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Bandwidth Optimization of Microstrip Patch Antenna- A Basic Overview

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Abstract — An antenna is a very important device in wireless applications. It converts the electrical energy into RF signal at the transmitter and RF signal into electrical energy at the receiver side. A micro strip antenna consists of a rectangular patch on a ground plane separated by dielectric substrate. The patch in the antenna is made of a conducting material Cu (Copper) or Au (Gold) and this can be in any shape of rectangular, circular, triangular, elliptical or some other common shape. Researches of past few year shows that, various work on Microstrip Patch Antenna is attentive on designing compact sized Microstrip Antenna with efficiency and bandwidth optimized. But inherently Microstrip Patch Antenna have narrow bandwidth so to enhance bandwidth various techniques are engaged. Today's Communication devices need several applications which require higher bandwidth; such as mobile phones these days are getting thinner and smarter but many applications supported by them require higher bandwidth, so microstrip antenna used for performing this operation should provide wider bandwidth as well as their shape should be more efficient and size should be compact so that it should occupy less space while keeping the size of device as small as possible. In this review paper, a review of different techniques used for bandwidth optimization & various shapes of compact and broadband microstrip patch antenna is given.

***Keywords**— Microwave Communication; Microstrip Antenna; Antenna Designing; Bandwidth Optimization; Rectangular shape Patch Antenna.*

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I. INTRODUCTION

An antenna is a very important device in wireless applications. It converts the electrical energy into RF signal at the transmitter and RF signal into electrical energy at the receiver side. A micro strip antenna consists of a rectangular patch on a ground plane separated by dielectric substrate [1]. The patch in the antenna is made of a conducting material Cu (Copper) or Au (Gold) and this can be in any shape of rectangular, circular, triangular, elliptical or some other common shape. In basic form, a Micro strip Patch antenna as shown in fig 1 consists of a radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The radiating patch and the feed lines are usually photo etched on the dielectric substrate.

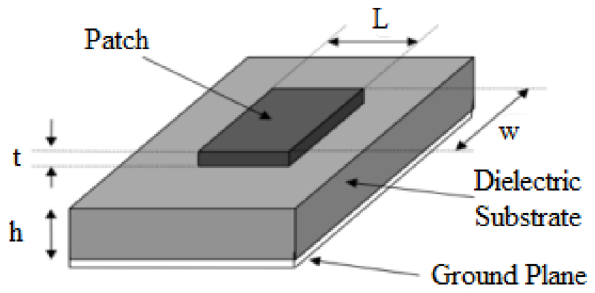

Figure 1 Micro strip Patch Antenna [2]

Micro strip antenna has a number of advantages which are small size, low profile, low weight but have a number of disadvantages like low bandwidth, low gain. Hence instead of improving this, fractal geometry has been applied on patch of antenna. Fractal geometry composed self-similar structure. Whenever fractal geometry is applied cuts are made on patch which causes current flow direction change to occur. Hence antenna resonates at different frequency bands. There are a number of bands at which antenna may operate. These bands are L, S, and C and X band. Whenever fractal geometry is applied, antenna can be useful for number of applications like GPS, satellite, communication, GSM, satellite and Radar. There are different fractals geometries that can be used but most commonly used geometry are Minkowski, Koch, and cantor shape. Further with increase in number of iterations, size of antenna decreases. By providing a number of slots over the patch, bandwidth is improved of patch antenna. Due to presence of multiple slots, Q factor decreases and value of patch inductance increases. By the decrease in Q factor, the bandwidth (BW) of patch antenna is increased accordingly,

$$\text{Bandwidth, BW [9]} = \frac{1}{Q\sqrt{2}} \quad (1)$$

Where,

$$Q = \frac{R}{\omega 0L} \quad (2)$$

II. MICROSTRIP **PATCH ANTENNA**

Antennas are based on transmission or reception of electromagnetic waves. Microstrip antennas have several advantages over conventional microwave antenna and

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therefore are used in a variety of practical applications. Microstrip antenna in its simplest design is shown in Figure 2. It consists of a radiating patch on one side of dielectric substrate (Єr≤10), with a ground plane on other side.

A microstrip patch antenna (MPA) consists of a conducting (metallic patch on a thin, grounded dielectric substrate) patch of any non-planar or planar geometry on one side of a dielectric substrate and a ground plane on other side. It is a printed resonant antenna for narrow-band microwave wireless links requiring semi-hemispherical coverage.

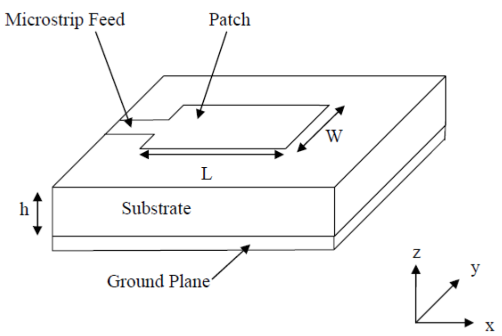

Figure 2 Microstrip antenna with substrate and ground

Due to its planar configuration and ease of integration with microstrip technology, the microstrip patch antenna has been widely utilized. The rectangular and circular patches are the basic and most commonly used microstrip antennas. The characteristic impedance of the microstrip line is determined by the substrate thickness, strip, width and dielectric constant.

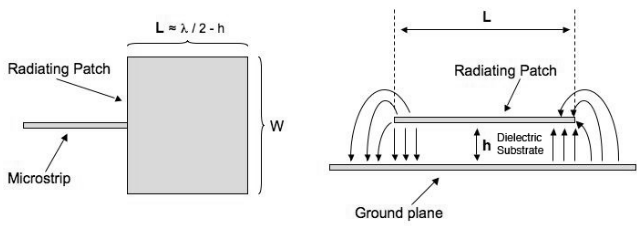

Figure 3 Microstrip antenna showing the radiating patch

Operation of Rectangular Microstrip Patch Antenna

Consider a basic rectangular patch microstrip antenna first as shown in Figure 4. Assuming a voltage input at the feedline, when operating in the transmitting mode, current is excited on the feedline to the patch and a vertical electric field between the patch and the ground plane. So therefore the patch element resonates at certain wavelength and this result in radiation.

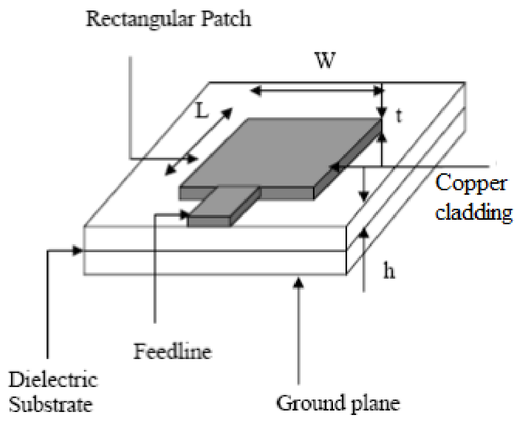

Figure 4 Rectangular Microstrip Patch Antenna

III. BANDWIDTH ENHANCEMENT OF PATCH ANTENNA

The following methods is to improve the band width of a RMPA.

A. Taper Matching

A patch antenna operating at 5GHz was designed using the conventional design equations available in it. In the 1st design (antenna a) we used a quarter wavelength long rectangular microstrip transmission line (TL) for impedance matching. The antenna substrate was RT/Duroid 5880 with $\varepsilon_r = 2.2$, h=3.175 mm and t=0.035 mm so that we can get large antenna's dimensions (see Fig.5), high gain and high bandwidth.

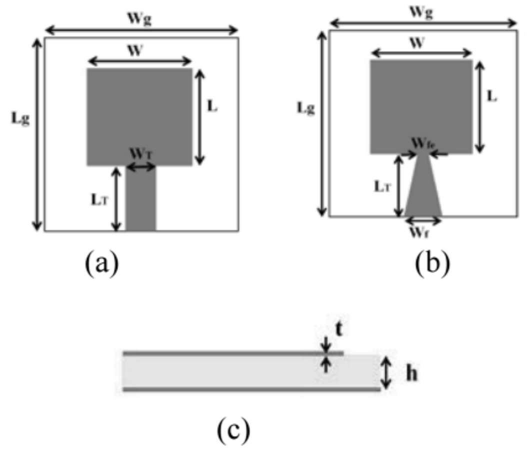

Figure 5 Antenna dimensions (a) rectangular quarter wavelength matching (b) taper matching (c) side view of the antenna

The original calculated length 'L' and width 'W' were 18.1mm and 23.7mm, respectively whereas the optimizedvalues of L, W and the transmission line dimensions 'L_T' and 'W_T' were 17.6mm, 23.7mm, 10.67mm, and 2.84mm, respectively. Also as shown in Fig.

5 the substrate length 'L_g' and width 'W_g' were, respectively, 37.15mm and 42.75mm. In the second (antenna b) design researchers used a tapered shape quarter wavelength long TL (L_T) on the original design (i.e. L=18.1mm, W=23.7mm) to improve the matching and bandwidth. The optimized taper widths 'W_{fe}' and 'W_f' were 0.3mm and 8.33mm, respectively, which corresponds to the 50Ω standard input impedance.

B. Quarter Wavelength Width Extension

For this method, firstly, the antennas dimensions are calculated from the conventional formulas as above. When the patch antenna's width 'W' is increased by let say $\Delta W \leq \lambda / 4$ (where λ is the guided wavelength), a second resonance starts appearing at a higher but close to the original resonance frequency. However, as ΔW approaches to λ / 4 the second resonance starts merging with the first one which ultimately gives a considerable increase in the antenna bandwidth. In our design (antenna b) the new value of the antenna width (i.e. $W + \Delta W$) becomes 34.38mm. Also as the antenna width increases the input impedance of the antenna decreases, so W_T (see Fig.1a) is increased to flatten the ripple in the pass band. Both the antenna length and width can be adjusted to finely control the edges of theS_{11} response. The antenna bandwidth and pass band flatness ofS_{11} can all be controlled by ΔW and W_T which give enough flexibility to create the desired response.

C. Width Extension and Taper Matching

This method is basically a combination of the two methods as described above. The patch antenna used in above section with $W = 34.38mm$ is redesigned to operate at 5GHz using tapered matching. The values of input (W_f) and output (W_{fe}) taper widths were optimised to increase the antenna bandwidth. These optimised values are W_f=6mm and W_{fe}=7mm which gives the widest and deepest response around 5GHz.

IV. ADVANTAGES AND DISADVANTAGES OF MICROSTRIP PATCH ANTENNAS

Microstrip patch antennas are increasing in popularity for use in wireless applications due to their low-profile structure. Therefore they are extremely compatible for embedded antennas in handheld wireless devices such as cellular phones, pagers etc. The telemetry and communication antennas on missiles need to be thin and conformal and are often in the form of microstrip patch antennas. Another area where they have been used successfully is in satellite communication. Some of their principal advantages discussed below:

- Light weight and low volume.
- Low profile planar configuration which can be easily made conformal to host surface.
- Low fabrication cost, hence can be manufactured in large quantities.
- Supports both, linear as well as circular polarization.
- Can be easily integrated with microwave integrated circuits (MICs).
- Capable of dual and triple frequency operations.
- Mechanically robust when mounted on rigid surfaces.

Microstrip patch antennas suffer from more drawbacks as compared to conventional antennas. Some of their major disadvantages are given below:

- Narrow bandwidth.
- Low efficiency.
- Low Gain.
- Extraneous radiation from feeds and junctions.
- Poor end fire radiator except tapered slot antennas.
- Low power handling capacity.
- Surface wave excitation.

Microstrip patch antennas have a very high antenna quality factor (Q). It represents the losses associated with the antenna where a large Q leads to narrow bandwidth and low efficiency. Q can be reduced by increasing the thickness of the dielectric substrate. But as the thickness increases, an increasing fraction of the total power delivered by the source goes into a surface wave. This surface wave contribution can be counted as an unwanted power loss since it is ultimately scattered at the dielectric bends and causes degradation of the antenna characteristics. Other problems such as lower gain and lower power handling capacity can be overcome by using an array configuration for the elements.

V. BACKGROUND & OVERVIEW

According to [3] the substrate material plays significant role determining the size and bandwidth of an antenna. Increasing the dielectric constant decreases the size but lowers the bandwidth and efficiency of the antenna while decreasing the dielectric constant increases the bandwidth but with an increase in size. Some research papers reviews are mentioned below.

In [4] antenna is feed using microstrip feeding technique and simulated using IE3D software The antenna shows single band bandwidth of 2 GHz for the working band of 4-6 GHz. The proposed antenna is useful for IEEE 802.11 WLAN standards in the 5.2/5.8 GHz band and WiMAX standards in the 5.5 GHz band. In [5] defected ground plane is in the

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form of L shaped slot and the rectangular parasitic patches and diagonal cuts at top corners can increase the bandwidth. For the first and second resonant frequencies Return losses of −17dB and −30 dB respectively, can be achieved when the diagonal cut is at optimum value.

In [6] a rectangular microstrip patch antenna with DGS has been simulated using High Frequency Simulation Software (HFSS) at 2.45 GHz frequency, antenna is fed by Quarter Transformer feeding. The rectangular patch antenna designed with swastik shaped DGS structure, shows gain of 7 dB. Patch antenna with Defected Ground Structure (DGS) demonstrate properties like improved returning loss, VSWR, bandwidth, gain of the antenna as compared to the conventional antenna.

In [7] a single frequency microstrip patch antenna feed using microstrip line fed and simulated using CST Microwave Studio software. Antenna operates at the frequency 5.2 GHz WLAN standard. Resultant impedance bandwidth is around 190 MHz with the having value of return loss as -47 dB has been obtained. The antenna also shows impedance of 50.89 ohm. In [8] circular patch antenna is designed with defect in ground plane.

In [9] antenna operating at 2.4 GHz frequency band for WLAN applications uses rectangular slot in the ground plane is located at different locations in the bottom of the substrate are considered and results of optimized patch antenna were obtained. Return loss improvement is from -17.72dB to -26.92dB. Gain improvement is from-5.1dB to -5.9 dB.

In [3] antenna Simulated at 4.30 GHz frequency and it is proved that when defect is introduced in ground plane of the single band antenna then the resulting antenna has its resonant frequency at lower side that is at 2.5GHz, which shows that the antenna has compact in size and showing improvement in gain and bandwidth. Here multiband operation of antenna is also obtained.

In [10] very compact antenna was designed, the antenna for WLAN operating in band of 2.4 and 5GHz. Various results are obtained by varying different dimensions of patch. Antenna is feed using microstripfeed. Different defected ground structures (DGS) have been developed analyzed.

In [11] and it is concluded that although the DGS has applications in the field of the, microwave oscillators, microwave filter design, microwave couplers to increase the coupling, microwave amplifiers, etc., it can be used in the microstrip antenna design for various advantages such as antenna size reduction mutual coupling reduction, harmonic suppression, cross polarization reduction, in antenna arrays etc. In [12] microstrip patch antenna for GSM and Wi-Max application was proposed. The proposed antenna shows promising characteristics at resonant frequencies of 5.5 GHz for WiMax, 5.2 GHz and 5.8 GHz for WLAN and 6-7 GHz for satellite application respectively.

A. Edge tapered wideband rectangular patch antenna

R.K.Sharan et.al [13] proposed an edge tapered wideband rectangular patch antenna with one slot at the center and parasitic stubs on two sides of the patch. In this paper partial ground is used. The height of the ground is varied from 8.6mm to 9.2mm and their effect on return loss was measured. Also the effect of varying the length of parasitic stub was measured.

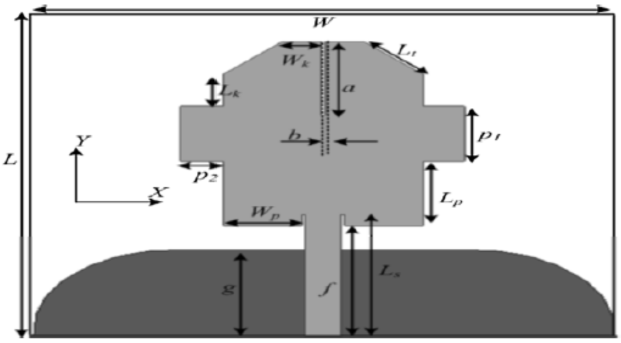

Figure 6 2D View of Proposed Antenna with Slot and Parasitic Stub [14]

Length was varied from 4 to 8 mm. This antenna was designed for wideband applications having bandwidth of 112%. This antenna also has good radiation pattern with a gain of 2.65dB and having 83.9% radiation efficiency. The overall dimension of the antenna is 35 × 35 × 1.6 mm3.

B. G- Shape Patch Antenna

K.Sankar et.al [15] proposed a circularly proposed dual band single layer G-Shaped patch antenna with using HFSS. By using four slots on patch antenna he designed a G shape on patch. Micro strip antenna has limited bandwidth due to resonance behavior. To increase the radiation and bandwidth, shape of patch can be changed by creating slots on it. The main idea behind this is to provide two resonance frequencies. These frequencies are 3 GHz and 3.8 GHz. At 3 GHz frequency achieved gain and return loss are 7.5 dB and -17 dB and at 3.8 GHz gain and return loss are 2.4 dB and -15 dB.

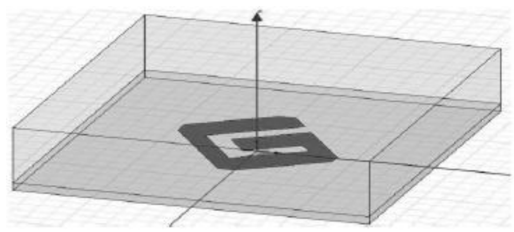

Figure 7 Design of G- Shape Patch Antenna in HFSS [14]

C. Micro strip -fed ultra-wideband (UWB) planar monopole antenna

Reza Zaker et.al [16] proposed a novel modified micro strip -fed ultra-wideband (UWB) planar monopole antenna with variable frequency band-notch function. In this design bandwidth magnification can be done by putting two slots in the both sides of micro strip feed line on the ground plane. This antenna is constructed using FR4 substrate with thickness of 1.0 mm with dielectric constant of 4.4. The additional current path can be provided by cutting slots and this also change the inductance and conductance of input impedance which changes the bandwidth. A modified H-shaped conductor-backed plane with variable dimensions is used in order to generate the frequency band-stop performance and control its characteristics such as band-notch frequency and its bandwidth. By changing the shape and size of slot, the resonant character of structure transmission with resonant frequency can be controlled. The designed antenna has a small size of 22×22mm2 and operates over the frequency band between 3.1 and 13.9 GHz for VSWR <2 with band rejection performance in the frequency band of 5.1 to 5.9 GHz.

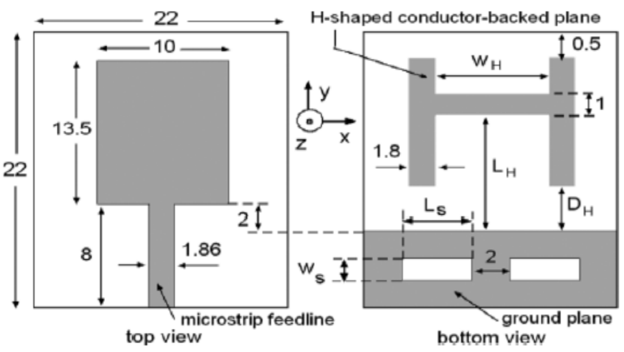

Figure 8 Geometry of the Proposed Planar Monopole Antenna (Unit: Mm) [15]

D. Dual band fractal micro strip antennas

Subhrakanta Behera et.Al. [17] proposed a multiport network approach for the analysis of dual band fractal micro strip antennas. To analyze the behavior of micro strip fractal antenna, multiport network approach is used. It has been observed that by increasing the indentation factor in the fractal section of the radiator, the resonance frequencies of the antenna changes and by suitably choosing this value one can get an antenna design with improved bandwidth with good gain at both the resonance frequencies.

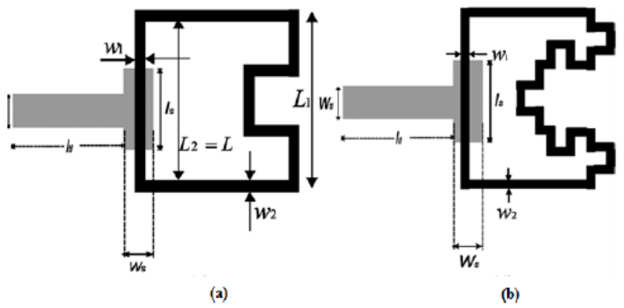

Figure 9 (a) Antenna with 1st iteration fractal. (b) Antenna with 2nd iteration fractal [16]

E. Wideband fractal shaped slot antennas

R.Ghatak et.Al. [18] proposed a wideband fractal shaped slot antennas for X- band application. A novel fractal patterned iris loaded cross dipole slot antenna along broad wall of rectangular waveguide at X- band is designed. To improve the impedance matching, the method of junction tapering of the cross slots is used. Bandwidth improvement is t better than 2 GHz with optimization of iris depth and inclusion of a second iteration slot in the vicinity of the primary cross slot. Peak realized gain remains around 7 dB over the operational bandwidth.

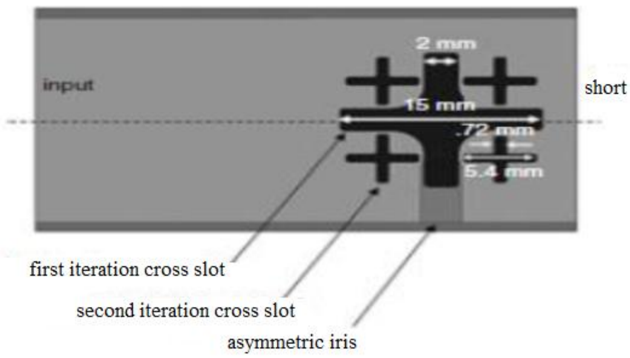

Figure 10 Structural layout [17]

TABLE 1 Table for the Comparative Analysis of Different Techniques

Sr. No	Title	Technique	Input parameter	Output parameter
1.	An Edge Tapered Rectangular Patch Antenna with Parasitic Stubs and Slot for Wideband Applications [14]	A rectangular patch antenna with tapered edge was designed. The slot and parasitic stubs were also used for this design.	FR4 Epoxy Glass was used as substrate with thickness of 1.6 mm Dielectric constant of substrate= 4.4 Antenna size=35 × 35 ×1.6 mm^3.	Percentage Bandwidth = 112% (centered at 6.01 GHz) Average radiation efficiency= 83.9%
2.	Single Layer DualBand G-shaped patch antenna [13]	A G- shape slot was cut on the patch for bandwidth magnification.	Dielectric constant =2.2 Substrate thickness =4mm Patch length (L) =30mm Patch width(W) =40mm	At frequency 3 GHz BW= 500 MHz Gain = 7.5 dBi Return loss= -17 dBi At frequency 3.8 GHz BW= 400 MHz Gain= 2.4 dBi Return loss= -15dBi
3.	Novel Modified UWB Planar Monopole Antenna with Variable Frequency Band-Notch Function [15]	In this paper H- shape was designed on patch antenna and also two square slots are inserted on ground plane. This DGS provide an additional current path.	Ground-22×22 mm^2 Patch length-13.5mm Patch width -10mm feed line length-8mm Feed line width- 1.86mm	(VSWR<2) for frequency band of 3.1 to over 13.9 GHz with rejection band around 5.1 to 6 GHz.
4.	Multi-Port Network Approach for the Analysis of Dual Band Fractal Micro Strip Antennas [16]	Fractal Minkowski geometry was used. In Minkowski initiator is divided into three equal parts of length and by two horizontal and a vertical segment of equal length middle segment was replaced.	Ground plane of aluminium of dimensions 20 cm× 20 cm was used.	At first iteration F_{r1}= 2.95 GHz BW= 38 MHz Gain = 5.98 dBi At 2nd iteration F_{r2}= 4.725 GHz BW= 59.8 MHz Gain= 5.3 dBi
5.	Wideband fractal shaped slot antenna for X-band application [17]	Fractal geometry was used. A second iteration fractal shaped cross slot is fabricated along the centre of the broadwall of a rectangular waveguide.	At 1st iteration length and width of + sign was 15mm and 2mm. At 2nd iteration length and width of + sign was 5.4mm and 72mm.	Bandwidth magnification better than 2 GHz and 2 GHz 3 dB pattern bandwidth was obtained.
6.	Micro strip Symmetrical E-Shape Patch Antenna for the Wireless Communication Systems [19]	E shape antenna was designed by cutting two slots from rectangular patch.	Resonant frequency fr 3.1GHz co-axial feed line was used. Ground plane-41×31 mm^2 Patch-31×21 mm^2	Gain = 4.7 dB Return loss = -28 dB

A pattern and impedance bandwidth better than 2 GHz (9.6 to 12 GHz) is calculated with a second iteration cross dipole fractal shape centered slot antenna loaded with a curved partial height iris of 4 mm thickness and 7.2 mm depth [18].

F. E-shape micro strip patch antenna

Ajay Yadav et. al.[19] represent a design & analysis of E-shape micro strip patch antenna for wireless communication. The benefits of this antenna were decrease in volume, low profile configuration, smoothly mounted, light weight, less production cost. The antenna operates on 3.1GHz and

3.45GHz frequencies. This antenna was implemented by using FR4 substrate with dielectric constant 4.2 and thickness of 1.6mm. To enhance the bandwidth two parallel slots were cut which provide additional current path. To achieve the desired output parameters, the dimensions of patch and ground can also be changed [20]. It has been detected that the position of feed points effects the behavior of the designed antenna. The return loss of -12dB of and -28dB at operating frequencies 3.1GHz and 3.45GHz respectively were calculated using this design. To simulate the results of designed antenna HFSS software was used.

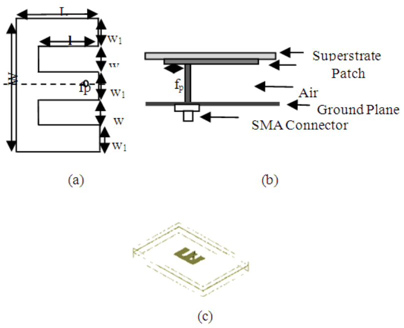

Figure 11 Design of Proposed Antenna (Top View) [18]

G. U-slot microstrip antenna

Khidrewt al. [21] proposed dual beam microstrip antenna, two radiation beams were obtained by operating patch at higher order mode instead of fundamental mode. In this, bandwidth of antenna is obtained by making use of u shaped patch.

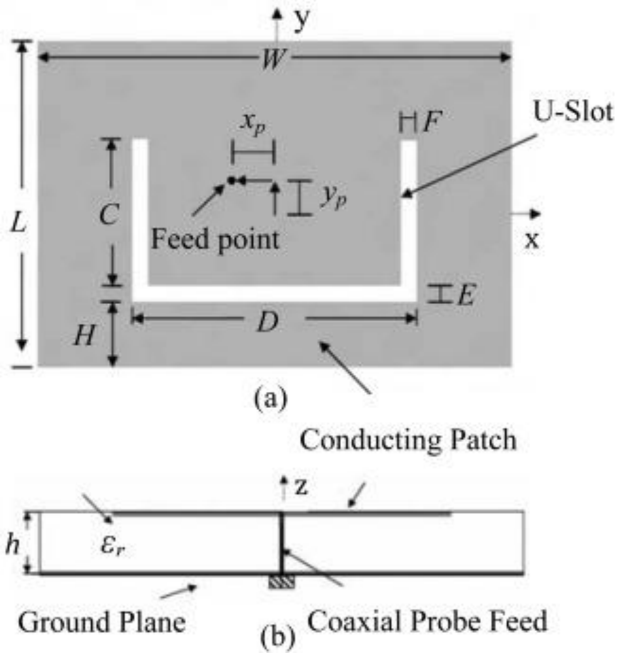

Figure 12 Geometry of the proposed U-slot microstrip antenna: (a) top view; (b) side view. [21]

Conventional U slot patch antenna, parametric analysis is analysed. Also effect of U slot inclusion on performance of patch antenna was analysed.

Antenna was designed and simulated using HFSS simulated software and good effects were obtained between practical and experimental results. The antenna operating frequency range is 5.18–5.8 GHz with VSWR less than 2, which corresponds to 11.8% impedance bandwidth. It exhibits two radiation beams, directed at 35 and with 7.92 dBi and 5.94 dBi realized gain, respectively at 5.5 GHz.

H. Circular symmetric slotted microstrip patch antenna

Nasimudin et al. [22] proposed circular symmetric slotted microstrip patch antenna with compact size. This antenna was obtained by cutting shapes in diagonal directions of microstrip patch antenna. . A measured 3 dB axial-ratio (AR) bandwidth of around 0.7% (6.0 MHz) with 2.0% (18.0 MHz) impedance bandwidth was achieved.

The measured boresight gain was more than 3.3 dBi over the operating band was obtained. Different shapes for the slots are studied and compared, based on the fixed overall volume of the antenna for circularly polarized diagonally symmetric slotted microstrip-patch antennas. This antenna was designed to have compact size of small dimensions.

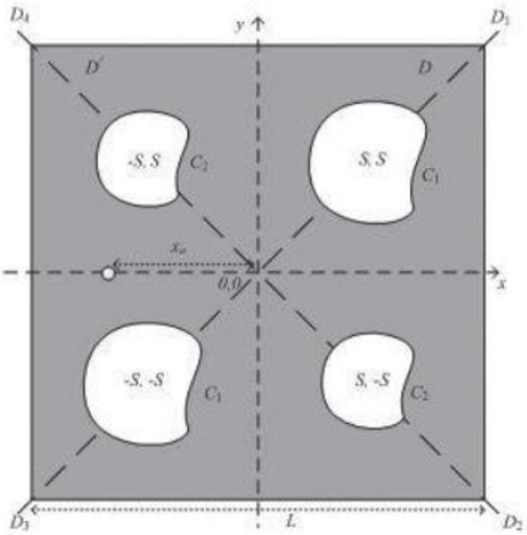

Figure 13 Generalized arbitrarily shaped slots for diagonally symmetric slotted microstrip-patch structures. [22]

I. Triband bowtie antenna

Liu et al. [23] proposed triband bowtie antenna using slot technique. This antenna was obtained by inserting two pairs of slot with different length of isosceles triangle without increasing area of triangle. This antenna is designed to operate for three different bands applications.

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TABLE 2 Table for the Comparative Analysis of Different Techniques

S. No.	Proposed Antenna	Technique Applied	Remarks
1.	Implementation of Slotted Meander-Line Resonators for Isolation Enhancement in microstrip Patch Antenna Arrays	A Defect is introduced called as meander line resonator by creating defect known as band notch function. Resonator is designed to block surface current at resonant frequency of two patch antenna.	To enhance isolation in microstrip patch antenna arrays and it has concluded that that technique only implemented on array antennas.
2.	Wide Band Dual-Beam U Slot microstrip Antenna	Bandwidth of antenna is obtained by making use of u shaped patch. Conventional U slot patch antenna, parametric analysis is analyzed.	The proposed design was used for stationary terminals of various indoor wireless communication networks.
3.	Circular symmetric slotted microstrip patch antenna with compact size	Obtained by cutting shapes in diagonal directions of microstrip patch antenna.	3 dB axial-ratio (AR) bandwidth of around 0.7% (6.0 MHz) with 2.0% (18.0 MHz) impedance bandwidth was achieved
4.	Triband bowtie antenna using slot technique	Obtained by inserting two pairs of slot with different length of isosceles triangle without increasing area of triangle.	Antenna was resonated at three different bands but its dimensions were made for middle frequency band. This antenna was resonated for 3.5 GHz, 4.5 GHz and 5.8 GHz.
5.	Compact and Small Planar Monopole Antenna with Symmetrical L- and U- Shaped Slots for WLAN/WiMAX Applications	Consists of a rectangular radiating patch with Land U-shaped slots and ground plane.	Obtained the required operational frequency bands—namely,WLAN(2.4/5.2/5.8 GHz) and WiMAX (2.5/3.5/5.5 GHz).

Antenna was resonated at three different bands but its dimensions were made for middle frequency band. This antenna was resonated for 3.5 GHz, 4.5 GHz and 5.8 GHz. Design and simulation was carried out using antenna simulation software.

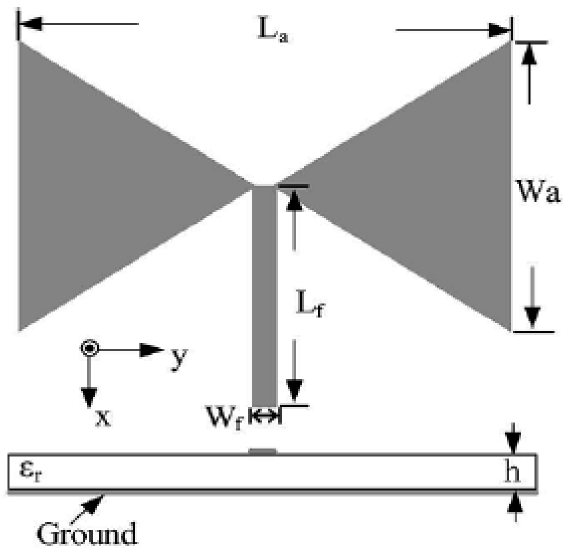

Figure 14 Geometry of the single-band bowtie antenna without slot (proposed parameters). [23]

VI. TECHNIQUES USED TO MODIFY SINGLE BAND PATCH INTO MULTIBAND

Various techniques have been proposed to modify a single band antenna into a multiband antenna.

A. CPW-FED Technique

The designed antenna configuration is depicted in Fig. 15. As seen, the microstrip antenna composed of two coupled metallic elements fed by 50-ohm coplanar waveguide (CPW) line.

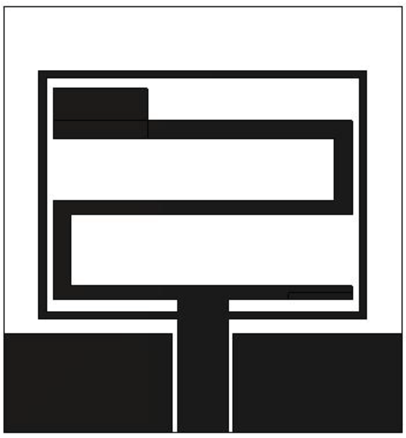

Figure 15 Antenna Configuration with CPW-FED technique

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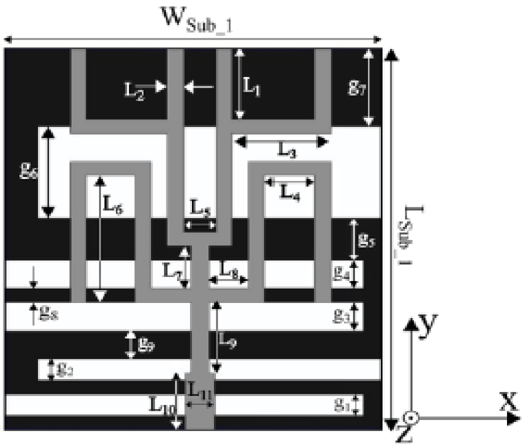
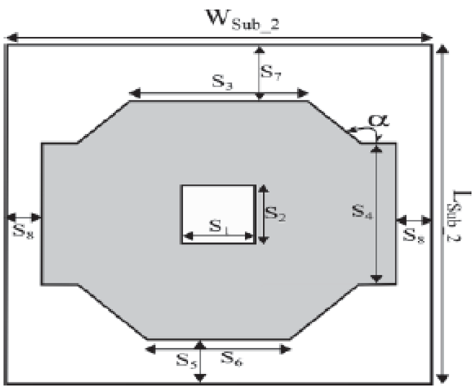
The outer element is consisting of rectangular ring microstrip antenna. As stated in [24], a rectangular ring microstrip antenna is formed when a rectangular slot is cut in the center of rectangular microstrip. With an increase in the slot dimensions, the rectangular microstrip antenna becomes rectangular ring microstrip antenna and then a printed loop antenna, and the resonance frequency decreases.

B. Proximity Coupled

A corner-truncated rectangular patch with a rectangular slot at its center is printed on top of the upper layer. The bottom side metal of this layer is fully etched out. Proximity coupling is obtained by a meandered microstrip feedline printed on top of the lower substrate layer. The slotted ground structure is on the lower side of this substrate. Length of the upper layer is slightly smaller than the lower layer in order to keep a provision for connection of inner conductor of a SMA connector to the microstrip feed.



(a)



(b)

Figure 16 Configuration of the proposed antenna: (a) geometry of ground and feed line, and (b) geometry of upper patch

C. Parasitic Elements

A new multiband MPA incorporating Inverted-Land T-shaped parasitic elements is proposed to cover Long-term Evolution time-division depleting number 34 (LTE TDD No. 34: 2.0175 GHz), wireless local area network (WLAN: 2.45 GHz), and Worldwide Interoperability for Microwave Access (WiMAX: 3.5 GHz) bands.

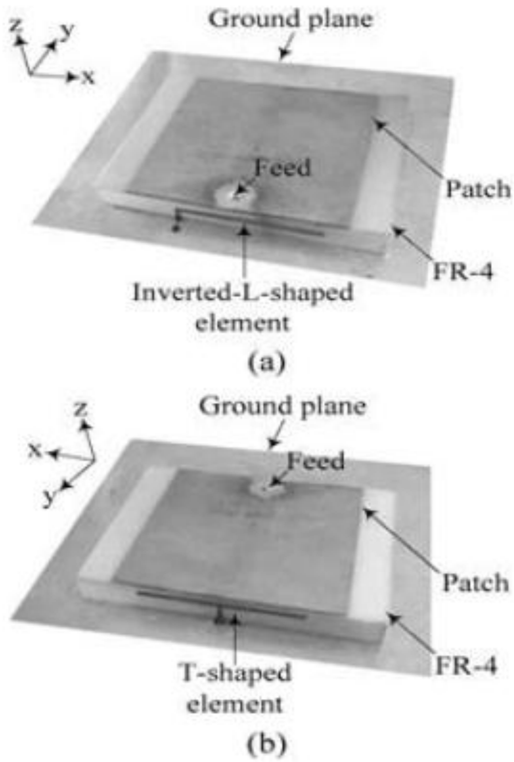


Figure 17 Fabricated prototype of antenna: (a) showing Inverted-L-shaped element; (b) showing T-shaped element.

Inverted-L-and T-shaped parasitic elements that resonate through perturbation and coupling with the MPA are used in this design. Because resonance can occur at low frequency without the need to increase the antenna size, especially height, proposed multiband MPAdesign can be compacted. Furthermore, the antenna has the capability to tune independent resonant frequencies.

D. L-Probe with Slots

In this study, instead of focusing on broadband operation, L-probe fed MSA with multiple U-slots will be used as a multiband antenna. By increasing the number of U-slots, multiple frequencies can be obtained. An L-probe feed is used to obtain good matching on all four frequencies using thin substrate. The antenna should have good return losses, gain and radiation patterns on all frequencies.

The multiband operation was due to the multiple U-slots loaded on MSA. By changing the dimensions of the

U-slots and L-probe feed, the antenna characteristics can be controlled.

After conducting parametric studies, a test antenna was simulated and fabricated. Good agreement between simulated and measured response was obtained on all four operating frequencies making it suitable multiband antenna. As a variation to U-slots, the slot geometry was slightly to V-slot with base. V-slot with base MSA gives higher operating frequencies and provided better overall antenna gain. [25]

E. Fractal Technique

Fractal has unique property that it can make copies of itself at different scales. The concept of fractal antenna is very old but designing for broadband application is quite new.

The antenna utilized a coaxial feeding technique and simultaneously possesses multiband, almost uniform radiation, and low profile. The self-similarity [26] of fractal gives rise to multiple bands. The length of the fractal at resonance is increasing due to space filling property, whereas the height reaches an asymptote reduction allowing an antenna to operate at lower frequency and shows a low resonant frequency. In 1970, Dr B. Mandelbrot coined the term Fractal. Fractal antenna has demand in military as well as commercial area Mandelbrot explained the complex structure to own the self-similarity geometrical structure. The phenomenal expansion in wireless communications has posed a great challenge to design compact, portable and multiband antennas to support several applications. Fractal antennas seen to be a viable solution to meet the challenges. Therefore active research initiatives are taken up at various organizations to develop new fractal antennas. These antennas not only have an effective length but the contours of its shape give a capacitance or inductance to match the antenna to the circuit.

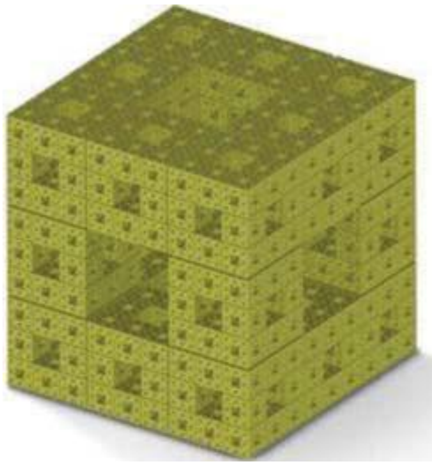


Figure 18 Basic structure of fractal antenna

TABLE 3 Comparison chart

S. No.	Modification Techniques	Configuration	Remarks
1.	CPW-FED Technique	The microstrip antenna composed of two coupled metallic elements fed by 50-ohm coplanar waveguide (CPW) line. [27]	The proposed antenna provides four desirable resonant frequencies and impedance bandwidth which are applicable for ISM band, CCTV and wireless video links, and WLANs.
2.	Proximity coupled	A corner-truncated rectangular patch with a rectangular slot at its centre [28]	It exhibits simultaneous operation at UMTS, LTS, Bluetooth, Wi-MAX, and WLAN bands.
3.	Parasitic Elements	Inverted-L- and T-shaped parasitic elements at both radiating apertures of the microstrip [29]	In this letter, a compact multiband microstrip antenna for LTE TDD No. 34, WLAN, and WiMAX bands was proposed.
4.	L-Probe with slots	MSA with multiple U-slots loaded in the centre implemented on a two-layer PTFE substrate [25]	Return losses on all four modes are better than -10 dB. The average measured gain is around 7 dBi.
5.	Fractal	Microstrip fed modified star triangular fractal antenna. [30]	Antenna resonated at five frequencies. The impedance bandwidth of antenna on these frequencies are 500 MHz, 400 MHz, 650 MHz, 500 MHz and 500 MHz, respectively.

CONCLUSION

Bandwidth enhancement, optimization, antenna shape selection and size reduction arebecoming major design considerations for practicalapplications of microstrip antenna. Many techniqueshave been used to achieve wideband and to reducethe size of microstrip antennas. This paper work shows thereview and survey of various such techniques. Out ofall techniques shown above in this paper various optimization scheme like particle swarm optimization, genetic algorithm, differential evolution etc. perform better with antenna's having rectangular or square patch for bandwidth optimization. Also, Slot-LoadingTechnique and Slotted Ground PlaneTechnique yields maximum bandwidth and compact in size.

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