Comparison for the Performance of Rectangular Microstrip patch Antenna of Base Shape, 8-Shape, DGS optimized and U-Shape

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Abstract— Microstrip patch antenna are becoming very popular day by day because of its ease of analysis and fabrication, low cost, light weight, easy to feed and their attractive radiation characteristics. This paper presents the comparison for Performance of Rectangular Microstrip patch Antenna with different shape. Rectangular Microstrip patch antenna was fabricated on FR-4 board with a substrate thickness of 1.6 mm to 3.5mm and dielectric constant εr = 2.7 to 5.0 with different frequency band. The patch antenna is being designed for radio and satellite applications and thus resonates in C-band and X-band. In this paper we compare Return loss, Gain, bandwidth percentage, VSWR and radiation pattern for different shape Rectangular Microstrip patch antenna.

Key words: Microstrip antenna, Return loss, VSWR, bandwidth percentage

I. INTRODUCTION

The Microstrip antennas, as a vital part of every communication system, should have features like light weight, small volume, omni directional radiation properties, low fabrication cost and ease of installation [1]. All these requisite features can be satisfied by using the Microstrip patch antenna. The concept of microstrip antenna was first proposed by G.A. Deschamps in 1953. In year 1970 it was modified further by Robert E. Munson with some fellow researchers. They used low-loss soft substrate materials to make it useful for practicalapplications[2]. The microstrip antenna has characteristic features such as low gain, narrow band and wide beam antenna. There are various factors that effects the gain and resonant frequency of the antenna, like the thickness (h) and dielectric constant (ε_r) of substrate, shape of patch, the dimensions of ground plane and method of feeding etc.

This patch cavity or slot can raise the resonant frequency in an appreciable way in different antenna configuration. Creating slots on the patch shows variation in different parameters of the antenna. A slot radiates electromagnetic waves in the same way as the dipole antenna does. The variation in shape and dimensions of slots influence different antenna characteristics like return loss, bandwidth percentage and radiation distribution pattern[12].

Many researchers have witnessed the improvement of return loss, gain and impedance bandwidth of the microstrip patch antenna using different slot configurations . Lee et al.[18] proposed a U-slot patch antenna for dual and triple band operations which can be used for circularly polarized applications. I-Shaped slot is gaining considerable attention because of its small structure, broad band and multiband response. A number of experimental and theoretical research papers have been published regarding different shape of slot in patch antenna [8]. The advantages associated with slots of Rectangular Microstrip patch Antenna for achieving the best return loss, bandwidth percentage, VSWR and radiation pattern when compare with other antenna.

The microstrip patch antennas possess characteristics such as low profile, low weight and low manufacturing cost. So, the rectangular microstrip patch antenna can be used in Radars, missiles, space crafts, robots and mobiles, where size, weight and cost are constraints[16]. Conventional microstrip patch antennas have a conducting patch printed on a substrate. The shape of patch of the antenna may be square, rectangular, circular, triangular, elliptical or of other specific configurations.

II. LITERATURE REVIEW

There are several experimental works done on different shape Rectangular Microstrip patch antenna where author calculate Return loss(RL), Gain, Bandwidth percentage, VSWR (voltage standing wave ratio), Directivity and radiation pattern.

[1] Ashok Kumar and Shailesh Kumar, ”Design & Simulation of 8–Shaped Coaxial Feed Patch Antenna” International Journal of Current Engineering and Technology Vol.6, No.3 (June 2016) describes the design and simulation of 8-shaped patch antenna using Hfss11.1 electromagnetic simulation software with coaxial feeding technique used. The 8-shaped patch antenna is being designed for amateur radio and satellite applications and thus resonates in X-band. FR4 epoxy dielectric material of relative permittivity 4.4 and loss tangent of 0.019. With the thickness of 1.6mm is used as a substrate of the antenna. The proposed antenna is excited by coaxial probe feeding technique and probe is located at (-2.9 mm, 0 mm,-3 mm). Dimension of patch of length 6.4 mm and width 9 mm. At this configuration the return loss of different shape Base shape, 8-shape and DGS-Optimise rectangular microstrip patch antenna are -16.0499dB, -27.4451dB and -44.1210dB respectively. The Bandwidth percentage of base shape 4.58%, for 8-shape patch antenna is 6.66% and for DGS-Optimise patch antenna is 6.68% at different resonance frequency of 8.5044GHz, 10.3316GHz and 10.3600GHz respectively. Fig.1 shows Return loss plot for base shape, 8–shaped and DGS optimized antenna.

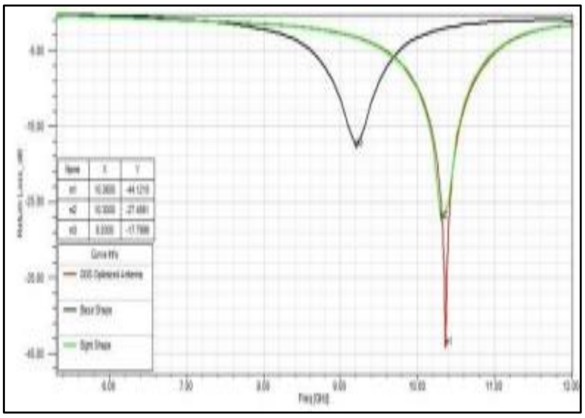

Fig. 1: Return loss plot for base shape, 8–shaped and DGS optimized antenna

[2] Srikanta Patnaik, Mihir Narayan Mohanty "Optimization of Z-Shape Microstrip Antenna with I- slot Using Discrete Particle Swarm Optimization (DPSO) Algorithm" 2nd International Conference on Intelligent Computing, Communication & Convergence (ICCC-2016) describes discrete particle swarm optimization technique has been utilized in HFSS software for optimization of the Z-shape patch antenna with I- slot dimensions in order to achieve return loss, VSWR, directivity and gain. The designed antenna is to operate in Wi-Max / S- band and C-band satellite application with the centre frequency at 3.5 GHz and 4.3 GHz and various important performance metrics of the patch antenna are analysed for performing comparative analysis between un-optimized patch antenna and optimized patch design.

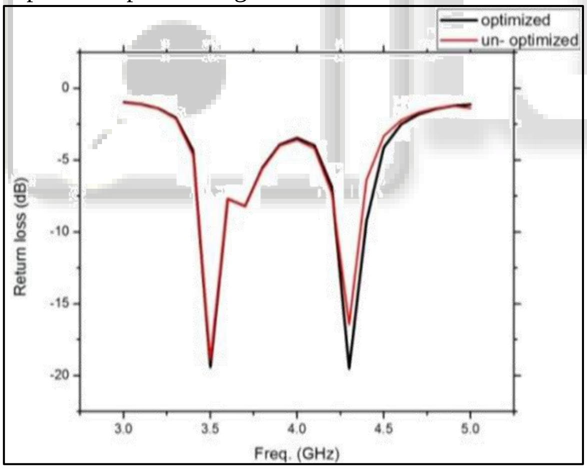

Fig. 2: Return loss plot of optimized and un-optimized Z-shape patch antenna with I-slot

In this paper FR4 epoxy dielectric material of relative permittivity 4.4 and loss tangent of 0.02. With the thickness of 1.6mm is used as a substrate of the antenna.The dimension of patch of length 38.04mm and width 29.44mm. At this configuration the optimized Z-shape patch antenna with I- slot exhibits return loss of -19.4077 dB at 3.5 GHz and -19.5182 dB at 4.3 GHz. Whereas the return loss plot of the un-optimized Z- shape patch antenna with I-slot is -18.88 dB at 3.5 GHz and -16.42 dB at 4.3 GHz. The un-optimized Z- shape patch antenna with I-slot has VSWR of 1.25 and 1.35 and the optimized Z-shape patch antenna with I-slot has a VSWR of 1.23 at 3.5 and 4.3 GHz. The directivity and gain for un-optimized Z-shape patch antenna with I-slot has 5.67dBi and 1.34dB respectively and directivity and gain for the optimized Z-shape patch antenna with I-slot has 5.93dBi and 1.53dB respectively. Fig. 2 shows Return loss plot of optimized and un-optimized Z- shape patch antenna with I-slot.

[3] Pawan kumar punia, Ria kalra and B. Mohapatra "Inset Fed Rectangular Microstrip Patch Antenna for UHF Radio Frequency Identification" International Journal of Engineering Research & Technology (IJERT)ISSN: 2278-0181Vol. 4 Issue 08, (August-2015) describe a 0.92 GHz inset line fed rectangular microstrip patch antenna has been designed for UHF RFID(Radio Frequency Identification) application with return loss more than -32db, bandwidth 2.71 % and VSWR 1.0473 using HFSS software. In this paper substrate having relative permittivity (ε_r) = 4.5 and thickness (h) = 1.5mm with Tangent (tanδ) = 0.002.The length (L) of patch antenna is 77 mm and its width (W) is 98mm.The inset feed line (Zp) is 7 mm, with feed line width (W_g) of 1 mm and inset gap ($L1$) is 3 mm. Here the input impedance is 51.21Ω and VSWR is 1.0473. Fig.3 shows Return loss and VSWR for UHF Radio Frequency Identification.

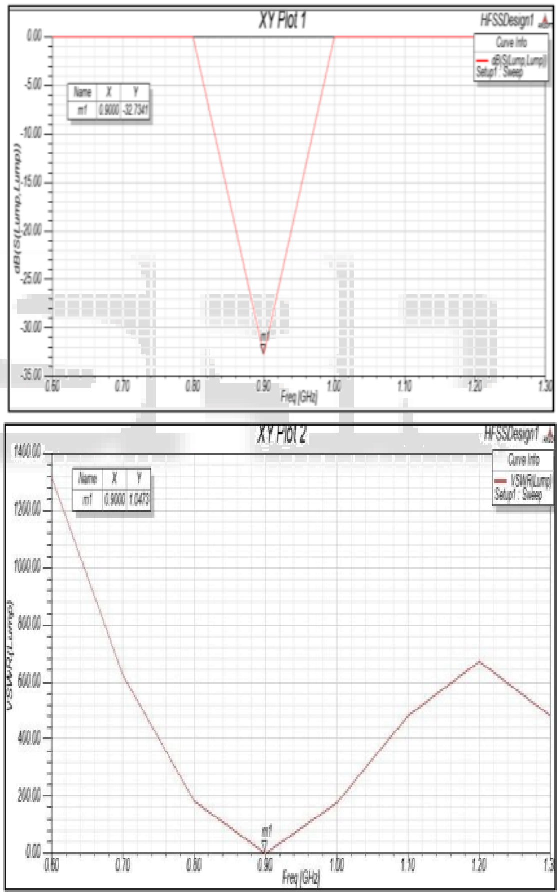

Fig. 3: Return loss and VSWR for UHF Radio Frequency Identification

[4] Bimal Garg, Himanshu Shrivastava, Prem Kumar, "Microstrip Patch Antenna with Parameters Improvement Using "Symmetric Cylinder Shapes of Zero & Four Segments" Metamaterial Structure" IRACST – International Journal of Computer Networks and Wireless Communications (IJCNWC), ISSN: 2250-3501 Vol.2, No.3, (June 2012) describe a Rectangular microstrip patch antenna loaded with "Symmetric Cylinder Shapes of Zero & Four Segments" metamaterial structure is designed at a height 3.2 mm from the ground plane by using CST-MWS software. The resonance frequency of the designed antenna is

2.5GHz.The 10 dB impedance bandwidth of proposed antenna is 33.7MHz.

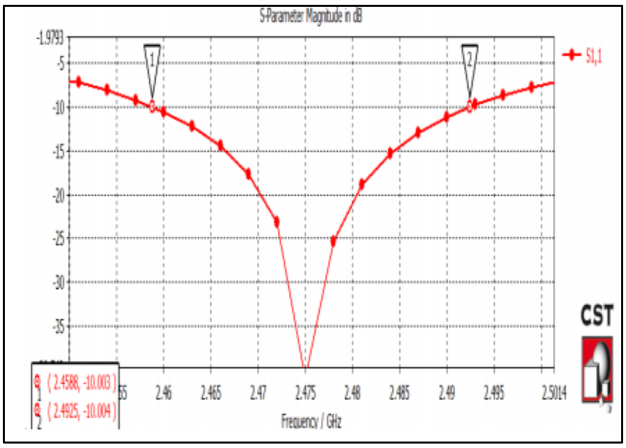

Fig. 4: Simulated Return Loss of Rectangular microstrip patch antenna loaded With “Symmetric Cylinder Shapes of Zero &Four segment” metamaterial Structure.

The Return loss of the proposed antenna is reduced by -41dB. In this paper author take Dielectric Constant (ϵr) 4.3and Loss Tangent (tan ∂) 0.02. The length of patch is 28.46mm and width of patch is 36.28mm. Fig.4 shows Simulated Return Loss of Rectangular microstrip patch antenna loaded With “Symmetric Cylinder Shapes of Zero &Four segment” metamaterial Structure.

[5] Liton Chandra Paul, Nahid Sultan, “Design, simulation and performance analysis of a line feed rectangular micro-strip patch antenna” International Journal of Engineering Sciences & Emerging Technologies, Volume 4, Issue 2, pp: 117-126 (Feb. 2013) describe a line feed rectangular micro-strip patch antenna with Dielectric constant of the substrate ε_r = 4.4 and Height of dielectric substrate 1.3mm taken. In this paper micristrip line feed method is used. Here the length of patch is 23.5mm and width of patch is 30.4mm. The return loss of line feed rectangular micro-strip patch antenna is -8.314dB at 2.937GHz. At this configuration of patch antenna Directivity Bandwidth percentage and gain 4.154dBi, 2.6515% and 2.059dB respectively. Fig. 5 shows S-parameter plot for Return loss v/s frequency for rectangular micro-strip patch antenna (RMSA).

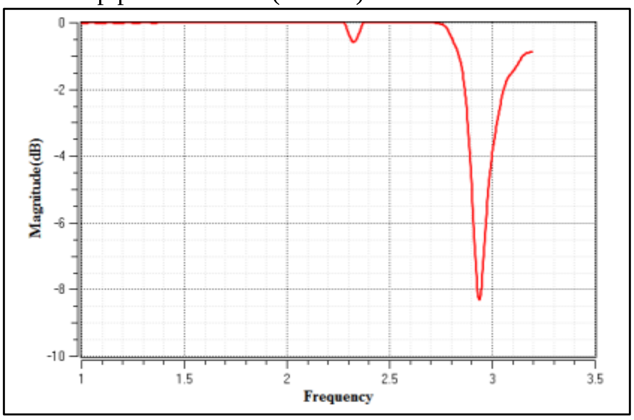

Fig. 5: S-parameter plot for Return loss v/s frequency for RMSA

[6] Ali Hanafiah Rambe, Eddy Marlianto, Nasruddin M.N., Fitri Arnia “Optimizing Rectangular Patch Antenna with Microstrip Line Feed Using Single Stub” International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 2 Issue 12, December – 2013 describe Microstrip Line Feeding in Rectangular Patch Antenna with Dielectric constant of the substrate ε_r = 4.4 and Height of dielectric substrate 1.6mm taken. Here the length of patch is 38.04mm and width of patch is 28.44mm. The return loss of Microstrip Line Feed rectangular micro-strip patch antenna is -45.61dB at 2.38GHz. The bandwidth percentage is 4.45% and Gain is 5.6dB. Fig.6 shows Simulated Return Loss vs. Frequency of Simple RMPA.

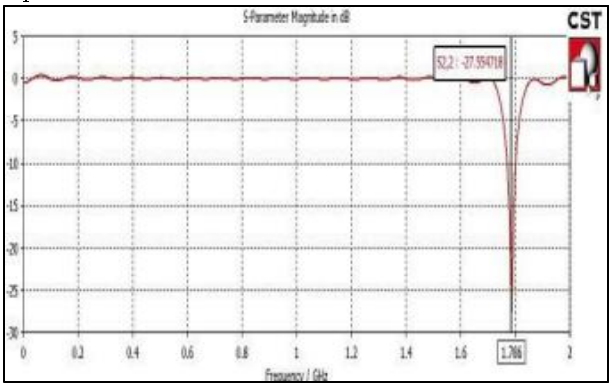

Fig. 6: Simulated Return Loss vs. Frequency of Simple RMPA is 27.554dB at 1.786GHz

[7] Hemant Kumar Gupta, Bhupesh Gautem, Poonam Sinha,Abha Soni “Design of Very Low Return Loss, Rectangular Microstrip Patch Antenna for Cellular and Mobile Communication” nternational Journal of Electronics and Electrical Engineering Vol. 1, No. 3, September, 2013 describe Rectangular Microstrip Patch Antenna design in CST software with Dielectric constant of the substrate ε_r = 6.15 and Height of dielectric substrate 1.6mm. Return loss of this paper is -27.55dB at 1.786GHz. The bandwidth is 31.63MHz and directivity is 5.56dB. Fig. 7 shows the simulated and measured return loss of Microstrip Patch Antenna for Cellular and Mobile Communication (CMC).

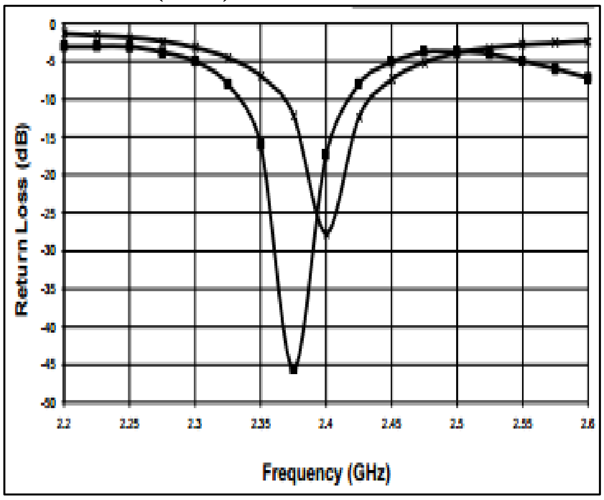

Fig. 7: The simulated and measured return loss of Microstrip Patch Antenna for CMC

[8] Kamariah Ismail and Siti Hasyimah Ishak “Sierpinski Gasket Fractal Antenna with Defected Ground Structure (DGS)” 978-1-4673-4828-7/12/$31.00 ©2012IEEE describe antenna design at 5.8GHz. A slot was used as a defected ground structure(DGS). The antenna was designed and simulated using Computer Simulation Technology (CST) software and fabricated on FR-4 board

with a substrate thickness of 1.6 mm and dielectric constant of 5.0 and dielectric loss tangent 0.025. The return loss bandwidth percentage and VSWR at 5.8GHz is -24.41dB, 3.57% and 1.128 respectivly. Fig.8 shows simulated and measured result for return loss for Sierpinski Gasket Fractal Antenna with Defected Ground Structure.

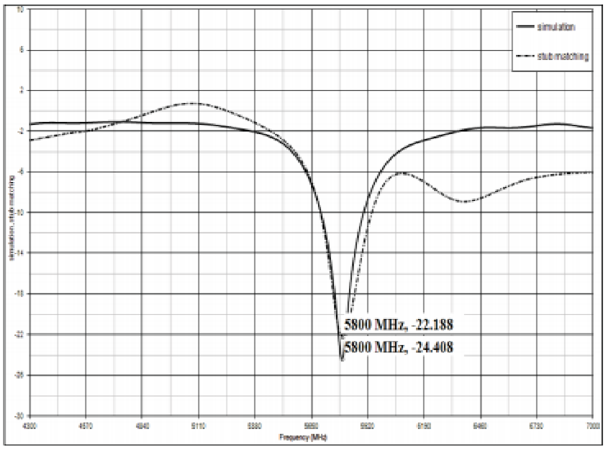

Fig. 8: simulated and measured result for return loss for Sierpinski Gasket Fractal Antenna with Defected Ground Structure

[9] Chandan Kumar Ghosh, Arabinda Roy, and Susanta Kumar Parui "Elevated CPW-Fed Slotted Microstrip Antenna for Ultra-Wideband Application" Hindawi Publishing Corporation International Journal of Antennas and Propagation Volume 2012, Article ID 425919,8pages doi:10.1155/2012/425919 describe CPW-Fed Slotted Microstrip Antenna is printed on FR4 substrate with the dielectric constant of εr =4.4, loss tangent of δ =.001, and the substrate thickness of h =1.587 mm. The return loss , VSWR and gain for this antenna at 6.45GHz is -31dB, < 2 and 0.8dB. Fig. 9 shows return loss for CPW-Fed Slotted Microstrip Antenna for G-slot.

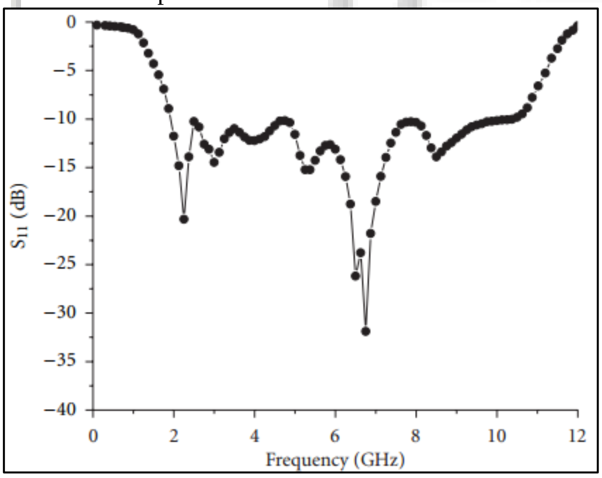

Fig. 9: return loss for CPW-Fed Slotted Microstrip Antenna for G-slot

[10] Sheikh Dobir Hossain, K. M. Abdus Sobahan, Md. Khalid Hossain, Md. Khalid Hossain Jewel, Rebeka Sultana, Md. Al Amin "A Linearly Polarized Coaxial Feeding Dual Band Circular Microstrip Patch Antenna for WLAN Applications" I.J. Wireless and Microwave Technologies, 2016, 3, 50-60 Published Online May 2016 in MECS DOI: 10.5815/ijwmt.2016.03.06 describe that antenna contains a substrate layer (FR-4 lossy) with a dielectric constant of 4.4 and there is a circular patch on the upper layer of the substrate.

The bandwidth is 120MHz. The return loss can be change by changing the radius of patch. The return loss VSWR and Gain for this antenna at 2.76GHz is -27.66dB, 1.08 and 7.81dB respectively and at 5.96GHz the return loss is -34.14dB, VSWR is 1.05 and Gain is 7.87dB. This antenna is designed by using Computer Simulation Technology (CST) microwave studio. Fig. 10 shows Simulated return losses of dual band MSA at 2.76 GHz and 5.96 GHz.

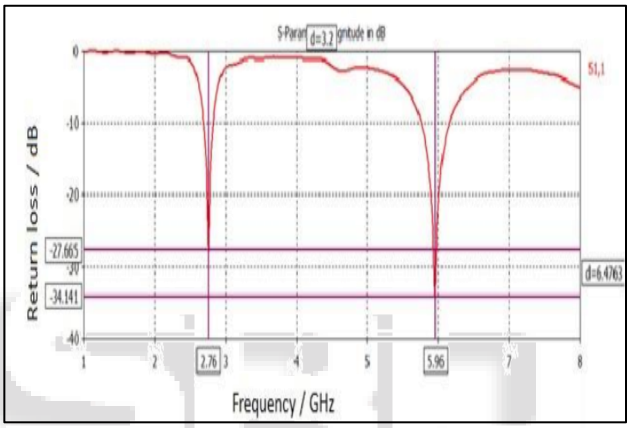

Fig. 10: Simulated return losses of dual band MSA at 2.76 GHz and 5.96 GHz

III. Problem Description

After studying the literature review we observe that number of experimental and theoretical research paper have been published regarding Return loss(RL), Gain, VSWR(voltage standing wave ratio), Bandwidth, Bandwidth percentage. But still by changing the slot good result in terms of Return loss(RL), Gain, VSWR(voltage standing wave ratio), Bandwidth, Bandwidth percentage can be achieved.

IV. Proposed Work

After analysing different published paper we observed that an approach to Rectangular Microstrip patch antenna in 'U' and 'I' shape will bring better result.

S.NO.	PAPER	FREQUENCY (GHz)	RETURN LOSS (dB)	VSWR	BW	BW %	GAIN (dB)
1	PAPER I	10.36	-44.12	-	-	6.68%	-
2	PAPER II	4.3	-19.51	1.35	-	-	1.34
3	PAPER III	0.98	-32	1.047		2.71%	-
4	PAPER IV	2.5	-41	-	33.7	-	-
5	PAPER V	2.937	-8.31	-	-	2.65%	2.059
6	PAPER VI	2.38	-45.61	-	-	4.45%	-
7	PAPER VII	1.786	-27.55	-	31.63	-	-

8	PAPER VIII	5.8	-24.408	1.128	-	3.57%	-
9	PAPER IX	6.45	-31	< 2	-	-	0.8
10	PAPER X	5.96	-34.14	1.05	200	-	7.87

Table 1: Comparision of Different Shape Micro Strip Antenna

Table 1 shows the Return loss , VSWR (voltage standing wave ratio), Bandwidth, Bandwidth percentage (BW%), and Gain at different frequency band (L,S,C,X band) for different different shape (circular and rectangular) micro strip antenna. This result obtained by cutting the slot of different shape (E-slot, G-slot, 8-slot etc.). Here we use material to make antenna of different dielectric constant (2.2 to 5.0) and thickness (1.6mm to 3.5mm).

V. Conclusion

In this paper we present a survey in the comparision of different microstrip antenna with 4GHz to 8GHz (C-band). Here we found Return loss ranging from -16dB to -44dB, Bandwidth percentage 2% to 6%, VSWR (voltage standing wave ratio) < 2 and Gain 3dB to 12dB for different shape Rectangular Microstrip patch Antenna with 4GHz to 8GHz frequency band.This antenna can be used for satellite and wireless communication. Concentrating on theoretical models and performance characteristics of different microstrip patch antenna improvement can be done by changing shape as ‘U’ and ‘I’ and changing material Return loss(RL), Gain, VSWR(voltage standing wave ratio), Bandwidth, Bandwidth percentage will be the performance parameter.

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