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Design of Metamaterial Based High Pass Filter Using CSRR at Cut Off Frequency 0.9 Ghz

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Abstract:
In this work, highly selective filters based on periodic arrays of electrically small resonators are pointed out. The high-pass filters are implemented in microstrip technology by etching complementary split ring resonators (CSRRs), in the ground plane, and series capacitive gaps, or interdigital capacitors, in the signal strip. The structure exhibits a composite right/left handed (CRLH) behavior and, by properly tuning the geometry of the elements, a high pass response with a sharp transition band is obtained.

Introduction:
By the design of high pass filters, it was demonstrated that this filter response can be achieved in microstrip lines periodic-loaded with CSRRs and series gaps. To do so, it is necessary to balance the line, that is, to achieve a continuous transition between the left handed band (due to the presence of the loading elements) and the right handed band (that appears at higher frequencies, where the line parameters are dominant). One key aspect of this composite right/left handed (CRLH) lines is that they exhibit a transmission zero to the left of the left handed band. Thus, high frequency selectivity can be achieved, as has been reported previously. One of the objectives of this paper is to demonstrate that by using complementary split ring resonators (CSRRs), further levels of minimization in these high pass filters can be achieved. The second objective is to point out that by properly modifying the topology of the CSRR, we can obtain an open resonator, the open complementary split ring resonator (OCSRR), which is very useful for the implementation of highly selective low pass filters in microstrip technology.

Compact High Pass Filters Based On CSRRS:
The typical unit cell topology and circuit model of these filters is depicted in Fig. 1. *L* is the line inductance; the CSRR is modeled by the resonant tank formed by *Lc* and *Cc*, and *Cg* and *C* (The coupling capacitance), are given by the line capacitance, *CL*, the fringing capacitance of the gap, *Cf*, and the series capacitance of the gap *Cs*

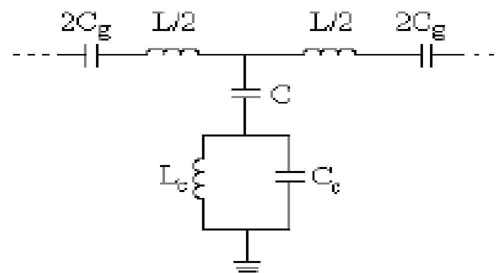

Fig 1.Equivalent Circuit

Formulae Used:

$$C_g = 2C_s + C_{par}$$

$$C = \frac{C_{par}\left(2C_s + C_{par}\right)}{C_s}$$

With $C_{par} = C_f + C_L$. To balance the line we simply force identical series and shunt resonance frequencies, that is

$$\omega_s = \frac{1}{\sqrt{LC_g}} = \frac{1}{\sqrt{L_c C_c}} = \omega_p$$

On the other hand, the transmission zero is given by that frequency that nulls the reactance of the shunt branch

$$\omega_z = \frac{1}{\sqrt{L_c(C+C_c)}}$$

The typical specifications in high pass filters are the rejection level in the stop band, the cutoff (3dB) frequency and the maximum ripple and/or insertion losses in the pass band. The number of filter stages determines the attenuation level in the stop band. Due to the transmission zero, these filters are of special interest in applications where it is necessary a high level of rejection close to the pass band of interest. In Fig 2 it is shown the layout and a photograph of a prototype device order-3 high pass filter with a cutoff (3dB) frequency of 1.5GHz, and 30dB attenuation in the stop band .The dimensions have been determined from reported models of the elements, but optimization to achieve a balanced line has been necessary. These filters can also be implemented by means of

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CSRs. The electrical size of these resonators is half the electrical size of CSRRs. For this reason further levels of miniaturization can be obtained.

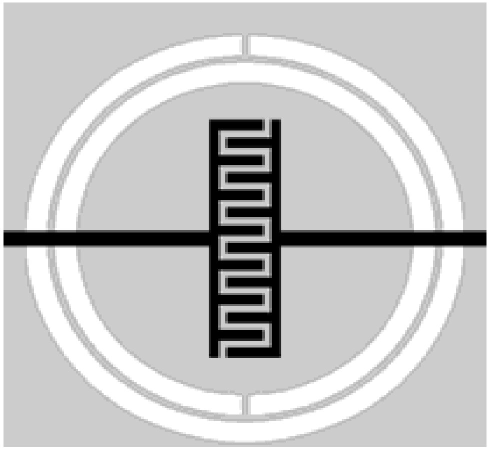

Fig 2.Proposed geometry of compact micro-strip high pass filter

Design of High Pass Filter Using CSSRs:

The substrate characteristics are:
Dielectric constant ε_r = 4.4
Thickness h =1.6mm
Loss tangent tan δ=0.02
Filter dimensions are:
External radius of the CSRRs , r_{ext} =16.56 mm
Width of the inner ring = 1.87 mm
Width of the outer ring = 1.40
Rings separation d = 1.55 mm
Number of fingers = 14
Width of each finger = 1.02 mm
Separation between each finger=1.02 mm
Line width W = 1.24 mm
Total filter length = 101 mm

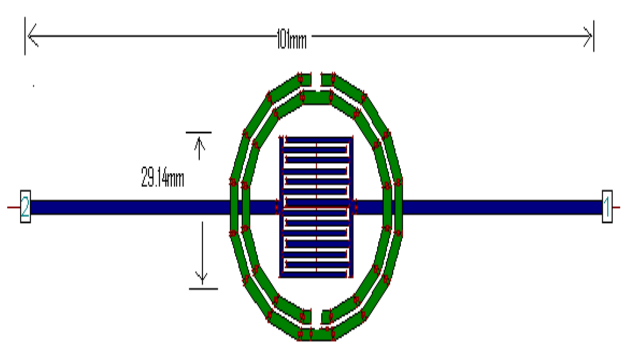

Fig 3. Simulated Geometry of Single Stage CSRR Based High Pass Filter

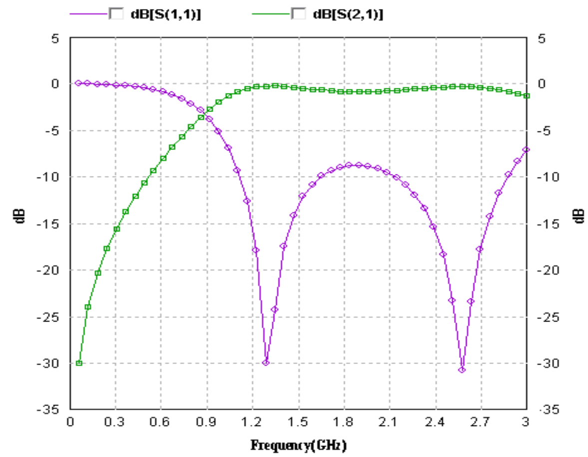

Fig 4. Variation of return loss and transmission coefficient verses frequency

Conclusions:

It has been shown that it is possible to implement compact high pass filters with very sharp cut-off by cascading metamaterial resonant particles in microstrip lines. Several prototype devices have been designed, and characterized to point out the possibilities of the approach. The measured characteristics are good. These filters are of interest in applications where size and selectivity are key issues. A compact micro-strip high pass filter using complementary split ring resonator (CSRR) is designed and fabricated as shown in figures The graph is plotted by taking gain (dB) on the Y-axis and frequency in GHz on the X-axis. From the graph it is clear that the cut-off frequency is found to be 0.9 GHz. Hence the filters are capable of passing the frequency greater than 0.9 GHz.

References:

[1] D.R. Smith, W.J. Padilla, D.C. Vier, S.C. Nemat-Nasser and S. Schultz, “Composite medium with simultaneously negative permeability and permittivity”, *Phys. Rev. Lett.*, vol. 84, pp. 4184-4187, May 2000.

[2] J.B. Pendry, A.J. Holden, D.J. Robbins and W.J. Stewart, “Magnetism from conductors and enhanced nonlinear phenomena”, *IEEE Trans. Microw. Theory Tech.*, vol. 47, pp. 2075-2084, November 1999.

[3] F. Martín, F. Falcone, J. Bonache, R. Marqués and M. Sorolla, “Split ring resonator based left handed coplanar waveguide”, *Appl. Phys. Lett.*, vol. 83, pp. 4652-4654, December 2003.

[4] F. Martín, F. Falcone, J. Bonache, T. Lopetegi, R. Marqués and M. Sorolla, “Miniaturized CPW stop band filters based on multiple tuned split ring resonators” *IEEE Microw. Wireless Comp. Lett.*, vol. 13, pp. 511-513, December 2003.

[5] F. Falcone, F. Martin, J. Bonache, R. Marqués, T. Lopetegi and M. Sorolla, “Left handed coplanar waveguide band pass filters based on bi-layer split ring resonators”, *IEEE Microw. Wireless Comp. Lett.*, vol. 14, pp. 10-12, January 2004.