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Compensation of Neutral Current, Reactive Power Mitigated by DSTATCOM, using a Unit Vector Control Algorithm

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Abstract: ***The load neutral current will help to carry the electrical power, it provides a path to current from load to source but whenever there is an unbalance condition on the load side it will affect the source system to a large extent. It will affect the whole electrical network and also affect the performance of equipment that we use in the provided system.That is why we need a system that improves this type of problem that occurs accordingly. Several different DSTATCOM topologies can be used for neutral current mitigation and power quality compensation in three-phase, four-wire systems that have a neutral terminal on either the positive or negative dc bus: a 4-legged voltage source converter (VSC), a 3-legged voltage source converter (VSC), To top it all off, the proposed way of boosting the electric supply system's quality by utilising three-phase four-wire distribution is far more efficient than previous approaches. Hence, the compensation of this current will help in increasing the performance of power system equipment. This paper presents the design and implementation of a distribution static compensator (DSTATCOM) with the T connected system. The unit vector template method based control algorithm has been implemented for the control of the proposed DSTATCOM. The proposed test model has been simulated in a SIMULINK/MATLAB environment. The simulations results show the effectiveness of the proposed algorithm.***

Keywords: Distribution static compensator, power quality, neutral current compensation, T-connected transformer, unit vector template method

1. Introduction

All business and hospital facilities employ three-phase electricity distribution networks. As a result, the distribution systems in these areas are frequently confronted with unbalanced loads as a result of the nonlinear loads. High reactive power and harmonics, unbalanced loads and excessive neutral current are major problems in three-phase four-wire systems.. [1-4] This overloading of the neutral conductor occurs when the fundamental and harmonic frequencies come into contact. [5-7] Additionally, the current distribution system's uncontrolled expansion and inclusion of diverse sorts of loads have made voltage regulation ineffective. The phrase "custom power devices" encompasses a wide range of tools for enhancing the quality of electrical power (CPD).Distribution static compensator, dynamic voltage restorer, and UPQC are a few of the specialised power devices available (unified power quality conditioner). [9-10] With these technologies, it is possible to reduce neutral current and increase power quality. [11-19] A shunt compensator installed on the distribution feeder improves voltage regulation. Active shunt compensators can be controlled by a variety of strategies, including IRPT, energy balance, synchronous reference frame, components-based symmetry (SCS), and others. The suggested DSTATCOM is guided by the principle of a constant reference frame. [20-22] The three-phase distribution system uses a T-connected transformer in several ways. Never before has a T-connected transformer been utilised to make up for the neutral current system. Never before has a T-connected transformer been utilised to make up for the neutral current. It is possible to utilise the T-connected transformer to balance the magnetomotive force (MMF). When a three-leg VSC is connected to a T-connected transformer, harmonics are balanced and reactive power is minimised. [23-28] Adjusting for load current, a dc bus capacitor is added to the IGBT-based VSC. Linear loads may be balanced using MATLAB's Simulink and Power System Block Set toolboxes to enable power factor correction and voltage control. A three-legged VSC (voltage source converter) has been proposed to improve power quality. Load current adjustment is handled by capacitors in an IGBT-based VSC. The VSC's dc bus voltage may be tuned to maintain a constant dc bus voltage.3P4W Distribution system. In authors have presented for Improvement of PQ with a T-connected transformer for the compensation of reactive power for voltage regulation or elimination of neutral current. In authors presented a comprehensive review of the neutral current compensation technique.

This paper presents the compensation of load neutral current using DSTATCOM with a T-connected transformer. A unit vector template method based control of the DSTATCOM has been proposed in this paper for neutral current compensation.

This paper is organized into five sections. Starting with an introduction in Section I, Section II describes the proposed test system. The proposed control algorithm has been described in Section III. The simulation results and their discussions are presented in Section IV. Finally, the conclusions are presented in Section V.

2. Proposed Test System

The basic circuit diagram of the proposed DSTATCOM connected to the 3-phase four-wire distribution systems supplying the power to three-phase four-wire loads is shown in Fig. 1.The T-connected transformer gives the path to the neutral current of the load. The DTSTATCOM is a voltage source converter (VSC) made by using six Insulated Gate Bipolar Transistors (IGBTs) switches with anti-parallel diodes and a DC capacitor. The DC-link capacitor helps in improving the ripples by continuously charging and discharging. For reducing the ripples in compensating currents with interfacing inductors are placed to connect the VSC to the supply system. The RC filter is used to reduce the switching ripples in the PCC voltage injected by the fast switching of DSTATCOM. The DSTATCOM is used to control and compensate the reactive and harmonic currents of the load. This helps in the voltage regulation at PCC. In power factor correction (PFC) mode the supply currents have zero phase shift concerning PCC voltages. DSTATCOM inject the currents in zero voltage regulation (ZVR) mode to regulate the PCC voltage at the desired reference value of voltage. In this case, the supply currents may be leading or lagging currents depending on the power factor of load and reference PCC voltage. The supply voltage of the system is 415 V, 50 Hz. Supply impedance is 0.1+j0.628. DC link capacitor is 8000μF and operated on voltage is 800 V. Interfacing inductor has the value 2.3 mH. switching frequency 10 kHz. For ripple, filter resistance is 2 **Ω** and capacitance 20 μF. The star connected transformer has the rating 7.5 kVA, 415/

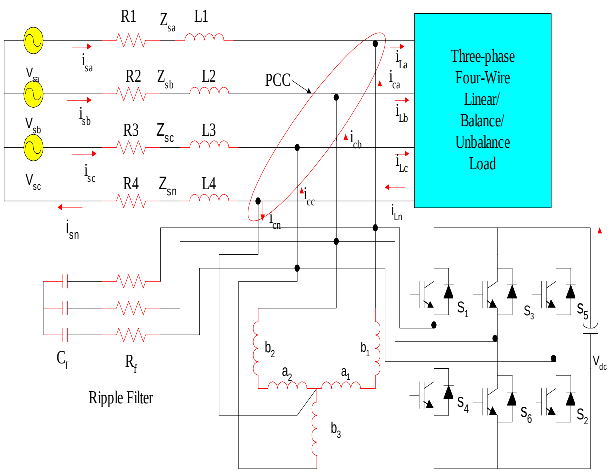


Figure 1: Schematic of a typical Distribution System Compensated by DSTATCOM

3. Proposed Control Algorithm

The schematic diagram for the proposed control is shown in Figure 2. For generating the switching pulses for the IGBTs of the VSC a fixed frequency carrier based sinusoidal PWM is used. This algorithm is based on the unit vector template method. In this method there is two PI controllers are use. One PI controller is use for the regulation of DC link voltage and the second PI controller is used for the regulation of AC terminal voltage The parameters used in the control theory are detailed in the Fig. 2 along with all types of signals used for the control of DSTATCOM.

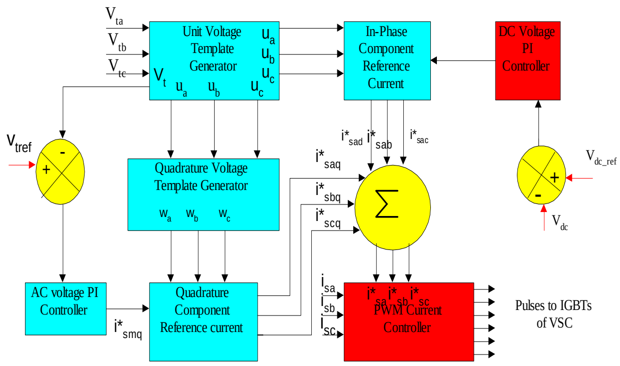


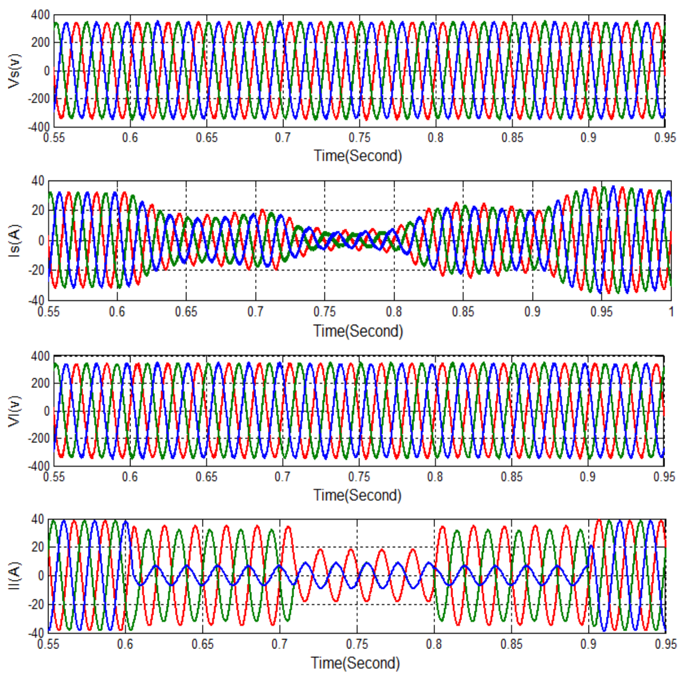
Figure 2: Proposed control algorithm

4. Simulation Results and Discussion

This section details the simulation results related to the neutral current compensation using DSTATCOM with T-connected transformer. The results without compensation using DSTATCOM, with compensation using DSTATCOM in the absence as well as presence of the T-connected transformer are detailed in the following subsections.

A. Healthy Balanced System

The test system shown in Fig. 1 is simulated in the healthy conditions without any disturbance in the system. The 3 phase 4 wire balanced linear load is used in the system. The voltage at PCC and load current are shown in the Fig. 3. The waveform of the source current is same as the load current. It is observed from the Fig. 3 that there is no disturbance in the load voltage and currents. In this condition there is no neutral current.



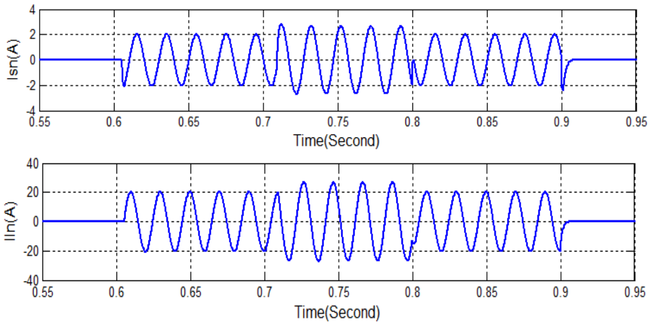


Figure 3: Voltage and without series compensation during LG fault in the presence of wind generation

B. Unbalanced System Without Compensation

The compensation using the DSTATCOM is not uitlized in this case of study. The phases B and C are opened at 11th cycle to simulate the unbalancing in the system and reclosed at 19th cycle to restore the original state of the system. The voltage and curremt waveforms are shown in the Fig. 4. The nuetral currents on the source and load side are shown in the Fig. 5. It is observed that the neutral current flow for the duration for which there is unbalancing in the network. For the period, the system is balanced there is no current in the neutral of the system. This neutral current during the unbalanced conditions, needs to be compensated to achieve high efficiency of the distribution system.

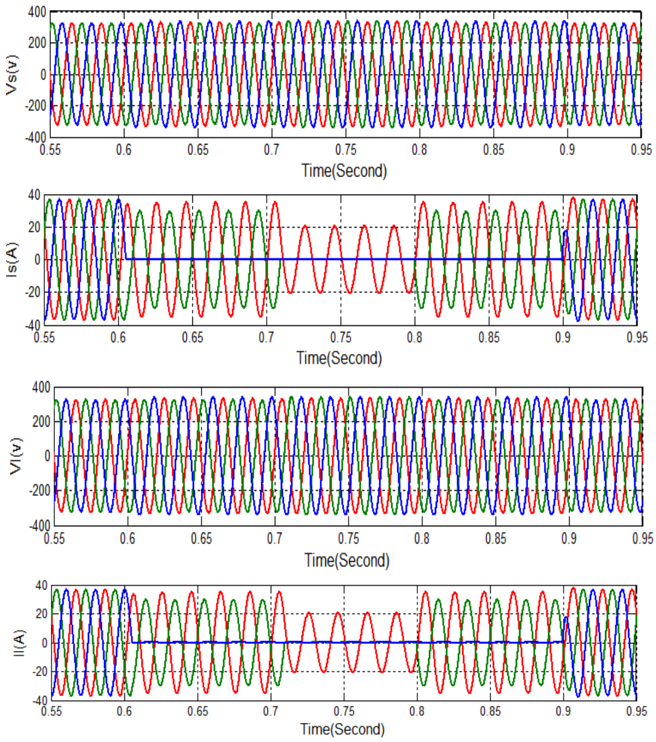


Figure 4: Voltage and current waveforms for unbalanced system with disturbance without compensation

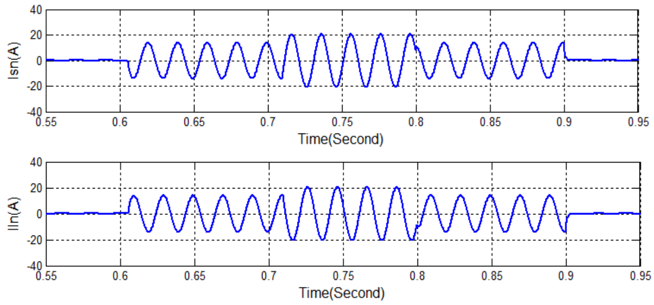


Figure 5: Neutral current on source and load side in unbalance system without compensation.

C. Unbalanced System with Neutral Current Compensation

The DSTATCOM is connecte at the PCC as shown in the Fig.1, to compensate the neutral current during the unbalanced load conditions. The source side voltage and current with neutral current compensation using DSTATCOM are shown in the Fig. 6. These voltage and currents are obtained with and without the T-conneced transfomer. It is observed that these values are not affected by the presence of the T-connected transformer. The source side current reduces during the unbalanced conditions which has been simulated by opening the phases B and C on the load side. The voltages of all the three phases are not affected due to the unbalancing.

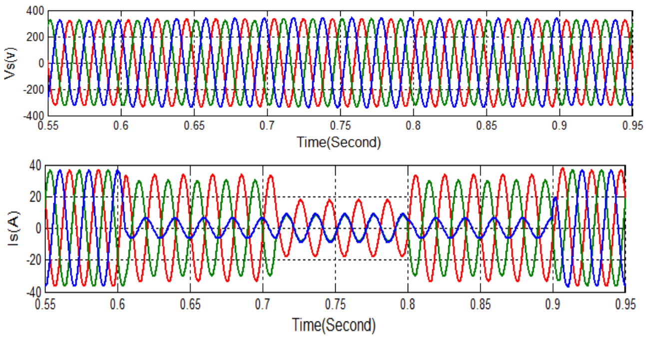


Figure 6: Voltage and current waveforms on source side with neutral current compensation.

The results of compensation using the DSTATCOM in the absence of T-connected transformer are provided in the Fig. 7. The voltage of dc link capacitor (Vdc), neutral current of the source (Isn), neutral current on load side (Iln), current supplied by the DSTATCOM (Icom) and current flowing in the neutral of the start-side of the transformer (Izn) are provided in the Fig. 7. The source neutral current is very high without the use of T-connected transformer. The current injected by the DSTATCOM during the unbalancing conditions is reduced. The small magnitude transient has also been observed in the voltage of dc link capacitor. This voltage slightly increases at the time of unbalancing and then attains the original value after the original state of the system is achieved.

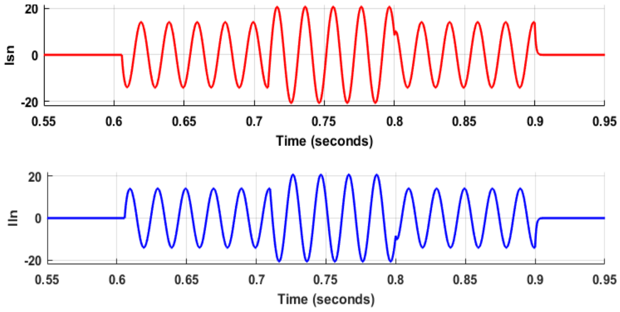


Figure 7: Load neutral current with series compensation in the absence of T-connected transformer.

The results of compensation using the DSTATCOM in the presence of the T-connected transformer are provided in the Fig. 8. The voltage of dc link capacitor (Vdc), neutral current of the source (Isn), neutral current on load side (Iln), current supplied by the DSTATCOM (Icom) and current flowing in the neutral of the start-side of the transformer (Izn) are provided in the Fig. 8. It is observed that the source neutral current is reduced significantly with the use of T-connected transformer. The current injected by the DSTATCOM during the unbalancing conditions is reduced. Hence, the use of T-connected transformer with the DSTATCOM reduces the source neutral current. The small magnitude transient has also been observed in the voltage of dc link capacitor. This voltage slightly increases at the time of unbalancing and then attains the original value after the original state of the system is achieved.

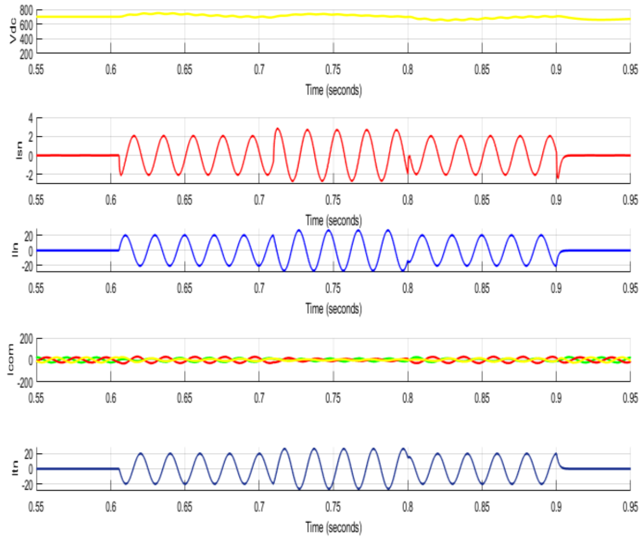


Figure 8: Load neutral current with series compensation in the presence of T-connected transformer

5. Conclusion

This paper presents a method for the compensation of source neutral using the distribution static compensator with the T-connected transformer. The unit vector template based control of the DSTATCOM has been proposed for the neutral current compensation. It has been observed that with the application of the T-connected transformer, the load neutral current circulates through the winding of the T-connected transformer which reduces the source neutral current.Hence, the compensation of source neutral current is achieved successfully. The results have been simulated in the MATLAB/Simulink environment.

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