Analysis of Transmission Characteristics of Microstrip Line Loaded with Noise-Suppression Device Arranged Three-Dimensionally

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1. Introduction

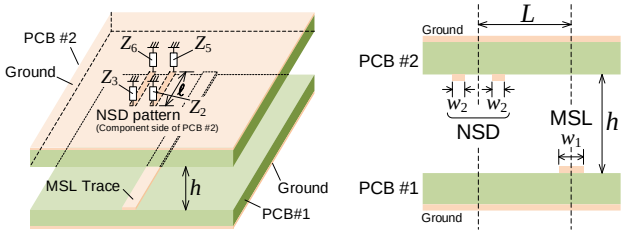
A noise-suppression device (NSD) arranged in three dimensions (3D) is proposed for suppressing the electromagnetic noise propagating along a microstrip line (MSL) on a printed circuit board (PCB) [1]-[3]. To obtain a higher noise suppression effect, it is useful to estimate the optimal arrangement position of the NSD. In this article, the transmission characteristics of the MSL loaded with the NSD arranged in 3D are theoretically analyzed.

2. Analytical Model and Calculated Results

Figure 1 shows the MSL loaded with the NSD arranged in 3D. The MSL and NSD are placed on PCB #1 and PCB #2, respectively, and PCB #2 is arranged above PCB #1. The both ends of the NSD shaped like a parallel-wire transmission line are terminated with Z_2, Z_3, Z_5, and Z_6. As the MSL loaded with the NSD arranged in 3D can be considered as a four-conductor transmission line, the equivalent circuit of the line can be drawn as Fig. 2. From Fig. 2., the relation among the terminal voltages and currents can be written as

$$\begin{bmatrix} \boldsymbol{V}(0) \\ \boldsymbol{I}(0) \end{bmatrix} = \begin{bmatrix} \boldsymbol{A} & \boldsymbol{B} \\ \boldsymbol{C} & \boldsymbol{D} \end{bmatrix} \begin{bmatrix} \boldsymbol{V}(\ell) \\ \boldsymbol{I}(\ell) \end{bmatrix} \tag{1}$$

where, $\boldsymbol{V}(x) = [V_1(x)\ V_2(x)\ V_3(x)]^T$ and $\boldsymbol{I}(x) = [I_1(x)\ I_2(x)\ I_3(x)]^T$. $\boldsymbol{A}$, $\boldsymbol{B}$, $\boldsymbol{C}$, and $\boldsymbol{D}$ are 3×3 submatrices of the chain matrix of the line shown in Fig. 2. The relation among the terminal voltages and currents at both sides are given as



(a) Overview (b) Cross-sectional view

Fig. 1 Physical structure of MSL loaded with NSD.

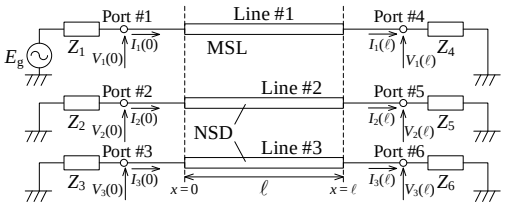


Fig. 2 Equivalent circuit of MSL loaded with NSD.

$$\boldsymbol{V}(0) = \boldsymbol{E_g} - \boldsymbol{Z_g}\boldsymbol{I}(0) \qquad \boldsymbol{V}(\ell) = \boldsymbol{Z_L}\boldsymbol{I}(\ell) \tag{2}$$

where $\boldsymbol{E_g} = [E_g\ 0\ 0]^T$, $\boldsymbol{Z_g} = \mathrm{diag}[Z_1\ Z_2\ Z_3]$, and $\boldsymbol{Z_L} = \mathrm{diag}[Z_4\ Z_5\ Z_6]$. Substituting (2) into (1), we can find the terminal currents of MSL $I_1(0)$ and $I_1(\ell)$. From these currents, we finally obtain the transmission coefficient of the MSL loaded with the NSD arranged in 3D. The calculated results of transmission coefficient $|S_{41}|$ of the MSL loaded with NSD arranged in 3D is shown in Fig. 3 as an example. Here, the characteristic impedance of the MSL is approximately 50Ω. Z_5 is the impedance of the capacitance C_5. From this result, it can be confirmed that large lowering of $|S_{41}|$ appears for $L = 2\mathrm{mm}$ not $0\mathrm{mm}$. This result shows the similar tendency to the experimental results in [3].

3. Conclusion

The transmission characteristics of the MSL loaded with the NSD arranged in 3D were analytically derived to estimate the most suitable position of the NSD. The future work is to develop the tunable NSD which has various noise-suppression characteristics.

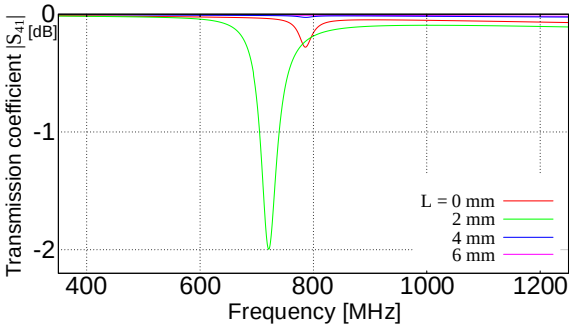


Fig. 3 Calculated results of transmission characteristics of MSL loaded with NSD arranged in 3D. Here, $\ell = 16\mathrm{mm}$, $h = 2\mathrm{mm}$, $C_5 = 6.8\mathrm{pF}$, $Z_2 = Z_3 = Z_6 = 1\Omega$, $Z_1 = Z_4 = 50\Omega$, $Z_5 = 1/(j\omega C_5)$, $w_1 = 3\mathrm{mm}$, $w_2 = 1\mathrm{mm}$.

Acknowledgments

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References

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