Removal of Harmonics from the output of Buck Converter by Hetero-associative Neural Network

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ABSTRACT
In almost all applications of power electronics there is always an influence of harmonics and noise in voltage and current waveforms. In this paper, a harmonic rejection technique has been proposed based on neural network platform. An ANN model has been developed which when trained can remove harmonics from the output of the buck converter. In this paper, a buck converter has been designed in MATLAB environment and the output voltage waveform is corrupted with harmonics. The corrupted output voltage is then passed through an ANN model. The developed model will remove the harmonics by hetero associative neural network approach. In the whole process a buck converter is simulated, one ANN model is developed, which is trained and tested on MATLAB platform.

General Terms
Buck converter, voltage waveform, harmonics, Target detection.

Keywords
Buck converter, Harmonic noise, Hetero associative neural network, Target detection, Filter design.

1. INTRODUCTION
The removal of harmonic noise mostly taken care for the case for speech processing. Due to the increasing requirement of precise control and equipment performance of a modern facility, the removal of harmonics from voltage and current waveforms in case of power electronics has drawn great attention recently. In the field of power electronics, dc-dc converter are widely used in industrial application as well as in commercial and residential applications. Once the power electronics gets polluted by harmonics, the operational characteristics of converters will be affected first. Therefore, studying the impacts of dc-dc converters like buck converters, under harmonic voltages has drawn the attention of many researchers. Various filters, which were basically low pass and high pass filters are used in the converters those not only make the converters bulky but also increases the cost.

While capturing any data through signal processing we have noticed that the harmonic noise influence the whole data set. Removals of these harmonic noises are essential for data manipulation in case of image representation and target detection.
he harmonic noise generally originates from various sources. Several methods have been proposed to suppress harmonic noise [2] [3] [4]. The attributes of harmonic noise always drift with time [2]. Harmonic plus noise model has also been proposed for speech synthesis [5] [6] they used HNM (Harmonic Noise model) for smoothing speech signal. Jose R Dorronsoro et al proposed a filter design approach by introducing a neural autoassociative linear filters [7. F Martin and P A Munoz developed a method to remove harmonics on vibrosesis data without the ground force signals [8]. Harmonic noise removal has been done on geophysical records by subtracting an estimate of the harmonic noise by Antoine Saucier, Matthew Marchant and Michel Chouteau [9] they proposed Nyman and Gaiser method to estimate harmonic noise. Jeng, Y. and Chen, C.-S et al. [10] proposed a filtering method which is based on the ensemble empirical mode decomposition algorithm conjunction with logarithmic transform.

The proposed method developed a filter design which removes harmonic noise completely with the help of neural network. In this paper,a simulation model for buck converter in MATLAB environment has been created where output is a 10 x 2 matrix. At second stage of the model harmonic noise have been imposed to the original matrix to get a contaminated matrix. A hetero associative neural network model has been prepared. A hetero associative neural network model contents an addressable structure that maps a set of input patterns with a set of output patterns. A content addressable structure refers to a memory organization where the memory generally accessed by its content as opposed to the explicit address in the traditional computer memory system. In hetero associative network the output pattern is different from the input pattern. Due to this nature of hetero associative model it has been used in this approach to map between the contaminated matrix and the original matrix. After passing the contaminated matrix through NN model the same original matrix has been received back.
The whole paper is organized as follows; the introduction section is combined with a brief discussion of harmonic noise along with hetero associative neural network model, next section also contains a brief description of the converter design and details of the ANN model. Methodology is discussed with the simulation model which is specially designed for making the whole environment. All received output and results were discussed in the section results and discussion. Lastly conclusion has been made for the proposed work and future works is also figure out in this section.

2. CONVERTER DESIGN
Based on the above theory, a buck converter is designed whose input voltage is 12v and the output voltage is 3.8v.The duty ratio is 0.316. The inductor selected is a 12 uH, 3 amp inductor having a resistance of 0.037 ohm. The capacitor

selected is 44uf .The diode selected for the design is 1N5820, 20V, 3 A Schottky diode. Now the designed model was run in hardware as well as in simulated platform which is created in matlab platform.

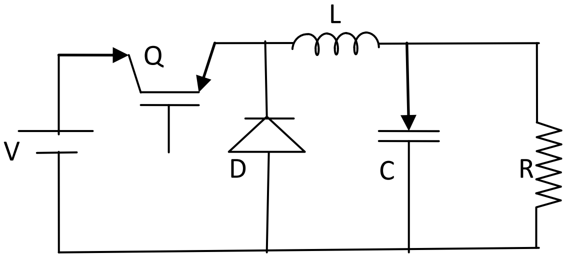


Fig. 1. Buck converter

The data from the output waveform is retrieved in the form of matrix which is having two columns. The first column indicates as voltage where as the second column indicated as time. We have named this matrix as target matrix in the whole procedure. The target matrix is passed through the through threshold value which is selected as 1(should be preferably 0 but in this it will not be able to distinguish between the various inputs) and marked as [x].

The output waveform is corrupted with various harmonics separately and passed through the threshold value 1 and stored in matrix [x1],[x2],[x3] [x4]in the following steps:

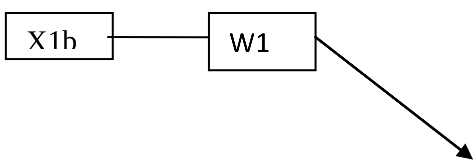
- First the output waveform of the buck converter is expressed as an array of time and voltage .
- 10 data were selected from the array for the ease of computation in form of matrix and passed through suitable threshold value and received a matrix [x] of size 10x2.
- Dimention having 1 column of voltage v1 …..v10 and the other as time from t1 … t10.
- A column matrix y is made which is a sine function of wt, 3wt or 5wt where time t varies from t1…..t10 and cosine of 3wt.
- Finally the matrix y is added to voltage of the target matrix [x] to form the corrupted matrix as [x1],[x2][x3]and [x4].

The corrupted matrix [x1],[x2],[x3],[x4] which when passed through threshold value 1 gives the[x1b],[x2b][x3b] and [x4b].

3. DESIGN OF THE NEURAL NETWORK MODEL

3.1 Artificial neural network model

The model used in this paper is hetero-associative neural network. Its a single layer network having input and output layer. In this approach, 4 sets of training data has been taken. The input layer consist of corrupted matrices having first, third and fifth order harmonics whereas the output layer consist of the original matrix I,e. the target matrix. The network is trained with 4 sets of data. the duration for the training required approximately 3 secs on MATLAB platform. Weight matrices were calculated by applying Hebb's learning rule.



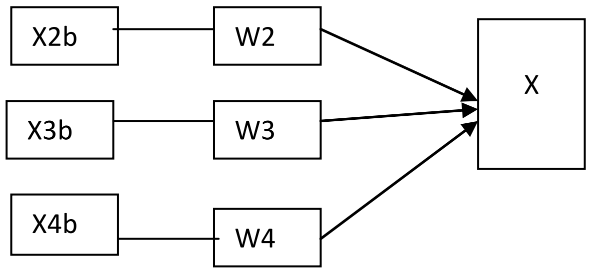


Fig 2: Block diagram of the ANN model

3.2 Algorithm for training the network

- Step1:Change the target matrix[x],corrupted matrix[x2],[x3]in terms of 0 and 1 by setting a threshold value.
- Step2:Find the weight matrix relating target matrix and corrupted matrices one by one:
- Step 3:

$$[w_1]=[x_1b]'*[x]$$
$$[w_2]=[x_2b]'*[x]$$
$$[w_3]=[x_3b]'*[x]$$
$$[w_4]=[x_4b]'*[x]$$

- Step4: Addition of the weight matrices.
- $[w_t]=[w_1]+[w_2]+[w_3]+[w_4]$

3.3 Weight Matrices

$$[w_1]=[x_1b]'*[x]$$
$$[w_2]=[x_2b]'*[x]$$
$$[w_3]=[x_3b]'*[x]$$
$$[w_4]=[x_4b]'*[x]$$

$$[w_t]=[w_1]+[w_2]+[w_3]+[w_4]$$

4. RESULTS AND DISCUSSION

The output of the designed buck converter[x] is given below:

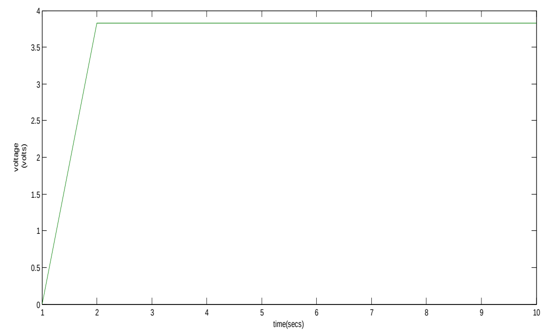


Fig3: Voltage waveform of the buck converter

The waveform is corrupted with 1st order harmonics ie *sin wt* and the waveform [x] gets disrupted as given below in fig 4.

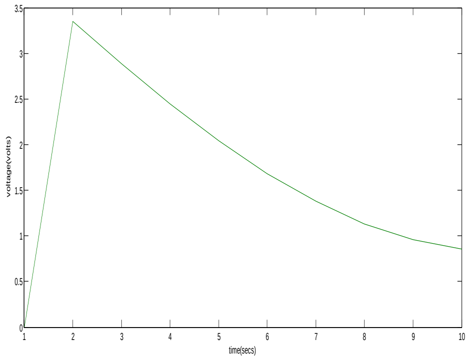


Fig4: Corrupted waveform with first harmonics

The waveform is again corrupted with 3rd order harmonics ie *sin 3wt* and the waveform [x1] gets disrupted as in the fig 5:

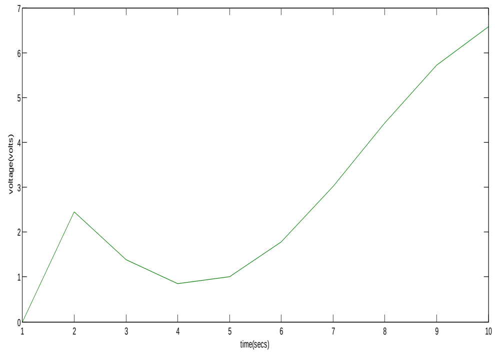


Fig5: Corrupted waveform with third harmonics

The waveform is more corrupted by using 5th order harmonics ie *sin 5wt* and the waveform [x1] gets disrupted as in fig6

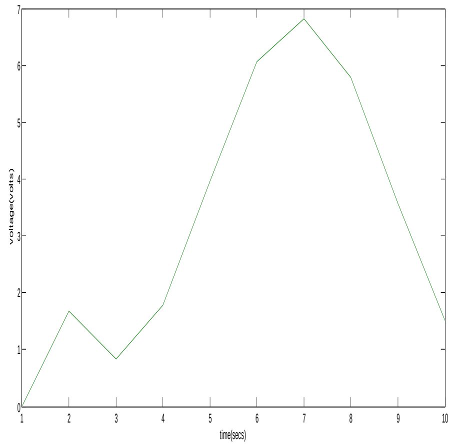


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Fig6: Corrupted waveform with fifth harmonics

The waveform is corrupted with 1st order harmonics ie cos wt and the waveform [x1] gets disrupted as given in fig 7 below :

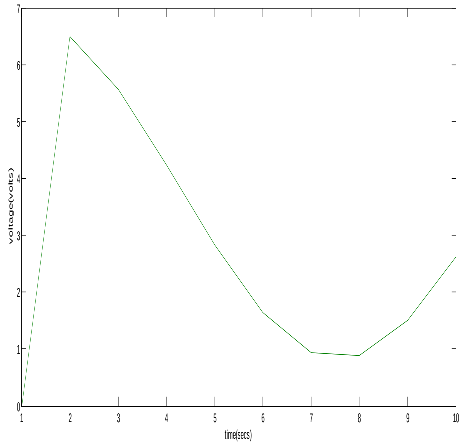

Fig7: Corrupted waveform with third harmonics(cos 3wt)

Once the training is complete the network needs to be tested to prove that it is working or not. The weight matrices are calculated and added to form the main weight matrix [w]. The network is then provided with 5 sets of data as discussed below:

Case1: The corrupted matrix[x1] is given to the network. The network uses the weight matrix and retrieves the target matrix I,e. the original waveform of the buck converter using the following formulae and then passing the output through suitable threshold function:

- $[t1] = [x1] * [w]$
- [t1] is same as with x, I,e after passing through threshold function t1 is equal to the target matrix [x].

Case2: The corrupted matrix[x2] is given to the network. The network uses the weight matrix and retrieves the target matrix ie the original waveform of the buck converter using the following formulae and then passing the output through suitable threshold function:

- $[t2] = [x2] * [w]$
- [t2] is same after passing through threshold function; I,e it is equal to the target matrix[x].

Case3: The corrupted matrix[x3] is given to the network. The network uses the weight matrix and retrieves the target matrix ie the original waveform of the buck converter using the following formulae and then passing the output through suitable threshold function:

- $[t3] = [x3] * [w]$
- [t3] is same after passing through threshold function, I,e. it is equal to the target matrix[x].

Case4: The corrupted matrix[x3] is given to the network after changing few of the elements of the matrix, which is x7. The network uses the weight matrix and retrieves the target matrix ie the original waveform of the buck converter using the following formulae and then passing the output through suitable threshold function:

- $[t2] = [x7] * [w]$
- [t4] is same after passing through threshold function I,e it is equal to the target matrix[x].

Case 5: The corrupted matrix[x4] is given to the network The network uses the weight matrix and retrieves the target matrix ie the original waveform of the buck converter using the following formulae and then passing the output through suitable threshold function:

- $[t5] = [x4] * [w]$
- [t5] is same after passing through threshold function, I,e. it is equal to the target matrix[x].

Case 6: The corrupted matrix[x10] is given to the network which is completely different from the trained matrices. The network uses the weight matrix and it has been noticed that it cannot retrieve the target matrix using the same formulae

- $[t6] = [x10] * [w]$
- But [t6] is not equal to the matrix [x] after passing through threshold function.

5. CONCLUSION

In this paper a neural network model is developed using heteroassociative neural network to remove the harmonics from the output voltage waveform of buck converter.The network tested with 5 data sets and is found to be working successfully without any error. The whole process took only 3 seconds to compute. Hetero associative network is robust in nature and fault toleran. When any data is given to the network with which it was not trained then also it gives the output which is nearest to the trained data. So,for a particular design of buck converter once the network is trained, it can be used to remove harmonics from the output and act as low pass filter. This work can further be extended for removing harmonics from other converters like boost, buckboost, cuk etc . Neural network can replace the function of filters from conververters which will make the converters less bulky and reduce its cost. Moreover, filters cannot always completely remove the effect of harmonics from output which makes neural network a better replcement A distinct advantage of neural computation is that, after proper training, a neural network completely bypasses the repetition of complex iterative processes for new design presented to it.

6. REFERENCES

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