Instructions for Running the 500-W PEM Fuel Cell stack Dynamic Models Developed at the Department of Electrical & Computer Engineering, Montana State University

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As a part of an NSF grant, a physically-based dynamic model for a 500W PEM Fuel Cell (PEMFC) stack has been developed at Montana State University using MATLAB/SIMULINK. It is an autonomous model operated under constant channel pressure with no control on the input fuel flow into the fuel cell. The fuel cell stack will adjust the input fuel flow according to its load current to keep the channel pressure constant. An equivalent electrical circuit model for the same PEMFC stack has also been developed using PSPICE. Both models have been validated through experimental data obtained on a 500-W Avista (now Relion) PEMFC stack. The models can be used in studies related to PEMFC performance evaluation, controller design, fuel cell vehicle studies, and for developing models of high power PEMFC power plants, to name a few. The details of model development and its application in fuel cell distributed generation (FCDG) studies have been reported in the following papers.

C. Wang, M.H. Nehrir, and S.R. Shaw, "Dynamic Models and Model Validation for PEM Fuel Cells using Electrical Circuits," *IEEE Transactions on Energy Conversion*, Vol. 20, No. 2, June 2005, pp 442-451.

M.H. Nehrir, C. Wang, and Steven R. Shaw, "Fuel Cells: Promising Devices for Distributed Generation - Understanding Their Modeling and Need for Control," *IEEE Power Engineering Magazine*, Vol. 4, No.1, pp.47-53, Jan/Feb 2006.

We ask that those who use the models for research or education acknowledge their use when reporting their works. Although the models have worked successfully, it is understood that the users will use the models at their own will, and the above authors and Montana State University accept no responsibility regarding the operation of the models.

Step-by-step instructions for how to run the models are given below.

I. MATLAB/SIMULINK Model

- Steps to run the model
  1. Open the file ("PEMFC500W.mdl") in MATLAB/ SIMULINK.
  2. Set proper model input quantities. The load current can either be set explicitly, or be measured from an actual load and then be fed back to the model.
  3. Choose a proper solver and set the simulation time. The recommended solver for this model is "ode23tb". (Select the solver by clicking the "Simulation" on the menu and then selecting "Simulation parameters").
  4. Click "Start simulation" to run the model.

- Model Input Quantities:
  Fuel cell load current (A), I. The maximum current is 25A.
  Channel pressure at anode (atm), Panode
  Channel pressure at cathode (atm), Pcathode
  Room temperature (K), Troom
  Initial temperature of FC (K), Tinitial

- Model Output Quantities
  Output terminal voltage (V), V
  FC temperature (K), Tout

- Examples
  1. Before running the MATLAB/SIMULINK model, three example load current files need to be loaded into Workspace. To do this, one can just run the file "firstload.m" under the directory. It will load the three example files into the MATLAB Workspace.
  2. Of course, one can use whatever load current data wishes. But the load current is limited to less than 25A in this model. Fig.1 shows an example when a 10-ohm resistor is connected to the PEMFC model.
  3. One also needs to set proper simulation time. For the 3 examples, the simulation times are as follows: InputI_stdy_ideal: ideal fuel cell load current in steady state (Simulation length: 4900s); InputI_stdy: real fuel cell load current in steady state (Simulation length: 3900s); InputI-dynshrt4: real fuel cell load current in transient state (Simulation length: 2040s)

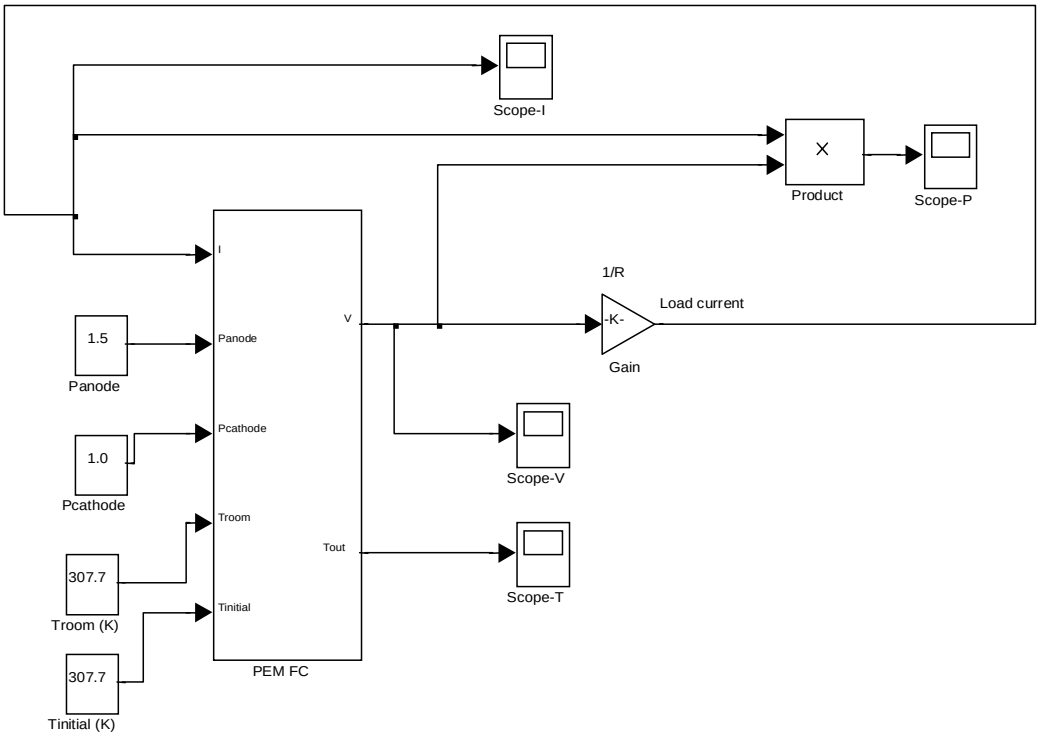

Fig. 1

II. PSPICE Model

- Steps to run the model
  1. Open the model file ("ETModel.opj") in Capture CIS (Version 10.0.0.p001).
  2. You will see a block named "PEMFC500". Connect the model in your simulation system properly. The fuel cell model block can be used as a regular PSPICE component. An example showing how to run the model is given below.

- Input Terminals:
  Room temperature: Troom. (Kelvin degree is presented in volts)
  Ground (see Fig. 2).

- Output Terminals
  Output terminal, Vout
  FC temperature, Tout (degree Kelvin is presented in volts)

♦ Example

An example system consisting of the above PSPICE PEMFC model, with a super-capacitor (the series combination of a large capacitor and a small resistor) connected across the PEMFC model output terminals, is given in Fig. 2. The load current is defined in a file named "iload_c". One can define whatever load current desired. One needs to make sure the load definition file is clearly specified in the system, otherwise one may get an error for finding the load file. One does not have to model the load as a current source, which is pre-defined by a file. For example, one can just connect the model to a resistor.

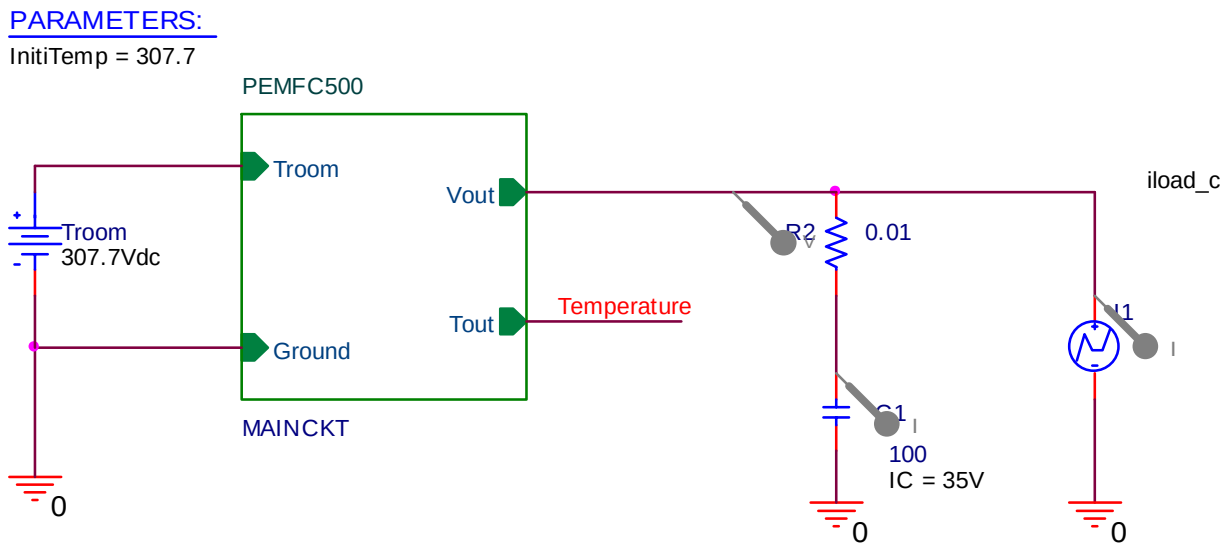

Fig. 2.

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Contact Information

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