CONSTRUCTIONS OF DC POTENTIAL INPUT INTO RESONATOR OF LINEAR ACCELERATORS

S. M. Polozov, P. R. Safikanov
National Research Nuclear University "MEPhI", Moscow, Russia

Abstract

Nowadays using of the dc potential was proposed for ion beam transverse focusing in linear accelerators. It was proposed to use the dc potential for combined beam focusing (electrostatic focusing and focusing by means of high order RF field spatial harmonics) in bunching section of linac [1]. An IH-resonator can be used for these targed. So-called linear undulator accelerator (UNDULAC) was proposed for ribbon ion beam bunching and acceleration [2]. One of the possible scheme of UNDULAC-E can be realized by means an electrostatic undulator in E-type resonator. In this report the different types of the electrostatic potential input into resonator will be discussed.

INTRODUCTION

Nowadays a lot of papers were appeared, where it is suggested to use RF field with dc potential in resonator.

The undulator linear accelerator with electrostatic undulator (UNDULAC-E) was considered in [2-3]. Beam acceleration and focusing in such system are realized by the force which is to be driven by combination of two or more non-synchronous spatial harmonic (RF and electrostatic field). This acceleration mechanism is similar to that for the inverse free electron laser (IFEL). In UNDULAC with electrostatic undulator it is possible to accelerate the ribbon ion beam. Increasing the beam current can be achieved by accelerating the ribbon beams.

The E-type resonator can be used for the accelerating system for the UNDULAC.

In [4] was suggested to use dc potential with a sequence of potential between drift tubes for increasing of the focusing efficiency for low energy ion beams. A supply of electrostatic potential to even drift tubes was designed by means of the blocking capacity.

It was also undertaken several attempts of using dc field for the multipactor discharge control. It reduces the possibility of electron avalanche appearance as a result of resonance condition violation.

The different types of electrostatic potential input in E-type and H-type resonators are studied in this article.

The purpose of this article are: conventional IH-resonator (see Fig. 1), H-funnelling resonator at frequency 150 MHz and π mode of RF-field and E-type resonator with 150 MHz and 2π mode. These structures will be compared in terms of electrodynamics efficiency: quality Q-factor and shunt impedance R_{sh}.

IH RESONATOR

The computer simulation of RF field distribution in IH-resonator was done and electrodynamics characteristics of structure were calculated. The general view and parameters of resonator is shown in Fig.1. Q-factor and shunt impedance of resonator without dc input are Q=10940 and R_{sh}=100 MOhm/m correspondly.

Further the various types of dc inputs into resonator were studied. Most effective structure was determined. The input construction showed in Fig. 2 is similar to a plane capacitor. One of the plate is a T-shape vane, to which the even drift tubes are attached and the second plate is the resonator's side.

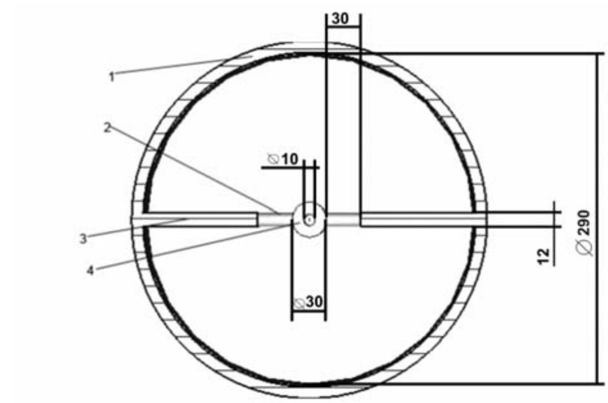
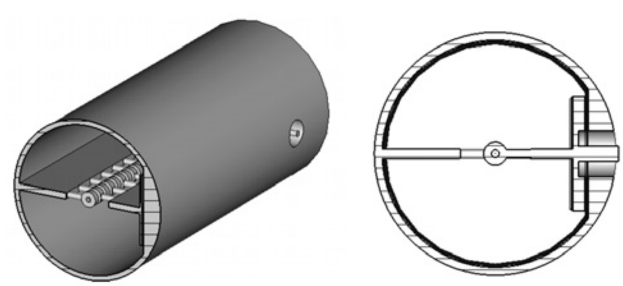


Figure 1: IH-resonator without electrostatic potential input. 1 – resonator, 2 – tube holders, 3 – vanes, 4 – drift tubes.



(a) *(b)*

Figure 2: IH-resonator with electrostatic potential input. (a) – perspective view, (b) – front view.

Computer simulation of RF field distribution in such structures was done. The field distribution at longitudinal axis of accelerating-focusing channel was calculated (Fig.3) and the electrodynamics parameters of the structure were calculated. After Q-factors comparing for several variants of electrostatic input? It was shown that the resonator with plate capacity has the more efficiency with Q=7550.

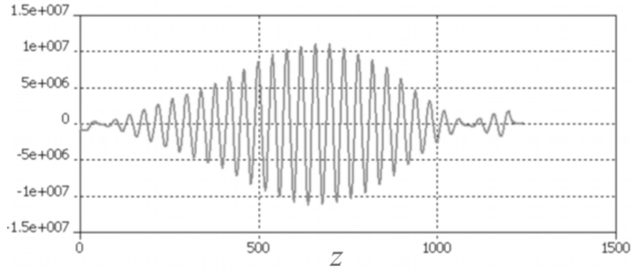


Figure 3: Distribution of E-field on longitudinal axis in IH-resonator with separator capacity.

Two contacts were placed in resonator side and are distant to λ/2. They are used for the supply of electrostatic potential to this structure. The internal hole diameters for contacts are chosen in terms of breakdown strength and no radiation from resonator. To decrease the radiation from supply hole the choke groove are used. Computer simulation of RF fields in resonator with two contacts supply and choke groove was done, the fields distribution and electrodynamics characteristic were calculated. It is clean by distribution of H-field showed in Fig.4.

As result the structure quality with supply has slightly decreased: Q=7350. The calculated shunt impedance is equal to R_{sh}=50 MOhm/m.

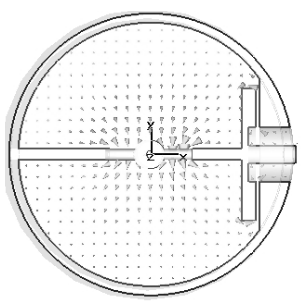


Figure 4: Distribution of H-field in IH-resonator with electrostatic input and the choke groove.

H-FUNNELING RESONATOR

The H-funnelling resonator was studied too. Computer simulation of RF field distribution without electrostatic potential supply was done initially (see Fig. 5), and electrodynamics characteristic were calculated. The quality and shunt impedance of H-type resonator without supply are Q=9800, R_{sh}=80 MOhm/m.

Three types of electrostatic potential supply in this H-resonator were considered. In Fig. 6a is presented H-resonator with one supply in the centre of resonator side. The contact is placed vertically below of inner resonator. Two supplies are placed at the side of resonator and distant to λ/2 (Fig.6b) in the second type. The supply contacts are placed vertically below of the inner resonator. The supply at the face surface is shown in Fig. 6c, contact is placed horizontally on the inner resonator here.

Computer simulation was done to define the optimal design of H-funneling resonator with electrostatic potential supply. The computer simulation of RF field distribution and electrodynamics characteristics were considered.

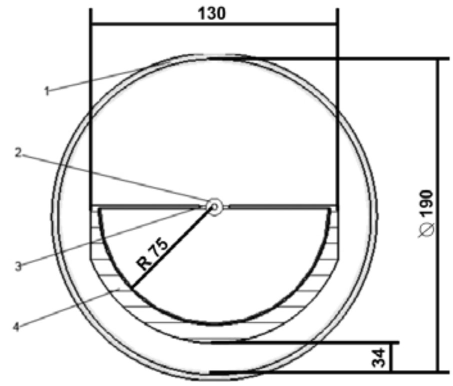


Figure 5: H-funnelling resonator without electrostatic input. 1 – resonator, 2 – drift tubes, 3 –vanes, 4 – inner resonator.

The RF field distributions are distorted by contact supply and supply holes.

Resonator quality was decreased as a result of introduced distortions. The minimal decreasing has the design with two contacts supply (Q=8900, R_{sh}=80 MOhm/m).

In such way the construction with two supply contacts at resonator side which distant from each other on λ/2 is optimal for H funneling resonator.

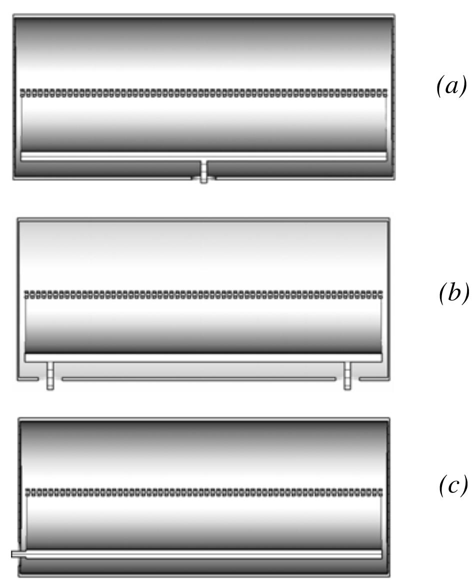


Figure 6: H-funnelling resonator, with: (a) – one supply at centre of side, (b) – two supplies at side, (c) – supplies at the face surface.

E-TYPE RESONATOR

The simulation of RF-field distribution was done for E-type resonator preliminary. It was done to match the resonator at the frequency 150 MHz and 2π mode of RF field.

Later the channel of structure was modified for ribbon ion beam acceleration (Fig. 7). The quality factor and shunt impedance were calculated: Q=51000 and R_{sh}=30 MOhm/m respectively.

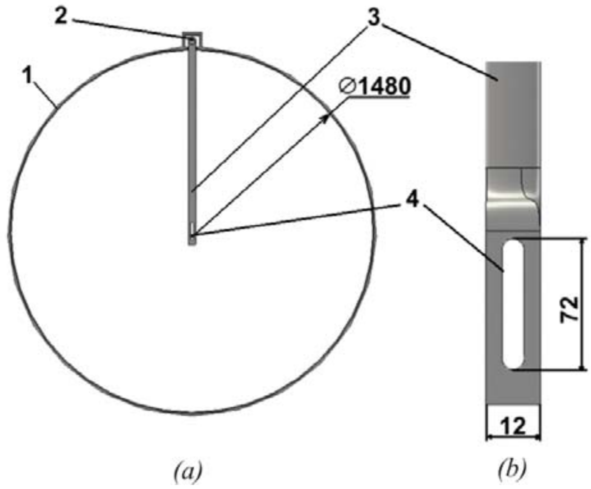


Figure 7: (a) - E-type resonator with electrostatic input; (b) – slot electrode for ribbon beam acceleration. 1 – resonator, 2 – common bus, 3 – electrode holders, 4 – electrode.

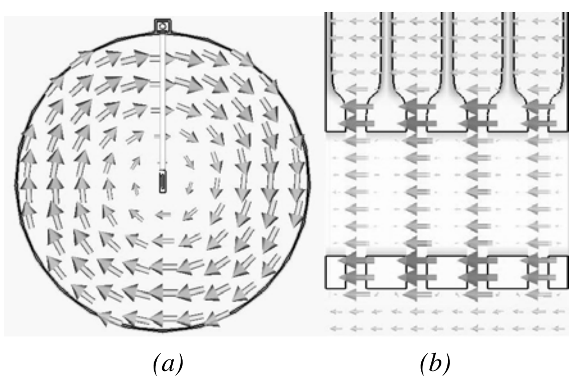


Figure 8: Distribution fields in E-type resonator with electrostatic input: (a) –H-field; (b) – E – field.

Several types of electrostatic potential input were considered. The optimal input construction was shown in Fig. 7. Electrostatic potential input was completed by connection of odd electrodes to the common bus under a constant potential; even electrodes were attached to inner side of resonator.

Computer simulation of RF field distribution was done. The distribution of field in E-type resonator was shown in Fig. 8. Electrodynamics parameters of structure were calculated: Q=50500 and R_{sh}=30 MOhm/m

It was concluded according the results of calculations that the electrostatic potential input in the E-type resonator does not reduce the structure electrodynamics efficiency.

CONCLUSION

Several types of electrostatic potential input into H-type resonator were described. Most effective accelerating structure design is defined by electrodynamics efficiency and construction simplicity. The optimal accelerating structure without electrostatic potential is IH-type resonator. It has high quality, low losses and is a simple to construct, as against H-funnelling resonator. In structures with electrostatic input electrodynamics efficiency is higher for H-funnelling resonator. The quality and shunt impedance reduce is smaller as for IH-resonator.

Unlike the H-type resonators, electrostatic potential input in the E-resonators has no effect on the structure electrodynamics efficiency.

REFERENCES

[1] Ye.V. Gussev, P.A. Demchenko at al., Problems of Atomic Science and Technology, Series "Nuclear Physics Investigations", 5(50), (2008) 28.
[2] E.S. Masunov. Sov. Phys. – Tech. Phys. 35(8), (1990) 962.
[3] E.S. Masunov et al., Radiation Physics and Chemistry 61 (2001) 491.
[4] V.S. Dyubkov, E.S. Masunov, Int. J. of Modern Phys. A 24(5), (2009) 843.