Design And Performance Analysis Of 1:6 Power Divider For L Band Frequency

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Abstracts

A miniaturized micro strip Wilkinson power divider design is proposed in this paper. The power divider is intended to divide or split a microwave signal power into other devices. The proposed power divider is comprised of 2 stages; the first stage is 1:2 power divider, whereas the second stage consists of a pair of 1:3 power dividers. The power divider has been designed on FR4 dielectric substrate with relative permittivity of 4.4 and thickness of 1.6 mm. The designed power divider is miniaturized by using the circle-shaped feed techniques. The designed Wilkinson power divider shows good performance of impedance matching at all ports. The simulated results show that the return loss of each port is less than − 10 dB for L-band operation. The isolation between two output ports is found to be better than − 20 dB. The insertion loss is less than-8 dB. The designed power divider is fabricated to validate the design.

Keywords: insertion loss, isolation, returns loss, L band, power divider, Wilkinson topology.

INTRODUCTION

Power divider is passive microwave component used for division or power combing. Power divider divides the power of an input signal into two or more output signal. Three ports divider can be T junction while four port networks can be directional coupler and hybrids. Power divider is frequently used in telecommunication, and radar technologies. The Wilkinson power divider as it is also known takes first name

from Ernest Wilkinson, the electronics engineer who initially developed it in the 1960s.Wilkinson published his idea in IRE Trans on microwave theory and technique, in January 1960 under the title:" an N way power divider".

This module has capability to divide the power from one device to some other device. The Wilkinson power divider concept can be useful for N way system, it is easiest to see how it Operates as a two way system, and later expand it out to see how the Wilkinson power divider can be used for N way device. Wilkinson power divider is an idea form of divider for RF application. It provides low loss and maintains a high level of isolation between ports.

In this paper, a 1:6 power divider is designed based on a Wilkinson technology. The proposed power divider is developed to work at L band frequency range. This module has capability to divide the power from one device to some other device. The Wilkinson power divider concept can be useful for N way system, it is easiest to see how it operates as a two way system, and later expand it out to see how the Wilkinson power divider can be used for N way device. Wilkinson power divider is an idea form of divider for RF application. It provides low loss and maintains high level isolation between ports.

The power divider is developed to work at L band frequency range. The power divider is divided into two stages, first stage is consisted of 1:2 power dividers and the second stage is 1:3 power divider.1:2 power dividers has two output ports. Both first and second stage has developed on Wilkinson technology. FR4 substrate is used for design of power divider. The power divider is designed, simulated and fabricated which works for L band. Software tool used for simulation of results is HFSS.

DESIGN OF1:6 POWER DIVIDER

The schematic design of 1:6 power dividers in Fig.1 Based on the theory of Wilkinson topology, the impedance N-output port (Z) is $Zo\sqrt{N}$, where Zo and N are the characteristic impedance of input line (50Ω) and the number of output ports, respectively.
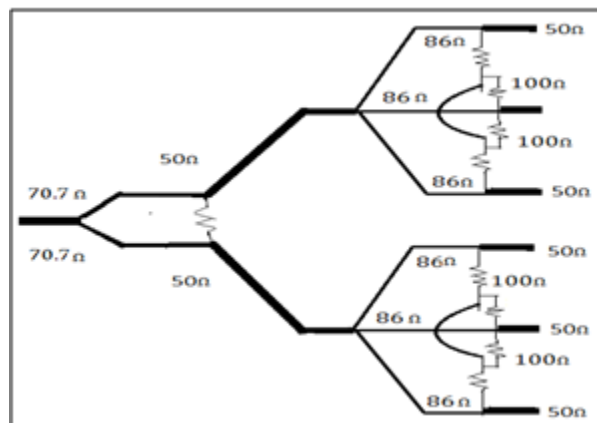

Figure 1: Schematic design of proposed 1:6 power divider

From the figure, it shows that 1:6 power dividers is formed from Wilkinson 1:2 power divider that is commonly used in several power dividers which is combined with 2 of 1:3 power dividers that are developed from [2]. FR4 substrate is used with nine resistors connected between λ/4 micro strip lines. The 1:3 power dividers is as shown in Fig. 2(b) the resistors which are connected to the middle branch of combiner are split into 2 equal parallel resistors 100Ω.
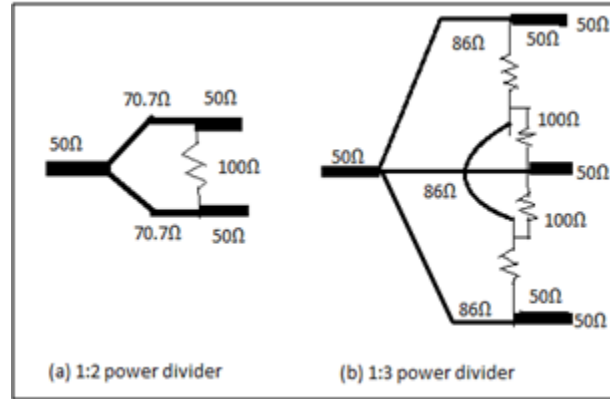

Figure 2: Basic schematic power divider used for design

MATHEMATICAL ANALYSIS
F=1.5GH
∈=4.4
h=1.6mm $\lambda=\frac{c}{F}$

$\lambda=\frac{3\times10^8}{1.5\times10^9}=0.2m$

Feed line length of power divider,

$$\frac{\lambda}{4\sqrt{\varepsilon r}}=\frac{200}{4\sqrt{4.4}}=23.83\ m$$

(1)

Width of power divider,

$$Z0=\frac{377}{\sqrt{\varepsilon r}(\frac{w}{h}+2)}=w=2.775mm$$

(2)

$where\ zo=50\Omega$
Quarter wave matching for width,
$$Z\ (\lambda\ /4)=\sqrt{ZOZL}=\sqrt{50\times100}$$

(3)

$=70.7\ \Omega$

LAYOUT
Figure3. Shows the deployment of 1:6 power dividers on FR4 substrate. The overall

physical dimension of 1:6 power dividers is about 180 mm height and 180 mm width. The micro strip lines with the thickness of 1.6 mm are positioned on the top side of FR4 substrate, while the bottom side is applied as a ground plane.
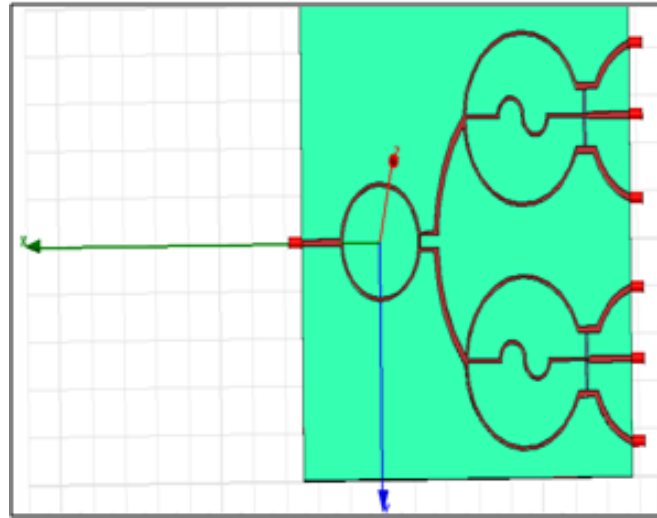

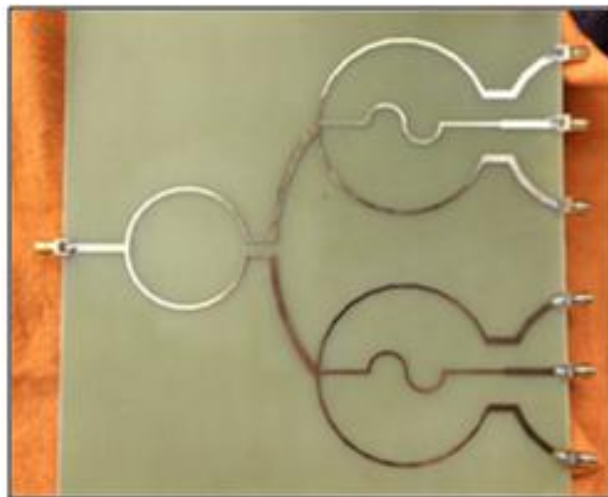**Figure 3:** Deployment of 1:6 power divider on FR4 substrate

PCB DESIGN

Figure 4: Photograph of 1:6 power divider

RESULTS AND DISCUSSION
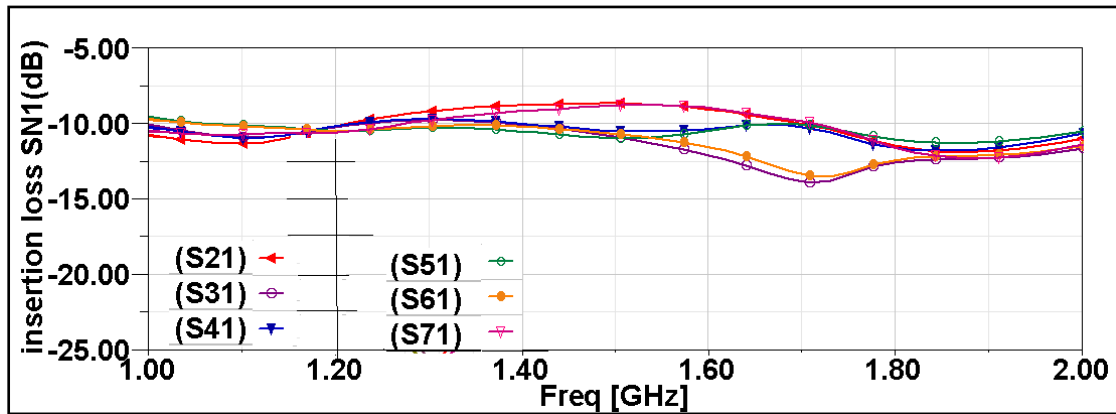**INSERTION LOSS**

Figure 4: Insertion loss of 1:6 power divider

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). It is defined as the ratio of the output to input power.

$$IL(DB) = 10 \log_{10} \frac{PT}{PR}$$

(4)

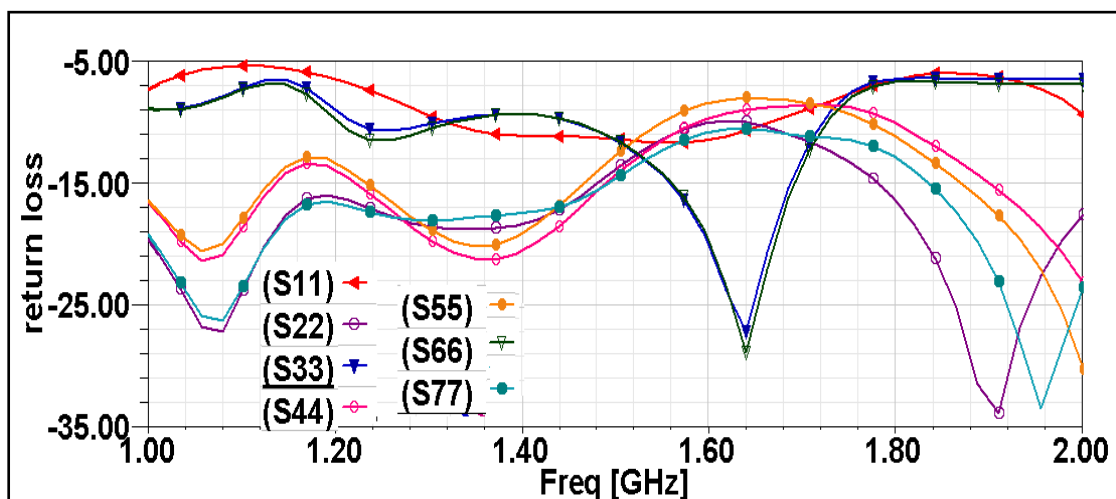PT= power transmitted
PR=power received

RETURN LOSS

Figure 5: Return loss of 1:6 power divider

Return loss proposed 1:6 power dividers for each output port is better than – 28 dB at frequency 1.6 GHz. Return losses is the loss of power in the signal returned/reflected by 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 expressed as a ratio in decibels (dB).

$$RL(DB) = 10 \log_{10} \frac{Pi}{Pr}$$

(5)

Pi = incident power
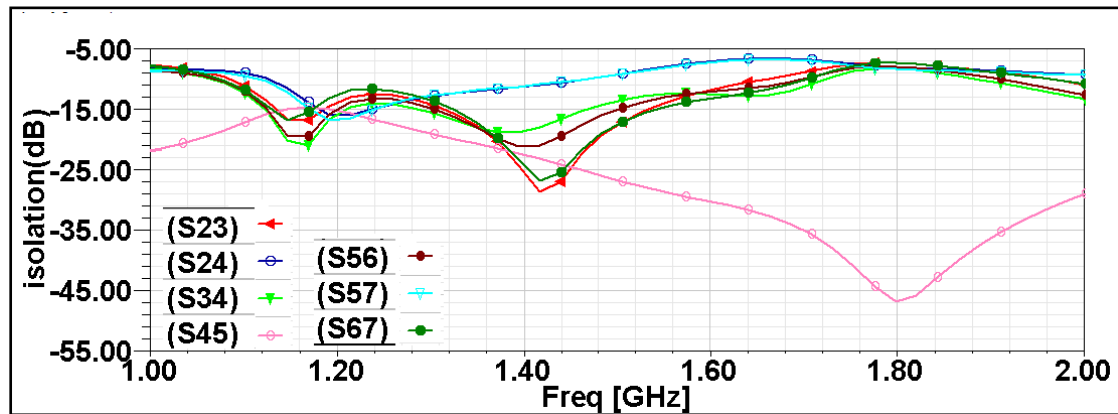Pr = reflected power

ISOLATION LOSS

Figure 6: Isolation between ports of designed 1:6 power dividers

Isolation of designed 1:6 power divider for each port is more than – 29 dB at frequency of 1.42GHz.
The isolation is defined as the ratio of signal that comes into some output port which is measured at the other output ports with the assumption that all ports are terminated with matched impedances/loads. Isolation of a directional coupler can be defined as the difference in signal levels in dB between the input port and the isolated port when the two other ports are terminated by matched loads.

$$I(4,1) = -10 \log \frac{P4}{P1}$$

(6)

COMPARISON PERFORMANCE OF POWER DIVIDER

Power divider	Freq (GHz)	S11 (dB)	Insertion loss (dB)	Isolation (dB)	Band Width (MHz)
1:2 power divider	1-2	-35.31	-3.7	-15.0	800
1:6 power divider	1-2	-27.47	-8.6	-27.5	1000

CONCLUSION

A 1:6 power divider has been designed at L band frequency range which based on Wilkinson topology. This topology has two stages first stage is 1:2 power divider and 1:3 power dividers at the 2nd stage has been deployed on FR4 substrate. The 1:6 power dividers has been designed, fabricated and simulated with parameter insertion loss, return loss and isolation loss. Insertion loss of 1:6 power divider less than -8 dB for frequency range from 1GHz to 2GHz,return loss less than -28 dB at frequency of 1.6GHz, the isolation less than -29 dB at frequency of 1.42GHz.

Application of 1:6 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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