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Microstrip Patch Antenna for Bandwidth Enhancement: A Review

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Abstract- New and exciting technology invented about twenty years ago in field of antennas i.e microstrip patch antennas .It has found increasing use of antennas because of it's advantages like light weight ,small size, low cost ,easy design and efficiency. Compatibility with printed circuit boards at microwave frequencies demanded in modern communication devices .This paper presents pentagonal shaped antenna design and study of past few years shows that MPA are targeted to plan compact antennas for bandwidth enhancement. Microstrip patch antenna is good choice for different wireless applications. Also study of different parameters is done.

Keywords- Bandwidth, Design parameter, Dielectric, Feeding technique, Microstrip Patch Antenna

I. INTRODUCTION

In this paper pentagonal shaped patch antenna that operates at 3.281GHz to 7.45GHz frequencies has been analyzed . Patch antenna is a narrowband, wide beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate such as a printed circuit board. There has been growing demand in military as well as commercial sector for antennas that possesses attributes like low profile, compact size, light weight, low cost ,compatibility with Microwave Monolithic Integrated Circuits (MMIC's) etc. Conventional patch antenna designs encounter severe limitations such as narrow bandwidth, low gain and surface wave losses. Commonly used antenna shapes are rectangular, circular, elliptical etc. Some of the techniques proposed by researchers for widening the bandwidth are; wide-slot antennas fed by a microstrip line with a fork-like tuning stub[1],E-patch[3], a Rotated Slot[7]etc. Another way to enhance the bandwidth is by introducing slot and patch with same shape in ground plane printed on same side of substrate also with increase in the substrate thickness or reduced dielectric constant .Proposed antenna shows that wideband characteristics are depend on various parameters such as slot–patch dimensions ,feeding technique etc. Antenna bandwidth broadening achieved by using same shaped slot and radiating patch geometry in pentagonal antenna. By changing geometrical dimensions and analysis is carried out with the help of High Frequency Structure Simulator (HFSS)

II. ANTENNA DESIGN AND PARAMETRIC STUDY

Three important parameters for design of microstrip patch antenna are

- Resonant frequency(fo)
- Substrate thickness(h)
- Dielectric substrate(εr)

Appropriate selection of resonant frequency is necessary in antenna design. Dielectric substrate thickness i.e h=1.6 is employed in this design .FR-4 Epoxy with dielectric constant 4.4 and 0.02 loss tangent used for the antenna design. Dielectric constants are normally in the range of ($2.2< \varepsilon r <12$).In the recent years much intensive research has been done to develop bandwidth enhancement techniques. Some techniques include the utilization of thick substrates with low dielectric constant, and slotted patch[2].

Pentagonal slot antenna designed on FR4 substrate with $25\times25\times1.6mm^3$ in size .The antenna made up of ground plane of length L and width W. Pentagonal shaped slot cut from ground plane. Side lengths of slot can be varied . Structure contains parasitic patch with same shape at origin. Antenna fed by microstrip line placed beneath .Length of feed line, distance from the origin and side lengths of slot varied to achieve

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impedance matching conditions for maximum signal transmission from feed line to parasitic patch . Pentagonal parasitic patch fed by microstrip line excites resonating frequencies. Results are observed for different parameters of antenna through variation in slot and patch dimensions. Designed antenna is suitable for multiband wireless applications such as WiMAX (3.5GHz),802.11aWLAN 5.2GHz,and HYPERLAN/2 5.5GHz. Aim is to integrate same antenna for wireless multimedia data communication for UWB devices.

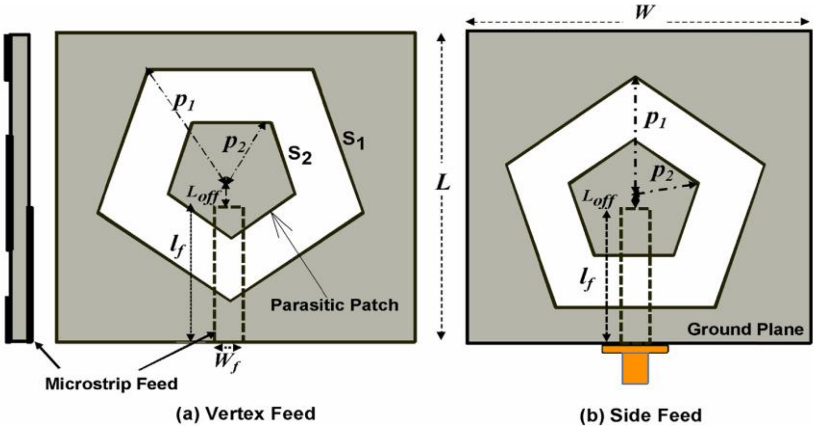

Fig 1.Geometrical configuration of an antenna

Designing parameters of antenna :

Antenna geometry can be designed by pre-calculations of Width ,Effective dielectric constant, actual length of patch ,calculations of legth extension ,Gain ,Directivity, Voltage standing Wave ratio and Bandwidth etc. for good performance of antenna:

1) **Width** :

The width can be formulated as:

$$W = \frac{C}{2fr\sqrt{(\varepsilon r + 1)/2}}$$

Where, c = free space velocity of light

εr = Dielectric constant of substrate

2) Effective Dielectric Constant Calculation:

The effective dielectric constant (εreff) is less than (εr) because the fringing field around the periphery of the patch is not confined to the dielectric speared in the air also.

$$\varepsilon_{eff} = \frac{\varepsilon r + 1}{2} + \frac{\varepsilon r - 1}{2}[1 + 12\frac{h}{w}]^{-1/2}$$

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3) The Actual Length Of The Patch (L):

The difference in the length (ΔL) which is given by:

$$L_{eff} = \frac{C}{2fr\sqrt{\varepsilon_{ref}}}$$

L = Leff - 2ΔL

4) Calculation Of Length Extension:

$$\frac{\Delta l}{h} = 0.412\frac{(\varepsilon\ eff + 0.33)(\frac{\omega}{h} + 0.264)}{(\varepsilon\ eff - 0{,}258)(\frac{\omega}{h} + 0.8)}$$

5) Gain And Directivity:

The expression for the maximum gain of an antenna is as follows:

G = η x D

η – The efficiency of the antenna

D – Directivity

6) Voltage Standing Wave Ratio:

$$VSWR = \frac{V_{max}}{V_{min}} = \frac{1 + |\Gamma|}{1 - |\Gamma|} = \frac{1 + S_{11}}{1 - S_{11}}$$

As the reflection coefficient ranges from 0 to 1, the

VSWR ranges from 1 to ∞.

7) Bandwidth :

The bandwidth is the ratio of the upper and lower frequencies of an operation. According to the bandwidth can be obtained as:

$$BW_{BROAD\ BAND = \frac{fH}{fL}}$$

$$W_{narrow\ band(\%) = \left[\frac{fH - fL}{fC}\right]100}$$

When the ratio fL /fH= 2 the antenna is said to be broadband. We can judge the antenna's performance by operating the antenna at a high frequency by observing VSWR, when VSWR ≤ 2 (RL ≥-9.5dB) the antenna is said to have performed well.

III. LITERATURE REVIEW

The construct of printed wide-slot antennas by Jia-Yi Sze fed with a microstrip line with a fork-like tuning stub gives results that indicates 1:1.5VSWRbandwidth of 1 GHz is achieved at operating frequencies around 2 GHz, It also achieved a 2-dB gain bandwidth of at least 0.5 GHz. The dimensions of antenna are 53.7mm×53.7mm. undesired higher order modes are present causes distortion in radiation pattern.[1]

coplanar waveguide (CPW) feed with a widened tuning stub, a square slot antenna proposed by Horng-Dean Chen .Experimental results show that the impedance matching for the proposed antenna strongly depends on the location of the tuning stub in the square slot. Wide impedance bandwidth of 60% can be obtained. Result shows that the measured antenna gain throughout the operating range of 3.75–4.88 dBi.[2]

Aliakbar Dastranj, Ali Imani, and Mohammad Naser proposed printed wide-slot antenna, fed by a microstrip line, for wideband communication antenna consist of E-shaped patch feed to excite the E-shaped slot. The substrate size is selected as 85 mm ×85 mm. When the coupling is increased to a certain value, an optimum operating bandwidth can be obtained. However, if the coupling is further increased more than this value, the impedance matching will deteriorate, showing that over coupling can also degrade the impedance matching.[3]

Printed E-Shaped Slot Antennas Fed by CPW and Microstrip Line invented by Aliakbar Dastranj and Habibollah Abiri The one fed by a microstrip line has a bandwidth over 136% (from 2.85 to 15.12 GHz) for S11 < -10dB. The other one fed by aCPWline has a bandwidth over 146% (from 2.83 to 18.2 GHz). This large operating bandwidth is obtained by choosing suitable combinations of feed and slot shapes.[4]

A broadband design of a coplanar waveguide fed square slot antenna loaded with conducting strips is proposed and experimentally studied by Jyh-Ying Chiou, Jia-Yi Sze. The obtained results show that the impedance bandwidth, determined by 10-dB return loss, of the proposed slot antenna can be greater than 60% with 70mm ×70mm size.[5]. A printed wide-slot antenna fed by a microstrip line with a rotated slot for bandwidth enhancement is proposed. The measured impedance bandwidth, defined by 10 dB return loss, can reach an operating bandwidth of 2.2 GHz at operating frequencies around 4.5 GHz, which is about four times that of a conventional microstrip-line-fed printed wide-slot antenna. 2-dB gain bandwidth of at least 1 GHz is achieved.[6]

A printed wide-slot antenna with a parasitic patch for bandwidth enhancement is proposed by Y. Sung.Square slot antenna has a relatively wider bandwidth than other types of antennas, but its applicability as a broadband antenna is limited due to the characteristics of a single resonant mode. Thus broadband characteristic of the wide-slot antenna is achieved. The measured results demonstrate that this structure exhibits a wide impedance bandwidth, which is over 80% forS11<-10 dB ranging from 2.23 to 5.35 GHz.[7]

Printed wide-slot antenna is presented. The design is based on the planar inverted cone antenna (PICA), introduced by Suh for UWB. The design is lower in profile, more compact and maintains comparable performance. Highly omnidirectional coverage can be seen at all measured frequencies. There is a stronger ripple at the higher frequencies, where the antenna operates at higher order modes instead of a typical monopole mode. The presented antenna is completely integrated in a two-layer PCB. With an antenna size of 60 mm 60 mm, The antenna has a high radiation efficiency and omnidirectional coverage with varying polarization[9].

low-profile and compact circularly-polarized (CP) antenna has been proposed and comprehensively investigated based on the combination of fractal metal surface and fractal resonator. The results indicate that the proposed antenna achieves a compact layout of 40 mm×45 mm×2.5 mm at 3.5 GHz, a relative wide bandwidth of more than 1.86% and also a comparable gain of about 6.3 dBic. Antenna is free of metallic via holes and the complex feeding network which predict a promising application in portable communication systems [14]

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IV. RESULTS AND ANALYSIS

Results and analysis of previous literature papers is given in literature review table given below ,

Literature review table

Ref no.	Approach	Antenna size	Gain	Bandwidth	Feeding mechanism
1	Printed wide-slot antenna with tuning fork like stub	53.7mm ×53.7mm	2dB	1GHz	Microstrip line feed
2	Square slot with widened tunning stub	72mm×72mm	3.75–4.88 dB	411MHz	CPW feed
3	E-shaped slot antenna	85mm ×85mm	7.5dB	2.8 to 11.4GHz	Microstrip line feed
4	E-shaped slot antenna	85mm ×85mm	6.5dB	2.8to 18.2	CPW feed
5	Square slot antenna loaded with conducting strips	70mm×70mm	5.8dB	1.5 to 2.5 GHz	CPW feed
6	Printed wide-slot antenna with rotated slot	70mm×70mm	2dB	2.2GHz	Microstrip line feed
7	Wide-slot antenna with a parasitic patch	70mm×70mm	2.4dB	2.23 to 5.35GHz	Microstrip line feed
9	Printed wide-slot with planar inverted cone	60mm×60mm	-	2.2 GHz	Microstrip line feed

V. CONCLUSION

This review paper shows that study of the Micro strip Patch Antenna for bandwidth enhancement. After study of literature survey it is concluded that multi resonance characteristics of MPA such as Gain, impedance bandwidth can be improved by changing the parameters such as operating frequency, ground plane structure dimensions, feeding techniques. compared with reference antennas. Pentagonal slot vertex feed antenna design reports wide bandwidth of 4.21 GHz, constant gain of 4.24 dBi with very compact size . Also it can be integrated into UWB module/device of consumer equipment

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