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Voltage unbalanced compensation using dynamic voltage restorer based on supercapacitor

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ABSTRACT

This paper presents the analysis and design of a three phase four wire Dynamic Voltage Restorer (DVR) based on supercapacitor as energy storage for power quality improvement in electrical distribution system. The proposed system comprises of a supercapacitor as energy storage, DC–DC converter, and the power circuit of the DVR. It involves the construction of the proposed DVR topologies consists of filtering scheme, isolation or distribution transformer, injection transformer and Voltage Source Inverter (VSI). The main aims of this paper covers design, modeling, construction and testing of a laboratory DVR prototype for a three phase four wire system. This system is capable to mitigate voltage disturbances at low voltage distribution system. The implementation of supercapacitor as an energy storage is to supply real power to the inverter during disturbances. The experimental results of the prototype were also illustrated. The controllers based on d–q–0 transformation technique and Proportional Integral (PI) was applied to the DVR. The proposed controller was then coded into a digital signal processor (DSP) TMS320F2812 board. The proposed system is verified through simulation and is implemented in a prototype, and the experimental results are compared.

1. Introduction

Consideration of power quality is one of the most important aspects at both transmission and distribution levels. Power quality can be defined as the delivery of sufficiently high-grade electrical services to the consumer or customer. High quality supply must be at rated frequency. Power quality problems in the present day distribution systems are addressed in the literature [1–5] due to the increased use of sensitive and critical equipments in the systems such as communication system, process industries precise manufacturing processes which is one of the important factors in the degradation of power quality.

According to [6] described power quality disturbances as transients, momentary interruptions, voltage sags, voltage swells, under voltage, overvoltage, harmonics distortion, electrical noise, flicker and voltage imbalance. There are various solutions to overcome these problems. One of the most effective solutions is the installation of a Dynamic Voltage Restorer (DVR) [7–10]. The DVRs can be used to mitigate voltage disturbances by injecting an appropriate voltage in series with the grid voltage in order to avoid a loss of power [11–14]. Normally the DVR maintains the load voltage at its a nominal magnitude and phase by compensating the voltage sag/swell, voltage unbalance and voltage harmonics presented at the point of common coupling [13,15,16].

Fig. 1, where the DVR consists of essentially a series connected injection transformer, a Voltage Source Inverter (VSI), inverter output filter and an energy storage device connected to the dc-link. The power system upstream to DVR is represented by an equivalent voltage source and source impedance. The disturbances correction capability of the restorer depends on the maximum voltage injection capability of the device.

The objectives of this paper are to design and implement of a three phase four wire DVR for power quality improvement in low voltage distribution system. The main aims of this paper is to cover the design, modeling, construction and testing of a laboratory DVR prototype, rated for a three phase four wire system capable of mitigating voltage disturbances supporting three phase load up to 5 kVA. The proposed system comprises of a supercapacitor as an energy storage, DC–DC converter, and the component of DVR. The DVR components consists of a three phase inverter, filtering scheme and its controller. Digital signal processing (DSP) was used in order to produce the required control to DC–DC boost converter and Voltage Source Inverter (VSI).

2. Three phase unbalance voltage sag

When there is a disturbance in the distribution system, the three-phase supply voltage generally becomes unbalanced with

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