8:1 High Power Combiner for S-Band Radar

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Abstract -- **8-way high power combiner is highly reliable microstrip design which can handle 2.5KW peak power at 10% duty cycle. Simulation and experimental results are discussed in this paper. Continuous monitoring of forward and reverse power through coupler provisioned in design facilitates system level health checks. Reverse power protection also included in design with phase matched circulators. The proposed power combiner has potential application in radar and defense systems.**

Keywords: High Power Combiner, Micro-strip, Geysal Combiner

I. INTRODUCTION

POWER Combiner plays vital role in various RF and communication applications [1, 2]. It is a passive component to combine/ distribute RF signal in proportion among different paths. The two main categories of power dividers are reactive and resistive and each can be suited for its own specific applications. Wilkinson Power Divider (WPD) belongs to reactive power divider in which it has some special properties such as lossless network, high isolation between output ports and low insertion loss [1- 3].

It has a single input port and more than one output port. But the main advantage of divider is that all ports are theoretically matched and output ports are isolated from one another [4].

It is usual, but not mandatory, for the transmission from the input port to be identical to all output ports. It can be designed with different transmission line sections such as strip-line coaxial, micro-strip, airstrip and lumped element circuit topographies. The desirable properties of a power combiner are low insertion loss, high isolation between outputs ports and high return loss. Additional desirable property of a power divider is wider bandwidth leading to number of sections for *N*-way power division [1, 2].

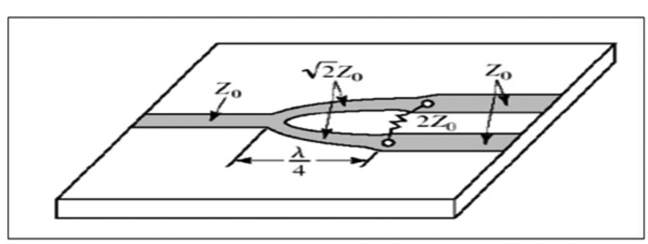
High power designs have high dissipation and system failures due to mismatch (amplitude and phase both). In this paper, detailed design of 8-way power combiner, with 4 in-phases and 4-quadrature phase inputs, is discussed. The design is capable to handle 2.5KW peak @10% duty for 2.7 to 2.9 GHz frequency.

II. PREVIOUS WORK

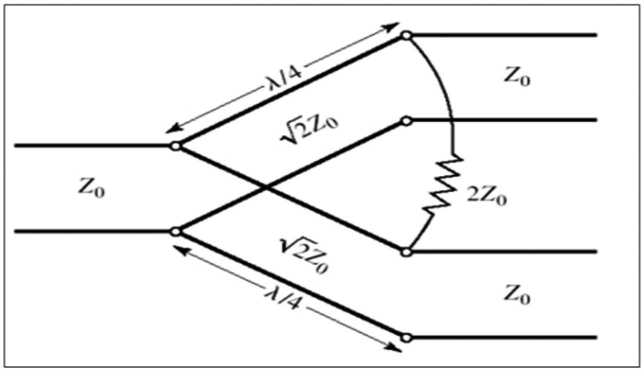
In 1960, a theoretical approach of power divider with *N*-output port (N >2) was developed by Wilkinson [5]. Some development to utilize a power-splitting network, such as corporate or parallel feed system has been applied for antenna array systems by use of 3-port power dividers [6]. In this work, the use of corporate feeding network is applied to split signal power between *N* outputs ports with a certain distribution while maintaining equal path lengths from input to output ports. Unfortunately, all the related works are usually for a normal condition of application. Whilst for a specific application, such as lower power surveillance radar, a power divider with an unusual number of output ports still needs to be further investigated to be developable. In addition to the Wilkinson topology, the main problem for *N* output port (more than 2) is the non planarity of the circuit due to the presence of a floating node connecting all isolation resistors together [7]. Nevertheless, the Wilkinson *N*-way divider or combiner topology still remains attractive up to now, at least, for some reasons such as the possibility of designing an odd number of outputs, the capability to have a compact size (only a quarter wavelength) and a theoretical ideal performance.

III. DESIGN ARCHITECTURES

Wilkinson Power Divider: The Wilkinson power divider is a three-port network which is lossless when the output ports are matched; where only reflected power is dissipated. Input power can be split into two or more in-phase signals with the same amplitude. The design of an equal-split (3 dB) Wilkinson power divider is often made in strip-line or micro-strip form. The basic topology and its equivalent transmission line model are shown in Fig.1.



(*a*)



(*b*)
Figure 1. Wilkinson power divider (*a*) an equal-split Wilkinson Power divider in micro-strip form and (*b*) Equivalent Transmission line circuit.

Gysel power Combiner: The Gysel power divider overcomes the high power-handling problem by introducing two short-ended resistors that can transfer the heat to the ground plane effectively. Figure 2 shows Gysel high-power in-phase planar combiner/divider.

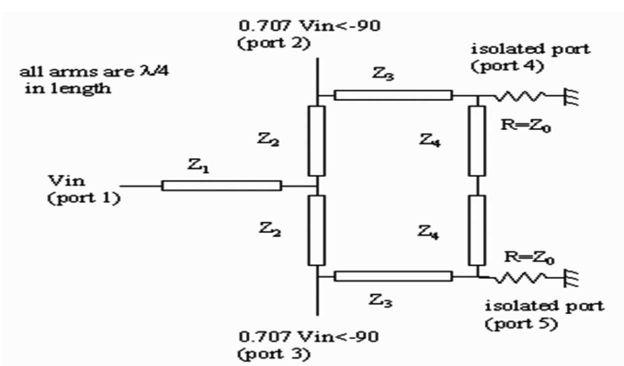


Figure 2. Gysel high power in-phase planar combiner /divider.

IV. DESIGN PARAMETERS

Isolation, VSWR, Input power, Amplitude balance, return loss, and insertion losses are the common measurable parameters for the WPD. Return loss is the loss of signal power resulting from the reflected power caused at a discontinuity in a transmission line, or optical fibre which may lead to a mismatch with the terminating load or with a device inserted in the line [10].

$$\text{RL (dB)} = -20 \log |S_{11}| \quad (1)$$

Insertion loss is the loss of the signal power resulting from the insertion of a device in a transmission line. In case the two measurement ports use the same reference impedance, the insertion loss in can be expressed as below:

$$\text{IL (dB)} = -20 \log |S_{21}| \quad (2)$$

For *N*-Port WPD,

$$\text{IL} = -10 \log N \text{ (dB)} \quad (3)$$

Isolation is when splitting a signal the voltage present on each side of the isolation resistor is of equal potential and therefore no current flows through the resistor and no power dissipated. The isolation can be expressed as below:

$$\text{Isolation (dB)} = -20 \log |S_{32}| \quad (4)$$

Voltage Standing Wave Ratio is a measure of the deviation of impedance from the characteristic impedance of the power divider and is given by

$$\text{VSWR} = 1 + |\Gamma| / 1 - |\Gamma| \quad (5)$$

$$|\Gamma| = 10 - \text{RL(dB)}/ 20 \quad (6)$$

Design of 2-Way Power Divider: The Micro-strip realization of 2-way Wilkinsion Power divide is shown in Fig. 3.

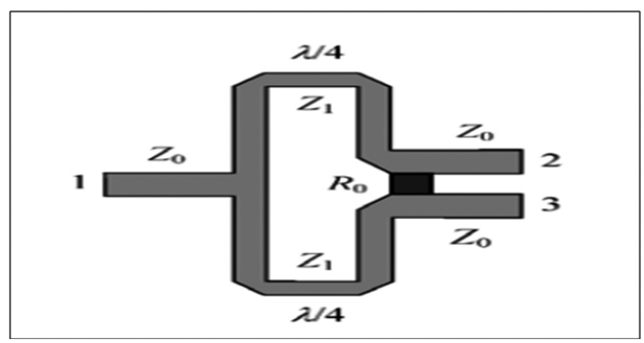


Figure 3. Micro-strip realization of 2-way WPD.

Circuit topology of 2-Way Gysel Power Divider is shown in Fig. 4.

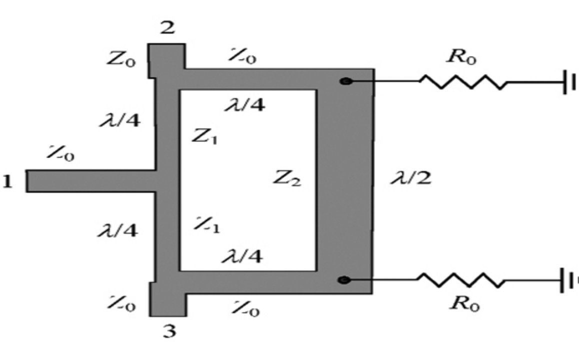


Figure 4. Gysel high power in-phase planar combiner divider.

Simulation of Design was done on ADS & Fig. 5 shows simulated layout. Figure 6 gives simulated resturn losses at all ports.

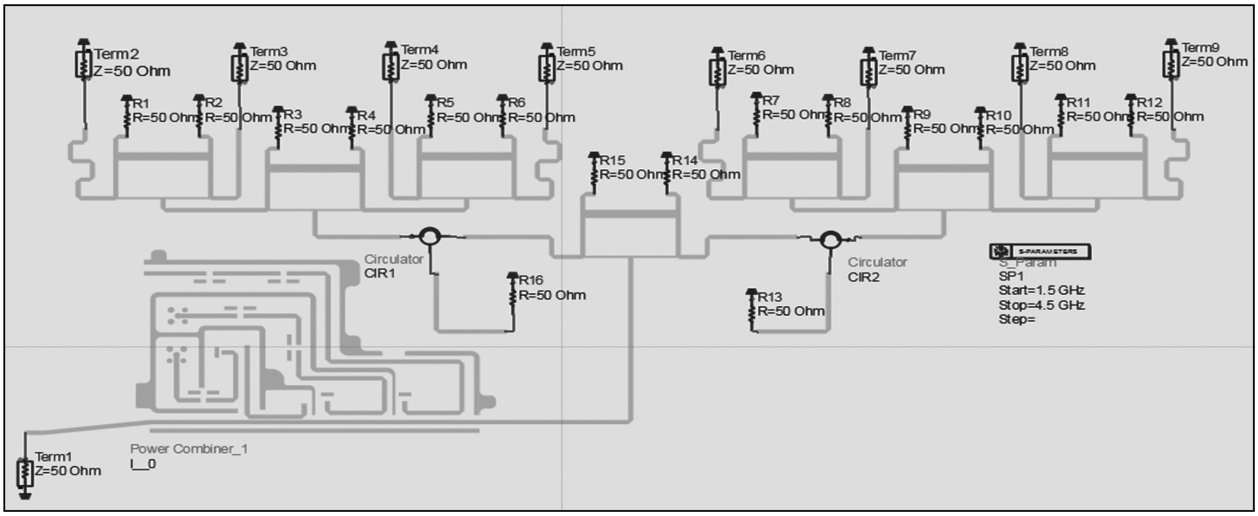


Figure 5. ADS-Design simulation (layout) of developed 8:1 power combiner.

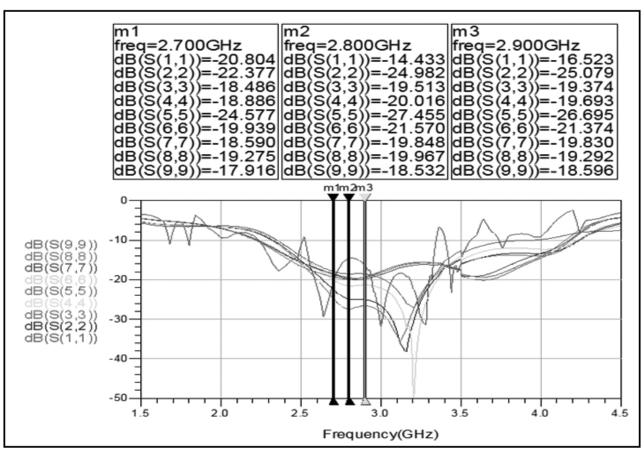


Figure 6 Simulation results of return losses at all ports.

Fig. 7 gives simulated results of Insertion losses. The frequency of application is 2.7 to 2.9 GHz.

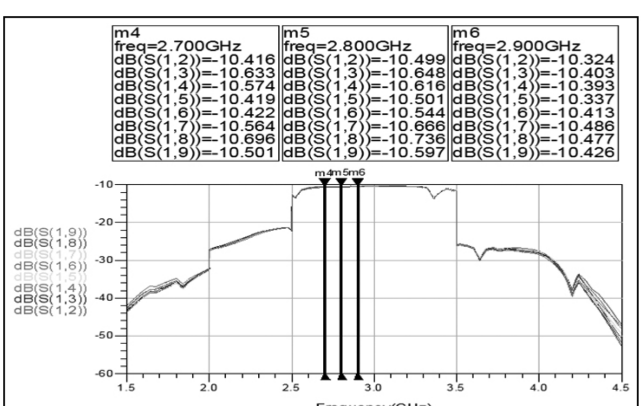


Figure 7. Simulation results of insertion losses at all ports.

Figure 8 gives Isolation among consecutive ports and non consecutive port. The isolation among consecutive ports is of the order of 18-19 dB & maximum isolation among farthest points is 54dB (min).

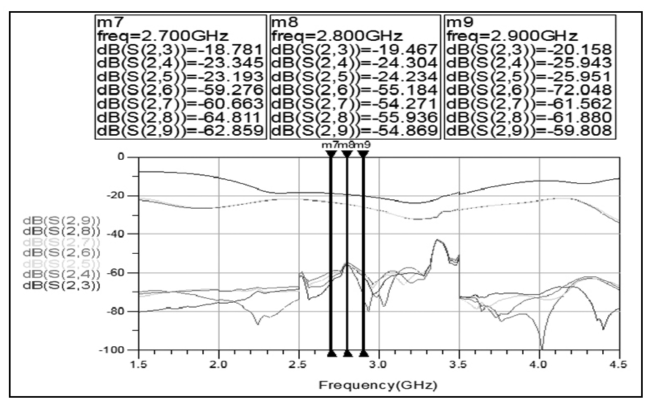


Figure 8. Simulation results of isolation at all ports.

Figures 9 and 10 give phase output of adjacent and non-adjacent ports respectively.

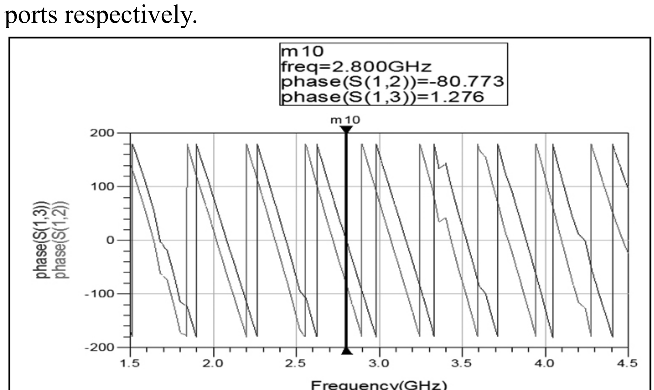


Figure 9. Simulation of phase difference of adjacent ports.

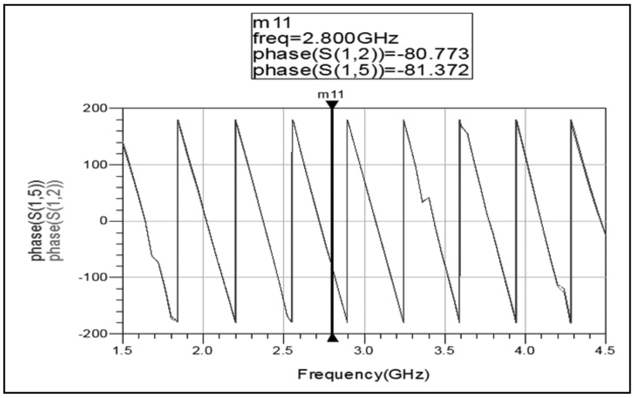


Figure10. Simulation results of non-adjacent port isolation.

V. RESULTS

In the developed power combiner power handling is maintained with proper selection of substrate and terminations in geysal design. The matched pair of circulator also facilitates the design to handle high power in case of high VSWR. The test results meet design specifications with return loss at input/ output ports >15dB. The input mismatch at system level of ± 8° was not affecting the performance of Combiner at high power as well. The combiner integrated with radar system meets all specs.

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