All Sciences Proceedings
http://as-proceeding.com/

1st International Conference on Pioneer and Innovative Studies

June 5-7, 2023 : Konya, Turkey

ICPIS
https://as-proceeding.com/index.php/icpis

Design of Wilkinson Power Divider for Mobile and WLAN Applications

Mehdi.Chemseddine. Farah*, Faouzi. Salah-Belkhodja

Telecommunications and Digital Signal Processing Laboratory, Djillali Liabès University of Sidi Bel Abbes, Algeria.

(fmc007@outlook.fr) Email of the corresponding author

Abstract – In microwave and radio frequency (RF) applications, the power divider is a well-known three-port device that is very essential. It can be used extensively in balanced power amplifiers, radar systems, and phase shifters. It is well-known that the power divider bearing Wilkinson's name is the most well-known and respected of all power dividers.This divider uses a single frequency band and has two lines with a length of L= λ/4 (quarter wave). It operates on a single frequency f=c/λ.

The primary function of these microwave devices is to establish a power distribution from an input signal to a predetermined number of output signals. This is a very important duty for these devices.

This power divider that has been presented has a design that includes three output ports. Optimisation with the help of the HFSS simulator will make it possible to have a power divider for applications related to WLAN (the band will cover WLAN at a frequency of 2.4 GHz).

The standard Wilkinson power divider (WPD) may have a straightforward design, but despite its ease of construction, it offers satisfactory performance despite its restricted bandwidth (isolation).

Keywords – Wilkinson Power Divider-Microwave-Insertion Loss-Return Loss-Isolation

I. Introduction

Current trends in the implementation of wireless communication services, such as LTE and 5G, call for flexible RF transceivers that are able to support these services. Every form of wireless communication utilises microwave components that can be either passive or active, such as couplers, filters, and power dividers.

Power dividers are a frequently used passive circuit in RF and microwave applications.

In applications pertaining to RF and microwave technology, these dividers are commonly used in various applications such as antenna arrays, balanced amplifiers, mixers, frequency multipliers, and more, serving as either combiners or power dividers. These dividers are primarily used for supplying a feed to an antenna array. To establish a connection, one or more power dividers (the Butler matrix) must be employed, which enables a junction between a single channel input and the output of multiple channels.

The exponential expansion of the telecommunications sector has propelled microwave technologies to their maximum potential in order to cater to the needs of users. Consequently, power splitters have been devised to facilitate the integration of multiple systems, broadband services, and other related functions. Developers are increasingly focused on the physical size constraints of radio frequency (RF) equipment, despite the progress made in its diversified and modernised functions. In response to these design priorities, a significant amount of research has been dedicated to the development of compact yet highly efficient power dividers.

In wireless communication systems, the Wilkinson Power Divider (WPD) and the are considered to be highly effective dividers.

The Wilkinson Power Divider (WPD) is widely regarded as one of the most valuable dividers in wireless communication systems due to its low insertion losses on both its matched and isolated ports. While possessing a straightforward structure and commendable performance, the conventional Wilkinson Power Divider (WPD) exhibits restricted bandwidth (isolation).

Our study aims to conduct an analytical examination of two power dividers (WPD) to comprehend their operating principles and behaviours. The forthcoming analytical study will be followed by a comprehensive parametric study utilising an HFSS simulator. This will enable us to enhance the performance of said dividers in relation to low insertion loss and isolation, while also expanding the bandwidth.

The primary aim of this study is to develop a WPD power divider that exhibits high performance.

The proposed power divider is designed with three output ports. Utilising the HFSS simulator, optimisation can be achieved for the development of a power divider suitable for WLAN applications, with a frequency band covering 2.4 GHz.[1-9]

II. Materials and Method

Wilkinson Power Divider:

Power dividers, commonly referred to as power combiners, find their application in various circuits such as mixers, balanced amplifiers, and antenna feed circuits. The performance of couplers plays a significant role in determining the overall performance of the circuits being constructed, including factors such as frequency band and isolation. These components are typically constrained by the limitations of circuit manufacturing technology. Passive structures are typically used as dividers at microwave frequencies.

Passive circuits in planar technology are commonly regarded as reciprocal components with tailored ports to attain optimal performance in various applications. The novel advancements in planar dividers pertain to the development of smaller-sized dividers with a simplified integration process into the intended applications.

Power splitters typically provide output signals that are in-phase and have an equal power split ratio of -3 dB. However, it is also possible for power splitters to have unequal power split ratios. Hybrid junctions exhibit a phase shift of either 90° or 180° between their two output ports. The initial power dividers were developed and evaluated at the MIT Radiation Laboratory during the 1940s. During the mid-1950s, microstrip (printed) technology was used to reinvent many of these dividers. The proliferation of planar lines has facilitated the emergence of novel divider variants, including the Wilkinson divider.

The Wilkinson Power Divider (WPD) is a lossy three-port network. It is presumed that all ports are matched and exhibit good isolation between the two output ports. The system consists of a pair of transmission lines, each with a length equivalent to one quarter of the wavelength (L=λ/4), where λ represents the wavelength. Each line possesses a characteristic impedance of the square root of two times Z0 and an isolation resistance of R equal to twice the value of Z0.

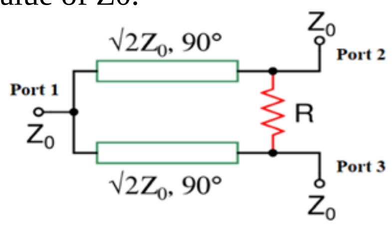

Fig 1: A two-way Wilkinson divider of equal power

The schematic of a WPD with two identical power outputs is shown in Figure 1

Upon entering port 1, the signal undergoes a splitting process, resulting in two signals of identical amplitude and phase at ports 2 and 3. The amplitudes and phases at ports 2 and 3 are equivalent. Due to the presence of symmetry, both terminals of the isolation resistor maintain an equal potential. As a result, no current passes through it, effectively decoupling the resistor from the input. Therefore, the procedure simplifies to equating R=2Z0 with Z0, as the two branches are connected in parallel. The λ/4 property enables the impedance transformation, and it is necessary for the characteristic impedances of both lines to be equivalent to 1.414Z0.

The WPD previously shown in Figure 2

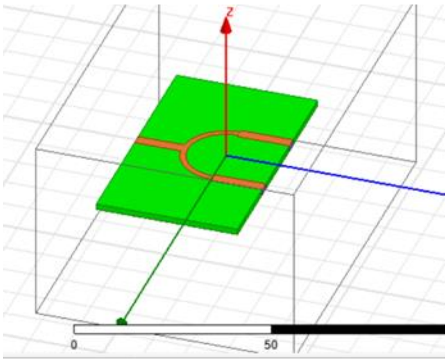

Fig.2: Structure of The WPD with HFSS

The structure of simulation of WPD with hfss is in Fig. 3. Bu using The substrate used is FR4 (Flame Resistant 4) with a relative permittivity εr=4.4 . The height of the substrate h=1.6 mm, the loss angle tg(α)=0.0023 and the metal is copper with a thickness T=35 um.

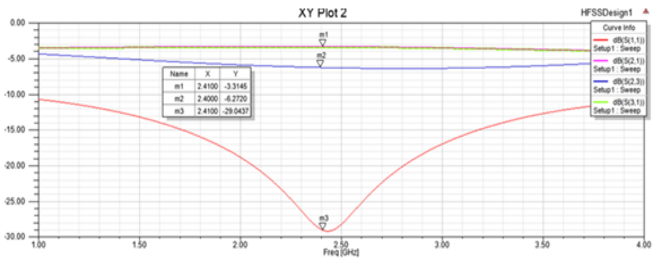

Fig3.The structure of simulation of WPD with HFSS

After the simulation part is completed, the realization of WPD is performed to make the realization of the work. Realization of the designed WPD is performed by a private and professional company to reduce manufacturing defects. The realized divider response measurements are performed at RF laboratory using a network analyzer Agilent Technologies E5071C. The complete WPD after fabrication is as shown in Fig. 4.

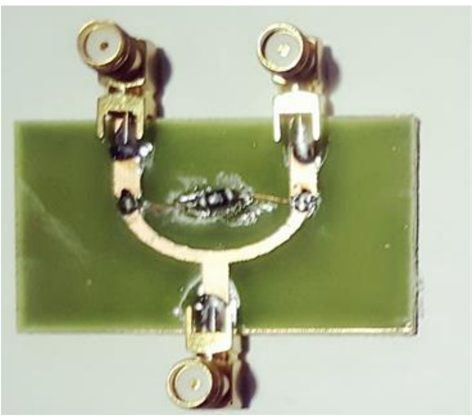

Fig:4 The complete WPD after fabrication

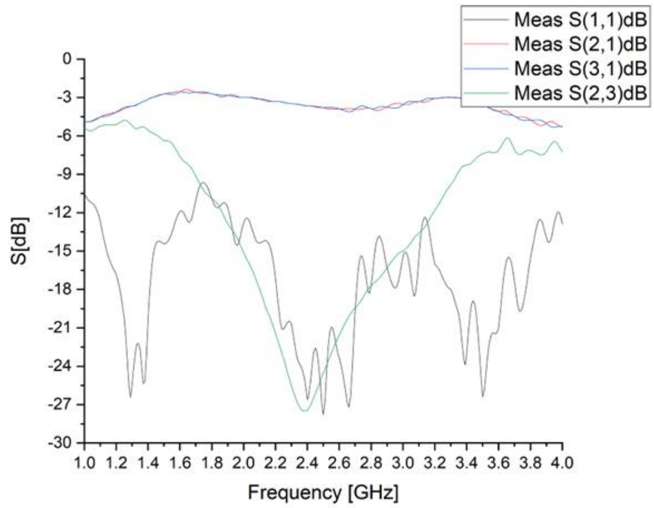

Fig. 5 the measured results of the proposed optimized the WPD microstrip divider.

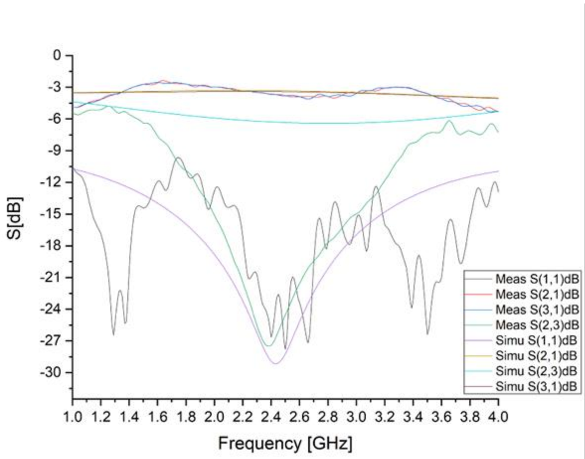

Fig. 6 Comparison between the simulated and the measured results of the proposed optimized the WPD microstrip divider

The measurement also gives very good selective divider characteristics at the frequency of 2.4 GHz, insertion loss of about -4.16 dB , return loss about-26.51dB and a isolation about -27.41dB.

III. CONCLUSION

This study outlines the design of a Wilkinson Power Divider (WPD) with three output ports, utilising the HFSS simulator.

Our initial step involved positioning the project by conducting an analytical study on the Wilkinson Power Divider (WPD).

The aim of our project was to develop a power divider that features three output ports, specifically designed for WLAN applications operating in the 2.4 GHz band.

In order to accomplish this goal, we will utilise the electromagnetic simulator HFSS. The electromagnetic simulator used in this context is founded on the resolution of Maxwell's equations through the implementation of the method of moments. A parametric study was conducted on the WPD power divider to investigate the impact of various physical parameters, including the width of the transmission line in each access, on the operational frequency and bandwidth characteristics of the divider. In order to attain this objective, an optimisation was conducted utilising the HFSS simulator. The implementation of these dividers is a straightforward process. This observation enables a comparison to be drawn between the simulated outcomes and the corresponding measured results. This task warrants consideration as a potential area for future work and exploration.

ACKNOWLEDGMENT

the authors would like to thank the telecommunications and digital signal processing laboratory and djillali liabes university for their support.

REFERENCES

[1]. David M. Pozar, Microwave Engineering, 3rd ed. USA : John Wiley & Sons, Inc, 2005

[2]. J Yang C Gu and W Wu “Design of Novel Compact Coupled Microstrip Power Divider with Harmonic Suppression ” IEE Microwave and Wireless Components Letters, vol. 18, no.9, pg. 572-574, Sept 2008

[3]. Jia-Lin Li, S.-W. Q., Q. X. "Capacitively Loaded Wilkinson Power Divider with Size Reduction and Harmonic Suppression." 49(11): 2737-2739 .2007

[4]. Ju Wu, En Li, Gao-fengGuo, “Microstrip Power Divider with Capacitive Stubs Loading for Miniaturisation and Harmonic Suppression” ICMTCE-2011, 22-25 May 2011 Beijing.

[5]. Hai Hoang Ta and Anh-Vu Pha m “Compact Wilkinson power divider on multilayer organic substrate” IEEE MTT-S 2012, 17-22 June 2012, Montreal, QC, Canada.

[6]. U. Ozkaya & L. Seyfi “Dimension optimization of microstrip patch antenna in X/Ku band via artificial neural network” Procedia-Social and Behavioral Sciences, 2015, 195, 2520-2526. [7]. I. KASA, Microwave Integrated Circuits, Elsevier, 1991.

[8]. Howe, “Stripline Circuit Design”, Artech House, 1974.

[9]. Helszajn, “Microwave Planar Passive Circuits and Filters”, Wilery, 1994