INPUT COUPLERS FOR THE DIPOLE MODE PERIODIC STRUCTURES

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Abstract

Three variants of the input coupler for the periodic deflecting structure, operating at hybrid dipole E_{11} mode, with the phase velocity equal to the light speed are considered: non-symmetric design and two symmetric designs with auxiliary rectangular waveguide and shorting plates in it along with auxiliary cut-off rectangular waveguide. The reflection coefficient dependences on the coupling window width and on the coupling cell diameter was been investigated for all these coupler variants. The reflection coefficient has been calculated in the whole dipole mode pass-band. The field asymmetry in the beam area has been investigated. The eigen frequency of the coupling cell has been calculated.

INTRODUCTION

Three input coupler designs have been developed for Transverse Deflecting System. 16-cell deflecting structure is shown on Fig.1 with three input coupler versions: non-symmetric coupler (a), symmetric coupler with shorting plates in additional waveguide (b) and symmetric coupler with cut-off additional waveguide. Three variants of the disk loaded waveguide (DLW), operating at 2997.2 MHz frequency and $2\pi/3$ mode, as a deflecting structure are considered: with two holes stabilizing the deflecting plane position, with two recesses at periphery cylindrical surface and with elliptical aperture hole [1].

SIMULATION MESH CHOICE

The simulation accuracy of the deflecting structure with two couplers in traveling wave operation depends on mesh used. The calculation of the TDS cell geometry has been done using 3-cell model with two coaxial couplers (Fig.2). The electric field distribution at $2\pi/3$ mode in resonant model and the tetrahedron simulation mesh in the traveling wave model are shown in Fig.2. The calculation has been done frequency band 2996.2 - 2998.2 MHz with frequency step df=0.05 MHz.

Figure 3 shows the number of mesh cells (a), reflection S_{11} (b) and tuning quality ratio K (c) depending on the number of simulation iterations for 16-cell deflecting structure with two couplers. The tuning quality ratio shows uniform distribution of the transverse electric field in the iris planes. The same mesh in 3-cell and in 16-cell models is equivalent to 64949 and 407464 tetrahedrons correspondently.

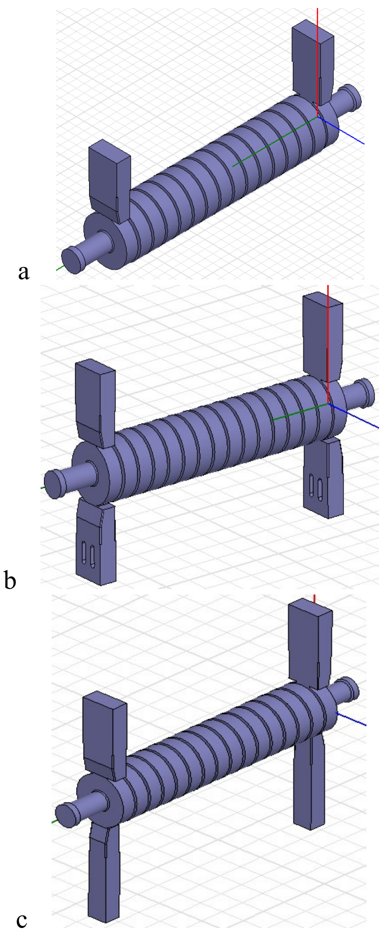


Figure 1: The deflecting structure with three input coupler variants.

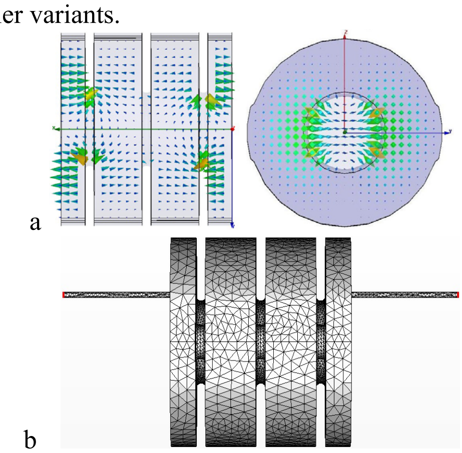
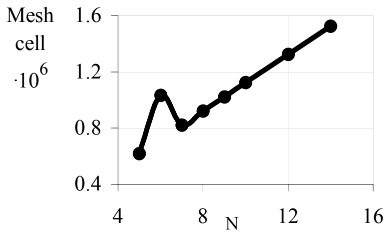
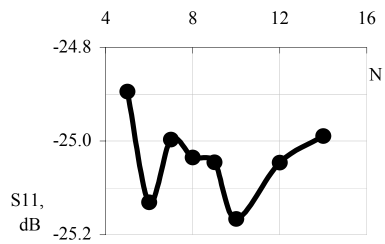


Figure 2: The field distribution in resonant model (a) and the mesh in the traveling wave model (b).



a



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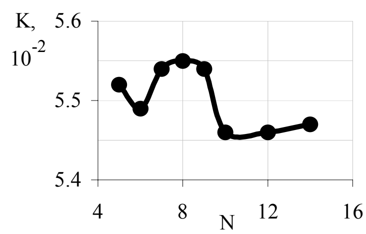


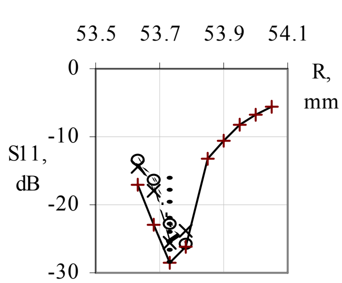
c

Figure 3: Dependences on the number of mesh cells.

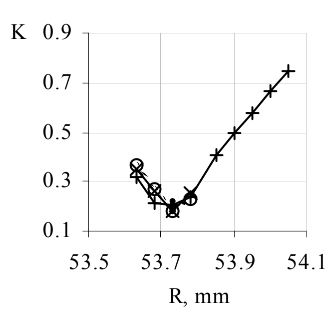
INPUT COUPLER TUNING

The simulation of the coupler with cut-off waveguide with 16-cell two stabilizing holes deflecting structure includes varying of the coupling window width X and the coupling cell radius R [2]. The reflection S_{11} in the input waveguide and the tuning quality ratio K are considered as tuning parameters. The reflection S_{11} in the input waveguide and the tuning quality ratio K depending on the coupling cell radius R and coupling window X are shown on Fig. 4. All dependences in f

Fig.4 presented for different X values: X = 32.15mm marked with "○", X = 32.25mm marked with "x ", X = 32.45mm marked with "+ " and X sweep X = 31.80 – 32.45mm for R = 53.68mm.



a



b

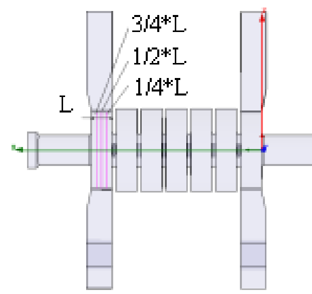
Figure 4: The reflection S_{11} in the input waveguide and the tuning quality ratio K depending on the coupling cell radius R and coupling window X.

FIELD SYMMETRY IN THE COUPLER

The transverse electric field asymmetry in the all variants of the coupler has been investigated. The field asymmetry is $\Delta E/E_1$, where $\Delta E=E_2-E_1$, E_2 is the field in the center of the coupling cell, E_1 is the minimal field strength value (Fig.5b). The field symmetry in the coupler with the plates in additional waveguides can be tuned changing of the plates position and changing of the coupling window for the additional waveguides.

The calculation has been done in three transverse cross-sections, shown in Fig.5a.

The calculation result of the field asymmetry for the three couplers are shown in Figure 5c. For three variants there are dependences: line marked with circles "○" for structure illustrated in Fig.1.c. For structure in Fig.1.a. line marked with rhombus "◊". And for structure from Fig.1.b. pointed with triangles "∆".



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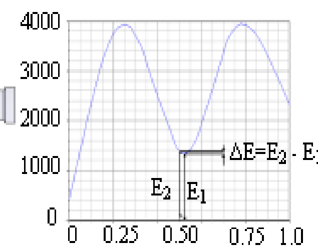

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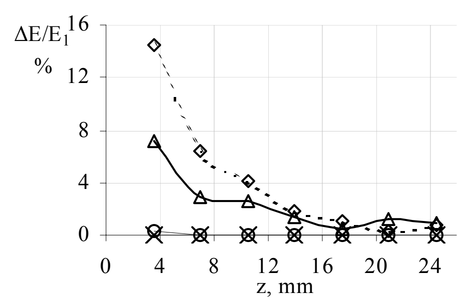

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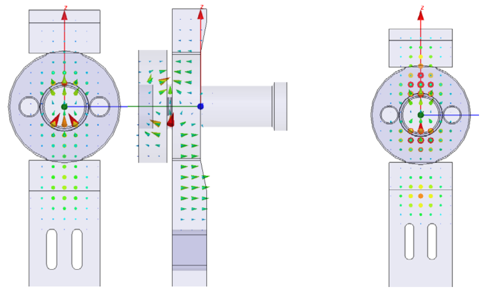
Figure 5: Cross-sections for the field asymmetry measurement (a) and the field asymmetry for the three couplers (b).

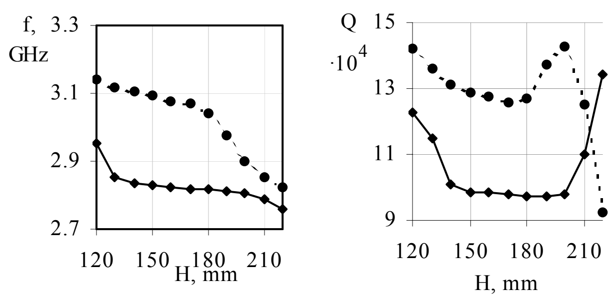
During the investigation of the coupler, shown in Fig.1b, additional resonances have been detected at the frequencies both lower than operation pass-band E_{11} and within it. The resonant frequencies depend on the plate position. The second cell has been detuned by addition plunger for the calculation of the first (coupler) cell frequency. The field distribution for two modes are shown in Fig.6.



a b

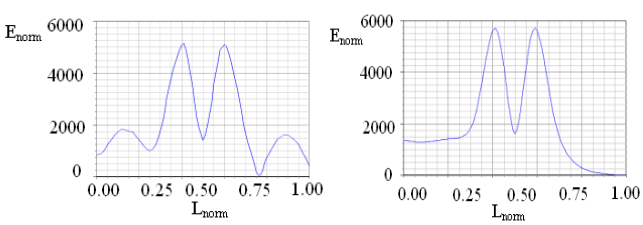
Figure 6: Electric field distribution at two modes.

Eigen frequencies and the Q-factors of the coupler cell at two modes depending on the plate position are shown in Fig.7. The frequency of one mode is below the operating frequency, and the second one is close to it. So the cavity in the additional waveguide may be excited at operating frequency. In Fig. 7 dash line for antiphased mode, constant line for cophasal mode.



a b

Figure 7: Eigen frequencies and the Q-factors of the coupler cell at two modes depending on the plate position.



a b

Figure 8: Distribution of the transverse electric field in the coupler cell along the waveguide axis in the coupler with the additional waveguide and the plates (a) and in the coupler with cut-off waveguide (b). Normalized length is L_{norm}=113.57 mm.

The coupler with cut-off additional waveguide is a chosen working variant [2].

AMPLITUDE AND PHASE OF DEFLECTING FIELD DISTRIBUTIONS

The amplitude and the phase per structure period of the deflecting field at the structure axis is shown in Fig.9.

MATCHING OF THE COUPLER

The calculated reflection S_{11} in the input waveguide for the structure with the coupler, shown in Fig.1c, in the frequency pass-band is shown in Fig.10. Similar data has been got for another couplers.

CONCLUSION

Performed investigations of different variants of the input coupler shown, that the variant with cut-off additional waveguide in preferable. There is no dangerous possibility to deriving of the power part to the resonance cavity in the additional waveguide, which could lead to the elongating of the filling time in the structure.

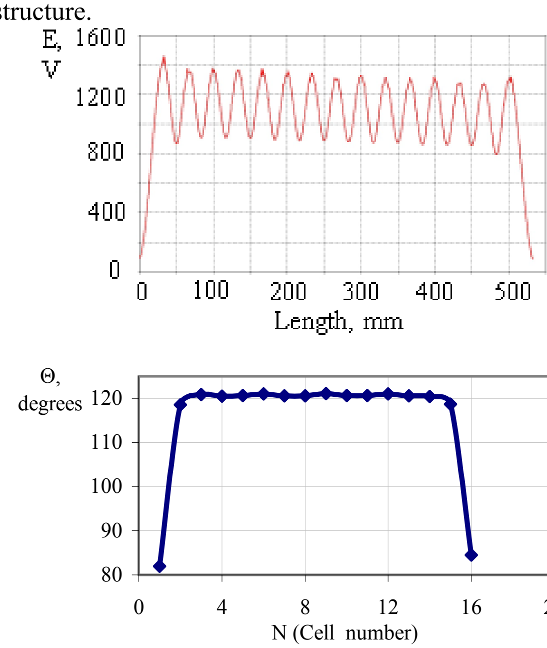


Figure 9: The amplitude and the phase per structure period of the deflecting field at the structure axis.

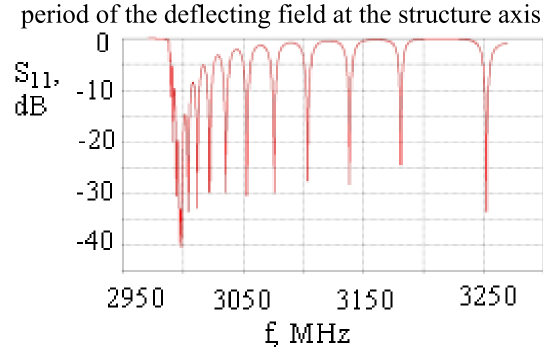


Figure 10: Reflection S_{11} in the input waveguide for the structure with the coupler, shown in Fig.1c.

REFERENCES

[1] N.Sobenin, M.Lalayan, S.Kutsaev, A.Anisimov A.Smirnov, I.Isaev, A.Zavadtsev, D.Zavadtsev. Stabilization of the Polarization Plane in Travelling Wave Deflectors, Proc. IPAC10, p.3759, 2010.

[2] L. Kravchuk, A. Anisimov et all.Layout of the PITZ Transverse Deflecting System for Longitudinal Phase Space and Slice Emittance Measurements, Proc. of LINAC2010.