International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 9 (2015) pp. 24681-24691

http://www.ripublication.com

Design and Simulation of Matched E-Plane Tee

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Abstract

Matched E-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 center to the tee junction for perfect match. These Matched E-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. For conical post the tee junction can be used beyond the X-band with a return loss of 15dB.

Index Terms- E-plane Tee, Rectangular Shorting Post, Cylindrical Shorting Post and Conical Shorting Posts.

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 auther analyzed a Folded E-Plane Tee Using Multiple Cavity power division can be achieved over the frequency range of 7-9 GHz and conclude that folding the E-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 the structures have also been done [6]. Panda and Chakraborty analyzed the longitudinal rectangular waveguide power divider using MCMT and concluded that the proposed power divider/combiner can be used as an H-plane Tee junction 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]. Lampariello and Oliner gave analytical simple and closed form expressions for the element of equivalent networks for open and slit coupled E-plane tee junctions. Physically based “stored power” considerations were also developed [9]. Abdelmonen and Zaki introduced and modeled slit coupled ridge waveguide tee junction using the single port mode matching technique [10]. 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 [11]. 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 [12]. 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 [13]. Das and Chakraborty discussed E-plane and H-plane T-junction using multi cavity modeling technique [14, 15]. Pereira et.al analyzed a Tee with a single post and double post using HFSS and compares with surface integral equation formulation technique [16].

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. In the case of conical post even if we can use the structure beyond the X-band with a return loss of 15dB. 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 E-PLANE TEE

The three dimensional view of the unmatched and matched E-plane Tees are shown in Fig. 1-4. Fig. 1 shows an unmatched E-plane tee. Whereas, Fig. 2- 4 show the matched E-plane tees.

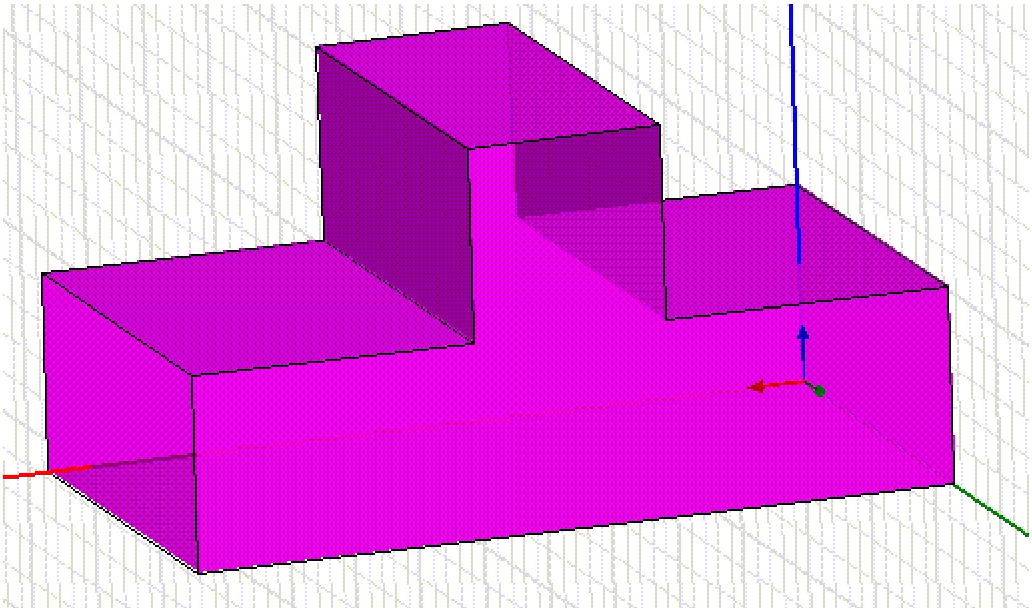

Fig. 1: Three dimensional view of an unmatched E-plane Tee.

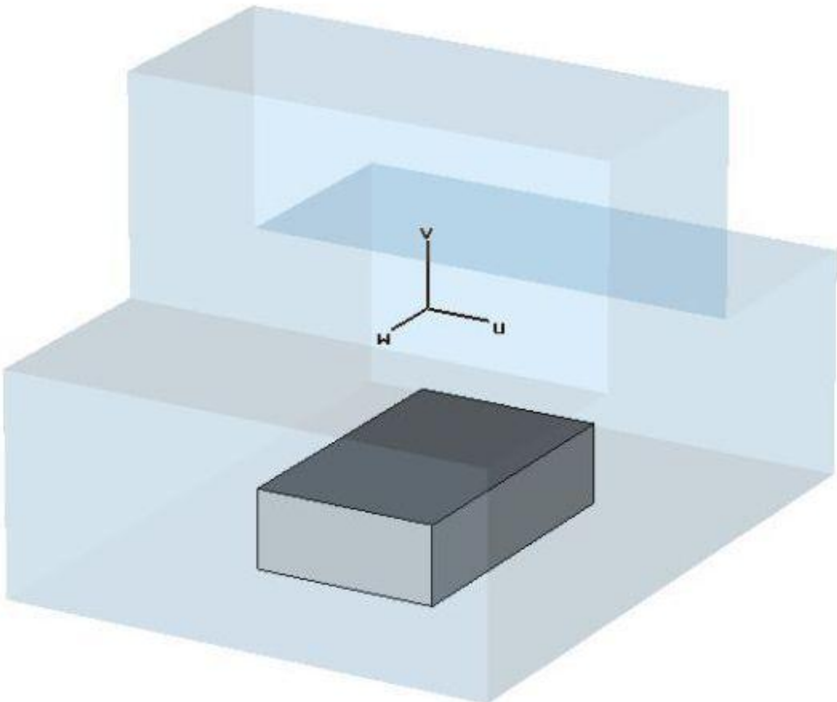

Fig. 2: Three dimensional view of a Matched E-plane Tee with rectangular shorting post.

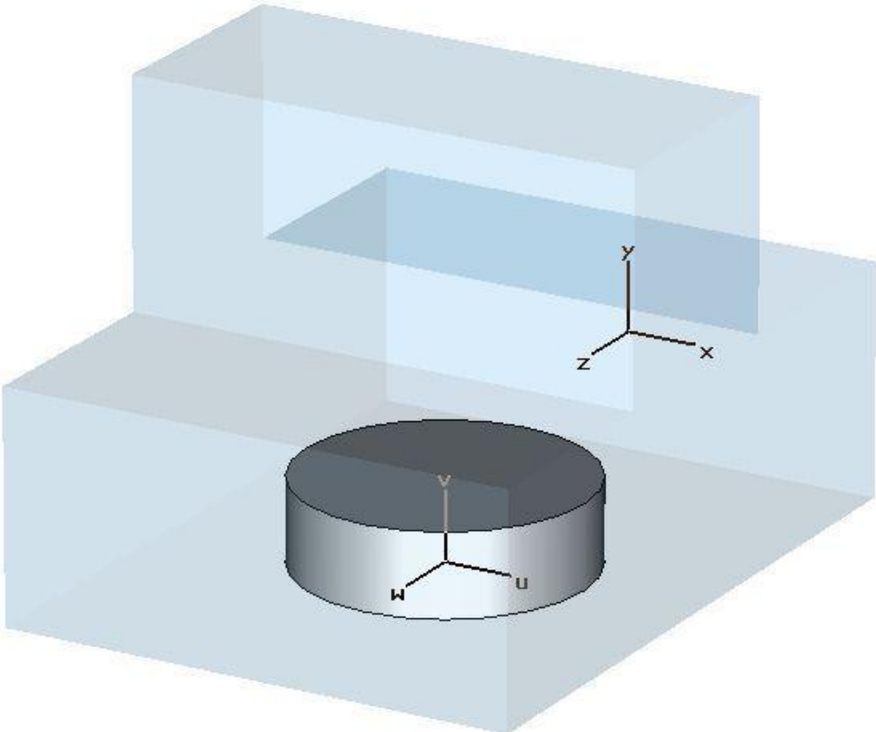

Fig. 3: Three dimensional view of a Matched E-plane Tee with cylindrical shorting post.

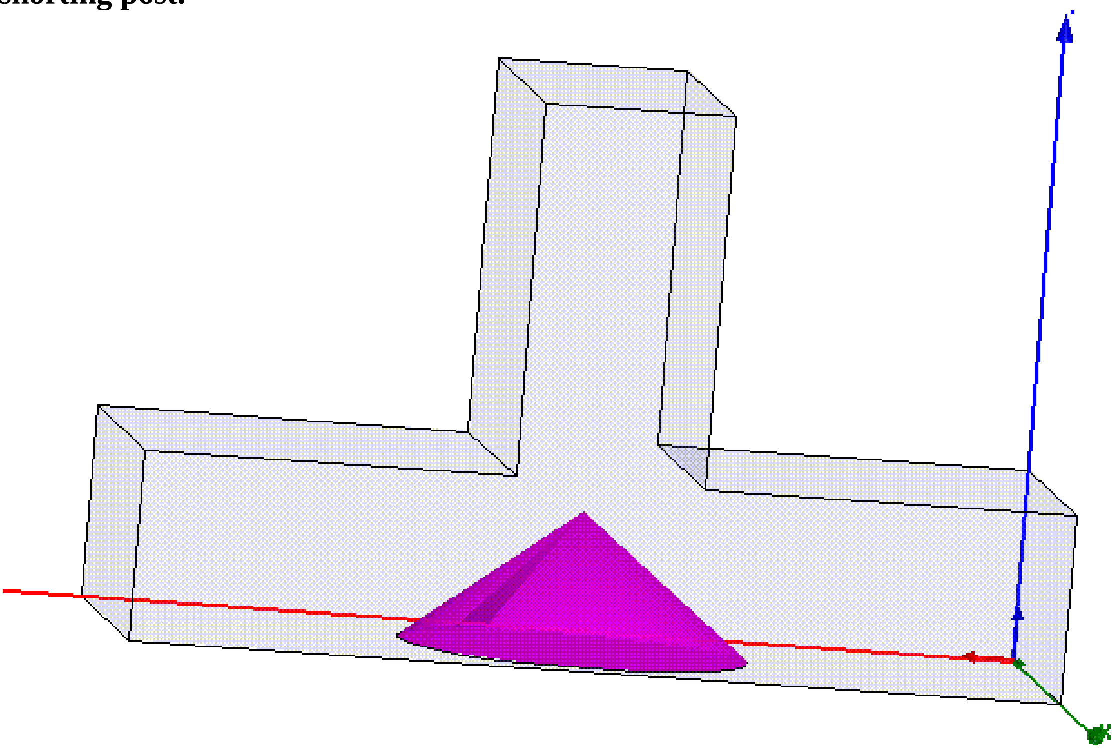

Fig. 4: Three dimensional view of a Matched E-plane Tee with conical shorting post.

A matched E-plane tee with rectangular shorting post is shown in Fig. 2. A matched E-plane tee with cylindrical shorting post is shown in Fig. 3. A matched E-plane tee with conical shorting post is shown in Fig. 4. The shorting post is placed at the center of the tee junction. The shorting posts are chosen as perfect electric conductors. The dimensions of the shorting post are given in table-1.

Table-1: Dimensions of Shorting Post

Rectangular	in mm	Cylindrical	in mm	Conical	in mm
Length(w)	13.7	Radius	6.4	Radius	9.4
Breadth(u)	8.4				
Height(v)	3.7	Height	3.6	Height	7.4

III. RESULTS AND DISCUSSION

The magnitude of the scattering parameters for E-plane Tees has been computed using CST Microwave Studio and HFSS. And also, the simulation data have good agreements with measured data for other types of structures by many researchers. In the structure the auxiliary arm is taken as port-3.

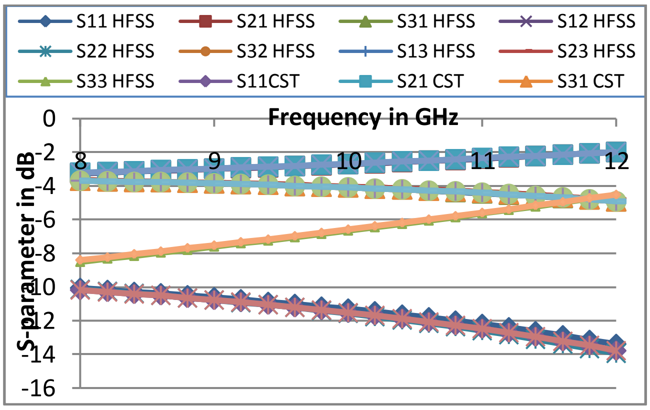

Fig. 5: CST Microwave Studio and HFSS simulated data of s-parameters for an unmatched E-plane Tee.

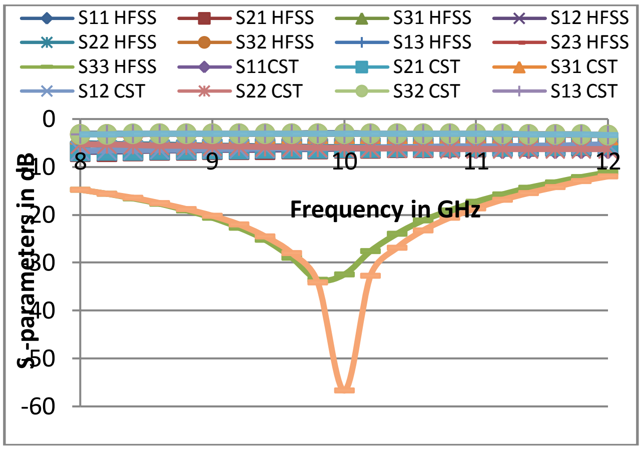

Fig. 6: CST Microwave Studio and HFSS simulated data of s-parameters for a matched E-plane Tee with a rectangular shorting post.

The magnitude of S-parameters for the unmatched E-plane Tee has been shown in Fig. 5, which shows return loss at port-3 is 8.39 dB at 8GHz and 4.5db at 12GHz. In Fig-6 the magnitude of S-parameters for the matched E-plane Tee with rectangular shorting post has been shown, which shows that the S_{31}, S_{13}, S_{32} and S_{23} have the equal magnitude and near about equal to -3dB with a variation of 0.13dB. In Fig. 6, magnitude of S_{33} is less than -15 dB in the band ranging from 8.2GHz to 11.5GHz with lowest at 10 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_{12} and S_{21} have the same magnitude over the entire X- band which is nearly equal to -6 dB.

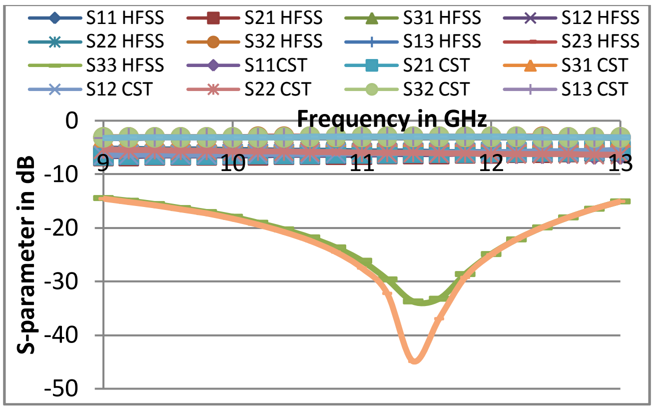

Fig. 7: CST Microwave Studio and HFSS simulated data of s-parameters for a matched E-plane Tee with a cylindrical shorting post.

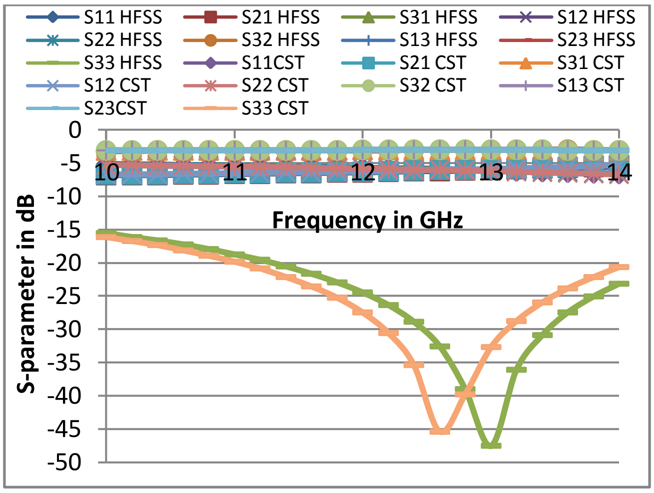

Fig. 8: CST Microwave Studio and HFSS simulated data of s-parameters for a matched E-plane Tee with a conical shorting post.

In Fig. 7 the magnitude of S-parameters for the matched E-plane Tee with cylindrical shorting post has been shown, which shows that the S_{31}, S_{13}, S_{32} and S_{23} have the equal magnitude and near about equal to -3dB with a variation of 0.15dB. In Fig. 7, magnitude of S_{33} is less than -15 dB in the band ranging from 9.2GHz to 13 GHz with lowest at 11.4 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_{12} and S_{21} have the same magnitude over the entire X- band which is nearly equal to -6 dB.

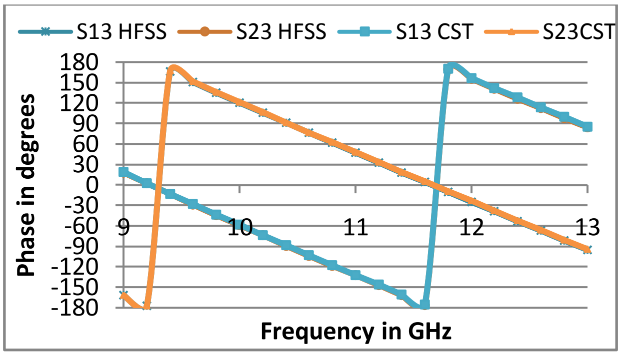

Fig. 9: CST Microwave Studio and HFSS simulated data for phase of s-parameters for a matched E-plane Tee with a rectangular shorting post.

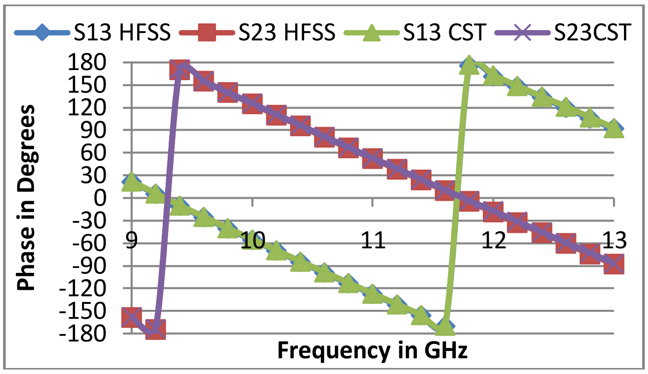

Fig. 10: CST Microwave Studio and HFSS simulated data for phase of s-parameters for a matched E-plane Tee with a cylindrical shorting post.

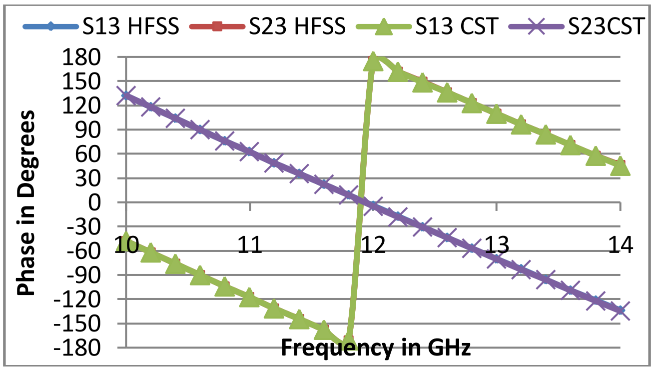

Fig. 11: CST Microwave Studio and HFSS simulated data for phase of s-parameters for a matched E-plane Tee with a cylindrical shorting post.

The magnitude of S-parameters for the matched E-plane Tee with conical shorting post has been shown in Fig. 8, which shows that the S_{31}, S_{13}, S_{32} and S_{23} have the equal magnitude and near about equal to -3dB with a variation of 0.11dB. In Fig. 8, magnitude of S_{33} is less than -15 dB in the band ranging from 10 GHz to 14 GHz with lowest at 12.6GHz by CST where as it is 12.8 of HFSS. The same conditions are also achieved as we get for other structures to other S–parameters.

The phase angle of the S_{13} and S_{23} are shown in the Fig. 9-11 for rectangular, cylindrical and conical shorting post tee junction respectively. It is seen that the phase difference is exactly 180^0. The simulation is carried out for a pass of 20 in the case of HFSS and a delta refinement of 0.02. So also for the CST, a hexahedral mesh with 20 lines per wavelength is taken.

ACKNOWLEDGMENT

The support provided by Kalpana Chawla Space Technology Cell, IIT Kharagpur is gratefully acknowledged.

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Authors biography

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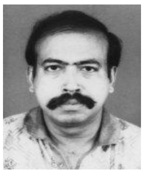

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