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Mitigation of Power Quality Problems in Distribution Generation System Using DSTATCOM

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ABSTRACT:

Power quality is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure of end use equipment's. In order to maintain the power system quality the DSTATCOM will absorb and provide reactive power to mitigate voltage sag, swell, interruption and improve power factor in various conditions. The proposed scheme exhibits several advantages compared to traditional voltage-controlled DSTATCOM where the reference voltage is arbitrarily... This scheme allows DSTATCOM to tackle power-quality issues by providing power factor correction, harmonic elimination, load balancing, and voltage regulation based on the load requirement The compensator injects lower currents and, therefore, reduces losses in the feeder and voltage-source inverter... The performance of DSTATCOM is found satisfactory under time varying and unbalanced loads. Its performance is simulated in the MATLAB environment using SIMULINK and Sim Power System (SPS) toolboxes

Keywords: voltage-source inverter, DSTATCOM dead beat voltage control, Power factor correction.

INTRODUCTION:

In recent years, use of power converters in adjustable speed drives, power supplies etc. It is a measure of deviations in voltage, current, frequency of a particular system and associated components. is continuously increasing. Power quality in distribution systems affects all the connected electrical and electronics equipment's. Some of power quality problems associated with these loads include harmonics, high reactive power burden, load unbalancing, voltage variation etc. A survey on power quality problems is discussed for classification, suitable corrective and preventive actions to identify these problems. This equipment draws harmonics currents from AC mains and increases the supply demands. These custom power devices are classified as the DSTATCOM (Distribution Static Compensator), DVR (Dynamic Voltage Restorer) and UPQC (Unified Power Quality Conditioner). These loads can be grouped as linear (lagging power factor loads), nonlinear (current or voltage source type of harmonic generating loads), unbalanced and mixed types of loads. A variety of custom power devices are developed and successfully implemented to compensate various power quality problems in a distribution system. The converter and value of interfacing inductors. For the control of DSTATCOM, many control algorithms are reported in the literature based on the instantaneous reactive power theory, The DSTATCOM is a shunt-connected device, which can mitigate the current related power quality problems. ANN and fuzzy based controller, SVM based controller, correlation and cross-correlation coefficients based control algorithm, Other techniques applied in active filters are based on Hilbert transform, soft phase locked loop and novel hysteresis current controller etc. deadbeat or predictive control, instantaneous symmetrical component, nonlinear control technique, modified power balance theory, enhanced phase locked loop technique, Adeline control technique, synchronous reference frame control technique. In this paper, this control algorithm based on the correlation and cross correlation function approach is used in a three phase distribution system for compensation of reactive current, harmonics current and load balancing in PFC and ZVR modes of operation of DSTATCOM. The control algorithm based on cross correlation function approach has been reported for single phase AC system.

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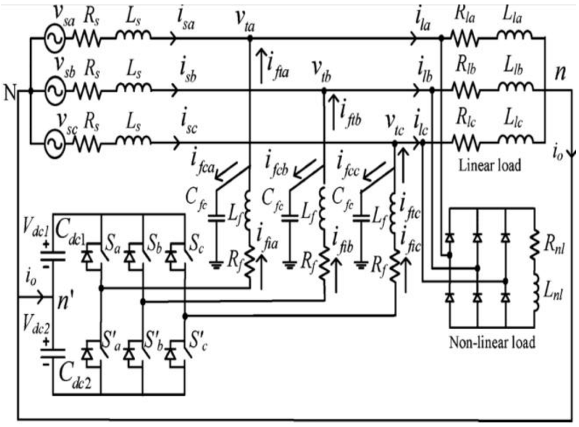
Design Structure of Distributed Static Compensator:

The device is shunt connected to the power distribution network through a coupling inductance that is usually realized by the transformer leakage reactance. In general, the DSTATCOM can provide power factor correction, harmonics compensation and load balancing. A DSTATCOM is a device which is used in an AC distribution system where, harmonic current mitigation, reactive current compensation and load balancing are necessary.



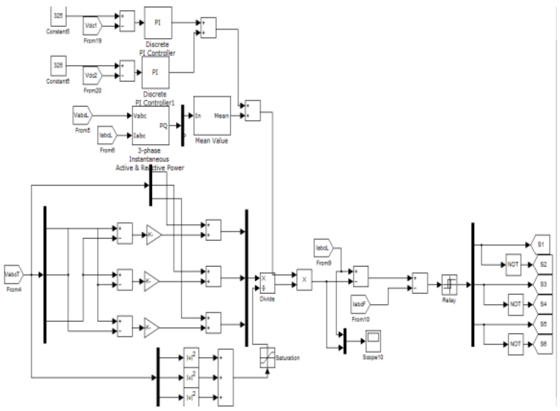
Circuit diagram of the DSTATCOM:

The rating of the switches is based on the voltage and current rating of the required compensation. For considered load of 35kVA, compensator data are given in Appendix, the rating of the VSC for reactive power compensation/harmonics elimination is found to be 25kVA (15% more reactive current from rated value). The selection of the DC bus voltage, DC bus capacitor, AC inductors and the ripple filter of DSTATCOM The size of the capacitor does not play an important role in steady-state reactive power generation, which results in asignificant reduction of the overall compensator size and cost. The building block of a DSTATCOM is a voltage source converter (VSC) consisting of self-commutating semiconductor valves and a capacitor on the DC bus. the schematic diagram of a DSTATCOM connected to a three phase AC mains feeding three phase loads. Three phase loads may be a lagging power factor load or an unbalanced load or non-linear loads or mixed of these loads.

For reducing gripple in compensating currents, interfacing inductors (Lf) are used at AC side of the voltage source converter (VSC). The harmonics/reactive currents are injected by the DSTATCOM to cancel the harmonics /reactive power component of the load currents so that the source currents are harmonic free (reduction in harmonics) and load reactive power is also compensated. A small series connected capacitor (Cf) and resistor (Rf) represent the ripple filter installed at PCC in parallel with the loads and the compensator to filter the high frequency switching noise of the voltage at PCC. The major advantages of DSTATCOM compared with a conventional static VAR compensator (SVC) include the ability to generate the rated current at virtually any network voltage, better dynamic response and the use of a relatively small capacitor on the DC bus.

CONTROL STRATEGY:

To achieve this, first the fundamental positive sequence component of load currents is computed. Then, it is assumed that these currents come from the source and considered as reference source currents at nominal load. With these source currents and for UPF at the PCC, the magnitude of the PCC voltage is calculated. Reference terminal voltages are generated such that, at nominal load, all advantages of CCM operation are achieved while DSTATCOM is operating in VCM. Hence, the DSTATCOM will inject reactive and harmonic components of load current.



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Simulation Circuit of Control Strategy:

Let three-phase load currents $i_{la}(t)$, $i_{lb}(t)$, and $i_{lc}(t)$be represented by the following equations:

$$i_{lj}(t) = \sum_{n=1}^{m} \sqrt{2}\, I_{lj\,n} \sin\left(n\,\omega t + \phi_{lj\,n}\right)$$

Where j = a, b, c represent three phases, n is the harmonic number, and m is the maximum harmonic order. ϕ_{lan} Represents the phase angle of the nth harmonic with respect to reference in phase- and is similar to other phases. Using instantaneous symmetrical component theory, instantaneous zero-sequence $i_{la}{}^{o}(t)$, positive-sequence $i_{la}{}^{+}(t)$, and negative-sequence $i_{la}{}^{-}(t)$current components are calculated as follows:

$$\begin{bmatrix} i_{la}^{0}(t) \\ i_{la}^{+}(t) \\ i_{la}^{-}(t) \end{bmatrix} = \frac{1}{3} \begin{bmatrix} 1 & 1 & 1 \\ 1 & \alpha & \alpha^2 \\ 1 & \alpha^2 & \alpha \end{bmatrix} \begin{bmatrix} i_{la}(t) \\ i_{lb}(t) \\ i_{lc}(t) \end{bmatrix}$$

Where α is a complex operator.

$$i_{sa}^{*} = i_{la1}^{+}(t) = \sqrt{2}\,\left|\bar{I}_{la1}^{+}\right| \sin\left(\omega t - \delta_0\right)$$

$$i_{sb}^{*} = i_{lb1}^{+}(t) = \sqrt{2}\,\left|\bar{I}_{la1}^{+}\right| \sin\left(\omega t - \frac{2\pi}{3} - \delta_0\right)$$

$$i_{sc}^{*} = i_{lc1}^{+}(t) = \sqrt{2}\,\left|\bar{I}_{la1}^{+}\right| \sin\left(\omega t + \frac{2\pi}{3} - \delta_0\right)$$

The fundamental positive-sequence component of load current I^{+}_{la1}, calculated by finding the complex Fourier coefficient, is expressed as follows

$$\bar{I}_{la1}^{+} = \frac{\sqrt{2}}{T} \int_{0}^{T} i_{la}^{+}(t)\, e^{-j(\omega t - 90^{\circ})}\, dt$$

$I^{+}_{la1}$is a complex quantity, contains magnitude and phase angle information.

Hence, it will be treated as reference source currents. For UPF at nominal operation, the nominal load angle is used. The fundamental positive-sequence component of load currents must be supplied by the source at nominal load. By knowing, fundamental positive-sequence currents in phases and can be easily computed by providing a phase displacement of -2π/3 and 2π/3, respectively.

$$v_{tj}(t) = v_{sj}(t) - L_s \frac{di_{sj}^{*}}{dt} - R_s i_{sj}^{*}$$

When reference source currents derived are supplied bythe source, three-phase terminal voltages can be computed.

$$v_{ta}(t) = \sqrt{2}\, V_t^{*} \sin \omega t$$

$$i_{sa}^{*} = \sqrt{2}\, \left|\bar{I}_{la1}^{+}\right| \sin \omega t$$

$$v_{sa}(t) = \sqrt{2}\, V \sin\left(\omega t + \delta_0\right)$$

The phas or equation will be

$$V_t^{*} \angle 0 = V \angle \delta_0 - \left(R_s + jX_s\right) \left|\bar{I}_{la1}^{+}\right| \angle 0$$

Let the rms value of reference terminal and source voltages be $V^{*}_{t}$and V, respectively. For UPF, the source current and terminal voltage will be in phase. However, to obtain the expression of V* independent of δo, we assume the PCC voltage as a reference ph as or for the time-being. Hence, phase-a quantities, by considering UPF at the PCC, will be Simplifying the above equation

$$V_t^{*} = V\cos\delta_0 + jV\sin\delta_0 - \left|\bar{I}_{la1}^{+}\right| R_s - j\left|\bar{I}_{la1}^{+}\right| X_s$$

The expression for reference load voltagemagnitude will be

$$v_{ta}^{*}(t) = \sqrt{2}\, V_t^{*} \sin(\omega t - \delta)$$

$$v_{tb}^{*}(t) = \sqrt{2}\, V_t^{*} \sin\left(\omega t - \frac{2\pi}{3} - \delta\right)$$

$$v_{tc}^{*}(t) = \sqrt{2}\, V_t^{*} \sin\left(\omega t + \frac{2\pi}{3} - \delta\right)$$

SIMULATION RESULTS FORCONVENTIONAL DISTIBUTED STATIC COMPENSATOR

Conventional operation

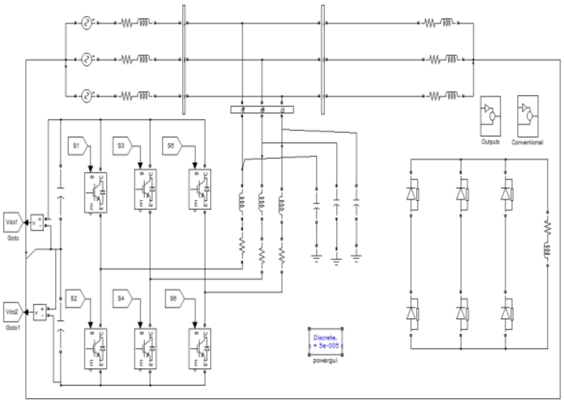

Fig 3: simulation circuit conventional DSTATCOM

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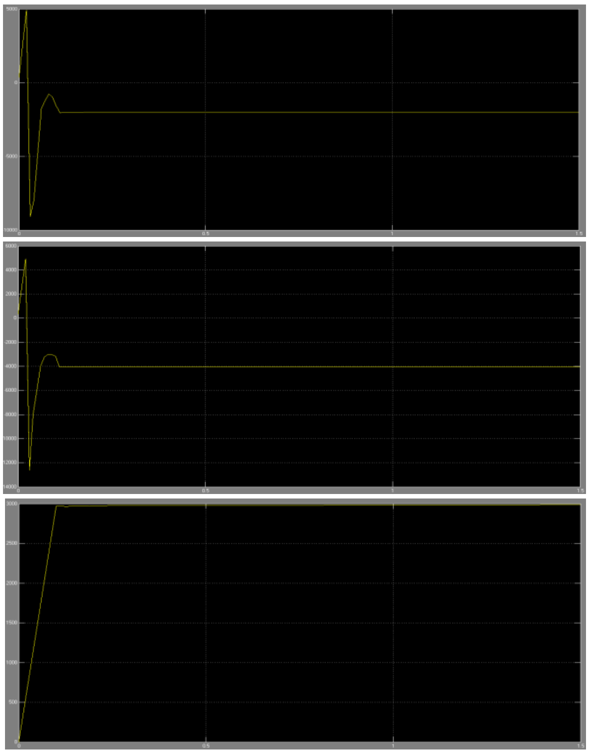
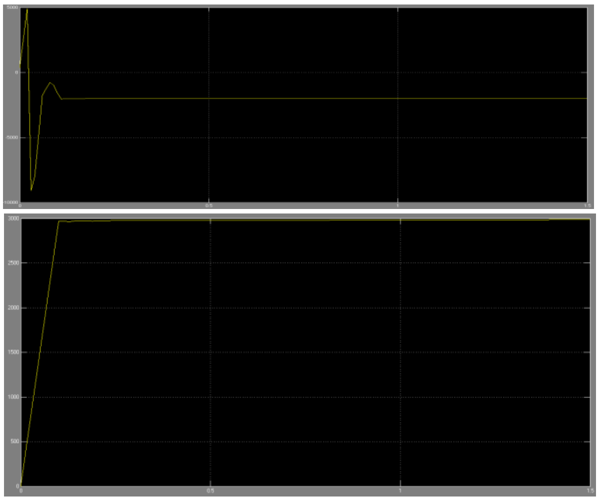
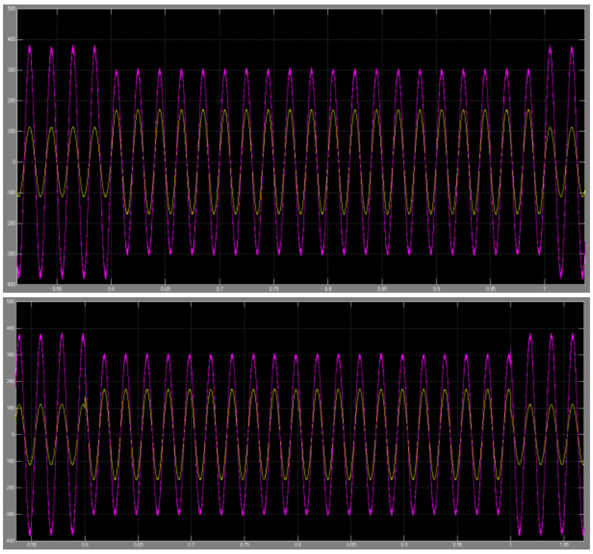
Three conditions, namely, nominal operation, operation during sag, and operation during load change are compared between the traditional and proposed method. The control scheme is implemented using PSCAD software. Distorted and unbalanced source currents flowing through the feeder make terminal voltages unbalanced and distorted.



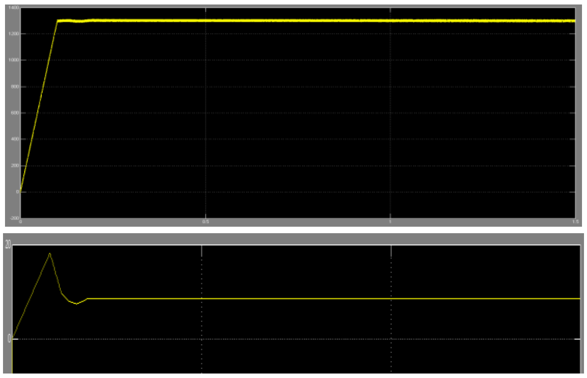
Load reactive power, compensator reactive power, and reactive power at PCC. (a) Traditional method.



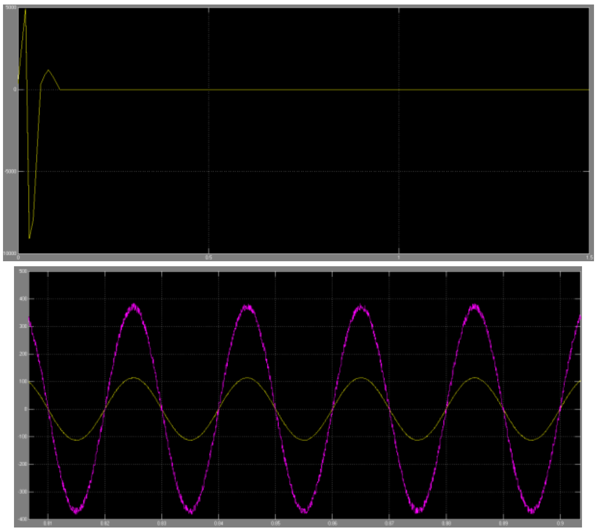
Load reactive power, compensator reactive power, and reactive power at PCC for proposed method.



Terminal voltages and source currents using the traditional method during sag.



(a) Voltage at the dc bus. (b) Load angle for proposed method.



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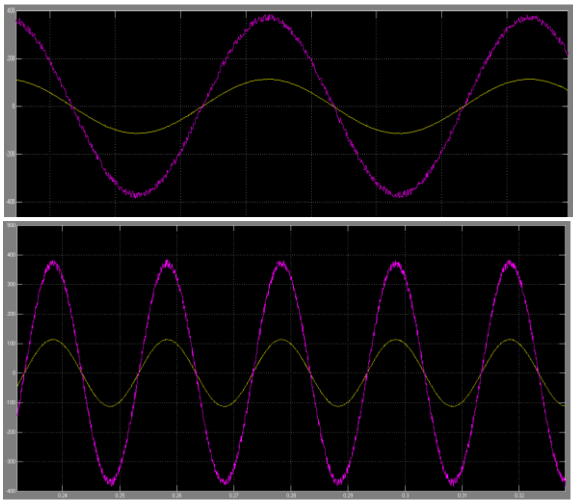
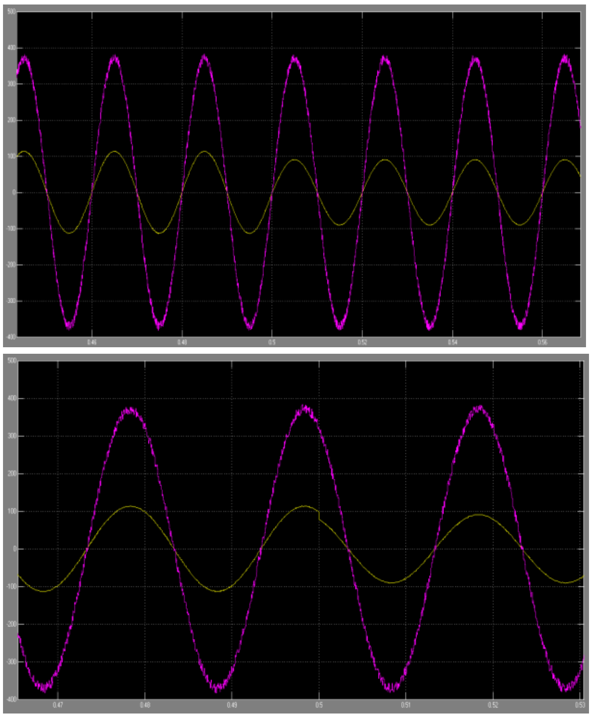
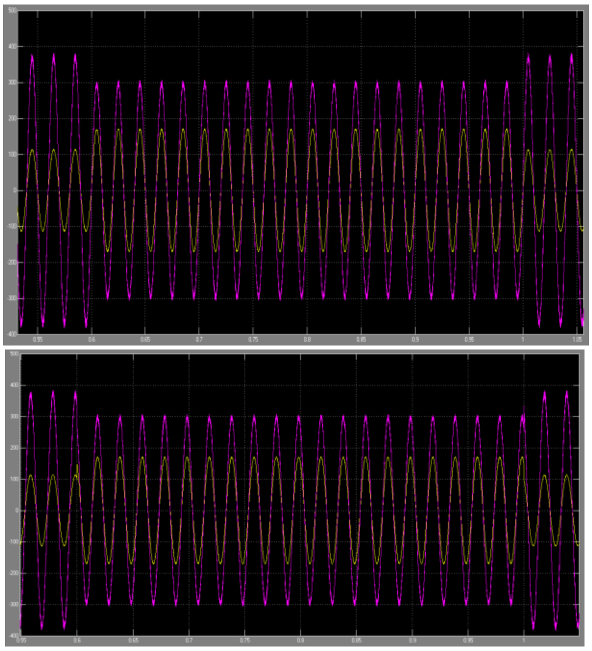


Terminal voltages and source currents using the traditional method. (a) Phase-a. (b) Phase-b. (c) Phase-c.



Terminal voltages and source currents using the traditional method during load change.



Terminal voltages and source currents using the proposed method during sag.

CONCLUSION:

The proposed method provides the following advantages.: 1) losses in the VSI and feeder are reduced considerably 2) at nominal load, the compensator injects reactive and harmonic components of load currents, resulting in UPF; ; 3) fast voltage regulation has been achieved during voltage disturbances 4) nearly UPF is maintained for a load change; and. The performance of the proposed scheme is compared with the traditional voltage-controlled DSTATCOM DSTATCOM control algorithm is flexible and it has been observed to be capable of correcting power factor to unity, eliminate harmonics in supply currents and provide load balancing.

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