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ELECTROMAGNETIC ANALYSIS OF RF WINDOW FOR S BAND HIGH POWER KLYSTRON

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Abstract: - The paper deals with the simulation and analysis of pillbox type RF window for high power S-band klystron. Numerical simulation of RF window has been performed by using μ - wave wizard code. The impedance matching technique has been used for the designing of pillbox type RF window. The simulation results have been validated through cold testing of few RF windows. The analysis of electromagnetic performance of the proposed design has been evaluated by varying window dimensions from the nominal values.

Keywords: Simulation, Window Dimension, Electromagnetic Performance

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1. INTRODUCTION

The RF window is a critical component of klystron, which transmits the output power to the external system. It must withstand high power, thermal and mechanical stresses and pressure gradient. Therefore, care must be taken in selecting the proper window material with low loss tangent, high thermal conductivity and mechanical strength. Ideally, it should also offer easy metallisation and brazing and make a strong vacuum tight seal with metals. Pillbox type window design with high purity alumina disc at edge cooled is simpler and more reliable for high power klystrons.

The major physical quantities being associated with the functioning of window are many, but few important are return loss, reflection coefficient, VSWR, power handling capability, attenuation and so on. The simulation of the following parameters for window have been carried out: dielectric material and their dielectric constant, thickness and diameter of disc, length and diameter of circular waveguide, input and output waveguide dimensions. The various sets of optimized variables have been obtained for the symmetrical pill box type RF window. A pill box structure is a complex window structure from microwave analysis and design point of view because of multiple discontinuities spaced quite closely.

2. RF Window Simulation Approach

μWave Wizard is a fast, mode matching synthesis and optimization (EM) CAD tool. The software allows the accurate design of rectangular and circular waveguide components. The simulation of RF window is carried out using mode-matching techniques. The input parameters provided to the software are operating frequency, window dimensions, material properties etc. and corresponding output results of return loss, VSWR etc. in terms of scattering parameters vs frequency are obtained.

The RF output window can be thought of as a reciprocating two port network. The term reciprocity implies that the scattering parameters being considered can be related through,

$$| s11 | = | s22 |$$

1. Where s11 and s22 are the scattering parameters at port 1 and port 2 respectively.

These are the parameters that physically depict the amount of signal energy that is returned after the transmission. Return loss is denoted by L_R and is defined as:

$$L_R = 10 * \log (P^+ / P^-)$$

But, $P^+ / P^- = 1 / |\Gamma|^2$

Where $|\Gamma|$ is the real value of reflection coefficient. Hence, it can be written as:

$$L_R = 20 * \log(|\Gamma|) \qquad (2.1)$$

2. The eqn. (2.1) is very important as it relates the values of return loss in dB to the reflection coefficient. Hence, the relation forms the basis of estimation of VSWR after obtaining the magnitude of scattering parameters via software.

As a first step of the approach adopted, initially the signed magnitude of the scattering parameter s11 is measured via software. This gives the return loss value in dB at port 1, which is also depicted in graphs. Since the software considers each and every circuit as a two port network or multi-port network as the case may be having the property of reciprocity i.e. satisfying the equality |s11| = |s22|, return loss obtained at port 2 may be considered equal to that of the value at port 1. The same result is also ascertained by the software use. After taking in all the necessary values from the software output as an input to the theoretical calculations, the following approach was found to proceed further. After obtaining return loss values from the software, (Eq.2.1) was used to estimate the values of $|\Gamma|$, which in turn, automatically provides with the corresponding value of VSWR.

The rf window simulation results have been summarized in table 1. The graphical output result for nominal window parameters is shown in figure 1.

Table 1: RF window nominal design parameters.

Operating frequency	2856 MHz
Window nominal diameter	90 mm
Window nominal length	33.20 mm
Alumina disc thickness	3.00 mm
Window material Die. Constt,	9.4
Return loss at 2856 GHz	- 38.9 dB
Band width	(2700 – 2900)

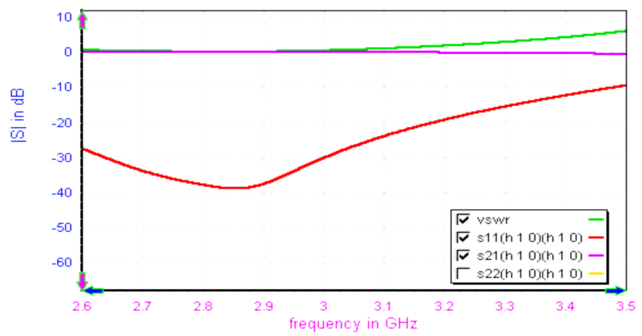

Fig.1 :- Plot of return loss vs frequency for window of diameter 90 mm , length 33.20 mm , disc thickness 3 mm and disc dielectric constant 9.4

3. Results of RF Window Analysis

The proposed window design is required to be analyzed for variation of influencing parameters. In this section results of window performance with changing dielectric permittivity, window length, diameter and disc thickness etc. have been presented.

Alumina disc of 99.5 % purity and having dielectric permittivity 9.4 has been selected for fabrication of window. The effect of variation of dielectric constant on the performance of window has been analyzed with changing dielectric constant from 9 to 10. These results are shown in figure 2. The variation of RL has been found to be ± 5 dB, which is in acceptable range.

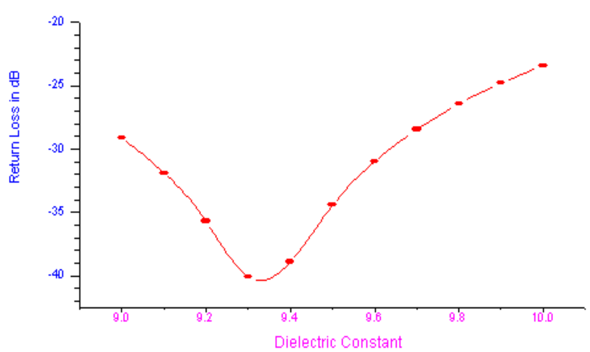

Fig.2 :- Plot of return loss vs disc dielectric constant for window of diameter 90 mm , length 33.20 mm and disc thickness 3 mm

The another important parameter is window length. The nominal value 33.2 mm has been obtained for 90 mm diameter window. We have varied window length ± 0.5 mm from nominal value and corresponding RL have been recorded. It has been found that the total variation in RL is ± 3 dB for ± 0.5 mm length variations. This plot is shown in figure 3.

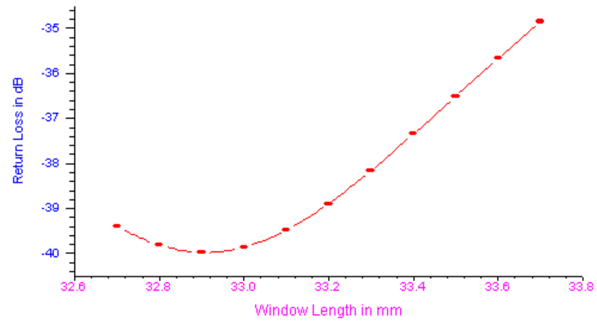

Fig.3 :- Plot of return loss vs window length for window of diameter 90 mm , disc thickness 3 mm and disc dielectric constant 9.4

The next parameter is window diameter. The nominal diameter has been chosen 90 mm for the proposed design. The RL variation has been obtained in the range –35 dB to -41.0 dB for ± 0.5 mm from 90 mm nominal value. The results are shown in figure 4. It has been observed that window disc thickness variation beyond ± 0.2 mm found to be very much critical.

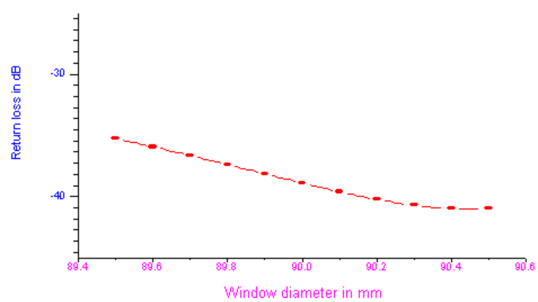

Fig.4 :- Plot of return loss vs window diameter for window of length 33.20 mm , disc thickness 3 mm , disc dielectric constant 9.4

4. CONCLUSION

Simulation of electromagnetic design of pill box type RF window for high power S - band klystron has been carried out using μ -wave wizard code. The results have been validated through cold testing on few RF windows. It has been found that performance of rf window remains in acceptable range even after ± 0.5 mm variation in length and diameter from nominal value. The variation of dielectric permittivity from 9.0 to 10.0 of alumina disc has been used in window fabrication acceptable to maintain the desired window performance. It has also been observed that window thickness variation beyond ±0.2 mm from the nominal value is very much critical.

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