Fuzzy multi-objective technique combined with VCS algorithm for unified power quality conditioner based on hybrid power source PEMFC/SC

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ABSTRACT
This paper is proposed to establish an optimal control method for UPQC (Unified Power Quality Conditioner) to improve power quality and manage effectively equal power sharing between shunt and series inverter of UPQC under electrical faults condition. The UPQC is modeled to protect sensitive load from source side voltage disturbances under nonlinear load conditions. A hybrid power generator that integrates a proton exchange membrane fuel cell (PEMFC) as the main energy source and a super capacitor (SC) as secondary source is proposed to feed the FACT device. In this work, a new control strategy is presented for considering the voltage sag, power factor and total harmonic distortion (THD) as multi-objective of UPQC controller. For this purpose, a new powerful algorithm named virus colony search (VCS) is used for determining the coefficients of the PI controller of UPQC. By using the fuzzification process for the objectives function, a suitable fitness function is established for the optimization method. From the simulations, it can be seen that the results obtained by the proposed algorithm are best and attractive compared to other method. Consequently, the proposed strategy is effective and outstrips other strategies.

Introduction
Currently the demand for stable and high quality electrical power has been increased considerably regarding to the progressive uses of semiconductor devices for different applications, such as uninterruptible power supply systems, computer processors, lighting and adjustable speed drivers. These nonlinear loads can draw non-sinusoidal current and voltage and result harmonic distortion in power systems. Consequently, all electrical and electronic equipment irrespective of its sensitivity might suffer due to degrading power quality. Moreover, due to sudden load activation and load shedding, voltage unbalancing among the three phases occurs at the common coupling point. Maintaining a steady state voltage is a major factor that can affect the consumer loads [1–2]. Power quality has become an important issue in differentiating between successful utilities in the power system specially deregulated environment. Relevant researches demonstrate that the Unified Power Quality Conditioner (UPQC) is an affordable custom power device employed at the point of common coupling (PCC) to protect the load from the
The structure of UPQC in simple terms has a power quality conditioner (UPQC) that can be used for power quality problems through electrical networks. The topology of a unified power quality controller (UPQC) has presented the topology and the control of a unified power quality controller (UPQC) extending its capability in power quality. Ch.sumanthiana rani [6] has explained a three-phase UPQC based on hybrid power source PEMFC/SC, International Journal of Hydrogen Energy (2018), https://doi.org/10.1016/j.ijhydene.2018.01.149

Optimization is the process of searching for the global optima of a problem under a given circumstance. The Virus colony search (VCS) has been recognized as a powerful and efficacious technique to solve complex problems. In addition, the VCS offers competitive solutions compared with other metaheuristic optimizers based on the reported results of series of classic benchmark functions [11]. Improving voltage THD and power factor indexes have been reflected as an objective function. Though, algorithms with high level of complexity have been used which may have problems in real-time implementation. In order to use stable controllers in the system, it should react in instantaneous to different faults conditions in the best way. In this paper, a multi-objective control structure is proposed to obtain an appropriate performance in term of sensitive load harmonic current, voltage sag and THD [36]. During this work, a new nature-inspired algorithm for optimization (VCS) is introduced and discussed. It will be shown that proposed approach can be effective for controlling UPQC based hybrid PEMFC/SC. To evaluate the performance of the proposed optimal controllers, the results are compared with those obtained by regulating PI’s coefficients with multi-objective DE and PSO algorithm.

Renewable energy policy has become an essential ingredient of social and economic development plans in the world due to the deficiency of fossil fuel and CO2 emission reducing [12,13]. The electrochemical energy is an alternative power source, more environmentally friendly. Systems for electrochemical energy storage and conversion include fuel cells, super capacitors and batteries. High power and high energy can be well achieved when two or more electrochemical systems are combined. In such hybrid electrochemical schemes, super capacitors provide high power while the fuel cells provide high energy [14]. The PEMFC/SC hybrid power source is emerging as an economically viable option for providing UPQC systems, which play a very important role as the backup and emergency power supply for important applications.

The recap of this paper is organized as follows:
- Section Introduction reviews the introduction to hybrid energy source PEMFC/SC for UPQC system.
- Section UPQC structure description configuration shows the UPQC structure description.
- Section Modeling of hybrid power source shows hybrid power source modeling.
- Section Basic concepts and structure approach of UPQC Basic concepts and the structure approach of UPQC.
- Section Objective functions shows objective functions.
- Section VCS algorithm for optimization problem describes VSC algorithm working.
- Section Proposed approach show proposed method.

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