Effect of Metamaterial on a Triangle Shaped Multi-Band Patch Antenna

[1]Ch.Manohar Kumar, [2]NVSS Kumar Muvvala
[1]Research Scholar, [2]Research Supervisor,
[1,2]School of Engineering & Technology,
[1,2]Career point University, KOTA, Rajasthan, India.

Abstract: This Paper, addresses the advantages of adding the metamaterial to the microstrip patch antenna. This is a Multiband antenna which was designed with triangular configuration and operable on several bands. These antennas are designed such that they can be modified according to a required operating frequency. Our Central aim is to introduce frequency shift such that it includes the operating frequencies of C band along with higher frequencies. The concept of metamaterials has been extensively used that involves in manipulating its physical structure which can result in either positive or negative change. The predicted achievable -10 dB return loss bandwidth of the antenna is confirmed by analytical modeling and simulation with the help of HFSS simulator.

Index Terms: microstrippatch antenna, Multiband configuration,Metamaterial,Frequency Shift.

I. Introduction:

Microstrip patch antennas became a fundamental constituent in the communication systems. The size of wireless devices is reducing exponentially which demands more compact and high antenna performance devices. Antennas are being accustomed for their lightweight, compact in size, low cost, low profile, and planar alignment. Currently, these antennas are desirable to meet remarkable properties like multifrequency/multiband and broadband operation with necessary improvements. An antenna designed should capable of operating at multiband so that it can be used for applications from different manifolds at the same time. Thispaper throws light on the design of a slotted single patch antenna operable at multiband.

Conventional antennas designed in a wireless communication system are restricted to operate in any one specific frequency band. However most of the modern devices are operable in Multiband frequencies, hence a need arises to design a multiband or wideband antenna. The Multiband antenna can be formulated by using Antenna Arrays, Cutting Slots or by using Varactor diodes. However, there is no unique method available in the literature to achieve specific application- multi-band antenna [3]. As the geometry of the multi-band antenna gets rigorous, there are no specific mathematical equations to analyze the radiation characteristics. As a result, the design of a multi-band antenna depends on the utilization and specific applications as per the requirement.

The designed multiband antenna achieved proficient characteristics at Wi-Fi band (5.8GHz), ISM Band (6.5 GHz), Satellite Communications (26-40GHz). In this paper a compact multi-band design of microstrip patch antenna is proposed, the bandwidth has been improved by adding slots. The paper divided asfollows: Significance of Metamaterial, Antenna design [(a) Metamaterial view and (b) Patch view], Simulation results of the antenna and Conclusion.

II. Significance of Metamaterial:

Metamaterials (Meta conveys “beyond” in Greek) are new artificial materials with unusual electromagnetic properties not found in naturally occurring materials. These are generally composite materials exhibiting electromagnetic properties that not only depend on their material composition, but also on the inclusion of macroscopic structures specially designed to obtain a specific response. Each and Every “natural” material such as glass, diamond and such has positive electrical permittivity, magnetic permeability and an index of refraction. In these new artificially fabricated materials—termed as negative index materials (NIM) or double negative (DNG) media or left-handed (LH) materials or backward wave (BW) media—all these material parameters are negative.

Many applications require antenna design such that it is operable at low-frequencies. To introduce a frequency shift, metamaterials have been appended to the designed patch antenna. Thepair electrical permittivity ε (response to an electric field) and the magnetic permeability μ (response to a magnetic field) are the main determinants of a material’s response to electromagnetic (EM) waves and to the metamaterials; the two of these material parameters are negative. Introducing metamaterials aids in suppression of surface wave which results in the gain enhancement and also reduction of side lobes which evolves in better radiation pattern and also introduced an improvement in bandwidth.

Apart from frequency shift, metamaterial also enhances the antenna's effectiveness by reduction of electrical size and coupling effects, shaping of aperture field-Directivity and gain enhancement, scanning of main beam direction.

Antenna Design:

a) Metamaterial view:

Metamaterials with negative ε and μ was introduced to the designed antenna for obtaining the desired frequency shift. Split Ring Resonators (SRRs) have different structures but the most common two types are circular and square with single rings, double rings, and multiple rings SRR cells. The metamaterial introduced is with the dimensions are M1=M2=2.6mm, M3=0.7mm, M4=0.5mm, M5=0.3mm, M6=0.2mm.

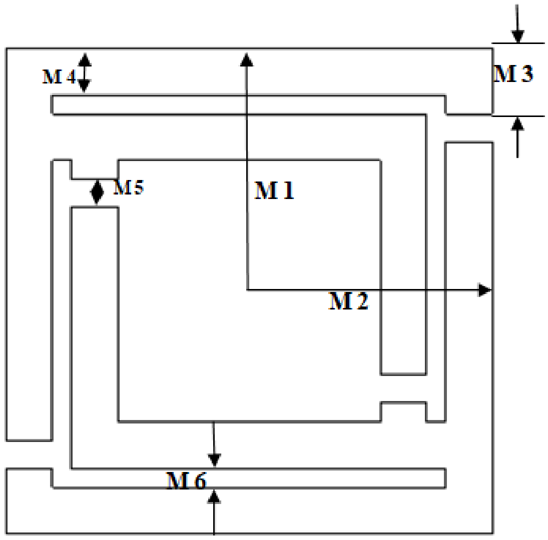

Fig1:Proposed Metamaterial

b)Patch View:

To obtain the desired characteristics, the FR4 epoxy substrate of dimensions 25x34x1.6 mm
With dielectric constant (ε) of 4.4 and loss tangent (δ) of 0.02 has been opted. To give structural benefits to the antenna, a triangular shape has been adopted. To instill the benefits to the design U shaped slots have been developed on either sides of the triangle. The slots are separated by an input line feed passing such that it coincides with the centroid of triangle maintain equal distance from either slot to the feed line. To further enhance the design, slots shaped as circular split ring resonators have been made at the center of triangle. The Multi-band antenna with the measurementsL1=28mm, L2=L3=14.2mm, L4=L5=4mm, L6=2.1mm, L7=2.35mm, L8=0.25mm, L9=1.25mm, L10=2mm, L11=0.25mm, L12=0.85mm and G1=4.05mm, G2=3.55mm, G3=1.55mm, G4=0.5mm, G5=0.25mm.

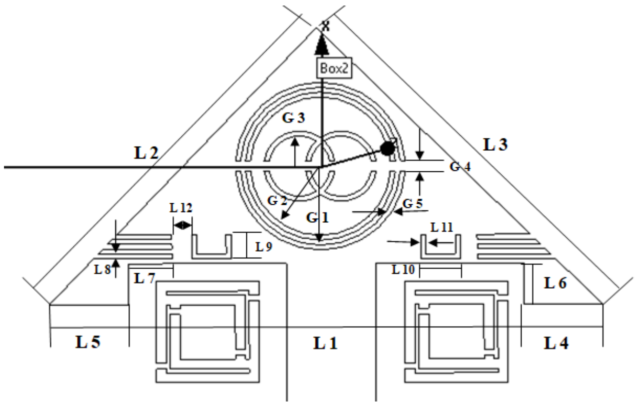

Fig2: Proposed Metamaterial Inspired Antenna

Design trails of Multi-band antenna:

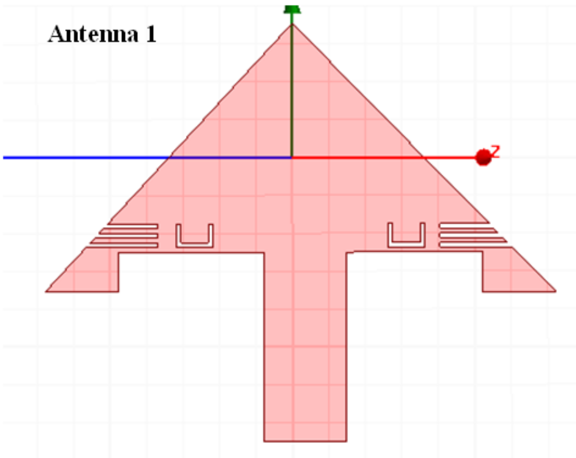

Fig3: Antenna 1

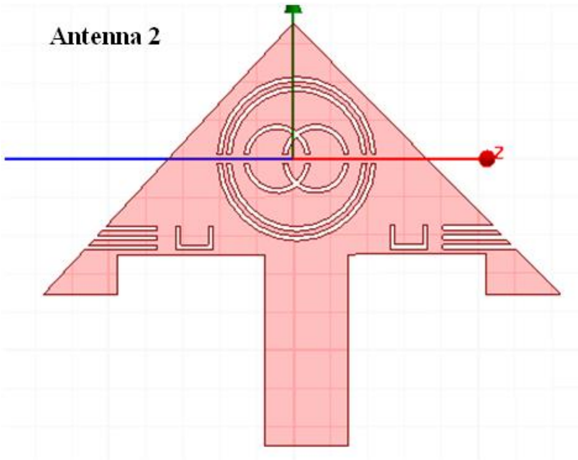

Fig4:Antenna2

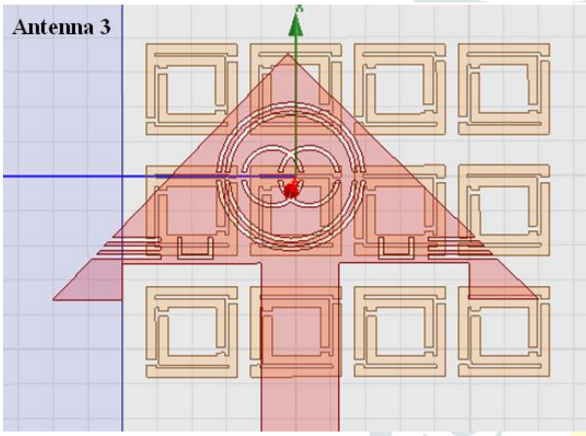

Fig5: Antenna

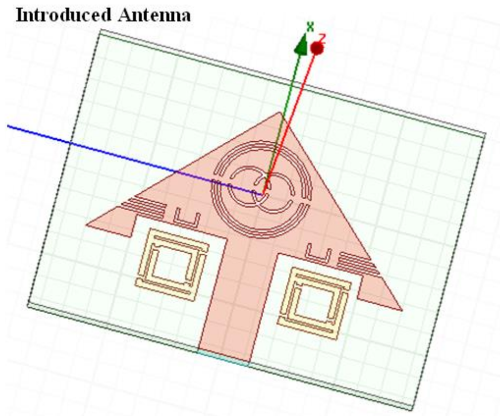

Fig6: proposed Metamaterial Antenna

IV.Results:

Introduced Antenna Results:

In this section, several parameters are going to be examined. A number of attempts had been conducted with the metamaterial array size and the position of metamaterial at the top and ground plane side of the antenna attains the finest accepted results. S-parameters relates the input-output relationship between ports. S_{11}illustrates how much power reflected back from the antenna. If S_{11}=-10 dB, this implies that if 3 dB of power is delivered to the antenna, -7 dB is reflected power. To observe the frequency shift, the below figures show the input reflection coefficient of different designs. Fig.4 (a) shows the response of the U-slots starts at 9.1GHz. After introducing two rings, there is a certain shift in the resonance frequency from 9.1GHz to 4.2GHz. Later then, introducing the array of metamaterials in the ground plane, it results in the negative change in S_{11} graph. Following that, 2x1 array of metamaterials is placed on the top of the substrate separated by line fed, it results in the required frequency shift for the desired applications. The proposed antenna has frequency bandwidth within the frequency range from 4GHz to

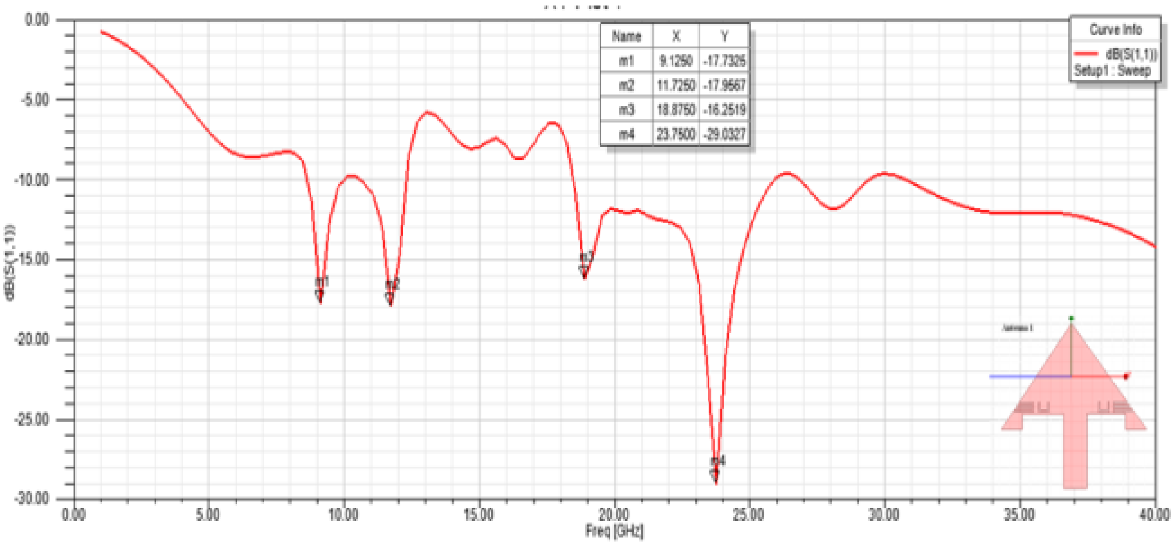

Fig.7 (a): S11 for the Antenna1

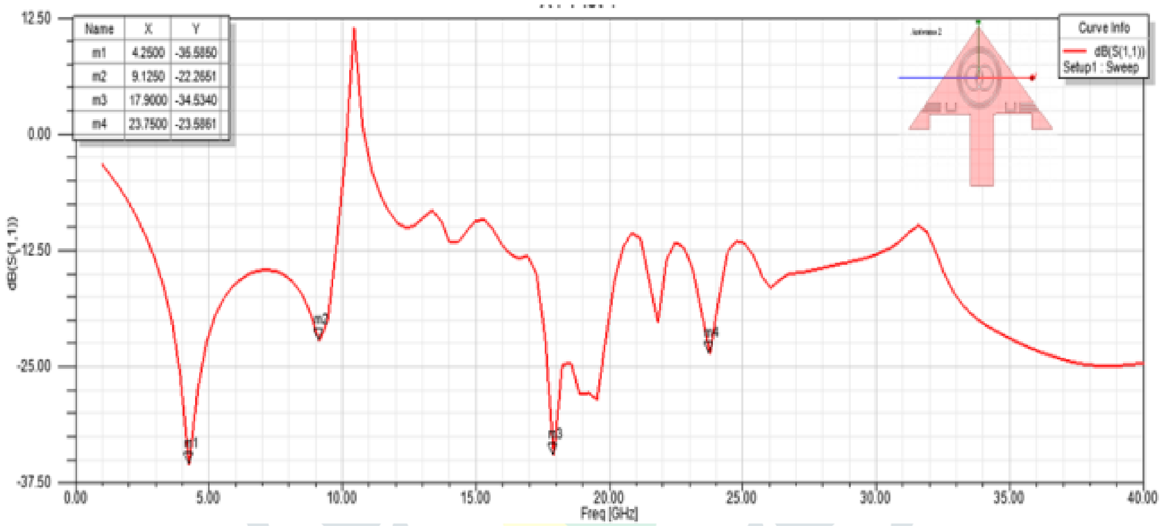

Fig.7 (b): S11 for the Antenna2

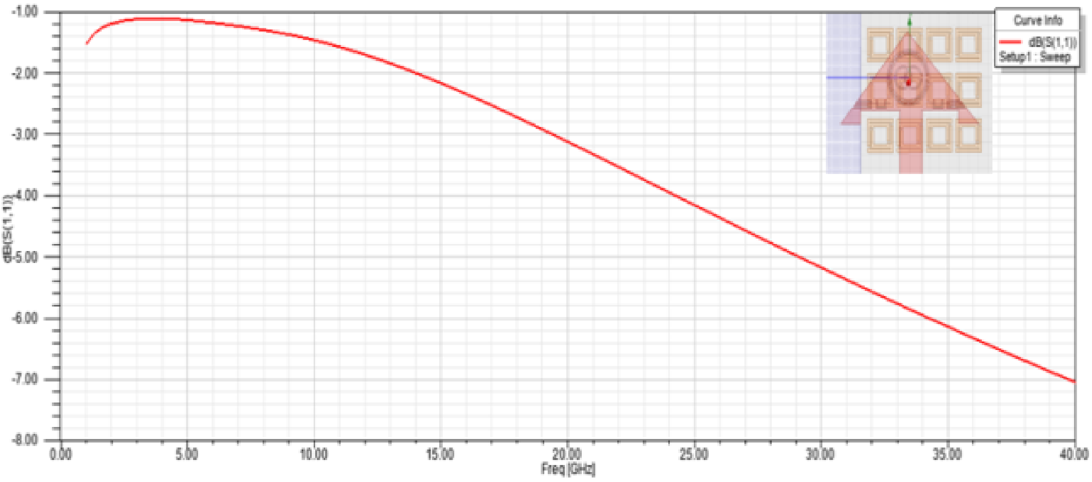

Fig.7 (c): S11 for the Antenna3

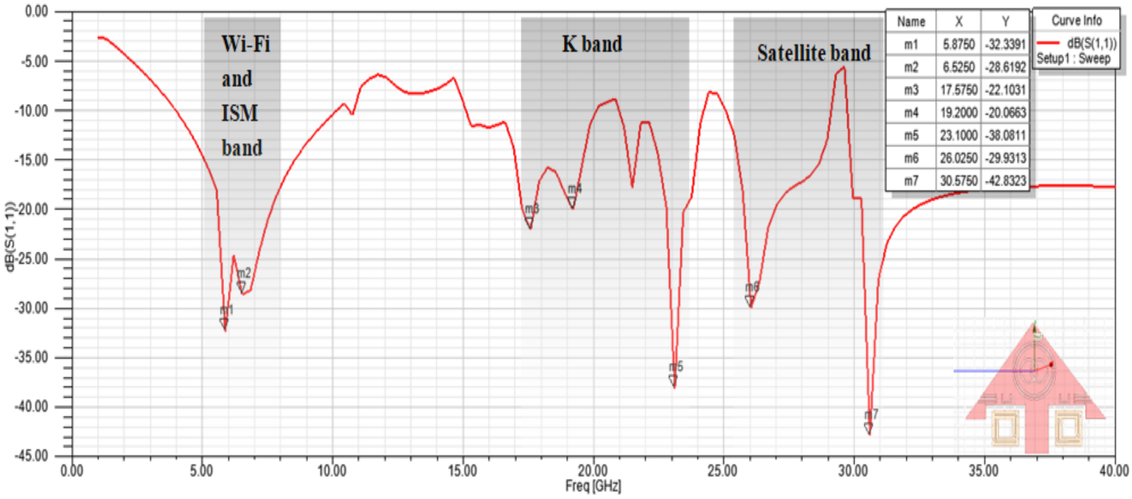

Fig.7 (d): S11 for the Introduced Antenna

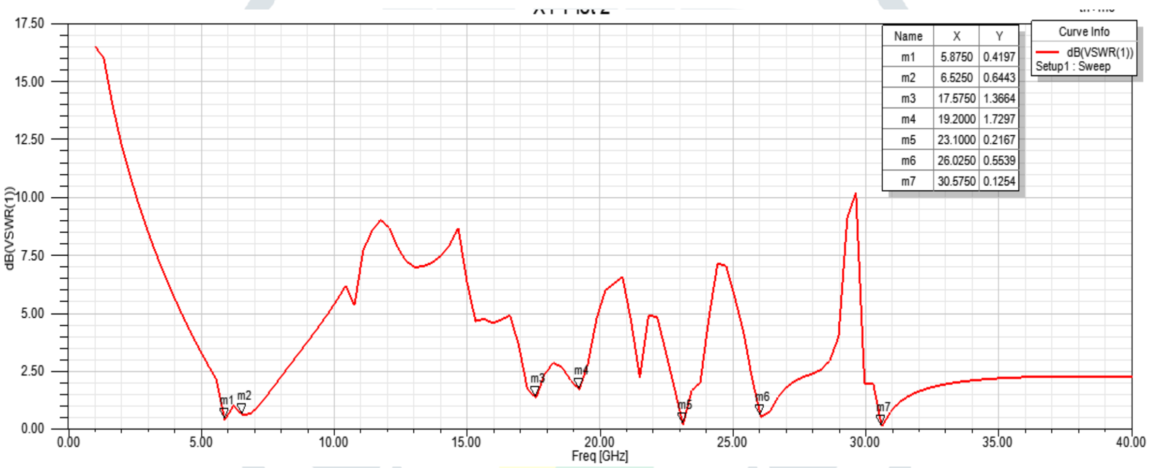

Fig.7(e)**: VSWR** of the Introduced antenna

The energy radiated by an antenna is known as radiation pattern, it is the distribution of radiated energy into space as the function of direction. The far-field radiation patterns of the multi-band antenna both E-plane and H-plane are represented in Fig.8. Both Omni-directional pattern and bi-directional pattern are obtained from H-plane and E-plane.

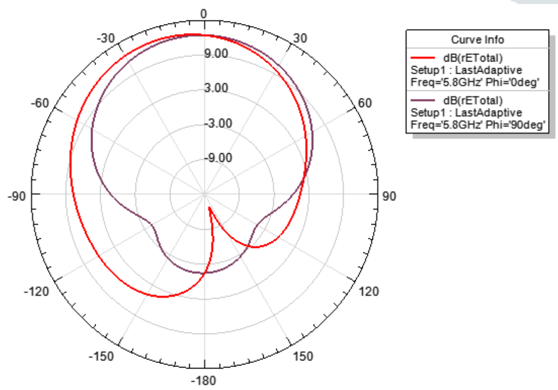

Fig.8 (a)

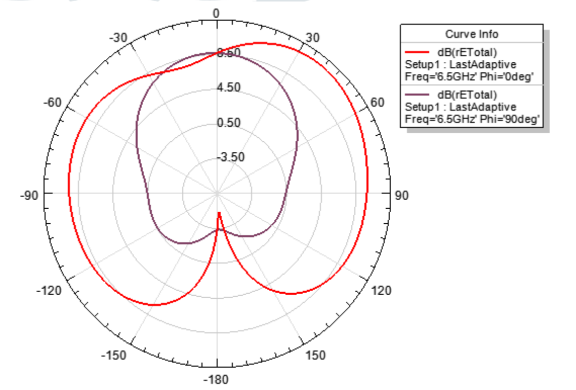

Fig.6=8 (b)

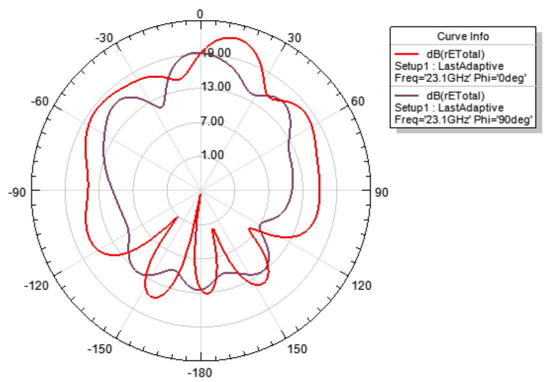

Fig.8 (c)

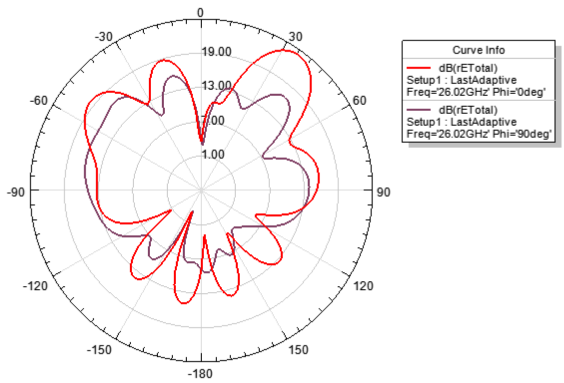

Fig.8 (d)

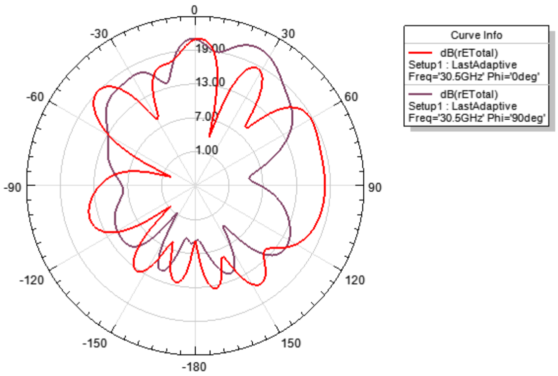

Fig.9 (e)

Far Field Radiation Patterns E-plane (Phi=0) and H-plane (Phi=90). Fig. 6(a) 5.87GHz, 6(b) 6.52GHz, 6(c) 23.10GHz, 6(d) 26.02GHz, 6(e) 30.57GHz.

The Below table illustrates the several parameters which are necessary for an antenna.

Freq(GHz)	**5.87**	**6.52**	**23.10**	**26.02**	**30.57**
Return Loss(S_{11})	-32.33	-28.61	-38.08	-29.93	-42.83
VSWR	0.4197	0.6443	0.2167	0.5539	0.1254
Max U(W/sr)	0.2112	0.2676	1.9392	39.301	2.0902
Peak Directivity	1.283	1.7479	3.1541	7.1327	8.1315

Table.No.I: Measured Proposed Antenna Parameters

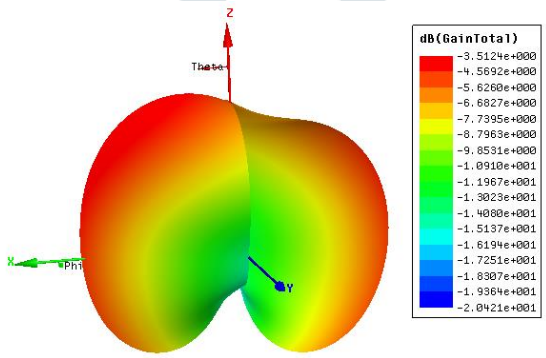

Fig.10 Gain total.

V. Conclusion:

In this paper, a newly reconstructed negative refractive index (NRI) metamaterial unit cell and array structure are presented, producing a wider bandwidth in the major portion of C and Ka-bands with double-negative (DNG) characteristics. Square Split Ring Resonator (SSRR) is used to analyze its effect on triangle shaped antenna with circular split rings. Different combinations were tested to inspect its impact on antenna bandwidth. Therefore, many designs of SSRRs can be worked with the antenna according to the application required frequencies.

VI. References:

[1]. Anzar Khan and Rajesh Nema "Analysis of Five Different Dielectric Substrates on Microstrip Patch Antenna".

[2]. Jithin VM "Analysis of Five Different Dielectric Substrates on Microstrip Patch Antenna".

[3]. G. Misra A. Agarwal and K.Agarwal "Design and Performance evaluation of microstrip antenna for Ultra-wideband applications Using Microstrip Feed".

[4]. Kwok Khan So and Xia GAO "Bandwidth Enhancement of a Monopolar Patch Antenna with V-shaped Slot for Car-to-Car and WLAN Communications ".

[5]. Arvind Kumar, P. V. Naidu, and Vinay Kumar "A Novel Rhombus Shaped ACS Fed Multi Band Antenna Loadedwith Meander Branches for Advanced CommunicationApplications".

[6]. Chow-Yen-Desmond Sim, Ming-Hsuan Chang, and Bo-Yu Chen "Microstrip-Fed Ring Slot Antenna Design With WidebandHarmonic Suppression".

[7]. Ahmad B. Numan and Mohammad S. Sharawi "Extraction of Material Parameters for Metamaterials Using a Full-Wave Simulator".

[8]. H. XIONG, J. S. HONG, M. T. TAN and B. LI, "Compact Microstrip Antenna With Metamaterial for Wideband Applications".

[9]. M.I. Hussein and ElhamSerria "Metamaterial Effect on UWB circular Microstrip Antenna".

[10]. Behnam Zarghooni, AbdolmehdiDadgarpour and Tayeb A. Denidni "Reconfigurable Metamaterial Dipole Antenna".

[11]. Monish Gupta .JyotiSaxena "Micostrip Filter Designing by SRR Metamaterial".

[12]. Jia-Sheng Hong and M.J. Lancestar "Microstrip Filters for RF/MW applications".

[13]. Md. Mehedi Hasan "A New Compact Double-NeagtiveMinoaturized Metamaterial for Wideband Operation".