Indian Journal of Science and Technology, *Vol 9(S1), DOI: 10.17485/ijst/2016/v9iS1/101950, December 2016*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Enhancement of Power Quality using PV Fed D-Statcom

D. Sattianadan, V. Kubendran, S. Vidyasagar and C. S. Boopathi*

Department of Electrical and Electronics Engineering, SRM University, SRM Nagar, Potheri, Kattankulathur, Kancheepuram District, Near Potheri Railway Station, Chennai 603203, Tamil Nadu, India; sattia.nadan@gmail.com, kubendran.v@ktr.srmuniv.ac.in, mailsvs@gmail.com,boopathi.cs@ktr.srmuniv.ac.in

Abstract

Objectives: A detailed analysis has been made to study the harmonics level with and without compensation. To compensate neutral current of the test system using synchronous reference frame controls analogy. **Methods/Analysis**: This work deals with harmonic reduction using recompense of source and neutral current. A modified control technique has been framed with the reference synchronous frame to mitigate these power quality issues with a model test system. **Findings:** Renewable energy sources are associated in distribution systems using power electronic converters for the melioration of power quality. One of the Renewable energy resources which are widely used in the distribution system is solar energy. The inclusion of power electronic converter/devices and due to composite loads present in power systems may lead to power quality issues. Without these controlling devices, transmission and distribution of electricity at required level cannot be attained. The test system comprises of PV array or battery, DC to DC promote converter and DSTATCOM for providing whole day compensation. Maximum benefits of the model can be achieved through this control technique when implemented in an A.C four-wire system. After implementing the control technique, it is observed that the harmonics of the source voltage, the source current and neutral current has been reduced and thus meliorates the calibre of power delivered to the consumers. Applications: Generally, the consumer loads are an unbalanced system due to the different types of loads such as Industrial loads, commercial loads and residential loads. The AC system is adopted to give supply to single phase and three phase loads. These unbalanced loads simulate large content of neutral current. To improve the reliability of distribution system many renewable energy sources are connected to the network and these sources are controlled by static devices. These static devices are induced harmonic content at higher levels. D-Statom is best suited in the distribution system to reduce the harmonic content and enhance the quality of power.

Keywords: Boost Converter, D-Statcom, Photo Voltaic, Power Quality Improvement, Voltage Source Converter

1. Introduction

Distributed Generation plays a key role to meet the raise in power demand worldwide. Many distributed generation systems are available and connected scattered in the distribution network. Due to the smaller in size and highly reliable, the solar system plays a significance role compared to the other renewable. The production of power by the PV is affected by weather conditions; insulation, and temperature. These control variables of the solar system are adjusted according to the requirement using real-time simulator[1]. Many more issues are arrived while connecting the renewable sources to the grid under normal or fault conditions. The development of power

**Author for correspondence*

electronic devices is capable of minimizing the transmission and distribution losses to control the harmonic content[2].

The efficiency of the converter is enhanced by lowering DC link voltage[3,4]. Using a large number of switches accelerate harmonics, switching losses and cost function of the system. The inverter circuit reduces the number of switches considerably and makes the system design and operation simple[5].The nonlinear loads in the distribution system draw excessive harmonic currents which over heat the conductor and transformer. By controlling the distribution transformer, suppress the consequence of harmonics[6]. The performance of the Voltage Source Converter (VSC) with various p. freduces the harmonizes and balances the loads[7]. Fuzzy logic based approach has been used to identify the point of maximum power for pumping plants[8]. TarakSalmi proposes a mathematical modeling of PV behavior under different physical and environmental parameters. It also outlines the working principle of PV array[9]. In the recent years, the hybrid system is so popular due higher reliability in a different environment and network condition. The load and battery storage management can yield better results and improves the system efficiency in a better way[10]. A new control theory has been developed to balance real and imaginary power in AC four wire system[11]. Usage of static devices for controlling the unbalance loads makes the system operating at low power. Many power factor corrector methods have been adopted at the inverter side to deliver the power at the required level[12]. The development of many facts devices acts an crucial part in power quality betterment during fault or heavy load conditions[13]. The shunt active power filter reduces the harmonic level at the great extent and provides maximum utilization of inverter to deliver a better quality of power[14].

1.1 Objective of this Work

- To abbreviate source voltage harmonics and source current.
- To perform a detailed study in harmonics provided with and without compensation technique and to observe the Total Harmonic Distortion level.
- To compensate neutral current, in the system which includes integration of multiple techniques along with electrical equipment and electronic devices?

1.2 Description About the Test System

The Schematic diagram of the test system is shown in Figure 1. The synchronous-rotating dq reference frame has been used to sense the load variation through by the feedback signals and gives the control signals to the PI controller. The detailed control flows diagram of D-Statcom is shown in Figure 2.

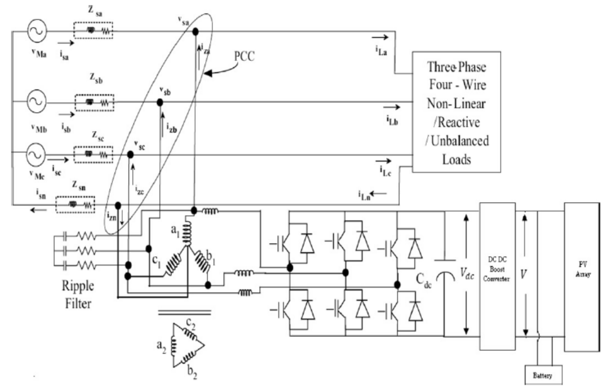


Figure 1. Schematic diagram of the test system.

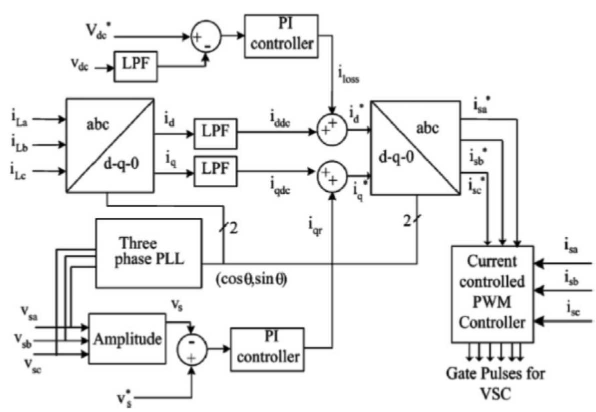


Figure 2. Control algorithm for three legs VSC.

2. Result and Discussion

The performance of the test system under changes in load condition without compensation is shown Figure 3 and Figure 4 respectively. The performance of phase A source voltage and phase A source current with its spectrum is shown in Figure 5 and Figure 6 respectively. The effect of neutral current and its waveform without compensation is shown in Figure 7.

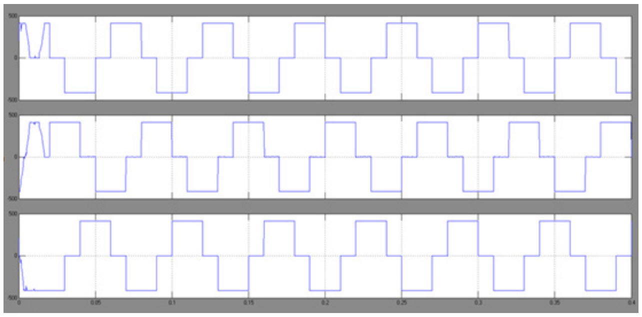


Figure 3. Performance of source voltage without compensation.

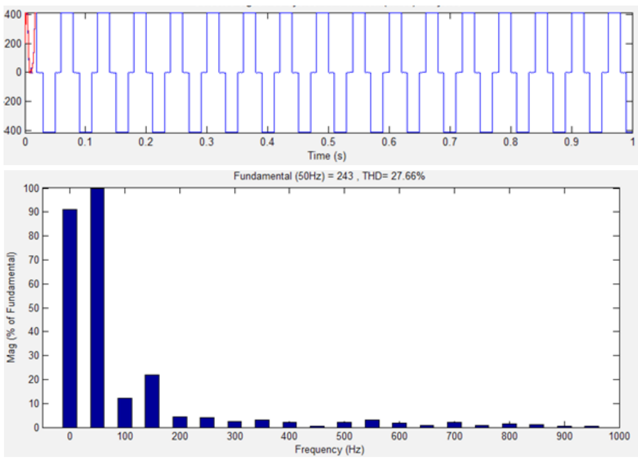


Figure 4. Performance of phase A source voltage with its spectrum without compensation.

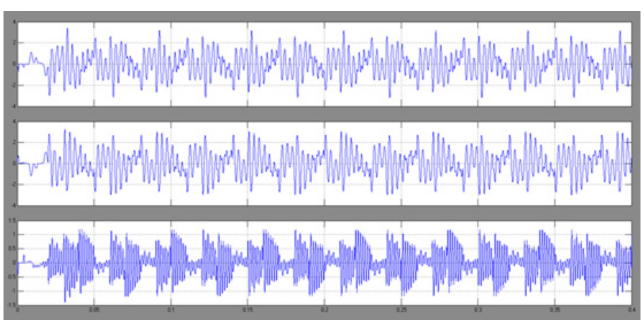
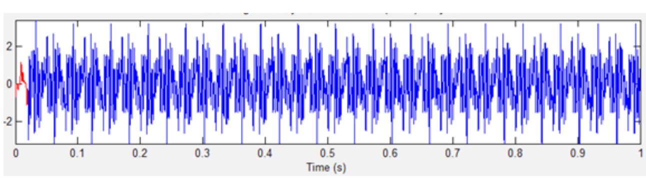


Figure 5. Performance of source current without compensation.



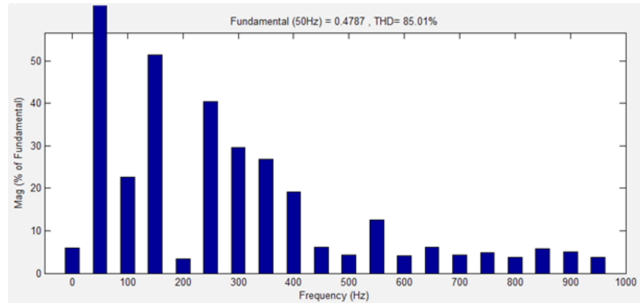


Figure 6. Performance of phase A source current with its spectrum without compensation.

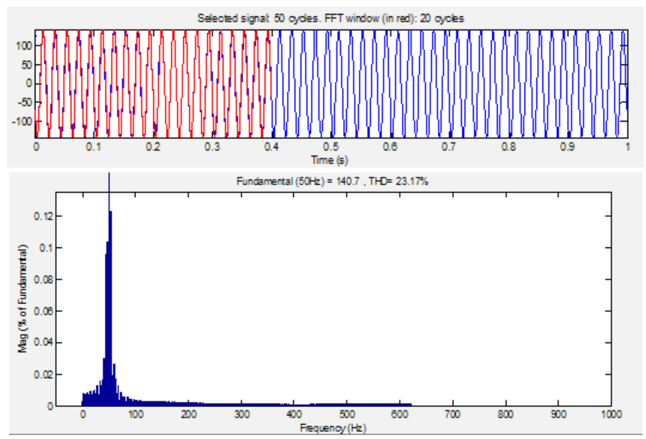


Figure 7. Performance of neutral current with its spectrum without compensation.

The performance of the test system under change of load condition for source voltage and source current after compensation is shown Figure 8, Figure 9, Figure 10 and Figure 11 shows the spectrum of phase A source voltage and source current. The performance of current in neutral after compensation is shown in Figure 12.

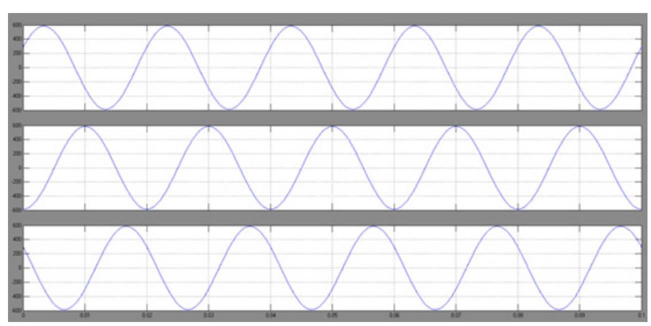


Figure 8. Performance of source voltage after compensation.

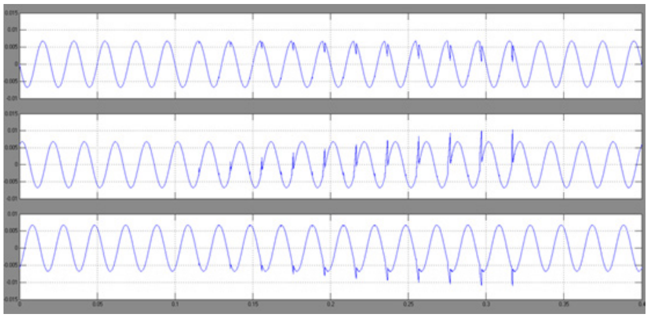


Figure 9. Performance of source current after compensation.

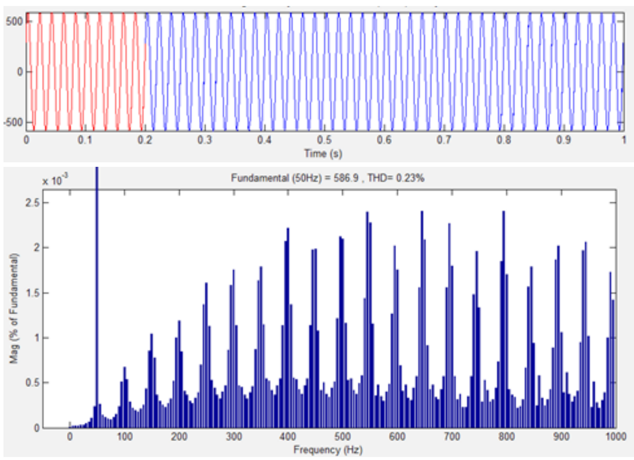


Figure 10. Performance of phase A source voltage with its spectrum after compensation.

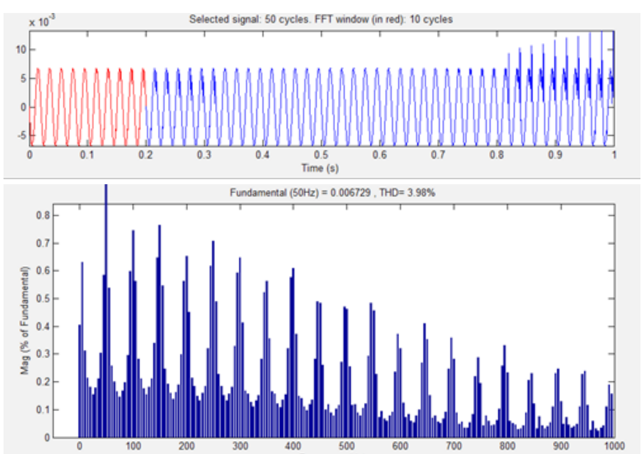


Figure 11. Performance of phase A source current with its spectrum after compensation.

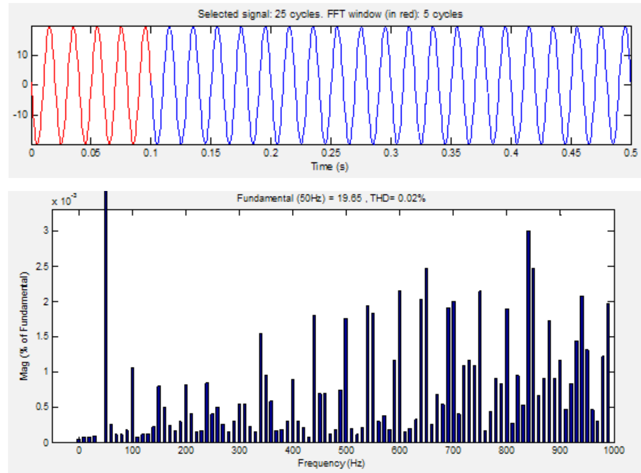


Figure 12. Performance of neutral current with its spectrum after compensation.

THD analysis is shown in Table.1. After implementing the control technique, it is celebrated that the harmonics of the source voltage have been found to have reduced from 27.66% to 0.23% after compensation. Similarly, it is celebrated that the harmonics of the source current and neutral current has been reduced from 85.01% to 3.98% and 29.17% to 0.02%.

Table 1. Total harmonic distortion of test system

Parameter	Before Compensation	After Compensation
Source Voltage	27.66	0.23
Source Current	85.01	3.98
Neutral current	29.17	0.02

3. Conclusion

A special control technique has been framed using synchronous reference frame theory to mitigate this power quality issue with a model test system. A detailed study has been done on the analysis of harmonics under several cases. Finally, source harmonics have been reduced and neutral current has been compensated. The photovoltaic established DSTATCOM for the AC system is successfully modelled and simulated.

4. References

1. Park M, Yu I–K. A Novel Real-Time Simulation Technique of Photovoltaic Generation Systems Using RTDS. Institute of Electrical and Electronics Engineers (IEEE) Transactions on Energy Conversion. 2004 Mar; 19(1):164–9.
2. Carrasco JM, Franquelo LG, Bialasiewicz JT et al. Power-electronic systems for the grid integration of renewable energy sources: a survey. Institute of Electrical and Electronics Engineers (IEEE) Transactions on Industrial Electronics. 2006 Jun; 53(4):1002–16.
3. Wang Y, Cai X. DC link voltage optimized control for efficient residential fuel cell converter. Electrical Power and Energy Systems. 2010 Nov; 32(9):1031–6.
4. Changchien S–K, Liang T–J, Chen J–F, Yang L–S. Novel high step-up DC–DC converter for fuel cell energy conversion system. Institute of Electrical and Electronics Engineers (IEEE) Transactions on Industrial Electronics. 2010; 57(6):2007–17.
5. Araújo SV, Zacharias P, Mallwitz R. Highly efficient single-phase transformerless inverters for grid-connected photovoltaic systems. Institute of Electrical and Electronics Engineers (IEEE) Transactions on Industrial Electronics. 2010 Sep; 57(9):3118–28.
6. Enjeti PN, Shireen W, Packebush P. Analysis and design of a new active power filter to cancel neutral current harmonics in three-phase four-wire electric distribution systems. Institute of Electrical and Electronics Engineers (IEEE) Transactions on Industry Applications. 1994; 30(6):1565–72.
7. Singh B, Jayaprakash P, Kothari DP. New control approach for capacitor supported DSTATCOM in three-phase four wire distribution system under non-ideal supply voltage conditions based on synchronous reference frame theory. Electrical Power and Energy Systems. 2011 Jun; 33(5):1109–17.
8. Mazouz N, Midoun A. Control of a DC/DC converter by fuzzy controller for a solar pumping system. Electrical Power and Energy Systems. 2011 Dec; 33(10):1623–30.
9. Salmi T, Bouzguenda M, Gastli A, Masmoudi A. MATLAB/Simulink based modeling of solar photovoltaic cell. International Journal of Renewable Energy Research. 2012; 2(2):213–8.
10. Dursun E, Kilic O. Comparative evaluation of different power management strategies of a stand-alone PV/Wind/PEMFC hybrid power system. Electrical Power and Energy Systems. 2012 Jan; 34(1):81–9.
11. Benhabib MC, Saadate S. New control approach for four-wire active power filter based on the use of synchronous reference frame. Electrical Power and Energy Systems. 2005 Mar; 73(3):353–62.
12. Lo Y–K, Lee T–P, Wu K–H. Grid-connected photovoltaic system with power factor correction. Institute of Electrical and Electronics Engineers (IEEE) Transactions on Industrial Electronics. 2008 May; 55(5):2224–7.
13. Bajaj M, Dwivedi VK, Kumar A, Bansal A. Design and simulation of DSTATCOM for power quality enhancement in distribution networks under various fault condition. International Journal of Emerging Technology and Advanced Engineering. 2013 Apr; 3(4):620–6.
14. Sundar T, Sankar S. Investigations on renewable energy sources for power quality improvement. International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering. 2013; 2(10):4871–9.