Novel Approach for Reducing THD in Distribution System by Using DSTATCOM

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Abstract:
This paper concentrated on the power quality improvement in distributed networks with utilizing FACTS technology. In the suggested paper implemented a new algorithm with the reference voltage are generated by presenting the distributed static compensator (DSTATCOM) under voltage control operation. The developing model which is maintained the unity power factor is generated under abnormal conditions; it is not possible by utilizing conventional topologies. Also maintained active and reactive powers effectively and the harmonic analysis is provided to improve the performance by identifying the THD distortion levels. Whenever the presence of voltage sags in the distribution regions in that situation DSTATCOM can identified the problems and those problems are compensated with the high rating capabilities from the STATCOM. Whenever the abnormal conditions occurred in the systems such conditions the presence of ripple contents very high in load side. But by the STATCOM we can reduce the harmonic levels effectively b controlling the voltage references in the voltage source converter effectively which can improves the behaviour of distributed side. The state space model is developed by DSTATCOM with hysteresis controller. The hysteresis controller is activated with the help of dead beat controller under the abnormal load conditions. The Simulink models are tested and verified within the MATLAB/SIMULINK. Finally as a result power quality issues were compensated, improves power factor levels, active and reactive power also compensated, THD levels also minimized load requirements are achieved properly by the utilization of DTSTATCOM.

I. INTRODUCTION

A DISTRIBUTION framework experiences present and voltage-related force quality (PQ) issues, which incorporate poor force component, twisted source current, and voltage unsettling influences [1]. A DSTATCOM, associated at the point of regular coupling (PCC), has been used to alleviate both sorts of PQ issues. At the point when working in current control mode (CCM), it infuses receptive and symphonies parts of burden streams to make source ebbs and flows adjusted, sinusoidal, also, in stage with the PCC voltages [2].

In voltage-control mode (VCM) [3], the DSTATCOM manages PCC voltage at a reference worth to shield basic burdens from voltage aggravations, for example, droop, swell, and unbalances. Then again, the preferences of CCM and VCM can't be accomplished at the same time with one dynamic channel gadget, since two modes are autonomous of each other.

In CCM operation, the DSTATCOM can't make up for voltage unsettling influences. Consequently, CCM operation of DSTATCOM is not valuable under voltage unsettling influences, which is a noteworthy inconvenience of this method of operation [4]. Generally, in VCM operation, the DSTATCOM regulates the PCC voltage at 1.0 p.u. [5] Nonetheless, a heap works agreeably for an allowable voltage range [6]. Thus, it is not important to direct the PCC voltage at 1.0 p.u. While keeping up 1.0-p.u. voltage, DSTATCOM makes up for the voltage drop in feeder. For this, the compensator needs to supply extra responsive streams which build the source streams. This expands misfortunes in the voltage-source inverter (VSI) and feeder.

Another essential perspective is the rating of the VSI. Because of expanded current infusion, the VSI is de-evaluated in relentless state condition. Thus, its ability to moderate profound voltage droop diminishes. Additionally, UPF can't be accomplished when the PCC voltage is 1 p.u. In the writing, in this way, the operation of DSTATCOM is not reported where the benefits of both modes are accomplished in view of burden necessities while defeating their negative marks.

This paper considers the operation of DSTATCOM in VCM what's more, proposes a control calculation to acquire the reference load terminal voltage. This calculation gives the consolidated points of interest of CCM and VCM. The UPF operation at the PCC is accomplished at ostensible burden, though quick voltage regulation is given among voltage aggravations. Likewise, the receptive and symphonies part of burden current is supplied by the compensator whenever of operation. The miscreant prescient controller [7] is utilized to create exchanging heartbeats. The control technique is tried with a three-stage four-wire dissemination framework. The adequacy of the proposed calculation is approved through simulation and experimental results.

II. PROPOSED CONTROL SCHEME

Circuit diagram of a DSTATCOM-compensated distribution system is shown in Fig. 1.

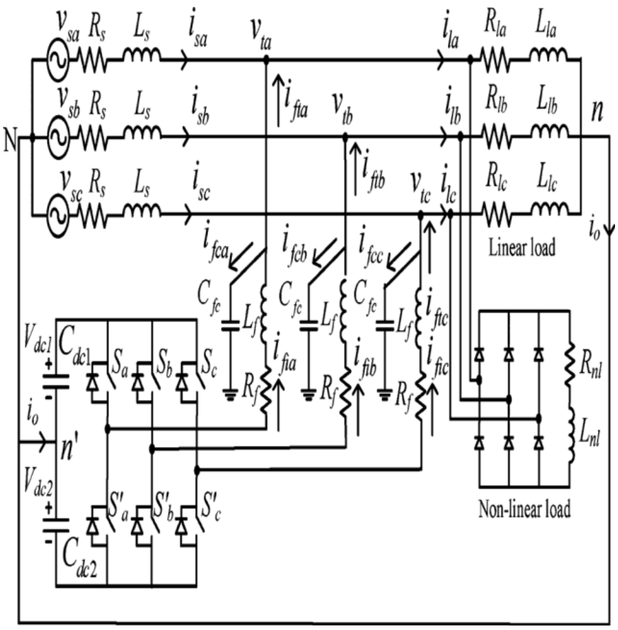

Fig. 1. Circuit Diagram of the DSTATCOM-Compensated Distribution System

It uses a three-phase, four-wire, two-level, neutral-point-clamped VSI. This structure allows independent control to each leg of the VSI. [8] Fig. 2 shows the single-phase equivalent representation of Fig. 1. Variable is a switching function, and can be either +1 or -1 depending upon switching state. Filter inductance and resistance are L_f and R_f, respectively. Shunt capacitor C_{fc}eliminates high-switching frequency components.

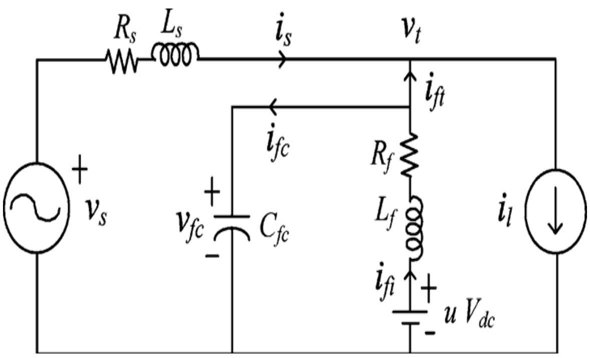

Fig. 2.Single-Phase Equivalent Circuit of DSTATCOM.

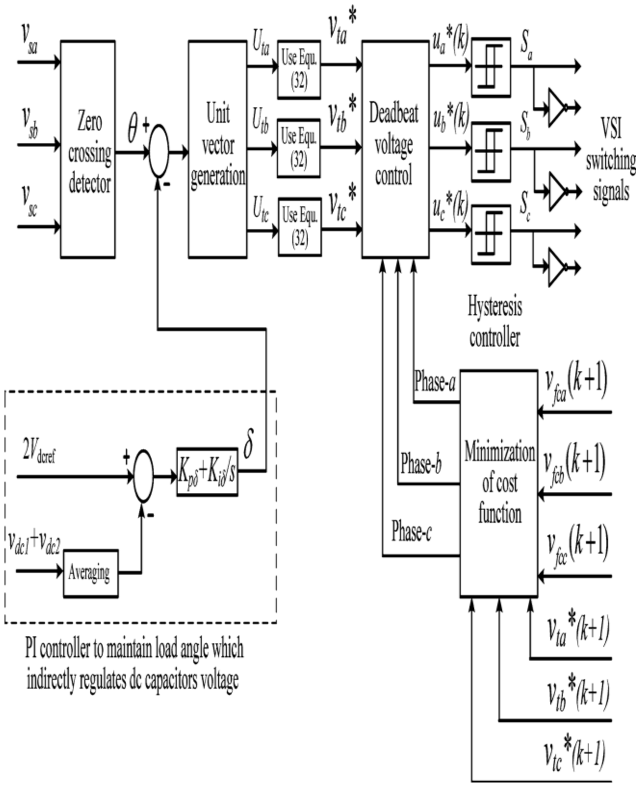

Fig. 3. Overall Block Diagram of the Controller to Control DSTATCOM In A Distribution System.

In the first place, discrete demonstrating of the framework is displayed to acquire a discrete voltage control law, and it is demonstrated that the PCC voltage can be managed to the coveted quality with legitimately picked parameters of the VSI. At that point, a system to outline VSI parameters is exhibited. A proportional-integral (PI) controller is utilized to control the dc capacitor voltage at reference esteem. In light of prompt symmetrical part hypothesis and complex Fourier change, a reference voltage extent era plan is suggested that gives the benefits of CCM at ostensible burden. The overall controller block diagram is shown in Fig. 3. These steps are explained as follows.

III. DESIGN OF VSI PARAMETERS

DSTATCOM controls terminal voltage acceptably, be contingent upon the correctly chosen VSI considerations. The design process of these considerations is existing as follows.

1) Voltage Across DC Bus (V_{dc}):

The dc bus voltage is occupied double the peak of the phase voltage of the basis for acceptable presentation [9]. Consequently, for a line voltage of 400 V, the dc bus voltage is retained at 650 V.

2) DC Capacitance (C_{dc}):

Estimations of dc capacitors are picked in view of a time of hang/swell and change in dc transport voltage amid drifters. Let the aggregate burden rating be kVA. In the most pessimistic scenario, the heap force may differ from least to greatest that is, from 0 to kVA.

The compensator needs to trade genuine force amid transient to keep up the heap force request. This exchange of genuine force amid the transient will bring about the deviation of capacitor voltage from its reference esteem.

The voltage keeps on diminishing until the capacitor voltage controller comes energetically. Consider that the voltage controller takes cycles, that is, seconds to act, where the framework is time period.

Subsequently, most extreme vitality trade by the compensator amid transient will be. This vitality will be equivalent to the adjustment in the capacitor put away vitality. So

$$\frac{1}{2}C_{dc}\left(V_{dcref}^2 - V_{dc}^2\right) = pST$$

Where V_{dcref} and V_{dc} are the reference dc bus voltage and maximum-allowed voltage during transients, correspondingly. Hence

$$C_{dc} = \frac{2pST}{V_{dcref}^2 - V_{dc}^2}$$

3) Filter Inductance (L_f):

Filter inductance L_f must be responsible for practically high switching frequency and a appropriate rate of change of current such that VSI currents follow desired currents. The following equation represents inductor dynamics

$$L_f\frac{di_{fi}}{dt} = -v_{fc} - R_f i_{fi} + V_{dc}$$

The inductance L_f is designed to provide good tracking performance at a maximum switching frequency (f_{max}) which is achieved at the zero of the source voltage in the hysteresis controller. Neglecting R_f , L_f is given by

$$L_f = \frac{2V_m}{(2h_c)(2f_{max})} = \frac{0.5V_m}{h_c f_{max}}$$

4) Shunt Capacitor (C_{fc}):

The shunt capacitor should not resonate with feeder inductance at the fundamental frequency (ω_0). Capacitance, at which resonance will occur, is given as

$$C_{fcr} = \frac{1}{\omega_0^2 L_s}$$

For proper operation, C_{fc} must be chosen very small compared to C_{fcr}. Here, a value of 5 mF is chosen which provides an impedance of 637 at ω_0 . This does not allow the capacitor to draw significant fundamental reactive current.

IV. DIFFERENT OPERATIONS OF D-STATCOM

The control plan is actualized utilizing PSCAD programming. Terminal voltages what's more, source streams before pay are plotted. Twisted and unequal source streams coursing through the feeder make terminal voltages uneven and bended. Three conditions, in particular, nominal operation, operation during sag, and operation during load change are thought about between the conventional what's more, proposed technique. In the traditional method, the reference voltage is 1.0 p.u, though in the proposed strategy, is utilized to discover the reference voltage.

A. *Nominal Operation*

At first, the conventional technique is considered. Demonstrates the controlled terminal voltages and relating source streams in stages, and, individually. These waveforms are adjusted and sinusoidal. In any case, source streams lead individual terminal voltages which demonstrate that the compensator supplies receptive current to the source to overcome feeder drop, moreover to supplying burden receptive and symphonies streams.

The dc transport voltage directed at an ostensible voltage of 1300V.Using the proposed strategy, terminal voltages and source streams in stages a, b and is appeared individually. It can be seen that the separate terminal voltages and source streams are in stage with one another, notwithstanding being adjusted and sinusoidal. In this manner, UPF is accomplished at the heap terminal.

B. *Operation During Sag*

To make list, source voltage is brought down by 20% from its supposed approval at t=0.6 s. List is uprooted at t=1.0 s. Since voltage regulation capacity does not rely on reference voltage, it is most certainly not demonstrated independently for the conventional strategy. Terminal voltages directed at their reference approval.

The controller gives a quick voltage regulation at the heap terminal. The all out dc transport voltage also, the heap edge, individually. Amid the transient period, Capacitors supply genuine energy to keep up burden power which results in releasing of capacitors.

C. *Operation During Load Change*

To demonstrate the effect of burden changes on framework execution, burden is expanded to

140%of its ostensible quality. Under this condition, the customary strategy gives less power variable as the compensator will supply more responsive current to keep up the reference voltage. The voltage and current waveforms, as appeared. In proposed system, a heap change will bring about little deviation in terminal voltage from its reference voltage. Compensator simply needs to supply additional receptive current to beat this little additional feeder drop, henceforth, almost UPF is kept up while managing the terminal voltage at its reference voltage.

V. PROPOSED SIMULINK MODEL

The implemented Simulink model consisted the parameters of three phases four wire source voltages which is distributed the sending voltage to customers. In this project non linear loads are placed in the load side and in between the loads we are presented the three phase problems.

Whenever the faulted conditions the presence of ripple contents will more. Generally the presence of non linear loads only harmonic contents increases in the load side also here three phase problems included, in order to solve these power quality issues purpose FACTS based D-STATCOM integrated in parallel to the system with filters.

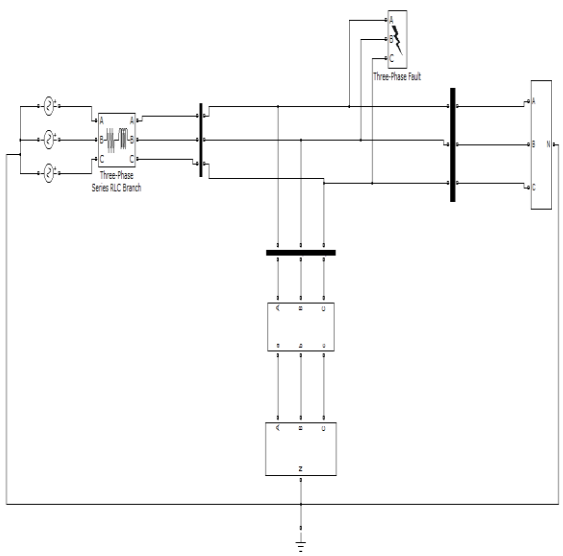

Fig 4: Proposed Simulink Model for the Distributed STATCOM

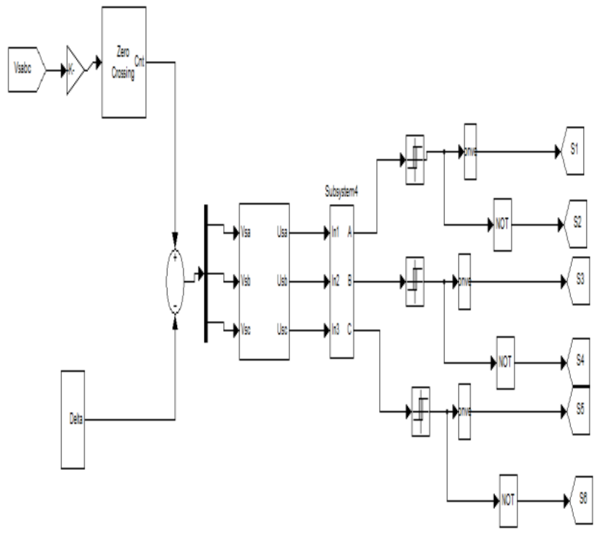

Fig 5: Proposed Control Strategy for the Distributed STATCOM With Hysteresis Controller

The D-STATCOM is a three phase voltage source converter with inductance and capacitance. The three phase voltage source converter acts as either rectifier or inverter depends up on the requirement it will perform. The VSC which is controlled by the hysteresis controlling Strategy is given for the generation of firing pulses. The inductance is used to absorb the unnecessary voltage at faulted conditions and also it reduces the ripple contents to the system. The capacitance which is used to stored energy at normal and it discharge the energy at faulted condition. The designed Simulink model is given below figure 4.

The hysteresis controller was developed for the STATCOM. The three phase source voltage measurement is connected to zero crossing circuit, in this it counts the number of zero crossings in signals, by maintaining the capacitance voltage is constant by PI controllers these two signals are compared and produces error signal. This is send to the unit vector system.

The unit vector system consisted the math operations with multiplies square root functions with divisions also these are maintained the proper relevant magnitudes individual phases from this process.

These signals transmitted to dead beat controllers; here numbers of PI controllers are provided to enhance the system stability levels.

The cost minimization scheme is also provided by load side voltage measurement and statcom voltage measurement by comparing these error signals generated which is also given to dead beat control to improve the steady state and transient response in the system.

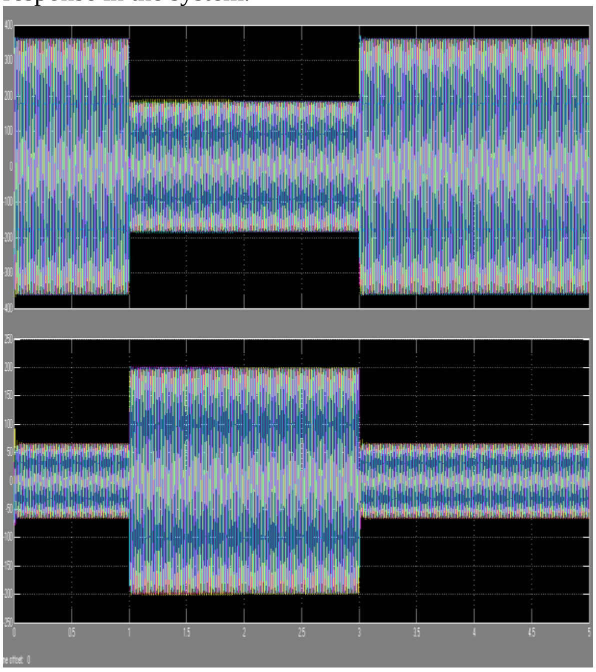

Fig 6: Source Voltage and Currents from distributed STATCOM

Finally the generated error less signal which is given to the hysteresis controller. The controllers have bandwidths for to create the frequency levels. Whenever the internal threshold voltage of hysteresis controller greater than the generated signal then only firing pulses were produced. The controller is shown in figure 5.

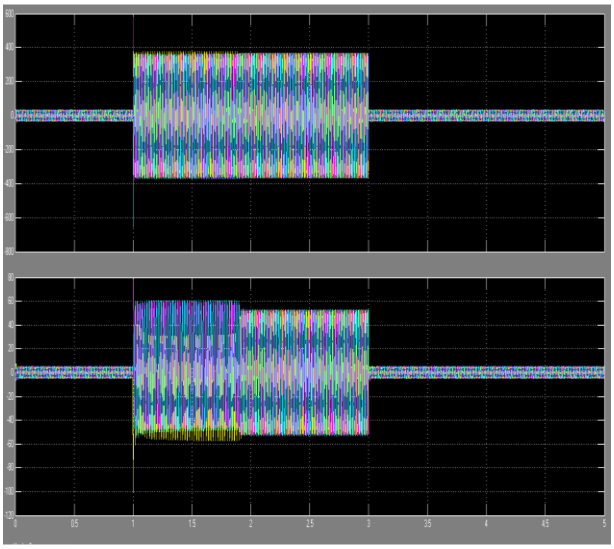

Fig 7: Distributed STATCOM Voltage and Currents

The firing pulses are given to the STSTCOM controller and it can identified the faulted conditions and it is compensated corresponding issues, which improves the active and reactive power levels, power factor improvement and finally it can improve the power quality of system by reducing the harmonic distortion levels as 0.28.

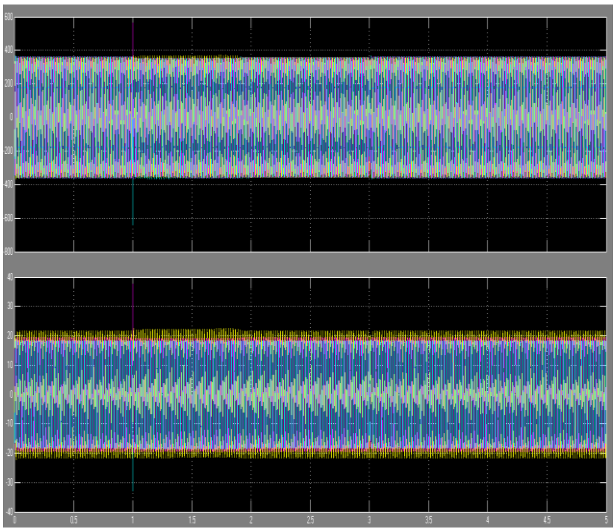

Fig 8: Load Voltage and Currents from distributed STATCOM

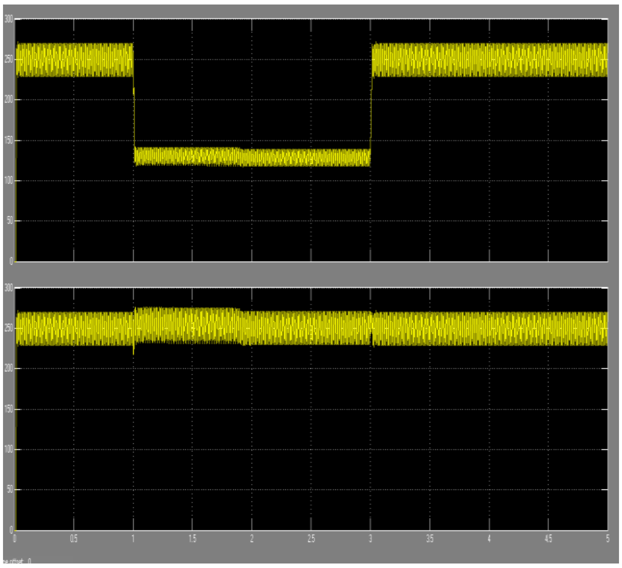

Fig 9: RMS voltages at source side & load side

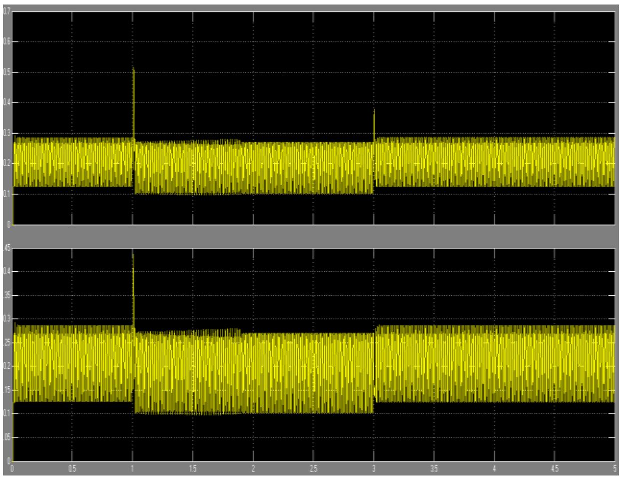

Fig 10: THD Values at Source Side & Load Side

The above figures are represents the outputs from system. Fig 6 explains the source voltage and current for the operating circuit. Fig 7 represents the generated voltage and currents from the DSTATCOM. Fig 8 denotes the voltage and currents at load side. fig 9 explains the R.M.S voltage for source and load . fig 10 gives the information related to generated THD values for source side and load side.

VI. CONCLUSION

This paper concentrated on the voltage control algorithm which is done by providing effective DSTATCOM under distributed networks. The implemented model provide different features like as load balancing conditions are achieved even at abnormal conditions, the controlling of active and reactive by injecting required powers to load which improves the power factor level nearer to unity, by the THD analysis technique the generation ripple contents mostly eliminated, the power quality issues like as sag problems are compensated permanently by the DSTATCOM rating level to the voltage source converter.

The Simulink models are implemented within the simulation which are tested and verified within the MATLAB/SIMULINK.

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