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Circularly Polarized Multi Band Patch Antenna for High Frequency Wi-Fi and Wi-MAX Application Simulated with CST Studio Suite

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Abstract: A circularly polarized multi band patch antenna for high frequency application was proposed. The main purpose of this antenna is for wireless communication mainly Wi-Fi and WiMAX applications and also satisfy the bandwidth quotation of 5G application. In our work, we presented a concept of designing antenna that can work simultaneously 1.1 / 2.8 / 3.3 / 5.7 / 6 and 7.4 GHz for multiple wireless and Network applications. The special shaped patch antenna is used to attain multiple bands. It is an I shaped antenna, along with a tilted and inverted two u shaped antenna patched over it. One thick inverted U shaped antenna, tilted with 45^0 and another is of thin inverted u shaped antenna that tilted 90^0 in accordance with a previous tilted patch, that is about 45^0 to I shaped antenna but on opposite side of thick patch. It is connected to thick U shaped patch not with an I shaped patch. All rotation and tilting are done in horizontal axis. A 6*6 square metallic patch antenna was designed in back for simple frequency selecting purpose. Those Metallic patch surfaces behave as a simple frequency select surface (FSS). The main purpose of tis antenna is to achieve a frequency range of 5.7/6 GHz which are used for WiMAX application all over the world but the use depends upon the countries and 7.4 GHz which is proposed by USA for 5G applications.
Keywords: Multiband antenna; Circularly polarized antenna; Wi-Fi and WiMax application; proposed 5G bandwidth; Patch antenna; CST studio suite;

I. INTRODUCTION

In 1886 Hertz built the first radio link service which acts as a milestone for the antenna development, since that the most critical technology involved in antenna design, which helped people to get connected globally. Due to the rapid development in the radio technology, several advancements happened in antenna technology for the past 130 years. We made our own advancement that, a circularly $_{\text{polarized}}$ multi band antenna was proposed. The main purpose of this antenna is for wireless Wi-Fi and WiMAX applications and also a proposed 5G bandwidth.

Wireless applications are going to rule the communication systems of next generations, hence a lot of research and development is going on in the wireless communication systems, concentrating on multi bandwidth and multi-functional antenna systems. In this antenna a multiple band, say six bands are identified for primary use.

Since the linearly polarized (LP) antennas have their own drawbacks, circularly polarized (CP) antennas took its place over time, in the modern wireless communication systems. There available a multiple patch antenna separately for each frequency application but not on a single antenna. So we are here to deal with a single patch antenna, that can handle all threads over distinguished different frequency simultaneously.

In our work, we presented a concept of designing antenna that can work simultaneously 1.1 / 2.8 / 3.3 / 5.7 / 6 and 7.4 GHz for wireless Network applications. These multiple bands are attained by using and special shaped patch antenna. It is an I shaped antenna, along with a tilted and inverted two u shaped antenna patched over it. One thick inverted U shaped antenna, tilted with 45^0 and another is of thin inverted u shaped antenna that tilted 90^0 in accordance with a previous tilted patch, that is about 45^0 to I shaped antenna but on opposite side of thick patch. It is connected to thick U shaped patch not with an I shaped patch. All rotation and tilting are done in horizontal axis. The 6*6 square metallic patch antenna was designed in back for simple frequency selecting purpose. Those Metallic patch surface behave as a simple frequency select surface (FSS). The main purpose of this patch antenna is to achieve a frequency range of 5.7 / 6 GHz which are used for WiMAX application all over the world and 7.4 GHz proposed for 5G application by USA. Antennas has to be designed in such a way that it must be efficient enough for the practical applications. So the design must be smaller and less complicated, which tend to be the motive of our design.

II. DESIGNING OF ANTENNA

The proposed antenna's design could be carried oud aa a three step procedure, where Preperm 1000 lossy of 1.53 mm thickness and a dielectric constant of 10. On which the multi-band CP antenna is suspended. The Preperm 1000 lossy is selected mainly for its variable dielectric constant property. The next step is designing the metallic Frequency Selecting surface, which is carried out by referring the reflection phase characteristics. Tri band patch antenna design is shown in Fig 1.

The final stage is designing a patch antenna which is to be held at a height h above the FSS. The Frequency selecting surface composed designed in a 6*6 layout each is of square shaped that overall comprises of 36 unit cells. It is designed on a Taconic RF-35 substrate. Its thickness is 1.53 mm, dielectric constant is 3.4 and a loss tangent of 0.002. Consider L to be the horizontal (x-plane) distance between the bottom edge of antenna substrate and FSS substrate. The Frequency Selecting Surface in an antenna is shown in Fig.2 which is simulated by using CST Studio Suite.

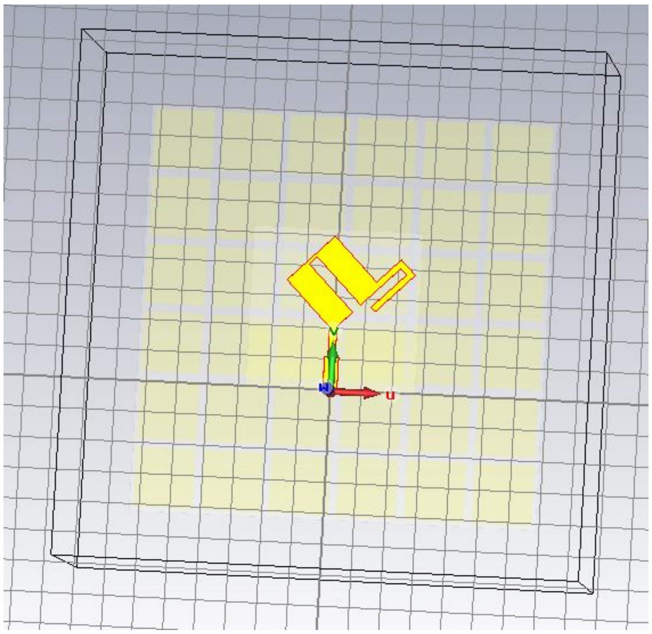

Fig 1. Tri band Patch antenna design

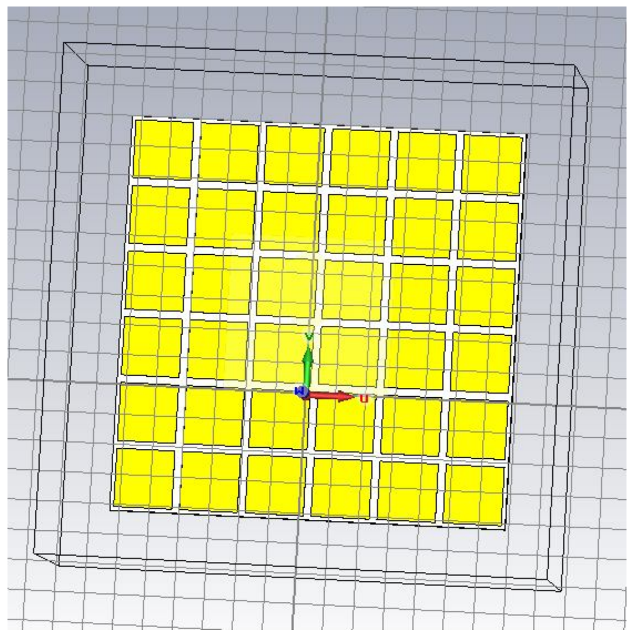

Fig 2. Frequency selecting Surface

A. Tri Band Patch Antenna Design

1.1 GHz, 2.8 GHz, 3.3 GHz are the three frequency bands that are attained by using and special shaped patch antenna. It is an I shaped antenna, along with a tilted and inverted two u shaped antenna patched over it. One thick inverted U shaped antenna, tilted with 45^0 and another is of thin inverted U shaped antenna that tilted 90^0 in accordance with a previous tilted patch, that is about 45^0 to I shaped antenna but on opposite side of thick patch. It is connected to thick U shaped patch not with an I shaped patch. Fig.1 shows the structure of Tri-band patch antenna. All rotation and tilting are done in horizontal axis. The final optimized geometrical structure of the tri-band CP patch antenna was obtained through simulations with CST Studio Suite.

B. Frequency Selecting Surace Design

The geometry of the square unit cell and the patch implemented are 19.55 mm and 22.185 mm respectively. The unit cell is designed with calculated reflection phase, that throttles between $+90^o$ and -90^o with

1) 5.7–5.45 GHz, as its frequency range with 5.7 GHz resonant frequency.
2) 6.15–5.85 GHz, as its frequency range with 6 GHz resonant frequency.
3) 7.75–7.15 GHz, as its frequency range with 7 GHz resonant frequency.

The overall size of the frequency selecting surface is 135.2 × 135.2 mm. A wave port which excites the CP patch was placed above the frequency selecting surface(FSS), at an altitude of 28.2 mm. The Fig.2 Shows the design of FSS.

C. Finalizing Antenna Design

The multi-band Circularly polarized patch antenna is first suspended at an altitude of 28.2 mm from the center of the frequency

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selecting surface. The characteristics of antenna for various unit cells of different number and character were studied. 6 × 6 metal patches were inferred along horizontal (x axis) and vertical axis (y axis) to have a better output. Finally, the necessary alterations and changes are made in position and dimensions antenna are made to get the best results at the required frequencies : 1.1 GHz, 2.8 GHz, 3.3 GHz, 5.7 GHz, 6 GHz and 7.4 GHz

III. ANALYSIS OF DESIGNED ANTENNA

S-parameter, Efficiency and VSWR (Voltage Standing Wave Ratio) is considered as the most important parameter of the antenna. The S-parameter and Efficiency are shown in Fig.3 and Fig.4 respectively.

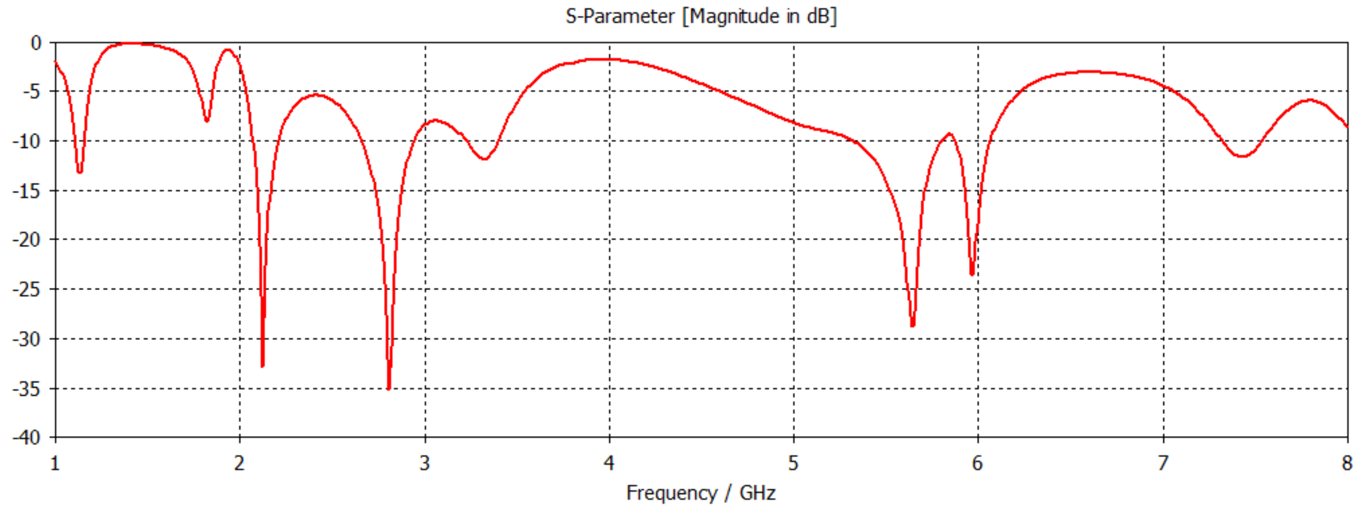

Fig 3. S-Parameter

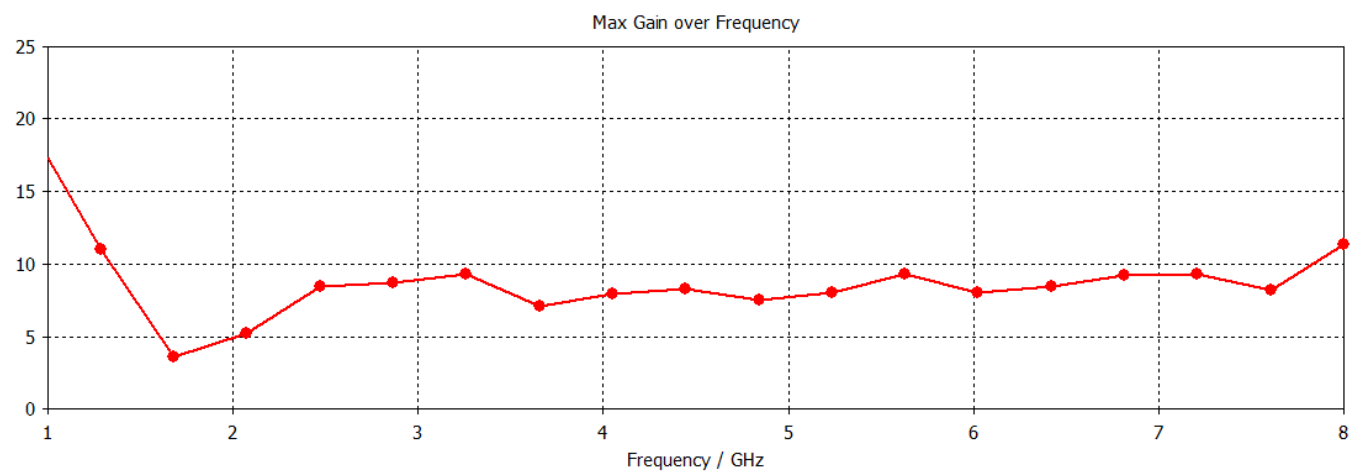

Fig 4. Maximum gain over frequencies

The fig.3 shows that the radiation of antenna is best at implied frequencies: 1.1/ 2.8/ 3.3/ 5.7/ 6 and 7.4 GHz. The Fig.4 shows the maximum gain of the antenna on all frequencies. It is to be noted that the gain is high on desired frequency than other frequencies.

The relationship between the output and the input terminals or ports can be analysed and described by an S-parameter. In antenna design return loss is a highly considerable parameter, which gives the magnitude of the reflected power from the antenna, if the parameter hits 0dB then all the power is reflected and no sign of power radiation.

The remaining power is accepted by antenna itself, so it is neither absorbed nor radiated by the antenna. Practically most of the power delivered to the antenna gets radiated hence VSWR directly impacts on the return loss of the antenna. The theoretical (simulated) and the practical return loss is shown in Fig. 3. the theoretical and measured results comes nearly close together, with some inevitable refinements with corresponding boundary conditions in the simulation environment.

VNA (Vector Network Analyser) is used to measure return loss and by using that we can plot S11. The proposed antenna design has

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shown a significant Multi-Band operation in the frequencies: 1.1GHz, 2.8GHz, 3.3GHz, 5.7GHz, 6GHz and 7.4GHz.

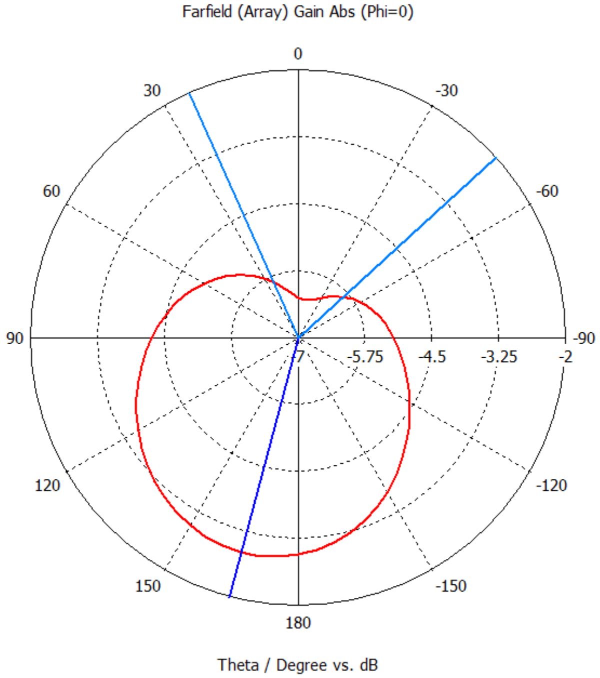

Fig 5. Farfield directivity plot for 1.1 GHz

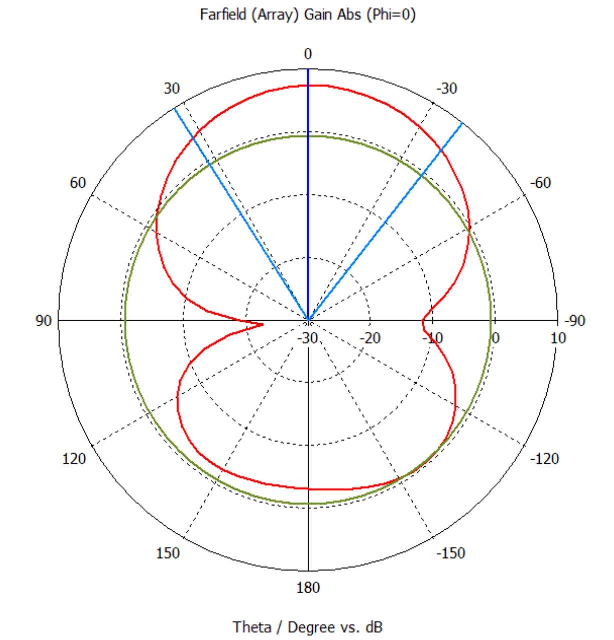

Fig 6. Farfield directivity plot for 2.8 GHz

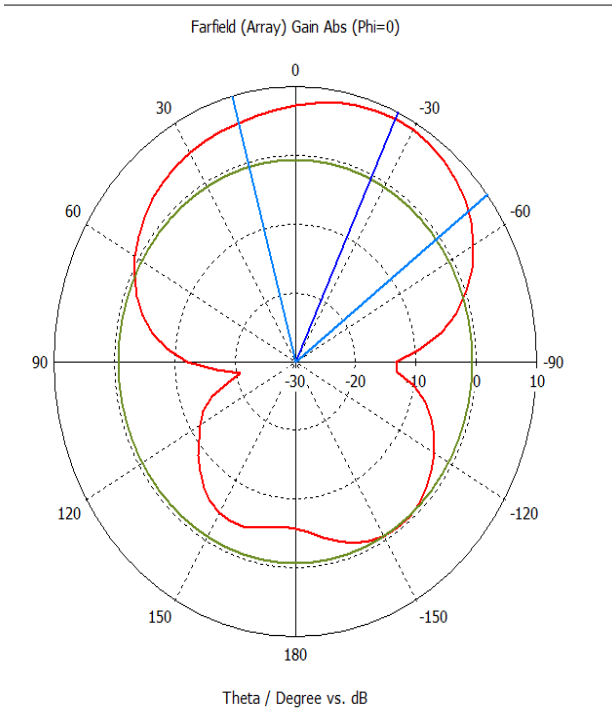

Fig 7. Farfield directivity plot for 3.3 GHz

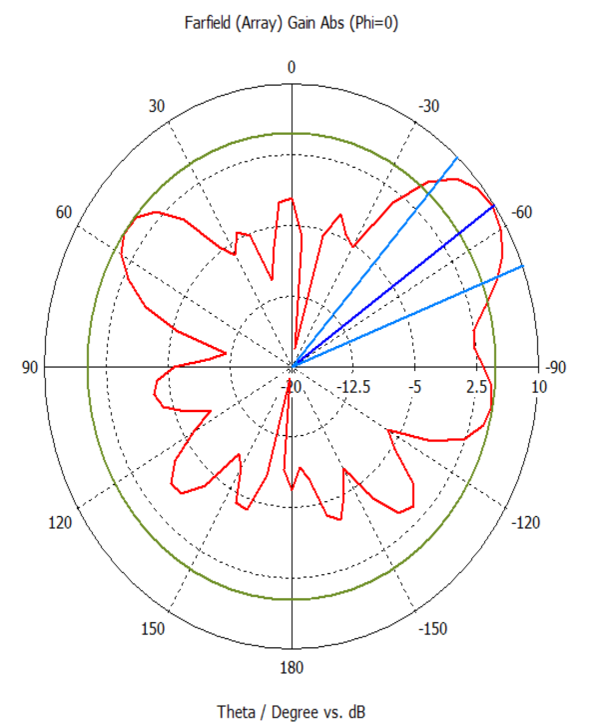

Fig 8. Farfield directivity plot for 5.7 GHz

The farfield directivity analysis and gain of the antenna for various frequency are shown from Fig.4 to Fig 10. Each radiation pattern for each frequency has its own parameters. The parameters to be considered are main lobe magnitude, main lobe direction, side lobe level, radiation efficiency, total efficiency and directivity.

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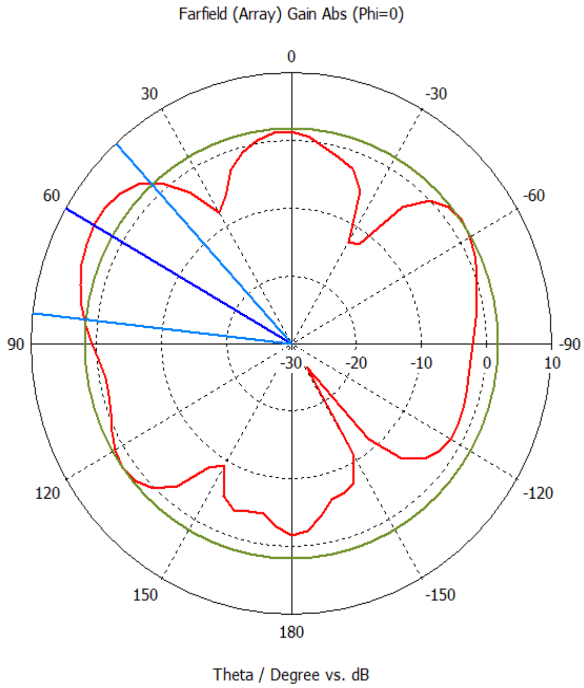

Fig 9. Farfield directivity plot for 6 GHz

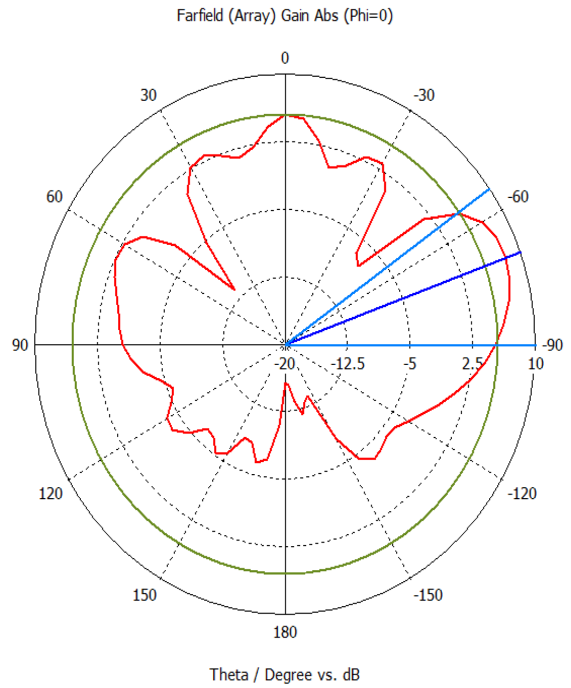

Fig 10. Farfield directivity plot for 7.4 GHz

The considered parameters for the designed antenna is tabulated below.

Frequency	**: 1.1**
Main lobe Magnitude	: -4.42 dB
Main lobe direction	: -175.0 deg.
Angular Width (3 dB)	:120.1 deg.
Side lobe level	: -4.3 dB
Radiation Efficiency	: -6.993 dB
Total Efficiency	: -8.187 dB
Gain	: 4.118 dB
Frequency	**: 5.7**
Main lobe Magnitude	:9.7 dB
Main lobe direction	: -55 deg.
Angular Width (3 dB)	: 27 deg.
Side lobe level	: -4.9 dB
Radiation Efficiency	: -0.3609 dB
Total Efficiency	: -0.9020 dB
Gain	: 10.31 dB
Frequency	**: 2.8**
Main lobe Magnitude	: 7.37 dB
Main lobe direction	: 0 deg.
Angular Width (3 dB)	: 70.5 deg.
Side lobe level	: -8 dB
Radiation Efficiency	: -0.3986 dB
Total Efficiency	: -0.7273 dB
Gain	: 8.118 dB
Frequency	**: 6**
Main lobe Magnitude	: 5.06 dB

Main lobe direction	: 60 deg.
Angular Width (3 dB)	: 41.3 deg.
Side lobe level	: -3.2 dB
Radiation Efficiency	: -0.3734 dB
Total Efficiency	: -0.7307 dB
Gain	: 8.104 dB
Frequency	**: 3.3**
Main lobe Magnitude	: 8.96 dB
Main lobe direction	: 25 deg.
Angular Width (3 dB)	: 67.7 deg.
Side lobe level	: -9.6 dB
Radiation Efficiency	: -0.1467 dB
Total Efficiency	: 0.1629 dB
Gain	: 8.958 dB
Frequency	**: 7.4**
Main lobe Magnitude	: 8.09 dB
Main lobe direction	: -70 deg.
Angular Width (3 dB)	: 35.6 deg.
Side lobe level	: -2.6 dB
Radiation Efficiency	: -0.49 dB
Total Efficiency	: -1.625 dB
Gain	: 8.677 dB

The radiation pattern of an antenna for different frequencies are shown below in 3D model diagram. These 3D models are shown below.

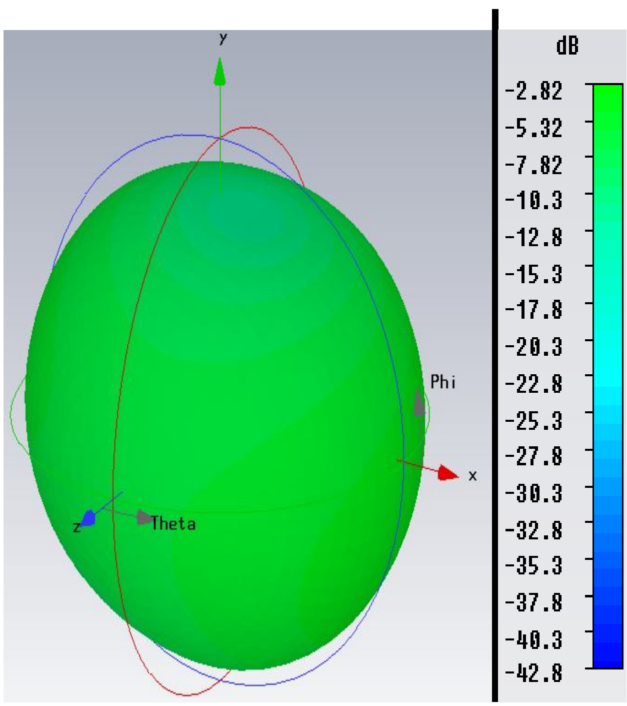

Fig 11. Radiation Pattern for 1.1 GHz

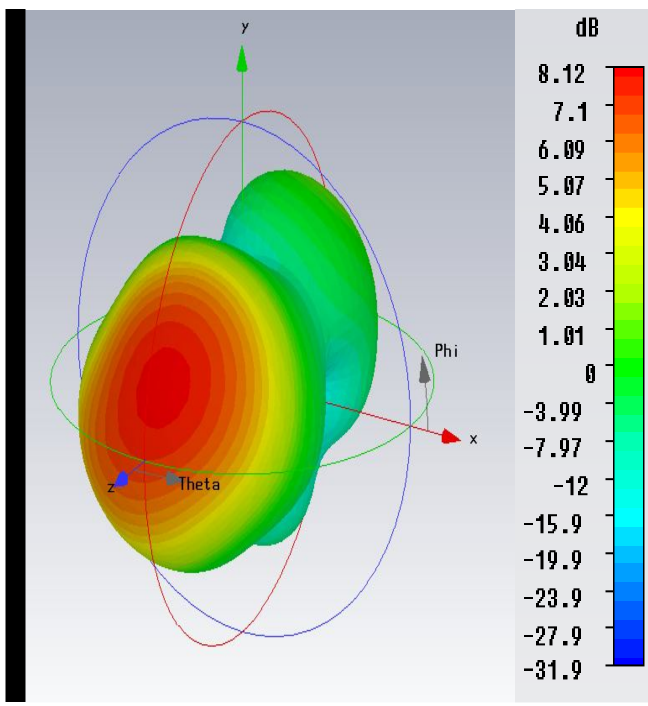

Fig 12. Radiation Pattern for 2.8 GHz

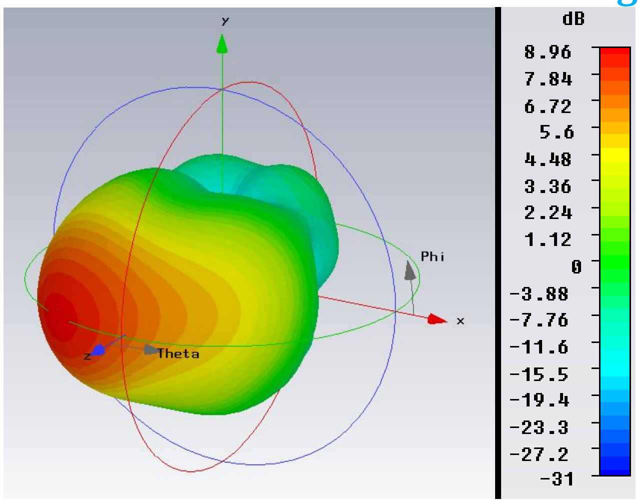

Fig 13. Radiation Pattern for 3.3 GHz

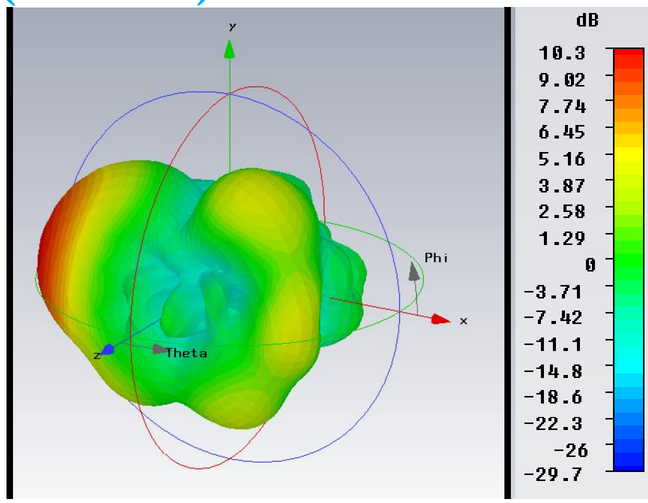

Fig 14. Radiation Pattern for 5.7 GHz

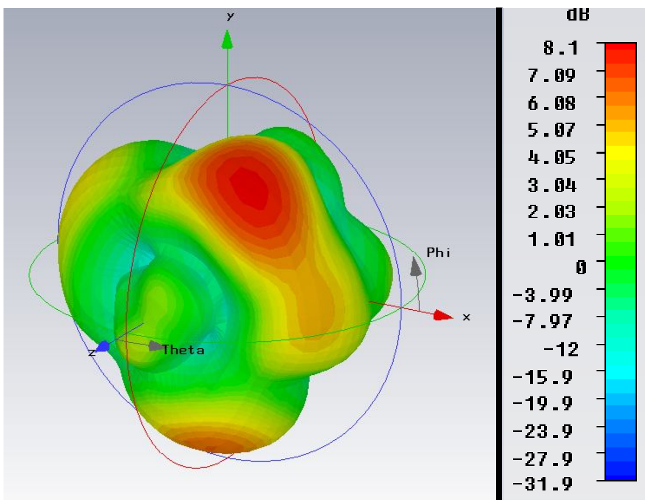

Fig 15. Radiation Pattern for 6 GHz

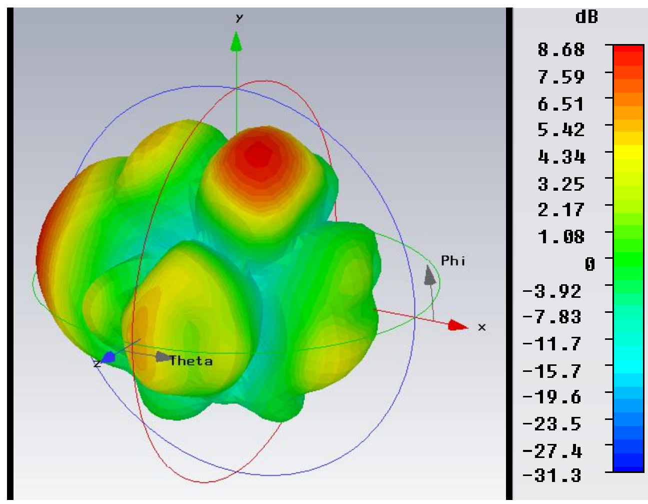

Fig 16. Radiation Pattern for 7.4 GHz

IV. CONCLUSION

The Circularly Polarized Multi band patch antenna for high frequency Wi-Fi and WiMAX Application and proposed 5G frequency range was designed, fabricated and characterized. The same is simulated using a simulation tool named CST Studio suite. In this antenna the six frequency bands was achieved. For NFC application 1.1 GHz is used, WLAN applications the frequency band of 2.8 / 5.7 / 6 GHz and for WiMAX applications the frequency band of 3.3 GHz was achieved effectively with high efficiency. It is to be noted that proposed 5G bandwidth of 7.4 GHz is also achieved.

The performance properties of the proposed antenna are analysed for the optimized dimensions and the proposed antenna was designed successfully.

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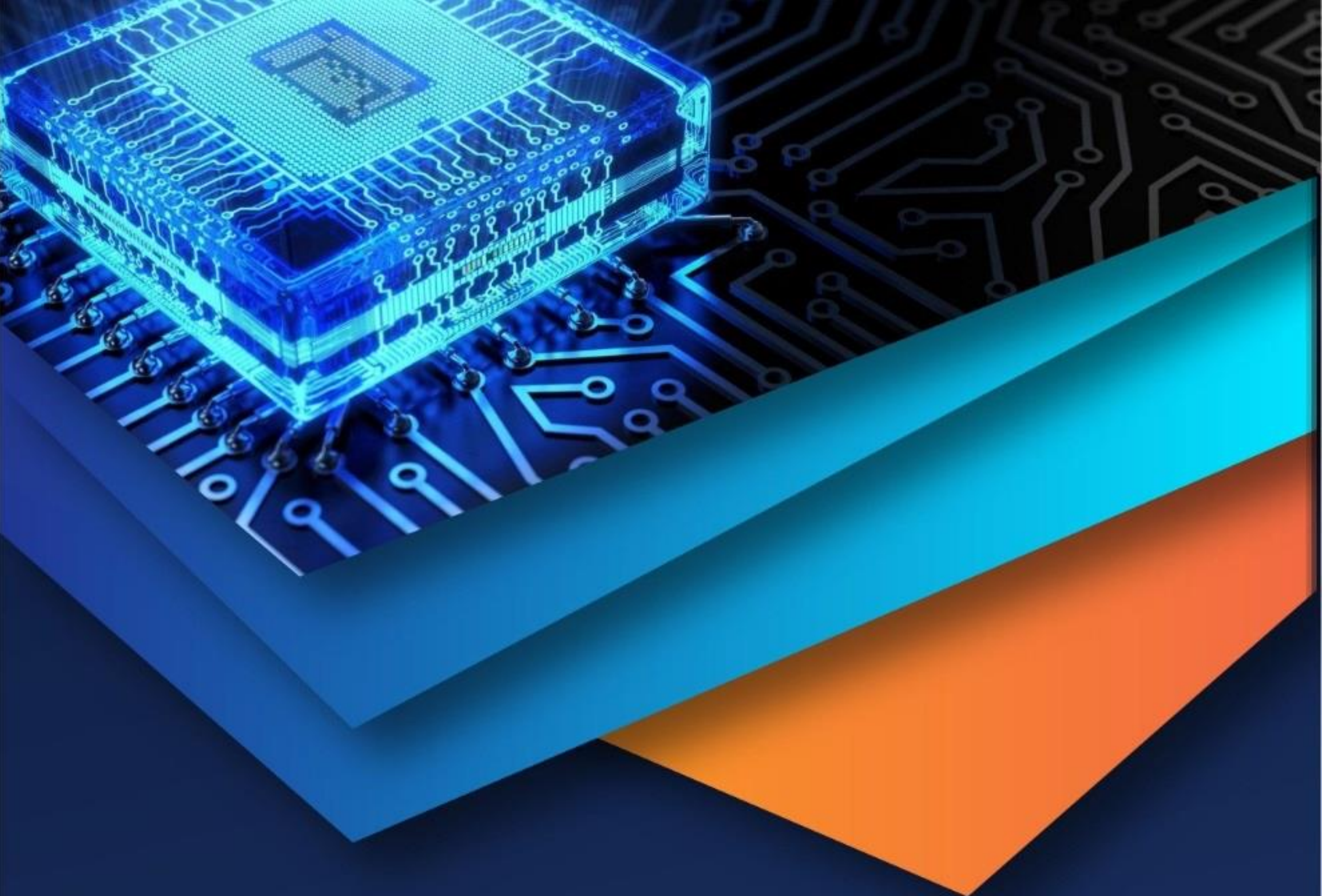

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