DESIGN OF 915MHz 3dB MINIATURIZED POWER DIVIDER FOR WIRELESS SENSOR NETWORK

First G. KALPANADEVI Second Dr.S.RAVIMARAN
M.A.M. College of Engineering, Siruganur, Trichy, 621105.
gkdmamce@gmail.com, 9443780910.

Abstract: *The power divider for wireless sensor network (WSN) is presented. WSN plays a vital role in many applications like Internet of Things (IoT), big data analytics and data mining etc., More number of sensors are used in WSN to collect the data. Power divider is used to divide the power for each sensor placed in wireless nodes. It is proposed to design of 3dB Wilkinson power divider to split the power equally for all the nodes of WSN. To overcome the size reduction challenges of WSN, fractal technique is used in proposed design. Simulation tool, advanced design system (ADS) is used for simulation. The proposed Wilkinson power divider has the reduced size of 54 percentage than conventional Wilkinson power divider. The planned style has easy structure, better isolation loss and good insertion loss.*

Key words: *Fractal structures, Power divider, Wireless Sensor Network.*

1. Introduction

Physical conditions like temperature, humidity, sound, wind etc., are monitored by sensors and data are recorded in central location. Data are transmitted wirelessly. Each sensor has transceiver, microcontroller unit, antenna and battery. Antennas are used to transmit and receive the data from one sensor node to another node. Wireless Sensor Network (WSN) plays a important role in military applications as battlefield surveillance, industrial and consumer applications as industrial process monitoring and control, machine health monitoring and so on. Figure 1 shows the architecture of wireless sensor network.

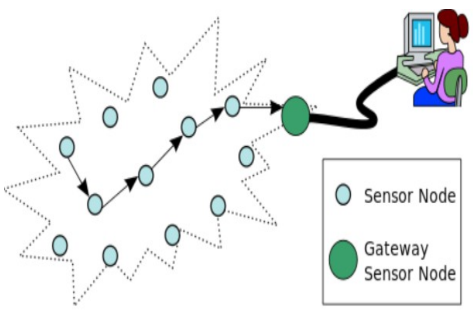

Fig 1. Architecture of wireless sensor network

Today's wireless communication system entails compact, high gain, and simple structure antennas to assure reliability and high efficiency characteristics. The key features of Microstrip technology draws researcher's attention and hence broadly used for both antenna and feed [8]. The limitations of microstrip antennas such as narrow bandwidth and low gain can be addresses with array of antennas [18]. The dissemination of voltages between the elements of an array depends on feeding network. Appropriate feeding network adds all of the induced voltages to feed into single point. Power distribution among antenna elements can be improved by corporate feed network. The phase change is introduced by beam steering in corporate feed network [16].

While composing associate antenna array, series or company feeding is also chosen. In the latter case, the feeding network requires power dividers in various topologies, such as Lange [2], Wilkinson [1] or a simple T-junction [10].

The Wilkinson power divider (WPD) is the robust power divider with all the output ports matched and only the reflected power is dissipated. The quarter–wave microstrip lines in the conventional WPD are substituted by eight– wave transmission line. The isolation loss of λ/8 transmission line is address by introducing a capacitor between the output ports [20]. Faroq Razzaz et.al proposed an UWB Wilkinson power divider with tapered transmission lines to reduce the element length [19]. In [9], author discussed broadband Wilkinson balun using purely left handed transmission line for better return loss.

In past, miniaturization of power divider involve various methods viz., 3D techniques [5], planar artificial transmission lines [12], capacitive loading [9], stepped impedances [6], large inductance with transverse slits [4], with lumped parameters by replacing quarter wave section [7, 3], varactor tuning [14], open stub technology [15], and periodically loaded stubs [13] etc. It is observed that the lumped element technique is dependent on the quality factor and self-resonant frequency of an inductor and the capacitive loading method reduces bandwidth and insertion loss [11]. However, to realize the standard performance whereas reducing the scale of the divider remains posh task. In past techniques are wide applied to antenna style for the aim of size reduction. In [17], author addressed the miniaturization using fractal structure.

Wireless sensor network are used to sense and monitor the power, communicating and processing abilities to deliver the sensed information between various nodes present in the network. A network consists of many nodes and each node consists of an antenna to share the information among the networks.

Power divider is a passive and reciprocal microwave device which can allow the signal to pass in two directions. The power dividers are used to divide the power to various antennas in the network and vice-versa.

In this work, we proposed simple WPD utilizing fractal technique to reduce the size without degrading the performance. The paper is arranged as, Sect. 2 outlines the design of the proposed power divider, Sect. 3discusses the results and performance of the power divider followed by conclusion.

2. Power Divider Structure and Design

In WPD, it is necessary to have two transitions from and back as characteristics impedance (Z_o). The Wilkinson power divider provides better isolation by matching all the output ports properly and dissipates the reflected power.

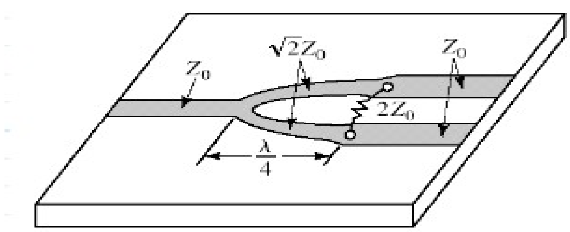

Fig. 2 Structure of Conventional Wilkinson power divider

The geometry of the Wilkinson power divider is shown in Figure 2. The Wilkinson power divider can also be used to provide arbitrary power division.The Z_0 transmission line is divided into two transmission lines of impedance $2\sqrt{Z_0}$ and vice versa after quarter wave section from $2\sqrt{Z_0}$ to Z_0. Initially, normal WPD is constructed with 50 ohm impedance. Keysight's Advanced Design System (ADS), electronic design automation software system is used to design and simulate the structure. For the dimensions of the microstrip line, the characteristics impedance can be calculated as

$$Z_0 = \begin{cases} \frac{60}{\sqrt{\varepsilon_e}} \ln\left(\frac{8D}{W} + \frac{W}{4D}\right) & for \frac{W}{D} \le 1 \\ \frac{120\pi}{\sqrt{\varepsilon_e}[W/D + 1.393 + 0.667 \ln(W/D + 1.444)]} & for \frac{W}{D} \ge 1 \end{cases} \quad (3)$$

The characteristic impedance (Z_O) of a microstrip line is also related to the conductor width and dielectric thickness. The Z_O of the microstrip line is determined by equation (1). More conveniently, the ratio of conductor width to dielectric thickness can be determined by equation (2) for given characteristic impedance and its relative permittivity by the following equations.

$$\frac{W}{D} = \begin{cases} \frac{8e^A}{e^{2A}-2} & for \frac{W}{D} < 2 \\ \frac{2}{\pi}\left[B - 1 - \ln(2B-1) + \frac{\varepsilon_r - 1}{2\varepsilon_r}\left\{\ln(B-1) + 0.39 - \frac{0.61}{\varepsilon_r}\right\}\right] & for \frac{W}{D} > 2 \end{cases} \quad (2)$$

Where $$A = \frac{Z_0}{60}\sqrt{\frac{\varepsilon_r + 1}{2}} + \frac{\varepsilon_r - 1}{\varepsilon_r + 1}\left(0.23 + \frac{0.11}{\varepsilon_r}\right)$$

(3)

$$B = \frac{377\pi}{2Z_0\sqrt{\varepsilon_r}} \quad (4)$$

For the design of constructing the width of the microstrip line is calculated by the design equation (5). From that equation the calculated value is the ratio of conductor width to the dielectric thickness followed the equation (2).

$$W = calculated\ value * D \quad (5)$$

The length of microstrip line is intended by equation (6)

$$l = \frac{90^0(\pi/180^0)}{\sqrt{\varepsilon_e}K_0} \quad (6)$$

where $K_0 = \frac{2\pi f}{c}$ is the value which relates the length and the resonant frequency of the power divider.

Figure 3 shows the geometry of the designed WPD with dimensions. The dimension of the designed WPD operates at 915 MHz is 118.62mm x 60.45 mm.

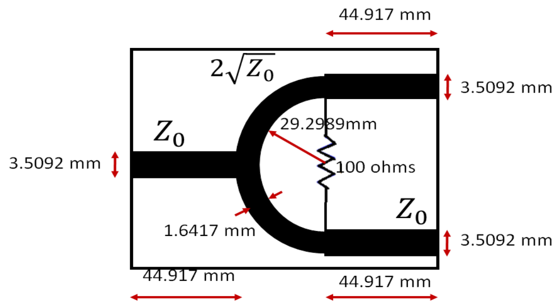

Fig.3 Geometry of Wilkinson Power Divider.

To reduce the size of the design a fractal structure is proposed. A form could be a self-similar style to maximize the length, or increase the perimeter (on inside sections or the outer structure), of material that can receive or transmit electromagnetic radiation inside a given total extent or volume. Such fractals are also referred to as multilevel and space filling curves, but the key aspect lies in their repetition of a motif over two or more scale sizes, or "iterations". For this reason, shape based mostly devices area unit terribly compact, multiband or band, and have helpful applications in wireless telephone and microwave communications. Fractal style is capable of in operation with good-to-excellent performance at many alternative frequencies at the same time. To miniaturize the size of the conventional design, fractal pattern is proposed with single iteration. With this FWPD, the dimension has reduced to 55.15mm x 56.48mm. Figure 4 shows the geometry of FWPD with its dimensions.

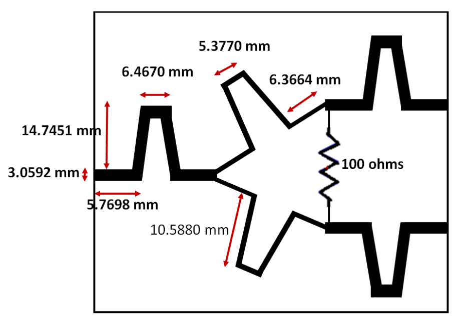

Fig.4 Geometry of proposed FPWD.

Both the general WPD and proposed FWPD are fabricated on FR4 substrate with dielectric constant 4.4 and a thickness of 1.6mm. Figure 5 shows the fabricated WPD and FWPD.

(a) (b)

Fig.5 Photographs of Prototype WPD.

A two way Wilkinson power divider has been designed for the frequency of 915MHz by using fractal techniques to reduce the size of the conventional WPD.

1. Results and Discussion

In the Power divider design return loss, insertion loss and isolation loss are the essential parameters. Hence, we mainly motivated on analyzing the mentioned characteristic. A Vector Network Analyzer of (ZVH4) of Rohde &Schwartz is utilized for validating the measured results.

Fig.6. Experimental setup of the proposed conventional WPD and fractal WPD.

Experimental setup of the proposed conventional Wilkinson power divider and fractal WPD are shown in Fig. 6.

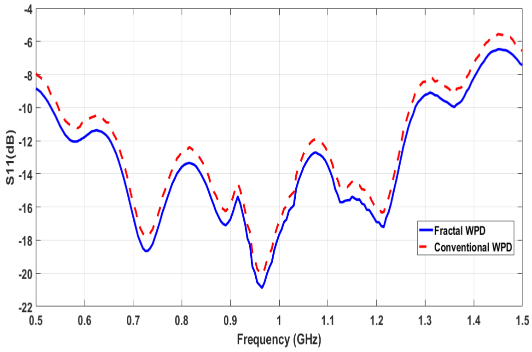

Fig 6. Input Return loss.

Figure 6 shows the input return loss of fractal WPD and normal WPD and shows that it has greater than 20dB for the operating frequency of 915MHz. It is observed that, there is a good agreement between fractal WPD and normal WPD.

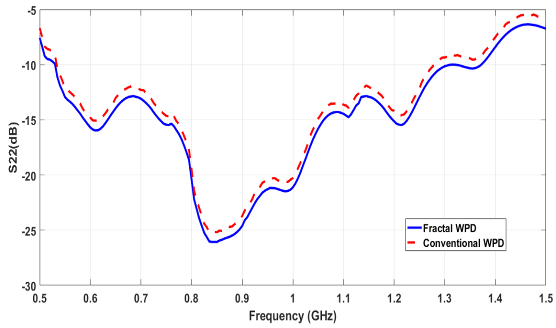

Fig 7. Output Return loss.

Figure 7 shows the output return loss of fractal WPD and normal WPD and shows that it has greater than 25dB for the operating frequency of 915MHz. Wilkinson power divider realized using fractal technique achieves the good return loss at all the ports.

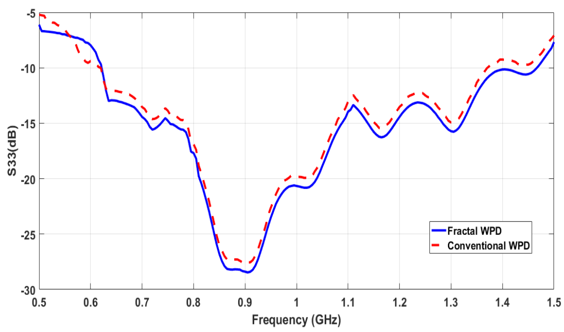

Fig 8. Output Return loss.

Figure 8 shows the output return loss of fractal WPD and normal WPD and shows that it has greater than 25dB for the operating frequency of 915MHz. Return loss at the two output ports 2 and 3 are equal and shown in figure 5 and figure 6 respectively which represents the proposed power divider has the equal power division at the two output ports.

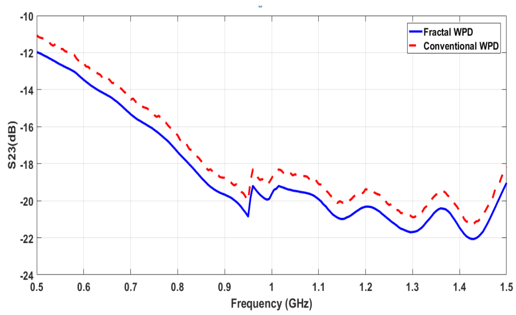

Fig 9. Isolation loss.

Figure 9 shows the isolation loss of fractal WPD and normal WPD and shows that it has greater than 20dB for the operating frequency of 915MHz. It shows that it has better isolation between two output ports.

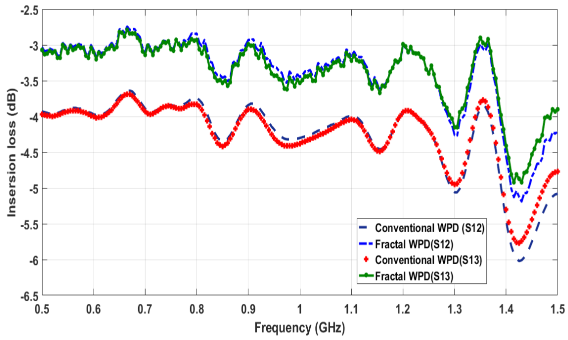

Fig 10. Insertion loss.

Insertion loss of fractal WPD and normal WPD are shown in Figure 10. It shows that it has 3dB insertion loss between port 1 & 2 and also between port 1 & 3. Figure 10 shows that there is a equal power division between port 1 and 2 and between port 1 and 3 for the operating frequency of 915MHz. Table 1 summerizes the performances of designed power dividers.

Table. 1 Performance Comparison of WPD and FWPD

Parameters	WPD	FWPD
Operating	915	915

Frequency (MHz)		
Input return loss(dB)	21	20
Output return loss	28.6	27.5
Isolation loss	20.5	19.8
Insertion loss	3.4	3.5
Dimension	118.62mm x 60.45 mm	55.15mm x 56.48mm

The performance characteristics of WPD and FWPD are compared in Table1. Fractal based WPD achieves a good result with ideal values of WPD with reduced size without degrading the performance. The proposed design has simple structure, better isolation loss, return loss and good insertion loss.

4. Conclusion

The design of a miniaturized fractal based Wilkinson power divider (FWPD) addressing GSM band has been presented. The proposed structure has a dimension of 5.648cmx 5.515cm where conventional WPD has a dimension of 11.862cm x 6.045cm. With the proposed fractal structure achieved 54% size reduction. The results show that with the FPWD, desired isolation and insertion loss are achieved. Simple and compact FWPD is a good candidate for drive system on substrate (SoS).

References

1. Wilkinson, E. J.,*An N-way Hybrid Power Divider*, IRE Transactions on Microwave Theory and Techniques, Vol. 8, No. 1,116-118, 1960.
2. Lange, J, *Interdigitated Strip Line Quadrature Hybrid (Correspondence*), IEEE Transactions on Microwave Theory and Techniques, Vol. 17, No. 12, 1150-1151, 1969.
3. Parisi, S. J., *180° Lumped Element Hybrid*, IEEE International Microwave Symposium Digest, pp 1243–1246, 1989.
4. Hirota, T. and M. Muraguchi, *K-Band Frequency Up-Convertors Using Reduced-Size Couplers and Dividers*, *Gallium Arsenide Integrated Circuit (GaAs IC) Symposium*., 53–56, Miami Beach, FL,1992.
5. Nishikawa, K., T. Tokumitsu, and I. Toyoda, *Miniaturized Wilkinson Power Divider Using Three-Dimensional MMIC Technology*, IEEE Microwave Guided Wave Letter, Vol. 6, No. 10, 372–374, 1996.
6. Ho, J. and N. V. Shuley, *Wilkinson Divider Design Provides Reduced Size*, Microwaves RF, 104, 1997.
7. Lu, L.-H., P. Bhattacharya, L. P. B. Katehi, and G. E. Ponchak, *X-band and K-band Lumped Wilkinson Power Dividers with A Micromachined Technology*, IEEE International Microwave Symposium Digest, pp 287–290, 2000.
8. Deslandes, D. and K. Wu, *Integrated Microstrip and Rectangular Waveguide In Planar Form,* IEEE Microwave and Wireless Components Letters, Vol. 11, No. 2, 68-70, 2001.
9. Scardelletti, M. C., G. E. Ponchak, and T. M. Weller *Miniaturized Wilkinson Power Divider Utilizing Capacitive Loading*, IEEE Microwave and Wireless Components Letter, Vol. 12, No. 1, 6–8, 2002.
10. Pozar, D. M., *Microwave Engineering*, 3rd edition, Wiley, Hoboken, NJ, 2005.
11. Kangasvieri, T., I. Hautaj ̈arvi, H. Jantunen, and J. Vahakangas , *Miniaturized Low-Loss Wilkinson Power Divider For RF Front-End Module Applications*, Microwave and Optical Technology Letters Vol. 48, No. 4, 660–663, 2006.
12. Yang, T., C.-J. Liu, L. Yan, and K.-M. Huang, *A Compact Dual-Band Power Divider Using Planar Artificial Transmission Lines For GSM/DCS Applications*, Progress In Electromagnetics Research Letters , Vol. 10, 185–191, 2009.
13. Rawat, K., and F. M. Ghannouchi, *A Design Methodology For Miniaturized Power Dividers Using Periodically Loaded Slow Wave Structure With Dual-Band Applications*, IEEE Transactions on Microwave Theory and Techniques, Vol. 57, No. 12, 3380–3388,2009.
14. Wenjia, T.,J.-H. Ryu, and H. Kim, *Compact, Tunable Wilkinson Power Divider Using Tunable Synthetic Transmission Line,* Microwave and Optical Technology Letters, Vol. 52, 1434–1436, 2010.
15. TaeGyu, K., B. Lee, and M.-J. Park, *Dual-Band Unequal Wilkinson Power Divider with Reduced Length*, Micro wave and Optical Technology Letters, Vol. 52, No. 5, 1187–1190, 2010.
16. Md. Tanvir Ishaque-ul Huque, Md. Kamal Husain, Md. Shihabul Islam and Md. Al-Amin Chowdhury, *Design and Performance Analysis of Microstrip Array Antennas with Optimum Parameters For X-Band Applications*, International Journal of Advanced Computer Science and Applications Vol. 2, No. 4, 2011.
17. N. Gupta, P. Ghosh, and M. Toppo, *A Miniaturized Wilkinson Power Divider Using DGS and Fractal Structure for GSM Application* **,** Progress In Electromagnetics Research Letters, Vol. 27, pp 25-31,2011
18. K. P. Wei, Z. J. Zhang, and Z. H. Fen, *Design of a Dual -band Omnidirectional Planar Microstrip Antenna Array*, *Progress* In Electromagnetics Research, Vol. 126, 101-120, 2012.
19. Reetu Sharma, Suman Kaur, SumitkumarJha, *Optimized Broad Band Wilkinson Balun-Design and Analysis Using Meta material*, International Journal Of

Engineering And Computer Science, Vol 2, Issue 7, pp 2266-2271, *2013.*

20. G. Kalpanadevi, Dr.S. Ravimaran and Dr.M. Shanmuga priya, *Two Way Wilkinson Power Divider Realised Using One Eighth Wave Transmission line for GSM Apllications*, World Academy of Science, Engineering and Technology International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering, Vol:9, No:11, 2015.