TWO DIMENSIONAL ANALYSIS OF RF ELECTROMAGNETIC FIELDS BY FINITE ELEMENT METHOD

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Abstract

We have already developed computer codes to solve electromagnetic field problems which reduce to two dimensional scalar Helmholtz equations. We improved these codes, and also developed bandwidth minimization code.

1. Introduction

In the design of RF resonators of accelerators, it is necessary to calculate electromagnetic fields, resonance frequencies, Q value, power loss, and other pertinent quantities in the cavities surrounded by metals. To get these, we have already developed two computer codes (H2DB and HAX) based on finite element method. H2DB code is for the fields in the straight resonator with arbitrary cross section and HAX code is for the axisymmetric fields. In both calculations, we must solve the boundary-value problems for two dimensional scalar Helmholtz equations. Automatic mesh generation codes MESHGEN2 and MESH2D, field plot code H2DPLOT, and Q value and power loss calculation code HAXQE also have been developed[1]. We improved these codes. Bandwidth minimization code BNDMIN was also developed.

2. Field calculation H2DB and HAX

We added new functions. One of them is a restart function. The calculation which is terminated by time limit can be restarted any number of times reading the preceding results from disk file.

3. Bandwidth minimization BNDMIN and mesh generation MESH2D

BNDMIN minimizes the bandwidth of band matrices in finite element method in order to save memory size and computing time. We use connection array to minimize it[2]. Minimization procedure is useful especially for complicated shape of cavity. The code MESH2D is also improved in numbering the nodal points to minimize the bandwidth.

4. Field plot H2DPLOT and Q value calculation HAXQE

In H2DPLOT and HAXQE, it is necessary to find boundary for plotting or calculation. But it takes much time to find boundary by the previous method. In the new method, we use connection array to find boundary. This extremely reduces computing time.

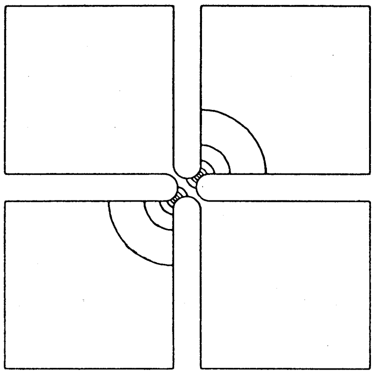
5. Example of calculations

Four-vane RFQ resonator of quadrangular shape is analyzed by H2DB code. We have already analyzed the quarter of four-vane RFQ resonator imposing symmetry conditions. At this time, we analyze full shape of this resonator. Figure 1 shows the calculated cut-off frequencies and the electric lines of force.

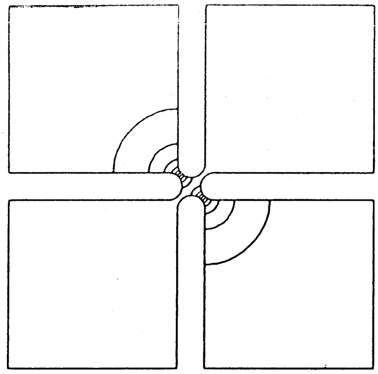
References

1) M. Hara, T. Wada, A. Toyama and F. Kikuchi : "Calculation of RF Electromagnetic Field by Finite Element Method" Scientific Papers IPCR, 75 (1981) 143.

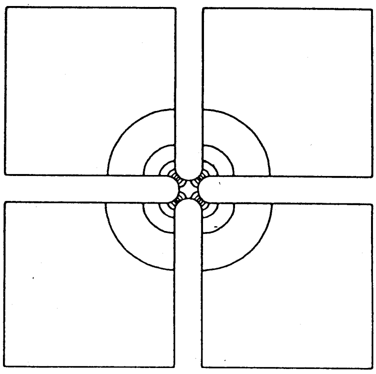
2) E. Cuthill and J. Mckee : "Reducing the Bandwidth of Sparse Symmetric Matrices", PROC. 24th Nat. Conf., Assoc. Comput. Mach., ACM Publ. p-69, 1122 Ave. of the Americas, New York, N.Y. (1969)



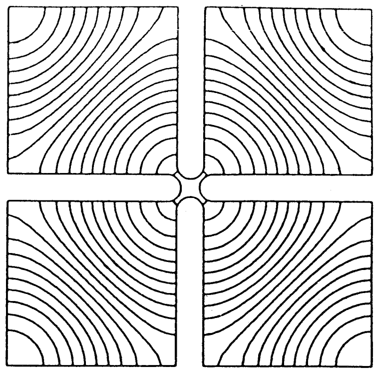
2nd mode TE_{110}
Freq. = 232.94 MHz



3rd mode TE_{110}
Freq. = 233.48 MHz



4th mode TE_{210}
Freq. = 238.48 MHz



5th mode
Freq. = 1602.9 MHz

Fig. 1. Cut-off frequencies and electric lines of force for four-vane RFQ resonator of quadrangular shape. (Side length = 200 mm, vane width = 15 mm, bore radius = 5 mm.) The eigenvalue of the 1st mode is zero. It has not significant physical meaning. Frequencies of the 2nd and the 3rd modes are expected to have the same value analytically, but are not equal in this calculation. The reason is that the approximate function used in this calculation is not symmetric.