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Performance of DSTATCOM for Linear and Non linear load Using T-connected Transformer

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Abstract: - *Distribution static compensator is a device which is capable of compensating power quality problems. The DSTATCOM is tested for harmonic elimination, neutral current compensation and balancing of linear as well as non linear load for topology of DSTATCOM i.e.(T-connected transformer with three leg VSC. The performance of the three-phase four wires DSTATCOM to improve power quality is verified by using MATLAB software with its simulink.*

Keywords - DSTATCOM, power quality T connected transformer.

I. Introduction

Industrial processes are based on electronic devices such as controllers and adjustable speed drives. Harmonics have adverse effect on electronic equipments because their operation depends on either the peak value or the zero crossing of the supplied voltage, which are all influenced by the harmonic distortion the ever-increasing use of non-linear loads, invites problems of harmonics and reactive power in distribution networks. Three phase and single phase non linear loads are the main cause of current harmonics in the supply system. A harmonic current passing through the supply impedances creates problem of voltage harmonics and voltage unbalance at the Point of common coupling (PCC).

II Different Custom Power Devices to Improve Power Quality.

With the introduction of custom power strategy, this is designed primarily to meet the requirements of industrial and commercial customer [1]. These CPDs (custom power devices) include: *(1)* Distribution static compensator (DSTATCOM). *(2)* Dynamic voltage restorers (DVR). *(3)* Unified power quality conditioner (UPQC).

DSTATCOM (Distribution static compensator) DSTATCOM is used to generate or absorb reactive power in a three phase and shunt connected power electronics based device [2]. Different components of a DSTATCOM are shown in Fig.1. It consists of a dc capacitor, three phase inverter (IGBT, thyristor) module, ac filter, coupling transformer and a control strategy. An inverter is used to convert the dc link voltage vdc on the capacitor to a voltage source of adjustable magnitude and phase. The DSTATCOM can also be seen as a current-controlled source. Voltage Source Converters (VSC) is widely used as a basic component in DSTATCOM. The harmonics in the output voltage of DSTATCOM can be reduced using Pulse- Width Modulation (PWM) switching techniques.

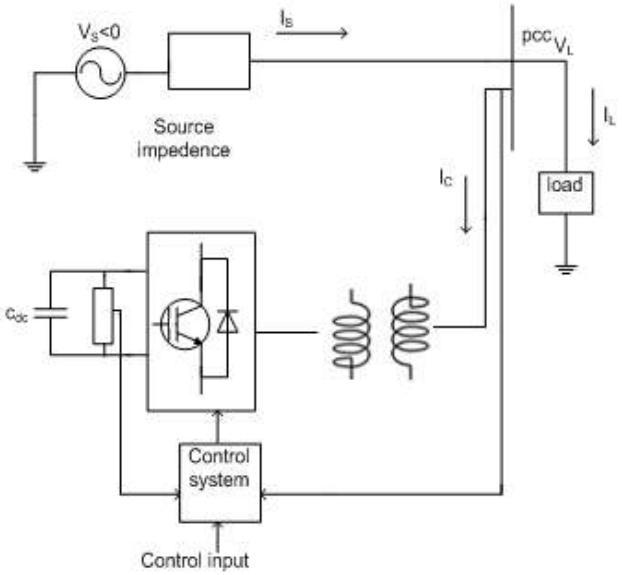


Fig.1 single line diagram of DSTATCOM.

PWM methods reduce the harmonics by shifting frequency spectrum to the vicinity of high frequency band of carrier signal. For proper operation of DSTATCOM, the PWM pattern must generate a fundamental voltage with the same frequency of the power source. The conversion of DC voltage across the storage device into a set of three-phase ac output voltages is done by VSC. These voltages are in phase and coupled with the AC System of coupling transformer. The effective control of active and reactive power exchange between the DSTATCOM and the AC system is done by suitable adjustment of the phase and the magnitude of the DSTATCOM output voltage. If the amplitude of the DSTATCOM output voltage is increased above the amplitude of the AC system voltage, the current flows through the transformer reactance from the DSTATCOM to the AC system, and the device generates reactive power (capacitive). If the amplitude of the DSTATCOM output voltage is decreased to a level below that of the AC system, then the current flows from the AC system to the DSTATCOM, so the device absorb reactive power (inductive). Since DSTATCOM is generating/absorbing only reactive power, the output voltage and the AC system voltage are in phase, when

neglecting circuit losses. The current drawn from the DSTATCOM is 90° shifted with respect to the AC system voltage, and it can be leading (generates reactive power) or lagging (absorbs reactive power). A capacitor is used to maintain dc voltage to the inverter. Phasor diagram for unity power factor is shown in Fig.2.

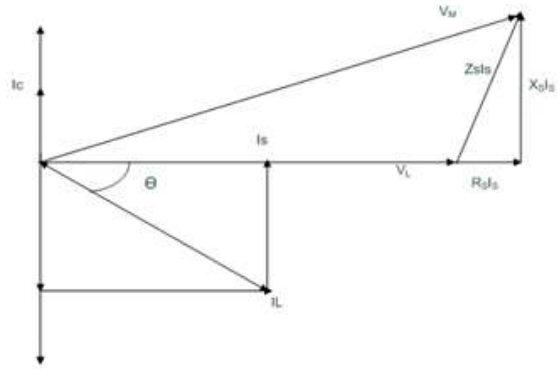


Fig.2 Phasor diagram for UPF operation.

III Principle of Reactive Power Control

The reactive power supplied by the DSTATCOM is given by

$$Q = \frac{V_{DSTATCOM} - V_S}{X} \cdot V_S$$

Where Q is the reactive power.

$V_{DSTATCOM}$ is the magnitude of DSTATCOM output voltage. V_S is the magnitude of system voltage. X is the equivalent impedance between DSTATCOM and the system. When Q is positive the DSTATCOM supplies reactive power to the system. Otherwise, the D-STATCOM absorbs reactive power from the system. It injects current in shunt with the load. For reactive power compensation, a DSTATCOM provides reactive power to the load and therefore source supplies only real power to the load. Thus unity power factor of source current could be achieved.

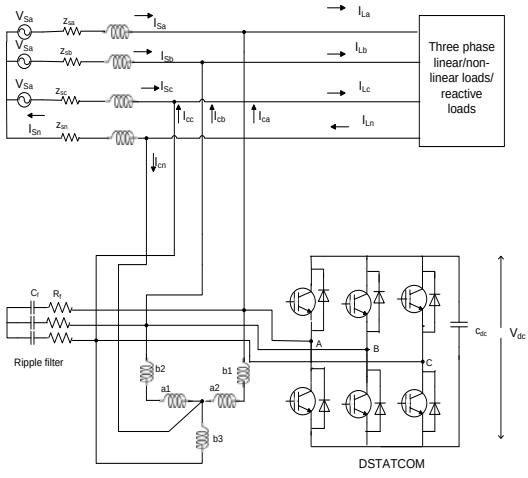


Fig.3 T-connected Transformer

IV Three-phase three-leg VSC with a T-connected transformer

The proposed DSTATCOM consisting of a three-leg VSC and a T-connected transformer is shown in Fig. 3. The neutral current is mitigated by using T-connected transformer and the three-leg VSC compensates harmonic current, reactive power, and balances the load [3]. Two single-phase transformers are connected in T-configuration for interfacing to a three-phase four-wire power distribution system and the required rating of the VSC is reduced. The insulated gate bipolar transistor (IGBT) based VSC is supported by a capacitor and is controlled for the required compensation of the load current. The dc bus voltage of the VSC is regulated during varying load conditions. Load is connected at the PCC.

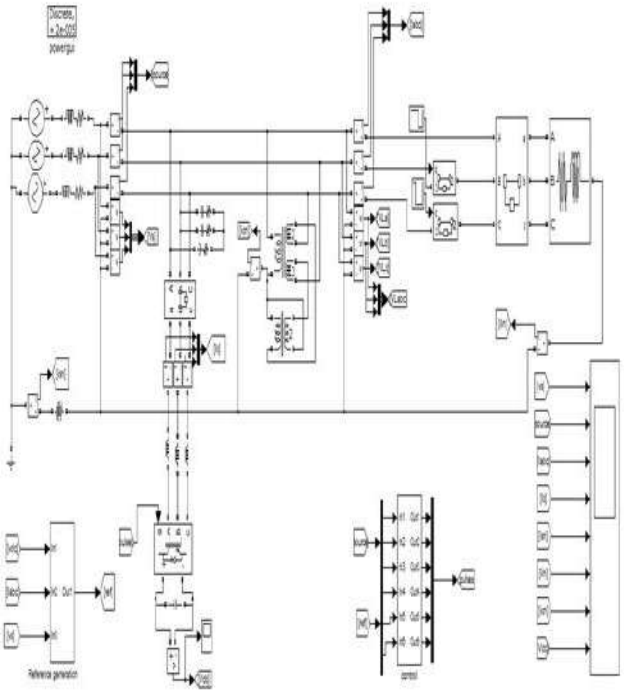


Fig.4 Mat lab model of three legs VSC and T-connected transformer for linear load.

The DSTATCOM provides the neutral current compensation, harmonic elimination and load balancing along with power factor correction or line voltage regulation three-phase four-wire distribution system. The zero sequence fundamental current resulted from the unbalanced load current is compensated by single phase VSCs of DSTATCOM. Thus the source neutral current is maintained at nearly zero.

V. Performance of DSTATCOM with linear load for neutral current compensation load balancing.

The three-leg VSC and T-connected transformer-based DSTATCOM for linear load is modulated and simulated using MATLAB and its simulink [4]. The DSTATCOM system for linear load is shown in Fig.4. For filtering the ripple in the PCC voltage ripple filter is connected to the the VSC of the DSTATCOM. The SRFT (synchronous reference frame theory) algorithm is used for the

control of DSTATCOM [5]. At 0.2 sec, the three-phase linear lagging power factor load is changed to a two-phase load and changed again to a single-phase load at 0.3 sec.

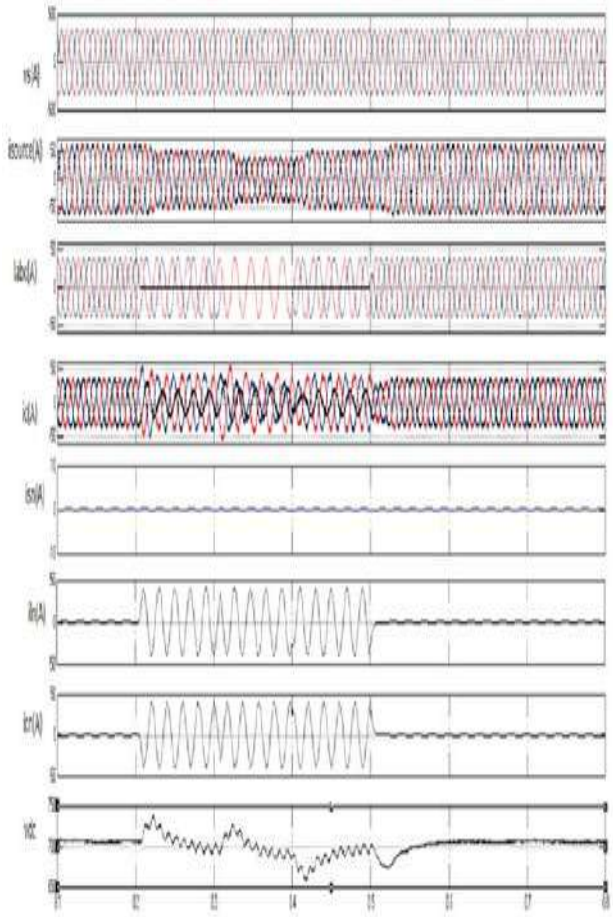


Fig.5 Performance of DSTATCOM for linear load

These loads are applied again at 0.4 sec. and 0.5 sec, respectively. The PCC voltage (v_s), balanced source current (isource), load current (i_{labc}), compensator current (i_C), source neutral current (i_{sn}), load neutral current (i_{Ln}),compensating neutral current (icn) DC bus voltage (v_{dc}),) are demonstrated in Fig.5 under changing load conditions. The source neutral current is observed as nearly zero, due to the proper compensation currents injected by the DSTATCOM and this verifies the proper compensation.

VI Performance of DSTATCOM with Non linear load for harmonic compensation, load balancing

Matlab based model for non linear load is shown in Fig.5.1 (g). Non linear load is connected at the PCC.at 0.2 sec, the three-phase linear lagging power factor load is changed to a two-phase load and changed again to a single-phase load at 0.3 sec. These loads are applied again at 0.4 sec. and 0.5 sec; respectively the performance of DSTATCOM with non linear and unbalanced load is shown in Fig.6. The total harmonic distortion of load current is 86.35% whereas the total harmonic distortion of source current is 4.05% figure 7 so the performance of DSTATCOM is realised.

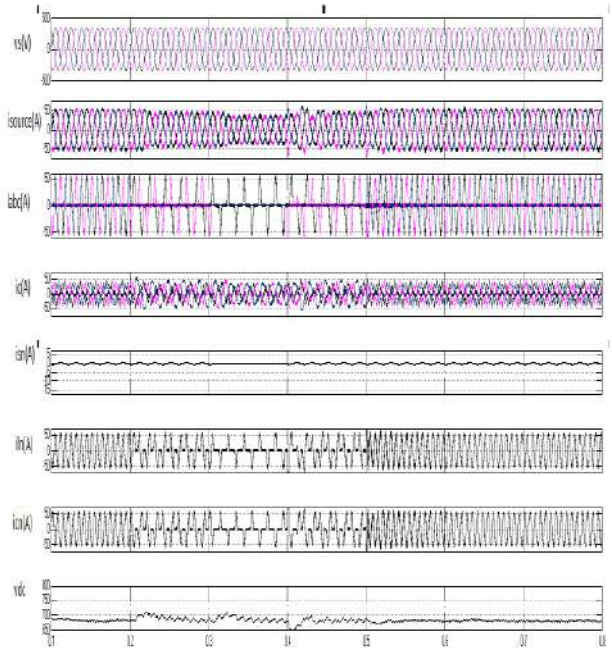
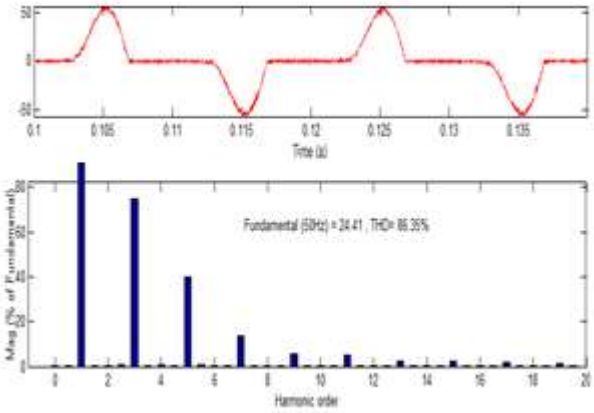


Fig.6 Performance of DSTATCOM for non linear load.



Harmonic spectrum for load current.

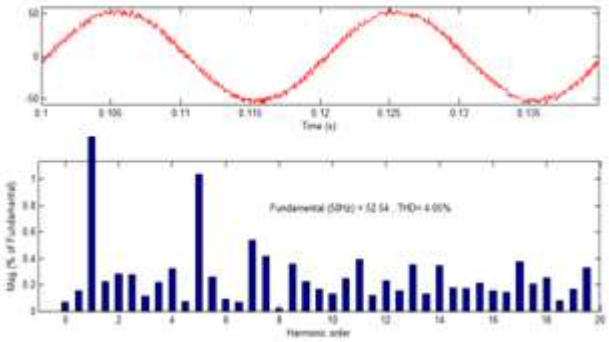


Fig.7 Harmonic spectrum for source current.

VII. Results and Discussion

The performance of DSTATCOM with T-connected transformer, It has been observed that DSTATCOM gives satisfactory response to neutral current mitigation, harmonic-compensation.

APPENDIX

(1) A T-Connected Transformer and Three-leg VSC Based DSTATCOM for Power Quality Improvement.

Line impedance=0.01Ω, L=1mH.

Loads:

Linear: 20KVA, 0.8PF lag.

Non linear: Three single–phase bridge rectifiers with R=25 Ω and C=470μF.

Ripple filter R_f = 5Ω, Cf = 5μF. DC bus voltage of DSTATCOM: 700V. DC Bus capacitance of DSTATCOM: 3000 μF.

AC inductor: 2.5mH.

DC voltage pi controller: k_{pd} = 0.19, k_{id} = 6.25

AC line voltage: 415V, 50 Hz.

T-Connected transformer: Two single-phase transformer of rating 5KVA, 240V/120V/ and 5 KVA.208V/208V

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