REVIEW ARTICLE

Performance Analysis of Split Rings Metamaterial for Wireless Application

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ABSTRACT

This paper presents the split ring metamaterial Patch Antennas design using microstrip technology. Microstrip split-ring metamaterial is parallel-coupled transmission lines formed by coupling two conducting strips (resonator) with the same width together at a certain distance, offering a research region with developing interest. Evolving uses of antennas in wireless communications have encouraged the swift development of the Patch Antenna for RF and microwave applications. The presented manuscript is a representative accumulation of the most recent advances in the field of Microwave Antenna and a scope of strategies that are causative to its development are exhibited. The astonishing highlights of this paper incorporate exchange of various novel microstrip Antenna arrangements with cutting edge separating attributes, we also review the design of different microstrip Antenna for wireless application and their findings are reported in the manuscript.

KEYWORDS

Microstrip Antennas, Microstrip line, Coupling factor and S Parameters.

1. INTRODUCTION

The microstrip patch antennas are broadly utilized in microwave applications in view of the few points of interest they have, i.e., manufacturability, repeatability, ease, and so forth. The Patch Antenna is utilized to check and verify the power, frequency and antenna reflection of a signal at transmission stations for mobile communication. The performance requirements of Patch Antennas are a strong coupling to reduce the effect on the transmitted power and high directivity to suppress the interference of the reflected signal and reduce the errors in communication. However usual architecture has a directivity of only 20dB, and there have been difficulties to achieve the higher directivity of 30 dB appropriate for GSM band. This task is even more complicated when using microstrip technology at lower frequency ranges such as very high frequency range, VHF, and ultra-high frequency range, UHF, due to increased physical length in the transmission lines. The key design parameters for Patch Antennas when used as a sampling device for measuring forward and backward waves, can be considered VSWR, directivity, coupling level, and insertion loss. Directivity is a measure of how well an Antenna can separate two signals. High directivity results enhanced the measurement accuracy. Consequently, it is the most decisive design parameter for accurate measurement systems. However, it is a great challenge to safeguard directivity, low VSWR, preferred coupling level, and insertion loss for wideband RF/Microwave applications.

The contents of the paper are organized in the following manner. Section II describe the basic concepts and design equations for Patch Antenna. Section III discusses the different metamaterials used in antenna designing. Section IV is devoted to the discussion of the literature review of microstrip Antenna, and furthermore, we discuss the various results obtained in the base paper. Moreover, finally, a conclusion is reached in section V.

2. DESIGN OF PATCH ANTENNA

As a rule, the outline of microstrip filter includes with the determination of microstrip line and resonating structure, changing over transmission line equivalent lumped component segments for a filter, and its qualities are then obtained by comparing the impedance of the transmission lines to the impedances of lumped components of microstrip line and resonating structure utilized in a composed filter. The decision of the reaction will rely upon the required particulars of a channel. The diverse parameters that impact the microstrip filter outline are discussed in this segment.

Transmission attributes of microstrips are portrayed by two parameters, in particular, the effective dielectric constant $\boldsymbol{\varepsilon_{re}}$and characteristic impedance Zc, which may then be acquired by quasi-static analysis [1][2],

$$\varepsilon_{re} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left(1 + \frac{10}{u}\right)^{-ab} \tag{1}$$

Where $u = W/h$, and

$$a = 1 + \frac{1}{49}\ln\left(\frac{u^4 + \left(\frac{u}{52}\right)^2}{u^4 + 0.432}\right) + \frac{1}{18.7}\ln\left[1 + \left(\frac{u}{18.1}\right)^3\right] \quad (2)$$

$$b = 0.564\left(\frac{\varepsilon_r - 0.9}{\varepsilon_r + 3}\right)^{0.053} \quad (3)$$

The accuracy of this model is better than 0.2% for $\varepsilon_r \leq 128$ and $0.01 \leq u \leq 100$.
The expression for the characteristic impedance is

$$Z_c = \frac{\eta}{2\pi\sqrt{\varepsilon_{re}}}\ln\left[\frac{F}{u} + \sqrt{1 + \left(\frac{2}{u}\right)^2}\right] \quad (4)$$

Where $u = W/h$, $\eta = 120\pi$ ohms, and

$$F = 6 + (2\pi - 6)\exp\left[-\left(\frac{30.666}{u}\right)^{0.7528}\right] \quad (5)$$

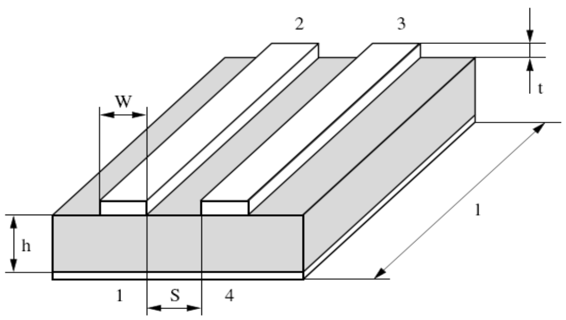

Figure 1. Geometry of the microstrip line.

3. METAMATERIAL EBG CONFIGURATIONS

Different kinds of metamaterial structures are utilized in literature to upgrade the execution of a microstrip patch. The objective of the metamaterial-based patch is to accomplish miniaturization, low VSWR, low reflection loss and larger bandwidth. Diverse kinds of metamaterial structures are outlined in Fig. 2.

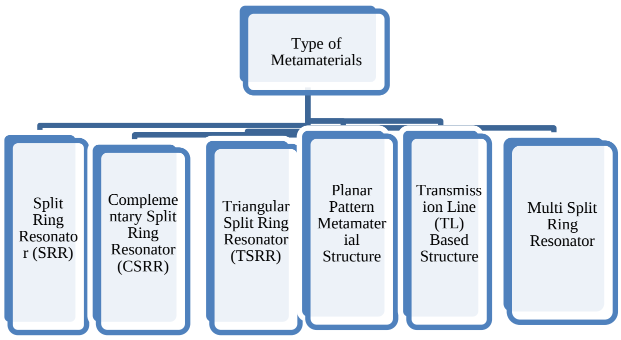

Figure 2. Various Metamaterial Structures.

A. Split Ring Resonator (SRR)

Split ring resonator (SRR) is the most widely recognized structure utilized in the planning of metamaterial-based patch. In this structure, a split is framed at any one side of the ring.

B. Corresponding Split Ring Resonator (CSRR)

This structure is for the most part utilized in the outlining of band stop filters, low pass filters, band pass filters, and high pass filter. This structure is framed by carving out the required shape and having the split at any one side of the structure.

C. Triangular Split Ring Resonator (TSRR)

The metamaterial structure is in the state of a triangle. The split is framed at any one edge or the vertex of the triangle and there is comparing variety in the execution of the patch.

D. Planar Pattern Metamaterial Structure

Planar example is engaged with the outlining of patch of microstrip structure with the end goal to accomplish larger bandwidth, high productivity and gain.

E. Transmission Line (TL) Based Structure

This structure is homogeneous with some one of kind properties. It is for the most part utilized for guided wave and radiation applications.

F. Multi Split Ring Resonator

The metamaterial structure contains various concentric split rings to accomplish reverberation at different frequencies. The resonance frequency can be changed by fluctuating the outline parameters.

4. REVIEW OF BASE PAPER

In this section some of the latest paper based on microstrip Antenna design is reviewed and a conclusion is drawn from the combined study.

Hamed E.A and N. N. Kisel, "Evaluation of the Efficiency of the Metamaterial in the Development of Microstrip patch Antennas using LTCC Technology", Moscow Workshop on Electronic and Networking Technologies (MWENT), 2020 [1]: The paper describes the results of the study and modeling of the characteristics of the metamaterial made of square open-loop ring resonators (SRR – split ring resonator), the SRR with a single ring and SR resonators based on the obtained results. The paper presents the computation through the coefficients of transmission and reflection of the effective values of the dielectric εeff and magnetic permeability μeff layer of metamaterial based on the spiral resonator SR. A microstrip antenna on a substrate of SR metamaterial is considered.

Md. Asaduzzaman, Reefat Inum, Md. Sabbir Hossain, Muhammad Abdul Goffar Khan "On the Design of Effective EBG Structures to Model Highly Efficient Rectangular Patch Antenna for Wireless Applications', IEEE International Conference on Robotics, Electrical and Signal Processing Techniques (ICREST) 2019[2].

This manuscript discuss the relative analysis of radiation parameters of various rectangular patch antennas with quarter wave feed line. Star shaped and fan shaped Electromagnetic Band Gap (EBG) are integrated independently on base plane of each antenna. Resonant frequency detained for the designed antennas is 5.25 GHz. The projected fan shaped EBG based antenna gives a bandwidth of 244 MHz used for wireless applications.

Guo-Ping Gao, Bin Hu*, Shao-Fei Wang, and Chen Yang,

"Wearable Circular Ring Slot Antenna with EBG Structure for Wireless Body Area Network", Antennas and Wireless Propagation Letters IEEE on 2018 [3] : This paper exhibits a wearable approximately ring slot microstrip antenna with electromagnetic Band-Gap (EBG) design for wireless body area network (WBAN) application The measured bandwidth of the projected antenna is seen to be 2.28-2.64 GHz, which covers the 2.4 GHz Industrial Scientific Medical (ISM) band.

Cristian Fiallos-Silva, and R´aul Haro-Baez. "On the Design, Simulation and Fabrication of Multiple Section Split ring metamaterial Patch Antennas at C-band using Microstrip Technology", IEEE International Conference 2017[4]: This paper presents the design of Split ring metamaterial Patch Antennas using microstrip technology. It is established from the manuscript that by increasing sections to a Split ring metamaterial Patch Antenna, the operational bandwidth of the device can be improved, this raise is also achieved by changing the dimension of the antenna viz. the width (W), length (L), and separation (Se) of microstrip lines inside the Antenna sections. For that reason, Antennas of different sections 1, 3 and 5 were designed. To authenticate the designs, two prototypes with 3 and 5 sections were constructed using microstrip techniques and experienced its working in the C-band. Finally, a suitable method for tuning a Patch Antenna, by changing the L, W and separation of the microstrip lines, is proposed.

Konradjanisz **and Robert Smolarz "Compensated 3-dB Lange Patch Antenna in Suspended Microstrip Technique", IEEE International Conference 2017[5]:** This paper is an investigation on the performance of large Antennas based on the suspended technique to minimize the total losses. The measured value of the proposed antenna has good agreement with the theoretical results; the total measured result of losses is only 0.16 dB.

5. CONCLUSION

In this paper, an exhaustive study is exhibited on the basic concept of design equation for microstrip antenna along with the different types of metamaterial techniques used for patch antenna designing. We had also discussed different latest literature available on various metamaterials techniques of our study and found that the split ring based metamaterial is an appropriate method for microstrip patch antenna designing for wireless applications. Thus the above survey gives us the basic idea of different metamaterial techniques used for microstrip patch antenna designing.

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