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Suppression of Harmonics using Custom Power Devices in Distribution Systems

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ABSTRACT: The power quality issues can be mitigated by making use of the active power filters. Custom power devices like shunt, series and shunt-series/series-shunt active filters applied to enhance the power quality in power distribution system. In this paper the following three custom power controllers like Dynamic voltage restorer (DVR), Distribution static compensator (D-STATCOM) and Unified power quality conditioner (UPQC) are used for voltage sag, voltage swell, Harmonics reduction and load compensation. Reference signal generation for active filtering is given by using instantaneous symmetrical component theory. Switching and triggering signals for the switching devices are provided by hysteresis current controller which are used to control the output of compensating devices. To compensate unbalanced nonlinear load with custom power devices is simulated using MATLAB SIMULINK, and the Total harmonic distortion (THD) in non-linear loads have also been presented.

KEYWORDS: Custom power, Distribution static compensator (D-STATCOM), Dynamic voltage restorer (DVR), Total harmonic distortion (THD), Unified power quality conditioner (UPQC).

I .INTRODUCTION

The power systems is a combination of generation, transmission and distribution. Generally generate stations are far from the consumer ends. Transmission system is used to transmit the far end generated power to the end users. The power distributed to the consumers should be high quality and reliable. The problems arises in transmission system are met by facts controllers. [1].The received power from the transmission system by the distribution method should reach to the consumers with good quality but due to the presence of unbalanced nonlinear loads in the distribution method various power quality problems like voltage sag swell, voltage interruption ,voltage unbalance , current Harmon , waveform distortion etc. In order to mitigate the above said power quality problems Custom Power Devices are suitable. Custom power devices include power inverters, converters, injection transformers, master-control modules, static switches and energy-storage devices that have the ability to inject currents and voltages or both within a power distribution system to provide high PQ [1]. Dynamic Voltage Restorer (DVR), Distribution Static Synchronous Compensator (DSTATCOM), and Unified Power Quality Conditioner (UPQC) [2], presently form a wide range of application. Control will play dominant role in these units. In this paper, Proportional Integral (PI) Controller is employed for producing control signal, whereas PWM Generator is employed for producing switching signal. Then we use instantaneous symmetrical component theory used to generate reference signal generation. Lastly, switching pulses to VSI is given by Hysteresis current controller [3].All this is carried out eventually by using DVR, DSTATCOM & UPQC respectively.

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II.SYSTEM CONFIGURATION

A. MODEL OF D-STATCOM

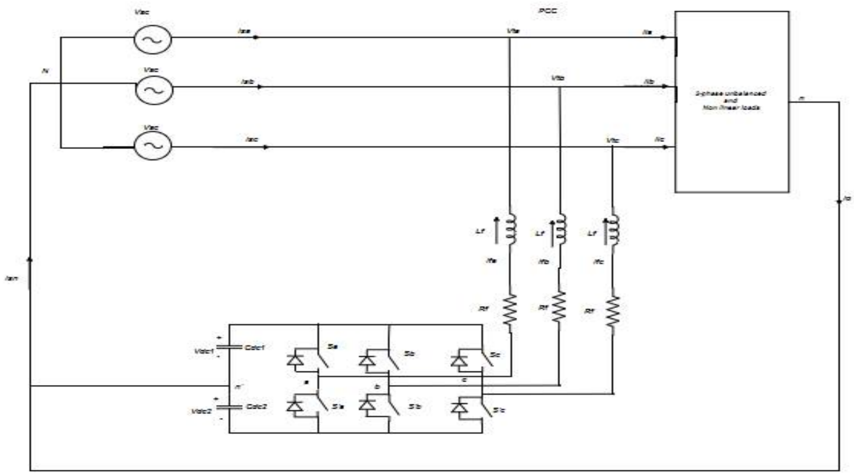

Fig1.Schematic diagram of neutral clamped VSI topology based DSTATCOM

It consists of three legs, in each leg two switches are connected which are controlled by complimentary gate signal derived from hysteresis control technique. Output of VSI is connected to two equal capacitors connected in series this two capacitors shares the voltage equally. Midpoint of the capacitor through n and n' is connected to neutral of source and load by this VSI cancelling zero sequence component of load current it will also control dc component of load. During this mode two capacitors are charged to different voltages which can be maintained at constant value by using PI controller. So VSI requires extra circuitry to compensate the dc component in the load but when dc component is not required this topology has advantages of using less number of switches and it can be operated without transformer [4].

B. MODEL OF DVR

The model picture of neutral clamped three phase three -leg VSI topology is depicted in Fig. 2, [5].

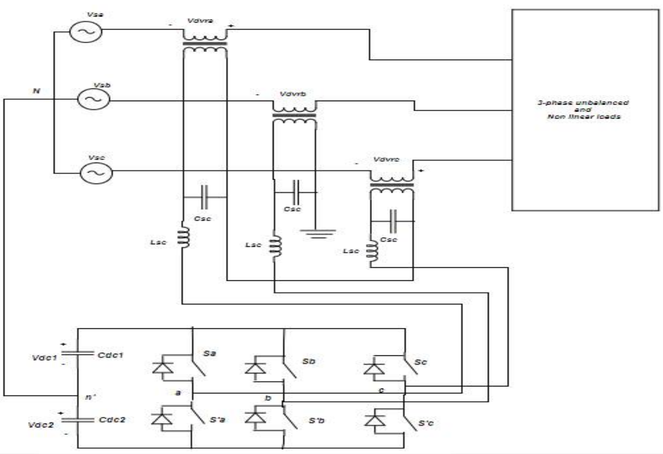

Fig2. Model picture of neutral clamped three phase three -leg VSI topology based DVR

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C .MODEL OF UPQC

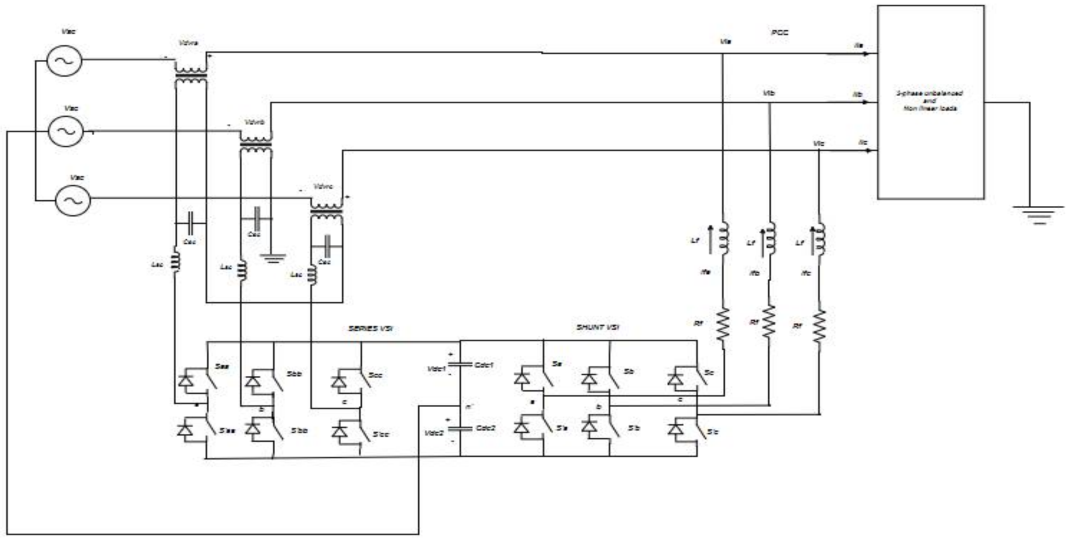

Fig3.Schematic diagram of neutral clamped VSI topology based UPQC

III. REFERENCE SIGNAL GENERATION

Instantaneous symmetrical component is employed in this study. The procedure to command is dependent on the instantaneous symmetrical component theory in any variety of unbalance and harmonics in the load using high bandwidth current sources to keep an eye on the filter reference currents as discussed by [6] ,and they have given the filter current expressions as:

$$i_{fa}^{*} = i_{la} - i_{sa}^{*} = i_{la} - \frac{v_{sa} + \beta(v_{sb} - v_{sc})}{v_{sa}^{2} + v_{sb}^{2} + v_{sc}^{2}}(P_{lavg} + P_{loss}) \quad (1)$$

$$i_{fb}^{*} = i_{lb} - i_{sb}^{*} = i_{lb} - \frac{v_{sb} + \beta(v_{sc} - v_{sa})}{v_{sa}^{2} + v_{sb}^{2} + v_{sc}^{2}}(P_{lavg} + P_{loss}) \quad (2)$$

$$i_{fc}^{*} = i_{lc} - i_{sc}^{*} = i_{lc} - \frac{v_{sc} + \beta(v_{sa} - v_{sb})}{v_{sa}^{2} + v_{sb}^{2} + v_{sc}^{2}}(P_{lavg} + P_{loss}) \quad (3)$$

Where, $\beta = \tan\phi/\sqrt{3}$ (4)

From the above reference current expressions it is observed that this scheme based on instantaneous symmetrical components is computationally much simpler than p-q theory. A complete and straight forward technique for receiving balanced and unified power factor and source currents for every type of load can be achieved effectively from this scheme.

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IV. SWITCHING CONTROL STRAGETY

Hysterics switching and reference filter current generation control block diagram is depicted in blow fig 4.

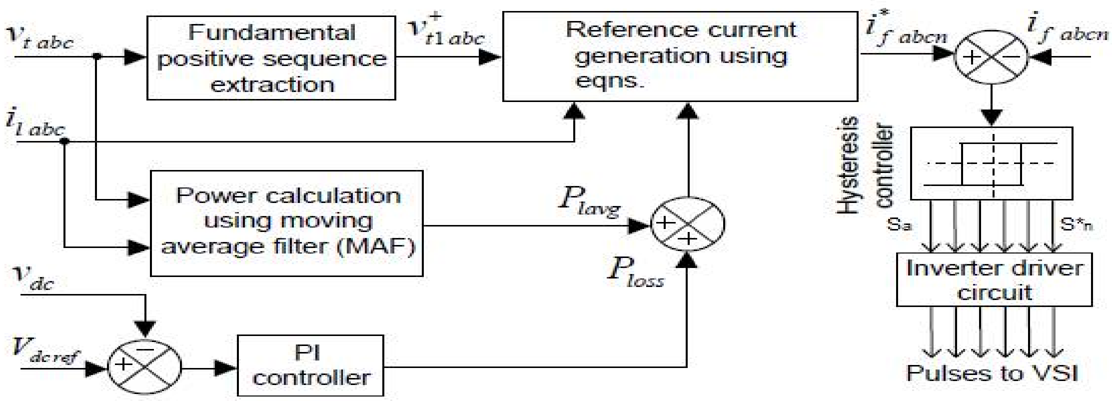


Fig 4. Block diagram of reference filter current generation with Hysteresis controller

Tolerance bands showing +h (above) and -h (below) are the reference quantities in this scheme. The upper legs a, b, c, n are given switching commands from (S_a, S_b, S_c, S_n) and their complement signals in bottom switches (S_a^*, S_b^*, S_c^*, S_n^*). The switching commands are generated from switching logic discussed below [3]:

If $i_{fa} \geq i_{fa}^* + h$, S_a=0, S_a^*=1(turn OFF (upper), turn ON (lower)) (5)

Else if $i_{fa} \leq i_{fa}^* - h$, S_a=1, S_a^*=0(turn ON (upper), turn OFF (lower)) (6)

End

In similar fashion, this above logic can be used for generating switching pulses for other legs of VSI.

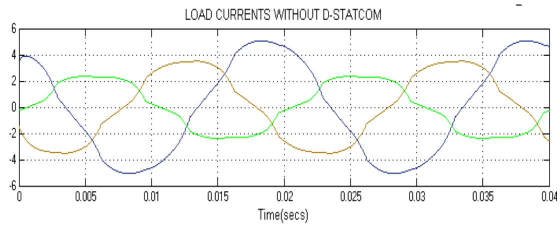
V. RESULTS AND ANALYSIS

Test cases:

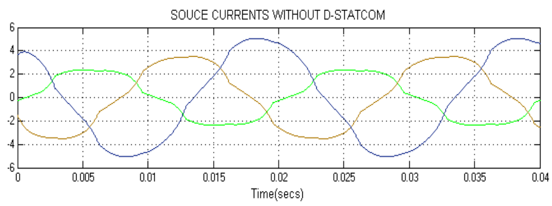
Simulations of D-STATCOM, DVR and UPQC are presented in this section [7]. Performance of the each device and corresponding results are presented to assess them as a custom power solution.

The system parameters chosen for simulation are chosen from Nagesh Geddada, etc.[3].

A.D-STATCOM simulations and results



(a)



(b)

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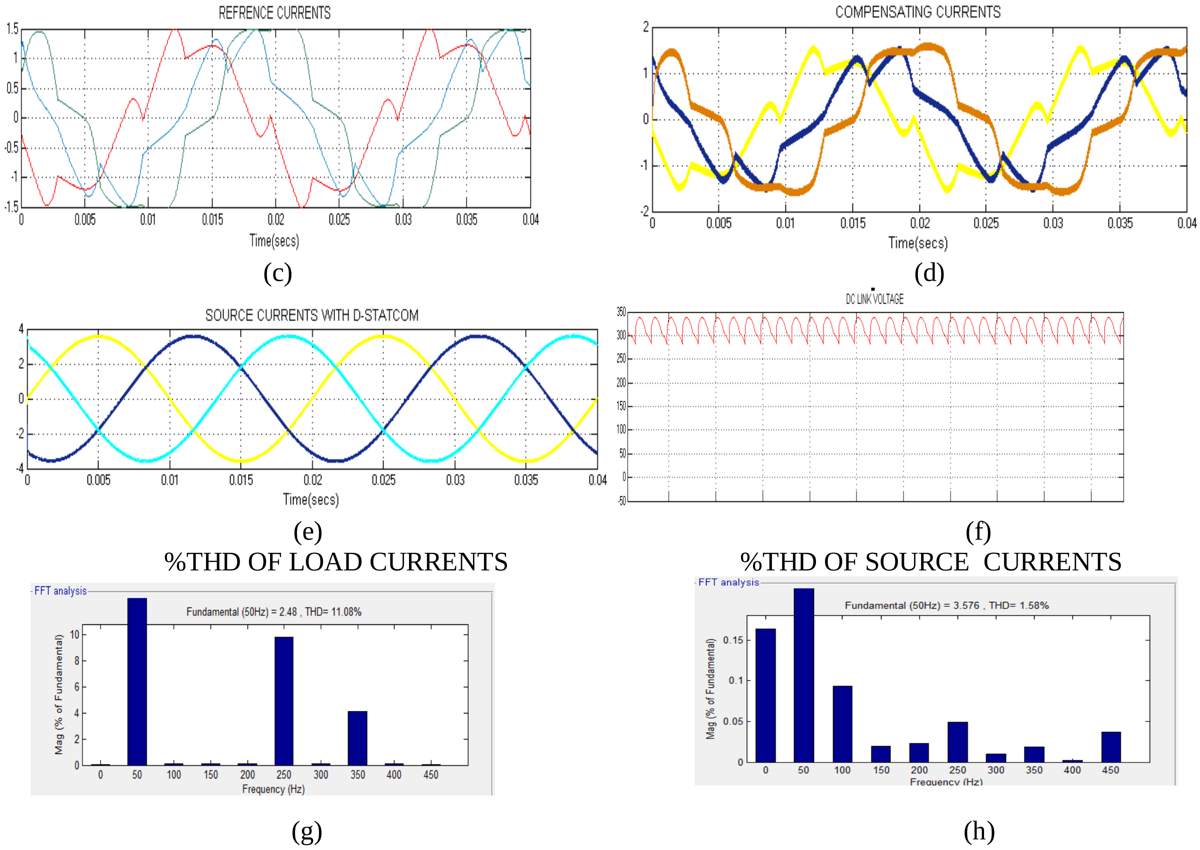

Fig.5. Dynamic behavior of DSTATCOM for unbalanced current compensation And suppression of Harmonics

Fig.5. (a) and 5. (b) Depict the distorted and unbalanced behavior of Load and source values respectably. The reference currents are extracted using equations-1, 2, 3 are given in Fig 5. (c).These currents are tacked using VSI hysteresis current control. Fig.5. (e) depicts source current values after suppression, they are balanced and sinusoidal. Fig.5. (f) depicts DC link voltage (i.e. 350V). THDs(%) of load currents is 11.08% and source currents are 1.58% which is less than 5% limit prescribed in IEEE- 519 standards.

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B. DVR simulations and results:

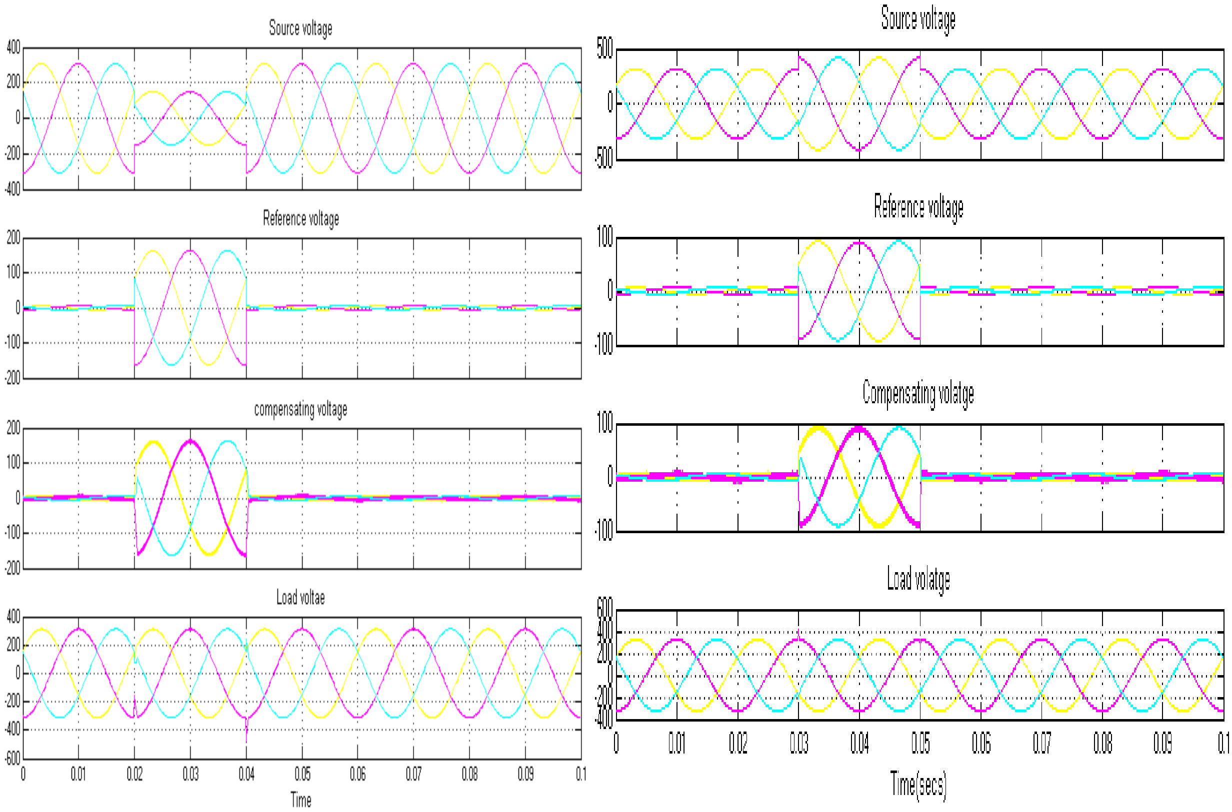

Fig.6.Dynamically varying nature of DVR for voltage sag and swell compensation

Fig.6 depicts various dynamically varying factors of DVR, that are supply current (I_S), the amplitude of load voltage (V_L), Terminal voltage (V_t), amplitude of terminal voltage (V_t) and the dc bus voltage (V_{dc}). Reference value is kept throughout for DC bus voltage. 40% sag is evident with 60% in magnitude in Voltages at the terminal () rated value at 0.02 sec goes up to 0.04sec). Fundamental voltage (V_c) is supplied in series with the terminal voltages (V_{la}, V_{lb}, V_{lc}) ,resulting in sinusoidal load voltage. Figure (6) shows a swell in terminal voltage (V_t) at 0.03sec up to 0.05 sec, and it is compensated by using DVR. In the below Fig. (7) Voltage Interruption between 0.03 to 0.05 seconds is compensated by using DVR .Voltage notching, Fig. (8), at 0.01 to 0.04 seconds is compensated by using DVR.

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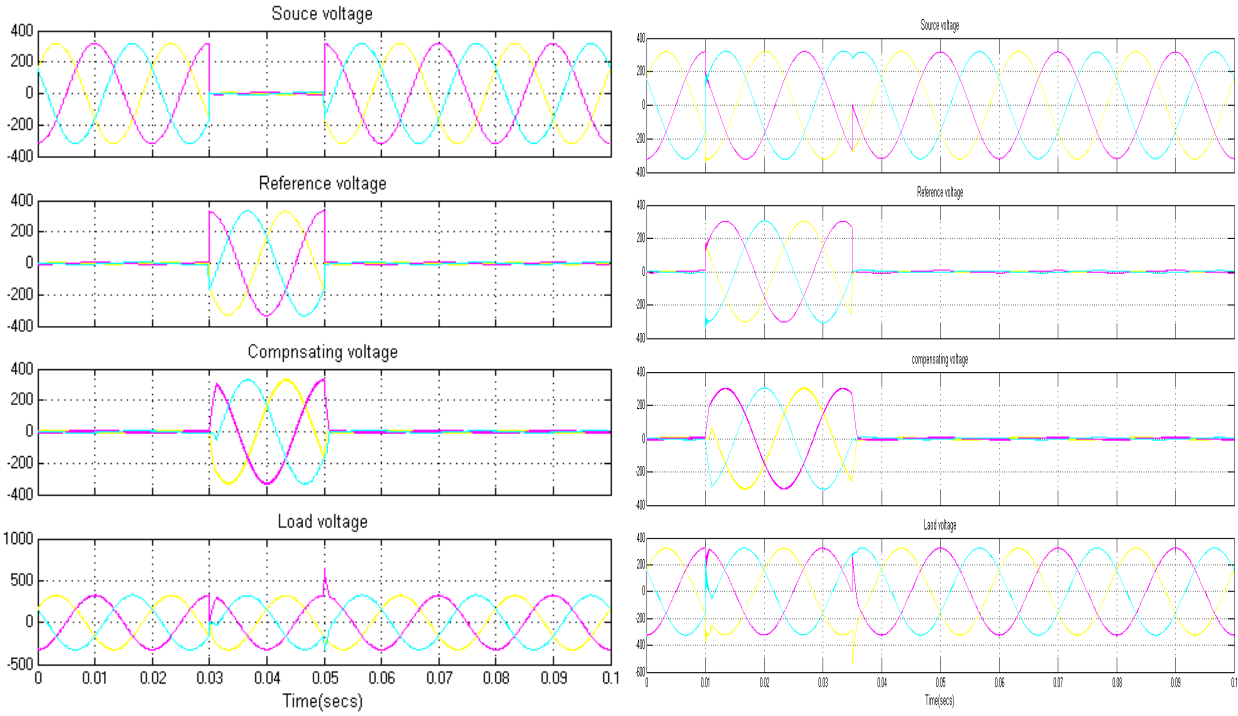
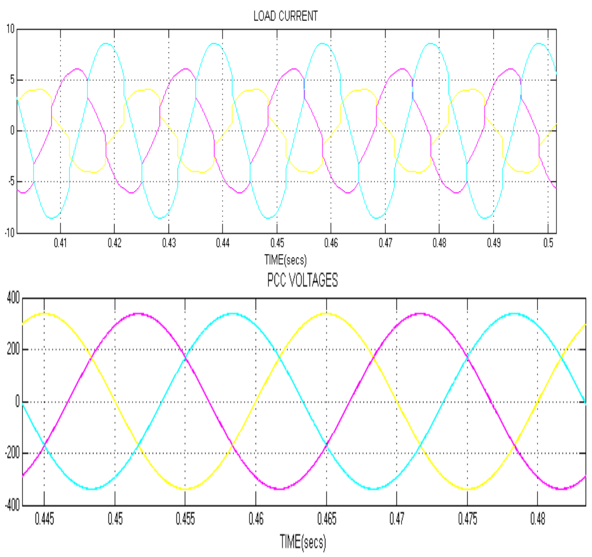
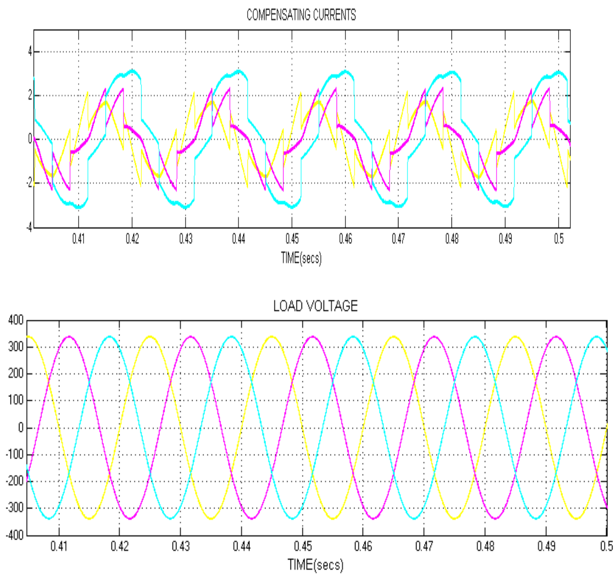


Fig. (7). Dynamic behavior of DVR for Interruption and notching compensation

C.UPQC simulations and results



%THD of load currents



%THD of source currents

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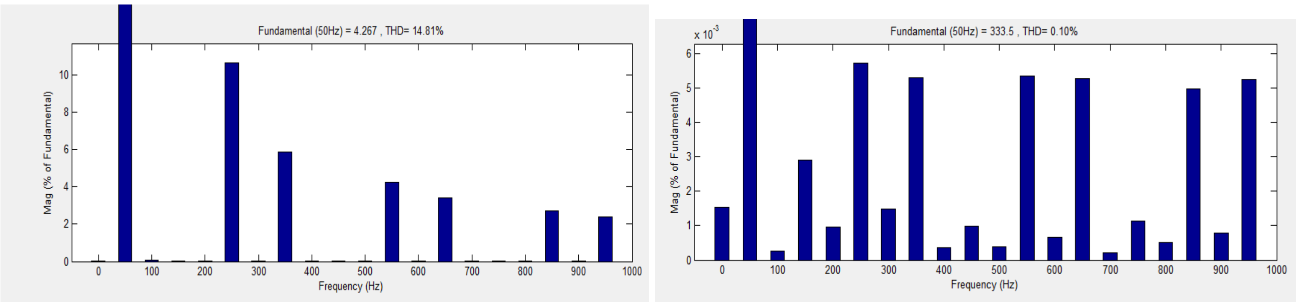

Fig. (9). Dynamic behavior of UPQC for voltage and current compensation

In the above fig (9) .shows voltage and current related distortions are compensated and THDs (%) of load current is 14.81% and source current is 0.10%.

VI. CONCLUSION

In this paper, shunt, series and shunt-series elements are employed as suppressors for studying the power quality comparisons among them. A comprehensive study on DVR was carried out, with hysteresis controller and voltage sag and swell type power quality problems which were compensated. DSTATCOM is proved to suppress harmonics in supply side and Total harmonic distortion is (THD) is 1.58. The voltage and current related power quality problems are reduced by using UPQC. Simulation results depict that UPQC with hysteresis controller gives a better outcome with a good efficiency than existence of DSTATOCM and DVR for the same.

REFERENCES

[1] N. Hingorani, "Introducing custom power," IEEE Spectrum, vol. 32, no. 6, pp. 41–48, June 1995.

[2] G nagesh Kumar, Ananthan.N, Performance Comparison Of UPQC For Improving The Power Quality With Various Controllers Strategy ,IJETCSE, Vol 13 Issue March2015,PP 12-17.

[3] Nagesh Geddada and Mahesh K. Mishra "Improved Load Compensation using Harmonic Compensator in dq0 Current Controller for DSTATCOM," International Journal of Emerging Electric Power Systems, Vol. 15, Issue 6, pp. 569-589,Nov 2014.

[4] K. Srinivas Bhaskar, Nagesh Geddada, Mahesh K. Mishra, and B. Kalyan Kumar,"A DSTATCOM Topology with reduced DC-link voltage rating for load compensation with non-stiff source," IEEE Transaction on Power Electronics, accepted for publication, DOI-10.1109/TPEL.2011.2163946.

[5] N. Woodley, L. Morgan, and A. Sundaram, "Experience with an inverter-based dynamic voltage restorer," IEEE Transactions on Power Delivery, vol. 14, no. 3,pp. 1181–1186, 1999.

[6] R. Herrera and P. Salmeron, "Instantaneous reactive power theory: A reference in the nonlinear loads compensation," IEEE Transactions on Industrial Electronics, vol. 56, no. 6, pp. 2015 –2022, June 2009.

[7] Mohammed Abdul Ahad Yahiya and Mohammed Abdul Rahman Uzair,"Performance Analysis of DVR, DSTATCOM and UPQC For Improving The Power Quality With Various Control Strategies," 2016 Biennial International Conference on Power and Energy Systems: Towards Sustainable Energy (PESTS E), 978-1-4673-6658-8116, and 2016.

[8] K. Srinivas Bhaskar, Mahesh K. Mishra, and B. Kalyan Kumar, "Particle Swarm Optimization based feedback controller design of Unified Power Quality Conditioner(UPQC)," IEEE Transaction on Power Delivery, vol. 25, no. 4, pp.2814-2824, Oct. 2010.