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Design of Matched H-Plane Tee

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Abstract

Matched H-plane Tees are presented in this paper. With the help of rectangular, cylindrical and conical shorting posts, matching is achieved over a wide band of frequencies. The position of shorting posts are chosen offset to center of the tee junction along broader wall for a better match. These Matched H-plane Tees have been simulated in CST microwave studio and HFSS. The results obtained for these structures are covering the complete X-band. The shorting post dimensions are chosen for best matching purposes. A near about 4GHz bandwidth is achieved for all the structures with a return loss of 15dB.

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I. INTRODUCTION

Waveguide Tees are widely used in radars as well as in onboard satellite application in various frequency bands ranging from 1 GHz to 1000 GHz which can be classified as beam forming networks. Hirokawa et al. analyzed a waveguide tee where a cylindrical post placed in the T-junction to improve the frequency response [1]. The author analyzed a Folded H-Plane Tee using Multiple Cavity Modeling Technique (MCMT), power division was achieved over the frequency range of 7-9 GHz and conclude that folding the H-plane arm gives compactness to the structure with same phase in the splitting arm [2]. Debnath & Roy analyzed a Wave Guide E-Plane Tee acts as 3dB splitter at X Band Using HFSS Software [3]. Liang et al. proposed a rigorous method, Three Plane Mode Matching Technique (TPMMT) for modeling rectangular waveguide T-junction [4]. Scattering parameters of waveguide and ridge waveguide stepped tee junctions were obtained by Yao et al. using an extension of TPMMT [5]. Das et al studied aperture Coupled Reduced Height H-Plane Tee Junctions using CAD at 17.55 GHz. Sensitivity studies of these structures have also been done [6]. The longitudinal rectangular waveguide power divider were analyzed by the author using MCMT and concluded that the proposed power divider/combiner can be used as an H-plane Tee without providing any separate matching to the junctions [7]. Sharp developed a method for the calculation of the electrical performance of the rectangular waveguide T junction and this analysis is valid for any number of modes, propagating in the waveguides forming the junction [8]. Abdelmonen and Zaki introduced and modeled slit coupled ridge waveguide tee junction using the single port mode matching technique [9]. Lee et al modified the E-plane stepped waveguide tee junction for good matching and equal power diversion characteristics and solved it by three plane mode matching techniques [10]. Shulga and Bagatskaya presented a rigorous method for solving 2D scattering by a PEC obstacle of arbitrary cross section shape within an interaction region of waveguide tee junction [11]. Das, Raju and Chakraborty analyzed a T-junction which differs from a conventional H-plane T-junction. The T-arm is rotated by 90 degrees and coupling takes place through an inclined slot [12]. Pereira et.al analyzed a Tee with a single post and double post using HFSS and compares with surface integral equation formulation technique [13].

In this paper three different types of shorting posts are used and analyzed using commercially available software CST microwave studio as well as HFSS. Results for the different type of shorting posts show that as per the requirement we can use these structures to different center frequencies with larger bandwidth. Near about 4GHz bandwidth is achieved in all the three cases. Further these designs are so simple these can be fabricated easily for mass production.

II. DESIGN OF MATCHED H-PLANE TEE

The three dimensional view of the unmatched and matched H-plane Tees are shown in Fig. 1-4. Fig. 1 shows an unmatched H-plane tee. Fig. 2-4 shows the matched H-plane tees. A matched H-plane tee with rectangular shorting post is shown in Fig. 2. A matched H-plane tee with cylindrical shorting post is shown in Fig. 3. With conical shorting post the matched H-plane tee is shown in Fig. 4. The shorting posts are placed offset to U-axis at the center of the tee junction. The shorting posts are chosen as perfect electric conductors. The dimensions of the shorting posts and offset distance are given in table-1.

Table-1: Dimensions of Shorting Post

Rectangular	in mm	Cylindrical	in mm	Conical	in mm
Length(w)	1.6	Radius	0.8	Top Radius	0.2
Breadth(u)	1			Bottom Radius	2
Height(v)	10.16	Height	10.16	Height	10.16
Offset to U-axis	2.63	Offset to U-axis	1.3	Offset to U-axis	1

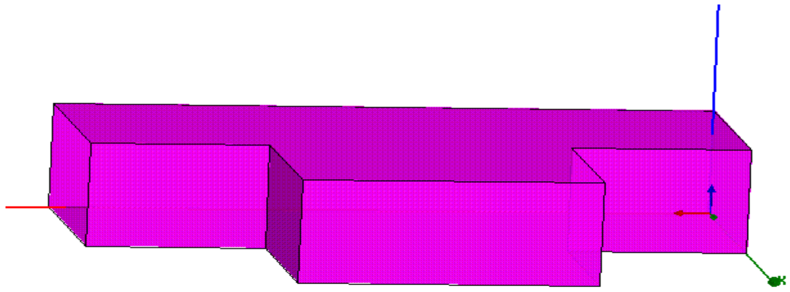

Fig. 1: Three dimensional view of an unmatched H-plane Tee.

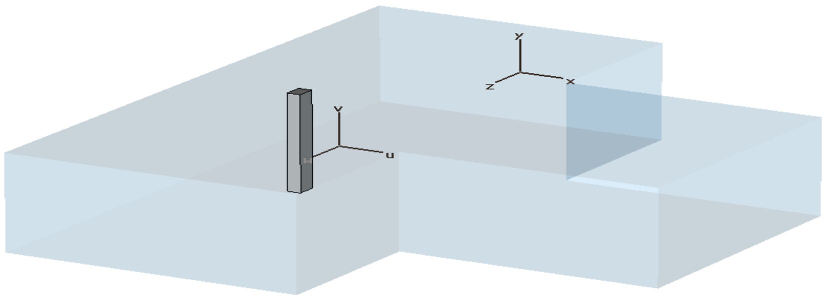

Fig. 2: Three dimensional view of a Matched H-plane Tee with rectangular shorting post.

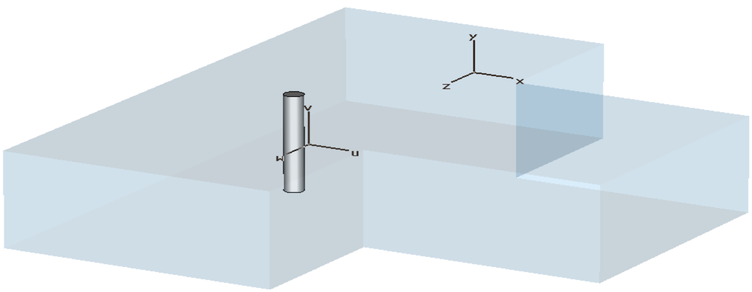

Fig. 3: Three dimensional view of a Matched H-plane Tee with cylindrical shorting post.

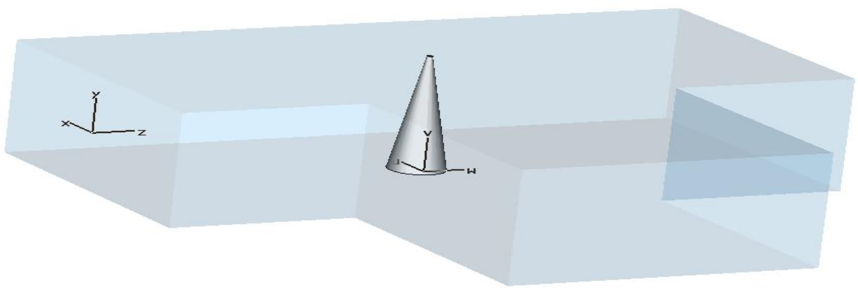

Fig. 4: Three dimensional view of a Matched H-plane Tee with conical shorting post.

III. RESULTS AND DISCUSSION

The magnitude of the scattering parameters for H-plane Tees has been computed using CST Microwave Studio and HFSS. In the structure the auxiliary arm is taken as port-1. The simulation is carried out with 20 passes in the case of HFSS and a maximum delta S per pass is 0.02. So also for the CST, a hexahedral mesh type with 20 lines per wavelength and lower mesh limit of 20 is taken.

The magnitude of S-parameters for the unmatched H-plane Tee has been shown in Fig. 5, which shows return loss at port-1 is 4.48 dB at 8GHz and .98db at 12GHz. In Fig. 6 the magnitude of S-parameters for the matched H-plane Tee with rectangular shorting post has been shown, which shows that the S_{21}, S_{31}, S_{12} and S_{13} have the equal magnitude and near about equal to -3dB with a highest variation of -0.19dB. In Fig. 6, magnitude of S_{11} is less than -15 dB in the band ranging from 9.4GHz to 12.8GHz. The parameters S_{22} and S_{33} have the same magnitude over the entire X-band which is nearly equal to -6 dB. The parameters S_{12} and S_{21} have the same magnitude over the entire X- band which is nearly equal to -6 dB.

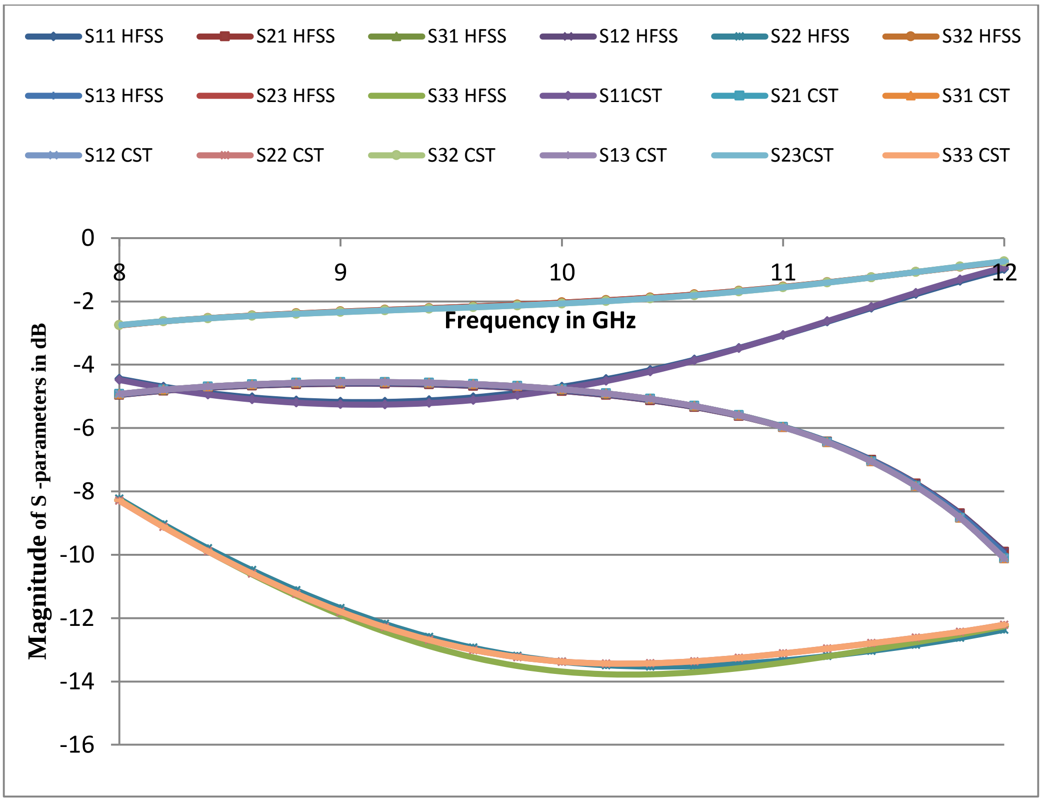

Fig. 5: CST Microwave Studio and HFSS simulated data of S-parameters for an unmatched H-plane Tee.

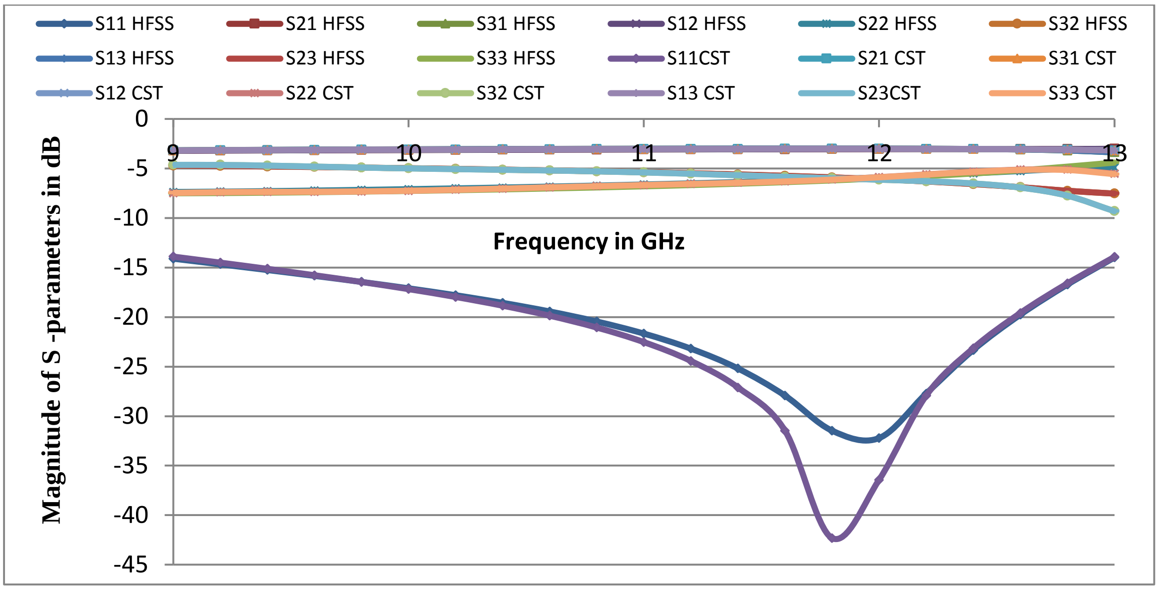

Fig. 6: CST Microwave Studio and HFSS simulated data of S-parameters for a matched H-plane Tee with a rectangular shorting post.

In Fig. 7 the magnitude of S-parameters for the matched H-plane Tee with cylindrical shorting post has been shown, which shows that the S_{21}, S_{31}, S_{12} and S_{13} have the equal magnitude and near about equal to -3dB with a variation of 0.12dB. In Fig. 7, magnitude of S_{11} is less than -15 dB in the band ranging from 8GHz to 11.4 GHz with lowest at 9.8 GHz. The parameters S_{22} and S_{11} have the same magnitude over the entire X- band which is nearly equal to -6 dB. The parameters S_{32} and S_{23} have the same magnitude over the entire X- band which is nearly equal to -6 dB.

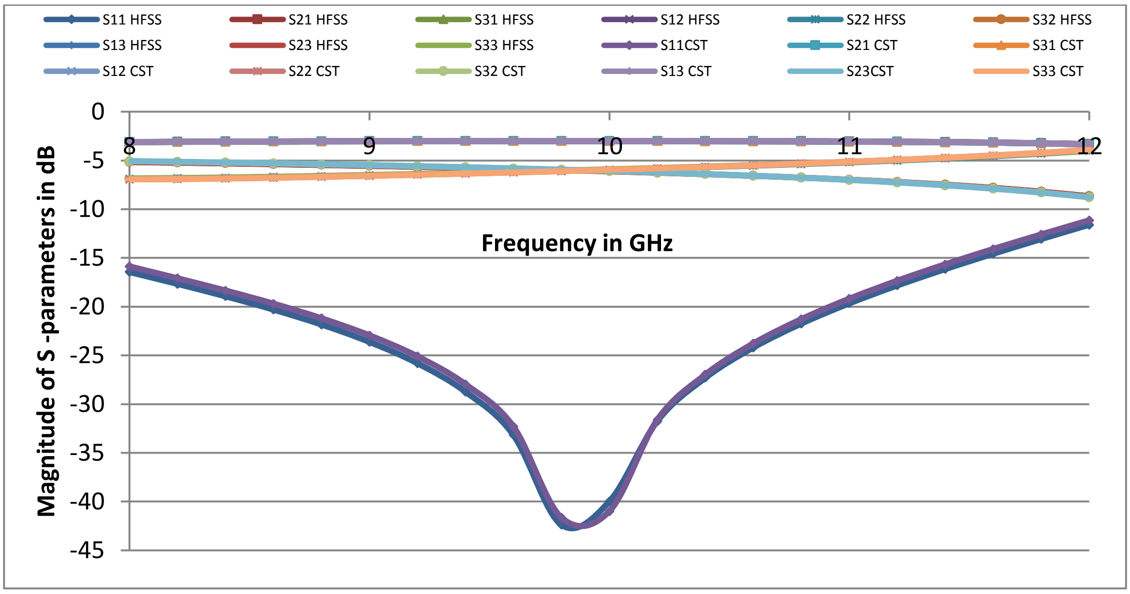

Fig. 7: CST Microwave Studio and HFSS simulated data of S-parameters for a matched H-plane Tee with a cylindrical shorting post.

The magnitude of S-parameters for the matched H-plane Tee with conical shorting post has been shown in Fig. 8, which shows that the S_{21}, S_{31}, S_{12} and S_{13} have the equal magnitude and near about equal to -3dB with a variation of 0.11dB. In Fig. 8, magnitude of S_{11} is less than -15 dB in the band ranging from 7.4 GHz to 11 GHz with lowest at 9.4GHz by CST. The same conditions are also achieved as we get for other structures to other S–parameters.

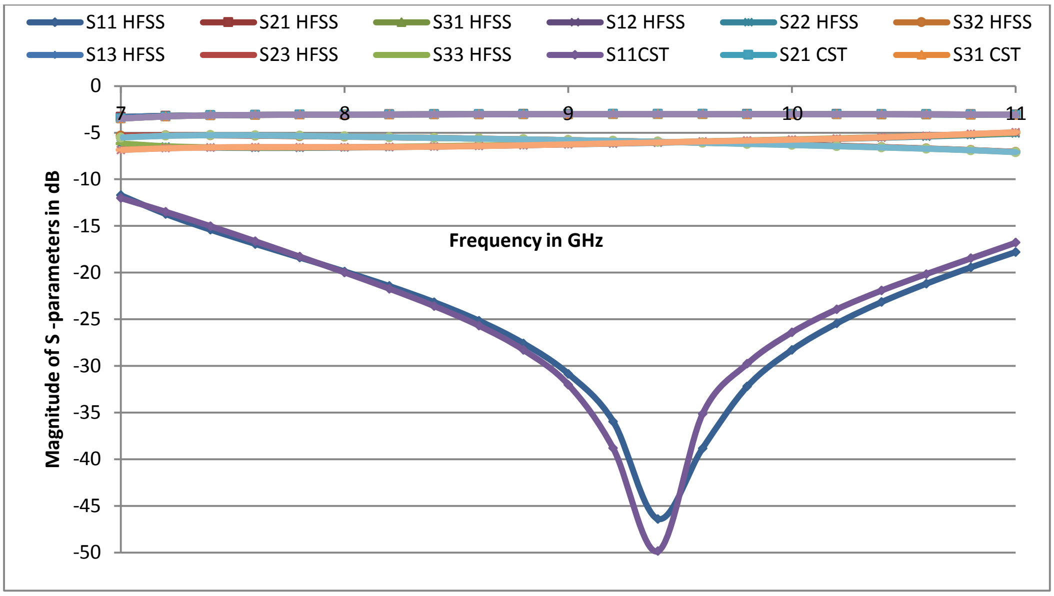

Fig. 8: CST Microwave Studio and HFSS simulated data of S-parameters for a matched H-plane Tee with a conical shorting post.

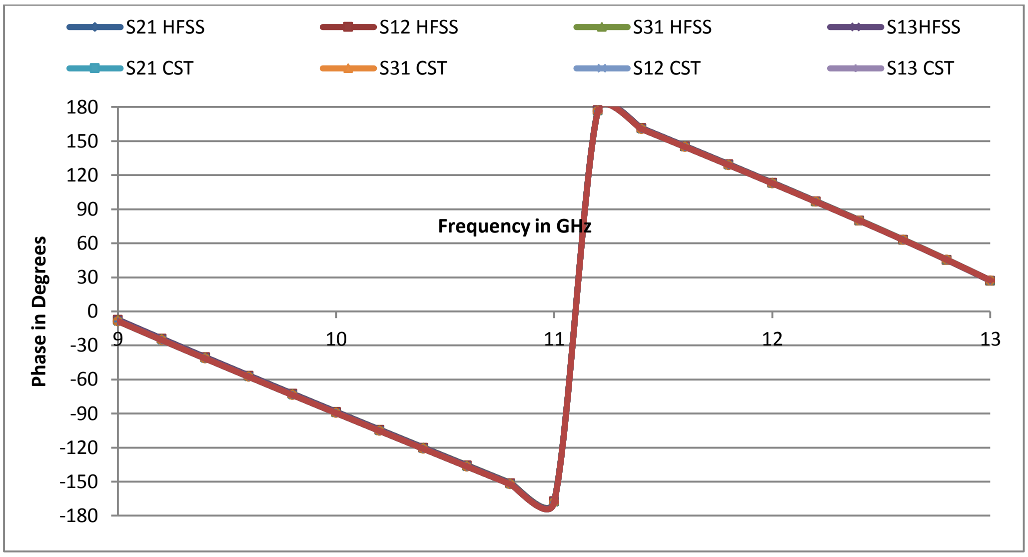

Fig. 9: CST Microwave Studio and HFSS simulated data for phase of S-parameters for a matched H-plane Tee with a rectangular shorting post.

The phase angle of the S_{21}, S_{31}, S_{12} and S_{13} are shown in the Fig. 9-11 for rectangular, cylindrical and conical shorting posts to tee junctions respectively. They have all the equal phases for the entire band of frequencies as required for an H-plane tee.

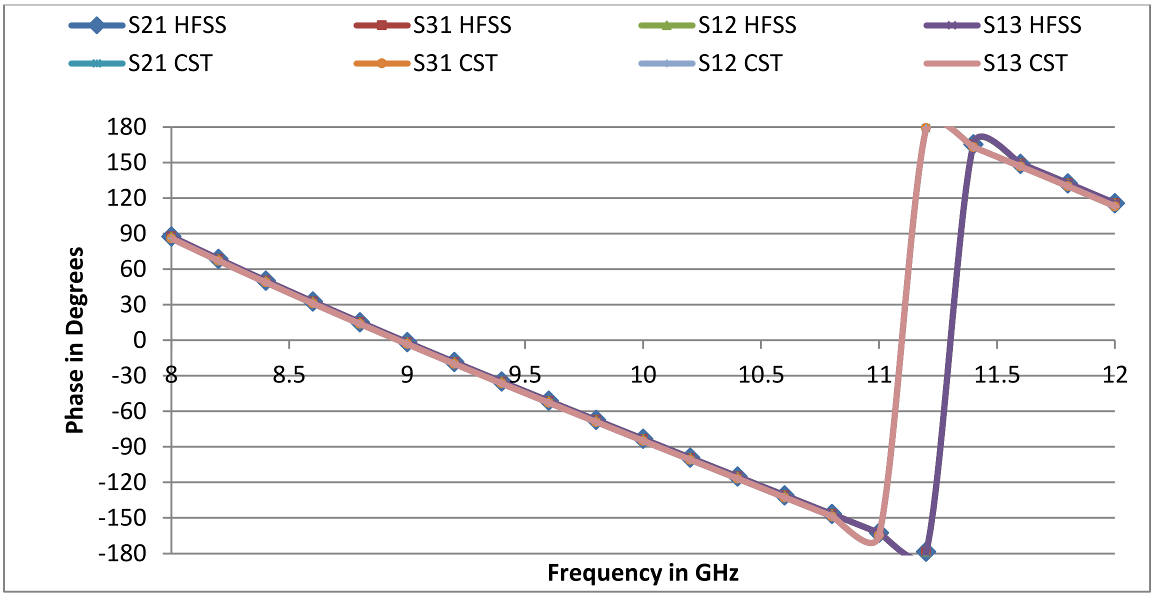

Fig. 10: CST Microwave Studio and HFSS simulated data for phase of S-parameters for a matched H-plane Tee with a cylindrical shorting post.

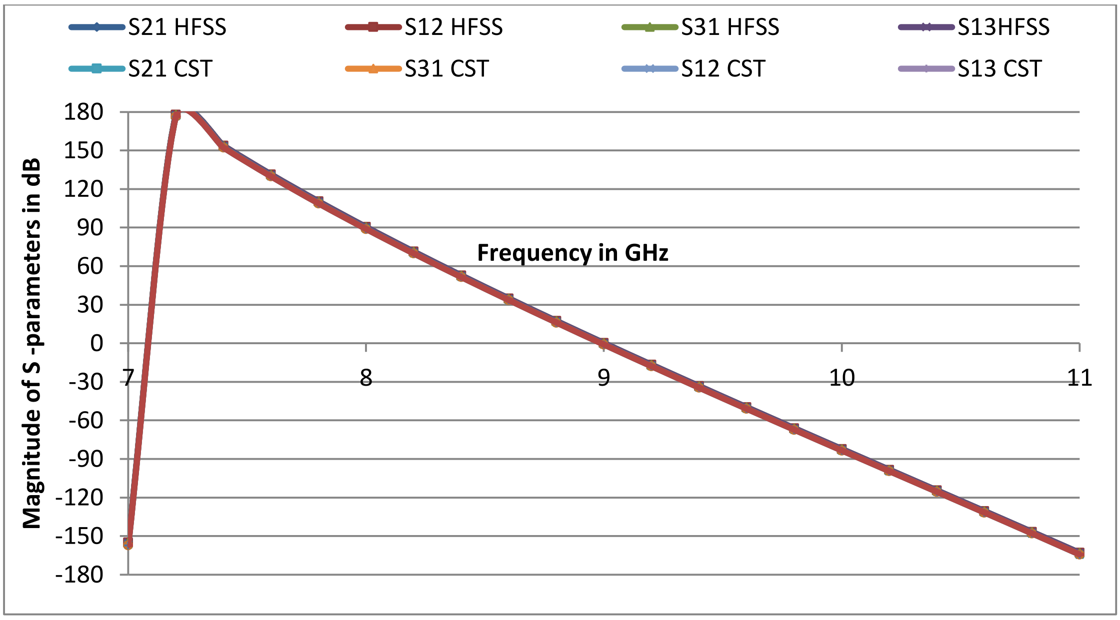

Fig. 11: CST Microwave Studio and HFSS simulated data for phase of S-parameters for a matched H-plane Tee with a cylindrical shorting post.

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