MULTIWAY IN-PHASE SINUSOIDAL MICROWAVE POWER DIVIDER

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Specially dedicated to my beloved parents, family, friends and colleagues for their support and encouragement.

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ABSTRACT

Multiport power dividers form the fundamental block in microwave and millimeter wave circuits that divides the input RF power by arbitrary ratios. The power divider is basically a device that splits the input power into a number of smaller amounts of power at multiple ports (*N*) to feed a number of branching circuits with isolation between the output ports. It has wide range of applications such as in antenna system, power amplifiers, power oscillators and balanced mixers A good power divider should feature high isolation at output ports, excellent phase and amplitude balance, low insertion loss, higher power handling capability, compact in size and wider bandwidth. The basic approach to design a good power divider is to have a performance comparison on the basic type of the power divider like triangular, sectorial and sinusoidal. The sinusoidal power divider having the most advantage compare with triangular and sectorial because of it geometry could achieve port alignments and structure compactness. Diffractive hole introduces in the circuit layout can improved the performance of the device. The proposed power divider is aimed to have features of high isolation at the output ports, excellent phase and amplitude balance, low insertion loss, higher power handling capability, compact in size and wider bandwidth. Good power dividers allow the system to have better performance in its application by giving better signal clarity, low non-linear signal distortion, reduce number of amplifiers, lower investment and cost effectiveness.

ABSTRAK

Pembahagi kuasa berbilang liang adalah binaan asas bagi litar gelombang mikro. Ia digunakan untuk membahagi isyarat terima kuasa mengikut ratio mengikut cabang yang telah ditetapkan. Pembahagi ini adalah bagi penting bagi aplikasi seperti penguat kuasa gelombang mikro dan system antenna. Pembahagi kuasa yang bagus mempunyai kualiti bermutu seperti kehilangan sisipan rendah dan lebarjalur luas. Pendekatan asas yang digunakan adalah menganalisa struktur asas pembahagi kuasa yang berbentuk segitiga, sector dan sinus. Pembahagi berbentuk sinus mempunyai tahap kemampuan yang bagus kerana mempunyai kebaikan mencapai penjajaran liang di samping kepadatan struktur untuk memudahkan ia digunakan dengan litar yang lain. Dengan pengenalan lubang pembelauan di dalam litar pembahagi kuasa ia meningkatkan lagi keseimbangan magnitude dan fasa isyarat keluaran. Dengan adanya pembahagi kuasa yang baik, aplikasi yang digunakan akan lebih bagus di samping menjimatkan kos pelaburan dalam mengawal selia litar tersebut.

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CHAPTER I

INTRODUCTION

1.1 Overview

Multiport power dividers form the fundamental block in microwave and millimeter wave circuits that divides the input RF power by arbitrary ratios. The power divider is basically a device that splits the input power into a number of smaller amounts of power at multiple ports (N) to feed a number of branching circuits with isolation between the output ports. It has wide range of applications such as in antenna system, power amplifiers, power oscillators and balanced mixers.

A good power divider should feature high isolation at output ports, excellent phase and amplitude balance, low insertion loss, higher power handling capability, compact in size and wider bandwidth. Furthermore, with good power dividers, the system performs better by giving better signal clarity, low non-linear signal distortion, reduce number of amplifiers, lower investment and low cost. N-way power dividers also very economical because a single unit can be replaced with several split band units.

1.2 Objective of Project

The objective of the project is to design an optimum 3-way symmetrical in-phase sinusoidal power divider that can operate at S-band region, which is between 2 GHz to 4 GHz.

1.3 Problem Statement

The power divider is an essential element in the design of transistor-based high power amplifiers and array-antenna related to beam-forming networks. The passive power divider circuits are used extensively at microwave and millimeter-wave frequencies. When the circuit is realized in microstrip configurations, two particular symmetric geometries are used; radial and circular oriented lines [1], [2] and the fan-out, Wilkinson type geometry [3].

Using power dividing circuits in the form of radial and circular topologies have the disadvantage of having multiple non-collinearly aligned ports. Hence it is difficult to integrate with other adjoining devices such as the solid-state power amplifier. Therefore it becomes necessary to use a vertically oriented feeding point.

This initiates the use of using the sectorial geometry or also known as the fan-out/Wilkinson geometry. It overcomes the divergence problem caused by the circular or radial geometry in view of the port alignments eventhough the size was not compact.

For this initiative, in order to achieve port alignments as well as maintaining the structure compactness, sinusoidal power divider was introduced [4].

For further improving the performance the power divider which is critical in high frequencies equipment, a hole can be introduced into the geometry, etched in the middle of the structure in order to equalize and synchronize the output signal [2], [4]. The hole will create a built-in diffraction used to compensate the electrical signal that going through the back-and-forth of the multiple reflection and transmission inside the geometry. Furthermore, different hole characteristics, set difference performance behavior for the different geometry of the power divider identified.

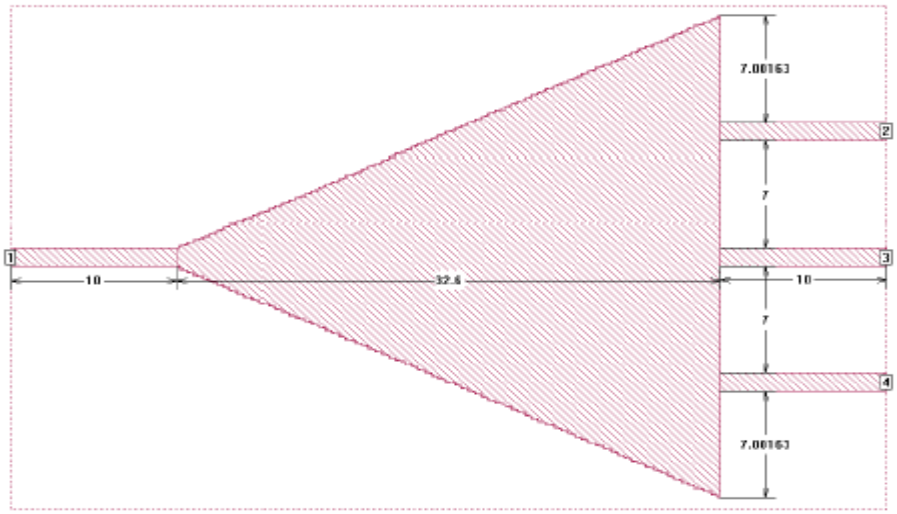
As the frequency become higher, therefore it is crucial to design power divider having compact in size, potential broadband operation, and easy-to-design collinearly aligned output ports. For this, repetitive analysis need to be done on the different geometries identified for the 3-way power divider in order to achieve the optimum performance.

1.4 Scopes of Project

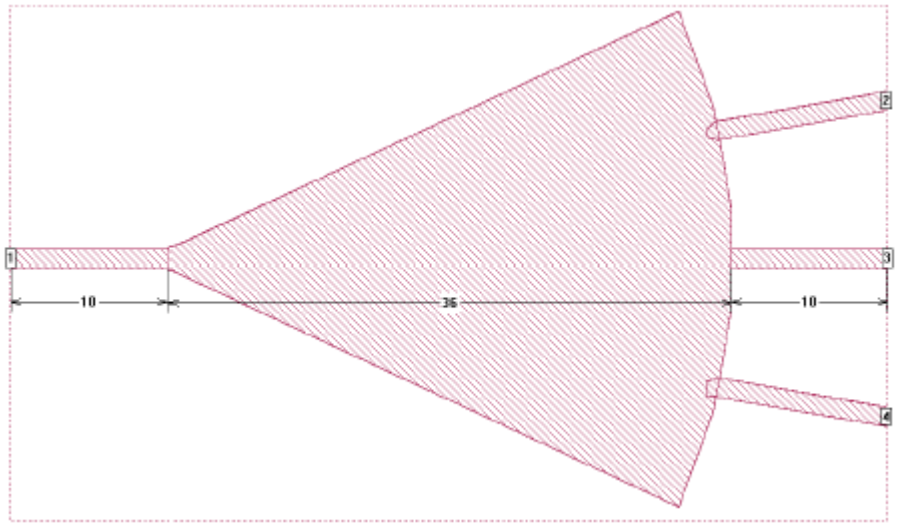
The project scopes are as follow:

- Literature review on transmission line theory , microwave technology and power divider concepts
- Discuss on the application of power divider and its future
- Design the power divider with different structure characteristics and simulate using electromagnetic simulation software
- Further simulate and analyze the performance characteristics
- Fine tune the power divider structure for optimum performance

The project investigates three different circuit geometries: triangular, sectorial and sinusoidal. A second set of similar geometries has an introduced rectangular hole. The geometries of the three power dividers are illustrated in Figure 1.1



(a)



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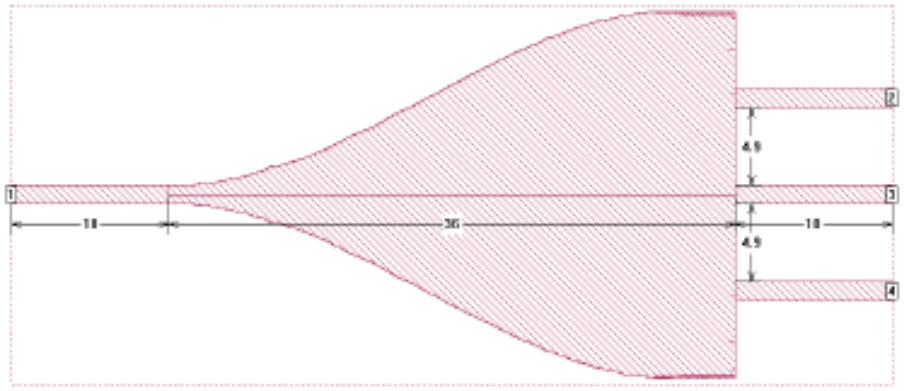

(c)

Figure 1.1 : Geometries of power divider (a) triangular (b) sectorial (c) sinusoidal.

1.5 Outline of The Thesis

The thesis is organized into 5 chapters. Chapter I describes the overview, objectives, problem statement and scopes of the thesis.

Chapter II discusses the literature review and theoretical background for the project. It includes transmission line theory, scattering parameters and theory on the power divider design. The basic structure of the power divider is also discussed and its function in the microwave applications is elaborated.

Brief description on the softwares used in the thesis is presented in Chapter III. These are mathematical MathCAD [5] software for computing design formulations, and electromagnetic simulation software Sonnet V9.52 [6] for simulating all the power divider circuits.

Chapter IV details the design methodology of the 3-way power divider. Three geometries of the power divider were presented; triangular, sectorial and sinusoidal. In addition, calculation of the transmission width is also shown and discussed.

The theoretical findings and simulation results of all the power dividers investigated are presented in Chapter V. The performances are then compared and discussed.

In Chapter VI, concludes the thesis and recommends future works for performance improvements.

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