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Analysis of Power Harmonics Using Artificial Neural Network

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ABSTRACT: The term harmonics is becoming very common in small medium or largepower system. The increasing application of power electronics facilities in the industrial environment has led to serious concern about source line pollution and the resulting impact on the system equipment and the power distribution system. Fortunately harmonics in a strict case are not transient phenomena. Their presence can be easily measured and identified. Harmonic distortion analysis, which is necessary in order to improve the quality of power distribution, is traditionally achieved using Fast Fourier Transform (FFT). FFT procedure is however susceptible to the presence of noise and sub harmonic in the distorted signal. Here we present the novel technique, based on neural network for analysis of power harmonics and its mitigation methods.

KEYWORDS: Harmonics, transient, artificial neural network and Fourier transform,

I. HARMONIC CAUSE AND EFFECT

Harmonics are current and voltages with frequencies that are integral multiple of fundamental power frequency being 50 or 60. For example, if the fundamental power frequency is 50Hz, then the second harmonic is 100Hz; the third harmonic is 150Hz, etc. In modern test equipment today harmonic can be measured up to 63rd harmonic. Harmonic frequency from 3rd to the 25this the most common range of frequency measured in electrical distribution system.

Harmonics are caused by and are the by-product of modern electric equipment such as personal computers, TVs, adjustable speed drive and variable frequency drives. SMPs equipment typically forms a large portion of electrical non-linear load is most electrical distribution system. Due to these undesired higher frequencies term in transformer the hysteresis loss increases due to voltage harmonic, copper loss and eddy current loss increases. In AC motor the torsional oscillation (twisting of motor shaft) occurs.
Corresponding function F (w) in the frequency domain. The F (w) and f (t) are given by:

$$F(\omega) = \int_{-\infty}^{\infty} f(t)e^{-i\omega t}dt$$

$$f(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} F(\omega)e^{i\omega t}d\omega$$

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II.HARMONIC ANALYSIS

Elimination and minimisation distortion is necessary for the identification of harmonics components and also for the determination of the magnitude and phase angle. Fourier transform is the traditional yet more precise method of determining harmonic components of any repetitive distorted waveform. For speedy computation Fast Fourier Transform (FFT) can also be used. However, the Fourier transform is affected by the presence of noise in the signal and hence signal is generally filtered before FFT application. Although high frequency noise can be eliminated through low pass filtering before applying Fourier transform it is still troublesome to eliminate possible sub-harmonics that exist in the distorted waveform.

III.NEURAL NETWORK SOLUTION

Neural network gives an alternative but approximate method based on neural networks to determine the Fourier coefficients even in the presence of noise or sub harmonics. Artificial neural network is characterised by ability to learn or modify its behaviour in the response to the environment. The conversion of time domain variables into frequency domain complex Fourier coefficients is affected through weight matrix in the ANN.A single hidden layer back propagation is used for this application because of its non-linear learning capability and simplicity.

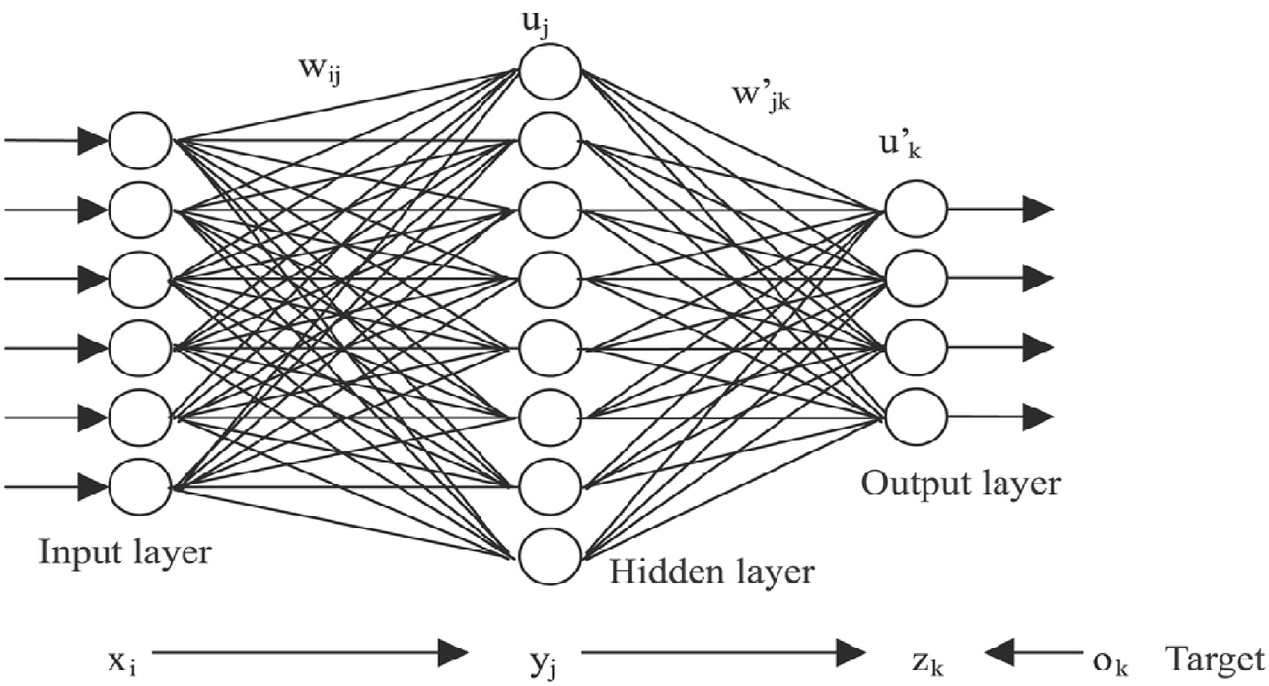

Fig.1 Model of single hidden layer back-propagation network

In Fig1 the back propagation model is shown. The hidden layer is visible in the diagram which increases the accuracy of the result.

Artificial neural network (ANN) is an information-processing paradigm that is inspired by the way biological nervous system, such as brain process information. It is composed of highly interconnected processing element (neuron) working in parallel to solve specific problem. Each neuron can influence others through this connection. Among the various architectures most widely used is the feed forward back propagation type model which is selected for this study. Each unit or neuron process all the inputs and send its output to the next unit connected.

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IV.THEORATICAL BACKGROUND

On the basis of Fourier transform theory any continuous repetitive function in an interval T can be represented by the summation of a fundamental sinusoidal component with a series of higher order components of frequencies which are integer multiples of fundamental frequency.

Harmonic analysis is the process of calculating the magnitude and phases of the fundamental and higher order harmonics of the distorted but periodic waveform.

V. ANN HARMONIC ANALYSIS NETWORK

ANN harmonic analysis network proposed on the back propagation network, as multilayer feed forward network is proposed in this paper the network can be better measuring result and precision its configuration.
Training the ANN model is as follows:
Step 1: select the initial weight value.
Step 2: select the input and target value.
Step 3: use the feed forward calculation and get the actual output.

$$3(k) = \int \left(\sum W_{kj} f\left(W_{ji} X_i + Q_j^2\right) + Q_k^3\right)$$

Step 4: calculate the error E of each layer neuron and the change of weights.

$$E^3 = O_3(k)\,((k) - O_3(k))\,(1 - O_3(k))$$

$$E_J^{\,2} = O_2(J)\,(1 - O_2(J)) \sum E_K^{\,3} W_{JK}^{\,3}$$

Step 5: Modify weight and threshold start from the output layer, make the error signal transmit on inverse direction; reduce the error by amending the weights.

$$W_{jk}^3(n+1) = Q_K^3(n) + uEj^2$$

Step 6: Return to step 2, go on the train until the error precision achieved.
The performance function which used to modify weight and threshold is defined as follow

$$B = \frac{1}{2}\sum (t_k - y_k)^2$$

Where,

W is weight Q is threshold
U is step size of learning
I is the number of input layer neuron
J is the number of hidden layer neuron
K is the output neurons

VI. RESULT

In this paper, widely used ANN-based control strategy is the feed-forward ANN is investigated .Artificial Neural Network (ANN) is characterized by the ability to learn and modify its behaviour in the response to the environment. A simple step-by-step procedure is provided to implement method in MATLAB environment. The Artificial Neural Network (ANN) is trained offline using back-propagation algorithm. The performance is evaluated through detailed simulation and experimental studies. Artificial Neural Network (ANN) provides more efficient result than conventional method Fast Fourier Transform (FFT) in presence of noise and sub-harmonics.

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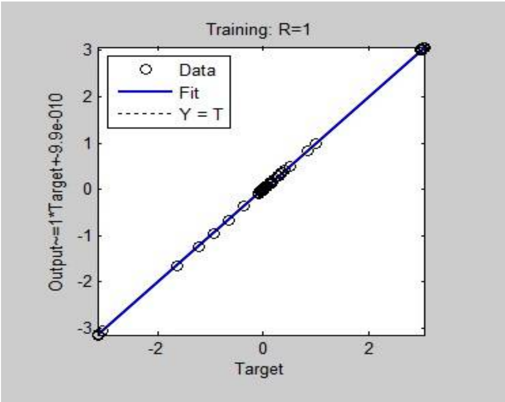

Fig.2 Training of ANN

The above Fig.2 represent the training of ANN blue line shows that the ANN is fit and data is correct.

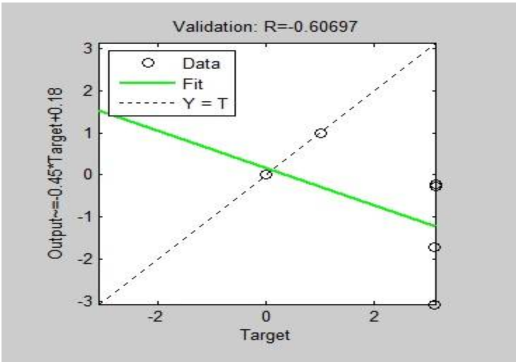

Fig.3 Validation of ANN

The above Fig.3 represent the validation of ANN.

The below Fig.4 represent the testing of ANN and the result shows that ANN is correctly Trained.

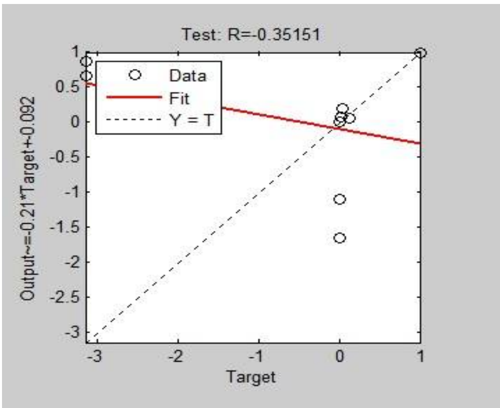

Fig.4 Testing of ANN

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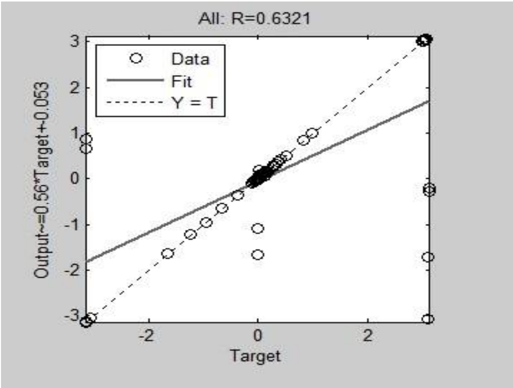

Fig.5 Overall regression

The Fig.5 represent the overall regression plot which is totally optimised to give good results.

Therefore, we use single hidden layer back propagation model for this application because of its nonlinear capability and simplicity. Multisim is used to get frequency values from electronic loads and these values are converted to time domain through MATLAB. These values are used to train the Artificial Neural Network (ANN) .Now this trained ANN is used to get the frequency directly. Here, we have completely analysed that the harmonics plot which we have plot through data that we have got through training the ANN is comparable to the original data with marginal error. Hence, the harmonics in the power system is analysed and for reduction of this harmonics a low pass passive filter is used.

VII. CONCLUSION

Hence by using ANN we analyse the harmonics present in the supply by first training the ANN through practical values of frequency and after that using this trained ANN we can identify the harmonics components easily. ANN works better in sub noise conditions thus is more efficient way of obtaining harmonics than through FFT. After identification of harmonics we use low pass filter with appropriate band frequency to eliminate the harmonics. This method can be used in industrial environment to reduce the impact of harmonics on system equipment's and power distribution equipment.

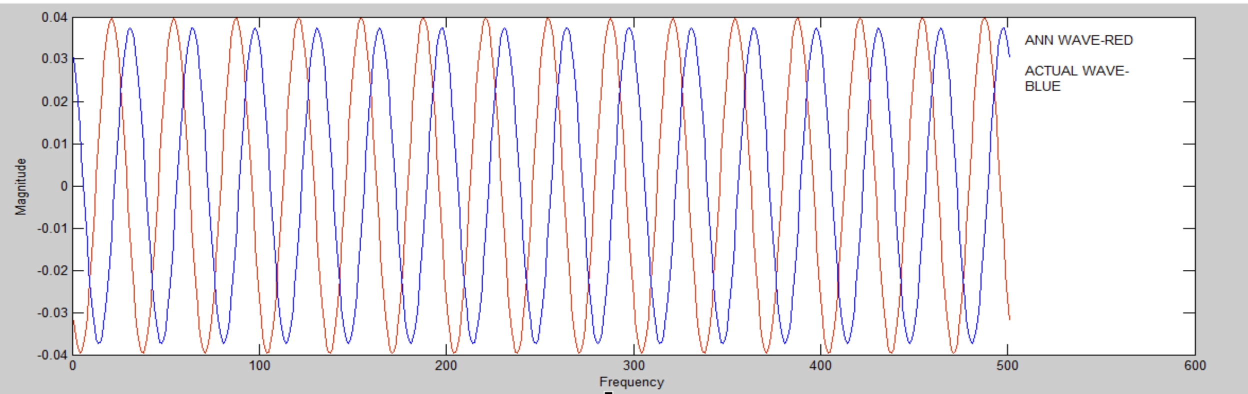

Fig.6 Comparison of 3rd Harmonics

In above Figure.6it represents the comparison of 3rd harmonics between actual wave obtained by Fourier analysis(Blue coloured waveform) and the waveform generated by the ANNanalysis(Red coloured waveform),it is also clear from the

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figure that the magnitude of both waveforms calculated from fourier analysis and ANN analysis is same due to less noise.

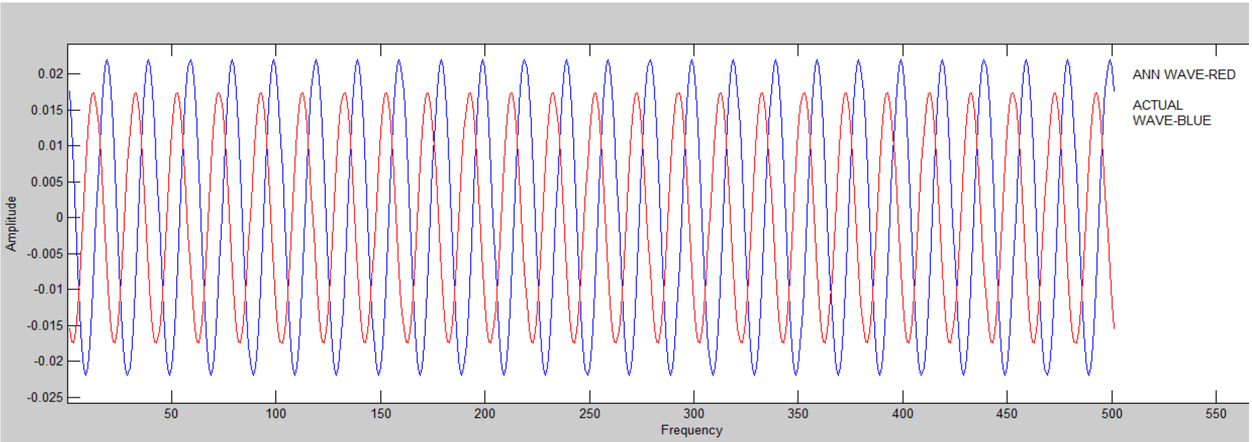

Fig.7 Comparison of 5th Harmonics

In above Figure.7 the magnitude of waveform calculated from Fourier analysis (Blue coloured waveform) is higher than the magnitude of wave calculated from ANN (Red coloured waveform) because incase of Fourier analysis noise is present whereas, in case of ANN noise is suppressed.

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