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Metamaterial Loaded Shorted Post Circular Patch Antenna

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Abstract

This Paper serve as investigation for the different behaviors of resonant modes of the metamaterial loaded shorted Microstrip circular Patch antenna where the inner core is loaded with MNG(μ negative) metamaterial. The material DPS is outside of the MNG Core material. DPS is a double positive regular dielectric. MNG metamaterial loaded with circular patch is used for frequency tuning and dual band operation. Simulation has been performed by way of CST software program.

Keywords: *Microstrip Antenna, DPS, MNG, Metamaterial*

1. Introduction

The advantages of microstrip antennas for outweigh their limitations. Presently those antennas are being increasingly used in the business region due to the decreased value of substrates fabric and mature fabrication generation with endured research and improvement and elevated utilization, microstrip antennas are ultimately expected to replace conventional antennas for most application. Circular disk antenna offer performance similar to that of the rectangular geometries. The circular disk tends to be slightly smaller than the rectangular disk. In some application such as arrays, circular geometries offer certain advantage over other configuration. The circular disk can easily be modified to produce a range of impedance values, radiation patterns, and frequency of operation. Various aspects of circular disk antenna, which include nodal based analysis, design, and effects of various antenna parameters on input impendence, radiation pattern, radiation efficiency, polarization and dielectric covers.

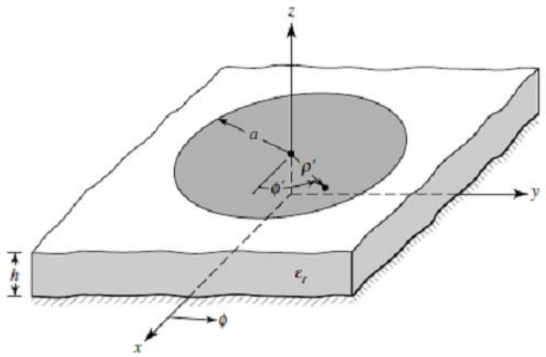

Figure 1. Overall Structural of Circular Microstrip Patch Antenna

The overall circular patch antenna geometry is shown in the Figure 1. Circular disk microstrip radiator geometrics offer certain advantage over other configuration. The circular disk can be without difficulty changed to produce a variety of frequency of operation [2]. Various method of analysis has been applied to the circular disk antennas,

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including the cavity model [3], mode matching with edge admittance the generalized transmission line model [1].

The cavity model, mode matching with edge admittance, and generalized transmission line version are relevant to the skinny substrates most effective due to the fact the version of the sector along the substrates thickness is negligible. Among several method of acquiring dual frequency function one different approach uses shorting post in microstrip circular patch radiator [4]. The analysis based on cavity model [3]. By way of locating shorting pins in right function. Without sacrificing the low profile structure a circular patch antenna can be adjusted in frequency for dual frequency. Some innovative methods are used, its depend upon artificially dielectric. These metamaterials seems to be more favorable in the sense presenting the course of massive success for the cause of size reduction [5]. Behaviors of metamaterial are also shown in Figure 2, [14-17]. Some researcher has recently projected the work of magneto dielectric materials received by such as loop like shapes of metallic resonant. Which is excited via the magnetic subject in a bunch dielectric with high value of permittivity [6-7]. This result has high value of effective permittivity. Analysis of resonance frequency of the inclusions, the effective permeability of the substrates capabilities a bulk resonance for high value or low value with respect to the resonance value is presented [8-9].

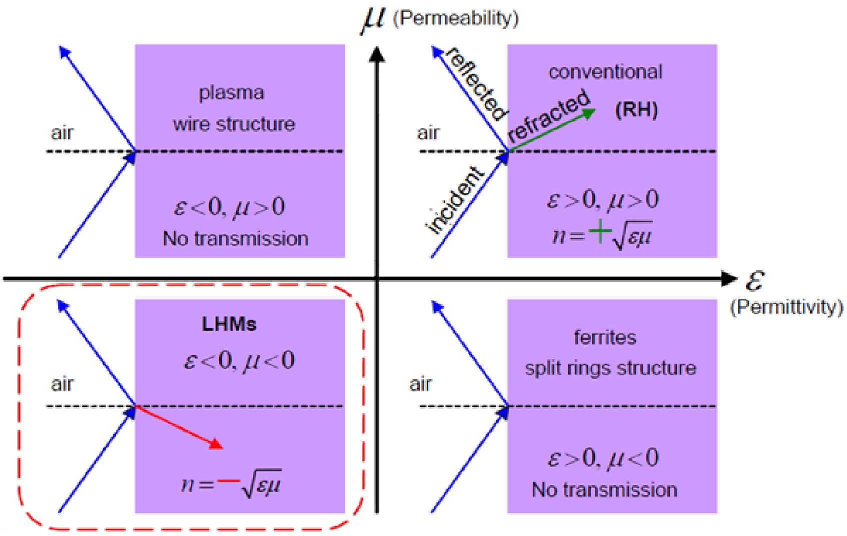

Figure 2. Metamaterial Classification

2. Analysis of the Antenna

The basic circular disk antenna geometry is shown in the Figure 3. This antenna has conducting circular disk on a dielectric substrates and other side is ground plane. Here d << λ_0 the field do not vary along the Z direction. The magnetic field has only rho and phi component [3] and The electric field within the substrates has only in Z component. The normal current components to the age of the microstrip disk approaches to zero at the age. It means that the tangential magnetic field component at the age of the disk is very small. With these suppositions, the microstrip circular patch can be model as a cylindrical cavity bounded at its bottom and top bioelectric walls and on its age by a magnetic wall. Thus the field within the dielectric region of the microstrip cavity, corresponding to the TM_{np} modes can be determined by solving the wave equation for the cavity. Resonate frequency is formulated from below equation.

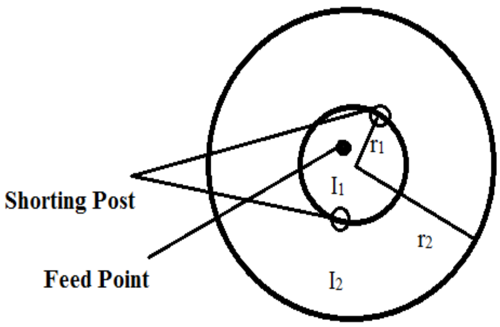

Figure 3. Circular Microstrip Radiator with Shorting Post

$$= \frac{1}{2\pi\sqrt{\mu\varepsilon}}\left(\frac{X'_{np}}{a}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where 'a' is the radius of a circular antenna. X_{np} represents derivative of Bessel's function. The top view of circular Microstrip radiator with shorting post is already shown in Figure 3, & side view of this antenna is shown in Figure 4.

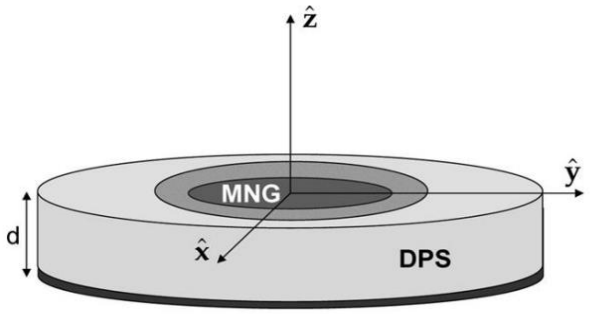

Figure 4. Side View of Circular Microstrip Radiator with MNG Metamaterial

The shorting post is shown in figure. The circular patch of radius r1 is loaded with p passive conducting post of radius Δ at angular locations Φ2 (I = 1, 2, … p) on the circumference of a concentric circle of radius r2, where r2<r1. The given circular patch in the presence of source can be considered to consist of two help disks.

For region I (r2>r>0) the expressions for the electric field and magnetic field are obtained as equation (2-4) given below

$$E_Z^{(1)} = -J\omega_{np}\mu\left[C_1 J_n\left(K_{np}r\right)\right]Cos\, n\Phi \ldots\ldots\ldots\ldots\ldots \quad (2)$$

$$H_r^{(1)} = -\left(\frac{n}{r}\right)\left[C_1 J_n\left(K_{np}r\right)\right]Sin\, n\Phi \quad (3)$$

$$H_\Phi^{(1)} = -K_{np}\left[C_1 J'_n\left(K_{np}r\right)\right]Cos\, n\Phi \ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where $J_n(X)$ = Bessel function of first kind

n = Order

ω_{np} = Angular frequency

K_{np} = Propagation constant of TM_{np} mode

C_1 = Constant

Similarly for region ɪɪ the expressions for the electric & magnetic field are obtained as equation (5-7) is given below

$$E_Z^{(2)} = -J\omega_{np}\mu\left[C_2J_n\left(K_{np}r\right) + C_3N_n\left(K_{NP}r\right)\right] Cos\, n\Phi \quad (5)$$

$$H_r^{(2)} = -\left(\frac{n}{r}\right)\left[C_2J_n\left(K_{np}r\right) + C_3N_n\left(K_{NP}r\right)\right] Sin\, n\Phi \quad (6)$$

$$H_\Phi^{(2)} = -K_{np}\left[C_2J'_n\left(K_{np}r\right) + C_3N'_n\left(K_{NP}r\right)\right] Cos\, n\Phi \quad (7)$$

As we have consider that the diameter of the circular post is small, then the thin post can be assumed to be replaced by a conductor in the form of circular are strip, with arc length equal to the diameter of the post coincidence with a circle of radius r2. The current per unit with is given as (E_Z/Z_0) where Z_0 is Impedance per unit length of the post. The impendence per unit length of such a post carrying a uniform current and connected between two conducting disk can be obtained on the basis of infinite length approximation [3] and the expression is given by.

$$Z_0 = \frac{J\omega_{np}\mu}{2\pi}\ln\left(\frac{\lambda_{np}}{2\pi\Delta}\right) \dots\dots\dots\dots\dots .. \quad (8)$$

Electric and magnetic field given by equation 2 to 7 satisfy the following boundary conditions.

$$E_Z^2 = E_Z^1 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots . \dots\dots \quad (9)$$

$$H_\Phi^2 = -Y_W E_Z^1 \dots\dots\dots\dots\dots\dots\dots\dots\dots .. \quad (10)$$

At r=r2 for $(\Phi_i - \alpha/2) < \Phi < (\Phi_i + \alpha/2)$

Where α = angle subtended by the shorted post at the center of the patch.

Y_W= complex wall admittance for circular cavity

The analysis of microstrip circular patch with shorting post is based on cavity model [10-13]. Substrate is electrically very thin (d<<λo). The electrical field is non- variant in the z-direction and only in z-components [1-3] and magnetic field is in x and y component. In figure 1 shorting posts are already shown. Radius r_1 of the circular microstrip patch is loaded with p passive post. The passive post has radius Δ and angular locations Φ_2 (I = 1, 2 … p) on the circumference of a concentric circle of radius r_2, where $r_2 < r_1$. In the presence of source circular patch consist of two help disks. First one is MNG. It means μ negative and DPS is double positive side. Specification of this antenna is shown in Table 1.

Table 1. Specification of Antenna

Parameters of the Antenna	Unit(mm)
r_1	20mm
r_2	12mm
d(height of substrate)	5mm
Δ(Conducting post radius)	0.95mm
Feed point	15mm far from patch center in the DPS region

3. Results

In this section simulated value of resonant modes of MNG Metamaterials loaded with shorted circular patch in CST Microwave studio. Return loss of circular patch antenna without MNG Metamaterial is shown in Figure 5, and with MNG metamaterial with shorted one post and two posts are shown in Figure 6, & Figure 7, respectively.

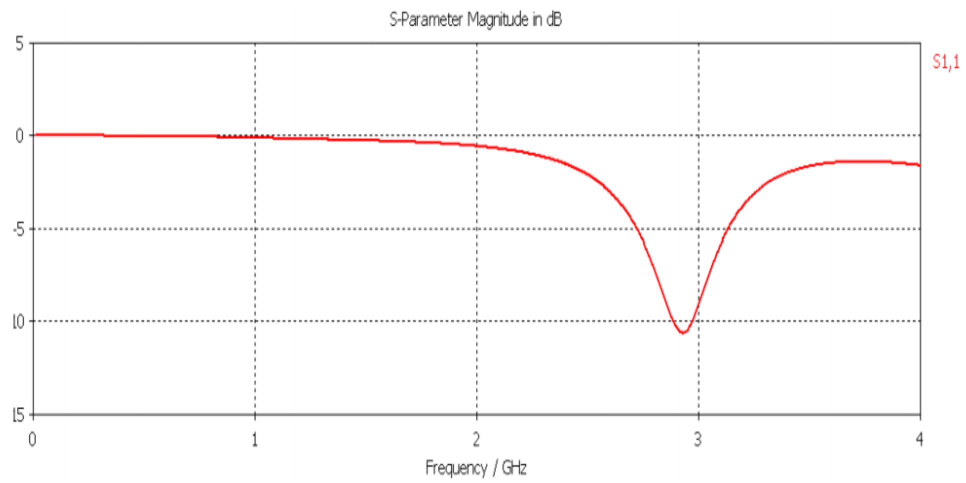

Figure 5. S_{11} of a Circular Patch Antenna without Post without MNG Metamaterial

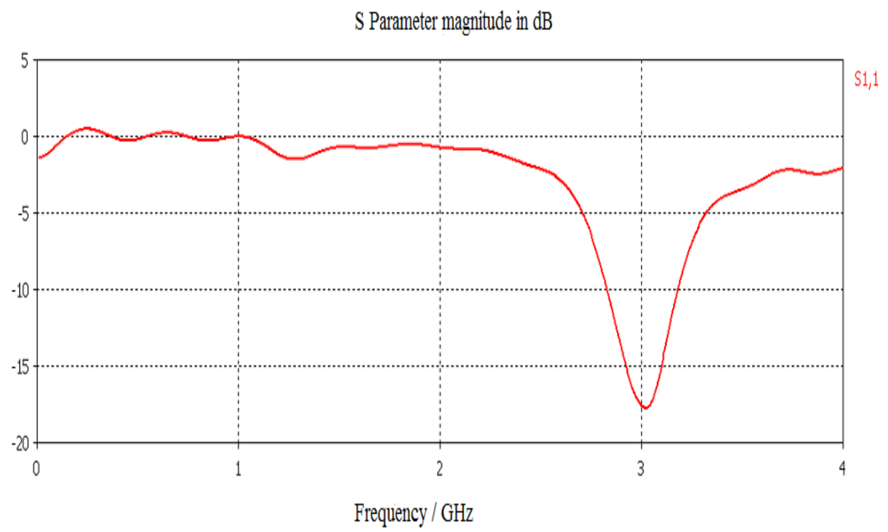

Figure 6. S_{11} of Circular Patch Antenna with Single Post Loaded MNG Metamaterial

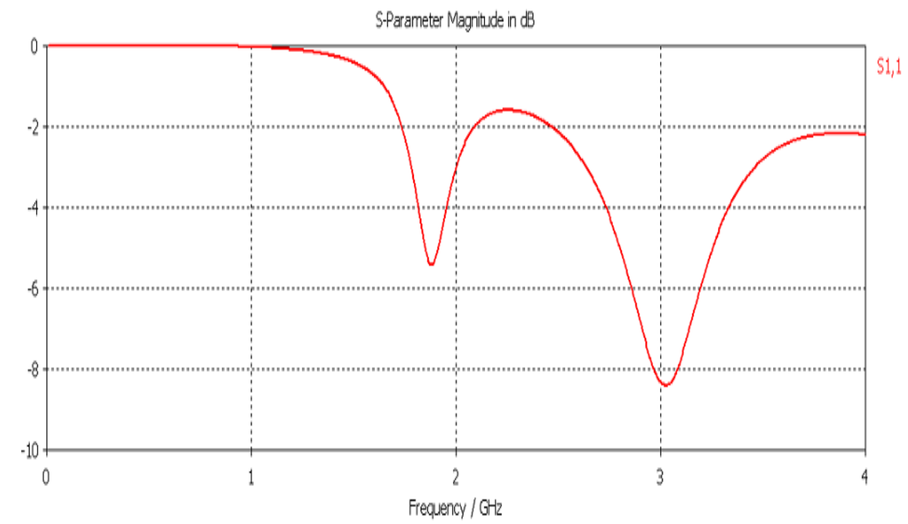

Figure 7. S_{11} of Circular Patch Antenna with two Posts Loaded with MNG Metamaterial

Figure 8, shows Return loss curve of MNG metamaterial shorted circular patch antenna without any post MNG metamaterial in region 1 and DPS in region 2 and Figure 9, & Figure 10, show return loss graph with shorted post one and two respectively.

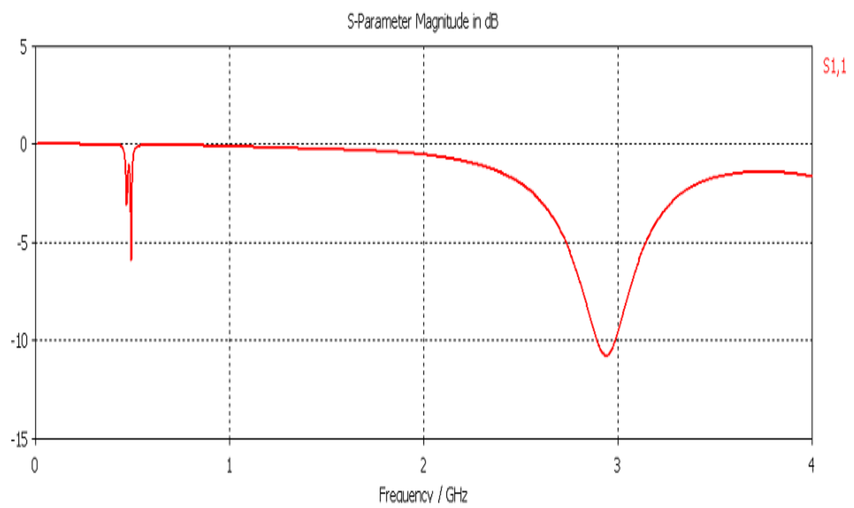

Figure 8. Return Loss Curve of MNG Metamaterial Shorted Circular Patch Antenna Without any Post MNG Metamaterial in Region 1 and DPS in Region

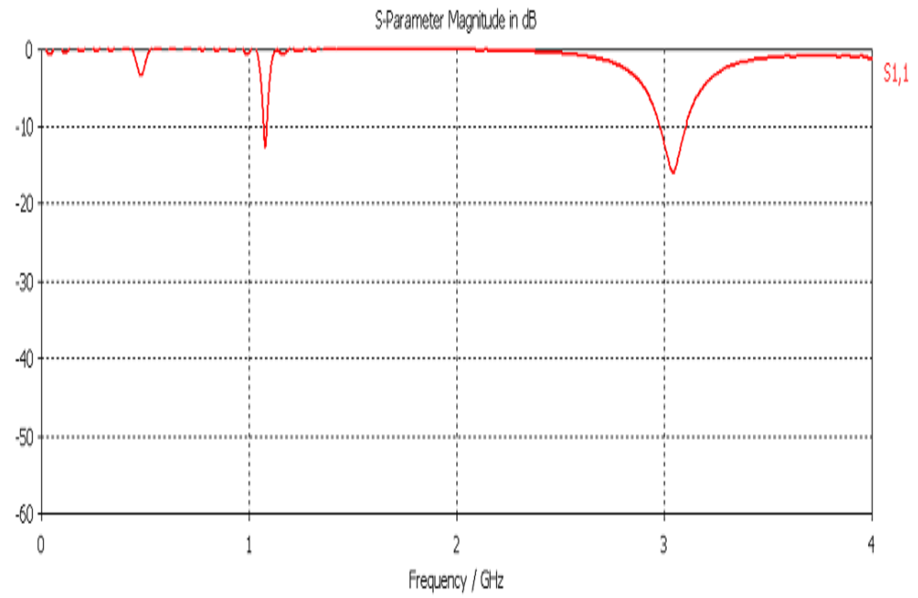

Figure 9. Return Loss Curve of MNG Metamaterial Shorted Circular Patch Antenna with One Post

All the results are tabulated in Table 2, & Table 3, where Table 2 ,has the simulated result of circular patch radiator without MNG and Table 3, has result of MNG metamaterial loaded with shorted circular patch.

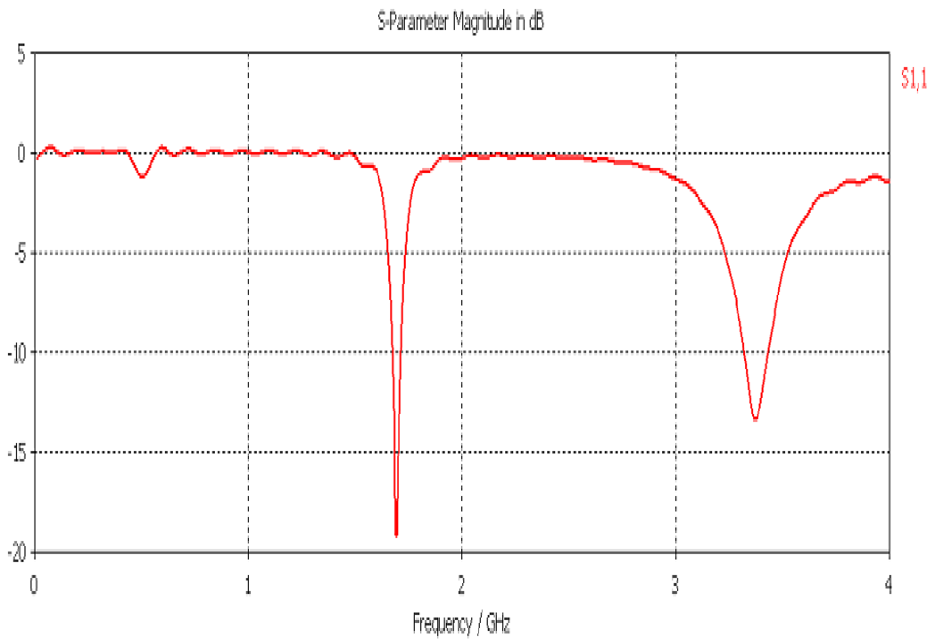

Figure 10. Return Loss Curve of MNG Metamaterial Shorted Circular Patch Antenna with Two Posts

Table 2. Circular Patch Radiator Without MNG

Antenna Type	Working frequency in GHz (Simulated values from CST Microwave studio)
Circular Patch	TM_{11} 2.9
Circular Patch with One post	TM_{01} 0.76 TM_{11} 3.03
Circular Patch with Two post	1.92 3.02

Table 3. MNG Metamaterial Loaded with Shorted Circular Patch

Antenna Type	Working frequency in GHz(Simulated values from CST Microwave studio)
Circular Patch	TM_{11} 2.97
Circular Patch with One post	TM_{01} 1.08 TM_{11} 3.036
Circular Patch with Two post	1.69 3.37

4. Conclusion

This paper offered correct and very simple model of a MNG metamaterial loaded with shorted circular microstrip patch antenna with random number of post which can employed. For these random numbers of post we achieved frequency tuning with addition of dual band operation for a circular patch antenna. Similar investigation can be done with other configuration, like inner core can be made of ENG metamaterial or DNG metamaterial and outer core is made of DPS.

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