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Design and Performance Analysis of Equal and Unequal Power Divider For ISM Band Frequency

R.S.Kawitkar, Ms.Harshada S. Ahiwale

Department of electronic and telecommunication (E&TC)

Sinhgad College of Engineering, Pune 411041.

E-mail:harshada087@gmail.com

*Abstract— **In this paper broadband and compact power divider is presented. The proposed circuit made up of two micro strip transmission lines. A pair of low and high impedance lines for equal and unequal power-dividing ratios. The proposed power divider exhibits arbitrary and non-arbitrary power divided ratios. Design equations for proposed circuit power division ratio cases are given. For the equal ratio case, two symmetric coupled Micro strip lines required. The unequal ratio case, two asymmetric coupled Micro strip lines required. Proposed power dividers has been study and investigated. The proposed Hybrid power divider operating at 2.4 GHz with power dividing ratio of 1:2 and 1:4 are designed, fabricated, measured respectively. The measured results are in good agreement with the simulated results. The power divider has been designed on FR4 dielectric substrate with relative permittivity εr=4.4 and thickness 1.6mm. The designed power divider miniaturized by using the T-shaped feed techniques. The overall size of the power divider is 42mm * 86mm*1.6mm3. The results shows that the isolation between output ports is found to be better than –15 dB and return loss at each port is less than -10dB.***

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Keywords—Power divider, isolation, insertion loss, ISM band, miniaturization, transmission lines, circuit design.

I. INTRODUCTION

Power divider is passive device mostly used for power division or power combing. This feed line network has two stages, first stage for equal power dividing ratio and the second stage for unequal power dividing ratio. So it has total four output ports. Both first and second stage has developed using Wilkinson technology. Transmission lines between output ports and in series with the isolation resistor. FR4 substrate is used to design a feed line network. The power divider is designed, simulated and fabricated which works for ISM band. Here HFSS software used for simulation. Wilkinson power divider is an idea form of divider for RF application. It provides minimum loss and maintains a better isolation between ports.

The length of transmission line that must be derived and the output ports can directly connect to the power divider. T-shaped micro strip lines have also been proposed to design power divider with high power dividing ratio. This approach replace micro strip lines have been replaced by the T shaped micro strip lines. The ability divider created is associate degree equal split 2 port device, whereas antenna arrays generally utilize quite 2 antennas.

Within the RF and microwave community, power dividers have served a distinguished role for years. The most perform of an influence divider is to separate a given input into 2 or a lot of signals as required by the circuit/system. A typical application for an influence divider is to separate a symbol to feed multiple low power amplifiers, so have the signals from

the amplifiers recombine into a high power signal. Another power divider application and therefore the inspiration for this paper work, is among a phased antenna array system. During this system a symbol is either fed through associate degree equal split power divider that includes a particular range of output ports, or a series of equal split power dividers. The split signals are then fed through section shifters so to associate degree array of transmission antennas. The section distinction between every signal being transmitted permits for electronic beam scanning, permitting the transmitted beam to be centered in numerous directions relying upon the section distinction. The ability divider created is associate degree equal split 2 port device, whereas antenna arrays generally utilize quite 2 antennas. Consequently, if this power divider style were ever employed in associate degree antenna array, multiple power dividers would possible have to be compelled to be accustomed split the signal into quite simply 2 signals (i.e. 4, 8, 16, etc.) and more slender or focus the beam

I.POWER DIVIDER CONFIGURATION

A. Simple model of 1:2 mcro strip feedline network.

Figure shows that unequal power divider is formed using Wilkinson power divider technology. It is commonly used in several power dividers.

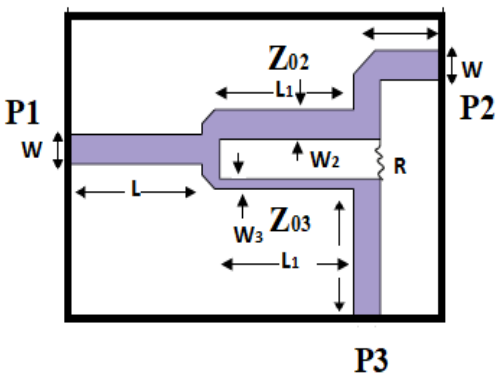

Fig.1 Design of unequal power divider

Figure 1 shows design of unequal power divider. Implemented by using an asymmetric micro strip transmission lines which is parallel to each other, including its various parameters and also shows the separated micro strip lines replaced by a uniform asymmetrical micro strip coupled lines.

F = 2.4GHz

εr = 4.4

h = 1.6mm

Guided Wavelength (λg) = c/f

λ=C/F ……..... (1)

λ=(3×□ 10□ ^8)/(2.4×□ 10□ ^9)=125mm

Length of power divider (L1) is given by

$$L1 = \lambda g/4\sqrt{\varepsilon r} = \frac{125}{4\sqrt{4.4}} \quad \text{……..…..……(2)}$$

sL1= 14.9mm

p3/p2=0.5(3dB)…….……(3)

$$k^2 = \frac{p3}{p2} = \frac{1}{2} \rightarrow k = 0.707 \quad \text{……...……(4)}$$

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$$Z03 = z0\sqrt{\frac{1+k^2}{k^3}} \quad \text{.....(5)}$$

$$= 50\sqrt{\frac{1+0.5}{(0.5)(0.707)}} = 103.0\Omega$$

$$Z02 = k^2 Z03 = (0.5)(103\Omega) \quad \text{.....(6)}$$

$$= 51.5\Omega$$

$$R = Z0\left(k+\frac{1}{k}\right) = 50\left(0.707+\frac{1}{0.707}\right) \quad \text{.....(7)}$$

$$= 106.1\Omega$$

$$Z0 = \frac{60}{\sqrt{\varepsilon}}\ln\left(\frac{8h}{W}+\frac{W}{4h}\right)(\Omega) \qquad for\ \frac{W}{h} \le 1 \quad \text{.....(8)}$$

$$Z0 = \frac{120\pi}{\sqrt{\varepsilon\left[\frac{W}{h}+1.393+0.667\ln\left(\frac{W}{h}+1.444\right)\right]}}(\Omega) \quad \text{.....(9)}$$

$$for\ \frac{W}{h} \ge 1$$

Zo is Impedance of microstrip line

Putting value of Z0=100 Ω in above equation we calculate W3 =1.0mm

Dimensions	Values(mm)
L	15
W	3
L1	15
L2	13.5
G	4
LS	42
WS	68

And putting Z0 =50Ω we Calculate W2 = 3.0mm

TABLE I. DIMENSIONS OF PROPOSED POWER DIVIDER ON FR4 MILIMETER

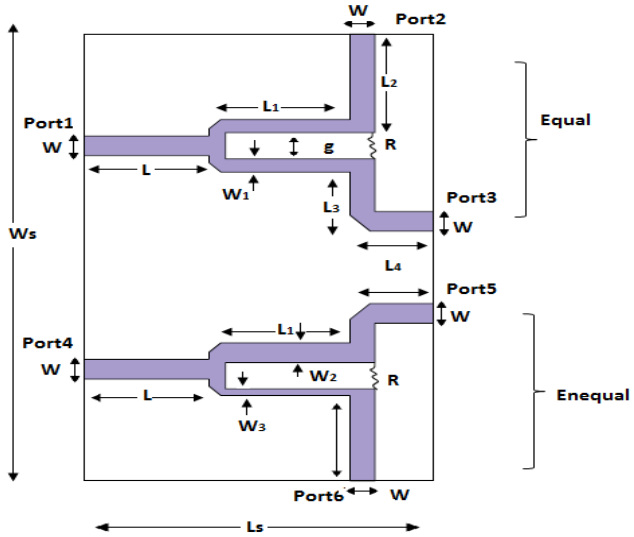
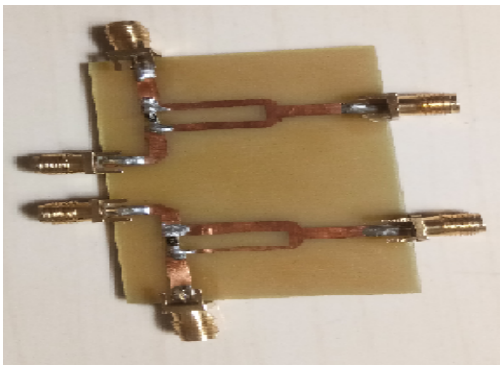


Fig.2. Design of a compact hybrid equal and unequal power divider.

Figure 2 shows a compact hybrid micro strip power divider design using HFSS software. It has two different transmission lines .Maximum fractional bandwidth of designed power divider is 148% that can be achieved using wider the width of coupled line. In the power divider circuit design, resistor is placed between coupled lines to achieve good isolation between the output ports. When power incident at port1 then equal power ratio will be getting at port2 and port3 and power lunch into port 4 then unequal power will be getting at port4 and port6.

II.PHOTOGRAPHS OF FABRICATED CIRCUIT



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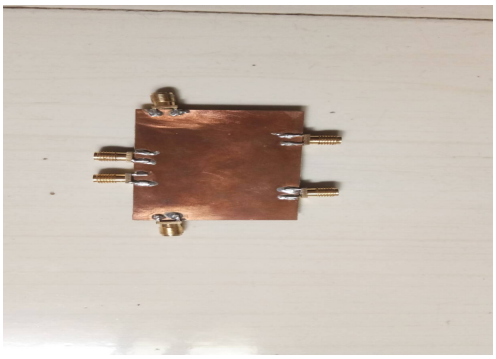

Fig.3. Front view and bottom view of fabricated circuit

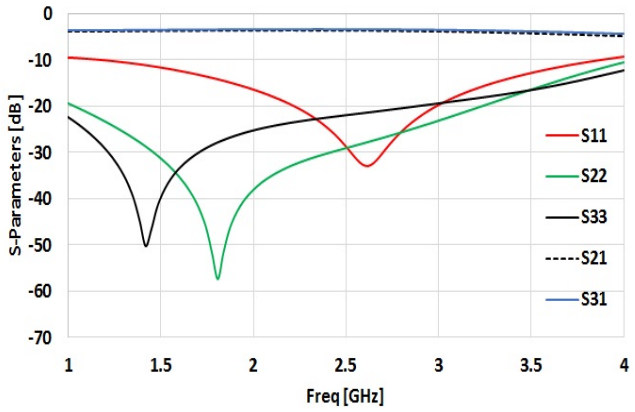

Fig.4. Simulated scattering parameters of designed equal power divider

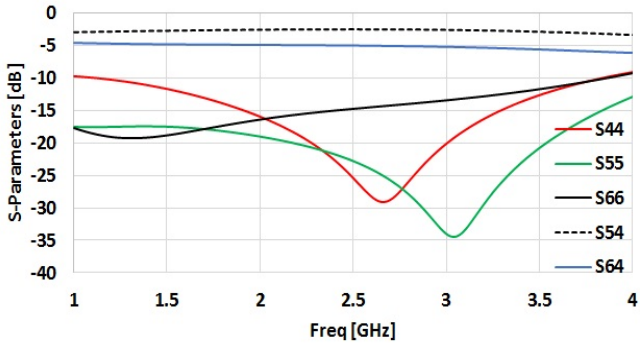

Fig.5. simulated scattering parameters of designed unequal power divider

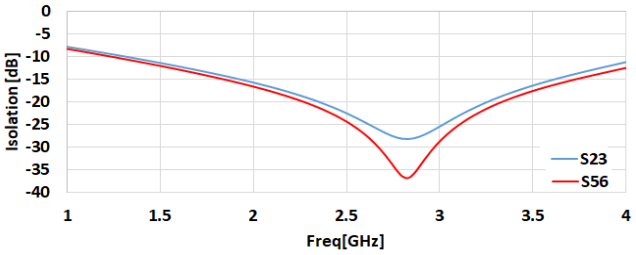

Fig.6. Simulated Isolation at scattering parameter (S23) and (S56)

Figure 6 shows simulated s-parameter unequal power divider using VNA for port (s_{23}) and port (s_{56}) at frequency 2.6 GHz

isolation is above 25dB.

I(4,1)=-10log□ P4/P1□

IV. EXPERIMENTAL RESULTS

On the other hand, PCB circuits are usually fabricated on FR4 which is cheap but on the expense of greater loss. Considering that substrates with varying thickness exhibit different loss and variations from the nominal dielectric constant, FR4 thin substrates with thickness h=0.5mm and h=1.6mm were tested

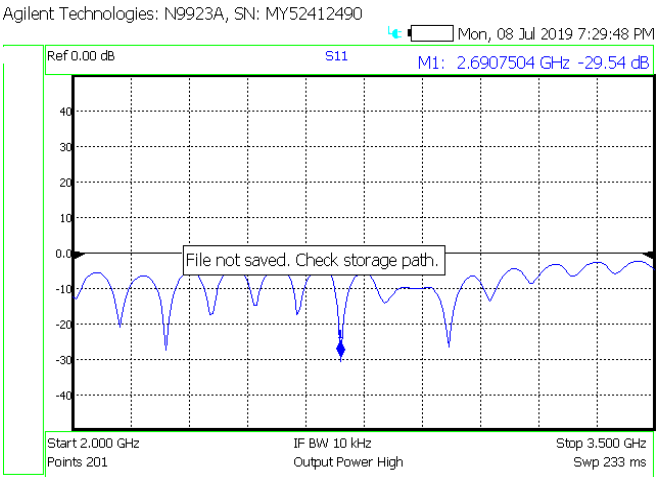

Fig.7. Scattering Parameter at Port (S_{11}) on VNA

Figure shows results of fabrication feed line network using VNA for port1 (s_{11}) at frequency 2.6 GHz return loss is -29.54dB. The return loss S (1, 1) is of 29.54dB at port 1

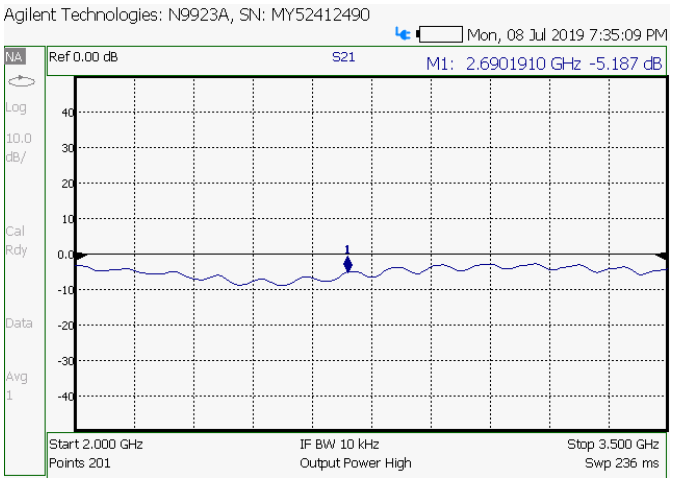

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Fig.8. Scattering Parameter at Port (S_{21}) on VNA

Figure shows measured s-parameter of unequal power divider using VNA for port2 (s_{21}) at frequency 2.6 GHz insertion loss is -5.187dB.The experimental circuits were measured by the vector network analyzer.

IV. CONCLUSION

This paper presents a Wilkinson power divider with equal and unequal power dividing ratio for high power applications. Based on theoretical analysis, power division ratio can be achieved by controlling the characteristics impedance of transmission lines. It can achieve good isolation between the output ports while maintaining a matched condition on all ports. The coupled power is 3.4dB at port2 and port3 over 1.2GHz to 3.2GHz at the output of equal power divider and the coupled power is -3.4dB at port5 and -5.6 port6 over 1.2GHz to 3.2GHz at the output of unequal power divider. The proposed circuit can be utilized in related applications with power dividing requirements. Application of power divider is GPS, GSM, radar, distributed antenna system, real time location system, amplifier, filter, mixer, LNA, cellular, base station, radios, micro wave radio etc.

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