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Design and Simulation of Directional Antenna for Millimetre Wave Mobile Communication

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Abstract: With increase in the smart phone users the capacity demand also increases, the fifth generation (5G) mobile technology would be able to greatly increase communication capacity by using the large amount of spectrum in the millimetre wave (mmWave) bands. The studied references shows that in addition to capacity boosting technologies 5G needs to offer ultra-reliable communications, low latency and massive connectivity. In this paper, we present the motivation for future antenna for 5G mobile communication, methodology, and offer a variety of simulation results that show 2.8 GHz frequency can be used when employing steerable directional antenna. The proposed idea is implemented by using HFSS software.

Keywords: 2.8GHz, millimetre-wave, 5G, Mobile Communication, Directional Antenna, HFSS.

I. INTRODUCTION

The rapid increase in mobile data growth and the use of smartphones are creating challenges for wireless service providers to overcome a global bandwidth shortage. At some point around 2020 wireless network will faces the conjunction problem as well as need to implement new technology to serve the demands of the customers. To overcome this problem millimetre wave mobile Communication which is nothing but 5G is introduced.

The mm-wave carrier frequencies allow for larger bandwidth allocations which increases the data transfer rate. It also allows service providers to significantly expand the channel bandwidths beyond the present 20 MHz channels used by 4G customers. Mm-wave frequencies, because of much smaller wavelength, the base station-to-device links, as well as links between base stations, will be able to handle much larger capacity than today's 4G networks in highly populated areas. 5G technology will be a key component of the Networked Society. It will provide low latency could range between 1ms to 10 ms, real-time response, high reliability communication and also support massive numbers of connected devices. It will be more adaptive to users need and demand. The main aim of the project is to design microstrip patch antenna which will work for 5G mobile communication based on the antenna parameter such as Gain, radiation pattern, Directivity etc. for simulation. This project introduces the millimetre wave mobile communications technique at 2.8 GHz frequency rather than 28 GHz or 38 GHz, as it is difficult to use such high frequencies practically.

II. LITERATURE REVIEW

In this paper “Millimetre-Wave Mobile Communications Microstrip Antenna for 5G - A Future Antenna”, they have designed microstrip patch antenna for millimetre wave mobile communication at 38 GHz frequency by using the basic micro-strip transmission line methodology and line calculation analyze from ADS software. In that design, input reflection coefficients or the S11 parameter for the antenna element was -42.78dB at resonant frequency 38.11GHz, peak Gain 9.025 dB, the maximum -10dB bandwidth of 1.27GHz was achieved in simulation of S11 parameter for frequency band 37.56-38.83 GHz and Directivity 10.0336dB was obtained by electric field radiation pattern of array in 3-D analysis of ADS software.

III. PROPOSED PLAN OF WORK

In the proposed system, microstrip patch antenna for millimetre wave mobile communication operating at center frequency of 2.8 GHz is designed by using the basic micro-strip transmission line methodology (formulas) and HFSS software which is shown in fig.1. Micro-strip patch antenna (MPAs) is used as it has features such as light weight, low cost, low profile, small size, as well as to the fact these are very simple to design, suited to planer and non-planer surfaces.

The proposed antenna consist of a Rectangular radiating patch on one side of dielectric substrate with a ground plane on the other side of it. Due to the absence of the top ground plate and the dielectric substrate above the strip, the electric field lines remain partially in the lower dielectric substrate and partially in air. This makes the mode of propagation not pure TEM but that is quasi-TEM. The micro-strip antenna design consists of finding the values of width (w) and length (l) of patch and width (W_g) and Length (L_g) of ground plane by using transmission line formulas which depends on three essential parameters which are:

- Frequency of operation (f_o): 2.8 GHz.
- Dielectric constant (ε_r): 1.964.
- Height of dielectric substrate (h): 2mm.

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The equations are as listed below as:

$W = C/2f_0 \sqrt{(\varepsilon_{reff} + 1)/2}$

$\varepsilon_{reff} = (\varepsilon_r+1)/2 + (\varepsilon_r-1)/2[1+12(h/W))-1/2$

$\Delta L = 0.412h\ [(\varepsilon_{reff} + 0.3)*\{(W/H)+ 0.264\}]\ /[(\varepsilon_{reff} - 0.258)*\{(W/H)+ 0.8\}]$

$L_g = 6h + L$

$W_g = 6h + W$

Effective length $L_{eff} = L + 2\Delta L$
Patch Width = 4.4 cm
Length = 3.483 cm
Height =30 um
Dielectric =1.964
Total Height = 5.20 cm
Centre frequency = 2.8GHz

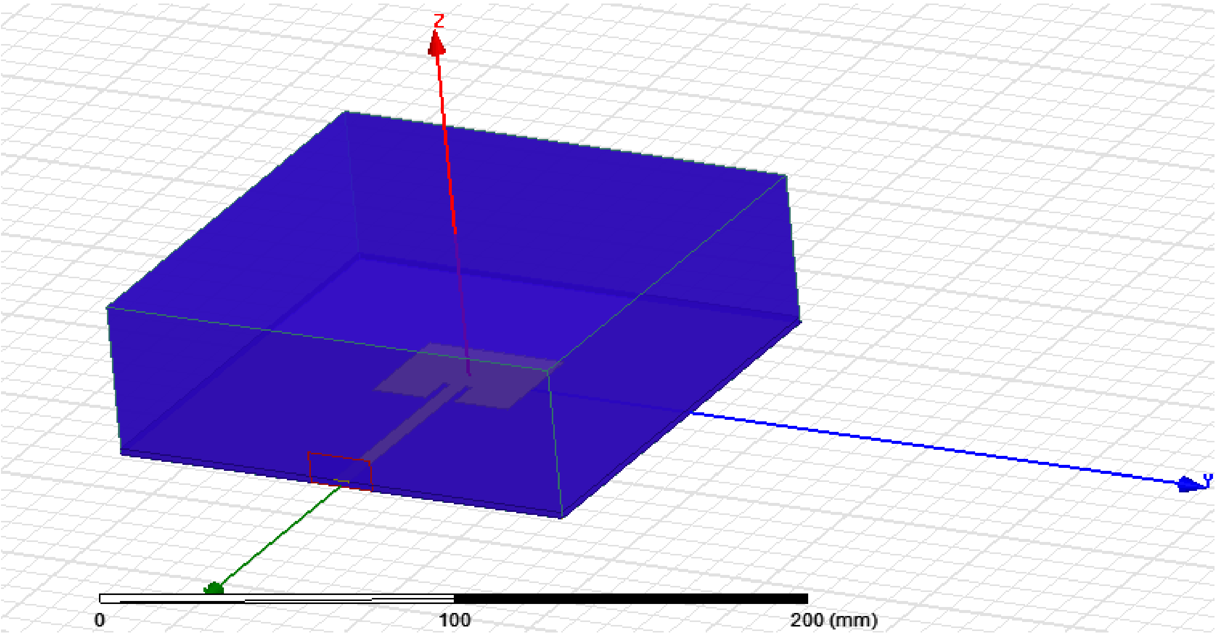

Fig.1. Microstrip patch antenna designed using HFSS

IV. SIMULATION RESULTS

The output results of designed antenna when simulated on HFSS are shown below which includes return loss, impedance plot, radiation pattern, gain Vs frequency and directivity.

A. Return Loss

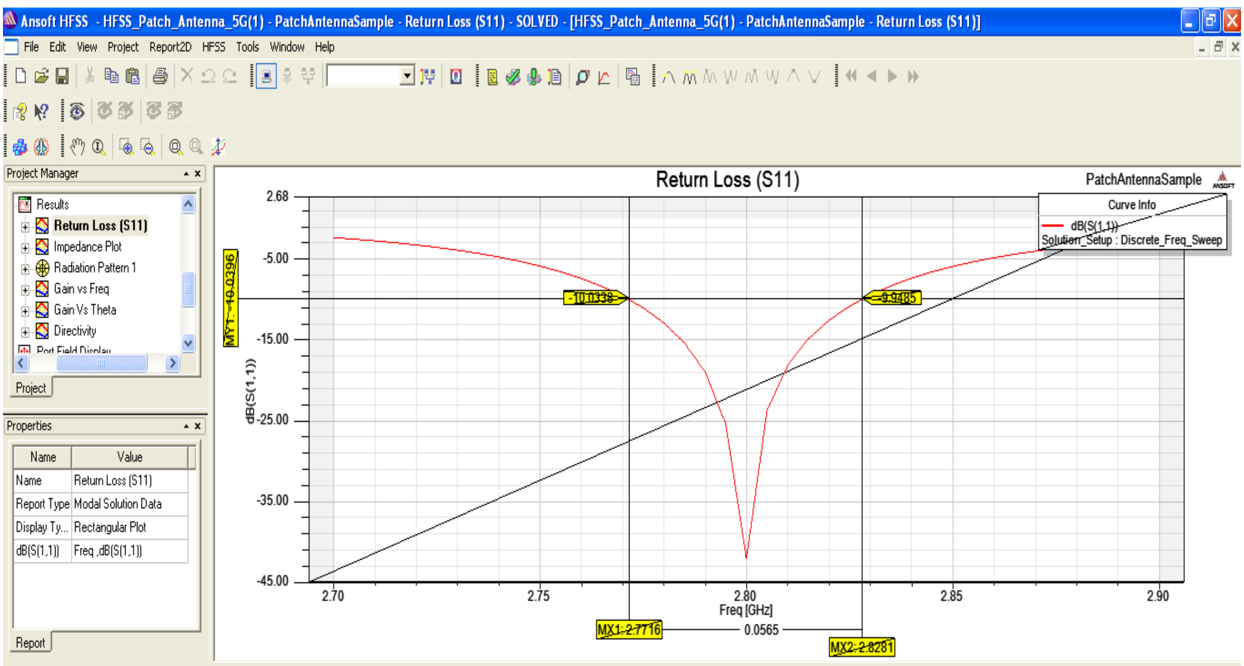

Fig.2. Return Loss Plot

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B. Impedance Plot

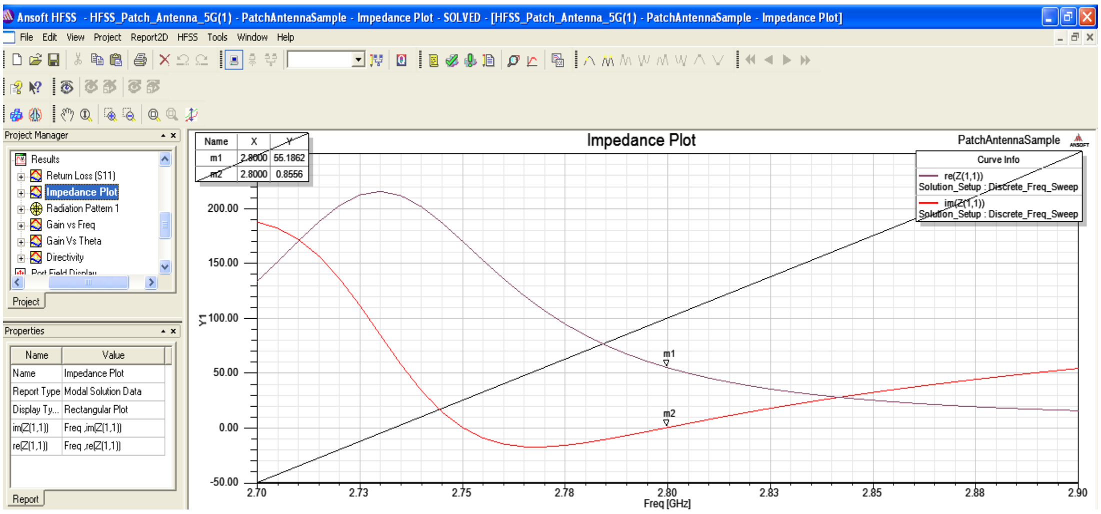

Fig.3. Impedance Plot

C. Radiation Pattern

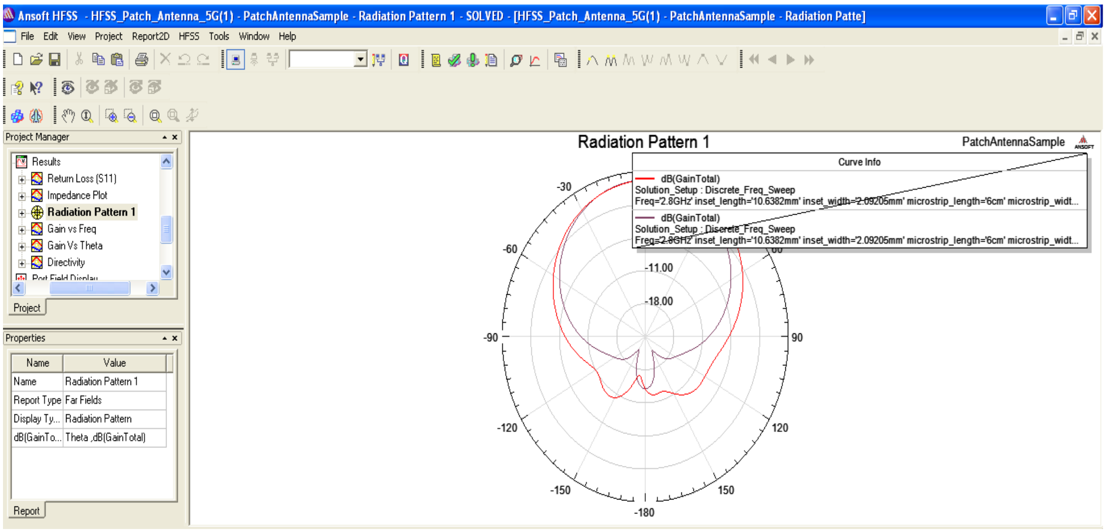

Fig.4. Radiation Pattern Plot

D. Gain Vs Frequency

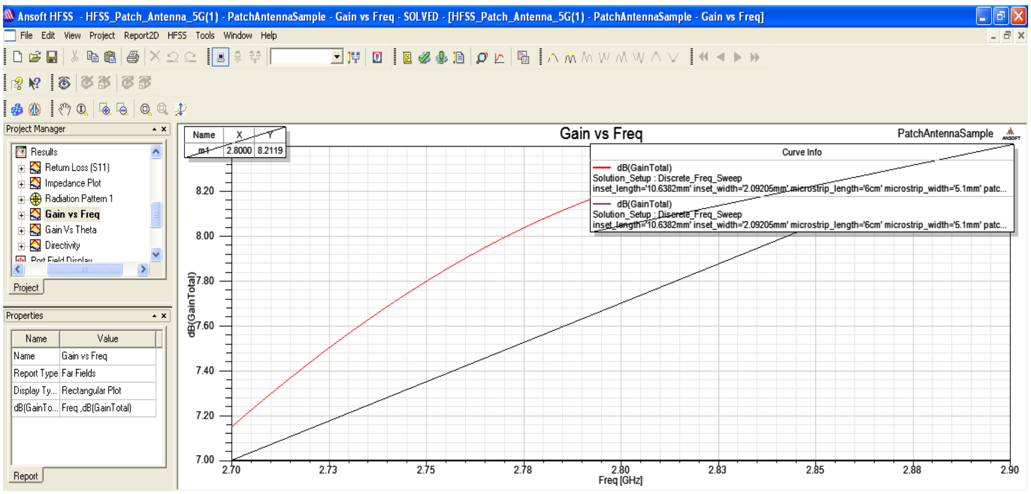

Fig.5. Gain Vs Frequency Plot

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E. Directivity

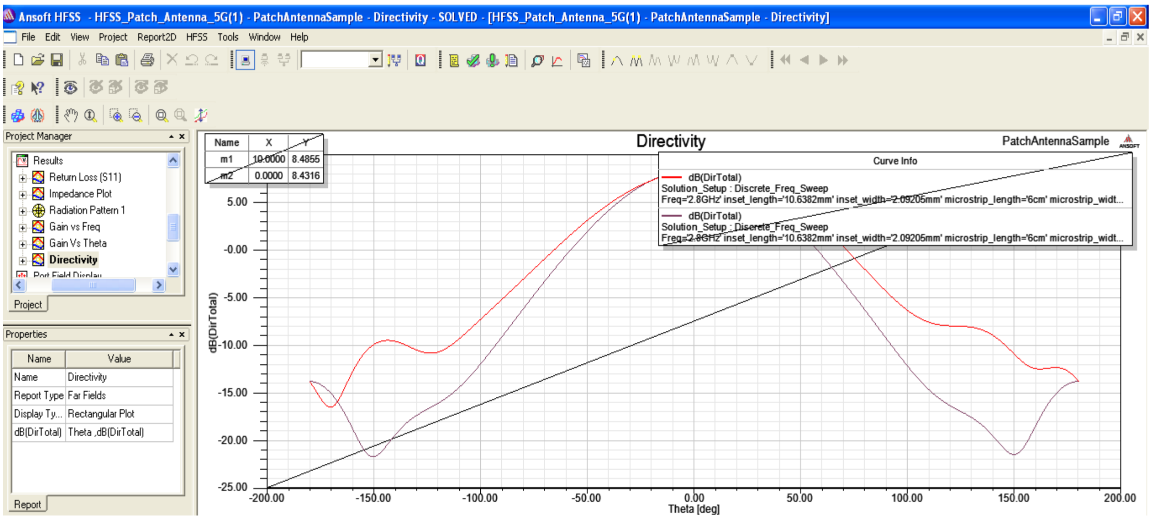

Fig.6. Directivity Plot

In proposed design excited in its fundamental mode has a maximum directivity in the direction perpendicular to the patch (broadside) and is 8.4316 dB. In this design, input reflection coefficients or the S11 parameter for the antenna is -42 dB at resonant frequency 2.8 GHz. The peak Gain 8.211 dB and the maximum -10dB bandwidth of 0.0565GHz has been achieved in simulation of S11 parameter for center frequency 2.8 GHz.

V. CONCLUSION

Serial No.	Parameter	Reported design F_o=38GHz	Proposed design F_o=2.8GHz	Remark
1.	Return loss	-42.78dB	-42dB	Return loss is not improved much. Commercial antenna has return loss of -40dB
2.	Bandwidth	1.27GHZ	0.0565GHz	Lesser bandwidth means higher noise immunity.
3.	Gain	9.025dB	8.2119dB	Gain Decreased in present work
4.	Directivity	10.033dB	8.48dB	Proposed design is more directional as compared to reported design

In this paper, the microstrip patch antenna is designed for 5G and simulated using HFSS software. The simulated result gives good performance in terms of different antenna parameters that are compared with reported design, which shows that the proposed design is working well and that it has achieved the desired results. Furthermore this approach can be used to design a directional antenna for the millimeter wave mobile communication which will work at frequencies 2.8 GHz.

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