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Dynamic Control of Fuel Cell Powered Water Pumping Station

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Recently a growing interest on utilizing renewable and green energy has been motivated by rapidly increasing oil prices, limited fossil fuel reserves and growing environmental green awareness. Renewable and green energy sources such as hydrogen, solar, wind, tidal and wave are all considered as alternative, renewable and green energy generation for replacement for fossil fuel oil, natural gas and coal. Hydrogen or hydrocarbons itself is clean, sustainable and emission free fuel. Full cells are now on the verge of being introduced commercially, revolutionizing the way we presently produce power. Fuel cells can use hydrogen as a fuel, offering the prospect of supplying the world with clean, sustainable electrical power.

A fuel cell by definition is an electrical battery cell, which unlike storage cells can be continuously fed with a fuel so that the electrical power output is sustained indefinitely. They convert hydrogen, or hydrogen-containing fuels, directly into electrical energy plus heat through the electrochemical reaction of hydrogen and oxygen into water. Because hydrogen and oxygen gases are electrochemically converted into water, fuel cells have many advantages over heat engines. These include: high efficiency, virtually silent operation and, if hydrogen is the fuel, there are no pollutant emissions. If the hydrogen is produced from renewable energy sources, then the electrical power produced can be truly sustainable. Currently hydrogen energy research is concentrating on the development of efficient and safe fuel cell technology. Enhancing the output efficiency and improving the performance of fuel cell are among main research topics.

An efficient renewable green energy system consisting a hydrogen PEM-fuel cell as an energy sources is simulated and studied in this paper. The proposed green scheme has four separate key components. The first is the green power generation source. The second is the interfacing DC-DC converter used to connect green power generator fuel cell to the load bus. The third is a common DC interface-bus where the generated energy is collected in a DC form. The fourth comprises all interfacing error driven controllers and novel modulated green plug power filter (GPPF) used to reduce ripple variations and stabilize the common DC-Bus voltage. In this paper, the novel multi-loop error driven dynamic controller scheme is implemented for speed control of the PMDC motor. This multi-loop controller comprises three basic loops, the main speed tracking loop, the motor current dynamic loop, and the supplementary dynamic momentum loop to ensure fast dynamic and minimum current and torque ripple content.

The proposed fuel cell generation scheme provides efficient and optimum dynamic operation to enhance system performance and secure energy supply. The proposed integrated hybrid system with all subsystems has been simulated using the Matlab Simulink/Sim-Power software environment and validated for voltage stabilization, efficient utilizations and enhanced power quality under different operating conditions, sudden load excursions, despite the non-linear volt-ampere characteristic of the fuel cell DC generator source..

Key words:

Multi-loop dynamic control, fuel cells, PMDC motor drive, DC-DC-chopper, green plug power filter