

SELF-EXCITED GENERATOR SYSTEM OF RF -POWER SUPPLY OF THE ONE-SECTION LINEAR ION ACCELERATOR

*L.D. Lobzov, N.G. Shulika
NSC KIPT, Kharkov, Ukraine*

The paper presents the block-diagram of a RF-power supply system of a single-section linear ion accelerator and the results of experiments on studying its mode of operation with changing the parameters of circuits of positive back coupling of the radio-frequency (RF) amplifier channel.

PACS number: 29.17.+w

The development of a high-stable self-exciting generator system of RF-power supply with a minimum number of amplifier stages for the accelerator MLUD-3, when upgrading its accelerating structure [1], was dictated by a number of advantages, which are considered to be characteristic for self-excited oscillation systems [2].

However, introduction of one positive back coupling (any), for energization of the amplifier channel, during correlation of the amplitude-phase relations in a self-excited oscillator circuit, did not provide its steady operation, because of a multipactor action being developed in the accelerator. Attempts to use the experts' experience accumulated in the field of development of similar systems [3] did not give the needed results because of features inherent in accelerating structures with variable-phase focusing on the comb-shaped holders of drift tubes and operation at H- mode oscillation [4].

tor resonator, and the loop of another is in the feeder of a power at which induced is the voltage proportional to the amplitude of an incident wave) allows to create a self-excited generator system of the RF-power supply of the accelerator effectively overcoming the multipactor effects and providing the steady operation of the amplifier channel and the accelerator in a whole [5, 6]. It is explained by the fact, that the mode of self-excited generation in the second circuit does not depend on the processes acting in the resonator, into which an appropriate part of a power arrives, providing violation of multipactor phenomena conditions.

This paper presents the results of investigations performed at the accelerator MLUD-3, taking into account the changes of some parameters of its self-excited generator system of RF-power supply.

The block-diagram of the self-excited generator system of RF-power supply of the single-section linear ion accelerator used for investigations is shown in Fig. 1.

The three-stage amplifier channel, with the amplification factor (~ 100) chosen taking into account the provided amplitude relations of the self-excited generation system, is covered by two positive back coupling, the signals of which are controlled by continuous attenuators and phase changers. The perturbation of accelerating fields entered into its resonator by a loop of positive back coupling does not exceed the value 1%.

The control of power mode transmission into the accelerator is made with measurement of a signal amplitude from the resonator and with measurement of incident and back wave amplitudes, both in a power feeder, and in circuits of positive back coupling.

The accelerator resonance frequency in a pulse mode is measured with the help of the equipment, comprising a frequency mixer, generator, frequency counter and oscillograph. The frequencies of self-excited oscillations at each of circuits are determined by a frequency of a high-Q resonator of the accelerator ($Q_{res} \approx 5000$). The study of the influence of the first positive back coupling (FPBC) and the second positive back coupling (SPBC) circuits together with their loops, placed, in corresponding points at a resonance frequency of the accelerator, was conducted in the mode of "cold" measurements. Within the accuracy of measurements ± 5 kHz the resonance frequency of the accelerator does not vary when connecting both together, and separately the indicated circuits, that is confirmed by the "weakness" of their influence on electrodynamic parameters of the accelerator.

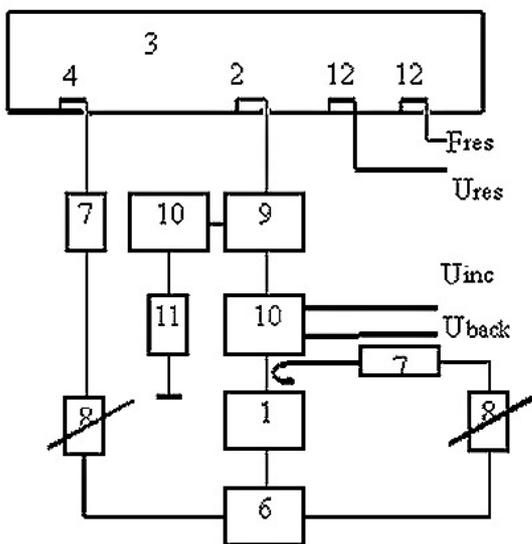


Fig. 1. Block diagram of the self-excited generator of RF power supply of the single-section linear ion accelerator.

1 – amplifier channel; 2 – loop of power supply; 3 – resonator; 4 – loop of the first positive back coupling; 5 – loop of the second positive back coupling; 6 – summarizing device; 7 – attenuator; 8 – phase changer; 9 – feeder commutator; 10 – feeder reflectometer; 11 – resistance; 12 – measuring loop.

Usage of superpositions of two positive back coupling (the loop of one of them is placed in the accelera-

Study of the relation of amplitudes of FPBC and SPBC signals in an operation mode of the accelerator have allowed to install the value of a SPBC signal in limits (0.1÷0.3) of the first positive back coupling amplitude, when simultaneously a high-stability operation of the accelerator is provided, and the value of an accelerating field is determined by a signal amplitude from the resonator.

In the plots (Fig. 2-Fig. 5) shown are the dependencies of basic parameters of the accelerator for changing, in limits $\pm 90^\circ$, the phase of positive back coupling of one of circuits, while another circuit has an optimum phase tuning.

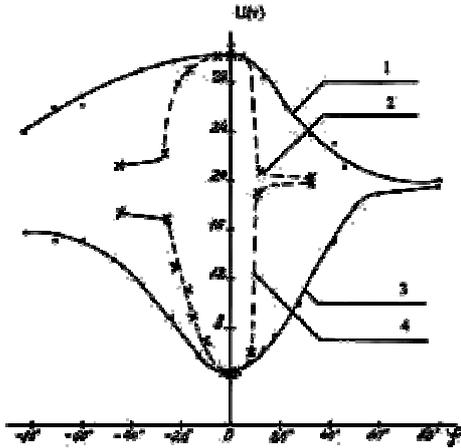


Fig. 2. Voltage amplitude of incident and back waves in feeder power supply as a function of back coupling signal phases: 1 - $U_{inc} = f(\varphi_{FPBC})$; 2 - $U_{inc} = f(\varphi_{SPBC})$; 3 - $U_{back} = f(\varphi_{FPBC})$; 4 - $U_{back} = f(\varphi_{SPBC})$.

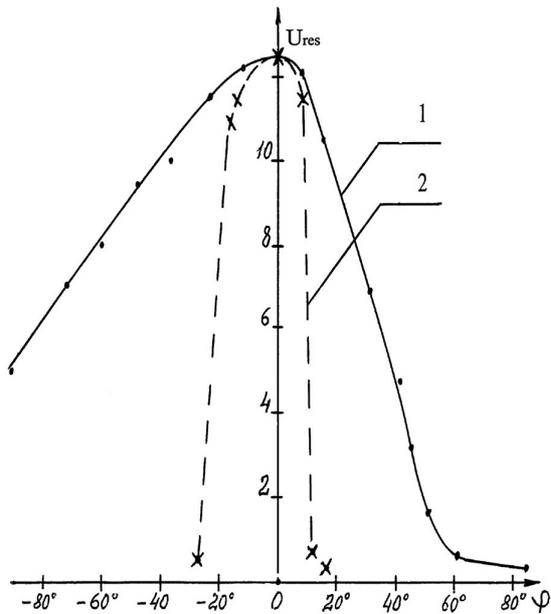


Fig. 3. Voltage amplitude with resonator measuring loop as a function of back coupling phases: 1 - $U_{res} = f(\varphi_{FPBC})$; 2 - $U_{res} = f(\varphi_{SPBC})$.

From the dependencies observed it follows that the required parameters of the accelerator describing the mode of matched power transmission into the accelerator, are supported by phase control in circuits of positive back couplings in limits $(1\div 2)^\circ$. The change of the matching degree is controlled by the back wave amplitude in a power feeder and together with measurements of basic parameters determines the operation mode of the accelerator.

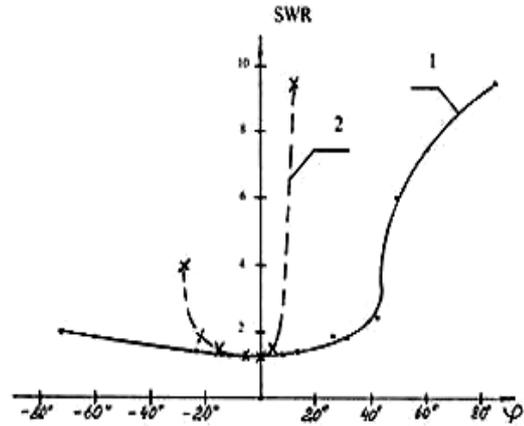


Fig. 4. Voltage standing wave rate in feeder power supply as a function of back coupling signal phases: 1 - $SWR = f(\varphi_{FPBC})$; 2 - $SWR_{nc} = f(\varphi_{SPBC})$.

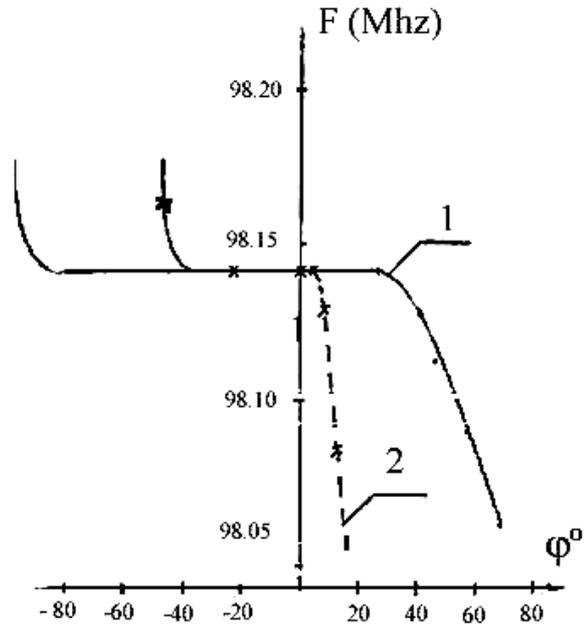


Fig. 5. Basic frequency of the resonator accelerator as a function of back coupling signal phases: 1 - $F_{res} = f(\varphi_{FPBC})$; 2 - $F_{res} = f(\varphi_{SPBC})$.

The present research allows one to determine the requirements for design of automatic controls stabilizing the amplitude and accelerating field phase in the accelerator, that will facilitate the maintenance of the accelerator and essentially will increase the reliability of its operation.

REFERENCES

1. A.S.Beley et al. Project of upgrading the accelerating structure of a small-size linear deuteron accelerator // *Voprosy atomnoj Nauki i Tekhniki. Ser.: Tekhnika fizicheskogo ehksperimenta.* (35). 1987, v. 4, p. 8 (in Russian).
2. *Linear Ion Accelerators.* v. 2 / Edited by B.P.Murin, Moscow, Atomizdat, 1978, 144 p. (in Russian).
3. V.A.Popov. *System of radio-frequency excitation of JINR LU-20 Synchrotron.* Preprint 9-11835, DUBNA, 1978.
4. L.N.Baranov et al. Experimental research of the small-sized linear accelerator of the 3 MeV deuteron energy 3 MeV with variable-phase focusing // *Voprosy atomnoj Nauki i Tekhniki. Ser.: Linejnye uskoriteli* (5). 1977, v. 2, p. 12 (in Russian).
5. L.D.Lobzov et al. *Radio-frequency self-excited generator.* License SU N1700783 A1, Bull. of invention N 47, 1991, p. 239 (in Russian).
6. L.D.Lobzov et al. RF self-excited generator of the linear ion accelerator // *XII All-Union Workshop of Linear Accelerators of Charged Particles (Kharkov, May 28-30, 1991)*, Abstracts, p. 51 (in Russian).