Calculation of transition processes in stabilized power sources on the basis of a single-phase serial current inverter

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Abstract. In article on the basis of an operational method the design procedure of transients duple key of converters of constant pressure in constant pressure with adjustable size of target pressure is offered. Are received recurrent parities for required currents and pressure which allow to make calculation of transitional process at change of entrance pressure, change of loading and also at their simultaneous change to settle an invoice transients at change of loading. Also results calculation of transitional process in the form of time diagram’s are presented.

An important area of application for valve converters is their use as DC-DC converters with adjustable output voltage, which are widely used to power DC motors, in various types of urban transport, on moving objects with a primary DC source (battery), also in the power supply devices for gas discharge lamps [1,2]. Recently, a rapid growth in the production of gas-discharge lamps has been observed, which is explained by their use as light sources with high intensity in various areas of industry, medicine, etc. In addition, this advantage of xenon arc lamps (XAL) as a small inertia allowed them to be used in systems of automatic transmission of information.

An important condition for the effective use of XAL is the development of reliable and cost-effective devices for their power, which in turn implies the need for preliminary calculations of transient processes to select the optimal parameters of the circuit to ensure that the requirements of the technical specifications are met.

In this connection, on the basis of the operator method, the article proposes a method for obtaining a mathematical model that allows one to carry out the necessary calculations of the circuit parameters over a wide range and, as a result, to make the appropriate choice of elements [3].

The development of a mathematical model is performed in the following sequence:

- based on the analysis of electromagnetic processes occurring in the circuit, possible structures of the power circuit are determined and their equivalent circuits are compiled;
- for each equivalent circuit of the possible structure of the power circuit, the corresponding operator equivalent circuit (ESS) is compiled, the recurrent formulas of the images and originals required for the calculation of currents and voltages are derived;
- possible ways of the development of the process are analyzed and the sequences of changing the types of equivalent circuits on the clocking intervals are identified;
by programming analytical expressions and ways of the development of the process, a mathematical model of the converter is obtained.

According to the above method, the article investigates transients in a stabilized power supply (SPS) circuit with a constant output voltage consisting of two series-connected valve converters. The role of the first link is performed by an autonomous sequential current inverter, and the second link is a single-phase rectifier. Both links are interconnected by a power transformer (figure 1). The load can be a static active consumer, a DC motor or an electronic lamp. In the analysis of transient processes, we have adopted an xenon arc lamp with a replacement circuit consisting of an e.m.f as a load $E_l$ and active resistance $r$.

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

**Figure 1.** Schematic diagram of SPS based on an autonomous serial current inverter.

Electromagnetic processes proceed as follows. When $t = 0$, unlocking pulses are applied to a pair of power thyristors (VS1, VS4) capacitor C has voltage $u_c(0)$ with polarity shown in figure 1 (without brackets). As the current $id$ passes, the capacitor discharges, then begins to charge with the opposite polarity. Due to the charge of the capacitor, the voltage at the “n” and “m” points begins to decrease. At the beginning of the considered interval, the load current in is equal to $id$, to this working condition of the circuit corresponds to ORS-1, shown in figure 2.

**Figure 2.** Operator replacement scheme ORS-1 type.

At a certain moment, the voltage between the points “n” and “m” becomes equal to zero, after which the equality of the currents in and $id$ will break, as part of the current in will start to flow along
the circuit: diodes - smoothing choke load (VD1-VD4-Ld-H). At the same time, the capacitor continues to be charged with the current $i_d$, this condition of the circuit corresponds to ORS-2, shown in figure 3.

![Figure 3. Operator replacement scheme of the ORS-2 type.](image)

Then, when the voltage of the capacitor reaches its maximum value $U_{co}$ with c polarity shown in figure 1 in brackets, the current $i_d$ becomes zero, and the thyristors VS1, VS4 are locked. Further, the load current flows through the circuits VD4-VD3-Ld-H and VD2-VD1-Ld-H. This state corresponds to the OPS-3 operator scheme presented in figure 4. The process of this operator circuit continues until the supply of the trigger pulses to the next pair of power thyristors (VS2-VS3).

![Figure 4. Operator equivalent replacement scheme type OPS-3.](image)

The electromagnetic processes of the next clocking interval from the moment of supplying the trigger pulses to the VS2-VS3 power thyristors and before the opening of the next pair (VS1-VS4) proceeds along the same three operator replacement circuits (figure 2, 3 and 4), and the process itself develops similarly to the above.

![Figure 5. Timing charts of currents when starting the SPS.](image)

Thus, in the transition process involved three structures of the power circuit with the corresponding ORS. Further, for each ORS, equations for the desired currents and voltages were compiled on the
basis of Kirchhoff's laws, formulas for their images were obtained, and then their originals were obtained. Further, programming the obtained analytical expressions and the development paths 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 currents and voltages sought are presented in figure 5 and 6.

![Figure 6. Timing diagrams of voltages at the start of SPS.](image)

On the basis of a series of computer studies using the developed mathematical model (algorithm and program), the recommended parameters and the nominal values of the elements of the SPS scheme based on a serial inverter were obtained and are presented in the table below.

| №  | Designation in the scheme | Tip scores         | Amount     |
|----|--------------------------|--------------------|------------|
| 1  | VS1, VS2, VS3, VS4       | PM25-8             | four       |
| 2  | VD1, VD2, VD3, VD4       | HF200-3            | four       |
| 3  | C                        | K75-10-1mkf-1000V  | 6 parallel |
| 4  | Ld                       | 100 μH             |            |
| 5  | L                        | DKSSh-3000         |            |

Summarizing the above, it can be said that by obtaining a solution in general form in the form of a list entry of analytical recurrence relations, it is provided: visibility, accuracy and formality in the implementation of the program implementation of the model and its further use, which creates, in turn, the prerequisites for high-quality and efficient work designers in the development of a subclass of converters with recommended parameters and types of elements of an SPS circuit based on a serial inverter, decree data above in the table 1.

References
[1] Zinoviev G S 2001 *Fundamentals of power electronics: Textbook* (Novosibirsk: Publishing house of NSTU) 199 p
[2] Suker K 2008 *Power Electronics. Developer's Guide* (M.: Dodeka-XXI Publishing House) 252 p
[3] Umarov Sh B, Abdullabekov I A, Dusmatov R K and Fayzullaev B Kh 2018 *Mathematical models of stabilized power sources based on current inverters* (Modern technologies)