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An Application of Indirect Model Reference Adaptive Control to a Low-power Proton Exchange Membrane Fuel Cell

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Abstract

Nonlinearity and the time-varying dynamics of fuel cell systems make it complex to design a controller for improving output performance. This paper introduces an application of a model reference adaptive control to a low-power proton exchange membrane (PEM) fuel cell system, which consists of three main components: a fuel cell stack, an air pump to supply air, and a solenoid valve to adjust hydrogen flow. From the system perspective, the dynamic model of the PEM fuel cell stack can be expressed as a multivariable configuration of two inputs, hydrogen and air-flow rates, and two outputs, cell voltage and current. The corresponding transfer functions can be identified off-line to describe the linearized dynamics with a finite order at a certain operating point, and are written in a discrete-time auto-regressive moving-average model for on-line estimation of parameters. This provides a strategy of regulating the voltage and current of the fuel cell by adaptively adjusting the flow rates of air and hydrogen. Experiments show that the proposed adaptive controller is robust to the variation of fuel cell system dynamics and power request. Additionally, it helps decrease fuel consumption and relieves the DC/DC converter in regulating the fluctuating cell voltage.