Research Article

Compact Koch Fractal Boundary Micro Strip Patch Antenna for Wide Band Applications

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Abstract: There is a lot of demand for the wideband antennas with considerable gain and compactness in size. The modern communication systems need such antennas for reliable data transmission. A novel compact monopole antenna is designed with Koch fractal boundary for wide band applications is presented in this study. The wide band fractal antenna is designed with coplanar wave guide feeding with 50 Ω impedance matching at feed line. The overall size of the antenna is very compact in nature with dimensions 20×15×1.6 mm. The proposed model is constructed initially by taking a basic fractal wide band model operating between 7.8 to 14.5 GHz at higher frequencies with impedance band width of 67%. The proposed antenna covers a wide band between 5-12 GHz with impedance bandwidth of 89%. The proposed antenna characteristics are analyzed with the help of commercial electromagnetic tool HFSS and presented in the study.

Keywords: Compact antenna, coplanar waveguide, impedance bandwidth, koch fractal, wideband antenna

INTRODUCTION

The demands of compact and wide band antennas are increasing day by day with their usage in the advanced communications systems (Madhav et al., 2014a; Baliarda et al., 2000). The self-similarity property of fractal antennas creating their impact in the design of these wide band antennas (Best, 2002; Li et al., 2012; Puente et al., 1996). Researchers proposed different models with fractal geometries for multiband and wide band antenna systems for different applications (Madhav et al., 2013a). Koch fractal monopole antennas are mainly used to get the compactness in the design as well as to achieve multiband characteristics. A multiband antenna can be converted into wide antenna by using small changes in the design with respect to the designed specifications (Madhav et al., 2014b, c; Madhav et al., 2015a; Srinivas et al., 2015). By introducing Koch fractal patches instead of triangular patch geometry will increase the operating frequency along the wide band matching (Madhav et al., 2015b; Madhav et al., 2013b). From the literature, we observed that for Koch fractal monopole shapes offer improved performance over common small antenna and that behavior of the Koch fractal monopole is peculiar to its geometric shape (Madhav et al., 2014d, e). In this study we designed a basic fractal monopole antenna to operate between 7.8-14.5 GHz. A proposed model which is modified geometry of previous Koch fractal monopole is also presented in this study. The proposed model consisting of more number of Koch fractal shapes inserted in the basic model radiating element.

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Table 1: Antenna dimensions

<table>
<thead>
<tr>
<th>W</th>
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<th>W2</th>
<th>L</th>
<th>L1</th>
<th>L2</th>
<th>d</th>
<th>d1</th>
<th>d2</th>
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<td>15</td>
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<td>20</td>
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<td>17.8</td>
<td>0.4</td>
<td>0.7</td>
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<td>1</td>
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</tbody>
</table>

**Fig. 3: Return loss vs. frequency**

**Fig. 4: VSWR vs. frequency**

**Fig. 5: Input impedance Smith chart**

**METHODOLOGY**

**Antenna design and geometry:** Figure 1 shows the basic Koch fractal monopole antenna with coplanar wave guide feeding ground plane is taken on the same side of the substrate material along with radiating element. This model is slightly modified by placing more number of Koch fractal iterations on the radiating element as shown in Fig. 2. The dimensional characteristics of these 2 models are presented Table 1. ‘The proposed model is fabricated on fr4 substrate with dielectric constant 4.4. The width of the feed line is fixed at 1.6 mm to implement 50 Ω impedance on both model that we design. Finally a standard assembly’s connected to measure the antenna parameters with the vector network analyzer.’

**RESULTS AND DISCUSSION**

The reflection coefficient of the base model and the proposed model are simulated using HFSS tool and presented in Fig. 3. The base model is resonating after 7.8 GHz with an impedance bandwidth of 67%. The proposed model is showing a high impedance bandwidth of 89% and covers the C and X bands. The proposed model is fabricated on fr4 substrate and the measured results are collected from Vector Network Analyzer (ZNB20VNA).

Figure 4 shows the VSWR less than 2 in the operating bands for both the models in addition with return-loss curve results.

Figure 5 shows the input impedance smith chart of the proposed model with good impedance matching at the resonant frequency bands.
Fig. 6: Radiation pattern at 7.8 GHz

Fig. 7: Radiation pattern at; (a): 9.2 GHz; (b): 13.06 GHz
Figure 6 shows the radiation characteristics of the base model at 7.8 GHz. Antenna shows monopole like radiation with low cross polarization at the resonant frequency of 7.8 GHz. Figure 7 shows the radiation pattern of the proposed antenna at 9.2 GHz. A low cross
polarization in the H-plane of -10 dB is obtained. The proposed model is also showing monopole like radiation in H-plane and eight like radiation with a particular direction in E-plane.

The current distribution over the surface of the antenna models are shown in Fig. 8 and 9. Figure 8 shows current density plot for the base model at its resonant frequency. The current direction on the feed line is towards radiating element and on the radiating element the direction is towards feed line. There is a cancellation of energy at a junction due to the opposite direction of the current elements with equal magnitude and with opposite phase. Figure 9 shows the current distribution over the surface of the proposed antenna. The current density is maximum in and around the feed point but away from the feed point on the ground plane. The intensity seems to be weak.

Figure 10 shows the frequency versus radiation efficiency of the antenna models. The proposed model is showing superior efficiency results compared to base model as shown in the figure.

Prototyped antenna is fabricated on FR4 substrate with thickness 1.6 mm. Figure 11 shows the fabricated antenna photograph taken at LCRC-R and D. Figure 12 shows the measured S11 parameter with ZNB 20 vector network analyzer. The simulation and measurement results are in good agreement with other corresponding to its resonant frequencies.

CONCLUSION

A compact koch fractal antenna is designed to operate at wideband conditions. The proposed antenna is showing wideband characteristics with good radiational characteristics. The efficiency of the antenna is more than 90% at corresponding resonant frequencies. The overall size of the antenna is very compact in nature with dimensions 20×15×1.6 mm. The proposed model is constructed initially by taking a basic fractal wide band model operating between 7.8 to 14.5 GHz at higher frequencies with impedance band width of 67%. The proposed antenna covers a wide band between 5-12 GHz with impedance bandwidth of 89%. The overall performance characteristics of the antenna model is analyzed and presented in this study with measured results from vector network analyzer. Simulation and measurement results are having similar characteristics, which gives motivation to use this model in desired band of operations.

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REFERENCES