© 2020 IJSRST | Volume 7 | Issue 7 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology
DOI : 10.32628/IJSRST

Study of Design of 6 DB Coupler

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ABSTRACT

In this paper, I present about the study of design of 6 dB. The importance lies in the present study of light weight, small size and lower cost planer transmission structure like MIC's of communications. Also, in the fact that radio astronomers use these frequencies to study electromagnetic radiation originating from stars & others celestial objects.

KEYWORDS: Stripline, Microwave, Microstripline Couplers.

I. INTRODUCTION

An ideal directional coupler makes use of basic feature that power flowing in one direction in the main transmission line induces a power flow in the secondary line. This is due to the mutual induction between the two transmission lines. This phenomenon is called coupling between the two lines [1-5]. This field has been developed due to advent of microwave integrated circuits (MICs). Using planar transmission structure Stripline or microstriplines directional couplers can be constructed by having a main transmission line in parallel proximity to a secondary line. The study will also explore how the parameters can be varied for different specifications (i.e. directivity and coupling factor). The demand for telecommunication services is increasingly shifting from a locally - based telephony to long - distance and wide - based services using mobile telephones & cellular phones. Parallel to this the advent of microwave technology has also revolutionized the concept of telecommunication and data transfer. In the modern world, exchange of information at faster rate is a critical management tool. The advances in microwave technologies have helped in bringing the world closer. The flow of power means the propagation of electromagnetic waves through these structures. There are different modes of propagation of waves such as (i) TEM-mode, (ii) TE-mode, (iii) TM-mode, and (iv) Non-TEM-mode. Which discussing the propagation of wave through Stripline or microstriplines TEM-mode is considered in the lower giga hertz range of frequency in the present work. There are various types of planar transmission structures such as (i) Stripline (ii) Microstrip line, (iii) Coplanar strip lines, and (iv) their various forms. Using these planar transmission structure stripline or microstriplines directional couplers can be constructed by having a main transmission line in parallel proximity to a secondary line. Due to coupling a fraction of the power present on the main line is coupled to the secondary line. Considering this fact, a directional coupler of given specification can be designed. The present work is based on this concept.

It is all due to development of fiber-optical communication technology and microelectronic technology. Optical electronics has changed the world into a global information village. This technology has come of age & is now not limited to Defence area such as radar but the use of satellites and repeaters has enabled us to link the remotest corners of universe with multi-TV channels and telecommunication networks. As a result, the growth of microwave technology in research is accelerating at fast rate.

Different methods have been developed for the study of characteristics, and design techniques for computing coupling factor and directivity of the coupled lines of given parameters. To design a 50-ohm 6 dB directional coupler mathematical formulation of the problem is accomplished using CAD to obtain specified parameters.

II. FORMULATION OF THE DIRECTIVITY OF THE MICROSTRIPLINE DIRECTIONAL COUPLER

It is the measure of discrimination of a directional coupler between forward and backward waves and is defined as the ratio of the voltage coupled to the desired port and of the voltage coupled to the undesired port, i.e.

$D = V_4/V_3$

$D(dB) = -20 \text{ Log } V_4/V_3$ --------------- 1

For an ideal forward directional coupler directivity is infinity, i.e. voltage at port 3 should be ideally zero. The signal is coupled only to port 4, ports (2) and (4) being perfectly matched. [3-5] With microstrip the differing field pattern associated with the odd and even modes, give rise to different phase velocities [6-9]. This results in some coupling to the unwanted port as well. The greater difference in the phase velocities of the even and odd modes makes the coupling tighter. This parallel microstrip directional coupler may not give a wide band width performance for tight coupling. Further the directivity depends on microstrip geometry and substrate property ϵ_r . An approximate but simpler mathematical expression for the directivity of the coupled microstrip coupler is given as

$D = [4|\xi| / \Delta\pi(1-|\xi^2|)]^{-2}$

$D = [\lambda\pi(1-|\xi^2|) / 4|\xi|]^2$ --------------- 2

Where,

$\Delta = [\lambda_{go} / \lambda_{ge}] - 1$ --------------- 3

λ_{ge} and λ_{go} are the guide wavelengths of the coupled lines for even and odd modes respectively and expressed by equation and

$\xi = [\rho_e / 1- \rho_e^2] - [\rho_o / 1+ \rho_o^2]$ ---------------- 4

Where,

ρ_e = Reflection coefficient for even mode.

$= Z_{oe} - Z_o / Z_{oe} + Z_{oo}$ --------------- 5

and ρ_o = Reflection coefficient for odd mode.

$= Z_{oo} - Z_o / Z_{oe} + Z_{oo}$ --------------- 6

III. DESIGN SYNTHESIS OF MICROSTRIPLINE COUPLER

The coupling coefficient (C) at mid band frequency has been expressed in equation 1. The feed line characteristic impedance is given by

$Z_o = [Z_{oe} \text{ x } Z_{oo}]^{1/2}$ ------------- 7

Now for the design of a microstripline directional coupler of given coupling coefficient and feed line characteristic impedance we calculate even and odd-modes characteristic impedances using equations

$Z_{oe} = Z_o [(1 + C) / (1 - C)]^{1/2}$ -------------- 8

$Z_{oo} = Z_o [(1 - C) / (1 + C)]^{1/2}$ -------------- 9

Again, using these values of characteristic impedances shape ratio for Alumina dielectric substrate ($\epsilon_r = 9.6$) is expressed as

$W/h = 20.37 [4/ Z_{oe} + 1/ Z_{oo}]$ - -------------- 10

And approximate value space ratio is given by

$s/h = 377 (4 Z_{oo} + Z_{oe}) / (3 + 5 \sqrt{\epsilon_r}) Z_o^2$ ---------------- 11

Using these equations stripwidth and spacing between two striplines have been calculated for given coupling. Again, these values of shape ratio and space ratio are used to calculate Z_{oo} and Z_{oe} and results obtained are compared for conformity as $Z_{oe} = 86.6\ \Omega$ and $Z_{oo} = 28.8\ \Omega$ for w = 18.8 mils and s = 15 mils. Here 1 mil stand for 10^{-3} inch.

IV. DESIGN OF 6 DB COUPLER

For designing a 6 dB coupler the specifications are:

(i) $C_{dB} = 6$ dB and $Z_o = 50\ \Omega$

This gives coupling coefficient; c = 0.5

(ii) Permittivity of dielectric substrate; $\epsilon r = 9.6$

(iii) Thickness of stripline; t = 0.01 mils

(iv) Midband frequency; f = 2 GHz

In this range of frequency dispersion effect is neglected.

V. DESIGN CALCULATION

Using above equations the characteristic impedance for even and odd-modes of the 6 dB directional couplers have been calculated to be $Z_{oe} = 86.62\ \Omega$, $Z_{oo} = 28.80\ \Omega$, The results yield $Z_o = [Z_{oe} \times Z_{oo}]^{1/2} = 49.99\ \Omega = 50\ \Omega$. This conforms the correctness of the calculations. When these values are placed in above equations the width of microstripline is found to be w = 18.8936 mils and spacing between two striplines s = 15.0935 mils. Also the effective dielectric constant for even and odd-modes are obtained to be $(\epsilon_{reff})_e = 6.582$ and $(\epsilon_{reff})_o = 5.442$. These results tally with those obtained in analysis process of the coupler.

VI. CONCLUSION

Different methods have been developed for the study of characteristics, and design techniques for computing coupling factor and directivity of the coupled lines of given parameters. To study the design of directional coupler mathematical formulation of the problem is accomplished using CAD to obtain specified parameters.

VII. REFERENCES

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