Selection and implementation of a reasonably priced microcontroller for online impedance measurements of batteries

Author: Songezo Kenene ***Supervisor: Paul Barendse*** ***Department of Electrical Engineering, 2022***

1. Introduction

Electrochemical Impedance spectroscopy (EIS) is a technique for determining/monitoring the AC impedance of a battery. It can be used to estimate the state of charge (SOC) and state of health (SOH) of a battery. The EI spectrum of the battery is compared with long- term collected experimental data to get the SOC and SOH.

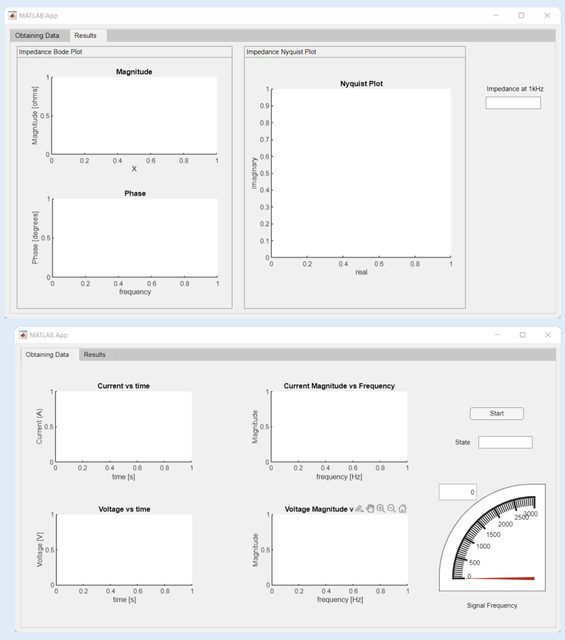
Online impedance measurement is when it is done on a battery that is connected in an application.

2. Objectives

1. Select a low-cost microcontroller.
2. Investigate the limits of the Selected microcontroller and how they would affect its use in the process of EIS.
3. Find solutions to assist selected microcontroller perform EIS.
4. To Implement impedance measurement with the selected microcontroller.
5. Test the implementation on an affordable microcontroller against impedance measurement with a frequency response analyser (FRA).

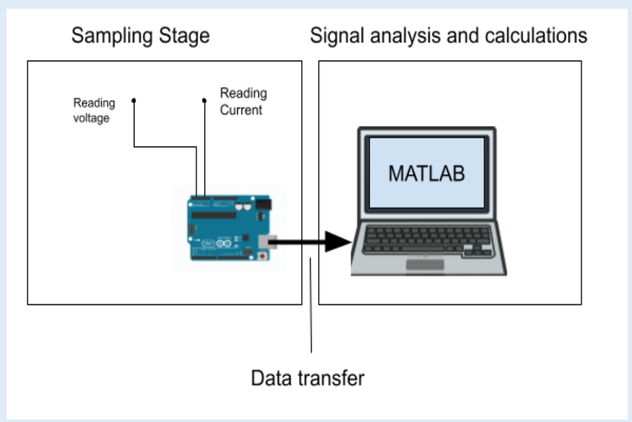
3. Software

The software used in the tests and implementation is the Arduino IDE, MATLAB and Excel. Arduino IDE was used for programming the Arduino Uno. Excel was used to collect and structure data. MATLAB was initially used for processing data from the tests. The MATLAB App Designer was then used as part of the implementation of impedance measurement on the Arduino Uno.



Software design using MATLAB App

4. Hardware



Overall system

- Signal generator
- Oscilloscope
- 2x Oscilloscope probes
- Arduino Uno
- USB A cable
- Laptop
- FRA

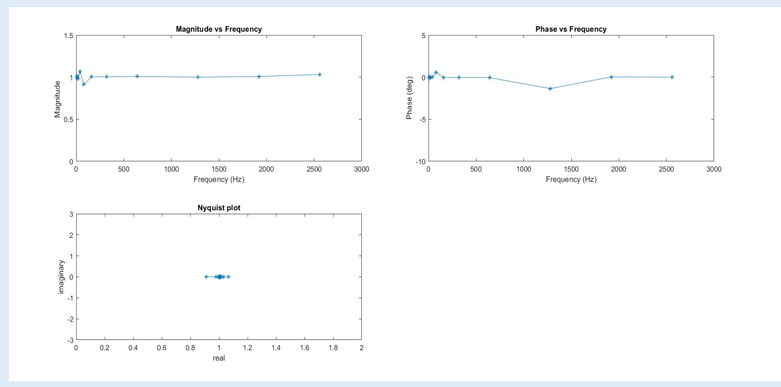
The signal generator was used to generate AC signals. The oscilloscope was used to validate the output of the signal generator. The Arduino samples the signals. The laptop is used to collect and process the sampled signals.

5. Results

The Arduino Uno can manage to sample signals at a maximum sampling frequency of__ and resolution of ___:

Sampling Frequency (kHz)	Voltage Resolution (mV)
153.85	4.88
307.69	34.18
615.38	134.28

Measuring impedance with the assistance of MATLAB.



Impedance bode plot and Nyquist

	Expected	Measured (mean)
Magnitude	1.0000	1.0026
Phase (°)	0.0000	0.0850

6. Conclusions

In conclusion, an Arduino Uno in a standalone implementation cannot handle the calculation requirements of EIS. A deduction can be made that microcontrollers with a low dynamic memory, like the Arduino would also fail. With the assistance of another device to take on the burden of the calculations and viewing of signals like a laptop, the Arduino can be used as demonstrated in this project.