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Line Loss Minimization in Distribution System by DSTATCOM

Rahul U. Ghanmare
Department of Electrical Engineering,
Dr. Babasaheb Ambedkar College of Engineering & Research
Wanadongri, Nagpur
Maharashtra, India
ghanmare.rahul@gmail.com

Anushree Helonde
Department of Electrical Engineering,
Dr. Babasaheb Ambedkar College of Engineering & Research
Wanadongri, Nagpur
Maharashtra, India
anushree.99helonde@gmail.com

Ashwini Dhete
Department of Electrical Engineering,
Dr. Babasaheb Ambedkar College of Engineering & Research
Wanadongri, Nagpur
ashwinidhete@gmail.com

Yogeshwari Bansod
Department of Electrical Engineering,
Dr. Babasaheb Ambedkar College of Engineering & Research
Wanadongri, Nagpur
Maharashtra, India
tokiyo.bansi@gmail.com

Vyankatesh Deshmukh
Department of Electrical Engineering,
Dr. Babasaheb Ambedkar College of Engineering & Research
Wanadongri, Nagpur
Maharashtra, India
vyanku.desh@gmail.com

***Abstract*—** As we know that it is essential to balance the supply and demand of active and reactive power in an electric power system. If the balance is lost , the system frequency and voltage excursion may occur resulting , in the worst case, in the collapse of the power system. Appropriate voltage and reactive power control is one of the most important factor for stable power system operation. The paper describe about 25KV distribution system where system voltage is unbalanced and problems of voltage regulation .To achieve the balance between the voltage proposed D-STATCOM is modulated and simulated using MATLAB SIMULINK software

Keywords- *DSTATCOM,Reactive power,VSC,control statergy,SPWM*

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I. INTRODUCTION

A Distribution STATCOM is a shunt connected voltage source converter which has been utilized to compensate power quality problem such as unbalanced load, voltage sag, voltage fluctuation and voltage unbalance. D-STATCOM is also utilized for the improvement of another aspect of power quality i.e., voltage compensates in long term.

A few research work were done on the impact of FACTS controllers on improving static performance of power system. The STATSCOM is capable of generating continuously variable reactive power at a level up its maximum MVAR rating. The D-STATCOM continuously checks the line voltage with respect to a reference ac signal, and therefore, it can provide the correct amount of leading or lagging reactive current compensation to reduce the amount of voltage fluctuations.

II. PRINCIPAL OF OPERATION OF STATCOM

A Static synchronous generator operates as a shunt-connected static var compensator whose capacitive or inductive output current can be controlled independent of the ac system voltage. It is used to generate or absorb reactive power. STATCOM systems are classified as Transmission STATCOM and Distribution STATCOM (DSTATCOM). While Transmission STATCOM having a larger MVAr rating is intended to inject a set of three balanced quasi-sinusoidal voltages for controlling reactive power flow in transmission system, DSTATCOM performs load compensation, i.e., power factor correction, harmonic filtering, load balancing in the distribution system. Therefore, DSTATCOM must be able to inject an unbalanced and harmonically distorted current to eliminate unbalance or distortions in the load current or the supply voltage

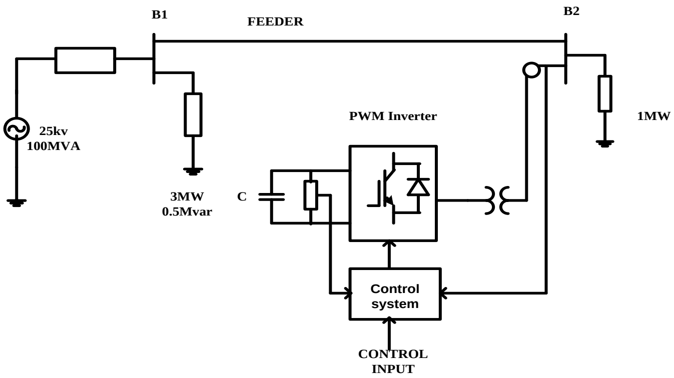

Fig. 1 Simplified Diagram of D-STATCOM connected to a Distribution Network

The D-STATCOM is a three-phase and shunt connected power electronics based device. It is connected near the load at the distribution systems. The major components of a DSTATCOM are shown in Figure. It consists of a dc capacitor, three-phase inverter (IGBT, thyristor) module, ac filter, coupling transformer and a control strategy.

The basic electronic block of the DSTATCOM is the voltage sourced inverter that converts an input dc voltage into a three phase output voltage at fundamental frequency. We are using the 3 level SPWM inverter. The controller of the D-STATCOM is used to operate the inverter in such a way that the phase angle between the inverter voltage and the line voltage is dynamically adjusted so that the D-STATCOM generates or absorbs the desired VAR at the point of connection We are using battery instead of dc capacitor so there is no Problem of balancing. Inductor present in the transformer act as a filter. The phase of the output voltage of the inverter Vi, is controlled in the same way as the distribution system voltage (Vs). With the help of control scheme we are generating modulating wave.

III. SYSTEM CONFIGURATION

A D-STATCOM is a power electronic system with a complex control system. Modeling the D-STATCOM including the power network and its controller in Simulink environment requires “electric blocks” from the Power System.

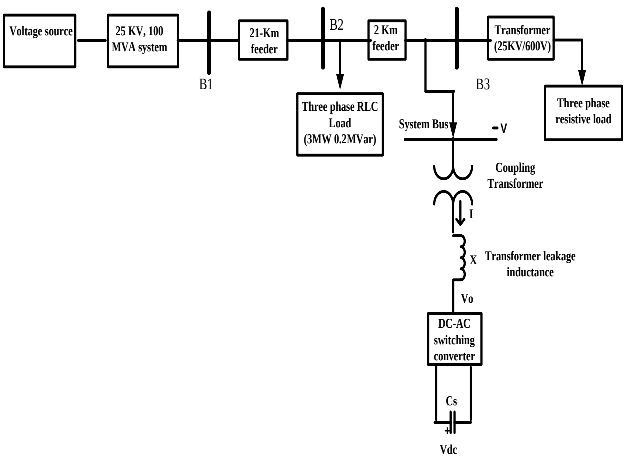

Fig. 2 Schematic Diagram Of 25 KV Distribution System

We consider here a -5Mvar D-STATCOM connected to a 25-kV distribution network. Figure 2shows a Simulink diagram which represents the DSTATCOM and the distribution network by a 21-km feeder which is modeled by a pi-equivalent circuit connected to bus B_2. At this bus, a 3-MW load is connected. A 25-kV/600V transformer and a 1 MW The feeding network is represented by a Thevenin equivalent(bus B_l) followed variable load are connected to bus B_2 by a 2-km feeder. The D-STATCOM output is coupled in parallel with the network through a step-up 5/25 Kv Δ/Y transformer. The primary of this transformer is fed by a voltage-source SPWM 3level diode clamped inverter consisting of a filter bank is used at the inverter output to absorb harmonics. A battery is used as dc voltage source for the inverter. A SPWM pulse generator with a carrier frequency of 1 kHz is used to control both IGBT bridges. The modulation scheme used is of sinusoidal type.

The controller diagram is shown in Fig.3It consists of several subsystems: a phase-locked loop (PLL), two measurement systems, a current regulation loop, a voltage regulation loop ,and a dc link voltage regulator. The PLL is synchronized to the fundamental of the transformer primary voltage to provide the synchronous reference(sin(wt) and cos(wt)) required by the abc-dq transformation. The measurement blocks “V_{rms}” and “I_{rms}” compute the d-axis and q-axis components of the voltages and currents. The inner current regulation loop consists of two proportional-integral (PI) controllers that control the d-axis and q-axis currents. The controllers outputs are the voltage direct-axis and quadrature-axis components (V, and Vs) that the PWM inverter has to generate. The V_d and V_q voltages are converted into phase voltages V_a, V_b,V_c which are used to synthesize the SPWM voltages.

The network bus voltage is regulated by a PI controller which produces the I_{ref} for current controller. The I_{ref} comes from the dc link voltage regulator which maintains the DC link voltage constant .This model simulation is developed into two part first is without STATCOM and second is with STATCOM.

As we are creating the fault on source side i.e. source side voltage is increased we get result of this in scope i.e. one phase RMS voltage i.e. 27kv this is faulted voltage this will create problem in our system i.e. excessive reactive power flow through the circuit. To compensate this problem we are using D-STATCOM in system .as we know that STATCOM is absorbed or generated the reactive power in the system. Here STATCOM will absorb excessive reactive power in the system act as a inductor and make the system stable this seen in scope where we get stable voltage i.e. 25KV for the system.

A. Control Stratergy

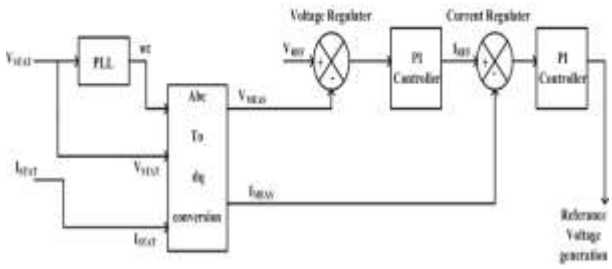

Fig. 3 Control Strategy of D-STATCOM

V_{stat} is given to PLL (Phase Locked Loop) block. It gives angle ωt which is used to synchronize D-STATCOM model with the system. abc to dq converter converts 3 phase rotating phasors to stationary vectors. Measured voltage at D-STATCOM bus is compared with reference voltage phasor. It is set as per reactive power requirement to regulate bus 3 voltage. Error signal is given to PI controller which gives correction factor. This fact is set as current reference I_{ref} . Actual measured current through D-STATCOM bus is compared with reference current I_{ref} error signal is given to another PI controller. It gives output as correction factor. From this correction factor reference voltage is generated, this reference voltage is used to set reference modulating wave for SPWM and pulses for inverter is generated.

B. Inverter Configuration

The diode-clamped multilevel inverter employs clamping diodes and cascaded dc capacitors to produce ac voltage waveforms with multiple levels. The inverter can be generally configured as a three-, four-, or five-level topology, but only the three-level inverter, often known as neutral-point clamped (NPC) inverter, has found wide application in high-power medium-voltage (MV) drives.

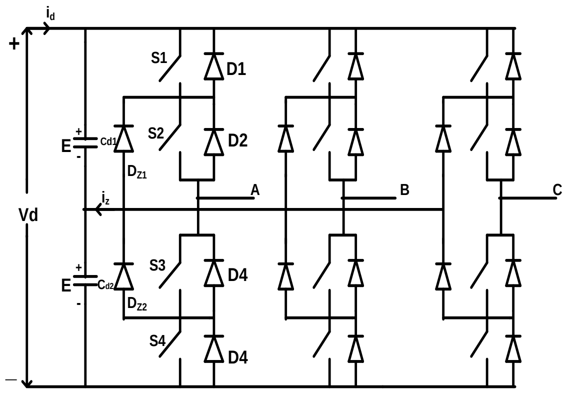

Fig. 4 Diode Clamp Multilevel Inverter

The main features of the NPC inverter include reduced *dv*/*dt*and THD in its ac output voltages in comparison to the two-level inverter discussed earlier. More importantly, the inverter can be used in the MV drive to reach a certain voltage level without switching devices in series. For instance, the NPC inverter using 6000-V devices is suitable for the drives rated at 4160 V.

IV. RESULT

The performance of D-STATCOM is studied with modified 3 level diode clamped SPWM inverter. The D-STATCOM is implementing on the 25 KV distribution systems.

Table:- Comparison of result of without & with D-STATCOM

Quantity	Without STATCOM		With STATCOM	
	BEFORE 0.1S	AFTER 0.1S	BEFORE 0.1S	AFTER 0.1S
Supply Voltages	25kv	27kv	25kv	25.54kv
Source Current	-	178ka	-	113ka
Reactive Power	-	5mvar	-	3.4mvar

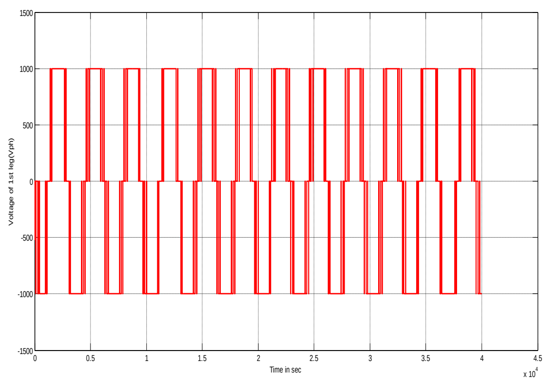

fig 5 Phase voltage

The three level inverter is connected across the 25kv distribution system fig 5 shows the output voltage of the inverter.

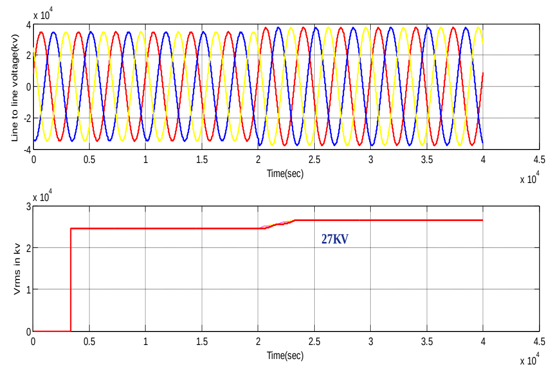

fig6(a) & 6(b): Source Voltage

The fig6(a) & 6(b) shows the source voltage which is 25KV for the time duration 0 to 0.1 sec and above the 0.1 sec it is 27 KV.

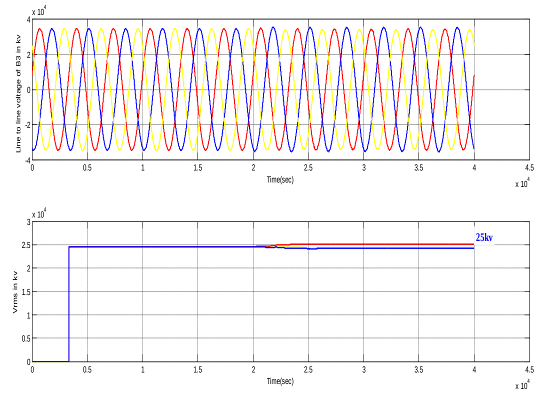

Fig7(a) & fig 7(b): Output results after connected STATCOM

Fig7(a) & fig7(b) Shows output result after connecting D-STATCOM at voltage bus at bus b3 where reactive compensation is done we get 25 KV regulated voltage at bus 3

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