METAMATERIAL LOADED DUAL BAND MICROSTRIP PATCH ANTENNA

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ABSTRACT: In this paper, design of metamaterial loaded dual band microstrip patch antenna is presented. Square shaped Split ring resonator (SSRR) is used to obtain µ-negative (MNG) metamaterial. The unloaded microstrip patch antenna has dual band, it resonant at 4.2 GHz and 7 GHz frequency. After introducing the seven SSRR on radiating side of patch antenna, the antenna now resonant at 3.8 GHz and 6.3 GHz. Thus reduction in size of patch antenna is obtained with the loading of SSRR.

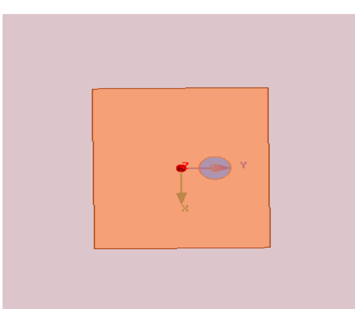
1. INTRODUCTION

With the growth of wireless industries, there is always a requirement of an antenna that can cover more than one frequency band, so reduces the requirement of more than one antenna. Dual band antenna is an antenna that works in two frequency band and because of this property dual band antenna plays a significant role in wireless industries. Veselago [1] in 1968 depicted the existences of a substance (Metamaterial) with extraordinary properties like simultaneously negative value of permittivity and permeability, negative refractive index, backward propagation, reverse Doppler effect and reverse Vavilov – Cerenkov effect. Metamaterials gain its properties from the structure rather than its material. Negative value of permittivity is obtained from metal rod and Split ring resonator is used to obtain the negative value of permeability [2, 3, 4]. Metamaterials are also referred as double negative (DNG) materials when permittivity and permeability both are negative, ENG (epsilon negative) materials when permittivity is negative and permeability is positive; MNG (mu negative) materials when permeability is negative and permittivity is positive. ENG and MNG materials are also termed as single negative (SNG) materials, because one of permittivity or permeability is negative, left handed materials (LHMs), negative refractive index materials (NRIMs). Various types of ring type structures have been proposed till now like circular, square, triangular, U- shaped, S- shaped, Ω- shaped. Out of these square, circle, spiral structures are most famous because of easiness of implementation. Metamaterials can be used as a unit cell or as an array of cells. These properties of metamaterial made it very popular among the antenna research community [5,6, 8-10]. Metamaterials can be used to enhance the performance of antenna like gain, directivity, bandwidth, also reduces the size of antenna.

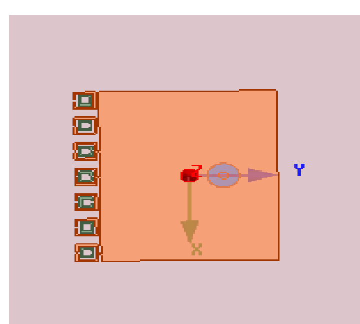
In this paper, metamaterial loaded dual band microstrip patch antenna is designed. Square shaped Split ring resonator (SSRR) is used to obtain µ-negative (MNG) metamaterial. Microstrip patch antenna is loaded with seven SSRR on the radiating side of patch. Reduction in the size of the patch antenna is obtained as we load the patch antenna with SSRR. Ansoft HFSS (Finite Element Method) is used as simulation tool.

2. ANTENNA DESIGN

Figure 1(a) shows the structure of unloaded rectangular microstrip patch antenna. The patch antenna is fed with coaxial excitation.FR4 of dielectric permittivity $\varepsilon_r = 4.4$ is used as substrate.



(a)



(b)

Figure 1: Structure of (a) Unloaded , (b) SSRR Loaded Rectangular Microstrip Patch Antenna

To determine the dimensions of rectangular microstrip patch antenna, the following equations are used:

Width of patch antenna: $W = \frac{c}{2f_r\sqrt{\frac{\varepsilon_r+1}{2}}}$ (1)

Where f_r is the desired resonant frequency.

Effective dielectric constant: $\varepsilon_{reff}=\frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1+\frac{12*h}{W}\right)$ (2)

The length of the patch :L = $L_{eff} - 2 * \Delta L$ (3)

where effective length L_{eff} is given by : $L_{eff} = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}}$ (4)

whereΔL is the field overflow.

The Table 1 shows the various dimensions of the proposed rectangular microstrip patch antenna.

Parameters	Dimension(cm)
Length of the patch (L)	1.98
Width of the patch (W)	1.59
Length of the ground and substrate	3.9
Width of the ground and substrate	3.3
Thickness of substrate	0.1575

Now, the microstrip patch antenna is loaded with seven Square shaped Split Ring Resonator (SSRR) on radiating edge of the patch. Figure 1(b) shows the structure of SSRR loaded rectangular microstrip patch antenna. The dimensions of SSRR are : L_{outers} = 2 mm, width of each ring = 0.2 mm, separation between outer and inner ring = 0.2 mm, width of split in each ring =0.2 mm.

3. ANALYSIS AND DISCUSSION

Figure 2 shows the return loss of microstrip patch antenna. The microstrip patch antenna resonant at 4.2 GHz with return loss S_{11} = -12 dB and at 7 GHz with return loss S_{11} = -13.5 dB . The antenna has -10dB bandwidth of 111 MHz with gain of 4.6 dB at 4.2 GHz (figure 3a) and -10dB bandwidth of 271 MHz with gain of 5.7 dB at 7 GHz (figure 3b) respectively.

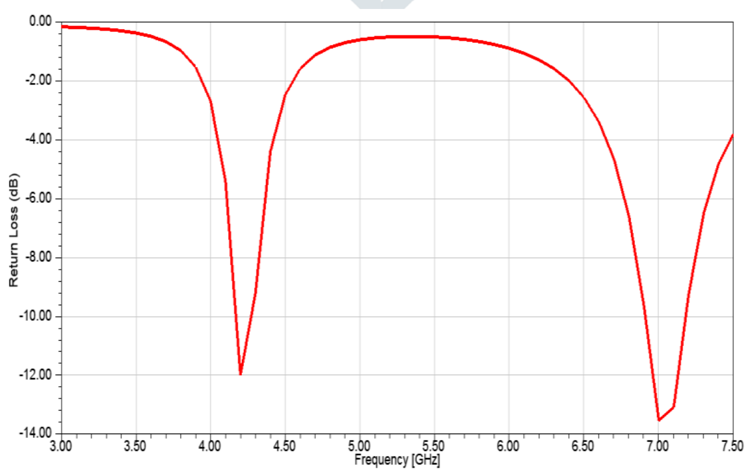
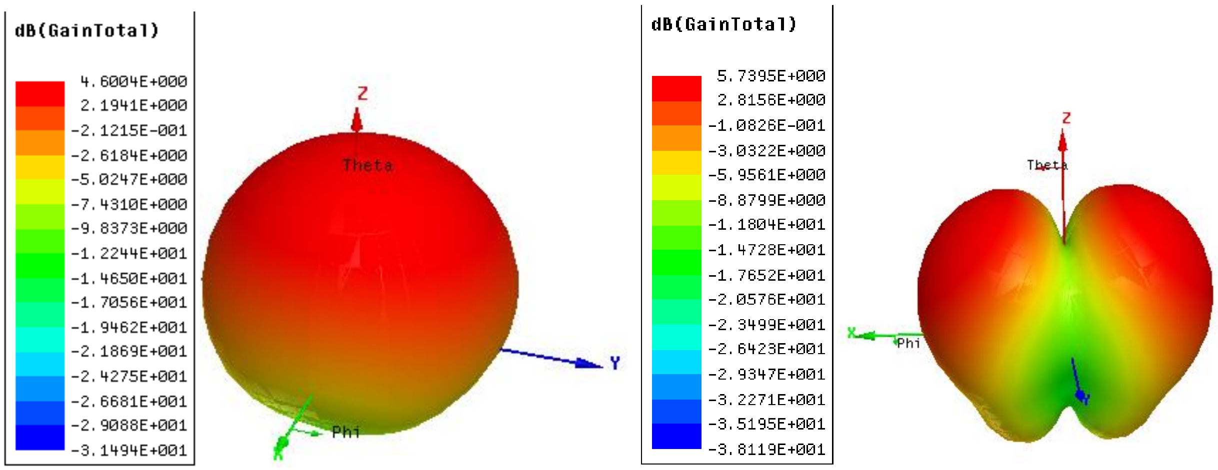


Figure 2: Return Loss of Unloaded Microstrip Patch Antenna



(a) (b)

Figure3 : Gain of Unloaded Microstrip Patch Antenna (a) at 4.2 GHz, (b) at 7 GHz

Figure 4 shows the return loss of SSRR loaded microstrip patch antenna. The microstrip patch antenna resonant at 3.8 GHz with return loss S_{11} = -18.3 dB and at 6.3 GHz with return loss S_{11} = -14.5 dB. The antenna has -10dB bandwidth of 172 MHz with gain of 4.16 dB at 3.8 GHz (figure 5a) and -10dB bandwidth of 111 MHz with gain of 4.18 dB at 6.3 GHz (figure 5b) respectively.

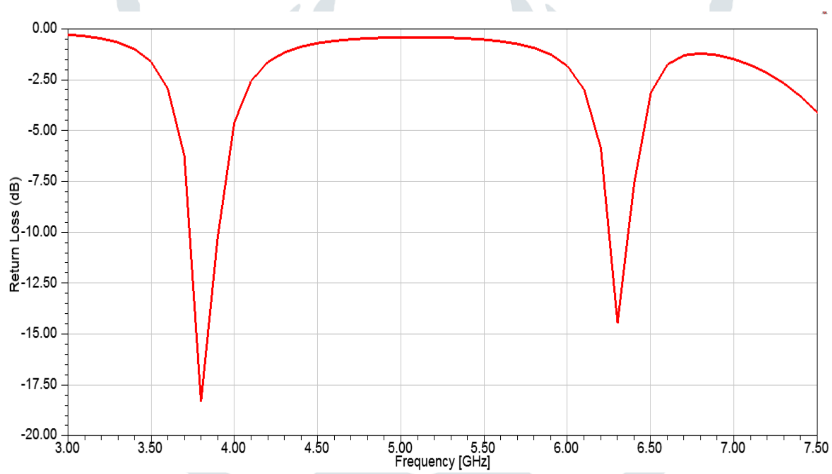
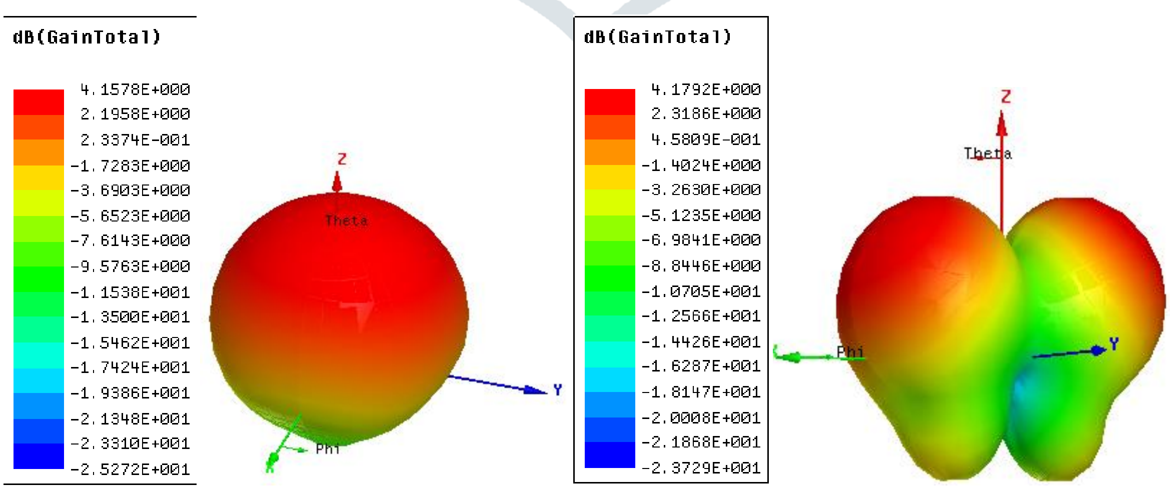


Figure 4: Return Loss of SSRR Loaded Microstrip Patch Antenna



(a) (b)

Figure 5: Gain of Unloaded Microstrip Patch Antenna (a) at 3.8 GHz, (b) at 6.3 GHz

4. CONCLUSION

A design of metamaterial loaded dual band microstrip patch antenna is presented. μ-negative (MNG) metamaterial is obtained by using Square shaped Split ring resonator (SSRR). First unloaded microstrip patch antenna has been designed and analyzed. The antenna shows dual band, it resonant at 4.2 GHz and 7 GHz frequency. Then the patch antenna is loaded with seven SSRR on radiating side of patch antenna, now the resonant frequencies of antenna becomes 3.8 GHz and 6.3 GHz. The same antenna resonant at lower frequency, thus reduction in the size of patch antenna is obtained with the loading of SSRR.

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