Coplanar Integration of Dual-Band Microstrip Patch Antenna Using CAD-FEKO

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Abstract- This paper represents microstrip antenna for dual band applications such as Global Positioning System (GPS) and Bluetooth applications. The designed antenna must perform dual frequency operation i.e. 1.57 GHz and 2.45 GHz. So antenna resonates at frequency 1.57 GHz for GPS and 2.45 GHz for Bluetooth applications. Using CAD-FEKO electromagnetic simulation software, antenna has been optimized for continuous frequency band 1.2 GHz – 2.8GHz. This paper focuses on the designing of dual-band microstrip antenna with microstrip feed and co-axial probe feed and analyzes the results like return loss, VSWR, impedance, Directivity and radiation pattern at 1.57 GHz and 2.45 GHz. The antenna was designed on FR4 with overall size of 50 mm x 70 mm with height h = 1.6mm and dielectric constant (ε_r) = 4.4. In this paper Koch fractal technique is used, so that antenna structure has been reduced.

Keywords – Koch curve, microstrip, CAD FEKO suit, dual band, antenna geometry.

I. INTRODUCTION

In the field of wireless communications, antenna plays very important role. Microstrip antenna is key building in wireless communication. Out of many antennas in communication system, microstrip antenna is very popular and well known for its advantages such as low fabrication cost, low profile, low volume and it has capability of dual and triple frequency operations. Because of these features this antenna attracts many researchers to investigate performance of antenna in various ways [1].

Different types of microstrip antennas have been proposed for many applications with different shapes such as rectangular, circular disc, elliptical etc. In this paper, we used rectangular structure. The major limitation of microstrip antenna is their narrow bandwidth. Narrow bandwidth of microstrip patch antennas makes researchers think of dual-band antennas [2]. In this paper, design of microstrip antenna with microstrip feed line and co-axial feed line as feeding method is presented. Feeding mechanism plays an important role in microstrip patch antenna. Microstrip antenna is designed on substrate such as FR4 with dielectric constant of 4.4 and thickness of 1.6 mm. Performance of microstrip antenna is strongly depends on several factors such as feeding technique, thickness and dielectric constant of substrate [3].

For reducing the size of antenna fractal geometries (Koch curve) have been introduced. Here, Koch curve on the patch is investigated for reducing the size and enhancing the gain. This paper is devoted to the simulation of this antenna in the frequency of 1.6 GHz for global positioning system (GPS) and 2.4 GHz for Bluetooth applications, to determine the parameters necessary for antenna's design. The key parameters of these simulations are: the resonance frequency, the reflection coefficient and the standing wave ratio (VSWR), with coaxial probe used to feed the patch antenna simulation is done by using CAD-FEKO software. The microstrip antenna has very low volume and low profile and it can be fabricated using printed circuit techniques. This can be implies that the antenna can be made potentially at low cost and conformable [9].

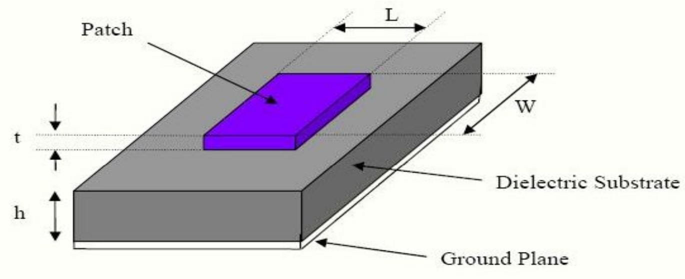


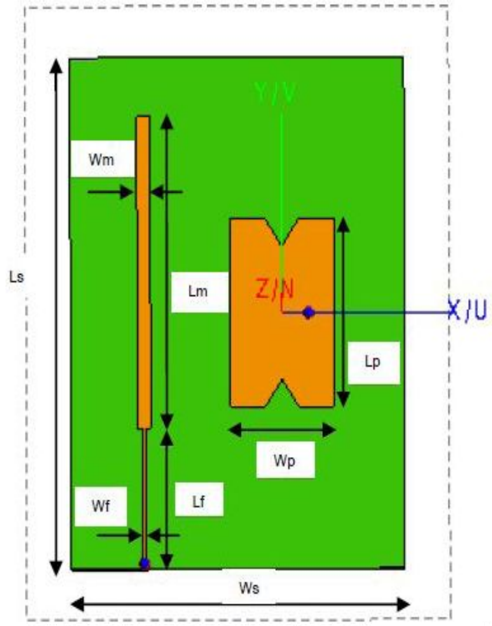
Figure 1: Structure of microstrip patch antenna

Basically, a Microstrip patch antenna consists of a radiating patch, dielectric substrate and ground plane as shown in Figure 1. The patch can take any possible shape and radiating patch is generally fabricated using conducting material such as copper or gold. For better performance, a thick dielectric substrate must have a low dielectric constant which is desirable. Since this provides better efficiency, larger bandwidth and larger radiation. However, such a configuration leads to a larger antenna size. In order to design a compact size Microstrip patch antenna, higher dielectric constants must be used which are less efficient and result in narrower bandwidth. Hence a compromise must be reached between antenna dimensions and antenna performance [4]. Feeding mechanism plays an important role in antenna design. Feeding mechanism are co-axial probe and microstrip line. This microstrip antenna reduces the production cost [7]. The gap between radiating patch and ground plane is also an important parameter to control the impedance bandwidth. This paper is divided into following sections. The antenna geometry and iterative structure of Koch fractal curve is presented in the next section. The section 3 presents the performance of rectangular shaped microstrip patch antenna and simulation is done using CAD FEKO electromagnetic software also presented. Finally conclusion of antenna is given.

II. ANTENNA DESIGN

A. Design Geometry –

The basic geometry of proposed antenna GPS/Bluetooth integrated antenna is shown in Fig. 2. The dimension of substrate is taken as 50 x 70 mm^2. The thickness (h) of substrate is taken as 1.6 mm. The geometry is being formed by mounting the radiating monopole antenna and rectangular patch antenna on same plane. This antenna is mounted on FR-4 printed circuit board (PCB) substrate with a dielectric constant of 4.4 and tangent loss of 0.002. Here microstrip feed line is used for monopole antenna for GPS applications and coaxial feed line is used for rectangular patch for Bluetooth applications. This antenna supports simultaneously for GPS at 1.57 GHz and Bluetooth at 2.45 GHz frequency band with linear polarization. This structure is designed because of requirements with different radiation and polarization so in order to improve the utility efficiency of limited spectra and special resources, different services using same antenna are required [11].



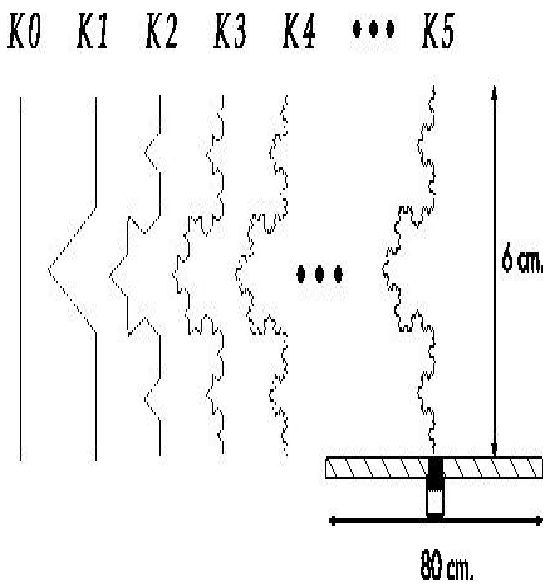


Figure 2. Design geometry of coplanar integrated microstrip antenna for GPS/ Bluetooth applications.

Figure 3. Iterative construction of Fractal Koch curve

For developing new and innovative design for antennas many fractal geometries are available. This design mainly consists of Koch fractal geometry of antenna. A fractal antenna uses a fractal design which maximize length, or increase the perimeter of material that can receive or transmit electromagnetic radiation within a given total surface area or volume. The improved feature of some antennas in terms of resonant frequency, radiation resistance and bandwidth is nothing but small fractal antenna [5]. The fractal design is achieved by systematically bending the wire, by keeping arc length remains the same but size is correspondingly reduced with addition of each successive iteration. In proposed design only one iteration is used. Iterative construction is as shown in fig. 3.

C.Design Flowchart-

The name FEKO is an abbreviation derived from the German phrase ***FE****ldberechnung bei* ***K****örpernmitbeliebiger* ***O****berfläche*. *(Field computations involving bodies of arbitrary shape).*

The basic flow of performing a FEKO analysis consists :

1. Building a geometry for the antenna in CADFEKO or EDITFEKO.
2. Building a geometry to represent surrounding geometry.
3. Meshing the created antenna and surrounding geometries.
4. Requesting solution types and setting solution parameters.
5. Running the FEKO solver .
6. Read in and interpret results using Post FEKO.

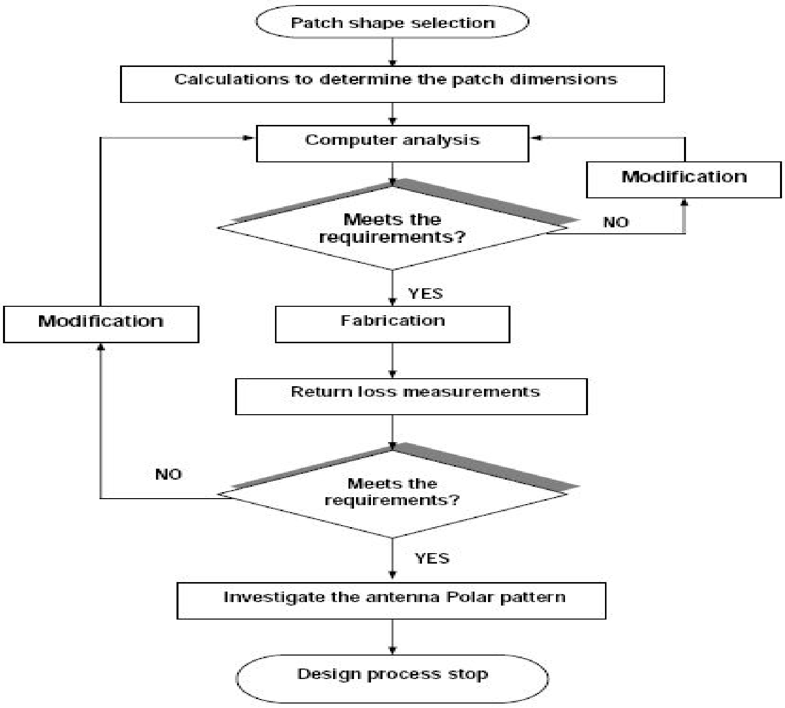


Figure 4. Design flow chart

D. Design Dimensions-

The optimal dimensions of designed antenna are as follows:

Table -1 Design Dimensions

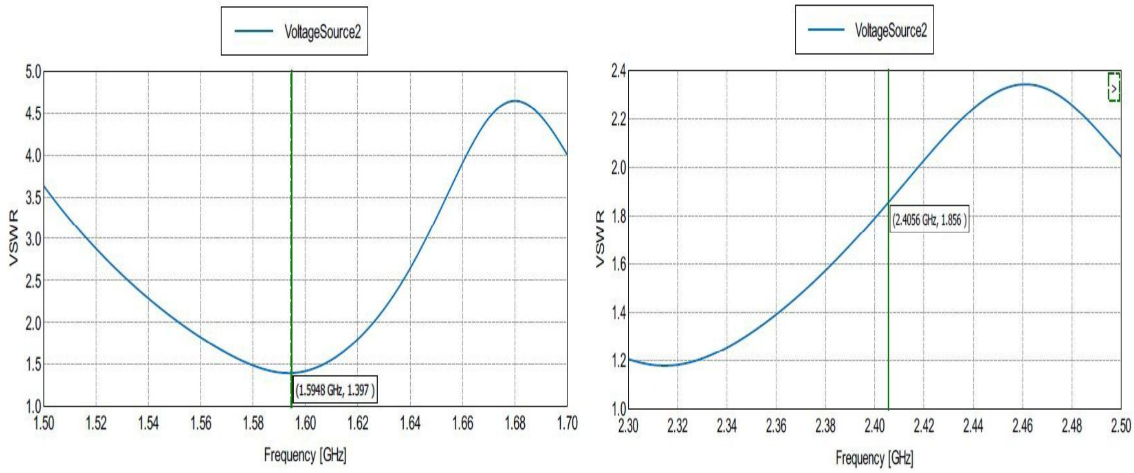
Parameters	**Specifications**
Width of Substrate	**50mm**
Length of Substrate	**70mm**
Width of Patch	**27mm**
Length of Patch	**44mm**
Width of Monopole	**4mm mm**
Length of Monopole	**96mm**
Feed Width	**1mm**
Feed Length	**16mm**

III.SIMULATED RESULTS

The microstrip antenna is simulated by electromagnetic simulation software CAD FEKO suit. The final goal of work is to get a dual band antenna with low return loss with good radiation patterns and increased directivity. By using the fractal Koch antenna high performance is achieved.

A. Voltage Standing Wave Ratio (VSWR)-

Voltage Standing Wave Ratio (VSWR) is ratio of maximum voltage and minimum voltage along transmission line. VSWR increases if there is mismatch between the antenna and transmission line and it is increases if there are good matching [9]. Fig.5 shows the simulated result of Voltage Standing Wave Ratio (VSWR) of proposed antenna. The two resonant frequencies at 1.6 GHz with Voltage Standing Wave Ratio (VSWR) of 1.5948 and at 2.4GHz with Voltage Standing Wave Ratio (VSWR) of 1.856 is achieved, as shown in fig.5.



(a) (b)

Figure 5. VSWR of simulated antenna (a) for 1.6GHz (b) for 2.45GHz

B.Return Loss-

The return loss is a parameter that indicates the amount of power i.e. lost to the load and does not return as a reflection. Fig 6 shows the simulated result of return loss of proposed antenna. The two resonant frequencies at 1.6 GHz with return loss of -10.5 dB and at 2.45GHz with return loss of -15 dB is achieved, as shown in fig.6. Ideal value of return loss is around-10dB which corresponds to VSWR of less than 2.

C. Impedance-

Input impedance is important to determine maximum power transfer between transmission line and antenna. This transfer only happen when input impedance of transmission line and input impedance of antenna matches [8]. The relation of voltage and current at the input of the antenna is nothing but antenna impedance. Fig.7 shows the simulated results for antenna impedance. The antenna impedance for this simulated antenna is 56.516.

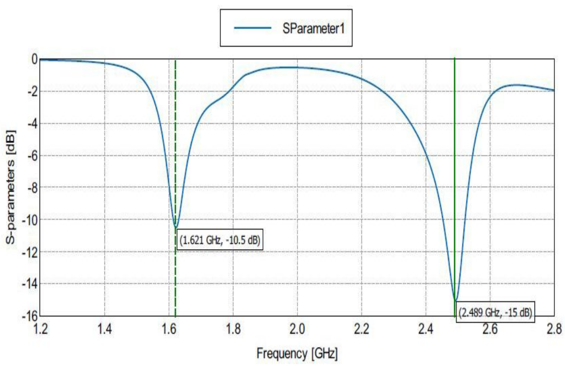


Figure 6. Simulated result for Return loss

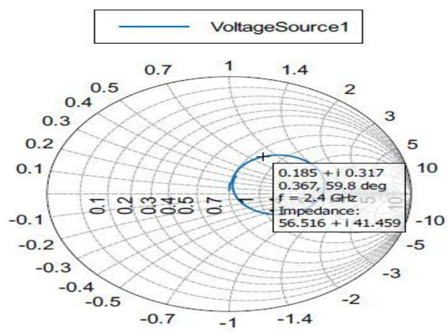


Figure 7.Simulated Result for Impedance

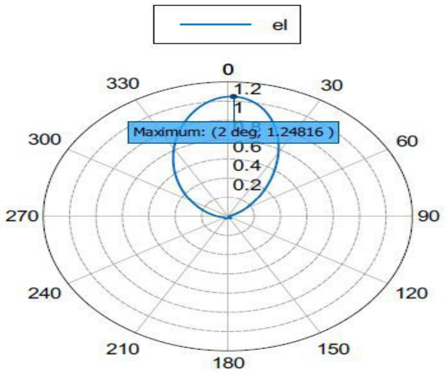


Figure 8. Simulated Result for Directivity

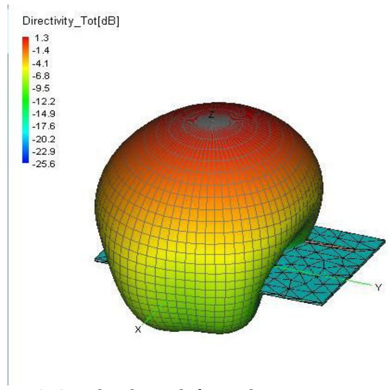


Figure 9. Simulated Result for Radiation pattern

D. Directivity-

The ability of the antenna focusing radiated energy is nothing but directivity, which is very important parameter of an antenna. Directivity is a ratio of maximum radiated to radiate reference antenna. Reference antenna is an isotropic radiator where the radiated energy is same in all the direction [6] and has directivity of 1. The simulated directivity of proposed patch antenna for coplanar integrated microstrip patch antenna as shown in fig.8. The maximum achieved directivity is 1.3 dB.

IV.CONCLUSION

The coplanar integrated dual-band microstrip antenna is designed and simulated. The design is simulated on CAD-FEKO suit which is electromagnetic simulation software which has resonating frequencies of 1.57GHz and 2.45 GHz with return loss of-10.5 dB and -15 dB. The dual band antenna has wide applications GPS/Bluetooth in the field of wireless communication. The unique feature of this antenna is its compact and small size to get higher performance. This coplanar integrated antenna designed is better because it gives maximum dual band return loss and also it reduces length of antenna elements.

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