

## Applying SRF Theory to the Simulation of a Three-Phase Four-Wire System

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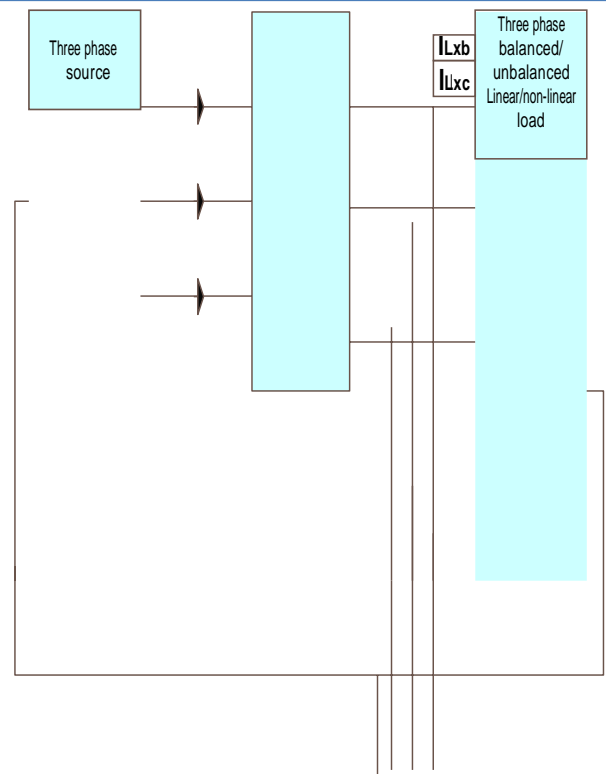
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*Abstract*— Switching components have a significant effect on electrical demand as the power sector develops. All of these things deform lines, which raises line losses, lowers power quality, and makes sin waves less pure. A DC coupling capacitor and DSTATCOM's voltage source converter (VSC) operate in a back-to-back manner. Injecting power from the VSC and generating the reference current are both done at the point of common coupling (PCC) using the synchronous reference frame control method. The PI controller isolates the harmonic components from the reference current, compares the reference to the real current, and then adjusts the pulse width to regulate VSC. The method being suggested is based on the idea of using MATLAB software for simulation purposes. With the use of Fourier transform (FFT) analysis The measurement of line current's total harmonic distortion (THD) is possible.

Keywords: Synchronous reference frame (SRF) theory, DSTATCOM, HBCC, PI controller, Power Quality.



capacitor.

- (b) Neutral current compensation
- (c) Load balancing

- (d) Perform under non-sinusoidal supply condition.
- (e) Indirect current compensation.

**SYSTEM DESCRIPTION**

The system represents a three phase four wire system main components of system are Source followed by a VI measurement, nonlinear load for balance and unbalanced system and there is a DSTATCOM connected in parallel

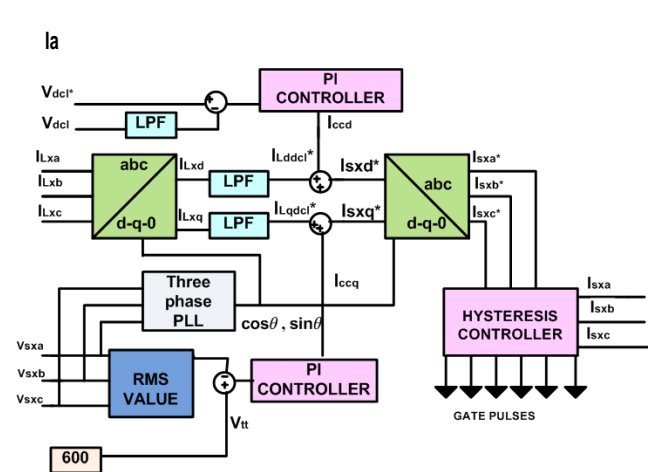
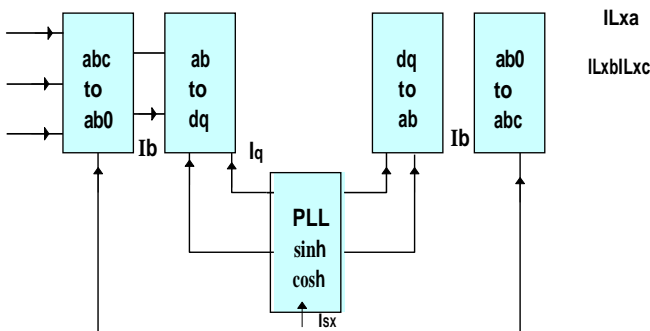
for which gating signals are provided by the pulse generator also including subcomponents as, Voltage source inverter, DC link capacitor, Reference current generator and Current Controller shown in Fig1.

**INTRODUCTION:**

A unit vector control technique requires only two feedback sensors for source voltages ( $V_{sxa}$ ,  $V_{sxb}$  and  $V_{sxc}$ ), one feedback sensor for dc bus voltage ( $V_{dcl}$ ), one feedback

sensor for source currents ( $i_{sxa}$ ,  $i_{sxb}$  and  $i_{sxc}$ ), and last sensor for the third phase voltage  $V_{sxc}$  [ $-(V_{sxa}+V_{sxb})$ ] & current  $i_{sc}$  [ $-(i_{sxa} + i_{sxb})$ ].

The main feature of unit based template control technique is to reduce number of feedback sensors which will improve performance of DSTATCOM, It is the effective solution to mitigate harmonics, load unbalancing, power factor correction, reactive power control and neutral current compensation [7].



$$\cos \omega t \quad \cos(\omega t - \frac{2\pi}{3}) \quad \cos(\omega t + \frac{2\pi}{3}) \quad 3$$

$$V_{dcle} = V_{dcl}^* - V_{dcl} \quad (10)$$

$$V_{tte} = V_{tt}^* - V_{tt} \quad (11)$$

### III. RESULTS AND DISCUSSION

$V_{dc}^*$  and  $V_{dc}$  are the reference voltage and actual voltage of DC bus and  $V_t$  and  $V_t^*$  are amplitude of PCC voltage and the reference voltage at PCC respectively.  $V_{dcle}$  is error in DC bus voltage,  $V_{tte}$  is error in amplitude of the PCC voltage PI controllers output corresponds to required current for self supporting DC bus and voltage regulation at PCC as:

$$I_{ccd} = K_{pd} V_{dcle} + K_{id} \int V_{dcle} dt \quad (12)$$

$$I_{ccq} = K_{pq} V_{tte} + K_{iq} \int V_{tte} dt \quad (13)$$

$K_{pq}$  and  $K_{iq}$  are the proportional and integral gains of the PI controller over the PCC voltage,  $K_{pd}$  and  $K_{id}$  are the proportional and integral gains of the PI controller over the DC bus voltage, the SRF control theory is based on the transformation of currents in synchronously rotating three to two dimensional frame d-q frame. The desired source current in d-q frame are obtain as,

$$I_{sxd}^* = I_{Lddcl} + I_{ccd} \quad (14)$$

$$I_{sxq}^* = I_{Lqdcl} + I_{ccq} \quad (15)$$

Where  $I_{sxd}^*$  and  $I_{sxq}^*$  are estimated dc components of active and reactive component of reference Source currents in d-q frame.  $I_{ccq}$  and  $I_{ccd}$  are the output results of the DC voltage of Proportional integral controller and AC voltage PI

**(a) Output waveform analysis of SRF based DSTATCOM with balance linear load for the compensation of harmonic components**

Under balanced system timings of circuit breakers are identical to each other also the load must having identical load parameters.

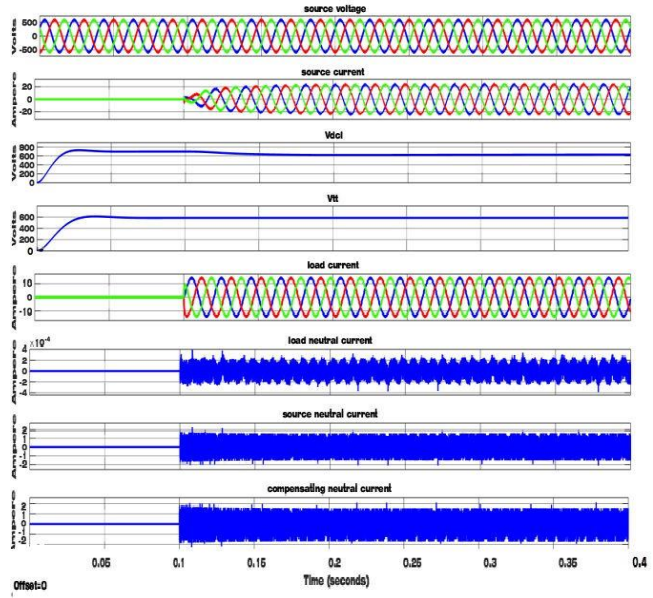


Fig.4 The performance analysis for linear balance load

It is observed that the at time  $t=0$  to  $t=0.1$  sec the DSTATCOM is switched OFF the source current is out of phase with source voltage and distorted at time  $t=0.1$ sec the DSTATCOM is switched ON the source current is setting down at time  $t=0.3$  sec and in phase with the source voltage as we desired ideally.

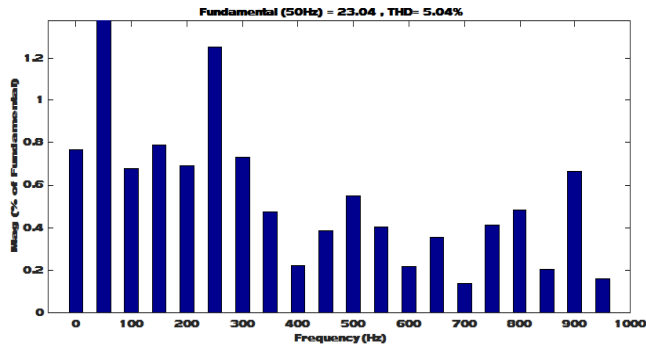


Fig.5 THD analysis

Fig.5 shows the harmonic distortion study of supply current before compensation the THD was 23.57% which is insupportable hence the harmonic distortion analysis of supply current after compensation the THD was 5.04%.

**(b) Results analysis of SRF based DSTATCOM with unbalance linear load for load balancing and neutral current compensation**

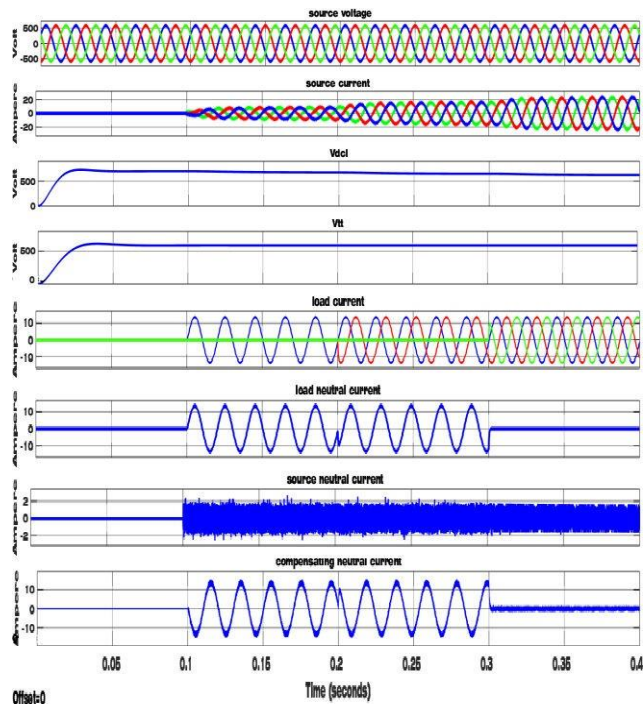


Fig.6

The performance analysis for linear unbalance load. It is found that at  $t=0$  to  $t=0.1$ sec when the controller was off the source voltage and current are out of phase. Fig.6 shows the performance analysis for unbalanced linear load. This figure shows that at  $t=0.1$ sec when the

controller was on the source current settled down in phase at  $t=0.3$ sec. Fig. 7 shows the FFT analysis for unbalanced nonlinear load, The THD was 23.57% which is intolerable hence the harmonic distortion analysis of supply current after compensation. The THD was 5.17%.

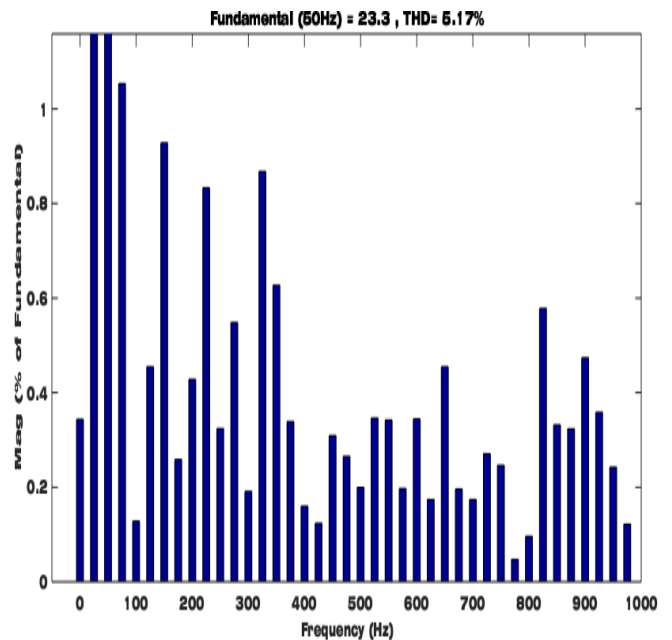


Fig.7 THD analysis

#### CONCLUSION

A innovative control scheme based on synchronous reference frame (SRF) theory had been used for the four-leg DSTATCOM for three-phase four-wire distribution system to improve the performance under Balanced/unbalanced linear load condition. The model was developed using Simulink and Sim Power System toolbox. The simulation was performed for balanced unbalance linear loads. It was seen that before the compensation for current was provided, the current and the voltage waveforms were out of phase

not a pure sine wave . The SRF based DSTATCOM was connected in the system, the compensation for current was provided, and making the current and voltage waveforms in phase and make approximate sinusoidal waveform. The following objectives have been successfully achieved.

- Harmonics Current Compensation.
- Voltage Regulation
- Load balancing

APPENDIX

Table I:- Simulink performance parameters

parameter	Unit	unbalanced linear load	balanced linear load
$V_s$	Volts	600	600
$I_s$	Ampere	25	25
$V_{del}$	Volts	630	630
$V_{tt}$	Volts	585	585
$I_{LX}$	Ampere	14	14
$I_{LN}$	Ampere	4	4
$I_{SN}$	Ampere	2	2
$I_{CN}$	Ampere	4	4
$I_{CC}$	Ampere	25	25
Thd	%	4.97	5.17

Three phase supply voltage=415V, 50Hz. Supply Impedance:  $R_s=0.01\Omega$ ,  $L_s=1mH$

Unbalanced/ Balanced Non-Linear loads: Three single phase diode bridge rectifier  $R=25\Omega$  and  $L=8mH$

DC bus Capacitor  $C_{dc}=4000 \mu F$

DC bus PI Controller:  $K_p = 0.10$ ,  $K_i = 0.1$

Low pass filter :25Khz pf:0.707

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