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Branch Line Directional Coupler with Ultra Wide Bandwidth

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Abstract
The present paper relates to "Branch Line Directional Coupler with Ultra Wide Bandwidth". The coupler discussed in this paper is capable of operating under the range of ultra-wide frequency and having 2.6 GHz value of operating frequency. Variety of "Micro-wave quadrature hybrids" are recounted for the realizing the stable circuitries, phase shifters, and matched attenuators. Because if convenient designing and execution, the coupler is considered as most popular hybrids. The drawback is it offers restricted bandwidth with huge space necessity. Therefore, the paper deals with a study and examination of the performance based on simulations for "micro-strip branch-line coupler" which is used along with PUFF. After considering analytical/theoretical evaluations using a software, the bandwidth can be enhanced in a range of 3.1- 10GHz with the help of stubs.

Keywords: *Stubs, Lumped Parameters, Shunt transmission Line, Open Circuited and Short Circuited Coupler.*

I. INTRODUCTION

There are many applications for branch-line couplers in the circuits of millimeter wave and microwave. Ninety degree and one hundred eighty degree fusion branch-line fitted couplers, like availability of 6dB/3dB coupler in the present millimeter/microwave systems in communication technology. They are functional with the odd multiples of the 1st order or fundamental frequency band that helps in preventing themselves from the multipurpose applications in multi or dual-band systems. Moreover, it escapes slight gaps of line and requirement of bond wires [1]. Usually 3dB value is decided for branch-line couplers, directional couplers with 4 ports and ninety degrees difference in phase between the 2 ports of output named as coupled and through arms. Quadrature Hybrid couplers (Branch-line couplers) are frequently prepared in the form of micro-strip. A conventional branch line coupler is represented in Figure 1, in the form of micro-strip-line. Frequency response is represented in Figure 2 for a conventional coupler along with the given constraints provided in the software.

II. FAULTY GROUND STRUCTURE

An engrave strctured DGS has a configuration of periodic/non-periodic defect in planar transmission line's ground like conductor backed coplanar wave guide, microstrip, and coplanar wherein shield current distribution is distressed by this in the ground plane reason of the ground's fault. The result of this trouble varies the characterstical appearances

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for the line of transmission like inductance/capacitance. In another way, any fault engraved in the micro-strp's ground plane enables rise in increasing operative inductance/capacitance.

III. RESONANT STUBS

For conveying the well-matched performance parallel operation of segments is used in place of lumped parameters at great frequencies of transmission. Transmission line generlly uses stubs in open or shorted form. Small segments of transmission line ended in short impedances act as inductors, although, when ended with high valued impedances act as capacitors. Consequently a parallely connected short parallel circuited stub works as inductive. (While effective length is inbetween 5-10 percent then it is considered as short line segment). To act like capacitor the stub should be open circuited in parallel connection.

IV. PROJECTED METHOD OF ULTRA WIDE BAND

The input impedance of transmission line is given

by $Z_{in}=Z_0\frac{Z_l+jZ0\tan\beta*l}{Zo+jZ_l\tan\beta*l}$ 1

$\Gamma_l=(Z_l-Z_0)/(Z_l+Z_0)$ 2

Where Γ_l is the reflection coefficient

here,

Z_0 is the characteristic impedance

Z_l is the load impedance

The input impedance of open circuit stubs is

$Z_{in}=-j\,Z_o\cot(\beta*l)$ 3

If $(\beta*l)=\lambda/4=90^0$ then $Z_{in}=0$

The input impedance of short circuit stubs is

$Z_{in}=j\,Z_o\tan(\beta*l)$ 4

If $(\beta*l)=\lambda/4=90^0$ then $Z_{in}=\infty$

From expression 4 it is concluded that the stubs with short circuited connection deliver infinite value of resistance at its operational frequency. Correspondingly, "0" value of resistance can be provided by open circuited connection of stubs nearby operational frequencies and also at the operational frequency.

In case of 3dB valued conventional coupler wherein $\theta_1=\theta_2=450$, the characteristical impedance is $Z0/\sqrt{2}$ in case of series transmission line while for shunt transmission line it is Z0, the outcomes would be:

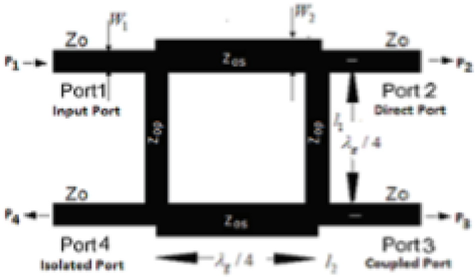

Fig. 1: Branch line coupler

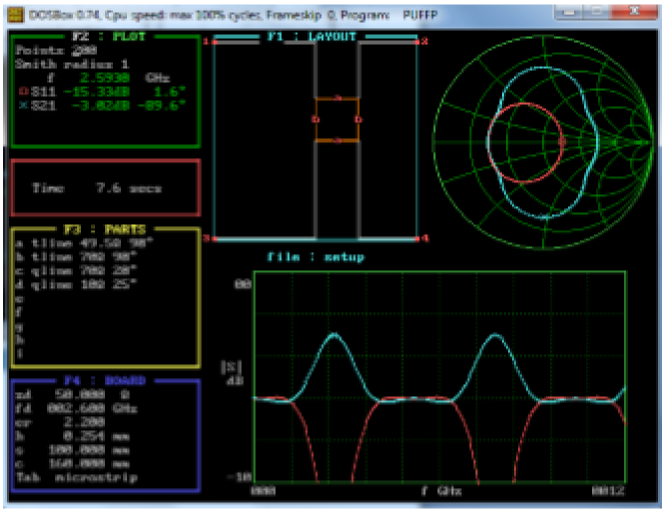

Fig. 2: Representation of bandwidth for the parameters as given in the figure.

The characteristic impedance with dielectric constant 2.2 for W/d ≥2 can be calculated as [5]

$Z_0=\{120\pi/\sqrt{\varepsilon_e}[W/d+1.393+0.667\log(W/d+1.44)]$

for W/d ≥1} 5

$\varepsilon_e=(\varepsilon_r+1)/2+(\varepsilon_r-1)/2*1/\sqrt{(1+12d/W)}$ 6

Where $1<\varepsilon_e<\varepsilon_r$ here W is width of transmission line , d is height of substrate , ε_e is the effective dielectric constant , Here ε_r is the relative dielectric constant.

In case of putting short-circuit stubs in the mid of the series as well as shunt transmission lines the bandwidth upsurges to some degree while facing the great attenuation at some intermediate value of the frequency. Therefore when exta stubs are added, that exhibit some finite value of impedance at different values of frequencies and operating frequency varies the total transmission line's impedance resulting in inaccurate coupler's performance.

V. DESIGN PARAMETERS OF THE COUPLER

Originally, maintaining the 50Ω value for the coupler characteristic impedance and 2.6 GHz value for frequency of the design and dielectric constant at 2.2 value of substrate. "Energy Conservation" can be used for the determination of coupler's attenuation.

$$|S_{12}|^2 + |S_{13}|^2 = 1 \quad 7$$

The series and shunt impedences varies with the variation of the frequency because there exists some limited stub's impedance. Meanwhile the input impedance and scattering parameter are real of the coupler at the center value of frequency.

Infinte input impedance exists in case of stub with short circuitry, while ninety degree is the stub's electrical length. A impeccable mismatching is provided by open/closed stub and co-efficient of reflection is either -1 or +1. When stubs are added proportionally the deviancy from the centeral frequency generates minute attenuation .

The different parameters of coupler have been determined for providing the outcome in ultra wideband by doing theoretical/analytical analysis. The parameters of scattering for the coupler can be indirectly identified using the software. By the stubs high impedance line can be designed and miniaturization can also be done.

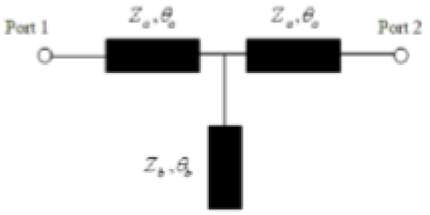

Fig. 3: Equivalent quarter wavelength transmission of T-model.

ABCD parameters are determined to calculate tha total impedence of the line and that are given as:

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix}_{\lambda/4} = \begin{bmatrix} 0 & jZo \\ jYo & 0 \end{bmatrix} \quad 8$$

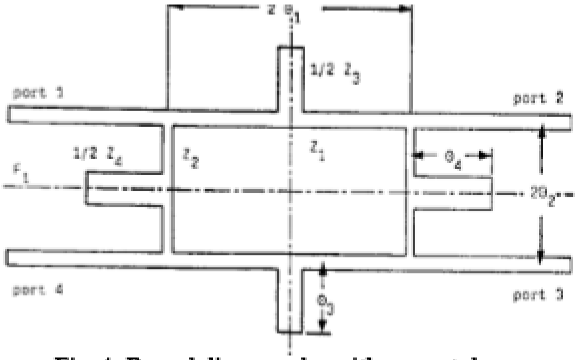

Fig. 4: Branch line coupler with open stubs

VI. COUPLER'S FREQUENCY RESPONSE WITH DIFFERENT PARAMETERS

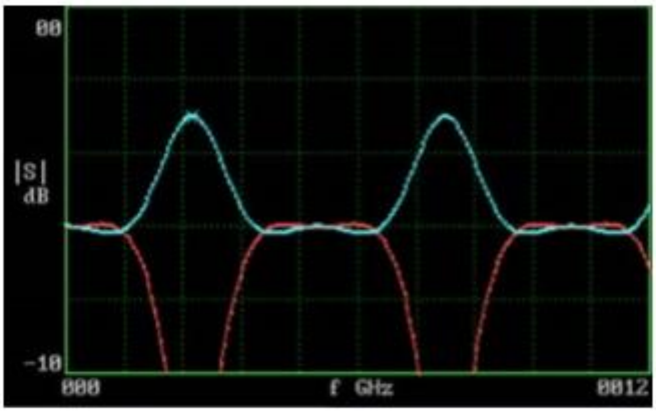

Fig. 5: Frequency behavior ofa simple branch line coupler with, Z_1=49.5Ω, Z_2=70Ω, Z_3=10Ω, Z_4=70Ω, $\Theta_1=90^0$, $\Theta_2=90^0$, $\Theta_3=25^0$, $\Theta_4=20^0$ electrical length

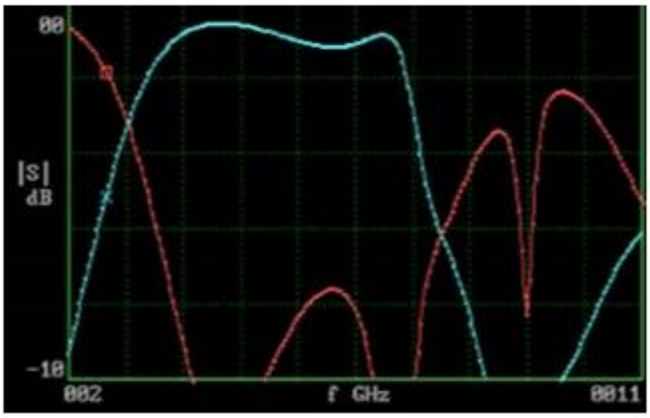

Fig. 6: Frequency behavior ofa branch line coupler open stubs with, Z_1=49.5Ω, Z_2=70Ω, Z_3=60Ω, Z_4=35Ω, $\Theta_1=45^0$, $\Theta_2=45^0$, $\Theta_3=30^0$, $\Theta_4=10^0$ electrical length

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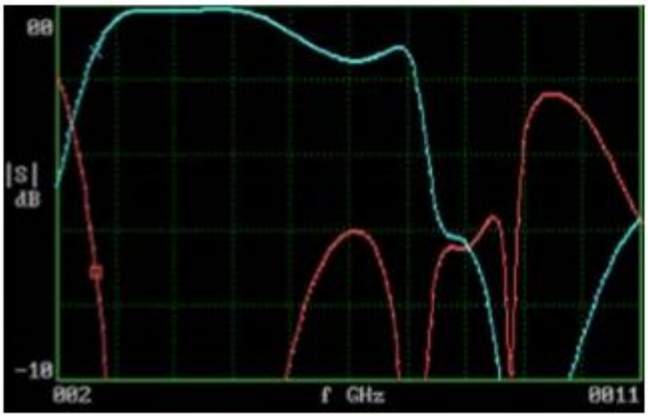

Fig. 7: Frequency behavior ofa branch line coupler with decreased characteristic impedance,Z_1=35.5Ω,Z_2=80Ω, Z_3=70Ω, Z_4=40Ω, $Θ_1$=45^0, $Θ_2$=45^0, $Θ_3$=30^0,$Θ_4$= 10^0 electrical length

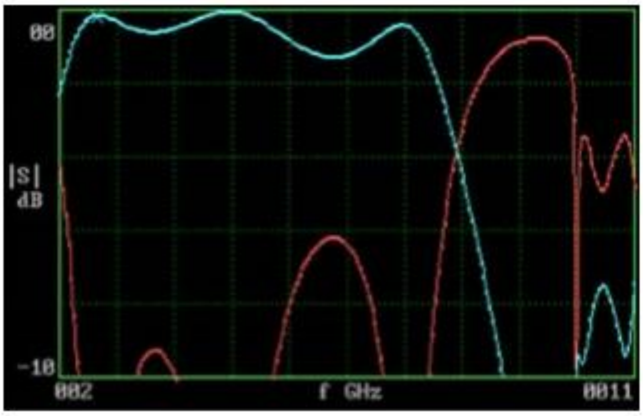

Fig. 8: Frequency behavior ofa branch line couplerwith increased electrical lengthwith Z_1=30.5Ω, Z_2=80Ω, Z_3=70Ω, Z_4=20Ω, $Θ_1$=50^0 , $Θ_2$=45^0, $Θ_3$=37^0,$Θ_4$= 10^0 electrical length

Fig. 9: Frequency behavior ofa branch line coupler with ultra wide bandwidth with Z_1=52.5Ω, Z_2=80Ω, Z_3=80Ω, Z_4=20Ω, $Θ_1$=58^0 , $Θ_2$=27^0, $Θ_3$=36^0,$Θ_4$= 11^0 electrical length.

Table 1 carries various enteries of the width as well as length and of shunt/series line of transmission achieved from figure 9.

Table 1: Length And Width Of The Transmissiom Line In BLC With Closed Stubs

Parameters	Length(mm)	Width(mm)
A	13.543	1.603
B	6.431	0.782
C	2.476	5.685
D	8.574	0.782

‘a’ denotes series transmission line, ‘b’ denotes shunt transmission line, ‘c’ and ‘d’ denote the closed stubs in parallel combination with shunt and series transmission line correspondingly represented in Table 1.

VII. CONCLUSION

The present work “Branch Line Directional Coupler with Ultra Wide Bandwidth” has been completed sucessfully. It is observed by the analysis, the enhancement in bandwidth of the coupler in an efficient manner can be done by changing series/shunt parameters of lines and also by changing the stubs open/short circuit parameters at or around the nearby values of operating frequency design.With the help of PUFF and different advanced the performance of the line coupler would be amplified. Moreover, the designing of high impedence line can be done by the open stubs wherein it also helps in improving outcome and miniaturization. The graphical plots achieved provides all of the scattering parameters indirectly on the particular design of parameters.

REFERENCES

[1] T. Moyra, A. Roy, S. K. Parui, and S. Das, “Design of 10 dB branch line coupler by using DGS,” in *Proceedings of the 2012 International Conference on Communications, Devices and Intelligent Systems, CODIS 2012*, 2012.

[2] S. I. Orakwue, R. Ngah, T. A. Rahman, and H. M. R. Al-Khafaji, “A 4 × 4 butler matrix for 28 GHz switched multi-beam antenna,” *Int. J. Eng. Technol.*, 2015.

[3] M. Y. O. Elhiwairis, S. K. B. A. Rahim, U. A. K. Okonkwo, N. B. M. Jizat, and M. F. Bin Jamlos, “MINIATURIZED SIZE BRANCH LINE COUPLER USING OPEN STUBS WITH HIGH-LOW IMPEDANCES,” *Prog.*

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ISSN: 0193 - 4120 Page No. 2448 - 2452

Electromagn. Res. Lett., 2015.

[4] F. Hosseinkhani and S. Roshani, “A compact branch-line coupler design using low-pass resonators and meandered lines open stubs,” *Turkish J. Electr. Eng. Comput. Sci.*, 2018.

[5] T. Kim, J. Lee, and J. Choi, “Analysis and design of miniaturized multisection crossover with open stubs,” *Microw. Opt. Technol. Lett.*, 2015.

[6] H. Jin, K. Wang, J. Guo, S. Ding, and K. Wu, “Slow-Wave Effect of Substrate Integrated Waveguide Patterned with Microstrip Polyline,” *IEEE Trans. Microw. Theory Tech.*, 2016.

[7] Z. Yi, M. Li, B. Muneer, and Q. Zhu, “A novel compact slow-wave microstrip resonant antenna,” in *Proceedings of 3rd Asia-Pacific Conference on Antennas and Propagation, APCAP 2014*, 2014.