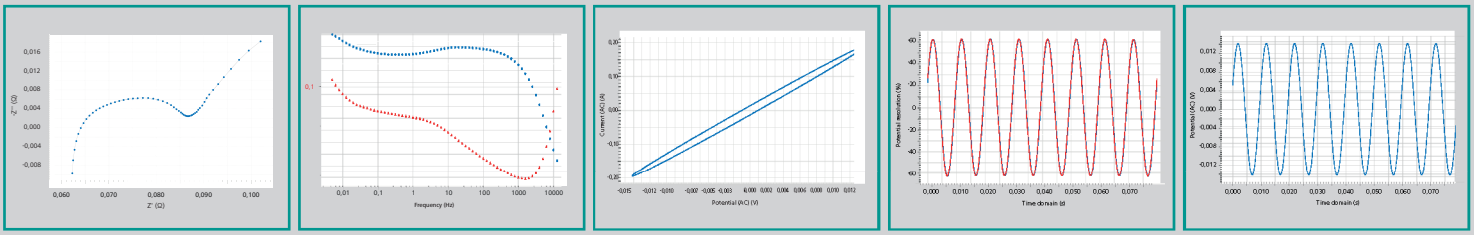
Metrohm Autolab

Impedance Station for Battery Applications



Versatility and efficiency for your battery research

Metrohm
Autolab


ON
OFF

More parameters, greater insight, minimal effort

The **Autolab Impedance Station** expands your research capability without complicating it. **Easy to integrate** into your existing lab setup, with the **Autolab Impedance Station** you can improve your **battery characterization** with more **in-depth and accurate data**. The **Autolab Impedance Station** gives you an expanded frequency range, opening a new domain of **experimental exploration.**

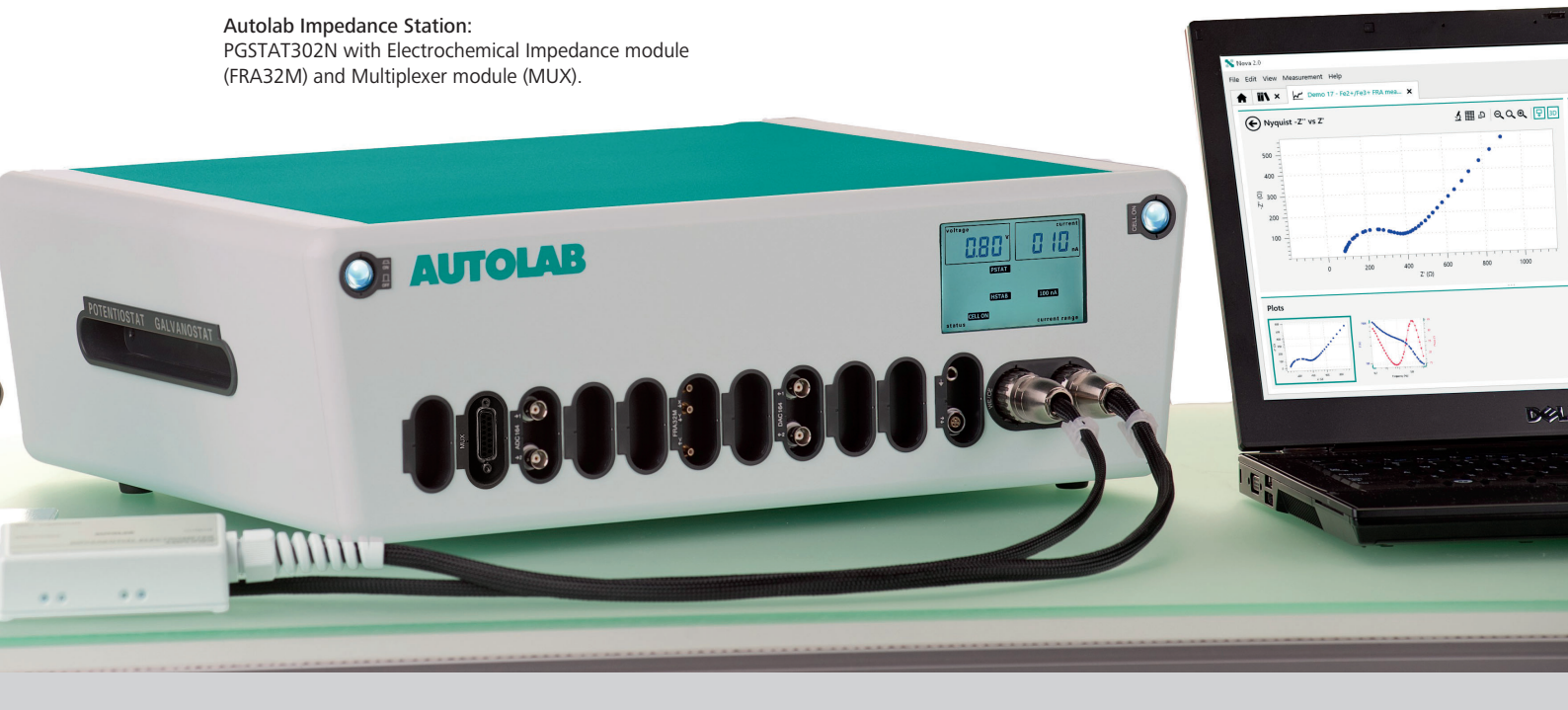
Typical applications

- Measurement of AC impedance at different frequencies.
- Determining the state of charge (SoC) and state of health (SoH) of the batteries.
- Understanding the fading mechanism of batteries.
- Conductivity measurement of battery electrodes and electrolytes.
- Solid-electrolyte interphase (SEI) study.

Typical experimental setup and method

- Sequential impedance spectroscopy on a batch of cells.
- Simultaneous impedance spectroscopy on a batch of cells.
- High frequency Electrochemical Impedance Spectroscopy (EIS) measurement suitable for solid state battery development.
- In-temperature impedance spectroscopy for battery performance discovery.

The **Autolab Impedance Station** provides results up to **99.7% accuracy** in typical **impedance measurements.**



Autolab Impedance Station:
PGSTAT302N with Electrochemical Impedance module (FRA32M) and Multiplexer module (MUX).

Autolab Impedance Station

Conveniently **add impedance** measurements to your existing workflow with the **easy to integrate Autolab Impedance Station:**

- Autolab PGSTAT302N (pictured below)
- Electrochemical Impedance Spectroscopy module (FRA32M)
- Multiplexer module (MUX) with one external MUX.MULTI4
- DuoCoin cell holder
- NOVA 2 software

DuoCoin cell holder for greater precision

- **4-point Kelvin gold-plated contacts**
- **Accommodates standard and non-standard cells***
- **Two cells can be processed at one time**

*Check out www.metrohm.com/autolabspecs for additional DuoCoin cell holder specification information.

Benefits of Autolab Impedance Station

- The **Autolab Impedance Station** includes the Frequency Response Analyzer module (FRA32M) with a **wide frequency range of 10 µHz to 1 MHz** for more extensive characterization of electrochemical systems.

- Ensure the success and **data validity** of your experiment with the **Autolab Impedance Station**. With 3 bandwidth options* available, the **Autolab Impedance Station** will **automatically choose** the right one to optimize your experiment with the correct signal.

Maximize your laboratory setup

- The **Autolab Impedance Station's digital and analog inputs/outputs** allow you to **couple with an external device**, such as an electronic load, that becomes a **programmable device via the NOVA 2 software**.

- Depending on the limits of your electronic load you can use the **high current** and **potential to enable the device under test (DUT) up to 300 A** in operating conditions.

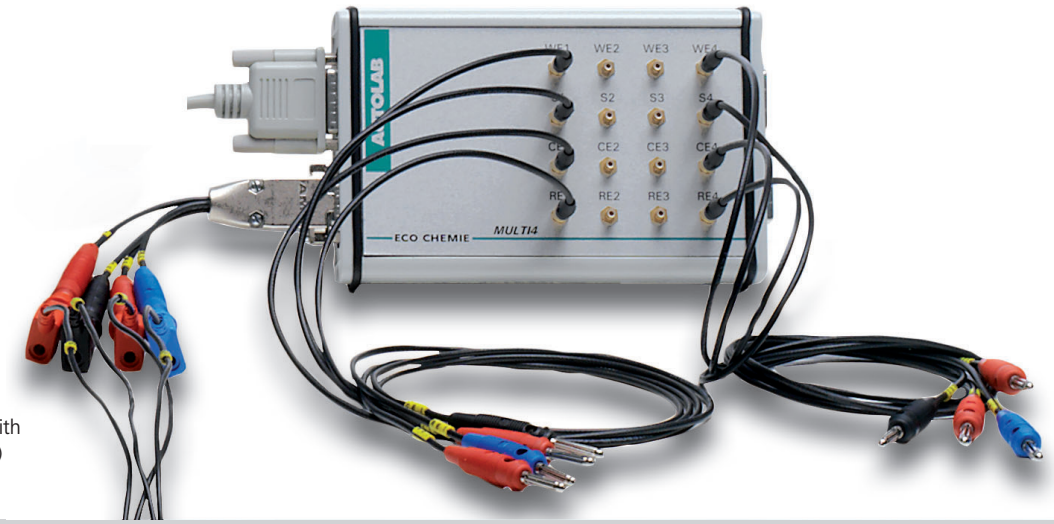
Automated Impedance Station Measurements

- **Click and go!** Maximize your **time and effort** with the **Autolab Impedance Station** and **NOVA 2** software. You can set up and **schedule automated impedance measurement** of a **large number of cells** and **walk away**. Return for **analysis** at your **convenience**.

- The **Autolab Impedance Station** includes the **Multiplexer module (MUX)** which allows you to **automate routine measurements** from **4 to 64 channels**.

Features
• **Easily** add **Autolab Impedance Station** measurements to your laboratory setup
• **Accurate** impedance measurements for greater insight
• **Automation** can be fully **customized** to **your required procedures**

*High stability, high speed, or ultra high speed



External MUX.MULTI4 used with the Multiplexer Module (MUX)

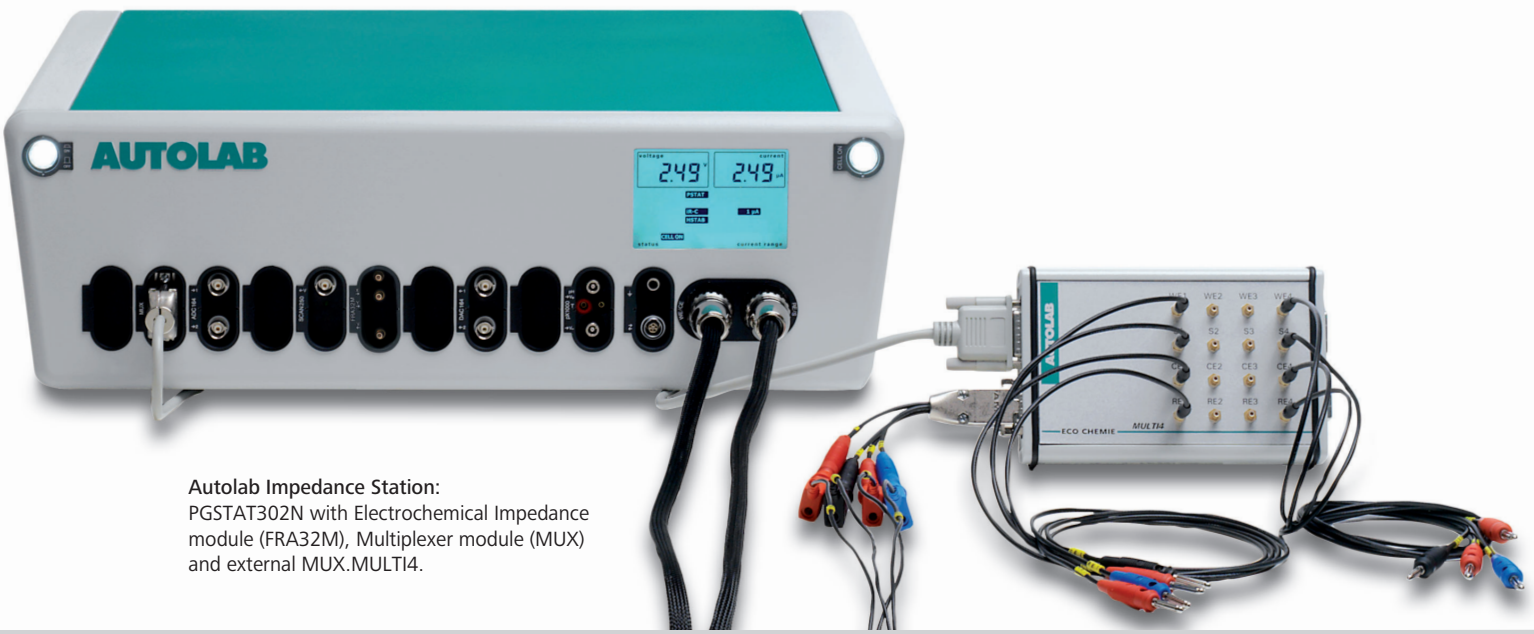
Autolab Impedance Station specifications

PGSTAT302N Specifications	
• Electrode connections	2, 3, and 4
• Potential range	± 10 V
• Compliance voltage	± 30 V
• Maximum current	± 2 A
• Current ranges	10 nA to 1 A (in 9 ranges)
• Applied potential accuracy	± 0.2% ± 2m V
• Minimum measured potential resolution	0.3 µV (gain 1000)
• Current accuracy	± 0.2% ± 0.2% of current range
• Current resolution	0.0003% (of current range)
• Potentiostat bandwidth	> 1 MHz
• Computer interface	USB
• Control software	NOVA 2

The 302N is the ideal instrument for the **Autolab Impedance Station** because it is so **versatile**. Containing a **FRA32M** module for **EIS** and a **MUX** module for **sequential measurements** you can add up to **6 additional modules** to your **Autolab Impedance Station** as and when your research requires.

- The **Autolab Impedance Station** provides results up to **99.7% accuracy** in typical **impedance measurements**.
- With a **4 electrode connection possible**, the **Autolab Impedance Station** provides the setup for **greatest accuracy** when executing impedance measurements.
- Interfaces with the **NOVA 2 software** for a wide variety of techniques including **temperature control procedures**.

FRA32M Specifications	
• Frequency range	10µHz – 1 MHz
• Frequency resolution	0.003%
• AC amplitude	0.2 mV to 0.35 V rms In potentiostatic mode 2 mV to 3.5 V rms (optional)



Autolab Impedance Station:
PGSTAT302N with Electrochemical Impedance module (FRA32M), Multiplexer module (MUX) and external MUX.MULTI4.

Additional modules available for installation

The versatile **Autolab Impedance Station** can be **supplemented with other modules**, even **post installation**, for **additional testing** and **parameters** to create a unique impedance station for your laboratory.

Are you a solid state researcher that requires high frequency?

The 302N comes with a **standard frequency of 1 MHz** that can be **expanded to 10MHz** with an **ECI10M** module.

More applied current?

The **Autolab Impedance Station** has 2 A current as standard but you can increase to either 10 A or 20 A with a **Booster** module.

Additional parameters?

By adding a pX1000 module to the **Autolab Impedance Station** you have the opportunity to **monitor** both **cathode and anode potential** of the battery separately. Or it is also possible to have a **temperature measurement.**

Our dedicated distribution and service network provides a fast response for sales and service, usually within 48 hours.

Capture, explore and understand your data with NOVA 2

Powerful data acquisition and analysis software

NOVA 2 allows you to simply design **unique experimental procedures** which completely fit your requirements. Plus these custom procedures can be **automated** for maximum efficiency. For example you can **program both cycling and impedance techniques in to one single procedure**. An unlimited number of parameters and commands can be included in your customized procedure with a simple drag and drop.

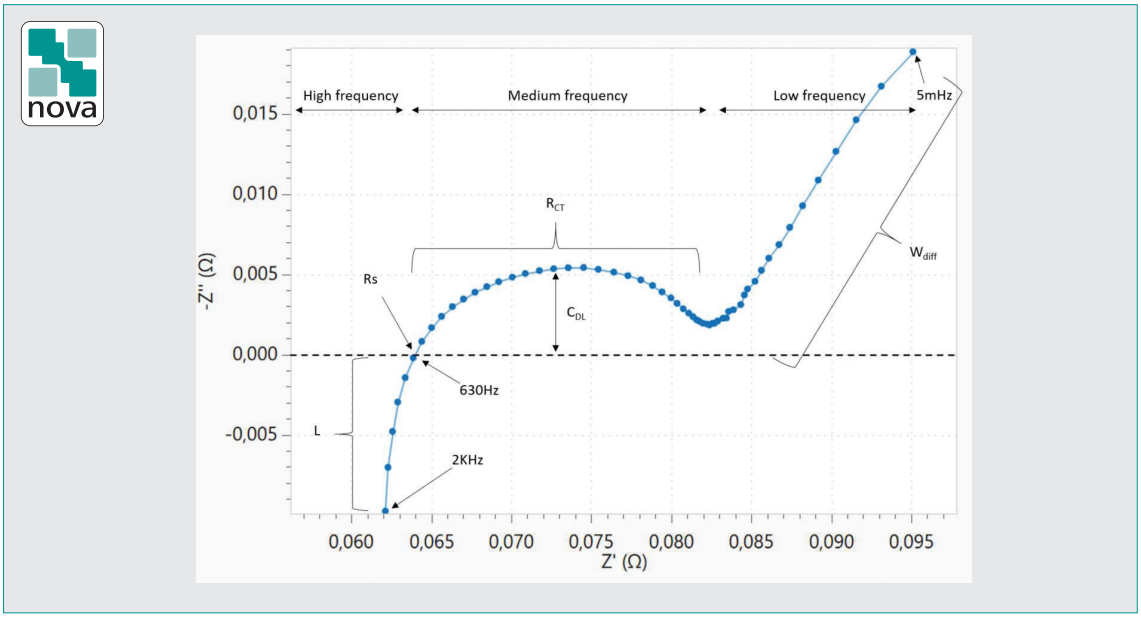
All of these tools make it easier to create customized analysis if you need it.

Effortless Intuitive Software

- Users are comfortable with NOVA's **modern user interface** and **straightforward navigation**.
- **NOVA 2** has approximately **60 essential electrochemistry procedures** available for preliminary exploration.

Customization Is Easy With NOVA's Helping Hand

- **NOVA 2** makes it easy to get going right away with the **Autolab Impedance Station default procedures**. NOVA 2 provides default procedures for potentiostatic and galvanostatic, current, potential and time scanned impedance which you can **also conveniently use** to build your **custom procedures.**
- **NOVA 2** supports you before and after to build the best possible procedure. **NOVA Validation** ensures you **easily build an error free procedure** that includes the exact parameters that you want. If you make a mistake **NOVA Validation Warning** will let you know. After your experiment is completed, **NOVA Validation Information** will give you advice to optimize your procedure for the next time.



Nyquist plot: Negative imaginary part of impedance as a function of real part of impedance for 18650 Li-ion battery.

Impedance measurements with NOVA 2

Powerful data acquisition and analysis software

Impedance Station Analysis With a Single Click

- **Save time** by using the existing analysis commands including **circle fit** and the **fit and simulation analysis** commands.
- In addition, **NOVA 2** includes a library of **37 pre-defined equivalent circuits** and the possibility to build and save **custom electrical circuits**.
- **NOVA 2** provides **impedance specific plots** that provide **data insight** in **real time:**
  - Nyquist
  - AC applied and acquired signal versus time
  - Bode
  - Lissajous plot
  - Resolution

Want to #KnowNOVA?

Check out **YouTube/ MetrohmAutolab** for a range of helpful NOVA 2 user videos.

Additional Features Unique to NOVA 2

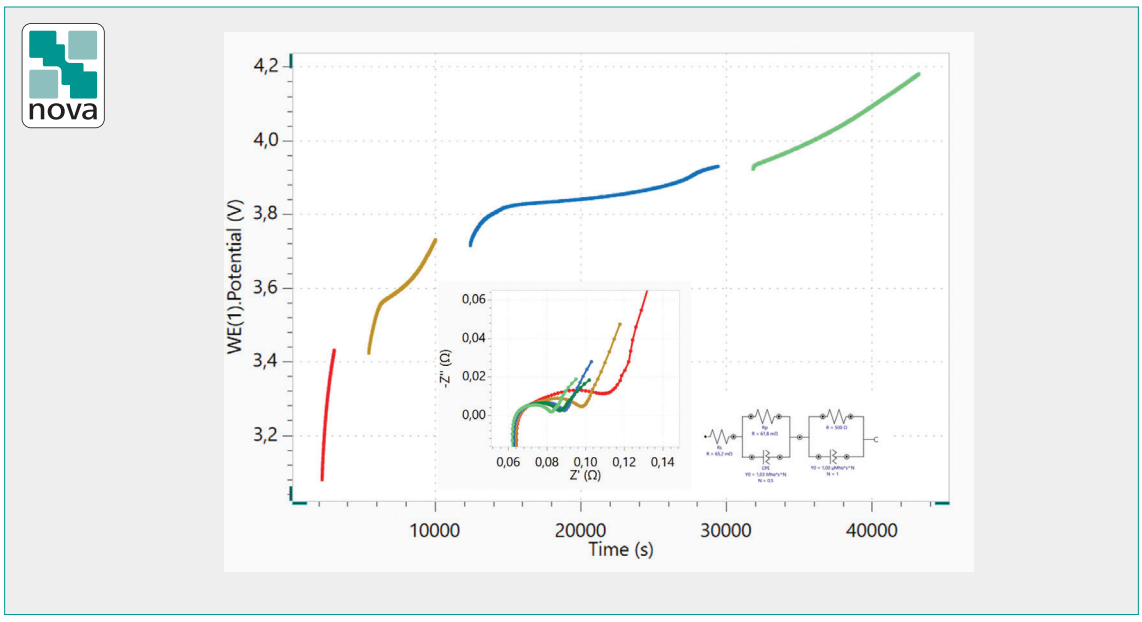
NOVA 2 comes with the features that improve the efficiency of your lab.

- **Message box** allows you to leave notes and instructions to others working in your lab, or reminders to yourself to help with experiment setup. **NOVA 2** even sends you an email to let you know that your **measurement is complete.**
- Sometimes you have unexpected results. With **NOVA 2** you can also **view time domain data** function to examine the raw data for early data validation to confirm the setup of your experiment and that your specific experiment parameters are being met.

Automate for Greater Efficiency

Keep the workflow moving!

- When creating your **Circuit Fit** procedure with **NOVA 2** you can use **Linking** to automate the next step of your analysis by including an **automatic export of the fit results**.
- No need to export manually when you can **save time and possible errors** with **NOVA 2 automation.**



Impedance measurements performed at different state of charge on an 18650 Li-ion battery.

YOUR Impedance Station

Parallel Measurements

Do you need to make impedance measurements in parallel?

If you prefer we can configure your **Autolab Impedance Station** with one or more **M204s**.

- **An M204 multichannel instrument** with **Electrochemical Impedance Spectroscopy modules (FRA32M)** will allow you to perform **simultaneous impedance spectroscopy measurements** on up to **6 channels** per instrument system, **increasing batch efficiency** and **overall lab productivity**.
- **NOVA 2** makes **automation** possible across a range of measurements including **impedance spectroscopy**.
- **NOVA Procedure Editor** enables you to design **unique experimental procedures** to create the research you imagined – without restrictions.

M204 / PGSTAT204 Specifications*	
• Electrode connections	2, 3, and 4
• Potential range	± 10 V
• Compliance voltage	± 20 V
• Maximum current	± 400 mA
• Current ranges	10 nA to 100 mA (in 8 ranges)
• Applied potential accuracy	±0.2% ± 2m V
• Minimum measured potential resolution	3µV (gain 100)
• Current accuracy	± 0.2% ± 0.2% of current range
• Current resolution	0.0003%
• Potential bandwidth	> 1 MHz
• Computer interface	USB
• Control software	NOVA 2

*The M204 is the multichannel version of the modular PGSTAT204.

YOUR Impedance Station

Exceptional Use

FRA32M Specifications	
• Frequency range	10µHz – 1 MHz
• Frequency resolution	0.003%
• AC amplitude	0.2 mV to 0.35 V rms In potentiostatic mode 2 mV to 3.5 V rms (optional)

- You want **impedance** but only for **occasional use**. You have **limited space** and you want an instrument that is **straightforward to use**.
- An **Autolab Impedance Station** configured with a **PGSTAT204** and an **Electrochemical Impedance Spectroscopy module (FRA32M)** is just what you need.
- You get all the built in **NOVA 2 impedance functionality** you want including the **specific impedance analysis tools**.
- This compact **Autolab Impedance Station** is ideal for smaller labs that want to **add only** impedance to their research parameters.

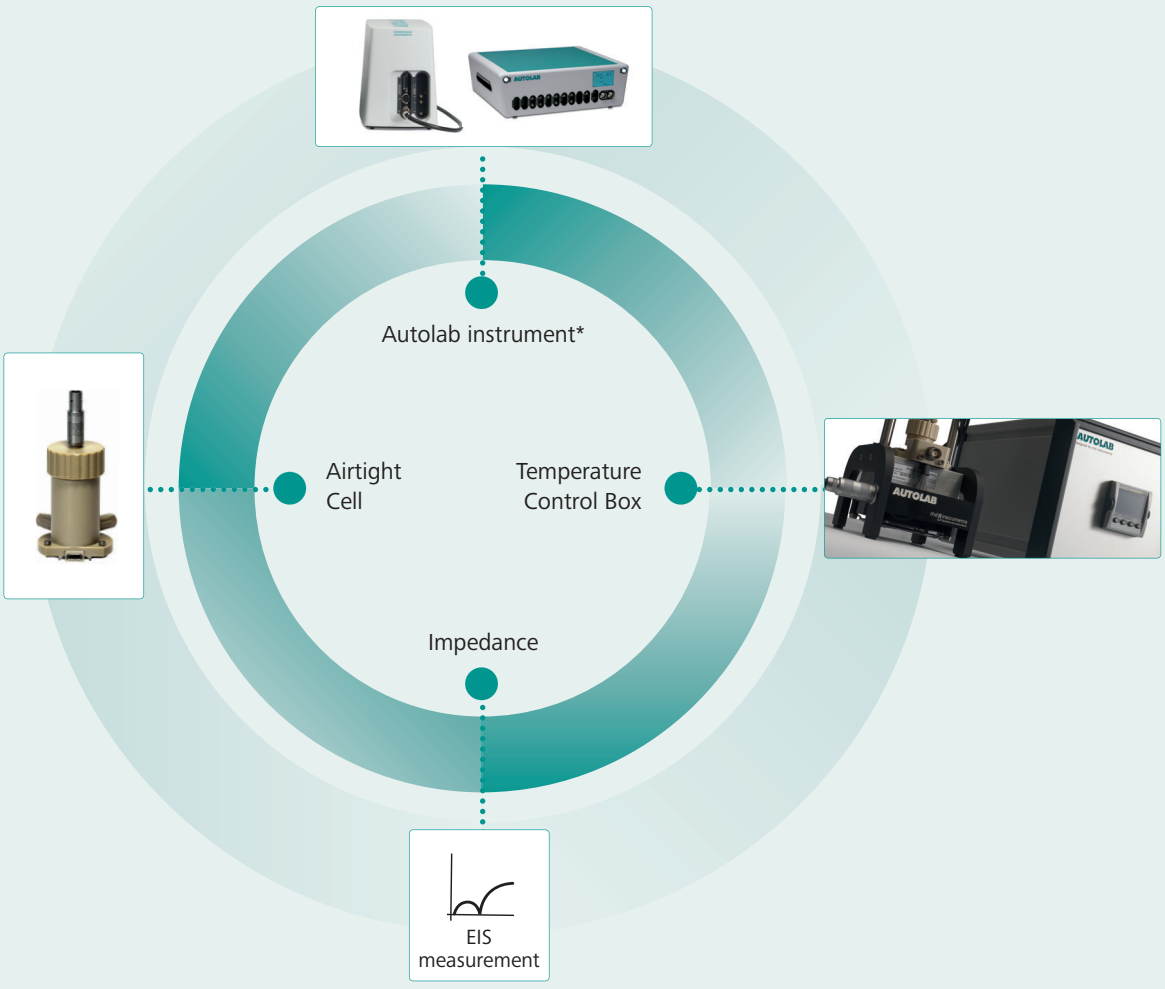
Exceptional Use Impedance Station: PGSTAT204 with Electrochemical Impedance module (FRA32M)

Solid State Workstation for greater precision

Are you a **solid state battery researcher** who wants to:

- **Measure conductivity** at **various temperatures**
- **Study** the battery **electrode interface**
- **Protect your sensitive samples** from atmospheric interference such as air and moisture

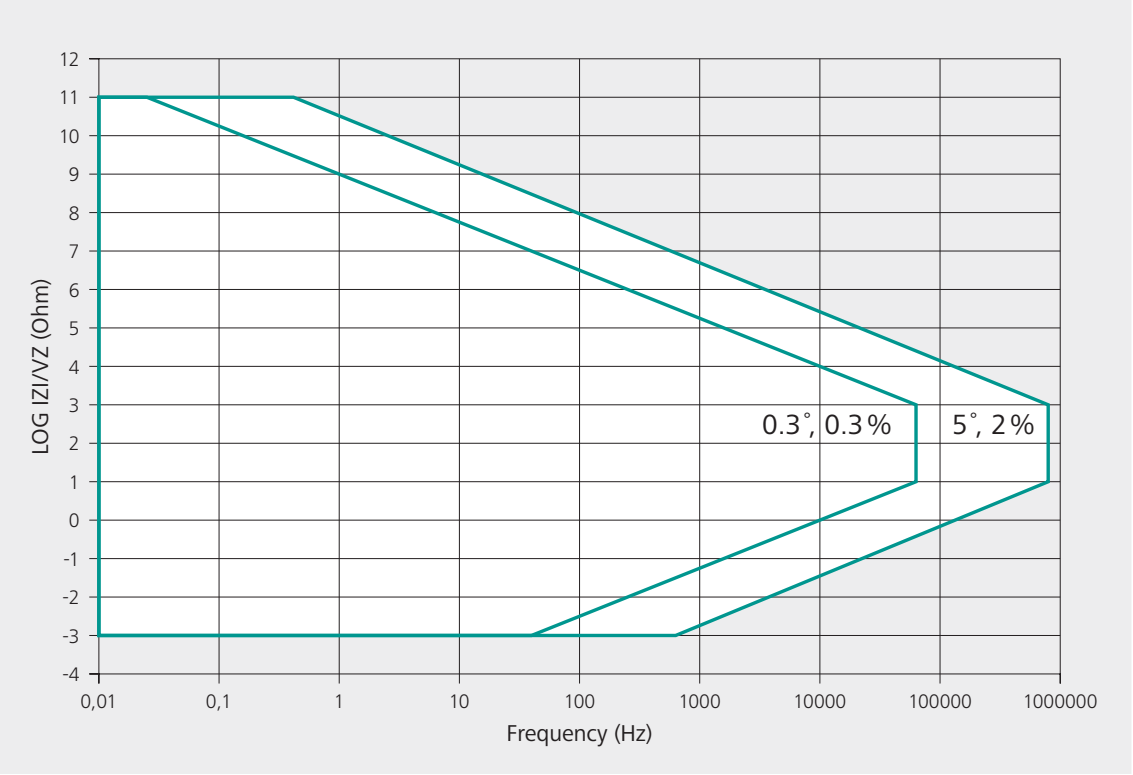
The **Autolab Microcell HC** is the accessory that you need to create the **solid state workstation** that you want.



*Choose from a PGSTAT204 or PGSTAT302N depending on your requirements.

High Performance Impedance Station

Contour Plot



This contour plot is an **accurate** and **precise** representation of the performance of a 302N with FRA32M module.

- **Autolab's FRA32M** module offers a **wide range of measurable impedance** suitable for applications from low impedance batteries to high impedance coatings and everything in between.
- **Autolab** offers **phase change accuracy** at a **wide impedance range** as well as the ability to **modulate** other **outside signals**.
- **Initiate Impedance Station** using the **NOVA 2 software** for measurements and analysis including **fit and simulation**.
- This module can be **added** to most **Autolab instruments** at purchase or later installed on-site by our service specialist.

The **Autolab Impedance Station** provides results up to **99.7% accuracy** in typical **impedance measurements.**

Dedicated to research

Metrohm Autolab sets the standard for electrochemistry instrumentation. Over 30 years ago, we created the first commercially available digital potentiostat/galvanostat that was completely computer controlled. Today our NOVA software is the most powerful electrochemistry software on the market.

Metrohm Autolab creates instruments that are suitable for most application areas including: corrosion, energy, environmental, sensors, and solar. Our customers may not always be electrochemists, but they are engaged in fundamental and applied research harnessing the power of electrochemistry for further understanding. They are driven to understand and improve electrochemical processes with the ambition to deliver new materials with superior properties and future possibilities.

With an Autolab potentiostat/galvanostat and NOVA software there are no limits to where your research can go.

Reliability

- Metrohm Autolab's **integrated testing process** ensures that each component is **traceable and tested individually** after installation in the instrument.
- Metrohm Autolab instruments undergo up to **405 quality checks** during the manufacturing process.
- Our installed instruments average **99%** uptime in the first **5 years of installation**.*

Versatility

- **Metrohm Autolab** instruments are the **workhorses** of **electrochemical research** delivering the **requirements of most application areas** with our range of **instruments, modules and accessories.**
- **Modular instruments** allow you to **change and expand** the **functionality** of your instrument.
- **Specialist modules can be installed** to provide additional electrochemical measurements and possibilities as your research progresses.

Superior Service

- Metrohm Autolab provides an **industry-leading 3 year warranty** for all its instruments, modules and instrument accessories.
- Our **dedicated distribution** and **service network** provide a **fast response** for sales and service, usually within **48 hours.**
- Our colleagues are **people you can trust** to understand your requirements and **provide solutions** to **support your research objectives**.

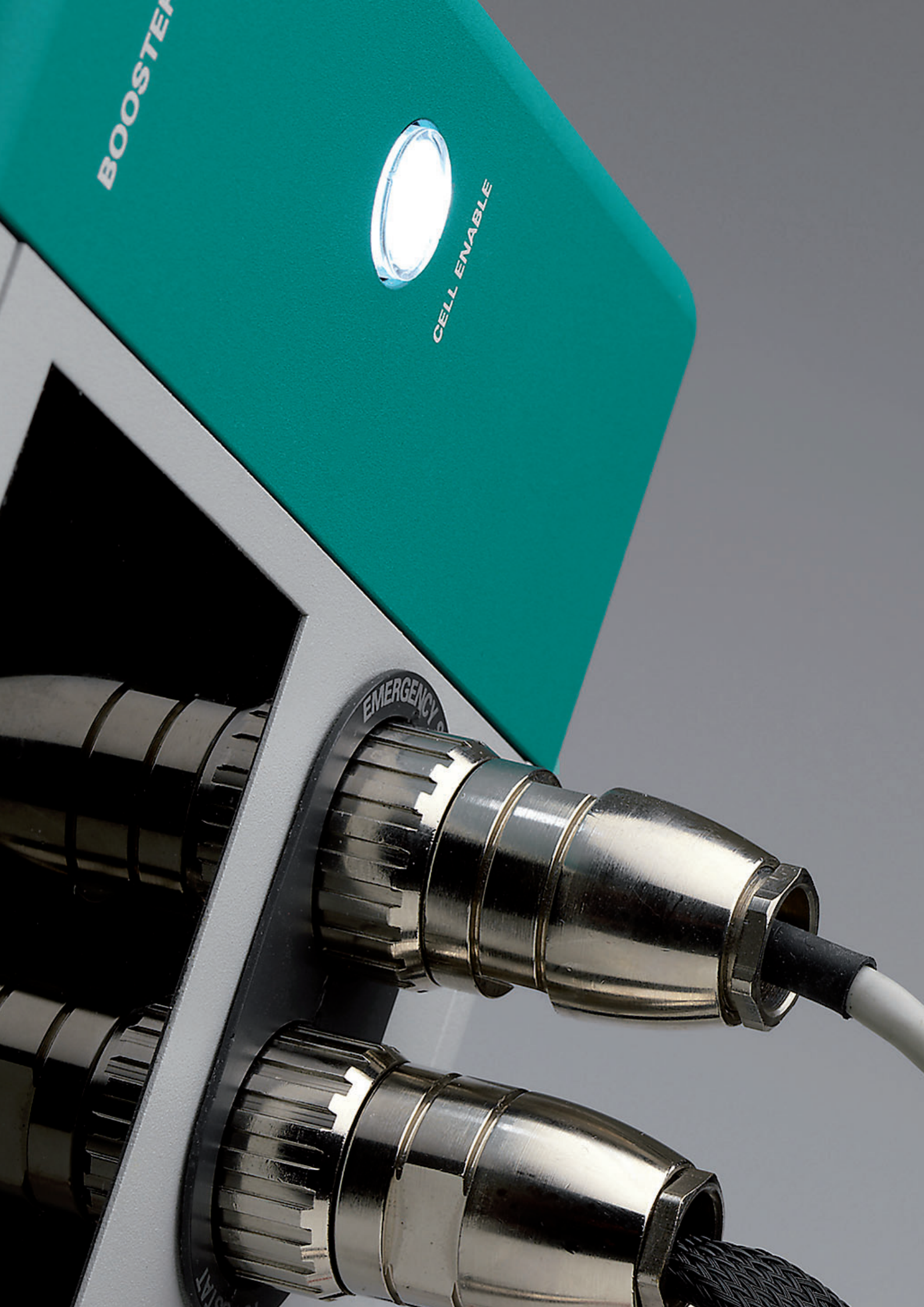
Powerful software

- NOVA is the **powerful data acquisition** and **analysis software** that powers your experiment.
- **Essential procedures** and **multiple analysis options** are built-in with the ability to **modify** and **create** your own.
- NOVA helps **maximize your laboratory throughput** with useful features that put the **focus** on **safety** and **production**.

3 year
instrument warranty

Metrohm Autolab is a member of the Metrohm Group, manufacturers of high-precision instruments for chemical analysis.

*Based on European markets most widely sold instrumentation.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Dedicated to research

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