International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319-6734, ISSN (Print): 2319-6726
www.ijesi.org ||Volume 10 Issue 1 Series I || January 2021 || PP 40-43

Neural Networks Use For Analysis Of Magnetic Fields Around A Medium Voltage Cable Line

Ivelina Hr. Metodieva[1], Stoyan Hr. Bozhkov [2]
[1](*Faculty of engineering and pedagogy of Sliven, Technical university of Sofia, Bulgaria)*
[2](*Faculty of engineering and pedagogy of Sliven, Technical university of Sofia, Bulgaria)*

ABSTRACT: *The article proposes a model and studies the magnitude of the magnetic field occurring around a three-phase medium voltage cable line, using artificial intelligence. For this purpose, a neural network model of a cable line in Matlab environment was created and trained. The model analyzes the magnitude of the magnetic field around a cable line, taking into account the relative position of the phase conductors of the cable line and the distances between them. The results are presented graphically. Based on the research, in the last part of the article conclusions are made.*

KEYWORDS *- cable line, electromagnetic compatibility, medium voltage*

Date of Submission: 30-12-2020 Date of Acceptance: 11-01-2021

I. INTRODUCTION

Low-frequency magnetic fields due to the operation of the individual elements of power transmission and distribution systems such as transformers, cable lines, power lines, substations, etc. are the subject of more and more frequent research and analysis. The reason is that they all cause disturbances and have a negative impact on neighboring electrical and electronic equipment, on people and in particular on the staff serving them [1].

With fast urbanization of the settlements, the construction of an increasing number of administrative and industrial buildings, the electricity distribution network grows and develops proportionally, and at the same time the length of the used medium voltage cable lines connecting the individual substations and distribution systems increases. For the quantitative assessment and analysis of "electromagnetic pollution", electromagnetic compatibility and the conditions for trouble-free operation of equipment, it is necessary to carefully analyze the magnitudes and distributions of magnetic fields created by the power cable lines used. An accurate engineering assessment of the impact of the configuration in which the individual phase conductors of the cable composition are grouped is required, both at the design stage and during their laying [2], [3].

II. NEURAL NETWORK MODELING OF ELECTROMAGNETIC FIELDS IN MATLAB ENVIRONMENT

Artificial neural networks (NN) are gaining more and more popularity as a subject of scientific research. They successfully deal with solving cases in traditionally the most difficult computational problems [4]. The ability to process a large flow of data, the ability to adapt and train makes them extremely suitable for analyzing the electromagnetic fields around the wires of different power lines, whose dynamic models are characterized by the presence of uncertainties and inaccuracies.

Their principle of operation is that the input data is presented in a parameterized way and processed in the network by a parallel method [5].

III. MATHEMATICAL VIEW OF AN ARTIFICIAL NEURAL NETWORK.

Figure 1 shows a model of an artificial neuron, which is the basis of all models in neural networks.

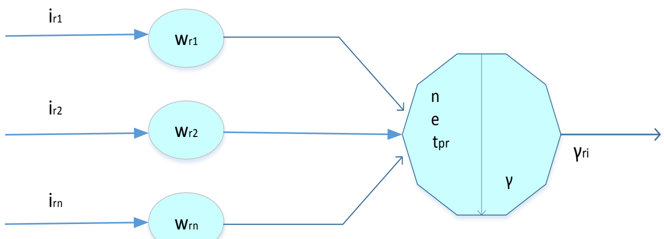


Figure 1. *Artificial neuron model*

Where:
$i_{r1}, i_{r2}, i_{r3}, i_{rn}$ – input signals, $w_{r1}, w_{r2}, w_{r3}, w_{rn}$ – connection weights
net_{pr} – network input, γ_{ri} - output signal
Individual neurons can be given both static and dynamic behavior by calculating their output, respectively, as a function of the current input only or as a function of the current input and the current activation value [6], [7]. The activation value is formed by (1):

$$O_{pr} = f\langle net_{pr}\rangle \qquad (1)$$

In case that

$$net_{pr} = \sum_{i=1}^{n} t_{r1} \, . \, i_{p1} + \mathrm{Y} \qquad (2)$$

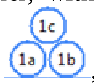
The activation value by dynamic neuron have a (3):

$$O_{pj}(t+1) = f\langle net_{pr}(t), O_{pr}(t)\ \rangle \quad (3)$$

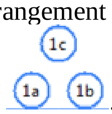
For this study are used dynamic neurons, based on the fact that input date are changing over time.
The selected network is trained to associate a different number of input vectors with their respective output signals. A precise choice of training sequence is made considering the close values of the input data. The purpose is to minimize the mean square error between the desired and current value of the network output. The error function is described by formula (4).

$$E = \sum_{p} E_p \qquad (4)$$

Where:
p – changes within the training sequence of input variables;
E_p – the error of the specified input vector.
Models of neural networks have been created, taking into account the change of magnetic induction around the conductors of a cable line, 20 kV at different arrangement of the phase conductors relative to each other. Neural networks are implemented using toolbox / nntool in Matlab environment .
The input-output parameters of the neural networks are data obtained from the simulations made in [8]. These parameters serve as a sample for the training of each of the networks. For precise work, each of the weights is set and specified in the training process. After the implementation of each of the networks, testing was done separately with known input-output data, which did not participate in the process of creating and training the network. The general example of the constructed neural network is shown in Fig.2 [9].
Each of the created networks corresponds to one of the four variants of the available phase conductors of the cables, namely: horizontally, touching each other, without distance between them 

, mutually tangent at the vertices of an equilateral triangle 

, horizontal arrangement with distance between them 

and in the form of a triangle, with distance between them 

.

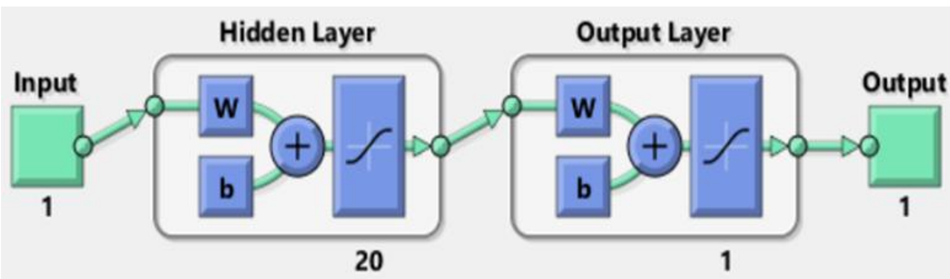


Figure 2. *General view of the created neural network*

For input values of the created neural network, values representing the change of the distance of the point of measuring the induction of the magnetic field in relation to the axis line of the conductor are used. The initial value represents the value of the magnetic field induction at the measuring point for each of the cases [9], [10].

Network training is performed by specifying each of the weighting factors determining the priority output value. A precise choice is made of the percentage ratio between the commands "Training", "Validation" and "Testing". Graphical results from different stages of the network training are shown in Fig.3.

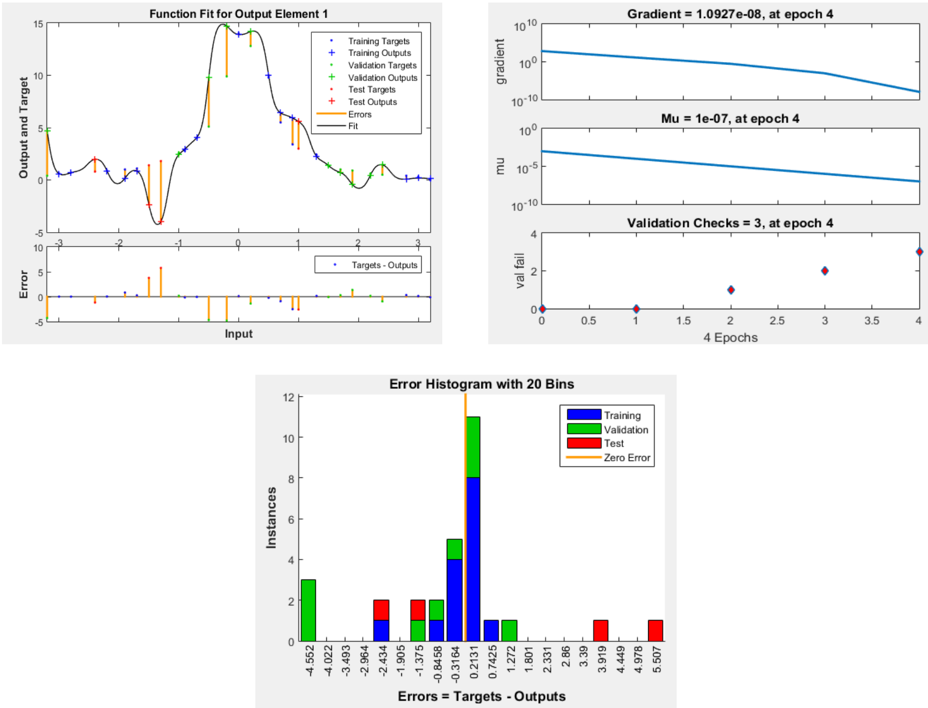


Fig.3. *Stages of neural network training.*

The last stage in the creation of the network, in view of its universal applicability in the implementation of simulations, is the conversion into Matlab / Simulink format.

On the graphics shown in Fig. 4, Fig. 5, Fig. 6 and Fig. 7 is compare the numerical results obtained from the models and known data from similar certified software products. The results presented in blue are known, reference data, and those presented in red/black - obtained from numerical modeling.

When comparing the values, there is a difference between reported and calculated data of less than 5%, which is within the engineering error.

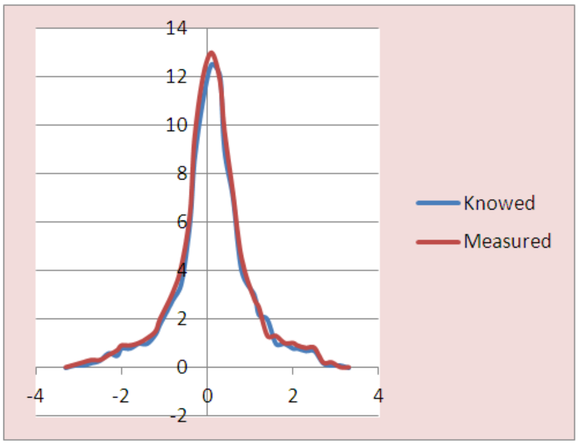


Fig.4. Horizontally, touching each other, without distance between them

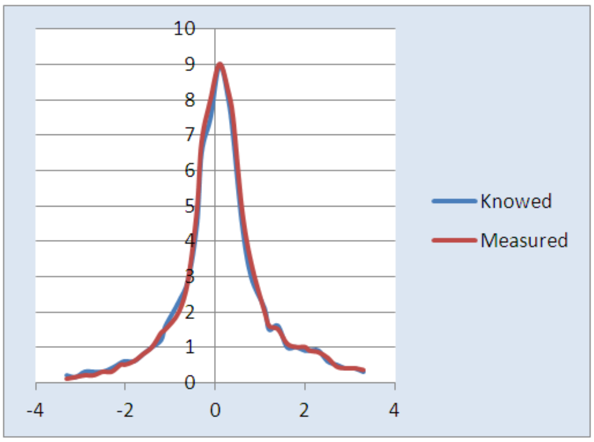


Fig.5. Mutually tangent at the vertices of an equilateral triangle without distance between them

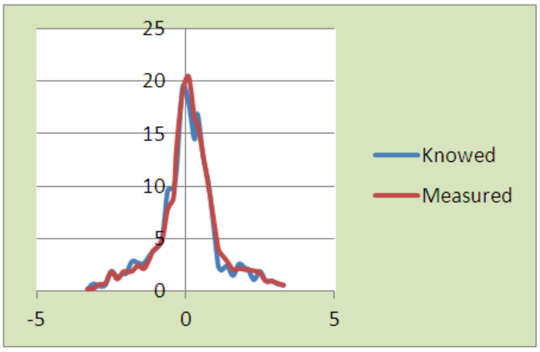


Fig.6. Horizontally, touching each other with distance between them

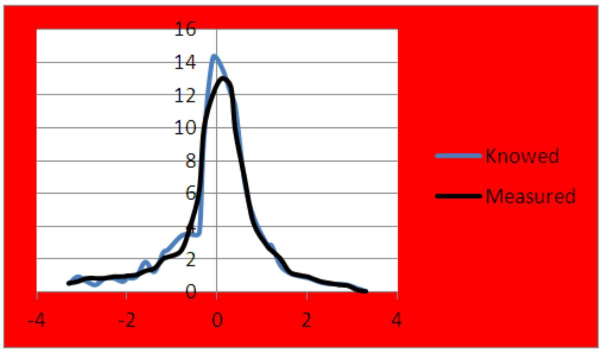


Fig.7. In the form of a triangle, with distance between them

IV. CONCLUSION

The realized researches and the made analysis show that the maximum value of the induction of the magnetic field is immediately above the axis of the conductors. Although the maximum induction is observed, its value is within the maximum allowable.

As move away from the wires in a horizontal direction, a observed sharp decrease. It is characteristic that for all four studied cases, after the second meter, the induction values become minimal.

When comparing the maximum value of the levels of the magnetic induction of the magnetic field with the way of laying the conductors, it is found that when laying the phase conductors in the form of an equilateral triangle without distance between them, the value of magnetic induction is the lowest compared to the other three analyzed case. The highest value is observed and confirmed in the model with horizontally placed conductors with a distance between them.

REFERENCES

[1]. Vince Trejcel, How to handle harmonics in electrical power systems, 2014.
[2]. David Chapman, Harmonics Causes and Effects, 2001
[3]. EPRI TR-114200. Electric and Magnetic Field Management Reference Book. USA, 1999
[4]. Anton Topalov, Mihail Topalov „Artificial intelligence methods in control systems“, 2010
[5]. Gencho Venkov, Bogdan Gelev „Application of neural networks in computer modeling“
[6]. Lee CC, Chung PC, Tsai JR, Chang CI. Robust radial basis function neural networks. IEEE Trans Syst Man Cybern 1999;29(6):674–85
[7]. Schilling RJ, Carroll JJ, Al-Ajlouni AF. Approximation of nonlinear systems using radial basis function neural networks. IEEE Trans Neural Networks 2001;12(1):1-14
[8]. Ivelina Metodieva „Simulation analysis of electromagnetic fields generated by a medium voltage cable line“, 2020
[9]. https://www.mathworks.com/

Ivelina Hr. Metodieva, et. al. "Neural Networks Use For Analysis Of Magnetic Fields Around A Medium Voltage Cable Line." *International Journal of Engineering Science Invention (IJESI)*, Vol. 10(01), 2021, PP 40-43. Journal DOI- 10.35629/6734