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Design and Comparision of Band Pass Cascade Trisection Microstrip Filter

[1,]Lakhan Singh And [2,]P. K. Singhal
[1]Shri *JJT University, Rajasthan,* [2]*M.I.T.S. Gwalior*

--Abstract--

In this paper two six pole of cascade trisection microstrip bandpass filter are design and simulated. The one cascade trisection filter is without split ring resonator and other is with split ring resolator. After simulation the results are compared. The filter without SRR is resonating at frequency 1.4 GHz with return loss -20db where as the filter with SRR is resonating at frequency 2.05 GHz with return loss -31db in the pass band. The filter with SRR having frictional band width (FBW) of 10% as compared to filter without SRR having frictional band width is 8.5%.

Keywords: *Microstrip Cascade Trisected filter, Meta meterial split ring resonator, cross coupling, Quality factor.*

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I. Introduction:

There have been increasing demands for advanced RF/u wave filter other than conventional chebyshew filter in order to meet stringent requirement for RF/uwave system, particularly for wireless communication system.

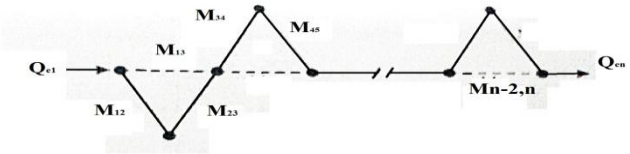

Fig shows two typical coupling structure of cascade trisection filter, where each mode representing of resonator. The full line between nodes indicates main or direct coupling and the broken line indicates the cross coupling. Each cascade tri-section is comprised of three directly coupled resonator with a cross coupling, it is this cross coupling that will produce a single attenuation pole and finite frequency. With an assumption that the direct coupling coefficient are positive the attenuation pole is on the low side of pass band. If cross coupling is positive too, where as the attenuation pole will be on the high side of the pass
band for negative cross coupling. The transfer function of casecade trisection filter may be expressed as

$$|s_{21}| = 1/\sqrt{(1+\varepsilon F^2 n(\Omega))}$$

$$F_n = \text{Cosh}\left[\sum_{i=1}^{n}\left[\frac{\cosh^{-1}\{(\Omega-(\frac{1}{\Omega ai}))\}}{\{1-(\frac{\Omega}{\Omega ai})\}}\right]\right]$$

Where ε is the ripple constant and Ω is the frequency variable of the low pass prototype filter. Ω_{ai} is the i_{th} attenuation pole and n is the degree of the filter. The number of finite frequency attenuation pole is less than n. therefore the remainder of poles should be place at infinity of Ω.The main advantage of cascade trisection filter is its capability of producing a symmetrical frequency response which is desirable for some application requiring only a higher selectivity on oneside of the pass band, but less than or none of the other side. In such case a symmetrical frequency response filter results in a large number of resonator with a higher insertion loss in the pass band a larger size and a higher cost.The three pole trisection filter is not only the simplest cascade trisection filter by itself but also the basic unit for construction of higher degree CT filter.
For a narrow band case an equivalent circuit of trisection filter is as given.

The coupling between adjacent resonator are indicated by the coupling coefficient M_{12} and M_{23} and cross coupling is representing by $M_{13.}$ Q_{e1} and Q_{e3} are the external quality factor representing the input and output coupling.The resonator are not necessary synchronously tuned for this type of filter.

For simplicity we can let $M_{12} = M_{23}$ And $Q_{e1} = Q_{e3}$

The frequency response of the trisection filter is to be a symmetric but the physical configuration of the filter can be symmetric.The microstrip trisection filter are of different resonator shapes such as open loop resonator, triangular patch can produce asymmetric frequency response with a attenuation pole of finite frequency on the either side of the passband.

II. Meta Material:

Meta materials are artificial materials engineered to provide properties which "may not be readily available in nature''. These materials usually gain their properties from structure rather than composition, using the inclusion of microscopic in homogeneities to enact effective macroscopic behaviour. The border between synthetic materials and Meta materials is vague-with science now able to probe deeper into subatomic levels, novels properties are being discovered in natural materials. Unusual properties are also produced in conventional materials by processing them at Nano scales. However, a distinguishing feature of Meta materials is that they are specifically designed to fulfil a certain objective and to fit the desired application. The research in Meta materials is interdisciplinary and involves such fields as electrical engineering electromagnetic, solid state physics, microwave and antennae engineering, optoelectronics, classic optics, material scientists, semi conductor engineering, nano science and others. Meta material applications are diverse and include remote aerospace application, sensor detection and infrastructure monitoring, smart solar power management, public safety, radomes, high frequency battlefield communication and lenses for high gain antennas.

III. Artificial Materials And Handedness:

The attempt to use artificial materials to control electromagnetic properties back to Jadagis Chunder bose in 1898 who researched elements with chiral properties and to studies by karl Ferdinand lindman on wave interaction with metallic helices as artificial chiral media in the early twentieth century. In the 1950s and 1960s, artificial dielectrics were studied for lightweight microwave antennas. Microwave radar absorbers moved into the research arena in the 1980s and 1990s as application for artificial chiral media. The term chiral is used to describe an object that is different from its mirror image. A well known example of such an object is human hand—no matter how the two hands are oriented, it is impossible for all the major features of both hands to coincide. The term chirality is derived from the Greek word for hand (cheir). It is a mathematical approach to the concept of 'handedness'. Helices, chiral characteristics (properties), chiral media order, and symmetry all relate to the concept of left handedness and right handedness. The chirality (or handeness) is an important characteristic in Meta material design and fabrication as it relates to direction of wave propagation. Meta metarials as left handed media occur when both permittivity **ε** and permeability **μ** are negative. Furthermore left handeness occurs mathematically from the handedness of the vector triplet **E**, **H** and **k**. Wave propagation as handedness is wave polarization in described in terms of halicity (occurs as a helix).Electrical polarization occurs in the direction propagation a linear polarization the electromagnetic wave occurs in an elliptical motion, which decreases over time, and finally flat lines. If the temporal rotation occurs clock wise then it is right handed. If the temporal rotation occurs counter clockwise then it is left handed (see federal standard 1037C) with the mirror image effect all the special axes should be transposed to equal, but opposite values. This process should, and often does demonstrate parity transformation, known as parity symmetry although parity symmetry is ordinary in our macroscopic world.Parity is broken at the sub atomic level. This is a basic tenet of physics. Furthermore, although the visual evidence of our everyday lives contradicts this], broken parity actually occurs at several different levels in nature. "Life on Earth is made of left handed amino acids, almost exclusively. Furthermore, from DNA molecules to "bacteria, winding plants, and right handed human beings to spiral galaxies, one of the handedness dominates over the other." Chirality is evident in structural objects transmission media, and electromagnetic effects. In natural occurring transmission media right handedness dominates i.e. permittivity and permeability are both positive resulting in an ordinary positive index of refraction. However, Meta material have the capability to exhibit a state where both permittivity and permeability are negative, resulting is an extraordinary index of negative refraction, i.e. a left handed material. The term left handed material (LHM),is interchangeable with the term double negative material (DNG).

IV. Classes Of Meta Materials:

Meta materials have the potential of an enormous impact, because with the capability to direct wave propagation at the electromagnetic level, whole system can be refined. In other words, “significant decreases in the size and weight of component, devices, and system” while at the same time enhancing or increasing performance can be achieved. Meta materials allow for a flexibility of design, which means the capability to the fit desired application. Composite Meta materials, is an alternate term that is used to expresses these developments. As development of Meta materials continues, and uses are found, it is necessary to focus on how to integrate Meta materials with other sturdier materials. In light of these developments Meta materials are represented by different classes. Split-ring resonator originally proposed by pendry have attract great intrest among microwave engineer due to their potential application to the synthesis of artificial material.

V. Design Procedure:

In this paper two six pole cascade trisection band pass filter are design and simulated. These filter structure are able to produce two finite frequency attenuation poles one on the low side and other on the high side of pass band. The element value of low pass proto type filter of this design are

$g_1 = 0.9834$ $B_1 = 0.0028$ $J_{12} = J_{23} = 1.0$
$g_2 = 1.586$ $B_2 = 0.6881$ $J_{13} = 0.4026$
$g_3 = 1.882$ $B_3 = 0.0194$ $J_{34} = J_{45} = 1.0$
$g_4 = 1.6581$ $B_4 = 0.7965$ $J_{35} = 0.4594$
$g_5 = 0.9834$ $B_5 = 0.0028$

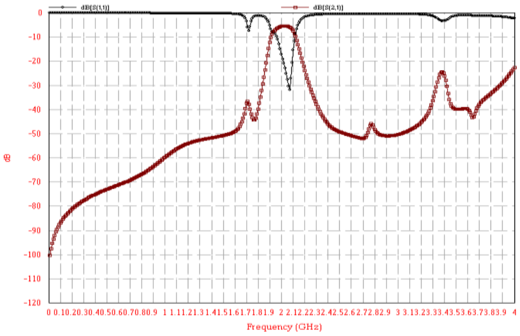

Fig. 1

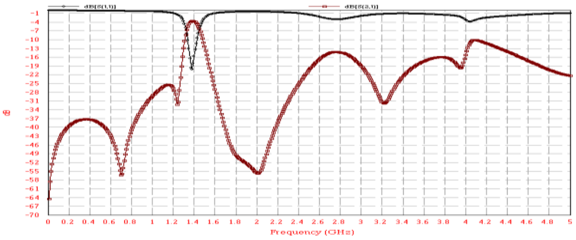

Fig. 2

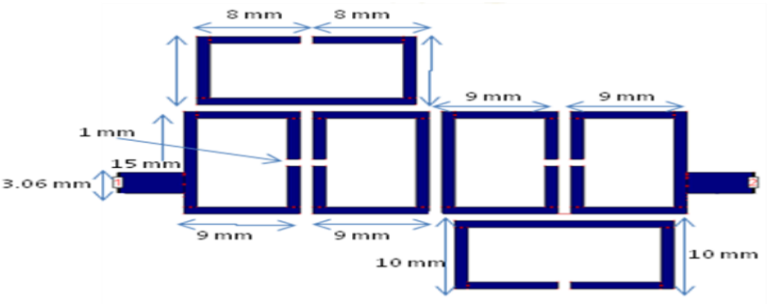

Fig. 3

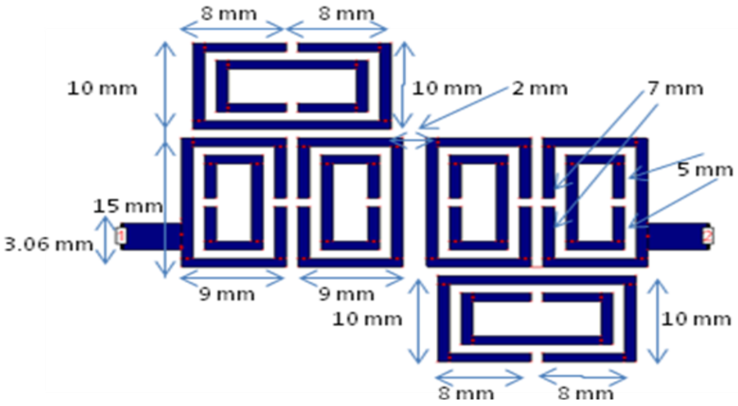

Fig. 4

VI. Result And Conclusion:

Fig 3 and Fig 4 shows the final layout of the design cascade trisection filter. The simulated result of filter 3 is shows in fig 2 and the simulated result of filter 4 is shows in fig 1 . The filter without split ring resonator having return loss of -20 dB at 1.4 GHz where as the filter with split ring resonator have return loss of – 31 dB at 2.05 GHz. The filter having split ring resonator have large frictional bandwidth [FBW] = 10% where as the filter without SRR have friction bandwidth of 8.55 %. And the rejection in the lower pass band is ≥ 25dB at 1.2 GHz. And the rejection for filters with SRR is ≥ 35 dB at 1.7 GHz. The filters are design on the top of FR/4 'Glass/Epoxy' substrate having the dielectric permittivity of 4.4 with thickness 1.6 mm. the loss tangent of the substrate is 0.02. The simulated result shows that by using Rectangular split ring resonator inside the split ring resonator the frictional band width in increases and the return loss in the pass band in also increase and the rejection in the lower side of the pass band in also increases.

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