

Study of Circular Waveguide Window for Millimeter Wave Transmission Line

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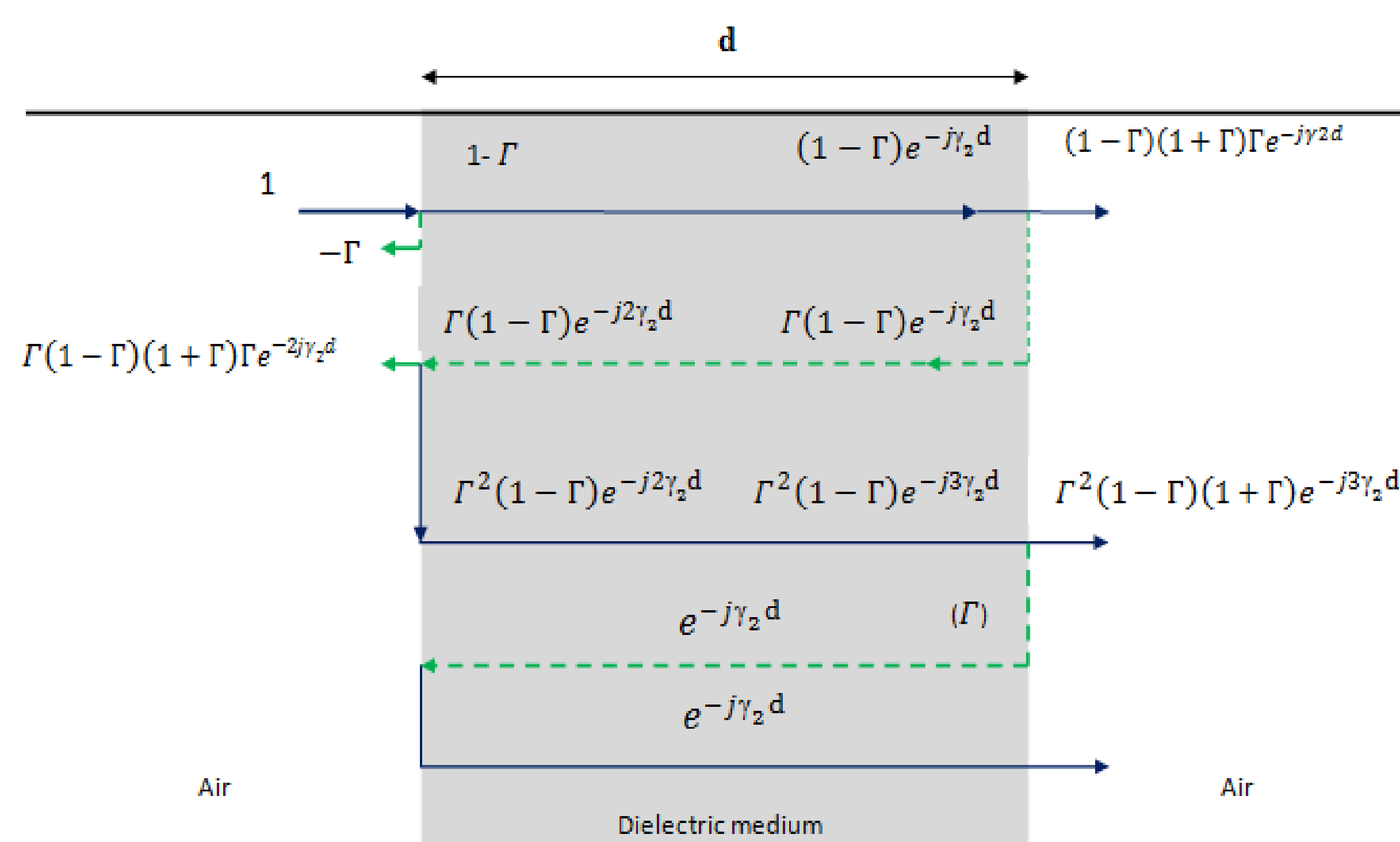
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ABSTRACT

- Vacuum window is required in the millimeter wave transmission line in ITER*. It is to be designed to minimize the microwave reflection while keeping a robust and safe approach to meet the requirements
- We have studied transmission characteristics of various dielectric materials over D-band frequency range (110-170 GHz) using RF Module of COMSOL Multiphysics v5.1. Purpose is to choose dielectric material with minimum transmission attenuation for designing of Circular Waveguide Window

*ITER is an international fusion reactor which is being constructed under the collaborative efforts of seven participating parties (termed as domestic agencies) namely China, European Union, India, Japan, South Korea, Russia and the United States of America.

Theoretical Approach



Transmission $T = \frac{(1-\Gamma)(1+\Gamma)e^{-2dj\gamma^2}}{1-\Gamma^2e^{-2dj\gamma^2}}$

Reflection $\rho = -\Gamma + \frac{\Gamma(1-\Gamma)(1+\Gamma)e^{-j2\gamma^2d}}{1-\Gamma^2e^{-j2\gamma^2d}}$

Parameters

Diameter of Waveguide = 19 mm Frequency Range = 110-170 GHz
 Launching Mode = TE01 Thickness of Window = 5mm

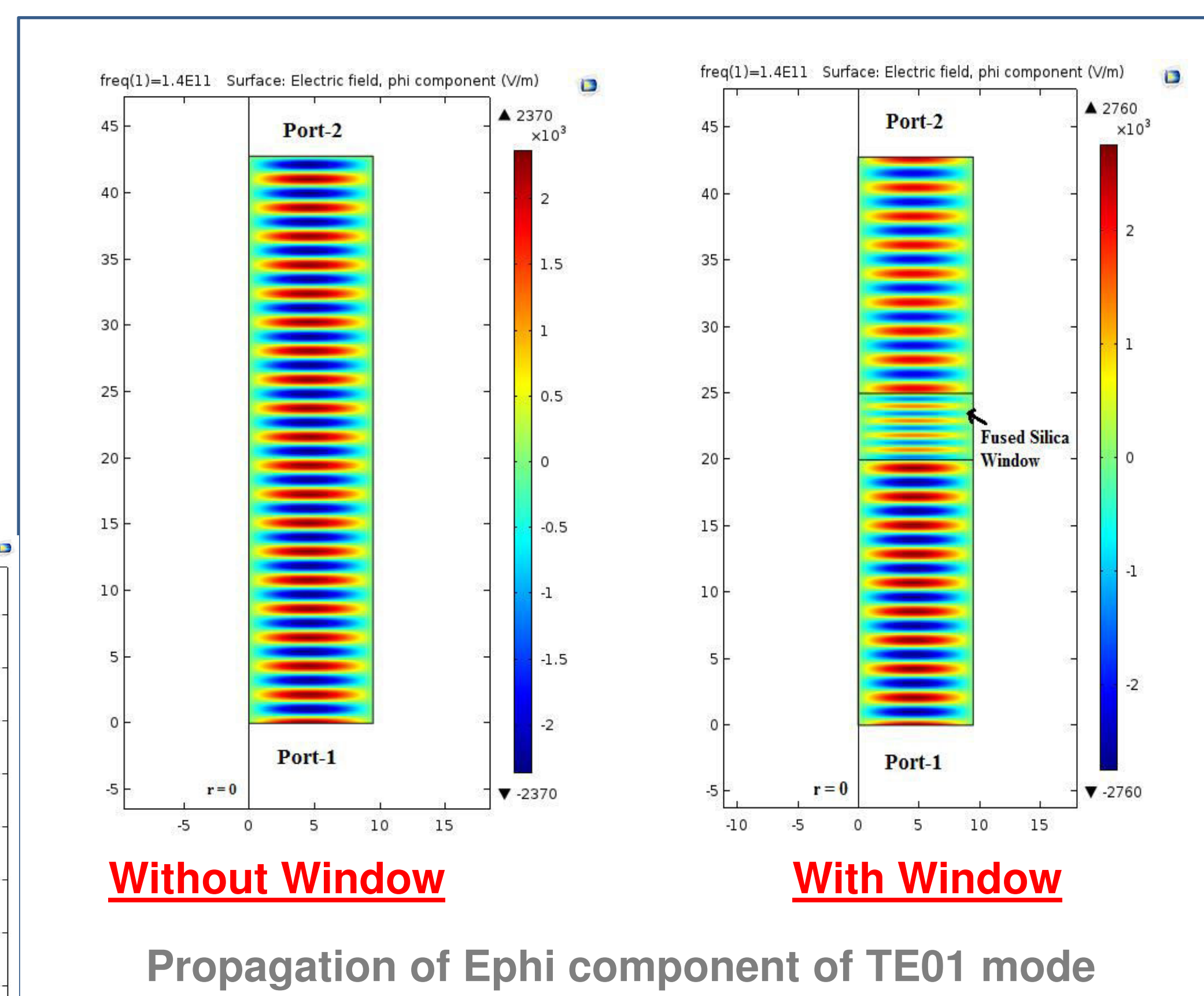
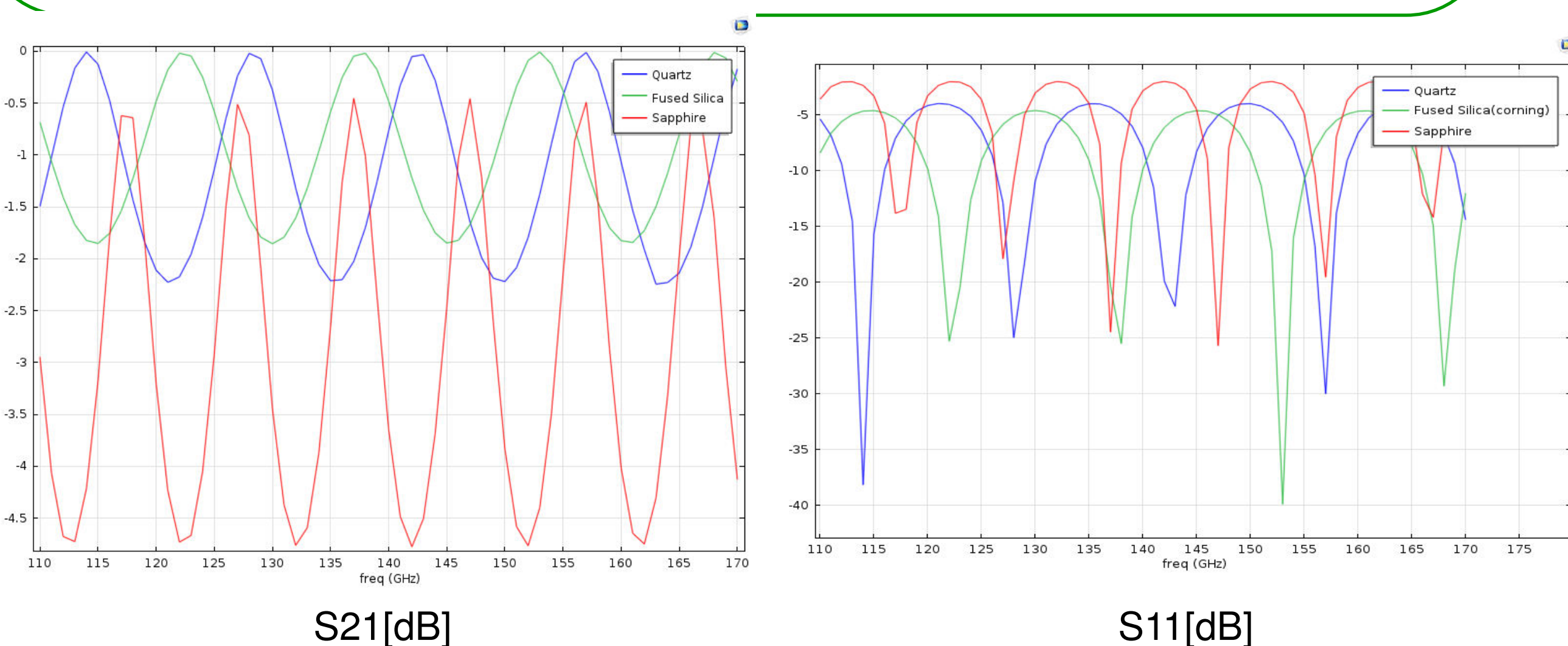
Window Materials : Sapphire, Fused Silica, Quartz [2,5]

Multiple reflection model of the electromagnetic scattering of a dielectric slab in a waveguide [1]

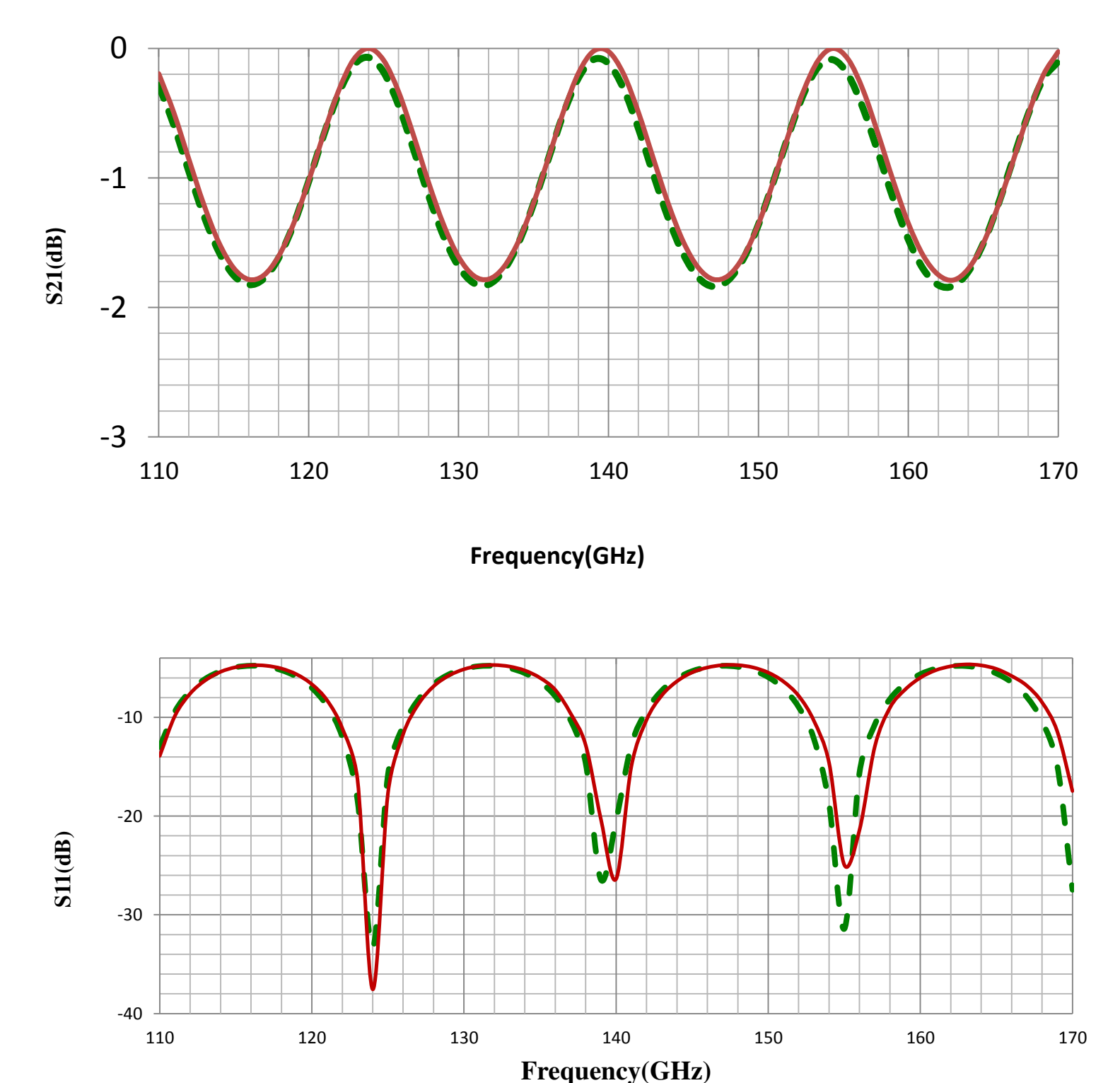
Numerical Study

Geometry : 2D Axial symmetrical
Study : Frequency Domain
Mesh : Unstructured free triangular mesh

The structure is meshed at 170GHz ($\lambda = 1.76\text{mm}$) with mesh size $\lambda/10$



Comparison with Theory



Conclusions

- Multiple reflections of EM wave are occurred inside waveguide window which is reason behind generation of standing wave pattern
- Fused Silica offers better transmission than other dielectric materials for millimeter waves
- Simulation results are matching excellent with theory. Simulation results show 0.17% variation with respect to analytical result

References

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