Designed by ZIVE LAB

High Current Electrochemical Workstation

SHP480HC

For Energy Storage & Conversion Devices Application

-1V~+5V @ 50A

10uHz to 50kHz EIS capability

Battery pack
Fuel Cell stack
Supercapacitors
Solar Cells

WonATech

High Current Electrochemical Workstation SHP480HC

The SHP480HC is for energy storage and conversion devices application having 50 ampere capability.

These are high current potentiostat/galvanostat/impedance analyzer which is the best choice complete DC and impedance characterization of high capacity single cell batteries including fuel cells, supercapacitors and solar cells, etc.

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

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

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

The SHP480HC provides impedance measurements over the frequency range 10uHz to 50kHz. These systems major target application is for high capacity single cell which has low impedance. These models might be used in other electrochemical application requiring high power such as fuel cell and super capacitor, etc.

With various advanced software packages, user can widen SHP480HC flexibility.

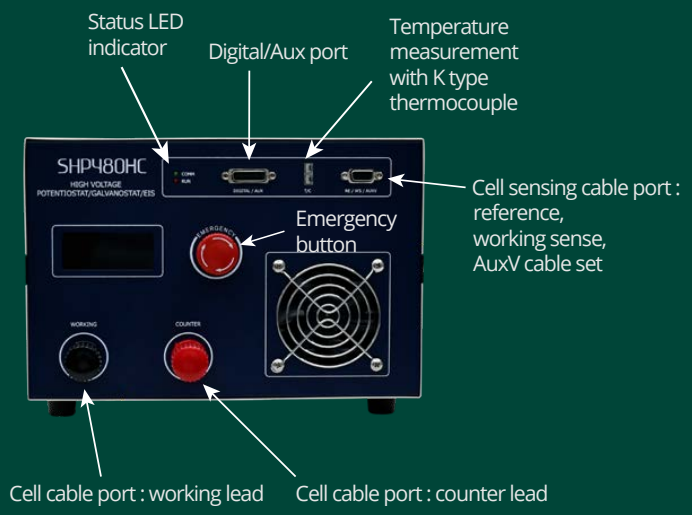
System Features

- Versatile all in one high current Potentiostat/Galvanostat/Impedance analyzer. (Not requiring external booster)
- 16 EIS techniques capability including multisine & real time EIS at affordable price
- IR measurement (fixed frequency sine wave) during charge/discharge control is available
- Main applications
  - Batteries, Fuel cell, Supercapacitors, Solar cells etc.
- User defined alias and unit display for max 3 auxiliary signals simultaneously.
- High speed data sampling time
  - 2usec or 3usec depending on data point number
- 3 measurement/control voltage ranges
- 7 measurement/control current ranges
- Internal 542,000 data point storage and continuing experiment regardless of PC failure.
- Full software packages are included as standard
  - EIS test software package(EIS)
  - Energy software package(BAT)
  - Corrosion test software package(COR)
  - Electrochemical analysis software package(EAS)
- Free software upgrade

Hardware Features

- -1V to 5V@50Amp
- Compact design in high current potentiostat/galvanostat hardware.
- Independent operation by DSP with FPGA
- Simultaneous 3 auxiliary voltage measurements
- Temperature measurement as standard
- 1 auxiliary analog output
- 2 digital outputs & 1 digital inputs
- Separated power and sensing line
- Max. 50kHz EIS capability
- Emergency stop button

- ***Front View***



- ***Rear View***

- ***Smart LCD Display***

DC Mode

EIS Mode

Versatility

The SHP480HC come with additional 3 analog inputs (auxiliary voltage input) and 1 analog output along with 2 digital outputs and 1 digital input, and one temperature input for K type thermocouple. It will help users expanding usage of the instrument.

For example,

1. User can measure the additional 3 voltage input by using auxiliary voltage input. (User can measure the voltage between reference and counter electrode and between working and counter electrode as well.)

2. With analog output, the system can control external devices (MFC flow rate, etc.) by ±10V full scale.

3. User can control using 3bit Digital Output and External control using 1 bit Digital Input.

High Current Electrochemical Workstation SHP480HC

Safety and Maintenance

1. Even though the communication failure occurs between PC and SHP480HC, the system continues its experiment on channel and saves the data in SHP480HC memory up to 542,000 data point set. After the communication is restored, SHP480HC will transfer saved data set to PC automatically or user can transfer data set when he/she wants. This function will be highly efficient for long-term 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 is controlled from a PC via USB.
6. There is an emergency button to cell off for emergency.

Application

The SHP480HC high current electrochemical workstation is the best choice to complete DC and impedance characterization of energy storage & conversion devices such as high capacity batteries, fuel cells, supercapacitors and solar cells, etc.

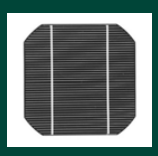
Batteries

SHP480HC is very well adapted for high capacity single cell batteries application. It provides various control modes for battery cycling with max 50 Ampere @5Volts. 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 with profile display is available.

Supercapacitors

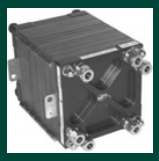
SHP480HC has fast potentiostat circuit with high speed data acquisition(50usec/point, burst mode). Also it provides high current EIS test for low impedance sample. These functions are well applicable to super capacitor testing. Charging/discharging capability is used for this application.

Solar Cells



Solar cell development and production requires extensive material and device testing to improve efficiency and match individual cells for panel construction. The SHP480HC 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.

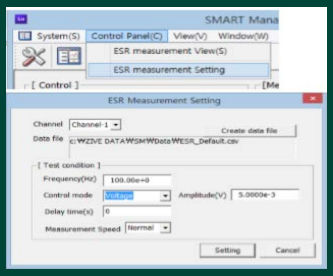
Fuel Cells



The SHP480HC 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).

Impedance(ESR) measurement for QC/QA

The SHP480HC is also suitable for impedance measurement at fixed frequency using independent software.

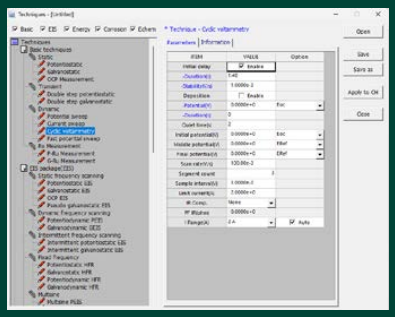


You can do the above function by replacing file name. It provides simple results with text data files showing "pass" "fail" decision.
The measurement operation is simply click the "start" button or press space bar.

Main Software

The Smart Manager (SM) is to control SHP480HC 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.

High Current Electrochemical Workstation SHP480HC

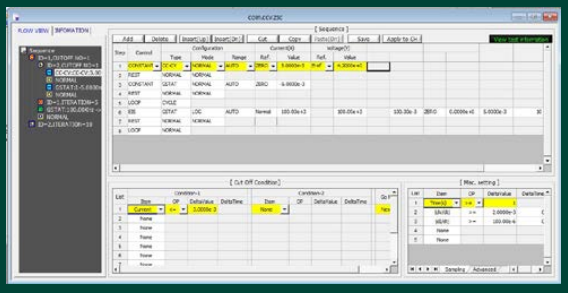


Technique list

- 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

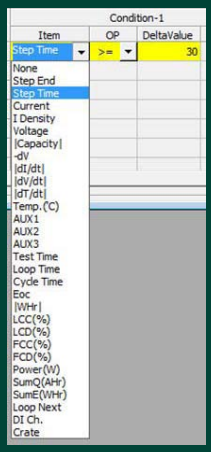
■ *Sequence editor*

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



Sequence editor

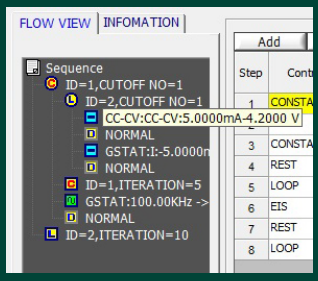
- **Cut-off(Vertex) Condition**
  - Time(step, test, loop, cycle)
  - Current, current density
  - Voltage
  - Capacity
  - C-rate
  - -dV
  - |dV/dt|
  - |dI/dt|
  - Aux1
  - Eoc
  - etc.



Cut-off 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.

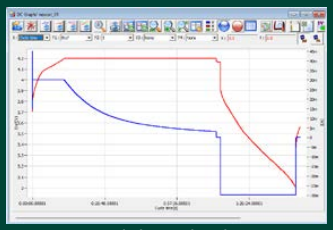


Flow view

- **Control Task Parameters**

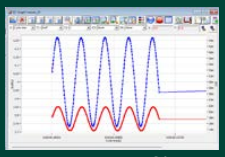
Control Mode		
constant	GSTAT	constant current control
	Crate	constant Crate control
	PSTAT	constant voltage control
	POWER	constant power control
	LOAD	constant load control
	CC-CV	constant current constant voltage control
	Crate-CV	Crate constant voltage control
	CP-CV	constant power constant voltage 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
	ACV	AC voltammetry
EIS	GSTAT	galvanostatic EIS
	PSTAT	potentiostatic EIS
	OCP	OCP EIS
	PSEUDO	pseudo galvanostatic EIS
	HFR G	galvanostatic HFR
	HFR P	potentiostatic HFR
	MsineG	galvanostatic multisine EIS
	MsineP	potentiostatic multisine EIS
	RTIG	galvanostatic real time EIS
	RTIP	potentiostatic real time EIS
Pulse	Vpulse	voltage pulse control
	Ipulse	current pulse control
	GSINE	current sine wave control
	PSINE	potential sine wave control
Rest		rest control
ZRA		ZRA control
Loop		loop control
Device	D OUT	Digital output control
	A OUT	Analog output control
	TEMP CTRL	Temperature controller control
	MUX	Multiplexer control

- **Battery charging test using sequence editor**



Sinusoidal ripple charging

=>



Sine wave profile

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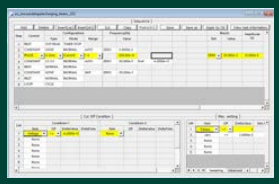

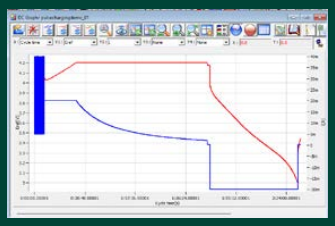
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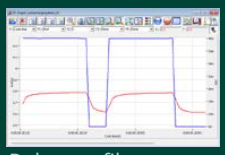
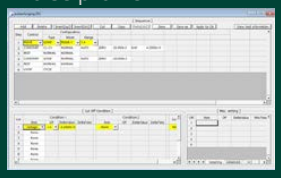
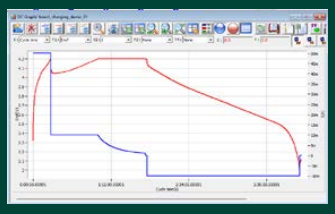
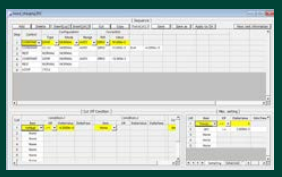
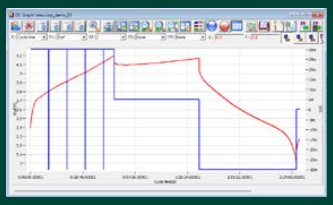

Pulse profile

Pulse charging
<=



Boost charging
<=



CCNP (Constant current with negative pulse) charging
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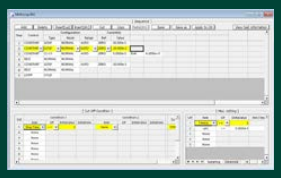

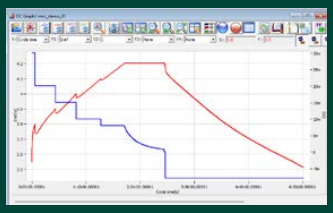
MCC (Multi-stage Constant-current) charging
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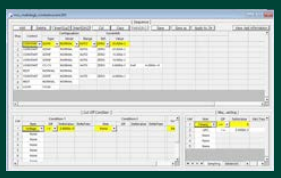
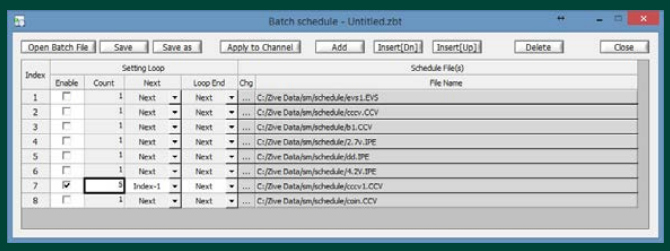


■ *Batch function*

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.



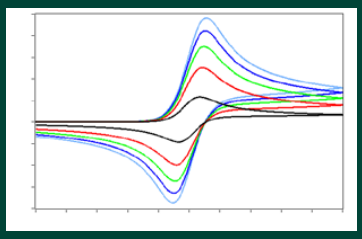
Smart Manager Techniques Software Package

For a wide range of application, techniques software packages for specific experimental techniques are available as standard. Each software package's upgrade will be provided at free of charge.

• *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

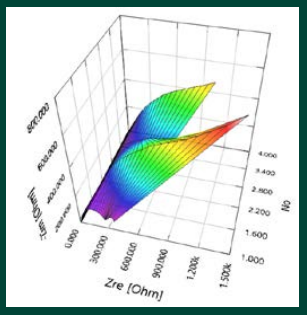


The above functions can be used sequentially by step control function.

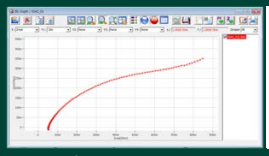
• *EIS Software Package(EIS)*

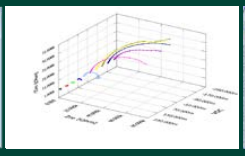
1. Potentiostatic EIS
2. Galvanostatic EIS
3. Pseudo galvanostatic EIS
4. OCP(*1) EIS
5. Potentiodynamic PEIS
6. Galvanodynamic GEIS
7. Potentiodynamic HFR
8. Galvanodynamic HFR
9. Potentiostatic HFR monitor
10. Galvanostatic HFR monitor
11. Multisine potentiostatic EIS
12. Multisine galvanostatic EIS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

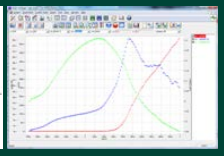
(*1) The system measures open circuit potential before each frequency change and apply AC sine wave on this potential.

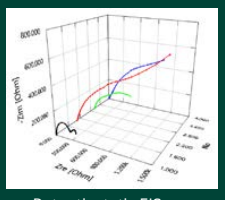


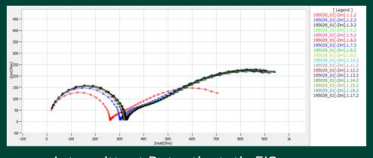
Potentiostatic EIS data of metal sample soaked in NaCl solution over time, 3D Nyquist plot by ZMAN


Galvanostatic EIS


Potentiodynamic PEIS


Rs, Cp & Idc vs Vdc plot


Potentiostatic EIS

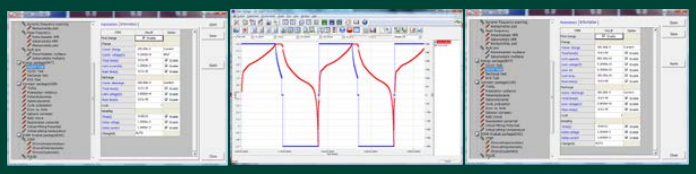

Intermittent Potentiostatic EIS

High Current Electrochemical Workstation SHP480HC

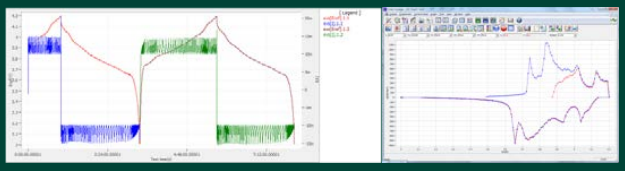
• *Energy Software Package(BAT)*

BAT software supports IR measurement.

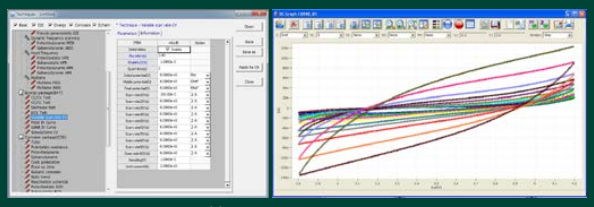
1. Battery test techniques
   - CC/CV test for cycle life test of lithium battery
   - CC/CC test for cycle life test of NiCd or NiMH battery
   - Discharging test
   - EVS(Electrochemical voltage spectroscopy)
   - Variable scan rate CV
   - Potentiostatic IV curve
   - Galvanostatic IV curve
   - Steady-state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



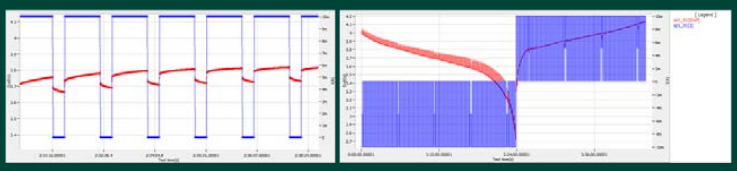
CC/CV test CC/CC test



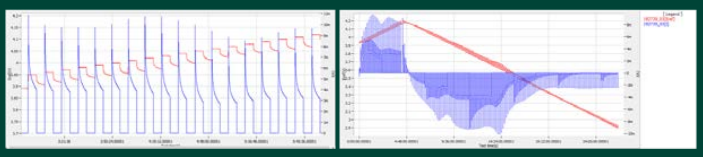
EVS test raw data EVS graph format (dQ/dV vs. V)



Variable scan rate CV

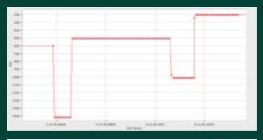


GITT Test

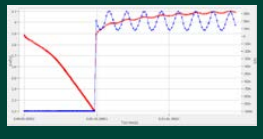


PITT Test

- 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.

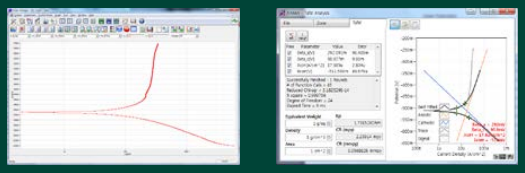
Various battery charge/discharge test is available including pulse discharge for GSM and CDMA application.

• *Corrosion Software Package(COR)*

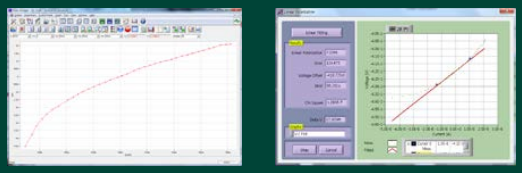
Corrosion technique supports IR compensation.
SHP480HC minimum voltage range is limited by minus 1Volt.

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. Critical pitting temperature(option)
12. ASTM critical pitting temperature(option)
13. Potentiostatic ECN
14. Galvanostatic ECN
15. ZRA mode ECN

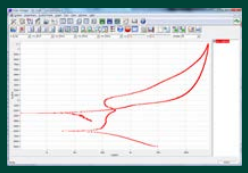
Each software package's upgrade will be provided free of charge.



Tafel experiment



Rp (Polarization resistance)



CYPOL(Cyclic polarization resistance)

• *Electrochemical Analysis Software Package(EAS)*

SHP480HC minimum voltage range is limited by minus 1Volt

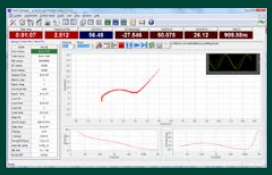
1. Step techniques
   CA(Chronoamperometry), CC(Chronocoulometry), CP(Chronopotentiometry)

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)

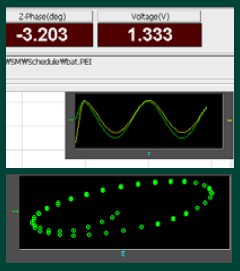
Control & Real Time Graph

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



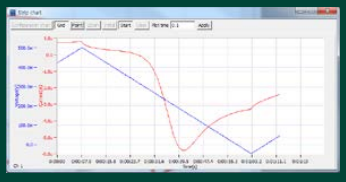
User can control and monitor for specific channel in detail and he/she can monitor data in VOI(value of interest) window and channel status in one window. Real time graph's X ,Y axis format will be changed per technique automatically. It can be defined by user's demand per techniques.

For experiment using sequence file or batch file, user can designate X,Y parameter on three different real time graph. The real time graph's format can be also selected.



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

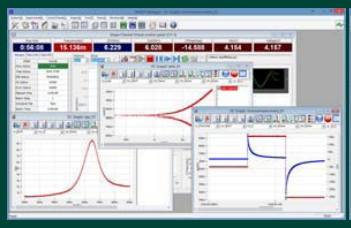
Strip Chart

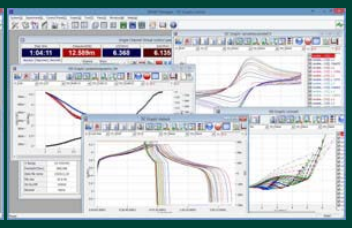


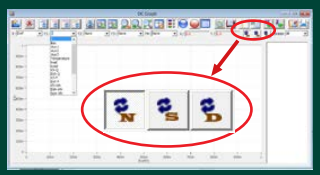
Strip chart recorder function provides real time graph function independently. You can monitor 2 Y axis data such as voltage, current, auxV1,2,3, temperature, power, and capacity etc. in real time.

▪ Graph

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





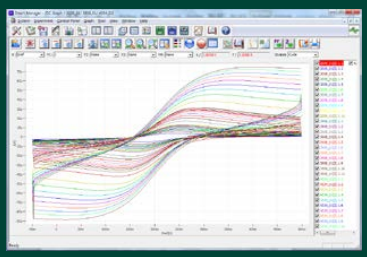


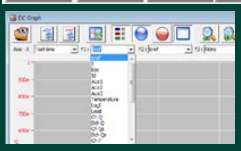
In DC and Cycle graph, whenever you click  or  , the parameters which are related to current such as current, capacity, energy, power, load, etc., are changed into calculated specific value or density value, respectively.

 : value divided by weight

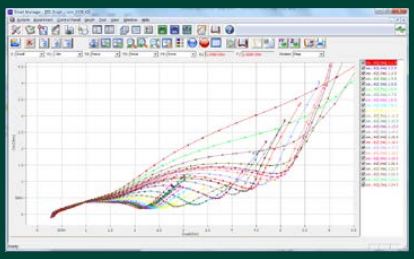
 : value divided by active area

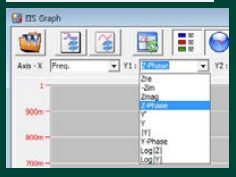
1) DC Graph
- For general data display
- 4 shortcut buttons: I vs. V, E vs. Logl, V, I vs. time, V vs. Q
- Graph parameters: time, Eref, I, Eoc, Id, Aux1, Aux2, Aux3, temp, Logl, Load, ChQ, DchQ, ChQs, DchQs, Ch P, Dch P, Ch-Wh, Dch-Wh, Sum Wh, Sum Q, Sum |Q|, |Q|, Rp, dQ/dV

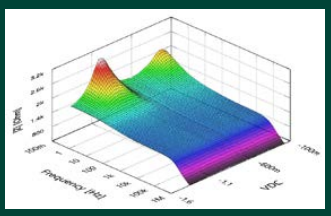




2) EIS Graph
- For EIS data display
- 3 shortcut buttons: Nyquist plot , Bode plot, Cs vs. frequency
- Graph parameters: Frequency, Zre, -Zim, Zmag, Zph, Y', Yimg, Y, |Y|, Yph, LogZ, LogY, Rs(R-C), Cs(R-C), Rp(R|C), Cp(R|C), Rs(R-L), Ls(R-L), Q(R-L), time, Vdc, Idc, temp, Aux(1,2,3)



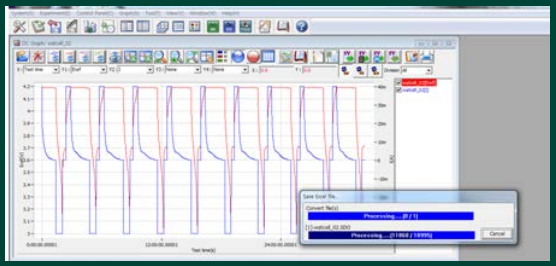




3D Bode Plot by ZMAN
Technique used: Potentiodynamic impedance measurement by using a corrosion cell

3) 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*



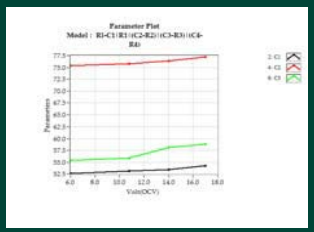
Selectable between 'Convert data on graph only' and 'Convert selected file(s)'

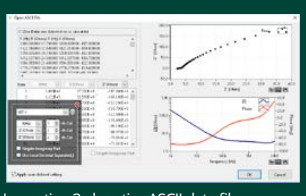
Data Analysis Software

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 photovoltaic cell data analysis and ZMAN™ software for EIS data analysis without license.

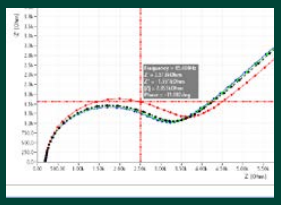
ZMAN™ EIS Data Analysis Software

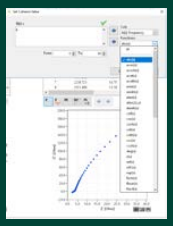
- Model simulation and fitting
- 2D- and 3D-Bode- and Nyquist plots
- Automatic equivalent circuit model search function
- Project concept to handle multiple EIS data analysis
- Parameter plot from fitted elements value
- Compatible with data format from Zahner, Gamry, Ametek etc. (License code is needed.)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

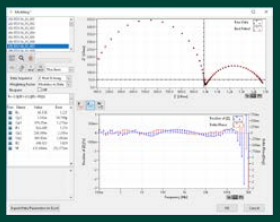
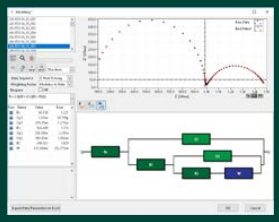

Parameter plot


Importing 3rd parties ASCII data file

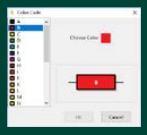

Project manager with data preview

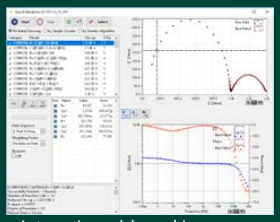

Cursor data display

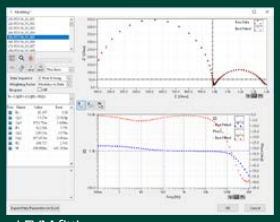

Data replacement by formula function

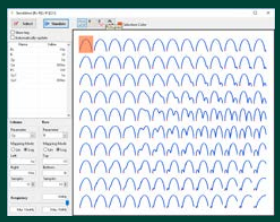


Fitting display

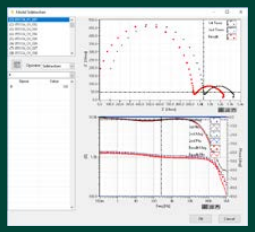



Model editor & model library

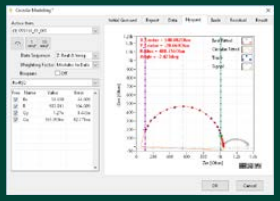

Automatic model searching

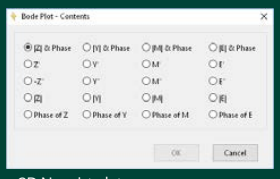

LEVM fitting


Parameter simulation


Element add/subtraction


Finding data file menu

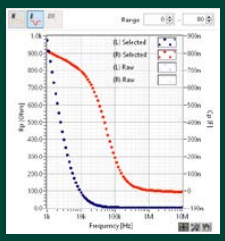

Circular fitting

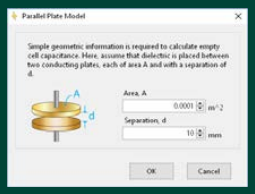


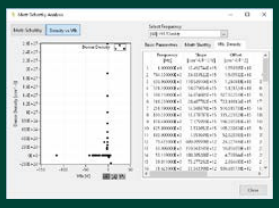
2D Nyquist plot

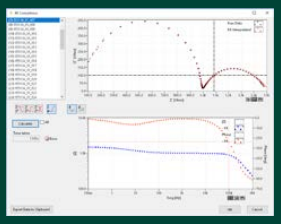
2D Bode plot

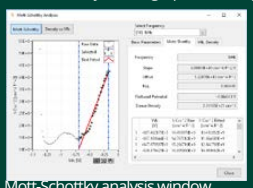
High Current Electrochemical Workstation SHP480HC

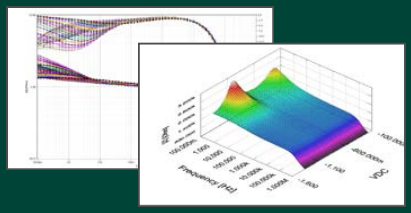

Rp,Cp vs frequency (R|C)

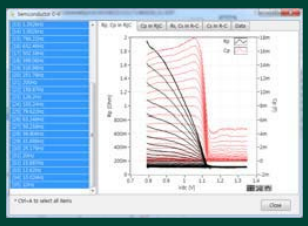

Empty cell capacitance

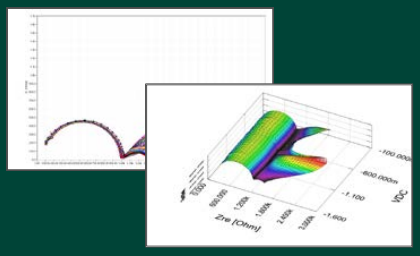

Donor density vs. Vfb graph and analysis


KK consistency


Mott-Schottky analysis window




C/R-V graph

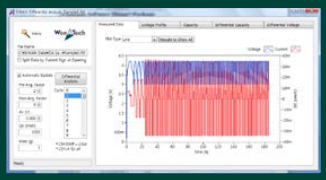

Bode & Nyquist overlay & 3D plots

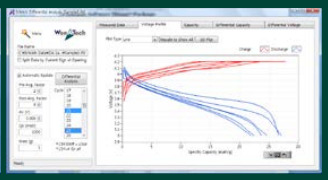
IVMAN™ DC Data Analysis Software

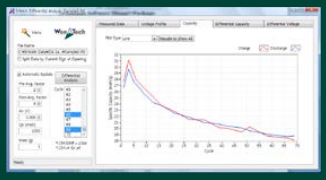
IVMAN™ software package consists of
- IVMAN software
- IVMAN utilities
  - IVMAN main software
  - IVMAN differential analysis software
  - IVMAN photovoltaic cell analysis
  - IVMAN Tafel analysis
  - IVMAN extractor
  - IVMAN peak find module

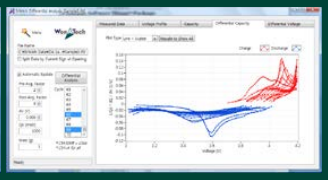
IVMAN DA™ Battery Test Data Analysis Software

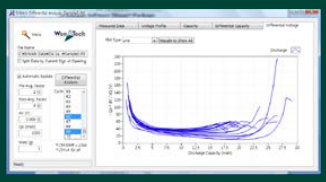
- Battery test data analysis
- Electrochemical voltage spectroscopy (dQ/dV vs. V)
- Voltage vs. Capacity analysis (V vs. Q)
- Cycle graph (Q vs. cycle)
- Differential voltage graph(dV/dQ vs. Q)

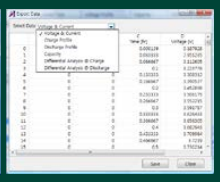

Measured data


V vs. Q

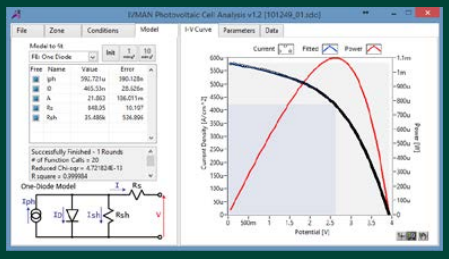

Cycle graph


dQ/dV vs. V


dV/dQ vs. Q


Export ASCII file

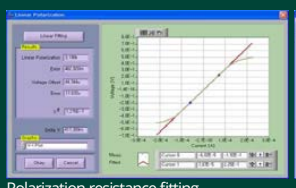
IVMAN™ Photovoltaic Cell Analysis

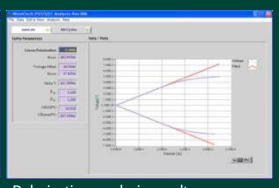


- Automatic analysis of parameters
  - open circuit voltage, open circuit current, max. power, efficiency, photo induced current, diode quality factor, series resistance, etc.

IVMAN™ 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

• Battery Jig

- 4 pin probe knob type
- lever or knob type

4PL-CBJ8-8P

- 4 pin lever type cylindrical cell jig
- 8 channels, Max.current 50A
- Direct connection method for jig cables
- Compatible with 26650 and 21700 batteries
- For high current application

UCBJ1

- 4 pin lever type high current universal cell jig
- For 1 channel, Max.current 50A
- Banana connectors for voltage measurement and connectors for high current
- Max. battery height: 170mm

4PL-UCBJ4-4P

- 4 pin lever type high current universal cell jig
- For 4 channels, Max.current 50A
- 4 channels per panel
- For high current application

4PK-PRCJ1

- 4-pin knob-type prismatic cell jig
- For 1 channel, Max.current 50A
- For prismastic batterry cell or pouch cell
- For high current application

4PK-UCJH4-4P

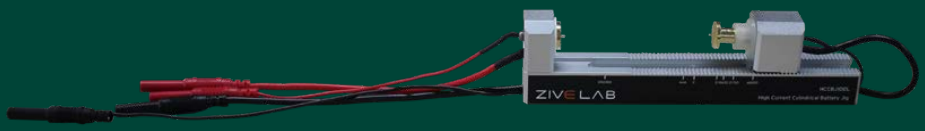
- 4 pin knob type high current universal cell jig
- For 4 channels, Max.current 50A
- 4 channels per panel
- For high current application

HPCCS

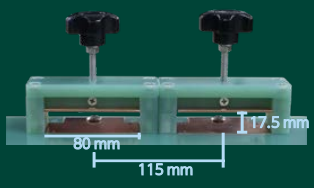
- Max.current 50A pouch cell clamp

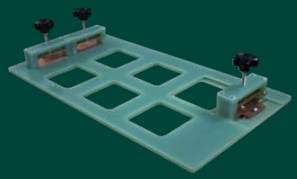
ZJIGL high capacity cylindrical cell jig

High current cylindrical battery holder, P/N: HCCBJ65L



High current cylindrical battery holder, P/N: HCCBJ100L





Dual-directional pouch cell holder, P/N: DDPCH

Specification

Main System	
PC communication	USB2.0 high speed
Line voltage	100~240VAC, 50/60Hz
Power requirement	480Watt
Size	285 x 550 x 207.2mm(WxDxH)
LED indicator	Run, Comm

System	
Cell cable Set	1.5 meter power cables (WE, CE) & reference, working sense, AuxV1 cable
Control DAC	DSP with FPGA 2x16bit DAC(50MHz) for bias & scan 1X16bit DAC(1MHz) for analog output
Data acquisition ADC	2x16bit ADCs(500kHz) for voltage, current 4x16bit ADCs(250kHz) for auxiliary voltage and temperature reading
Calibration	Automatic
Filter selection	4ea(5Hz, 1kHz, 500kHz, 5MHz)
Scan rate	0~200V/sec in common mode 0~5000V/sec in fast mode
Internal data memory	542,000 points

Power Amplifier(CE)	
Max. current	±50A
Control speed selection	4ea
Bandwidth	200kHz
Slew rate	2V/usec

Potentiostat Mode (voltage control)	
Voltage control	
Control voltage range	-1V~5, 0.5, 0.05V
Voltage resolution	16 bit per each range
Voltage accuracy	2mV
Max. scan range	-1V~5V/ref
Current measurement	
Current range	10ranges 50A~50nA 50nA with gain
Current resolution	16 bit 1.5mA~1.5pA
Current accuracy	±0.05% f.s.(gainx1)> 5uA f.s.

Galvanostat Mode (current control)	
Current control	
Current range	10 ranges 50A~50nA 50nA with gain
Current resolution	16 bit 1.5mA~1.5pA
Current accuracy	±0.05% f.s.(gainx1)> 5uA f.s.
Control voltage range	-1V~5, 0.5, 0.05V
Voltage resolution	16 bit per each range
Voltage accuracy	2mV

Electrometer	
Max. input voltage	±5V
Input impedance	>$10^{13}\Omega$
Bandwidth	>22MHz
CMRR	>114dB

EIS Measurement for System	
Frequency range	10uHz~50kHz
Frequency accuracy	<0.01%
Frequency interval setting (Point / Decade)	Max. 1000/decade (<43mHz) Max. 5000/decade (>43mHz)
Amplitude	0.5mV ~ 1.7Vrms 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	
Digital & Auxiliary port	
Digital output	3(open collector)
Digital input	1(photo coupler)
Auxiliary voltage inputs	3 analog inputs: ±10V For measurement of WE vs. CE CE vs. RE or other signal
Analog output	1 analog output: ±10V For external device control such as MFC etc.
Peripheral communication	I2C to control external devices
Temperature input port	
Temp. measurement	1 K-type thermocouple input

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 7/8/10/11(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)
Digital/Auxiliary cable	Option
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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