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Comparative Analysis of Two Modelling Methods for Autonomous Current Inverters

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ABSTRACT: This paper presents the results of a comparative analysis of the modelling capabilities of two methods of modelling autonomous current inverters. The first modelling method is based on developing a mathematical model using an operator method based on the Laplace transform. The second modelling method is based on developing a model of autonomous current inverters using simulation modelling. We describe their capabilities in the modelling of valve inverters based on autonomous current inverters.

KEY WORDS: autonomous current inverters, solar panel, operator method, simulation modelling

I.INTRODUCTION

At the present time when designing complex electrical systems, including electromechanical systems based on valve converters, special attention is paid to the issue of ensuring a high level of reliability of their operation under different conditions [1-3]. It stipulates development and use of mathematical models allowing taking into account with high accuracy not only a variety of commutation circuits, different modes of operation both at the constant load and input voltage parameters, but also practically continuous change of power circuit structure in process of switching on and off valves of autonomous current inverter. An indispensable step in the development of the inverter circuit is the assessment of the appropriateness of the chosen mode type in terms of reliability and technical and economic performance of the device. Such an assessment can be made using the data obtained from the physical model, computer model of inverter [2-6] and others.

II. METHOD

One of the most successful frequency-controlled asynchronous electric drive power supply circuits is the autonomous current inverter circuit [1], which is shown in Fig. 1.

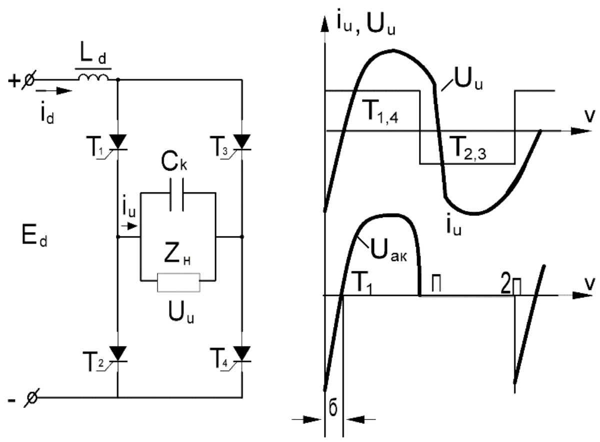

Fig. 1. Single-phase AIT diagram and load current and voltage time diagrams

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In this article the results of comparative analysis of two ways of modeling of autonomous current inverter are presented: analytical and simulation. In calculating the transient and steady-state processes of current inverters, the analysis method based on the Laplace transform is often used. In this case, equivalent operation substitution diagrams (EOS) are prepared for all possible operating structures of the power circuit. Equations for the operator representations of the variables are then written using these EOSs. By solving these equations, the images and then the originals of the desired currents and voltages are found [5].

In the paper to build the complete model the operator method is applied, which most fully and accurately reflects the development of dynamic processes in valve circuits [2]. The application of the operator method for analyzing transient and steady-state processes in the classical form, along with extensive preparatory procedures in developing the mathematical model, also leads to deterioration of the quality of the resulting model: increase of the required memory, complexity of the algorithm and low calculation speed. These disadvantages are primarily related to the large number of equivalent EOS used in the development of the mathematical model.

Therefore, in this paper, when developing a mathematical model based on the operator method, the use of such substitution schemes (hereinafter referred to as universal substitution schemes), which would be equivalent to several possible power circuit structures, is proposed [4-6]. Such approach to development of mathematical model, preserving the advantages of the operator method, makes it possible to reduce the size of the model, reduce the required volume and counting time, makes it possible to perform necessary calculations of circuit parameters in a wide range taking into account the excitation and regulation method, to make as a result an appropriate choice of elements and, thus, will allow to solve the analysis of the studied circuits more effectively.

During development of mathematical models we have accepted the following generally accepted assumptions: gates are ideal, their commutation is instantaneous, magnetizing current of power transformer is zero [1, 3-6].

In order to reduce the mathematical model based on the operator method, it is proposed to use such substitution schemes (hereinafter referred to as universal substitution schemes) that would be equivalent to several possible structures of the power circuit. This approach to developing a mathematical model, while maintaining the advantages of the operator method, will make it possible to reduce the size of the model, reduce the required volume and counting time and, thus, make it possible to solve the analysis of the circuits in question more efficiently. For each EOS on the basis of Kirchhoff's laws the equations for the required currents and voltages were made, formulas for their images were obtained, and then their originals were obtained. Below are the formulas of the original currents and voltages:

$$i_d(t) = \frac{E_d}{r_1} + \left(\frac{B_2}{D_1}\right) e^{-\sigma_2 t} + K_1 A_1 + K_2 B_1;$$

$$i_{\text{н}}(t) = \frac{E_d}{r_1} + \left(\frac{B_4}{D_2}\right) e^{-\sigma_2 t} + K_3 A_3 + K_3 B_3;$$

$$u_c(t) = \frac{r_{\text{н}} E_d}{r_1} + \left(\frac{B_4}{D_1}\right) e^{-\sigma_2 t} + K_1 A_3 + K_2 B_3$$

Based on the formulas obtained for the instantaneous values of currents and voltages, a structural diagram of the algorithm for calculating the transient process was developed based on fulfilling the boundary conditions for the process development stages and identifying the sequence of substitution circuit type changes at clocking intervals.

III. RESULTS

The methodology presented in the paper can be used to analyse electromagnetic processes in parallel, parallel-series, series-parallel, sequential, as well as in inverters with cut-off gates and with two-stage switching.

Thus, development of mathematical models of the investigated circuits in this paper is made in the following sequence [4-6]:

(a) possible types of substitution circuits for the selected excitation and stabilization method are determined;

b) universal schemes of substitution are compiled, images and originals of currents and voltages are derived;

c) on the basis of analysis of possible ways of process development on the clocking intervals, the sequence of substitution circuit types change and boundary conditions of their change at the stages of transient processes are determined;

d) on the basis of search for fulfilment of boundary conditions taking into account the selected method of excitation and regulation, a structural scheme of the transient process calculation algorithm is formed.

Programming the obtained analytical expressions and making up the algorithm of the process paths, the mathematical model was obtained. The mathematical model was used to calculate the transients and to plot the time

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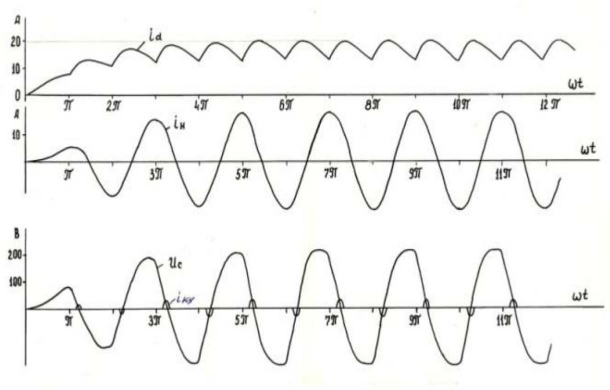
diagrams of the currents and voltages to be expected, as shown in Fig. 2, a. Fig. 2, b shows the time diagrams of currents and voltages obtained by simulation. As can be seen from the presented diagrams, the time diagrams of currents and voltages at start-up of the autonomous inverter have a good agreement within 4-6%.



a)

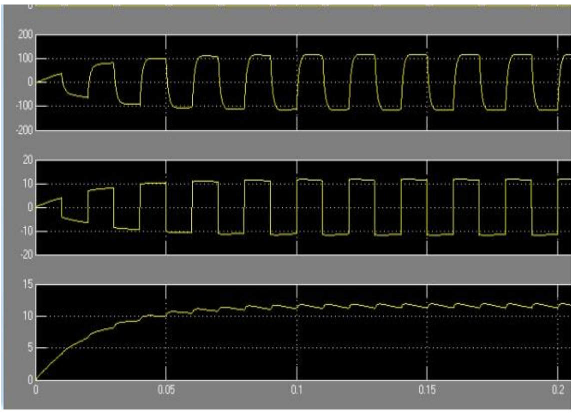


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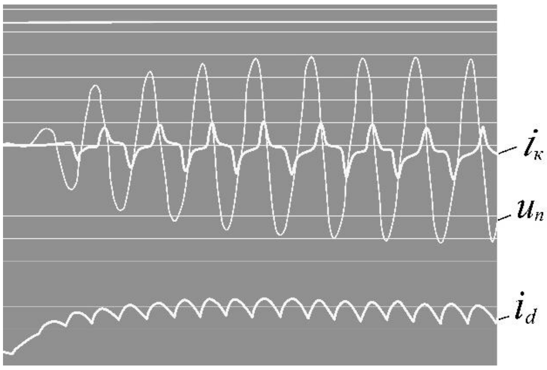
Fig. 2. Time diagrams of currents and voltages at start-up:
a) analytical modelling; b) simulation modelling



a)

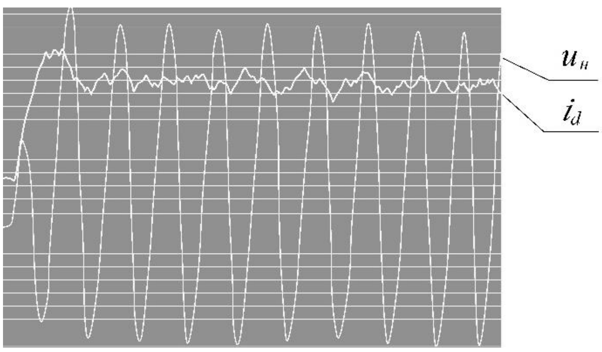


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Fig. 3. Waveforms of single-phase (a) and three-phase (b) stand-alone current inverter at start-up

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IV. CONCLUSION

A comparative analysis of analytical and simulation modelling has shown that analytical modelling is more effective in the following cases:

- to verify the accuracy of the simulation results;
- to quickly obtain initial conditions.

The advantages of simulation modelling are:

- Visibility and the possibility of obtaining results in tabular or graphical form.

To summarize, these models are to some extent interrelated and each of them is quite effective depending on the class of scheme under study, the type of problem and the ultimate goal of the study.

REFERENCES

1. Rozanov Y.K., et al. Handbook on Power Electronics. - Moscow: MPEI Publishing House, 2014. - 472 p.
2. Hongru Yu, Jianhui Su, Haining Wang, Yiding Wang, Yong Shi, Modelling method and applicability analysis of a reduced-order inverter model for microgrid applications IET Power Electron., 2020, 13, pp. 2638-2650
3. Pogaku, N., Prodanovic, M., Green, T.C.: 'Modeling analysis and testing of autonomous operation of an inverter-based microgrid', IEEE Trans. Power Electron., 2007, 22, (2), pp. 613–625
4. Alam, K.S., Xiao, D., Zhang, D., et al.: 'Single-phase multicell AC-DC converter with optimized controller and passive filter parameters', IEEE Trans. Ind. Electron., 2019, 66, (1), pp. 297–306.
5. Kh Sapaev, Sh Umarov. Two approaches for automating analysis of electromagnetic processes in non-linear circuits with valves. E3S Web of Conferences 139, 010 (2019)21.
6. Shukhrat Umarov, Dilmurod Maxammatov, Fayzulla Akhunov and Fazliddin Qodirov. Mathematical model for calculating transient modes of a valve converter. MIP: Engineering-2021. AIP Conference Proceedings 2402, 060012 (2021); https://doi.org/10.1063/5.0071554.