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Wi-MAX Frequency Band Notch Antenna using Inbuilt Filter Application

Novel Approach

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***Abstract*—After release of unlicensed band of 3.1 GHz to 10.6 GHz by Federal Communications Commission in February 2002, the ultra-wideband (UWB) system has experienced rapid growth. This paper deals with design and fabrication of simple Circular Microstrip Patch antenna and its variations i.e. Rectangular Cut Circular Microstrip Patch and Flower shaped microstrip patch antenna for the Ultra Wide Band frequency operation. The substrate material used is Flame Resistant class-4 (glass epoxy) with thickness 1.53 mm having the dielectric constant ε_r = 4.4. The patch material is copper having thickness of 0.1 mm. To overcome the inherent limitation of narrow bandwidth of microstrip patch this work follows the method of smoothening of the edges of patch. Thus rectangular patch having bandwidth 835.1 MHz is transformed into circular patch of same size with increased bandwidth of operation covering more than 8947.1 MHz, with some modifications in ground plane and is used as basic Ultra wideband Antenna.**

Regulations over the use of Ultra Wideband frequencies clearly states that it should not cause interference with existing narrowband systems i.e. Worldwide Interoperability for Microwave Access (3.3 GHz-3.6 GHz) and Wireless Local Area Network (5.15 GHz- 5.825 GHz

Key Words: Microstrip antenna, Notch-band, VSWR, UWB band, CPW.

I. INTRODUCTION

No matter how good the circuit production technology is, we, as the design engineers, are in a position, to squeeze the best electrical performance out of it. As far as the design of communication systems are concerned, the most critical issue is the error free transmission and reception of electrical signals over the band of operation .In order to squeeze the limits of the production technology; we must be able to provide best of signal transmission over a wide frequency band. Signal transmission starts with a properly designed antenna. This way of understanding design problems guides us to construct antennas with high gain and wide frequency bandwidth as much as possible.

In 2002, Federal Communication Commission (FCC) authorized unlicensed use of UWB band ranging from 3.1 GHz to 10.6 GHz. The UWB antenna is a specific component that's transmitting and receiving properties differ from those for conventional narrowband operation.

To avoid interference due to these frequencies UWB Antenna must be able to reject such frequencies with very fine rejection characteristics. For this purpose numerous notches are created atParticular frequency band which have rejection characteristic over a limited bandwidth (specifically less than 1GHz).Lately, a number of antennas with band-notched
Property has been discussed and various methods have been used to achieve the function.UWB antenna can be created by use of simple micro-strip line and proper designing of ground structure [1]. The widely used methods for are etching slots on the patch or on the ground plane, i.e., straight, triangular, E-shaped, H-shaped, U-shaped, and folded strip-line slots [2] [3] [4] [5].The notched bands can be generated by a band notched filter composed of double Stepped Impedance Resonators (SIRs)[7][8].Adding parasitic elements is another method to generate notched band e.g. Ring shaped parasitic elements designed on the bottom of the substrate [7]. Square Ring Resonator and a square parasitic element canbe used to have notched characteristics in UWB Antenna. Split Ring Resonator is one of the widely used and appreciated structures used for creating notches at particular frequencies.

This paper uses above concepts altogether to minimize the system size by developing inbuilt filter in antenna. For developing antenna, more advanced Printed Circuit Board (PCB) technology is to be used with very precise design upto 0.1 mm. High Frequency Structure Simulator is Finite Element Method based electromagnetic solver which is used as pre-design tool.

II. OBJECTIVE

Design and fabricate Wide Band antenna with notched band and the identities of Omni-directional radiation pattern,small size, high data transmission rate, short-range characteristics, low power consumption, constant gain, and a linear phase response. These characteristics can be tabulated as follows:-

TABLE I. System Requirements

Sr. No.	Parameter	Specification
1.	Frequency Range	Wide Band (3.1-10.6GHz)
2.	Total Bandwidth	Greater than 2.00 GHz
3.	Radiation Pattern	Omni-directional
4.	Group delay	Constant (less than 2 nSec.)
5.	Rejection Band	Around 5.4 GHz

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III.SIMPLE RMSA DESIGN

A. Type A - Basic Rectangular Micro stripPatch Antenna)

Basic Rectangular Microstrip Patch Antenna consists of simple Coplanar Microstrip Patch Antenna with no any modifications in patch or ground shape. Hereafter termed assimple RMSA. Design and dimensions are described in brief in next section.

a. Structure of simple RMSA

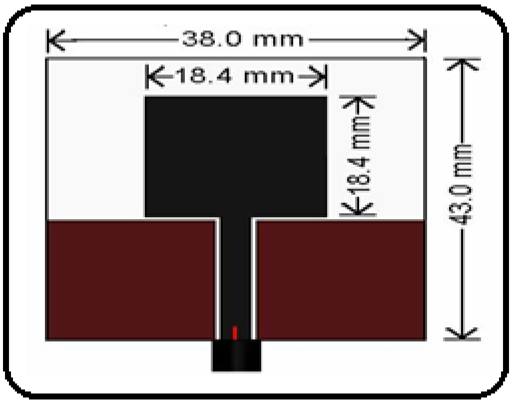

Figure 1: Structure of Basic Rectangular Microstrip Patch Antenna (Type A)

CPW fed RMSA i.e. Rectangular Microstrip Patch Antenna is designed in HFSS on generally available FR4 substrate of size 38mm X 43mm X 1.53mm and having dielectric constant of 4.4 and loss tangent (tan δ)=0.02. As shown in Figure 1 both sides of actual radiating copper patch are chosen to be 18.4mm and structure is known to be coplanar as both ground and patch are on same plane. Thickness of the copper material is assumed 0.1mm which negligible in comparison with 1.53mm thickness of FR4 substrate material. As the structure is monopole, length of patch and ground are same. Dimensions of ground are 18.4mm * 16.9mm * 0.1mm. Feed width is 3.1mm fixed. Gap between feed and ground is optimized to 0.55mm and gap between patch and ground is 0.5mm.

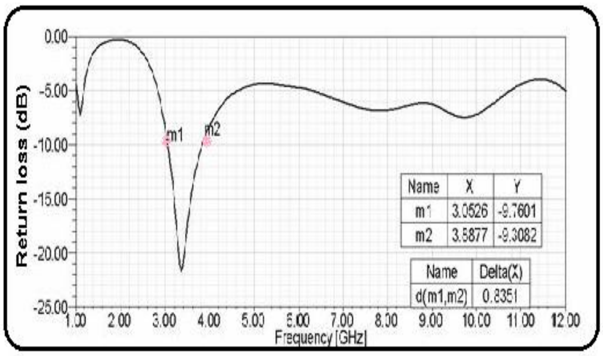

Figure 2: Return Loss vs. Frequency for simple RMSA (Type A)

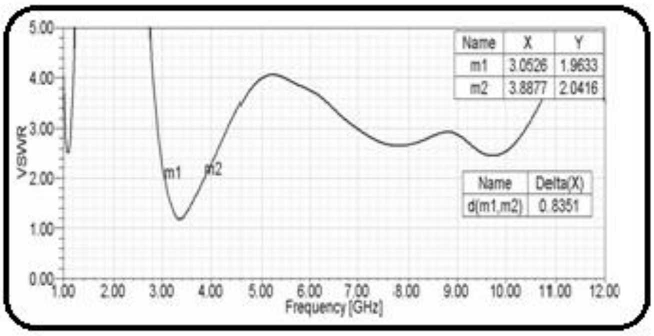

Figure 3: VSWR vs. Frequency for simple RMSA (Type A)

B. Simulation Results

The structure is designed and simulated over HFSS v11. Figure 2 and 3 shows simulation results. The operating band of any antenna is described by return loss less than -10 dB or VSWR less than 2. Return loss of -10dB indicates that, 90% of the power fed to antenna is accepted and only 10% is reflected at the feed. Thus Return Loss<-10dB is universally accepted convention to decide operating band of an antenna. In Figure 2 and 3, m1 is lower end operating frequency and m2 is higher end operating frequency, marking the -10dB crossing line. As can be seen from following figures, simple rectangular microstrip patch antenna covers bandwidth of 835.1 MHz, starting from 3.0526 GHz to 3.8877GHz.

Split Ring Resonator

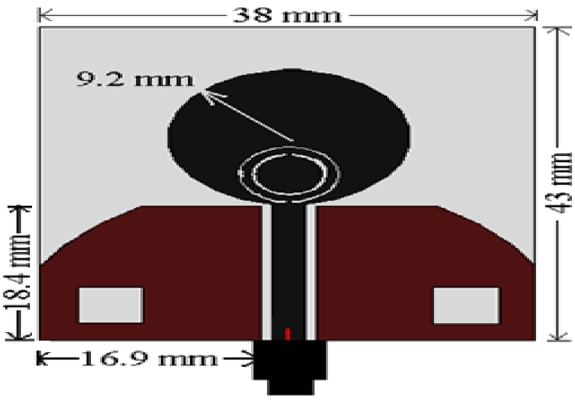

Figure 4: Structure of SRR Microstrip Patch Antenna

The proposed antenna is optimized first for each design parameters to achieve the required ultra wide bandwidth. In this, ground width, ground length, feed width, gap between feed and ground, and crucial gap between patch and ground are optimized rigorously. After this, slit ring resonator are cut from radiating patch. The dimension of both split rings resonators is optimized to have the correct notched center frequency and bands. Simulation has been in both frequency domains as well as in time domain. In frequency domain return loss S_{11}dB has been calculated for different ground length, ground width, gap between feed and ground. Then the peak gain in dB Vs frequency and radiation pattern also have been calculated for different frequencies. As known from literature for proper transmission of signal by antenna S_{11} parameter of antenna should be less than -10dB. The optimized performance in term reflection coefficient and VSWR are shown in Figure 5 and Figure 6.

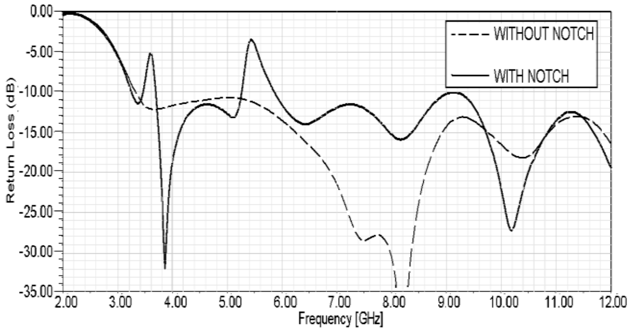

Figure 5: S-parameter vs. Frequency for SRR MSA

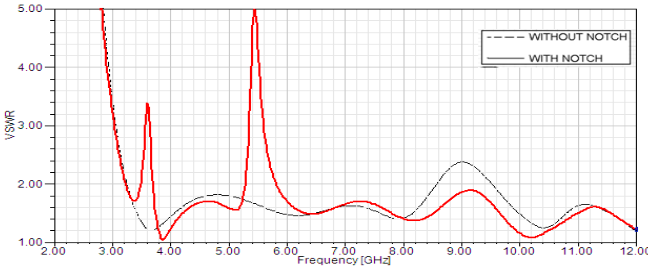

Figure 6: VSWRvs. frequency for SRR MSA(TypeA)

Figure 4 shows the SRRmicrostrip antenna and Figure5,6 gives the output result after simulating it into HFSS design simulation result. Two different graphs tell us that bandwidth of SRR MSA is 7.4GHz.

Modified circular patch with parasitic element

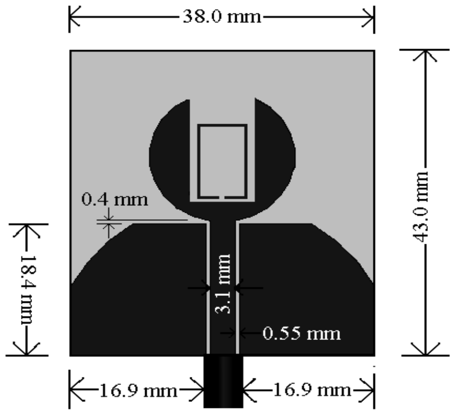

Figure7:Structure of Modified Circular Patch with Parasitic Element

In literature, it had been proved that a free element placed near the radiating patch also resonates. It is then said to be feed by Electromagnetic coupling. Such element is called as a parasitic element. Coupling depends on gap as well as length along which the two patches run. More the gap weak is the coupling hence gap between patches should be minimum with maximum possible running length. To introduce a parasitic element in previous design a rectangular cut is made in radiating patch which also helps to improve impedance bandwidth of an antenna as will be shown in Figure

The proposed antenna is optimized first, for each design parameters to achieve the required ultra wide bandwidth. In this, ground width, ground length, width and length of Rectangular cut in Radiating patch, feed width, gap between feed and ground, and crucial gap between patch and ground are optimized rigorously. After this, parasitic element is inserted in rectangular space created on purpose. The dimensions of parasitic element are optimized to have the correct notched center frequency and band. The optimizedperformance in term reflection coefficient and VSWR are shown in Figures 8 and Figure 9 below, with and without notched band. The reflection coefficient is less than -10dB over band starting from 3GHz to 12GHz except at notched band 5.2GHz to 5.8 GHz where its value is -5dB. Similarly VSWR is less than 2 over entire band except at notched band where it shows value more than 4 indicating strong rejection characteristics over this band. Insertion of parasitic element also improves the bandwidth slightly by lowering the lower cut off frequency.

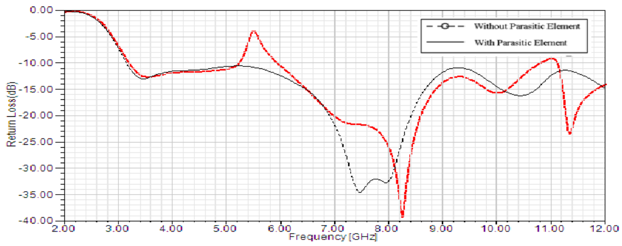

Figure 8: Simulated return loss vs. frequency of basic and modified circular patch.

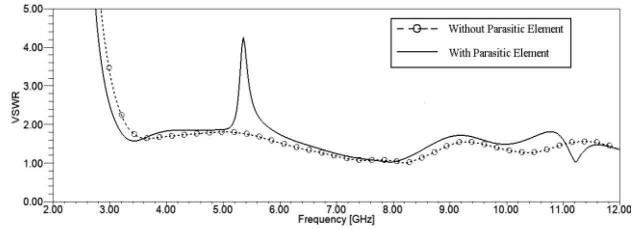

Figure 9: Simulated VSWR vs. Frequency of basic and modified Circular Patch

Modified Circular Patch with Smile Shape Notch

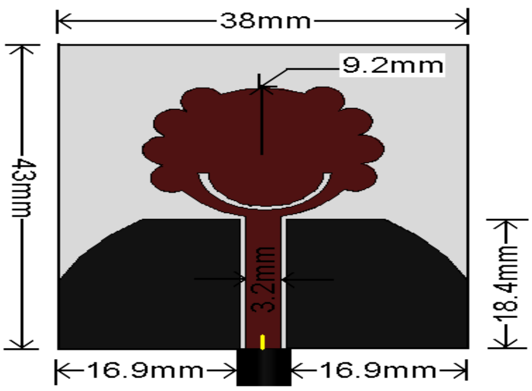

Figure 10: Structure of Modified Circular Patch with Smile Shaped Notch

Figure 10 shows Modified Circular Patch Antenna with Smile Shaped Notch. 8 Small circles of radius 2mm are added along the periphery of circular patch as seen in Figure 10. Semicircular smile shaped notch is removed from patch to have band notched characteristics at WLAN band.

After this, split ring is cut from radiating patch. The dimension of split ring is optimized to have the correct notched center frequency and bands. The optimized performance in term reflection coefficient andVSWR are shown in Figures 11 and 12, with and without notched bands.

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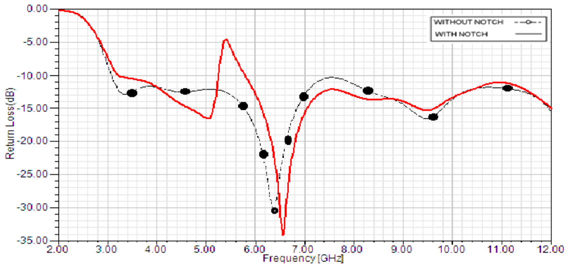

Figure 11: Simulated Return Loss vs. Frequency of Modified Circular Patch with and without Smile Shaped Notch

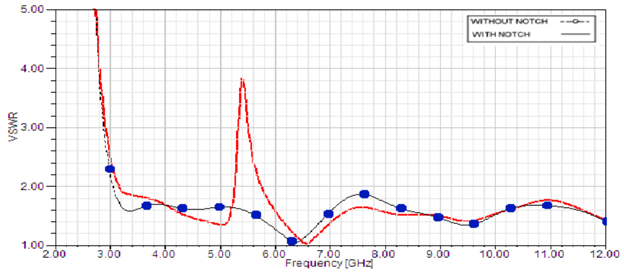

Figure 12: Simulated VSWR vs. Frequency of Modified Circular Patch with and without Smile Shaped Notch

IV. METHODOLOGY

Using AnSoft Corporation's High frequency Structure Simulator (HFSS™) various types of antennas can be designed and tested.HFSS™ is an interactive software package for calculating the electromagnetic behavior of a structure. The software includes post-processing commands for analyzing this behavior in detail.

Using HFSS™, you can compute:

- Basic electromagnetic field quantities and, for open boundary problems, radiated near and far fields.
- Characteristic port impedances and propagation constants.
- Generalized S-parameters and S-parameters renormalized to specific port impedances.
- The Eigen-modes, or resonances, of a structure.

V. EXPECTED APPLICATIONS

UWB has characteristic attributes that make it especially attractive for communication and special radars. These include the following:

- *Local area networks* – The exceptionally large available bandwidth can be used as the basis for a short-range wireless local area network with data rates approaching gigabits per second.
- *Position location* – Some UWB systems are capable of determining the 3D location of any of its transponders to within a few centimeters.
- *Radar imaging* – UWB systems can be used as an open-air through-wall or ground-penetrating radar imager.
- *Vehicular radar systems* – UWB has an available vehicular radar band in the frequency range 22 to 29 GHz for use in collision avoidance and parking aids.

CONCLUSION

Above simulated result provides a brief idea of how narrowband simple RSMA can be transformed to Ultra Wide Band modified RSMA without changing its physical dimension. Circular edge truncation proves to be more efficient than straight edge truncation. Smoothening of corner of rectangle increases reflection and current at the boundary of patch. If shape and size changes the radiation property and VSWR, S-parameter are also changes.

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REFFERENCES

[1]. EmadTammam, Kuniakiyoshitomi.:'Miniaturization of a UWB antenna with Dual band notched at WLAN/Wimax frequency bands.' IEEE 2012

[2]. Azim, R., Islam, M.T., and Misran, N.: 'Ground modified double-sided printed compact UWB antenna', Electron. Lett., 2011, 47, (1), pp. 9–11

[3]. Xiao,J.X.,Wang, and Li, G.J.: 'A ring monopole antenna for UWB application', Microw. Opt. Technol. Lett., 2010, 52, pp.179–182

[4]. Ojaroudi, M., Yazdanifard, Sh., Ojaroudi, N., and Sadeghzadeh,R.A.:'Band-notched small square-ring antenna with a pair of T-shaped stripsprotruded inside the square ring for UWB applications',IEEE Antennas Wirel. Propag.Lett., 2011, 10, pp. 227–230

[5]. Liao, X.-J., Yang, H.-C., Han, N., and Li, Y.: 'Aperture UWBantenna with triple band-notched characteristics', Electron.Lett., 2011, 47, (2),

[6].Ahmed Shaker1, Saber Helmy Zainud-Deen2**,**Compact Bluetooth/UWB Antenna withMulti-Band Notched Characteristics,"Journal of Electromagnetic Analysis.

[7]. Jiechen Ding, Zhili Lin, Zhinong Ying, and Sailing He, "*A CompacUltra Wideband Slot Antenna with Multiple Notch FrequencyBands*,"Microwave And OpticalTechnology Letters December 2007.

[8]. HomayoonOraizi, Mehdi Hamidkhani, "*Dual-band MicrostripNotchFilters Using SlottedSquare Patch Resonators,*" IEEEAntennas and Propagation Magazine 2010.