A Test bed for Impedance Measurements on PEM Fuel Cells

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Planned Completion = March 31, 2007

Research Goals and Objectives

- Research Goal:
  - Create a test bed for PEM fuel cells suitable for evaluating new catalysts, membranes, and flow configurations.
  - Enhance the application of impedance spectroscopy as a tool for electrochemical characterization of fuel cells.
- Objectives:
  - Integrate experiments with model development to obtain meaningful parameters.

Relevance to Current State-of-the-Art

- Impedance spectroscopy commonly used in fuel cell research, but interpretation of data is generally inadequate.
- Measurement model analysis to assess impedance artifacts.
- Integration with interpretation models will provide meaningful parameters related to electrochemical, thermodynamic and transport processes in PEM fuel cell.

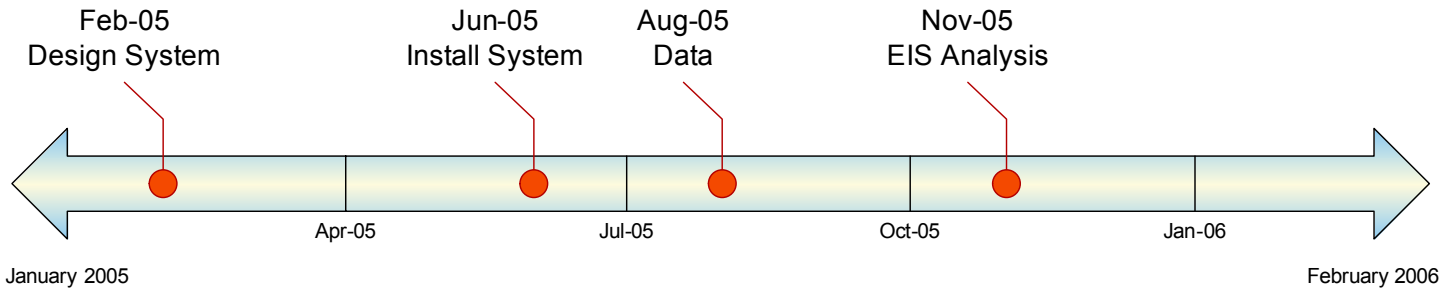
Relevance to NASA

- Enhance NASA research efforts in PEM fuel cells.
- Make impedance spectroscopy a more useful tool.
- Fundamental information will guide research to enhance performance of fuel cells.

Budget, Schedule and Deliverables

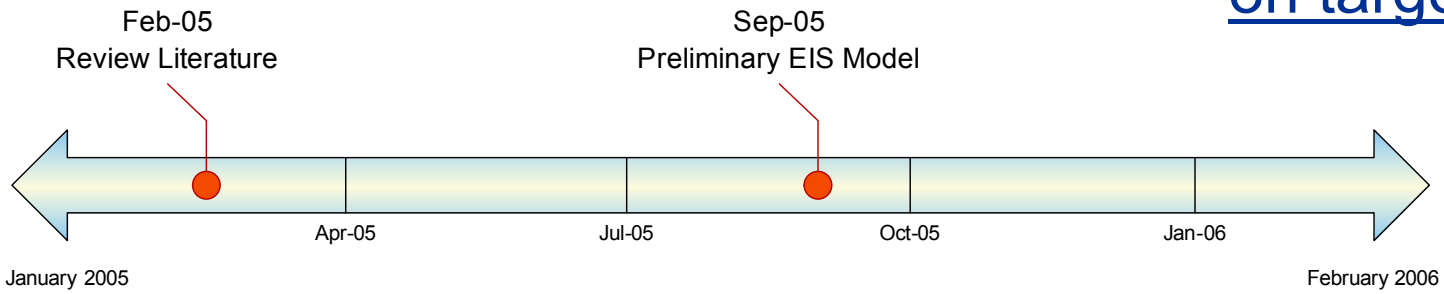
Budget: $91,982 in FY04
88% expended

Experimental System



Interpretation Models

on target

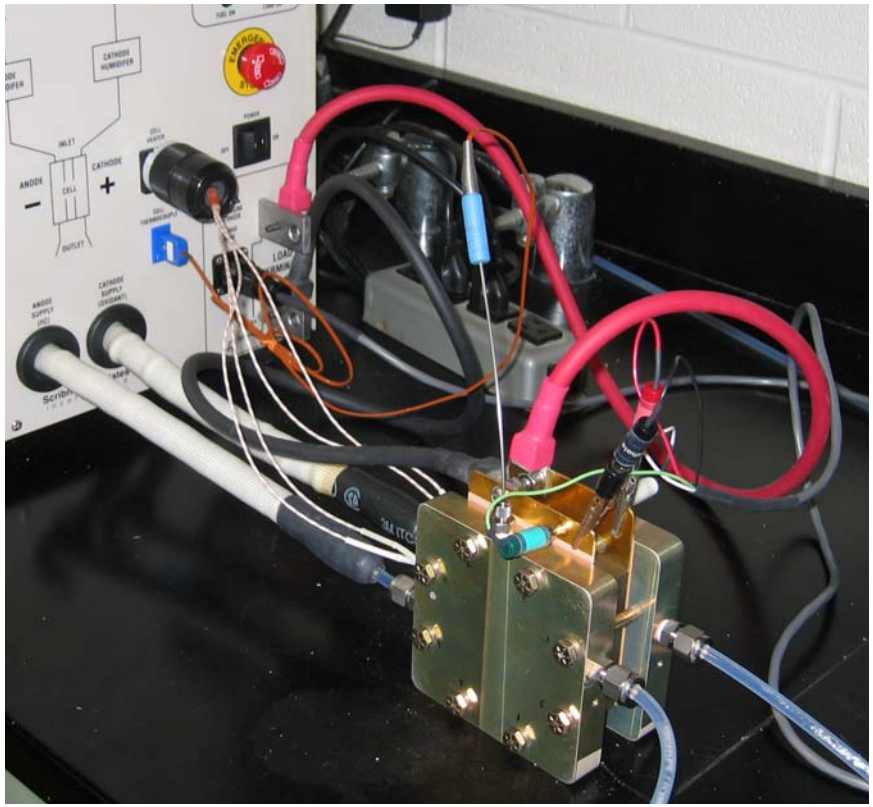


Anticipated Technology End Use

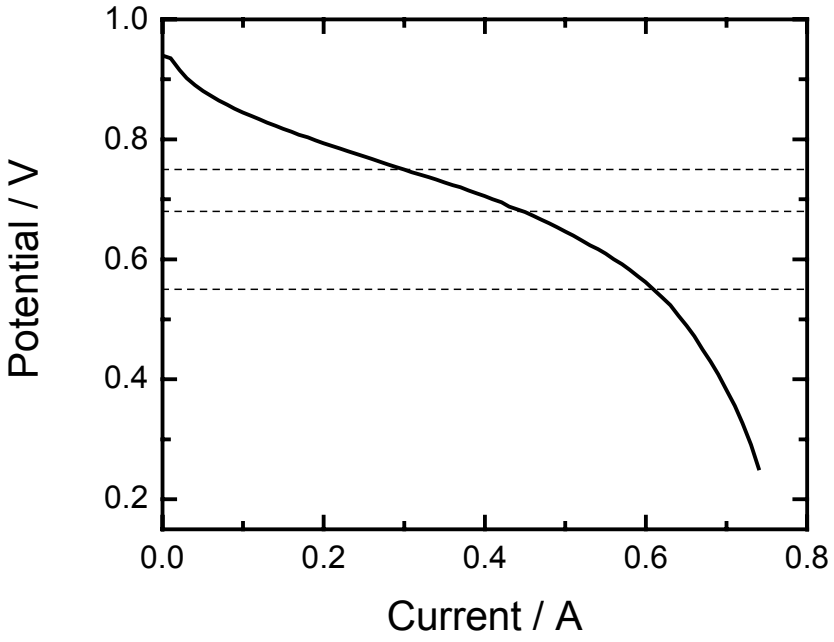
- Testbed for new developments in the University of Florida fuel cell group
- Transfer know-how and technology to NASA

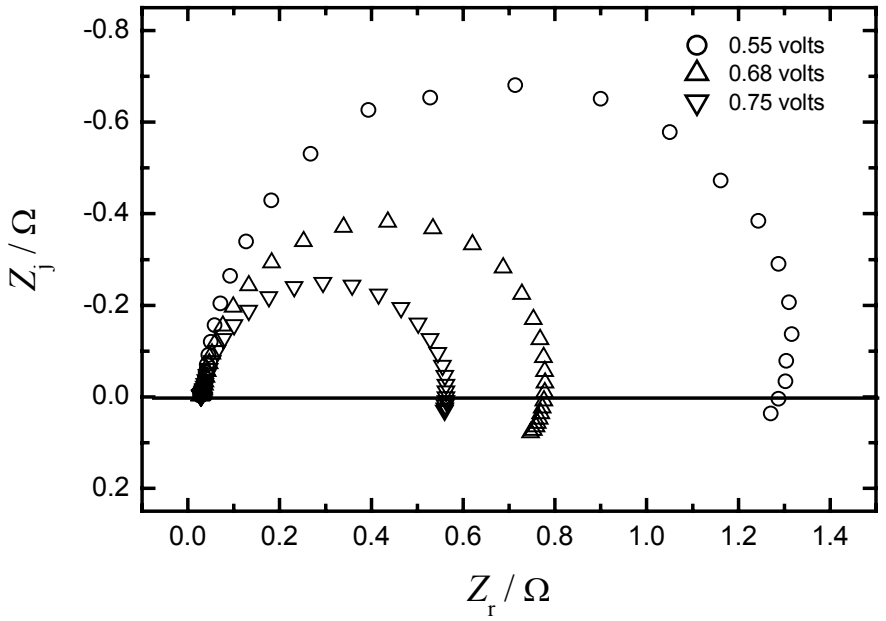
Accomplishments and Results

Fuel Cell Operational: 5 cm^2 MEA

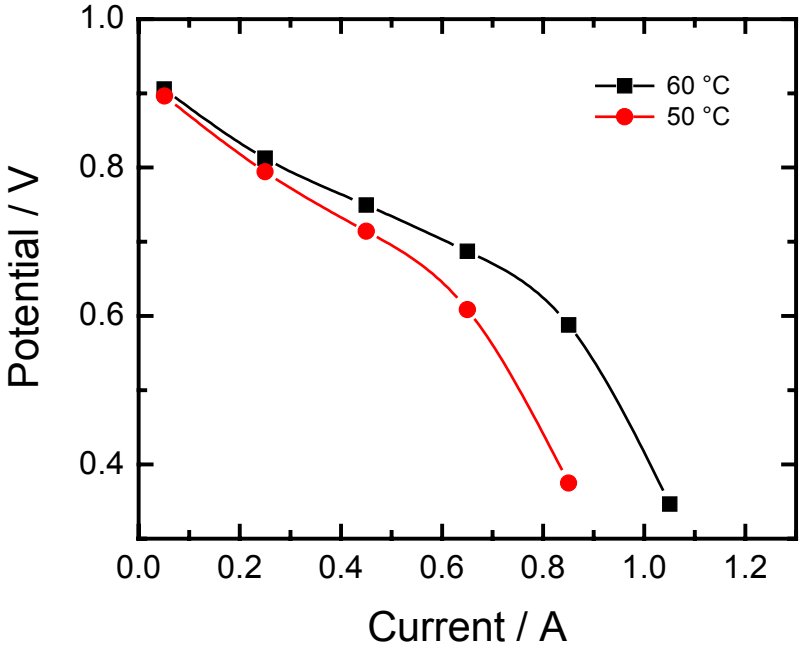


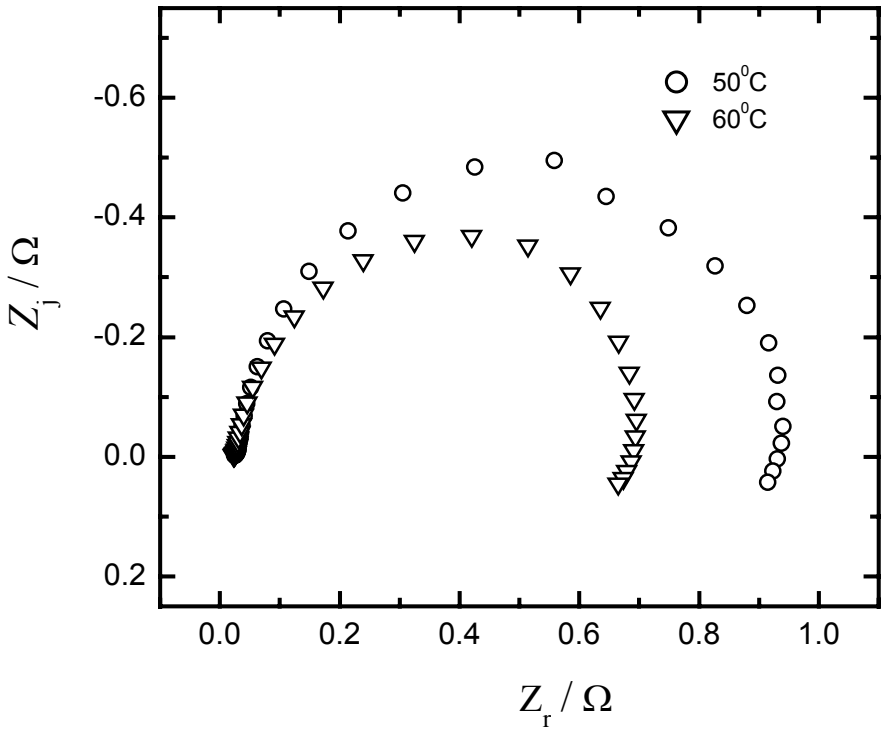
Influence of Potential at 40 ºC





Influence of Temperature at 0.68 V



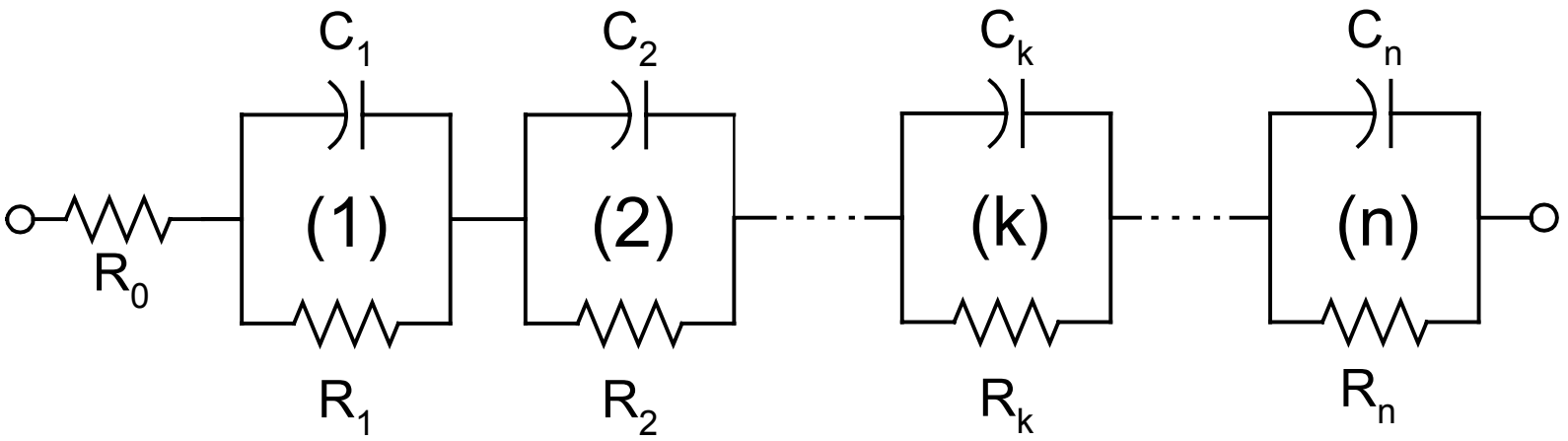


Benefits of Impedance Analysis

- Identification of time constants for physical phenomena
- Increased sensitivity – Enhanced signal-to-noise
- Checks for Kramers-Kronig consistency
- Ability to resolve physical phenomena

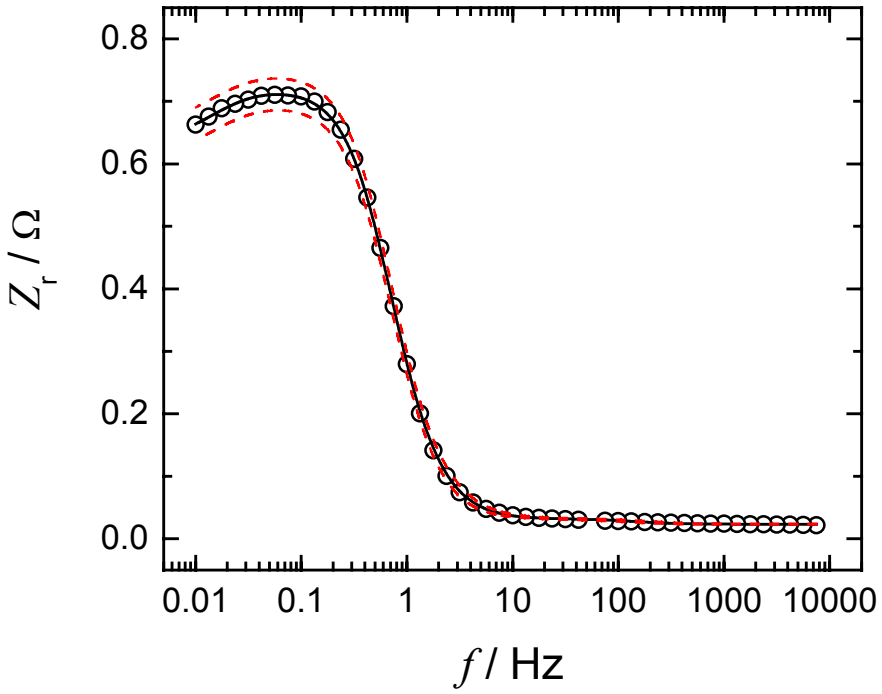
Use measurement model to assess error structure

- Noise level of measurement
- Consistency with Kramers-Kronig relations

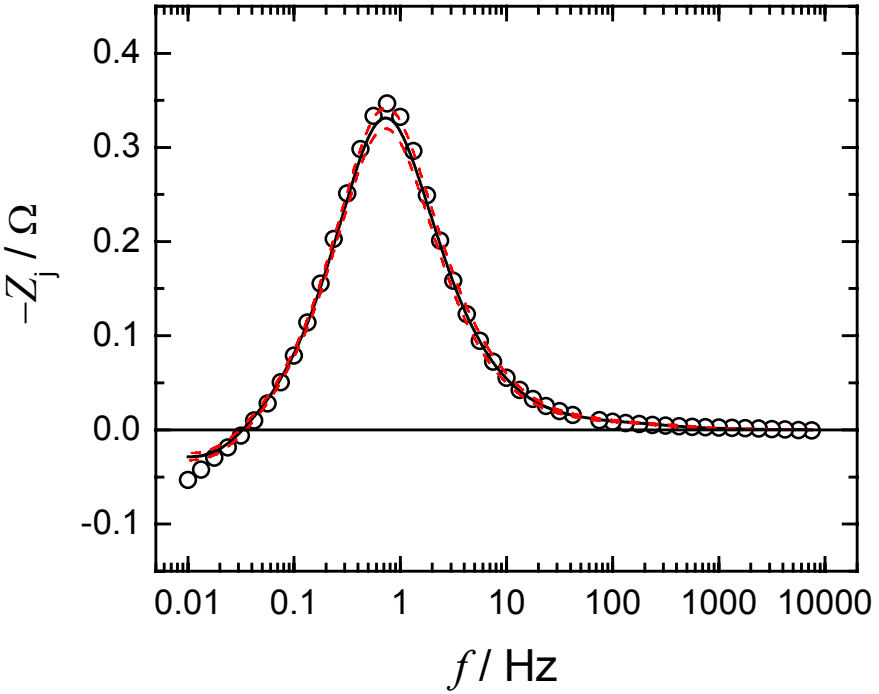


Kramers-Kronig Consistency

Fit

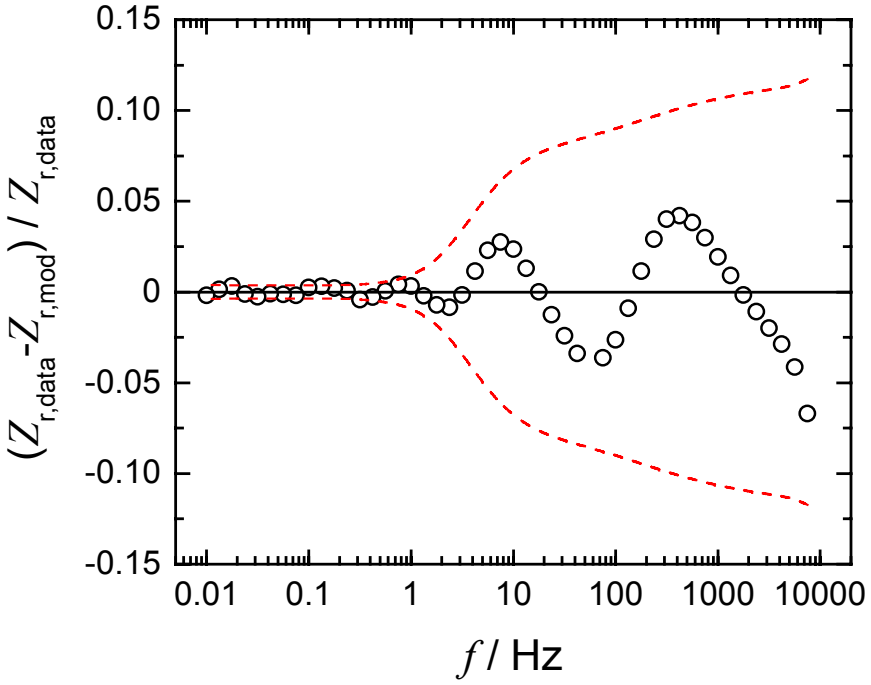


Predicted

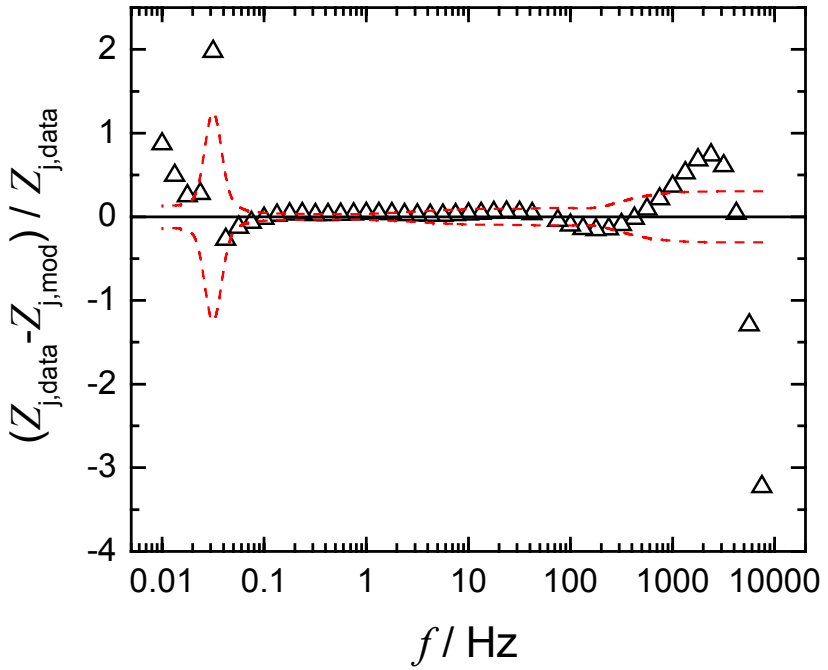


Kramers-Kronig Consistency

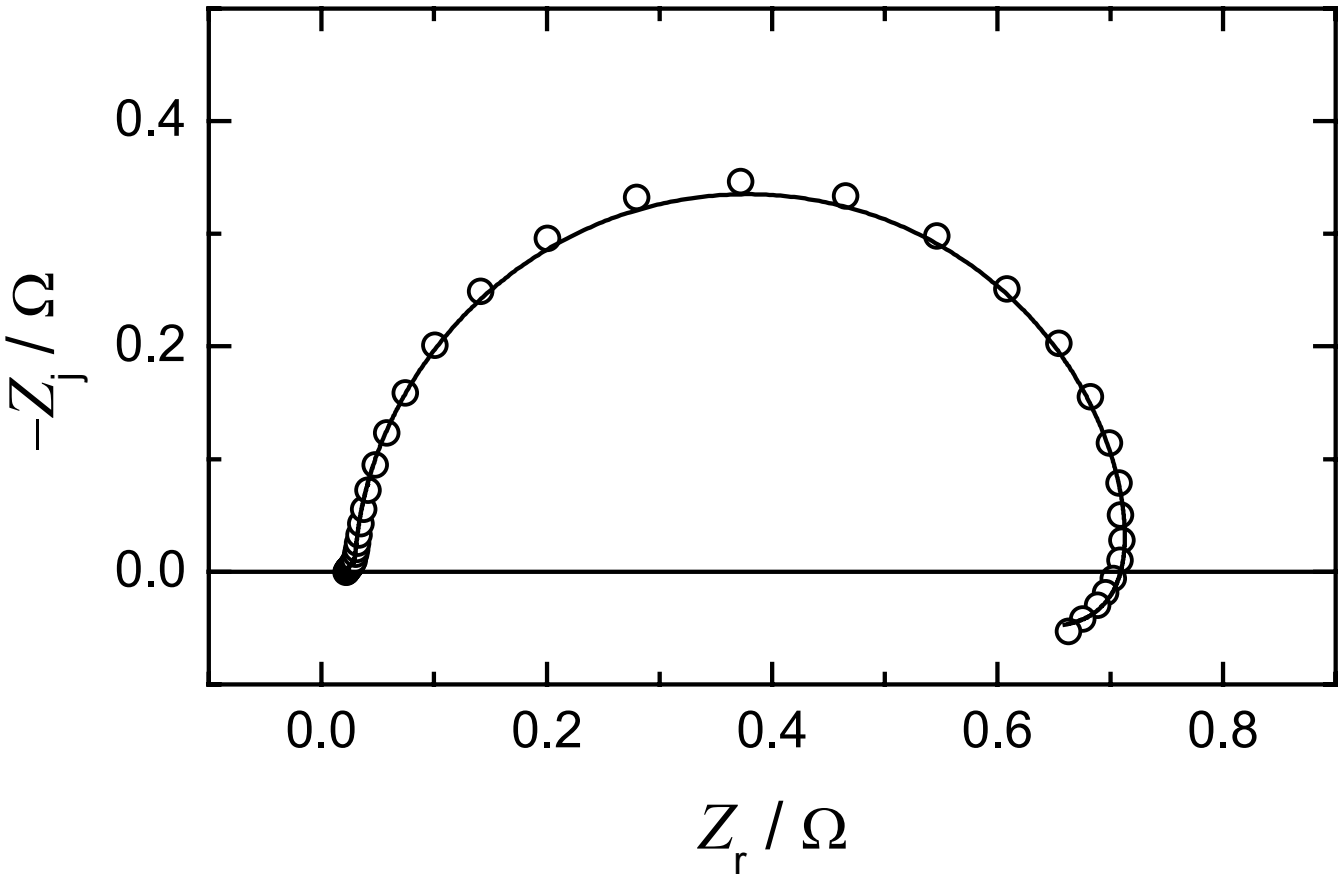
Fit



Predicted



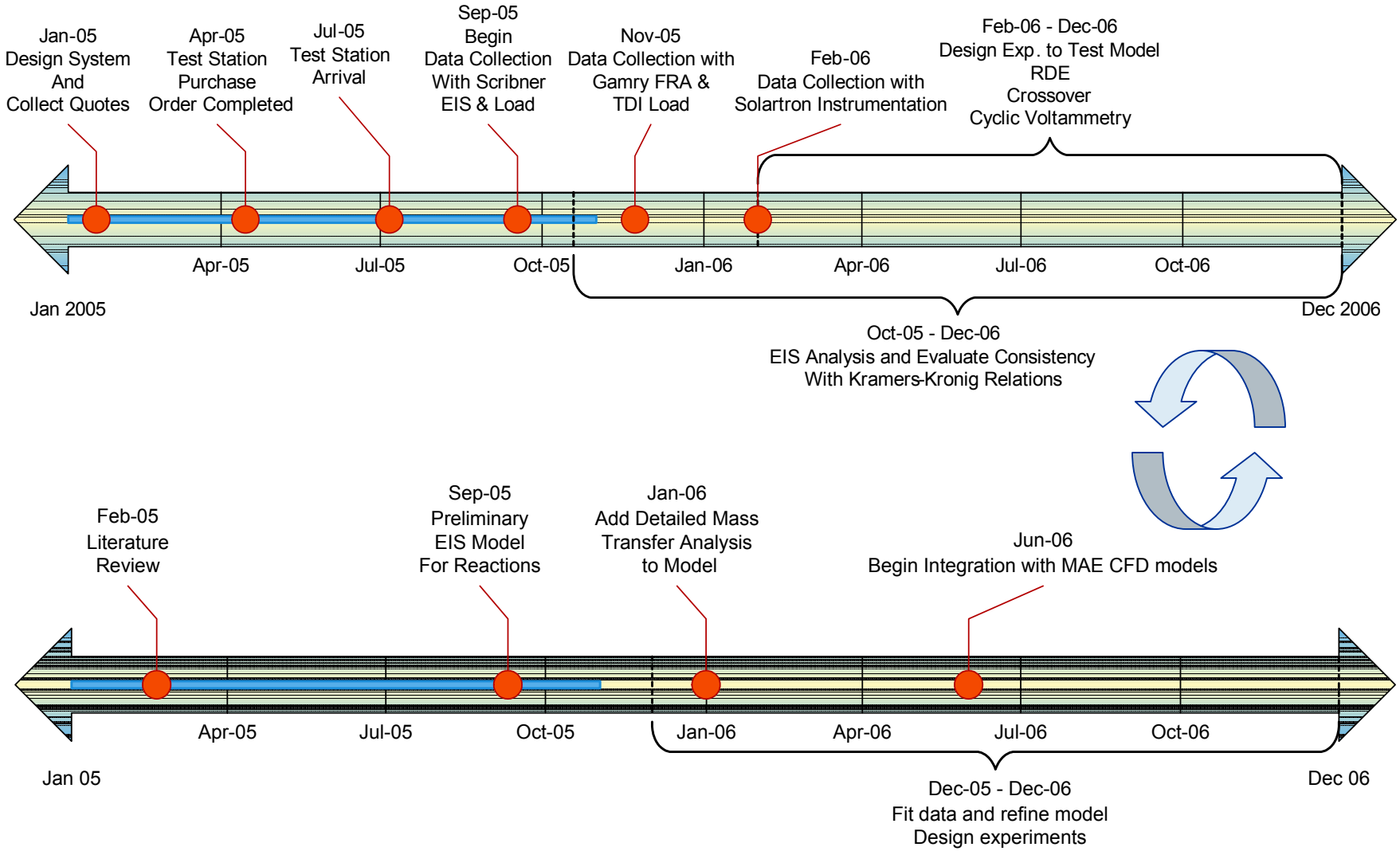
Nyquist Plot



Future Plans

- Refine Experimental Protocol
  - Reduce Problems Associated with water condensation
  - Implement New Load and Impedance System
  - Add capability for kinetic studies using ring-disk systems
- Continue Error Analysis Approach
  - Needed to guide experimental development
  - Needed for regression studies
- Integrate with Model development for Interpretation
  - Resolve artifacts using the Kramers-Kronig relations
  - Evaluate physical parameters (rate constants, diffusivities, film thickness) from process model.

Timelines


Jan-05
Design System
And
Collect Quotes
Apr-05
Test Station
Purchase
Order Completed
Jul-05
Test Station
Arrival
Sep-05
Begin
Data Collection
With Scribner
EIS & Load
Nov-05
Data Collection with
Gamry FRA &
TDI Load
Feb-06
Data Collection with
Solartron Instrumentation
Feb-06 - Dec-06
Design Exp. to Test Model
RDE
Crossover
Cyclic Voltammetry
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan 2005
Dec 2006
Oct-05 - Dec-06
EIS Analysis and Evaluate Consistency
With Kramers-Kronig Relations
Feb-05
Literature
Review
Sep-05
Preliminary
EIS Model
For Reactions
Jan-06
Add Detailed Mass
Transfer Analysis
to Model
Jun-06
Begin Integration with MAE CFD models
Apr-05
Jul-05
Oct-05
Jan-06
Apr-06
Jul-06
Oct-06
Jan 05
Dec 06
Dec-05 - Dec-06
Fit data and refine model
Design experiments