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DETECTION AND CHARACTERIZATION OF VOLTAGE SAG USING WAVELET TRANSFORM

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ABSTRACT

This paper presents a new technique for detecting and characterizing voltage sag in power systems based on wavelet transforms. Using the first detail wavelet coefficients, voltage sag characteristics are extracted. This paper presents a MATLAB simulink model implementing the wavelet transform and the values of characteristics are displayed. For this purpose the wavelet technique is used for detecting starting and ending points of voltage sags by energy coefficient. The method is developed by using the discrete wavelet transform analysis.

KEYWORDS: Simulink, Voltage sag, MATLAB, DWT.

INTRODUCTION

The wide spread of electronic equipment like computers, adjustable speed drive, PLC, CFL will create the power quality problems in the power system network. Voltage sag, swell, flicker, harmonics, impulse transient and interruptions are of most power quality problems. If we see the other side of this, the equipments which create the power quality problems are major victims of power quality problems.

This paper presents the technique of wavelet transform for extracting the characteristics of voltage sag by implementing the discrete wavelet transform. The wavelet multi resolution analysis (MRA) is a new and powerful method of signal analysis. In multi resolution analysis technique that can be decompose the original signal into several other signals with different level of resolution. When original signal is decomposed approximation coefficients and detailed co-efficients are obtained. Details and approximations of original signals are obtained by passing it through a filter bank, which consists of low and high –pass filter. A low pass filter removes the high frequency components while the high pass filter pick out the high frequency contents in the signal being analyzed. From these decomposed signals the original time-domain signal can be recovered without loosing any information

Voltage sag is a short-duration reduction in RMS voltage usually caused by faults in the electric supply system. It is defined as one of the most important aspects of power quality, and is necessary to establish the common way to characterizing this phenomenon. Voltage sags are considered of rectangular shape, characterized by magnitude and duration. Commonly, the magnitude of voltage sag is defined as a reducing of voltage under a threshold. According to IEEE 1159/95 standard this threshold is 90% of rated voltage, and if voltage falls below 10% the perturbation is considered as interruption. The duration of voltage sag, is the time measured from the moment when RMS voltage drops below the threshold to when it rises above the threshold. It is from few periods (tens of milliseconds) to some minutes. In three-phase systems, it is normally assumed that the sags are balanced. In reality, most voltage sags are due to unbalanced faults, which introduce different values of voltage for each phase and phase angle shift. This paper presents set of simulink models used to simulate voltage sag.

CHARACTERIZATION OF VOLTAGE SAG

The IEEE Standards 1159-1995 [13] and IEC 61000-4-30 [3] are the two main standards that define voltage sag (dip), swell, and interruption. In this paper, based on these standards, voltage sags are characterized by their magnitude (rms value) and duration as follows.

- The voltage sag starts when at least one of the rms voltages drops below the threshold of 90% of the reference voltage and ends when all three rms voltages have been recovered above this threshold for durations from half-cycle to 1 min.
- Voltage sags are mainly due to faults [1]. Only voltage sags will be properly dealt with in this paper. However, the analysis accomplished here can be extended for voltage swell and interruption characterization.
- Voltage sag duration is defined by the fault clearing time.
- Point on wave of sag initiation is nothing but the point at which fault occurs.
- Point on wave of sag recovery is nothing but point at which fault recovers.
- Phase angle jump is the shift in the zero crossing of instantaneous voltage. Phase - angle jumps as during three phase faults are due to a difference in the X/R ratio between the source and the feeder

RMS-Based Analysis
The IEC PQ measurement standard 61000-4-30 [3] prescribes a precise rms-based method for obtaining the voltage magnitude as a function of time. In fact, most commonly used PQ monitors calculate not the fundamental component but the rms value over a one-cycle or half-cycle window of the power system frequency [2]. The calculation of the one-cycle rms voltage can be repeated every half-cycle [3]. However, in this paper, the rms voltage is obtained over a one-cycle window sliding sample by sample in time (voltage sliding window), as follows:

$$V_{RMS}[k] = \sqrt{\frac{1}{N}\sum_{i=k-N+1}^{k} v_i^{\,2}} \text{ ------}(1)$$

Where k indicate the number of samples.

SEVEN TYPES OF VOLTAGE SAG

This paper implements a MATLAB Simulink model to detect and extract the seven different types of voltage sags. The different type of voltage sag is created at different fault condition and also on load and transformer windings connections. Following table shows the seven different types of voltage sags and also the different conditions at which they occur.

TABLE 1 Types of voltage sag

Voltage Sag Type	**Fault Type**
Type A	Three-phase
Type B	Single-phase to ground
Type C	Phase-to-phase
Type D	Phase-to-phase fault (experienced by a delta connected load), single-phase to ground (zero sequence component removed)
Type E	Two-phase-to-phasefault (experienced by a Wye connected load)
Type F	Two-phase-to-phase fault (experienced by a delta connected load)
Type G	Two-phase to phase fault (experienced by a load connected via a non-grounded transformer removing the zero sequence component)

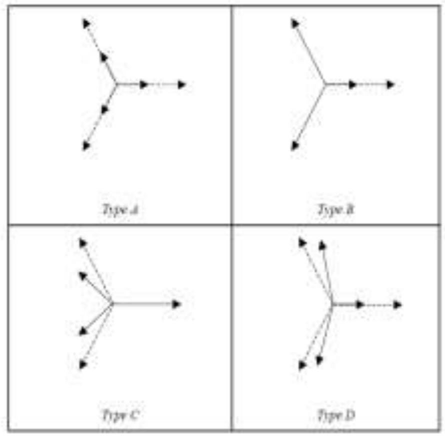

Fig 1 Phasor representation of Type A, Type B, Type C, Type D voltage sag

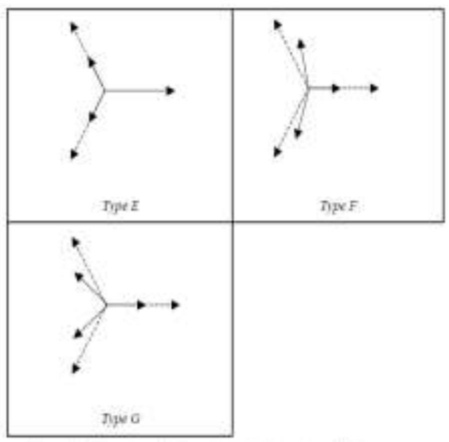

Fig 2 Phasor representation of Type E, Type F, Type G voltage sag

MATLAB SIMULATION

Main Simulink model

Figure below depicts the simulation model used to create the voltage sag of the required type and extract its different characteristics.

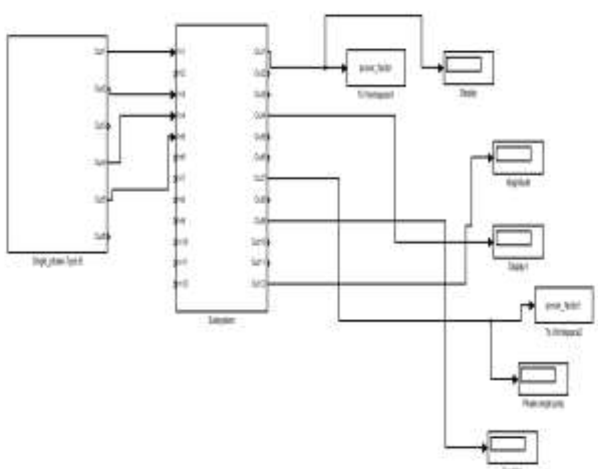

Fig 3 Main simulink model

The very first block implements the fault block in which the desired fault could be created to create required type of voltage sag to be analyzed. Following figure shows the fault model used to simulate sag. The first block in the above model consists of the following sub modules.

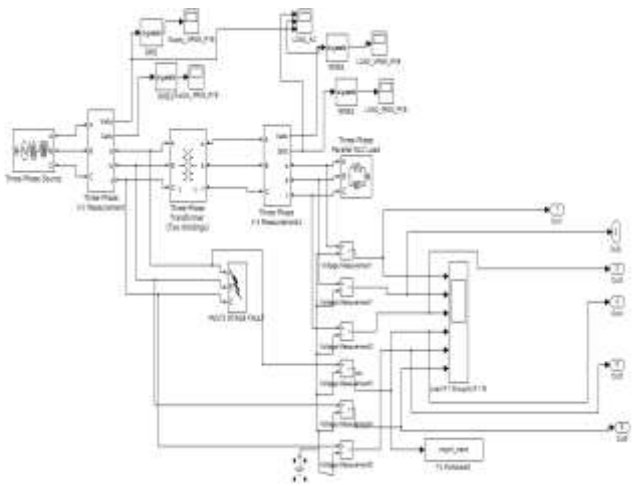

Fig 4 Simulink fault model

DWT block for the extraction of Magnitude and Duration

Dyadic Analysis Filter bank:

This block decomposes frame-based signals with frame size a multiple of 2^n into either n+1 or 2^n sub bands. To decompose sample-based signals or frame-based signals of different sizes, use the Two-Channel Analysis Sub band Filter block.

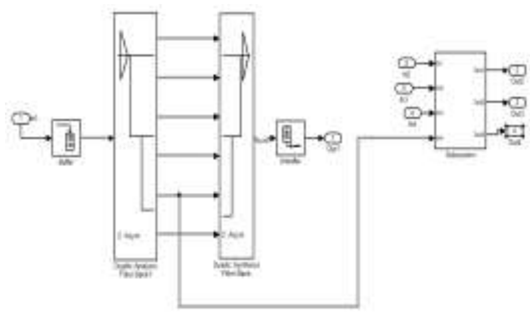

Fig 5 DWT block

You can specify the filter bank's high pass and low pass filters by providing vectors of filter coefficients. If you install the Wavelet Toolbox product, you can also specify wavelet-based filters by selecting a wavelet from the Filter parameter. You must set the filter bank structure to asymmetric or symmetric, and specify the number of levels in the filter bank.

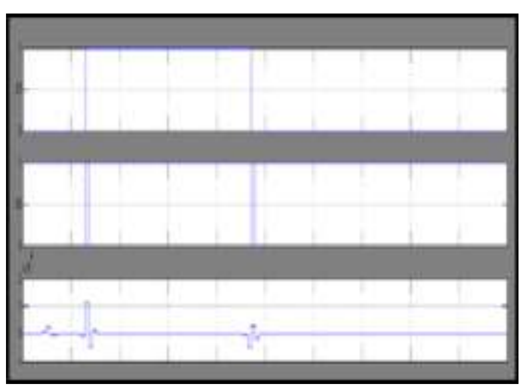

Fig 6 Output waveform decomposed by DWT

As shown in the above diagram the DWT(Discrete wavelet transform) block decomposes the time domain signal into discrete values and the energy co-efficient are obtained at the time of fault occurrence and fault recovery that is starting and end points of voltage sag are extracted.

ZCD for the extraction of Phase angle jump

Phase angle jump is nothing but the shift in zero crossing of the instantaneous voltage. The concept of zero crossing detection is implemented to calculate the phase angle jump.

The following figure depicts the simulink model implementing the ZCD.

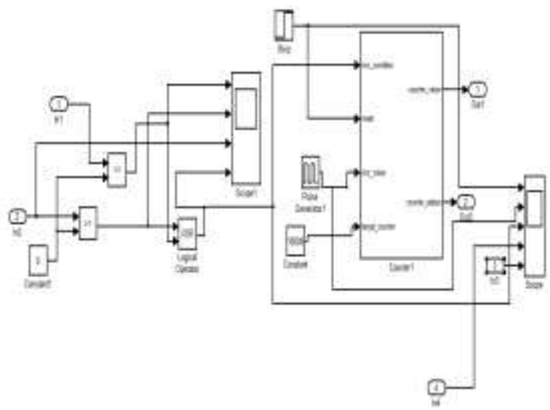

Fig 7 Sub modules implementing the ZCD

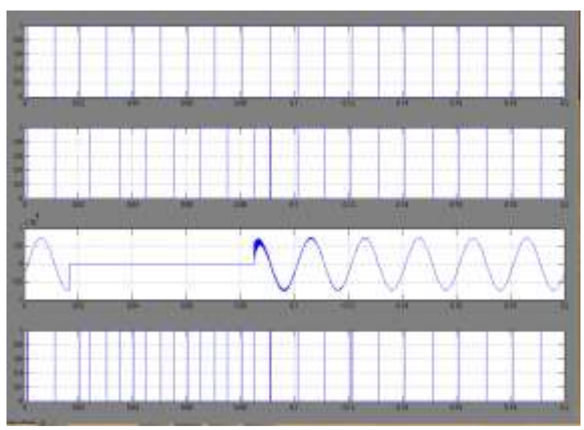

Fig 8 Decomposed waveforms fed to ZCD block for the calculation of Phase angle jump

As discussed above the various characteristics of voltage sag are extracted by the application of Discrete Wavelet transform. The figure below shows the display of these characteristics as the final output of the main simulink model.

OUTPUT OF THE SIMULATION

The output waveforms of the different types of voltage sag look as shown in the following waveforms.

Table 2 Values of magnitude, duration and phase angle jump of Sag type A, B, C, D

	Magnitude (pu)	Duration (sec)	Phase angle jump (Rad/sec)
Sag A	0.0045	0.1202	479
Sag B	0.5228	0.1748	1395
Sag C	0.4472	0.1170	208

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Sag D	0.4452	0.117	850

Sag Type A:

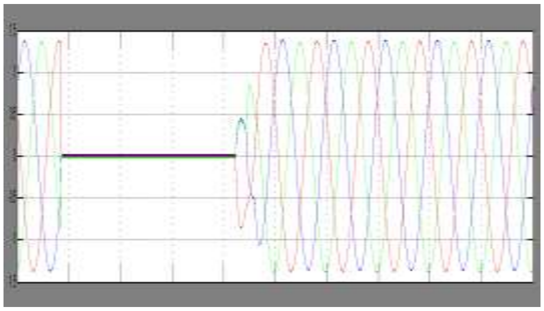

Fig 10 Output waveform for sag type A

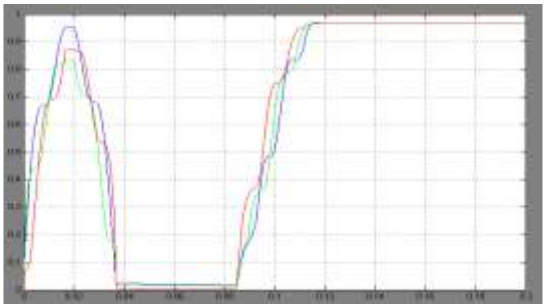

Fig 11 RMS output waveform for sag type A

Sag type B

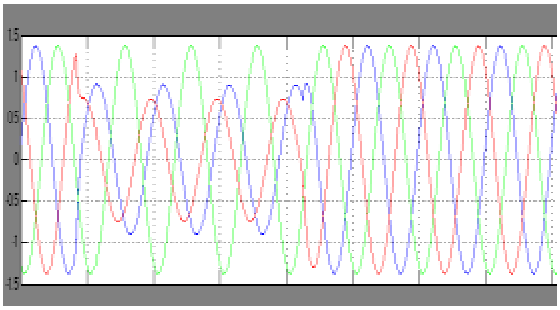

Fig 12 Output waveform for sag type B

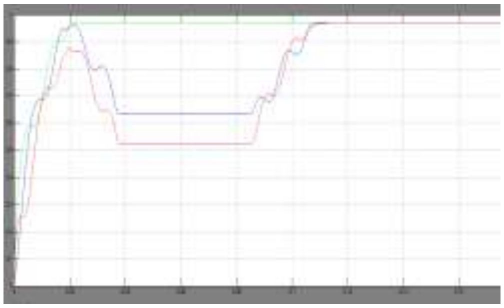

Fig 13 RMS output waveform for sag type B

Sag Type C

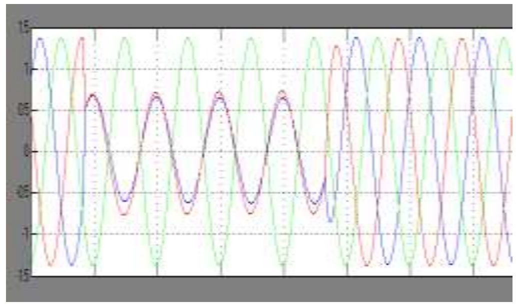

Fig 14 Output waveform for sag type C

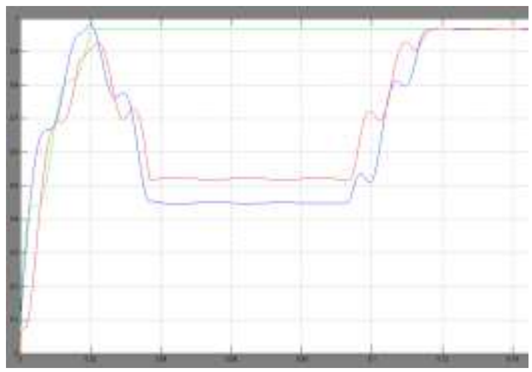

Fig 15 RMS output waveform for sag type C

Sag Type D

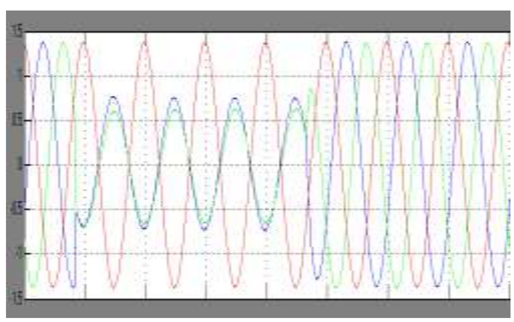

Fig 16 Output waveform for sag type D

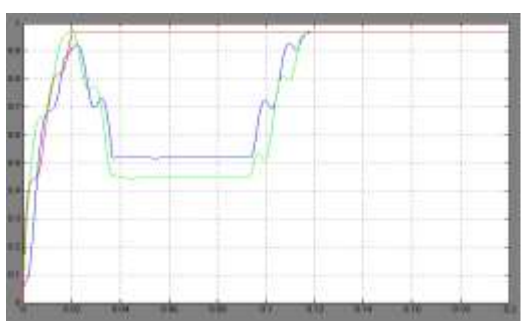

Fig 17 RMS output waveform for sag type D

CONCLUSION

This paper presents MATLAB simulink model that is capable of simulating Voltage sag event at distribution level. Also the important characteristics of voltage sag namely 'Magnitude ' and 'Duration' and 'Phase Angle Jump' have been extracted by the implementation of Discrete Wavelet Transform and Zero Crossing Detection Technique. These simulink models serve as a fundamental basis model for building more complex power quality event simulation. These models are also useful to simulate various power quality waveforms for power quality analysis.

REFERENCES

[1] M. H. J.Bollen, Understanding Power Quality Problems: Voltage Sags and Interruptions. New York: Wiley, 2000.
[2] M. H. J. Bollen and I. Y.-H. Gu, Signal Processing of Power Quality Disturbances. Hoboken, NJ: Wiley, 2006.
[3] F.B.Costa∗†, Member, IEEE, B.A.Souza, Senior Member, IEEE and N.S.D.Brito.Real time detection of voltage sag based on wavelet transform, 2010 IEEE,PES conference
[4] P. K. Dash, Senior Member, IEEE, and M. V. Chilukuri, Member, IEEE, Hybrid s transform and kalman filtering approach for detection and measurement of short duration disturbances in power networks,2004 IEEE transaction on instrumentation and measurement
[5] H. Amarís, Member, IEEE, C. Álvarez, M. Alonso, D. Florez, T. Lobos, Member, IEEE, P. Janik, J. Rezmer, Z. Waclawek,Computation of votage sag initiation with fourier based algorithm,Kaman filters and wavelets,2009 IEEE Budapest conference
[6] Electromagnetic Compatibility (EMC)—Part 4-30: Testing and Measurement Techniques–Power Quality Measurement Methods, IEC 61000-4-30, Oct. 2008.
[7] N. S. Tanaboylu, E. R. Collins, and P. R. Chaney, "Voltage dirturbance evaluation using the missing voltage technique," in Proc. 8th Conf. Harmonics Qual. Power, 1998, pp. 577–582
[8] S. Santoso, E. J. Powers, W. M. Grady, and P. Hofmann, "Power quality assessment via wavelet transform analysis," IEEE Trans. Power Del., vol. 11, no. 2, pp. 924–930, Apr. 1996.
[9] A. C. Parsons, W. M. Grady, and E. J. Powers, "A wavelet-based procedure for automatically determining the beginning and end of transmission system voltage sags," Proc. IEEE Power Eng. Soc., vol. 2, pp. 1310–1315, Feb. 1999.
[10] O. Gencer, S. Öztürk, and T. Erfidan, "A new approach to voltage sag detection based on wavelet transform," Elect. Power Energy Syst., pp. 133–140, Jul 2009.
[11] K. M. Silva,B.A. Souza, and N. S. D. Brito, "Fault detection and classification in transmission lines based on wavelet transform and ANN," IEEE Trans. Power Del., vol. 21, no. 4, pp. 2058–2063, Oct 2006.
[12] F. B. Costa, B.A. Souza, andN. S.D. Brito, "Detection and classification of transient disturbances in power systems," Inst. Elect. Eng. Jpn. Trans. Power Energy, pp. 910–916, Oct 2010.
[13] F. B. Costa, B. A. Souza, and N. S. D. Brito, "Real-time detection of voltage sags based on wavelet transform," presented at the IEEE/Power Eng. Soc. Transm. Distrib. Conf. Expo.: Latin America, São Paulo, Brazil, Nov. 2010.
[14] D. B. Percival and A. T. Walden, Wavelet Methods for Time Series Analysis. Cambridge, U.K.: Cambridge Univ. Press, 2000.
[15] F. B. Costa, B. A. Souza, and N. S. D. Brito, "Real-time detection of fault-induced transients in transmission lines," Inst. Eng. Technol. Electron. Lett., pp. 753–755, May 2010.
[16] IEEE Recommended Practice for Monitoring Electric Power Quality, IEEE Standard 1159-1995, Jun 1995.
[17] R. Naidoo and P. Pillay, "A new method of voltage sag and swell detection," IEEE Trans. Power Del., vol. 22, no. 2, pp. 1056–1063, Apr. 2007.
[18] S. Z. Djokic, J. V. Milanovic, and S. M. Rowland, "Advanced voltage sag characterisation ii: Point on wave," Inst. Eng. Technol. Gen. Transm. Distrib., vol. 1, no. 1, pp. 146–154, Jan 2007.
[19] C. Fitzer, M. Barnes, and P. Green, "Voltage sag detection technique for a dynamic voltage restorer," IEEE Trans. Ind. Appl., vol. 40, no. 1, pp. 203–212, Jan./Feb. 2004.