

# Implementation of Impedance Spectroscopy Genetic Programming for PEM fuel cell

Y. Binyamini; Adviser: Prof. Y. Tsur, Dr. S. Hershkovitz & Dr. S. Baltianski

## Objective

Implementation of an analysis method developed in the research group - "impedance spectroscopy genetic program" (ISGP), for PEM fuel cells, to facilitate better informed research and development.

## Introduction

### The Impedance Spectroscopy Genetic Program (ISGP) technique<sup>[1]</sup> is used to find the best fitted distribution of relaxation times (DFRT) and calculate its parameters.

The simulations are based on an initial population that is composed of random models and evolve toward better solutions over recursive generations. In each generation, the population is doubled by creating new models through evolutionary operators (e.g., adding a peak). Then each one of the new models in the population is assigned with parameter values that generate its best possible fit. Then The best fitted peaks survive for the next generation.

The main problem using the conventional way, equivalent circuits, for analysis of the IS data is that different configurations of equivalent circuits can provide the same impedance spectrum and this may result in a misleading interpretation of the different processes.

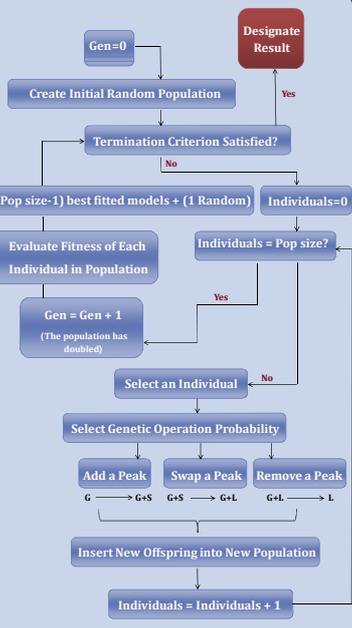


Figure 1: Flow chart for genetic programming

## The experimental system

The Arbin system was purchased and received last March. This system allows the user to operate a PEM fuel cell by supplying a fuel (hydrogen) and an oxidant (oxygen from air) in varying flow rates. The system also enables the determination and monitoring of other operating parameters like the temperatures of the gases and the cell itself and the humidity of the gases. Cell testing is done by writing and running a program that controls one of the following parameters: current, voltage or load. The system measures the resulting two parameters. As for today there are several operating issues that need to be solved before starting the tests designed to adapt the ISGP algorithm for PEM fuel cells.

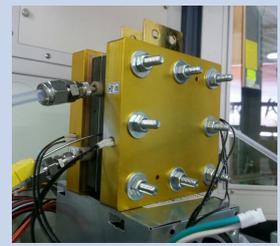


Figure 2: PEM fuel cell

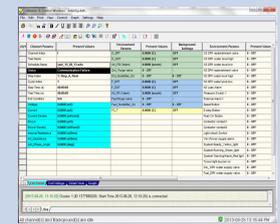


Figure 3: Monitor & control window



Figure 4: The ARBIN system

## Result's analysis

For now, until successful operation of the Arbin system, we use synthetic data produced from equivalent circuits<sup>[2]</sup> for testing the ISGP algorithm to ensure it will be able to handle with the expected results. The next step will be explaining the internal cell processes by the resulting distribution of relaxation times.

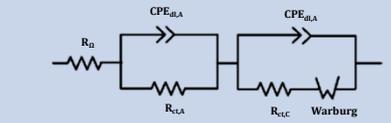


Figure 5: Low current equivalent circuit for 1.2 kW PEM fuel cell for currents up 4 Adc.

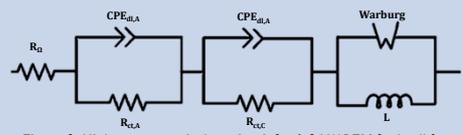


Figure 6: High current equivalent circuit for 1.2 kW PEM fuel cell for currents from 5 Adc to 40Adc.

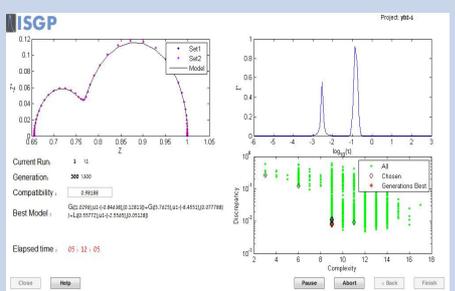


Figure 7: ISGP's output of the circuit presented in Fig. 5, include Cole-cole plot, distribution of relaxation times and discrepancy-complexity plot.

## Goals for the future

- Operating the Arbin system properly and start testing different PEM fuel cells under various conditions.
- Analyzing the results by using the ISGP algorithm and characterizing PEM fuel cells and their internal processes by distribution of relaxation times.

## References

1. Shany Hershkovitz, Sioma Baltianski, Yoed Tsur; Solid State Ionics, vol. 188, 2011.
2. Aparna M. Dhirde, Nilesh V. Dale, Hossein salehfar; IEEE transactions on energy conversion, vol. 25. no. 3, 2010.