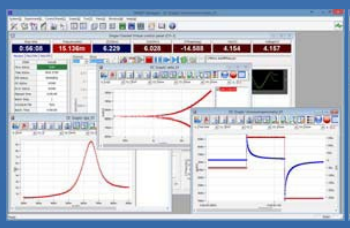
User can control and monitor for specific channel in details and he/she can monitor data in VOI(value of interest) window and channel status in one window. Real time graph's X ,Y axis format will be changed per technique automatically. It can be defined by user's demand per technique.
For experiment 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 channel number which you control can be changed in this window. Even if you control the channel in this mode, you can also monitor and control the same channel in this control panel at same time.

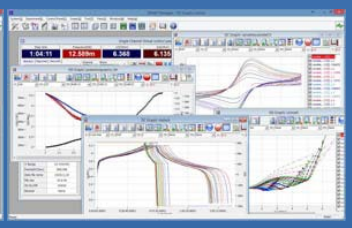


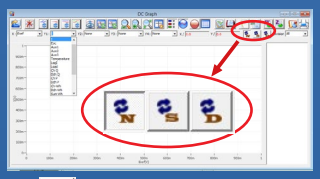

The real time graph and VOI will be changed depending on DC test or impedance test automatically. The virtual control panel always displays the graph for recent test result. For impedance measurement, wave monitor will be displayed on real time graph to check wave's quality. This monitor can be switched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

## 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.



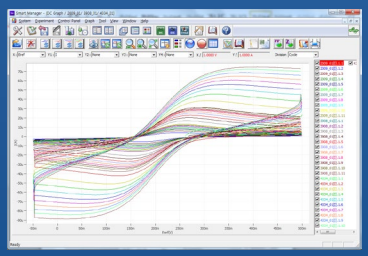


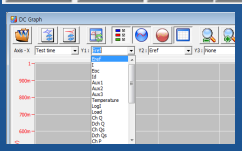


In DC and Cycle graph, whenever you click S or D, the parameters which are related to current such as current, capacity, energy, power, load, etc., are changed into calculated specific value or density value, respectively.

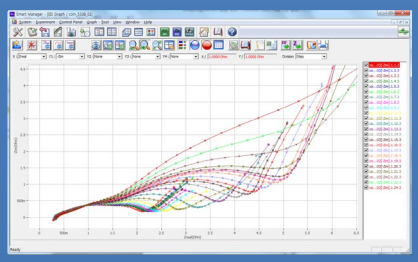
S : value divided by weight  D : value divided by active area

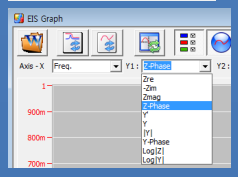
1) DC Graph
- For general data display
- 4 shortcut buttons: I vs. V, E vs. LogI, V, I vs. time, V vs. Q
- Graph parameters: time, Eref, I, Eoc, Id, Aux1, Aux2, Aux3, temp, LogI, Load, ChQ, DchQ, ChQs, DchQs, Ch P, Dch P, Ch-Wh, Dch-Wh, Sum Wh, Sum Q, Sum |Q|, |Q|, Rp, dQ/dV

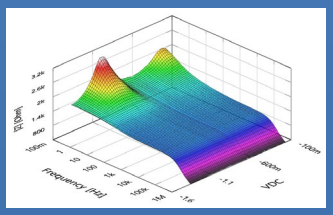




2) EIS Graph
- For EIS data display
- 3 shortcut buttons: Nyquist plot , Bode plot, Cs vs. frequency
- Graph parameters: Frequency, Zre, -Zim, Zmag, Zph, Y', Yimg, Y, |Y|, Yph, LogZ, LogY, Rs(R-C), Cs(R-C), Rp(R|C), Cp(R|C), Rs(R-L), Ls(R-L), Q(R-L), time, Vdc, Idc, temp, Aux(1,2,3)

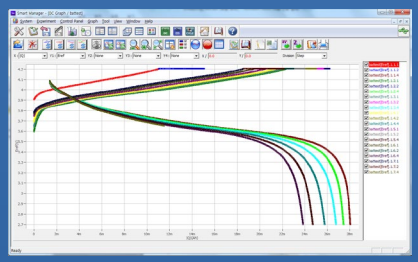


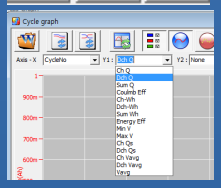


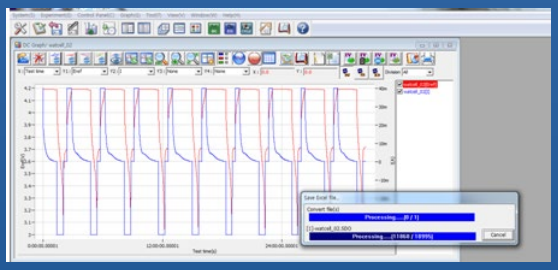

3D Bode Plot by ZMAN
Technique used: Potentiodynamic Impedance Measurement
By Using A Corrosion Cell

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



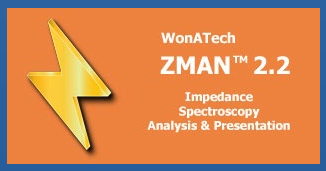
Selectable between 'Convert data on graph only' and 'Convert selected file(s)'

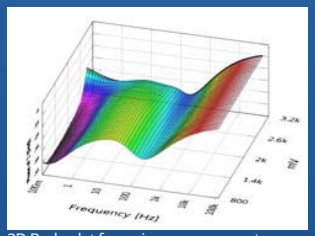
## Data Analysis Software

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.

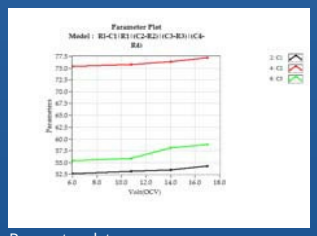
## ZMAN™ EIS Data Analysis Software

- 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



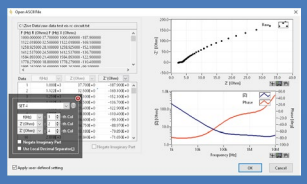



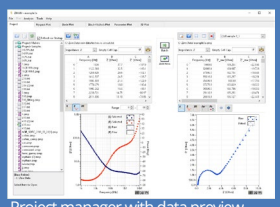

3D Bode plot for series measurement

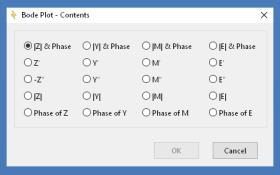



Parameter plot

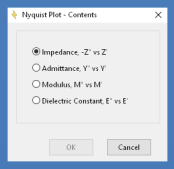
# Electrochemical Workstation ZIVE MP5


Importing 3rd parties ASCII data file

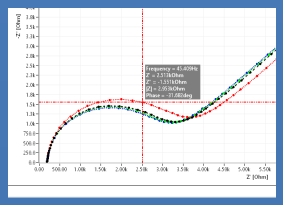

Project manager with data preview

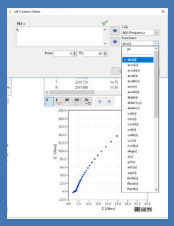


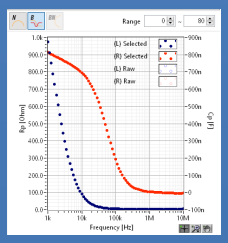
2D Nyquist plot

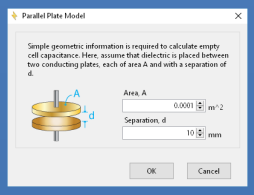


2D Bode plot

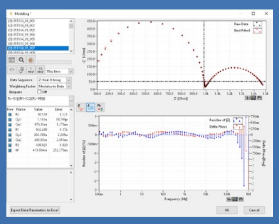
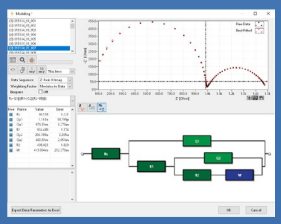

Cursor data display

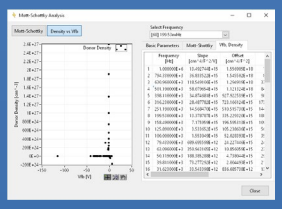

Data replacement by formula function

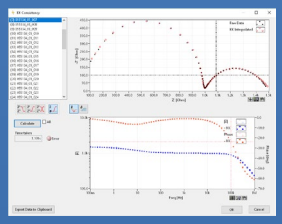

Rp,Cp vs frequency (R|C)

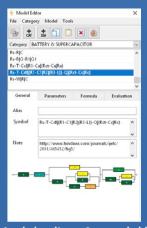
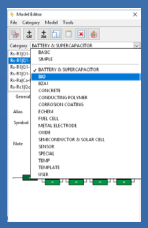
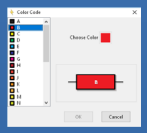


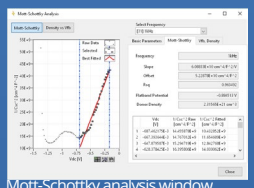
Empty cell capacitance

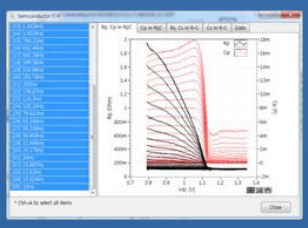


Fitting display

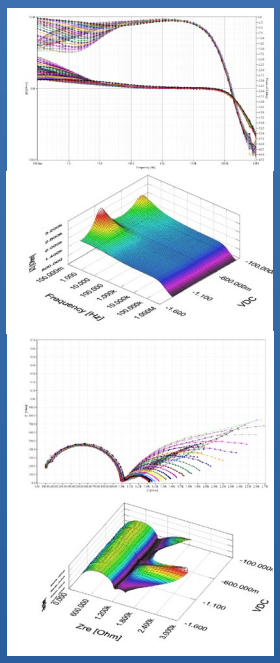

Donor density vs. Vfb graph and analysis

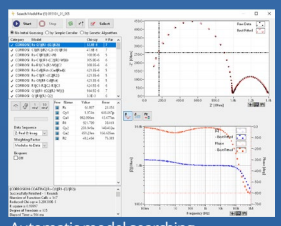

KK consistency

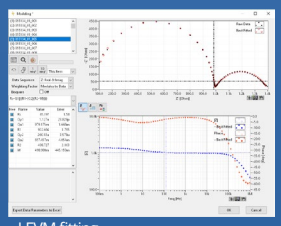



Model editor & model library

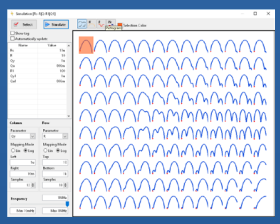

Mott-Schottky analysis window

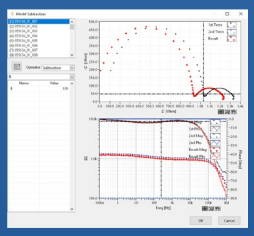

C/R-V graph

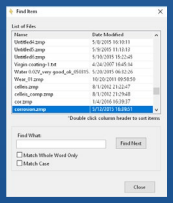

Bode & Nyquist overlay & 3D plots

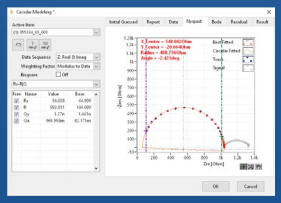

Automatic model searching


LEVM fitting


Parameter simulation


Element add/subtraction


Finding data file menu

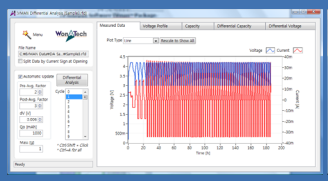

Circular fitting

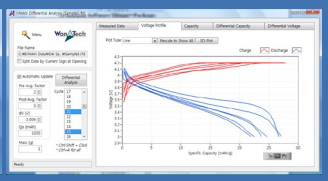
## IVMAN™ DC Data Analysis Software

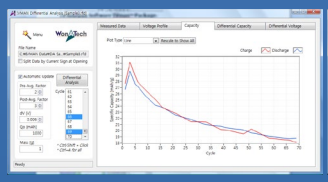
IVMAN™ software package consists of
- IVMAN software
- IVMAN utilities
  - IVMAN differential analysis software
  - IVMAN photo voltaic cell analysis.
  - IVMAN Tafel analysis
  - IVMAN extractor
  - IVMAN peak find module

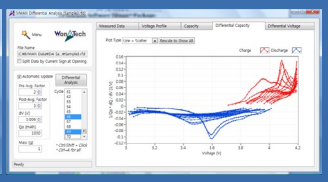
## IVMAN DA™ Battery Test Data Analysis Software

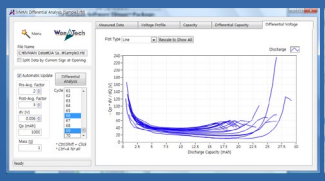
- Battery test data analysis
- Electrochemical voltage spectroscopy (dQ/dV vs. V)
- Voltage vs. Capacity analysis (V vs. Q)
- Cycle graph (Q vs. cycle)
- Differential voltage graph (dV/dQ vs. Q)

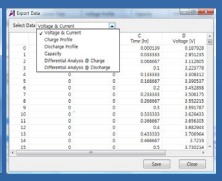

Measured data


V vs. Q

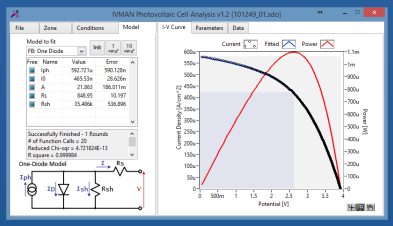

Cycle graph


dQ/dV vs. V


dV/dQ vs. Q


Export ASCII file

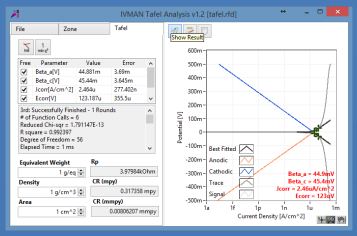
## IVMAN™ Photovoltaic Cell Analysis



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

## IVMAN TA™ Tafel Analysis

- Simple Tafel calculation

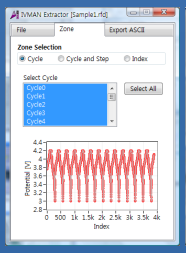


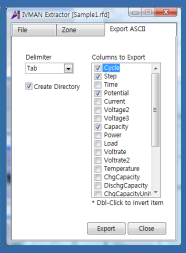
## IVMAN™ Main Software

- 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

## IVMAN EX™ Extractor

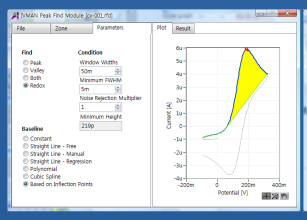
- Extracting data by cycle number or step
- Exporting ASCII file

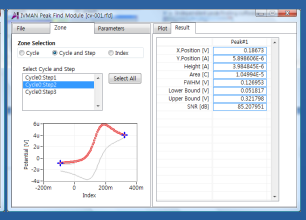




## IVMAN PF™ Peak Find Module

- Independent peak finding software





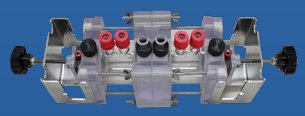
## Optional Accessories

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

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

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

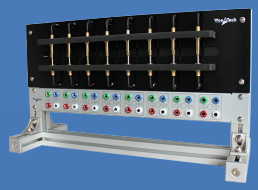
• Permeation Cell



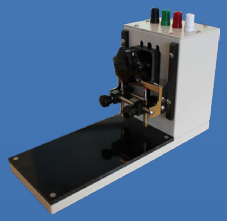
PMC1 Standard Type

WPMC1 Water-Jacketed Type

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



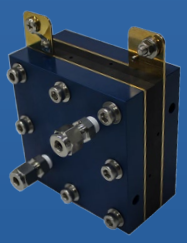
• Pouch Cell Jig
- pull-down or banana connector type contact
- 4 contact point type (Kelvin probe)

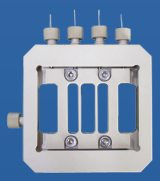


• Through-Plane Conductivity Test Jig
- for through plane conductivity measurement
- 2 probe type

• 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.

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





• Pt Plate Electrode

• Photo Echem Cell Kit

PCELL1

## Specification

| Main System | |
|---|---|
| PC communication | USB2.0 high speed |
| Line voltage | 100~240VAC, 50/60Hz |
| Max. channel number | 8 independent channels per unit |
| Max. channel | 32 channels(4 units) expandable per PC |
| Size/weight | 448.7x277.3x535.4mm(WxHxD)/29kg(8ch) |

| System | |
|---|---|
| Cell cable | 1 meter shielded type(standard)<br>working, reference, counter,<br>working sense |
| Control<br>DAC | DSP with FPGA<br>2x16bit DAC(50MHz) for bias & scan<br>1X16bit DAC(1MHz) for analog output |
| Data acquisition<br>ADC | 2x16bit ADCs(500kHz) for voltage, current<br>1x16bit ADCs(250kHz) for auxiliary voltage<br>and temperature reading |
| Calibration | Automatic |
| Filter selection | 4ea(5Hz, 1kHz, 500kHz, 5MHz) |
| Scan rate | 0~200V/sec in common mode<br>0~5000V/sec in fast mode |
| LED indicator | Busy, Run |
| Max. output power | 40Watt per channel |
| Internal data memory | 542,000 points |

| Power Amplifier(CE) | |
|---|---|
| Power | 40Watt |
| Compliance voltage | ±10V |
| Max. current | ±5A within 40Watt |
| Control speed selection | 8ea |
| Bandwidth | 1MHz |
| 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 | ±0.02% fs (gain x1) |
| Max. scan range | ±10V vs. ref. E |
| Current measurement | |
| Current range | 11 ranges(auto/manual setting)<br>5nA~5A<br>500pA with gain |
| Current resolution | 16 bit<br>150uA, 15uA, 1.5uA, 150nA, 15nA, 1.5nA<br>150pA, 15pA, 1.5pA, 150fA, 15fA |
| Current accuracy | ±0.02% f.s.(gain x1)>500nA |

| Galvanostat Mode (current control) | |
|---|---|
| Current control | |
| Control current range | max. ±5A<br>± full scale depending on selected range |
| Current resolution | 16 bit<br>150uA, 15uA, 1.5uA, 150nA, 15nA, 1.5nA<br>150pA, 15pA, 1.5pA, 150fA, 15fA |
| Current accuracy | ±0.02% f.s.(gain x1)>500nA f.s. |
| Voltage measurement | |
| Voltage range | 10V, 1V, 100mV |
| Voltage resolution | 16 bit<br>0.3mV, 30uV, 3uV |
| Voltage accuracy | ±0.02% fs (gain x1) |

| Electrometer | |
|---|---|
| Max. input voltage | ±10V |
| Input impedance | 2x10 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)<br>0.1~70% f.s.(Galvanostatic) |
| Mode | **Static EIS:**<br>Potentiostatic, Galvanostatic,<br>Pseudogalvanostatic, OCP<br>**Dynamic EIS:**<br>Potentiodynamic, Galvanodynamic<br>**Fixed frequency impedance:**<br>Potentiostatic, Galvanostatic,<br>Potentiodynamic, Galvanodynamic<br>**Multisine EIS:**<br>Potentiostatic, Galvanostatic<br>**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<br>For measurement of WE vs. CE<br>CE vs. RE or other signal |
| Analog output | 1 analog output: ±10V<br>For stirrer, MFC, RDE, etc. |
| Misc. port | |
| Sig generator output | 1 analog output for FRA output or<br>waveform generation output |
| Peripheral communication | I2C to control external devices |
| Temp. measurement | 1 K-type thermocouple input |
| Zero Resistance Ammeter | 5nA ~ 5A 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) |
| Auxiliary cable | Option |
| Misc. cable | Option |

The specifications are subject to change without notice.
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