SolarLab

Apps-XM series

AMETEK

solartron analytical

Apps-XM series

- ***Smaller Footprint***
- ***Competitively Priced***
- ***Best In Class XM Accuracy***

SolarLab XM is one of Solartron Analytical's Apps-XM series of **X**treme **M**easurement products that are each precisely focused on the requirements for specific applications.

These exciting new products have a much smaller footprint than most competitive units - delivering unmatched **XM** measurement performance while taking less of your restricted lab space.

Each **XM** module is individually calibrated using Solartron Analytical's unique multi-point calibration and tested to rigorous standards ensuring best accuracy.

Apps-XM	
EnergyLab XM	for battery, fuel cells, supercapacitors
EchemLab XM	for corrosion/coatings and physical electrochemistry
SolarLab XM	for solar/PV cells
Materials Lab XM	for dielectrics, insulators, and electronic materials

- ***Includes fully integrated optical bench***
- ***Multiple techniques IMPS, IMVS, I-V, Charge extraction, PV decay with automated data analysis***
- ***Wide bandwidth impedance and capacitance measurements***
- ***IPCE available as an option***

SolarLab xm

Xtreme Measurement

SolarLab XM is an application specific **XM** (**X**treme **M**easurement) product that is primarily focused on solar cell / photovoltaic research, developed in conjunction with Professor Laurie Peter of the University of Bath, UK.

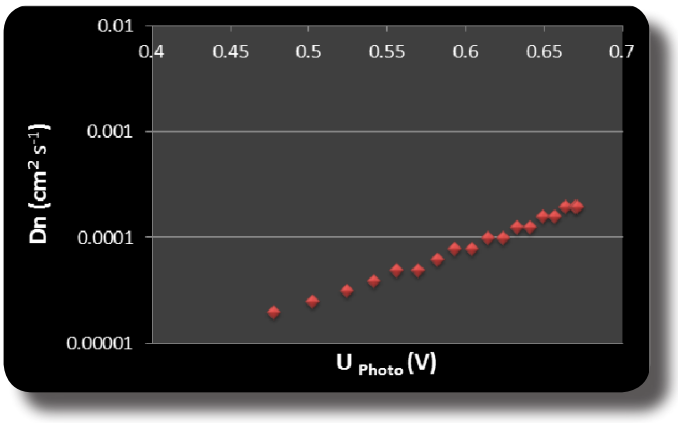
SolarLab XM includes a reference grade potentiostat, frequency response analyzer (FRA) and PhotoEchem module that provide complete characterization of a wide range of Solar/PV cells, including Perovskite and Dye Sensitized Solar Cells (DSSC). Additionally, the system can be used for development of visible spectrum photoelectrochemical systems such as Iron-Oxide photo-splitting of water.

A key feature of this system is its ease of use, with data analysis requiring just one click of the mouse! For experienced users **SolarLab XM** offers the ability to develop new experiment types with the powerful step sequencer. **SolarLab XM** includes:

- Frequency and time domain techniques including IMPS, IMVS, Impedance, Photovoltage Decay, Charge Extraction, I-V
- Auto analysis for calculating effective diffusion coefficients and electron lifetimes
- NIST traceable light source calibration
- Excellent thermal management of light sources for long term stability
- Wide range of monochromatic high brightness LEDs
- Full set of electrochemical techniques (cyclic voltammetry, chrono methods, galvano methods, impedance and AC voltammetry)
- Auxiliary channels (12-wire) for simultaneous anode/cathode voltage and impedance
- Best in class frequency response analyzer (FRA) - fast single sine, multisine/Fast Fourier Transform, Harmonic Analysis over the full frequency range
- IPCE option for quantum efficiency measurements

Technique	Parameters
IMPS	Effective Diffusion Coefficient of Electrons
IMVS	Effective Lifetime of Electrons
Photo Voltage Delay	Effective Lifetime of Electrons
I-V	Fill Factor, Pmax, Voc, Isc, Efficiency
Charge extraction - Dark	Trapped Charge Density
Charge extraction - Short Circuit	Trapped Charge Density
IPCE Option	Quantum Efficiency
AC measurement	Impedance/capacitance

A comprehensive suite of techniques is available



Auto analysis of IMPS

SolarLab XM Xtreme Measurement

Optical Bench

At the heart of the **SolarLab XM** system is a collimated and highly focused, high power light source. Key features:

- NIST traceable light source calibration
- High light intensity measurements with excellent thermal stability
- Control/measure 6 decades of light intensity
- Collimating and focussing optics
- Reference detection technique up to 100 kHz for solid state devices

Not just a PhotoEchem System...

SolarLab XM utilizes powerful **XM** Potentiostat and frequency response analyzer technology to provide a wide range of electrochemical test capabilities:

- Cyclic Voltammetry (staircase/linear sweep)
- Normal and differential Pulse Techniques
- Potentiostatic and galvanostatic impedance (single sine, multisine/FFT, harmonics)
- AC voltammetry
- 12-wire DC/impedance measurements (anode/cathode characterization etc.)

The optical bench can be integrated with all of the above electrochemical test methods allowing development of future new techniques.

Control/Measure six decades Intensity

The fast Si photodetector has seven gain stages that provide excellent measurement resolution for very low level intensity studies. A 0.01 Neutral Density Filter is included to extend the light controlled intensity range to over 6 decades.

Reference Detection

A 50:50 beam splitter and reference detector are used to compare the response of the cell under test vs. the reference, eliminating errors associated with phase shift and changes in light magnitude as first developed by Professor Laurie Peter in the late 1980's

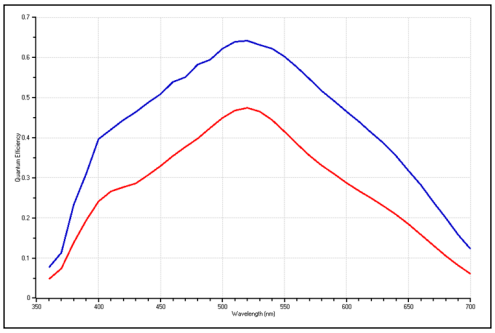
NIST Traceability

Each optical bench is equipped with a 10 MHz, fast Si photodetector that is custom designed for XM products. The NIST traceable sensor inside each detector is supplied with an individual factory calibration file. Measurements in units of power per unit area can be referenced with full confidence in the accuracy and repeatability of the results.

IPCE Option

IPCE (Incident Photon to Current Efficiency) add-on module enables Quantum Efficiency measurements of a wide range of photovoltaic materials. The use of FRA technology has many advantages over traditional light chopper techniques including improved built in noise rejection and bias rejection, allowing white bias measurements for non-linear cells to be included as standard functionality rather than an expensive option.

- Wavelength range 350 nm - 1100 nm
- White light bias source included
- 0.1 to 10 Hz AC modulation technique for superior noise rejection at low frequencies
- Automatic determination of Quantum efficiency and Short Circuit current

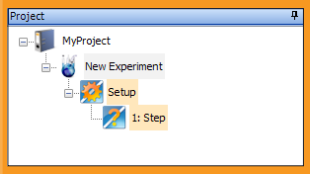


IPCE spectrum of ionic liquid based Dye Cell with (Blue) and without (Red) white bias source

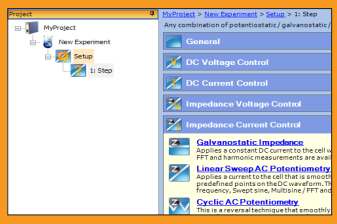
XM-studio software easy as 1... 2... 3... 4...

XM-studio PhotoEchem software provides the complete range of facilities in one very easy to use package. From test setup, to experiment execution, to data analysis and final report; the software provides ready built templates to get you started. Tests can be setup and run with auto analysis of results in just a few clicks:

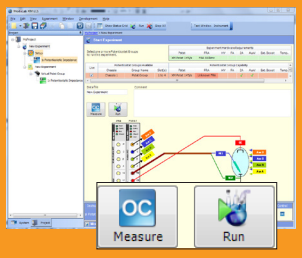
1 Create new experiment



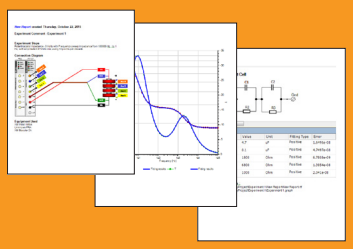
2 Select Step type (Impedance in this case):

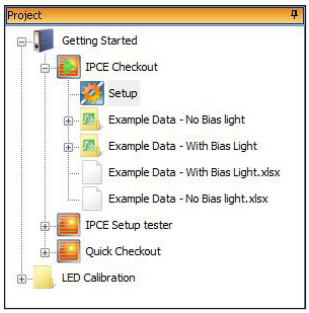


3 Check your cell connections - match the diagram in the "Experiment" menu, and click "Run"



4 Analyze the data using equivalent circuit fitting, and automatically generate reports using your favorite word processor software

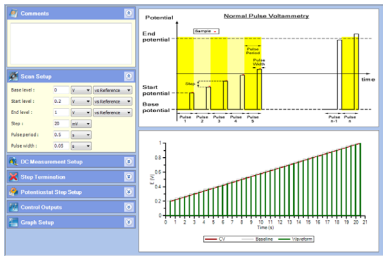


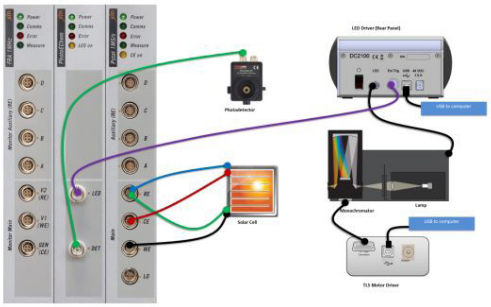


XM-studio PhotoEchem software is fully featured and graphically oriented for ease of use:

- Experiment sequences are setup using intuitive standard copy/paste, and drag/drop techniques.
- New experiments can be derived from previous experiments, by copying and then adjusting step parameters and test sequencing.

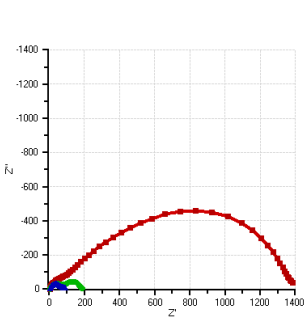
- Extensive use of graphical waveforms in the software enable full understanding of test parameters and experiment settings. The effect of parameter changes are seen real-time at setup, allowing setup errors to be identified and corrected before the test is run.

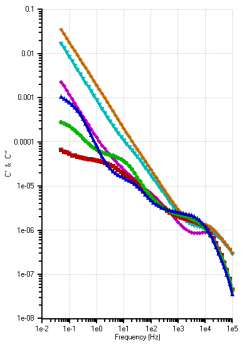




- **XM-studio PhotoEchem** software shows connection diagrams that ensure that your cell is correctly connected before the test starts.

- Equivalent circuit fitting is included, no need to export data
- R, C, L, Warburg constant phase elements, distributed elements...
- Auto PhotoEchem result analysis





Accessories

SolarLab XM is specifically designed for solar/PV applications but when paired with suitable accessories it can be used in other electrochemical applications including energy, corrosion and coatings, as well as physical electrochemistry.

External Power Booster

SolarLab XM is compatible with external power boosters that extend its current and impedance measurement range - especially important for new generation ultra-low impedance batteries, fuel cells, supercapacitors, and solar cells.

- Floating design - enables tests on grounded cells
- Time domain and impedance tests on anodes/cathodes and short stacks up to 8 V
- Can boost current up to 100 A and extend impedance measurements to 1 μΩ
- External boosters provide 100 kHz impedance bandwidth for SOFC and other high frequency applications
- Automatically controlled by **SolarLab XM** with **XM-studio PhotoEchem** software

Corrosion Cell

The cell permits a series of metal specimens and liquid environments to be tested quickly and uniformly. Most of the common electrochemical techniques for corrosion testing can be employed under aggressive conditions (except for HF)

Flat Cell

The practical design of the Flat Cell makes it simple to use for corrosion and/or coatings research. It can accommodate a wide range of electrode sizes, eliminating the need for specialized machining or mechanical procedures.

Rotator

The 636A is suitable for use in hydrodynamically modulated systems. Its solid state controlled servosystem allows the electrode speed to follow an input signal with minimum distortion. This excellent performance is due to the use of a high speed, low inertia, permanent magnet DC motor and a high voltage, bipolar power supply. The rotational speed is adjustable to within 1% of the input setting 50 to 10,000 RPM. A voltage signal proportional to the rotational speed is available as an output.

Applications

Solar Cells / Photovoltaics

Solar cell materials operate by using photons of light to excite electrons into higher energy states where they are made available as charge carriers to produce an electrical current. There are many types of solar cells including multi-junction, GaAs, crystalline silicon, thin film (e.g. CdTe), and a host of emerging technologies including organic photovoltaics (OPV), dye sensitized solar cells (DSSC), Perovskite cells and nanomaterials including quantum dot cells. Efficiencies vary from over 40% to as low as 5% for some of the emerging technologies, but low efficiency can often be offset by much lower manufacturing costs allowing for, as an example, large panels to be constructed or even sprayed onto windows, roofs or walls of buildings at a fraction of the cost of conventional cells.

Specifications - Optical Bench

Wavelength Range	350 nm - 1100 nm
Intensity Range	6 Decades (With ND Filter)
Maximum Beam Divergence	4°
Maximum Beam Diameter / Cell Size	1 cm
IMPS / IMVS Transfer Function	Reference Photodetector
Calibration	NIST Traceable
LED Driver Maximum Current	2 A
Typical LED Stability at MAX Power	< 2% Drift After 24 Hours
LED Driver Maximum Frequency (IMPS and IMVS)	100 kHz*

*Up to 1 MHz with modification

LED Options (nm)	Maximum Power (mA)	Bandwidth (FWHM) (nm)
420	500	12
455	1000	18
470	1600	29
505	1000	30
530	1600	31
590	1600	14
625	1000	16
660	1200	25
Cold White	1000	n/a
Warm White	1000	n/a

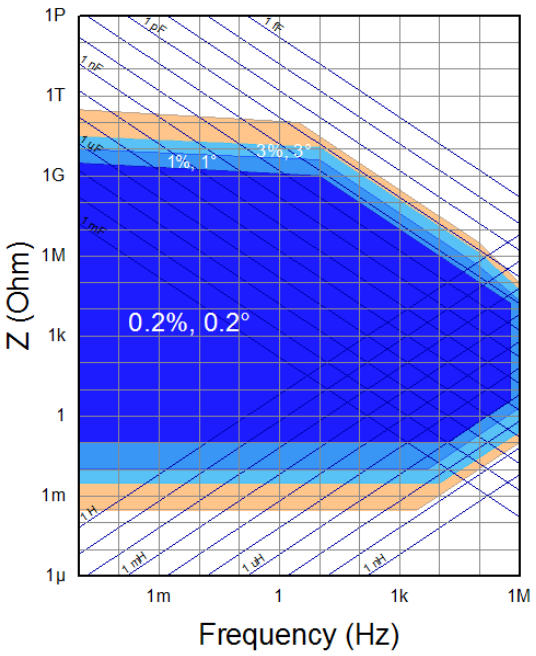
SolarLab xm Xtreme Measurement

Specifications

Potentiostat/Galvanostat	
Cell connections	2, 3, or 4 terminal
Instrument Connections	CE, WE, RE, LO
Floating measurements	yes
Impedance measurement bandwidth	1 MHz (via FRA)
IR compensation	yes
Counter Electrode (CE)	
Smooth scan generator	64 MS/s interpolated and filtered
Voltage polarization range	±8 V
Current polarization range	±300 mA
Recommended voltage scan rate	25 kV/s to 1 µV/s
Recommended current scan rate	1 kA/s to 200 µA/s
Maximum compliance (CE vs. LO)	±8 V
Bandwidth (decade steps)	1 MHz to 10 Hz
Polarization V/I error (setting+range)	0.1% + 0.1%
Minimum pulse duration	1 µs
Slew rate	>10 V/µs
Reference Inputs (RE)	
Connections	Differential input
Cable Shields	Driven (3T) / Ground (4T)
Maximum voltage Measurement	±8 V
Ranges	8 V, 3 V, 300 mV, 30 mV, 3 mV
Accuracy (reading % + range % + offset)	0.1% + 0.05% + 100 µV
Maximum resolution	1 µV
Input impedance	>100 GΩ, <28 pF (3T)
Input bias current	<10 pA
Maximum ADC sample rate	1 MS/s
Working Electrode (WE)	
Maximum current	±300 mA
Ranges	300 mA to 30 nA (decades)
Accuracy (reading % + range % + offset)	0.1% + 0.05% + 30 fA
Maximum resolution	1.5 pA
Compliance voltage range (floating)	±8 V
Maximum ADC sample rate	1 MS/s
Auxiliary electrodes (A, B, C, D)	
Differential Auxiliary Electrodes	4 (same spec. as RE)
DC Measurement	Sychronized to RE
Impedance measurement bandwidth	1 MHz (via FRA)

Frequency Response Analyzer	
Maximum sample rate	40 MS/s
Frequency range	10 µHz to 1 MHz
Frequency resolution	1 in 65,000,000
Frequency error	±100 ppm
Minimum ∫ time per measurement (single sine, FFT or harmonic)	10 ms
Signal Output	
Waveform	Single sine, multi-sine
Single Sine	Linear / logarithmic
Multi-sine / harmonic frequencies	All or selected
Analysis channels	
Accuracy (ratio)	±0.1%, ±0.1°
Anti-alias, digital filters, DC bias reject	Automatic
Analysis channels	RE, WE, Aux A/B/C/D
Analysis modes:	Single sine, FFT, harmonic
DC Bias rejection	Automatic

Impedance Accuracy



- External high power boosters extend accuracy to 1 µΩ
- 3T connections for high impedance / low capacitance measurements, 4T otherwise
- Gstat mode <1 Ω
- Faraday cage and suitable screening recommended

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