Study of Microwave Simulation Technology

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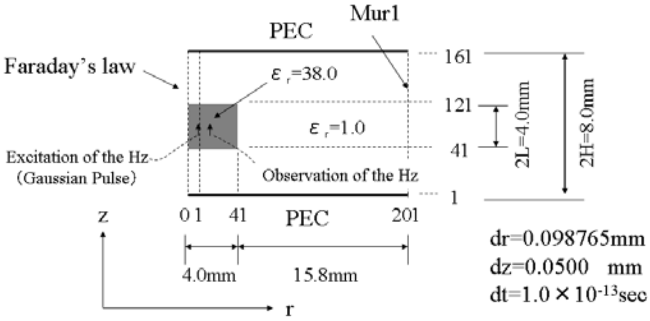
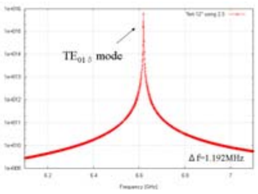
Resonant Frequency and Quality Factor Analysis with a Cylindrical FDTD Resonant frequency and unloaded (conductor, dielectric) Q values can be calculated for cylindrical cavities and dielectric resonators. The computation time can be reduced with an FDTD/GPOF combination.

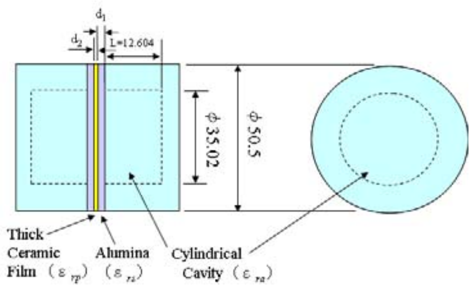




2H Dimension	FDTD +GPOF	Mode Matching	Error [%]
5.0mm	7.553	7.5605	0.099
6.0mm	7.064	7.0715	0.106
8.0mm	6.620	6.6225	0.038

Table 1. Comparison of calculated results [GHz] and error rates

Analysis of a Cylindrical Cavity Resonator Using the Mode-matching Method The resonant frequency of a divided TE_{011} cylindrical cavity resonator can be calculated by inserting sample materials.



Resonant frequency is determined to satisfy $\boldsymbol{detZ}=0$ by applying the mode-matching method for the surround of a sample material with perfect electric conductor (PEC) properties, where $\boldsymbol{Z}$ is the matrix, and

$$\boldsymbol{Z}=\begin{bmatrix}\boldsymbol{Q} & \boldsymbol{-R}\\ \boldsymbol{S} & \boldsymbol{-P}\end{bmatrix} \quad (1)$$

In this matrix element, m and n terminate as M and N as finite values. Moreover, $\boldsymbol{Q}$, $\boldsymbol{R}$, $\boldsymbol{S}$ and $\boldsymbol{P}$ are as follows:

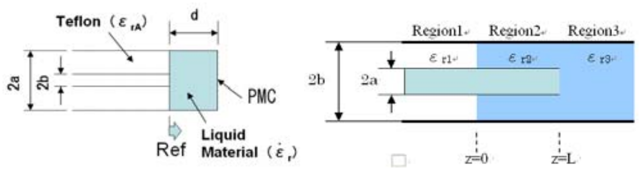
$$\boldsymbol{Q}_{mn}=U_n\frac{a\cdot ku_n}{ks_m^{\ 2}-ku_n^{\ 2}}J_0(ku_n a)J_1(ks_m a)\cdot sin(\beta u_n\cdot L) \quad (2)$$

$$\boldsymbol{R}_{mm}=V_m\frac{b^2}{2}J_0^{\ 2}(ks_m b)\cdot\left[B'_m\,cos\left(\beta s_m\cdot\frac{d_1}{2}\right)+C'_m\,sin\left(\beta s_m\cdot\frac{d_1}{2}\right)\right] \quad (3)$$

$$\boldsymbol{S}_{nn}=U_n\beta u_n\frac{a^2}{2}J_0^{\ 2}(ku_n a)\cdot cos(\beta u_n L) \quad (4)$$

$$\boldsymbol{P}_{nm}=V_m\beta s_m\frac{a\cdot ku_n}{ks_m^{\ 2}-ku_n^{\ 2}}J_1(ks_m a)J_0(ku_n a)\cdot\left[B'_m\,sin\left(\beta s_m\cdot\frac{d_1}{2}\right)-C'_m\,cos\left(\beta s_m\cdot\frac{d_1}{2}\right)\right] \quad (5)$$

Discontinuity Analysis at the Boundary Plane from the Coaxial to the Cylindrical Waveguide The input impedance of a discontinuity structure from the coaxial to the circular waveguide can be calculated if each region's dielectric constant is different.



Using the mode-matching method, the input admittance can be calculated using Equation (6):

$$\dot{y}_m=j\cdot\frac{2k_0 a\cdot\dot{\varepsilon}_r}{\sqrt{\varepsilon_{rA}}\cdot ln\left(\frac{a}{b}\right)}\left(y_0-\sum_{q=1}^{\infty}\boldsymbol{y_q}\cdot\boldsymbol{x_q}\right) \quad (6)$$

where

$$y_0=\sum_{i=1}^{\infty}\frac{tanh\left|\left(\lambda_i^{\ 2}a^2-k^2a^2\right)^{1/2}d/a\right|}{\left(\lambda_i^{\ 2}a^2-k^2a^2\right)^{1/2}\lambda_i^{\ 2}a^2}\cdot\frac{J_0^{\ 2}(\lambda_i\cdot b)}{J_1^{\ 2}(\lambda_i\cdot a)} \quad (7)$$

and $\boldsymbol{x_q}$ is calculated by

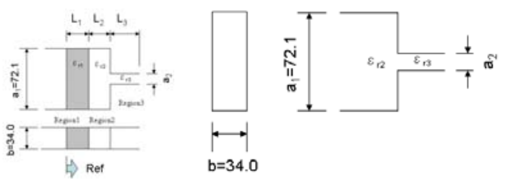
$$\boldsymbol{x_q}=\boldsymbol{A_{qn}}^{-1}\cdot\boldsymbol{y_q}\,. \quad (8)$$

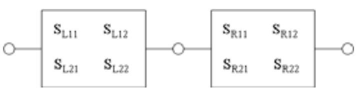
In their matrix element, $\boldsymbol{A_{qn}}$ is

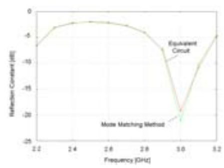
$$\boldsymbol{A_{qn}}=\sum_{i=1}^{\infty}\frac{\lambda_i^{\ 2}a^2\cdot tanh\left|\left(\lambda_i^{\ 2}a^2-k^2a^2\right)^{1/2}d/a\right|}{\left(\lambda_i^{\ 2}a^2-k^2a^2\right)^{1/2}\left(\lambda_i^{\ 2}a^2-\xi_q^{\ 2}a^2\right)\cdot\left(\lambda_i^{\ 2}a^2-\xi_n^{\ 2}a^2\right)}\cdot\frac{J_0^{\ 2}(\lambda_i\cdot b)}{J_1^{\ 2}(\lambda_i\cdot a)}$$

$$+\frac{1}{\dot{\varepsilon}_r}\cdot\frac{\delta_{qn}}{4\left(\xi_n^{\ 2}a^2-k_0^{\ 2}a^2\cdot\varepsilon_{rA}\right)^{1/2}}\cdot\left[\frac{a^2}{b^2}\cdot\frac{Z_1^{\ 2}(\xi_n\cdot a)}{Z_1^{\ 2}(\xi_n\cdot b)}-1\right] \quad (9)$$

Rectangular Waveguide Discontinuity Analysis Using the Generalized Scattering Matrix The S-parameter of the rectangular waveguide discontinuity can be calculated.







The mode-matching method can be applied to this analytical model. Accordingly, the S-parameter for a single h-plane discontinuity of the rectangular waveguide as shown in Fig. 4 can first be calculated as follows:

$$S_{11}=\left[L_E L_H+I\right]^{-1}\left[L_E L_H-I\right]\ldots \ (10)$$

$$S_{12}=2\left[L_E L_H+I\right]^{-1}L_E \qquad \ldots \ (11)$$

$$S_{21}=L_H\left\{I-\left[L_E L_H+I\right]^{-1}\left[L_E L_H-I\right]\right\}\ldots \ (12)$$

$$S_{22}=I-2L_H\left[L_E L_H+I\right]^{-1}L_E \qquad \ldots \ (13)$$