Chapter 6

Conclusion and Recommendations

Presented in this chapter are the conclusion and recommendations regarding this project. Conclusions and improvements regarding the simulation model are discussed. Conclusions and improvements on the practical implementation and results are discussed. The future work and possible improvements on the practical implementation are discussed.

6.1   Conclusions

The NVR method was used to obtain the parameters of the Randles cell and the CS method for the Randles-Warburg cell. The EEC parameters provide information about the important electrochemical characteristics of a PEM electrolyser.

Simulation data was used to verify that the Randles cell EEC parameters can be calculated from the NVR method. The values of the Randles-Warburg cell equivalent electric circuit parameters were verified with simulation data from the CS method. Negligible errors were introduced in the calculation of the Randles-Warburg cell.

For the practical implementation the data obtained from the CS method is filtered to remove undesirable frequencies. This is required since noise can influence the experimental data and incorrect results may be obtained. The conductivity of the PEM electrolyser calculated from experimental data, is in accordance with published conductivity values of Nafion$^\circledR$ 117.

It is noted that the NVR method provides sufficient information on the membrane resistance and charge transfer resistance. However, it is difficult to obtain an accurate representation of the double layer capacitance with the NVR method. It is difficult to obtain an accurate reading of (v_{t1}) and (τ_{rc}), since the overpotential slowly decreases.

Since the double layer capacitance is a frequency dependent component, it is better to model it with the CS method. From the results it is seen that the model of the Randles-Warburg cell needs to be improved in order to lower the error between the measured response and the simulated response.

6.2 Future work

In terms of future work, the experimental data generated during the PRBS perturbation will be improved in order to model the Warburg impedance accurately. MEA's with different attributes which include the membrane type, membrane thickness and the catalyst type will be characterised.

The results obtained for the Randles-Warburg cell must be validated with existing literature or a suitable equivalent method. The parameters of the Randles-Warburg cell can be validated with other electrochemical characterisation methods such as EIS.

A better estimation of the Warburg impedance, in terms of an EEC, must be investigated. The Warburg parmeters R_d and τ_d should also be interpreted.

The different software user interfaces in LabVIEW™ will be integrated. This feature will allow the user to adjust software settings, acquire experimental data and perform the analysis from one central software platform.

The experimental setup needs to be improved. A power supply with a clean DC output needs to be used in order to obtain better results. A power supply with a fast transient response needs to be used. The transient response of the power supply needs to be at least five times higher than the maximum excitation frequency of interest.

The cables needs to be as short as possible to lessen the inductive effects within the cable. The cable needs to be twisted in order to minimise the inductive and other parasitic effects. An RF choke can be implemented in the AC cable of the power supply to minimize noise.

A switch with less parasitic effects need to be implemented. The switch needs to be cooled in order to lower the losses through the switch. The characteristics of the switch is directly proportional to the temperature of the switch. The higher the temperature of the switch the higher the losses through the switch.

Better signal conditioning has to be implemented on the measured signals. Digital filtering is an appropriate option to condition the measured signals. This can be implemented since the anti-aliasing (low pass) filter is applied before the signals are sampled.

Part of the aim was to see whether it is possible to estimate an EEC of a PEM electrolyser through the CI method. From the practical results it is seen that it is possible to obtain an estimation of the Randles cell and the Randles-Warburg cell of a PEM electrolyser. The membrane resistance (R_m) was validated with existing literature. The next step would be to validate all the remaining parameters of these two EECs with existing literature or an suitable equivalent method.