International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 12
April 2018

Mitigation Of Voltage Sag, Swell And Thd Using Dynamic Voltage Restorer With Photovoltaic System

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ABSTRACT

The most severe power quality problems are known as voltage sag, swell and harmonics. Series connected custom power device called as dynamic voltage restorer (DVR) is the most effective device used in electrical systems to compensate these power quality problems.

Traditional DVR compensates only voltage sag/swell in electrical grids. The main contribution of this paper is that FFT based a novel reference generation method is used in DVR to compensate unbalanced voltage sag/swell and unbalanced voltage harmonics, simultaneously.

In this study, FFT achieves both voltage sag/swell detection and voltage harmonics extraction at the same time. FFT controlled DVR compensates voltage sag/swell within 5 ms while unbalanced selective voltage harmonics (5th, 7th, 11th and 13th) are compensated in the system, simultaneously. The system is analyzed for various case studies. The performance of proposed controller method is presented and confirmed through simulation results using PSCAD/EMTDC.

INTRODUCTION

Voltage sag/swell and voltage harmonics are the most harmful power quality problems which distort voltage waveforms. Voltage sag and swell are voltage variation problems in the rms value of grid voltages. Voltage sag is defined as reduction of voltage amplitude between 10% and 90%. Voltage swell is known as an increase if voltage amplitude greater than 10%. The interval of these variations changes from half period to 1 minute. Voltage harmonics is described as a distortion of voltage at an integer multiple of fundamental frequency. These power quality problems cause equipment failure, economical loss and several negative effects in distribution systems. The voltage waveforms of these disturbances are presented. Several custom power devices are used to solve these problems in an electrical grid. The most well-known systems are Dynamic Voltage Restorer (DVR), Series Active Power Filter (Series APF), Static

Compensator (STATCOM), Uninterruptible Power Supply (UPS) to compensate voltage disturbances in distribution systems. DVR is one of them which is series connected between load and grid, and injects controlled voltage to compensate voltage sag/swell and voltage harmonics in the system.

But, in these studies, grid side voltage sag/swell and load-side voltage harmonics are analyzed in performance results. In this paper, FFT is used to fulfill both voltage sag/swell detection and voltage harmonics extraction at the same time. FFT controlled DVR compensates voltage sag/swell within 5 ms while selective voltage harmonics (5th, 7th, 11th and 13th) is compensated in the system, simultaneously.

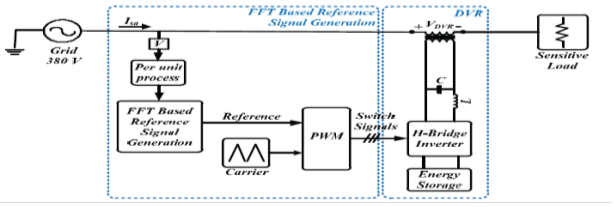
The traditional DVR is mainly designed to compensate for the voltage sag, which provides a good solution for those application environments with simple power quality issues.

The DVR can effectively suppress all these problems, the promotion and the assembly of a high voltage and a large capacity DVR is particularly urgent, and a multilevel DVR is becoming a focus point now. While DVR absorbs real power from battery to compensate voltage sags in the system, voltage swell causes the continuous rise at dc-link capacitor voltage.

This

PROPOSED SYSTEM

The conventional DVR and applied FFT based controller method. DVR is located in the front of sensitive load to mitigate negative effects of voltage disturbances at grid-side. Reference signal generation is the most significant subject to compensate voltage sag/swell/harmonics fast and accurately. In DVR controller mechanism, grid side voltages are measured against voltage sag/swell. Firstly, all voltage signals are converted to per unit (Pu). Then the fundamental voltage and selective harmonic signals are obtained by using FFT method. In next step, reference signal is acquired via fundamental voltage and selective harmonic signals. In final process, reference signal is compared to a carrier signal for switching inverter gates.



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Conventional DVR and applied proposed reference signal generation method

The conventional DVR and applied FFT based controller method. DVR is located in the front of sensitive load to mitigate negative effects of voltage disturbances at grid-side. FFT provides to generate reference signals rapidly in addition to extraction of selective voltage harmonics. It is a faster process of discrete Fourier transform (DFT) because of reducing complex calculations in less time. In this study, 1024 samples are used in a period, and thus radix- 2 FFT algorithms is applied.

The most widespread algorithm is Cooley-Tukey algorithm dividing DFT into pieces .According to Cooley-Tukey algorithm, FFT form of the grid voltage is

$$V[k] = \underbrace{\sum_{n=0}^{\frac{N}{2}-1} v(2n) W_{\frac{N}{2}}^{nk}}_{V_{even}(k)} + W^k \underbrace{\sum_{n=0}^{\frac{N}{2}-1} v(2n+1) W_{\frac{N}{2}}^{nk}}_{V_{odd}(k)}$$

where, $Wk = e- j2\pi k / N$. *'k'* is harmonic frequency index and '*N*' is number of samples. where, *Vm* and θ are the magnitude and phase angle of *kth* harmonic, respectively FFT based reference signal generation method is shown in Fig. 3. FFT extracts all harmonics components in the system.

$$SS_{depth} = \left|1 - Mag_{RMS}\right|$$

Therefore, reference signal for voltage sag/swell (Refss) is calculated as:

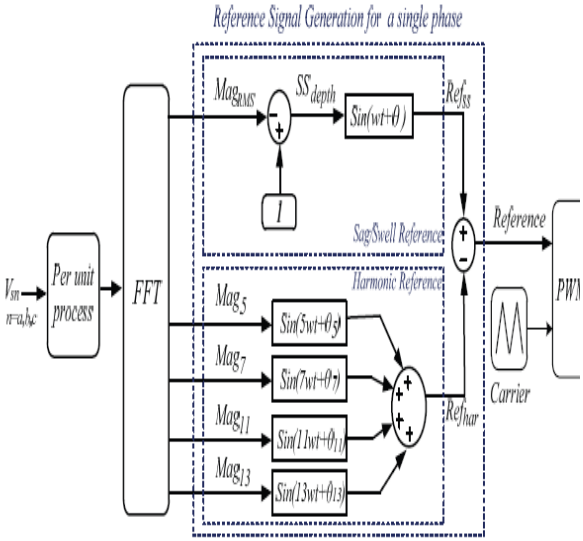
$$Refss = \left|1 - Mag_{RMS}\right| Sin\ (wt + \theta)$$

In generation of reference signal of voltage harmonics, the selective components (5th, 7th, 11th and 13th) for each phase are extracted using FFT, separately. The sine function of each selective component at its integer multiple of fundamental frequency gives reference signal of selective harmonics component.

The sum of all selective harmonic components creates harmonic reference signal (Refhar). Harmonics compensation is achieved with injection of inverse voltage. Therefore, final reference signal is the sum of *Refss* and inverse of Refhar.

$$Reference = Ref_{ss} - Ref_{har}$$

$$= (1 - Mag_{RMS}) Sin(wt + \theta) - \sum_{n \subset M} Mag_{har,n} Sin(wt + \theta_n)$$



Proposed FFT based reference signal generation method to compensate simultaneous voltage sag/swell and selective voltage harmonics.

CONCLUSION

In this paper, a novel FFT based controller method is first approach to compensate simultaneous unbalanced voltage sag/swell and unbalanced selective voltage harmonics at grid side voltage. In order to verify the effectiveness of proposed controller, the system is tested for different case studies. By this way, 30% voltage sag, 25% voltage swell and unbalanced selective voltage harmonics which are 5th, 7th, 11th and 13th are compensated in this study. According to simulation results, the proposed study achieves good performance in voltage harmonic elimination which reduces THD from 12.78% to 2.16% in addition to voltage sag/swell compensation at grid side voltages.

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