Novel CAD Models of Propagation Characteristics for Non-Planar CPS

Abstract

The structure is transformed to the parallel plate cylindrical surfaces. Their semi major axis and semi minor axis are transformed to the elliptical coplanar strip lines (ECPS) and cylindrical coplanar strip lines (CCPS) respectively. Moreover, the dielectric constant is assumed to be isotropic and lossless medium. The available static closed form models for semi circular cylindrical surfaces are compared against two 3D Simulators (SECPS and SCCPS) and CST Microwave Studio

1. Introduction

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2. Closed-form Models for SECPS and SCCPS

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Figure 1. Novel CAD Models of Propagation Characteristics for Non-Planar CPS

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3. Analysis Based Applications

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Figure 2. Novel CAD Models of Propagation Characteristics for Non-Planar CPS

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4. Conclusion

The structure is transformed to the parallel plate cylindrical surfaces. Their semi major axis and semi minor axis are transformed to the elliptical coplanar strip lines (ECPS) and cylindrical coplanar strip lines (CCPS) respectively. Moreover, the dielectric constant is assumed to be isotropic and lossless medium. The available static closed form models for semi circular cylindrical surfaces are compared against two 3D Simulators (SECPS and SCCPS) and CST Microwave Studio

Figure 3. Novel CAD Models of Propagation Characteristics for Non-Planar CPS

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5. References

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The following references are cited in the text:


The above mapping function provides the following conducing slot width \( s \), strip width \( w \), substrate thickness \( h \) and strip conductor thickness \( t \) of the transformed SECPS into the corresponding planar CPS:

\[
s = \arctan \left( \frac{2t}{w} \right) + \arctan \left( \frac{2a}{w} \right)
\]

\[
t = \frac{r_c}{r_i} = \frac{a + b}{a - b}
\]

\[
h = \ln \left( \frac{b}{a} \right) - \ln \left( \frac{b}{a} \right) - \ln \left( \frac{b}{a} \right)
\]

The effective relative permittivity \( \varepsilon_{\text{eff}} \) of the S-shaped DS with conductor thickness is computed from the following empirical relation [5]:

\[
\varepsilon_{\text{eff}} = \frac{1}{2} \left( \frac{a + b}{a - b} \right) + \frac{1}{2} \left( \frac{a + b}{a - b} \right)
\]

The above mapping function provides the following conducing slot width \( s \), strip width \( w \), substrate thickness \( h \) and strip conductor thickness \( t \) of the transformed SECPS into the corresponding planar CPS:

\[
r_i = \left( a + b \right) \right) + \frac{1}{2} \left( \frac{a + b}{a - b} \right)
\]

\[
r_c = \left( a + b \right) \right) + \frac{1}{2} \left( \frac{a + b}{a - b} \right)
\]

The confocal semi-ellipsoidal cylinders are transformed into the semi-circular cylinders in the \( Z \)-plane on using the following mapping function [2-3]:

\[
z = \frac{r}{c} \left( \sqrt{x^2 + y^2} - c \right)
\]

The above mapping function provides the concentric semi-circular cylinders of radius \( r_1 \), \( r_2 \) and \( r_3 \):

\[
r_1 = \frac{a + b}{a - b} \quad r_2 = \frac{a + b}{a - b} \quad r_3 = \frac{a + b}{a - b}
\]

The CPS on the concentric semi-circular cylinders is transformed into the planar CPS using the following mapping function [2-3]:

\[
u = j \left[ \frac{z}{r} \right] + \frac{\pi}{2}
\]
\[ k_{xy} = \sqrt{\left(\psi + \phi\right) \left(\theta + \phi\right)} = \sqrt{\left(\theta + \phi\right) \left(\psi + \phi\right)} \]

\[ k_{y} = \frac{1}{\sqrt{\left(\psi + \phi\right) \left(\theta + \phi\right)}} \]

\[ k_{x} = \frac{1}{\sqrt{\left(\theta + \phi\right) \left(\psi + \phi\right)}} \]

**B. Characteristic Impedance**

\[ Z(f) = \frac{\sqrt{\pi} x S}{\sqrt{\varepsilon'_\text{eff}}} \text{ where } S = \frac{K k_{a}^2 K k_{b}^2}{K k_{a} K k_{b}} \]

**C. Wheeler’s Incremental Inductance Rule**

\[ \alpha_i = \frac{\pi}{\lambda} \left[ \varepsilon'_\text{eff} \left( \frac{a + b}{a - b} \right) \right] \]

\[ \Delta Z = \frac{\pi}{\lambda} \left[ \varepsilon'_\text{eff} \left( \frac{a + b}{a - b} \right) \right] \]

**D. Improved Holloway and Kuester (IHK)**

\[ a_{\text{IHK}} = \frac{\pi}{\lambda} \left[ \varepsilon'_\text{eff} \left( \frac{a + b}{a - b} \right) \right] \]

**E. Dielectric Loss**

\[ \alpha_d = \frac{\varepsilon''_\text{eff} f \left( 1 - \frac{\varepsilon''_\text{eff}}{\varepsilon'_\text{eff}} \right)}{\lambda} \]

\[ \varepsilon''_\text{eff} f \left( 1 - \frac{\varepsilon''_\text{eff}}{\varepsilon'_\text{eff}} \right) \]

**3. Discussion of Results**

The accuracy of the closed-form models developed for propagation characteristics of non-planar CPS are tested against the results obtained from EM-simulators- HFSS and CST.

Fig. 2 presents comparisons of performances of CPS on the circular and semi-circular cylindrical surfaces in respect of effective relative permittivity, characteristic impedance and losses. It also presents such comparisons for the CPS on the elliptical and semi-ellipsoidal cylindrical surfaces. The results are obtained.

\[ \varepsilon''_\text{eff} \text{ at } f = 2.5 \text{ GHz, } \theta = 25^\circ, \psi = 40^\circ, \]
Table 1: Characteristics of models with respect to simulators

(a) Increase

<table>
<thead>
<tr>
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<th>HFSS</th>
<th>CST</th>
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(b) Decrease

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4. Conclusions

The expressions derived for both \( \pi - \theta - \psi \) and \( \pi - \theta - \varphi \) ground plane widths are non-planar CPS, and are presented for both symmetric elliptical and circular cylindrical coplanar strip lines. The nature of dispersion is found to be almost identical for one layer CPS with different ground plane widths for the antenna and integrated optical applications. The agreement with HFSS at higher frequencies is within a maximum deviation of (6.5%, -11%), and the nature of dispersion is almost identical for one layer CPS with different ground plane widths for the antenna and integrated optical applications. The average deviation of (6.5%, -11%) and (3%, 8%) respectively against both 3D EM simulators, excluding results at 1 GHz.

5. Acknowledgements

The authors would like to thank CST GmbH, Ansoft HFSS Version 11, CST Studio Suite v 2011, and Ansoft Corporation for providing access to the software.

6. References