Modified Peano-Gosper Fractal Geomatry Based Wideband Microstrip Patch Antenna Design Analysis

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Abstract: ***In this paper, the modified Peano Gosper curve has been applied on the perimeter of square patch of microstrip antenna to obtain new antenna design. The proposed antenna was designed, fabricated and characterized on a 1.6 mm thick FR4 substrate. The proposed antenna has dual band characteristics for 3.43 - 3.655 GHz and 3.97 - 7.12 GHz band with maximum negative return loss of -40 dB at 4.33 GHz. Wide bandwidth was achieved by placing an air gap between the patch substrate and ground plate. The proposed antenna has wide bandwidth of 3.15 GHz and peak gain of 1.90 dB.***

Keywords: Microstrip, fractals, bandwidth, gain, patch antenna.

1. Introduction

IEEE 802.11 works on unlicensed bands which are also called as Industrial, scientific and medical (ISM) band. All IEEE 802.11 works on frequency band 2.4 GHz except IEEE 802.11a, which works on 5 GHz band. For maximum throughput of 2 Mbps, narrow band systems are sufficient but for throughput of 11 Mbps and 54 Mbps, there is a need for broadband systems. Along with broadband characteristics, systems also required such mechanism which reduces the chance of failure in signal strength along with good coverage area. The broadband characteristics, signal strength and range of coverage area directly depend upon antenna performance and hence significance of broadband antennas. WLAN system works mainly on two frequency bands that are 2.4 GHz and 5 GHz. IEEE 802.11b works on 2.4 GHz band but several other devices such as Bluetooth, microwave oven also operate in this frequency range which makes this band congested. IEEE 802.11a works on 5 GHz frequency band which is less crowded as compared to standard IEEE 802.11. WLAN systems mostly use omni-directional discone antennas which radiates energy in all direction, cases interference to the nearby WLAN systems which reduces efficiency. Directional antennas can reduce interference. Besides this, it also reduces power consumption. Microstrip antennas are low profile, rigid and planar to surface have good directivities but have narrow bandwidth also. By using fractal geometry, miniaturization of an antenna is achieved. Beside this wide bandwidth of an antenna is obtained by introducing the gap of 6mm under the patch substrate and ground plane.

2. Methodology

With the understanding of the Microstrip Patch Antenna Technology, including the property studies such as Radiation Pattern, Input Impedance and Operating frequency, a design is proposed to increase bandwidth and obtain desirable gain in antenna. Ansoft HFSS software, based on the Finite Element Method (FEM) is used to design the proposed microstrip antenna with the application of modified peano gosper fractal geometry applied on the perimeter of the patch. Analytical and mathematical study of the proposed antenna is examined for the application of WLAN IEEE 802.11a. A reference microstrip patch antenna is shown in the figure-1 on which fractal geometry has applied. The coaxial cable with inner conductor radius is of 0.7mm and outer radius is of 1.6mm is used.

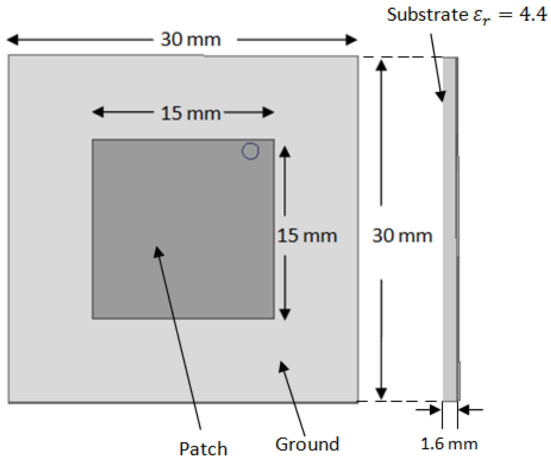

Figure 1: Reference Microstrip Patch antenna

The return loss of reference antenna for a frequency 8.47 GHz was -18.65 dB. The Proposed design has number of steps such as creating the model, setting up boundaries and excitation; assign input wave-port and output wave-port with the use of HFSS. For achieving wide bandwidth characteristics, the air gap of 6 mm is introduced under the FR4 substrate and ground plate. The excitation through co-axial cable of 50Ω characteristic impedances fed to the patch. Due to fractal geometry applied at patch dimensions, miniaturization of antenna is obtained. The antenna operates at resonance frequency of 4.33 GHz with bandwidth of 3.15 GHz.

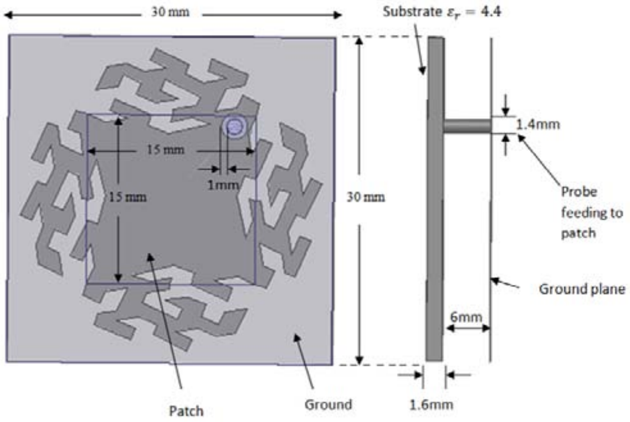

Figure 2: Design of Proposed antenna using HFSS

Figure 3: Prototype of Peano Gosper fractal geometry based proposed Antenna

The patch length determines the resonance frequency, and it is a critical parameter in design. For the proposed design, the initial length and width have dimensions 15.5 mm respectively. The patch dimensions are modified according to modified Peano Gosper curve. In this design, co-axial probe feed is used to excite the antenna. The location of the feed point is (-8.5 mm, -7.5 mm, 0) which is perfectly matched the input impedance.

3. Results

The range of frequencies, in which Voltage Standing Wave Ratio is less than 2 (VSWR<2), were from 8.245 GHz frequency to 8.74 GHz frequency. Thus the bandwidth of antenna was 495 MHz. The peak directivity was 2.13 dB and the peak gain was 4.59 dB. After excitation, the solution data is specified for particular resonant frequencies. The step size is also specified for the defined band. The analysis of it is based on the Finite Element Method. The model is validating after assigning the solution data in the HFSS. Then the model is analyzed for a solution data and result is measured by the different plots. Return Loss is good when the curve has a deep and wide dip, which shows that the antenna will work at that frequency at which return loss is less than -10 dB. Here at frequency 4.33 GHz, return loss is -40.20 dB shows that it will radiate energy efficiently at frequency 4.33 GHz.

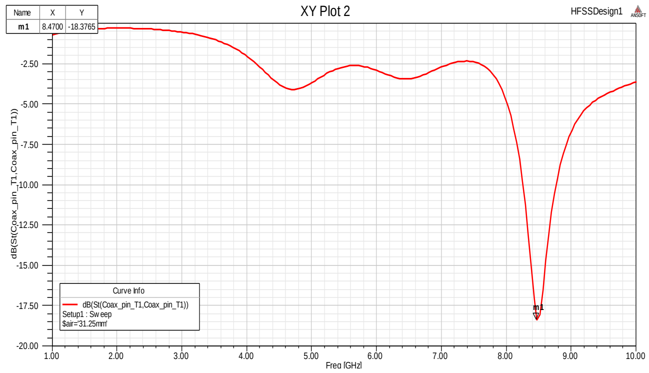

Figure 4: Return Loss verses frequencies of reference antenna

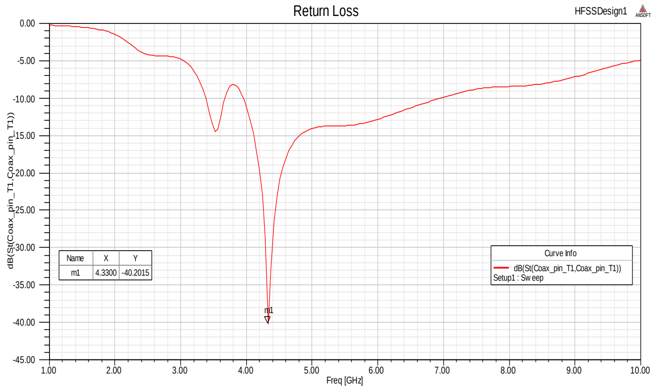

Figure 5: Return loss Pattern of proposed antenna

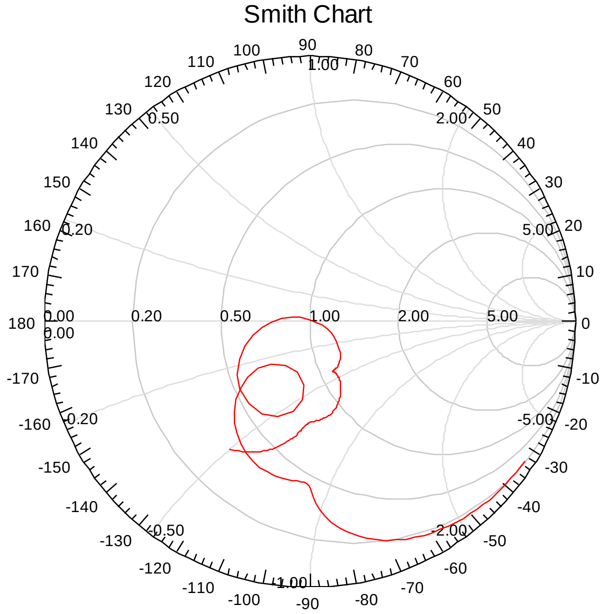

Figure 6: Smith Chart simulated in HFSS

Figure-6 shows the smith chart for the proposed model. Smith chart shows the reflection coefficient, standing wave ratio as well as various transmission line parameter results. Bandwidth of an antenna is defined as the range of frequencies in which the value of VSWR (Voltage Standing Wave Ratio) is less than 2. In this design, the range of frequencies is from 3.97 GHz to 7.12 GHz that is total bandwidth is 3.15 GHz. Since a microstrip patch antenna radiates normal to its patch surface, the elevation pattern for Φ=0 and Φ=90 degrees would be important. Figure-7 shows the gain of the antenna for Φ=0 and Φ=90 degrees. The maximum gain is obtained in the broadside direction and this is measured to be 4.019194 dB for both Φ=0 and Φ=90 degrees. The radiation efficiency of the proposed antenna is 0.9376 for both Φ=0 and Φ=90 degree. The maximum directivity is 1.6535.

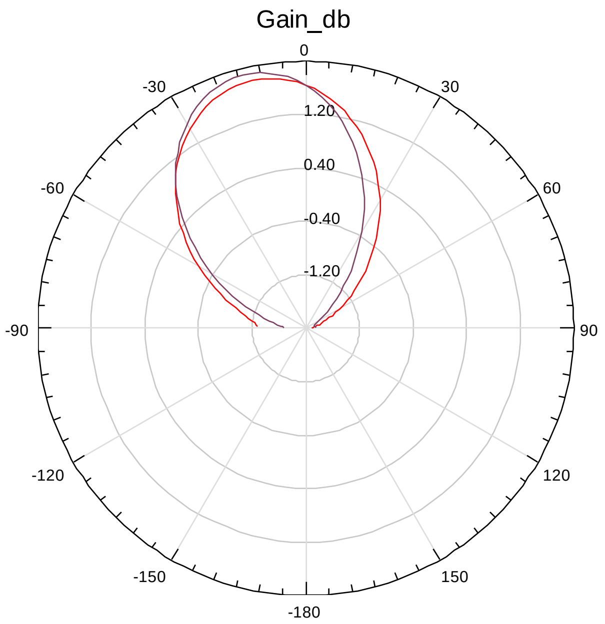

Figure 7: Radiation Pattern

4. Conclusions

The Peano Gosper fractal geometry based microstrip antenna is proposed with its return loss, radiation pattern, VSWR is shown in the results in previous chapter. As it is analyzed from the results that proposed antenna has good characteristics to work for Wireless LAN applications as well as for RADAR altimeter. It is offering return loss to be less than -10 dB for frequency range from 4 GHz to 7 GHz that supporting IEEE 802.11a wireless LAN standards and RADAR altimeter. It has bandwidth of 3.14 GHz. The radiation pattern shows that it is directional antenna that provides better security and less interference from nearby equipment that operate on same frequencies in Wireless LAN systems. Thus the proposed antenna can be installed in Wireless LAN equipment's because of its small size and weight. As it provides comfortably required bandwidth according to IEEE 802.11a standards, it can be used to provide connectivity for large number of systems within WLAN network. Due to its light weight and small size, it can be used for RADAR altimeters in aircrafts. RADAR altimeters are used to measure height of aircraft from earth and operate in the range of frequency band from 4.2 GHz to 4.4 GHz.

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