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Design and Analysis of Wilkinson Power Divider Using Microstrip Line and Coupled Line Techniques

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Abstract: *In mobile and wireless application Wilkinson Power divider and Combiner is used to split or combine the power for supporting different devices with same or different band of frequencies. It is a passive device used in the field of radio technology to couple a defined amount of the electromagnetic power in a transmission line from one port to another port. Wilkinson power divider uses the micro strip technology, Coupled Line technology, coupled line technique and strip line technique. This paper proposes a design and comparison of 3dB Wilkinson power divider to split the power equally at the outputs by using micro strip technique and Coupled Line technique. It is planned to design a Wilkinson power dividers for mobile applications which has the operating frequency of 915MHz. Wilkinson power divider is simulated using a simulation tool advanced design system (ADS).*
Keywords: *Wilkinson Power Divider, Coupled Line technique, Mobile Applications, Micro strip Technology*

I. Introduction

The Wilkinson power dividers are essential component of microwave electronics that have been employed for decades for signal power splitting or combining in power amplifiers, transceivers, antenna feed networks etc. The Wilkinson power divider (WPD) proposed in 1960 has good match at all ports as well as excellent isolation between two output ports at the central frequency. It has been extensively applied to microwave circuits and antenna arrays, but suffers from its narrow bandwidth. Several design methods have been studied to increase bandwidth and high isolation between output ports.

Table 1: Comparison Of Passive Power Divider

Passive Power Divider	Advantage	Disadvantage
T-Junction	Lossless ports	Not matched at all ports. No isolation between the ports.
Resistive	Can be matched at all ports	No isolation between the output ports. Poor power handling, limited by resistor tolerances.
Wilkinson	Lossless (if matched at all ports)	Reflected power is dissipated through isolation resistor if mismatching is occurred.

The Wilkinson power divider is a basically a three port network that is lossless when the output ports are matched, only reflected power is dissipated. Input power can be split into two or more in phase signals with the same amplitude. For a two way Wilkinson power divider using λ/4 impedance transformer having characteristic impedance 2Z0. Generally, in microwave engineering field, all the Wilkinson Power Dividers are considered as microstrip lines as shown in Fig.1 (a). The equivalent circuit for the same has been shown in Fig. 1 (b).

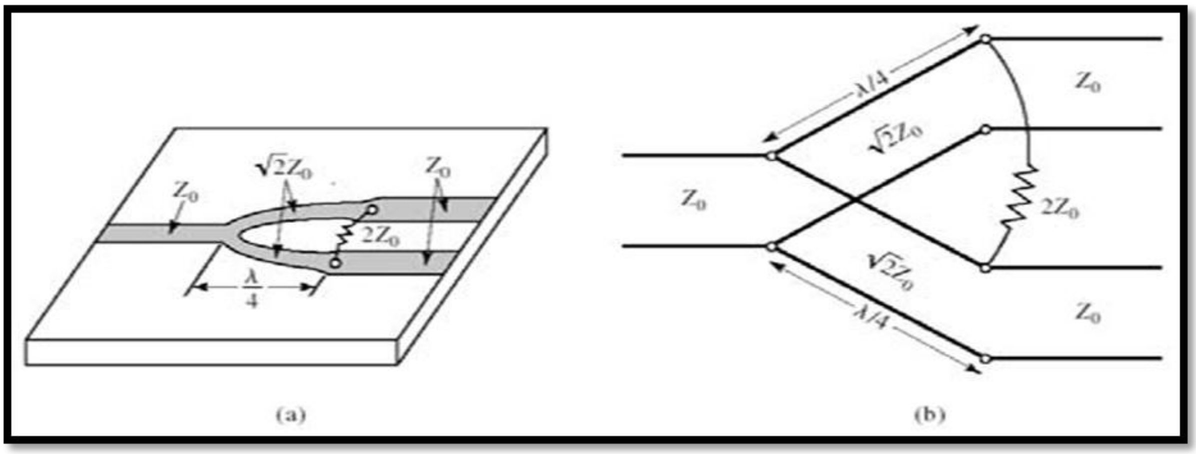


Figure1. (a) An equal-split Wilkinson Power Divider Microstrip form &
(b) Equivalent transmission line circuit

Modern trends in development of wireless communication systems are towards support of many different air interface standards. In consequence, wireless equipment components such as power dividers should cover all necessary frequency bands. The operational bandwidth of the conventional Wilkinson power divider seems to be insufficient for some applications

II. Headings

1.1 POWER DIVIDER PARAMETERS:

The following parameters are to consider while designing a power divider.
The parameters are:
Insertion loss
Return loss
Isolation loss
Bandwidth
Input and output Impedance

1.1.1) INSERTION LOSS:

Insertion loss is the loss of signal power resulting from the insertion of a device in a transmission line or optical fiber and is usually expressed in decibels (dB).The ideal value of insertion loss is 0dB.

Insertion loss (dB) = 10 log (pi/po)

Where,
Pi: Maximum amount of power that can be transmitted before the insertion of a device in a transmission line.
Po: Maximum amount of power that can be received after the insertion of a device in a transmission.

1.1.2) RETURN LOSS:

Return loss or reflection loss is the loss of signal power resulting from the reflection caused at a discontinuity in a transmission line or optical fiber. This Discontinuity can be a mismatch with the terminating load or with a device inserted in the line. It is usually expressed in decibels

Return loss (dB) = 10 log (Pi/Pr)

Where,
Pi: Amount of power incident on a transmission line
Pr: Amount of power reflected back to transmission line

1.1.3) ISOLATION LOSS:

Isolation is the insertion loss in the open path of a switch or between two ports on a passive device. It is measured between any one of the output port and input port with the condition of another port in terminating condition. It allows the signal only in the forward direction value should be high.

Isolation loss (dB) =10 log (Po/Pi)

Where,
Po: Amount of power received at output ports

Pi: Amount of power incident on a transmission line.

1.1.4) BANDWIDTH:

The efficient use of frequency between lower and higher lev~~els.10D~~b bandwidth is commonly calculated for return loss where VSWR is less than 2 and more than 90% of signal transmitted.

Return loss (dB) =-20log (1-VSWR/1+VSWR)

Bandwidth = $f_{H} - f_{L}$

1.2)THEORY

The simplest two-way Wilkinson power divider consists of two quarter-wavelength transmission line (TL) sections ($\theta = 90°$) and a resistor connected between the output ports. In case of equal power division, the normalized TL characteristic impedance and resistor impedance are Zo = 50 ohm and R = 2Zo.The design of the Wilkinson divider is composed of a transmission line (typically micro strip or strip line) that has been split into a specific number of transmission lines, each one quarter-wavelength long. In Wilkinson's original proposal, a shorting plate is used at the input to connect each of the transmission lines.

1.3) Microstrip background

Microstrip transmission lines are commonly used to build power dividers among other devices, because it can be easily fabricated through various techniques such as photolithography or milling. The microstrip layout shown in Fig 1.3.A is composed of a dielectric substrate between a ground plane and thin conductor where W is the conductor width, D is the thickness of the dielectric substrate, and ε_r is the relative permittivity of the substrate.

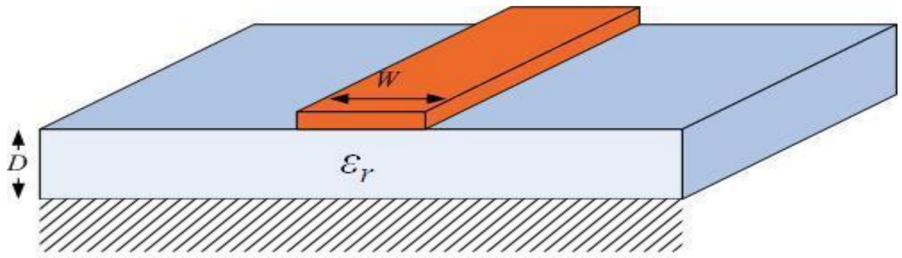


Fig (1.3.A) Microstrip Line

1.4) Coupled Line

Coupled Line is a planar transmission line .It is widely used for microwave integrated circuit design. As shown in figure, Coupled Line consists of a conductor strip at the middle and to ground planes are located on either side of center conductor. All these lie in the same plane. In Coupled Line, EM energy is concentrated within the dielectric. The leakage of the Electromagnetic energy in the air can be controlled by having substrate height (h) twice that of the width (s).

III. Design & Analysis

The Advanced Design system (ADS) is used for Design and Simulation of Wilkinson power divider networks using microstrip techniques and Coupled Line technique. The FR4 substrate of permittivity 4.4 and thickness of 1.6 mm has been used in the fabrication process. The design of microstrip power divider is constructed using one input and two output ports which are terminated by 50 ohm.

FR4 substrate parameters:

Dielectric constant (ε_r) = 4.4mm

Height (H) = 1.6mm

Micro strip line design of Wilkinson power divider

The characteristics impedance of microstrip line and microstrip curved bend are 50 ohm and 70.7 ohm respectively.

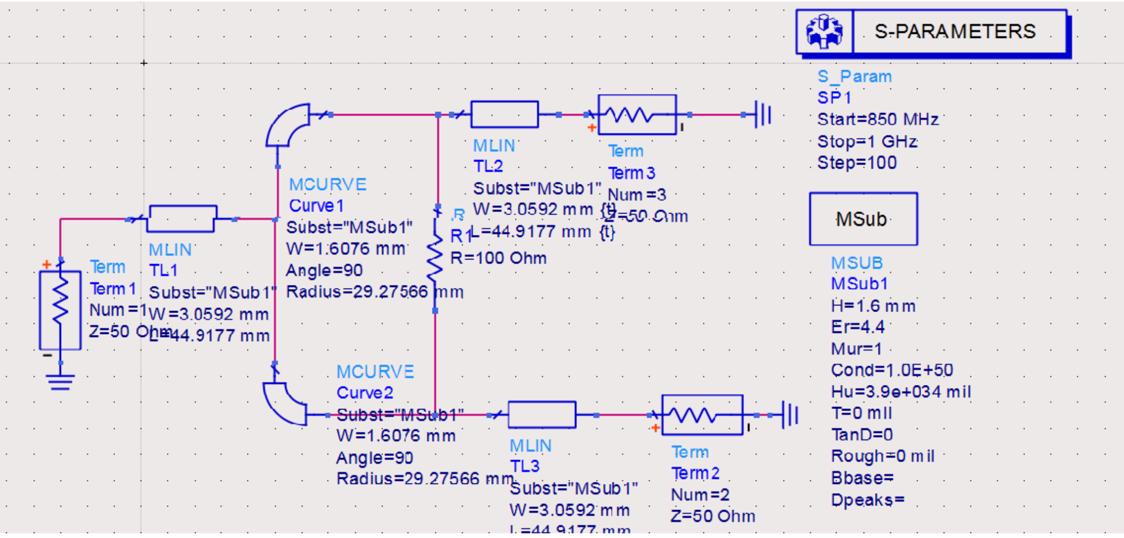


Figure 4: Schematic Diagram Of Microstrip Wilkinson Power Divider

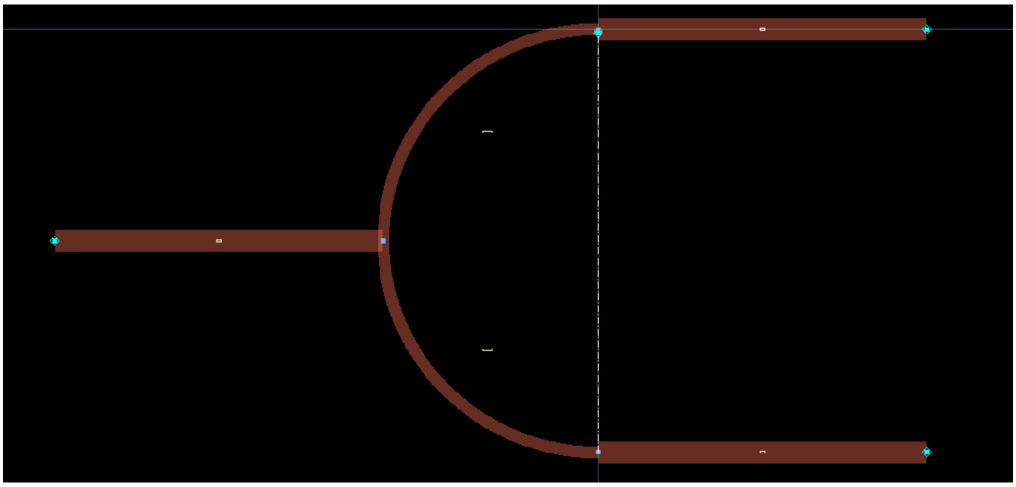
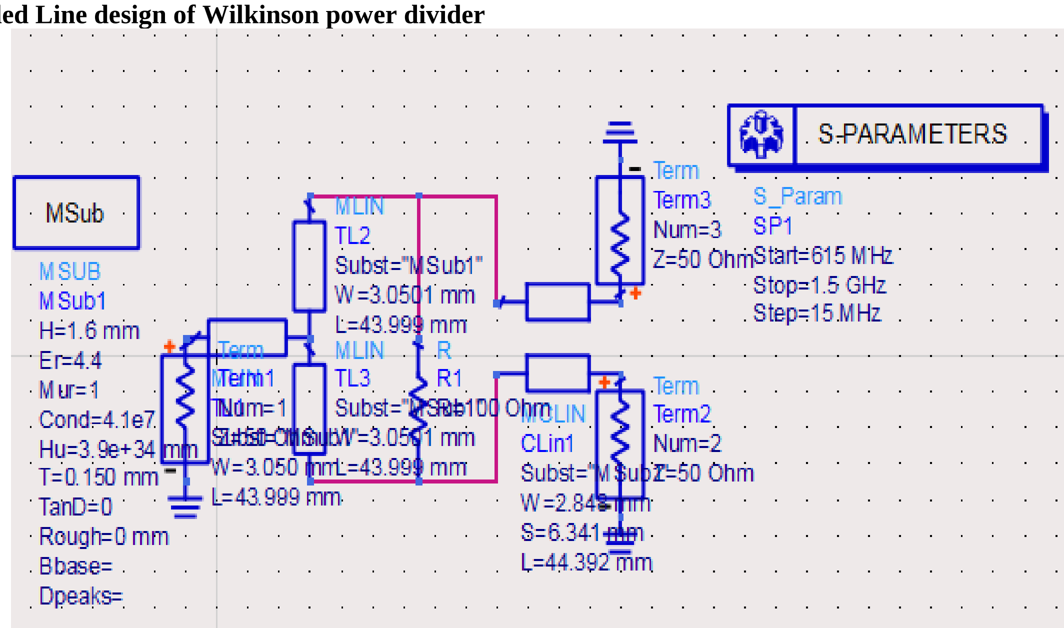


Figure5: Layout Diagram Of Micro Strip Wilkinson Power Divider

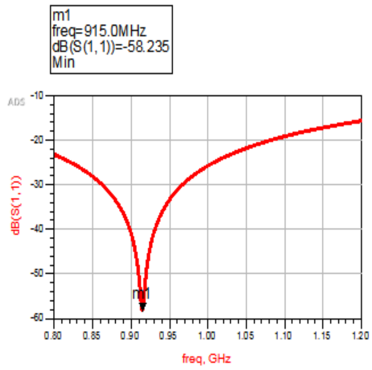
Coupled Line design of Wilkinson power divider

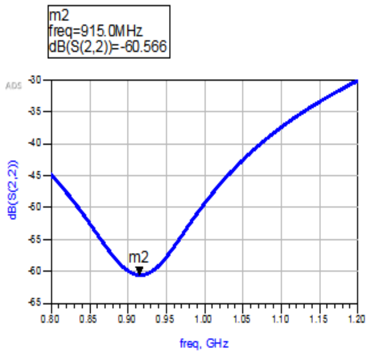


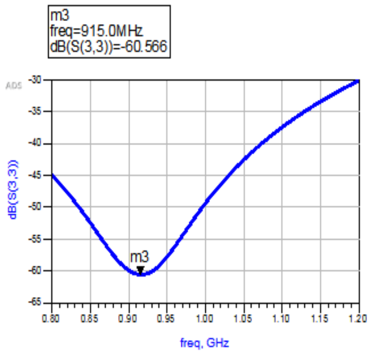
IV. Result And Analysis

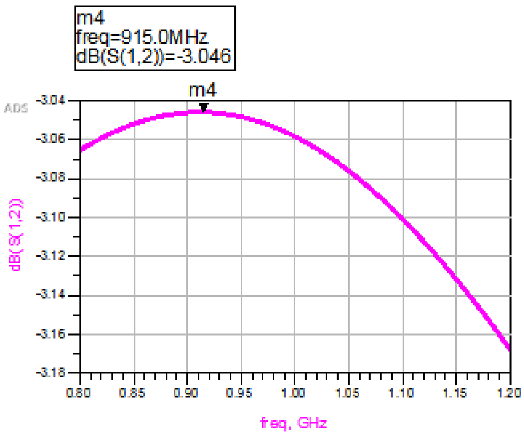
Simulation and experiment results show that our proposed Wilkinson power divider using microstrip and Coupled Line techniques performs well and the design method are applicable. The power dividing ratio is equal, the frequency is 915 MHz and a good isolation effect at two output port can be obtained using the proposed design.

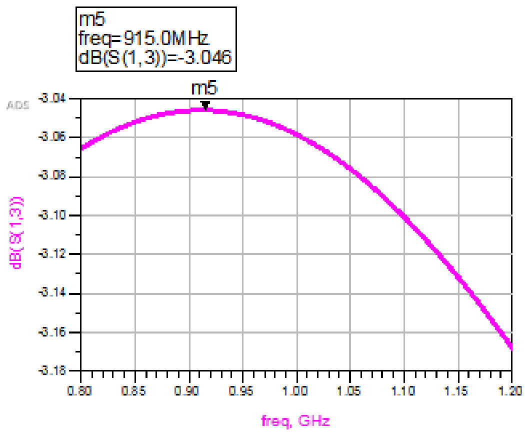
Result of Wilkinson Power Divider using microstrip line

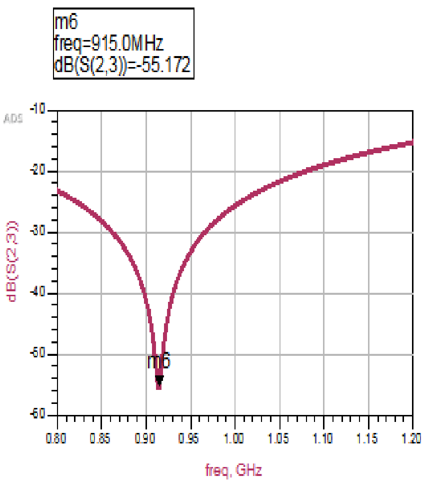


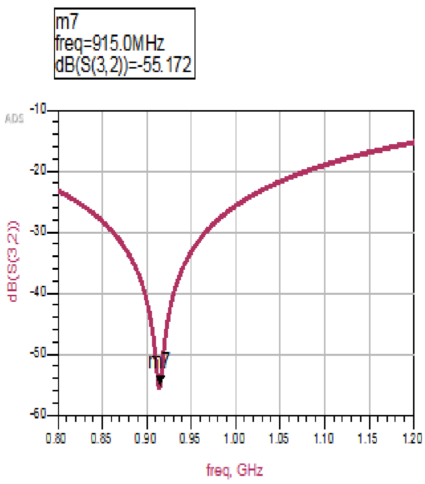




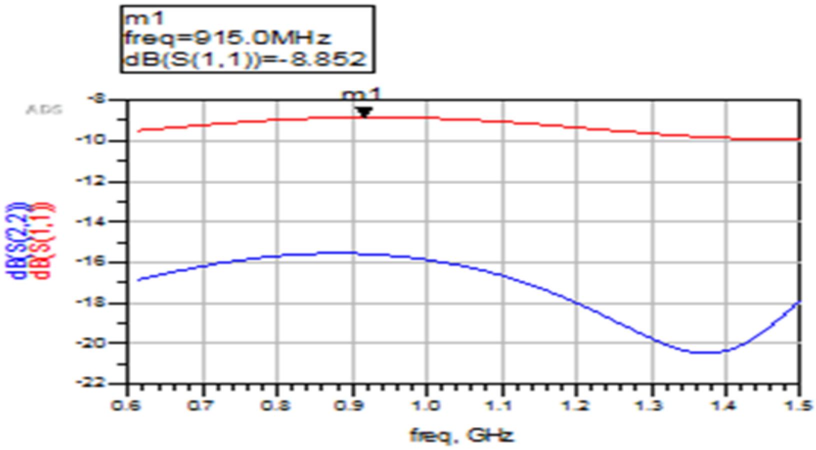


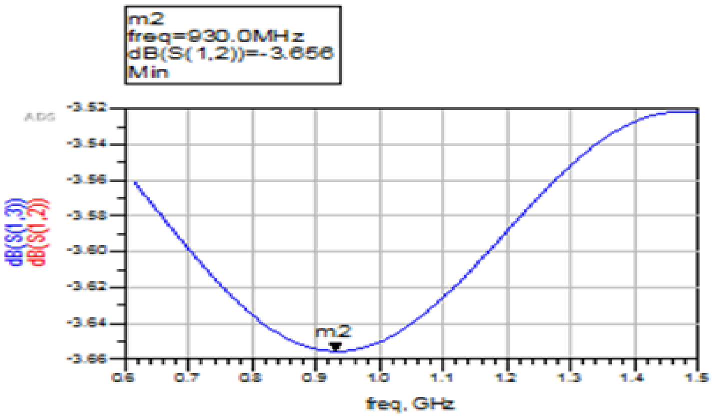






Result of Wilkinson Power Divider using Coupled Line





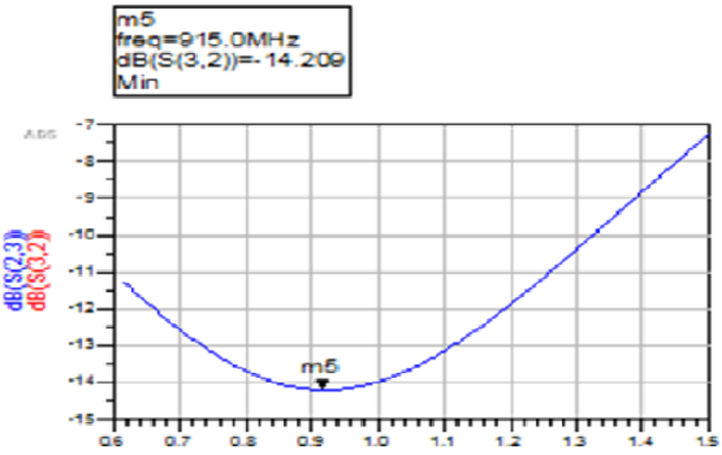


TABLE 2: Comparisons of Parameters of WPD Microstrip and Coupled Line Techniques

Parameters	S value	Ideal value	Microstrip line value(in db)	Coupled Line value (in db)
Input Return loss	S11	>-10 db	-58.235	-8.852
Output Return loss	S22	>-10 db	-60.566	-8.852
	S33	>-10 db	-60.566	-8.852
Insertion Loss	S12	=-3 db	-3.046	-3.656
	S13	=-3 db	-3.046	-3.656
Isolation loss	S23	>-20 db	-55.172	-14.209
	S32	>-20 db	-55.172	-14.209

V. Conclusion

In this paper, Wilkinson power divider design and analysis using microstrip line technique and Coupled Line technique are presented. There is almost equal power division at the all output ports and very good isolation between the output ports is obtained in the required frequency 915 ~~MHz.~~ These power divider networks are fabricated and tested. The test results shows very closed matching between the simulated and fabricated results. The very slight difference that is coming between the simulated and fabricated models are because of cable losses, connector losses, interference by the other power sources in the measurement setup.

Acknowledgements

An acknowledgement section may be presented after the conclusion, if desired.(8)

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