PhiSimFuelCell
Model and simulate Fuel Cell Systems

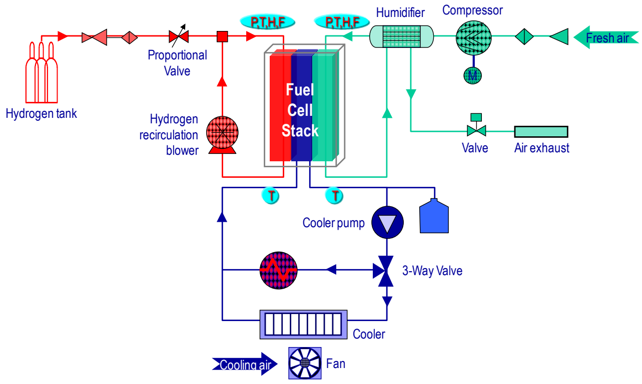
Introduction

PhiSimFuelCell extends Simulink® with tools for simulation and model-based design of Fuel Cell systems.

Based on a components library, it allows users to build a system model with its controller, and to validate its compliance with its performance and safety requirements.

PhiSimFuelCell can be used in several steps of a fuel cell system development cycle, such as:

- Subsystems network design and components choice
- Design, tuning and analysis of the control system
- Development of functional tests for the system



Fuel Cell System Configuration

Key Features

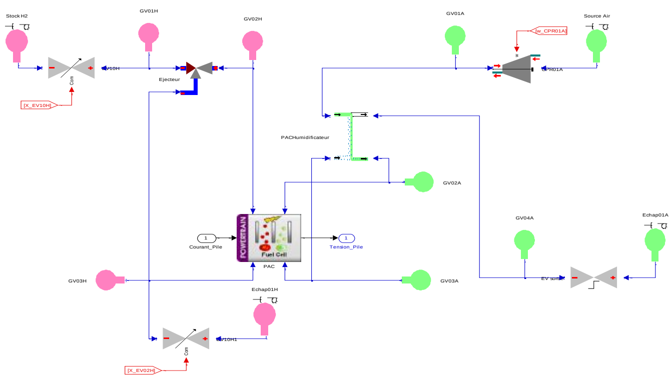
- Modeling and simulation of a Fuel Cell System using standard components
- Comprehensive block libraries for building detailed Fuel Cell subsystems (including air, H2 and cooling lines)
- Examples of a generic Control System easily adaptable to the system's architecture

Building Fuel Cell Systems Models

PhiSimFuelCell provides tools for building Fuel Cell systems models and their environment.

You can simulate the fuel cell system behavior and estimate the vehicle response to the driver demands.

Available subsystems are:



- A reduced model of the Fuel Cell Stack (including electrical, hydraulic and thermal equations)
- The hydrogen subsystem: hydrogen supply at required pressure and flow rate
- The air subsystem: air supply at required pressure, flow rate, temperature and humidity
- The cooling subsystem: guarantee adequate cooling of fuel cell stacks and ensure small temperature gradient across stacks

Model-Based Design for control system

PhiSimFuelCell provides control algorithms that let you quickly design the control system.

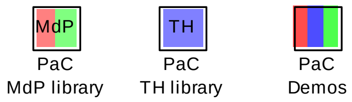
The library includes basic blocs (control and signal processing) and examples of control networks used with the fuel cell subsystems.

Sherpa Engineering develops a model based control of the fuel cell system. The model based control design approach consists on using a hierarchical decomposition of the system and, on the other hand, on using a model based predictive control methodology. MBPC allows users to handle in a straightforward way the multivariable interactive control problems.

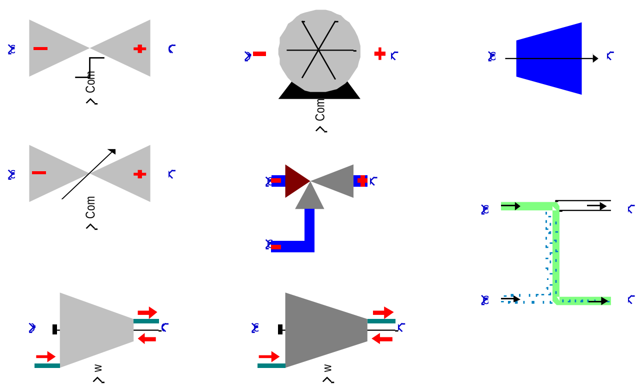
This modular and efficient approach is easily adaptable to different sorts of fuel cell systems or even to similar traditional systems (thermal management of a classic thermal engine ...).

The PhiSimFuelCell Block Library

The library is divided in three sublibraries:



- Thermo-fluid components: constant volume chamber, fixed or variable orifice ...
- Fuel Cell System components: Fuel Cell Stack and auxiliaries
- Design case studies: for each subsystem (H2, air, cooling) and for the global system. These models include the control system.



It provides a representative library of hydraulic, thermo-fluid blocks and phisical components:

- H2 subsystem: ejector, H2 pump, proportional valve, H2 tank ...
- Air subsystem: compressor, humidifier, pressure control valve ...
- Cooling subsystem: variable-speed electric pump, air-water heat exchanger, water reservoir, variable-speed fans ...

Main Characteristics

- The use of Phi-Graph concepts brings modularity and makes it easy to build subsystems
- Use of tables to determinate fluid properties
- Model based conception of the control system, in which the model becomes the control's main parameter; this approach makes control tuning much easier
- Use of Model Based Predictive Control techniques; this modular and extensible approach is easily adaptable to system's architecture evolutions

Upcoming Improvements

The improvements that will be available in the next version of PhiGraphFuelCell can be divided in three points:

- Enrichment of the model library with a reduced model of the electrical circuit (including a DCDC Converter, a battery...) and of the vehicle's chain traction. Additional components such as a butterfly valve and a motorized fan will also be developed
- Each component will come with a calibration function, capable of extracting model parameters from a constructor datasheet or experiments data. These functions will rely on the global identification method, and provide a degree of uncertainty on each obtained parameter, thus validating the coherence between the model and the available data
- Introduction of a fault diagnostic system with, on one hand, fault and failure simulation (sensor failure, hydrogen leakage...), and on the other hand, fault detection algorithms and associated reduced modes strategies

Required Products

MATLAB® and Simulink®

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