Available online at www.sciencedirect.com
SCIENCE DIRECT®
Simulation Modelling Practice and Theory 14 (2006) 112–125
SIMULATION MODELLING PRACTICE AND THEORY
www.elsevier.com/locate/simpat

Verification of a new energy control strategy for dynamic voltage restorer by simulation

M.R. Banaei [a,*], S.H. Hosseini [a], S. Khanmohamadi [a], G.B. Gharehpetian [b]

[a] *Electrical Engineering Department, Tabriz University, Tabriz 51664, Iran*
[b] *Electrical Engineering Department, Amirkabir University of Technology, Tehran 15914, Iran*

Received 17 March 2004; received in revised form 1 February 2005; accepted 7 March 2005
Available online 29 April 2005

Abstract

To restore the load voltage, dynamic voltage restorer (DVR), which installed between the supply and a sensitive load, should inject voltage and active power from DVR to the distribution system during voltage sag. Due to the limit of energy storage capacity of DC link, it is necessary the minimize energy injection from DVR. In this paper the techniques of the supply voltage sag compensation in a distribution feeder are presented. In addition, a new concept of restoration technique is suggested to inject minimum energy for a given apparent power of DVR.

Simulation results carried out by PSCAD/EMTDC[1], verify the efficiency of the proposed method.

Keywords: Power quality; Dynamic voltage restorer; Control strategies; Minimal energy control

* Corresponding author. Tel.: +98 9143134864; fax: +98 411 3300819.
E-mail address: banaei_mohamad@yahoo.com (M.R. Banaei).

[1] Power Systems Computer Aided Design/ElectroMagnetic Transients including DC.

1569-190X/$ - see front matter
doi:10.1016/j.simpat.2005.03.001

1. Introduction

One of the most important power quality issues is voltage sags. The increasing usage of voltage sensitivity devices has made industrials processes more susceptible to supply voltage sags [1]. Voltage sags may cause equipment tripping, shutdown for the domestic and industrial equipment, and miss-operation of drive systems. When a fault occurs in the system, the customer voltage drops below its nominal value on one or more phases. Voltage sags of down to 70% are much more common than complete outages [2]. Dynamic voltage restorer (DVR) with energy storage can be used to correct the voltage sag at distribution system [3–7]. A DVR is basically a controlled voltage source installed between the supply and a critical and sensitive load. It injects a voltage on the system in order to compensate any disturbance affecting the load voltage. The compensation capacity of a particular DVR depends on the maximum voltage injection ability and the active power which can be supplied by the DVR. When DVR restorers voltage disturbances, active power or energy should be injected from DVR to the distribution system. DVR could maintain load voltage unchanged during any kind of faults, if the capability of energy storage of DVR were infinite [4]. Energy storage devices, such as batteries or super-conducting magnetic energy storage systems (SMES) are required to provide active power to the load when voltage sags occur. Because of the energy limitations of these devices, it is necessary to minimize energy injection from DVR.

In this paper the techniques of restoring voltage sag are discussed and then, a new concept of voltage restoration is proposed. The simulations carried out by PSCAD/EMTDC [8] show the capability of proposed technique.

2. DVR in distribution system

The main function of a DVR is the protection of sensitive loads from voltage sags coming from network. Therefore, as shown in Fig. 1, the DVR is located on approach of sensitive loads. If a fault occurs on other lines, DVR inserts series voltage, V_{dvr} and compensates load voltage to pre fault value.

When earth faults occur on the higher voltage level of a delta-star transformer, zero-sequence voltages will not propagate through the transformer. Therefore, only restoration of positive sequence and compensation of negative sequence voltages are necessary [6]. As shown in Fig. 1 the main elements of the DVR are the energy storage system, the voltage source converter, the LC filter and the coupling transformers.

3. Conventional control strategies

Several control techniques have been proposed for voltage sag compensation such as pre-sag method [6], in-phase method [6] and minimal energy control [3,4].

It must be said that the characteristics of the sensitive load determine the control method and the compensation strategy for the DVR. For example, the linear loads are not sensitive to phase angle jump and only magnitude of voltage is dominant.