# Designed by ZIVE LAB



Won A Tech

# Power Electrochemical Workstation ZIVE SP10

Including Internal FRA/ZRA 5Volts/10Amp

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

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

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

#### DAC Control

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

#### ADC Reading

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

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

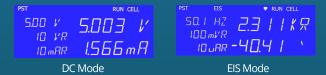
## System Features

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

### **Hardware Features**

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

#### • Smart LCD Display



• Front View **Built-in FRA** FPGA/DSP control Plug-in type Status LED indicator COMM BUSY Busy, Run, Pstat, Gstat POWER CELL ON POTENTIOSTAT MODE Temperature measurement with K type TEMP. INPUT THE T/C thermocouple (option) ANALOG DIGITAL Aux port: 3 analog inputs -(auxiliary voltage Cell port: measurement) 6 (power) 1 analog output MIS working, 2 digital input counter, zra I2C FRA OUT V INPUT I INPUT 3 digital output 6 0 Cell port: (sense) working sense, Misc port: reference I2C com port for external device control FRA port 1 sig generator output 1 voltage input 1 current input

# Versatility

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

For example,

- 1. User can measure the voltage between working and reference electrode and, by using 2 additional analog inputs(auxiliary voltage input), user can also measure the voltage between reference and counter electrode and between working and counter electrode as well.
- 2. With analog output, the system can control rotating speed of the rotator, MFC flow rate etc. by  $\pm 10V$  full scale.
- User can control on/off of an external device by 3 DO(digital ouput) signal and 2 Dl(digital input) signal from an external device can be used for cutoff condition.

# Safety and Maintenance

- Even though the communication failure occurs between PC and ZIVE SP10, the system continues its experiment on channel and saves the data into ZIVE memory up to 542,000 data point set. After the communication is restored, ZIVE will transfer saved data to PC automatically or user can transfer data when he/she wants. This function will be highly efficient for long time experiment.
- 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.
- If the control value of voltage or current is different from measured value, the experiment will stop automatically to protect the cell.
- 4. Automatic calibration function is available for user calibration.
- 5. The hardware parameters and calibration data are stored in the device.
- 6. The system is controlled from a PC via USB.

# Application

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

#### Batteries



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

#### Super Capacitors



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

#### Solar Cells



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

#### Fuel Cells



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

#### General Electrochemistry



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

#### Impedance(ESR) measurement for QC/QA

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

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20.5m         1.0996         12.2.4         1.0996         4.997         11.0096         201.24m,2         1.01096           39.15%         0.0996         11.0.4         1.4196         4.997         11.0096         201.34m,2         D.71.59           39.15%         1.0996         11.019         1.0196         4.997         11.335         201.34m,2         D.71.59           39.15%         1.0096         1.0196         4.997         1.1335         201.34m,2         D.71.59           39.15%         1.0096         1.0296         4.997         1.3335         201.34m,2         D.71.49           39.15%         1.0096         1.0296         4.997         1.3335         201.34m,2         D.71.49           39.15%         1.0297         4.919         1.3356         201.34m,2         D.71.49	250.35m         1.05/96         122.34         1.05/96         4.5977         13.00%         2013.3un.29         17.35.36           375.67m         1.0496K         119.47         1.0566K         4.4922         13.322u         2013.3un.28         17.31.56								
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20.5m         10.9m         122.24         1.6mm         4.997         11.00m         201.3mm         10.33mm           39.5 %         1.6mm         1.6mm         4.997         11.00m         201.3mm         10.33mm           39.5 %         1.6mm         1.6mm         4.997         11.00m         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         4.907         11.33mm         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         4.907         11.33mm         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         1.610m         1.0 %         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         1.610m         11.3 %         201.3mm         10.31mm           39.7 %         1.0 %         1.0 %         1.0 %         1.0 %         201.3mm         10.31mm	250.35m         1.05/96         122.34         1.05/96         4.5977         13.00%         2013.3un.29         17.35.36           375.67m         1.0496K         119.47         1.0566K         4.4922         13.322u         2013.3un.28         17.31.56								
20.5m         10.9m         122.24         1.6mm         4.997         11.00m         201.3mm         10.33mm           39.5 %         1.6mm         1.6mm         4.997         11.00m         201.3mm         10.33mm           39.5 %         1.6mm         1.6mm         4.997         11.00m         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         4.907         11.33mm         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         4.907         11.33mm         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         1.610m         1.0 %         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         1.610m         11.3 %         201.3mm         10.31mm           39.7 %         1.0 %         1.0 %         1.0 %         1.0 %         201.3mm         10.31mm	250.35m         1.05/96         122.34         1.05/96         4.5977         13.00%         2013.3un.29         17.35.36           375.67m         1.0496K         119.47         1.0566K         4.4922         13.322u         2013.3un.28         17.31.56								
1         20-50+         12096         122-4         14996         4.997         11009,         2013,00-         10,020,           373,55+         1,0496         1,010,0         1,010,0         1,010,0         1,013,00         1,013,00           373,55+         1,0496         4,007         1,33,00,0         1,013,00	250.35m         1.05/96         122.34         1.05/96         4.5977         13.00%         2013.3un.29         17.35.36           375.67m         1.0496K         119.47         1.0566K         4.4922         13.322u         2013.3un.28         17.31.56								
20.5m         10.9m         122.24         1.6mm         4.997         11.00m         201.3mm         10.33mm           39.5 %         1.6mm         1.6mm         4.997         11.00m         201.3mm         10.33mm           39.5 %         1.6mm         1.6mm         4.997         11.00m         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         4.907         11.33mm         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         4.907         11.33mm         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         1.610m         1.0 %         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         1.610m         11.3 %         201.3mm         10.31mm           39.7 %         1.0 %         1.0 %         1.0 %         1.0 %         201.3mm         10.31mm	250.35m         1.05/96         122.34         1.05/96         4.5977         13.00%         2013.3un.29         17.35.36           375.67m         1.0496K         119.47         1.0566K         4.4922         13.322u         2013.3un.28         17.31.56								
20.5m         10.9m         122.24         1.6mm         4.997         11.00m         201.3mm         10.33mm           39.5 %         1.6mm         1.6mm         4.997         11.00m         201.3mm         10.33mm           39.5 %         1.6mm         1.6mm         4.997         11.00m         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         4.907         11.33mm         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         4.907         11.33mm         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         1.610m         1.0 %         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         1.610m         11.3 %         201.3mm         10.31mm           39.7 %         1.0 %         1.0 %         1.0 %         1.0 %         201.3mm         10.31mm	250.35m         1.05/96         122.34         1.05/96         4.5977         13.00%         2013.3un.29         17.35.36           375.67m         1.0496K         119.47         1.0566K         4.4922         13.322u         2013.3un.28         17.31.56								
20.5m         10.9m         122.24         1.6mm         4.997         11.00m         201.3mm         10.33mm           39.5 %         1.6mm         1.6mm         4.997         11.00m         201.3mm         10.33mm           39.5 %         1.6mm         1.6mm         4.997         11.00m         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         4.907         11.33mm         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         4.907         11.33mm         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         1.610m         1.0 %         201.3mm         10.31mm           39.7 %         1.600m         11.9 %         1.610m         11.3 %         201.3mm         10.31mm           39.7 %         1.0 %         1.0 %         1.0 %         1.0 %         201.3mm         10.31mm	250.35m         1.05/96         122.34         1.05/96         4.5977         13.00%         2013.3un.29         17.35.36           375.67m         1.0496K         119.47         1.0566K         4.4922         13.322u         2013.3un.28         17.31.56								
1         20-50+         12096         122-4         14996         4.997         11009,         2013,00-         10,020,           373,55+         1,0496         1,010,0         1,010,0         1,010,0         1,013,00         1,013,00           373,55+         1,0496         4,007         1,33,00,0         1,013,00	250.35m         1.05/96         122.34         1.05/96         4.5977         13.00%         2013.3un.29         17.35.36           375.67m         1.0496K         119.47         1.0566K         4.4922         13.322u         2013.3un.28         17.31.56								
1         20-50+ 20-57         1.09%         122.24         1.09%         4.997         11.00%         2013.04/2         1.052.9           275.57         1.096         1.014         1.0168         4.997         11.00%         2013.04/2         1.052.9           275.57         1.014         1.0168         4.997         11.02%         2013.04/2         1.052.9           20.57         1.014         1.0168         4.997         1.034.9         2013.04/2         1.015.9           20.57         4.919         1.024         2.0157         4.919         1.015.9         2013.44/2         1.015.9	250.35m         1.05/96         122.34         1.05/96         4.5977         13.00%         2013.3un.29         17.35.36           375.67m         1.0496K         119.47         1.0566K         4.4922         13.322u         2013.3un.28         17.31.56								
1         20-50+ 20-57         1.09%         122.24         1.09%         4.997         11.00%         2013.04/2         1.052.9           275.57         1.096         1.014         1.0168         4.997         11.00%         2013.04/2         1.052.9           275.57         1.014         1.0168         4.997         11.02%         2013.04/2         1.052.9           20.57         1.014         1.0168         4.997         1.034.9         2013.04/2         1.015.9           20.57         4.919         1.024         2.0157         4.919         1.015.9         2013.44/2         1.015.9	250.35m         1.05/96         122.34         1.05/96         4.5977         13.00%         2013.3un.29         17.35.36           375.67m         1.0496K         119.47         1.0566K         4.4922         13.322u         2013.3un.28         17.31.56								
1         20-30*         100%         122-4*         1.040%         4.497         13.00%         2013.0%         12.03.0%           273.5%         1.040%         1.040%         4.007         13.00%         2013.0%         1.053.9%           273.5%         1.040%         1.040%         4.007         13.00%         2013.0%         1.053.9%           273.5%         1.000%         1.010%         4.000         13.34%         2013.0%         1.011.9%           273.5%         1.000%         1.010%         4.000         13.34%         2013.0%         1.011.9%           273.5%         1.000%         1.040%         4.000         1.33.9%         2013.0%         1.011.9%           273.5%         1.000%         1.040%         1.021%         4.000         1.03.9%         2013.0%         1.011.9%           273.5%         1.000%         1.040%         1.027%         4.000         1.03.9%         2013.0%         1.03.1%	375.07n L0408K 119.47 L0566K 4.4922 13.322a 2013.3an28 17:31:56								
1         20-50+         12096         122-4         14996         4.997         11009,         2013,00-         10,020,           373,55+         1,0496         1,010,0         1,010,0         1,010,0         1,013,00         1,013,00           373,55+         1,0496         4,007         1,33,00,0         1,013,00	250.35m         1.05/96         122.34         1.05/96         4.5977         13.00%         2013.3un.29         17.35.36           375.67m         1.0496K         119.47         1.0566K         4.4922         13.322u         2013.3un.28         17.31.56								
1         20-50+         12096         122-4         14996         4.997         11009,         2013,00-         10,020,           373,55+         1,0496         1,010,0         1,010,0         1,010,0         1,013,00         1,013,00           373,55+         1,0496         4,007         1,33,00,0         1,013,00	250.35m         1.05/96         122.34         1.05/96         4.5977         13.00%         2013.3un.29         17.35.36           375.67m         1.0496K         119.47         1.0566K         4.4922         13.322u         2013.3un.28         17.31.56	ex OCV(V) ESR(Dhm) -0m 2(Dhm) (2)(Dhm) Phase() ESC(F) Date Time	ex OCV(V) ESR(Dhm)	-Im Z(Ohm)	(Z1(Ohm))	Phase()	ESC(P)	Date	Time
1         20-50+ 20-57         1.09%         12.2-4         1.09%         4.997         1.00%         201.2-3           23-55- 20-57         1.5-96%         1.010- 20-57         1.010- 20-57         2.010-20- 20-57         2.010-20- 20-20-20-20- 20-20-20-20-20- 20-20-20-20-20- 20-20-20-20-20-20- 20-20-20-20-20-20- 20-20-20-20-20-20- 20-20-20-20-20-20- 20-20-20-20-20-20-20- 20-20-20-20-20-20- 20-20-20-20-20-20-20- 20-20-20-20-20-20-20-20- 20-20-20-20-20-20-20-20- 20-20-20-20-20-20-20- 20-20-20-20-20-20-20- 20-20-20-20-20-20-20-20- 20-20-20-20-20-20-20-20-20- 20-20-20-20-20-20-20-20-20- 20-20-20-20-20-20-20-20-20- 20-20-20-20-20-20-20-20-20- 20-20-20-20-20-20-20-20-20-20-20- 20-20-20-20-20-20-20-20-20-20-20- 20-20-20-20-20-20-20-20-20-20-20-20-20-2	250.35m         1.05/96         122.34         1.05/96         4.5977         13.00%         2013.3un.29         17.35.36           375.67m         1.0496K         119.47         1.0566K         4.4922         13.322u         2013.3un.28         17.31.56	tex OCV(V) ESR(DIm) -(m.2(DIm) 12((DIm) Phase()) ESC(P) Date Time	dex OCV(V) ESR(Ohm)	-Un Z(Ohm)	(21(Ohm)	Phase()	ESC(F)	Date	Time



## Main Software

The Smart Manager (SM) is to control ZIVE SP10 model and it provides user defined sequential test by using sequence file, technique menu and batch file. The batch file allows the users to do a serial test by combining sequence files and/or technique files.

Sм

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.

- 9 Dynamic					
Potential sweet	Mdde potential(V)	4.2000e+0		<b>IRef</b>	
Current sweep	Pinal potential(1)	2.7000e+0		Dief	
- Cyclc voltammetry	Step-potential(1)	13.000e-3			
🖋 Fast potential sweep	Interval(V)	3010			
P-Ru Measurement	Rest limit type	Time(c)			
G-Ru Measurement	-Time(s)	30:0	_		
EIS package(EIS)	Sample period(s)	1			
Potentiostatic EIS	Segment		2		
- 🖉 Galvanostatoc EtS	Il Nessre	E 08			
Preudo generostato, EZS	I Range(A)	1A		R	A(4)
GAManodynamic CES     GAManodynamic CES     Distantisent potentioestatic EES     Intermittent potentioestatic EES     Potentioestatic MR     GAManodynamic MR     Potentioestatic MR     Ordentidowamic MR					
A distant water Mit					

Techniques

Asic Eleminado Static Potentiostatic Galvanostatic Double step potentiostatic Double step galvanostatic OCP Measurement

Potential sweep

Current sweep

Cyclic voltammetry Fast potential sweep

P-Ru Measurement

🖉 G-Ru Measurement

ITEM VALUE Svitul delay P Bruble

#### **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 Mod	le	
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
	ld	ld control
	ls	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

							-[ Seque	ice ]						
	Add Do	iete I	inset[Up] D			Copy	Paste[Dr		1499Y	to CH			Value bes	
1 20	Cantrol		Configuration	on		ment(A)		spe(ii)						
-		Туре	Mode	Range	Ref.	Value	Ref.	Value						
	CONSTANT -		- NORMAL	<ul> <li>AUTO</li> </ul>	- 22240 -	5.0000e-3	Dref +	4.2000e+0						
2	REST	NORMAL	NORMAL											
3	CONSTANT	GSTAT	NORMAL	AUTO	ZERO	-5.0000e-3								
4	REST	NORMAL	NORMAL											
5	LOOP	CYCLE												
6	EIS	GSTAT	LOG	OTLA	Normal	100.00e+3		100.00e+3	200	.00e-3	ZERO	0.0000e+0	5.0000e-3	10
7	REST	NORMAL	NORMAL											
	1004	NORMAL												
8	1004	NORMAL		1040	ff Conditio	nl						[ Mac	etting ]	,
			direct 1	[ Cut 0	ff Conditio		Atur. 7							
			ditor-1 Detavielue	[ Cut O	ff Conditio	Con	álton-2 Defte/Vév	DebsTime	Got	List	Ite	n OP	DeltaValue	
•	Item	Core	DeltaValue			Con		DetsTime	Go P	1	Time)	n 09 (1 • >=	CeltaValue	DeltaTin
•	Item	Core	DeltaValue		Dem	Con		DetsTime	Gon	1 2	Tine) (dv)	n 09 1 <mark>1 • &gt;=</mark> 91) >=	Deitai/islue	DeltaTin
	iten Currot	Core	DeltaValue		Dem	Con		Defaffme	Gon	1 2 3	Tine) (dv) (dt)	n OP 1 • >= 91 >= 91 >=	Deitai/islue	DeltaTin
1	Dem Current Nore	Core	DeltaValue		Dem	Con		Defailtre	Gon	1 2 3 4	Time3 (dv) (dt) No	n OP 11 • >+ 91 >+ 91 >+ 91 >+	Deitai/islue	DeltaTin
4 1 2 3	Dem Current None None	Core	DeltaValue		Dem	Con		Defaffme	Gon	1 2 3	Tine) (dv) (dt)	n OP 11 • >+ 91 >+ 91 >+ 91 >+	Deitai/islue	Detalina
4 Us 1 2 3 4	Diam Carrent None None	Core	DeltaValue		Dem	Con		Debafine	Gon	1 2 3 4	Time3 (dv) (dt) No	n OP 11 • >+ 91 >+ 91 >+ 91 >+	Deitai/islue	DeltaTin
4 1 1 2 3 4 5	Diem Current None None None	Core	DeltaValue		Dem	Con		Delafine	Gon	1 2 3 4 5	Time) (dv) (dt) No No	n OP 11 • >+ 91 >+ 91 >+ 91 >+	DeltaValue	DeltaTin

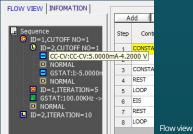
#### Sequence editor

- · 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|
- |dl/dt|
- Aux1
- Eoc
- etc.
- Sampling Condition
  - time, |dl/dt|, |dV/dt|, |dT/dt|, |dA1/dt|, burst time
- Flow View

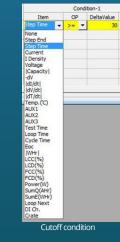
#### • User can see the sequence flow at a glance.



#### Batch function

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

3								Batch schedule - Untitled.zbt	+	
Open	Batch Fil	h File Save Save as Apply to Channel Add Insert[Dn] Insert[Up]					co Channel Add Insert[Dn] Insert[Up]	Delete	Close	
Index		S	etting Loop					Schedule File(s)		
Index	Enable	Count	Next		Loop End		Chg	File Name		
1		1	Next	-	Next	•		C:/Zive Data/sm/schedule/evs1.EVS		
2		1	Next	-	Next	•		C:/Zive Data/sm/schedule/cccv.CCV		
3		1	Next	*	Next	*		C:/Zive Data/sm/schedule/b1.CCV		
4		1	Next	-	Next	•		C:/Zive Data/sm/schedule/2.7v.IPE		
5		1	Next	-	Next	+		C:/Zive Data/sm/schedule/dd.IPE		
6		1	Next	-	Next	+		C:/Zive Data/sm/schedule/4.2V.IPE		
7	7	5	Index-1	*	Next	*		C:/Zive Data/sm/schedule/cccv1.CCV		
8	П	1	Next	*	Next	•		C:/Zive Data/sm/schedule/coin.CCV		



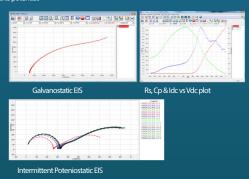
## Smart Manager Advanced Software Package

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

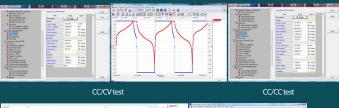


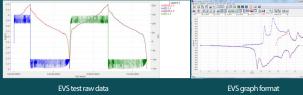


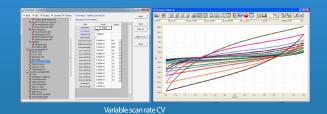
#### Energy Software Package(BAT)

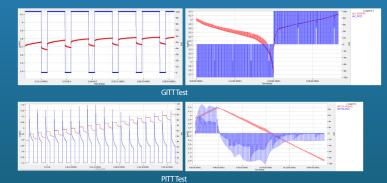
#### BAT software supports IR measurement.

- 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









• Pulse mode is available for GSM & CDMA profile. Pulse shape profile



Pulse shape profile monitor (micro seconds order)

Current sine wave (charge ripple simulation)

#### 2. Control mode

- Charge: CC, CC-CV, pulse, sine wave

• 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

• Discharge: CC, CP, CR, pulse, sine wave

3. Cutoff condition

(dQ/dV vs.V)

Coin cell intermittent PEIS

3D Nyquist plot by ZMAN

#### Electrochemical Analysis Software Package(EAS)

1. Step techniques

CA(Chronoamperometry), CC(Chronocoulometry), CP(Chronopotentiometry)

2. Sweep techniques

LSV(Linear sweep voltammetry), SDV(Sampled DC voltammetry), Fast CV, Fast LSV

3. Pulsed techniques

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

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

# 





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

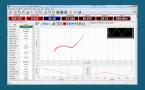
💈 : value divided by weight

😤 : value divided by active area

## Control & Real Time Graph

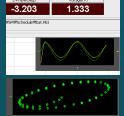
Smart Manager provides 2 kinds of control & data acquisition with real time graph.

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

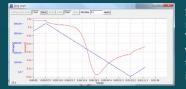


For experiment using sequence file or batch file, user can designate X,Y parameter on three different real time graph. The real time graph's format can be also selected.

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



#### Strip Chart



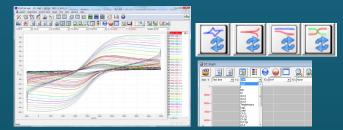
Strip chart recorder function provides real graph function independently. You can monitor 2 Y axis data such as voltage, current, auxV1,2,3, temperature, power, and capacity etc. in real time.



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

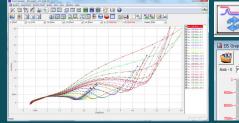
#### 1) DC Graph

- For general data display
- 4 shortcut buttons: l 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

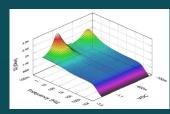


2) EIS Graph

- 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)



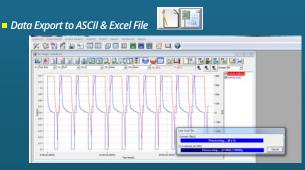




3D Bode plot by ZMAN Technique used: Potentiodynamic impedance measurement by using a corrosion cell

- 3) 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

3 3 🔣 🗄 😔 1 the time the time the time



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

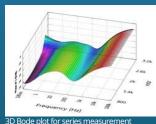
## **Data Analysis Software**

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<sup>™</sup> software for EIS data analysis without license.

## ZMAN<sup>™</sup> EIS Data Analysis Software

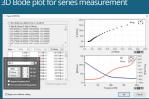
- Model simulation and fitting
- 2D- and 3D-Bode- and Nyquist plots
- Automatic equivalent circuit model search function
- Project concept to handle multiple EIS data analysis
- Parameter plot from fitted elements value
- · Compatible with data format from Zahner, Gamry, Ametek etc. (License code is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





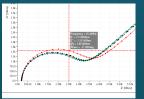
+0

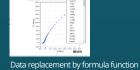




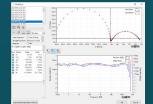
Farameter Plat Model : RI-C1 (R1+C2-R2+(C3-R3)+(C4 R4)

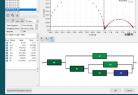
Importing 3rd parties ASCII data file



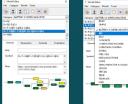




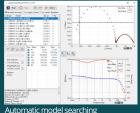




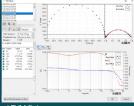
#### Fitting display











LEVM fitting



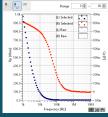
Parameter simulation



Finding data file menu

🖲 [Ζ] & Phase	⊖ [Y] & Phase	◯ [M] & Phase	⊖  E  & Phase
⊃z	Or	Ом	○ E
⊃ -z:	Ov	Ом:	○ E-
) IZI	OM	Ојиј	
O Phase of Z	O Phase of Y	O Phase of M	O Phase of E

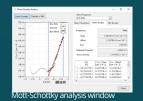
2D Nyquist plot

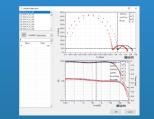


Rp,Cp vs frequency (R | C)

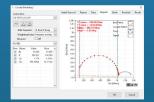


Donor density vs. Vfb graph and analysis





Element add/subtraction

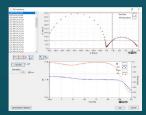


Circular fitting

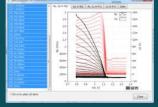


2D Bode plot





KK consistency



C/R-V graph

## IVMAN<sup>™</sup> DC Data Analysis Software



IVMAN<sup>™</sup> software package consists of

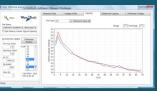
- IVMAN software
- IVMAN utilities
- IVMAN differential analysis software
- IVMAN photo voltaic cell analysis.
- IVMAN Tafel analysis
- IVMAN extractor
- IVMAN peak find module

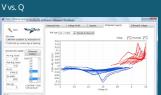
#### IV IVMAN DA™ Battery Test Data Analysis Software

- 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

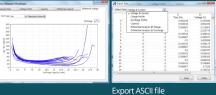






Differential Analysis 

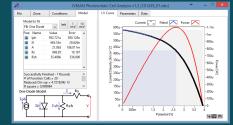
dQ/dV vs. V



dV/dQ vs. Q



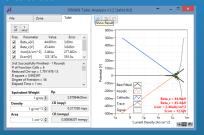
# *IVMAN™* Photovoltaic Cell Analysis



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



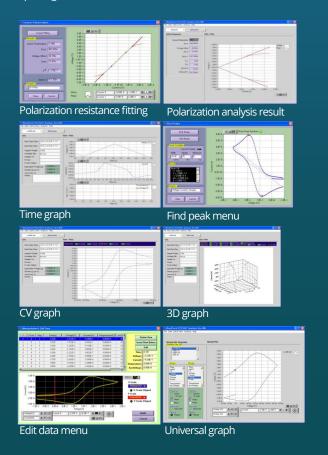
#### Simple Tafel calculation





#### 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



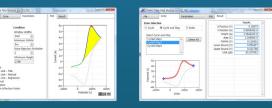
#### IVMAN EX™ Extractor

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



#### IVMAN PF<sup>™</sup> Peak Find Module

• Independent peak finding software



Export

## **Optional Accessories**

Peak
 Valley
 Soth
 Redon

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



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



#### Power Booster

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



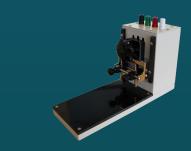


 Battery Jig & Coin Cell Jig
 for cylindrical cell or coin cell - 4 or 2 contact pin depending on models - rack type is available.





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



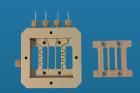


- Single Cell Hardware Fixture
   for PEMFC and DMFC
- max. temp. : 120°C or 180°C
- 5, 9, 25, 50, 100cm<sup>2</sup> MEA is not included.

## • Membrane Conductivity Cell

- for 5, 9 and 25cm<sup>2</sup> fuel cell hardware fixture
   material : PEEK(cell body),
- platinum(wire)
- operating temp. : up to 130°C





#### • Through-Plane Conductivity Test Jig - for through plane conductivity

- 2 probe type



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



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



## Specification

Main System	
PC communication	USB2.0 high speed
Line voltage	100~240VAC, 50/60Hz
Max. output power	60Watt
Size	239x361x241.2mm(WxDxH)
LED indicator	Run, Busy, Potentiostat, Galvanostat

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

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

Potentiostat Mode (voltage	control)
Voltage control	
Control voltage range	±5V, ±500mV, ±50mV
Voltage resolution	16 bit per each range
Voltage accuracy	±0.02% fs(gain x1)
Max. scan range	±5V vs. ref. E
Current measurement	
Current range	11 ranges(auto/manual setting)
	1nA~10A
	1nA with gain
Current resolution	16 bit
	300uA, 30uA, 3uA, 300nA, 30nA, 3nA
	300pA, 30pA, 3pA, 300fA, 30fA
Current accuracy	±0.03% f.s.(gain x1)>1uA

Galvanostat Mode (current	control)
Current control	
Control current range	max. ±10A ± full scale depending on selected range
Current resolution	16 bit 300uA, 30uA, 3uA, 300nA, 30nA, 3nA 300pA, 30pA, 3pA, 300fA, 30fA
Current accuracy	±0.03% f.s.(gain x1)>1uA
Voltage measurement	
Voltage range	±5V, ±500mV, ±50mV
Voltage resolution	16 bit 150uV, 15uV, 1.5uV
Voltage accuracy	±0.02% fs(gain x1)

Electrometer	
Max. input voltage	±5V
Input impedance	2x10 <sup>13</sup> Ω  4.5pF
Bandwidth	>22MHz
CMRR	>114dB

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

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

1000
Voltage, current, temperature, etc.
2usec or 3usec depending on data point number
Unlimited
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
USB	High speed 2.0

General	
Dummy cell	One external dummy cell included
Thermocouple	K-type, 1.5 meter long(option)
Aux. & Misc. cable	Option
Impedance analysis S/W	ZMAN™ software
DC data analysis S/W	IVMAN™ software package
The specifications are subject to change without notice.	

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<u>Mon ATech</u>

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