Condition Monitoring of Li-Ion Battery Ageing

Figure 1: Lithium Ion cells that were used in the experiment

Introduction

Lithium Ion cells (Li-Ion) are being increasingly used in the world. A leading example of this is the increase in electric vehicles using this technology. It is crucial that these batteries can be monitored properly so that progressive faults can be identified before catastrophic failures occur. The cells could individual combust and cause fires, having a cascading affect. The project explores cell analysis through the use of frequency impedance spectroscopy. By applying varying frequencies of voltage across the cells to gather the electrical characteristics to evaluate the internal electro-chemistry.

Aims

- Identifying if frequency-impedance spectroscopy can accurately assess Li-Ion cells health and state of degradation by analysing electrical characteristics throughout the cells lifespan.
- Highlight gaps for future work for deeper research and understanding

Method

- Various frequency ranges are applied across the lithium ion cell
- Electrical characteristics such as Impedance were collected at every sample point
- This is repeated up to 200 charge and discharge cycles (as many as could be done in the given time) a charge cycle can be seen in figure 2.
- Data is extracted and analysed using MATLAB and plotted in comparative graphs

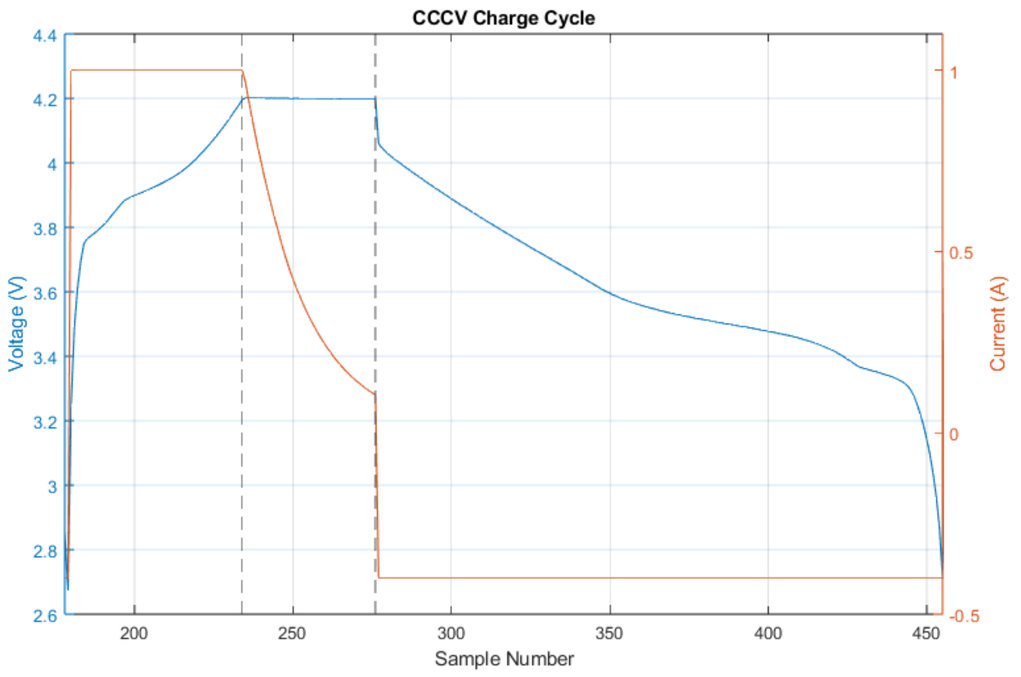

Figure 2: Constant Current Constant Voltage (CCCV) Charge discharge cycle

Results

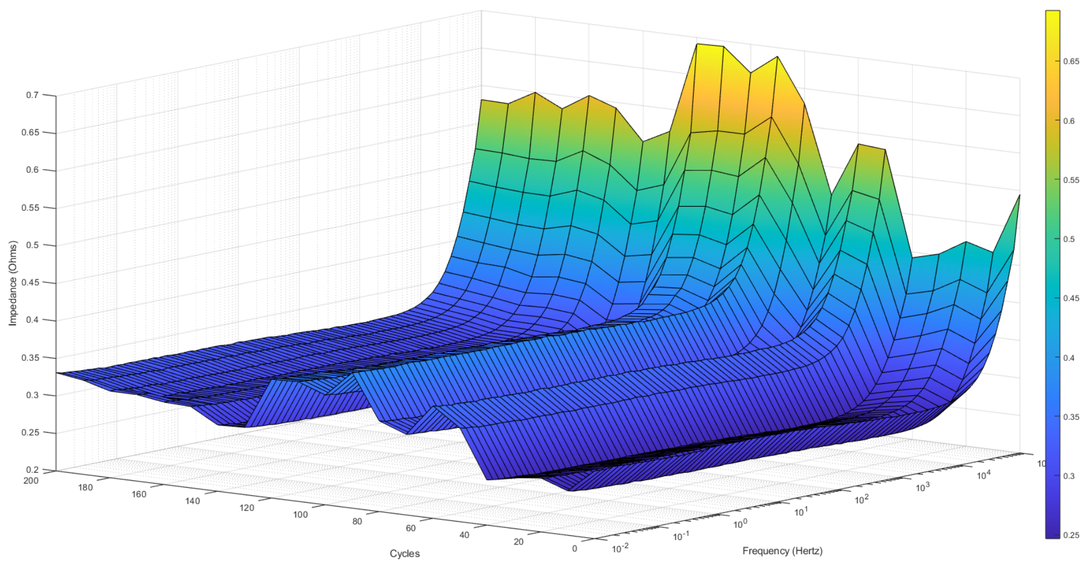

Figure 3: Bode plot comparing impedances across the different cycles. Up to 200 cycles

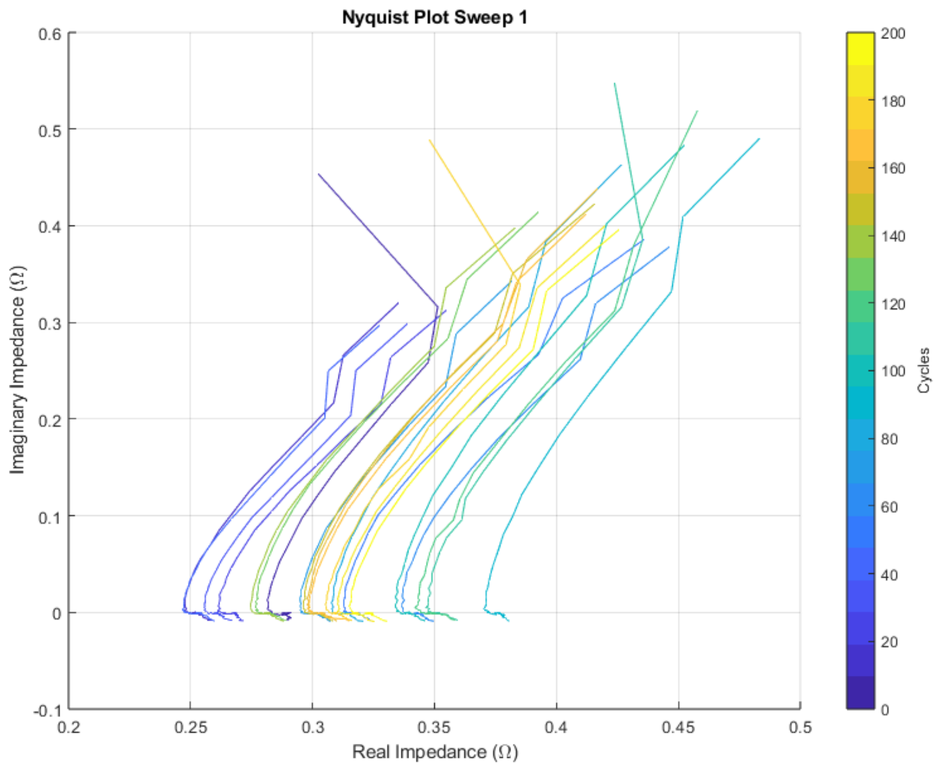

Figure 4: Nyquist plot comparing imaginary and real impedance across the 200 cycles

Discussion

⇒ Figure 2 shows a snapshot of a single charge and discharge cycle. It shows the constant current applied and the constant voltage maintained as apart of a CCCV cycle. The cell is charged at 1 Amp until 4.2 Volts is reached, at which point the voltage is held at 4.2 Volts until the current decreases to 0.1 Amp. The cell is then discharged until it reaches 2.5 Volts.

⇒ Figure 3 shows that there is a gradual trend of impedance increasing with a greater number of cycles. The impedance increases rapidly at higher frequencies. This means the cell exhibits frequency dependant impedance which is the same as capacitors and inductors.

⇒ Figure 4 shows the real impedance against the imaginary impedance across multiple cycles. All follow similar trends whilst having different starting points. This shows that there are different real impedances across the cycles, with the lower cycles being shifted left having lower real impedances.

⇒ Frequency—impedance spectroscopy could be used to analyse cells and assess their level of usage and degradation, but would require additional research. As data shows impedance increase with age.

Further Work

The data shows a general trend is emerging, that the internal impedance is increasing across it's lifespan. To fully explore this, additional cycles could be tested. Beyond the 200 tested. Further, to evaluate data from multiple cells to gather more samples. Cells in different configurations could be evaluated too, with multiple cells in series or parallel with each other.

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