Metrohm Autolab DuoCoin Cell Holder with EIS measurements on a commercial battery

Introduction

Figure 1. The Metrohm Autolab DuoCoin Cell Holder

The Metrohm Autolab DuoCoin Cell Holder, shown in **Figure 1**, has been developed to perform electrochemical experiments on coin cell batteries.

The DuoCoin Cell Holder can host up to two coin cells, each of 3.2 mm maximum thickness and 24 mm maximum diameter. Typical coin cell sizes which can be hosted in the DuoCoin Cell Holder are CR2016, CR2020, CR2025, CR2032, CR2325, and CR2330. Each connector of the DuoCoin Cell Holder is directly connected to the battery. Therefore, the leads sensing the potential are separated from the leads carrying the current, resulting in a minimized voltage drop due to the impedance of the wires.

In this application note, electrochemical impedance spectroscopy (EIS) is used to test a commercial battery. As comparison, the results from the four-electrode configuration are compared with results from two-electrode configuration, in which the RE and CE leads are connected together, as well as the WE and S leads.

The difference in how the leads are connected results in different measured impedance values.

Experimental Setup

Figure 2. The Metrohm Autolab PGSTAT204, equipped with the FRA32M module.

For the EIS measurements, a Metrohm Autolab PGSTAT204 equipped with a FRA32M module is used (**Figure 2**).

The battery used for the experiments is a rechargeable Li-ion, Panasonic VL2330, with 30 mAh of nominal capacity and a nominal voltage of 3 V.

EIS potentiostatic measurements are performed at open circuit potential (OCP), between 10 kHz and 100 mHz, 10 mV amplitude, with a rate of 10 frequencies per decade.

AUT204.S - Autolab PGSTAT204

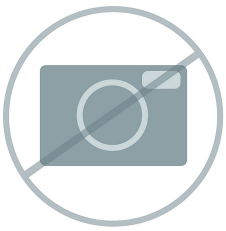
The PGSTAT204 combines the small footprint with a modular design. The instrument includes a base potentiostat/galvanostat with a compliance voltage of 20 V and a maximum current of 400 mA or 10 A in combination with the BOOSTER10A. The potentiostat can be expanded at any time with one additional module, for example the FRA32M electrochemical impedance spectroscopy (EIS) module.The PGSTAT204 is an affordable instrument which can be located anywhere in the lab. Analog and digital inputs/outputs are available to control Autolab accessories and external devices are available. The PGSTAT204 includes a built-in analog integrator. In combination with the powerful NOVA software it can be used for most of the standard electrochemical techniques.

AUT302N.S - Autolab PGSTAT302N

This high end, high current potentiostat/galvanostat, with a compliance voltage of 30 V and a bandwidth of 1 MHz, combined with our FRA32M module, is specially designed for electrochemical impedance spectroscopy.The PGSTAT302N is the successor of the popular PGSTAT30. The maximum current is 2 A, the current range can be extended to 20 A with the BOOSTER20A, the current resolution is 30 fA at a current range of 10 nA.

AUT.COIN2.HLD.S - Autolab DuoCoin Cell Holder

The Autolab DuoCoin Cell Holder has 4-point Kelvin gold-plated contacts to assure the highest precision measurements for your battery research. A versatile accessory that can accommodate all standard cells sizes with capacity for smaller and larger non-standard cells and two cells can be processed at one time.Autolab DuoCoin Cell Holder gold plated contacts and gold plated PCB provide protection from corrosion and damage to the accessory in your busy laboratory.Experimental set up is simplified with the Autolab DuoCoin Cell Holder with visible electrode labels and cable connections that correspond to the Autolab potentionstat /galvanostat cable colors. Autolab's attention to detail is reflected in the silicon surface grippers on the bottom of the Autolab DuoCoin Cell Holder to provide stability in a complex experiment set up.



NOVA - Advanced software for electrochemical research

NOVA is the package designed to control all the Autolab instruments with USB interface.Designed by electrochemists for electrochemists and integrating over two decades of user experience and the latest . NET software technology, NOVA brings more power and more flexibility to your Autolab potentiostat/galvanostat.NOVA offers the following unique features:Powerful and flexible procedure editor; Clear overview of relevant real-time data; Powerful data analysis and plotting tools; Integrated control for external devices like Metrohm Liquid Handling devices;

Results and Discussion

In **Figure 3** the Nyquist plot of measurement performed with the four-electrode configuration (red dots) are compared with the results obtained with two-electrode configuration (blue and red dots).

Regarding the two-electrode configuration, EIS measurement is performed with connecting the WE and S leads together and the CE and RE leads together, having therefore the RE and S leads closer to the battery (blue dots). Another measurement has been carried out with the leads connections inverted, so connecting S and WE leads together and the RE and CE together, having the WE and CE leads closer to the battery (green dots).

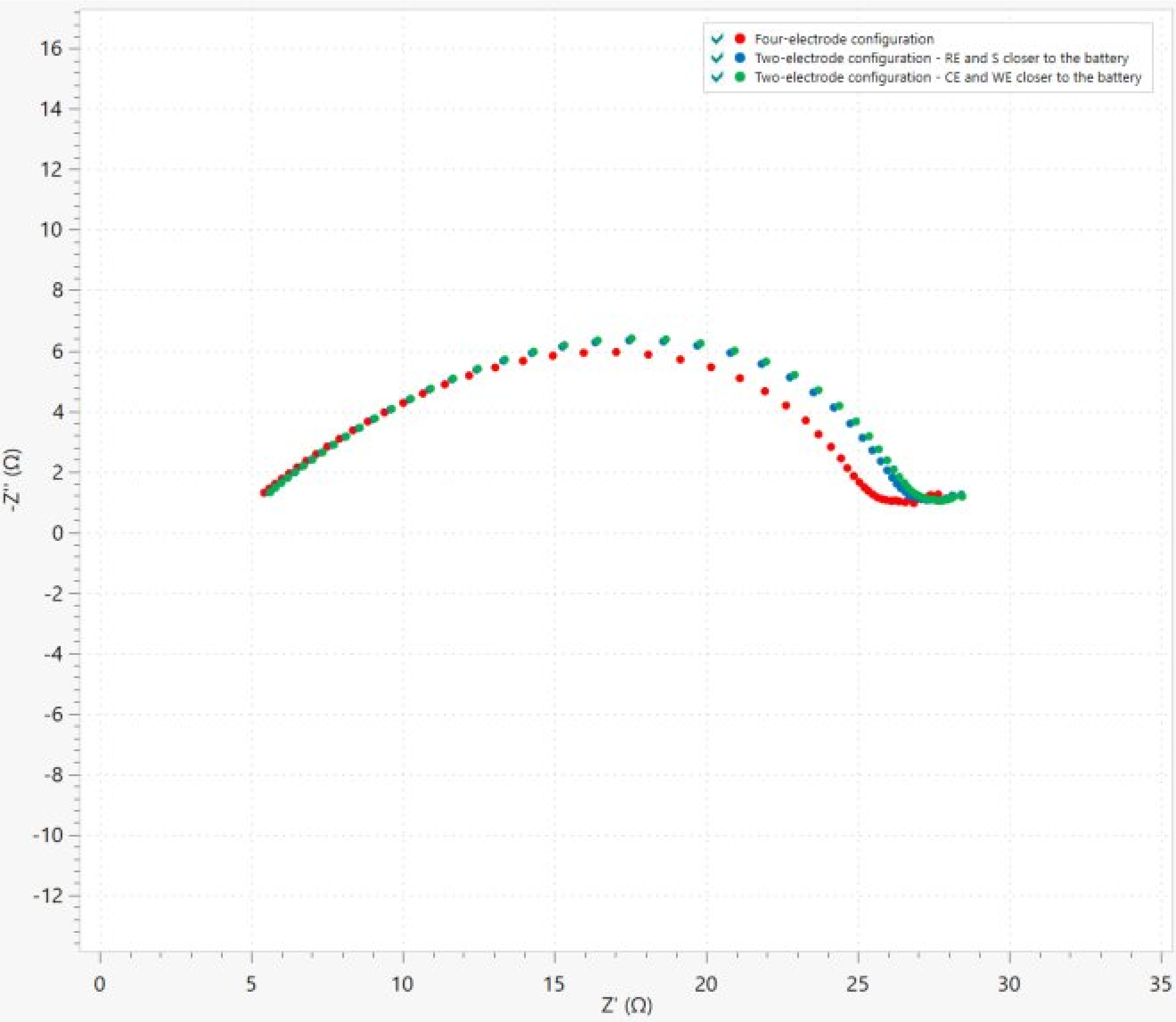


Figure 3. Nyquist plots from EIS measurements performed on the Li-ion battery with four-terminal (red dots) and two-terminal (red dots) sensing configurations.

While there is no appreciable difference between the two-lead configurations, the Nyquist plot corresponding to the four-terminal configuration is shifted towards lower impedance values, with respect to the Nyquist plots resulting from the two-terminal configuration. In **Figure 4**, the magnification at high frequencies of **Figure 3** shows a difference in impedance of approximately 170 mΩ.

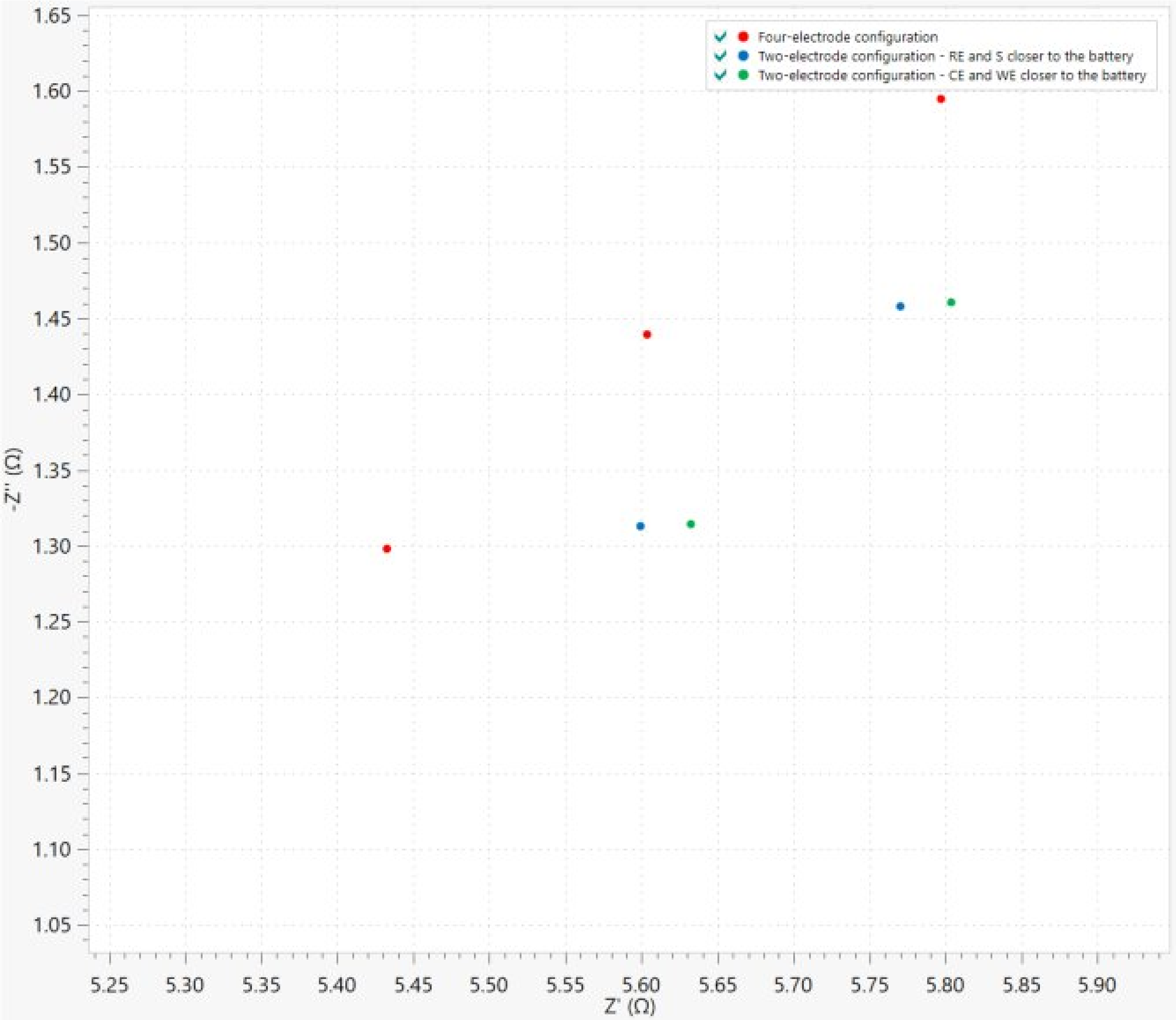


Figure 4. Magnification of Figure 3 at high frequencies.

However, the difference is more evident at low frequencies, as shown in **Figure 5**, where the difference in impedance between the four-terminal and two-terminal configuration at the end of the semicircle is approximately 2 Ω.

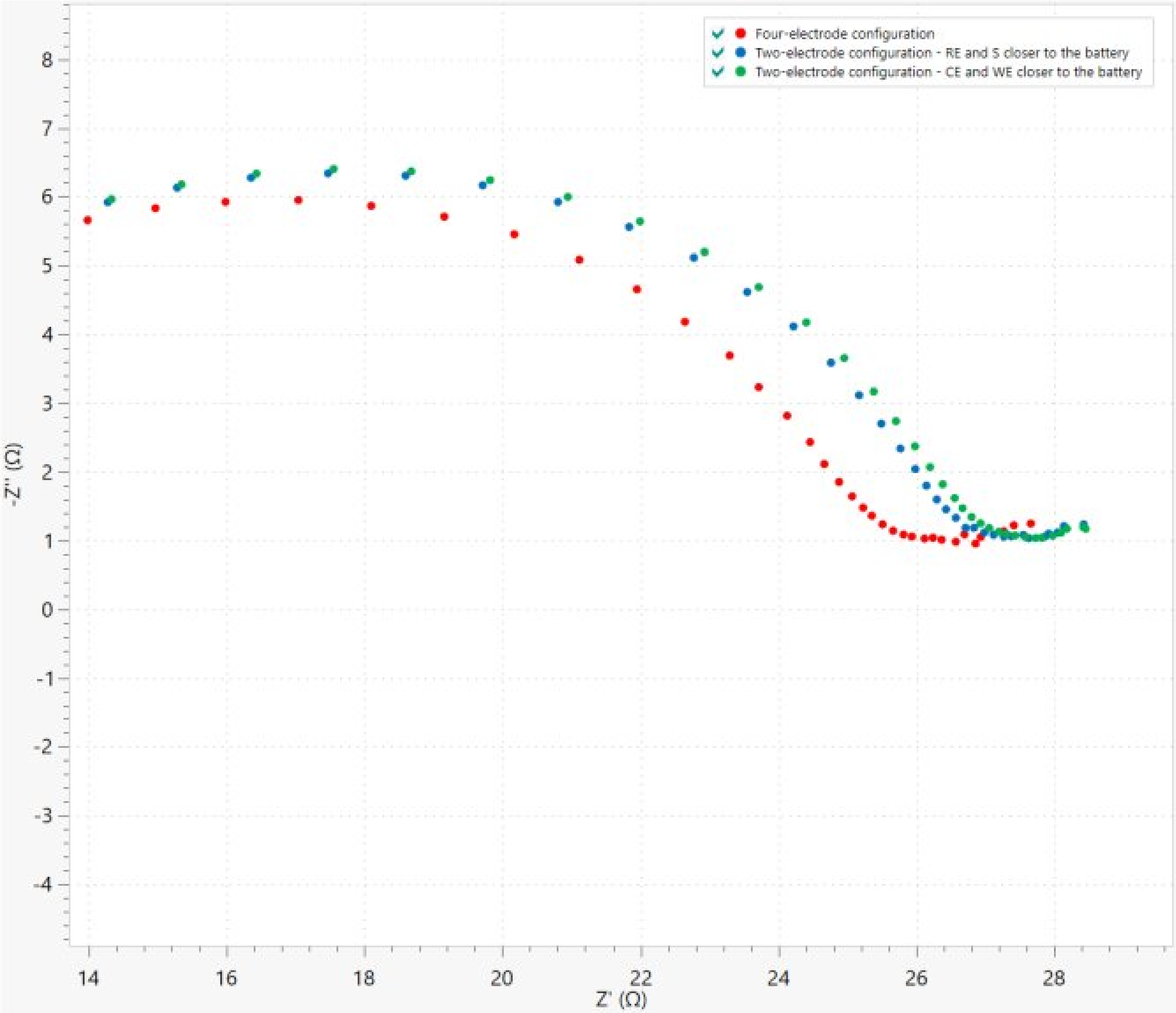


Figure 5. Magnification of Figure 3 at low frequencies.

Finally, it is worth noting that the use of the four-terminal sensing configuration is important only when low-impedance devices are under investigation, like batteries, since the contribution of the wires to the overall impedance is low.

Conclusions

The DuoCoin Cell Holder is introduced. EIS measurements on a commercial coin cell battery are performed. Differences in impedance between the four-terminal configuration and two-terminal configuration is highlighted, putting in evidence the importance of having a direct four-terminal configuration, when low-impedance DUTs are investigated.

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