Study on Three Phase Power Quality System Events Based on Artificial Neural Network

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Abstract— In this paper one of the very popular soft computing techniques called artificial neural network is employed to diagnose the stator inter turn short-circuit fault in a three phase squirrel cage induction machine. Firstly, a artificial neural network (ANN) has been applied for solving the above fault diagnosis problem. In order to apply multilayer perception artificial neural network for fault diagnosis, an induction machine in the lab is considered. Three phase variable AC voltage is applied to induction machine through a three phase variac and the stator line voltage and stator currents were measured for both healthy and faulted motor. Then an artificial neural network was developed with 3 layers namely input, hidden and output layer with 2 nodes in input and output layer whereas four nodes in the hidden layer. Using the stator line voltage and stator currents, back propagation algorithm is employed to train the said ANN. The root mean square error was plotted and the least value was found to be 0.065. In view of improving the training performance, a radial basis function neural network (RBFNN) with the same configuration as that of back propagation algorithm and the results of both the artificial neural networks based fault diagnosis approaches applied to the induction machine.

Key words: Artificial Neural Network, Three Phase Power Quality

I. Introduction

The Power Quality (PQ) becomes a major concern for recent power industries and research field. These techniques have gained popularity over other conventional techniques. These are easy to apply and modify besides their improved performance. The neural system can represent any non-direct model without having the points of interest of the genuine structure and can give bring about a brief while. Due to the use of automated control equipments in industry, it becomes necessary for a power engineer continuous monitoring of the power signal increased and continuous control of power system equipment is required. The power quality (PQ) includes disturbances both of current and voltage like voltage swell, sags, harmonics, and oscillatory transients which cause malfunction of power equipment. Hence Power quality may be defined as "nonstop deviation of voltage, current and/or frequency in time". For smooth operation of power system, the proper maintenance of equipment as well as good power quality is required. The main cause of PQ disturbance is the power-line disturbances. The PQ disturbance leads to decrease in life span, permanent failure electrical equipment. PQ has direct economic impacts on many industrial consumers. A lot of emphasis has been given on revitalizing industry with lots of automation and modern engineering equipment. The power quality events monitoring requires signal processing technique and artificial intelligence techniques are used to examine detection, compression, and classifications of power quality disturbances. These techniques are typically applied to the spectral analysis of monitoring signals, in estimation of power quality indices.

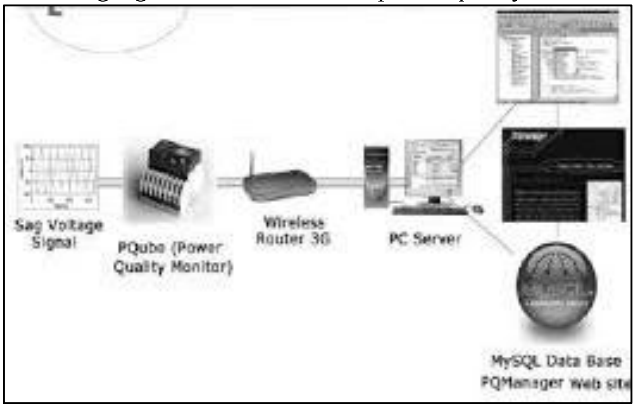

Fig. 1: The power quality processing

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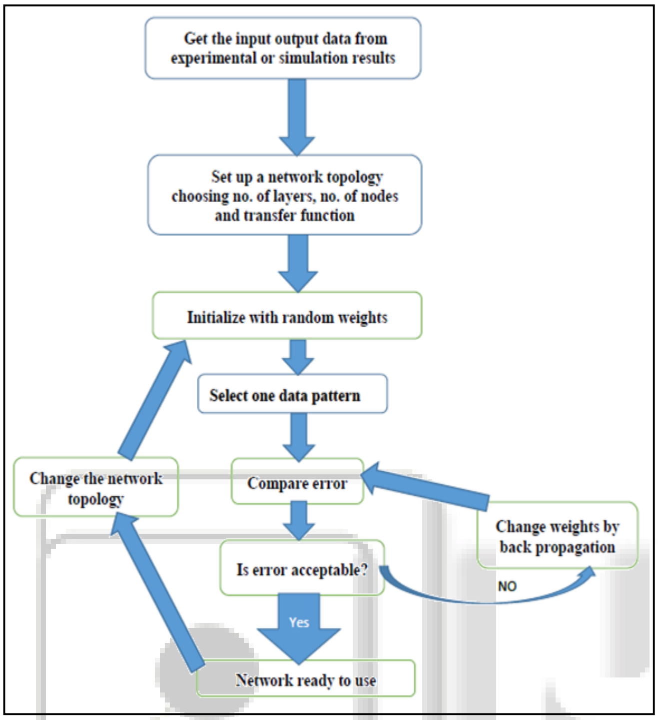
- Use of semiconductor devices
- Nonlinear loads
- Lighting controls
- Capacitor switching
- Industrial plant loads for three phase rectifiers and Circuit

II. Processing Techniques in Three Phase Circuit

Processing Techniques in Three Phase Circuit, nowadays MATLAB is a very powerful simulation software and is widely used in engineering, research and educational purposes. Doing real-time simulation in MATLAB requires better programming knowledge in Three Phase Circuit. The real time simulation in MATLAB gives better understanding of our system. The real time simulation can be done in two ways in Three Phase Circuit in a artificial neural network (ANN). One way is through programming in MATLAB editor and the other way is through MATLAB. In this project this is accomplished by normal programming. However offline simulation of Circuit is done in Simulink and the model, results are discussed in Appendix. First of all, in order to do real time simulation one needs a real timer in the real time simulator hardware. In conventional PC there is inbuilt timer so there is no need to worry about it. There is need to have some idea about MATLAB timer programming for MATLAB simulation in Three Phase Circuit. We need to take into consideration the processor clock speed. For that one can use the command "cputime" in MATLAB for artificial neural network (ANN). In generating an empty loop one has to keep reading the stopwatch time and when it reaches the wait time, get out of the loop by using the "break" function. By this way one can get accurate time interval in the order of micro seconds.



Block diagram of Real time simulation using MATLAB

A. Three Phase Circuit:

Three phase Circuit are generally used for high power applications. Three single phase half bridge Circuit are to be connected in parallel to form a three phase inverter.

The inverter is fed by a fixed dc voltage and has three phase-legs each comprising two transistors and two diodes. With SPWM control, the controllable switches of the inverter are controlled by comparison ofa sinusoidal control signal and a triangular switching signal. The sinusoidal control waveform determines the desired fundamental frequency of the inverter output, while the triangular waveform decides the switching frequency of the inverter. The ratio of the frequencies of the triangle wave to the sinusoid is referred to as the modulation frequency ratio.

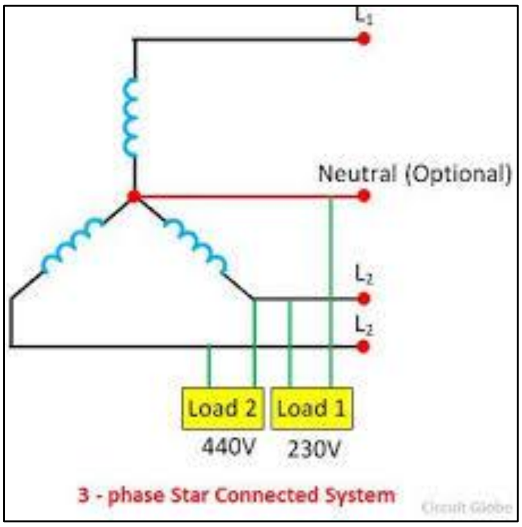


Fig. 2: 3- Phase Connection System

A. 180^0 mode of operation:

Each transistor conducts for a period of 180^0. Three of the transistors remain on at any instant of time. When Ta+ is switched on, terminal a is connected to positive terminal of dc input voltage. When Ta- is switched on, terminal a is brought to negative terminal of dc input. There are six modes of operation in a cycle and duration of each mode is 60^0.

The load can be connected in either Y or Δ. Switches of any leg of the inverter cannot be switched on at the same time since this would result in a short circuit across the dc link voltage supply. Similarly to avoid undefined states and thus undefined ac output line voltage, the switches of any leg of the inverter may not be switched off simultaneously since this can result in voltages that depend on respective line current polarity

III. ACTIVE ALL PASS FILTER FOR PHASE SHIFTING:

The type of filter that doesn't affect the amplitude and shifts the phase of any signal is known as all pass filter. The main purpose of this filter is to add phase shift to the response of the circuit. The amplitude of an all pass filter is same for all frequencies. There are two kinds of filter first order and second order all pass filter. The transfer function of the first order all pass filter active filter will be in the form of:

$$T(s) = (s - a) / (s + a)$$

The pole of this transfer function is located in the left half plane and the zero in the right half plane at equal distance from the origin on real axis. The magnitude of the numerator is identical with the magnitude of the denominator and $|T(j\omega)| = 1$ for all ω. the circuit having this characteristics is known as all pass filter (APF). The APF circuit is shown in Fig. (2) & (3) using operational amplifier can be used to obtain specified phase shift at one frequency without changing the magnitude of T (jω), even if frequency changes.

IV. SUMMATION CIRCUIT FOR OBTAINING SEQUENCE COMPONENTS OF VOLTAGES:

Using the phase shifting circuits a phase shift of 120^0 or 240^0 can be obtained for Voltages V_b and V_c .In order to extract the sequence components we have to sum up V_a , V_b and V_c according to the following formulas:

$$V_{a0} = \frac{1}{3}(V_a + V_b + V_c)$$
$$V_{b0} = \frac{1}{3}(V_a + aV_b + a^2 V_c)$$
$$V_{c0} = \frac{1}{3}(V_a + a^2V_b + a V_c)$$

V. Artificial Nural Network (ANN)

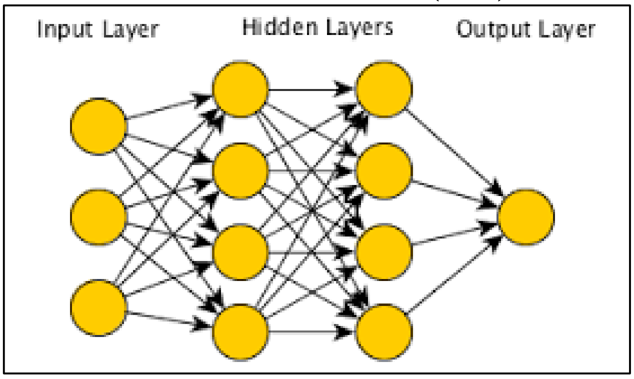


Fig. 3: Different Layers of ANN

A. Standard deviation

The standard deviation gives information about multi resolution analysis of each level IMFs. A standard Deviation is always a positive quantity. In order to extract features of power system Signals, the standard deviation of power quality problem Signals is subtracted from the standard deviation of pure Sinusoidal waveform.

For non-stationary frequency data, standard deviation can be given as:

$$\text{Standard Deviation} = \sqrt{\frac{\sum_{i=1}^{N}(\text{Xi}-\bar{\text{X}})}{N}}$$

Where, X_i are non-distributed frequency data $\bar{X}$ is the mean of data and N is number of data.

B. Energy of the signal

The energy of a signal is calculated using parse Val's theorem which states that if *v (t)* is the voltage across the resistor or current through the resistor then the energy dissipated is Energy value of frequency of signal is given as:

$$\text{Energy} = \text{norm (IF)}^2$$

C. Entropy of the signal.

The feature entropy of a signal is helpful to represent the characteristics of the signal and measure the uncertainty of information and events. HHT entropy is used for the analysis of power quality disturbances.

The Shannon entropy of a discrete random variable X and probability distribution P is given as:

$$H(X) = -\sum_{i=1}^{N} P\, P_i \log(P_i)$$

Where, P_i is the probability of the system.

D. Power Quality events classification using BPA in multilayer feed-artificial neural network

Neural Networks (NN) are one of the most widely adoptable data mining techniques used for classification and clustering. In this work most simple and popular NN has been used known as Back Propagation (BP) Algorithm. The BP algorithm is very simple and output of NN is evaluated against desired output. If error results are not satisfactory, connection weights between layers are modified and process is repeated again and again until error is small enough.

Back Propagation algorithm is a feed artificial neural network. ANN divided the BP algorithm into to four steps. First of all the weights matrix of the network is chosen randomly, the back propagation algorithm is used to compute the necessary corrections.

V. Algorithm (Multilayer Feed-Artificial Neural Network)

1) *Step1. The feature vector obtained from extraction process are first normalized and*
2) then selected as input to the model.
3) *Step2. Each decomposed signals are allowed to pass neural network model. Random weigh is taken between hidden to output layer and input to output layer for Initialization of neural network model.*
4) *Step3. For training purpose, 25 samples from each signals has been selected, so that*
5) *total of 5*25= 125 samples of data from five signals is collected for training.*
6) *Step4. Output obtained from the input node is directly feed to the hidden layer and output obtained from hidden layer and output of output layers are evaluated by using sigmoid activation function.*
7) *Step5. This process continues from Step1 to step4 till convergence occurs.*
8) *Step6. After convergence the weights obtained are considered as the final weight and are collected in a data sheet.*
9) *Step7. For testing the network model 50-60 feature vector samples are given as input to NN model. The output is used for calculation of classification accuracy.*

VI. Conclusion

A new approach to detect the fault in three phase circuit has been presented in this paper. The total processes involved are highly concentrated on "Symmetrical Component Theory". In case of simulation work using Multisim voltage is sensed. So the symmetrical voltage components are calculated using various electrical components present in the library of Multisim. Basic requirement for calculation of symmetrical component requires phase shifting of faulty voltages/current. The operational amplifier as all pass filters is used to shift the voltages by 120^0 or 240^0. Again the op-amp as summer gave the symmetrical voltage components. We are concentrated only on the magnitude of symmetrical components, the output of summer circuit passed through a filter circuit. The Power quality monitoring is an important issue before mitigation because types of disturbance and fault localization must be known in order to take any corrective measure. Therefore PQD Detection and classification is the very important aspect for power quality. In this thesis, six different types of PQ disturbances which includes compound disturbances such as swells with harmonic and sags with harmonic for the categorization purpose. At the First phase, these PQ disturbances are decomposed using EMD algorithm and for plotting Time-frequency plot and instantaneous frequency and amplitude vs. time plot. By using, Time-frequency domain approach, PQ signals are investigated at different frequency resolution levels. Different features like standard deviation, entropy, energy of the PQ events are obtained from

EMD technique. A data sheet is prepared from these for further classification purpose of the PQ disturbances with various magnitudes. The classification is obtained through a suitable and simple neural network known as Multilayer Feed Artificial Neural Network (MFNN).

REFERENCES

[1] Oyedoja, kayode, Obiyemi, Obiseye, Wavelet transform in the detection of electrical power quality disturbances". April 2013. Vol. 3, No. 2, 2012.
[2] Lin, C.-H. Tsao, M.-C. "Power quality detection with classification enhancible wavelet probabilistic network in a power system" Generation, Transmission and Distribution, *IEEE Proceedings*- 4 Volume: 152, Issue: 6 On pages: 969 – 976.
[3] R. A. Flores, "State of the art in the classification of power quality events, an overview," in *Proc. 10th Int. Conf. Harmonics Quality of Power"*, 2002, vol. 1, pp. 17–20.
[4] L. Satish, "Short-time Fourier and wavelet transforms for fault detection in power transformers during impulse tests", Proceedings of the Institute of Electrical Engineering–Science.
[5] I. W. C Lee and P. K Dash, "S-transform based intelligent system for classification of power quality disturbance signals," *IEEE Trans. Ind. Electron.*, vol. 50, no. 4, pp. 800–805, Aug. 2003.
[6] P. K. Dash, B. K. Panigrahi, and G. Panda, IEEE member "Power Quality Analysis Using S–Transform", IEEE Transactions on Volume:18 , Issue: 2 ,April 2003.
[7] R. Sedaghati, N.M Afroozi, Yaser Nemati, Ahmad Rohani, Ali Reza Toorani," A Survey of Voltage Sags and Voltage Swells Phenomena in Power Quality Problems".
[8] M. A. S. Masoum, S. Jamali, and N. Ghaffarzadeh, "Detection and classification of power quality disturbances using discrete wavelet transform and wavelet networks," *IET Sci., Meas. Technol.*,vol. 4, no. 4, pp. 193–205, Jul. 2010.
[9] Y. H. Gu and M. H. J. Bollen, "Time-frequency and time-scale domain analysis of voltage disturbances," *IEEE Trans. Power Del.*, vol. 15, no. 4, pp. 1279–1284, Oct. 2000.
[10] N. E. Huang and z. Shen, "the empirical mode decomposition and the Hilbert spectrum for non-linear and non-stationary time series analysis," roy. Soc. Lond., vol. 454, no. 1971, pp. 903–995, mar. 1998.
[11] B. Biswal, P. K. Dash, and B. K. Panigrahi, "Power quality disturbance classification using fuzzy C-means algorithm and adaptive particle swarm optimization," *IEEE Trans. Ind. Electron.*, vol. 56, no. 1, pp. 212–220, Jan. 2009.
[12] S. Shukla, S. Mishra, and B. Singh, "Empirical-mode decomposition with Hilbert transform for power-quality assessment," *IEEE Trans. Power Del.*, vol. 24, no. 4, pp. 2159–2165, Oct. 2009.
[13] B. Biswal, *Member, IEEE*, M. Biswal, *Member, IEEE*, S. Mishra, *Senior Member, IEEE*, and R. Jalaja "Automatic Classification of Power Quality Events Using Balanced Neural Tree", IEEE transactions on industrial electronics, vol. 61, no. 1, January 2014.
[14] Norman C. F. Tse, *Member, IEEE*, John Y. C. Chan, *Student Member, IEEE*, Wing-Hong Lau, *Senior Member, IEEE*, and LoiLeiLai, Fellow, *IEEE*, "Hybrid Wavelet and Hilbert Transform With Frequency-Shifting Decomposition for Power Quality Analysis".

