

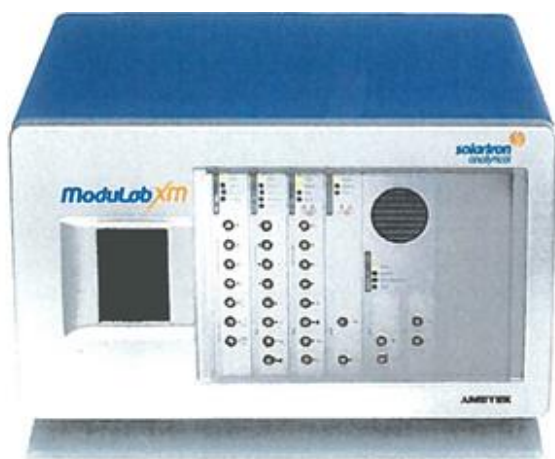


-Technical Specifications: 2 potentiostats comprising FRA - Summary

2 potentiostats comprising Frequency Response Analyzers (FRA) were procured in 2016, to be integrated to 2 existing Maccor Series 4000 battery cycler (S/N A131207 and A131208), which were purchased in 2013. Both potentiostats are from Solatron Analytical, model: Modulab® XM (Xtreme Measurement). Modulab® XM ECS is an electrochemical test system that is capable of measuring micro-ohm impedance cells (latest generation batteries and fuel cells, for example), while able to accurately characterize corrosion coatings at the other extreme.

The system is independently calibrated, ensuring the specified accuracy of results. The system uses ultra-fast sample rate digital electronics to provide:

- Smooth analog waveforms that are applied in all option configurations
- High-speed pulse and measurement capability
- Wide range of techniques including CV, CC-CV charge/discharge, Square-Wave Voltammetry, Differential Pulse Voltammetry, Linear Sweep Voltammetry, and the equivalent Potentiometry techniques
- The smoothest AC waveforms delivering highest accuracy AC measurement performance (40x oversampled FRA)- includes impedance, admittance, permittivity/capacitance, electrical modulus, Matt-Schottky, etc.



The system comprises of two main control modules: the potentiostat/galvanostat (XM PSTAT 1 Ms/s) and the FRA (XM FRA 1 MHz/300 KHz) module.

The former module allows measurements of highest conductivity/highest impedance cells are available by appropriate choice of 'plug and play' option modules

Two additional option modules were purchased to complement the equipment: the High Voltage XM, XV 100/XV30 module, that allows tests with voltage up to 100V, and

the internal Booster XM Booster 2A, that provides significant additional technical features, as shown in the summary Table below.

General	control module potentiostat XM PSTAT 1 Ms/s	High Voltage XM, 100/XV30 XV	XM Booster 2A
Cell connections	2, 3, or 4 terminal	2, 3, or 4 terminal	2, 3, or 4 terminal
Instrument Connections	CE, WE, RE,LO	CE, WE, RE,LO	CE, WE
Floating measurements	yes	yes	yes
Impedance measurement bandwidth	1 MHz (via FRA)	1 MHz (via FRA)	1 MHz (via FRA)
DC scan rate (potentiostatic)	1.6 MV/s to 1 μ V/s	10 MV/s to 1 μ V/s	1.6 MV/s to 1 μ V/s
DC scan rate (galvanostatic)	60 kA/s to 200 μ A/s	10 kA/s to 200 μ A/s	400 kA/s to 200 μ A/s
Counter Electrode (CE)			
Voltage polarization range	± 8 V	± 100 V/ ± 30 V	± 20 V
Current polarization range	± 300 mA	± 100 mA/ ± 200 mA	± 2 A
Maximum compliance (CE vs LO)	± 8 V	± 100 V/ ± 30 V	± 20 V
Bandwidth (decade steps)	1 MHz to 10 Hz	1 MHz to 10 Hz	1 MHz to 10 Hz
Slew rate	>10 V/ μ s	>10 V/ μ s	>10 V/ μ s
Reference-Inputs (Reference electrode RE)/ Auxiliary electrodes {A, B, C, D})			
Connections	Differential input	Differential input	PSTAT or HV (Potentiostat or High Voltage module)
Working Electrode (WE)			
Maximum current	± 300 mA	± 100 mA/ ± 200 mA	± 2 A
Ranges	300 mA to 30 nA	300 mA to 30 nA	3 A to 30 nA
Accuracy (reading % + range % + offset)	0.1% + 0.05% + 30 fA	0.1% + 0.05% + 30 fA	0.1% + 0.05% + 30 fA
Best resolution	1.5 pA	1.5 pA	1.5 pA
Compliance voltage range (floating)	± 8 V	± 100 V/ ± 30 V	± 20 V