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COMPACT MICRO STRIP ANTENNA FOR 5G MOBILE PHONE APPLICATIONS

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Abstract
In this paper, the antenna design is modified for better gain in the frequency spectrum proposed for 5G mobile applications in India. The proposed antenna can be implemented using low cost FR-4 substrate with εr=4.4, tanδ=0.02 and dimensions 50mm (Ls) × 50mm (Ws) × 1.6mm (h), while maintaining good performance in terms of gain and efficiency. The proposed antennas have been characterized using the commercially available software Ansoft's HFSS (High frequency structure simulator). The performance of the designed antenna is analyzed in terms of bandwidth, gain, return loss, VSWR and radiation pattern. The proposed antenna have S11<-10dB and VSWR<2.5 and gain is 3dB obtained at 3.5GHz

Key words: 5G, Mobile application, *return loss, Gain*

I. INTRODUCTION

We have seen fast evolutions in the mobile communication systems from the first generation (1G) to the fourth generation (4G), where the newer generations always came with significant upgrades in their performance. The existing 4G systems can provide over 1 Gbps maximum data rates, which has made various attractive applications (such as wireless video calls, remote house monitoring and machine type communications) possible. Furthermore, it is predicted that the commercial deployment of fifth-generation (5G) systems will be approximately in the early of 2020s. In order to meet the increasing need for even higher data rates required in future applications (such as wireless broadband connections, massive machine type communications and highly reliable networks), the research activities on 5G mobile communication systems have started. Compared with 4G systems, one of the major differences in 5G cellular systems is the shift to higher frequencies where is easier to obtain wider bandwidths. As illustrated in Fig:1, the centimeter/millimeter wave bands could provide bandwidths several times broader than 3G and 4G frequency bands. Therefore, the centimeter/millimeter wave bands can support the higher data rates required by applications in the future. In addition, there are different frequency band candidates that could be potentially used for 5G, and research activities can be found in all of these bands. However, moving to these centimeter/millimeter wave bands would bring new challenges in the designs of antennas for mobile phone devices.

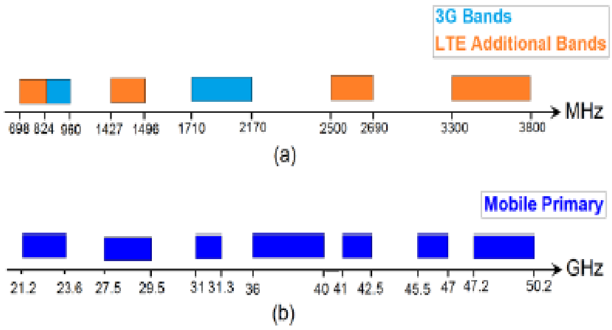

Fig. 1: (a) Frequency bands of 3G and 4G, (b) candidates Bands for 5G in 20-50 GHz (US).

In this paper, a compact micro strip patch antenna for 5G mobile phone application.The proposed antenna with a compact size of 50 mm × 50 mm is fabricated. It is observed that the antenna shows a -10 dB impedance bandwidth from from 3.3 – 3.6 GHz i.e.0.3GHz.

II. ANTENNA DESIGN

The stepwise modifications of circular compact micro strip antenna are shown in Fig. 2. Starting the design with the circular patch gives the flexibility for further modification because current is mainly concentrated along the periphery of circular micro strip antenna. The proposed micro strip antenna is designed on the FR4 substrate with relative permittivity and loss tangent of 4.4 and 0.02 respectively.

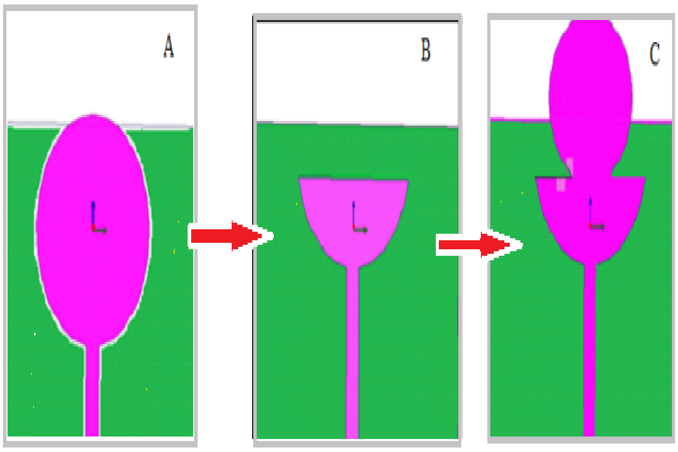

Fig2: Evolution of proposed 5G mobile antenna

The substrate thickness is chosen as,

$$h \le \frac{0.3c}{2\prod fr\sqrt{\varepsilon r}} \qquad (2.1)$$

Where is the velocity of light (=3×10^{8}m/s) the εr is the relative dielectric constant f is the maximum operating frequency. The geometry of the proposed antenna is shown in Fig: 3. Antenna is designed and simulated in HFSS13 (High Frequency Structural Simulator) software which enables to include fine details in the design.

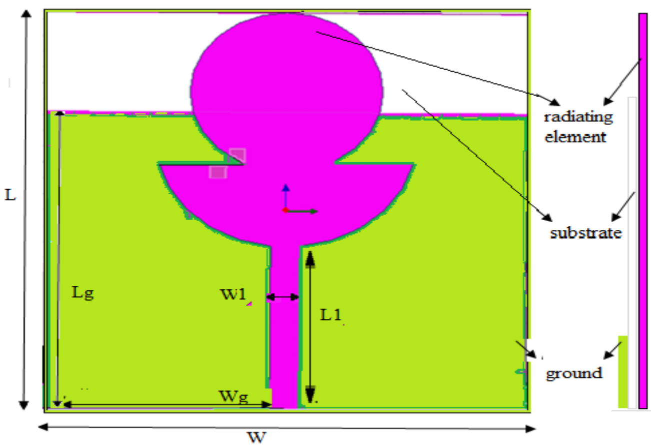

Fig 3: Proposed geometry of Antenna configuration.

Table 1: Dimensions of the Proposed Antenna illustrated in Fig 3

Parameters	L	W	Lg	Wg	L1	W1	R1	R2
Dimensions	**50**	**50**	**37.5**	**23.5**	**26**	**3**	**13.5**	**10**

III.CALCULATIONS

Formulaes that are used to find out the absolute band width from both upper edge of (fh) band width and lower edge of (fl) band width.

Table 2: Simulated -10db bandwidth of proposed antenna at Lg=37.5

Parameters				**Lower edge ofBW (GHz) Fl**	**Upper edge of BW (GHz) fh**	**Absolute BW (GHz) fh-fl**
Lg	**R1**	**R2**	**Wf**			
37.5	**13.5**	**10**	**3**	**3.33**	**3.58**	**0.25**
37.5	**14**	**10.5**	**3**	**3.32**	**3.56**	**0.24**
37.5	**14.5**	**11**	**3**	**3.35**	**3.57**	**0.22**

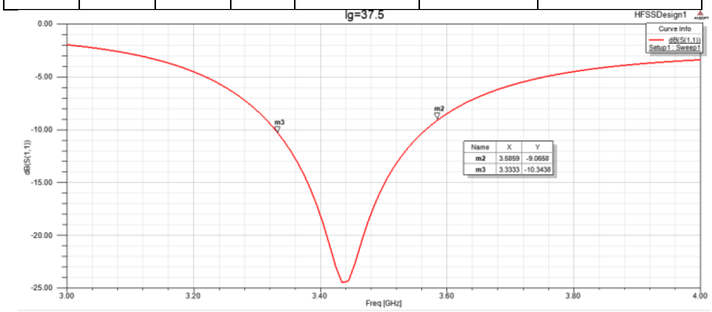

Fig 4: The simulated Returnloss of the designed 5G mobile antenna at solution frequency of 3.5 GHz where length of ground (Lg=37.5)

Fig 4, shows the simulated return loss S(1,1) curve of a 5G antenna at an solution freq. of 3.5 GHz. It is evaluated for 3GHz-4GHz. It is observed that the antenna shows a -10db impedance bandwidth from lower edge bandwidth (FL) 3.33 to upper edge bandwidth (FH) 3.58 GHz i.e. the absolute bandwidth (FH-FL) is 0.2 GHz.The maximum absolute bandwidth is obtained at R1= 13.5, and R2=10.

Table 3: Simulated -10db bandwidth of proposed antenna at Lg=37.6:

Parameters				**Lower edge of BW (GHz) FL**	**Upper edge of BW (GHz) FH**	**Absolute BW (GHz) FH-FL**
Lg	**R1**	**R2**	**Wf**			
37.6	**13.5**	**10**	**3**	**3.32**	**3.57**	**0.25**
37.6	**14**	**10.5**	**3**	**3.33**	**3.53**	**0.2**
37.6	**14.5**	**11**	**3**	**3.36**	**3.60**	**0.24**

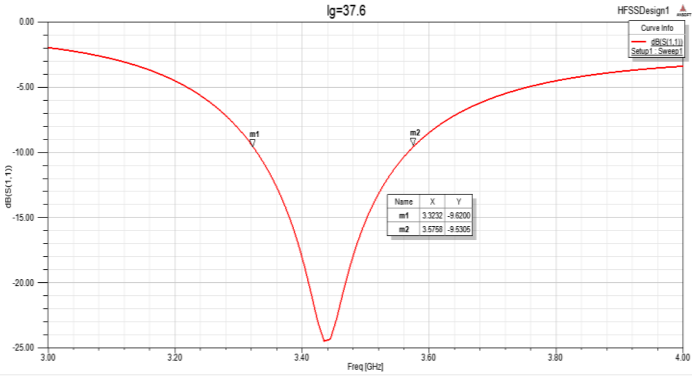

Fig 5: The simulated Returnloss of the designed 5G mobile antenna at solution frequency of 3.5 GHz where length of ground (Lg=37.6)

Fig 5, shows the simulated return loss S(1,1) curve of a 5G antenna at an solution freq. of 3.5 GHz. It is evaluated for 3GHz-4GHz. It is observed that the antenna shows a -10db impedance bandwidth from lower edge bandwidth (fl) 3.32 to upper edge bandwidth (fh) 3.57 GHz i.e. the absolute bandwidth (fh-fl) is 0.25 GHz. Therfore,The maximum absolute bandwidth is obtained at R1= 13.5, and R2=10.

Table 4: Simulated -10db bandwidth of proposed antenna at Lg=37.7:

Parameters				**Lower edge of BW (GHz) FL**	**Upper edge of BW (GHz) FH**	**Absolute BW (GHz) FH-FL**
Lg	**R1**	**R2**	**Wf**			
37.7	**13.5**	**10**	**3**	**3.33**	**3.56**	**0.23**
37.7	**14**	**10.5**	**3**	**3.33**	**3.56**	**0.23**
37.7	**14.5**	**11**	**3**	**3.33**	**3.56**	**0.23**

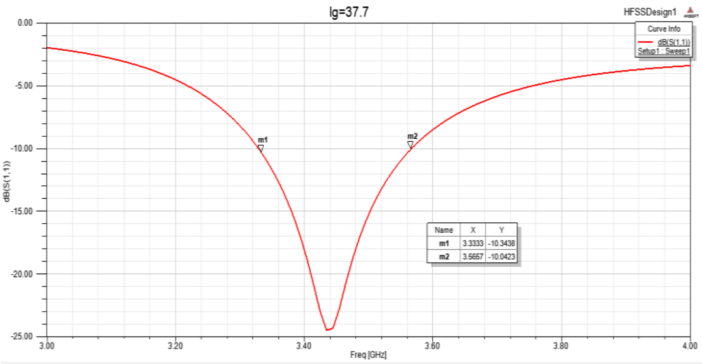

Fig 6: The simulated Returnloss of the designed 5G mobile antenna at solution frequency of 3.5 GHz where length of ground (Lg=37.7)

Fig 6,shows the simulated return loss S(1,1) curve of a 5G antenna at an solution freq. of 3.5 GHz. It is evaluated for 3GHz-4GHz. It is observed that the antenna shows a -10db impedance bandwidth from lower edge bandwidth (fl) 3.33 to upper edge bandwidth (fh) 3.56 GHz i.e. the absolute bandwidth (fh-fl) is 0.23 GHz. Therfore,The maximum absolute bandwidth is obtained at R1= 13.5, and R2=10.

Table 5: Simulated -10db bandwidth of proposed antenna at Lg=37.8:

Parameters				**Lower edge of BW (GHz) FL**	**Upper edge of BW (GHz) FH**	**Absolute BW (GHz) FH-FL**
Lg	**R1**	**R2**	**Wf**			
37.8	**13.5**	**10**	**3**	**3.33**	**3.56**	**0.23**
37.8	**14**	**10.5**	**3**	**3.33**	**3.56**	**0.23**
37.8	**14.5**	**11**	**3**	**3.33**	**3.56**	**0.23**

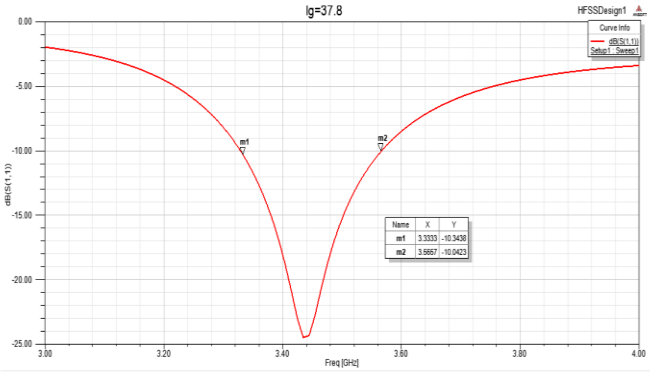

Fig 7: The simulated Returnloss of the designed 5G mobile antenna at solution frequency of 3.5 GHz where length of ground (Lg=37.8)

Fig 7, shows the simulated return loss S(1,1) curve of a 5G antenna at an solution freq. of 3.5 GHz. It is evaluated for 3GHz-4GHz. It is observed that the antenna shows a -10db impedance bandwidth from lower edge bandwidth (FL) 3.33 to upper edge bandwidth (FH) 3.56 GHz i.e. the absolute bandwidth (FH-FL) is 0.23 GHz. Therfore,The maximum absolute bandwidth is obtained at R1= 13.5, and R2=10.

III. SIMULATION RESULTS

The performance of micro strip antenna can be varied depending on number of parameters such as radius of circular patch (R1), semicircular radius of patch (R2), length (L) and width (W) of substrate, length (Lg) and width (Wg) of ground.

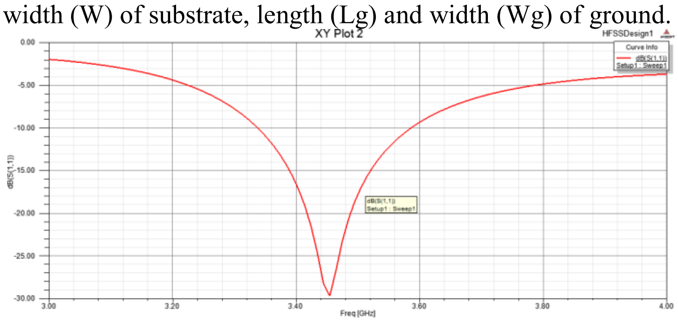

Fig 8: The simulated Returnloss of the designed 5G mobile antenna at solution frequency of 3.5 GHz

Fig 8, shows the simulated return loss S(1,1) curve of a 5G antenna at an solution freq. of 3.5 GHz. It is evaluated for 3GHz-4GHz. It is observed that the antenna shows a -10db impedance bandwidth from 3.3 – 3.6 GHz i.e.0.3GHz. The minimum value of S(1,1) is found to be -29.5 dB at 3.5 GHz. The S(1,1) parameter is also known as reflection coefficient.

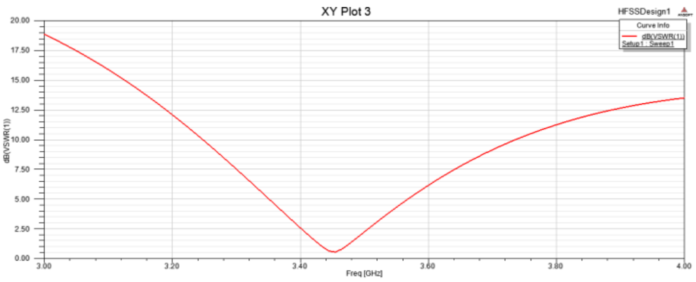

Fig 9: The simulated VSWR of the designed 5G mobile antenna at solution frequency of 3.5 GHz

Fig 9, shows the simulated VSWR of the designed a 5G antenna at solution freq. of 3.5 GHz. For better results VSWR readings should be taken below the value 2.5, VSWR less than 2.5 is obtained with value 1 at 3.5 GHz, and 2.5 at 3.4 GHz.

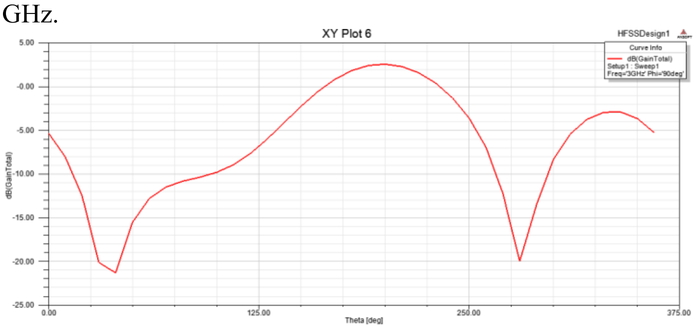

Fig 10: The simulated Gain of the designed 5G mobile antenna at solution frequency of 3.5 GHz

Fig 10, shows the gain Vs frequency plot of the designed 5G antenna at solution freq. of 3.5 GHz. The maximum gain is found to be 3 dB.

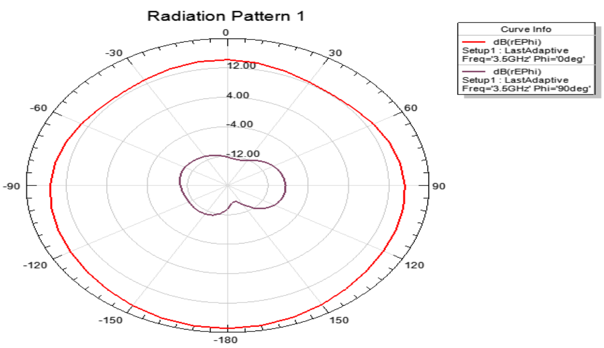

Fig 11: The simulated near field pattern of the proposed antenna at 3.5 GHz

Fig 11, shows simulated radiation pattern of the proposed antenna at 3.5 GHz of near Ephi field radiation. It is evaluated at the $\Phi=0^0$& $\Phi=90^0$ for all values of θ.

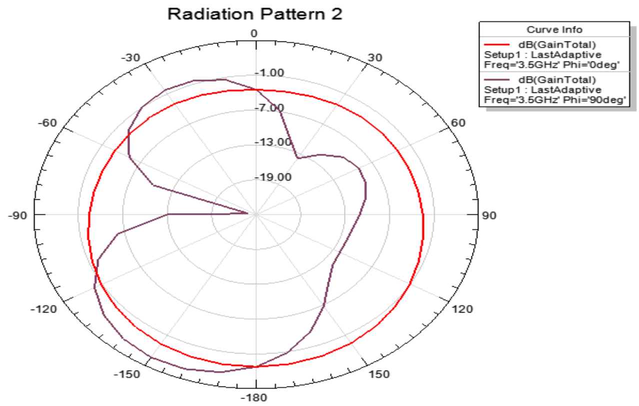

Fig 12: The simulated far field pattern of the proposed antenna at 3.5 GHz

Fig 12, shows simulated radiation pattern of the proposed antenna at 3.5 GHz of far field pattern. It is evaluated at the $\Phi=0^0$, it is in H plane & $\Phi=90^0$, E plane.

V.CONCLUSION

A design approach for a single band micro strip patch antenna, suitable for 5G Mobile Communications is proposed. The whole design is based on the partial ground plane approach. The applicability of the method is verified to fit the antenna for mobile application, since the achieved results fulfill the design constraints combining minimum S11 and low VSWR at the desired frequencies. The proposed antenna permits the coverage of single band including both lower and upper Mobile band (Spectrum assign in India for 5G application).Due to the frequency of operation and compact area occupied, the proposed antenna is promising to be embedded within the mobile device.

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