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Estimation and Improvement of Voltage Quality Using RES fed Facts Device

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Abstract:The main aim of this paper is to focus on Integration of renewable energy source Renewable Energy Resources (RES) to the grid. The problems posed by the power electronic converters through which the power is transferred to grid can be addressed byDynamic Voltage Restorer (DVR) maintaining power quality. This work proposes configuration of RES fed DVRVoltage sags and swells in the medium and low voltage distribution grid are considered to be the most frequent type of power quality problems based on recent power quality studies. Their impact on sensitive loads is severe. For sensitive loads, even voltage sags of short duration can cause serious problems in the entire system. Normally, a voltage interruption triggers a protection device, which causes shutdown of the entire system. Different solutions have been developed to protect sensitive loads against such disturbances but the DVRis considered to be the most efficient and effective solution. The control strategy for extracting the compensation voltages in DVR is based on synchronous reference frame theory (SRF) along with Proportional Integral(PI) controller. The control strategy is verified through extensive simulation studies using MATLAB & SIMULINK to demonstrate the improved performance of DVR.

Key words: DVR, Voltage sag &swell, SRF Theory, DVR, CUPS, DG and MATLAB &SIMULINK

1. Introduction:

Conventional power generation leads to two main problems – reduction of fossil fuel availability and emission of greenhouse gases leading to global warming. Also transmission of power for long distances increases losses. This led to Distributed Generation (DG), where the power is been generated at load side with the aid of RES reducing losses and emissions. Recent interest of many researchers was to study about medium and low voltage transmission of power due to the penetration of DG. But RES fed power generation will be integrated to grid only with the help of power converters. High frequency switching operations of power electronic converters leads to the induction of harmonics creating power

qualityproblems in the system [3].The power quality gets degraded because of the disturbances, occurring within the transmission yet as within the distribution sides. Flexible

AC transmission devices squaremeasure utilized at the transmission facet to beat thepower quality issues. The Custom Power System (CUPS) devices utilized within the distribution facet make amends for sags, swells, harmonic distortions, interruptions etc., to enhance the facility quality [1]. Though several CUPS devices square measure commercially available in the monetary losses further more.

The single phase P-Q market, dynamic voltage restorers (DVRs) is developed recently to enhancethe power quality. Now a days due to increased power quality problems by using of switch off/on introduction loads, nonlinear load and induction motor etc. in domestic and industries, power-quality (PQ) problems, such as harmonics, flicker, and imbalance have become serious concerns. In addition, lightning strikes on transmission lines, switching of capacitor banks, and various network Faults can also cause PQ problems, such as transients, voltage sag/swell, and interruption. On the other hand, an increase of sensitive loads involving digital electronics and complex process controllers requires a pure sinusoidal supply voltage for proper load operation. To meet power quality to the standard limits need some sort of compensation. In few years back to mitigate the power quality problems in distribution system by using passive filters like capacitor banks. Now these research going very fast to mitigate the power quality problems with help of power conditioning devices.

Typically the DVR topologies are classified into two main categories. As first cluster, the desired energy for compensation is taken from the energy storage part. The secondcluster of the topologies uses ac/dc/ac conversion. In these topologies, the desired dc voltage is provided through an electrical device from the grid (source facet or load side) via a rectifier. In each category of topologies, it is necessary to engraft an outsized electrical device within the dc link so as to take care of the voltage across the device. DVRs supported energy storage units suffer from limitations like, like of huge and expensive energy storage units, maintenance issues related tothe storage units and better weight per kVA rating.

2. Literature survey

a) In 2010, **Ali O Al-Mathnani***t. al*. presented a fast DVR with controller to compensate the short outage, reduced the harmonic distortion and transient voltage for balanced and unbalanced load.

b) In 2010, **Rosli Omar***et. al*. discusses the mitigation of power quality disturbance in low voltage distribution system due to voltage swells using one of the powerful power custom devices namely Dynamic Voltage Restorer (DVR)using improved d-q-o controller technique.

c) In 2013, **M. Sharanya***et. al*. gives the use of Dynamic voltage restorer improve the quality of power by voltage profile improvement and by the mitigation of harmonics in the supply current.

d) In 2014, **Y. Prakash***et. al*. proposed DVR with emergency control in distribution systems is analyzed by using the proposed multifunctional DVR control strategy

e) In 2015, **T. C. Archana***et. al*. proposed DVR to reduce voltage sag, swell, harmonics etc by DVR. Synchronous Rotating Frame (SRF) theory is used to extract the fundamentals of terminal voltage and reference voltage is generated.

f) In 2012**M.kanakaraj**et, al. Voltage Sag/Swell Compensation using Fuel cell fed InverterBased Dynamic Voltage Restorer

g) In 2013**U.T.Patil,A.R.Thorat**et, al. Hysteresis Voltage Control Technique in Dynamic Voltage Restorer for Power Quality Improvement

h) In 2012 **Chen Songsong**et, alResearch and Design of Dynamic Voltage Restorer.

i) In 2013**Priyanka Kumari1**et, alSimulation of Dynamic Voltage Restorer Using MATLAB to Enhance Power Quality in Distribution System

j) In 2012 **U. VidhuKrishnan**et, alAn Enhancement Method for the Compensation of Voltage Sag/Swell and Harmonics by Dynamic Voltage Restorer

3. Research Methodology

Many DVR strategies were proposed in the literature for power quality improvement. Dynamic Voltage Restorer (DVR) belongs to series connected FACTS controllers. The first performance of DVR is to compensate voltage sags and swells. However, it may perform tasks like harmonic elimination, reduction of voltage transients and fault current limitation. DVR is generally placed in between source and the load that should be protected. Even the shortest voltage sag can cause serious instrumentality damage, interruption of production cycles and so Control Strategy for three-leg VSC based DVR in the distribution system was proposed in [2]. The basic principle of DVR function is to inject or draw thecompensating voltage to or from the supply voltage in order to mitigate voltage sags or swells on the load side. At every moment the control algorithm comparesdesired voltage and actual measured voltage [4]. The differencebetween these two signals is considered as a compensating voltage signal (control signal), which is directlyproportional to compensating voltage. Compensating signal is a digital input signal for a pulse width modulation. The control of DVR with PI and FUZZY controllers were proposed in [5]. DVR contains DC-link capacitor acting as a voltage source. This can be altered with a RES connected to DVR to reduce the DC-link capacitor size.

This research work is focusing on Integration of renewable energy source (RES) to the grid. The problems posed by the power electronic converters through which the power is transferred to grid can be addressed by DVR maintaining power quality. This work proposes configuration of RES fed DVR. For the configuration MATLAB/SIMULINK based model will be developed and simulation results will be presented. Finally the proposed two configurationswill be implemented for IEEE 3-bus system and for IEEE-5 bus system and simulation results will be presented.

The widely used energy storage systems are capacitors andbatteries. But capacitors have limitations of low storage and charging and discharging speeds. Battery backup systems operate similarly to adding capacitive energy storage, with the advantage that their energy per volume ratio is much higher than standard capacitors. The batteries are easily available with low cost; provide ride through for deep sags and full outages [6].

These have low life and require additional space and maintenance. A super capacitor can overcome these limitations and provide an efficient working but super capacitors do not have a conventional solid dielectric. Fuel cell is used to charge the supercapacitor to restore the voltage during distortions. Systems for electro chemical energy storage and conversion include batteries, fuel cells and electro chemical capacitors. Although the energy storage and conversion mechanisms are different, there are electro chemical similarities of these three systems. In batteries and fuel cell, electrical energy is generated by conversion of chemical energy via redox reactions at anode and cathode.

4. DYNAMIC VOLTAGE RESTORER (DVR) CONFIGURATION

DVR is a Custom Power Device used to eliminate supply side voltage disturbances. DVR also known as Static Series Compensator maintains the load voltage at a desired magnitude and phase by compensating the voltage sags/swells and voltage unbalances presented at the point of common coupling. The power circuit of the DVR is shown in Fig. 1.

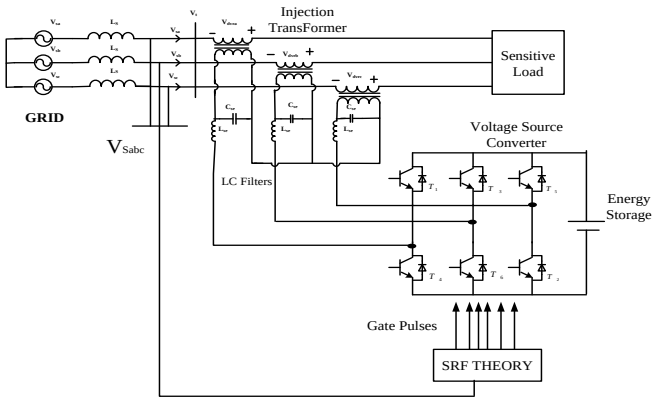

Fig.1 DVR Block Diagram

The DVR consists of the following major parts:-

A. Voltage Source Inverter (VSI)

PWM inverter using IGBT switches is used in the model. IGBT switches are commonly used in series connected circuits. The insulated gate bipolar transistor or IGBT is a three-terminal power semiconductor device, noted for high efficiencyand fast switching. Pulse-width modulation (PWM) is a very efficient way of providing intermediate amounts of electrical power between fully on and fully off. The voltage source converter is used to convert the DC to AC and then supply the voltage to distribution feeder through an injection transformer.

B. Injection Transformers

The injection transformers connect the DVR to the distribution network via the high voltage windings. They transform and couple the injected compensating voltages generated by the VSI to the incoming supply

voltage. Basically injection transformers used in the model presented in this paper are three single phase transformers. The high voltage side of the injection transformer is connected in series to the distribution line, while the low voltage side is connected to the DVR power circuit. For a three-phase DVR, three single-phase or three-phase voltage injection transformers can be connected to the distribution line, and for single phase DVR one single-phase transformer is connected. The transformers not only reduce the voltage requirement of the inverters, but also provide isolation between the inverters.

C. Passive Filters

Passive filters are placed at the high voltage side of the DVR to filter the harmonics. These filters are placed at the high voltage side, as placing the filters at the inverter side introduces phase angle shift which can disrupt the control algorithm.

D .Energy storage

The energy storage unit supplies the required power for compensation of load voltage during voltage sag. A dc battery is used for this purpose. Batteries, flywheels or SMEs can be used to provide real power for compensation. Compensation using real power is essential when large voltage sag occurs.

5. DVR CONTROLLING BASED ON SYNCHRONOUS REFERENCE FRAME THEORY

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 PWM based DC-AC inverter, correction of any abnormalities in the series voltage injection and termination of the trigger pulses when the event has passed. The compensation for voltage sags using a DVR can be performed by injecting/absorbing reactive power or real power. The control technique adopted should consider the limitations such as the voltage injection capability (inverter and transformer rating) and optimization of the size of energy storage.

The Following figure shows the Control Block Diagram of the DVR .In this control, Source Voltage is sensed and gives it as an input to the abc/dq transformation block and same source voltage is given as an input to the PLL block .The PLL block gives the information of sin, cos .This is given as an input to the abc/dq block .With these two inputs this transformation block gives the information of Vd, V_qi. This information is compared with V_{dact}; V_{qact} which are the actual parameters .The quadrature axis is compared with 0 p.u .The error generated is given as an input to the pi controller. The pi controller output is again given as an input to dq/abcblock, and PLL information is also given as an input to dq/abc block. This block gives us the pulse information which is given as an input to pwm generator and from that gate pulses are generated, those gate pulses are for inverter.

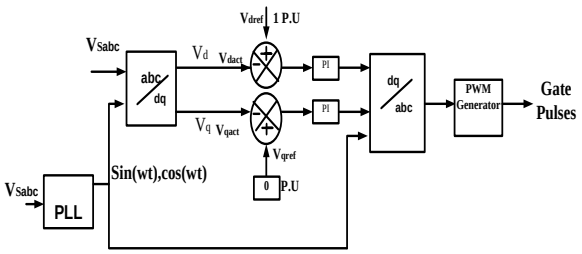

Fig.2 DVR Control Block Diagram based on SRF Theory.

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