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Size miniaturization and bandwidth amelioration in microstrip antenna with metamaterials

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***Abstract*— We suggest a noval miniaturized wideband microstrip patch antenna[6] with acceptable gain for potential wireless applications. The basic patch antenna is loaded with Split Ring Resonators (SRR's) on the substrate at its back above the ground plane. The proposed antenna shows bandwidth of 765.9 GHZ revealed by shifting the resonance from 3.4GHZ to 2.5GHZ. The antenna may find the application in WiFi,Bluetooth, zigbee and WLAN.Later on, simulation and optimization of the structures is carried out with a CST-Microwave studio ; a benchmarked E.M. simulator.**

***IndexTerms*—SRR,patch antenn,miniaturization**

I.INTRODUCTION

Microstrip antennas find tremendous application in the wireless communication domain such as in mobile communication, RFID, LAN, WAN, satellite communications, RADAR, medical field etc due to features like compactness, integrability and low cost but they offer modest bandwidth and gain which need to be improved. Narrow bandwidth and low gain are the two most serious disadvantage of the microstrip antennas[6]. The compactness further deteriorates these two parameters. This is because of the fact that there is a fundamental link between the size, bandwidth and efficiency of an antenna.

Small, lightweight and compact integral element are the main requirement of modern wireless communication systems. Antenna size miniaturization is needed in order to integrate antenna into a new communication system. There are many techniques employed for miniaturization of antenna size.Capacitive or/and inductive effect can be introduced by the Slot techniques [1].[4]. As the antenna size are made smaller, either the antenna efficiency or operating bandwidth must decrease. The size of antenna normally effect its gain , that is small antennas typically yield small gain than larger antennas.

One of the main design goals for most practical applications of patch antennas for wireless communication are the simultaneous increment in gain and bandwidth along with size reduction. To enhance the gain and bandwidth of patch antennas numerous techniques have been reported by the researchers. Electrically thin ground-plane which is having dielectric substrate, which leads to a high Q resonance behavior is responsible for the narrow impedance bandwidth of the basic microstrip element[3][4]. Bandwidth improves as the substrate thickness is enhanced, or the dielectric constant is decreased, but these ways are limited by an inductive impedance offset that increases with thickness. A resonable approach, therefore, is to exploit a thick substrate or replacing the substrate by air or thick foam [4] with a type of additional impedance matching to remove this inductance. Thick substrate introduces surface wave excitation. We can also load the suspended microstrip antenna with dielectric resonator to improve bandwidth.

Operating bandwidth of a single linearly polarized microstrip patch antenna is limited by its input vswr and is inversely proportional to the Q factor of the patch resonator.Over last decades,several attempts have been made for improving the bandwidth of microstrip patch. Various techniques used to increase bandwidth of microstrip patch antenna may be classified as follows :

- increasing the substrate height to decrease the Q factor of the patch by and lowering the dielectric constant
- use of multiple resonator located in one plane
- use of multilayer configuration with multiple resonators stacks vertically
- use of impedance matching networks .

This paper discusses the bandwidth enhancement and miniaturization technique by utilizing SRR.The design and simulation done in CST microwave studio.

II.SPLIT RING RESONATOR

Periodic material that derive its properties from its structures rather than its components.Metamaterials[7] are artificial materials designed to have properties that may not be availabe in nature. The Metamaterials are normally arranged in repeated patterns. Metamaterial structure composed of SRR and strip wires. Negative permeability can be achieved by using SRR and negative permittivity can be attained by using strip wire. SRR are common in the metamaterial

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design as they show negative permeability for frequencies close to their resonant frequency .

This structure consists of two concentric rings separated by a gap, both having splits at opposite sides. Magnetic resonance is produced by the splits at the rings and by the gap between inner and outer rings. SRR vary in their shape and structure such as square SRR and circular SRR[5].Rarer structures include multiple SRR , spiral SRR , triangular SRR and elliptical SRR. In this proposed work ,circular SRR is used.

III.ANTENNA DESIGN

A.Reference Antenna

A Rectangular Inset fed microstrip patch antenna is designed to resonate at 3.5 GHz.The antennas are designed on FR-4 substrate with relative permittivity of 4.4 and loss tangent of 0.02 and antennas have 50 Ω feed lines is made with inset fed. Patch dimensions L=20 mm and W =20 mm fed by a 50 ohm center fed microstrip line feed having dimensions Lf=5mm and Wf=4.1mm through a quarter wave transformer of dimension Lt = 10mm and Wt =0.80 mm. The length Lg=40mm and Wg=45mm of the ground plane of the antenna is calculated by Lg=6h+L and Wg=6h+ W, substrate length =40and width =45.This design is shown in fig.1

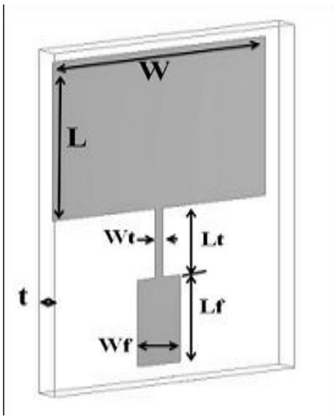

Fig.1. Patch antenna design

Circular shape SRR with inner circle inner radius, r_o=1.6,Outer circle's radius, r_{ext} =2.1, width C =0.2,ring gap d=0.3 and the split gap is 0.2 which is shown in fig.2.An 8×6 array of this circular SRR is placed at the back of substrate above the ground plane.

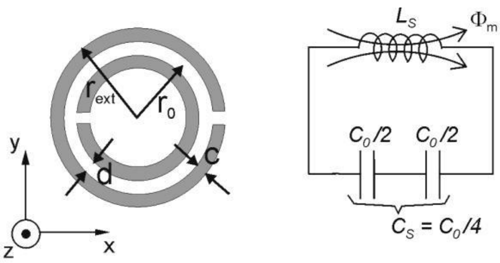

Fig.2 . circular SRR dimentions

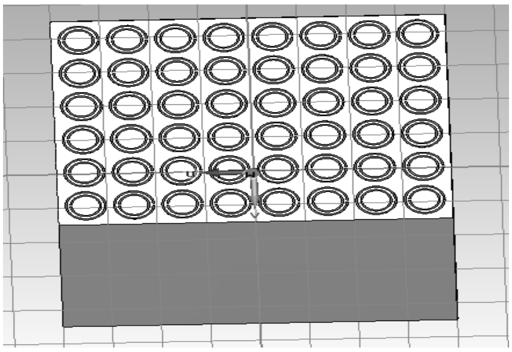

Fig.3 . Rectangular patch antenna with srr on substrate

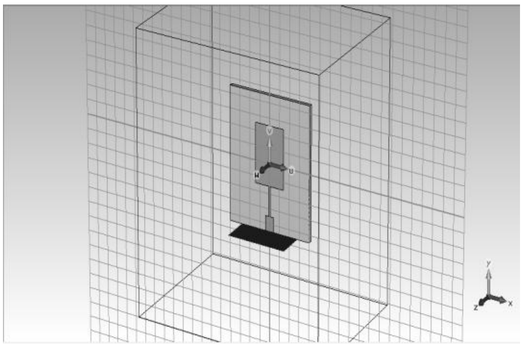

Fig.4 . Conventional Rectangular Patch antenna

IV.RESULTS AND DISCUSSIONS

Patch when loaded with an 8×6array of circular SRR on the substrate ,we can find that almost 765.9MHZ bandwidth improvement from 79.9MHZ and its return loss is at 2.5 GHZ.Thus miniaturization of antenna with bandwidth improvement is observed with acceptable gain.

With the ameliorated bandwidth from 2.2038 to 2.9697 many users can be incoorporated for applications such as WiFi,bluetooth etc.Compared to simple patch more number of channels are available for the specific applications and helps to improve the capacity.Miniturization is clearly visible as for heigher frequencies size of radiating element is small compared to lower frequencies.The patch designed for 3.428 Ghz can be used for 2.5 Ghz frequency by loading SRR to the substrate .

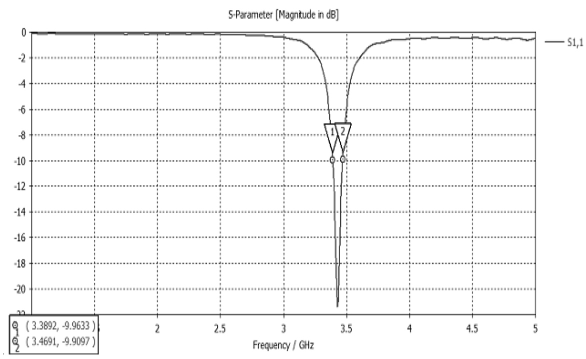

Fig.5. Return loss of simple patch resonating at 3.428ghz

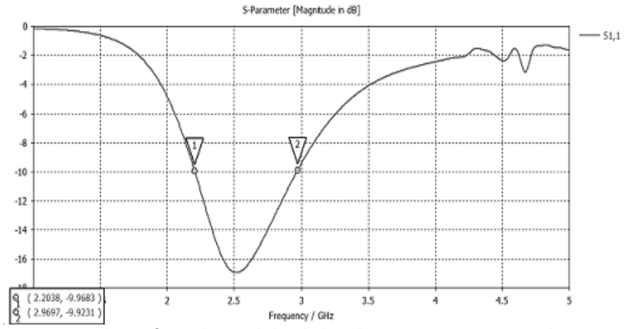

Fig.6 . Return loss of simple patch loaded with srr resonating at 2.5ghz enhanced bandwidth.

CONCLUSION

Here has been presented, periodic SRR structures implementation in antenna design for wireless application for improved bandwidth and miniaturized antenna.Simulation of the metamaterial antenna has been done in CST microave studio.

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