Specification Sheet for Electrochemical Impedance Spectroscopy Setup for Solar Photovoltaic Devices

सौर फोटोवोल्टिक उपकरणों के लिए विद्युत रासायनिक प्रतिबाधा स्पेक्ट्रोस्कोपी सेटअप के लिए विवरण पत्र

Here we are looking for a Potenstiostat Galvanostat Impedance Analyzer for the following applications:

1. I-V characteristics of thin films and semiconductor devices (like solar photovoltaic, diode etc.).
2. Impedance spectroscopy of semiconductor devices (like solar photovoltaic, diode etc.).

S. No.	**Particulars**	S. No.	Specifications	
1	**Power Amplifier**	1.1	Compliance Voltage	≥ ± 25 V
		1.2	Maximum Current	≥ 1 A
2	**Potentiostat Bandwidth**	2.1	≥ 5 MHz	
Potentiostatic Mode				
3	**Voltage Control**	3.1	Applied DC Voltage Range	± 10 V (selectable)
		3.2	Applied DC Voltage Resolution	≥ 16 bit
		3.3	Maximum DC voltage scan Rate	≥ 100 V/sec
4	**Current Measurement**	4.1	Measured DC Current Range	10nA to 1A 9 decades (ranges) or more
		4.2	Measured DC Current resolution	≥ 16 bit
Galvanostatic Mode				
5	**Current Control**	5.1	Applied DC Current Range	10nA to 1A 9 decades (ranges) or more
		5.2	Applied DC Current resolution	≥ 16 bit
6	**Voltage Measurement**	6.1	Measured DC Voltage Range	± 10 V
		6.2	Measured DC Voltage Resolution	≥ 16 bit
7	**Leakage Current Or Input Bias Current**	7.1	≤ 10 pA	
Electrochemical Impedance Spectroscopy (EIS) Mode				
8	**Impedance (EIS mode)**	8.1	Mode	Potentiostatic and Galvanostatic
		8.2	Frequency Range	10μHZ to ≥ 5MHz
		8.3	Frequency Resolution	10 to 100 steps / decade
		8.4	Maximum Input Voltage range	±10V
		8.5	Input Impedance	≥ 1 Tohm in parallel with ≤ 10 pF
		8.6	Applied AC amplitude	≤ 1mV rms to ≥ 100 mV rms
		8.7	AC voltage resolution	≤ 0.5mV
		8.8	Swipe Mode	Linear and Logarithmic
9	**Cell Connections**	9.1	Cell / Electrode Connections	2, 3, 4 (WE, S, CE, RE) and ground electrode
		9.2	End Connectors with cables	Following types of end connectors are required: 1. Crocodile Clips 2. Male type BNC connection (both for each connection) 3. Proper required connectors to be given for converting connections from 4 to 2 probe connections (Note: we have probe setup with panel mounted female BNC connections)
10	**Data Acquisition**	10.1	A/D converter (ADC)	≥ 16 bit
		10.2	D/A converter (DAC)	≥ 16 bit
11	**Interface to PC**	11.1	USB (with required cable length for connection between PC to instrument and with matching end connectors at both ends)	
12	**Dummy Cell**	12.1	External Dummy Cell should be provided with the instrument for testing purpose	
13	**Power Requirement**	13.1	Total Maximum Power	≤ 1000 W
		13.2	Mains Input	230V, 50Hz, Single Phase AC, Indian Standards
		13.3	Connection	3 pin top plug as per Indian Standards

14	**PC (Computer Specification)**	14.1	A suitable computer desktop with minimum 21 inch LED monitor **OR** a laptop with minimum of 15 inch LED screen should be provided with instrument.
		14.2	Licensed windows 10 Professional should be provided with computer
		14.3	Microprocessor: i5-10th generation or higher version
		14.4	Hard Disk : ≥ 500 GB
		14.5	appropriate required USB ports for connection of instrument
		14.6	USB mouse (in case of desktop)
		14.7	USB Key board (in case of desktop)
		14.8	One spare USB port and One spare HDMI port should be available
		14.9	All necessary power and other cables and connections should be provided.
15	**Software**	15.1	software for all measurement, fitting, analysis etc. should be provided
		15.2	software should have proper user friendly graphic environment for plotting, overlay, fitting, analysis, simulation etc.
		15.3	Control of all the hardware should be done through software
		15.4	Data Analysis - Capability of Real Time fit, equivalent circuit fitting, Simulation etc.
		15.5	Compatible to Windows 10 operating system
		15.6	License - Lifetime
16	**Type of Measurements**	16.1	Cyclic Voltammetry
		16.2	Electrochemical Impedance Spectroscopy (EIS)
		16.3	Linear Sweep Voltammetry
		16.4	Chrono Techniques (Voltammetry + Amperometry)
17	**Measurements of Solar Photovoltaic Device**	17.1	Current - DC bias Voltage (I-V)
		17.2	Capacitance - DC bias Voltage (C-V) with various frequencies
		17.3	Mott Schottky analysis ($1/C^2$ -V) with various frequencies
		17.4	Capacitance - Frequency (C-f) with various biasing voltage
		17.5	Imaginary Impedance - Real Impedance (Z_{im} - Z_{re}) with various frequencies (i.e. Nyquist Plot / Cole-Cole plot)
		17.6	Impedance - Frequency (Z-f) (i.e. Bode Plot)
		17.7	Current - Time (I-t)
		17.8	Voltage - Time (V-t)
18	**Warranty and Service**	18.1	Minimum One Year warranty from the date of installation
		18.2	Supplier should provide onsite warranty and service support.
19	**Scope of Vendor**	19.1	Fabricate / Supply & Testing of setup
		19.2	Installation and commissioning at FCIPT, IPR, Demonstration on IPR's thin film solar photovoltaic device sample
		19.3	Operation Training to IPR personnel at IPR site (FCIPT campus)
20	**Delivery Time**	20.1	12 weeks from the date of P.O.
21	**Installation**	21.1	2 weeks from the date of delivery
22	**Factory Acceptance Test**	22.1	Following test should be conducted using external dummy cell available with the instrument and results of the test should be sent to IPR for approval before dispatch: 1. DC measurement: a. Connect the instrument to the resister in the range of 1 MOhm (as per available in dummy cell) in the dummy cell and swipe the voltage from -10V to +10V (in equidistance 100 points) and record the current. Data should be sent in excel file format with screen shot of the measurement for approval of dispatch. b. Connect the instrument to the resister in the range of 1 KOhm (as per available in dummy cell) in the dummy cell and swipe the voltage from -10V to +10V (in equidistance 100 points) and record the current. Data should be sent in excel file format with screen shot of the measurement for approval of dispatch. 2. EIS measurement: a. Connect the instrument to the Randle circuit of the dummy cell and measure the impedance (i.e. Nyquist Plot) for 10µHz to 1MHz frequency range and calculate the value of circuit components (i.e. series resistance (100-1000 Ohm as per available in dummy cell), parallel resistance (1-10 KOhm as per available in dummy cell) and capacitance (~1µF as per available in dummy cell)) by fitting the measured data using the software. Data should be sent in excel file format with screen shot of the measurement for approval of dispatch.

23	**Acceptance Criteria (Testing at IPR)**	23.1	Testing will be performed by vendor's engineer at IPR in presence of IPR's technical person.
			Following tests will be done for resistivity measurement using I-V characteristics:
			1. I-V test for the range of instrument with different resistors in potentiostatic and galvanostatic mode (2-probe measurements)
			    a. 1 Ohm or less to 10 Ohm for lower voltage (1V range) and higher current range (1 A range)
			    b. 100 Ohm – 10 KOhm for mid voltage (5 V range) and mid current range (10 mA range)
			    c. 1 MOhm for higher voltage (10 V range) and lower current (10 nA range)
			2. Measurement of Sheet resistance of thin film using 4-probe setup to test the working in four probe mode. (galvanostatic mode) (Note: four probe setup and metallic thin film will be provided by the IPR with four banana lugs to connect to the instrument)
			3. Following tests will be performed at external dummy cell and IPR provided photovoltaic cell (CZTS absorber based thin film solar cell) in impedance (EIS) mode:
			    a. I-V characteristics of the cell (as per PN junction)
			    b. Mott Schottky analysis ($1/C^2$ -V) where voltage is applied -5 to +5 V and Capacitance is measured with various frequencies 100 Hz, 1KHz, 10KHz, 100KHz, 1MHz, 5MHz
			    c. Capacitance - Frequency (C-f) where frequency is varied from 100Hz to 5MHz in steps decades with various biasing voltage(-5V to +5V)
			    d. Imaginary Impedance - Real Impedance (Z_{im} - Z_{re}) with various frequencies (from 10µHz to 5 MHz with variation of 10 to 100 points in every decade) (i.e. Nyquist Plot / Cole-Cole plot)
			    e. Impedance - Frequency (Z-f) (i.e. Bode Plot) for the same range as mentioned above.