Reflection Properties of Mushroom-Type Surfaces With Loaded Vias
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Introduction – Mushroom-Type HIS

Reflection Characteristics and Natural Modes

Additional boundary condition for the “microscopic” current at the via-ground plane connection (y = 0) and via-patch connection (y = h):

**Reflection phase characteristics and natural modes (surface waves and leaky waves)**

- Reflection phase characteristics and natural modes (surface waves and leaky waves) are accurately predicted by the homogenization model.
- The presence of the patch grid significantly reduces the spatial dispersion (SD) effects.

Nonlocal Homogenization Model

- Generalized additional boundary condition at the via-to-patch connection, z = 0:

\[
\begin{align*}
\frac{d(yj\psi}{dy} + \frac{d}{dz} (C \frac{d\psi}{dz}) = 0
\end{align*}
\]

In terms of field components:

\[
\begin{align*}
k_a \psi + k_y \psi = 0
\end{align*}
\]

- Generalized additional boundary condition for the lumped load at the via-to-ground connection, z = h:

\[
\begin{align*}
k_a \psi + k_y \psi = 0
\end{align*}
\]

In terms of field components:

\[
\begin{align*}
k_a \psi + k_y \psi = 0
\end{align*}
\]

\[
\begin{align*}
k_a \psi + k_y \psi = 0
\end{align*}
\]

Lumped and Cpar are the correction terms, due to non-uniformity in the charge and current distribution by inserting a load in the wire.

**Reflection Coefficient**

\[
\begin{align*}
&\begin{align*}
K = y_{in} \sinh y_{in} h_0 \cosh y_{in} h_0 &= 0
\end{align*}
\end{align*}
\]

Reflection Coefficient

Dispersion Behavior for 0.4 nH Load

- The dispersion behavior shifts to lower frequency when compared to the structure without loads.

Ultra Thin HIS

- Thickness (h) = 1 mm
- Period (a) = 2 mm
- Gap (g) = 0.2 mm
- Permittivity \(\epsilon_r = 1\)

Dispersion Behavior for 5 nH Load

- Exhibits a wide stop-band for surface waves, 8.29 GHz – 25.51 GHz.
- 73% reduction in the plasma frequency when compared to the structure without loads.

Conclusion

- The reflection characteristics of the mushroom-type surface with loaded vias can be accurately predicted by the homogenization model.
- The reflection phase depends strongly on the value and the type of load. With an increase in the value of the inductive load, we have a decrease in the plasma frequency with a reduction in SD effects.
- Ultra thin structure exhibits wide stop-band for surface waves.
- The proposed concept of lumped loads can be used as EBG substrates in ridge waveguides and in the design of ultra-thin absorbers.