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Design and Analysis of 3-Way Power Divider for UWB Applications

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Abstract- *The proposed Wilkinson power divider has been designed and printed on low-cost Epoxy laminate substrate FR4 along with the thickness of 1.6mm and relative permittivity of εr =4.3 respectively. The transformation of power divider network which are based on bent corners as a replacement of sharp corners or edges used for the decrement in unintended radiation and employing a single radial stub on each branch to encounter the antenna-specifications. Further some adjustments in the dimension of stubs matching in order to increase the reflection of the power divider network. The design presents the model of a power divider and maintains an equal power splitting at different ports with practical insertion loss and conventional return loss below -10dB. The reasonable impedance matching has achieved at every single port with acceptable isolation performance values over the (3-to-10 GHz) frequency range. The divider as well as antenna elements design and its optimization are practicable via computer simulation technology (CST) simulation software. The experimental results are revealed to encounter the array-specifications under ultra-wideband frequency range.*

Key Words: UWB, Array, simulation, power, gain

1. INTRODUCTION

Power Splitter or Divider is considered as a significant component especially in microwave circuit design as well as interconnected subsystems. It is extensively used in power amplifiers, mixers and phase shifters. At this time the power divider strongly considers as a significant component mainly in an ultra-wide band application and antenna array related system feeding network. The design model of Wilkinson power divider is very popular due to its narrow bandwidth and particularly used in UWB antenna array application. For the further advancement in frequency bandwidth and expansion in channel frequency a general design of power divider with some modification in basic geometrical shape has been developed.

The following parameters like return loss, isolation, insertion loss, group delay and bandwidth achieved from divider network has necessary for the configuration of any power divider and the mentioned parameters generally used to evaluate the specific performance in many satellite and radar communication application system.

Currently, the most focused type of power divide named Wilkinson is an optimal selection of several researchers. It is typically used in feeding network of antenna array system because of its simple geometrical structure, low insertion losses and compacted in size. Although, the isolation circuit is associated with output ports and it also offers electrical separation but cannot physical isolation to the circuit.

2. CONVENTIONAL DESIGN

Two parallel uncoupled quarter wavelength transmission-lines have been used for the formation of conventional Wilkinson power divider. The characteristic impedance of all uncoupled lines is √2Z0 and matched with the input port of divider. For the better isolation of divider a shunt resistor 2Z0 would be associated among the output ends of the port. The basic structural configuration of 1 to 2 sections power divider is represented in Figure 1(a) and Figure 1(b) correspondingly.

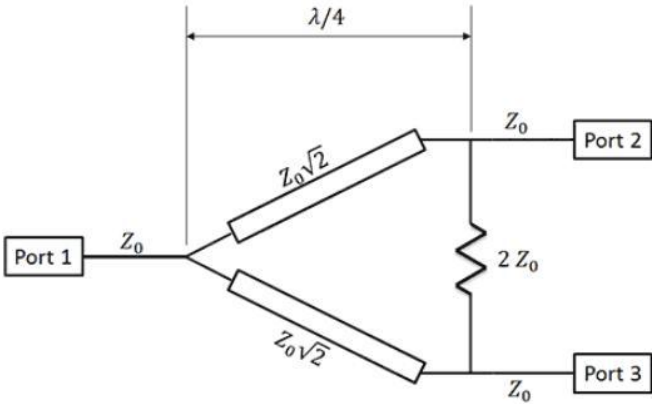


Fig 2(a): Equally-Split 2-way Wilkinson Power Divider

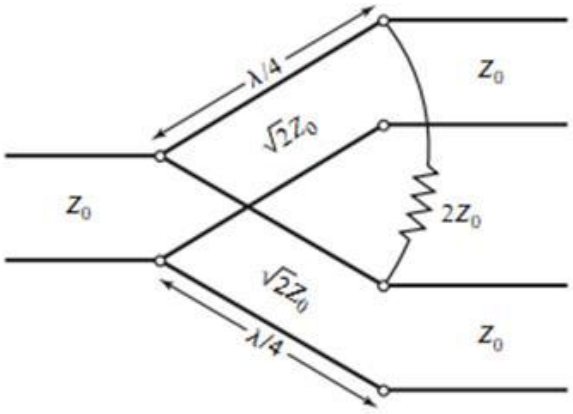


Fig 2(b): Equivalent Circuit of Conventional Power Divider Network

The concept of N-way divider is formally used for improvement in the number of output ports as signify in Figure 2(c). The elementary circuitry of mentioned power-divider can be coordinated at all network ports and corresponding port is matched with isolation among all network ports.

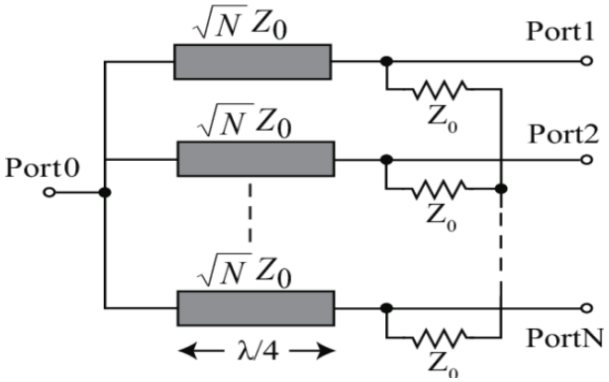


Fig 2(c): N-Way Power Divider for Equal Power Split

3. PROPOSED DESIGN OF POWER DIVIDER

The schematic of the proposed equal-split WPD is shown in Fig. 3.1. It comprises of a Multi section 3 way Wilkinson power divider, and three ports of power divider are matched for 50 Ohms the even- and odd-mode characteristic impedances and it's analysis gives the correct estimation of impedances and power. The quarter-wave transformer provides a simple means of matching any real load impedance to any line impedance. For applications requiring more bandwidth than a single quarter-wave section can provide, multi section transformers can be used. The design of such transformers is the subject of the next two sections, but prior to that material we need to derive some approximate results for the total reflection coefficient caused by the partial reflections from several small discontinuities. This topic is generally referred to as the theory of small reflections.

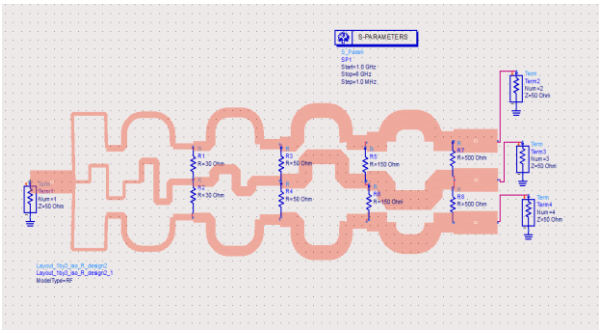


Fig 3: Proposed wideband Wilkinson power divider (WPD). Multi section chebyshev matching network

4. SIMULATION AND DISCUSSION

The general design equations have been developed in the previous section; here they are used to assess the capabilities of the proposed UWB 3 way Wilkinson power divider. To that end, we begin with the special case mentioned in (3.8)-(3.9). If Z_s =50Ω, the difference between the even-odd-mode impedances are required to be 150Ω. The simulated S-parameters and phase difference of a design at f_0=3.5GHz. for different value of Z_{ol} =Z_{or} =Z_o. It is apparent from these simulation results that as the value of Z_o is increased, the corresponding bandwidth of return loss (S_{11}) and that of the transmissions (S_{21}, S_{31}) shrinks. Specifically, the bandwidth for 10dB return loss is 200% for Z_o=50Ω.Enhancement on return loss is done by tuning and optimization on calculated values for chebyshev Multisection transformations. For isolation (S_{23}) bandwidth, if 15dB isolation criteria is adopted then the bandwidth is higher than the entire simulated frequency range, that is, more than 200%. However, if 14dB isolation criteria is adopted, then a higher value of Z_o (1:3 Ultra Wideband Equal Power dividers from 1GHz to 6 GHz.

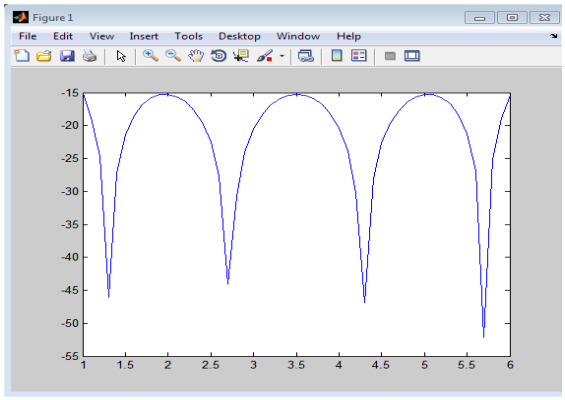
N= number of quarter wave sections

f0= Centre frequency (in GHz)

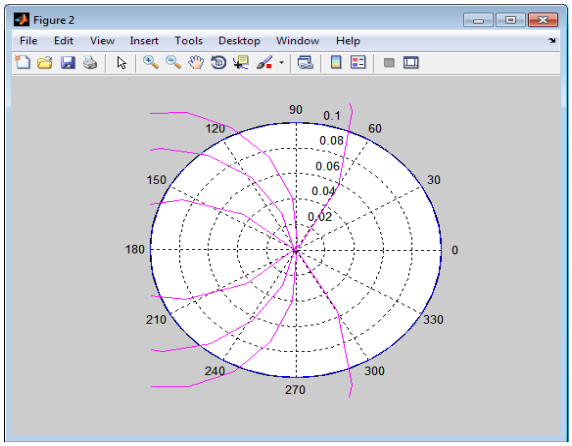
f1= lowest cut=off frequency (in GHz)

f2=highest cut=off frequency (in GHz)

fa=frequency array with steps



(a)



(b)

Fig 4: (a) Return Loss (b) Smith Chart

5. Conclusions

The objective of this thesis was to pursue wideband techniques to tackle this problem. To that end, a scheme to get best out of the advantages that WPD offer was discussed. Specifically, a clear design methodology to for Power divider as a combination of multi section transformer and WPD employing some isolation resistor was discussed. It is found that considering 15dB return-loss reference, the bandwidth is 200% for the proposed design.

By employing matching network at each port of conventional Wilkinson divider core structure, a 3 way UWB Power Divider with fairly good performance was described. Specifically, parallel coupled lines were used at each port to facilitate a wideband matching. Due to the use of these coupled line structure, a DC isolated WPD is obtained which can be potentially be used in balanced amplifiers with having requirement of coupling capacitors. A prototype was fabricated to validate the proposed theory. The EM simulated results matches quite well with the measured results and the measured isolation bandwidth is 200% considering 15dB reference.

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