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A STUDY PAPER ON DIFFERENT STRUCTURES USED TO REALIZE MULTIBAND ANTENNA FOR WIRELESS APPLICATIONS

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ABSTRACT

Today the use of mobile communication systems has increased remarkably and the market demand still continues to increase. Although there are several similar definitions, an antenna can be mainly described as a device, which transforms the electromagnetic waves in an antenna to radiating waves in an unbounded medium such as air in transmitting mode and vice versa in receiving mode. The Microstrip antennas should provide wide bandwidth at the compact size for performing this type of operation. This paper gives study on design different structures used to realize Multiband Antenna for wireless applications using coaxial feed. The aim of this study is to design multiband antenna using coaxial feed and study the various structures for realization of multiband antenna.

Keywords: Multiband antenna,GSM,Bluetooth,Coax feed,MSA.

I. INTRODUCTION

The fast growth of mobile communication systems has forced to the use of novel antennas for base and mobile station applications. Previously, mobile systems were designed to operate for one of the frequency bands of 2G systems, which are Digital Cellular System (DCS), Personal Communications Service (PCS) and Global System for Mobil Communications (GSM) networks. Presently, many mobile communication systems use several frequency bands such as GSM 900/1800/1900 bands (890-960 MHz and 1710-1990 MHz); Universal Mobile Telecommunication Systems (UMTS) and UMTS 3G expansion bands (1900-2200 MHz and 2500-2700 MHz); and Wi-Fi (Wireless Fidelity)/Wireless Local Area Networks (WLAN) bands (2400-2500 MHz and 5100-5800 MHz) [6].

Typically, because a single antenna cannot operate at all of these frequency bands of Mobile communication, multiple different antennas covering these bands separately should be used. However, usage of many antennas is usually limited by the volume and cost constraints of the applications. A multiband antenna in a mobile communication system can be defined as the antenna operating at distinct frequency bands, but not at the intermediate frequencies between bands. Recent vogue in multiband antenna designs used in mobile devices can be divided into four types, slot - type antennas, stacked patch antennas and planar inverted-F antennas (PIFA) and Fractal antennas. In the past years, different designs of multiband antennas have been proposed [8].

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There are countless numbers of approaches to obtain multiband antennas. There are different structures used to realize Multiband Antennas which are divided into four types, stacked patch antennas, slot - type antenna, antenna with shorting pin r, inverted-F antennas (PIFA) and Fractal antennas.In the case of stacked patch, the lower metallic patch is fed directly via connector (obviously coaxial probe) and the upper metallic patch is in parasitic coupling with the lower one. In shorting pin antenna structure a good impedance matching in the required frequency bands is achieved using shorting pins [8]. PIFAs are widely used multi-band antennas mounted in a broad range of communication devices. Space between the ground plane and the patch is filled with dielectric. PIFAs can be used also for three- and four-band applications, but the design of such antennas is rather than complicated.

II. RELATED WORK

2.1 Stacked Patch Antenna

This [1] paper represents a novel design of a circular polarized antenna for multiband GPS receivers is presented as shown in Fig.1. The design employs the concept of multi stacked patches fed through a single coaxial probe. The antenna is made up of three square patches stacked on one another Three patches being stacked together with a slit and symmetry I-slot are used to achieve triple operating frequency bands for GPS including L1 (1.575 GHz), L2 (1.227 GHz) and L5 (1.176 GHz). The use of stacked patch design has helped to solve the issue of narrow bandwidth in Microstrip patch antennas [1]. The patches are etched on three different substrates. The lower substrate has a thickness of h3=1.524 and permittivity $\varepsilon_{r=}$ 3.38, the middle and upper substrates are similar with a thickness of h2=h1=1.6 and permittivity of $\varepsilon_{r=}$ 4.4.The lower, middle, and upper patches are designed to resonate at L5, L2, and L1 frequency bands, respectively. The ground plane size is 80 mm 80 mm; the lower (P3), middle (P2), and upper (P1) patches have a length of 66, 56, and 45 mm, respectively. The simulated results appear to be 1.164–1.184(1.7%), 1.219–1.242 (2.0%), and 1.550–1.590 GHz (2.5%) as shown in Fig.2.The proposed antenna has achieved a bandwidth of 2.0%, 1.5%,and 1.7% at GPS L1, L2, and L5 bands, respectively.

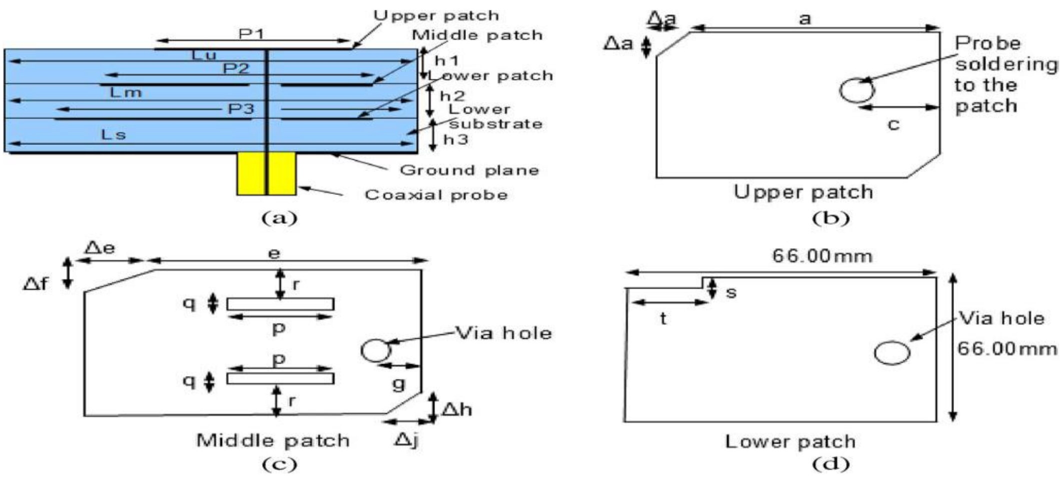

Fig.1 Geometry of the proposed stacked patch CP antenna showing (a) side view, (b) upper patch,(c) middle patch and (d) lower patch.

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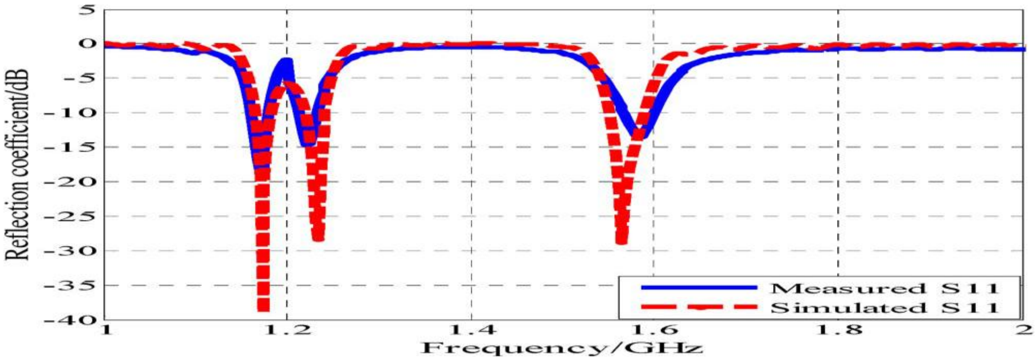

Fig.2 Measured and simulated reflection coefficients of the proposed antenna.

2.2 Slot type Multiband Antenna

In this paper, [2] a compact triple-band H-shaped slot antenna is proposed, which can be used for GPS and Wi-Fi applications. This design combines a narrow-width rectangular slot and a strip monopole to generate four resonant modes, including the fundamental modes of the monopole and the rectangular slot, as well as their high-order modes. The design of configuration of the H-shaped slot antenna, which is fabricated on an FR4 substrate of thickness εr = 4.5, a thickness of 0.7 mm, and a loss tangent of 0.025 and 60 mm× 60 mm in size, coated with copper on one side and the H-shaped slot can be viewed as a wide aperture of size, inserted with two metal strips of dimensions, leaving two slots of width on both edges of the aperture. A prototype H-shaped slot antenna is fabricated to verify the simulated results of both the input impedance and the radiation characteristics. Fig.3 shows the reflection coefficient of this H-shaped slot antenna. The measurement results match the simulation results reasonably well; the deviation may be caused by fabrication tolerance. Four resonant modes are excited as expected. The simulation results reveal four resonant bands at frequencies of 1.56, 2.62, 5.3 and 5.85 GHz respectively as shown in Fig.4. For proposed antenna, the simulated peak gains across triple operting bands are about 0.26, 4.36, 5.3 and 5.85 dB respectively.

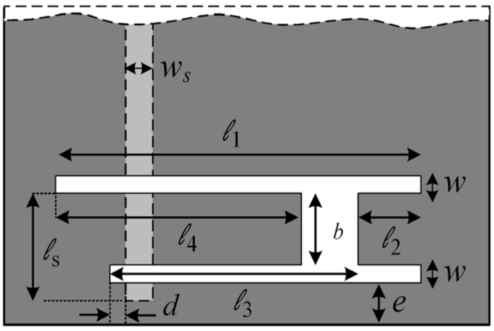

Fig.3 Layout of Antenna Design.

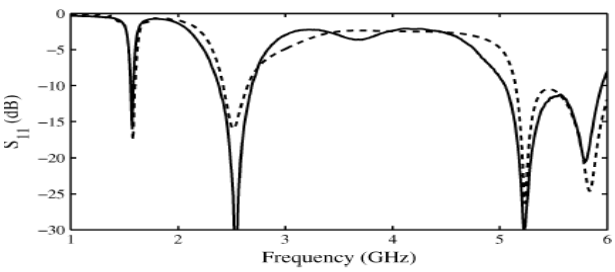

Fig.4 Simulated Return Loss for Proposed Design.

2.3 Antenna with Shorting Pin Structure

The paper presents the notch loading effect on the pin shorted equilateral triangular shaped microstrip antenna (ETMSA)[3].The proposed antenna shows the dual band behaviour due to pin shorting and also the effect of circular notch for bandwidth enhancement, with dual shorting pin. Length of each arm of ETMSA =20 mm is taken and dielectric constant and height of dielectric and loss tangent are εr=3.2, h=1.6 mm and tanδ =0.001

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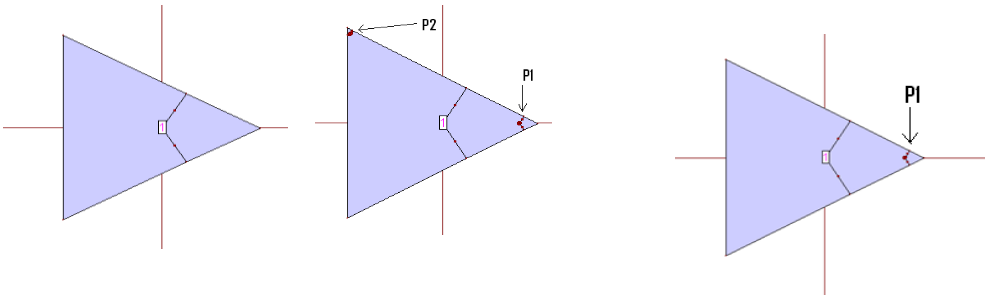
respectively. The two resonant frequencies are 6.03GHz and 7.238GHz are obtained from dual pin shorting as shown in Fig.6. The two pin shorting effect produces dual band antenna. The notch loading along with the two shorting pins results in enhanced bandwidth performance.



(a) (b) (c)

Fig.5.Geometry of antenna (a)patch without pin shorting,(b)Effect of single Pin shorting, (C)Effect of dual Pin shorting.

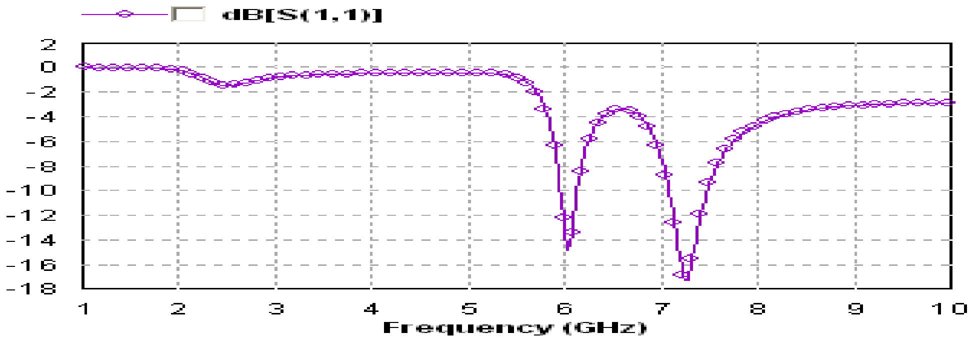


Fig.6 Simulated Return loss For Proposed Design.

2.4 PIFA Structure

The proposed antenna consists of a ground plane, a shorting plate, a feeding pin, and top patch that has two slots of L-shaped in order to obtain a triple frequency[4].An FR4 dielectric substrate was used on the ground plane and the radiating patch (top patch) which have thickness of 1.6mm. An air gap is separating between the ground plane and the radiating patch. A coaxial feeding probe is used through the feeding pin. The proposed antenna is shown in Fig.7.The simulation results reveal four resonant bands at frequencies of 0.96GHz, 1.804GHz, and 2.4GHz respectively. For proposed antenna, the simulated peak gains across triple operating bands are about 5.1, 6.632, 5.482 dB respectively as shown in Fig.8.

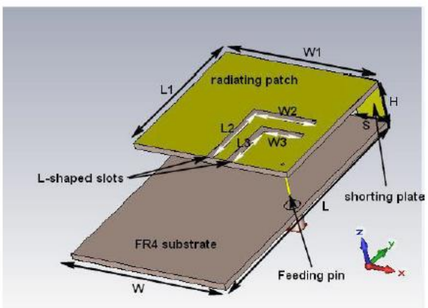


Fig.7 Geometry of the proposed antenna.

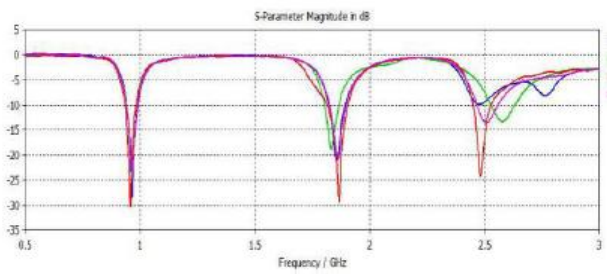


Fig.8 Simulated Return loss For Proposed Design.

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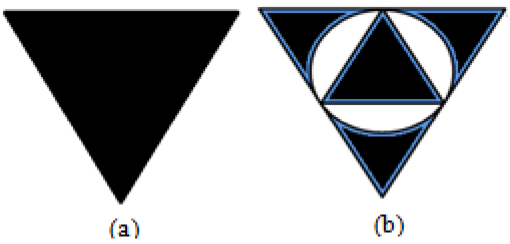
2.5 Fractal Geometry Structure

Design and Simulation of a Compound Fractal Antenna for Multiband Applications is studied for fractal geometry structure for realization of multiband antenna [5]. The proposed fractal antenna is based on the Sierpinski Gasket antenna. The difference is that instead of a triangular slot a circular slot is removed from the initial structure. The initiator and generator of the proposed compound fractal antenna is shown in Fig. 9(a) and Fig. 9(b) respectively. Initially it starts with an equilateral triangle which is the initiator. Then a circle with a triangle is inscribed in the equilateral triangle and this circular part is removed, which forms the first iteration. The geometry of the proposed compound fractal antenna is shown in Fig.10.The substrate material is of thickness 1.6mm and with permittivity 4.4. The dimension of substrate is same, 60mmx60mm. The ground is also kept perpendicular to the patch and with the dimension 60mmx60mm. Similarly the effective side length (se) is 52.8mm. The structure was fed through a 50 coaxial probe with an SMA connector on the bottom vertex of equilateral triangle. The structure of the proposed compound fractal antenna on the substrate is shown in Fig. 11.



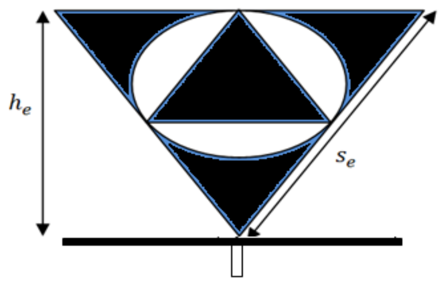


Fig.9 Proposed compound fractal antenna (a) Initiator antenna, (b) Generator

Fig.10 Geometry of proposed compound fractal

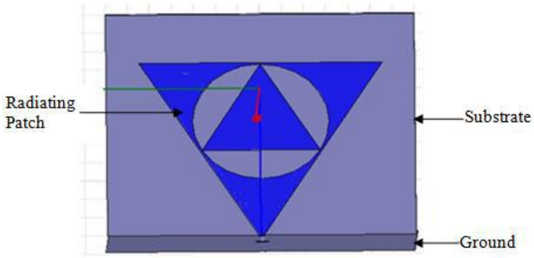


Fig.11 Structure of proposed compound fractal antenna on substrate FR4.

The simulation has been performed using Ansoft HFSS. Fig.12 shows the S11 for the first iteration of the Proposed Compound Fractal Antenna with respect to the frequency. The radiating patch, the ground plane and all conductors are assumed to be perfect electric conductor. It can be seen from Fig.12 that using a compound generator return losses lower than -10 dB are obtained. So two resonances are achieved from the first iteration. The first resonance are slightly lower at 0.86 GHz exhibits a return loss of -42.98 dB and the second resonance at 3.18 GHz exhibits a return loss of -37.43dB.

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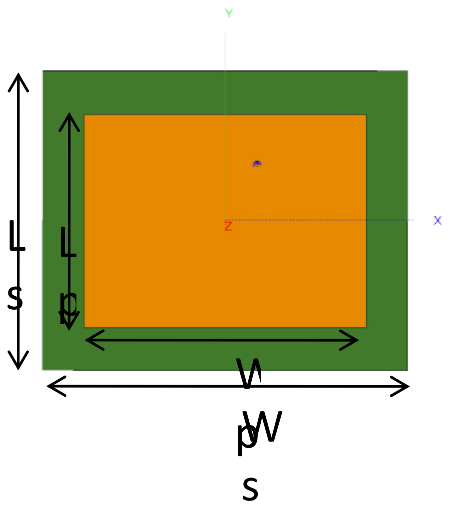
Fig.12.Simulated Return loss For Proposed Design in dB.

Table 1. Comparison Table for Contributed survey Paper.

Paper	size(mm3)	Substrate	Frequency (GHz)
1	80x80x1.6	FR4 Substrate	1.176,1.227,1.57
2	60x60x0.7	FR4 Substrate	1.56,2.62,5.3,5.85
3	20x20x1.6	FR4 Substrate	6.03,7.238
4	84x46x1.6	FR4 Substrate	0.96,1.804,2.4
5	60x60x1.6	FR4 Substrate	0.86,3.18

III. PROPOSED ANTENNA DESIGN

The geometry of the designed antenna is as shown in fig.13.The [9] designed antenna is realized using co-axial feed on a 1.6mm thick FR-4 dielectric substrate with 38.60mm x 46.70mm surface area and feed by a Co- axial feed of 50Ω.The antenna is designed with full ground having dimensions same as FR-4 substrate. The relative permittivity and loss tangent of the substrate is 4.4 and 0.02 respectively as shown in table 2.



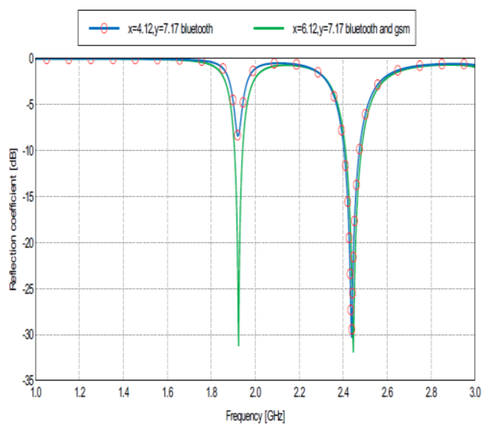


Fig.13 Geometry of proposed Antenna.

Fig.14.Graph of its Simulated Reflection coefficient Versus frequency for dual band.

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Table 2. Dimensions of proposed antenna

Parameter values	Calculated Values
Resonant Frequency (f_r)	2.4 GHz
Substrate	FR4
Dielectric constant (ε_r)	4.4
Substrate Height (h)	1.6 mm
Feed	Co-axial
Patch Length (LP)	36.10 mm
Patch Width (WP)	27.40 mm
Substrate Length (Lsub)	44.80 mm
Substrate Width (Wsub)	38.60 mm
Length of Ground Plane (Lsub = Lg)	44.80 mm
Width of Ground Plane (Wsub = Wg)	38.60 mm
Distance of feed point from LP (X)	6.12 mm
Distance of feed point from WP (Y)	7.17 mm

The Design equations of antenna is shown below from equations 1-8.

Width of patch (W_P):

$$W_P = \frac{c}{2 * f_r \sqrt{\frac{\varepsilon r+1}{2}}} \quad (1)$$

Where, c is the speed of the light.f_r is the resonant frequency and ε_r is the dielectric constant of substrate.

Effective dielectric constant(ε_{reff}):

$$\varepsilon_{reff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2\sqrt{(1+\frac{12h}{W})}} \quad (2)$$

where, ε_{reff} is the Effective dielectric constant ,ε_r is the dielectric constant of Substrate,h is the Height of dielectric substrate and W is the Width of the patch.

Effective length(L_{eff}):

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

Patch Length(ΔL):

$$\frac{\Delta L}{h} = 0.412 \left(\frac{(\varepsilon reff+0.3)(\frac{W}{h}+0.264)}{(\varepsilon reff-0.258)(\frac{W}{h}+0.8)}\right) \quad (4)$$

Length of Substrate(Ls):

$$Ls = Lp + 6h \quad (5)$$

Width of Substrate(Ws):

$$Ws = Wp + 6h \quad (6)$$

Distance of feed point from L_P (X):

$$X = \frac{L_P}{2\sqrt{\varepsilon reff}} \quad (7)$$

Distance of feed point from W_P (Y):

$$Y = \frac{W_P}{3\sqrt{\varepsilon reff}} \quad (8)$$

.Results and discussions are done by using parametric analysis of patch length, patch width, feed positions of an antenna. Simulation is done using CADFEKO 7.0 Version. Initial dimensions of antenna are Lp x Wp (29.46mm x 38mm) with Ls x Ws (39.06mm x 47.60mm) fed by coaxial feed line of (L1 x L2 ie.. 7.29 x 6.05). By varying patch length from 29.40 to 25.40 GHz, parametric analysis is done. It is observed that the antenna with gives Bluetooth band at patch length of 27.40, S11 ≤-10dB is for the frequency 2.4 to 2.487 GHz. From observation we can say that as we vary the patch length the frequency band is shifted from 2.31 to 2.52GHz center frequency). By varying patch width from 39.10 to 35.10GHz, parametric analysis is done. It is observed that the antenna with gives GSM band at patch width of 36.10 and patch length of 27.40 S11 ≤ -10dB is for the frequency 1.90 to 1.946 GHz. From observation we can say that as we vary the patch width the frequency band is shifted from 1.84 to 1.97 GHz center frequency. By varying feed position, parametric analysis is done. It is observed that the antenna with gives GSM and Bluetooth band at patch width of 36.10 and patch length of 27.40 and of (L1 x L2 i.e. 7.17 x 6.12), S11 ≤ -10dB is for the frequency 1.90 to 1.946 GHz and 2.4 to 2.487 GHz. The simulation results reveal four resonant bands at frequencies of 1.923 and 2.443 GHz respectively as shown below in Table 2.

Table.2 Simulated Results

Frequency Range GHz	Return Loss dB	Center Frequency GHz
1.90 to 1.946	-24.89 dB	1.923
2.4 to 2.487	-31.06 dB	2.443

IV. CONCLUSION

This paper presents a study of the different structures used to realize multiband antenna. We have studied four structures of multiband antenna, slot - type antennas, stacked patch antennas and planar inverted-F antennas (PIFA) and Fractal antennas. From this study or a survey of the different structures used to realize multiple frequency operation in either a single-element patch antenna or a multi- element scheme, we can conclude that, to integrate as many standards such as GPS, WIMAX, and WLAN into single wireless device, different multiband antennas have been studied. In proposed antenna design, Bluetooth and GSM bands are achieved by optimizing the Co-axial feed position and width of the patch, length of the patch. Thus we have integrated two technologies in one antenna.

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