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Bandwidth Enhancement of Microstrip patch Antenna using Suspended Techniques for Wireless Applications

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Abstract - Antenna is plays vital role in wireless application systems. The microstrip antenna has features such as light weight, easily mountable and easy for mass production. A wideband suspended Hexagonal patch antenna with capacitive coupling is introduced for (2.26-3.72 GHz) Wireless applications. Suspended Hexagonal microstrip antenna with a capacitive coupling feed is presented in this article in order to be employed for high speed WLANs & wireless communication applications. Employing only a single patch, a high impedance bandwidth is achieved. The simulated percentage bandwidth is about 60.83%. The structure of the antenna consists of a perfect conductor on the top of a substrate (FR4 material) with a dielectric constant of about 4.4 and a height of 9 mm, which is backed with a perfect conductor ground plane. The impacts of different parameters of antenna are also studied in this article.

Key words— Suspended MSA, Hexagonal, Slot, Wideband, S-band and Wireless.

I. INTRODUCTION

A microstrip antenna (MSA) in its simplest form consists of a radiating patch on one side of a dielectric substrate and a ground plane on the other side. However, other shapes, such as the square, circular, triangular, semicircular, sectoral, and annular ring shapes are also used. Microstrip antennas are popular for their attractive features such as low profile, low weight, low cost, ease of fabrication and integration with RF devices. The major disadvantages of microstrip antennas are lower gain and very narrow bandwidth [1]. Microstrip patch antenna consists of a dielectric substrate, with a ground plane on the other side. Due to its advantages such as low weight, low profile planar configuration, low fabrication costs and capability to integrate with microwave integrated circuits technology, the microstrip patch antenna is very well suited for applications such as wireless communications system, cellular phones, pagers, radar systems and satellite communications systems[4].

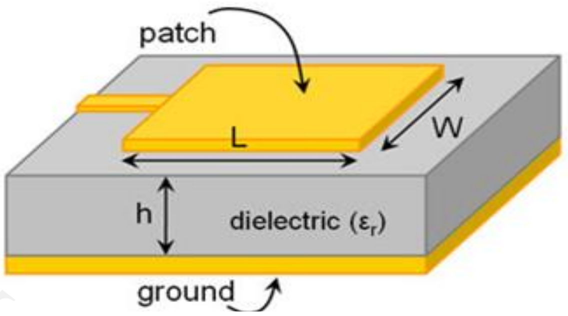

Fig. 1 Basic Structure of Microstrip antenna

Several designs have been investigated and reported to decrease the size of the antenna [7] and to improve the bandwidth of the antenna [8, 9].

In this paper Hexagonal MSA is proposed. The bandwidth of antenna was broadening to 70 MHz and good return was obtained. Bandwidth of antenna was obtained to 2.90%.

Laterally two corner slot is at side surface of microstrip antenna was taken. Due to corner slot at side surface the Bandwidth of antenna obtained was 130 MHz Due to air gap between substrate and ground plane of 9 mm Bandwidth was increased up to 1.46 GHz. Capacitive coupling techniques was proposed mainly to broadening the bandwidth of antenna and finally get very good return loss with 60.83% of bandwidth enhancement.

II. Antenna Design and Geometry

The geometry of suspended patch is shown in figure1. The microstrip antenna is fabricated on FR4 substrate with dielectric constant 4.4 and loss tangent=0.02. The substrate is suspended over ground plane with air gap of 9 mm and total thickness of antenna is 11.6 mm.

The initial calculation starts from finding the width of the patch which is given as:

Step 1: Calculation of width of the patch

The width of the Microstrip patch is given as

$$W = \frac{c}{2 f_0} \sqrt{\frac{\varepsilon_r + 1}{2}} \quad (1)$$

W= 38 mm

where:

c = free space velocity of light=3x 10*8 m/s
fo = frequency of operation= 2.4 GHz
ε_r = dielectric constant= 4.4

Step 2: Calculation of Effective dielectric constant
Effective dielectric constant (ε_{reff}):

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}[1 + 12\frac{h}{w}]^{-\frac{1}{2}} \quad (2)$$

ε_{reff} = 4

Where:
ε_r = dielectric constant
h = height of dielectric substrate
W = width of the patch

Step 3: Calculation of Effective length $L_{eff} = \frac{C}{2 f_o \sqrt{\varepsilon_{reff}}}$

(3)

L_{eff} = 30 mm
Where:
c = free space velocity of light 3 x 10 8 m/s
fo = frequency of operation
ε_{reff} =effective dielectric constant
Step 4: Calculation of Patch length extension (ΔL):

$$\Delta L = 0.412h \frac{(\varepsilon_{reff} + 0.3)(\frac{W}{h} + 0.264)}{(\varepsilon_{reff} - 0.258)(\frac{W}{h} + 0.8)} \quad (4)$$

$\Delta L = 738 \mu m$
Where:
W = width of the patch
ε_{reff} = effective dielectric constant
h = height of dielectric substrate

Step 5: Calculation of actual length of the patch

$$L = L_{eff} - 2\Delta L \quad (5)$$

L= 29 mm

Step 6: Calculation of Substrate dimension

For this design this substrate dimension would be

Ws = 2*6h + W = 2*6(1.6) + 38 = 58 mm (6)

Ls = 2*6h + L = 2*6(1.6) + 29 = 49 mm (7)

Fig. 2 Hardware of Hexagonal Microstrip antenna.

III. PARAMETRIC ANALYSIS

The suspended patch design deals with effect of various parameters. By increasing length, the whole VSWR curve shift towards lower frequencies. The change is higher in resonant Frequency of higher mode, since the relative change in current path length for higher mode is greater than the lower mode current path. The width significant effect on the matching to the input impedance. Increasing height of antenna by placing air gap between substrate and height it helps to improve the height of MSA. Design of Suspended microstrip patch antenna is shown in figure below.

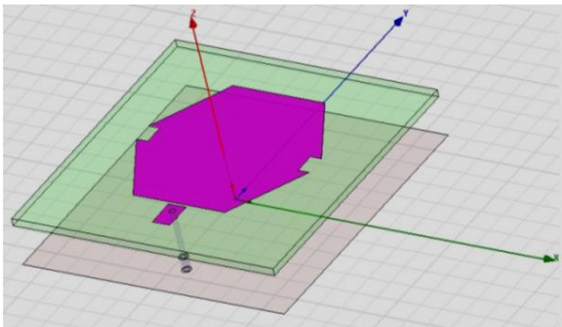

Fig. 3 Suspended Microstrip patch antenna

Suspended patch design is mainly proposed to enhance bandwidth of antenna. Hexagonal radiating patch with two corner slot design with capacitive coupling is used. In antenna design we generally calculate at -10 db i.e. Return loss of antenna which given in figure below.

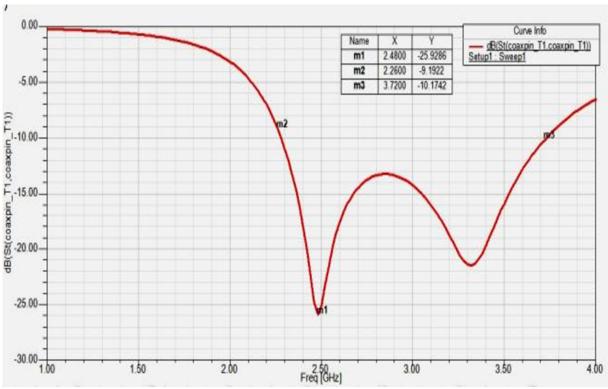

Fig. 4 Return Loss

The antenna is radiate between Mainly 2.26 to 3.72 GHz which comes under S-band. There are 2 Peaks shown in figure one is at 2.4 GHz and other one is at 3.2 to 3.5GHz. Mainly 2.4 to 2.5 GHz range is comes under ISM band. In that mainly different wireless operation is used like Wi-Fi, Bluetooth etc. These applications are operated at very good return loss i.e. -25.92 dB means 99.70% power is transferred by antenna. Other peak is at 3.2 to 3.5GHz range which usually used for Wi-Max operation. For this band also we get return loss is at -21.29 dB. i.e. 99.30% power is transmitted and only 0.70% is reflected back by antenna. So total bandwidth of antenna is enhanced by 60.83% and total band covered by antenna is 1.46GHz.

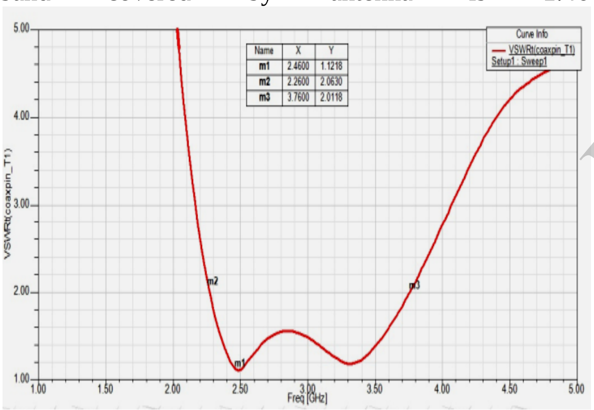

Fig. 5 VSWR

Generally VSWR of antenna is measured between 1 to 2 GHz. At the 2.4 GHz and 3.2-3.5 GHz we get very good VSWR i.e. 1.11 and 1.18 respectively. Finally directive power gain of antenna is 3.22 and Microstrip antenna is comes under category of directional antenna which is preferred over the particular distance. Microstrip antenna has main drawback is low gain antenna. This problem is also overcome by suspended patch design with capacitive loading. A coaxial feeding technique is preferred over other techniques for obtaining maximum radiations towards particular direction.

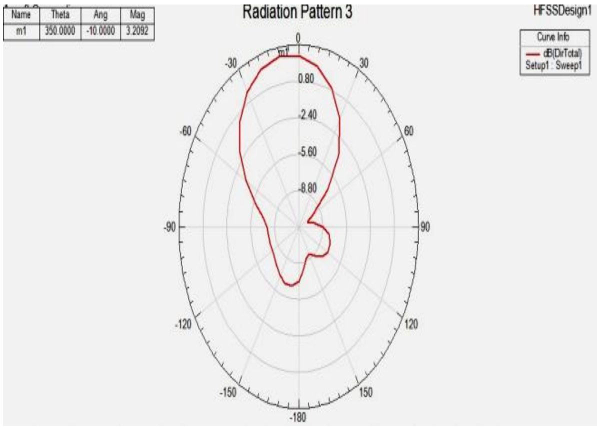

Fig. 6 Radiation pattern of Suspended patch antenna

A narrowband antenna is converted in to Ultra Wide Band antenna which have max. Radiations with directive power gain 3.22 w.r.t. isotropic antennas.

IV. RESULTS

The numerical simulation and optimization is performed with software ANASOFT HFSS 11.1 V. By optimizing length and width of slot, the feed location and the distance between two slot resulting yield excellent returns loss, VSWR and radiation character.

Sr. No.	Antenna Parameters	Simulated	Measured
1	Frequency range	2.26-3.72 GHz	2.32-3.74 GHz
2	Return Loss	-25.92 dB	-24.62 dB
3	VSWR	1.11	1.18
4	Bandwidth	1.46 GHz	1.42GHz
5	BW enhanced (%)	60.83	59.16

Table 1. Comparison of Simulation and Measured result.

The applications comes under the S-band is covered by suspended patch design with return loss -26.92 dB and VSWR is 1.11. The band covered is from 2.26 GHz to 3.72 GHz. There are many wireless applications like Wi-Fi, Bluetooth and Wi-Max is covered. Finally Narrowband antenna i.e. band is limited to 1-3% of centre frequency which is converted into Ultra Wide antenna with 60.83% of Bandwidth enhancement is achieved.

V. CONCLUSION

Regarding the simulated results, it is concluded that suspended patch design using capacitive feed geometry provides wide bandwidth. It helps to reduce size of antenna. The effects of various parameters of antenna have been studied without changing permittivity and height of substrate. This design is simple in nature and mainly cost effective. By adjusting electrical length of antenna we optimize its shape. With quality of substrate used antenna provides good directivity.

From the result we observe that Suspended Microstrip patch antenna is cover wireless application which comes under the S-band. A very good return loss is obtained with particular operation in S-band. Maximum bandwidth i.e. 1.46 GHz is achieved by using Suspended patch technique.

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