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Comparison of Dual Band UWB Microstrip Antennas

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***Abstract*— The basic objective of the paper is to design a microstrip patch antenna for UWB wireless communication. The paper presents different types of microstrip antennas and compares their performance based on various characteristics so as to find the best antenna that can be used We have compared them on the basis of gain, return loss, VSWR, radiation efficiency, bandwidth, single and dual frequency operation. The developed prototype may find its application in mobile networks, base antennas, IEEE 802.11 a and j standards. Conclusion has been drawn from the two designs and the antenna providing optimal performance is selected for further implementation.**

Index Terms*—Gain, *MoM, modified E-shape. return loss VSWR

I. INTRODUCTION

For wireless communication system, the antenna is one of the most critical components. A good design of the antenna can relax system requirements and improve overall performance of the system. [1]. Patch antenna usually consists of a metal (conducting) patch on a layer of substrate (dielectric) on the ground plane. They are low profile, low gain, and narrow bandwidth antennas. The radiation from the patch antenna takes place from the narrow gap i.e. slot between the conducting layer and the ground plane along the length of the antenna. Patch antennas are usually used for low profile applications for the frequency above 100 MHz such as in airplanes, in communication devices and wireless communication since their designing is easy and they can be easily customized. A conventional type of patch antenna suffers from narrow bandwidth, therefore broad banding techniques such as reactive loading with slots is preferred [2]. E-shaped microstrip patch antenna is constructed by inserting two parallel slots into the rectangular patch. Slots which are introduced in the E-shape pattern demonstrate a bandwidth enhancement of 25%. [3]. The slot obstructs the current flow, thus introducing a local inductive effect. It basically consists of two side arms of equal length and a coaxial feed in between. The frequency of the second resonant mode can be tuned without affecting the fundamental mode by trimming the length of the center arm, keeping the length of side arm constant and by placing the feed at the appropriate location. Method of moments (MOM) is used for the analysis.

Theoretical explanation

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For designing an antenna the following parameters must be calculated: patch length, width, thickness of the substrate and position of the feed from the slots.

$$W = \frac{c}{2f0\frac{\sqrt{\varepsilon r+1}}{2}} \quad (1)$$

$$\varepsilon e = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2}[1+\frac{10h}{W}]\wedge(-0.5) \quad (2)$$

$$fo = \frac{c}{2\sqrt{\varepsilon r}}[\left(\frac{m}{L}\right)\wedge 2 + \left(\frac{n}{W}\right)\wedge 2]\wedge 0.5 \quad (3)$$

$$Le = L + 2\Delta L = \frac{\lambda}{2\sqrt{\varepsilon e}} \quad (4)$$

$$We = W + 2\Delta W \quad (5)$$

$$\Delta L = \frac{h}{\sqrt{\varepsilon e}} \quad (6)$$

Where,
W= width of the patch
Ɛe= effective dielectric constant
fo= resonant frequency
Le= effective length
We= effective width

The performance of the antennas is based on radiated efficiency, voltage standing wave ratio, and the gain of the antennas. Radiated efficiency is the ratio of power radiated from the antenna as an electromagnetic wave to the power fed through the antenna probe. Thickness of the substrate and value of dielectric constant is assumed. Location of the feed is adjusted by using trial and error method.

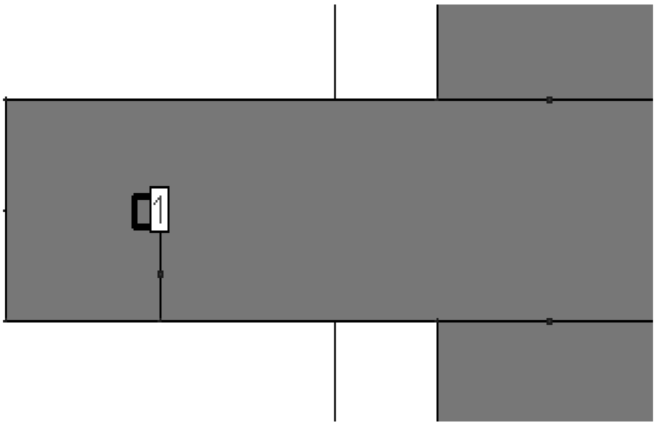

Fig. 1 Antenna Geometry

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Table 1. Parametric Study

Parameters	***Antenna 1***
Length of patch (L)	17.5mm
Width of patch (W)	7.5mm
Length of slot (ls)	15mm
Width of slot (ws)	5mm
Substrate height	5
Dielectric constant (ε_r)	2.2

Table 2. Antenna Characteristics

Parameters	***Antenna 1***
Return loss (db)	-29.25
VSWR	< 2
Polarization	Linear
Resonant frequency (GHz)	5.6 – 7
Directivity (db)	7.75
Bandwidth	1400MHz

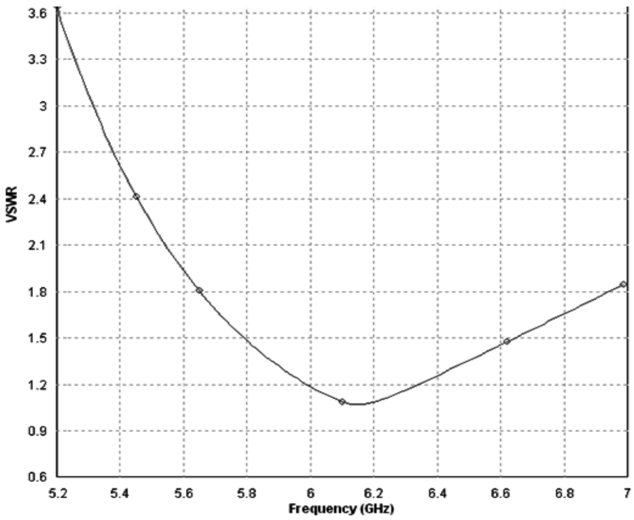

Fig. 2 VSWR for Antenna 1

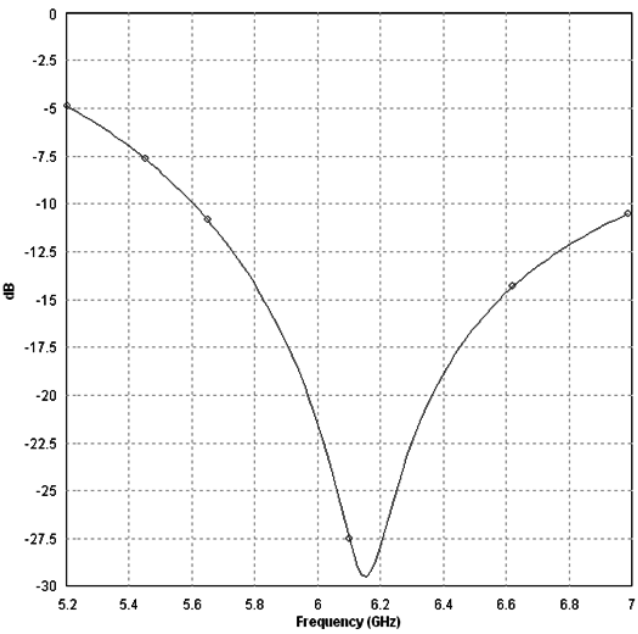

Fig. 3 Return Loss for Antenna- 1

Return loss for antenna-1 is -29.25 db at frequency 6.15GHz

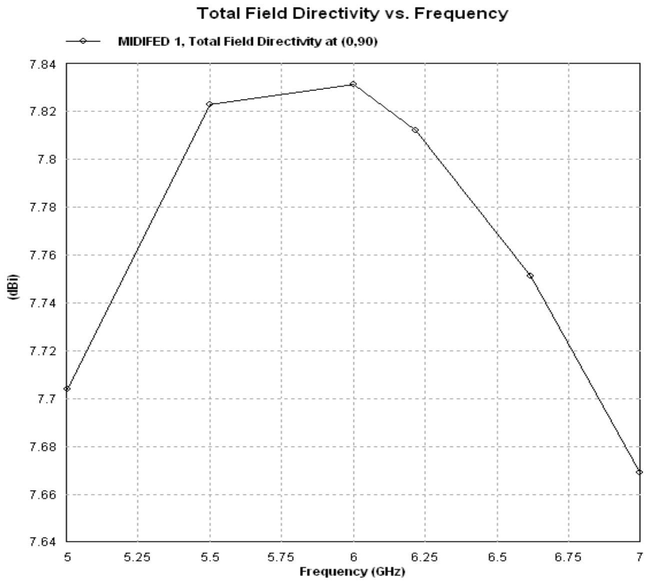

Fig. 4 Directivity of Antenna -1

The directivity for antenna-1 is 7.75 db at 6.16GHz

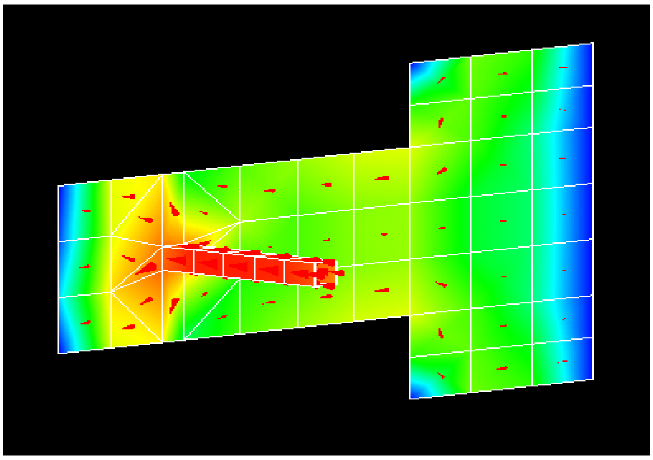

Fig. 5 Scalar and Vecrtor Mixed Current Distribution of Antenna 1

The simulation results of the proposed antennas are shown in this section. The return loss gives the understanding that by adding slots symmetrically, the basic radiation characteristics of the rectangular patch do not change. The structure of antenna-1 is evolved from E-SHAPE antenna. This is achieved by trial and error method of simulation. In telecommunication, standing wave ratio is the ratio of the amplitude of a partial standing wave at antinodes (maximum) to the amplitude at an adjacent node (minimum).SWR is used as an efficiency measure for the transmission line. It also expresses the degree of match. In fig. 2 we can observe that antenna is well within the VSWR limit. The return loss against frequency for the realised antennas is shown in fig. 3. The return loss for antenna-1 is -23 db which is good. Directivity is a fundamental antenna parameter. It is a measure of how 'directional' an antenna's radiation pattern is .An antenna's normalized radiation pattern can be written as a function in spherical coordinates as

$$F(\theta,\phi) \quad (7)$$

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Mathematically, the formula for directivity (D) is written as

$$D = \frac{1}{\frac{1}{4\pi}\int_0^{2\pi}\int_0^{\pi}\left|F(\theta,\phi)\right|^2 \sin\theta d\theta d\phi} \quad (8)$$

Antenna Patterned with Four C Slots

According to the literature review there are numerous ways of increasing the bandwidth of the antenna, one such method is using C slots. There are four C slots incorporated on the rectangular patch having L = 39mm, W = 48mm and total area of 1872mm^2. The antenna design parameters are optimized to satisfy the best return loss and radiation pattern. square microstrip patch having dimensions Ls = 39mm, Ws = 39mm and a total area of 1521mm^2 yields a bandwidth of 118 MHz and 275 MHz at two resonant frequency. The proposed antenna is capable of generating multi resonant frequencies with single and dual feeds. The 50Ω feed position can be achieved by locating the feed points along the diagonal of the square patch.

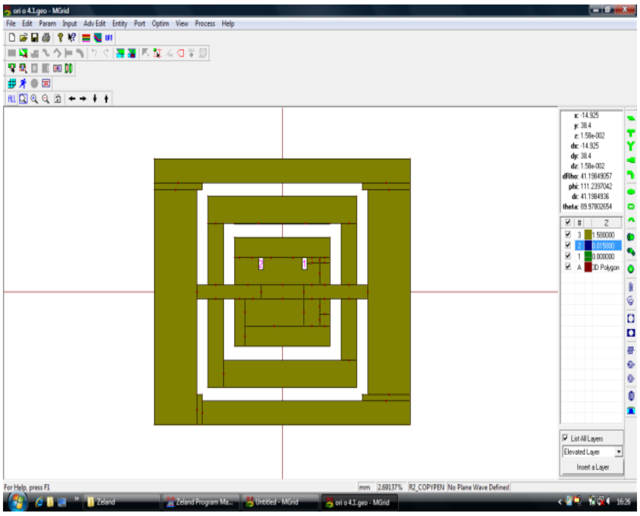

Fig. 6 Antenna Patterned with Four C Slots

Table 4 Parametric Study

Parameters	Antenna 2
Length of patch (L)	39mm
Width of patch (W)	48mm
Length of slot (ls)	39mm
Width of slot (ws)	39mm
Substrate used- h	1.58

Table 5 Antenna Characteristics

Characteristic	Freq 1.55GHz	Freq2.45GHz
Return loss (db)	-36.5	-35
VSWR	1.02	1.09
Polarization	linear	Linear
Bandwidth	110MHz	273MHz

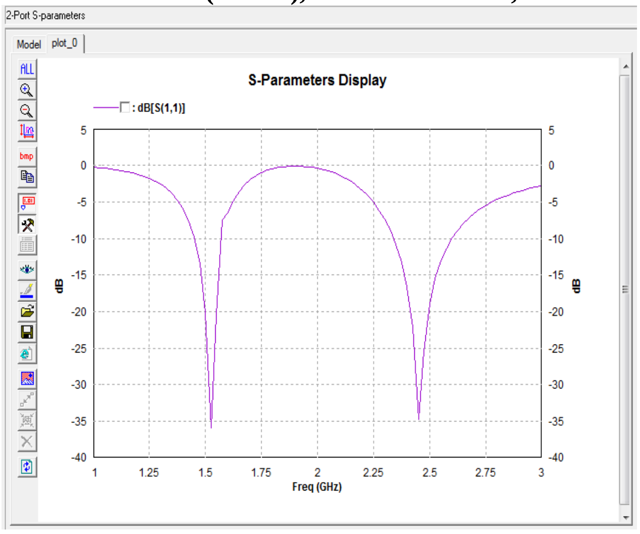

Fig. 7 Graph of Return Loss vs. Frequency for Patch Antenna with C Slots

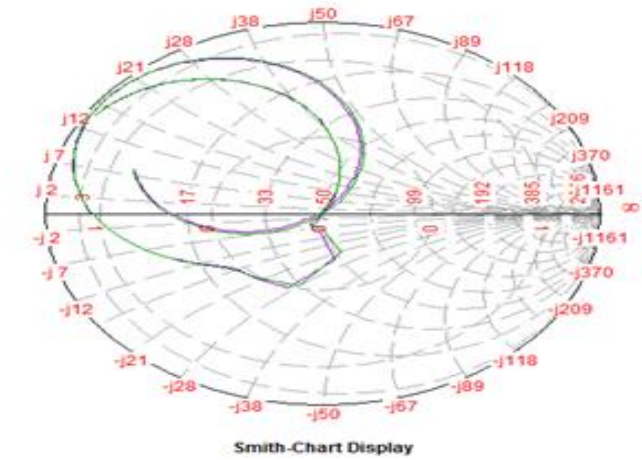

Fig. 8 Smith Chart for Patch Antenna with C Slots

The impedance plot is well within the unity circle for dual frequency but with increased bandwidth.

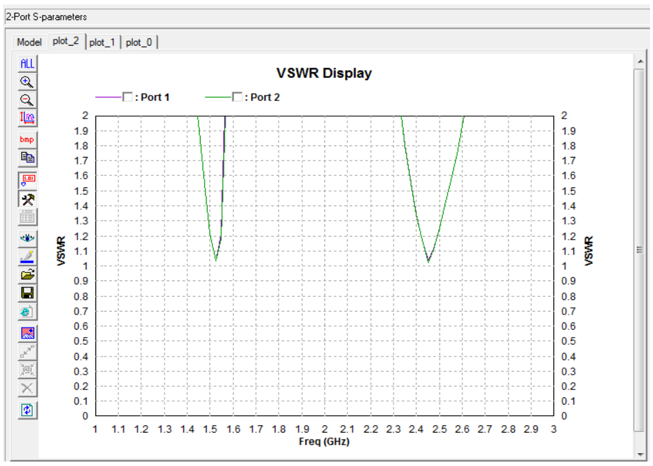

Fig. 9 Graph of Voltage Standing Wave Ratio vs. Frequency for Patch Antenna with C Slots

The fig.9 shows graph of Voltage Standing Wave Ratio vs. frequency for patch antenna with C slots having VSWR of 1.02 at frequency of 1.55GHz and VSWR of 1.095 at frequency of 2.45GHz.

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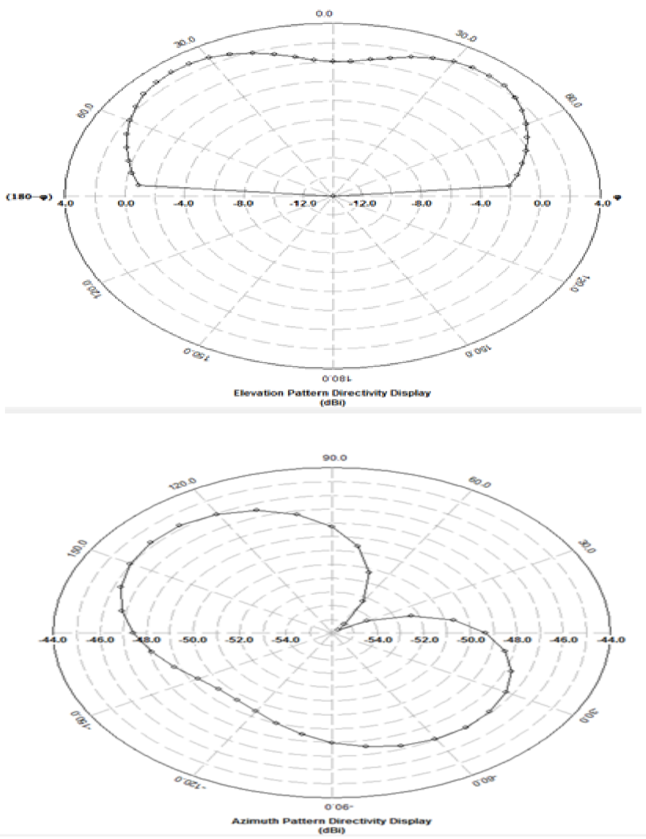

Fig. 10 2D Radiation Pattern with C slots at 1.55GHz (Elevation and Azimuth)

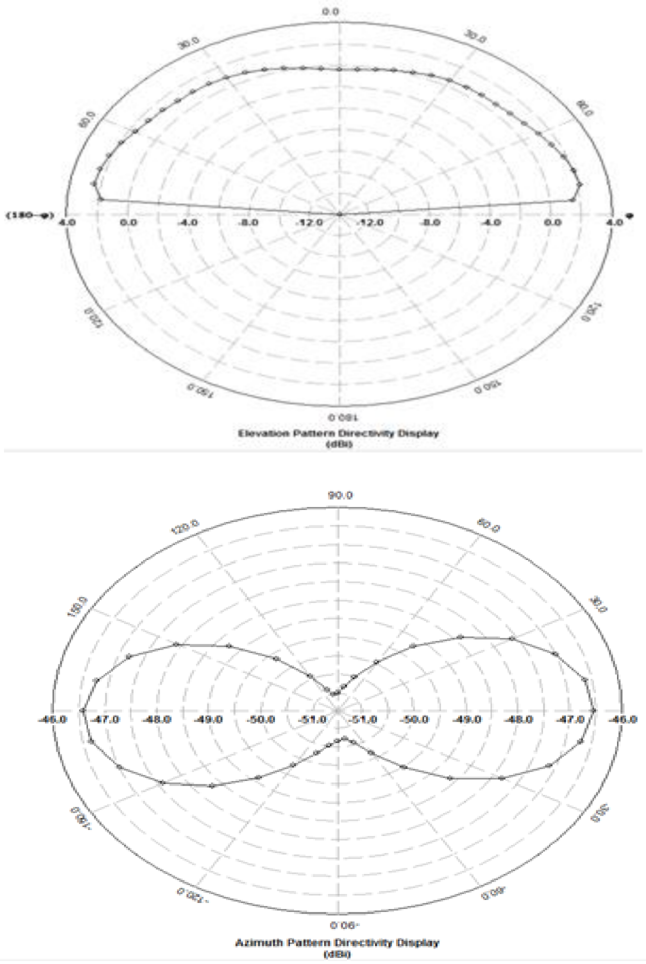

Fig. 11 2D Radiation Pattern with C Slots at 2.575GHz (Elevation and Azimuth)

C slots are capable of operating at two frequencies 1.55GHz and 2.45GHz. The design provides two large bandwidths of 110MHz and 273MHz at 1.55GHz and 2.45GHz respectively.

II. CONCLUSION

Wide band modified E-shape microstrip patch antenna and C slot has been designed for wireless communication system. The bandwidth of antenna 1 is 25.86% (from 5.3-6.8 GHz) ie.1400MHz, while the antenna 1, also maintains a thin thickness of 0.1λ at the centre frequency f= 5.8GHz, and for antenna 2, it has dual frequency operation at 1.55GHz and 2.45GHz. The design provides two large bandwidths of 110MHz and 273MHz at 1.55GHz and 2.45GHz respectively. Both the antennas are thin and compact with low dielectric constant substrate material. The conclusion till now is that on the same patch different patterns can be created to provide efficient results. The main objective of this is to achieve new antennas designs that operate at multiple frequencies band having larger bandwidth where it can be integrated with any handheld devices given its low profile and small size characteristics. The multiband and wide-bandwidth antennas for wireless communication system which would operate in different frequency bands can be fabricated and the antennas can then be implemented. Depending on the requirement of the application the two antennas can be used. Further enhancement on the antenna parameters can be done by implementing aperture coupling.

III. APPLICATION

The E—shaped patch antenna and C slot can be designed to provide Ultra Wide Band**.** The developed prototype may find its application in mobile networks, base antennas, IEEE 802.11 a and j standards as wireless devices continue to shrink in size, there is an overwhelming need to miniaturize and improve the performance of the antenna.

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