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FFMCCF-PLL based DSTATCOM for Power Quality Improvement

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Abstract - This paper proposes a novel frequency fixed multiple complex coefficient filter-phase locked loop (FFMCCF-PLL) based approach of load compensation for distribution static compensator (DSTATCOM). The non-linear and unbalanced load make the source current distorted. The proposed FFMCCF-PLL control approach provide switching pulses in a way to make source current balanced & sinusoidal and also improve power quality of system. Here FFMCCF is act as a pre-filter for the PLL and improve performance under distorted grid conditions. The proposed FFMCCF-PLL control approach is simulated in MATLAB/ Simulink environment for different operating conditions. The ability of the proposed approach has been related to the instantaneous PQ theory based control technique.

Index Terms - Point of Common Coupling (PCC), Power Quality (PQ), Total Harmonic distortion (THD)

1. INTRODUCTION

In electric power system stability of power supply is important for proper operation of all the equipment connected in the system. The quality of power supply is important in all the levels of power system in distribution and transmission area [1-4]. The non-linear loads at the consumer end pollute the supply by consuming non-sinusoidal current at the distribution level which may leads to malfunction of equipment at consumer side. Due to this nonlinear load the PQ issues like harmonics, unbalance & poor power factor arises in distribution system [5-8]. To improve the power quality where is active power filter were developed to operate at the distribution system. The DSTATCOM is one of the custom power device to improve PQ at the distribution level. Various control algorithms were developed for DSTATCOM to improve the PQ [9-16]. In this paper FFMCCF-PLL based control approach is implemented for PQ improvement distribution system.

2. PROPOSED SYSTEM

The figure 1 shows the structure of FFMCCF-PLL based DSTATCOM with unbalanced load is connected to the three phase supply. The DSTATCOM is connected to PCC & ripple filter which is used to reduce switching ripple and supplies the compensating current which improves PQ at PCC. The various components in DSTATCOM such as the DC bus capacitor and interface inductor can be designed using the following expressions

The DC capacitor reference voltage,

$$V_{dc} = 2\frac{\sqrt{2}}{\sqrt{3}}\ \frac{\sqrt{V_{ll}}}{\sqrt{m}} \qquad (1)$$

The DC Bus Capacitor,

$$½\ C_{dc}\ (V_{dc}^2 - V_{dc1}^2) = 3Vt(I * a\ ) \qquad (2)$$

The Interface inductor,

$$L_f = \frac{\sqrt{3mV_{dc}}}{12} * a * f_s * \ i_{cr} \qquad (3)$$

The Weight adaptation:

$$w(n+1) = \ \mu u(n) * E(n) + w(n) (4)$$

Filter output:

$$Y(n) = u(n) * w(n) \qquad (5)$$

Error signal:

$$(n) = d(n) - Y(n) \qquad (6)$$

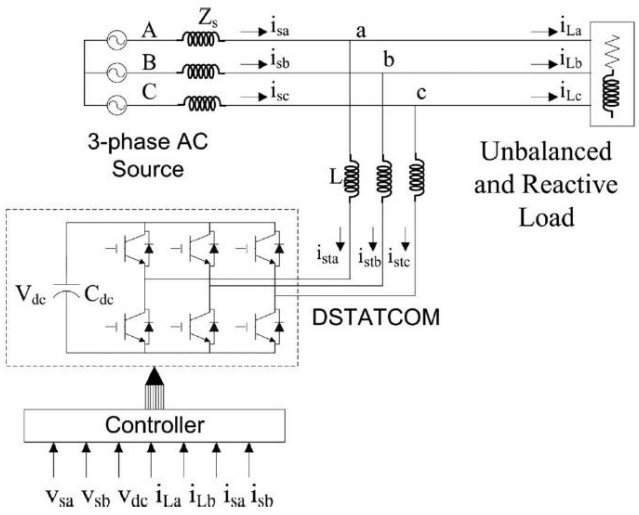

Figure 1:

Structure of FFMCCF-PLL based DSTATCOM of distribution system

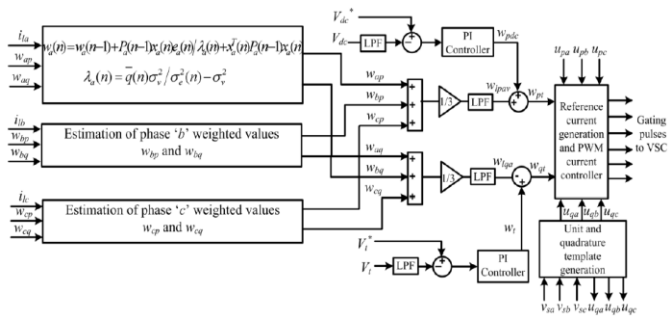

Figure 2:

FFMCCF-PLL based control approach

The proposed FFMCCF-PLL based control technique to compensate the non-linear load & improves PQ of the distribution system is shown in figure 2. Here the switching pulses for the switches in VSI are developed by the proposed approach which is given to VSI switches.

The unit templates,

$$U_{pa} = \frac{V_a}{V_t} \; ; U_{pb} = \frac{V_b}{V_t} \; ; U_{pc} = \frac{V_c}{V_t} \quad (6)$$

The DC voltage,

$$V_{dce}(t) = V_{dcref}(t) - V_{dc}(t) \qquad (7)$$

The reference currents are i^*_{sabcp} and i^*_{sabcq},

$$i^*_{sa} = i^*_{sap} + i^*_{saq} \; ;$$

$$i^*_{sb} = i^*_{sbp} + i^*_{sbq} \; ;$$

$$i^*_{sc} = i^*_{scp} + i^*_{scq} \qquad (8)$$

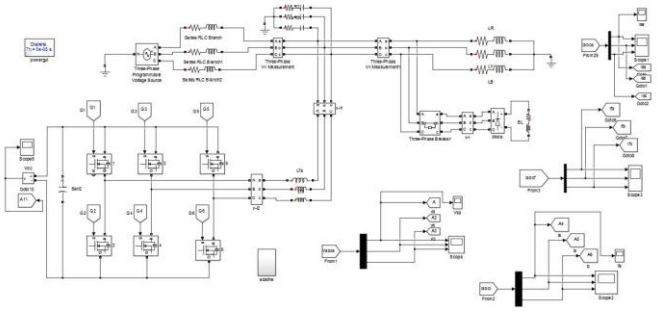

Figure 3

Simulation of FFMCCF-PLL DSTATCOM system

3. RESULTS AND DISCUSSION

The MATLAB/Simulink model of FFMCCF-PLL DSTATCOM system is shown in figure 3. Here the grid supplies 3 phase non-linear load. The voltage, current at load and source ends were measured then supplied to the FFMCCF-PLL control approach to generate pulses for VSI.

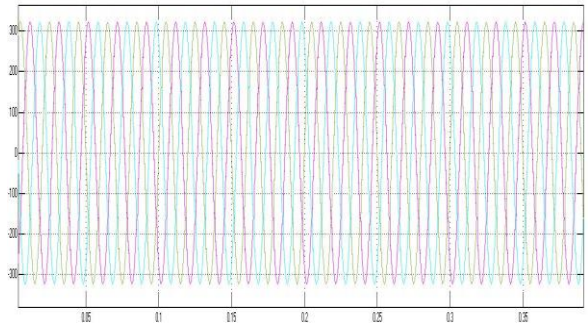

Figure 4

Source voltage

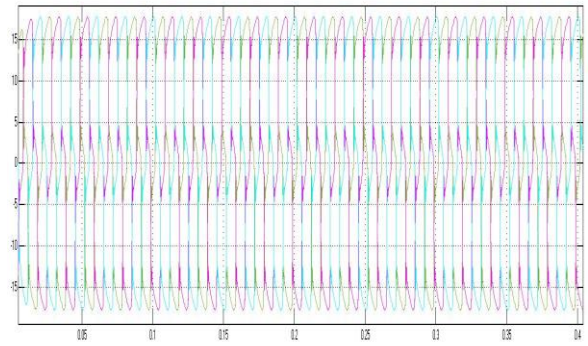

Figure 5

Source current

Figure 6

Load voltage

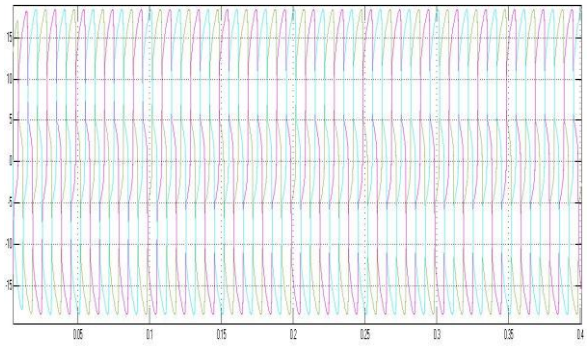

Figure 7

Load current

The figures 4,5,6 & 7 show the source & load voltage & current waveforms before compensation of system.

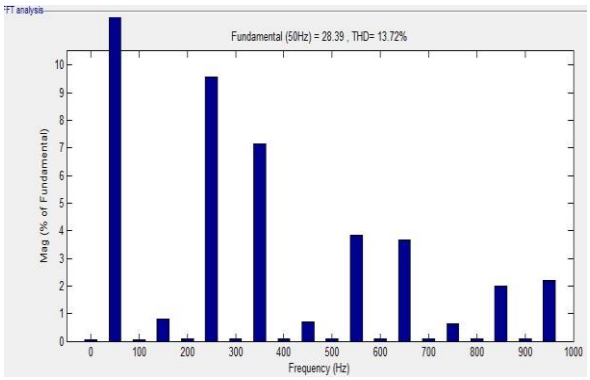

Figure 8

THD - Load current

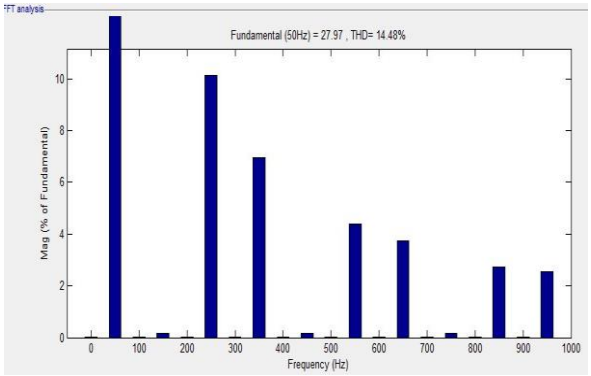

Figure 9

Source current – THD without compensator

The figures 8,9 & 10 show the THD for load & source current and source voltage waveforms before and after compensation of system with FFMCCF-PLL based DSTATCOM.

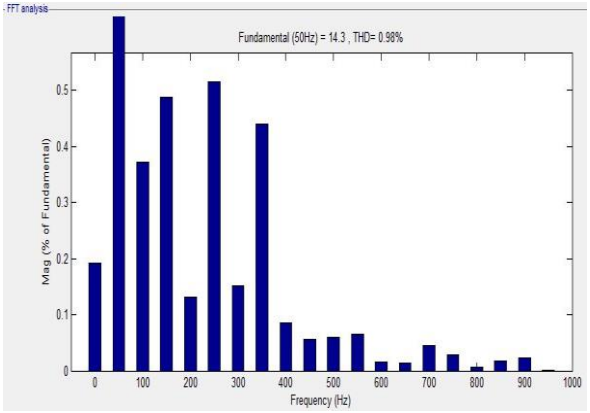

Figure 10

Source current – THD with compensator

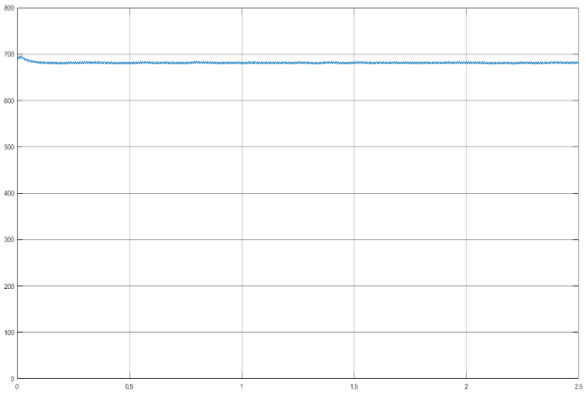

Figure 11

DC link voltage

4. CONCLUSION

The proposed novel frequency fixed multiple complex coefficient filter-phase locked loop (FFMCCF-PLL) based load compensation approach for distribution static compensator (DSTATCOM) has been successfully implemented in distribution system with unbalanced and non-linear loads. The proposed FFMCCF-PLL based control approach effectively compensate the loads by generating switching pulses for VSI even under polluted grid conditions. The proposed FFMCCF-PLL control approach is simulated in MATLAB/ Simulink environment for different operating conditions. The ability of the proposed approach has been related to the conventional control. The THD of source current without compensator is about 14.48%. The proposed FFMCCF-PLL based DSTATCOM compensates and reduce source current THD to 0.98% which describes the activeness of the proposed controller in load compensation.

REFERENCES

[1] Azhagesan Dheepanchakkravarthy, Marappan Rakkiannan jawahar, Kandadai vankatraman, Manickavasagam parvathy selvan, Sridharan Moorthi, ' Performance evaluation of FPGA based predictive current controller for FL-DSTATCOM in electric distribution system', vol 13, *IET Gener.Trans.Distrib*., 2019.

[2] Bhim singh, 'Power quality and mitigation techniques', 1st edited in *John wiley publisher*, 2015.

[3] Arindam Ghosh, Gerard Ledwich, 'Power quality enhancement using custom power devices', *Kluwer Academic Publishers*, 2002.

[4] Jose Rodriguez, Patricio Cortes, 'Predictive control of power converters and Electrical Drives', *Wiley publication*, 2012.

[5] C Dugan, Mark F. McGranaghan, surya santoso, H. wayne Beaty , *'Electrical power systems quality*', 2nd McGraw-Hill, 2004.

[6] Kazmierkowski, M.P., Malesani, L.: 'Current control techniques for three phase voltage-source PWM converters: a survey', *IEEE Trans. Ind. Electron*., 1998, 45, (5), pp. 691–703.

[7] Naouar, M.W., Monmasson, E., Naassani, A.A., et al.: 'FPGA-based current controllers for AC machine drives-a review', *IEEE Trans. Ind. Electron*., 2007, 54, (4), pp. 1907–1925.

[8] Rodriguez, J., Pontt, J., Silva, C.A., et al.: 'Predictive current control of a voltage source inverter', *IEEE Trans. Ind. Electron*., 2007, 54, (1), pp. 495– 503.

[9] Xu, Y., Tolbert, L.M., Chiasson, J.N., et al.: 'A generalised instantaneous nonactive power theory for STATCOM', *IET Electr. Power Appl*., 2007, 1, (6), pp. 853–861.

[10] Cortes, P., Kazmierkowski, M.P., Kennel, R.M., et al.: 'Predictive control in power electronics and drives', *IEEE Trans. Ind. Electron.,* 2008, 55, (12), pp. 4312–4324.

[11] Singh, B., Arya, S.R., Jain, C., et al.: 'Implementation of four-leg distribution static compensator', *IET Gener. Transm. Distrib*., 2014, 8, (6), pp. 1127–1139.

[12] Sanchez, P.M., Machado, O., Pena, E.J.B., et al.: 'FPGA-based implementation of a predictive current controller for power converters', *IEEE Trans. Ind*. Inf., 2013, 9, (3), pp. 1312–1321.

[13] Carrasco, G., Silva, C.A., Pena, R., et al.: 'Control of a four-leg converter for the operation of a DFIG feeding stand-alone unbalanced loads', *IEEE Trans. Ind. Electron*., 2015, 62, (7), pp. 4630–4640.

[14] Kumar, C., Mishra, M.K.: 'Operation and control of an improved performance interactive DSTATCOM', *IEEE Trans. Ind. Electron*., 2015, 62, (10), pp. 6024–6034.

[15] Venkatraman, K., Selvan, M.P., Moorthi, S.: 'Predictive current control of distribution static compensator for load compensation in distribution system', *IET Gener. Transm. Distrib.*, 2016, 10, (10), pp. 2410–2423.

[16] Govind Kumar Maurya etal.: 'Fixed-Frequency MCCF Based Grid Synchronization Technique', *International Conference on Power Electronics, Drives and Energy Systems*, Dec. 2018.