Design of a Coaxial Ceramic Window

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Abstract. A ceramic window is designed for the coaxial power coupler having inner conductor diameter of 34.8 mm and outer conductor diameter of 80 mm that will be a part of superconducting linac. An alumina disk of thickness 3.6 mm is used as a ceramic. The dimensions of inner conductor near ceramic disk are modified so as to achieve impedance matching at 1050 MHz. Two different window designs viz., a choke type and a capacitive type are compared. It is observed that a capacitive type window provides wide frequency bandwidth compared to choke type.

Keywords: ceramic window, choke, capacitive, TW
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INTRODUCTION

The superconducting (sc) cavity development program in BARC was initiated as the technology for ADS application. A 1 GeV proton accelerator operating at 1 MW power level and a beam current >20 mA will be required for this application [1]. A proton beam will be provided by an ECR ion source, an accelerator will consist of a normal conducting (nc) structure up to 100 MeV and a superconducting structure from 100 MeV to 1 GeV. The nc accelerator structure will operate at a frequency of ~350 MHz. A SC structure will be a coupled cavity linear accelerator made up of elliptical cavities.

To initiate the study on sc structure, single cell elliptical cavities were designed for β_g~0.42 at the second (700 MHz) and third harmonic (1050 MHz) of the operating frequency of nc linac. The copper prototypes were fabricated and tested to verify the design parameters. A coaxial power coupler is designed for the same. A scheme is worked out for the power coupler where a power from the power source will be carried by a rectangular waveguide, while the power to the cavity will be fed by a coaxial antenna. The waveguide and coaxial line will be connected through a loss-free door-knob transition. The coaxial line with 50 Ω impedance will be connected to the beam pipe. Thus the maximum size of the coupler is limited by the beam pipe radius of the cavity, the coaxial coupler having outer diameter of ϕ80 mm is suitable for 1050 MHz cavity [2-6].

A ceramic window is the most vital part of the high power coupler that needs special attention. The paper presents the design of ceramic window operating at 1050 MHz. We have adapted a disk type ceramic window design. Two types of ceramic window designs, viz., a choke type [7] and a capacitive type [8], are optimized and their performance is compared in terms of bandwidth, ease of fabrication and the power handling capacity.

DESIGN OF A WINDOW

A traveling wave (TW) ceramic window is designed for a coaxial coupler having inner conductor diameter of 34.8 mm and outer conductor diameter of 80 mm. An Alumina disk of thickness 3.6 mm is used as a ceramic. The dimensions of the inner conductor near the ceramic disk are modified so as to obtain an impedance matching at a frequency of 1050 MHz. The impedance matching can be achieved by a capacitive or an inductive coupling. The following sections describe the design of both the types and show the comparison between various parameters. The optimization of the geometrical parameters is carried out by using Microwave Studio.

Choke Type window

This type of window design is based on the design by C.Travier for TESLA project [7]. Here, the shape of the inner and outer conductor near the ceramic is modified in such a way that the ceramic is hidden in the cavity formed by the outer conductor as shown in Fig. 1.

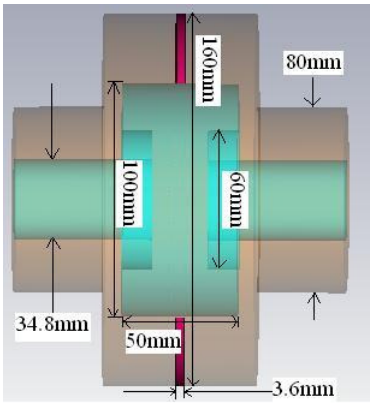

FIGURE 1. Choke Type TW Window

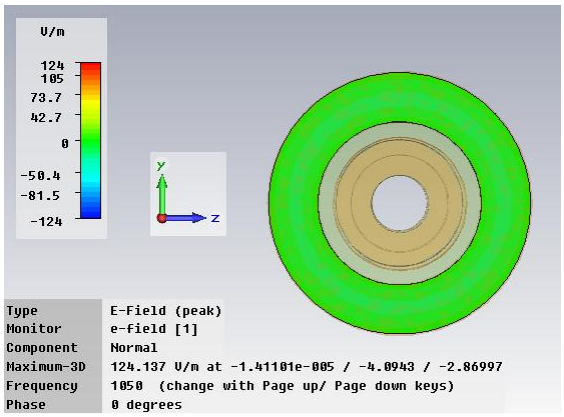

FIGURE 2. Normal Component of Electric Field

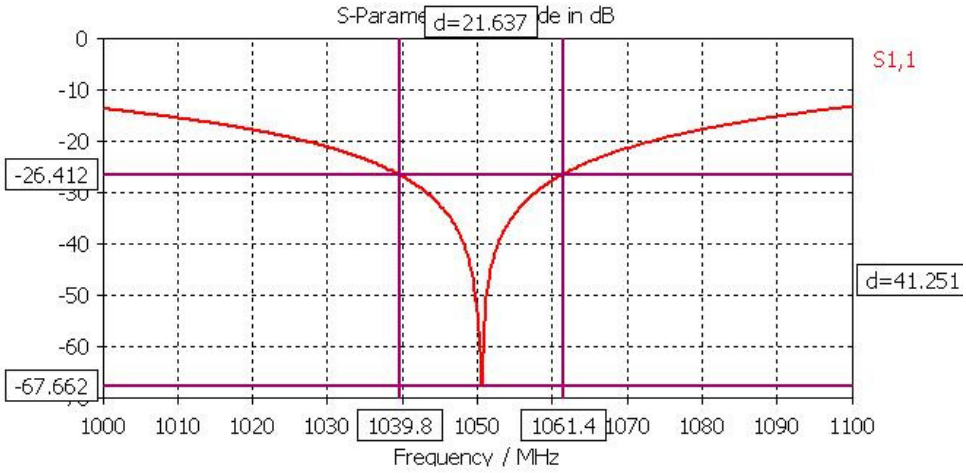

FIGURE 3. Frequency Response of a Choke Window

A normal component of electric field on the ceramic is reduced to zero (see Fig. 2) but a finite component of tangential electric field (~0.1 V/mm) exists near a brazing joint of ceramic and inner conductor. Also a small component of magnetic field (~1.6 mA/mm) exists at the same location. The bandwidth of ~22 MHz is obtained at a VSWR ~1.1 (-26.4 dB) as shown in Fig. 3. No resonant mode exists in the frequency pass band.

Capacitive Type window

This type of window is developed at KEK [8] that presents better isolation from room temperature as there is no physical contact between the inner conductor and the ceramic. The gap between ceramic disk and inner conductor is ~4 mm (see Fig. 4). The normal electric field of 1 V/mm is observed near the center of the ceramic while tangential component of electric field and magnetic field is negligible (see Fig. 5). This window provides wide bandwidth of ~100 MHz at a VSWR ~1.1 as shown in Fig. 6. A resonant mode of window is observed ~20 MHz below the operating frequency.

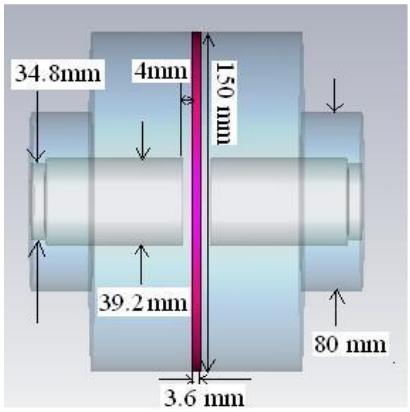

FIGURE 4. A Capacitive Window

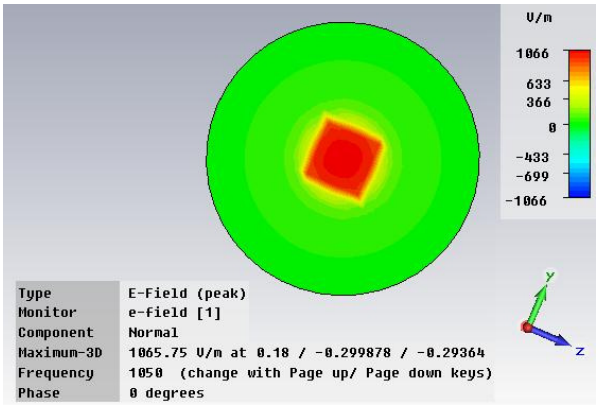

FIGURE 5. Normal Component of electric Field

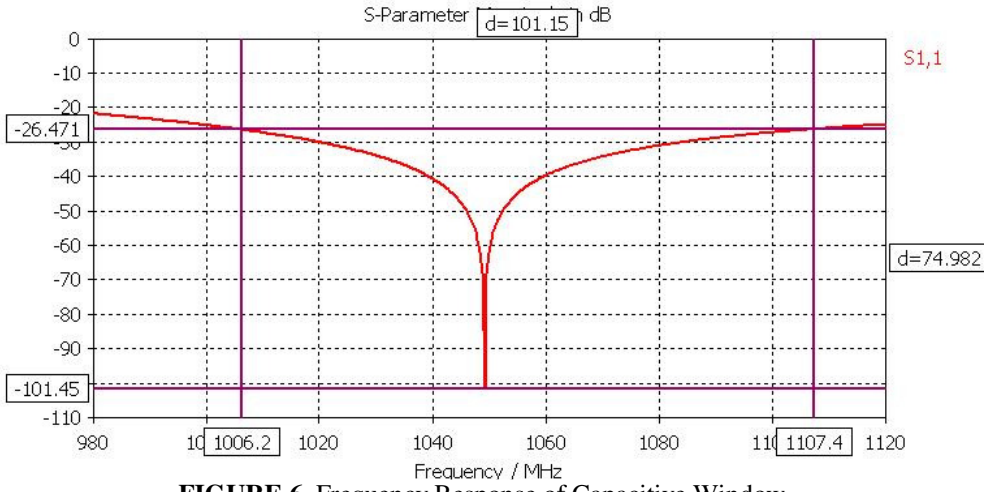

FIGURE 6. Frequency Response of Capacitive Window

CONCLUSION

Both the types of windows have certain advantages and disadvantages in terms of design, mechanical stability as listed in a Table 1. Though the capacitive type of window provides wide bandwidth and is easy to design and fabricate, small spacers are required between inner and outer conductor in order to maintain the position of inner conductor, so the structure is mechanically delicate. At the same time it provides better isolation between room temperature and LHe temperature as compared to choke type.

Though the choke type window has a narrow bandwidth, it will be able to handle higher power compared to a capacitive type as the magnitude of electric field on the ceramic surface is reduced considerably.

The final choice will be made upon testing the prototypes of both the windows. Also a further analysis is required to analyze the multipacting levels in the window.

TABLE 1. Comparison of a Choke and Capacitive Type window

	Advantages	**Disadvantages**
Capacitive Type	1. Wide Bandwidth, ~100 MHz at VSWR ~1.1 2. Simple Design 3. A small thermal contact with the room temperature 4. A component of magnetic field is negligible on the ceramic surface	1. Mechanically not rugged.
Choke Type	1. Mechnically rugged 2. Normal component of electric field is zero on the ceramic surface 3. A component of magnetic field is negligible on the ceramic surface 4. Protection of the ceramic from a direct view of the electrons coming from the cavity	1. Narrow bandwidth ~ 22 MHz at VSWR ~ 1.1

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