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Research Article

A Miniaturized Fractal Printed Circuit Board Antenna For Vo5g Applications

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Abstract: A compact Fractal patch antenna is proposed for 5G applications operating in Sub-7 GHz band which covers *IEEE P802.11 ay/D4.O standard* applications and resonated exactly at 5.5 GHz with the wide band characteristic is achieved with the dimension of 13 x 19 x 1.6 mm^3 and the dielectric material used in the proposed fractal antenna is FR4 with dielectric constant of 4.4. A defect is embedded in the ground plane and the antenna is stacked by the fractal technique. The experimentation of antenna have been carried out and results are in good agreement with the simulated results and the antenna real time efficiency rate is 61% and the structures are analyzed using HFSS v.20 which gives high accuracy in simulation.

Introduction

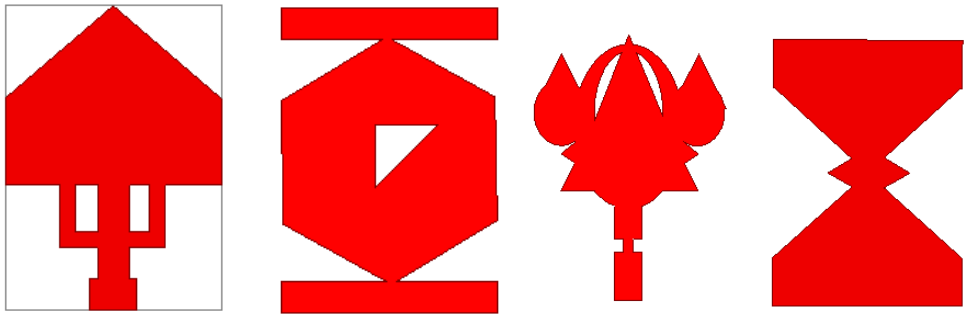
Now-a-days the wireless communication and networking systems has become very popular[2] and earning major attraction in current research area[16] because it is often studied. New technologies and methods for wireless communication have been increasing day by day. The wireless technologies for 5G applications are [15] based on the *IEEE 802.11 s*tandard for Sub-7 GHz for the obtained 4.74 GHz to 6.34 GHz bandwidth this mentioned bandwidth is said to be *n79* in ITU standards [4] and it uses radio technologies to transmit and receive data [13]. From the study of lower frequencies proves that can provide good coverage for recent wireless communication [4, 8]. The most important equipment for wireless communication is transceiver [6] and in trending wireless communication systems the transceiver is required with wide band width in smaller dimensions. Here micro-strip patch antenna is taken into an account due to the tremendous benefits of MSPA and it has attracted significant attention among antenna engineers [1, 12]. In the year of 1950's the microstrip antenna was introduced initially and later in the year of 1970's PCB was introduced from that time this Micostrip antenna became popular for its wide range of applications such as in missile guidance, vehicle collision avoidance, satellite communications etc…[4]. In 1873 by combining the theories of electricity and magnetism the maxwells equation is invented and this equation act as backbone of antenna theory [3]. The MSPA has radiating patch which is generally made up of conducting materials [7] and this MSPA will suffers some disadvantages like less directivity, less bandwidth to overcome this may techniques are implemented such as Defected Ground Structure and implementing different patch shape [15] such as rectangle, square elliptical, triangular or any other desired configuration [14, 11].

When compared to normal patch like square and rectangular shape can achieve high directivity while designing the patch in triangular shape. The high directivity in signal is achieved is due to the triangular shape which has sharp point in radiating element in forward direction [9, 10]. From the investigation it shows that other than triangular shape patch square and rectangular shapes have been reported widely in before few years back but in recent days it is emerging in the antenna design and taking into an account by analyzing its benefits [16]. At present this triangular patch antenna are used in microstrip sensor designing because in the triangular patch antenna the quality factor is very high so it exhibits narrow bandwidth and initially they are designed using cavity resonator model in the proposed antenna it is designed using transmission line model [14]. As we know that proposed shape exhibits narrow bandwidth to achieve wide bandwidth various techniques are implemented [5] such as adding parasitic elements, making slots and low permittivity material [6] among that the Defected Ground Structure (DGS) is taken in to an account [1]. The Defected Ground Structure is making the defects in the ground plane of the patch antenna by making slots on it and it can be either periodic or a-periodic imperfection in ground of a transmission line which interrupts [7] the current distribution this interruption leads to change the inductance & capacitance characteristics of transmission line the another advantage of implementing this technique is can reduce the copper thickness of the patch antenna [10]. To suppress

the cross polarization level in patch antenna in wideband this defected ground structure techniques is introduced [2] and also plays a prominent role in patch antenna miniaturization by reducing it physical dimension [11].
In past few years many review papers are published by reporting the combination of MSPA with Fractal geometry. This combination of designing proves that can able to simulate compact antennas with very high directivity and also with reduced side-lobes [6] this above mentioned combination opens an interesting window for research [12]. In the year 1974 Dr. B. B. Mandelbrot coined the term Fractal from the Greek word 'fractus' which means broken [3] and explain that the whole geometry repeat itself [2], the main purpose of this geometry is to increase the perimeter of the patch of the antenna without affecting the radiation characteristics [7]. Initially this fractal concept's get implemented in many fields such as in astronomy & medicine and in later 90^s it also used in the field of electromagnetic [3] by N. Cohen in 1995 [2] and Kim & Jaggard reported the first application to the field of antenna systems [11]. Around past 40 years researchers took a deep study [8] on its unique characteristics [2, 16] and implementing the fractal antennas to diverse applications [8] with achieving good performance rate in real time.

Design Analysis

In this section a detail comparative study is done by making comparison on two designs by converting the normal triangular shaped patch antenna to the fractal antenna with obtained simulated results and to show that while converting to the fractal also can achieve better simulated results. Initially the antenna is designed using the triangular patch with the FR4 substrate of permittivity value of 4.4 and implementing DGS technique by making triangular shaped slots in the ground plane. The initial design resonates at 5.2GHz with wide bandwidth of 4.68 GHz to 5.51 GHz with corresponding return loss of -24 dB. Now this initial stage of design is simulated into fractal geometry and achieved compactness by reducing the physical dimension of the antenna when compared to initial design and shows better gain, improved return loss with the high efficiency of 61% by resonating at 5.5 GHz with a wide band in 4.74 GHz to 6.34 GHz. In the next upcoming section obtained simulated values for initial design and fractal design is studied by comparing the both the results. The figure 1 represents the initial design and fractal design which is mentioned above this figure gives the visualization of the above given information



(A) ***(B)***

Figure 1 (A) Triangular patch antenna (B) Fractal antenna

In upcoming literature a detail comparative study is taken for the both design with the obtained simulated results from the HFSS software all the antenna parameters are taken and done a comparative study. This comparison shows the improvement in the results and this leads to prove the final design and it is fabricated & tested using the VNA.

Result Analysis

For proposed triangular shaped patch antenna & fractal antenna parameters is discussed & analyzed in this section by simulating it in the HFSS software by placing a comparative graph itself so this literature section will gives the detail comparative analysis in obtained simulated results with very high accuracy.
The measure of the reflected power of the patch antenna is called as Return loss and it is represented in decibel. The simulated antenna should have low range of signal reflection to achieve this scenario the S11 parameter of simulated antenna should remain at negative values. Here obtained S11 parameters values for both the design is falls in negative so the designed triangular patch antenna and fractal has low range of scattering in transmission. From the below figure it shows the comparative values for the both the design, from the analysis it shows that fractal designed antenna shows the better results the corresponding return loss for fractal is -47 dB so the signal reflection is suppressed in fractal when compared to the triangular patch.

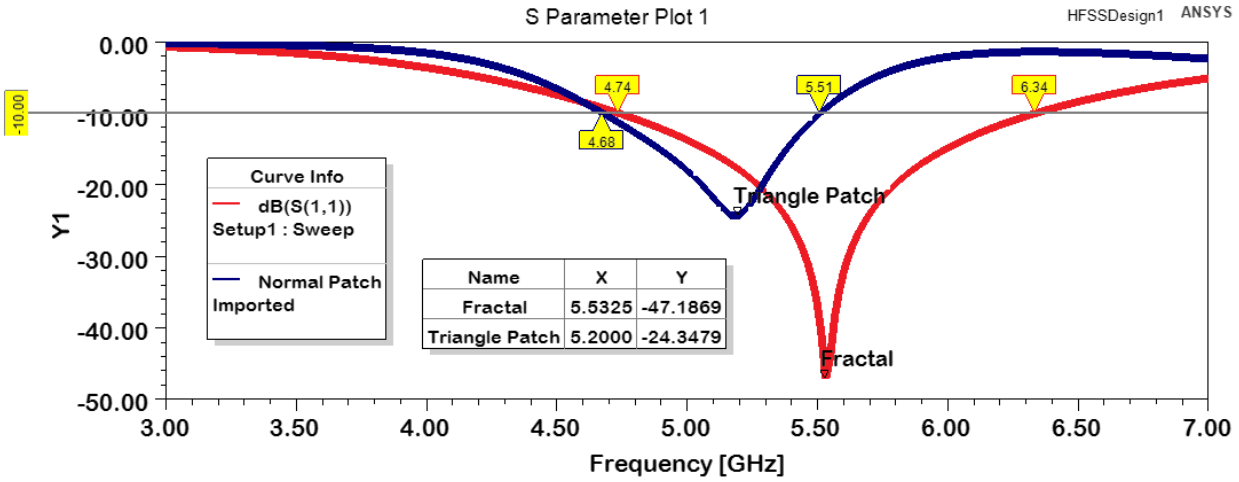


Figure 2 Represent the comparative S parameter of proposed designs

For the all MSPA the voltage standing wave ratio should be falls near to unity. From the obtained simulated results of the VSWR of the simulated triangular shaped patch antenna and fractal antenna lies near to unity so it proves that without any reflection the given input signal is completely radiated by the antenna.

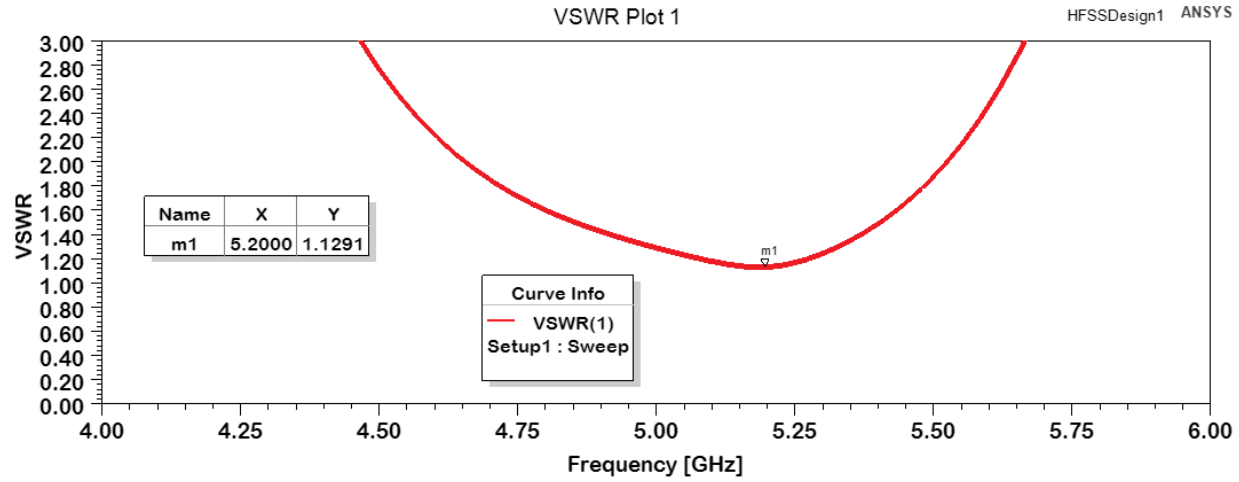


Figure 2 Represents the VSWR of triangular patch antenna

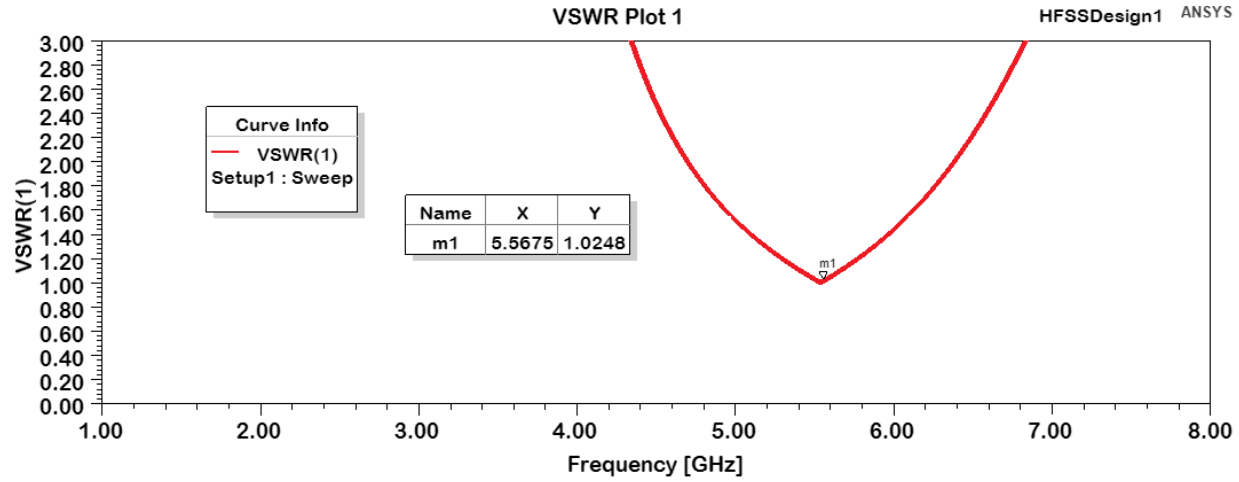


Figure 3 Represents the VSWR for fractal antenna

The below represented graph for the triangular patch and fractal based antenna is said to be impedance plot of the proposed designs. The term impedance in the patch antenna relates input voltage and current to the antenna. The Y

parameters, Z parameters, reflection coefficient for the proposed triangular and fractal design plotted in the smith chart and analyzed.

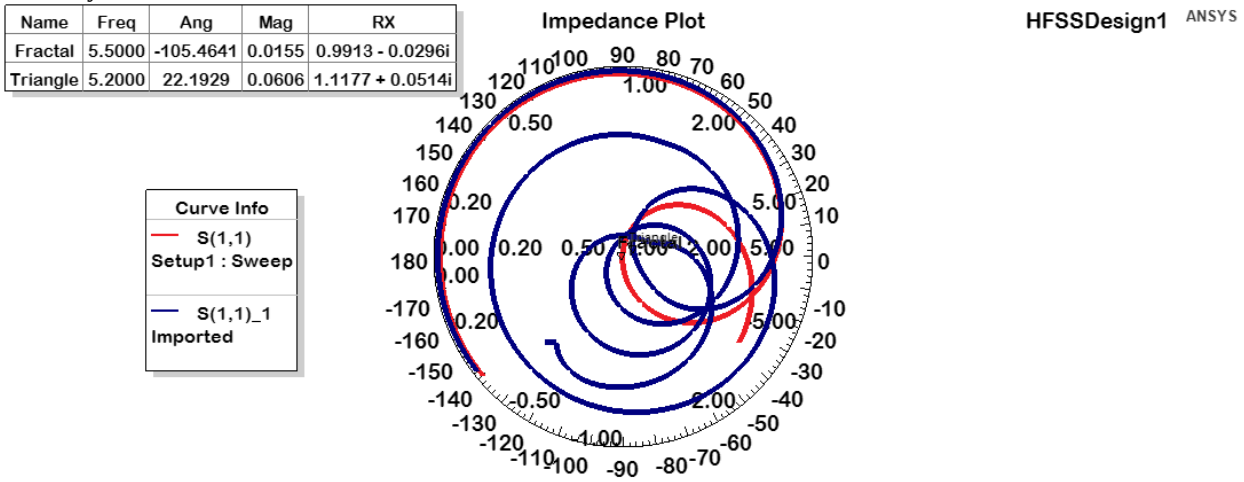


Figure 4 Represents the comparative impedance plot graph

The gain pattern is called as the plot of gain at particular direction. The gain of the proposed triangular patch and fractal transceiver is represented in 2D plot using the EM software by placing comparative graph for the both design proposed in the paper. From the comparative analysis the fractal design shows the high gain than triangular patch antenna. The gain of the fractal antenna is around 3.7 dB and for triangular patch it is around 1.2 dB.

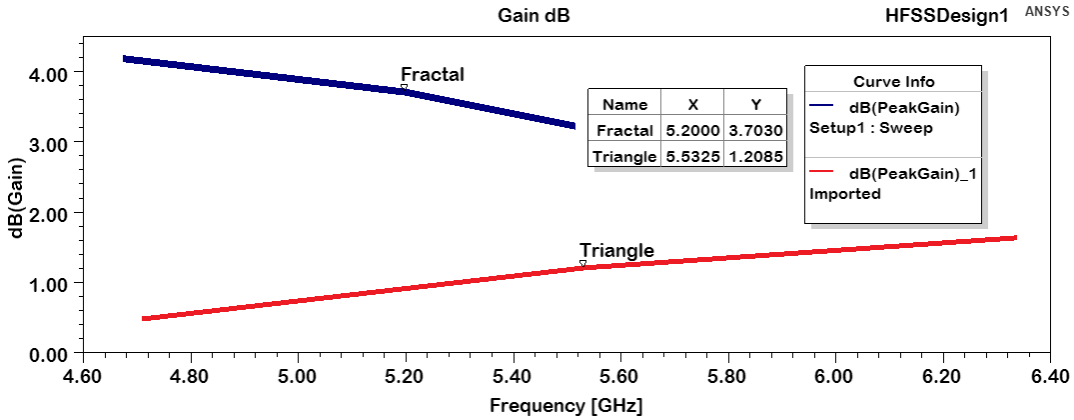


figure 5 represents comparative 2D gain plot graph

The radiation pattern is said to be the power radiated by an antenna. the strength of the radio waves of the antenna at different directions is illustrated with the help of radiation pattern. The below figure represents the radiation pattern for the 5.2 GHz & 5.5 GHz frequency application for triangular patch and fractal antenna in zero, ninety degrees and analyzed by the HFSS software. From the analysis of obtained radiation pattern it produces linear polarization in zero degree for the both design so the signal of the proposed antenna is travelled both in parallel and perpendicular to the surface of the antenna.

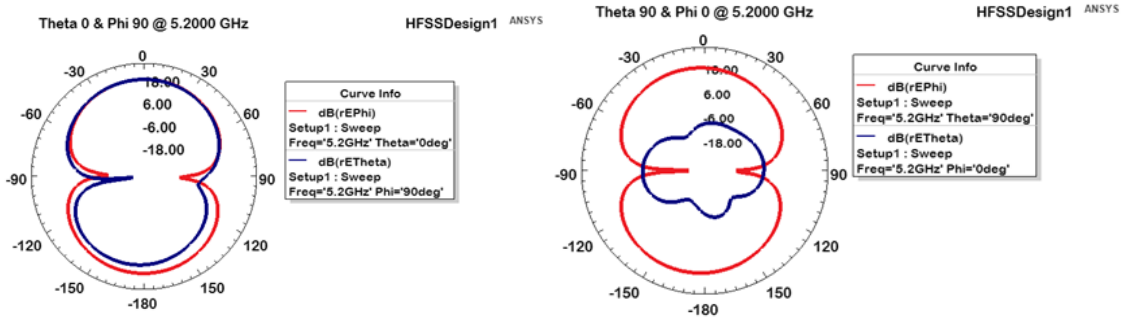


Figure 6 Reppresents radiation pattern for triangular patch antenna

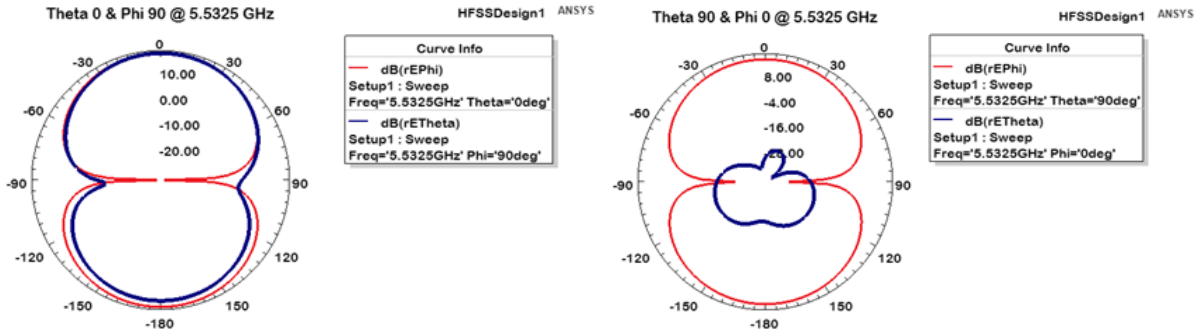


Figure 7 Reppresent radiation pattern for fractal antenna

The FBR parameter is important in scenario where interference or coverage to be reduced in reverse direction. The below graph is analyzed by comparing the gain of proposed triangular patch and fractal based designed antenna in specified direction by comparing the gain in specified direction and expressing it in dB10.

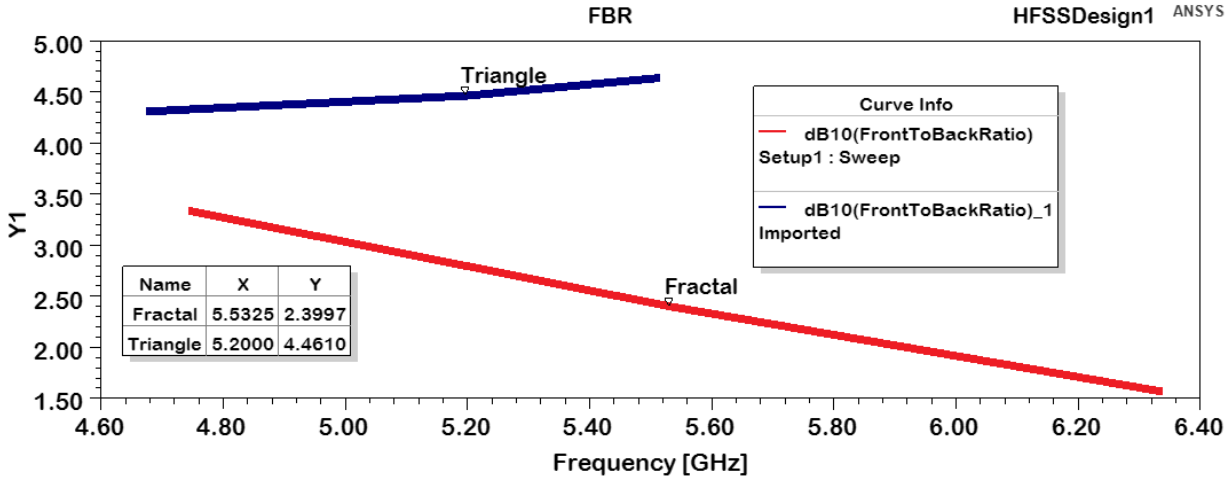


Figure 8 Represents comparative FBR graph

The graph represents the power pattern for the proposed triangular shaped patch antenna and fractal antenna by placing the obtained comparative graph of radiation intensity for proposed designs.

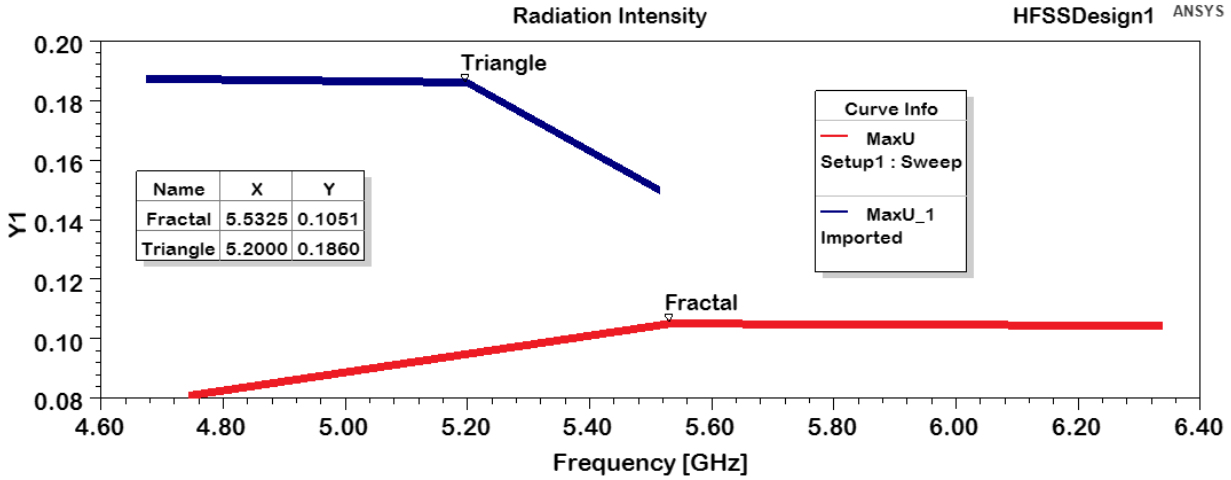


Figure 9 Represents comparative radiation intensity graph

The below figure represents the radiation efficiency of the proposed triangular patch and fractal antenna by placing the comparative graph for the both design and analyzed and expressed in percentage in sometimes. From the analysis both the designs simulated results are reported between zero & one according to IEEE std 145-1993.

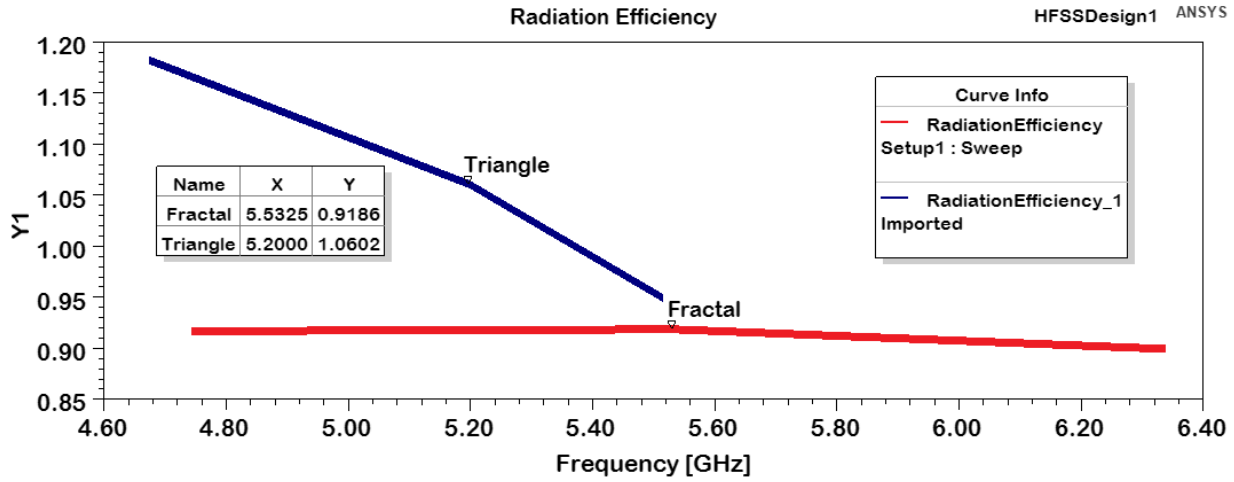


Figure 10 Represents comparative radiation efficiency graph

Once the antenna is connected to an transmitter the radiated power is calculated and it is the measure of how much power is radiated by an antenna. If the radiated power and accepted power is high then the radiation efficiency is also high on that resonated frequency. From the graph below shows that proposed designs shows high radiated power.

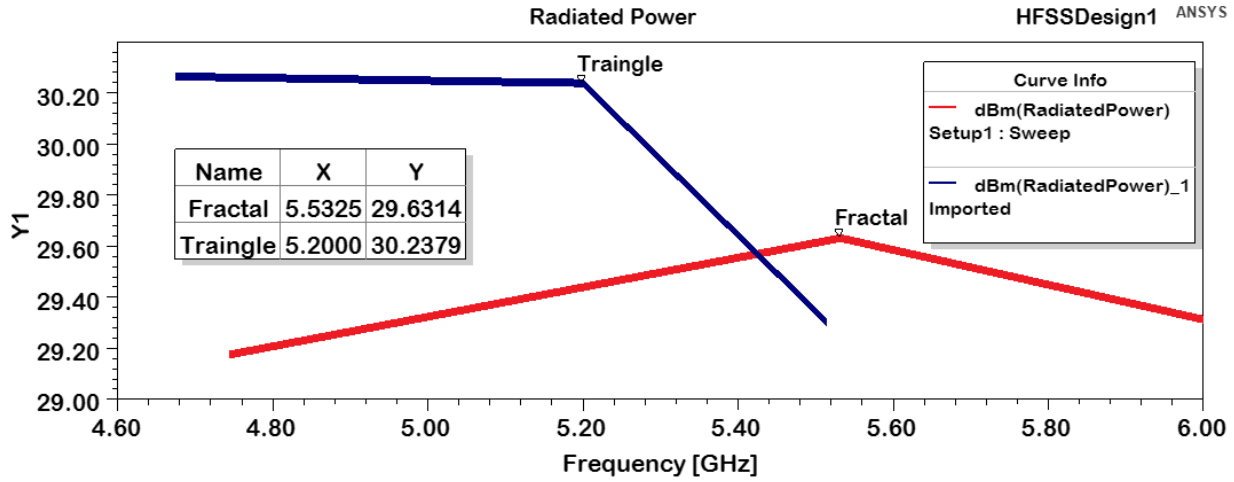


Figure 11 Represents comparative radiated power graph

The accepted power for the proposed triangular patch and fractal based antenna is represented in the below graph and analyzed. From the analysis both the fractal & triangular patch antenna shows similar range of accepted power.

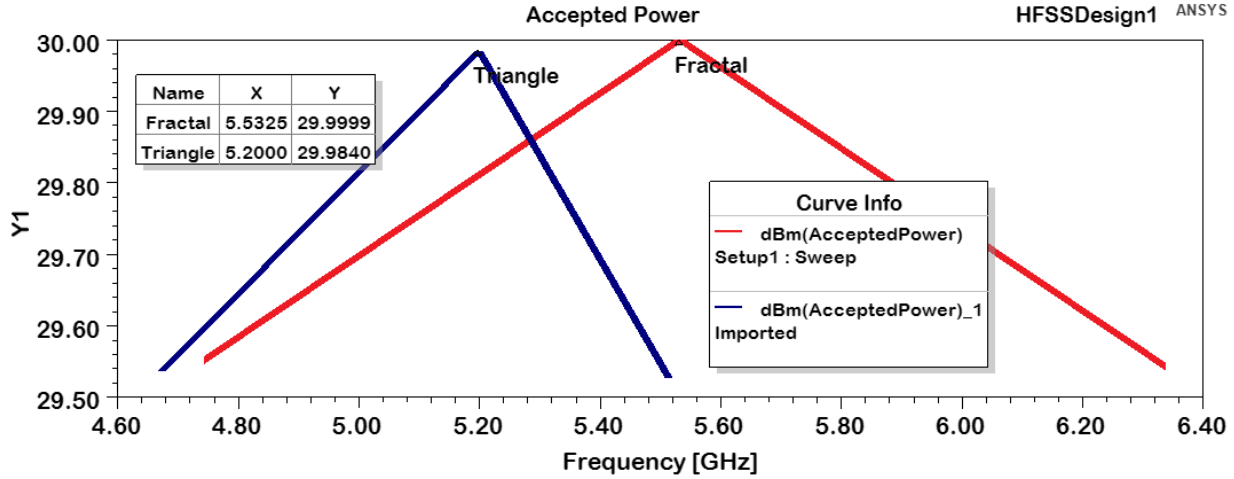


Figure 12 Represents comparative accepted power graph

From the above comparative study on all the antenna parameters for the triangular patch and the fractal antenna is analyzed with the help of comparative graph obtained using HFSS software. From the analysis of simulated results that the fractal antenna shows the better results in performance and in all other aspects so considering it as the final simulated design. By this can prove that the combination MSPA and fractal geometry will show better results in all aspects when compared to normal patch antenna.

Conclusion

The simulated antenna plays a prominent role in microwave and other wireless application systems. The proposed fractal geometry antenna was designed using the substrate material such as FR4 and achieved to work in *IEEE P802.11 ay/D4.O standard* applications in sub-7GHz band with low signal reflection. As we know already that the fractal antenna is good choice to use due to its unique characteristics which leads to high performance rate so all the performance parameters were noted and analyzed in this letter The proposed methodology (i,e) merging the MSPA with Fractal revealed the better performance rate from the analysis and I assure that once it is fabricated in future it work most efficiently in real time.

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