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# Fuzzy Neural Network-Based Dynamic Voltage Restorer for Regulation of Voltage Quality

With the development of renewable energy and smart grid, the power quality has become an important issue for system operation. Among the numerous power-quality disturbances, the sag, swell, and interruption related to the voltage quality are the main factors for system stability. Dynamic Voltage Restorer (DVR) is mainly designed for solving the sag or swell phenomenon which may also accompany with other voltage quality problems on the distribution line or microgrid system. To deal with the single or multiple phase voltage magnitude variation as well as some power quality problems, a three-phase four-wire inverter is adopted in this paper. As the voltage event happens, DVR must detect the voltage magnitude and phase, compute the appropriate quantity which is needed to be compensated, and then restore the load voltage to pre-sag condition as soon as possible. The basic operating principle of DVR is displayed in Fig. 1 [1]-[3].

Fig. 1. Basic operating principle of DVR.

Many useful techniques have been proposed in the literature. A voltage sag detection technique detects the occurrence of the sag, sag depth (magnitude to be restored), and phase shift has been proposed in [4]. Common voltage sag detection techniques, such as the peak value method and Root Mean Square (RMS) method, keep calculating the magnitude of the source voltage is also addressed in [4]. And the Fourier Transform is another approach to perform voltage detection through orthogonal decomposition of the power system signal. It is possible to obtain not only the magnitude but also the phase of each frequency component in the source side voltage signal. However, these afore-mentioned methods all need some response time, which is more than a half period to derive an accurate measurement. In this way, it is difficult to apply these techniques in DVR due to the demand of the immediate compensation. Space vector method is a better choice. With the Clarke's transform (alpha-beta) and Park's transform (d-q), three-phase AC voltage signals are transformed to two DC values which represent magnitude and phase information respectively. Then, it would be easier to detect the magnitude variation just in one sampling time. For this great advantage, the space vector method is almost applied in DVR system nowadays.

In addition, the compensation strategy is another crucial part in the DVR design. It is relative to the operation and performance of DVR. In this paper, the fuzzy neural network-based control strategy is proposed to deal with voltage compensation under the disturbances of phase jump, unbalanced sag/swell, frequency deviation, flicker, and so on. In order to verify the performance of proposed design of DVR, the simulations are carried out by software (Matlab/Simulink). From the simulation results, it is realized that lots of voltage quality problems can be effectively improved and the load voltage can be maintained to a standard level with the implemented method, as shown in Figs. 2 and 3.

Fig. 2. Unbalanced sag: (a) Source side voltage. (b) Load side voltage. (c) Source side voltage RMS value. (d) Load side voltage RMS value. (e) DVR compensation waveform.

Fig. 3. Flicker: (a) Source side voltage. (b) Load side voltage. (c) Source side voltage (13.32%). (d) Load side voltage (1.243%). (e) DVR compensation waveform.

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