METHOD OF SUPPRESSING THE MULTIPACTORING DISCHARGES

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The present paper describes a method of suppressing the multipactoring discharges between electrodes in an accelerating structure of an evacuated resonator of an accelerator. The method consists in synchronous exciting the superposition of radio-frequency electric fields at a resonator operating frequency from two self-excited oscillatory circuits, the parameters of one circuit being independent on the shunt effect of discharges being suppressed.

In this method the priority of fields is of equal value with meeting the condition that every of them could ensure the exceeding of the upper discharge range limit of any multipactoring which appears, while another field provides a main contribution into a required level of the operating electric field in the accelerator.

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The multipactoring discharges (the secondary electron resonance discharges), observed in evacuated resonators of linear and cyclic accelerators at an initial stage of RF power input, can cause the failing of the stable operation of accelerators. Thereby, the multipactoring can appear not only between the electrodes of the accelerating structure but also in different spaces with conditions for its resonance development (both for two-electrode and single-electrode discharge at the resonator surface, input hermetizing window, etc) [1].

The above-mentioned multipactoring exerts an influence being the most dangerous for stable operation of the single-resonator accelerator with a simplified (1-3 cascades in the oscillatory channel) self-oscillatory RF power supply system with a positive feedback (PFB) from the resonator, due to the change of equivalent accelerator parameters and disturbance of self-excited oscillator amplitude ratios**,** as well as during operation of the self-excited oscillator with an internal or external PFB onto the evacuated resonator due to disturbing the conditions of matched power transmission into the accelerator.

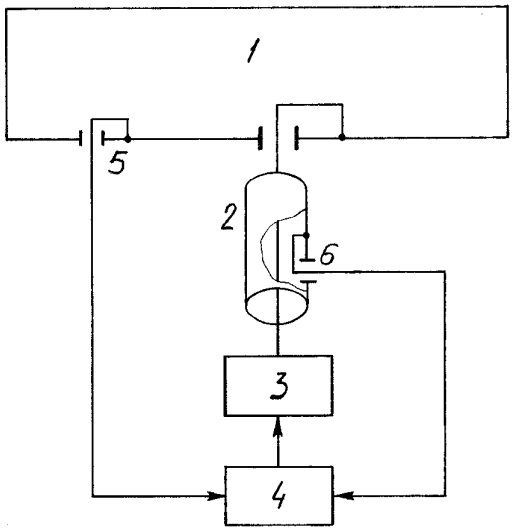
To prevent the multipactoring action some precautions are taken to decrease the secondary-electron emission coefficient, namely: coating the radio-frequency surfaces with a thin layer of titanium-nitride [2], changing the electrode shape [3], setting the additional electrodes, nearby but off the working gaps, with applying into them a positive (electron "absorbing") voltage of several kilovolts [4]. The effective technique of suppressing the multipactoring is the frequency modulation of the working electric field being excited in the self-excitation mode with PFB from the evacuated resonator by applying the voltage of an additional oscillator (AO) having a frequency different from the accelerator working frequency. The voltage is turned off after passing the region of the multipactoring build-up [5] and so on. However, all these special precautions are accompanied by the increase of radio-frequency losses that deteriorates the equivalent parameters of the accelerator resonator such as a figure of merit, shunt resistance, electric strength. The electric circuits and design performance, as well as the process of adjustment and maintaining of the accelerator become more complicated.

The proposed method for suppressing the multipactoring is based on the synchronous excitation of radio-frequency electric fields at a frequency of the evacuated resonator working oscillation from two self-oscillatory circuits operating for the general resonator. One of the circuits with a positive feedback from the resonator can ensure the conditions for developing and existing the discharge, and the other one, independent on the discharge shunt influence, provides a constant gain of the resonator working field amplitude thereby disturbing the amplitude conditions for the multipactory does not have a time to build-up and exist [6].

The effective suppression of the multipactoring discharges in the evacuated resonator, by synchronous excitation, from the single self-excited oscillatory rf power supply system, superposition of two rf electric fields, was realized at a single-resonator accelerator MLUD-3 (small-size deuteron linear accelerator) [7].

The resonator accelerating structure [8], formed with the use of drift tubes attached on the comb-shaped holders, consists of sixteen parallel accelerating gaps spaced at a distance increasing from 1.353 cm (first gap), 1.753 cm (second gap) and to 6.422 cm (last gap). The resonant frequency of accelerator is 99.34 MHz, Q-factor is ~5000. The radio-frequency power from the three-cascade linear amplifier channel embraced by two oscillatory circuits with positive feedbacks (a coupler loop of the one is mounted in the resonator and a coupler loop of the other is mounted in the feeder) enters into the accelerator in the pulse mode with a pulse length of 250 μsec and pulse repetition rate of 1Hz. Input and output circuits of high-frequency cascades of the amplifier channel are tuned to the working frequency of the accelerator resonator. The input impedance of the resonator corresponds to the wave impedance of the feeder.

The working pressure is $P=5\cdot10^{-5}$ mm Hg. The operating principle of this method is explained in the figure with the following designations: 1 – evacuated resonator of the accelerator with a power input element, 2 – coaxial feeder, 3 – amplifier channel, 4 – summator, 5 – coupler loop mounted in the resonator, 6 – coupler loop mounted in the feeder.



Applying the electric voltage to the oscillator tube of the amplifier channel, noise, and then rf-oscillations, go through the feeder to the loop power supply resonator accelerator. While doing this, at the element PFB mounted in the resonator, a voltage is induced, which is proportional to its shunt impedance, and at the element PFB mounted in the feeder, a voltage is induced, which is proportional to the output power of the amplifier channel. The total voltage, being the sygnal of amplifier channal excitation, determines the value of its output RF power and, respectively, the level of electrical field in accelerating gaps of resonator. The synchronism superposition of electrical fields in the accelerator origins because of the frequencies of self-oscillation of each chain are determined by the working frequency of the high-quality resonator.

During preparation of working surfaces and accelerating structure electrodes for initiation of electron release, under RF heating condition from the self-excited oscillator circuit with PFB from the resonator, in the first gap of the accelerating structure there arises the multipactoring evoking the failing of the required level of the accelerator electric field stability, but maintaining the conditions for existence of the discharge with a definite intensity.

Connecting the self-oscillatory circuit, the positive feedback of which couples the output of the amplifier channel with its input, provides an increasing character of synchronous excitation of another electric field in the resonator.

While one of the electric fields initiates and provides conditions for building-up of the the multipactoring, the second electric field, being excited by the oscillatory circuit independent on the processes taking place in the resonator, automatically increases the resulting electric field amplitude in the gaps thereby disturbing the amplitude conditions of the multipactoring existence.

In the case of simultaneous operation of the two oscillatory circuits, the amplitude conditions of multipactory phenomena are disturbed from the very beginning of electron release and prevent from multipactoring.

The offered method for suppressing the multipactoring based on synchronous excitation of radio-frequency electron fields in the accelerating channel of the accelerator from the two independent self-oscillatory circuits embracing the amplifier channel of the evacuated resonator RF power can be used for distinguishing the type of discharges when their unambiguous interpretation is complicated.

REFERENCES

1. *Ion linear accelerators.* Edited by B.P. Murin. Moscow: “Atomizdat”, 1978, v. 2, p. 135 (in Russian).
2. W.D. Cornelius. *CW operation of the FMIT RFQ accelerator.* IEEE Transaction on Nuclear Science, V. NS-32, №5, October, 1985, p. 3139-3143.
3. D.K. Aitken. Long-transit-time multifactoring at ultra high frequencies, and the effect of surface emitting layers // *Proc. IEEE.* 1958, v. B105, Suppl., №12, p. 824-828.
4. B.I. Polyakov, B.T. Zarubin, B.B. Kushin. *Electrical strength of the small accelerating gap*. Transaction of Radio-Technical Institute of Acad.of Sciences USSR, v.1, №2, 1959, p.93 (in Russian).
5. V.G. Andreev, D.G. Zajdin. *Method of suppressing the secondry electron resonace discharche*. Inventor’s Certificate №263767. Bull. of Invention №8, 1970 (in Russian).
6. L.D. Lobzov et al. *Radio-frequency self-excited oscillator.* Licence SU №1700783 A1, Bull. of Invention №47, 1991 (in Russian).
7. L.D. Lobzov, Y.P. Mazalov, E.V. Gusev, N.G. Shulika. *Investigation of multipactoring in the H-type resonator of the linear ion accelerator*. Proc. of XIII Conf. on Charged Particle Accelerators, Dubna, 1993, v. 1, p. 269-273 (in Russian).
8. A.S. Beley et al. Project of upgrading the accelerating structure of a small-size deuteron linear accelerator // *Voprosy Atomnoj Nauki i Tekhniki, Ser.: Tekhnika fizicheskogo eksperimenta (35).* 1987, № 4, p. 8 (in Russian).