Performance Analysis Of E- Shape And 5G Microstrip Patch Antennas

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Abstract: This paper presents analysis of two patch antenna, an E-shape patch antenna and a patch antenna in the 5G frequency spectrum or better which is still in the mm wave frequency band. The comparative studies among both the antennas showed that the mm wave antenna is best suited for the modern mobile communication which requires data transfer at an extremely high data speed. The first design is an E- shape patch antenna proposed with a return loss of -15 decibels at a frequency of 2.4 GHz. The VSWR below 2 for the entire band of frequency. The second design which is proposed is a rectangular patch with microstrip line feed. The return loss is approximately -15 decibels at a frequency of 26.5 GHz. The second antenna design is compact with a satisfactory value of return loss in the mm wave band suitable antenna for use in 5G technology for mobile communication.

Index Terms: EM spectrum, E shaped patch antenna, 5 G spectrum antenna, HFSS, return loss, resonant frequency, mm wave.

1. INTRODUCTION

THE initial phase of communication among the humans started by sound (voice). As there was a need to increase the distance involved in communication, more tools like drums and visual techniques like smoke signals and signal flags were adapted. These tools that were a part of the optical communication, used only the light section of the EM spectrum. Recently, in the history of us humans, the EM spectrum (outside the visible region) has been used for communication purposes by the implementation of radio frequencies system. The significant natural resources of humankind include the EM spectrum and the antennas have been influential in controlling this resource [1]. Therefore microstrip antennas has been introduced for the communication through the EM spectrum. A main factor that contributes for the current advances of the microstrip antenna is the ongoing rebellion in miniaturization of electronic circuit which happened due to the advancement in the large-scale integration. As these microstrip antennas are often costly and heavy part of any electronic system, these conventional antennas based on a photolithographic technology are proof of an engineering advancement

1.1 Microstrip Antennas

A Microstrip Antenna is made up of a ground plane (separated by dielectric substrate) with a conducting patch. This was not developed until the rebellion of miniaturization of electronic circuits and the large-scale integration of the 1970s. Past that, various authors differently described the ground plane radiation (by a dielectric substrate) for different arrangements. Munson worked on the Microstrip Antenna (antenna having a lower profile, mounted on flush for its use in missiles and rockets) and the study showed that this was a practical concept which could be used for different antenna related issues. Numerous mathematically designed models were made and its applicability was increased for its use in another fields.

1.2 Patch Antennas

Patch antennas are appealing because of their features low weight, consistency and cheap cost. This type of antennas can be meshed with strip-line that's printed feed-networks and several active devices [2-3]. The application for this antenna began in the early 1970's when the consistent antennas were in demand as they could be used in missiles [4-5]. Since then, circular, rectangular, E-shape [6-7] microstrip patches (resonant) have been in use enormously in distinct array configurations.

2. Design Specifications, Analysis and Observations

2.1 Design Equations: The equations from (1-7) represents the mathematical Equations used in

designing the both the antennae discussed here.

$$\lambda g = \frac{\lambda o}{\sqrt{\varepsilon\, eff}} \quad (1)$$

where, $\varepsilon\, reff = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r+1}{2}\left[1+12\,\frac{h}{w}\right]-\frac{1}{2}$ (2)

Where ε_r is the relative permittivity and ε_{reff} is the effective relative permittivity of the substrate, λ_o is the resonant wavelength and ΔL is the due to fringing effect.

$$Leff = \frac{c}{2fr\sqrt{\varepsilon\, reff}} \quad (3)$$

$$L = Leff - 2\Delta L \quad (4)$$

$$\Delta L = \frac{(\varepsilon\, reff+3)\left(\frac{w}{h}+\ 0.264\right)}{(\varepsilon\, reff-8.258)\left(\frac{w}{h}+0.8\right)} \quad (5)$$

For rectangular patch antenna, the resonance frequency (f_o) is given by

$$fo = \frac{c}{2\sqrt{\varepsilon\, reff}}\left[\left(\frac{m}{L}\right)^2 + \left(\frac{n}{W}\right)^2\right]^{\frac{1}{2}} \quad (6)$$

where m & n are modes, and for efficient radiation, the width of the patch is (w) and c is the velocity of EM wave respectively.

$$w = \frac{c}{2\ f_0\sqrt{(\mathcal{E}r+1)/2}} \quad (7)$$

2.2 Tools Used (HFSS)

ANSYS HFSS is a 3-Dimensional EM software that is used for simulation and designing of electronic products working on high-frequency like antenna arrays, antennas, high-speed interconnects, RF or microwave components, IC packages, connectors, filters and printed circuit boards. The High Frequency Structure Simulator (HFSS) uses an intuitive GUI and versatile solvers to provide an unmatched performance and in addition to that a deep understanding into all the 3-Dimensional EM issues. HFSS gives a strong analysis of electronic devices, and ensures their structural and thermal reliability.

2.3 Design of E shaped patch antenna

The table no. 1 shows the design specifications of an E-patch antenna. The figure 1 shows layout of an E shaped antenna after considering the design specification from table no. 1. The simulation result for E shaped patch antenna is shown in figures (2-5), figure 2 shows return loss, figure 3 shows VSWR, figure 4 shows the radiation pattern and figure 5 the current distribution in the antenna.

Table 1

Specifications of E shaped Patch Antenna

S. No.	Parts of Antenna	Size
1	Ground	7mm * 7mm
2	Radiating Patch	2mm * 2.4mm
3	Feed Line	1.5mm(Length)*0.168mm (width) {50 ohm feed line }
4	Slots	0.7 mm * 0.2mm
5	Port	0.168mm(V) * 0.13mm(Z)

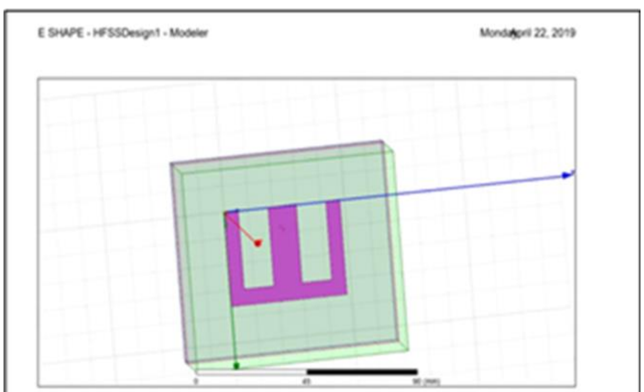

Fig1. Design of E-shape Patch antenna.

2.4 5 G Antenna

5G (5th Generation) is a frequently used word for a particularly advanced wireless system [8-9]. The 5G network is a cellular digital network, in which the area where the service has to be provided by the providers is split into small pieces of the geographical areas and are called cells. Analog signals represent images and sounds are digitized in the mobile phones, changed by an analog to digital converter and then sent as a stream of small bits. The table no. 1 shows the design specifications of an E-patch antenna. The figure 6 shows layout of an 5G patch antenna after considering the design specification from table no. 2. The simulation result for 5G patch antenna is shown in figures (7-9), figure 7 shows return loss, figure 8 shows the radiation pattern and figure 9 the current distribution in the antenna.

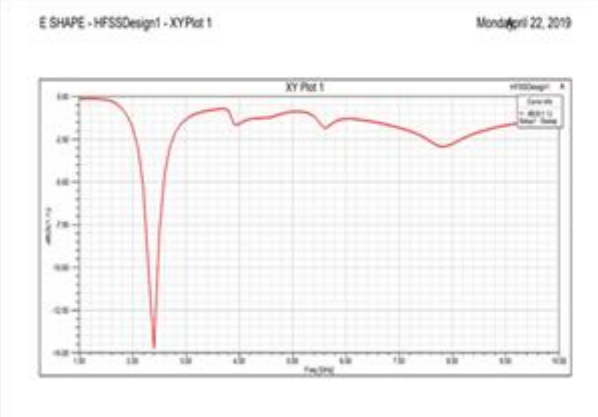

Fig 2. Return Loss of E-shape Patch antenna

Table 2

Specifications of 5G Antenna

S. No.	Parts of Antenna	Size
1	Ground	7mm * 7mm
2	Feed Line	1.5mm(Length)*0.168mm (width) {50 ohm feed line}
3	Radiating Patch	2mm * 2.4mm
4	Slots	0.7 mm * 0.2mm
5	Port	0.168mm(V)*0.13mm(Z)
6	Material, Substrate	Copper (Path & Ground), (RO3006), Rogers RO3006 = Box1

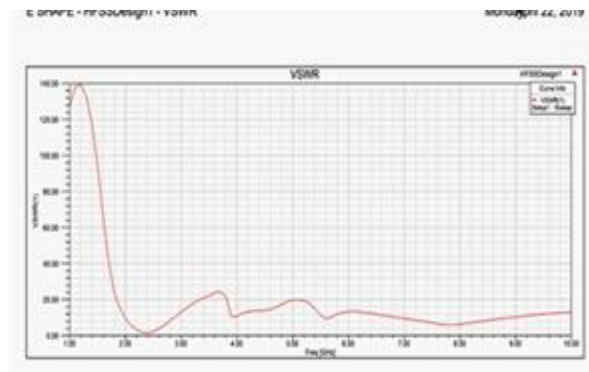

Fig 3. VSWR of Patch antenna.

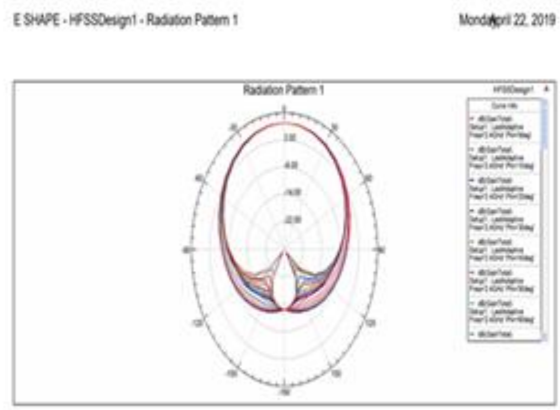

Fig 4. Radiation Patten of Patch antenna.

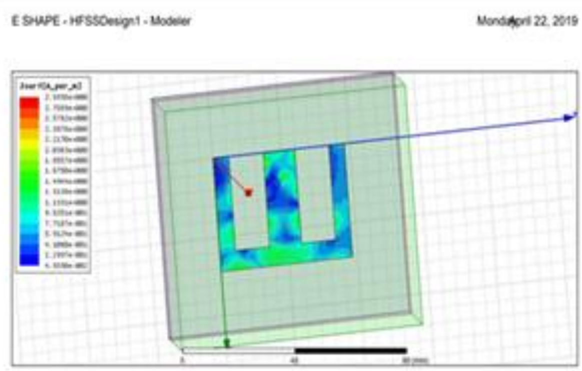

Fig.5: Current distribution of Patch antenna

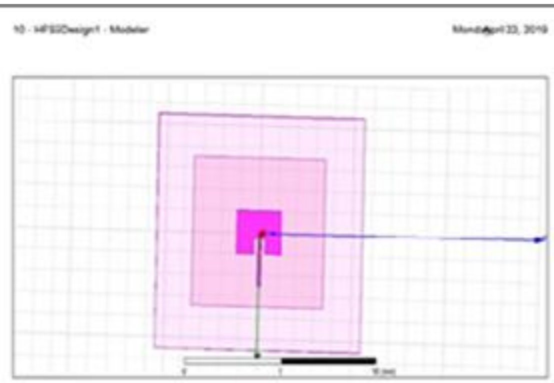

Fig6: Design of 5G Patch antenna

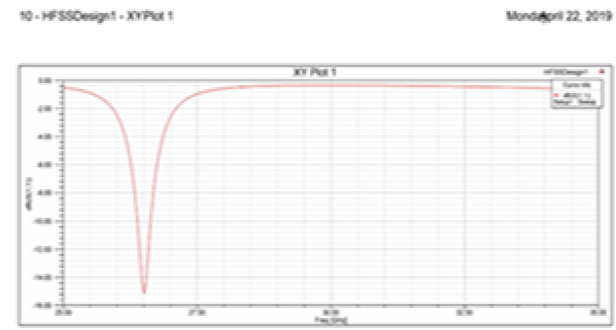

Fig.7: Return Loss of 5G Patch antenna

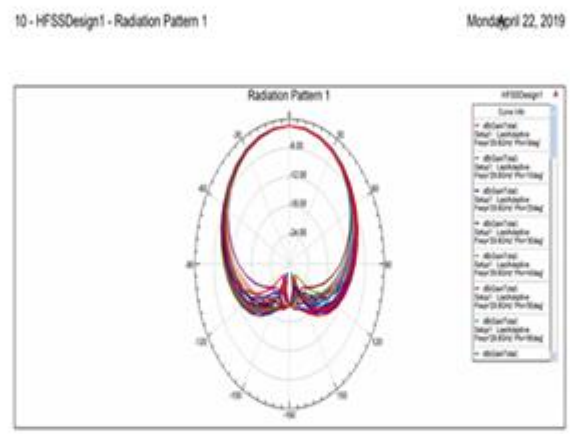

Fig.8. Radiation Patten of 5G Patch antenna.

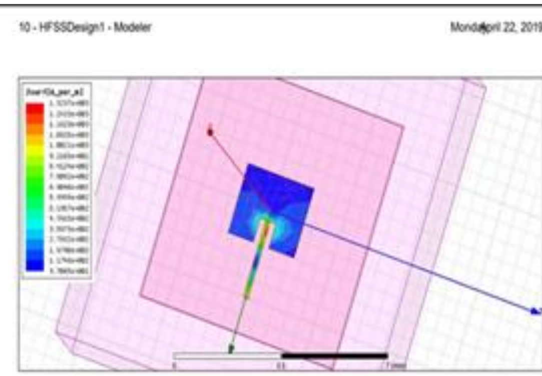

Fig.9. Current distribution of 5G Patch antenna

3. RESULT

A comparative study of results is done for both the designs as shown by table 3. The result shows that resonant frequency 5G patch antenna has increased manifolds than E-shape patch antenna and lies in the 5G spectrum of the mm wave frequency with a considerable value of return loss. The antenna achieves the required design results to be used for applications running on mm wave range by attaining a return loss of -15 dB.

Table 3

Comparative result of E shaped and 5G patch antennae

S.No.	Comparison Factors	E-shape patch antenna	5G patch antenna
1.	Resonant Frequency	2.4 GHz	26.5 GHz
2.	Return Loss	-15 dB	-15 dB

4. CONCLUSION

Antenna designs for the 5G communication introduce new challenges for the designers. The dimensions that are reduced inflicted through the larger frequencies could result in non-applicable prototype. This restriction can be seen by attaching the antenna prototype's dimensions to the accuracy and resolution of the manufacturing capacity. The antennas shows it to be an actual low cost combination to the already existing antenna (WiGig) in the market. Further, the combination of re-constructability and other smart antenna approach compared to the currently used antennas remain yet to be found. A re-constructible or an array of antennas can be re-constructed according to its own systemic geometry.

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