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Implementation of DSTATCOM for Improvement of Power Quality in 3P4W System

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Abstract:- Power quality is convinced a foremost concern in the present circumstance it becomes above all important with the introduction of complicated tools whose recitation is extremely sensitive to the quality of power supply. Novel industrialized progressions are sustained a great quantity of electronic applications for instance programmable logic controllers and adjustable speed drives. The electronic machine is very sensitive to troubles. Now a day electrical power faces several quality issues like voltage distortion, load unbalancing, excessive neutral current due to harmonics. In paper D-STATCOM with T-connected transformer and a single phase active power Filter is used to reduce harmonics and to compensate the neutral current. SRF based control algorithm is used to control the D-STATCOM. The complete model is designed in MATLAB Simulink environment and the results are shown.

Keywords:- custom power devices, DSTATCOM, T-connected transformer, Active power filter

I. INTRODUCTION

At the present time are strict power-quality difficulties for example poor voltage regulation, high reactive power and harmonics current trouble, load unbalancing excessive neutral current and so on these days distribution systems are facing. The source voltage in the distribution schemes are also experiencing power quality issues such as harmonics, deranged and flicker, sag or swell and that as stated in the paper. The corrective results to the power quality difficulties could be reduced by using custom power devices (CPDs).The distribution static compensator (DSTATCOM) is proposed in favor of compensating power quality problems in the current.3-phase 4-wire (3P4W) distribution power systems are extensively used in workplace constructions and marketable complexes, industrialized services and so on, to supply less significant stage voltage. The loads linked to the 3P4W distribution system possibly will be either single-phase or three-phase loads. The enhance of nonlinear loads owing to the abundance of power electronic apparatus in present day 3P4W distribution systems basis load reactive power load and as well as power quality problems such as current and voltage harmonics, unbalance in the load. Numerous proposals have been description in literature for resolve the power quality difficulties in 3P4W arrangements. The DSTATCOM (distribution static compensator) is a shunt attached CPD competent of compensate power quality difficulties into the load current. Different topologies of DSTATCOM used for3-phase 4-wire system for the lessening of neutral current in conjunction with power quality compensation. There are many control schemes reported in the literature for control of compensators such as instantaneous reactive power theory, power balance theory, synchronous reference frame theory, symmetrical components based, etc. In this investigation the synchronous reference frame theory is used for the control of the proposed DSTATCOM and T-connected transformer is used in the distribution system for different applications. But the application of T-connected transformer for neutral current compensation is demonstrated for the first time. Moreover, the T-connected transformer is suitably designed for magneto motive force (MMF) balance. T-connected transformer mitigates neutral current. The IGBT based VSC is self supported with a dc bus capacitor and is controlled for the required compensation of the load current. The DSTATCOM is designed and simulated using MATLAB software with its Simulink. The DSTATCOM applications are mainly for sensitive loads that may be drastically affected by fluctuations in the system voltage.

II. IMPLICATION OF DSTATCOM

The Distribution-STATCOM is one of the vitally valuable devices. An innovative PWM stand control proposal has been executed to control the electronic control devices in the D-STATCOM. The D-STATCOM has added potential to carry on reactive current at low voltage and could be expanded as a voltage besides frequency. To boost the power quality for instance voltage sags or swells harmonic distortion and small power factor in distribution scheme. The D-STATCOM for all intents and purposes consists of a coupling transformer among a leakage reactance and a 3-phase GTO or IGBT voltage source inverter (VSI) in adding together to a DC capacitor. A voltage source converter is a power electronic tool which is causes sinusoidal voltage among an only some necessitates magnitudes with frequency and phase angle. Voltage source converters are regularly used in adjustable speed drives other than could also be used to lessen voltage dips. In common the VSC is not only employs for voltage sag or swell mitigation but also for in addition power quality concerns such that flicker and harmonic.

- *Algorithm of Proposed DSTATCOM*

The proposed action is located on Synchronous Reference Frame method (SRF METHOD). A block diagram of the control arrangement prepared with the purpose of voltage regulation is given away in Figure1. We utilize of two

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proportional integral (PI) controllers for control dc bus voltage of DSTATCOM also ac voltage by PCC. The compensation current should lead or lag by 90ºforms the voltage. The compensating current brings together a voltage drop later the line voltage amplitude is reserved via its reference value. In the method whilst the load is an inductive followed bythe Distribution-STATCOM works as a capacitor in concurrence with reactive current control than the controlling of Distribution-STATCOM consists of the afterward control rationales for immediate harmonic reduction than load balancing furthermore neutral current compensation. Above figure shows the control algorithm of DSTATCOM with two PI controllers. The controller's functions were discussed above. The in-phase element of current is dependable for power factor enhancement of load whereas to regulate AC system voltage at PCC, quadrature component of SRF based DSTATCOM is responsible.

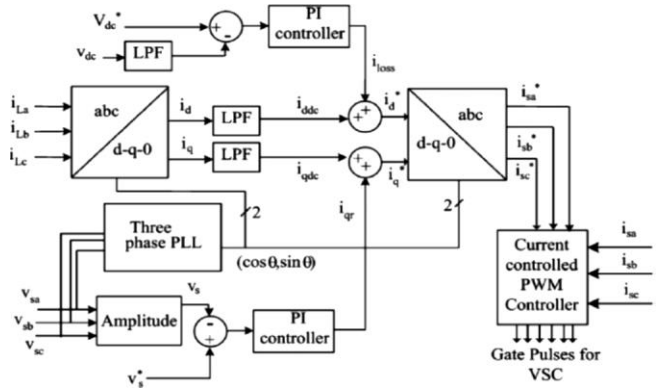

Fig. 1:- Control Approach of DSTATCOM

The output of PI controller over the DC bus voltage (Ispdr) is measured as quadrature component of supply reference currents. The instantaneous reference currents (isar, isbr and iscr) are obtained with adding the in-phase supply reference currents (isadr, isbdr and iscdr) and quadrature supply reference currents (isaqr, isbqr and iscqr). When reference supply currents generated in the circuit, a hysteresis current controller controls the sensed supply currents (isa, isb and isc) and instantaneous reference currents (isar, isbr and iscr) for generating gating pulses for ICBT'S of DSTATCOM. The function of controller is to control the DSTATCOM currents within a band around the desired reference currents values. The hysteresis controller generates suitable switching pulses for six IGBT'S of the VSI working as DSTATCOM. The control approaches available for the generation of reference source currents for the control of VSC of DSTATCOM for three-phase four-wire system.

- *T-Connected Transformer*

The T-connected transformer is realized by using 2 single phase two winding transformers as shown in Fig. 2. The T-connected windings of the transformer not only provide a path for the zero-sequence fundamental current and harmonic currents but also offer a path for the neutral current when connected in shunt at point of common coupling (PCC). T-connected transformer is realized by using 2 single phase transformer: consequently, the cores are economical to build and also easy to assemble. And therefore the transformer is small is the floor space, low height and weight with comparison to any other types of transformer available. The realization is shown in Fig. 2.

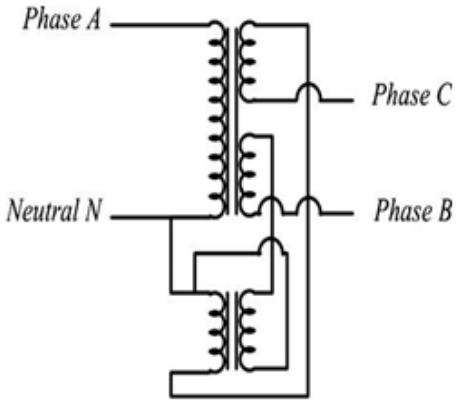

Fig.2:- Realization of the T-connected Transformer using three Single-Phase Three Winding Transformers

III. OPERATION AND CONTROL APPROACH OF PROPOSED SYSTEM

Fig.3 shows the simulation diagram of the 3P4WD-STATCOM. The realization of the T-connected transformer is shown Figure2. As shown in Figure3 a T-connected transformer is connected in parallel to the load and a single-phase APF is connected between the neutral conductor of the utility and the neutral point of the T-connected transformer through a filter inductance. The single-phase APF produces the desired current for compensating source neutral current and injects the produced current through the neutral of the T-connected transformer. The inverter of the single-phase APF is energized from a separate single-phase transformer through a diode bridge rectifier of a very low VA rating. However, with stringent voltage unbalance or distortions the voltage across the single-phase inverter of the APF increases to a large value. Under these conditions the single-phase APF must be protected with a switch (S). The switch is realized by using protective devices such as Metal Oxide Varistors (MOVs) and it operates under sustained unbalanced and distorted utility voltage conditions or fault conditions. When the switch S is closed then the active power filter is bypassed and only T-connected transformer along with DSTATCOM acts as the compensating device the T-connected transformer make available the low impedance path for the zero sequence current to flow between T-connected transformer and the nonlinear load. T-connected transformer and D-STATCOM takes care of the compensation of sequence currents while the compensation characteristics depends on their locations,

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impedances of the transformers and utility voltage condition. The capacitor connected on the DC side of VSC is charged by the real power taken from distribution system.

When switch S is open then the active power filter is connected into the circuit and the single phase active power filter is supplied by the separate single phase source. Single phase APF operates and produce the desired current for compensation of source neutral current and injects the same through neutral of T-connected transformer. This current split equally and flow through each T-connected winding of transformer. Such that APF circulate neutral current to the load via T-connected transformer. Therefore effectiveness does not depend on the zero sequence impedance of T-connected transformer and its location. Hence, special design for T-connected transformer for low zero sequence impedance is not requiring. The APF takes care of the harmonics in the system and reduces the neutral current to very less value which results improving power factor.

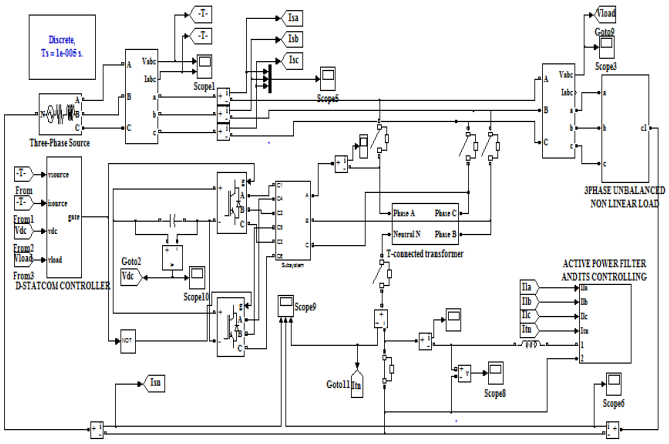

Fig.3:- Simulation diagram of the three-phase four-wire system

- Control Strategy of Single Phase APF

The block diagram of the closed-loop control system for single-phase APF is shows in Fig. 4. The current reference for the single-phase APF is derived by summing up the load currents flowing in each phase.

The current reference generated is compared with the actual T-connected transformer neutral current (ITn) and the difference of these two quantities is passed through a PI controller. The output of the PI controller is compared with the triangular carrier wave to obtain the required gate patterns for the single phase inverter.

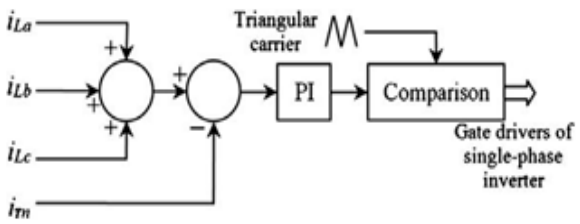

Fig.4:- Control scheme for single-phase APF.

IV. SIMULATION RESULT

The T-connected transformer based DSTATCOM connected to a three-phase four-wire system is modeled and simulated using the MATLAB.. The MATLAB based model of the three-phase four-wire DSTATCOM is shown in Fig.3 When 3 phase unbalanced non-linear load is connected across the 3 phase source and the unbalancing is provided in the utility voltage by changing the phase difference by 0º, -110º and 120º.

The outcomes are shown in the Figure5. Trace 1: three phase source voltage, trace 2: three phase source current, trace 3: source neutral current, trace 4: DC side voltage, and trace 5: T-connected transformer neutral current. At time 0.25 sec DSTATCOM is turned on with 12 pulse which improves the current but phase difference is still disturbed, then at time 0.5 sec APF is also turned on which reduces the harmonics in the system and neutral current is also reduced to a great extent that can be shown in figure5.

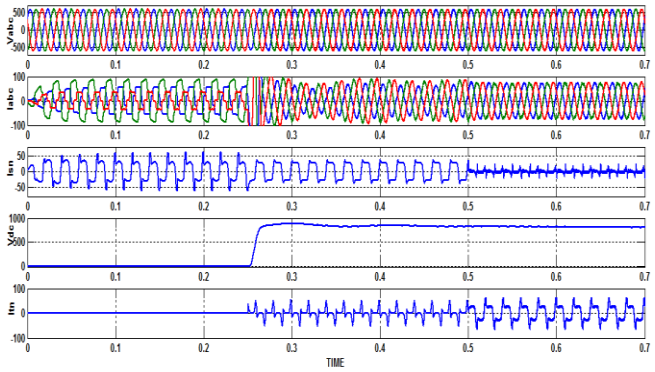

Fig.5:- Performance of three phases four wire distribution system

The total harmonic distortion (THD) at 0.1 sec is 22.43%. When D-STATCOM is turned on THD reduces to 8.04%but phase difference is still unbalanced then APF is turned on at 0.5 sec and the THD is reduces up to 3.80% with balanced condition and neutral current also reduces to a great extent

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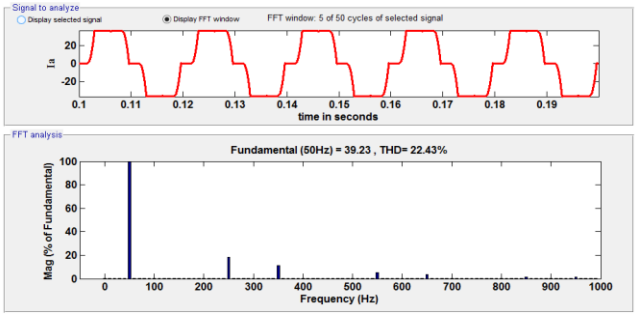

Fig. 6:- When no Compensation is provided THD Of source current is 22.43%

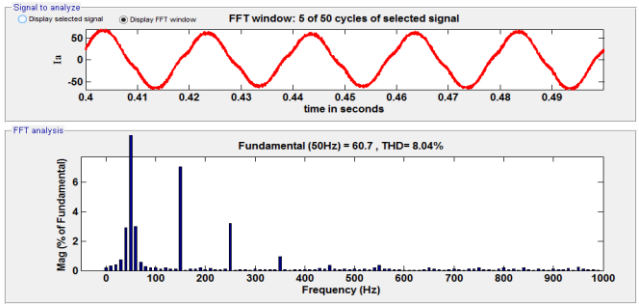

Fig. 7:- D-STATCOM with T-connected Transformer acts as Compensating Device without APF when THD of source currentis8.04%.

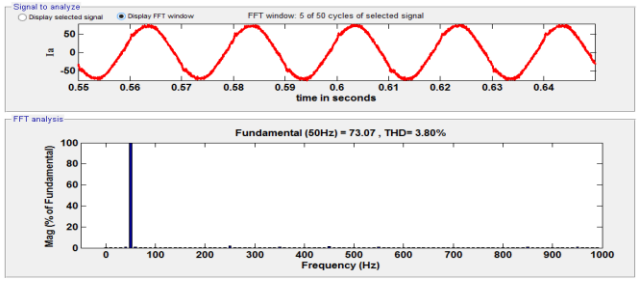

Fig. 8:- D-STATCOM with T-connected Transformer acts as Compensating Device without APF when THD of source current is 3.80%.

V. CONCLUSION

The intended DSTATCOM demonstrates the proficiency to effectually terminate undesirable excessive currents flowing in the neutral line of a three-phase four-wire system and is elevated well organized. In this paper an active power filter to cancel neutral currents in the three-phase four-wire system has been proposed. The recommended topologies consider improves the system concert and contributes to proficient exploit of electric energy and close to eliminates excessive heating of distribution transformers attributable to neutral currents. Active Power Filter is connected to circuit which further reduces the source neutral current to great extent and THD becomes 3.80%. which is within the acceptable limit of THD given by IEEE. The voltage regulation and power factor correction modes of operation of the DSTATCOM have been observed. The circuit is simulated with MATLAB/SIMULINK and the satisfactory results are obtained.

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