



Improved Synchronous Reference Frame based controller method for multifunctional compensation



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ABSTRACT

In this paper, a novel reference generation method based on Improved Synchronous Reference Frame (ISRF) is presented for Dynamic Voltage Restorer (DVR). This method is applicable for both single phase and three phase systems in order to compensate unbalanced voltage sag/swell and unbalanced voltage harmonics at the same time. To reduce the drawbacks of Conventional SRF and Symmetrical components based SRF (SCSRF), ISRF is proposed in this paper for compensation of unbalanced voltage sag/swell and harmonics. In this paper, the compensation of 50% voltage sag and 25% voltage swell is performed in addition to unbalanced voltage harmonics. Performance results of proposed method show good robustness and faster detection for balanced/unbalanced voltage sag/swell/harmonics compared with SCSRF. By the proposed method, total harmonic distortion is reduced to values which are fairly less than the limits defined in IEEE 519 Standards.

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1. Introduction

Voltage sag/swell and harmonics are defined as the most hazardous disturbances in distribution systems. These disturbances cause several serious problems such as equipment failure and economical loss in critical loads. Voltage disturbances can disturb the operation of sensitive loads like regulation devices, computer hardwares and monitoring devices. Among voltage disturbances, voltage sag is defined as short duration reduction in rated voltage magnitude between 10% and 90%. On the other hand, voltage swell is determined as short duration rise in magnitude to 110% and 190% of its rated value. The duration of voltage sag/swell varies from half-period to 1 min in IEEE 519 standards [1,2]. Voltage harmonics are defined as a distortion in voltage waveform due to integer multiple components of fundamental voltage frequency. To compensate these voltage quality problems, inverter based Custom Power Devices (CPDs) are applied in distribution systems, where series active power filter, Dynamic Voltage Restorer (DVR) and D-Statcom are the most widespread used CPDs. DVR is the most effective inverter based device which eliminates voltage disturbances among CPDs.

DVR is a series connected device between sensitive load and grid in distribution systems [3–5]. Its main components are an inverter, energy storage unit, output filter and injection transformer. Inverter generates controlled voltage to compensate voltage sag/swell and harmonics. The controlled voltage is injected to the grid through transformer [6–8]. Conventional DVR structures are only applied to compensate voltage sag/swell in distribution systems. In addition to voltage sag/swell compensation, voltage harmonics have been recently compensated through DVR. DVR is known as “multifunctional DVR” in studies if it achieves the compensation of both voltage sag/swell and voltage harmonics

Table 1 presents the compensation capabilities of multifunctional DVR studies in Refs. [8–19]. In Refs. [18,19], voltage sag/swell and only balanced voltage harmonics are eliminated. Conventional SRF (CSRF) theory [18] and perceptron based control algorithm [19] are used to generate reference signal for multifunctional DVRs. There is no study that investigates the simultaneous compensation of both unbalanced voltage sag/swell and harmonics. Therefore, this paper proposes a novel controller which performs the compensation of unbalanced voltage sag/swell and unbalanced voltage harmonics components.

This paper introduces a novel reference signal generation method based on Improved SRF (ISRF) so as to compensate both balanced/unbalanced voltage sag/swell and balanced/unbalanced voltage harmonics by multifunctional DVR in distribution systems.

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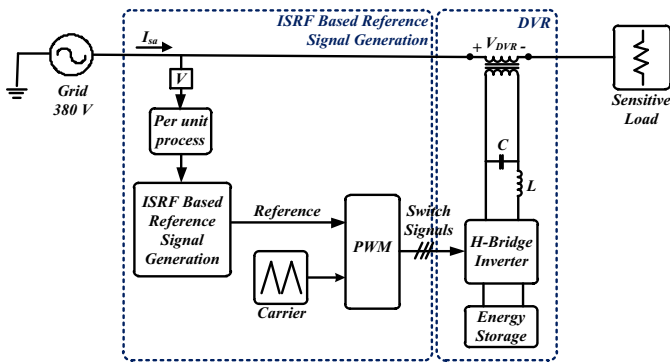


Fig. 1. The system configuration for multifunctional compensation.

- The proposed method is performed for the first time to compensate both balanced/unbalanced voltage sag/swell and all components of balanced/unbalanced voltage harmonics, simultaneously.
- A fast detection algorithm based on ISRF is also presented for voltage sag/swell.
- The compensation capability of the system is rated as 50% voltage sag, 25% voltage swell and 14.12% total harmonic distortion (THD) in voltage. THD level of system voltage is reduced to 2.84% from 14.12% by proposed ISRF based controller method while voltage sag/swell is compensated in system.

ISRF is a more accurate and fast method compared to CSRF and symmetrical components based SRF (SCSRF) methods.

This paper has novel contributions in DVR and has the following purposes:

In the arrangement of this paper, theoretical background of ISRF is presented in Section 2. Besides, proposed controller method is compared with other SRF methods. Section 3 introduces the performance results of proposed reference generation method in multifunctional DVR. In Section 4, the significant results are briefed in conclusion.

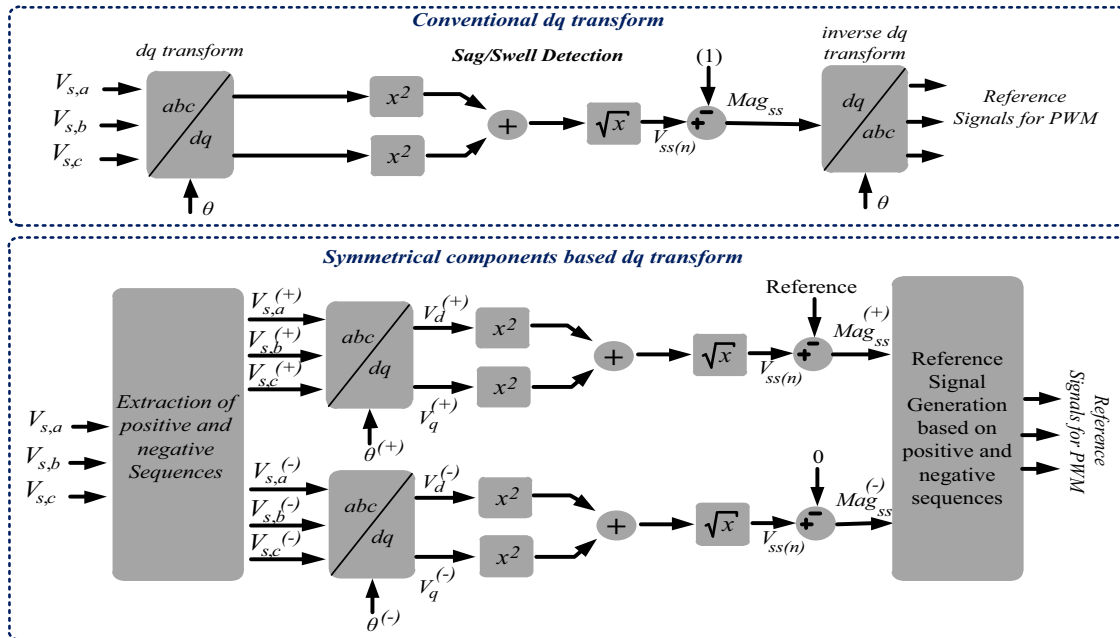


Fig. 2. Conventional SRF and SCSRF based voltage sag/swell detection algorithms.

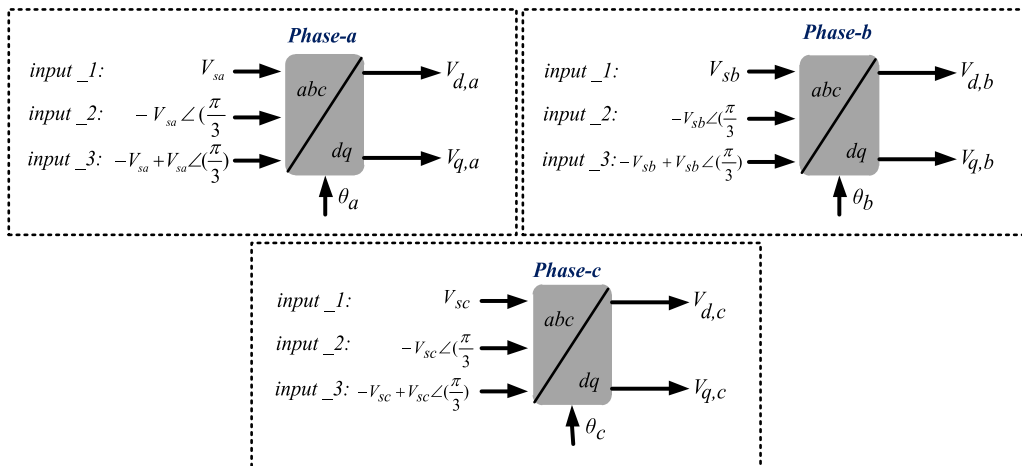


Fig. 3. ISRF based dq transform.

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