Design & Development of Metamaterial Based Microstrip Patch Antenna for Wireless Applications

G.Sujith[1] G.Nikhila[2] B.Sivanagaraju[3] CH.Dilip Narayana[4] Dr.S.V.Ramarao[5], Dr. R. Sunitha[6]
[5]*Assistant Professor, Department of ECE, NRIIT, Agiripalli, AP*
[6]*Professor & Head, Department of ECE, NRIIT, Agiripalli, AP*
[1,2,3,4] *UG student, Department of ECE, NRIIT, Agiripalli, AP*

Abstract: Metamaterials have received great attention due to their novel electromagnetic properties. It consists of artificial metallic structures with negative permittivity (ε) and permeability (μ). The average cell size of Metamaterial must be less than a quarter of wavelength, hence, size reduction for the Metamaterial antenna is possible. The objective of this project is to design metamaterial-based antennas for the portable wireless applications and is analyzed by using HFSS (High-Frequency Structure Simulator) software. In this project we have designed a Microstrip Double Patch Antenna, Microstrip Double Patch antenna with Metamaterial isolation and Metamaterial Patch Antenna with CSRR (Complementary Split Ring Resonator) on ground and observed their results of these antennas in the areas of the Gain, VSWR (Voltage Standing Wave Ratio) and Return loss. The results regarding Gain, VSWR and Return loss are simulated for the Double patch, Double patch with Metamaterial isolation and Metamaterial Patch antenna with CSRR ground at the operating frequencies at 5.2GHz, 4.8GHz and 4.2GHz.

Keyword: Frequency, Permeability, Permittivity Microstrip Patch, Metamaterial Patch, Return loss, VSWR.

I.INTRODUCTION

As the antennas are made smaller, either the operating bandwidth or antenna efficiency must decrease. The small antennas usually provide lower gain than larger antennas. Several works have been implemented in order to develop such antennas to overcome these limitations such as bandwidth can be increased to more than 70%by using multilayer aperture coupled micro- strip antennas, low power handling problem can be overcome through an array configuration and poor efficiency can be overcome by the use of photonic band gap structures. Patch antennas consist of a very thin ($t<<\lambda0$, where $\lambda0$ is the free space wavelength) Metallic strip (patch) placed a small fraction of a wavelength ($h<<\lambda0$, usually $0.003\lambda0 \leq h \leq 0.05\lambda0$) above a ground plane. The patch and the ground plane are separated by a dielectric sheet (referred to as the substrate). Figure 1.18 shows a printed patch antenna. In this configuration, the upper layer or patch is the source of radiation where the EM energy fringes off the edges of the patch and into the substrate. The lower conducting layer acts as a perfectly reflecting ground plane, bouncing energy back through the substrate into the free space. The patch can take any arbitrary shape, but it is usually taken as are angular shape (The radiating patch may be square, rectangular, thin strip(dipole), circular, elliptical, triangular, or any other configuration) for ease of analysis and understanding of the antenna characteristics.

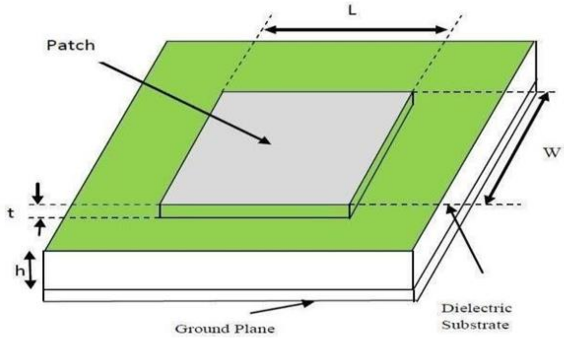


Fig. 1.1: Structure of Microstrip Antenna

Microstrip or patch antennas are becoming increasingly useful because they can be printed directly onto a circuit board. Microstrip antennas are becoming very widespread within the mobile phone market. Patch antennas are low cost, have a low profile and are easily fabricated. Consider the microstrip antenna shown in Figure 1.1, fed by a microstrip transmission line. The patch antenna, microstrip transmission line and ground plane are made of high conductivity metal (typically copper). The patch is of length L, width W, and sitting on top of a substrate (some dielectric circuit board) of thickness h with permittivity. The thickness of the ground plane or of the microstrip is not critically important. Typically, the height h is much smaller than the wavelength of operation, but should not be much smaller than 0.025 of a wavelength (1/40th of a wavelength) or the antenna efficiency will be degraded.

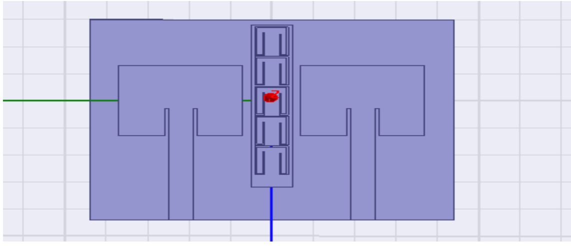


Fig. 1.2 Design of Microstrip Double patch antenna with Metamaterial isolation

II.LITERATURE SURVEY

This paper presents a compact split ring resonator metamaterial-embedded rectangular microstrip patch antenna. The inset-fed rectangular microstrip patch antenna (RMPA) resonates at 5.29 GHz frequency with return loss −12.108 dB is designed with applications in wireless communication. After then, RMPA is embedded with metamaterial split ring resonator. This metamaterial structure gives reduced resonant frequency and improved bandwidth along with good impedance matching. This technique also provides 27% reduction in size of RMPA. The proposed antenna is simulated using HFSS software, the prototype antenna has been fabricated and results are measured [1].

The microstrip antenna required for wideband correspondence ought to be lightweight, ease in fabrication and smaller in size. The present situation plan is to create a simple geometrical shaped structure of the microstrip antenna, which would give decent broadband. The paper presents the design analysis of rectangular and square shaped microstrip antenna. Both the antennas used microstrip line for feeding purpose. The square-shaped microstrip antenna is offering wider bandwidth as compared to rectangular microstrip and sufficient return loss. The compact antenna is meant for its operation in X band of frequency. The proposed microstrip antenna is showing a wide bandwidth of 500 MHz with a high return loss of-24 dB. This high bandwidth provides its usefulness in many wideband utilities in X-band[2].

Advances in communication systems involve the promotion of low cost, low weight, light weight and low-profile antennas has been improved over last few years. It has capable of maintaining higher performance over a large range of frequency spectrum. This technological trend has focused a great deal of effort on growing of micro strip patch antennas due to its unalienable characteristics. It meets the requirement of modern communication devices. In this work, the inset feed technique was used to present the design and simulation of a compact rectangular slot patch antenna for double frequency operation at 5.27 GHz. The simulation of the built antenna was performed using the 2019 studio suite of computer simulation technology (CST) and MATLAB which will be used to measure the parameters. The substrate used for the proposed antenna is the four flame-resistant (FR-4) with a dielectric constant of 4.3 and a loss tangent of 0.023. The antenna proposed could find applications in Wireless Local Area (Wi-Fi) and Bluetooth technology [3].

III.IMPLEMENTATION AND WORKING

Here a conducting strip is connected directly to the edge of the Micro strip patch. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element. This is achieved by properly controlling the inset position. Hence this is an easy feeding scheme, since it provides ease of fabrication and simplicity in modeling as well as impedance matching.

i)Dimensions

Regions	Length in mm	Breadth in mm	Thickness in mm
Substrate	44	55	1.6
Patch	13	15	1.6
Feed	18	3	1.6

TABLE 3.1 Dimensions of Double Patch Antenna

IV. SIMULATION RESULTS USING HFSS

The study was employed in simulation and experimental methods consisting of designing, manufacturing, and measurement. The design of the antenna was carried out by utilizing the HFSS 13.0 software. This chapter contains simulations of Metamaterial unit cell antenna.

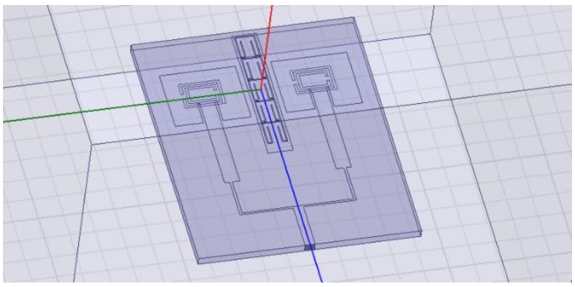


Fig 4.1 HFSS design of patch antenna with CSRR on the ground

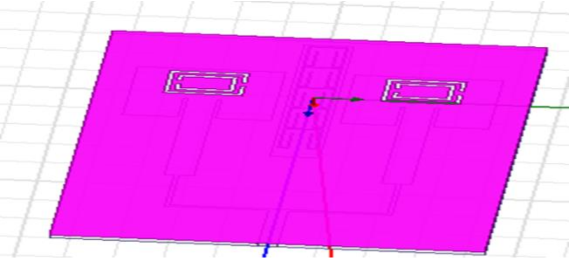


Fig 4.2 HFSS 3D View of Patch Antenna with CSRR on the ground

In this type of feed technique, a conducting strip is connected directly to the edge of the Micro strip patch. The conducting strip is smaller in width as compared to the patch and this kind of feed arrangement has the advantage that the feed can be etched on the same substrate to provide a planar structure. The purpose of the inset cut in the patch is to match the impedance of the feed line to the patch without the need for any additional matching element. This is achieved by properly controlling the inset position. Hence this is an easy feeding scheme, since it provides ease of fabrication and simplicity in modeling as well as impedance matching.

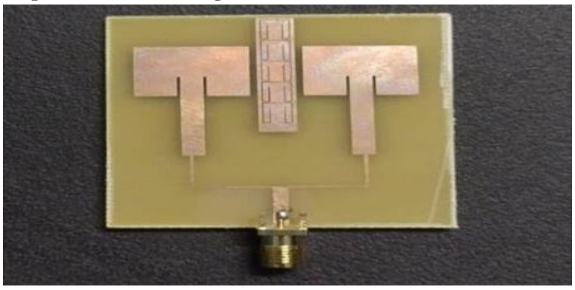


Fig 4.3 Fabricated patch antenna with CSRR on the ground

a) GAIN

Gain is nothing but the power transmitted per unit solid angle. The Gain of the antenna must be greater than 3dB. That means the antenna is radiating and it is working. The designed antenna gain is above 3dB. The obtained Gain is 5.3456 dB.

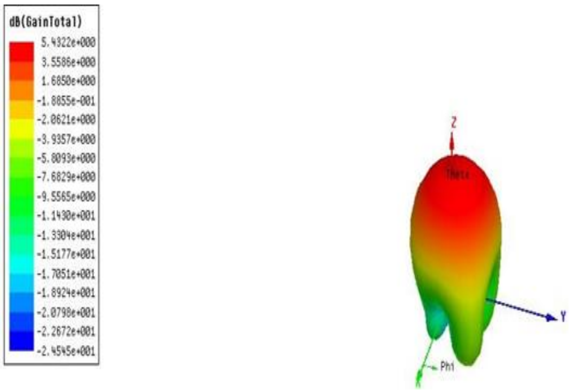


Fig 4.4 Gain of Patch Antenna with CSRR on the ground

VSWR

The minimum VSWR which corresponds to a perfect match is unity. The VSWR of the antenna is 1.5 at 4.8GHZ. The simulated result of the VSWR measurement of the antenna is shown. The value lies between 1 and 2

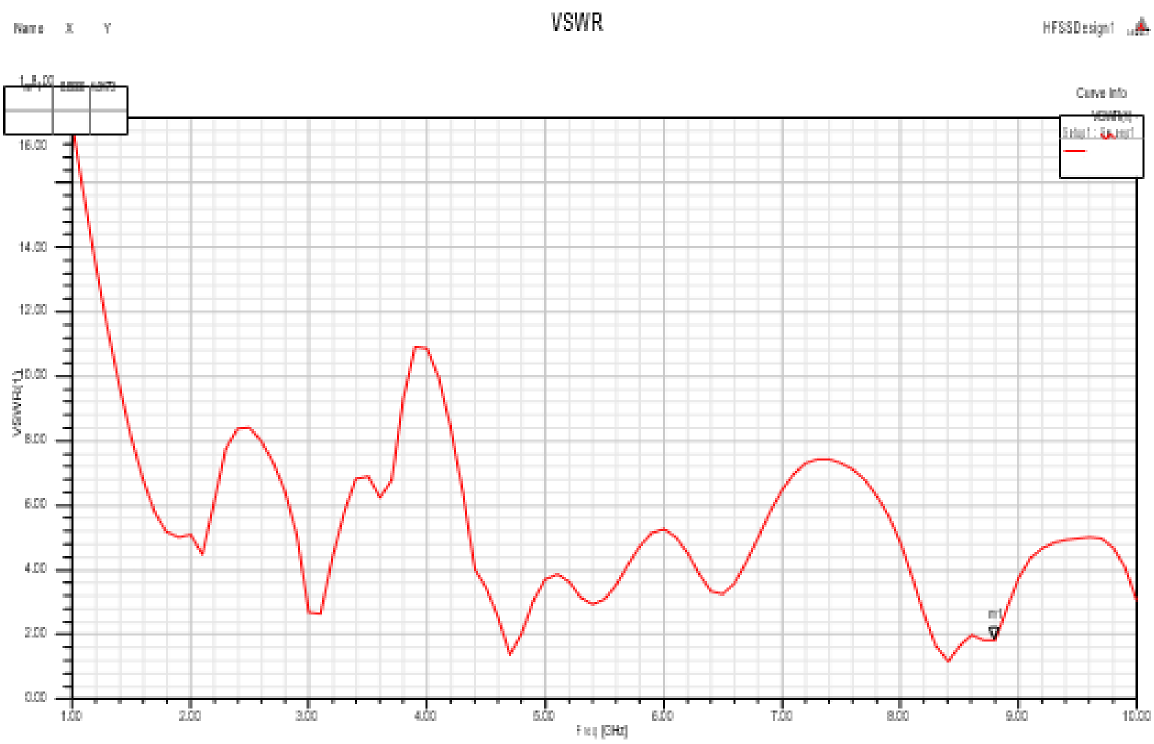
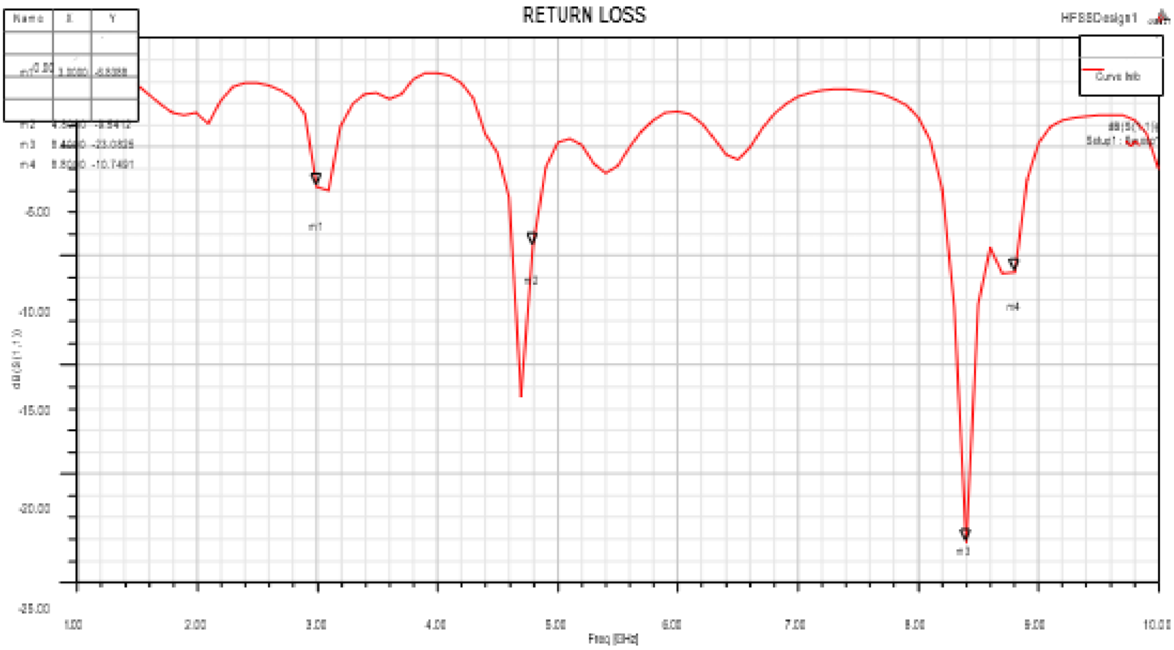


Fig 4.5 The VSWR of Patch Antenna with CSRR on the ground

b)RETURN LOSS

It is expressed in dB. As described above the antenna is designed for the frequency 4.8GHZ. The antenna is showing a return loss of less than -10dB. The antenna showed a return loss of -23.0825 dB at 4.8GHZ. The antenna is showing a return loss of less than -10dB at the operating frequency

Fig 4.6 The Return loss of Patch antenna with CSRR on the ground



Fabrication Results using Network Analyzer

i. VSWR

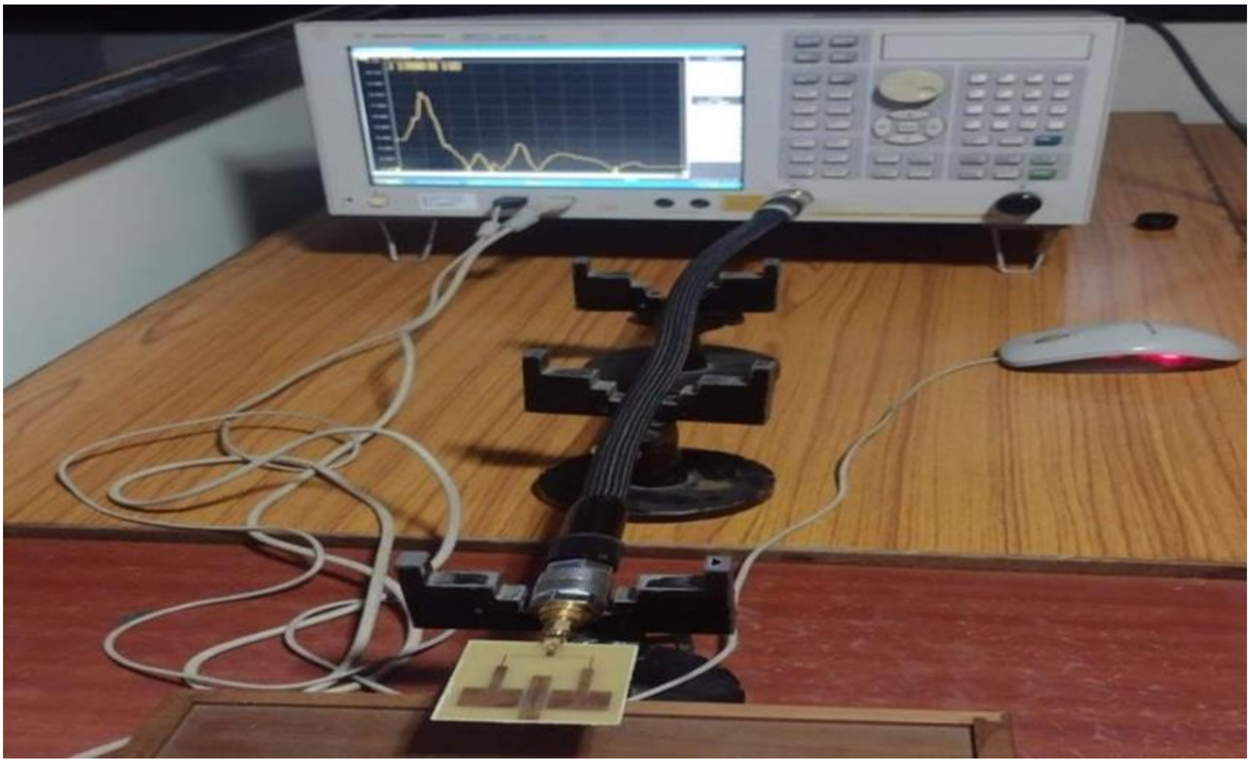


Figure 4.7 The VSWR of Patch Antenna with CSRR on the ground when tested the results in network analyzer

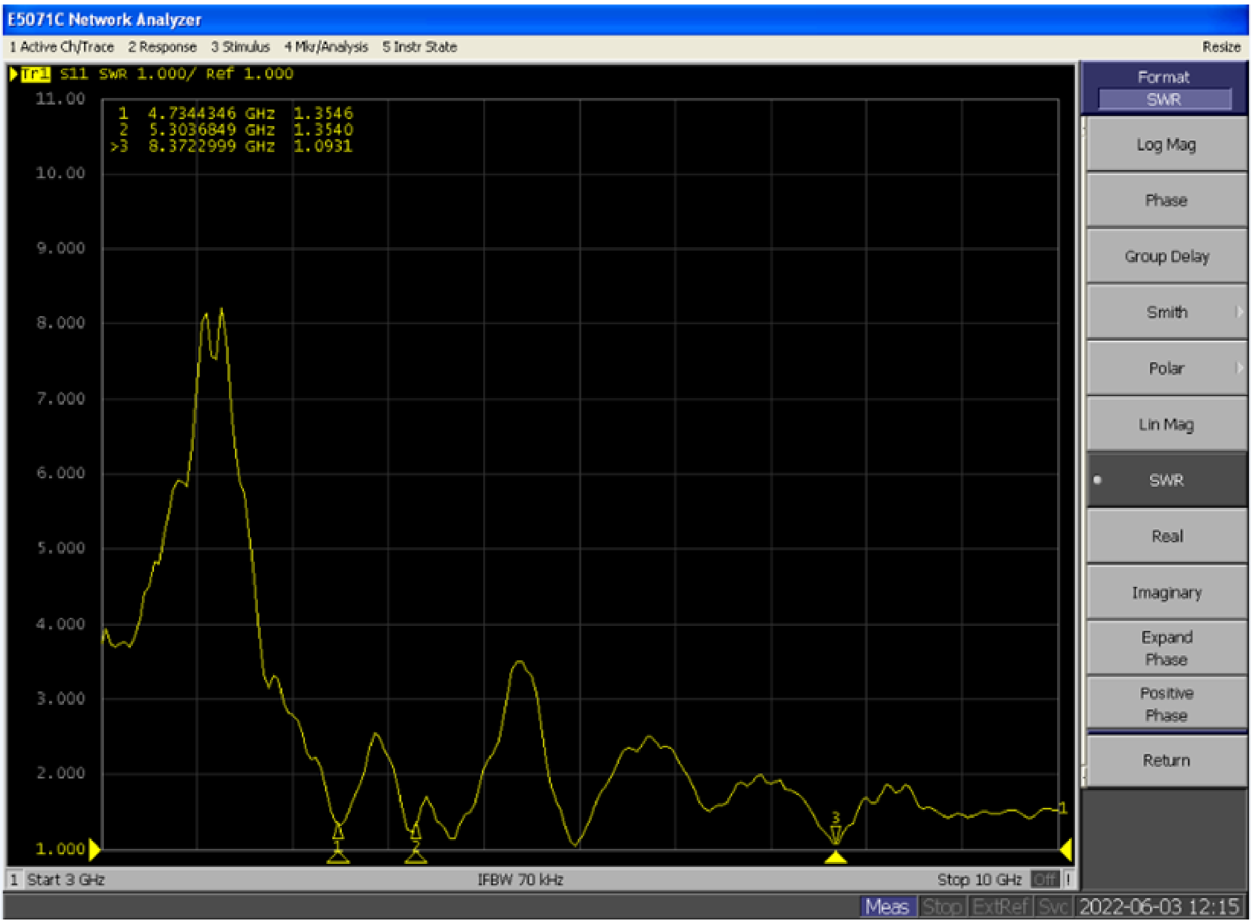


Figure 4.8 The VSWR of patch antenna with CSRR on the ground result in network analyzer

Return Loss

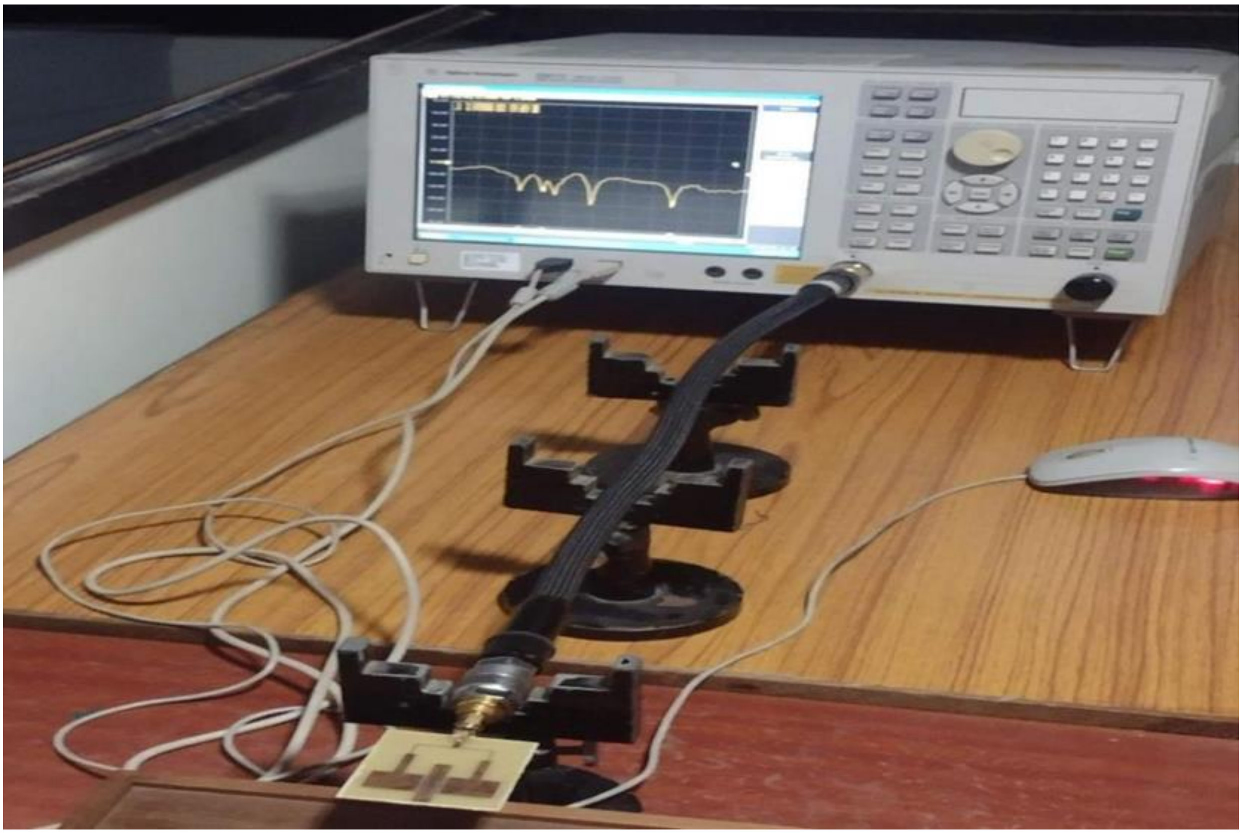


Figure 4.9 The return loss of Patch Antenna with CSRR on the ground when testes the results in network analyzer

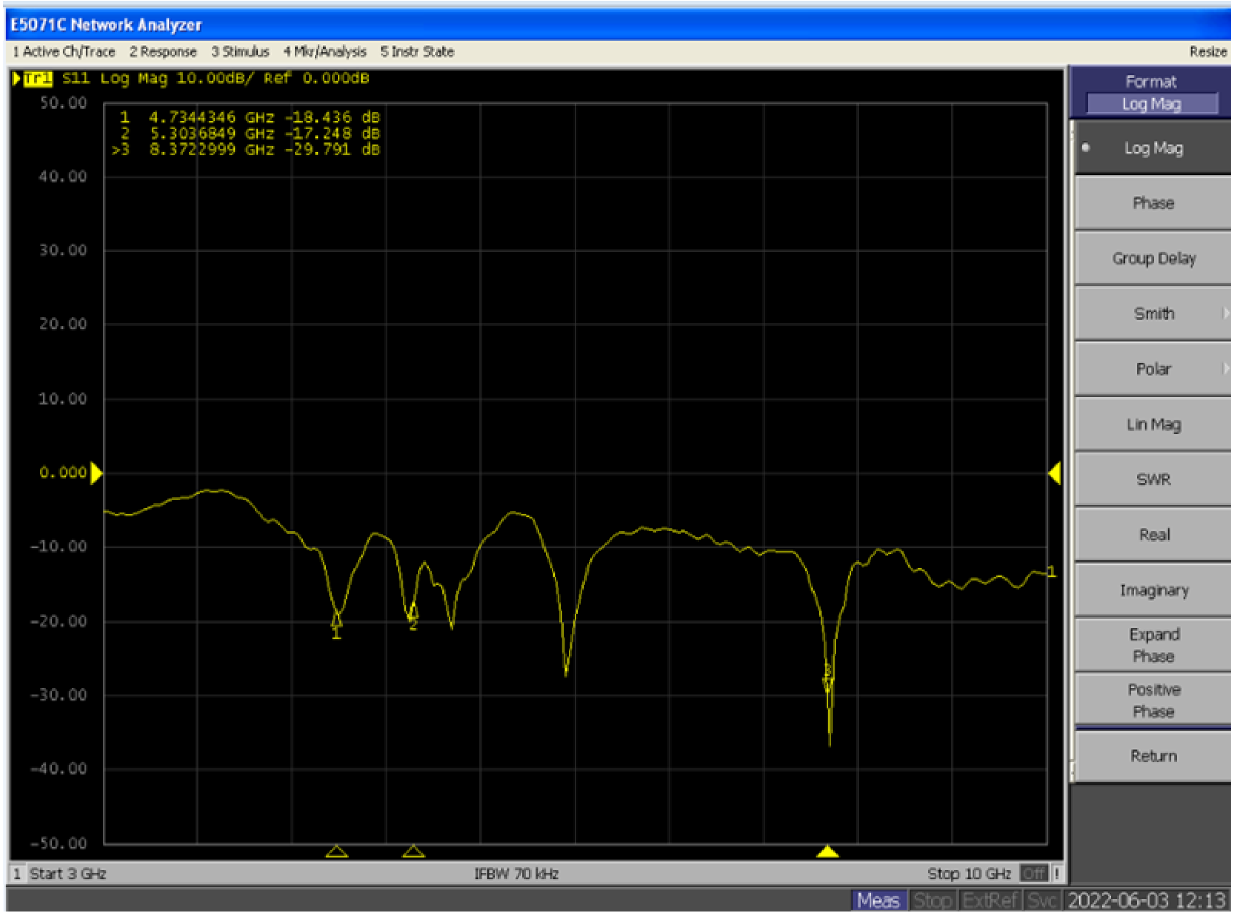


Figure 4.10 The Return Loss of Patch Antenna with CSRR on the ground result network analyzer

TABLE 4.1: Parameters of antennas mentioned till now

Antenna	Gain (dB)	Return loss(dB)	VSWR	Frequency in GHz
Double patch antenna	4.9601	-0.9948	17.4810	5.2
Double Patch Antenna with CSRR on ground	3.9498	-18.9052	1.9791	4.8
Double patch antenna with metamaterial isolation	5.4322	-23.0825	1.8173	4.2

IV. CONCLUSION AND FUTURE SCOPE

Throughout the scope of the presented project, the design, prototyping, and measurement relating to metamaterial-based antennas for the portable wireless applications. In this project we have designed a microstrip Double patch antenna, microstrip Double patch antenna with metamaterial isolation, microstrip patch antenna array, microstrip Double patch antenna with metamaterial isolation and metamaterial antenna array with CSRR on ground and observed their results of these antennas in the areas of the gain, VSWR and return loss. The results regarding gain, VSWR and return loss are simulated for the Double patch, Double patch with isolation, patch antenna with CSRR ground and patch antenna with CSRR on ground at the operating frequencies at 5.2GHz, 4.8GHz and 4.2GHz. For the microstrip patch antenna the gain is 4.9601dB, VSWR is 17.4810, return loss is -0.9948. For the microstrip Double patch antenna with metamaterial isolation the gain is 3.9498, VSWR is 1.9791 and return loss is - 18.9052. For the patch Antenna with CSRR on ground the gain is 5.4322, VSWR is 1.8173 and the return loss is -23.0825. This novel active metamaterial antenna may be receiving or transmitting the channels in 5G. In future large dish operating at above said frequency may get replaced by a small patch antenna (array) Method. To do this Double patch design will not be helpful. Instead of this, array of patches will be required. The array can be of linear type or rectangular type.

REFERENCE

[1] Design of Compact Microstrip Patch Antenna Using SRR Metamaterial for Wireless

Applications Swapna Kumari Budarapu, Kanakavalli Harshasri, Y. Ravi Kumar & B.
[2] Rajendra Naik Conference paper First Online: 02 September 2021
[3] Design of Compact Microstrip Patch Antenna Using SRR Metamaterial for Wireless Applications,Rajan Mishra International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8 Issue-7 May 2019
[4] Microstrip patch antenna design for wireless network applications, S. Mohideen Abdul Kadhar , A. Yasodai International Conference on Advances in Materials Research 2019. https://doi.org/10.1016/j.matpr.2020.11.125.
[5] C. Caloz et al., “Electromagnetic metamaterial Transmission line theory and microwave applications,” John Wiley & Sons, 2005.
[6] D. R. Smth et al., “Composite medium with simultaneously negative permeability and permittivity” Phy. Review Lett., Vol. 84, No. 18, pp. 4184-4187, 2000.
[7] M. A. Antoniades et al., “Multiband Compact Printed Dipole Antennas Using NRI-TL Metamaterial Loading,” IEEE Transactions on Antennas and Propagation, Vol. 60, No. 12, pp. 5613-5626, 2012.
[8] Anwer Mekki et al., “Gain Enhancement of a Microstrip Patch Antenna Using a Reflecting Layer,” International journal of Antennas and Propagation, 2015.
[9] Arvind Kumar and Mithilesh Kumar, “Gain Enhancement in a Microstrip Patch Antenna Using metallic ring at 10 GHz ,” International journal of Computer Application, 2014.
[10] Ashmita et al., “Gain Enhancement in a Microstrip Patch Antenna Using H shaped defected ground structure,” Advances in Intelligent System and Computing, 2017.
[11] Sandeep Kumar Singh, Himanshu Parasar, Rajendra Singh, Vepakomma Kavya "Design of Compact UWB Rectangular Patch Antenna for WiMAX/WLAN Applications," International Journal of Computer Sciences and Engineering, vol. 6, issue.3, pp. 157-160, 2018.
[12] Anand Mohan, Ashok Kumar "Cylindrical Dielectric Resonator Optical Antenna (CDROA) & its Applications for Convenient Technology," International Journal of Computer Sciences and Engineering, vol. 7, issue.1, pp. 283-286, 2019.
[13] R. Luo et al., "Negative index material composed of electromagnetic resonators," Appl. Phys.Lett., vol. 90, pp. 263504-263504-3, 2007.