Eco Chemie Autolab MAC80012

# Multi-Channel Potentiostat / Galvanostat


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# Metrohm Autolab

## Instruments for Electrochemistry

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# History of Metrohm Autolab

- Founded in 1986 as Eco Chemie in Utrecht
- Develops state of the art instruments for electrochemistry
- Joined the Metrohm group in 1999
- Name changed to Metrohm Autolab in 2009

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# Metrohm Group





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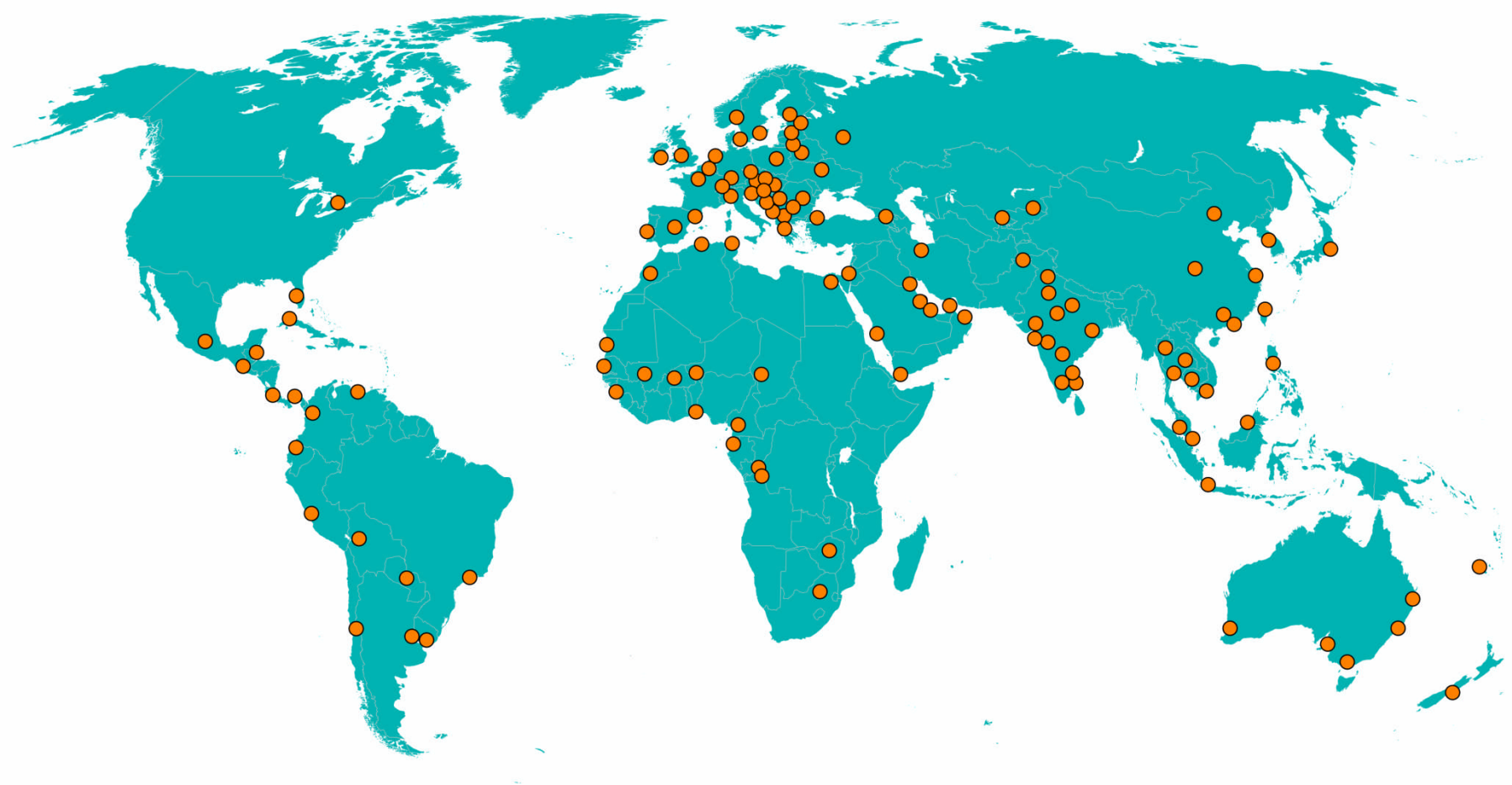
# International presence



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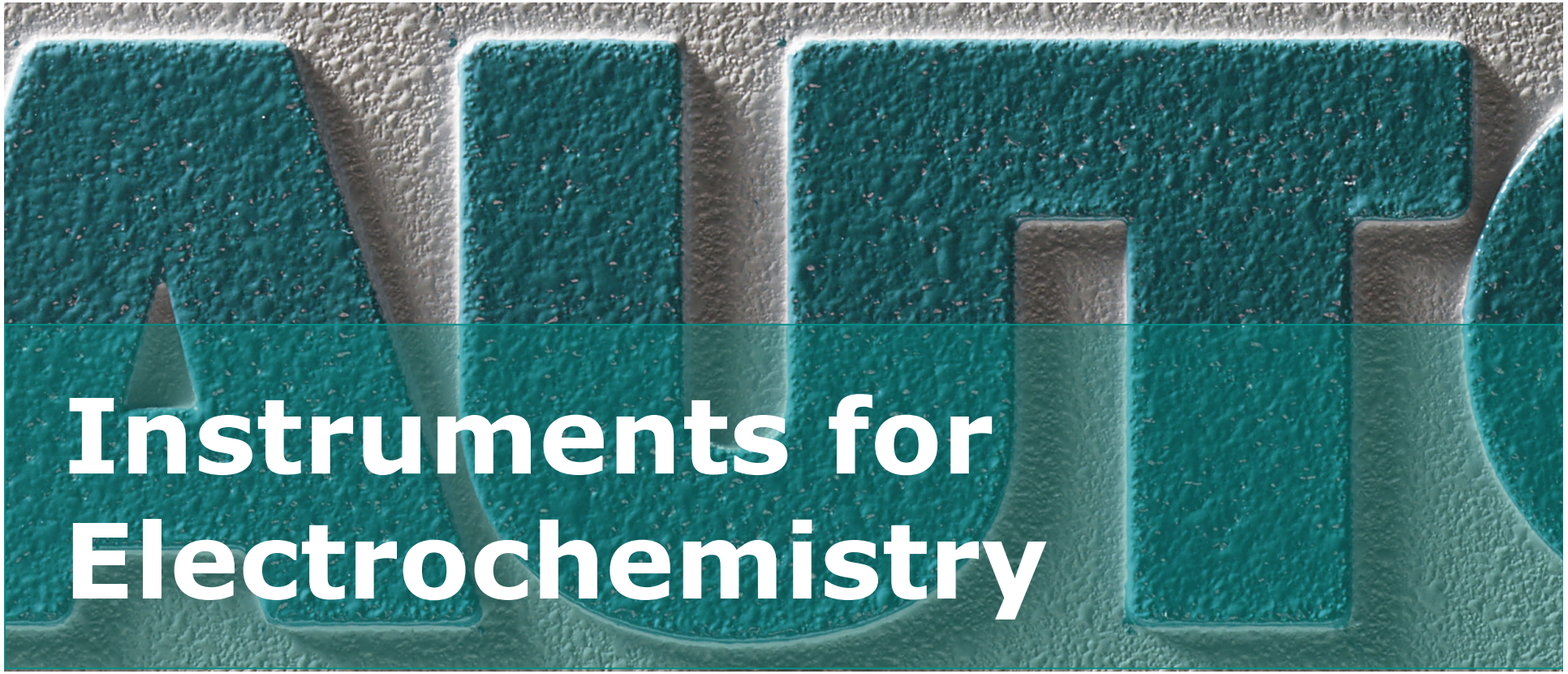

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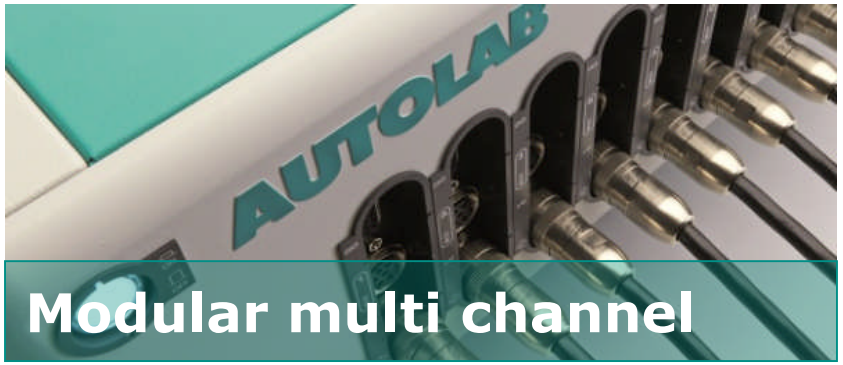
# Four instrument ranges


Modular single channel




Modular multi channel


Compact design


Special applications

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# Single Channel, Modular

## State of the Art, Future Proof Instruments

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# Single channel, modular

- N series of Autolab instruments
- Potentiostat/Galvanostat with USB
- Module bays for instrument extensions

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# The N series of PGSTATs

- Three models available


**PGSTAT128N**
12 V / 800 mA


**PGSTAT302N**
30 V / 2 A


**PGSTAT100N**
100 V / 250 mA

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# N Series Summary

| | PGSTAT128N | PGSTAT302N | PGSTAT100N |
|---|---|---|---|
| Compliance voltage | 12 V | 30 V | 100 V |
| Maximum current | 800 mA | 2 A | 250 mA |
| Bandwidth | 500 kHz | 1 MHz | 400 kHz |

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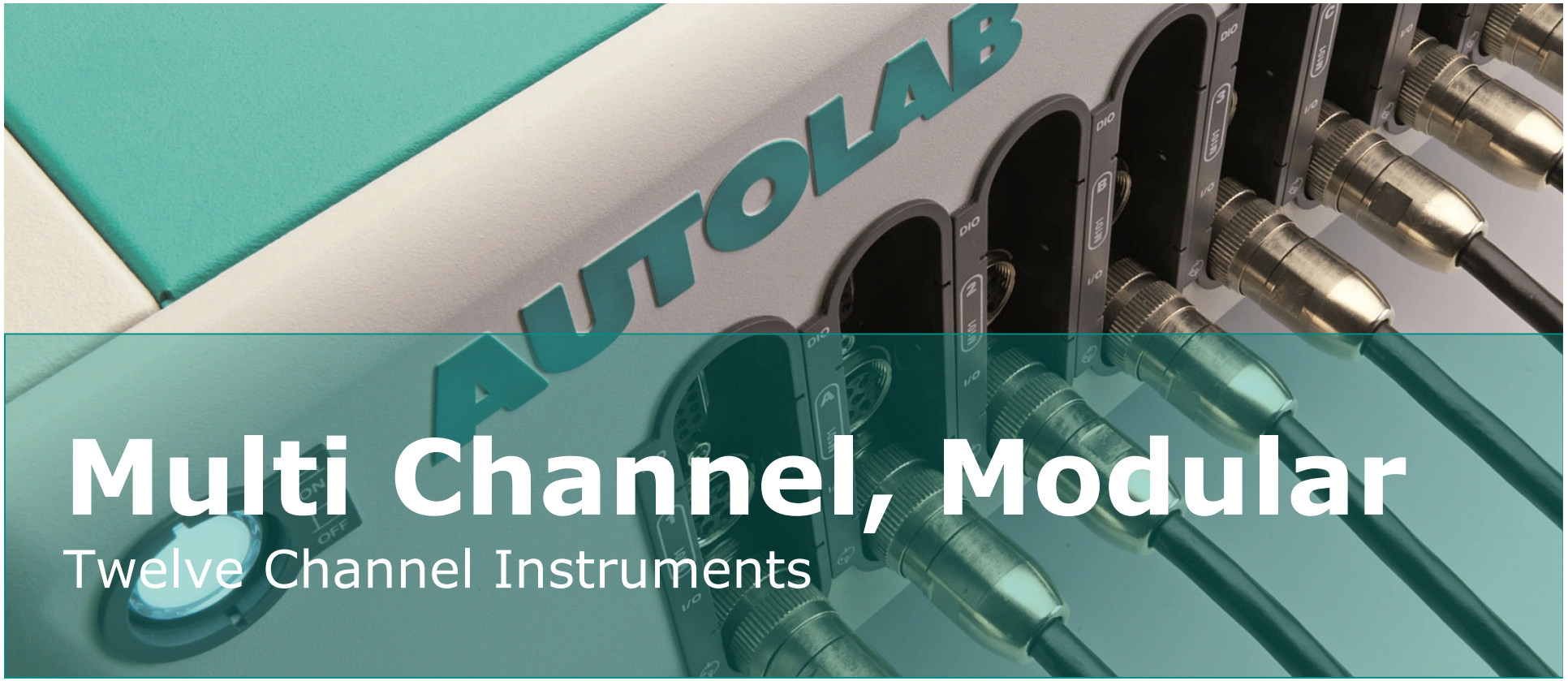


# Multi Channel, Modular

## Twelve Channel Instruments

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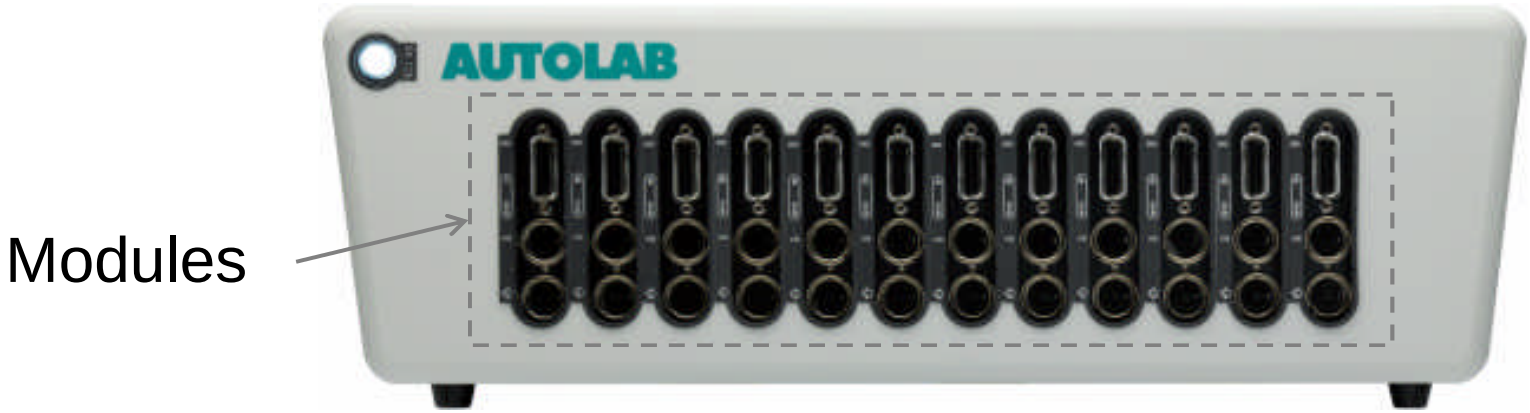
# Multi channel, modular

- 12 channel cabinet with USB
- Fitted with M101 PGSTAT modules
- Fitted with optional modules



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# M101 module


- Single channel PGSTAT module
  - Output power: 10 V / 100 mA
  - Potential range: 10 V
  - Current range: 10 nA to 10 mA in 7 decades
- Up to 12 modules can be installed

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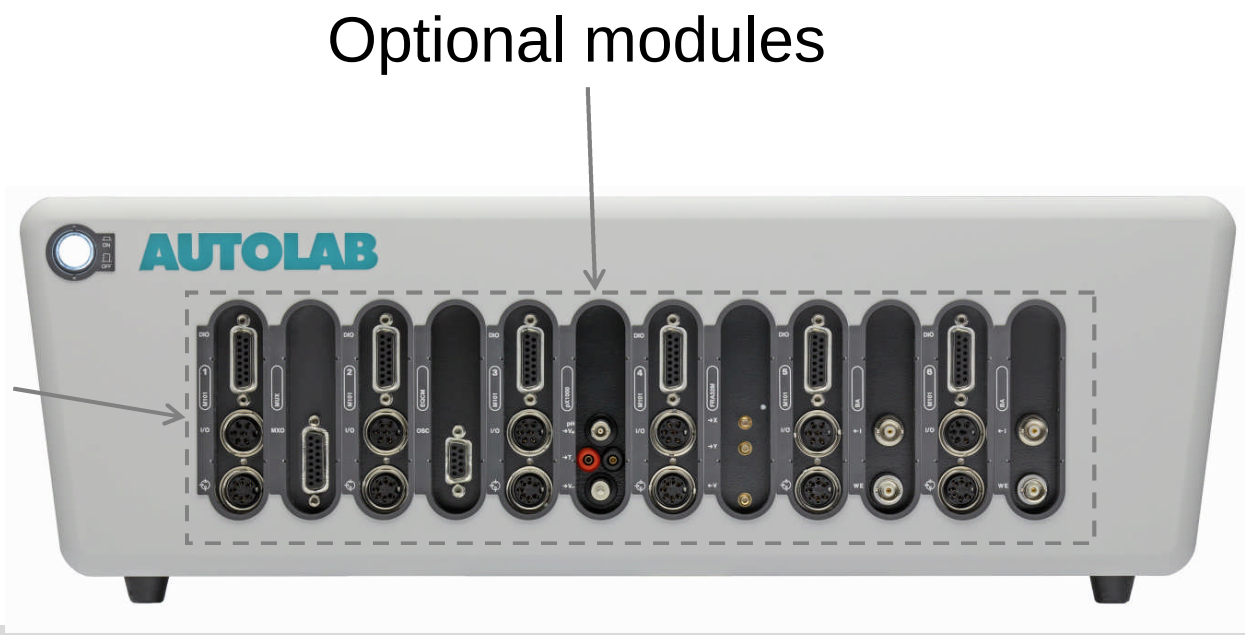
# Multi channel, modular

- Combination with optional modules



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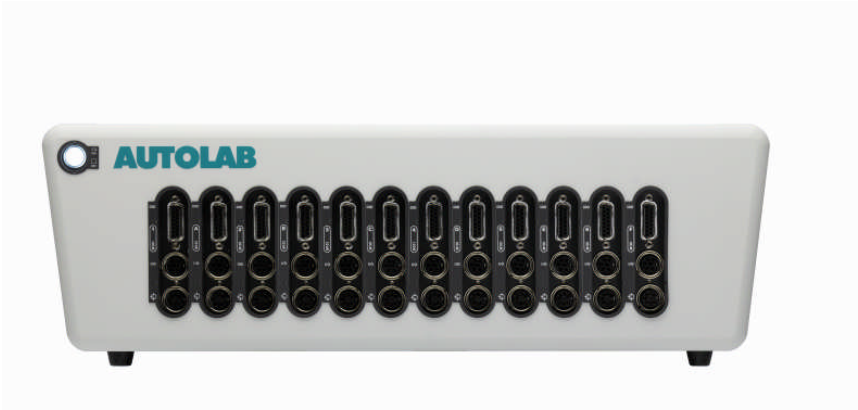
# Flexible System




**PGSTAT only**
12 M101 modules per frame


**PGSTAT/Module combination**
1-11 M101 modules per frame
1 optional module / M101

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# Compatible Modules

- Optional modules can be installed alongside each M101 PGSTAT module
  - pX1000
  - MUX
  - FRA32M
  - BA
  - EQCM

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# Unique Features

- Built-in hub allows control from 3 different computers
- Synchronization between channels possible

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# Single Channel, Compact

## Conveniently Priced, High Quality Instruments

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# Compact design

- Potentiostat/Galvanostat with USB
- Compact design at entry level price


**PGSTAT101**
10 V / 100 mA


**PGSTAT204**
20 V / 400 mA

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# New product!
# PGSTAT204

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# PGSTAT101 vs PGSTAT204

| | PGSTAT101 | PGSTAT204 |
|---|---|---|
| Compliance voltage | 10 V | 20 V |
| Potential range | 10 V | 10 V |
| Maximum current | 100 mA | 400 mA |
| Modularity | No | Yes |
| Impedance option | No | Yes |

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# Special Applications

## Customized Instrumentation

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# PGSTAT302F

- Switchable floating mode instrument
- Suitable for working on grounded cells or setups requiring floating instrument
- Can be fitted with impedance spectroscopy module

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# PGSTAT302F


- Entry level modular PGSTAT
  - Output power: 30 V / 2 A
  - Potential range: 10 V
  - Current range: 10 nA to 1 A in 9 decades
  - Switchable from grounded to floating

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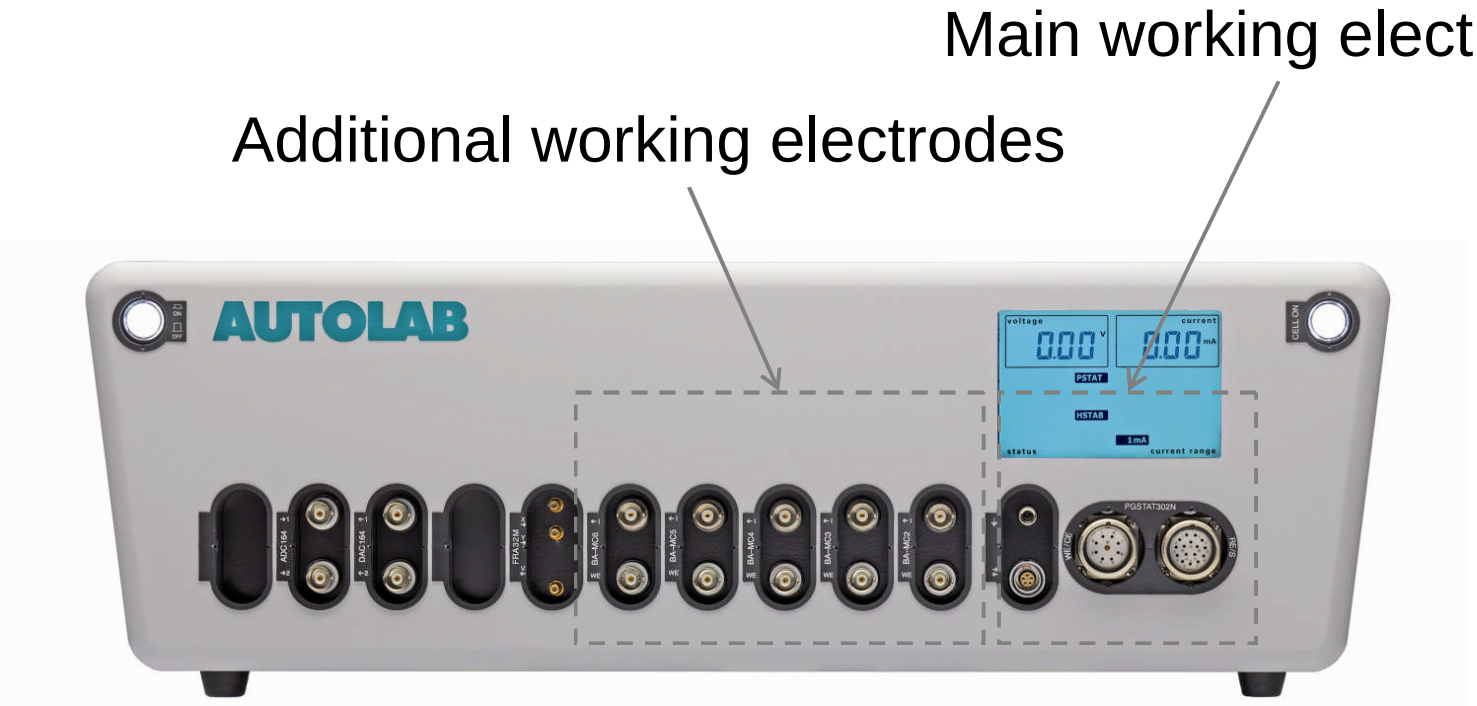
# MultiBA Systems

- Multi working electrode system



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# MultiBA Systems


- Multi working electrode system
- Shares the same Reference and same Counter electrode with up to 6 working electrodes
- Independent control on all electrodes

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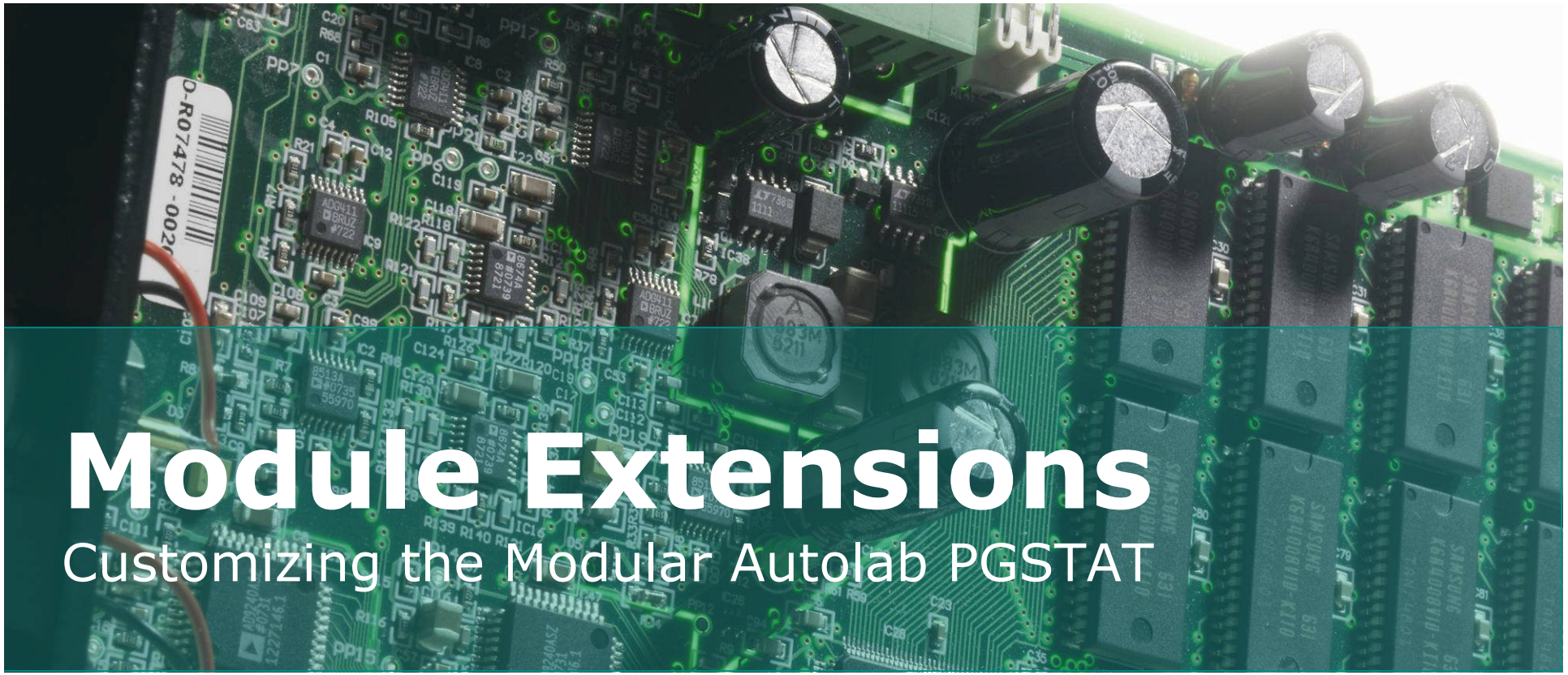

# Module Extensions

## Customizing the Modular Autolab PGSTAT

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# Modules

- Extension cards for the modular PGSTATs
- Can be added at any time
- Reverse compatible
- Can be installed onsite

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# Modules

| Module | Description | Main particularities |
|---|---|---|
| **FRA32M** | Electrochemical Impedance Spectroscopy | 10 μHz-32 MHz*, single sine and multi sine, fit and simulation |
| **SCAN250** | True Analog Scan and Fast Scan | 250 kV/s, analog scan generator |
| **ADC10M** | Fast Data Aquisition | 10 MHz data acquisition card for very fast measurements |
| **BA, MultiBA** | Bi-Potentiostat | Bipot and Array, up to 6 WE |
| **ECD** | Low Current Amplifier | 300 aA current resolution, RC filter included |

* *1 MHz when used with a PGstat*

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# Modules

| Module | Description | Main particularities |
|---|---|---|
| **pX1000** | pH, pX, Voltage and T | Additional diffamp for voltage measurements |
| **EQCM** | Electrochemical Quartz Crystal Microbalance | 6 MHz, < $\mu g/cm^2$ possible |
| **FI20** | Yes | Real time Filter & Integrator |
| **MUX** | Multiplexer | Up to 64 cells or 255 WEs |
| **ECN** | Electrochemical Noise | 800 nV voltage resolution |
| **Booster10A, 20A** | Current Boosters | Apply and measure up to 20A |

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# Impedance Modules

- Frequency Response Analysis module (FRA) for impedance spectroscopy
  - FRA32M (2011)
  - FRA2 (→ 2011)

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# Impedance Modules

- Frequency Response Analysis module (FRA) for impedance spectroscopy
  - FRA32M (2011)
  - FRA2 (→ 2011)

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# FRA32M Module

- Module for electrochemical impedance spectroscopy
  - 32 MHz to 10 µHz
  - 1 MHz to 10 µHz in combination with the PGSTAT
  - DC range: up to 10 V
  - Single sine and multi-sine

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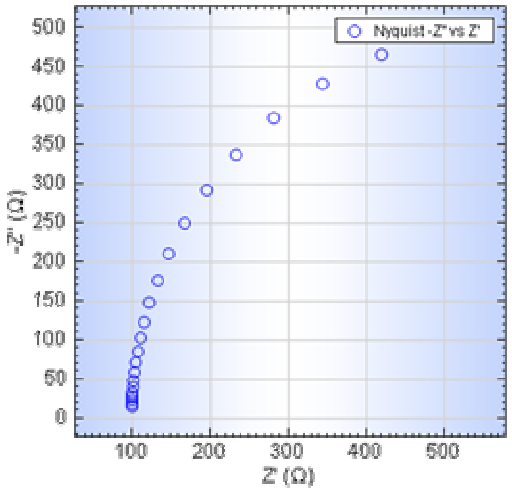
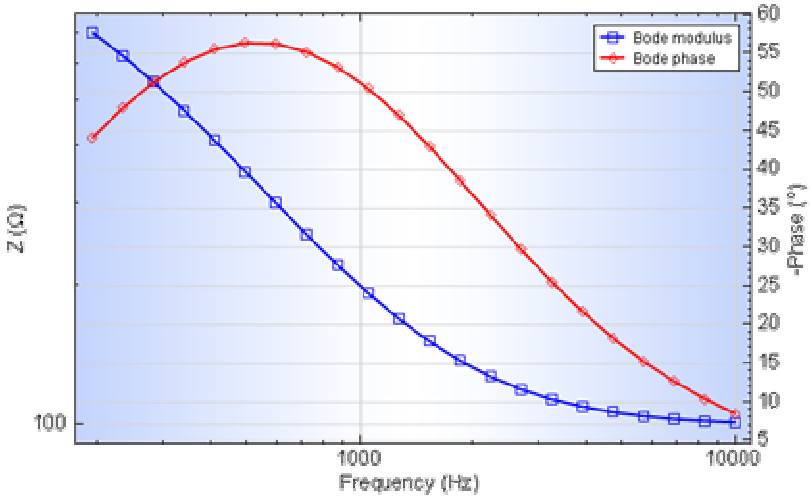
# FRA32M/FRA2 Module

- Electrochemical impedance spectroscopy



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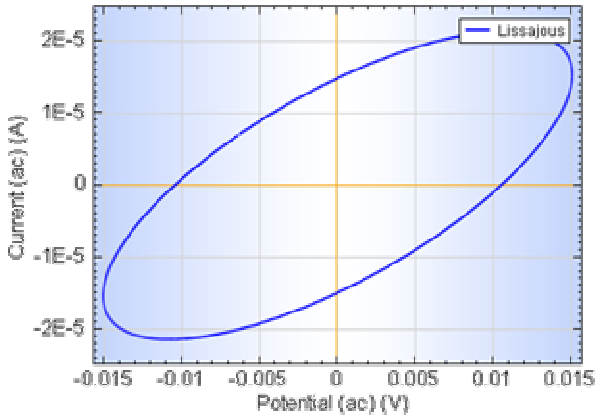
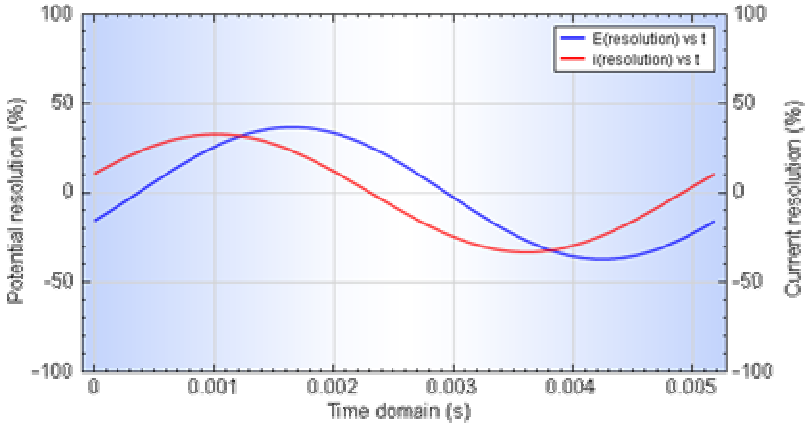
# FRA32M/FRA2 Module

- Electrochemical impedance spectroscopy




Advanced plots for raw measured data

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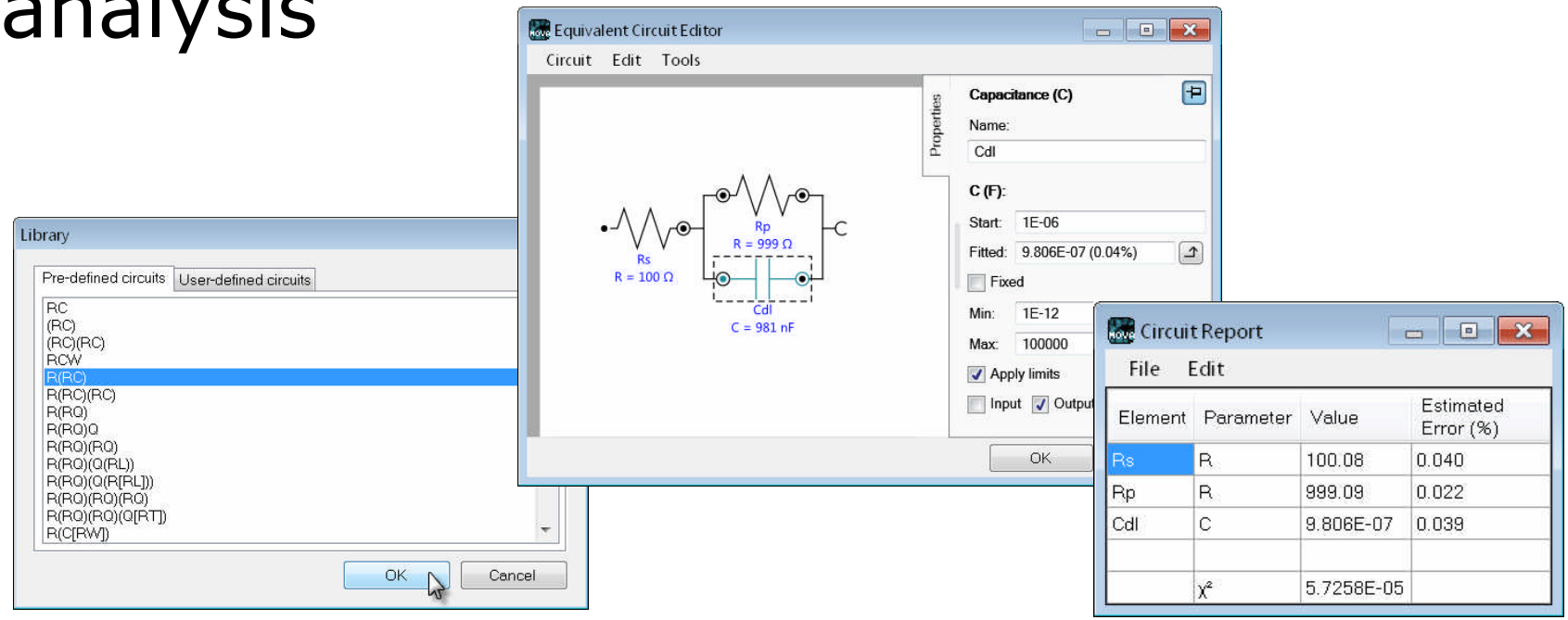
# FRA32M / FRA2 Module

- Software integrates powerful data analysis



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# FRA32M/FRA2

- Module compatibility

| | FRA32M | FRA2 |
|---|---|---|
| PGSTAT128N | Yes | Yes |
| PGSTAT302N | Yes | Yes |
| PGSTAT100N | Yes | Yes |
| PGSTAT101 | No | No |
| M101 | Yes | No |
| PGSTAT204 | Yes | No |
| PGSTAT302F | Yes | Yes |
| MultiBA | Yes | Yes |

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# SCAN250 Module

- True analog scan generator module
  - Scan rate: 10 mV/s to 250 kV/s
  - Scan range: ± 5 V vs DC offset
  - Linear scan (no staircase)

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# SCAN250 Module

- Critical difference between staircase and linear scan
- Significant reduction in currents with staircase methods
- Can lead to the wrong conclusions

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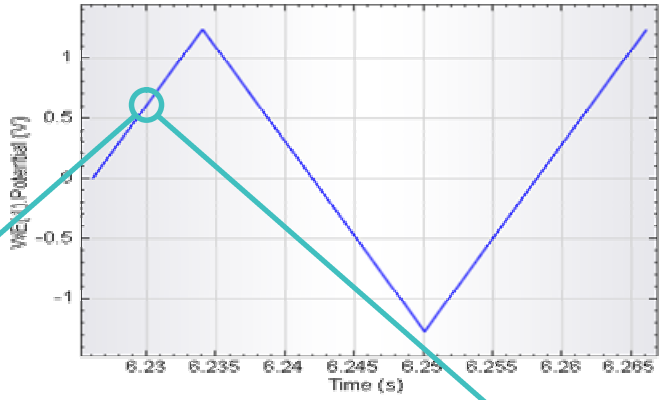
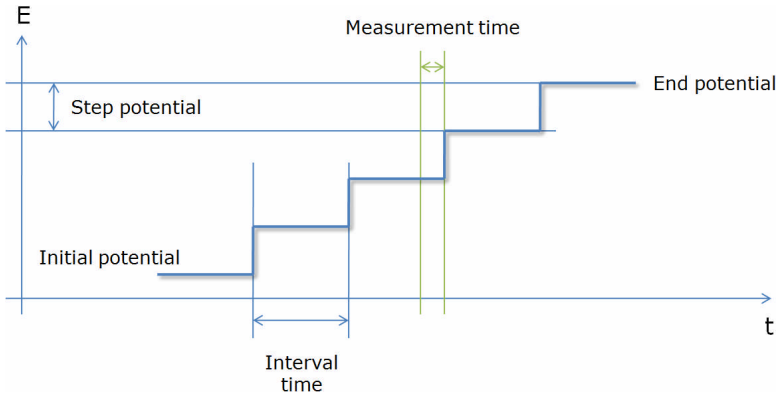
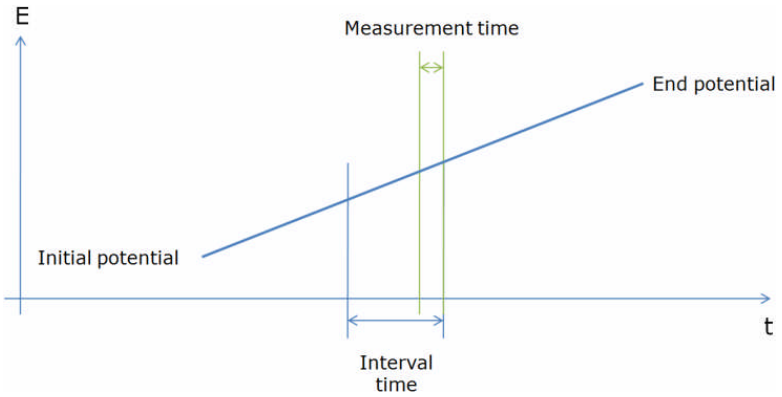
# SCAN250 Module




staircase

linear



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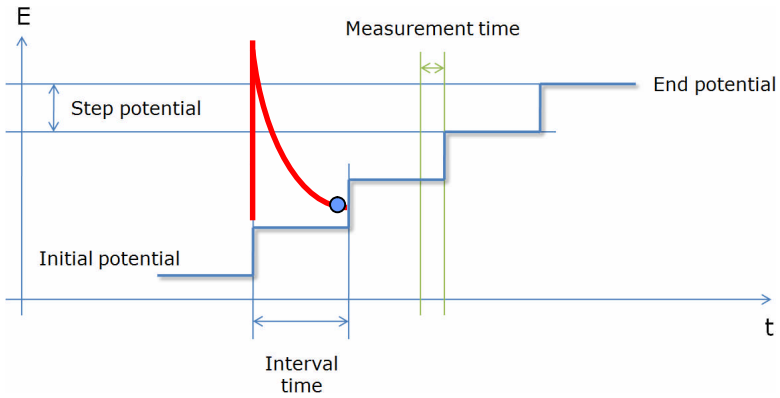
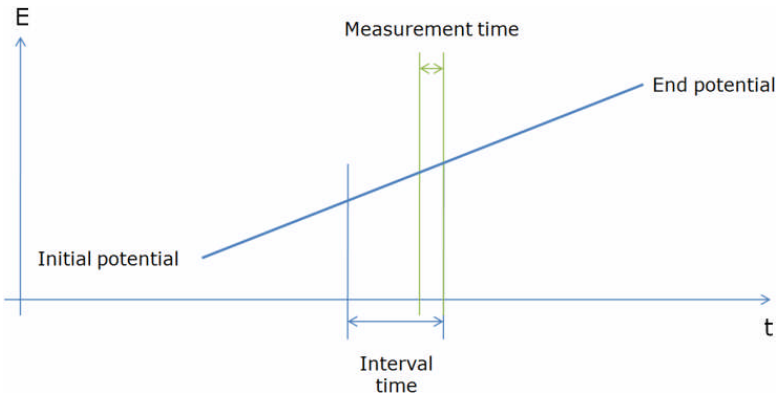
# SCAN250 Module

staircase




linear




Step: $\frac{\partial V}{\partial t} \rightarrow \infty$

Current spike: $i_c = C_{dl} \frac{\partial V}{\partial t}$

Plateau: $\frac{\partial V}{\partial t} = 0$

Current decay: $i = \frac{E_{step}}{R_u} e^{-\frac{t}{R_u C_{dl}}}$

Ramp: $\frac{\partial V}{\partial t} = const \neq 0$

Const charging current: $i_c = C_{dl} \frac{\partial V}{\partial t}$

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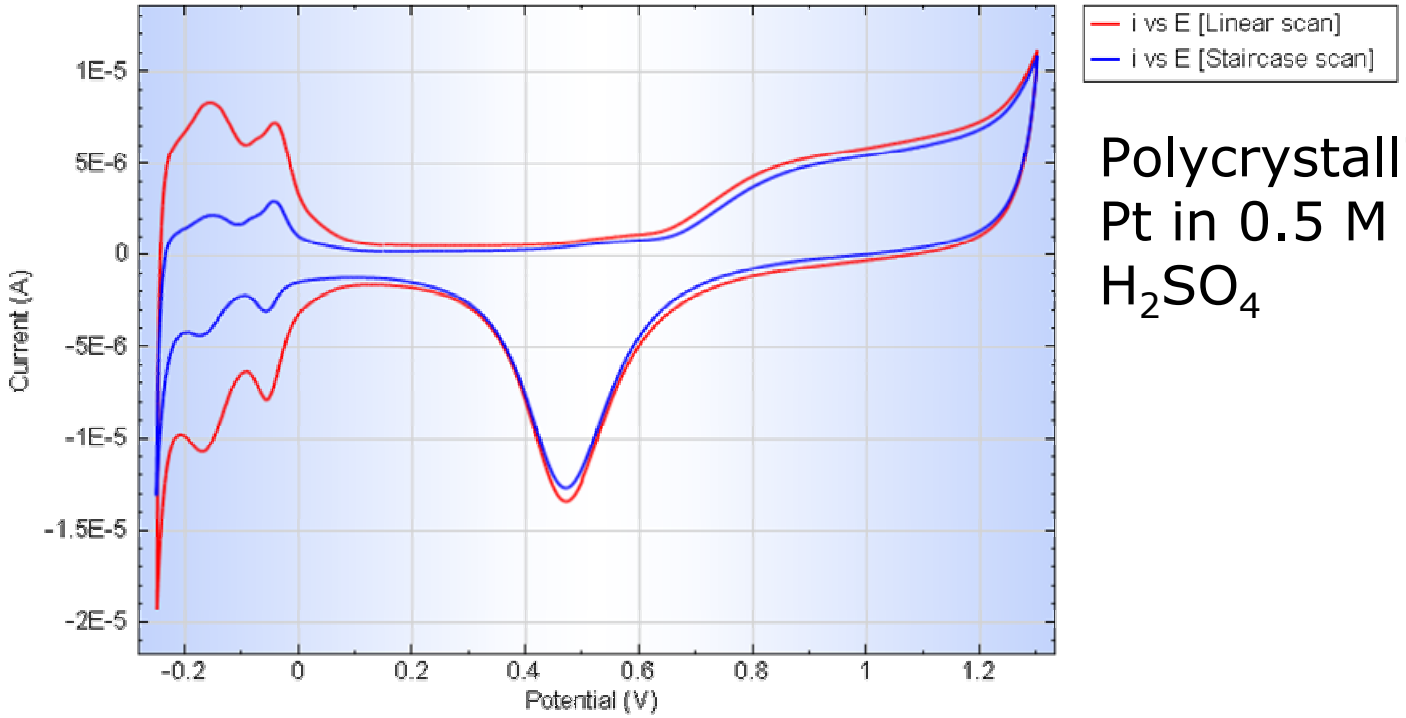
# SCAN250 Module

- Linear scan vs Staircase




Polycrystalline Pt in 0.5 M $H_2SO_4$

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# SCAN250 Module

- Module compatibility

| | SCAN250 |
|---|---|
| PGSTAT128N | Yes |
| PGSTAT302N | Yes |
| PGSTAT100N | Yes |
| PGSTAT101 | No |
| M101 | No |
| PGSTAT204 | No |
| PGSTAT302F | No |
| MultiBA | No |

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# ADC10M Module

- Ultra fast sampling synchronous A/D converter
- Sampling rate: 10 M samples/s
- Lowest interval time: 100 ns

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# ADC10M Module

- Sampling rate: 10 M samples/s
- Lowest interval time: 100 ns
- Maximum scan rate in combination with SCAN250: 250 kV/s
- Maximum number of points: 1 M

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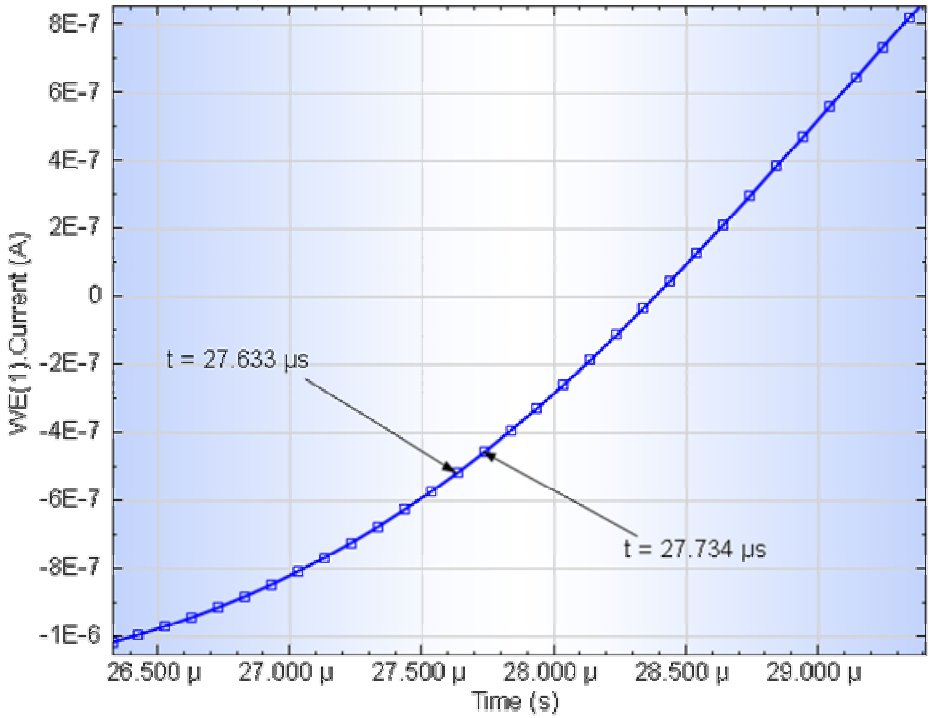
# ADC10M Module

- 100 ns interval time



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# ADC10M Module

- Module compatibility

| | ADC10M |
|---|---|
| PGSTAT128N | Yes |
| PGSTAT302N | Yes |
| PGSTAT100N | Yes |
| PGSTAT101 | No |
| M101 | No |
| PGSTAT204 | No |
| PGSTAT302F | No |
| MultiBA | No |

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# BA Module

- Dual mode Bipotentiostat module
  - Bipot (vs RE) or Scanning Bipot (vs WE)
  - Potential range: 10 V
  - Maximum current: 50 mA
  - Current ranges: 10 nA to 10 mA in 7 decades

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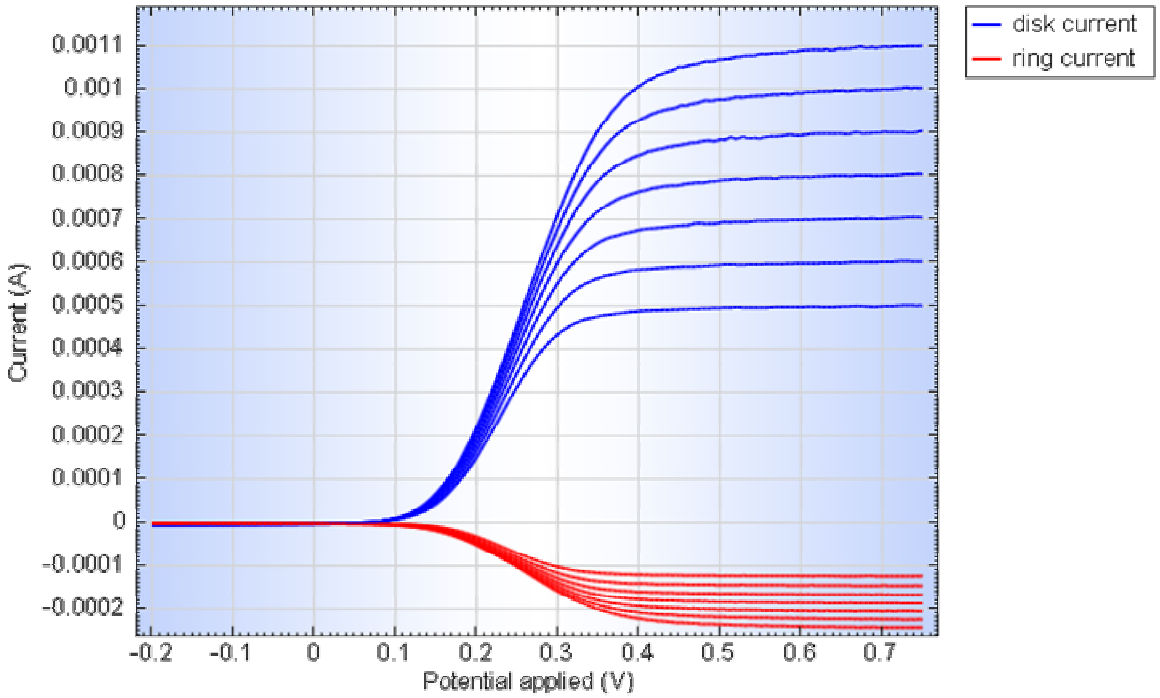
# BA module

- Measurements on 2 working electrodes




**RRDE**
Rotating Ring Disc Electrode measurements

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# BA Module

- Module compatibility

| | BA |
|---|---|
| PGSTAT128N | Yes |
| PGSTAT302N | Yes |
| PGSTAT100N | Yes |
| PGSTAT101 | No |
| M101 | Yes |
| PGSTAT204 | Yes |
| PGSTAT302F | No |
| Multi BA | Yes (max. 5) |

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# ECD Module

- Low current amplifier module
- Current ranges: 100 µA to 100 pA in 7 decades
- Integrated 3$^{rd}$ order Sallen-Key filter (0.1 s, 1 s & 5 s)
- Resolution: 0.003 % of current range
- Maximum resolution: 300 aA

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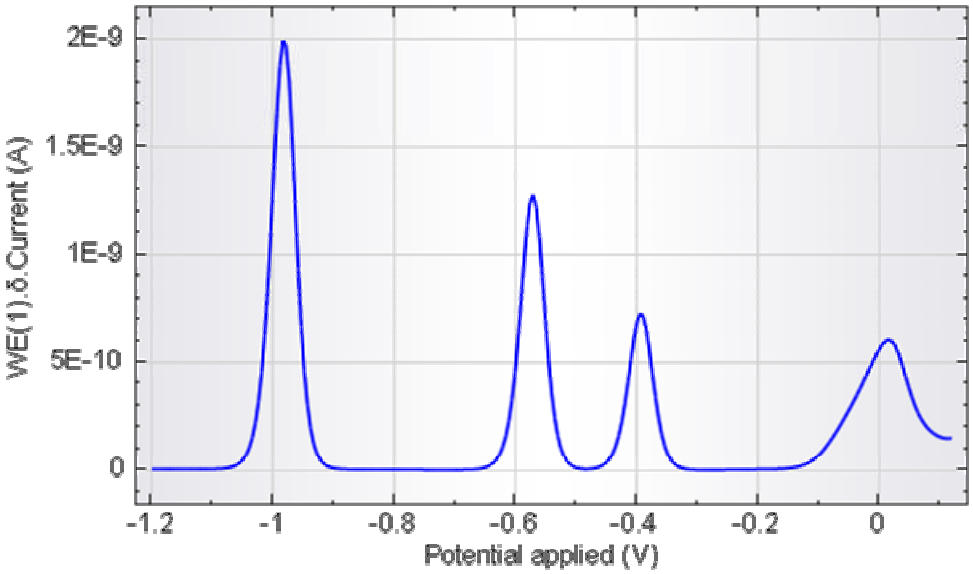
# ECD Module

- Built-in offset compensation for low current measurements



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# ECD Module

- Module compatibility

| | ECD |
|---|---|
| PGSTAT128N | Yes |
| PGSTAT302N | Yes |
| PGSTAT100N | Yes |
| PGSTAT101 | No |
| M101 | No |
| PGSTAT204 | No |
| PGSTAT302F | No |
| MultiBA | No |

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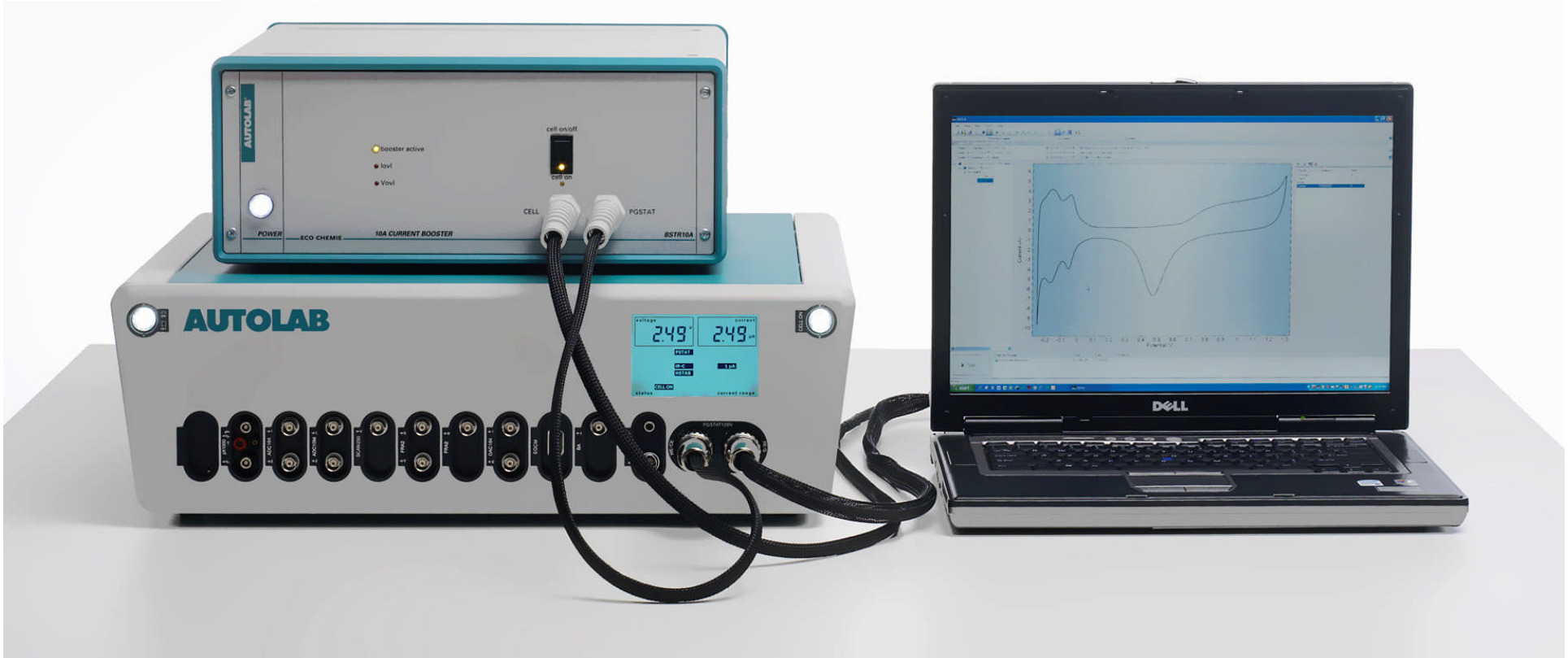
# Booster10A/20A




External high current amplifiers

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# Booster10A/20A

- High current amplifier
  - 20 A maximum current (Booster20A)
  - 10 A maximum current (Booster10A)

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# Booster10A/20A

| | Booster10A | Booster20A |
|---|---|---|
| Compliance voltage | 20 V | 20 V |
| Maximum voltage | 10 V | 10 V |
| Maximum current | 10 A | 20 A |
| Bandwidth | 10 kHz | 20 kHz |
| Compatibility | PGSTAT128N/302N/100N | PGSTAT302N |

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# pX1000 Module

- pH and T measurements
- Input range: 10 V
- Potential resolution: 30 µV
- Temperature resolution: 0.1°C

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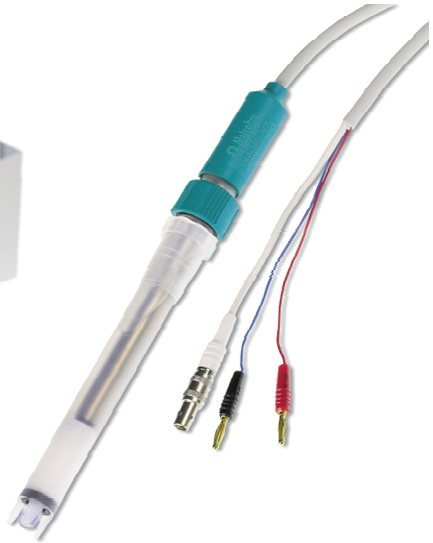
# pX1000 Module

- pH sensor connection
- Automatic pH correction with temperature
- Built-in calibration application

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# pX1000 Module

- Module compatibility

| | pX1000 |
|---|---|
| PGSTAT128N | Yes |
| PGSTAT302N | Yes |
| PGSTAT100N | No |
| PGSTAT101 | No |
| M101 | Yes |
| PGSTAT204 | Yes |
| PGSTAT302F | No |
| MultiBA | No |

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# ECN module

- Electrochemical noise and galvanic coupling
  - Input range: 2.5 V
  - Maximum resolution: 760 nV
  - DC offset compensation circuit

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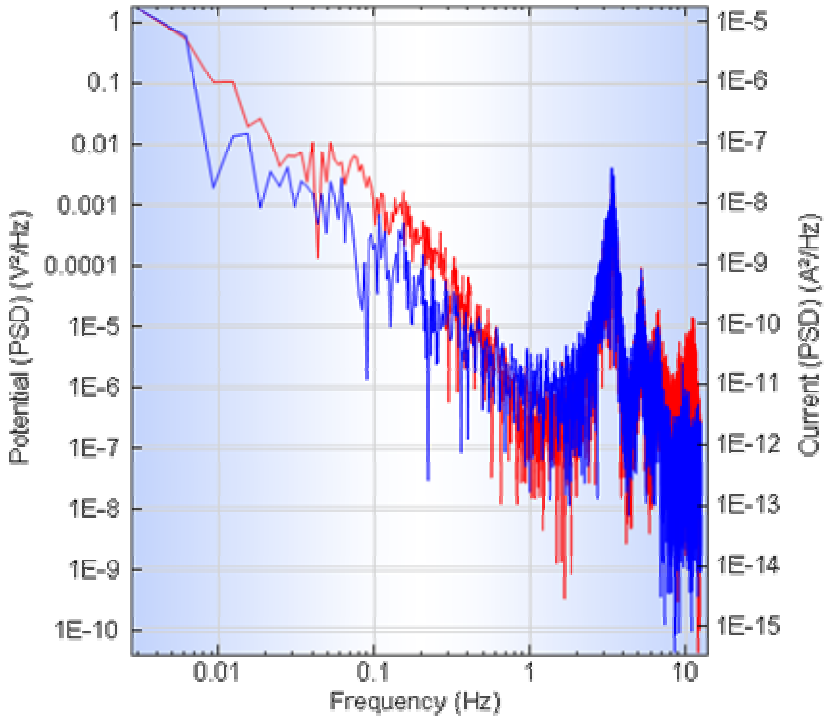
# ECN module

- Current and potential noise measurements



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# ECN Module

- Module compatibility

| | ECN |
|---|---|
| PGSTAT128N | Yes |
| PGSTAT302N | Yes |
| PGSTAT100N | No |
| PGSTAT101 | No |
| M101 | No |
| PGSTAT204 | No |
| PGSTAT302F | No |
| MultiBA | No |

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# FI20 module

- Analog filter and integrator
  - Integrated 3rd order Sallen-Key filter: 0.1 s, 1 s & 5 s)
  - Available integration time constants: 0.01 s, 0.1 s, 1 s & 10 s

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# FI20 Module

- Module compatibility

| | FI20 - Filter | FI20 - Integrator |
|---|---|---|
| PGSTAT128N | Yes | Yes |
| PGSTAT302N | Yes | Yes |
| PGSTAT100N | Yes | Yes |
| PGSTAT101 | No | Built-in |
| M101 | No | Built-in |
| PGSTAT204 | No | Built-in |
| PGSTAT302F | No | No |
| MultiBA | No | No |

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# MUX module

- Multiplexer device for single or multiple electrodes
  - **MUX-MULTI4:** monitor up to **64** electrochemical cells in sequence
  - **MUX-SCANNER16:** monitor up to **255** working electrodes in the same cell in sequence

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# MUX Module


Sequential measurements on independent electrochemical cells or on several working electrode

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# MUX Module

- Module compatibility

| | MUX |
|---|---|
| PGSTAT128N | Yes |
| PGSTAT302N | Yes |
| PGSTAT100N | No |
| PGSTAT101 | No |
| M101 | Yes |
| PGSTAT204 | Yes |
| PGSTAT302F | No |
| MultiBA | No |

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# EQCM module

- Quartz crystal microbalance module
  - 6 MHz crystal oscillator
  - Dynamic range: 80 kHz
  - Integrated temperature sensor
  - Detection limit: < 10 ng/cm$^2$

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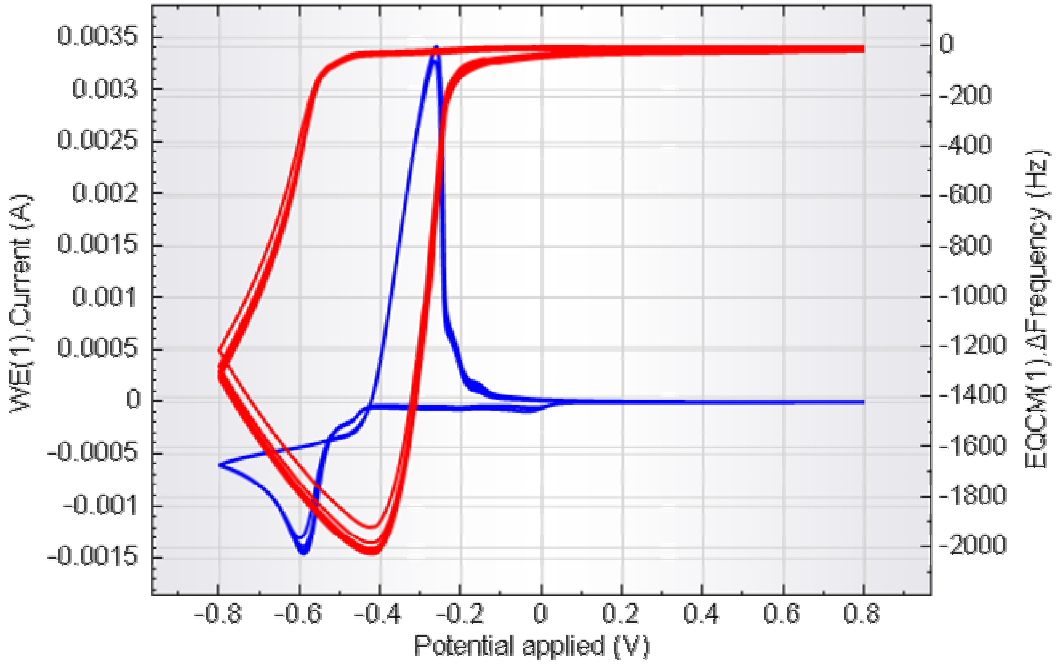
# EQCM module

- Electrogravimetric measurements



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# EQCM Module

- Module compatibility

| | EQCM |
|---|---|
| PGSTAT128N | Yes |
| PGSTAT302N | Yes |
| PGSTAT100N | No |
| PGSTAT101 | No |
| M101 | Yes |
| PGSTAT204 | Yes |
| PGSTAT302F | No |
| MultiBA | No |

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# Software

## Advanced NOVA Electrochemical Software

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# Software Overview

- Two software packages available:
  - NOVA – Advanced electrochemical software
  - SDK – Software Development Kit

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# Autolab NOVA

- One application for any electrochemical experiment
- New software for the Autolab Potentiostat/Galvanostat with USB
- From simple to advanced experiments
- Real time data handling for dynamic procedures

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# Autolab SDK

- Software Development Kit
- Provides controls for the Autolab instruments through 3rd party application like LabVIEW, Mathlab, …

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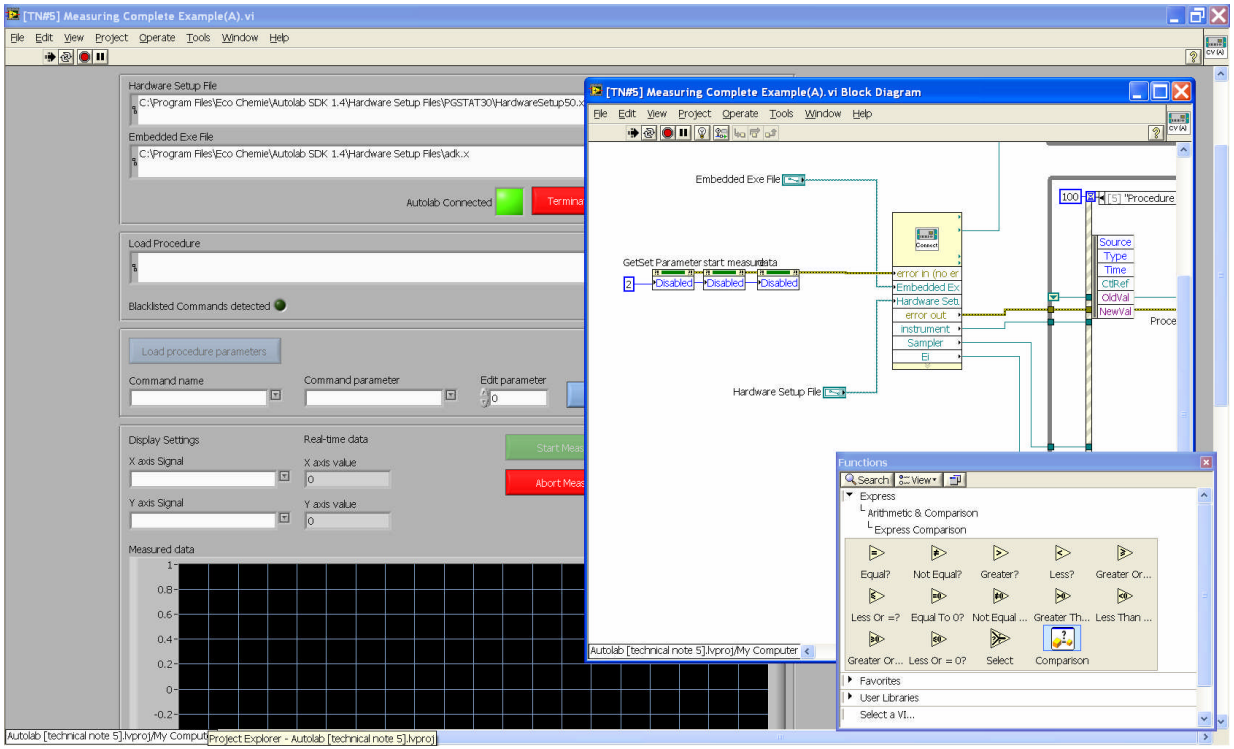
# Autolab SDK

Library of LabVIEW VIs provided with the SDK



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# Accessories

## A Complete Range of Electrochemical Accessories

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# Rotating Disc Electrode (RDE)

- Supplied with external motor controller

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# Rotating Disc Electrode

- Mercury contact for friction-less measurements
- 0 – 10000 RPM (manual or software)
- 4000 RPM/s acceleration
- Compatible with 3 and 5 mm electrode tips

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# Autolab Optical Bench

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# Autolab Optical Bench

- For studying the optical behaviour of photovoltaic cells
- Software integrated control of light intensity
- Up to 10 interchangeble LEDs

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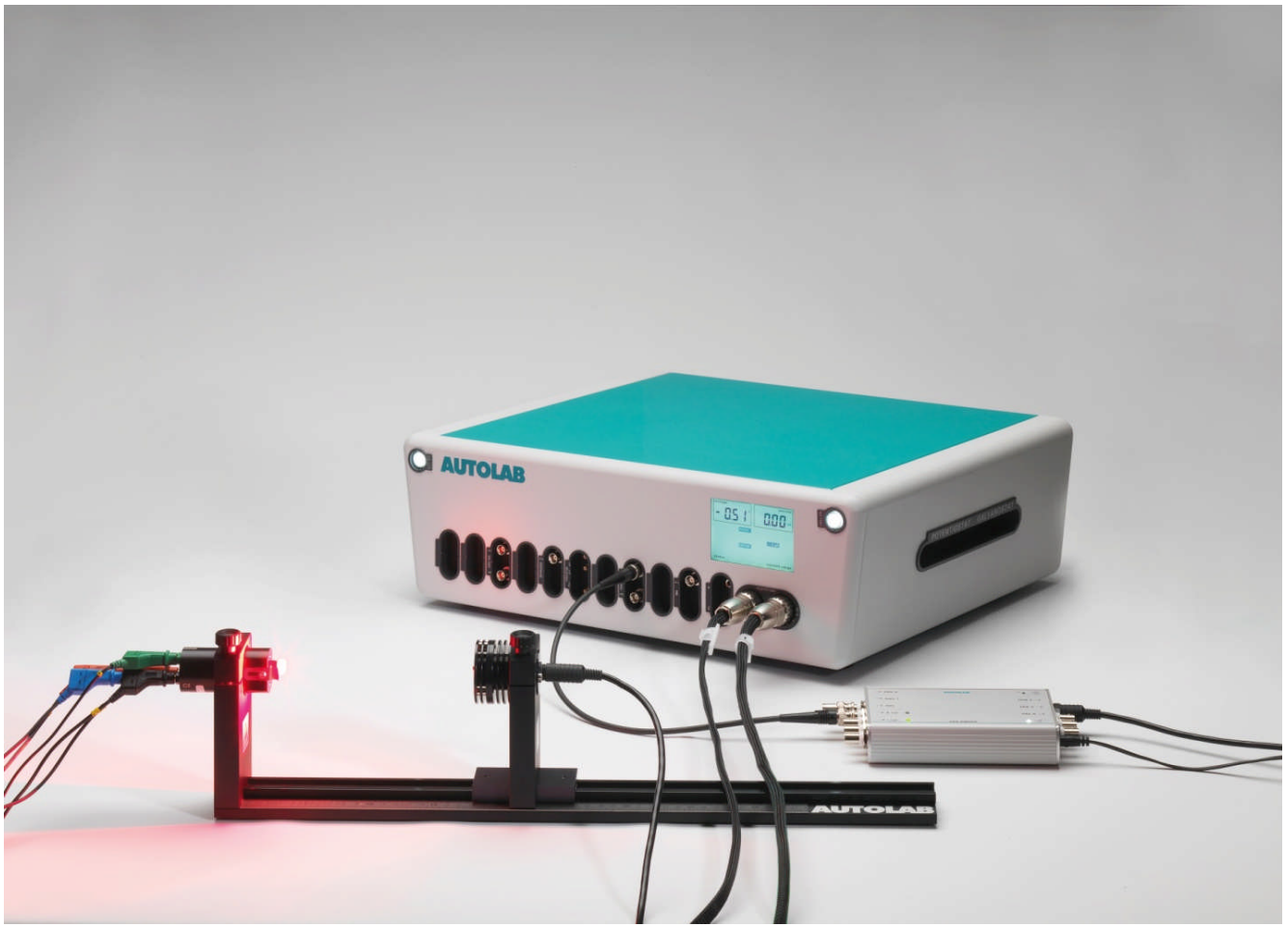
# Autolab Optical Bench



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# Autolab Optical Bench

| Article code | Color | Wavelength (nm) |
|---|---|---|
| **AUT.LED.LDC655** | Deep-Red | 655 |
| **AUT.LED.LDC627** | Red | 627 |
| **AUT.LED.LDC617** | Red-Orange | 617 |
| **AUT.LED.LDC590** | Amber | 590 |
| **AUT.LED.LDC530** | Green | 530 |
| **AUT.LED.LDC505** | Cyan | 505 |
| **AUT.LED.LDC470** | Blue | 470 |
| **AUT.LED.LDC** | Cool white | - |
| **AUT.LED.LDC** | Warm white | - |
| **AUT.LED.LDC** | Neutral white | - |

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# Voltammetric analysis stand


Hg drop electrode stand (663 VA Stand) and IME663 interface

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# Voltammetric analysis stand

- Remote control through the IME663 interface
- Stirrer, purging and new drop control
- DME, SDME, HDME control
- Voltammetric analysis methods

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# Multi Mode Electrode

- Hg drop
  - DME
  - SMDE
  - HDME

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# Electrochemical Cells

- General purpose cells and stands

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# Corrosion Cells

- Dedicated cells for corrosion measurements
  - 1 L cell
  - 400 mL cell
  - Flat cell

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# Corrosion Cell (1 L)

- ASTM compliant
- 1 $cm^2$ sample holder
- 6 conical fittings
- Luggin capillary

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# Corrosion Cell (400 mL)

- 5 conical fitting
- Sample area 0.785 $cm^2$
- Luggin capillary
- Thermostatic jacket

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# Flat Cell

- Corrosion cell for large surface areas
- Surface area > 15 $cm^2$

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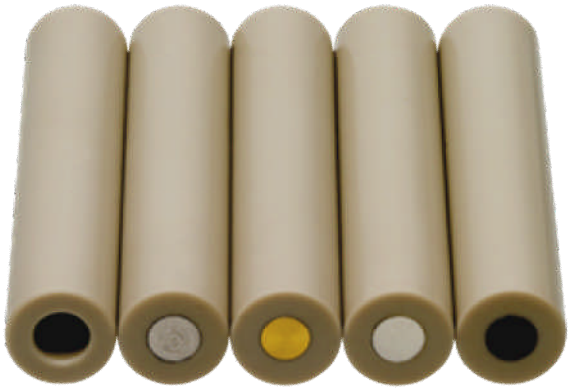
# Working Electrodes

- 3 mm and 5 mm electrode tips
- Au, Pt, GC, Ag
- Empty tip for custom material



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# Microelectrodes

- Different µm range diameters available

| Material | Diameter (µm) |
|---|---|
| Platinum | 10, 20, 25, 50, 100, 200, 300, 500 |
| Gold | 10, 25, 40, 100, 200, 300, 500 |
| Palladium | 25, 60, 100, 200, 300, 500 |
| Silver | 25, 30, 60, 100, 200, 300, 500 |
| Iridium | 75 |

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# Reference Electrodes

- Different reference electrodes available
- Single and double junction

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# Counter Electrodes

- Range of materials available
- Pt, GC, Stainless steel

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# Faraday cage

- Provides shielding for the electrochemical cell
- Compatible with Metrohm cell stands

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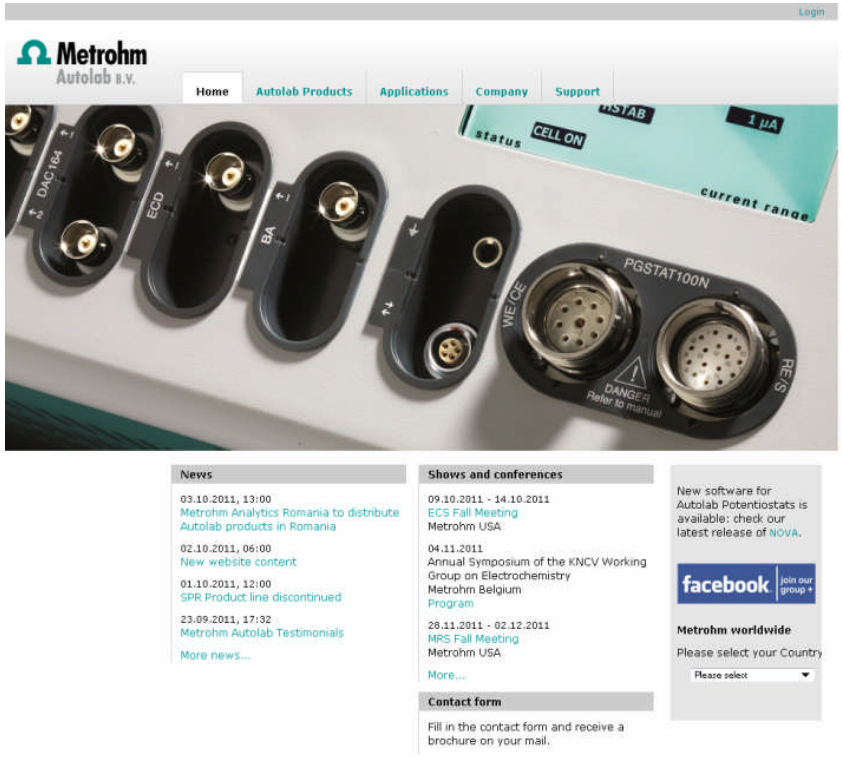
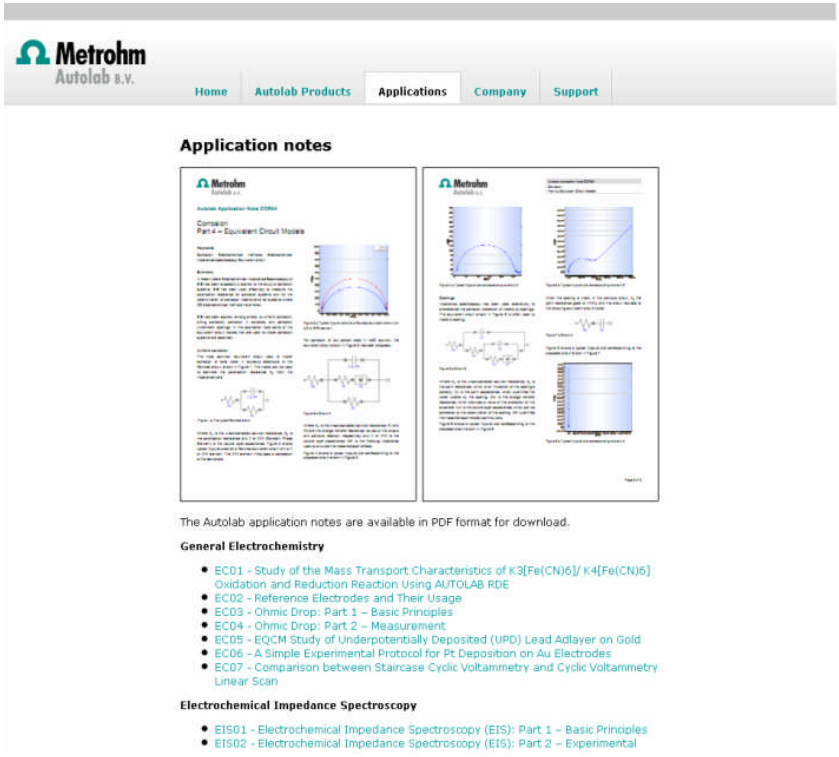
# www.metrohm-autolab.com



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# Service and Support

- All instruments covered by 3 years factory warranty

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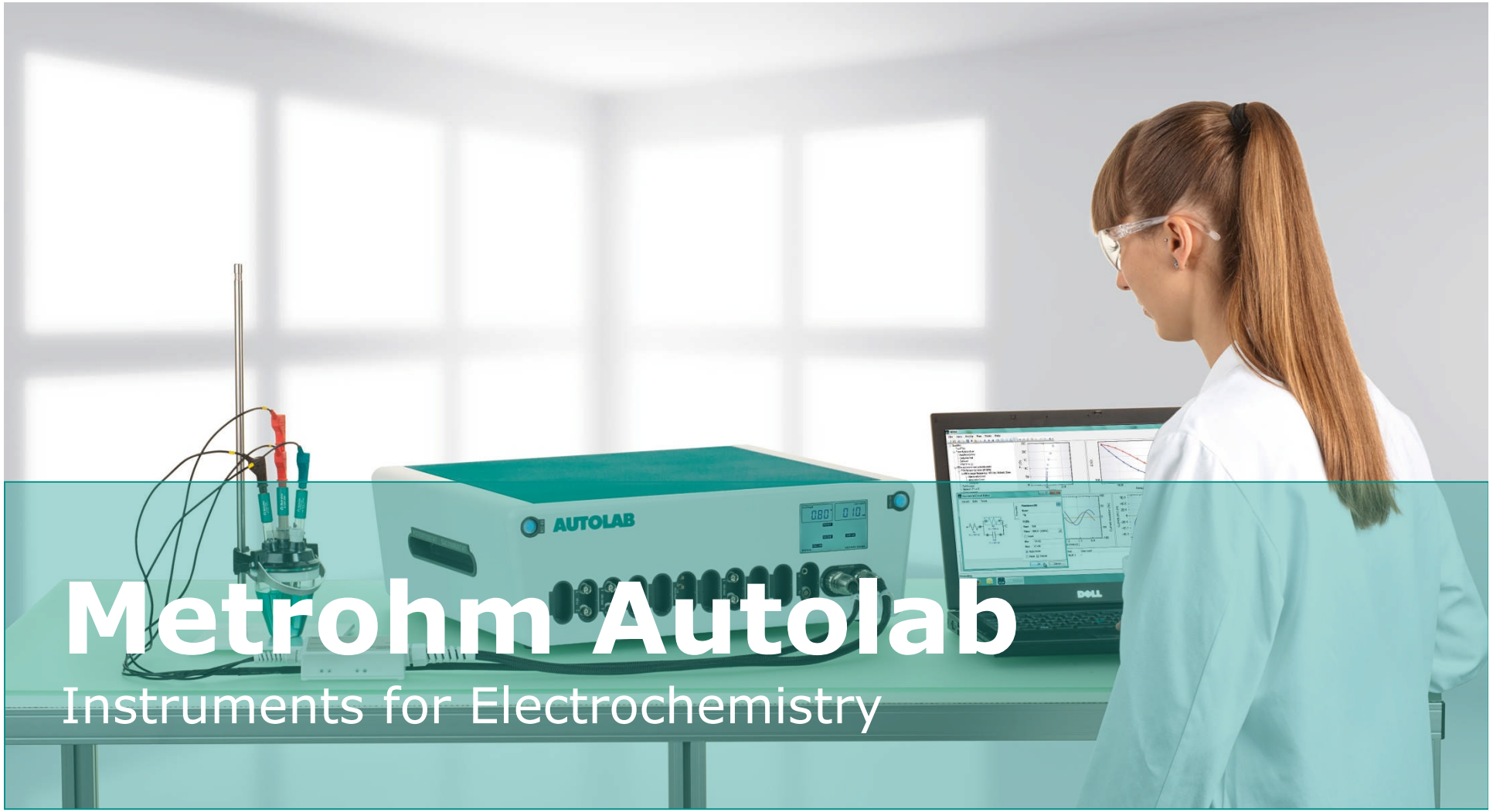


# Metrohm Autolab

## Instruments for Electrochemistry