ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 8 , August 2019

Mathematical Models of Stabilized Power Supplies Based On Current Inverters

Umarov Shukhrat Badreddinovich

Ph.D. in Technical Sciences, Associate Professor, Tashkent State Technical University of the Republic of Uzbekistan

ABSTRACT:Based on the application of the Laplace operator method, a method of development and an example of the development of a mathematical model for the calculation of transients of two-stroke valve DC-DC converters with adjustable output voltage is proposed in the article. The investigated two-stroke valve converter, which can be used as a stabilized power supply (SPS) with a constant output voltage, consists of two series-connected valve converters. The role of the first link is a single-phase autonomous serial current inverter, and the second link is a single-phase rectifier. Both links are connected by a power transformer. The model allows the calculation of transients when the input voltage of the inverter changes, when the load changes, as well as the simultaneous change of the input voltage and load.

KEY WORDS: Converter, power supply, mathematical model, operator method, transition, rectifier, inverter, load

I.INTRODUCTION

As is known, one of the important areas of application of valve converters is their use as converters with adjustable output voltage [1-3], which are widely used to power DC motors, in various types of urban transport, on mobile units with a primary source of DC (battery), as well as in devices of guaranteed power supply. According to [4-6], an important condition for the effective development of reliable and economical valve converters is the need for preliminary calculations of transients to select the optimal parameters of the circuit, ensuring the fulfillment of the requirements of the technical specifications. For this purpose, a mathematical model corresponding to the task is developed. Undoubtedly, the choice of the method of object analysis is important in the development of a mathematical model [7].

In addition, given that about 70% of the mechanisms and units used in the production are equipped with an electric drive [1], the development of energy-efficient frequency-controlled electric drives based on converters is becoming increasingly important. Various authors are engaged in the development of mathematical models focused on the calculation and study of valve transducers [4-9].

Evaluation of the capabilities of a number of existing methods used for the analysis of this subclass of valve transducers showed that in accordance with the task the most acceptable is the method of instantaneous values based on the Laplace transform (operator method). Despite a number of advantages, the mathematical models obtained on the basis of the operator method have limited application in view of the large number of operator equivalent circuit structures involved in the development of the model of electromagnetic processes [6].

In this regard, the article for the development of a mathematical model based on the operator method proposes the use of such equivalent circuits (called universal equivalent circuits), which would be equivalent to several possible structures of the power circuit [7]. This approach to the development of a mathematical model, while maintaining the advantages of the operator method, makes it possible to reduce the size of the model, reduce the required volume and time of calculations, allows for the necessary calculations of the circuit parameters within a wide range, taking into account the method of excitation and regulation, and as a result, the appropriate choice of elements.

The mathematical model is developed in the following sequence:

a) a set of possible types of equivalent circuits is compiled, corresponding to the structures of the power circuit that appear in the selected method of excitation and regulation;

b) generic operator equivalent circuits (OEC) are compiled, recursion formulae of approximation are derived, necessary to calculate currents and voltages;

c) the possible ways of development process are analysed, the sequences of changing the types of equivalent circuits at intervals of the clocking are identified, as well as the boundary conditions for the various phases of the development process are formed;

d) a block diagram of the algorithm for calculating the transition based on the search for the fulfilment of boundary conditions, taking into account the selected method of excitation and regulation;

e) the obtained analytical expressions and ways of process development are programmed.

According to the above method, the article examines the transients in the circuit of a stabilized power supply (SPS) with a constant output voltage consisting of two series-connected valve converters. The role of the first link is an autonomous serial current inverter, and the second link is a single-phase rectifier. Both links are connected by a power transformer (Fig.1). The load can be a static active consumer, a DC motor or an electronic lamp. In the analysis of transients, we have adopted as a load an arc xenon lamp with an equivalent circuit consisting of a counter electromotive force *Eл* and an active resistance *rл*.

Regulation of the output voltage and, consequently, stabilization is carried out by changing the frequency of the pulses supplied to the power thyristors of the inverter.

Electromagnetic processes proceed as follows. At $t = 0$, the unlocking pulses are fed to a pair of power thyristors (*VS1, VS4*), the capacitor C has a voltage *uc* (*0*) with the polarity shown in Fig.1 (without brackets).

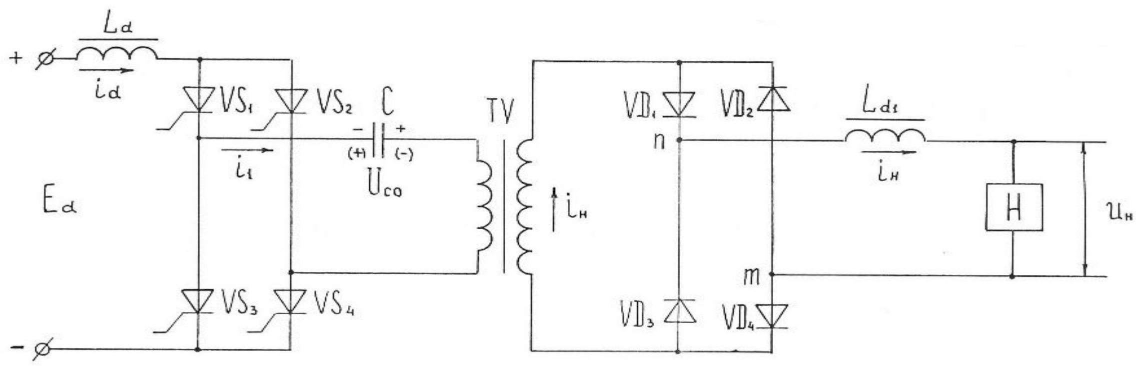

Fig.1. Schematic diagram of the SPS on the basis of the autonomous consistent current inverter.

As the *id* current passes, the capacitor discharges, then begins to charge with the opposite polarity. Due to the charge of the capacitor, the voltage at the points "*n*" and *"m"* begins to decrease. At the beginning of the considered interval, the load current *iн* is equal to *id*, this working state of the circuit corresponds to OEC-1, shown in Fig.2.

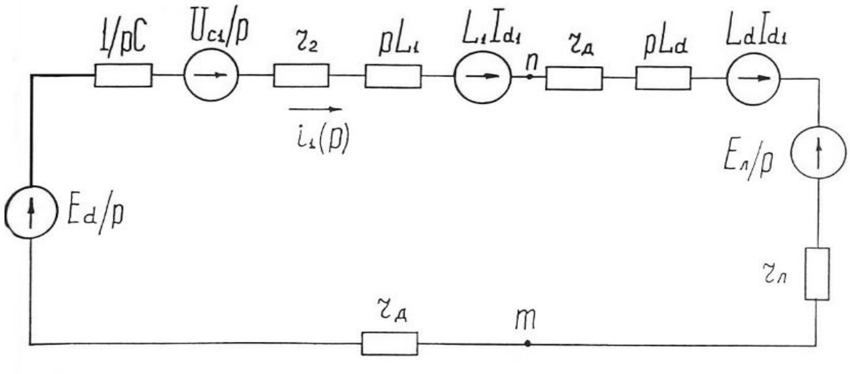

Fig. 2. Operator equivalent circuit of OEC-1 type.

At some point, the voltage between the points *"n"* and *"m"* becomes zero, after which the equality of currents *iн* and *id* is violated, as part of the current *iн* will begin to flow along the circuit: diodes – smoothing inductor -load (*VD1-VD4-Ld-H*). In this case, the capacitor continues to be charged with the current *id*, this state of the circuit corresponds to the OEC-2, shown in Fig.3.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 8 , August 2019

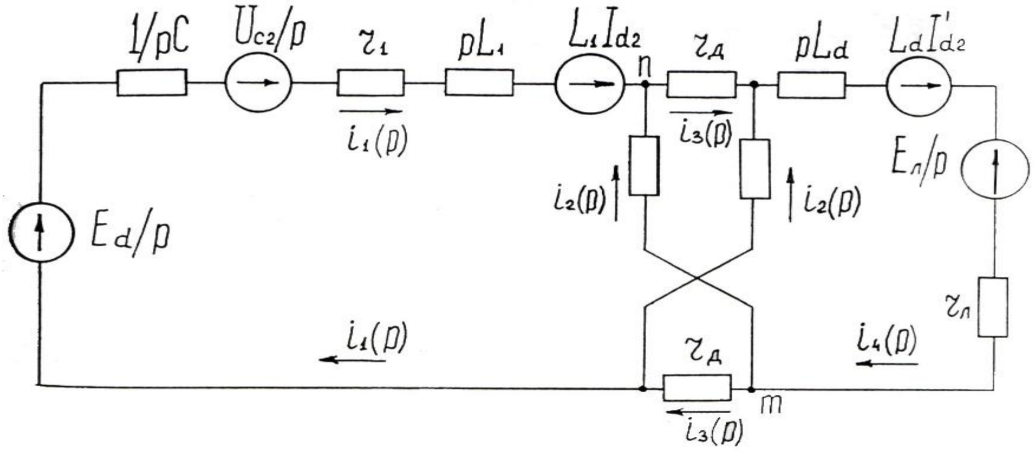

Fig. 3. Operator equivalent circuit of OEC-2 type

Then, when the capacitor voltage reaches the maximum value of *Uco* with c polarity, shown in Fig.1 in brackets, the current *id* becomes zero, and the thyristors *VS1, VS4* are locked. In the future, the load current flows through the circuits *VD4-VD3-Ld-H* and *VD2-VD1-Ld-H*. This state corresponds to the operator circuit OEC-3, shown in Fig.4. The process under this operator circuit continues until the supply of unlocking pulses to the next pair of power thyristors (*VS2 - VS3*).

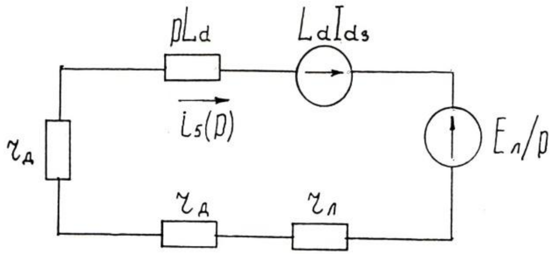

Fig. 4. Operator equivalent circuit of OEC-3 type

Electromagnetic processes of the next cycle interval from the moment of supply of the unlocking pulses to the power thyristors *VS2 - VS3* and to the opening of the next pair (*VS1 - VS4*) proceeds according to the same three operator equivalent circuits (Fig.2, 3 and 4), and the process develops similarly to the above.

Thus, three structures of the power circuit with corresponding OECs participate in the transition. Further, for each OEC, on the basis of Kirchhoff's laws, equations for the required currents and voltages were compiled, formulas for their images were obtained, and then their originals were obtained. Further, programming the analytical expressions and ways of development of the process, mathematical model of the converter was obtained, which was used to calculate the transients, time diagrams of the desired currents and voltages are shown in Fig. 5.

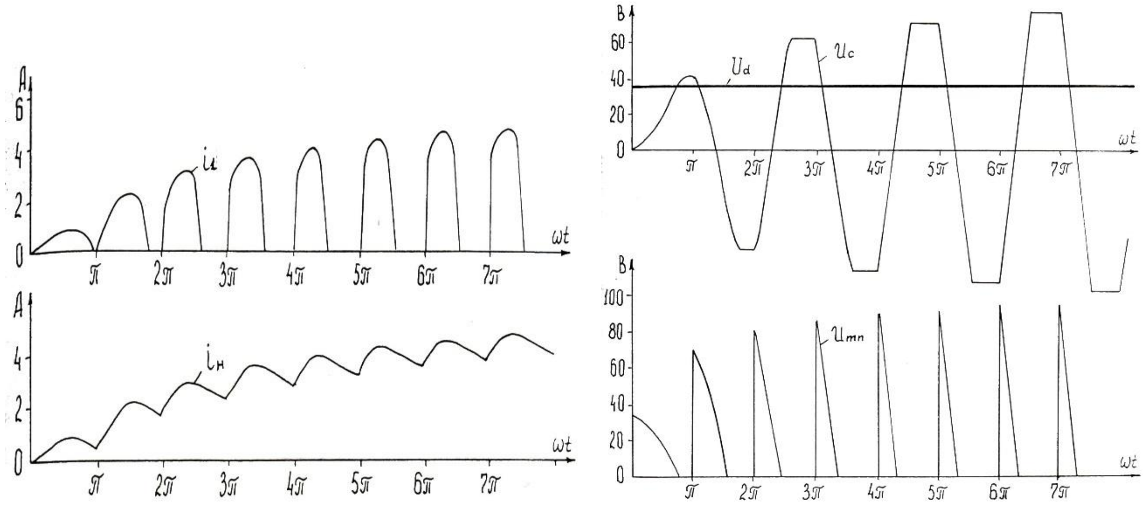

Fig. 5. Time diagrams of currents and voltages when starting the SPS.

Based on a series of computer studies with the help of the developed mathematical model (algorithm and program) the recommended parameters and the part type of elements of the SPS circuit based on a serial inverter were obtained, as shown in Table 1 below.

Table 1
Recommended parameters and part types of the circuit elements

No.	Designation in the circuit	Part types	Quantity
1	VS1, VS2, VS3, VS4	TCH25-8	4
2	VD1,VD2,VD3,VD4	VCH200-3	4
3	C	K75-10-1ufd-1000V	6 parallel
4	Ld	100 uH	
5	L	DKSSH-3000	

V.CONCLUSION

Summarizing the above, we can say that the proposed method of developing mathematical models for the calculation of transients of stabilized power supplies based on single-phase autonomous current inverters through the use of universal equivalent circuits allows to reduce the size of the model, provides a reduction in the required time and volume, and obtaining a solution in general in the form of a list recording analytical recurrence relations, provides visibility, accuracy and formalization in the implementation of the programmed implementation of the model, which creates, in turn, prerequisites for qualitative and effective work of designers in the development of a subclass of converters with the recommended settings, and part types of the circuit elements of the SPS on the basis of autonomous current inverter.

REFERENCES

[1] Khashimov A., Mirisaev A.U., Kann L.T. Energy-saving induction motor drive. Fan. 2011. p. 186.
[2] Braslavskiy I.Ya., Ishmatov. Z.Sh., Polyakov V.N. Energy-saving induction motor drive. – Moscow, ACADEMA, 2004, p. 0-280.
[3] Onishchenko G.B. Electric drive. – M.: RASHN, 2003-p. 320.
[4] Zinin Yu., Tereshkin V., Karamov A. Transients of thyristor bridge inverter start-up with frequency doubling. Power electronics. 2011. No. 5.
[5] Zinin Yu.M., Tereshkin V.M. Features of transient modelling of thyristor frequency converters in the Micro-Cap system. Proceedings of the International Conference "Theoretical Informatics – 2000: from theory to practice". Ufa: USATU. 2000.
[6] Umarov Sh.B., Abdullabekov I.A. Algorithm of calculation of transients of the stabilized power supply on the basis of a single-phase sequential autonomous current inverter with frequency regulation. International scientific journal. "Young scientist", 2016 No. 21, pp. 228-232.
[7] Umarov Sh.B. Mathematical model for calculation of transients in stable power sources on the basis of single-phase sequential inverter current. Journal "Problems of energy and resource saving". -2015, No. 4, pp. 112-115.
[8] Zinin Yu., Tereshkin V., Karamov A. Transients of thyristor bridge inverter start-up with frequency doubling. Power electronics. 2011. No. 5.
[9] German-Galkin S.G. Computer simulation of semiconductor systems in MATLAB environment. Textbook.-SPb.: KORONA print, 2001.-p. 320.