ELECTRODYNAMIC CHARACTERISTICS OF HIGH ORDER MODES IN BIPERIODIC ACCELERATING STRUCTURE

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The influence of coupling slot number and geometric sizes, and diaphragm thickness between cells on electrodynamic characteristics (EDC) of biperiodic accelerating structure (BAS) on main and dipole oscillation modes are investigated. The research is executed with the help of solution of a three-dimensional problem by computing methods. The adjustment possibilities of dipole mode frequency to keep out from the condition of multiplicity to frequency of working mode of oscillation were shown.
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1 INTRODUCTION

For creation of linear electron accelerators with a large beam current based on BAS there is a problem on possibility of dipole mode EDC modification with maintenance of the main mode EDC. The interest represents first of all a possibility of transverse shunt impedance (r_{shII}) modification and frequency spectrum of dipole modes. With this purpose we conducted the study of influence for the parameters of a number of coupling slots between cells, and also diaphragm thickness. The resonance frequency (f), longitudinal shunt impedance (r_{shII}), Q-factor (Q), coupling coefficient (k_c) on the main mode and also frequency, transverse shunt impedance ($r_{sh\perp}$) and Q on the dipole modes were calculated. The BAS tuning by means of slot size or diaphragm thickness modifications were conducted at the structure consisting of an accelerating half-cell and a coupling cell. Then EDC were calculated on main and high-order modes for sequential adding of accelerating cells (and coupling cells) up to 2, 3 and 4, respectively.

From high-order modes the greatest danger and, therefore, the greatest interest for study the dipole mode of the type E_{11} is represented. It is necessary to distinguish at least three variants of excitation of these modes: in coupling cells E_{11} (C), in accelerating cells E_{11} (A), and also the electrical field can be simultaneously excited in an accelerating cell and a coupling cell E_{11} (A) + E_{11} (C). Also there are frequencies with combined E_{11} and H_{11} modes, which differ one from other by a number of excited cells and localisation. In this case the following label is entered: E_{11} (C) + H_{11} (A).

2 STRUCTURES WITH DIFFERENT DIAPHRAGM THICKNESS

For a structure with two slots (see Fig.1) EDC on high-order modes were compared for the diaphragm thickness 3.5 mm and 5 mm. For such modification of the diaphragm thickness the structure characteristics on the main mode were practically maintained (r_{shII} = 54.9 - 54.2 MΩ /m, k_c = 7.3% - 6.2 %, respectively for t = 3.5 mm and 5 mm on the frequency π /2-mode 2856 MHz)[1].

It is necessary to take into account that only for an odd number of periods (1, 3, 5 etc.) it is sufficient to consider a high-order mode EDC only for one polarisation in consequence of such structure symmetry.

Let's consider two variants of accelerating structure sizes (see Table 1). Calculations were made for quarter of 3 periods.
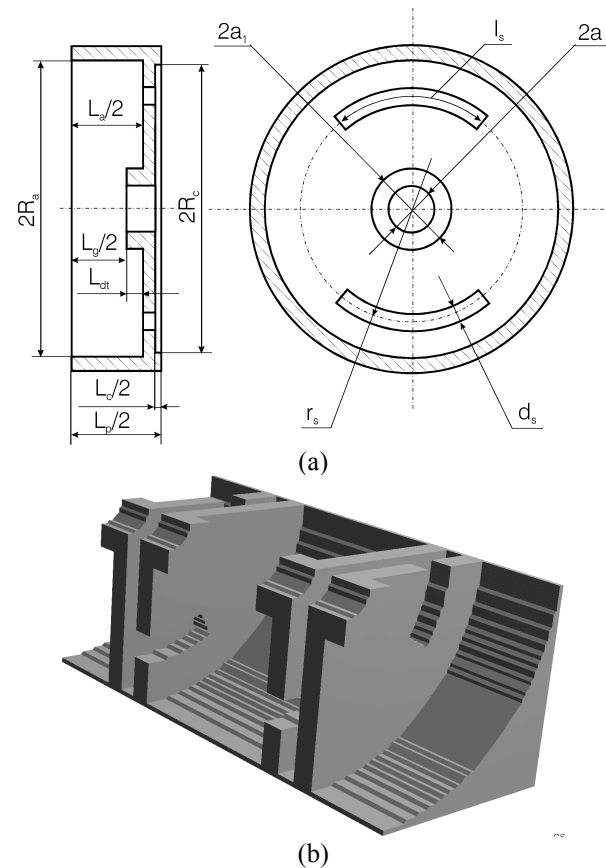

(a)

(b)

Fig. 1. Structure with two coupling slots in each diaphragm: dimensions (a) and quadrant cutaway for two periods (b).

Table 1. Structure' dimensions

	Structure I	Structure II
t, mm	5	3.5
Ra, mm	38.21	37.20
Rc, mm	34.84	34.28
La, mm	37.5	42
Lc, mm	5	3.5

In Table 2 the high-order mode characteristics for

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ВОПРОСЫ АТОМНОЙ НАУКИ И ТЕХНИКИ. 2001. №3.
Серия: Ядерно-физические исследования (38), с. 104-105.

Structure I and in Tab.3 - for Structure II are given.

It is seen from the tables, that the frequency spectrum was changed. The frequency magnitude of the dipole mode with a large transverse impedance was changed at 140 MHz. It allows to make conclusion about the dipole mode frequency adjustment possibility to keep out from the condition of multiplicity to frequency of working mode for diaphragm thickness modification**.** This is necessary for reduction of accelerated beam losses.

Table 2. EDC for structure I

Mode	t=5mm			
	f, MHz	Q	$r_{sh\perp}$, MΩ/m x,y=0.5mm	Type
1	4288.7	7073	0.097	$H_{11}(A_3)+E_{11}(C_2+C_3)$
2	4513.9	4594	3.212	$E_{11}(C_2+C_3)$
3	4513.9	4493	0.860	$E_{11}(C_1)$
4	4547.2	16910	0.194	$H_{11}(A_2)$
5	4731.0	5270	0.516	$H_{11}(A_3)+E_{11}(C_2+C_3)$
6	4826.8	19000	0.901	$E_{11}(A_2+A_4)$
7	4826.9	15570	12.283	$E_{11}(A_2+A_4)$
8	4858.1	9513	3.030	$E_{11}(A_1+A_3+C_1+C_2+C_3)$
9	4858.1	9465	0.589	$E_{11}(A_1+A_3+C_1+C_2+C_3)$

Table 3. EDC for structure II

Mode	t=3.5mm			
	f, MHz	Q	$r_{sh\perp}$, MΩ/m x,y=0.5mm	type
1	4157.9	8605	0.010	$H_{11}(A_2)+E_{11}(C_1+C_2)$
2	4368.1	16730	0.340	$H_{11}(A_3)$
3	4522.1	4373	1.262	$E_{11}(C_1+C_2+C_3)$
4	4522.2	4325	2.246	$E_{11}(C_1+C_2+C_3)$
5	4706.7	4778	0.522	$H_{11}(A_2)+E_{11}(C_1+C_2)$
6	4969.5	19470	1.608	$E_{11}(A_1+A_3)$
7	4969.6	16460	12.616	$E_{11}(A_1+A_3)$
8	4989.0	10920	4.400	$E_{11}(A_2+A_4+C_1+C_2+C_3)$
9	4989.2	11370	0.378	$E_{11}(A_2+A_4+C_1+C_2+C_3)$

3 STRUCTURES WITH DIFFERENT NUMBER OF SLOTS

Let us compare a high-order mode EDC for a structure with two, three and four slots. For comparison of EDC for different number of slots, we shall consider one period of a structure. In Fig. 2 the models of three structures are shown.
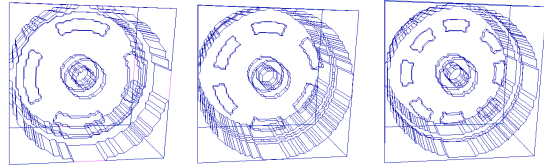

Fig. 2. Models of structures with two, three and four slots in each diaphragm, respectively.

It is necessary to note, that in case of choice of identical full square of two, three and four slots the coupling coefficient is equal to 7.74%, 3.30%, 1.85%, respectively. Therefore high-order mode EDC accounts for BAS with three and four coupling slots in each diaphragm were conducted for slots (for identical values of their widths and position concerning an structure axis), which would ensure an identical coupling coefficient on the main mode. It is provided with coupling slot length modification. The account results for three and four coupling slots are given in Table 4.

Table 4. EDC of structures with 3 and 4 slots

3 slots			4 slots		
f, MHz	Q	$r_{sh\perp}$, MΩ/m	f, MHz	Q	$r_{sh\perp}$, MΩ/m
4274.61	12320	0.01	4336.15	15950	0.16
4608.20	4438	1.03	4336.16	15950	0.02
4648.36	4691	1.26	4413.92	13131	5.26
4919.10	16740	4.18	4578.18	3608	0.01
4848.45	12430	6.89	4578.19	3630	0.34
4975.68	13090	0.06	4931.12	12730	4.41

Increase of a number of slots, for preservation of the constant k_c, practically does not affect on the longitudinal shunt impedance on a working mode. At the same time, the modification of dipole mode frequencies with a large transverse impedance is observed. It allows to make the conclusion about dipole mode frequency adjustment possibility to keep out from the condition of multiplicity to frequency of working mode of oscillation.

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