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Mathematical Model of a Push-pull Converter Based on a Single-phase Series Current Inverter and Rectifier

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ABSTRACT: The article, based on the operator method, proposes a method for calculating transient processes of push-pull DC-to-DC valve converters with an adjustable output voltage. Recurrence relations have been obtained for the desired currents and voltages, which make it possible to calculate transient processes when the input voltage of the inverter changes, when the load changes, and also when the input voltage and load simultaneously change. The results of calculating transient processes are presented in the form of time diagrams.

I. INTRODUCTION

Valve converters (VC) are widely used as DC-DC converters with an adjustable output value. They are especially common in DC power systems for engines of various types of urban transport and moving objects, which are supplied with energy from batteries. [1-5].

In addition, they also find application in special-purpose objects such as medical equipment, lighting technology, optoelectronics and automation. These applications often require high DC voltage, which is provided by using batteries as the primary energy source. An important condition for their effective use is the development of reliable and economical devices for their power supply, which in turn implies the need to carry out preliminary calculations of transient processes to select optimal circuit parameters that ensure compliance with the requirements of the technical specifications. [4-6].

II. METHOD

The article proposes a methodology for developing a mathematical model of valve converters based on the operator method. This approach allows you to carry out the necessary calculations of circuit parameters in a wide range and select the appropriate elements.

The process of developing a mathematical model includes the following stages [7-10]:
a) Carrying out an analysis of electromagnetic processes in the circuit to determine possible structures of the power circuit and drawing up their equivalent circuits.
b) For each equivalent circuit, an operator equivalent circuit (OEC) is formed, from which recurrent formulas for calculating currents and voltages are derived.
c) Analysis of possible paths of process development, identification of sequences of changing types of equivalent circuits at clock intervals.
d) Programming analytical expressions and process development paths to create a mathematical model of the converter.

Thus, the use of the operator method allows us to systematize the process of developing a mathematical model and ensure its adequacy for calculating parameters and selecting elements of the valve converter circuit.

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Using this method, transient processes are studied in the circuit of a stabilized power supply (SPS) with a constant output voltage, which consists of two series-connected valve converters.

The first link is an autonomous series current inverter, and the second is a single-phase rectifier. Both links are connected to each other by a power transformer (see Fig. 1). The load can be a static active consumer, a DC motor or a vacuum tube. In this study, an equivalent circuit including a counter emf was selected as the load *Eл* and active resistance *rл*. To regulate the output voltage and ensure its stabilization, a change in the frequency of pulses supplied to the power thyristors of the inverter is used.

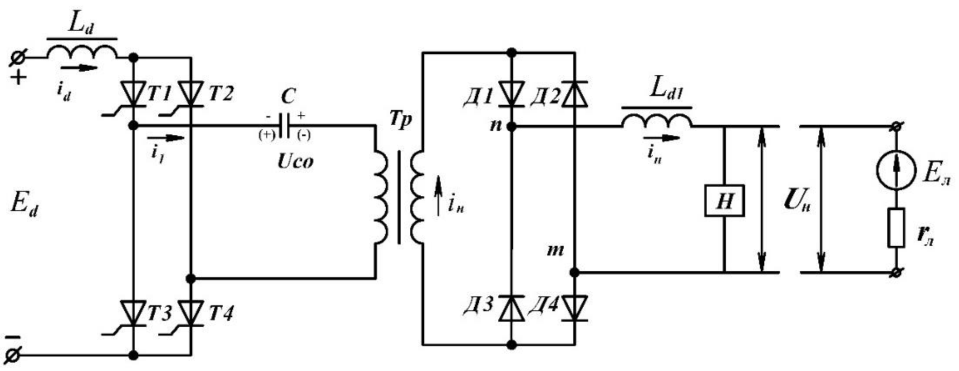

Fig.1. Schematic diagram of a push-pull converter based on an autonomous series current inverter.

Electromagnetic processes proceed as follows. At t = 0, unlocking pulses are applied to a pair of power thyristors (T1, T4); capacitor C has a voltage uc (0) with the polarity shown in Fig. 1 (without brackets). As current id passes, the capacitor discharges, then begins to charge with the opposite polarity. Due to the charge of the capacitor, the voltage at points "n" and "m" begins to decrease. At the beginning of the interval under consideration, the load current in is equal to id; this operating state of the circuit corresponds to OEC -1, shown in Fig. 2.

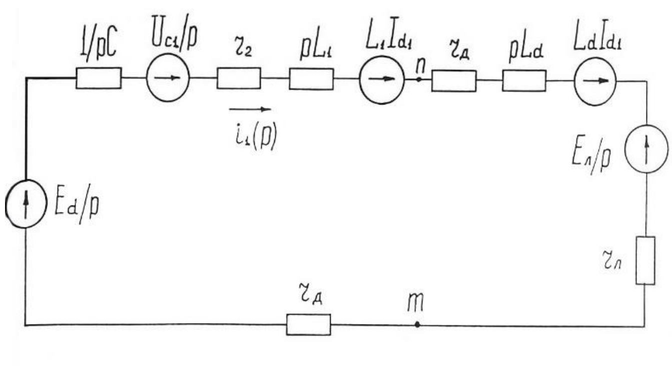

Fig. 2. Operator substitution circuit type OEC -1.

At a certain moment, the voltage between points "n" and "m" becomes equal to zero, after which the equality of currents in and id will be violated, since part of the current in will begin to flow along the circuit: diodes - smoothing choke-load (Д1-Д4-Ld-H). In this case, the capacitor continues to be charged with current id; this state of the circuit corresponds to OEC -2, shown in Fig. 3.

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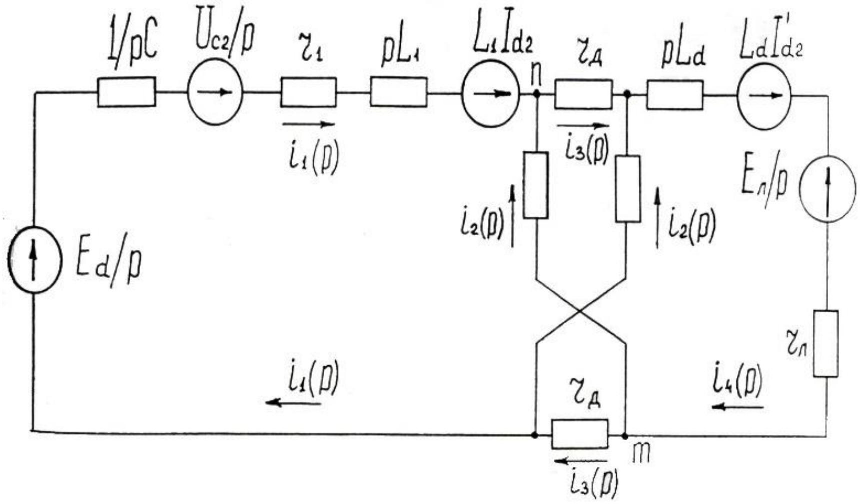

Fig. 3. Operator substitution circuit type OEC -2

Then, when the capacitor voltage reaches the maximum value Uso with the polarity shown in Fig. 1 in parentheses, the current id becomes equal to zero, and the thyristors T1, T4 are turned off. Subsequently, the load current flows through the circuits Д4-Д3-Ld-H and Д2-Д1-Ld-H. This state corresponds to the operator diagram of OEC-3, presented in Fig. 4. the process according to this operator circuit continues until unlocking pulses are supplied to the next pair of power thyristors (T2-T3).

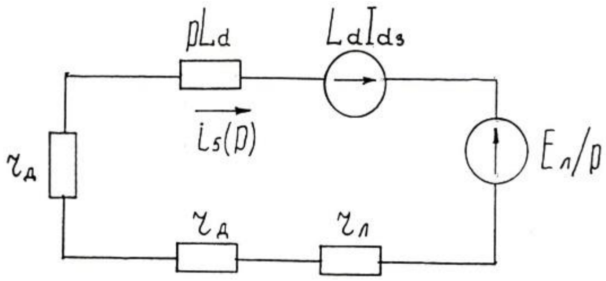

Fig.4. Operator equivalent circuit type OEC -3

The electromagnetic processes of the next clocking interval from the moment the unlocking pulses are supplied to the power thyristors T2-T3 and until the opening of the next pair (T1-T4) proceed according to the same three operator equivalent circuits (Fig. 2, 3 and 4), and the process itself develops similarly to that described above.

Thus, three structures of the power circuit with the corresponding OECs participate in the transition process. Next, for each OEC, based on Kirchhoff's laws, equations for the desired currents and voltages were compiled, formulas for their images were obtained, and then their originals were obtained. Further, by programming the obtained analytical expressions and the path of development of the process, a mathematical model of the converter was obtained, with the help of which the transient processes were calculated, the time diagrams of the desired currents and voltages are presented in Fig. 5 and 6.

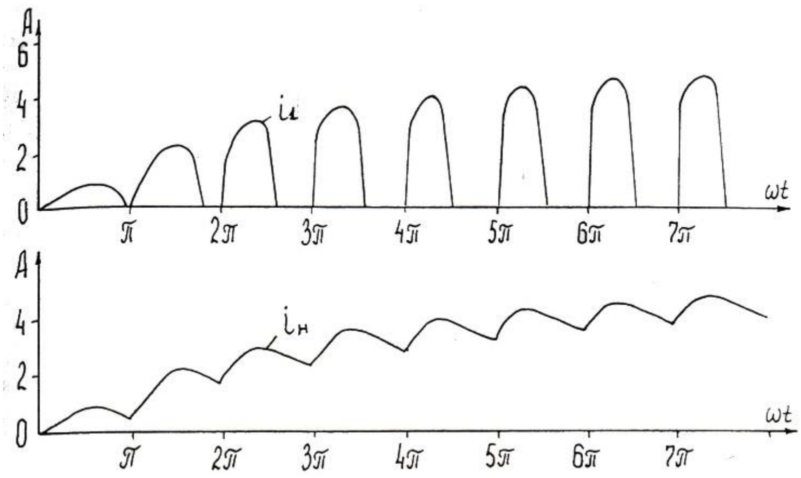

Fig. 5. Time diagrams of currents when starting push-pull converter

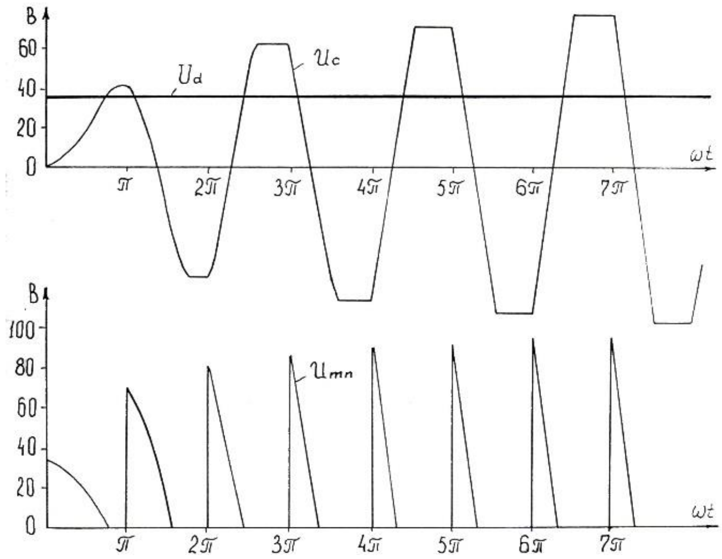

Fig. 6. Time diagrams of voltages when starting push-pull converter

Based on a series of computer studies using a developed mathematical model (algorithm and program), the recommended parameters and standard values of elements of a SIP circuit based on a series inverter were obtained, presented below in the Table.

Table

№	Designation in the diagram	Standard ratings	Quantity
1	T1, T2, T3, T4	ТЧ25-8	4
2	Д1, Д2, Д3, Д4	ВЧ200-3	4
3	C	К75-10-1mkF-1000V	6 parallel
4	L_d	100 mkGn	
5	Л	ДКСШ-3000	

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III. CONCLUSION

Summarizing the above, we can say that by obtaining a solution in a general form in the form of a list entry of analytical recurrence relations, the following is ensured: clarity, accuracy and formalization in the implementation of the software implementation of the model and in its further use. This, in turn, creates the prerequisites for high-quality and efficient work of designers when developing a subclass of converters with the recommended parameters and standard ratings of SIP circuit elements based on a series inverter, indicated above in the Table.

REFERENCES

1. Онищенко Г.Б. Электрический привод. Учебник для вузов. — М.: РАСХН, 2003. — 320 с. С. 143-145.
2. G. C. Diyoke, Okeke C., Uchechi Aniagwu. Different Methods of Speed Control of Three-Phase Asynchronous Motor. American Journal of Electrical and Electronic Engineering, 2016, Vol. 4, No. 2, 62-68
3. Jakub Bernatt; Stanisław Gawron; Tadeusz Glinka. Energy-Saving Electric Drives. 2018 International Symposium on Electrical Machines (SME). DOI: 10.1109/ISEM.2018.8442715
4. Slobodan Mircevski.Energy Efficiency in Electric Drives/https: //www.researchgate.net/journal/Electronics-ETF. 2012. DOI: 10.7251/ELS1216046M2007
5. Аллаев К.Р. Энергетика мира и Узбекистана.-Ташкент: Molia,.- 388 с.
6. Анучин А.С. Системы управления электроприводов: учебник для вузов.- М.: Издательский дом МЭИ, 2015.-373с.
7. Егоров А.Н., Семёнов А.С., Федоров О.В. Практический опыт применения преобразователей частоты POWER FLEX 7000 в горнодобывающей промышленности//Издательство НГТУ.- 2017, №4, с.86-93.
8. 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.
9. Gu, Y., Bottrell, N., Green, T.C.: 'Reduced-order models for representing converters in power system studies', IEEE Trans. Power Electron., 2018, 33, (4), pp. 3644–3654
10. Shukhrat Umarov. Dependence of Current Inverter Critical Frequencies on its Load Parameters. 2023 International Russian Smart Industry Conference (SmartIndustryCon) | 978-1-6654-6429-1/23/$31.00 ©2023 IEEE | DOI: 10.1109/SmartIndustryCon 57312.2023.10110751