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STATCOM Based Power Quality Improvement in Non-linear Networks

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Introduction

Power quality is a set of electrical boundaries that allows a piece of equipment to function in its intended manner without significant loss of performance. [1]Harmonics have always present in the power system and recently due to widespread use of power electronic systems the magnitude of harmonics gets increased and it becomes a key issue. Harmonic disturbance generally come from equipment with non linear voltage current characteristics. Nowadays large part of the industrial, commercial and domestic loads are non linear and it creates distortion on the voltage supply network. Under these conditions Total Harmonic Distortion becomes high and it is dangerous to the system.[2] Therefore to improve the power quality power electronic converters are employed for active filtering, compensation and power conditioning. In this work one such power electronic compensator (D-STATCOM), is discussed and modeled to improve the power quality of the network. Proposed model consists of inverter block, a control block and a PWM module. Variation of THD for various loads is studied and the results are tabulated with a graph.

D-STATCOM:

The STATCOM is a power electronic converter constructed from voltage source converters (VSC). It is advanced power electronic equipment whose prime function is to exchange reactive power with the host AC system. In a distribution system STATCOM is mainly used for voltage regulation. It can also supply real power to the loads with an energy storage device. Moreover STATCOM may also be employed to balance the distribution network by compensating load imbalances. STATCOM control can be done in both αβ frame and dq frame. Since control of dq frame has widespread technical literature, it is discussed here and moreover in dq frame formulation and analyze of Phase Lock Loop dynamics can be easily done.[3]

Model description

Figure1 shows the simulation model of the proposed D – STATCOM. This model is divided into three sub systems namely NONLINEAR LOAD BLOCK, CONTROL BLOCK AND INVERTER BLOCK. Input to the system is single phase ac source with RMS Voltage of 230 V and frequency of 50 Hz. Control block subsystem generates gate signal for the IGBT inverter. The control block has single input which is the ERROR SIGNAL (ie. difference between actual load current and reference current). The output of the control block is the four gate pulses which drives the two leg inverter. Voltage source for the Inverter is provided by separate DC source. The harmonics in the currents are measured using the FFT analysis.

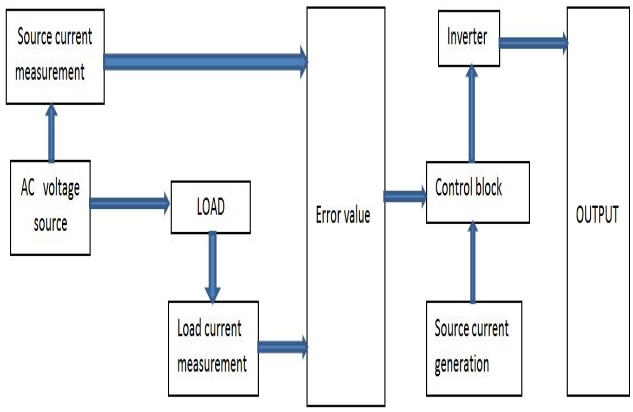


Figure 1: Proposed Model

Load block

Figure 2 shows the simulation model of the non- linear load. Controlled rectifier drives the Non linear load and the average voltage across the load is adjusted using the single phase four pulse bridge rectifier. Natural commutation occurs because of zero current crossing of the ac source. Voltage across the load is controlled by adjusting the firing angle of the thyristor. The thyristor1 and thyristor4 are maintained same firing angle and thyristor2 and thyristors3 are maintained same firing angle. Firing angle of two pairs is delayed by 180 degree (or 0.001 s). Pulse from the pulse generator having four components a) Pulse width is the duration of the pulse, b) Pulse amplitude is the voltage magnitude of the pulse , c) Pulse Period is the repetition timing and d) Pulse delay is the triggering time for the thyristor in seconds.

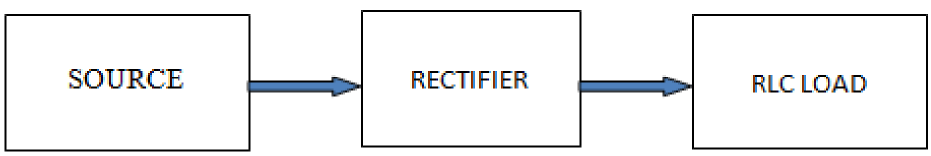


Figure 2: Non linear load model

Control block

Figure 3 is the simulink model of the control subsystem for the STATCOM. Input to this subsystem is the error signal between STATCOM current and the load current. Outputs of the block are four gate pulses. Main components of the control subsystem are signal generator, absolute block, and the relational operator. The signal generator generates the sinusoidal signal of specified frequency and amplitude. Constant block is used to inverse the error signal. Absolute block provides unidirectional output. Pulse Width Modulation technique is used to generate gate signal to the inverter. Signal generator generates the carrier wave for PWM. Modulation index of the system is fixed constant so the magnitude of the carrier signal is held constant. When the magnitude of error signal is higher than the magnitude of the carrier signal, pulse is generated and the duration of the pulse depends on the difference in magnitude. The pulse generated by PWM technique drives gate of IGBT Inverter.

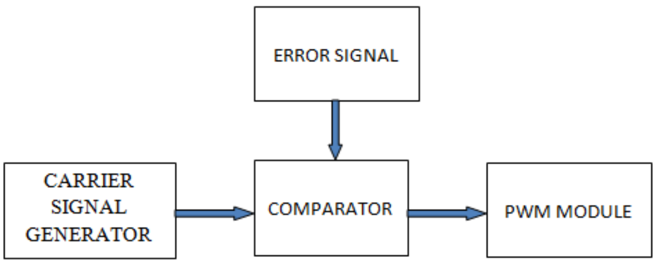


Figure 3: Control block

With the proposed model there is a significance improvement in the power quality. The output contains a lesser value of THD compared to the input as shown in the tabulation.

Tabulation

Table 1: Firing angle and load current

Firing angle (degrees)	% of THD without compensation	% of THD with compensation
15	9.72	4.00
30	15.78	4.82
45	25.99	5.73
60	37.44	5.82
90	65.28	6.38

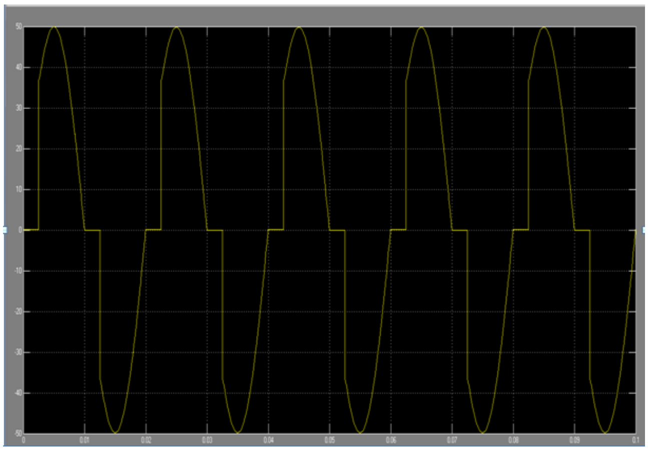


Figure 4: Before compensation

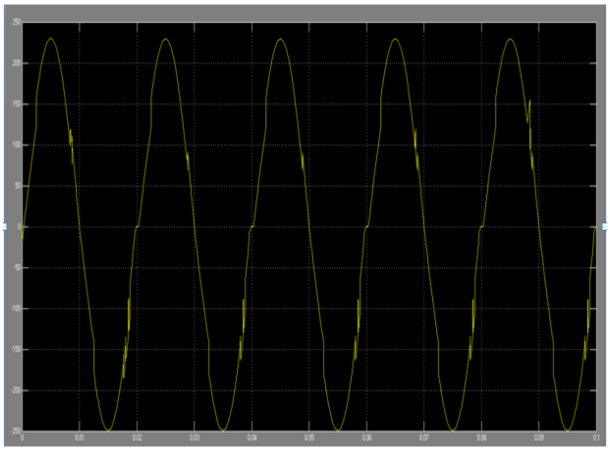
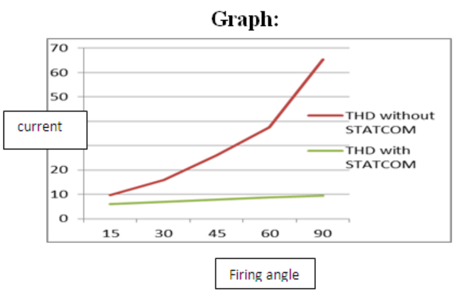


Figure 5: After compensation

Figure (4 & 5) shows the current waveform of the source before and after Compensation using the proposed model.
Graph:



Graph 1: % of THD Vs Firing angle

Is calculated using the relation and assume wi = 0.5

$$PQI = \sum_i w_i * (1 - QA_i)$$

$$\sum_i w_i = 1$$

Where, wi is the weighing factor.
QAi is the ith Quality Aspect.

The notable features of Power Quality Index [7] are

- It gives quick assessment of the power transfer quality at the selected point of the supply.
- It can also be expanded to include additional power quality problems like Sag, Swell, and Flicker that are appropriately defined in terms of their frequency and/or amplitudes.
- The Weighing factor can be flexibly selected to reflect the technical and economic priorities in different environments.

Therefore, the power quality index

Power Quality Index	Without STATCOM	With STATCOM
	0.7432	0.9521

Conclusion

Various power quality issues that degrade the quality of power and in this work harmonics are taken in to consideration and it is controlled using STATCOM a fact device which shows a considerable improvement in the Total Harmonic Distortion. Here harmonics issue is discussed only for single phase and it may be extended to three phase signal with different non linear loads. Statcom control can be done in both αβ frame and dq frame in future.

References

[1] C. Sankaran , ”Power Quality”, CRC Press special edition , 2009
[2] Angelo Baggini ,” Hand Book of Power Quality” John Wiley and sons limited , 2008
[3] Amirnaser Yazdani, Reza Iravani,”Voltage-sourced Converters in power Systems”, John Wiley & Sons, 2010.
[4] Yacamini, R. “Power system harmonics. Part 1. Harmonic sources ”, Power Engineering Journal, IEEE, Volume: 8 Issue:4 , Aug. 1994,pp: 193 – 198.
[5] Yacamini, R. “Power system harmonics. Part 2. Measurements and calculations ”, Power Engineering Journal, IEEE, Volume: 9 Issue:1 , Feb. 1995 ,pp: 51 – 56.

[6] Yacamini, R.“ Power system harmonics: Part 3. Problems caused by distorted supplies”, Power Engineering Journal, IEEE, Volume: 9 Issue:5, Oct. 1995,pp : 233 – 238.

[7] Daniel Sharon, Juan-Carlos Montano, Antonio Lopez, Manuel Castilla, Dolores Borras and Jaime Guierrez, “ Power Quality Factor for Networks Supplying Unbalanced Nonlinear Loads”, IEEE Transactions On Instrumentation and Measurement, volume: 57 , Issue:6, june 2008, pages: 1268-1274.

[8] Hingorani .N.G., “Introducing Custom Power”, IEEE spectrum, volume: 32 , issue: 6, 1995, pages: 41-48.

[9] READ, J.C.: 'Calculation of rectifier and inverter performance characteristics,', I/€€, 1945, 92, Pt.lll, p.495

[10] IEEE Task Force on the Effects of Harmonics on Equipment: 'Effects of harmonics on equipment', /IEEE Trans. on Power Delivery, April 1993,8, (2). pp. 672-680

[11] A. Ekstrom and Y. Jiang, “General analysis of harmonic transfer through converters,” IEEE Trans. Power Electron., vol. 12, no. 2, pp. 287–293, Mar. 1997