Performance Analysis of NEURO-FUZZY based Power Conditioner

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***Abstract*— This paper presents Neuro-Fuzzy logic based Power Conditioner for elimination of current harmonic. In it neuro-fuzzy based technique is used for generating compensating current to eliminate/reduce the harmonics content which is generated by the system. The modelling of Fuzzy rule base on Neural Network is also mention in this paper. FFT analysis also has been done for the calculation of Total Harmonic Distortion (THD) of before compensation and after compensation of current signal. The complete model is prepared and tested on MATLAB/SIMULINK to validate this theory.**

Keyword- Current harmonic elimination, Neuro-Fuzzy, Power Conditioner, Power quality improvement, THD

I. Introduction

Being closely involved in the task of supplying electric power, the problem of harmonics leading to loss of power quality and distortion of sinusoidal waveform , has been observed as a serious challenge to a power system engineer. The root of problem lies in increasing trend of loads which is non-linear in nature. The choice of consumer for non-linear loads is growing exponentially, because the consumer wants to avail uninterrupted power supply on one hand and the use of equipments which involve rectifiers, televisions, computers, traction motors, heating and welding components etc.. These power electronic devices produce harmonics in the system. These harmonics are directly injected in the power system network and create very sever problem in it i.e. Transformer saturation [1][2], Mains voltage flickering, Incorrect operation of voltage sensitive devices[3], Malfunction of protective relaying systems, Audible noise in power system components, Electromagnetic interference, Shorter life of organic insulation etc.[4]. A number of techniques are used to elimination/reduction of harmonics in supply system i.e. Instantaneous reactive power theory [5], generalize IRP theory [6][7], Synchronous double reference frame[8], artificial intelligence based technique etc. [9][10][11][12]. Most of them are complicated and hard to implementation.

In this paper neuro-fuzzy based Power conditioner proposed for conditioning of current. The Modelling of Fuzzy rule base on Neural Network logic technique is also mention hear for the generation of compensating current.

II. Proposed POWER CONDITIONER FOR HARMONIC ELIMINATION

The general block diagram to represent the idea of proposed system for harmonic elimination has been shown in Fig.1. Neural Networks, which act as a true replica of human brain has been used as a source to derive the Non-fundamental part contained by the A.C. load current. The negative Non-fundamental part is inverted and then mixed with the corrupted signal. This leads to the recovery of an approximate sinusoidal wave shape. In order to be more closer to the sinusoidal shape the approximate sinusoidal wave is passed through neural fuzzy inference system.

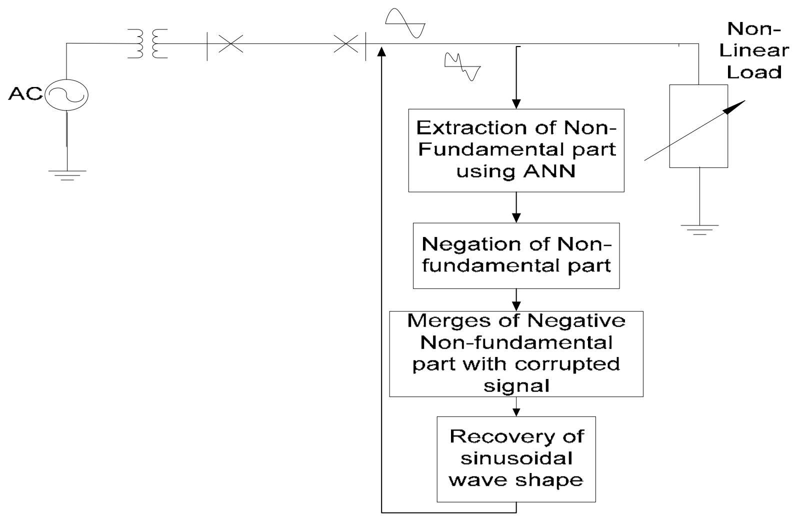


Fig. 1 Block Diagram of the Proposed Power Conditioner

A. Modelling of Fuzzy rule base on Neural Network:

Based on the understanding of the present problem, it is required to obtain the peak value of the signal for known r.m.s values of the approximate sinusoidal waves as received form ANN. The r.m.s. value of the ANN response is classified in Low, Medium and High classes. It is aimed to obtain the peak value and the r.m.s. value of the ANN response and to regenerate equivalent sinusoidal wave using the peak value as obtained by Neural-Fuzzy Inference System. For this purpose the following Fuzzy rule base is suggested.

IF **R** is Low THEN **P** is MIN.

IF **R** is Medium THEN **P** is AVG.

IF **R** is High THEN **P** is MAX.

These rules have been modeled on Neural-Fuzzy Inference Sytem. The block diagram for the same is given in Fig. 2.

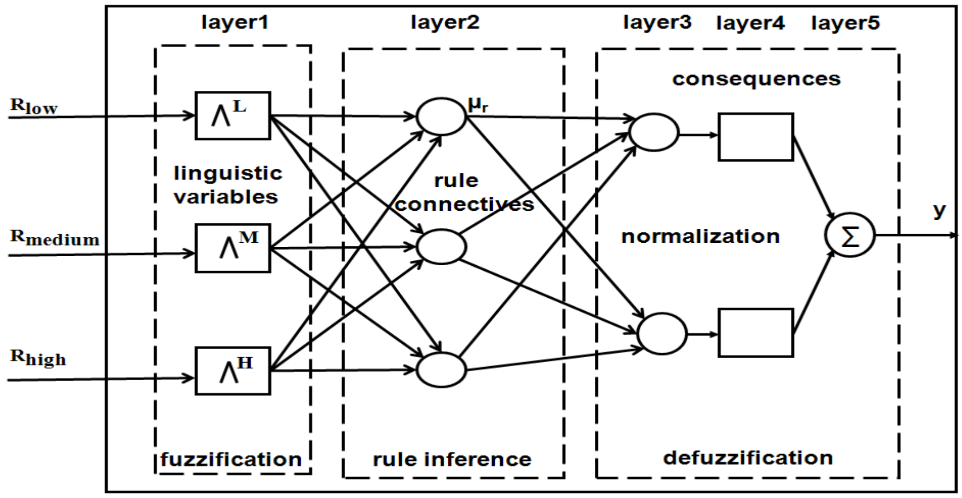


Fig. 2. Neural-Fuzzy Inference System

ANFIS can be used as adaptive filter for noise cancellation and therefore can be used for generation of reference current in active power conditioner in which the job of ANFIS will be to remove the fundamental component of the distorted waveform. At the first input port of ANFIS distorted signal of voltage/current is applied and at the second port also distorted signal is applied but delayed by one sample. There are four steps required for using ANFIS for generation of reference current in simulink.

Step-1: Creation of Fuzzy Inference System (FIS)

Step-2: Training of ANFIS

Step-3: Testing of training

Step-4: Transferring ANFIS in simulink

Step-1:Creation of Fuzzy Inference System(FIS)

The FIS can be created by the command;

in_fismat = genfis1(data,numMFs,inmftype,outmftype)

genfis1 generates a Sugeno-type FIS structure used as initial conditions (initialization of the membership function parameters) for ANFIS training. The arguments for genfis1 are as follows:

- *data*: Data is the training data matrix in which the last column represents the single output/target.
- *numMFs:* It is is a vector whose coordinates specify the number of membership functions associated with each input .Here we used three member functions.
- *inmftype:* It is a string array in which each row specifies the membership function type associated with each input. This can be a one-dimensional single string if the type of membership functions associated with each input is the same. Type member function used is triangular member function.
- *outmftype:* outmftype is a string that specifies the membership function type associated with the output. There can only be one output, because this is a Sugeno-type system. The output membership function type must be either linear or constant. The number of membership functions associated with the output is the same as the number of rules generated by genfis1.outmftype used is linear.

Step-2: Training of ANFIS

The training of ANFIS is done by the following command

[out_fismat, error, stepsize] = ...

anfis(data, in_fismat, [epoch_n nan ss], [1,1,1,1]);

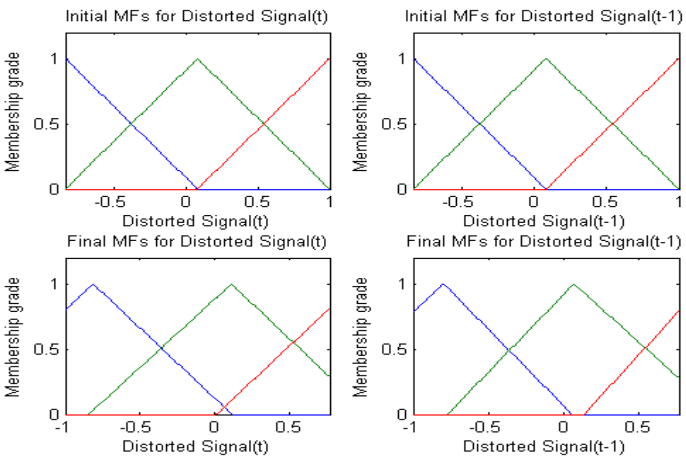
where

- *out_fismat* is out put FIS after training
- *error* is output error after training
- *stepsize* is size step after training of ANFIS
- *epoch_n* is No. of maximum epochs for training of ANFIS
- *ss* is intitial stepsize

Rest all parameters of function ANFIS are default parameters.

The training is stopped when either error is within limit or maximum No. of epochs have reached.

The training of ANFIS has been carried in two ways. First the input to ANFIS were hundreds of distorted signal and in second case these distorted signal were applied to FTDNN and outputs of FTDNN were applied to ANFIS so that when both FTDNN and ANFIS are used in cascaded mode the output is within acceptable limits. The shape of member ship function changes during training and adopt the shape towards best shape as shown below for general bell and triangular member ship function because the training was carried out with triangular member ship function and repeated with general bell membership functions as shown in Fig.3



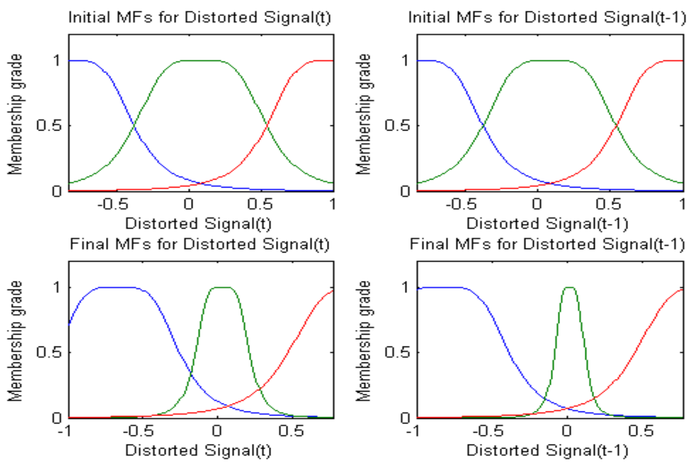


Fig. 3. Training of FIS which Adapts Bell-shaped Function from Triangular Function

The shapes of member ship function changes during training and final shapes when FTDNN and ANFIS are used in cascaded connection as shown in Fig.4.

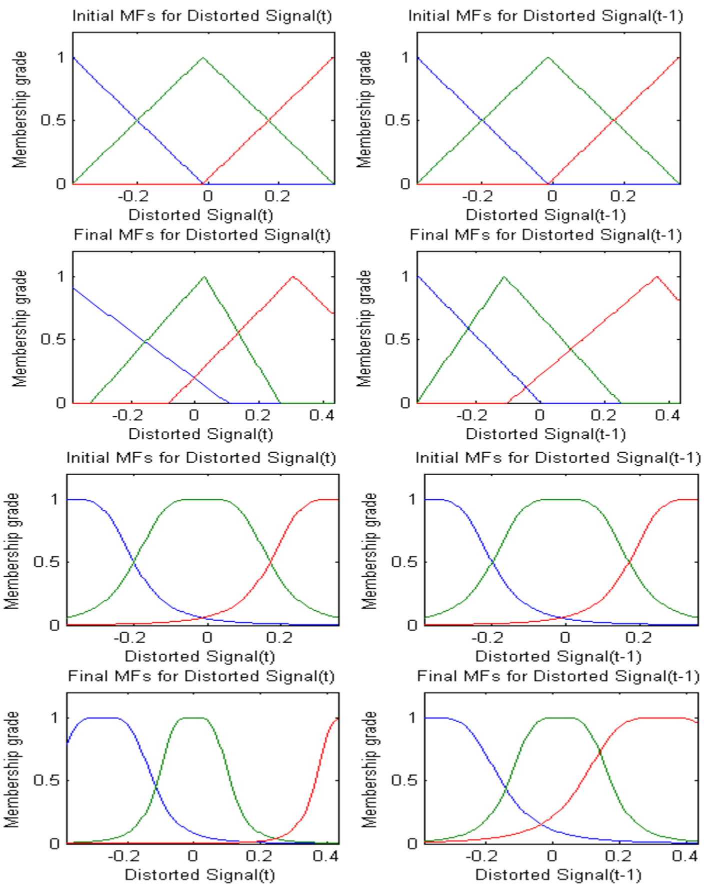


Fig. 4. Changes in Membership Function when FTDNN & ANFIS are Cascaded

Step-3: Testing of training

The testing of training is done with following command

output= evalfis(input,in_fismat)

Where

output is output of ANFIS corresponding to input data

input is input data matrix without target

Step-4: Transferring ANFIS in simulink

There is no direct command for using ANFIS in simulink (Refer Fig.5.7) and the ANFIS is transferred to simulink for Neuro-Fuzzy Power Conditioner through user defined blocks using level 2 s-functions (Refer

Fig.3.). The developed power conditioner is tested for varying load conditions on the simulink as shown in Fig.4. in the preceding section. The load conditions refer to varying degree of non linearity's introduced by the non linear loads.

III. SIMULATION OF NEURO FUZZY POWER CONDITIONER

In order to obtain the acceptable level of sinusoidal wave shape for injection at the load end, the soft computing techniques have been used in this section. The (-) Non fundamental is merged in to the corrupted signal and the resultant of the two, which is an approximate sinusoidal wave, is later processed through neural-fuzzy inference system leading to an acceptable level of sinusoidal wave. The sinusoidal wave so derived is injected at load end. Since the process is continuous load end is always maintained at sinusoidal shape of voltage. It therefore marks the improvement in power quality based on elimination of harmonics. The developed device is thus known as Neuro-Fuzzy power conditioner. The simulated model of power conditioner based on neuro-fuzzy system is shown in fig.5. The Simulink Model of Equivalent Current Sources is shown in fig.6.

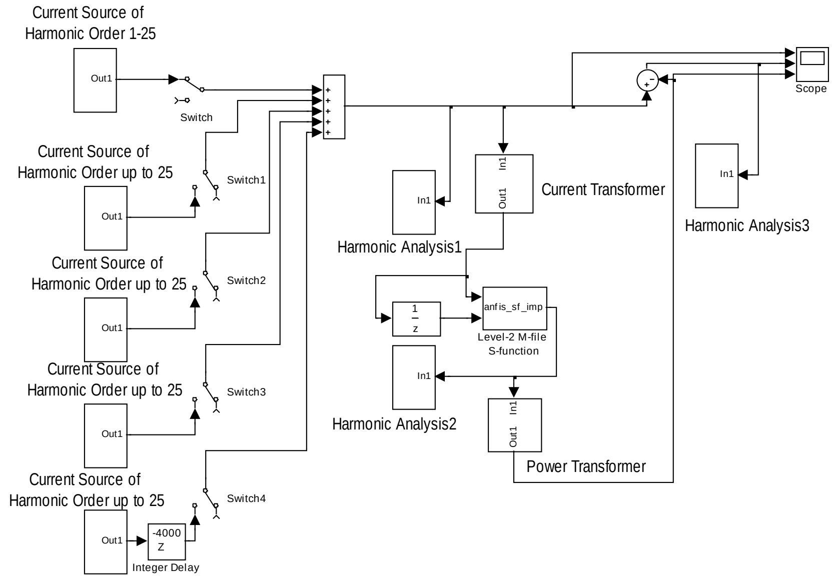


Fig. 5. Simulink model for Neuro-Fuzzy Power Conditioner

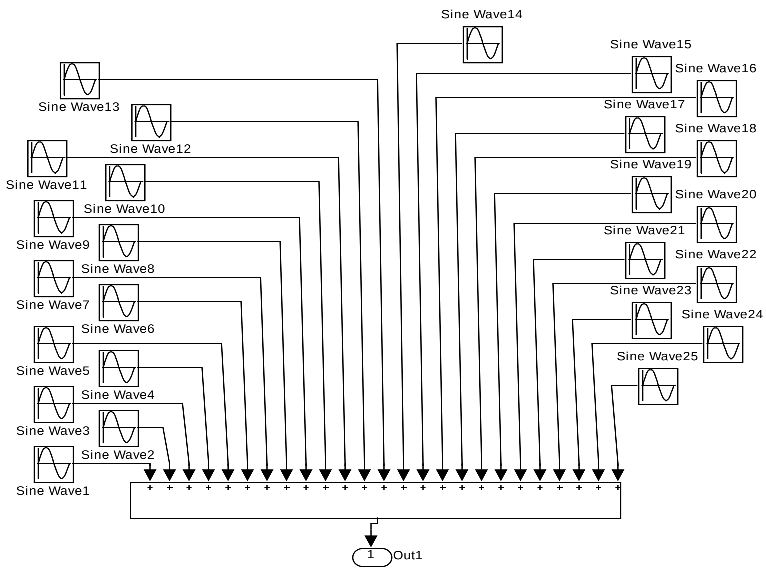


Fig. 6. Simulink Model of Equivalent Current Sources

IV. RESULT AND DISCUSSION

The current corrected waveform, distorted waveform and output of FTDNN is shown in fig.7. The FFT analysis has been done for one cycle to calculate total harmonic distortion (THD), distorted current (before compensation) THD 125.8% and after compensation the corrected current the THD 17%. Hence conclude that this proposed theory is work significantly for the compensation of harmonics. So increases the power quality of system.

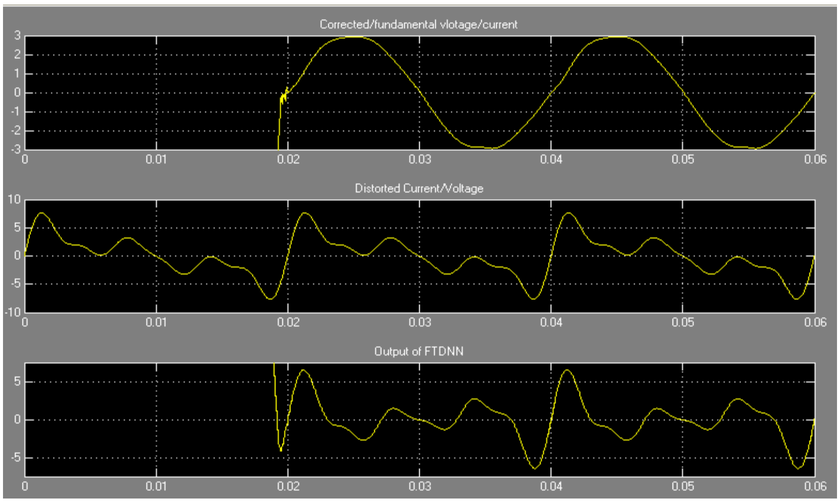


Fig.7. Corrected Waveform, Distorted Waveform and output of FTDNN. THD before Compensation=125.8% and THD after Compensation=17%

V. CONCLUSION

This proposed theory gives a reliable and satisfactory improvement in power quality which got adversely deteriorated due to nonlinear condition in the load. The outcome of FTDNN shows a remarkable improvement in power quality. The complete model is tested in MATLAB/SIMULINK which can validate the theoretical concept.

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