# Bandwidth Enhancement of a Class of Power Divider using Multiple Cascade Microstrip Hairpin Resonators

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## 1. Introduction

Compact size and high-performance microwave elements are highly demanded in several communication systems. One of these elements is power divider for power division and/or combination. This element has wide applications in several microwave circuit such as HMIC and MMIC.
Recently, several classes of power divider were proposed using parallel connection of a resistor, an inductor and a capacitor [1]-[2]. The use of spiral compact microstrip resonators cell (SCMRC) is an interested method to design of this element [3]-[4]. Further, in order to reduce the size and enhance the bandwidth of the microwave elements have suggested many solutions [5]-[6]. While, these methods give us a chance to have a small design area, they can not enhance the bandwidth. In [7], a dual-band power divider has been proposed using microstrip hairpin resonators. In this investigation, an interested solution has been proposed to reduce the size and cost of these elements. It consists of two quarter wavelength and a microstrip hairpin resonator. The use of connecting lines as a cascade two unit elements instead of the internal series stubs is a useful method to increase bandwidth in the digital elliptic filters [8]. The implementation of this method is very difficult in practice and needs suspended bars and dielectric shims. In [9], a model of coupled transmission lines has been proposed that has the simple structure and the same performance with it. In this paper, is tried to propose a structure for designing a power divider with enhancement of bandwidth using multiple cascaded microstrip hairpin resonators for the broad-band property that also has a same performance with a cascade two unit elements.
An equivalent circuit model for the stepped-impedance hairpin resonators is described and a compact power divider using cascaded these resonators is designed. The exact dimensions of the power divider are synthesized by electromagnetic (EM) simulation and it is designed for a 3-dB cut-off frequency of 5 GHz on a 25-mil-thick substrate with relative dielectric constant $\varepsilon_r$ = 9.6.

## 2. Equivalent Circuit Model for the Power Divider

Figure.1. (a) shows the basic layout of the microstrip stepped-impedance hairpin resonator. It consist a single transmission line with length $l_1$ and coupled lines with length $l_2$. $Z_1$ is the characteristic impedance of the single line; $Z_e$ and $Z_o$ are the even and odd mode impedance of the symmetric capacitance-load parallel coupled lines.

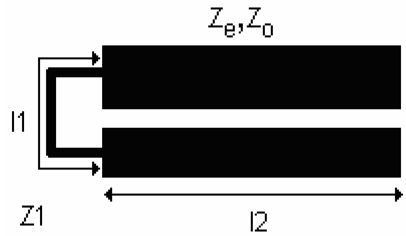


Figure 1: Stepped-Impedance Microstrip Hairpin Resonator

It has been shown; by selecting $Z_1 > \sqrt{Z_e Z_o}$ the size of this layout can be small and compact [10]. In this paper, is tried to design a compact power divider by regarding this restriction.
Following of this condition, a power divider is designed using multiple cascade microstrip hairpin resonators. Fig.2. (a) shows the layout of this element. It consists of two quarter wavelength and a series of cascaded microstrip hairpin resonators. Referring to [7], the equivalent circuit model of this structure can be derived easily as shown in Fig.2 (b).

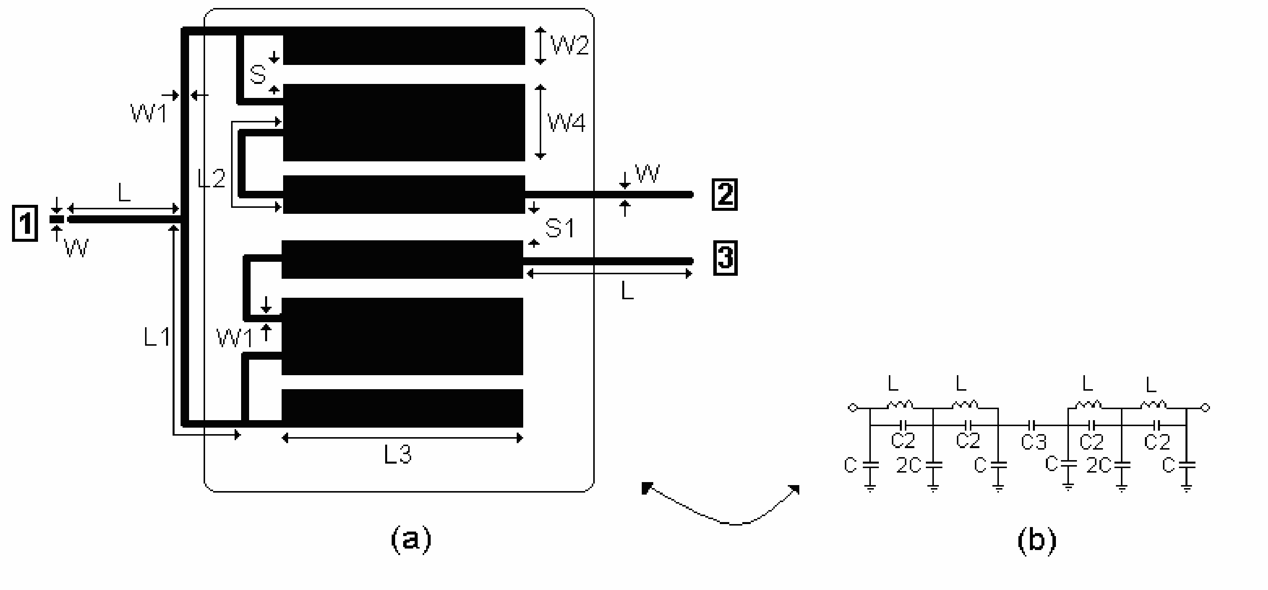


Figure 2: (a) The Proposed Power Divider (b) Its Equivalent-Circuit Model

Since, the proposed model has a symmetric structure, similar to [7], the even and odd modes analysis can be used to analyze of its and to obtain the necessary equations. The proposed power divider in [7], has been designed to operate in two band frequency, in this paper, is tied to diminish the return-loss between the two bands using cascaded microstrip hairpin resonators to enhance the bandwidth of this element.

## 3. The Proposed Multiple Power Divider

As stated in previous section, a power divider can be designed by this proposed model. In fact, a wide band power divider is designed by cascade microstrip hairpin resonators. The exact dimensions of transmission lines are adjusted to optimize the performance of the power divider using EM simulation software ADS.
The power divider is designed for an equal-split (3-dB) with fractional bandwidth larger than 18.5% at the centre of 5 GHz on a 25-mil-thick substrate with a relative dielectric constant $\varepsilon_r = 9.6$. Table 1 shows the optimized dimensions of the proposed power divider. The frequency response of the power divider has been shown in Fig.3.

Table 1: The Optimized Dimensions of the Proposed Power Divider

| Parameter | L | L1 | L2 | L3 | W |
|---|---|---|---|---|---|
| Opt. Value | 7 mm | 5.258 mm | 3.266 mm | 10 mm | 0.62 mm |
| Parameter | W1 | W2 | W4 | S | S1 |
| Opt. Value | 0.279 mm | 1 mm | 2 mm | 0.429 mm | 0.3 mm |

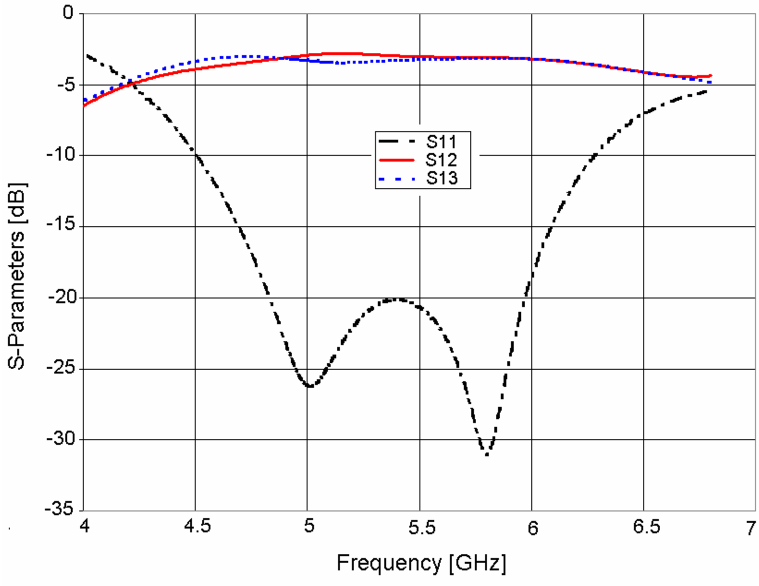


Figure 3: Simulated Frequency Response of the Proposed Power Divider

# 4. Conclusion

A wide-band power divider has been designed and introduced for the brood-band property; this element is designed with multiple cascaded microstrip hairpin resonators and its equivalent circuit. The structure of this element has the same performance with what has been used in digital elliptic filters for enhancement of bandwidth. To optimize the performance of this power divider, electromagnetic simulation is used to tune its dimensions. It has the fractional bandwidth larger than 18.5% at the center frequency of 5 GHz.

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