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Detection and Classification of Sag and Swell in the Supply to Induction Motor

Pooja V¹, Sridhar S², Kodeeswara Kumaran G²

P.G. Student, Department of Electrical and Electronics Engineering, M S Ramaiah Institute of Technology
Bengaluru, Karnataka, India¹

Associate Professor, Department of Electrical and Electronics Engineering, M SRamaiah Institute of Technology
Bengaluru, Karnataka, India²

ABSTRACT: Induction motor has redefined the concept of electro mechanical conversion in modern day industry. Presently it accounts for about 60% of total industrial loads. Hence any failure occurring in the induction motor leads to severe bottle neck in industrial process, loss of production and revenue. The quality of the supply given to the IM plays a major role in its performance. Any variation in the supply will adversely affect its normal operation. Hence it is important to detect any PQ disturbances and identify the nature of the disturbance. This work proposes a novel method for the detection of seven types of sag and swells (Type – A, B, C, D, E, F, G) in supply to the IM using the signature of the stator current. Statistical methods such as mean, standard deviation, skewness and kurtosis of the stator current are used for feature extraction. Feed - Forward Neural network is used for classifying different types of sag and swell for varying degree of disturbances. It is observed that the proposed network has performance efficiency of 88%.

KEYWORDS: Feed-Forward Neural Network, Statistical features, Induction motor, PQ disturbance.

I. INTRODUCTION

Power quality (PQ) is generally understood to be the electrical network's capacity to deliver a steady and clean power flow that acts as a perfect power supply and is constantly available, has a pure noise-free sinusoidal wave shape and is always within frequency and voltage tolerances. The quality of the supply has a significant impact on the optimal operation and efficiency of today's power-driven equipment. Induction motor drives are preferred for its simple and easy control. Voltage sag, harmonics, voltage swell, imbalance, impulse surges, short interruptions, overvoltage, and under voltage are power quality issues that have an impact on the behaviour of induction motors[1]. Thermal effects, a reduction in torque and speed values to levels below the rated values, skin effect, insulation failure, and are all effects of PQ disturbances on the motor.

Frequent power quality disturbances are voltage sag and voltage swell in supply to the induction motor. The IEEE defines voltage sag as: "Reduction in the rms voltage in the range of 0.1 to 0.9 p.u for duration greater than half a mains cycle and less than 1 minute". It is caused by faults and increased load demand. The IEEE defines voltage swell as: "An increase in the rms voltage in the range of 1.1 to 1.8 p.u for duration greater than half a mains cycle and less than 1 min". It is caused by load switching, system faults and capacitor switching, large equipment start-up or shutdown, sudden change in the load and etc.

The Short Time Fourier Transform (STFT) method, Fast Fourier Transform (FFT), Fractal based approach, S-transform (ST) method and Discrete Wavelet Transform (DWT) method are frequently used to extract the features of non-stationary signals. Only stationary signals—that is, signals whose characteristics do not fluctuate over time—are shown to operate better with FFT. The STFT struggles to work well with non-stationary signals due to the constraints of a predetermined window width. In order to extract the features from stator current of the induction motor, statistical approaches are called upon while taking these drawbacks into account.

This work consists of

- By using statistical approach, feature extraction from the IM's single phase stator current. In this instance, single phase stator current measurement is used instead of three phase stator current measurement.
- detection and classification of PQ disturbances using feed-forward neural network.

Paper is organized as follows. Section II describes the feature extraction technique, which involves sampling and processing stator currents of the induction motor using statistical techniques including kurtosis, skewness, standard deviation, and mean. The feed-forward neural network classification technique for PQ disturbances is presented in Section III. Section IV presents a flowchart that depicts the work's process flow. Finally section V draws the conclusion.

II. FEATURE EXTRACTION USING STATISTICAL METHOD

The simulation in MATLAB uses a 5.4 HP, 400 V, 50 Hz, three phase squirrel cage IM with 4 poles. Fig.1 shows the simulation model for injecting power quality disturbances in the supply to the induction motor. To inject voltage sag and swell in supply to the IM, 3 phase programmable voltage source and single phase AC voltage source are utilized. The supply frequently experiences sag and swell at the points of common coupling connected to industrial loads with induction furnaces, welding transformers, big IM drives and arc furnaces among other PQ disturbances. Voltage sags and swells come in seven different varieties. The supply to the IM is depicted in Figs. 2 and 3 as having all different types of sag and swell. Table I displays the mathematical formulas governing every sort of voltage sag and swell.

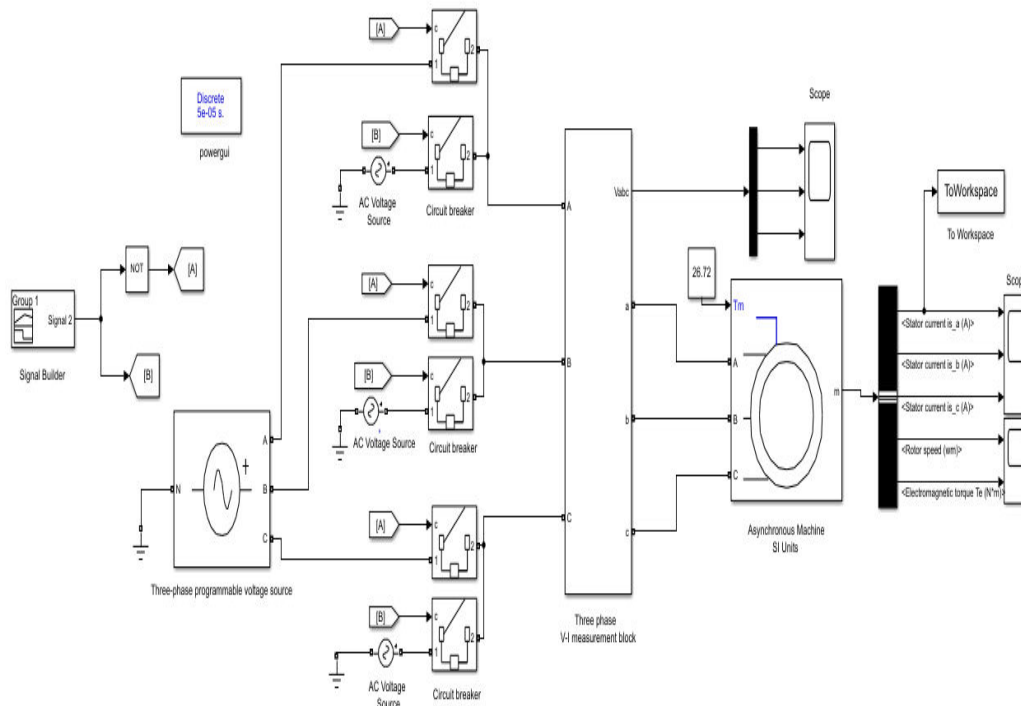


Fig.1. MATLAB/Simulink model to inject voltage swell and sag in supply to IM

TABLE.1: Sag and Swell Types In Equation Form

<p>Type - A</p> $v_a = hv$ $v_b = -\frac{1}{2}hv - j\frac{\sqrt{3}}{2}hv$ $v_c = -\frac{1}{2}hv + j\frac{\sqrt{3}}{2}hv$	<p>Type - B</p> $v_a = hv$ $v_b = -\frac{1}{2}v - j\frac{\sqrt{3}}{2}v$ $v_c = -\frac{1}{2}v + j\frac{\sqrt{3}}{2}v$
<p>Type - C</p> $v_a = v$ $v_b = -\frac{1}{2}v - j\frac{\sqrt{3}}{2}hv$ $v_c = -\frac{1}{2}v + j\frac{\sqrt{3}}{2}hv$	<p>Type - D</p> $v_a = hv$ $v_b = -\frac{1}{2}hv - j\frac{\sqrt{3}}{2}v$ $v_c = -\frac{1}{2}hv + j\frac{\sqrt{3}}{2}v$
<p>Type - E</p> $v_a = v$ $v_b = -\frac{1}{2}hv - j\frac{\sqrt{3}}{2}hv$ $v_c = -\frac{1}{2}hv + j\frac{\sqrt{3}}{2}hv$	<p>Type - F</p> $v_a = hv$ $v_b = -\frac{1}{2}hv - j\frac{1}{\sqrt{12}}(2+h)v$ $v_c = -\frac{1}{2}hv + j\frac{1}{\sqrt{12}}(2+h)v$
<p>Type - G</p> $v_a = \frac{1}{3}(2+h)v$ $v_b = -\frac{1}{6}(2+h)v - j\frac{\sqrt{3}}{2}hv$ $v_c = -\frac{1}{6}(2+h)v + j\frac{\sqrt{3}}{2}hv$	<p>Where 'h' is the magnitude of sag/swell and 'h' varies from 0 to 1 for sag and 1 to 1.8 for swell</p> <p>$V = \frac{V_L}{\sqrt{3}}$ (phase - ground voltage)</p>

Voltage sags and swells can be either balanced or unbalanced depending on the cause. Type A sag/swell is symmetrical, so it is called balanced sag/swell. Other types of sag/swell are unbalanced.

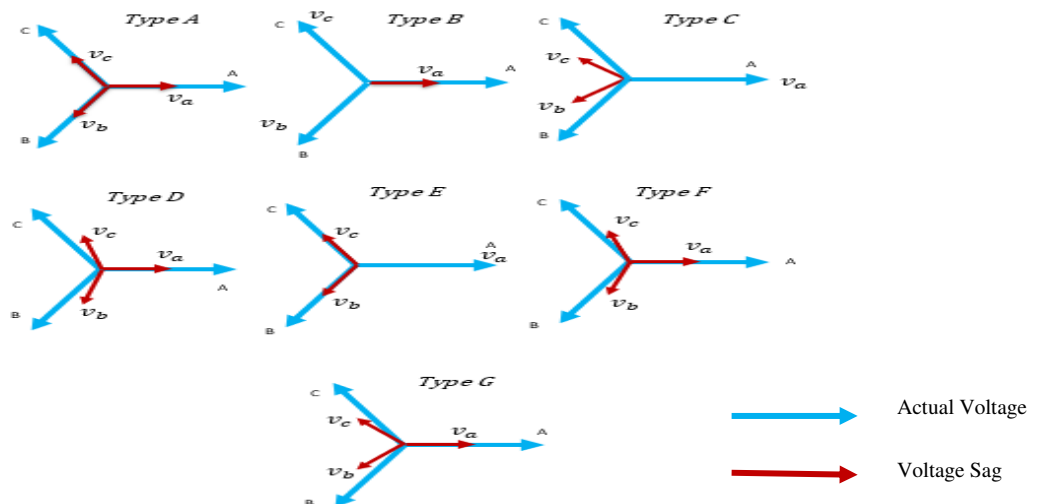


Fig.2. Pictorial representation of all types of sag

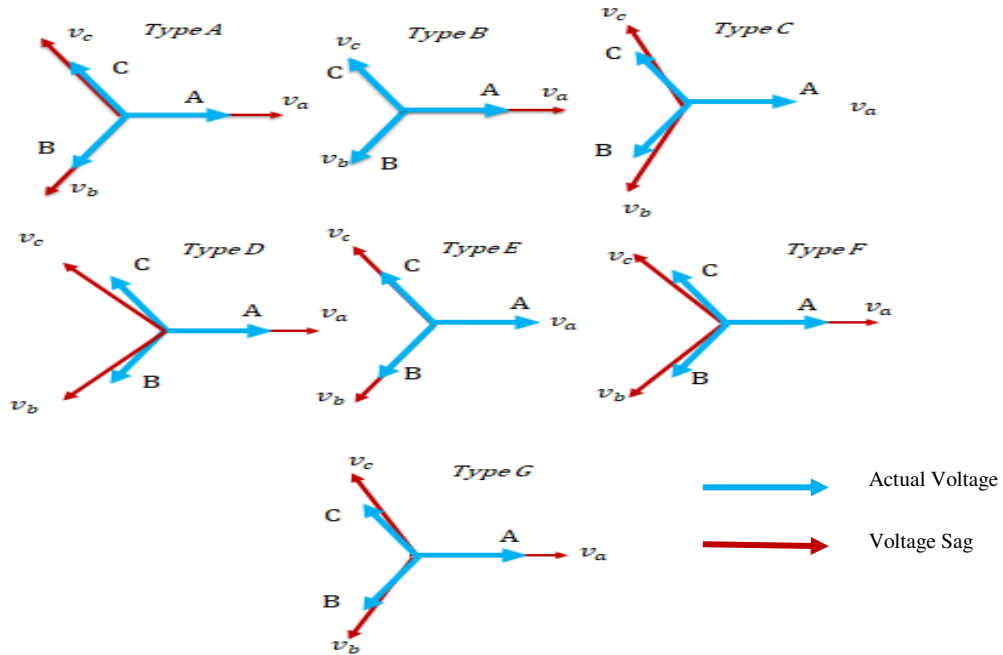


Fig.3. Pictorial representation of all types of swell

The following equation can be used to obtain statistical characteristics for the stator current, including standard deviation, mean, skewness, and kurtosis.

$$\text{Mean } \mu = \frac{1}{N} \sum_{i=1}^N y_i \tag{1}$$

$$\text{Standard deviation } S = \sqrt{\frac{1}{N} \sum_{i=1}^N (y_i - \mu)^2} \tag{2}$$

$$\text{Skewness} = \frac{\sum_{i=1}^N (y_i - \mu)^3 / N}{S^3} \tag{3}$$

$$\text{Kurtosis} = \frac{\sum_{i=1}^N (y_i - \mu)^4 / N}{S^4} - 3 \tag{4}$$

Where N = total number of samples, y_i = sample values of stator current. The feed-forward classifier is trained with statistically derived parameters and the classification result identifies the kind of voltage sag and swell.



III. FEED-FORWARD BACKPROPAGATION NEURAL NETWORK

The final step in the identification of voltage sag and swell is classification of disturbance. A multilayer feed forward neural network is used to execute learning through the back-propagation technique. A collection of weights are learned iteratively to predict the class label of tuples. There are one or more hidden layers, an output layer, and an input layer in a multilayer feed forward neural network. Fig. 4 illustrates the use of a multilayer feed forward neural network. The input/output pair's signal patterns are taught to the feed-forward back-propagation network from the disturbance database. The pattern has types and percentages of sags and swells as outputs, and statistical features as input.

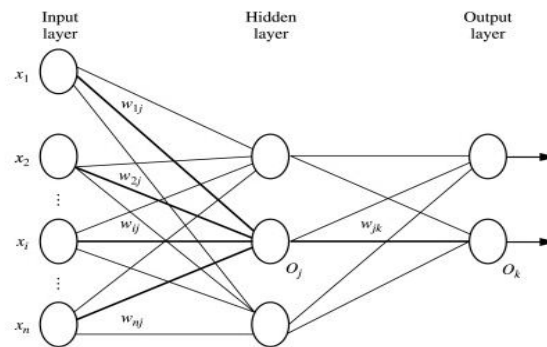


Fig.4. Generalized Architecture of Multilayer feed forward neural network

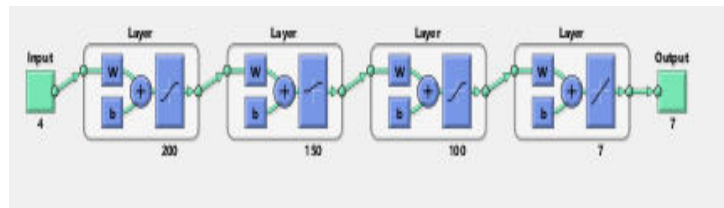


Fig.5. Architectural view of feed forward neural network

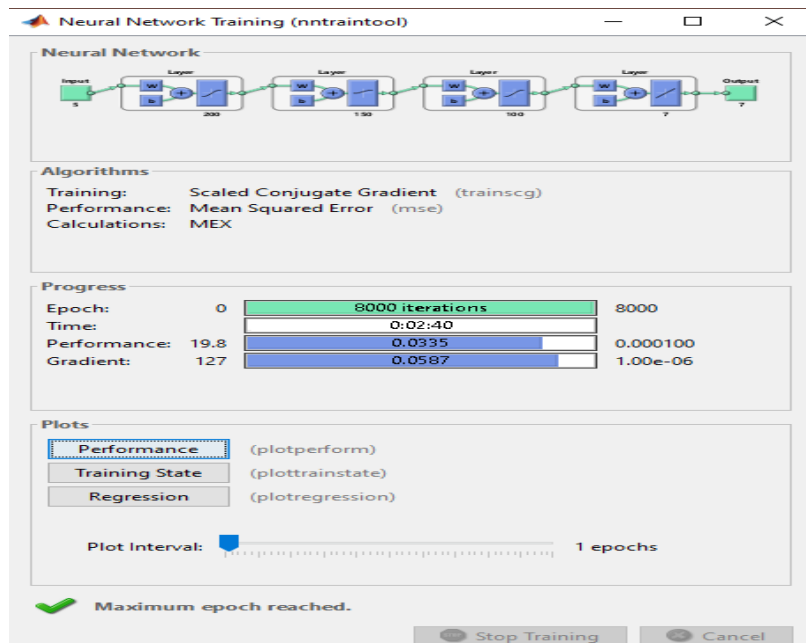


Fig.6. Feed Forward Back Propagation Neural Network Training using statistical feature

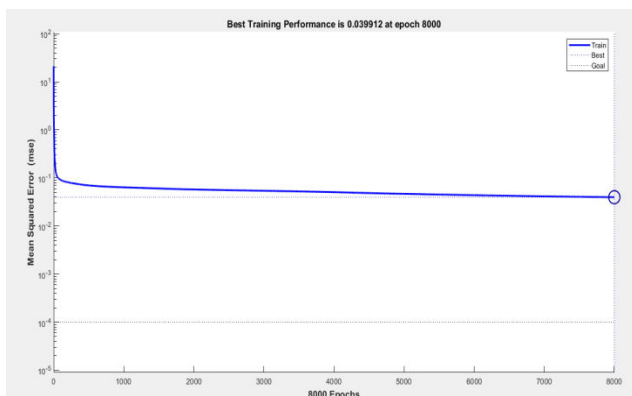


Fig.7. Performance plot of the training data set

IV. PROPOSED METHODOLOGY

The process of feature extraction utilizing statistical methods and using those feature voltage sags and swells are classified as shown in Fig.6's flowchart.

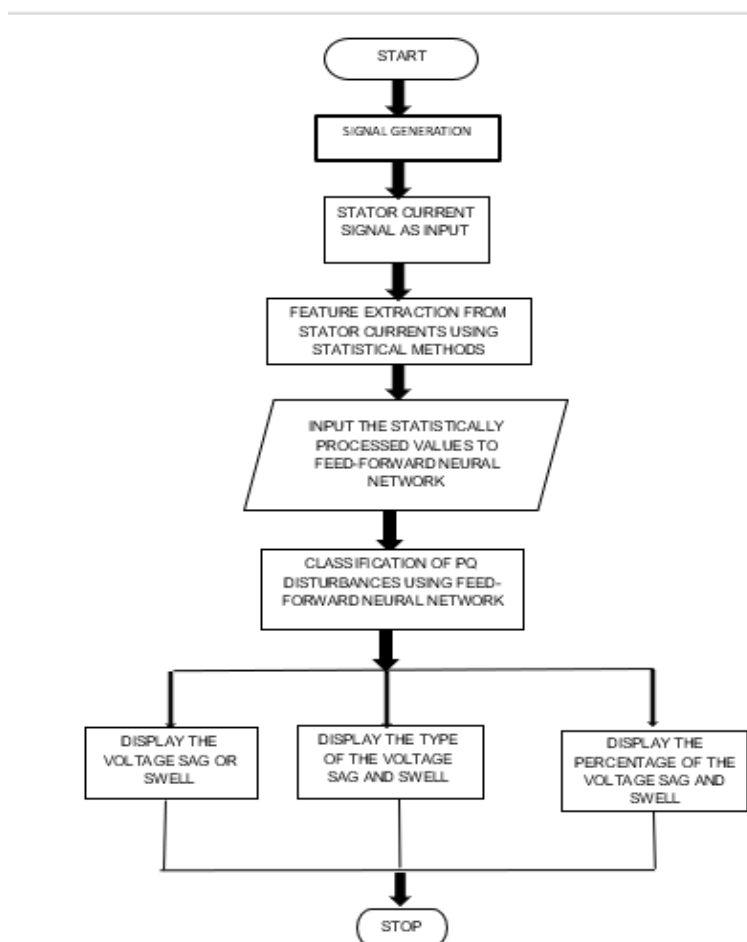


Fig.8. Flow chart of the proposed methodology



V. RESULTS

As shown in the table 2, 406 training data are used to train the Feed – Forward Back Propagation classifier and 105 additional test datasets are used to evaluate the network.

TABLE.2: Classification Result

Types of voltage sag and swell	Trained data	Test data	Total	Accuracy
Type- A	57/58	12/15	69/73	94.52
Type -B	56/58	9/15	65/73	89.04
Type- C	55/58	8/15	63/73	86.3
Type- D	56/58	9/15	65/73	89.04
Type- E	57/58	12/15	69/73	94.52
Type- F	54/58	7/15	61/73	83.56
Type- G	55/58	11/15	66/73	90.04
Grand Total	390/406	68/105	458/511	89.6%

VI. CONCLUSION

This work presents a technique for the automatic classification of PQ disturbances. The PQ disturbance is first identified using statistical techniques and classified using ANN. It is observed that the statistical values alone can be used as an effective variable for the detection and identification of disturbances. A database of 390 signals is generated with different PQ disturbances for training an additional 68 signals is used testing. The overall performance evaluation of the proposed Feed- forward Neural Network is 88%.

REFERENCES

- [1] G. T. Heydt, "Electric Power Quality: A Tutorial Introduction," IEEE Comput. Applicat. Power, vol. II, pp. 15-19, Jan. 1998.
- [2] Heydt, G. T., Fjeld, P. S., Liu, C. c., Pierce, D., Tu, L., & Hensley, G. "Applications of the Windowed FFT to Electric Power Quality Assessment", IEEE Transactions on Power Delivery, 14(4), pp.1411- 1416,1999.
- [3] Huang, S. 1., & Hsieh, C. T, " Feasibility of Fractal Based Methods for Visualization of Power System Disturbances", International Journal of Electrical Power & Energy Systems, 23(1), pp.31-36, 2001.
- [4] Gaouda, A. M., Salama, M. M. A., Sultan, M. R., & Chikhani, A. Y. "Power Quality Detection and Classification using WaveletMultiresolution Signal Decomposition", IEEE Transactions on Power Delivery, 14(4), pp. 1469-1476, 1999.
- [5] Sridhar S., K. U. Rao and S. Jade, "Detection and classification of PQ disturbances in the supply to induction motor using wavelet transform and feedforward neural network," 2015 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT), 2015, pp. 1-5, doi: 10.1109/ICECCT.2015.7225930.
- [6] Sampath Kumar, Sridhar & Rao, U. & Umesh, Raksha & K., Harish. (2016). "Condition Monitoring of Induction Motor using Statistical Processing". 10.1109/TENCON.2016.7848597.
- [7] Dash, P. K., Chilukuri, M. V., & Panigrahi, B. K, "Power Quality Analysis using S-transform", IEEE Transactions on Power Delivery, 18(2),406-411,2003.



- [8] S.Khalid1 & Bharti Dwivedi, “Power quality issues,problems,standards and their effects in industry with corrective means”, International Journal of Advances in Engineering & Technology,Vol.1,Issue 2, May 2011, pp1-11.
- [9] Uday Modha, Preeti Dave, “ Image Inpainting-Automatic Detection and Removal of Text From Images”, International Journal of Engineering Research and Applications (IJERA), ISSN: 2248-9622 Vol. 2, Issue 2, 2012
- [10] Muthukumar S, Dr.Krishnan .N, Pasupathi.P, Deepa. S, “Analysis of Image Inpainting Techniques with Exemplar, Poisson, Successive Elimination and 8 Pixel Neighborhood Methods”, International Journal of Computer Applications (0975 – 8887), Volume 9, No.11, 2010.
- [11] Dongdong Zhang, Tianhao Liu, “Effects of Voltage Sag on the Performance of Induction Motor Based on a New Transient Sequence Component Method”, CES Transaction on Electrical Machines and Systems, VOL. 3, NO. 3, September 2019.
- [12] D.Saxena, K.S. Verma and S.N. Singh "Power quality event classification: an overview and key issues"- International journal of Engineering Science and Technology, Vol.2, No.3, 2010, pp.186-199.
- [13] C. Venkatesh, Swathi Agarwal, Thomas Kappen and D.V.S. S. Siva Sarma, "Wavelet based modular Neural Network for Power Quality Disturbance classification" XXXII National Systems Conference, NSC 2008, December 2008, pp.89-94.
- [14] Subhamita Roy and Sudipta Nath "Classification of Power Quality Disturbances using Features of signals", International Journal of Scientific and Research Publications, Vol 2, Issue 11, November 2012.
- [15] Dr.M. Sushma, Dr G. Tulasi Ram and Dr. A. Jaya Laxmi "Detection of Power Quality Disturbances Using Wavelet Transforms". International Journal of the computer, the Internet and Management, Vol 18, No.1, January- April 2010, pp.61-66.
- [16] P. Hari Ramakrishna, S. Sendilkumar and Joseph Henry "Detection of Power Quality Events Using Wavelet Transform" ISSN-0973-1334, National Journal of Technology, Vol. 10, No.2, June-2014, pp.31-37.
- [17] P. Janik and T. Lobos "Automated classification of Power Quality Disturbances using SVM and RBF Networks", Power delivery, IEEE Transactions, Vol.21, Issue3, July 2006, pp. 1663-1669.



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