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PERFORMANCE COMPARISION OF MULTIBAND MICROSTRIP PATCH ANTENNA DESIGNS USING OPTIMIZATION: A REVIEW

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ABSTRACT

The need of designing a multiband micro strip patch antenna is obvious, as in today's lifestyle and requirements, different applications like Mobile Communication, GPS, Satellite television broadcasting, remote sensing, wi-fi, Bluetooth, Infrared sensing, Wireless LAN etc. We require an instrument or a device working efficiently for all these microwave frequency bands. An easy to fabricate, easy design, efficient, multiband, broadband, high gain, patch antenna design technique is studied, in this paper and proper result analysis with effect of specific techniques is studied.

KEYWORDS: Multiband, Mobile communication, GPS, Satellite TV broadcasting.

1. INTRODUCTION

Microstrip occupies a place in the Electromagnetic spectrum with frequency above ordinary radio waves and below infrared light, ranging from 300Mhz to 300Ghz. This range is called microwave spectrum. Bands of frequencies in the microwave spectrum are designated by letters. As per the "Radio society of Great Britain" (RSGB), microwave spectrum is divided as-

BAND NAME	FREQUENCY RANGE(GHZ)
L	1 – 2
S	2 – 4
C	4 – 8
X	8 -12
Ku	12-18
K	18-26.5
Ka	26.5-40
Q	33-50
U	40-60
V	50-75
W	75-110
F	110-140
D	110-170
	UPTO 300

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These are the bands with wavelength ranging from 30cm to 1.8mm or less. Due to this wide coverage of Microwave frequencies, microwave spectrum is used in Global Positioning System (GPS), Global System for Mobile Communication (GSM), Industrial Scientific and Medical Instruments and Devices operating frequency band (ISM-band),wireless LAN, Bluetooth, Satellite Communication, Radar Broadband Communication, Universal Mobile Telecommunication System (UMTS), Terrestrial Microwave Communications, military radar targeting and tracking applications, Radio astronomy, Satellite television Broadcasting, Microwave remote sensing etc. Apart from mobile communications, wireless transmission of data is a service provided by worldwide Interoperability Mobile Access (WIMAX). [1],[2],[3] [7]

These different frequency bands of above table, used in various fields in mobile and wireless communications have driven the demand of antenna , that can operate in multiband frequencies. For this purpose, a micro strip patch antenna is most suitable with its inherent capabilities such as low cost, less weight, low profile and multiband support. Although they are less bulky and capable of resonating at different bands but they suffer from disadvantages like low bandwidth, low gain, poor polarization, high Q, and low efficiency. There are number of techniques for improving these drawbacks of patch antenna, which includes using fractal geometry, defective ground structure cutting slots etc.

Figure drawn below shows a basic inset fed microstrip patch antenna.

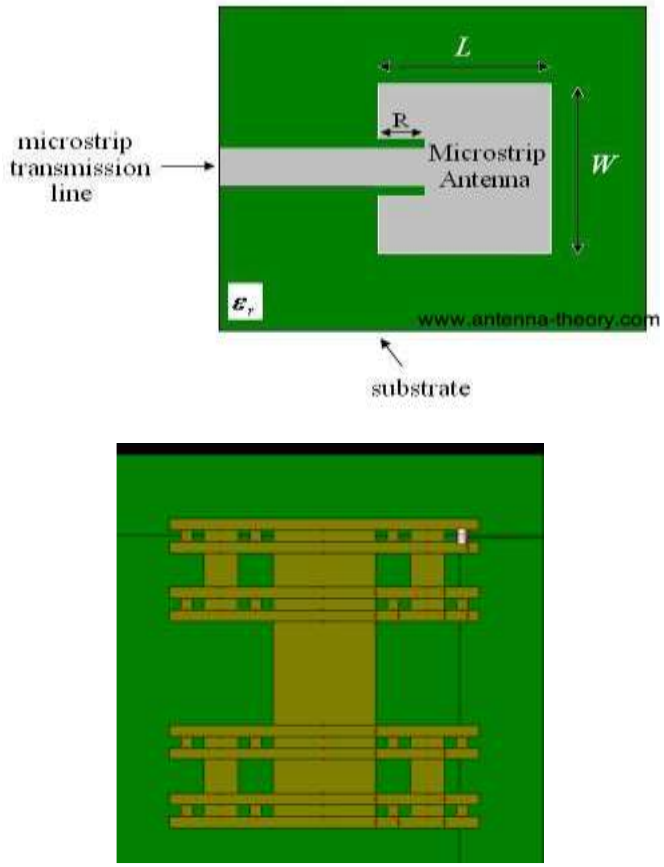

FIG1. Example of use of fractal geometry

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FIG2. Example of use of slotting technique

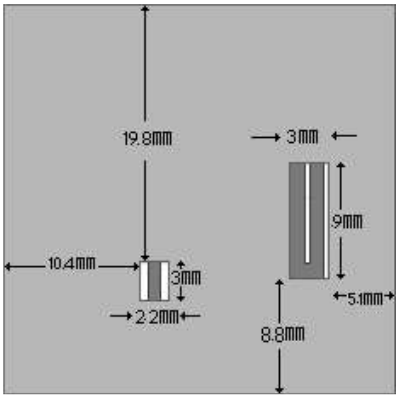

FIG3. Example of use of defective ground

Following are the important formulas used to design micro strip patch antenna :-

Width of the patch

$$W = \frac{c}{2\text{fr}}\sqrt{2/(\text{Er}+1)}$$

where c is speed of light, fr is resonant frequency & Er is dielectric constant.
Length of the patch

$$L = Leff - 2\Delta L$$

Here

$$Leff = \frac{c}{2fr\sqrt{\text{Ereff}}}$$

&

$$\text{Ereff} = \frac{\text{Er}+1}{2} + \frac{\text{Er}-1}{2\sqrt{(1+12\times h/w)}}$$

&

$$\Delta L = 0.412h\frac{(\text{Ereff}+0.3)(w/h+0.264)}{(\text{Ereff}-0.258)(w/h+0.8)}$$

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DESIGNING SOFTWARE

We are designing this antenna using HFSS. HFSS is a commercial finite element method solver for electromagnetic structures from ANSYS. The acronym HFSS stands for High Frequency Structure Simulator. HFSS is one of several commercial tools used for antenna design and other complex circuit elements .There are six main steps to design and analyze an antenna in HFSS:-

a) Create geometry
b) Assign boundaries
c) Assign excitation
d) Set up the solution
e) Solve
f) Post-process the results

2. LITERATURE SURVEY

"Split quadrilateral miniaturized multiband micro strip patch antenna design for modern communication system", Md. J. Alam, Md. R. I. Faruque, Md. M. Hasan, Md. T. Islam [4]:-A mixed split quadrilateral multiband micro strip patch antenna is designed. It is the shape of the antenna that makes it possible to resonate at a different range of frequencies. In the designed antenna, the metal bar is responsible for the inductive effect. With the addition of new metal bar, the inductive effect is increased and with the raise of the inductance the resonant frequency is shifted towards the lower frequency. There is also a polo metric study regarding the ground of the patch.

The full ground plane reduces the antenna capacitance because the capacitance is developed by the slot or splits in the structure. When the capacitance is raised, the resonance shifts to the higher frequency and when the inductance is increased resonance shifts to the lower frequency. When the ground size is reduced to the half of the size, the capacitance is increased and the resonance shifts towards the higher frequency and when a slot is made in the half ground plane, the resonance frequency is increased, for increased capacitance effect. [IET microwave antennas Propag., 2017,Vol. 11, Iss. 9,PP. 1317-1323]

"Compact Multiband Microstrip Patch Antenna For Wireless Applications", Amal K. A., Subin Joseph, R. Ratheesh, Ajoy K. Menda [5]:-An antenna with multiple resonance and miniaturization of the path using high dielectric constant substrate is designed. The desired frequencies are obtained by cutting slots in the patch and impedance matching is done by providing defective ground. An increase in dielectric constant provides a size reduction factor on the order of ε for the leaky dielectric and cavity resonator type antennas.

Cutting slots in the patch increases the effective length and disturb electric field. Two slots have been cut in the patch in order to generate two additional frequencies other than natural resonance of the patch. These slots increase the effective length of the patch without increasing the physical length. The impedance is matched by the inset feed and defective ground structure. The inset length is optimized after cutting the slots in order to match perfectly with 50ohm line. [978-1-5090-3349-2/16/$31.00©2016IEEE]

"Design and Optimization of Multiband Fractal Microstrip Patch Antenna for Wireless Applications" : S. Kohli, Sukhwinder Singh Dhillon, Anupama Marwaha [6]:-By using fractal geometry, area of the patch can be reduced. Fractal geometry provides size shrinkage and better impedance matching. By applying different iterations of fractal geometry, characteristics of antenna improve a lot.

Initially square patch is taken and antenna resonates at single band. By applying 3 iterations of fractal geometry, number of bands increases from 1 to 4. Fractal means broken or irregular fragments. Fractal geometry increases resonance length of the patch, so current has to travel a long path and hence it helps to get multiple bands of resonance. Hence fractal geometry and slotted ground had been used to obtain broadband characteristics. [978-0-7695-5069-5/13 $26.00 © 2013 IEEE]

"Patch Antenna Design with FR-4 Epoxy substrate for multiband Wireless Communication using CST Microwave Studio", Dr. P. A. Harsha vardhini, N. Koteshwaramma [7] :-Here, a meandering technique is used to reduce the size of the antenna by making the strips in a coil-like or snake-like shape. To perform the technique n V-strip as well as S-strip, the strip width is made as small as possible to be more easily folded. In

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addition, to avoid higher order mode excited by feeding network, the 50ohm microstrip line is reduced by cutting the angle, on its bended corners. The meandering helps to reduce the size of the patch, as the patch strips contributes to multiple bands from GSM to WiMAX. [978-1-46739939-5/16/$31.00©2016 IEEE]

"Modified easy to fabricate E-shaped compact patch antenna with wideband and multiband functionality" : Anastasios G. Koutinos, Dimitris E. Anagnostou, Rahil Joshi, Synon K. Podilchak, George A. Kyriacou, Michael T. Chryssomallis [8]:-Here, first a novel folded L-shaped feed is used for improved wideband operation. Then, multiband operation is enabled through scaling and tight packing with low mutual coupling. Dual band operation can be supported through geometry parameterization in conjunction with frequency scaling, which allows tighter packing. The structure has one resonance due to the patch, which acts as parallel RLC resonant circuit and a second resonance due to the series combination of the inductance and resistance, offered by the L-shaped probe, along with the capacitance which is due to the energy stored between the probe ground and the probe patch. The broadband operation of the antenna is due to this double resonance. [IET microwave antennas Propag.,2018,Vol.12 ISS. 3,PP. 326-331]©The Institution of Engineering and Technology 2017]

3. RESULTS ANALYSIS

Results analysis has been done using previously published papers on multiband antennas. The performance comparison between some existing multiband antennas, is shown below :

REFERENCE	COVERED BANDS	APPLICATIONS	ADVANTAGES	DISADVANTAGES
[4]	C, X, Ku, K	WLAN, Satellite communication	High Gain(>4dbi) ,High Directivity(>4.5dbi), compact design, high efficiency(86.35%)	Complex geometry, difficult to fabricate
[5]	L, S, C	Wi-fi, WiMAX, Bluetooth	Compact size, reduced reflection losses, easy to fabricate	Low efficiency at lower frequencies, low gain(3.36dbi), low directivity(<3dbi)
[6]	C, X	Radar Applications, Satellite communication, UWB, WLAN	Broadband characteristics, small patch, high gain(>7dbi), high directivity(>9dbi)	Useful Only for specific bands
[7]	L, S, C	GSM, UMTS, WiMAX, ISM, WLAN, GPS	Small size, high beam width(>330deg.), omnidirectional radiation pattern	low gain, complex geometry
[8]	L, S, C	LTE, Wi-fi, WiMAX, Bluetooth	Easy to fabricate, high bandwidth(>2GHZ)	Ground plane and patch are separately fabricated generating losses, bulky

4. PROPOSED ALGORITHM

A) By using the values of center frequency and dielectric constant , calculate all the required design parameters.
B) Prepare the basic micro strip patch antenna design using HFSS.
C) After the simulation we check results (gain plot, return loss, axial ratio, VSWR , efficiency etc).
D) The axial ratio bandwidth should be greater than 3db. If the bandwidth is less then we try to improve the design.
E) The impedance bandwidth or s11 bandwidth should be high below -10db.if it is less we make changes to improve it.
F) By using FSS/Slotting/Fractal geometry/defective ground structure etc. we try to obtain better results.

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5. CONCLUSION

We require high gain(>5dbi),high directivity(>7dbi),high efficiency ,low return loss, compact size, low VSWR(<2) and high bandwidth. In this paper, we can evidently conclude that by using Fractal Geometry, Frequency Selective Surface, Meta Materials, Defective Ground Surface, Super substrates and many other different techniques, we can get a less complex design, easy to fabricate, multiband and broadband antenna for working for modern communication systems.

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