November 29th, 2007

Master Internship

Impedance spectroscopy for networks of dynamical systems and application to reduced modeling of fuel cell systems for supervision/diagnosis

The subject of this internship falls within the scope of a monitoring and diagnosis project for fuel cell systems in stationary applications. The purpose is to develop diagnosis methods with limited instrumentation, using the stack of electrochemical cells itself as a sensor. These techniques will be used either in real-time (coupled with the control system of the fuel cell), or during regular and scheduled maintenance phases. They will allow for reliability improvement and life duration increase, by anticipating the degradation effects.

The techniques developed are based on reduced models for monitoring/diagnosis: 0D models (ordinary differential equations) in time-domain and in frequency-domain for use in impedance spectroscopy (monitoring), and 1D models (partial differential equations with single space variable) for diagnosis. These models permit to describe the behavior during normal working conditions or in some degraded modes (CO poisoning, drying or water accumulation in the catalytic membrane).

In this context, the subject of the internship consists in the study of the equivalent stack impedance in the presence of various defects. These impedances, described by Nyquist loci, represent the data measured by impedance spectroscopy. The issues of identification, monitoring and diagnosis will be studied, based on these loci, measured or computed from the 0D and 1D models.

From a mathematical point of view, the stress will be put on aspects resulting from the organization of the stack as a network of dynamical systems (the fuel cells), and in particular to an approximate description of the dynamical behavior in periodic or almost-periodic regime. This description will permit to deduce from observations on the global behavior a more accurate vision of the state or of the ageing of the stack.

Prerequisites: The subject is at the boundary of Engineering and Applied Mathematics. A good background in at least one of the fields is welcome. Good skills in English are needed. Fluency in French is an advantage, but is not required.

The internship will last 6 months. It will take place in the team SISYPHE, at the research center of INRIA in Rocquencourt. INRIA, the French national institute for research in computer science and control, is dedicated to fundamental and applied research in information and communication science and technology (ICST). The research center of Paris-Rocquencourt is located about 20 km West from Paris. The team research activity, devoted to modeling, observation and control of dynamical systems, and to model-based signal processing, is motivated by applications in physiology, clinical practice or engineering.

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