JCBPS; Section C; August 2017 – October 2017, Vol. 7, No. 4; 801-808. E- ISSN: 2249 –1929
[DOI: 10.24214/jcbps.C.7.4.80108.]

Journal of Chemical, Biological and Physical Sciences

An International Peer Review E-3 Journal of Sciences

*Available online at*www.jcbsc.org

Section C: Physical Sciences

CODEN (USA): JCBPAT Research Article

Investigation and Mitigation of Power Quality Events inDistribution System

Chetan E. Morkhadeand Chetan M. Bobade

Departmentof Electrical Engineer, GHRCEM, Amravati, (MH).India

Received: 05 July 2017**; Revised:** 16 July 2017; **Accepted:** 02August 2017

Abstract: The investigation and mitigation of power quality events in power systems are important work in monitoring and protection of power system network. Most of the power system disturbances are non-stationary and transitory in nature and new tools are being used nowadays for the analysis of power quality disturbances. This paper presents a wavelet based feature extraction method for the detection of power quality problem. The disturbance waveforms obtained from simulation are decomposed by discrete wavelet transform. The custom power device DSTATCOM is used for the mitigation of power quality events. Voltage sag, Transient and under voltage have been tested and mitigated in PSCAD.

Keywords: Sag, transients, under voltage, DWT, Energy Distribution, Power Quality, DSTATCOM, PSCAD.

1. INTRODUCTION

Power quality study has become an important issue in recent years because poor power quality may cause many problems for the sensitive loads such as malfunctions, instabilities, short life time etc. Hence mitigation of power quality disturbances is a challenging task for the power system engineers. The disturbance waveforms contain serious data and directly provide very little information for identification of power quality problems. Hence power quality experts are needed for the development of expert systems which can detect power quality problems. Discrete Wavelet transform with MATLAB software can extract unique features from voltage and current waveforms that characterize power quality events. To extract power quality disturbance features the energy distribution at different levels of decomposition has been considered.

In this paper a wavelet based approach for power quality disturbance recognition and identification has been proposed. To extract power quality problems features the energy distribution at each decomposition level has been considered. DSTATCOM is proposed to mitigate the said events using PSCAD software.

2. PROPOSED METHODOLOGY

In this work a single bus distribution network is considered for analysis. First power quality disturbances created on the bus and simulated using PSCAD software, then discrete wavelet transform (DWT) with MATLAB used for extraction of energies and different parameters. Wavelet transform is one of the signal processing technique which has the ability to analyze the signal in both time and frequency domain. It can be used on both stationary as well as non-stationary signal. The signal can be accurately reproduced with the wavelet analysis using small number of components. The wavelet energy is the sum of square of detailed wavelet transform coefficients. The energy of wavelet coefficient is varying over different scales depending on the input signals. The energy of the distorted signal can be partitioned at different resolution levels in different ways depending on the power quality problem. Hence the coefficient of the detailed version at each resolution level has been examined to extract features of the distorted signal for classifying different power quality problems.

The analyzing wavelets are called as Mother Wavelet and the transformed version are called as Daughter wavelet. The “mother wavelet” determines the shape of the components of the decomposed signals. There are many types of wavelets such as Harr (H), Daubechies 4 (D4), Daubechies 8 (D8), Coiflet 3 (C3), Symmlet 8 (S8), and so on. A particular type of wavelet is selected depending on the particular type of application. It has been proved hat Daubechies family of mother wavelet has good efficiency in power quality events. In this work decomposition level five is selected.

3. BASICOPERATION OFDSTATCOM

The D-STATCOM is a three-phase and shunt connected power electronics based device. It is connected near the load at the distribution systems. The major components of a DSTATCOM are shown in **Figure.1**. It consists of a dc capacitor, three-phase inverter module, ac filter, coupling transformer and a control system. The basic electronic block of the D-STATCOM is the voltage-sourced inverter that converts an input dc voltage into a three-phase output voltage at fundamental frequency.

The D-STATCOM employs an inverter to convert the DC link voltage V_{dc} on the capacitor to a voltage source of adjustable magnitude and phase. Therefore the D-STATCOM can be treated as a voltage-controlled source. The DSTATCOM can also be seen as a current-controlled source. The voltage V_i is the effective output voltage of the DSTATCOM and į is the power angle. The reactive power output of the D-STATCOM can be inductive or capacitive depending can be either on the operation mode of the DSTATCOM. Referring to **figure.1,** the controller of the D-STATCOM is used to operate the inverter in such a way that the phase angle between the inverter voltage and the line voltage is dynamically adjusted so that the D-STATCOM generates or absorbs the desired VAR at the point of connection.

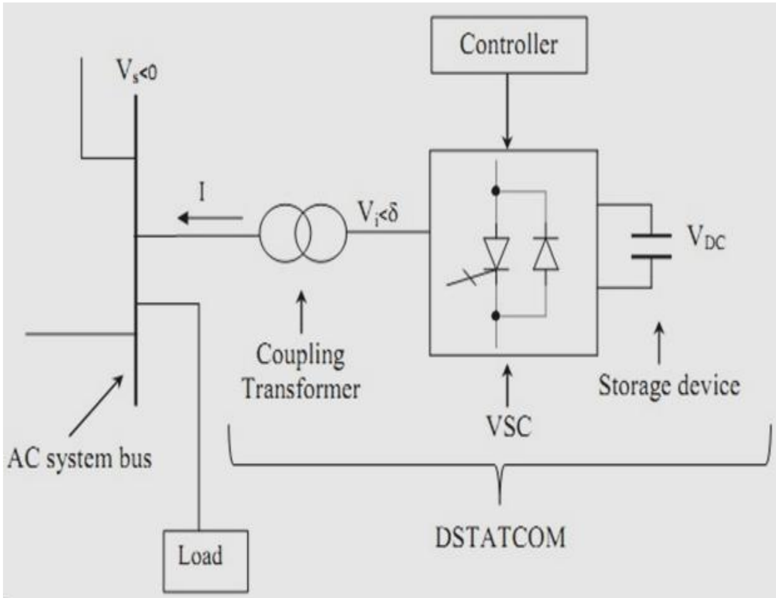

Fig.1. Basic blocks for DSTATCOM

The phase of the output voltage of the thyristor-based inverter, V_i, is controlled in the same way as the distribution system voltage, V_s. There are three basic operation modes of the D-STATCOM output current, I, which varies depending upon V_i. If Vi is equal to V_s, the reactive power is zero and the D-STATCOM does not generate or absorb reactive power. When V_i is greater than V_s, the D-STATCOM shows an inductive reactance connected at its terminal. The current, I, flows through the transformer reactance from the DSTATCOM to the ac system, and the device generates capacitive reactive power. If V_s is greater than V_i, the DSTATCOM shows the system as a capacitive reactance. Then the current flows from the ac system to the D-STATCOM, resulting in the device absorbing inductive reactive power.

4. DETECTION OF POWER QUALITY DISTURBANCES

Network study

Fig.2 shows the distribution network which feeds load.

Table I shows the parameters for the same network.

The waveforms of events were loaded to the wavelet toolbox. Daubechies 5 was used as mother wavelet. Five level decomposition of Db5 wavelet was used for analysis. The following results were observed.

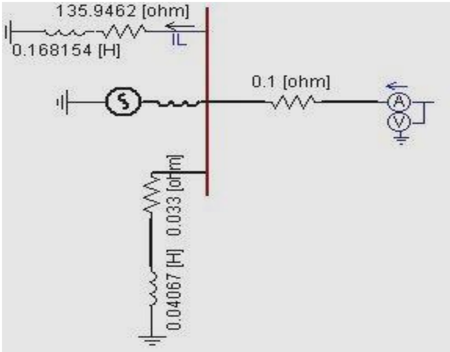

Fig.2. Distribution network under analysis

Table I: Parameters for given network

Source	Inductive(L),115KV,60Hz
Load	Load1:(R=0.033ohm/ph,L=0.04067H/ph) Load:(R=135.9462ohm/ph,L=0.168154)

Three phase to ground fault created (for time t=1.0to t=2.0sec) on load bus for identification of voltage sag and capacitor switching done (for time t=1.0to t=2.0sec) to the bus for identification of transient. Heavy load on system maintained for identification of under voltage. The voltage waveforms before mitigation for sag, transient and over voltage are as shown in **fig.3, fig.4** and **fig.5** respectively. Then data of voltages is given to DWT for extraction of features for above events. Energy distribution and statistical parameters for sag, transient and over voltage are tabulated in **Table.2, Table.3** and **Table.4** respectively. **Fig.6** shows the comparison graph between energy distribution and decomposition level for all the above said events. Voltage magnitude is reduced to 20% in sag with the rated value. All the signals are of 60 Hz. frequency and amplitude 1 p.u.. The sampling frequency is 2KHz.

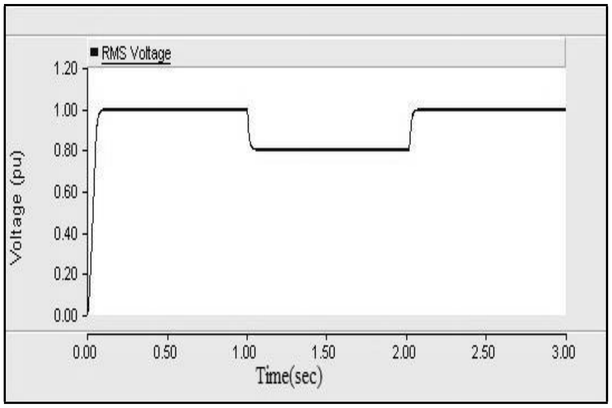

Fig.3.voltagesagwithoutDSTATCOM

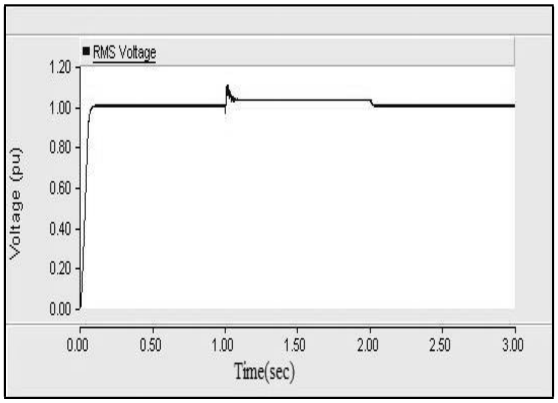

Fig.4. Transient voltage without DSTATCOM

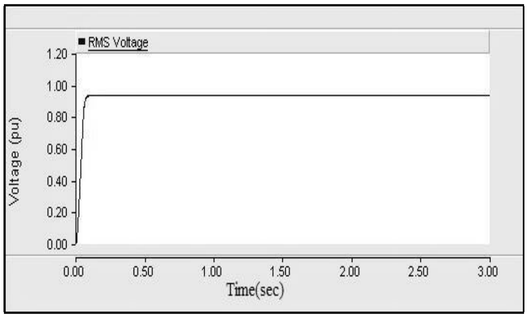

Fig.5: Under voltage without DSTATCOM

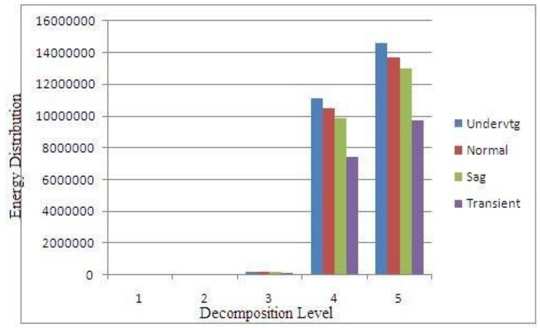

Fig.6: Energy distribution comparison for all events

Table2: Energy Parameters for sag

Time	E1	E2	E3	E4	E5	MEAN(E1+E2)	AVG	STDEV
t1	0	0	0	0	0	0	0	0
t2	5.13E-08	8.75E-07	9.94E-06	2.37011E-05	7E-05	4.63329E-07	2.2E-05	3.1E-05
t3	4962.238	1531.106	193562	9870252.921	1E+07	3246.671937	4617990	6331297
t4	4093.904	1635.898	192478.9	9864497.167	1E+07	2864.901075	4598598	6300836
t5	4093.904	1635.898	192478.9	9870983.053	1E+07	2864.901086	4598584	6300026
t6	4093.904	1635.898	192478.9	9864497.167	1E+07	2864.901051	4598627	6300883

Table 2: Energy Parameters for Transient

Time	E1	E2	E3	E4	E5	MEAN(E1+E2)	AVG	STDEV
t1	0	0	0	0	0	0	0	0
t2	5.13E-08	8.75E-07	9.94E-06	2.3701E-05	7.5E-05	4.63329E-07	2.2E-05	3.1E-05
t3	46.47621	1083.648	144917.4	7439084.91	9738094	565.0622308	3464645	4747963
t4	2059.869	10159.42	144976	7439769.87	9746099	6109.645639	3468613	4748720
t5	2059.869	10159.42	144976	7438271.58	9747597	6109.645601	3468613	4748902
t6	2059.869	10159.42	144976	7439769.87	9746099	6109.645546	3468613	4748720

Table 4: Energy Parameters for under voltage

Time	E1	E2	E3	E4	E5	MEAN(E1+E2)	AVG	STDEV
t1	69.2714	1624.4	216861	1.1E+07	1.5E+07	846.8353541	5183584	6122748

In this work the power quality problems such as voltagesag, Transients and under voltage created for different sampleinstants and energy is calculated for each instant. Alsocalculated the different statistical parameters such as averagemean and standard deviation for analysis purpose.

5. MTIGATION OF POWER QUALITY DISTURBANCES

After detection of disturbances the next work is carried out to mitigate the disturbances. This work is carried out by taking DSTATCOM as a custom power device. The simulation is done in PSCAD software and connected to the system through injecting transformer. It inject or absorbs the reactive power which is depend on the lead/lag current.DSTATCOM uses 6 pulse invertor and GTOs as switching device.

The simulated waveforms observed and hence the powerquality disturbances like, voltage sag, transient and undervoltage are mitigated. The simulation waveforms for saiddisturbances are shown in Figure.7, Figure.8 and Figure.9respectively. Figure.7 shows voltage sag is mitigated byinjecting reactive power by using DSTATCOM. Figure 8shows the transient voltage is mitigated by absorbing reactivepower by using DSTATCOM Figure.9 shows the undervoltage is mitigated by injecting reactive power by usingDSTATCOM.

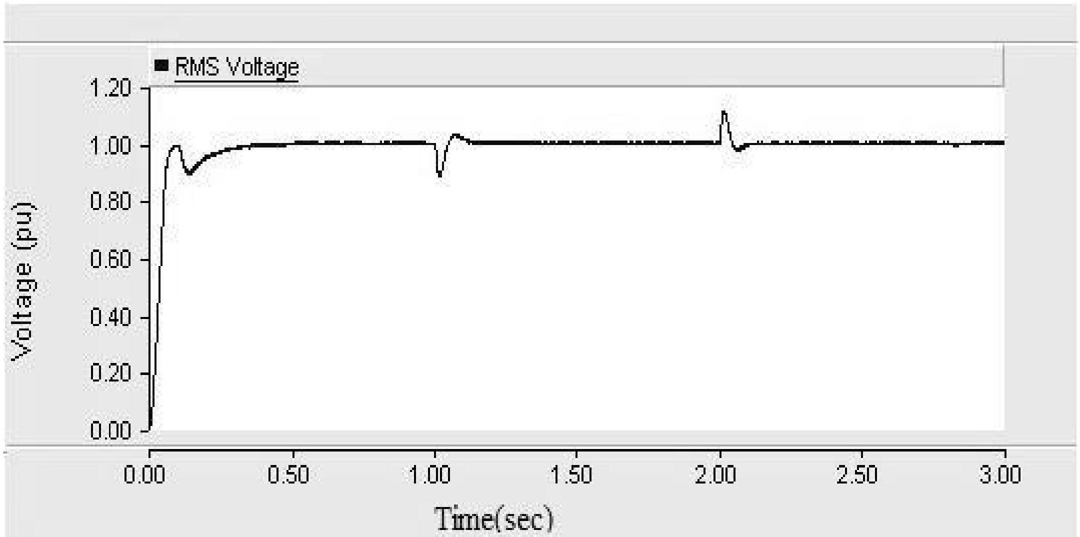

Fig.7: voltage sag with DSTATCOM

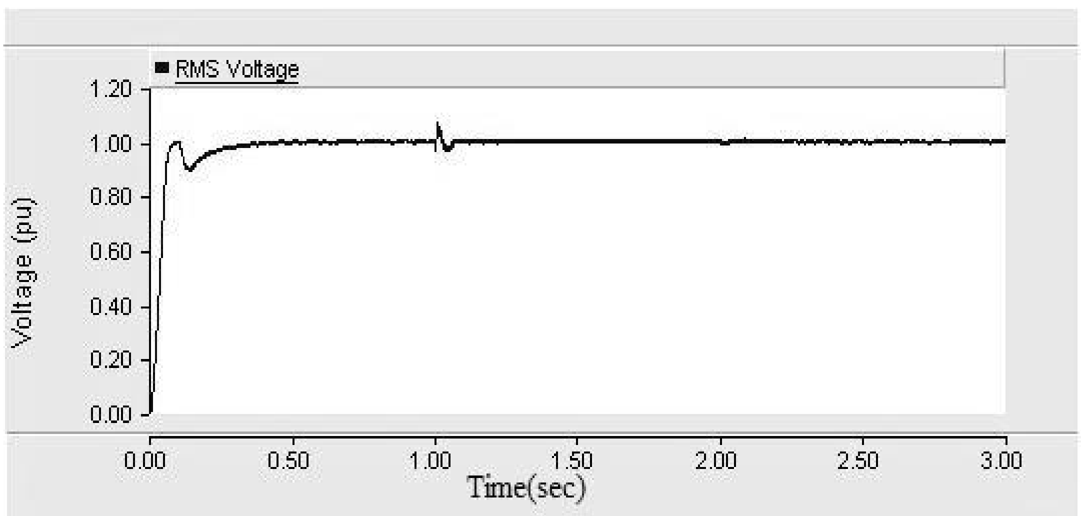

Fig.8: Transient voltage with DSTATCOM

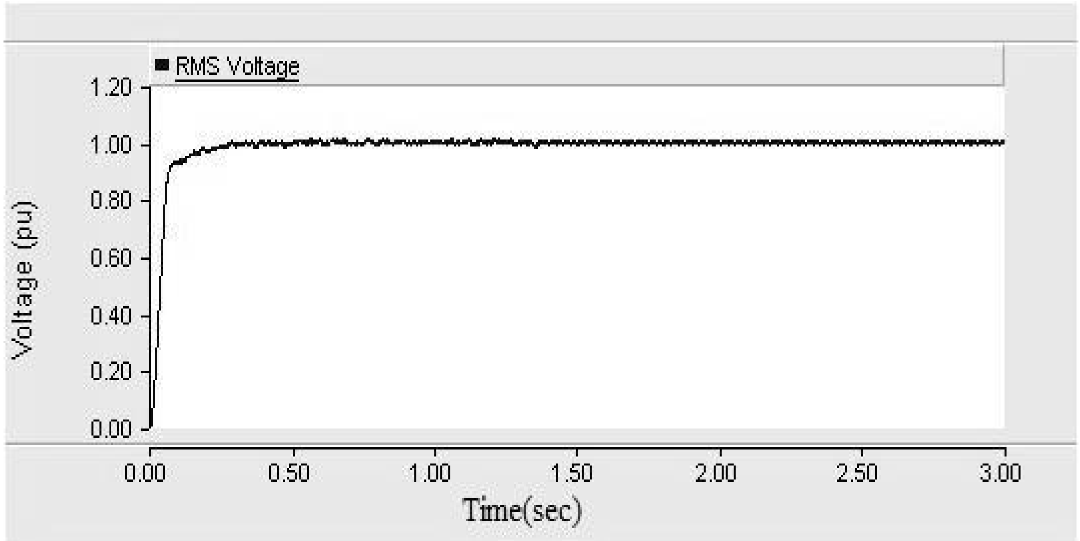

Fig.9: Under voltage with DSTATCOM

From the above waveforms it is clear that voltage sag,transient and under voltage are mitigated by DSTATCOM.Theresult analysis for the mitigation of above disturbances is shown in **Table V.**

Table 5: Result analysis for mitigation

Events created for 60 cycle(1 second)			
Normal Voltage	Sag Voltage	Transient Voltage	Under Voltage
115KV (Line to Line)	92KV(0.8pu) Reduced by 23KV(0.2pu)	126KV(1.1pu) Increased by 11KV(0.1pu)	109 KV(0.95pu) Reduced by 6 KV(0.05pu)
Mitigation (Aprox)	100%	100%	100 %

CONCLUSION

In this paper we have proposed energy based wavelet scheme for identification of power quality events. The energy distribution patterns in the frequency domain are used as power quality disturbance features. It has been found that energy distribution for above events is distinguished.
DSTATCOM is a suitable custom power device for the mitigation of power quality problems at given magnitudes of faults in distribution network.

REFERENCES

1. Olimpo Anaya-Lara and E.Acha, Modeling and Analysis of Custom Power Systems by PSCAD/EMTDC, IEEE Transaction on power delivery,2002, .17,1,202-212

2. SudiptaNath and Priyanjali Mishra, Wavelet based feature extraction for classification of Power Quality Disturbances,Internatinal Conference on Renewable Energies and Power. Quality (ICREPQ'11), 2011, Spain,13th and 15th April,2011.
3. Chetan.B.Khadse, S.L.Shaikh, "Multiresolution Analysis and StandardMRA Curve for Analysis of Power Quality Disturbances", 2013, 3, 2, 747-753.
4. Z. L. Gaing, "Wavelet –based neural network for power disturbance recognition and classification", IEEE Trans. Power Delivery, 2004, 19, 1560 -1567.
5. M. Uyar, S. Yilidrim, and M.T. Gencoglu, An effective wavelet-based feature extraction method for classification of power quality disturbance signals, International journal of Electric power systems research,2008, 78 ,1747- 1755,
6. O. Gencer, S. Ozturk, and T. Erfidan, A new approach to voltage sag detection based on wavelet transform,International journal of Electrical power and Energy systems, 2010, 32, 133-140.
7. Z. Y. He, X. Q. Chen and G. M. Luo, Wavelet Entropy Definition and Its Application for Transmission Line Fault Detection and Identification (Part II: Fault Detection in Transmission Line)," Proceedings of International Conference on Power System Technology, Chongqing, October 2006, 1-5.
8. S. Asha Kiranmai,M.Manjula, A.V.R.S.Sarma, Mitigation of VariousPower Quality Problems Using Unified Series Shunt Compensator in PSCAD/EMTDC," 16th national power systems conference, 15th-17th December, 2010.
9. Whei-Min Lin *et al*, Detection and Classification of Multiple Power Quality Disturbances with Wavelet Multicass SVM" IEEE Transaction on Power Delivery, 2008, 23, 4, 2575-2582,
10. HendriMasdi, Norman Mariun, design of a prototype dstatcom for voltage sag mitigation, [Conference Paper, December 2004 DOI: 10.1109/PECON.2004.1461617.
11. LabibDaloub, Nasser Shtawa, Mustafa R. Abuzaid and Ali Yousef,statcom modeling in reactive power control of distribution network,al-azhar engineering tenth international conference December 24 - 26, 2008
12. S.V Ravi Kumar and S.SivaNagaraju, Simulation of DSTATCOM and DVR in Power System" J.N.T.U college of Engineering,Kakinada,A.P,India, 2007, 2, 3,156-162.

Corresponding author:Chetan E. Morkhade

Department of Electrical Engineer, GHRCEM, Amravati, (MH).India

On line publication Date: 02.08.2017