IJAREEIE
e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

Volume 11, Issue 4, April 2022

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.18

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.18|

||Volume 11, Issue 4, April 2022||

|DOI:10.15662/IJAREEIE.2022.1104002 |

Impedance Derivationforan Asymmetrical Cross-shaped Microstrip Resonator

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ABSTRACT:The impedance of an asymmetrical cross-shaped microstrip resonator is derived. This resonator has three attenuation poles, and can be used to design microwave triband bandstop filters with smaller circuit sizes. The impedance derivation is mainly based on microwave transmission line theory.

KEYWORDS:impedance, resonator, transmission line.

I.INTRODUCTION

Microstrip bandstop filters (BSFs) are widely used as microwave subsystems [1]. Tri-band BSFs are very useful because of their three separate stopbands. A tri-band BSF can be designed by cascading three different BSFs. The side effect of this conventional technique is the increase in circuit size and high passband insertion losses. Size reduction of BSFs is always an important research topic. Triband microstrip BSFs have not been widely investigated by the research community [2].

To design triband BSFs using a single resonator can significantly reduce filter circuit sizes. In one research, an asymmetrical cross-shaped microstrip resonator was used to design triband BSFs [2]. This single resonator has three attenuation poles, and can generate three stopbands. The filter design process starts from the resonator impedance calculations. Then the resonant conditions can be found and the electrical lengths inside the resonator can be calculated. In this paper, the impedance derivation process for this resonator is presented.The impedance derivation process is mainly based on microwave transmission line theory.

II.RESONATOR IMPEDANCE DERIVATION

The asymmetrical cross-shaped microstrip resonator is shown in Figure 1. The characteristic impedance of all the microstrips is Z. The electrical lengths of the bottom and the top arms in the vertical direction are θ_1 and θ_2, and the electrical lengths of the right and the left arms in the horizontal direction are θ_3 and θ_4. Since the cross is not symmetrical, θ_3 does not equal to θ_4. And also often θ_1 is much shorter than θ_2.

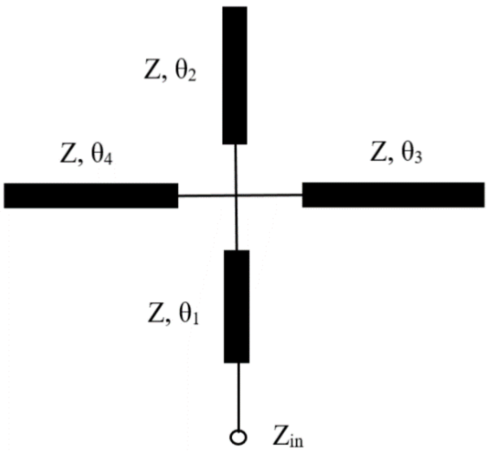

Fig. 1. The configuration of the asymmetrical cross-shaped resonator.

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Based on transmission line theory, at microwave frequency (such as 1 GHz), the impedance of a transmission line terminated with a load can be calculated as [3]

$$Z_{in} = Z\frac{Z_L + jZ\tan\theta}{Z + jZ_L\tan\theta} \tag{1}$$

The transmission line impedance is Z, and the load impedance is Z_L. The electrical length of the transmission line is θ. The four outer end of the four arms in the resonator are open, and hence, Z_L is infinity for the four arms.
The impedance of the top arm seen from the center of the cross is

$$Z_{in2} = -jZ\cot\theta_2 \tag{2}$$

The impedance of the right arm seen from the center of the cross is

$$Z_{in3} = -jZ\cot\theta_3 \tag{3}$$

The impedance of the left arm seen from the center of the cross is

$$Z_{in4} = -jZ\cot\theta_4 \tag{4}$$

The total impedances of the three above arms seen from the center of the cross can be calculated as

$$Z_L = \frac{Z_{in2}Z_{in3}Z_{in4}}{Z_{in2}Z_{in3}+Z_{in3}Z_{in4}+Z_{in2}Z_{in4}} = \frac{-jZ}{\tan\theta_2+\tan\theta_3+\tan\theta_4} \tag{5}$$

From (1) and (5), the impedance at lower end of the bottom arm can be derived as

$$Z_{in} = jZ\frac{\tan\theta_1(\tan\theta_2+\tan\theta_3+\tan\theta_4)-1}{\tan\theta_1+\tan\theta_2+\tan\theta_3+\tan\theta_4} \tag{6}$$

III. DISCUSSIONS

At DC and low AC frequencies, the impedance of the resonator is apparently infinity, since it is only an open circuit. But at microwave frequencies, the wavelength is comparable or even shorter than the conductor size, and the signals must be treated as traveling waves. Based on transmission line theory, the impedance of a transmission line with an open end is not infinity anymore [3]. Based on (6), the resonator impedance is function of the line impedance Z and the four electrical lengths, from θ_1 to θ_4.

IV.SUMMARY

The impedance of an asymmetrical cross-shaped microstrip resonator is derived. At DC and low AC frequencies, this impedance should be infinity. But at microwave frequencies, this impedance is a function of the line impedance and the four electrical lengths in the resonator. From the resonator impedance, the resonant conditions can be found, and the attenuation poles can be located.

ACKNOWLEDGMENT

This work was supported by NSF through a grant (1849454). The author would like to thank Dr. Montgomery, Dr. Scott, and Dr. Heidary for their assistance.

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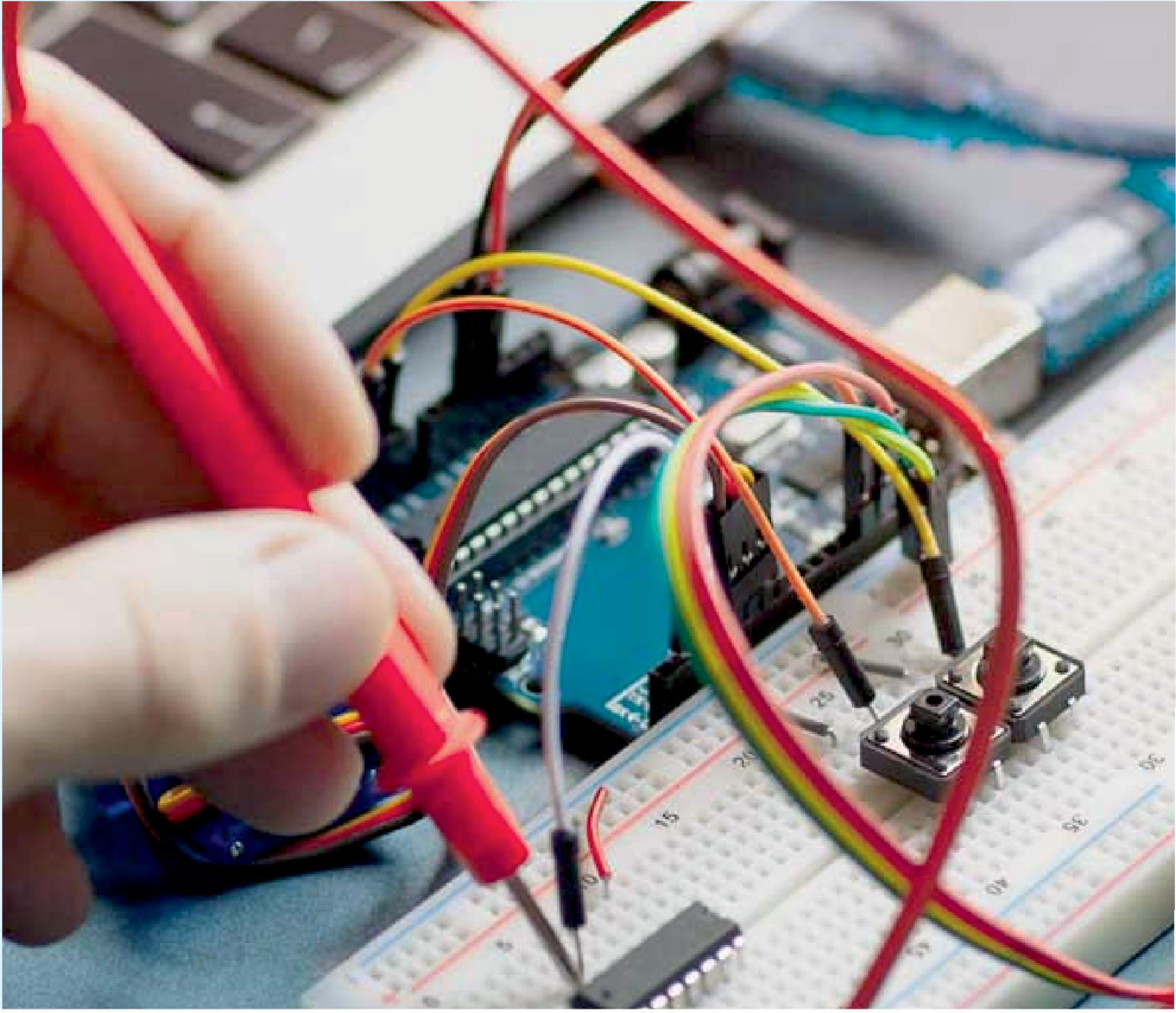

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SJIF Scientific Journal Impact Factor
Impact Factor: 8.18

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