Compact Size and Enhanced Bandwidth Microstrip Antennas: A Review

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Abstract:- Now a days, antenna is the common component in the wireless communication. It is a challenge to design a small size microstrip antenna with a broad bandwidth for wide range of applications which require higher bandwidth; such as mobile phones these days are getting thinner and smarter but many application supported by them require higher bandwidth, so microstrip antenna used for performing this operation should provide wider bandwidth as well as their size should be compact so that it should occupy less space while keeping the size of device as small as possible. In the paper, a critical review has been carried out for compact size and higher bandwidth. There are various techniques to reduce the size of the antenna as well as to enhance the bandwidth**.**

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I. Introduction

The core of all wireless system in today's era is formed by Antenna. Small antennas generally with higher efficiency and good gain are the general features of today's communication system. With the advancement in technologies the bigger is becoming the utilization of the application the smaller is getting the size of the technological components used in it. During 1950s Microstrip antenna was first time introduced.

Antennas are used in our day to day life for the commercial as well as industrial purposes such as broadcasting of radio and television and also in mobile communication system. Due to advancement in the technologies the devices have become more application specific along with their shrinking size. Microstrip patch antenna are a low profile [3] antenna with thin in its thickness which is the basic requirement of the antennas for mobile and satellite communication. These antennas are generally light in weight. In the portable handheld devices for internet connectivity Microstrip Antenna is a sole constituent. They are also used for short distance and long distance communication where the main principle demands for the omni directional radiation pattern and the size must be small. For wireless communication systems requirement is of low profile antennas with omni directional radiation pattern. Various other application involves vehicle collision avoidance system, Global positioning System (1227MHz -1575MHz) [6] and surveillance systems. For military purposes it is used in Radar Applications, missile guidance where low profile and light in weight antennas are required

Microstrip Antennas have extended its application in the field of Telemedicine [1] also. Antennas with a gain of 6.7dB and Frequency to Bandwidth ratio stands at 11.7dB which resonates at 2.45 GHz. Such antennas are prioritized. Also these antennas have a higher front to back ratio in comparison with other antennas. These antennas also possess semi directional radiation pattern which is advantageous to avoid unnecessary radiation in many directions which is not needed. These antennas are also used in the treatment of malignant tumor [1]. Microstrip Antennas are also used for Worldwide Interoperability for Microwave Access (WiMax) applications. They have a date transfer rate of 70 Mbps. Microstrip Patch Antenna have following resonant modes valued at 2.7 GHz, 3.3 GHz and 5.3 GHz [2].

Low profile antennas with omni-directional radiation pattern are mostly suitable for modern day wireless communication systems. This requirement is met with the use of monopole and dipole antennas. However, these devices being large couldn't meet the demands of compact, portable devices. Metamaterials comes into picture to solve this problem as metamaterials are popularly used to design low profile antennas. The composite right/left handed metamaterial transmission lines is an effective method to realize low profile, compact infinite wavelength zeroth order resonant antennas. They also possess superior portability which is suitable for antenna array. They have variable frequencies which is the most important requirement for the various applications as they are capable of dual and triple frequency operation. In Microstrip Antennas Feed lines and matching

Apart from the fore mentioned features these antennas have superior portability which is in accordance for antenna array. These antennas are capable of dual and triple frequency operations which are required for fabrication purposes. Due to its low fabrication cost these can be manufactured in bulk. Etching of microstrip based antennas on PCB are easy hence they are easy to troubleshoot for any technical fault during design process. Hence it results to ease of fabrication which makes its integration on MICs or on MMICs.9717127080

There are various types of Microstrip Antennas named as Microstrip Patch antenna, Microstrip dipole, Printed slot antennas and Microstrip travelling wave antenna. Properties of these antennas are being compared broadly in the following table:

Table 1: : Characteristics comparison of types of Microstrip Antenna

Characteristics	Microstrip patch antenna	Microstrip slot/travelling wave antenna	Printed dipole antenna
Profile	Thin	Thin	Thin
Fabrication	Very easy	Easy	Easy
Polarization	Both linear and circular	Both linear and circular	Linear
Dual-frequency operation	Possible	Possible	Possible
Shape flexibility	Any shape	Mostly rectangular and circular shape	Rectangular and triangular
Spurious radiation	Exists	Exists	Exists
Bandwidth	2-50 %	5-30 %	30 %

II. TECHNIQUES USED FOR BROADBAND MICROSTRIP PATCH ANTENNA

Due to reduction in the size of communication devices with every passing day microstrip patch antenna being used have a compact size. We know that bandwidth of the antenna depends on its size hence forth smaller the size of the antenna smaller will be its bandwidth. To enhance the bandwidth different techniques like Shorted Patch, Stacked Shorted Patch, Slot-Loading Technique Slotted Ground Plane Technique and Metamaterial Transmission Line are used. These techniques are discussed further [4][5]

A SHORTED PATCH

By using a shorting pin through ground using substrate material radiating patch of antenna can be shorted. Further the short circuit is wounded by covering it up with a copper strip across it the edge of the antenna which can be simulated further by shorting its post

For the designing of GPS antenna operating at 1.575 GHz this configuration is used which also accounts in the size reductions of 24.6% when compared to that of conventional microstrip patch antenna. As compared to conventional microstrip antenna the size reductions are achieved. Further the bandwidth of 17.8% at a frequency of 1.562-2.225 GHz is yielded by single shorting posts technique. Hence we find that the size of is reduced by using the single shorting post technique.

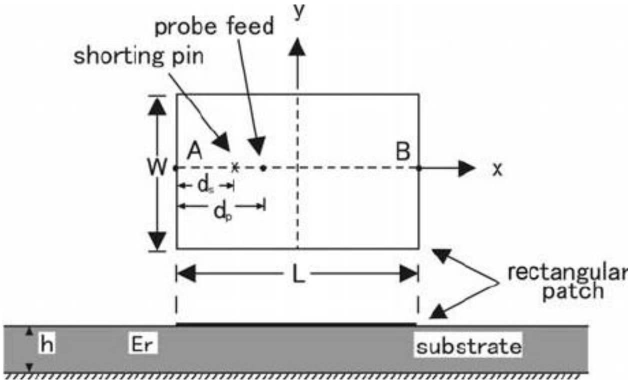

Fig 1: Configuration of microstrip antenna with shorted pinq4

This technique operates on frequency band of 1.5 GHz and 2.45 GHz further leads to yielding bandwidth of 17.4% for lower operating bands and ranging for upper frequency bands is 3%.

B STACKED SHORTED PATCH

The stacked configurations are used in S-shaped Microstrip Antennas. Such configurations are used by cutting a resonant S-shaped slot inside the S-shaped Microstrip Antenna and also square Microstrip Antenna with its corner being shorted. Using stacked configuration or by using a resonant slot inside a patch which is cut down in it the bandwidth can be increased. The bandwidth can further be enhanced by using the multi resonator gap coupled. Upon comparison of S-shaped MSA with C-shaped MSA the gain of S-shaped MSA turns out to be greater than former one. The simulated bandwidth of S-shaped MSA is 1.05MHz (12.7%) and the measured one is 1.15 MHz (14%).

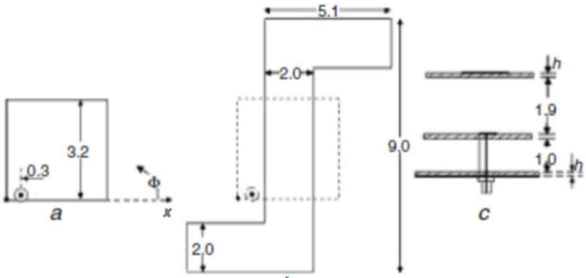

Fig 2. Design of broadband S shaped microstrip antenna

Let us consider another design of antenna which square shaped patch having two walls at the edges along with slots available which yields the bandwidth of 76.25% and the frequency ranging 4.95 GHz to 11.05GHz when the VSWR is less than 2. The minimum return loss is -14dB.The dimensional calculation of the desired antenna is h1(2.524mm),h2(5.75mm).The lower and upper substrate have the permittivity of 5.4 and 4 respectively. The loss tangent for loss of lower substrate for h1 and h2 are 0.002 and 0.02 respectively. The measurement of size of square slot turn out as (2mm X 2mm).

 ISSN: 2454-4248
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C. SLOT LOADING

Using this technique we can attain wider Bandwidth while we have a smaller size of antenna. This is done on a radiating patch of microstrip antenna by implanting a slot over it. This implementation of slot leads to increase the current path length which further acquires the desired wider bandwidth in accordance with small sized antenna

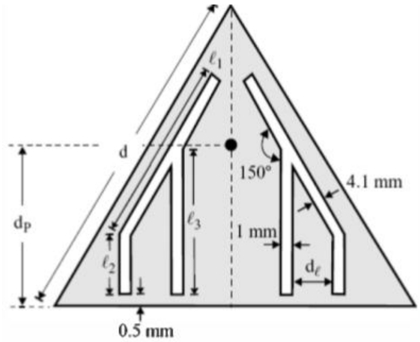

Fig 3 : Slot loaded Triangular Microstrip Patch Antenna

Using slot loading technique the bandwidth achieved is 3 times that of a triangular microstrip patch antenna. The reduced size is almost 25% than the original size. It also leads to achieving reduced peripheral area by 65% of the patch by using rectangular slot loaded technique. While peripheral area is reduced by 60% of the patch by using a V-slot loaded technique in microstrip antenna. But the Impedance Bandwidth of rectangular loaded microstrip antenna is less than that of V-slot loaded microstrip antenna.

D SLOTTED GROUND PLANE TECHNIQUE

In this technique on a ground plane of microstrip antenna a slot is made. Since the slotted patch is increased, thus leads to the increase in length of bandwidth. This produces the antenna with reduction in size upto 56% along with an increase in bandwidth. While embedding pair of narrow slots the size reduction of about 39% is achieved.

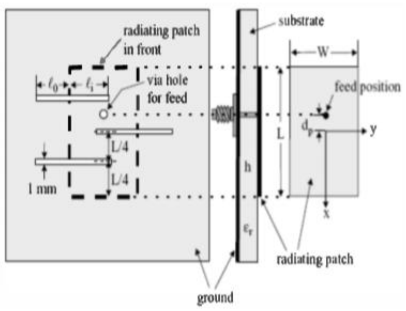

Fig 4: Design of compact microstrip antenna with meandering slots in the ground plane.

Let us consider another design which yields wider bandwidth upto three times that of a civic antenna and size reduction of 36% is achieved. Hence producing wider bandwidth. Hence forth mentioned techniques can be used to produce antenna suitable for any handheld devices and with compact size and wider bandwidth.

E. METAMATERIAL TRANSMISSION LINE

Small antennas are basic requirement for wireless communication system. Maintaining its radiation characteristics is sole requirement along with its reduction in size. This requirement can be implemented using monopole and dipole antennas which are capable of aligning the requirement of compactness for portable devices. This lead to he arise of metamaterials which can be used for designing antennas with low profile. Th Composite Right/Left Handed (CRLH) transmission lines is perfect for alignment of characteristics simultaneously i.e. low profile and compact infinite wavelength ZOR antennas.

Zeroth Order Resonator (ZOR) is a phenomenon which depends on infinite wavelength without depending on its physical size at its fundamental mode. This infinite wavelength is dependent on some finite frequency which is Zero Order Resonant frequency. At this finite frequency the distribution of voltage and current is uniform across the entire CRLH TL. A CRLH TL is composed of series capacitance C_L and inductance L_R as well as a shunt capacitance C_R and inductance L_L. The series and shunt resonant frequencies are given by :

$$\omega_{se} = \frac{1}{\sqrt{L_R C_L}} \text{ rad/sec}$$

$$\omega_{sh} = \frac{1}{\sqrt{L_L C_R}} \text{ rad/sec}$$

In the open-ended CRLH resonator case, the fractional bandwidth can be calculated by :

$$B.W. = G\sqrt{\frac{L_L}{C_R}}$$

By applying periodic boundary conditions (PBCs) related to the Bloch-Floquet theorem, the CRLH TL unit cell's dispersion relation is determined to be

$$\beta(\omega) = \frac{s(\omega)}{\Delta Z}\sqrt{\left[\omega^2 L_R C_R + \frac{1}{\omega^2 L_L C_L} - \frac{L_R C_L + L_L C_R}{L_L C_L}\right]}$$

As we see that bandwidth is inversely proportional to Area of Substrate (C_R) and directly proportional to length of these spiral inductors (L_L),hence an increased bandwidth of 5% and higher gain (2.1054dB) is obtained. The methodology of using elliptical unit cells with inductors also accounts for increased radiation efficiency of 65.937% at zeroth mode of 4.88GHz. The reflection coefficient achieved is 24.283dB at the zeroth order mode

III. DESIGN METHODOLOGY

A single band ZOR antenna possessing compact mono mode along with two elliptical unit cells is our suggested model. The radiating patch is provided a small gap of 0.2mm. As a result of this gap we obtain length of spiral inductor in series (L_H) and capacitance (C_L). While the parasitic R_H and inductance L_R is obtained as a result of the magnetic flux that was produced along its radiating patch by the flow of current. With the width of 0.4mm spiral inductors it is responsible for the introduction of short ended L_H along with inductance L_L. We also observe that the gap of among these spiral inductors is 0.4 mm.which further simulates the reflection coefficient at -24.2836dB also gain of 2.1054dB is achieved at ideal mode operating at a frequency of 4.88GHz. Below mentioned Fig.7 shows the E-radiation pattern at x-y plane and H-radiation pattern at x-z plane at n = 0 mode.

IV. RESULT AND DISCUSSION

On a Rogers RT/duroid 5880 a substrate a compact metamaterial based elliptical antenna has been designed. This compact metamaterial based elliptical antenna radiates only omnidirectional waves in horizontal plane. By the usage of combination of spiral and anti-spiral stub inductors which enabled in increasing of L_H inductor, the size of the antenna has been reduced. A simulated 3D gain of 2.1054dB (Fig.8) and incremental bandwidth of almost 5% with an antenna efficiency increased upto 65.937% had been exhibited by an antenna of size 0.158 0×0.07 0. We also observe that the gap of among these spiral inductors is 0.4 mm. which further simulates the reflection coefficient (Fig.6) at -24.2836dB also gain of 2.1054dB is achieved at ideal mode operating at a frequency of 4.88GHz. A dumb bell shaped E-radiation pattern is obtained along with H-radiation pattern which radiates omni directionally. Figure 9 [4] shows that VSWR of antenna at n=0 turns out to be 1.13 at Zero Order Resonant frequency (4.88GHz).

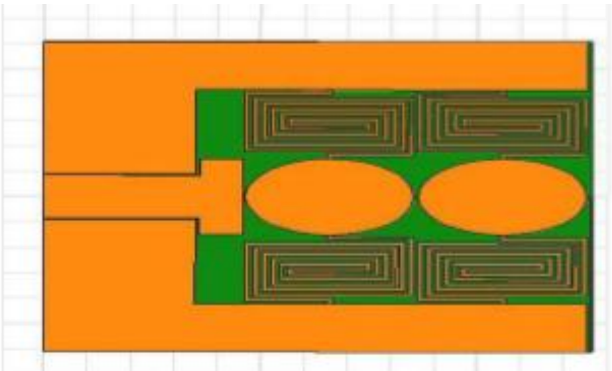

Figure 5: Geometrical model of the proposed single-band, monomode ZOR antenna (with two unit cells). [4]

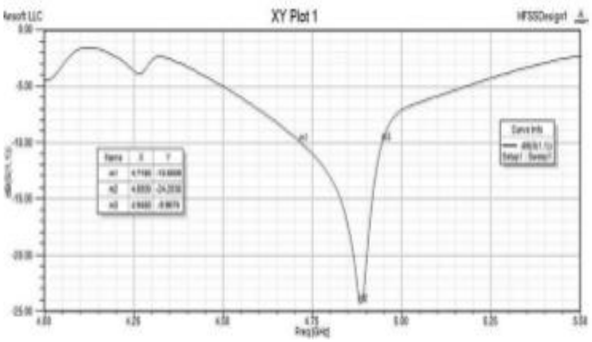

Figure 6: Simulated reflection coefficients of the proposed ZOR antenna [4]

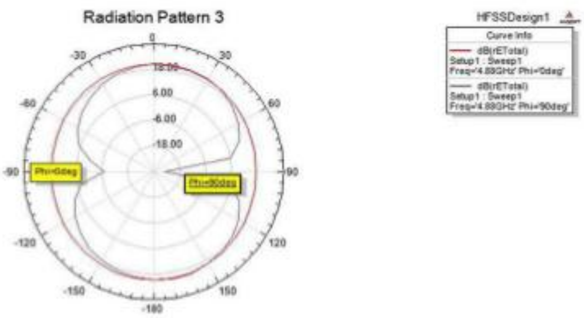

Figure 7: Simulated radiation pattern at n = 0 mode (freq = 4.88GHz) [Phi = 0deg (x-z plane) and Phi = 90deg (y-z plane)] [4][7].

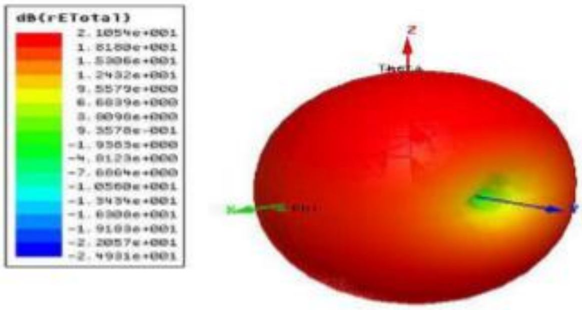

Figure 8: 3D-Gain of the proposed antenna at n = 0 mode (freq = 4.88GHz) [4]

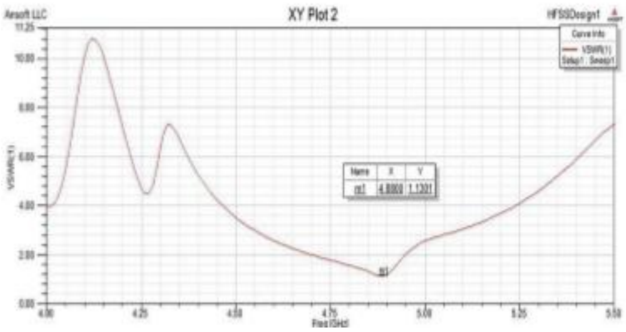

Figure 9: VSWR of the proposed antenna at n = 0 mode (freq = 4.88GHz) [4].

V. CONCLUSION

Antenna designing with bandwidth enhancement and size reduction are major considerations for practical applications. Several methods have been adopted to achieve broadband and reduce the size. This paper shows the review and survey of various such techniques. Out of all techniques shown above in this paper Slot Loading Technique and Slotted Ground Plane Technique yields maximum bandwidth and compact in size.

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ISSN: 2454-4248
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