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Design and Development of Pill-Box Type Reduced Waveguide RF Window for 5 GHz, 250 KW Klystron

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ABSTRACT

The paper deals with the design study of pillbox-type reduced waveguide RF window[1] for 5 GHz klystron. Numerical simulation of the window has been carried out using the software "CST MW Studio". The proposed window is designed for 5 GHz operating frequency for handling a few kilowatts of RF power. The simulated results are validated through experiments. In the proposed window geometry, metalized alumina disc (99.5 % purity) of diameter 56 mm and thickness 1.5 mm is brazed in a cylindrical waveguide of diameter 56 mm. The cylindrical waveguide is terminated to WR 187 waveguide at its one end and 8 mm reduced height waveguide on the other end of the window. The return loss and insertion loss of the window length 26.7 mm has been found to be –34.88 dB and - 0.014 dB respectively. The bandwidth of 60 MHz is achieved.

Key words: RF Window, Klystron, pill-box type, alumina, S -parameters

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INTRODUCTION

RF window is one of the important issues for developing the high power klystrons and accelerators. RF window is a critical component of all microwave high power tubes and is used on the input as well as output section of the device for the transport of microwave power from vacuum to external pressurized atmosphere. RF window is a passive component that must be transparent to microwaves and hold ultra high vacuum. The desired features of an ideal window are: minimum reflection, minimum insertion loss, high power handling capability, wide bandwidth, excellent mechanical strength, high thermal shock resistance and vacuum tightness. Pill-box type microwave windows are generally preferred for high power klystrons due to their higher capacity for handling high peak and average RF power. The other functional advantages are broad bandwidth and easy impedance matching with the rest of the transmission line. The studies on high power RF windows are motivated by the need for 250 kW CW high power klystron for linear accelerators and fusion systems.

Window Design

Asymmetric pillbox type window shown in Fig.1 has been simulated with following dimensions. In 3D design window look like as shown in Fig. 2.

Table -1 Specifications of C-Band Klystron

Operating Frequency	5 GHz
Output Power	250 kW
Beam Voltage	60 KV
Beam Current	10 Amps
Focusing	Electromagnet
Efficiency	> 40 %
Gain	> 45 dB

Table -2 Specifications of Asymmetric Pillbox Type Window

Alumina ceramic disc diameter	56 mm
Alumina disc thickness	1.5 mm
Window diameter	56 mm
Input side circular W/G length	30 mm
Output side circular W/G length	30 mm
Input W/G	a = 47.55 mm, b = 8 mm
Output W/G	a = 47.55 mm, b = 22.15 mm

SIMULATION AND DISCUSSIONS

The asymmetric pillbox type RF window is designed for C-band high power klystron where input side waveguide is reduced. As described above the input, output cylindrical waveguide length is different; we found in simulation the

analytical dimensions have small variation with simulated results. But the approach to change the length of the circular waveguide on the both side of dielectric disc well followed. The simulated value of window parameters are- Return Loss is 65.76 dB and IL 0.002 dB.

MODIFIED WINDOW STRUCTURE

The earlier structure has an assembly of cavity, window and step transformer and later it is modified as the transformer is removed and the window is directly connected to the cavity structure. Accordingly window is modified to asymmetric structure which is simplified and has better performance. Here are the simulated values of RL & IL by dielectric constant variation and keeping frequency constant at 5 GHz. The simulated [2] length found 26.7 mm with 1.50 mm thickness alumina disc. The measured value of return loss and insertion loss of this asymmetric RF window is found to be 35.98 dB and 0.0116 dB respectively. From CST software simulation, we get the return loss –34.009 dB and insertion loss –0.014dB at 5GHz frequency as shown in fig. 5.

Table -3 Simulated Values of RL & IL

Dielectric Constant	Length L_1	Length L_2	Return loss	Insertion loss
9.2	8.215	16.985	26.5073	0.0227
9.3	8.085	17.115	29.8538	0.0173
9.4	7.965	17.235	34.8872	0.0142
9.5	7.85	17.35	47.185	0.0127

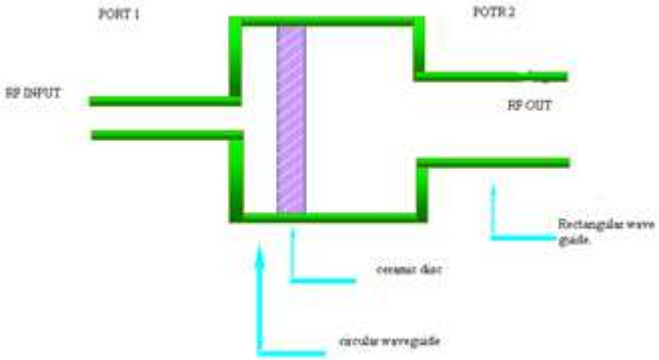

Fig. 1 Schematic diagram of Asymmetric pillbox type RF window

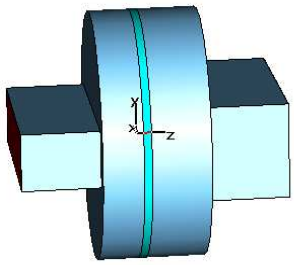

Fig. 2 3D view of Asymmetric pillbox type RF window

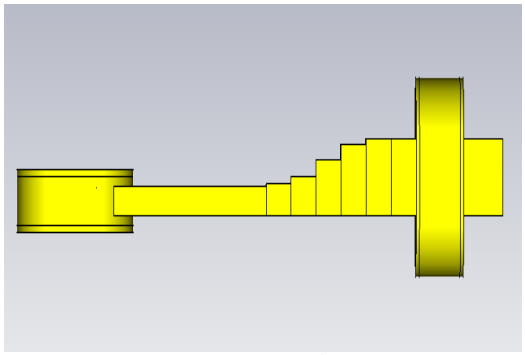

Fig. 3 RF window with transformer & cavity

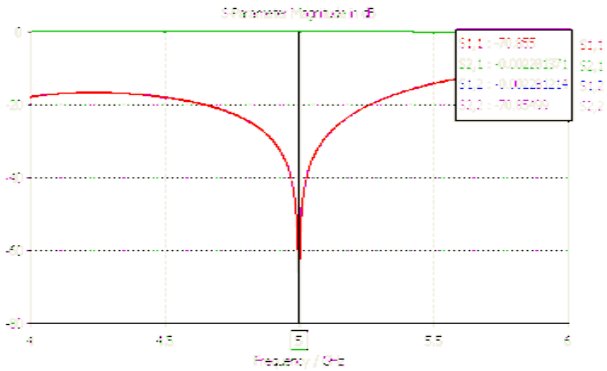

Fig.4 Plot of return and Insertion loss of symmetric window

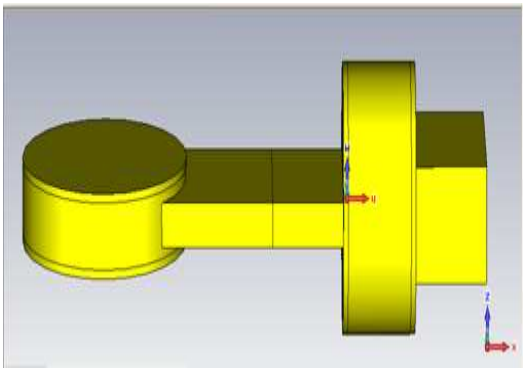

Fig. 5 RF asymmetric window with cavity

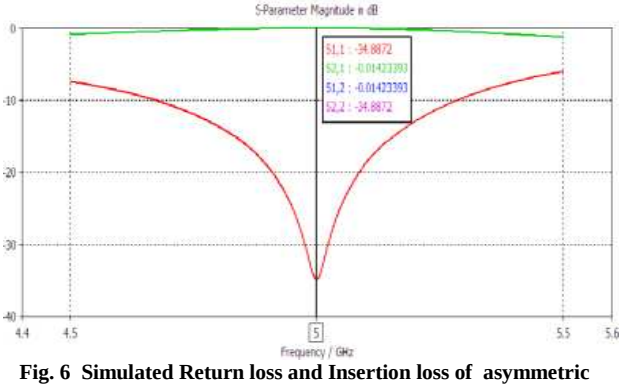

Fig. 6 Simulated Return loss and Insertion loss of asymmetric window

Table -4 Variation in Frequency with Change in Dielectric Constant

Dielectric constant	Frequency	Return loss	Insertion loss
9.2	5.039	32.85	0.015
9.3	5.019	33.81	0.014
9.4	5.0	34.88	0.014
9.5	4.981	36.10	0.013
9.6	4.96	37.50	0.013

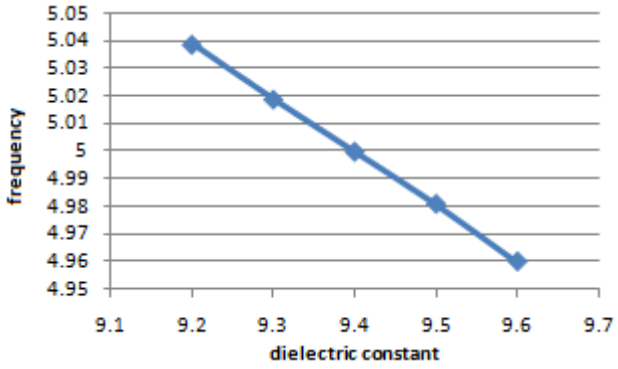

Fig.7 Plot showing dielectric Vs frequency variation

Table -5 Variation in Frequency with Change in Thickness of the Disc

Thickness	Frequency	Return loss	Insertion loss
1.54	4.957	36.139	0.0136
1.52	4.978	35.493	0.0139
1.50	5	34.887	0.0142
1.48	5.022	34.3.4	0.0145
1.46	5.044	33.750	0.0147

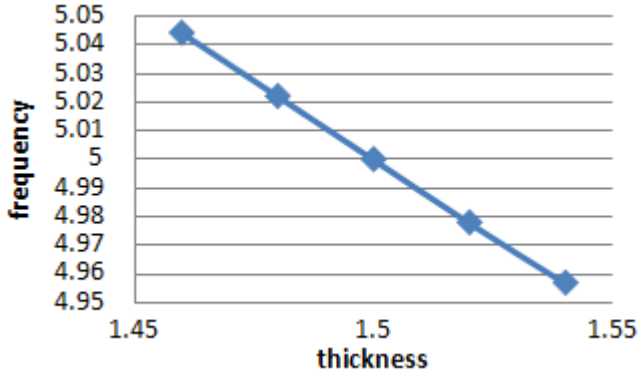

Fig.8 Plot showing disc thickness Vs frequency variation

CONCLUSION

The Asymmetric pillbox RF window of type 1, performance has been found better than the symmetrical RF windows. The Asymmetric pillbox type 1 window RL –34.009 dB and IL -.014 dB has been achieved. This RF window have been planned to use in design and development of 250 kW CW power C-band klystron. Performance of RF window remains in acceptable range .A method for design of RF window with asymmetrically placed ceramic in cylindrical waveguide has been developed. It is very useful for devices like high power klystrons which use reduced height waveguide on tube side to accommodate focusing coils. The asymmetric window design with excellent matching has been achieved without any extra matching transformer which is normally required in case of symmetrical windows.

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