LAYOUT OF A BROADBAND CIRCULAR WAVEGUIDE TO COAXIAL TRANSITION+

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1 ABSTRACT

Broadband coupling of higher order cavity modes to an external load is one way to suppress multibunch instabilities in electron storage rings. A numerical study is presented on the transmission properties of a waveguide to coaxial transition which features a double-ridged waveguide with circular cross section. Optimization using the HFSS program results in a design configuration with broadband RF transmission. Such a transition combined with a broadband coaxial vacuum window allows the rf-absorbing material to be placed outside the vacuum.

2 INTRODUCTION

In accelerator cavities of electron storage rings the high quality factors of the higher order modes (HOMs) lead to slow decay of the beam induced fields and consequently to potential beam instabilities due to the coupling of multiple bunches through the persistent fields.

Damping of individual modes with selective mode damping antennas is sometimes helpful [1]. However, often many HOM's are excited which motivates the design of broadband coupling systems to extract energy from many modes. Rectangular waveguides have been proposed [2] and adopted [3, 4] for several cavities. They provide broadband capability and offer the advantage that coupling to the cavity fundamental mode can be minimized by proper choice of the waveguide cut-off frequency. With ridged rectangular waveguides the cross-section can be reduced for a given cut-off frequency. From an engineering point of view, however, the combination of rectangular waveguides with a rotationally symmetric cavity is a somewhat complicated mechanical match. Waveguides with circular cross-sections have the advantage that they fit more naturally with a cavity of cylindrical structure [5].

To damp the HOM fields propagating in the waveguide, rf-absorbing materials may be either placed directly in the waveguide or separated by a ceramic window to avoid vacuum problems caused by outgasing of the absorber material. Ceramic windows of large cross-sections must be relatively thick and therefore are limited in bandwidth. This can be overcome by using a waveguide to coaxial transition which transforms the dominant waveguide mode into the TEM coaxial mode. Coaxial windows with adequate bandwidth are available, and standard 50 Ω power loads may then be used to dump the HOM energy. A rectangular waveguide to coax transition has been described in [3]. Here we present the conceptual design of a circular waveguide to coaxial transition (CWCT) for a 500 MHz cavity as proposed in [5].

3 BASIC DESIGN GOALS

The bandwidth of the CWCT must cover the frequency range from the lowest HOM to the cut-off of the beam pipe (760 MHz to 2.5 GHz for our model cavity). For a waveguide to coax transition the response at low frequency is limited by the cut-off frequency f_c of the waveguide dominant mode,

$$f_C = \frac{c}{2\pi}\,\frac{1.841}{r}$$

for a circular waveguide with radius r. Our aim was to provide good matching with a reflection $|S_{11}| \le 0.3$ in the above frequency range, corresponding to 91% power transmission to the coaxial output. The CWCT must be capable of handling the HOM power of about 1.5 kW extracted from the cavity without sparking conditions which are likely to occur on small size gaps and rough surfaces.

4 DESIGN PROCEDURE

Figure 1 shows an outline of the geometrical structure of the transition which is conceptually similar to the DAPHNE rectangular to coax transition [6] and by a similar structure proposed in [7]. The transition consists of two main subsections, a circular double-ridged waveguide and a transformer. The tapered waveguide section connects the circular opening of the cavity through the transformer section to a 50 Ω coaxial line (7/8" EIA).

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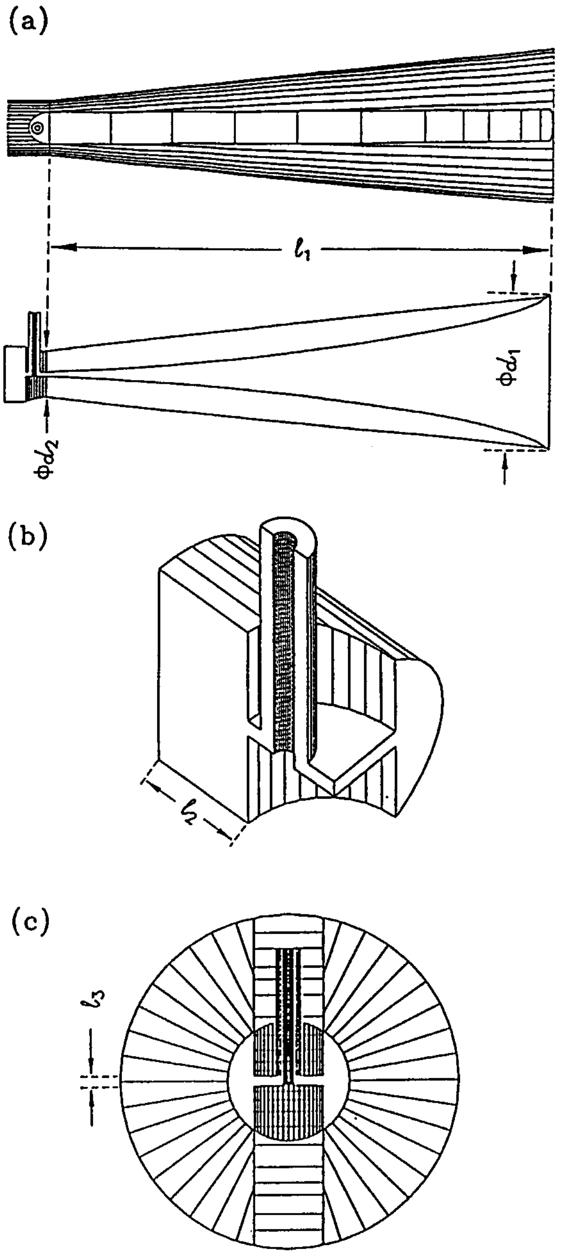

Fig. 1: Geometrical structure of the circular waveguide to coaxial transition, l_1 = 800 mm, l_2 = 35 mm, l_3 = 7 mm, d_1 = 250 mm and d_2 = 90 mm.

Shape and dimensions of the two sections have been optimized with the HFSS program [8] for maximum transmission in the band of 0.7 to 3 GHz, while the overall size is kept small. In our final configuration (see Fig. 1), the outer diameter of the tapered waveguide section varies linearly from d_1 = 250 mm to d_2 = 90 mm over a length of l_1 = 800 mm, whereas the ridges are profiled in such a way as to maintain a constant cut-off frequency of 710 MHz along the waveguide. The reflection parameter S_{11} as shown in Fig. 2a indicates good transmission of the waveguide over the passing band. The coaxial to waveguide transformer is optimized at high frequencies by proper choice of the end cavity length (l_2 in Fig. 1b) so that the standing wave pattern has its maximum at approximately the probe position. For good transmission at low frequencies, the transformer structure is optimized by wall shaping near the ridge‘s end (Fig. 1b) to achieve efficient matching between the coaxial line and the waveguide. With a minimum gap of l_3 = 7 mm between the ridges the power capability of the transition is expected to exceed 1.5 kW. The resulting S_{11} parameter of the ridged waveguide and of the transformer section is plotted in Fig. 2a. Figure 2b shows the combined S_{11} parameter of the two sections as arranged in Fig. 1a.

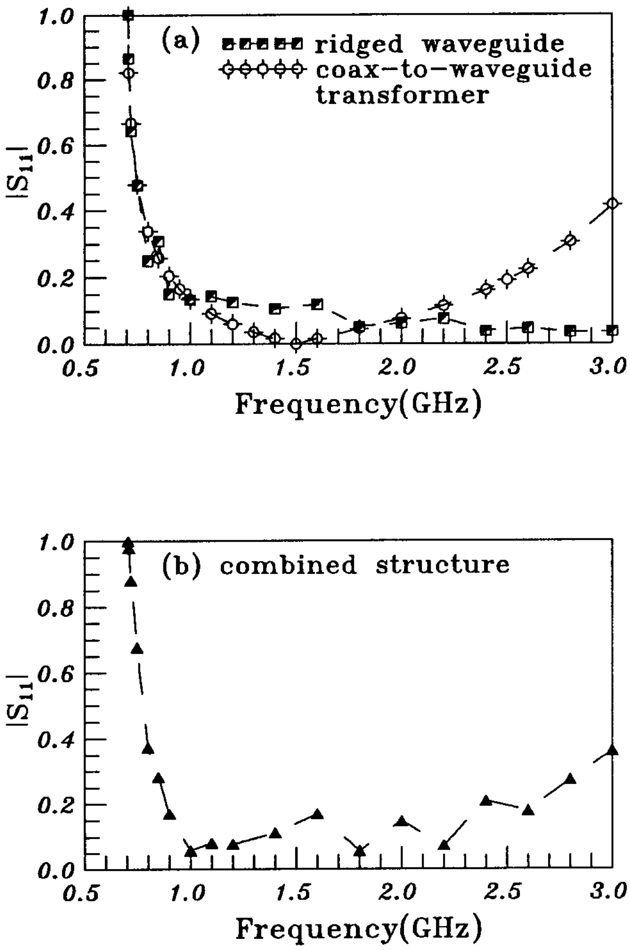

Fig. 2: (a) Reflection coefficient of the ridged circular waveguide and of the transformer part. (b) Reflection curve of the combined structure.

5 CONCLUSIONS

An outline design for a circular waveguide to coaxial transition has been worked out by numerical simulation with the HFSS code, giving a maximum reflection of 0.3 in the frequency range from about 830 MHz to 2.8 GHz. This opens the possibility to use standard 50 Ω loads outside the vacuum of the circular waveguides of a simple HOM damped cavity.

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6 REFERENCES

[1] - Y. Yamazaki, K. Takata, S. Tokumoto, IEEE NS-28 (1981) p. 2915
- E. Haebel, J. Sekutowicz, DESY Int. Report M-86-06 (1986)
- N. Fewell, Z. Wen, IEEE NS-32 no. 5 (1985) p. 2781

[2] M. Svandrlik, G. D'Auria, A. Fabris, A. Massarotti, C. Pasotti, P. Pittana, C. Rossi, Proc. Europ. Part. Acc. Conf. (1994) p. 2146

[3] S. Bartalucci, R. Boni, A. Gallo, L. Palumbo, R. Parodi, M. Serio and B. Spataro, Proc. Part. Acc. Conf. /1993), Vol. 2, p. 778

[4] R. Pendleton, K. Ko, C. Ng, H. Schwarz, J. Corlett, J. Johnson, R. Rimmer, SLAC-PUB-6552 (1994)

[5] F. Schönfeld, E. Weihreter, H. Henke, R. Apel (these proceedings)

[6] R. Boni, F. Caspers, A. Gallo, G. Gemme, R. Parodi, Laboratori Nazionali di Frascati Report LNF-93/075 (P)1993

[7] T. Rizawa, R. Pendleton, Proc. IEEE Particle Acc. Conf., Dallas (1995)

[8] Hewlett Packard Company:"HFSS: the High Frequency Structure Simulator HP 85180 A".