High Power Fuel Cell Simulator Using an Unity Active Power Factor Rectifier

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Abstract.

Fuel Cells are energy sources that produce electrical energy from electrochemical energy. Some heat energy is also produced during the conversion. FC seems to be a clean and friendly with environment at the same time that shows a higher energy performance that other energy sources currently in use. Reduction in the use of fossil fuels and in CO2 production, braking of the climatic changes and a energy sustainable system are the main characteristics related with the use of FC. Hydrogen is seen as the fuel for the next future.

The cost of FC is nowadays high. The use of real FC in R&D laboratories demands some hardware around the FC unit: hydrogen tank, coolers, pressure regulators, installation of pipes for gases and liquids and so on. All these determining factors justify the development of FC simulators. These types of equipment show the same behaviour than real FC systems but are cheaper and its use requires fewer infrastructures. Some FC simulators are based in the use of a semi empirical equation. The evaluation of the semi empirical equation results in a voltage that is used as a reference voltage in the control circuit of a DC/DC switched converter. Other simulators model the semi empirical equation using resistances, inductances, capacitances and voltage sources, obtaining at the output a signal that reproduce the FC behaviour. This paper proposes a new FC simulation method based on a piecewise-linear equivalent model of the V/I curve in different regions. With this piecewise-linear equivalent model the behaviour of a stack is obtained.

The model obtained is used by the control of an active rectifier to produce in the dc output the FC stack behaviour. The DC energy needed in the output is obtained from the power network as three positive-sequence fundamental currents, working with a power factor near to 1 an introducing the minimum non active powers in the electrical system. Fig. 1 shows the block diagram of the applications described in the paper.The use of a three-phase system reduce the voltage ripple in the dc capacitor and allows to use a smaller capacitance, improving the dynamic response of the systems respect other system that uses conventional rectifiers to produce the dc output voltage.

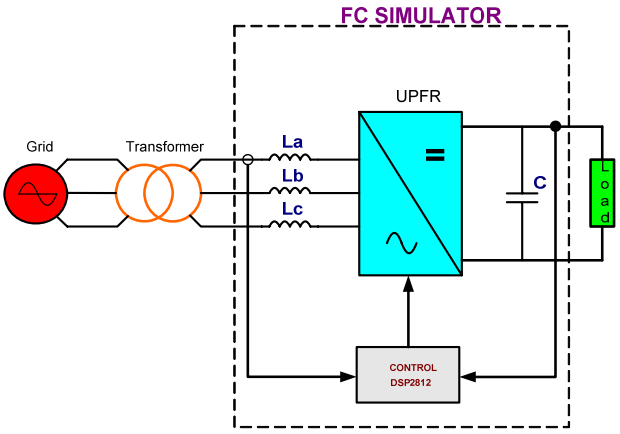

Fig. 1. Block diagram of the FC proposed system

In short, this paper proposes a high power fuel cell simulator built by means of an active power rectifier that works with unity power factor in the grid side. The Unity Power Factor Rectifier (UPFR) is controlled by a digital processor to produce in the dc terminals the electrical behaviour of commercial high power fuel cells (FC). The control used in the paper is based in the FC model developed in the paper. The UPFR control algorithms are explained in the paper and some simulated results are presented in the paper. The simulated results demonstrate the behaviour of the proposed system.