Developement of Microstrip Patch Antenna for Wireless Utility & 5G IMT Services

Surendra Kumar Saini, Vikas Verma, Ashish Kumar, Jaiverdhan, Ashish Sharma

Abstract—the current antenna technology in the India is the era of antenna for 5G applications. The Frequency range from 3.3GHz to 3.8GHz is available for 5G application. The proposed antenna is for 5G IMT services. The paper includes 3 iantenna styles. Slot insertion and Defected iground technique is utilized in the ultimate antenna style to boost the antenna performance. FR4 is employed as substrate having dielectric constant 4.4. The bandwidth of the ultimate antenna is 1.98GHz ranges from 2.52 gigahertz to 4.50 GHz. The antenna resonates at 3.6 GHz. The Gain of the antenna is 6.1dB.

Index Terms— S11 Parameter, VSWR, IMT services, Bandwidth, Gain, Radiation pattern

1 INTRODUCTION

As the technology is going very fast in frequency uses. The current technology need antenna for current application but with small profile. This is very challenging task in front of the antenna designer to design an antenna with all specifications with small profile [1]. The current technology era is related to the 5G communication. The frequency band from 3.3GHz to 3.8 GHz is released for 5G IMT services. Microstrip patch antenna is very much uses in the antenna designing due to its low profile low cost and fabrication cost. It is very easy to design microstrip patch antenna for above frequencies. 5G technology will use cell phones within very high bandwidth. 5G is a packet switched wireless system with wide area coverage and high throughput [2]. 5G technology use millimeter wireless will have data rate greater than 100Mbps at full mobility and higher than 1Gbps at low mobility. The 5G technology will include all types of advanced features which make 5G technology most powerful and in huge demand in the near future. Such a huge collection of technology being integrated into a small device [3]. The 5G technology provides the mobile phone users more features and efficiency. Microstrip antenna consist of patch which is very thin metallic strip or sheet placed above ground plane separated by a substrate of dielectric material [4]. The performance of the microstrip antennas depends on the height of the substrate and dielectric constant of substrate.

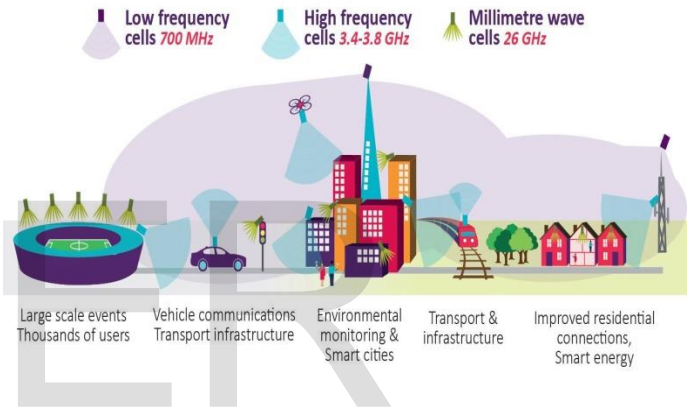

Fig1. Frequency spectrum for 5G Communication

The performance of the microstrip antennas are good for thick substrate with lower dielectric constant of substrate material. The major drawback of antenna is low bandwidth and low gain. As there are several other techniques that increases the bandwidth and gain without much changes [5]. The proposed antenna will cover the whole range from 3.3GHz to 3.8GHz. According to need the proposed antenna having low profile, high impedance bandwidth and gain.

2. DESIGN IEQUATIONS IOF IMICROSTRIP IANTENNA

The effective length of the patch Leff now becomes [2]

$$L_{\text{eff}} = L + 2\Delta L$$

$$\Delta L = 0.412h \frac{\varepsilon_{\text{reff}} + 0.3}{\varepsilon_{\text{reff}} - 0.258} \left(\frac{W/h + 0.264}{W/h + 0.813} \right)$$

For a given resonant frequency f0, the effective length is[5][6]

$$L_{\text{eff}} = \frac{c}{2f_0\sqrt{\varepsilon_{\text{reff}}}}$$

For a rectangular microstrip patch antenna, the resonance frequency for any TMmn mode is given by James and Hall as [2]

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$$f_0 = \frac{c}{2\sqrt{\varepsilon_{reff}}}\left[\left(\frac{m}{L}\right)^2 + \left(\frac{n}{W}\right)^2\right]^{0.5}$$

Where m and n are modes along L and W, respectively.

The width W is [3]

$$W = \frac{C}{2f_0}\left(\frac{\varepsilon_r+1}{2}\right)^{-0.5}$$

Where f0 = resonant frequency C = speed of light in free space

3 ANTENNA IDESIGNS

3.1 Microstrip patch antenna with full ground plane.

This is the first structure of antenna design for 5G application. This antenna design consists of dielectric substrate of FR4 having dielectric constant of 4.4, rectangular patch and full ground plane. The size of the antenna is given in table 1.1.

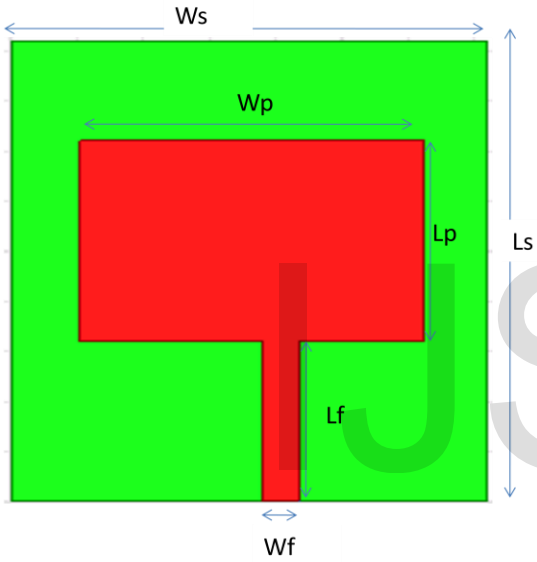

Fig 2. Conventional MPA with complete lower plane

TABLE 1.1 DIMENSIONS OF CONVENTIONAL MICROSTRIP PATCH ANTENNA

S.No.	Parameter	Size(in millimeter)
1	Length of Substrate (Ls)	46
2	Width of Substrate(Ws)	36
3	Length of Patch(Lp)	19.98
4	Width of Patch(Wp)	26
5	Length of Feed Line(Lf)	18
6	Width of Feed Line(Wf)	2.8
7	Height of substrate	1.5

3.2 Simulation Results

S11 Parameter VS Frequency

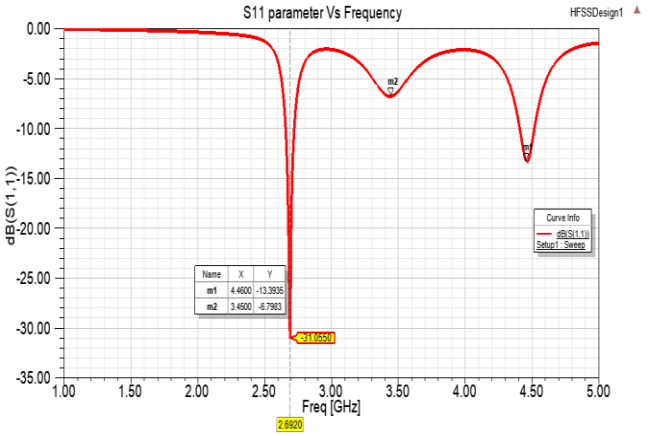

Fig 3. S11 Parameter Vs frequency graph

The frequency response for microstrip patch antenna is not good for full ground plane structure. So to better response the size of the ground decreases. The reduction in the size of the ground plane decreases the q factor which increases the frequency response and bandwidth.

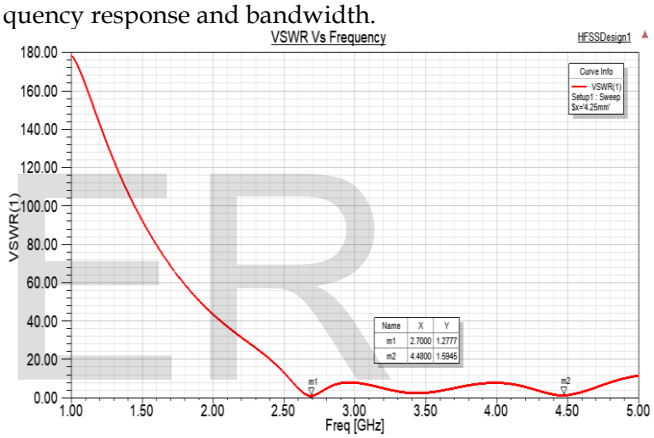

Fig 4. VSWR Vs frequency variation for convention Microstrip Patch Antenna

B. Microstrip patch antenna with Partial Ground Plane

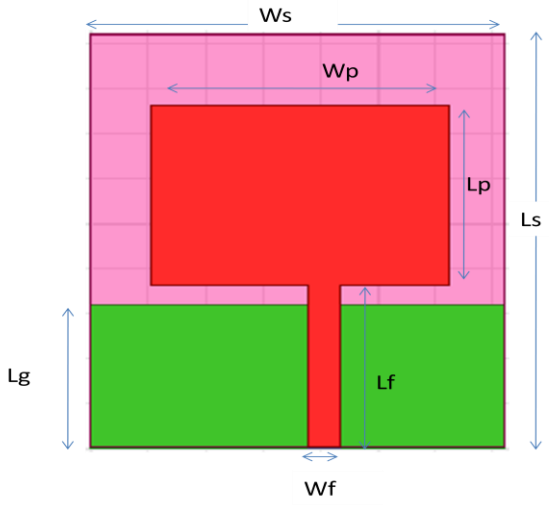

Fig 5. Microstrip Patch Antenna with Partial ground plane

TABLE 1.2 DIMENSIONS OF MICROSTRIP PATCH ANTENNA FOR PARTIAL LOWER PLANE STRUCTURE

S. No.	Parameter	Size(in millimeter)
1	Length of Substrate (Ls)	46
2	Width of Substrate(Ws)	36
3	Length of Patch(Lp)	19.98
4	Width of Patch(Wp)	26
5	Length of Feed Line(Lf)	16
6	Width of Feed Line(Wf)	2.8
7	Length of Ground (Lg)	16

B.1 Simulation Results

B.1.1 S11 Parameter VS. Frequency

Fig shows the variation of return loss with respect to the frequency. The return loss should be as minimum as possible. The return loss of the antenna is -38dB at frequency 3.46GHz. The band width of the antenna is 2.01GHz ranges from 2.52 to 4.53GHz. The range cover the S band and the frequency of 3 3.3 GHz to 3.6 GHz for 5G ITM Services

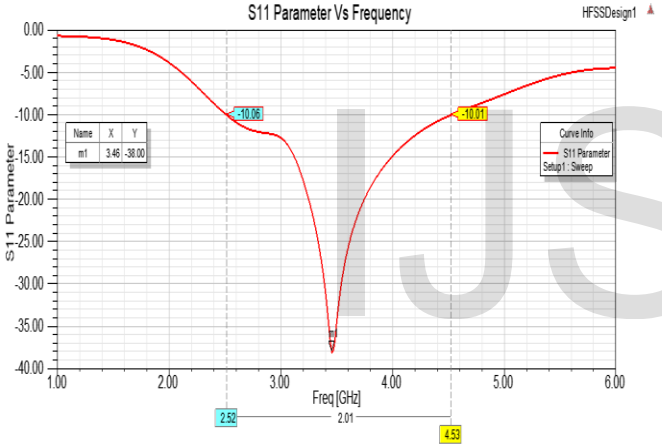

Fig 6. S11 Parameter Vs frequency Graph for Microstrip patch antenna for partial ground plane

B.1.2. VSWR VS Frequency

The value of VSWR should be less than 2. It is clear from the below response as the vswr is less than 2 for response frequency.

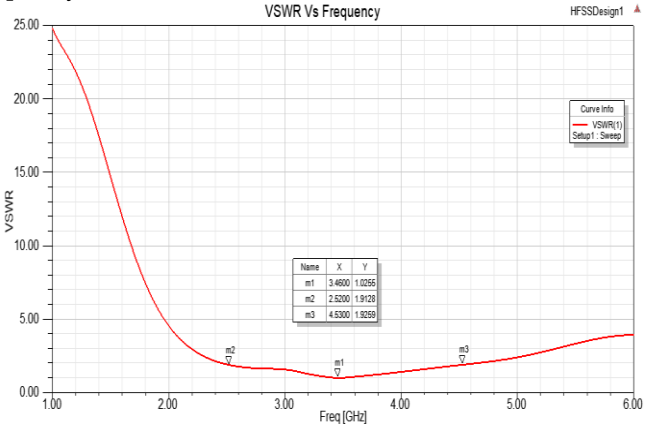

Fig 7. VSWR Vs frequency Graph for Microstrip patch antenna for partial ground plane

B.1.3. Radiation Pattern

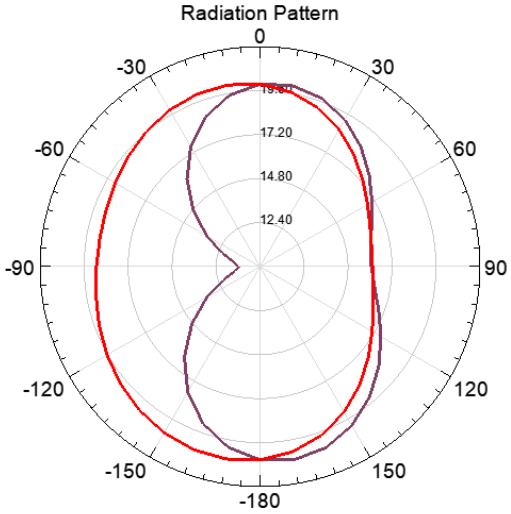

Fig 8. Radiation Pattern Graph for Microstrip patch antenna for partial ground plane

B.1.4. Gain Pattern

The gain of the antenna is preferably good and equal to 2.16 dB.

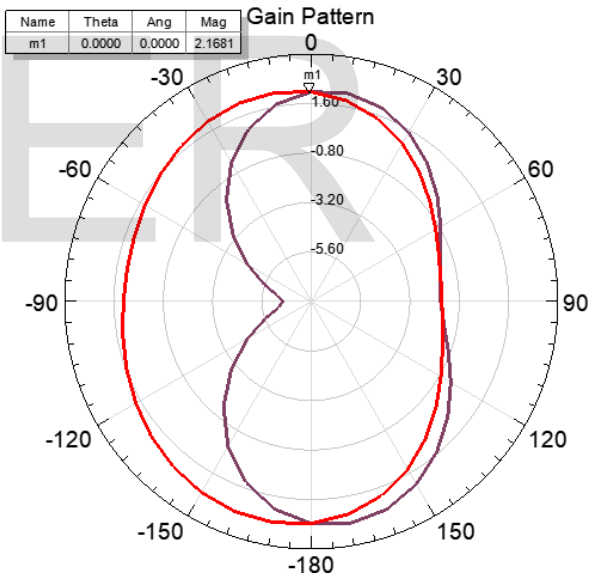

Fig 9. Gain pattern for Microstrip patch antenna for partial ground plane

C. Microstrip patch antenna with U slot and EBG Structure

The proposed antenna having U slot and EBG structure to provide better antenna response. The presence of U slot provide an new dip in the output response at 2.1GHz and by using EBG the band width is slightly increase and 50ohm resonance will produced. The antenna resonance frequency is 3.5GHz. the second dip in the output is at 3.5GHz.

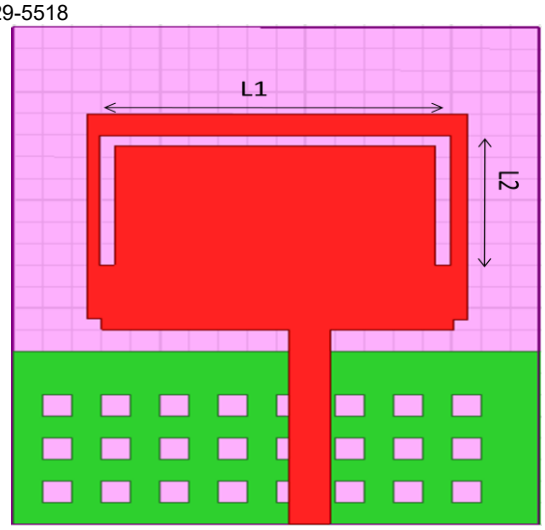

Fig10. Proposed Microstrip patch antenna

TABLE 1.3 DIMENSIONS FOR PROPOSED MICROSTRIP PATCH ANTENNA

S.No.	Parameter	Size(mm)
1	L1	24
2	L2	12
3	Width of all slots	1
4	Dimensions of EBG Slots	2x2

C.1 Simulation Results

C.1.1. S11 Parameter VS. Frequency

Fig shows the variation of return loss with respect to the frequency. The return loss should be as minimum as possible. The return loss of the antenna is -38.05dB at frequency. 3.5GHz. the band width of the antenna is 2.01GHz ranges from 2.74 to 4.75GHz. The antenna resonants at two frequencies 2.03 GHz and 3.5GHz. The range cover the S band and the frequency of 3 3.3 GHz to 3.6 GHz for 5G ITM Services.

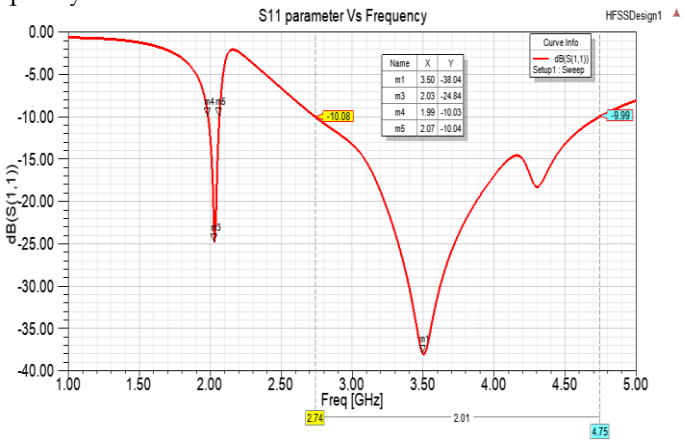

Fig 11. S11 Parameter Vs frequency Graph for Proposed Microstrip patch antenna

C.1.2. VSWR VS Frequency

The Practical value of VSWR should be less than 2. The proposed antenna having vswr less than 2 for all resonant frequencies.

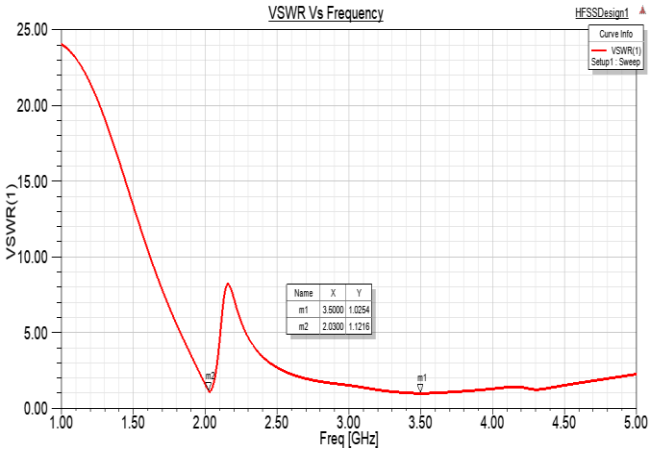

Fig12. VSWR Vs frequency Graph for Proposed Microstrip patch antenna

C.1.3. Radiation Pattern

The radiation pattern tell about the maximum radiation in the intended direction. The radiation pattern of the proposed microstrip patch antenna is Omni-directional. The maximum radiation is around 18.50. This practically good for any antenna. Fig13 show the variation of the radiation with respect to the space coordinates.

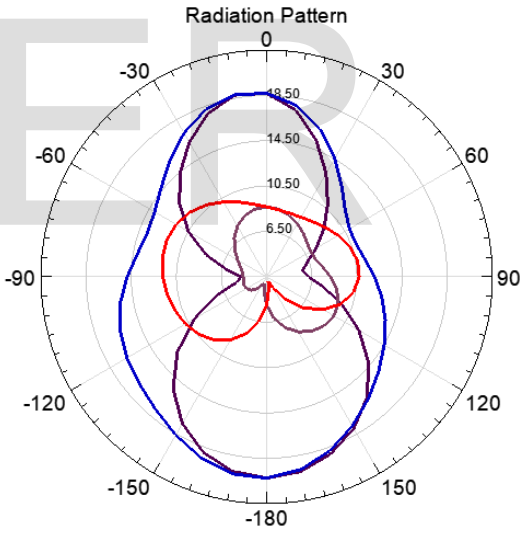

Fig 13. Radiation pattern for Proposed Microstrip patch antenna

C.1.4. Gain Pattern

The Gain of the proposed microstrip patch antenna is practically very good and equal to 7.65dBi.

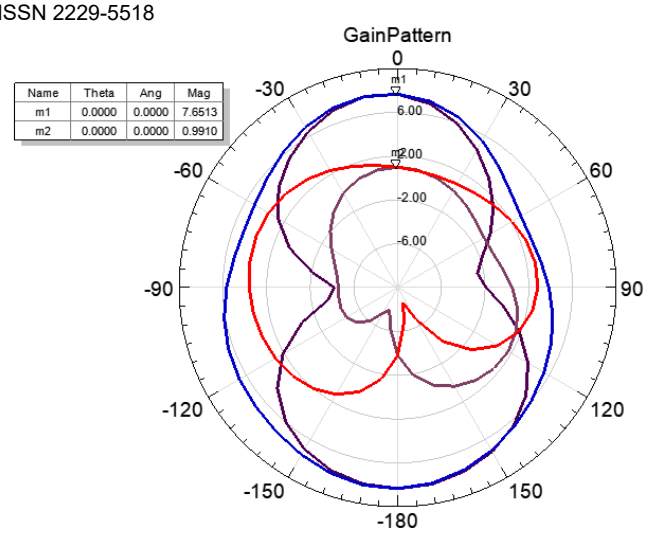

Fig14. Gain pattern for Proposed Microstrip patch antenna

4. CONCLUSION

The Proposed microstrip patch antenna is practically small. The proposed microstrip operates for both wireless and 5G application. The designed on HFSS software. FR4 substrate used as substrate. The bandwidth of the proposed antenna is 2.01 GHz and gain of the antenna is 7.65dBi. The antenna also have good radiation pattern. In the future scope the may be design by using different substrate or there are several other techniques such as PBG, use of passive elements which enhance the radiation characteristics of antenna.

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