Role of Dynamic Voltage Restorer (DVR) in Smart Grid

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Abstract- *This document mainly deals with the Dynamic Voltage Restorer (DVR). The Dynamic Voltage Restorer (DVR) is the most efficient and effective modern custom power supply device used in power distribution networks. Its attractiveness includes lower costs, smaller size and a quick dynamic response to noise. The power quality of electricity is one of the main concerns. This has become particularly important with the introduction of sophisticated devices, whose performance is very sensitive to the quality of the power supply. Distribution networks, sensitive industrial loads and critical commercial operations suffer from various types of outages and business interruptions that can cause significant financial losses. With the restructuring of power systems and the trend towards decentralized and distributed energy generation, the issue of energy quality will take on new dimensions. Now a daily smart grid is the best solution to all power quality problems.*

Keywords- Power Quality, Smart Grid, Voltage sags /swells, Facts, DVR

I. INTRODUCTION

The term "smart grid" generally refers to an electricity grid equipped with advanced technologies designed for purposes such as improving reliability, easy control and management, the integration of distributed energy resources and the functioning of the electricity market. Improving power reliability for end users is one of the main goals of using intelligent network technologies. Modern industrial plants are more sensitive to problems with power quality such as voltage drop, voltage swell, interruptions, harmonics, flickering and pulse transients. Failures due to these disruptions have a major impact on production costs [1].

High quality energy is a basic requirement for highly automated industries today. The electricity industry is ready to transition from a centralized network controlled by the manufacturer to a less centralized and more interactive one for the consumer. Moving to a smarter network promises to change the overall business model of the sector and its relationships with everyone involved, including utilities, regulators, energy providers, technology and automation providers, and all electricity consumers [1-4].

As an automated and distributed power distribution network, the intelligent network has a mutual flow of electricity and information and can monitor everything from power plants to customer preferences to individual devices. Integrate the benefits of distributed computing and communication into the network to provide real-time information and an immediate balance between device and demand. An intelligent network uses digital technology to improve the reliability, safety and efficiency of the electrical system.

The organization of this document is as follows. Section II presents the driving forces for smart grid technologies. Section III presents the key elements of the smart grid and their applications, e.g. the uninterruptible power supply (UPS), the adaptive var compensators (AVC), the synchronous static compensator (STATCOM) and the dynamic voltage recovery (DVR). the quality of the uniform energy transfer technologies of the air conditioning system (UPQC), the micro network, the generation of solar and wind energy and high-voltage direct current (HVDC). Section IV contains the circuit diagram of the DVR. Section V control algorithm. Section VI concludes this document.

The Driving Forces of the Smart Grid

The Smart Grid (SG) is the next generation intelligent electricity grid that optimizes energy efficiency to integrate information technology into the existing grid and exchange information in real time between electricity suppliers and customers.

In addition, Smart Grid is an integration of electrical and IT infrastructures as well as the integration of automation and information technologies into our existing electrical network. Offers complete solutions that improve power supply reliability, operational performance and overall productivity of the energy supplier, increase energy efficiency and reduce CO2 emissions and offer consumers the opportunity to control

energy consumption and save money without compromising their lifestyle.

In addition, Smart Grid is also the solution that can optimize the integration of renewable energies and allow a wider penetration. In summary, Smart Grid is the infrastructure that offers significant, measurable and sustainable benefits to energy suppliers, consumers, the economy and the environment.

Facts Devices for Smart Grid

Fig.1 shows the FACTS devices which can be utilized to adjust power flow of the transmission and distribution systems.

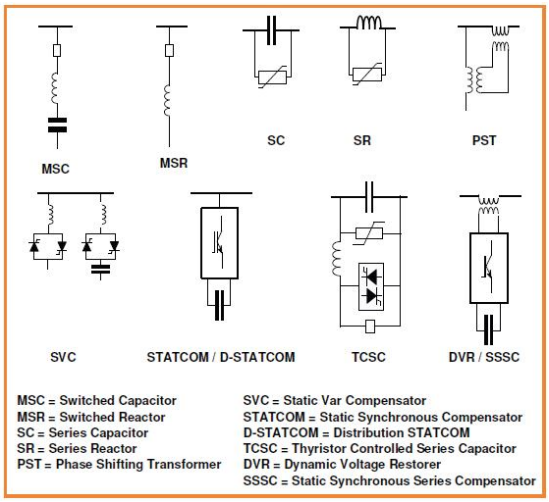

Fig.1 FACTS devices to improve system stability and reliability

Mechanical switched capacitors (MSC) are used for high-voltage transmission systems to provide capacitive reactive power and thereby increase the power factor. In addition, mechanical switching reactors (MSR) are used to absorb excessive capacitive power from the distribution network, which is normally installed in 110 kV and 35 kV distribution systems, to reduce the low load phenomenon at night. Series capacitors (SC) and series reactors (SR) are installed in series with the transmission line to adjust the effective electrical impedance of the network.

Phase shift transformers (PST) are used in distribution systems to modify the phase angle of the electrical voltage and thereby increase the harmonic properties. The Static Var Comparator (SVC) is a combination of a controlled thyristor reactor and a thyristor capacitor that is widely used in distribution and transmission systems to dynamically modify the reactive power of the network, increase system stability and increase system efficiency. the network.

With the development of power electronic devices and the advent of isolated bipolar gate transistors (IGBT), synchronous static compensators (STATCOM) have been developed, such as the latest version of SVC, which is widely used in modern power networks and is considered one of the main building blocks of intelligent networks . D-STATCOM is abbreviated as STATCOM, which is used in distribution systems. Thyristor Controlled Capacitors (TCSC) are the new generation of FACTS controllers used in high voltage transmission systems to increase transmission capacity, increase generator transient stability and reduce subsynchronous oscillation (SSR) of the transmission system. HVDC. The synchronous series compensator (SSSC) is installed in series with the transmission network, whereby basic powerless electronic components are similar to the STATCOM system. Dynamic Voltage Restorers (DVRs) are conditioners for the customer's power quality, with which voltage drops are reduced and sensitive loads are protected [5-8]. Of all these FACTS devices, the DVR is the most common.

II. DYNAMIC VOLTAGE RESTORER (DVR)

The modern industrial plant is subject to failure or failure due to voltage drop problems. The Dynamic Voltage Restorer (DVR) is considered the best option to protect industrial plants from brownouts and other voltage disturbances.

The DVR is a recently proposed serial connected solid state device that supplies the voltage to the system to regulate the voltage on the load side. It is usually installed in a distribution system between the power supply and the power supply for critical loads.

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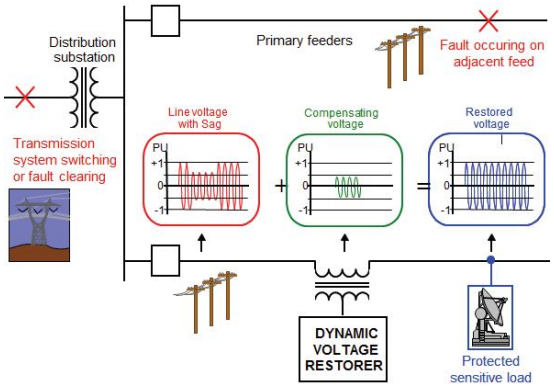

Fig.2 The circuit diagram of the dynamic voltage restorer (DVR)

Other than voltage sags and swells compensation, DVR can also added other features like: line voltage

harmonics compensation, reduction of transients in voltage and fault current limitations.

Basic Configuration of DVR

The general configuration of the DVR consists of:

i. An Injection/ Booster transformer
ii. A Harmonic filter
iii. Storage device
iv. A Voltage Source Converter (VSC)
v. DC charging circuit
vi. A Control and Protection system

The design of the DVR allows the supply or absorption of active and reactive power during operation. If a small error occurs in the protected system, the DVR can correct it only with the reactive power generated internally. The DVR may need to develop active power to correct important errors. An energy storage device must be used to allow for the development of active power. As soon as the error has been corrected and the power supply works under normal conditions, the DVR restores the energy consumed by the healthy system.

The central element in the design of the DVR is the three-phase voltage converter. This converter uses solid state power electronics (isolated gate bipolar transistors, IGBTs) to convert direct current to alternating current during operation and vice versa during charging. The DVR is connected in series with the distribution line via an injection transformer, actually three single-phase transformers. The output voltage waveforms are generated by the pulse width modulated switching. If the voltage drop with zero energy reaches a value lower than the correction limit, the energy storage system in the DVR must be used to support the voltage correction.

Injection/ Booster transformer:

The Injection / Booster transformer is a specially designed transformer that attempts to limit the coupling of noise and transient energy from the primary side to the secondary side. Its main tasks are:

It connects the DVR to the distribution network via the HV-windings and transforms and couples the injected compensating voltages generated by the voltage source converters to the incoming supply voltage.

In addition, the Injection / Booster transformer serves the purpose of isolating the load from the system (VSC and control mechanism).

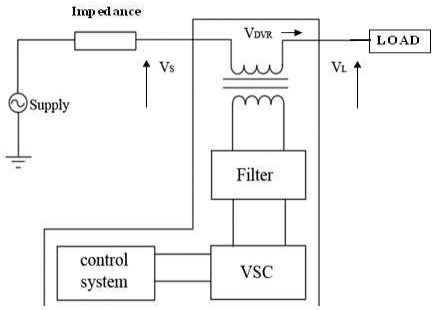

Fig. 3 Schematic diagram of DVR

Harmonic Filter:

The main task of harmonic filter is to keep the harmonic voltage content generated by the VSC to the permissible level.

Voltage Source Converter (VSC):

A VSC is a power electronic system consists of a storage device and switching devices, which can generate a sinusoidal voltage at any required frequency, magnitude, and phase angle. In the DVR application, the VSC is used to temporarily replace the supply voltage or to generate the part of the supply voltage which is missing. The purpose of storage devices is to supply the necessary energy to the VSC via a dc link for the generation of injected voltages.

DC Charging Circuit:

The dc charging circuit has two main tasks:

- The first task is to charge the energy source after a swell compensation event.
- The second task is to maintain dc link voltage at the nominal dc link voltage.

Control and Protection system:

The control mechanism of the general configuration typically consists of hardware with programmable logic. All protective functions of the DVR should be implemented in the software. Differential current protection of the transformer, or short circuit current on the customer load side are only two examples of many protection functions possibility.

Control algorithm

The basic functions of a controller in a DVR are

- the detection of voltage sag/swell events in the system
- computation of the correcting voltage
- generation of trigger pulses to the sinusoidal PWM based DC-AC inverter
- correction of any anomalies in the series voltage injection
- termination of the trigger pulses when the event has passed

The controller may also be used to shift the DC-AC inverter into rectifier mode to charge the capacitors in the DC energy link in the absence of voltage sags/swells.

The dqo transformation or Park's transformation is used to control of DVR.

The dqo method gives the sag depth and phase shift information with start and end times.

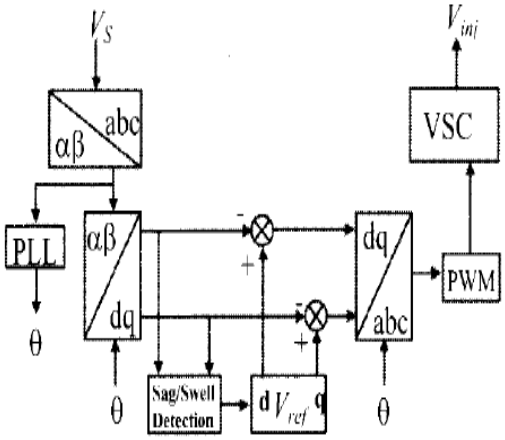

Fig.4 Control structure of DVR.

The quantities are expressed as the instantaneous space vectors. Firstly convert the voltage from abc reference frame to d-q-o reference. For simplicity zero phase sequence components is ignored.

Figure 5 illustrates a flow chart of the feed forward dqo transformation for voltage sags/swells detection. The detection is carried out in each of the three phases.

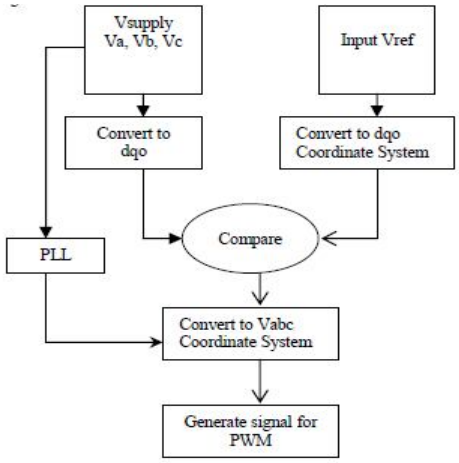

Fig.5 Flow chart of feed forward control technique for DVR based on dqo transformation

The control scheme for the proposed system is based on the comparison of a voltage reference and the measured terminal voltage (Va,Vb,Vc).The voltage sags is detected when the supply drops below 90% of the reference value whereas voltage swells is detected when supply voltage increases up to 25% of the reference value. The error signal is used as a modulation signal that allows to generate a commutation pattern for the power switches (IGBT's) constituting the voltage source converter. The commutation pattern is generated by means of the sinusoidal pulse width modulation technique (SPWM); voltages are controlled through the modulation.

III. CONCLUSION

This document aimed to develop an approach to predict the reliability impact of advanced solutions to improve reliability within the functional zone of a power distribution system. When using a particular set of smart grid technologies, some of the fault management activities are affected and ultimately change the reliability of the electricity supplied to customers. The popular smart grid device DVR is discussed. The results show that the DVR easily copes with balanced and asymmetrical situations and feeds the corresponding voltage component in order to correct any anomalies in the supply voltage and to keep the load voltage balanced and constant. This document can be used as a useful reference for engineers in the field of research and implementation of the intelligent network.

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