DEVELOPMENT AND STUDY OF THE OPERATING MADE OF A PROGRAMMED CURRENT SOURCE FOR SCANNING ELECTROMAGNET OF TECHNOLOGICAL ELECTRON LINACS

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Technological electron linacs are equiped by electron beam-scanning systems at the accelerator exit which create of a demanded radiation special zone [1]. The electromagnet of the scanning system is placed at the linac disposed in the bunker. It is energized from the source of the current, situated in the operator panel and connected with the electromagnet by a feeder (its length is 80 m). The source of the current is the powerful low-frequency amplifier (PA), which is energized by the scan voltage formed in the drive generator (AG). Three-phase rectifier provides a power supply for the device. Main technical features of the scanning system [3] are shown in the Table 1.

Table 1

Swing of output current	±30 A
Scan frequency	3,0 Hz +3%
Minimum swing of current	± 5 A
r_{out} of amplifier	0,18 Ω
Increase in velocity of an impulse front	1 ms
Load parameters of electromagnet	$r_м$ = 0,12 Ω $l_м$ = 9,3 mH

Two drive generators have been device for the current source of the scanning system. The analog AG gives a possibility for the accelerator can work with linear scanning and the numerical AG allows one to program a scan voltage form for the research and special work [2]. Now we will briefly remind a composition and structure of the numerical AG. Device reads numerical code from his read only memory (ROM) in cycle and convert it into the scan voltage signal. The numerical AG contains adjusting cascades and ensures a matching with PA, as well as work in the mode on-line within the automatic linac control system. Fig.1 represents the block- scheme of numerical AG.

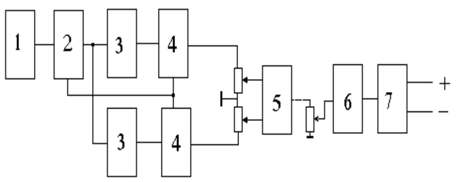


Fig. 1. 1. Pulsing generator, 2. ROM address register, 3. PROM, 4. DAC, 5. Adder for signals from two channels, 6. 7. Buffer cascades.

Parameters numerical AG are provided in table 2.

Table 2

Frequency scan range	0,5 ÷ 5 Hz
Voltage amplitude AG	± 28 V
Number of levels of amplitude	256
Number of spots in the scan half-time of one polarity	128
Number of channels defining the voltage scan form	2
Amount of programs in memory	16

The experimental stand with the real source of the current and load-magnet-scanner without the long feeder line was collected for the simulation of the different work regimes and their reset (Fig.2).

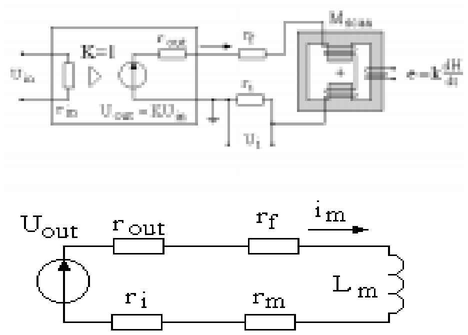


Fig.2. Simplified equivalent scheme of output cascade of the scan block with load elements (in the top); scheme for calculation of the relation between U_{out} and current of the magnet-scanner (in the bottom). U_{in} is the voltage created by the drive generator at the input resistor of the output cascade, U_{out} is the output voltage of the scan block, K is the voltage transmission coefficient, r_f- is the feeder resistance, M_{ska} is the magnet-scanner, L_m is the magnet winding inductance, r_m is the winding resistance, r_i is the measuring resistor, E is e.m.f. of the detector recording the speed of changes of the magnetic field dH/dt, r_{out} is the output of resistor.

Usually one uses the low frequency (of the order of magnitude of several Hz) for scanning the electron beam. Therefore, it is possible to represent the scanning magnet as a consequent connection of an inductance and active resistor. Then we can write an equation, connected output voltage with the magnet winding current:

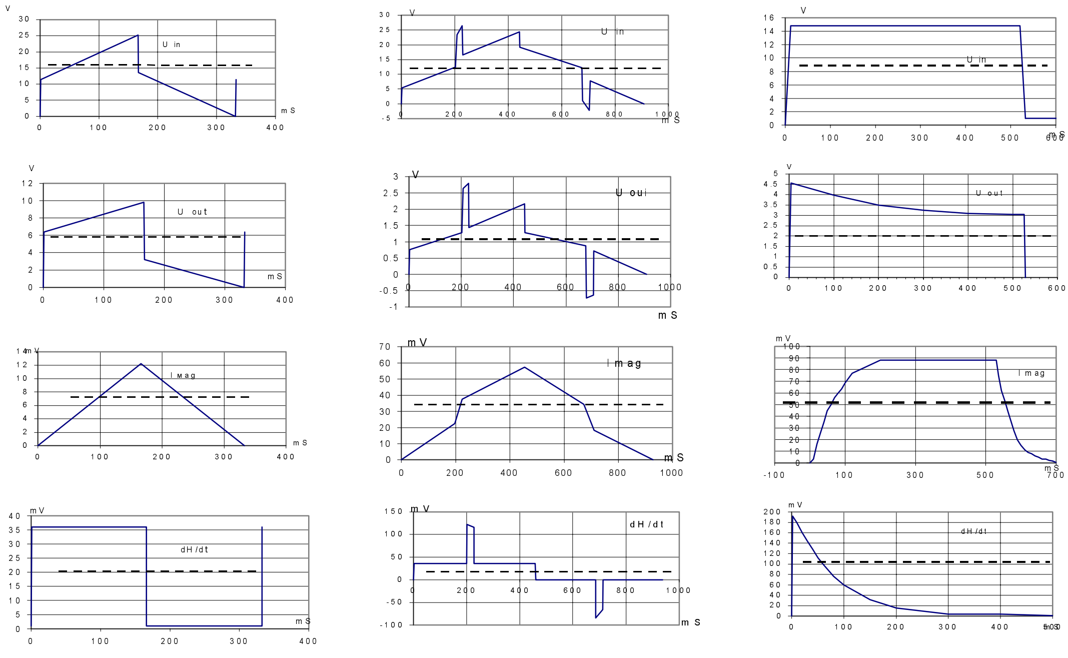
$$U_{out} = i_m * (r_{out} + r_f + r_m + r_i) + l_m * \frac{di_m}{dt} \quad . \qquad (1)$$

If we introduce the efficient resistance of the output circuit $r_{ef}=r_{out}+r_f+r_m+r_i$, then (1) will look like:

$$U_{out} = i_m * r_{ef} + T_{ef} * \frac{d(i_m * r_{ef})}{dt} \quad , \qquad (2)$$

where $T_{ef} = \frac{l_m}{r_{ef}}$ is the efficient time constant of the magnet. In our case the density distribution of the electron beam defines the time dependence of the magnet field $H(t)$ (and, respectively, of the current $i_{M(t)}$). If the output voltage is represented as the sum of two components $U_{out} = U_1 + U_2$, where $U_2 = T_{ef} * \frac{dU_1}{dt}$, then the magnet circuit current is determined, according to relation (2), only by the component $U_1=I_M \cdot r_{ef}$ and initial conditions $U_{1(0)} = i_{m(0)} * r_{ef}$ at $t=0$. The optimal relation between U_2 and U_1 essentially depends on the ratio $\frac{T_{ef}}{T}$ (T is the time of the half-cycle of the scan) and requires the changing with modification of the beam scanning frequency.

The special regime was created in the described scan block for ensuring measurement of the value l_m, T_{ef} r_{out}, r_m under conditions similar to a basic operating mode. For this the output voltage U_{out} was formed in the manner of two polar rectangular pulses of a length near 500 ms (Fig.3c), that ensured a switching of the magnet-scanner from the mode with the current $-I_0$ in the mode with the current $+I_0$. The data on the transitional process for current i_m and the voltage on the magnet terminals allow to get the above mentioned values. In result of measurements it was obtained: $l_m = 27{,}4$ mH, $r_m + r_i = 0{,}165$ Ω, $r_{out} = 0{,}17$ Ω, $T_{ef} = 82$ ms, when $r_i = 0{,}05\,\Omega$ and $r_f = 0$. It is necessary to note here that the measurements of the magnet-scanner inductance with the core plates of a 2 mm thick at frequency 50 Hz give the values essentially less of that above mentioned. But the similar measurements at the frequency of the measuring bridge (1000 Hz) give the values which differ from working values in several times. The regime of the beam scanning for the linear scan (Fig. 3a) and the regime, in which the center target area got the doze less than the target edges (Fig. 3b), were calculated and programmed after refinement of the parameters of system elements. The results of the experimental check have been introduced on the signal oscillogramms: U_{in}, U_{out} amplifier, I_{mag} and detector dH/dt.



a **b** **c**

Fig.3. The experimental signal oscillogramms.

CONCLUSIONS

The investigation of the programmed current source for the beam scanning system has shown the possibility of flexible regulation of characteristics of electron beams at a linac exit.

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