

**solartron**  
analytical



**mxm**

# ModuLab<sup>®</sup> X<sub>m</sub>

materials test system






the **X<sub>m</sub>** difference

**AMETEK**



# ModuLab<sup>®</sup> XM

## the xm difference

-  Market leading impedance analysis
-  Widest voltage and current range available
-  Time domain and impedance analysis in a single system

ModuLab<sup>®</sup> XM MTS is an extreme measurement Materials Test System able to measure the extremes of ultra-high impedance/low capacitance dielectric and insulator materials as well as high conductivity materials in the sub-milliohm range. The ModuLab XM MTS is an all around player capable of time domain and AC measurement, high and low impedance, high and low voltage and current as well as temperature control all in one convenient system.

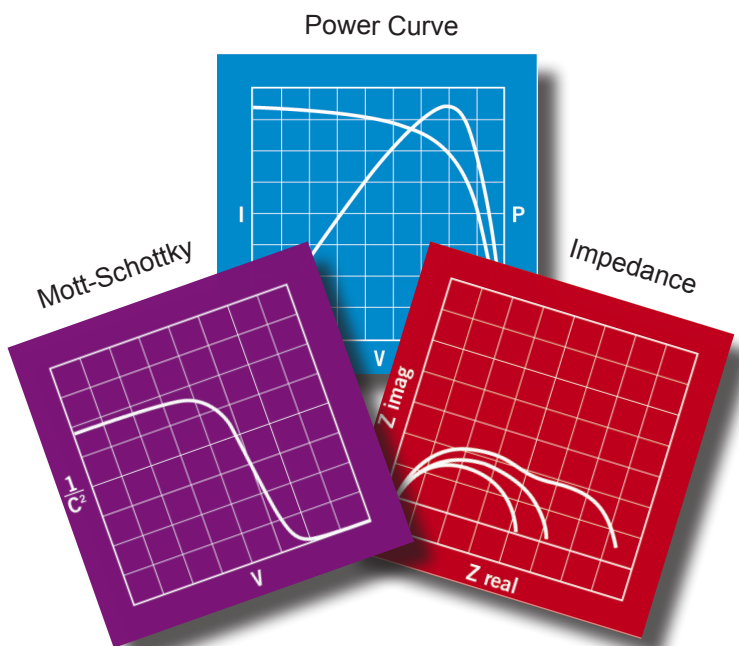


The ModuLab XM MTS system is able to auto-sequence all of the above time domain and AC techniques without switching cables, removing the need to configure complicated systems using discrete measurement units. The ModuLab XM MTS PC software also controls a wide range of temperature accessories in convenient, easy to configure experiment sequences.

## Time Domain / AC Auto-sequence Capability

The ModuLab XM MTS system is able to test materials using a wide range of time domain and AC measurement techniques including:

- I-V (current / voltage - used to characterize electronic and dielectric materials)
- P-E (polarization / electric field - used to characterize ferroelectric materials)
- High-speed pulse (used for electronic and dielectric materials)
- Staircase and analog smooth ramp waveforms
- Impedance, admittance, permittivity / capacitance, electrical modulus
- C-V (capacitance vs. DC voltage), Mott-Schottky



# Xtreme Measurement

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## Control and Slave Modules

The ModuLab XM system has two 'intelligent' Control Modules:

- XM MAT 1MHz for time domain measurements
- XM MFRA 1MHz for AC measurements

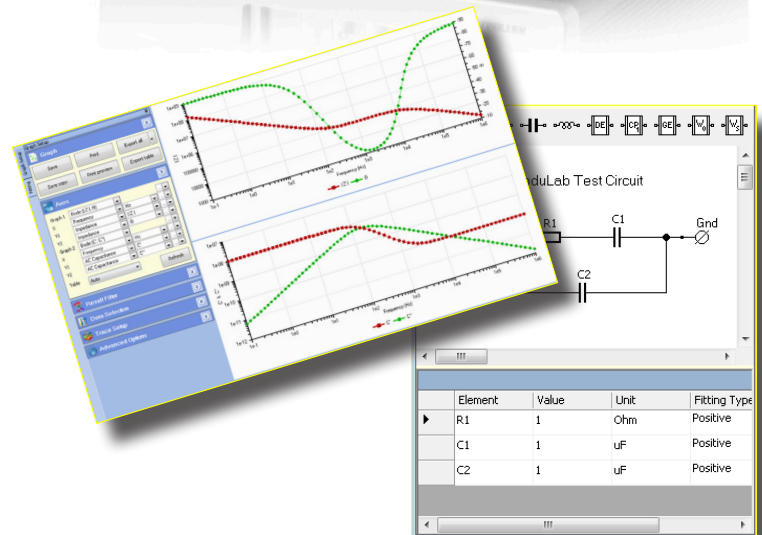
In addition there are several Slave Modules that amplify the signals produced by the Control Modules to provide high voltage/current polarization waveforms to the sample, and provide amplified/attenuated high resolution signals back to the control modules:

- XM MHV100 – High voltage option (100 V)
- XM MFA – Low current measurement option
- XM MREF – Sample/reference module for increased AC analysis accuracy
- XM MBST 2A – High current option (2 amps)

Part of the XM difference, is the way that modules are designed to integrate together without limitations. For example the XM MHV100 module allows impedance tests to be run over the full range of the module (using up to 100 V peak AC waveform or any combination of AC + DC up to 100 V). The XM MFA is able to resolve current levels in the sub-fA range. Used together, this combination can provide extreme dielectric/insulator measurements in the region of >100 Tohms.

## System and Software

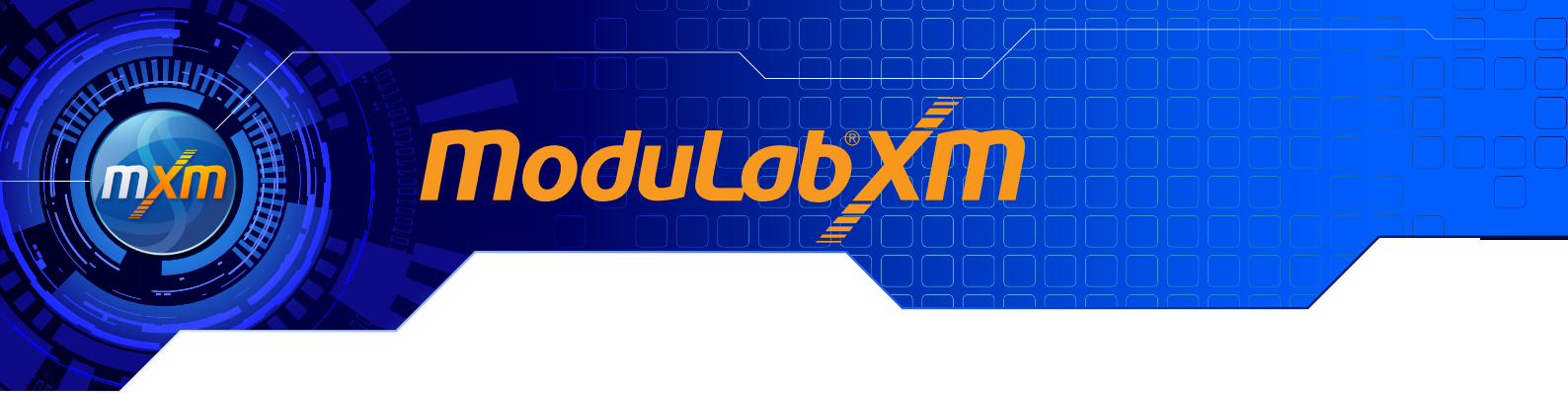
ModuLab XM may be configured as a single or multichannel system depending on which options are needed. In multichannel configurations each channel can be independently controlled from separate PCs, allowing tests on multiple samples to be run in parallel by separate researchers. It is also possible to configure groups of modules in the same chassis from ModuLab XM MTS and from the XM ECS Electrochemical System (refer to the separate brochure).



An example application is XM MTS modules characterizing high impedance SOFC ionic membrane materials, while XM ECS modules test the complete fuel cells.

All modules are 'plug and play' allowing the user to easily add modules in the field. Once additional modules or channels have been installed, the software recognizes the modules and enables them for use in future experiments.

The software provides powerful automatic sequencing of time domain and AC techniques and provides a wide range of data analysis facilities including Fill Factor, and equivalent circuit fitting functions. This powerful combination of hardware and software functionality adds to the difference...



## XM control modules



### Materials Core Module

XM MAT 1MHz makes use of latest generation high-technology hardware for accurate waveform generation and data acquisition.

- Fast auto-sequencing of I-V, ramp, P-E and high-speed pulse techniques without switching cables

- Measurements from highest conductivity to highest impedance materials by appropriate choice of 'plug and play' slave option modules
- No matter which modules are in operation, ModuLab XM provides smooth analog voltage ramp waveforms essential for many research applications
- Selectable high-speed data acquisition up to 1 MS/s available for all measurement techniques including pulse and fast I-V



### Frequency Response Analyzer

XM MFRA 1MHz is the most versatile Frequency Response Analyzer available today. It is fully compatible with all XM slave modules for high voltage, high/low current and sample/reference AC measurements, and is able to auto-sequence time domain and AC measurements without switching cables.

#### Single Sine Analysis

- AC tests include impedance, capacitance, and C-V/Mott-Schottky (with stepped or smoothly ramped DC)
- Ultra-high frequency resolution for resonant materials characterization

#### Multi-sine / Fast Fourier Transform (FFT) Analysis

- AC tests include impedance, capacitance, and C-V/Mott-Schottky (with stepped or smoothly ramped DC)
- Faster measurements across the whole frequency range saves test time and minimizes errors for time-variant materials

#### Harmonic / Intermodulation Analysis

- To investigate sample linearity and breakdown



# Xtreme Measurement

mxm

## XM slave modules

### Low Current Option

- Extends current measurement resolution to 0.15 fA
- Available for time domain and AC (with FRA) tests
- Combined with XM MHV100 option provides ultra-high impedance measurement

### 100 V High Voltage Option

- High voltage time domain analysis for IV, ramp, P-E, and pulse sample characterization
- AC characterization with small AC / high DC bias, or with high AC over the full 100 V range
- Combined with XM MFA option provides ultra-high impedance measurement

### Sample/Reference Option

XM MREF provides increased accuracy impedance measurements by comparing the material under test with known pre-calibrated reference components.

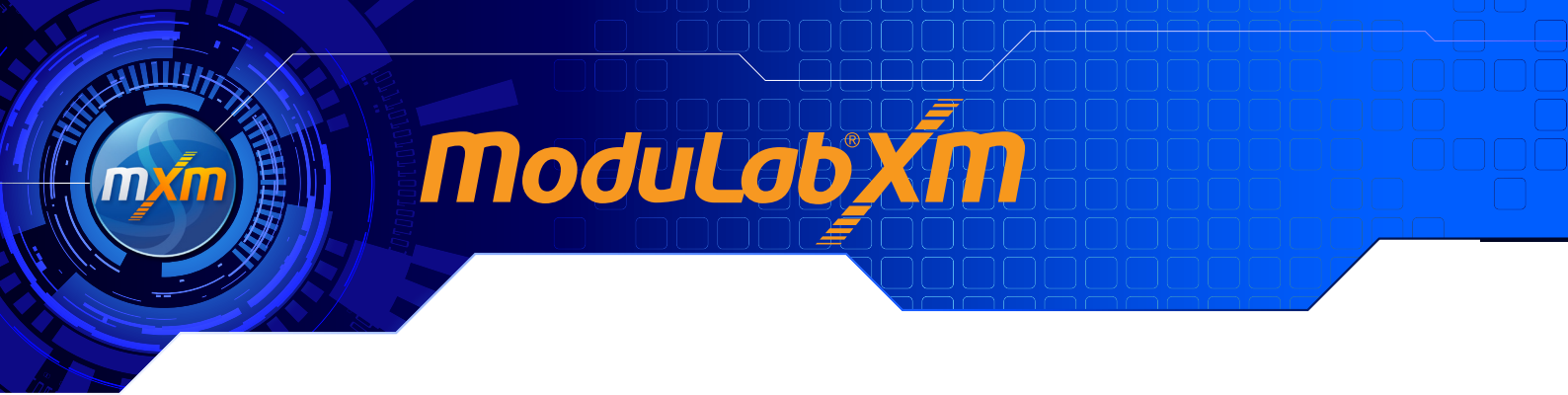
- Compensates for cable impedance in temperature control accessories – cryostats, furnaces, etc.
- Compensates for any residual measurement system errors

### 2 A High Current Option

XM MBST 2A extends XM's high current to 2 Amps for accurate time-domain and impedance tests of low impedance materials:

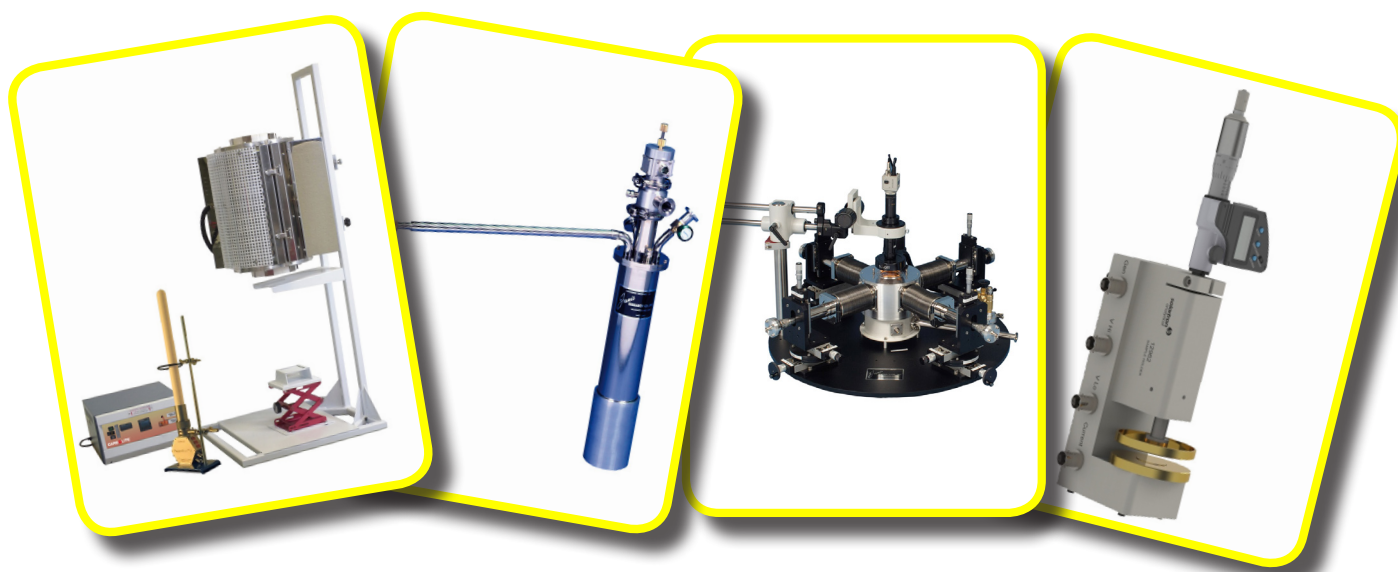
- XM MBST 2A has low output impedance useful for testing electronic materials in their 'ON' state
- Combined with XM MHV100 provides high power tests





## Accessories

A wide range of accessories are available for use with the ModuLab XM MTS, including sample holders, cryostats, furnaces and amplifiers.



### Temperature Control

The 129610A cryostat provides fully integrated temperature related measurements of solid, liquid or powder materials samples over a wide range of temperature (5 K to > 600 K) using liquid nitrogen or liquid helium cryogen. This system ensures that the sample is not exposed to the cryogen vapor which could cause it to crack or swell, by positioning the sample in a separate chamber that heats or cools the sample via an exchange gas (usually dry inert helium gas)

The ModuLab XM MTS is compatible with various furnace systems for very high temperature tests up to 1200 °C. Other temperature systems may be configured for special requirements.

### Semiconductor Probe Stations

The ModuLab XM can be used with third party probe stations for testing semiconductor wafers. Probe stations provide accurate positioning of sample probes on the surface of semiconductor to allow precision measurements of the wafer's electrical properties. Cryostatic probe stations are also compatible with ModuLab XM MTS to provide combined temperature and electrical characterization.

### Room Temperature Sample Holders

In addition to the purpose-built sample holders that are provided as part of the cryostat and furnace systems, Solartron Analytical also provides additional room temperature holders for testing solids, liquids and powders. One example is the 12962A sample holder that can be used to perform 2 and 4 terminal testing on a range of materials.

# Xtreme Measurement



## Specifications

General	Control Module	Slave Modules		
	XM MAT 1MHz	100 V High Voltage XM MHV100	Femto Ammeter XM MFA	2 A Booster XM MBST 2A
Chassis slots taken	Single	Single	Single	Double
Measurement mode	2 or 4 terminal	2 or 4 terminal	2 or 4 terminal	2 or 4 terminal
Sample connections from module	Gen, VHi, VLo, I	Gen, VHi, VLo MAT- I	I MAT- Gen, VHi, VLo	Gen- I MAT- VHi, VLo
Sample connection cables (1 M length)	4 x BNC to BNC	MAT cables	Triax to BNC	MAT cables
Floating	Yes	Yes	Yes	Yes
<b>Generator Output - (Gen)</b>	<b>XM MAT 1MHz</b>	<b>XM MHV100</b>	<b>XM MFA</b>	<b>XM MBST 2A</b>
Maximum waveform generator sample rate	64 MS/s interpolated/filtered	Uses MAT	N/A	Uses MAT
Maximum voltage (open-circuit load) DC + peak AC (subject to slew rate limit)	±8 V	±100 V	N/A	±8 V with MAT ±20 V with MHV
Maximum voltage resolution	150 µV (< 3 V) 400 µV (≥ 3 V)	2 mV (< 37 V) 5 mV (≥ 37 V)	N/A	1.5 mV
Maximum output current	±100 mA	±100 mA	N/A	±2 A
Output impedance (nominal)	50 Ω	50 Ω	N/A	< 1 Ω
Applied voltage error (open-circuit load)	±0.2% setting ±800 µV (< 3 V) / ±2 mV (≥ 3 V)	±0.2% setting ±12.5 mV (< 37 V) / ±35 mV (≥ 37 V)	N/A	±0.2% setting + 10 mV (< 3 V) / ±25 mV (≥ 3 V)
Voltage sweep rate	1.6 MV/s to 1 µV/s	10 MV/s to 1 µV/s	N/A	1.6 MV/s to 1 µV/s
Recommended maximum sweep rate (using 1 MS/s acquisition rate)	25 kV/s	150 kV/s	N/A	25 kV/s
Minimum pulse duration	1 µs	Uses MAT	N/A	Uses MAT
Maximum slew rate	>10 V/µs	>15 V/µs	N/A	>10 V/µs
<b>Voltage Measurement - (VHi / VLo)</b>	<b>XM MAT 1MHz</b>	<b>XM MHV100</b>	<b>XM MFA</b>	<b>XM MBST 2A</b>
Maximum voltage	±8 V	±100 V	N/A	N/A
Voltage ranges	8, 3 (V) 300, 30, 3 mV	100, 37.5, 3.75 (V) 375, 37.5 (mV)	N/A	N/A
Voltage measurement error	0.1% reading + 0.05% range + 100 µV	0.1% reading + 0.05% range + 100 µV	N/A	N/A
Maximum time domain measurement rate	1 MS/s	N/A	N/A	N/A
Maximum time record	Unlimited	N/A	N/A	N/A
<b>Current Measurement (I)</b>	<b>XM MAT 1MHz</b>	<b>XM MHV100</b>	<b>XM MFA</b>	<b>XM MBST 2A</b>
Maximum current	±100 mA	N/A	±100 mA	±2 A
Current ranges	100 mA, 30 mA to 30 nA in decades	N/A	100 mA, 30 mA to 3 pA in decades	2 A plus MAT ranges
Maximum resolution	1.5 pA	N/A	0.15 fA	1.5 pA (MAT)
Current measurement error	±0.1% reading + +0.05% range + ±100 pA	N/A	±0.1%** reading + +0.05% range + ±30 fA	±0.1% reading + +0.05% range + ±0.1 mA
<b>Auxiliary Voltage Inputs</b>	<b>XM MAT 1MHz</b>	<b>XM MHV100</b>	<b>XM MFA</b>	<b>XM MBST 2A</b>
Number of auxiliary DC channels	Four	N/A	N/A	N/A
Voltage ranges	8 V, 3 V to 3 mV	N/A	N/A	N/A
Maximum resolution	1 µV	N/A	N/A	N/A
Synchronized to VHi, VLo measurement	Yes	N/A	N/A	N/A

\*\* MFA Femto Ammeter current measurement "reading %" error term is 0.2% for 300 pA range, 2% for 30 pA range and 5% for 3 pA range



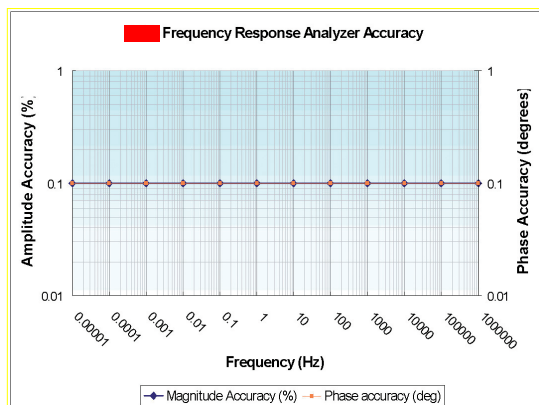
## Specifications XM MFRA

Frequency Response Analyzer	XM MFRA 1MHz
Chassis slots taken	single
Maximum sample rate	40 MS/s
Frequency range	10 $\mu$ Hz to 1 MHz
Frequency resolution	1 in 65,000,000
Frequency error	$\pm 100$ ppm
Minimum measurement integration time	10 ms
Analysis modes (10 $\mu$ Hz to MHz)	
Fixed frequency	Linear / logarithmic
Single Sine	All or selected
Multi-sine / harmonic frequencies	
Accuracy (ratio)	$\pm 0.1\%$ , $\pm 0.1^\circ$
Anti-alias, digital filters, DC bias reject	Automatic

## Specifications XM MREF

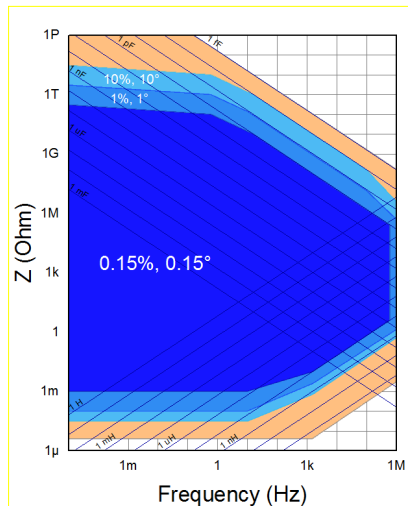
Sample / Reference Option	XM MREF
Chassis slots taken	Single
Reference modes	Internal / External
Connections to MAT, MHV, or MFA	Gen, I
Calibrated reference capacitors	10 nF to 1 pF (3 per decade)

## MFRA Accuracy



## System Impedance Accuracy

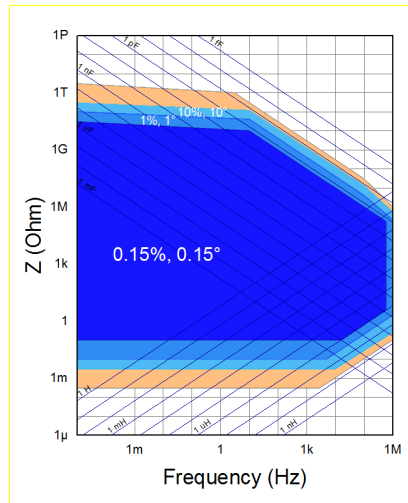
Impedance accuracy specification for MAT, Femto Ammeter, 2A booster and MREF



\*High Voltage option module provides up to 10X higher impedance than shown  
 \*Femto ammeter and MREF is used for dielectrics (1 pF to 10 nF) and for high impedance  
 \*2A booster is used for very low impedance measurements (sub 100 mohm)  
 \*Faraday cage is recommended for dielectric and high impedance measurements

## MAT Impedance Accuracy

Impedance accuracy for MAT operating stand alone



\*High Voltage option module provides up to 10X higher impedance than shown  
 \*MREF is used for dielectrics (1 pF to 10 nF) and high impedance measurements  
 \*Faraday cage is recommended for dielectric and high impedance measurements

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