

# Reconfigurable Notch Band Antenna for UWB Application: A Review

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**Abstract-** Microstrip Patch antenna is generally used in a number of antenna systems because of their low profile, light weight, low cost, compactness etc. Patch antenna is also used with Microwave IC's and Monolithic Microwave IC's because of its compatibility. Reconfigurable band notches in UWB antennas are dynamic research area. The advantage of the antenna with reconfigurable band notch is to efficiently exploit the frequency spectrum resources and work collectively well with the presented narrowband wireless services. Various methods were used by the researchers for the purpose of rejection of frequency bands for several narrow band applications existing in ultra wide band. In this paper we have made a study and survey on a portion of the diverse Reconfigurable Notch Band Antenna for UWB Application.

**Keywords:** DGS, Microstrip, Gain, Reconfigurable antenna, P-I-N diode

## 1. INTRODUCTION

In any wireless communication system, when a radio frequency (RF) signal is generated in a transmitter, some device must be used to spread out this signal through space to a receiver. The device that does this work is the antenna. Microstrip antenna contains a radiating patch on one side of a dielectric substrate and a ground plane on other side. The patch conductor is of copper. Relative permittivity of the substrate must be low to increase the fringe fields which are responsible for radiation. They have several applications over the band of frequency range from 100 MHz to 50 GHz but main disadvantage is bandwidth of small extent. In 2002 FCC has stated the band of frequency from 3.1 GHz to 10.6 GHz for ultra wide band (UWB) [8].

The main advantage of UWB antenna is that they are capable to utilize the complete ultra wide band spectrum and when an interfering signal shows up, the antenna can alter its arrangement in order to produce a notch band which removes the interference

from the coexisting system. Because of huge applications found in ultra wide band, UWB antenna has involved a plenty of research. Main problem with the ultra wide band antenna is interference from various applications with narrow band. Frequency bands allocated in ultra wide band are 1) Wi-Fi / WLAN, IEEE 802.11 used: 2.4 GHz frequency band ( 2.4 GHz to 2.5 GHz ) and 5 GHz or 5.8 GHz frequency band ( 5.15 GHz to 5.35 and 5.725 GHz to 5.875 GHz ). 2) Wi-MAX, IEEE 802.16 used different frequency ranges of 2.3 GHz, 2.5 GHz, 3.3 GHz, 3.5 GHz and 5.8 GHz in various regions. 3) Bluetooth, IEEE 802.15.1 has frequency band at 2.4 GHz. 4) C band for satellite communication in range of 3.7 GHz to 4.2 GHz. 5) X band for down link satellite communication in the 7.25 to 7.75 GHz. 6) High performance LAN (HIPERLAN) operating in the 5.15 to 5.825 GHz. These will cause interference to the existing wireless communication systems. So the UWB antenna with a band stop performance is required to generate the frequency band notch function [38].

There are several methods for analysis of microstrip antennas. The most popular are the transmission line, cavity and full wave. The transmission-line model is the easiest among all because of good physical insight. The design procedure assumed that information which includes the dielectric constant of the substrate ( $\epsilon$ ), the resonant frequency ( $f$ ) and the height of the substrate ( $h$ ). A rectangular microstrip antenna is defined according to an array of two radiating narrow apertures, each of width  $w$  and height  $h$ , separated by a distance  $L$ . The antenna design procedure is as follows:

A practical width of the patch that leads to good radiation efficiencies is given as

$$w = \frac{1}{2f\sqrt{\epsilon_0\mu_0}} \sqrt{\frac{2}{\epsilon+1}} \quad (1)$$

where  $\epsilon_0\mu_0 = c = 3 \times 10^8$  m/s and  $f$  defined resonant frequency.

Effective dielectric constant of antenna for  $w/h > 1$  is given as

$$\epsilon_{\text{reff}} = \frac{\epsilon+1}{2} + \frac{\epsilon-1}{2} \frac{1}{\sqrt{1+12\frac{h}{w}}} \quad (2)$$

Extension of length  $\Delta L$  is given as

$$\Delta L = 0.412 h \frac{(\epsilon_{\text{reff}}+0.3)(\frac{w}{h}+0.264)}{(\epsilon_{\text{reff}}-0.258)(\frac{w}{h}+0.8)} \quad (3)$$

The actual length of the patch is determined according to

$$L = \frac{c}{2f\sqrt{\epsilon_{\text{reff}}}} - 2\Delta L \quad (4)$$

Thus, most important aim of antenna design is to define an ultra wide band antenna which covers about the complete ultra wide band with smallest interference from presented narrow band applications. For reducing EMI, frequency bands of offered applications should be detached from ultra wide band. DGS has been emerged as most common choice due to increase of bandwidth and introduce of stop bands (notch bands). Diverse DGS structures have been used in the literature such as rectangular shaped, square shaped, circular shaped, dumbbell shaped, spring, L shaped, U shaped, V shaped, hairpin shaped, hexagonal shaped, cross shaped and combined DGS [9]. The DGS is equivalent to L-C resonance circuit. The inductance value and capacitance value depends upon the area and size of the defect. DGS is described by using parameters: the etched lattice dimension and the gap distance. The values of inductance and capacitance for DGS are given by:

$$Ls = \frac{1}{\omega^2 C} \quad (5)$$

$$Cs = \frac{f_c}{2Z_0} \cdot \frac{1}{2\pi(f_0^2 - f_c^2)} \quad (6)$$

Reconfigurable band notches in UWB antennas are dynamic research area. The advantage of the antenna with reconfigurable band notch is to efficiently exploit the frequency spectrum resources and work collectively well with the presented narrowband wireless services. On the other hand, the frequency of band notch UWB antennas is uncontrollable after their manufacture, which fails to fulfill the requirements of the reconfigurable notch band in real time. Thus reconfigurable techniques have accepted major attentions in the field of wireless communications. A number of reconfigurable notch bands UWB antennas have been discussed, the notch band frequency can be continuously tunable with varactor diode and discretely tunable with P-I-N diode [19].

Reconfiguring property of antenna is classified in four fundamental types, Antenna with frequency reconfigurable, Antenna with polarization reconfigurable, Antenna with pattern reconfigurable and Antenna with hybrid reconfigurable (those are the combinations of any of the above three).

Frequency reconfigurable antennas are capable of changing their resonant frequency for various operating bands. In long-age, improvement in frequency reconfigurable has been developed. Several switching techniques are employed to obtain any operating condition of reconfigurable antenna. A patch antenna uses PIN diode for several modes of switches to control the surface current path length. Coaxial feed is slipped over the feed of the micro strip line which is controlled by Microcontroller. Position of the feed which is changed by coaxial feed is used to build antenna resonate at several frequencies. Resonant frequency of the microstrip patch antenna is also changed by photo conductive switch which is optically controlled [21].

Varactor diodes are also used for reconfigurability which is positioned between each radiating stem and bias voltage of varactor diodes can be controlled separately. Then resonant frequency can be varied by changing the bias voltage. In addition, frequency reconfigurable antennas using field effect transistor switches are also presented. In this, changing the state of field effect transistor switch could break rectangle ring radiator [33].

## 2. Reconfigurable Antenna Technology

Reconfigurable antennas in terms of frequency are frequently implemented by utilizing radio frequency micro electromechanical switches, varactors diodes and P-I-N diodes. In the given sections, various reconfigurable antennas, operating mostly in UWB range, have been covered. In this article, the references are chosen according to the applied technologies and design concepts.

[5] A. Grau et al. proposed a compact dual linearly polarized reconfigurable antenna with two ports. The Structure is executed on a Quartz substrate, with monolithically integrated micro electro mechanical switches to choose between the two abovementioned polarization bases. The proposed structure operated at 3.8 GHz and defined a partial bandwidth of 1.7%. The attention of the structure is twofold. Micro electromechanical technology is preferred for the reason that micro electromechanical switches provide little insertion loss, huge isolation, approximately a small consumption of DC power, and most significantly they can be monolithically integrated inside the structure since they can be made up on

inexpensive substrates such as printed circuit board or Quartz. The return loss found at the receiving wire ports was observed to be constantly over 15 dB and the separation between ports bigger than 30 dB.

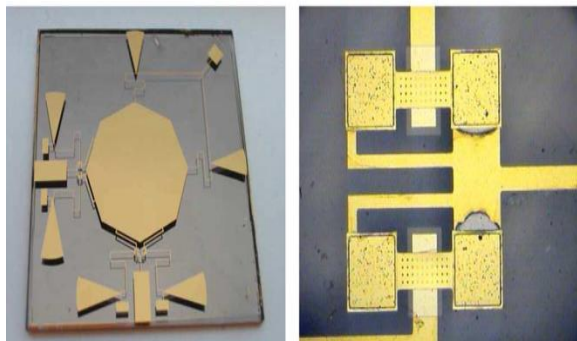


Figure 1: Reconfigurable Octagonal Isolated Orthogonal Element Antenna [4]

[14] Yan Zhang et al. proposed a novel ultra wideband antenna with the reconfigurable notch band (3.3 GHz to 3.6 GHz and 5.15 GHz to 5.825 GHz). The proposed antenna has an elliptical shaped patch along with a 50 Ohm coplanar waveguide feed line and a tapered ground plane. Reconfigurable notch band is gotten with the ring formed opening structure with different switches, these are included into the patch. The elliptical shaped patch and ground structure are optimized to enhance the bandwidth of the UWB antenna. Changing of the position of the switch is responsible for the shifting of notch band. The notch band covers either 3.3 GHz to 3.6 GHz band for Wi-MAX and 5.15 GHz to 5.825 GHz band for WLAN. Zero ohm resistors are used to take place of the switch. UWB antenna with different notch bands is made-up by using the zero ohm resistors.

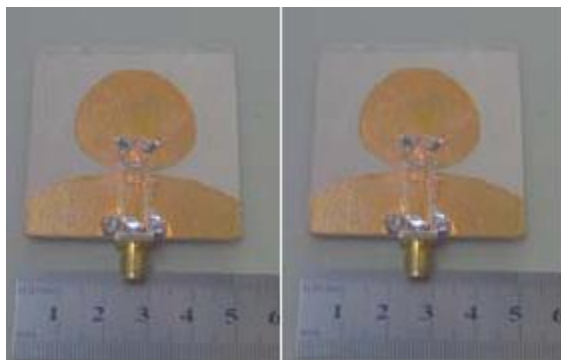


Figure 2: Reconfigurable ultra wide band Antenna [14]

[18] Mohammad Naser Moghadas et al. Proposed a UWB dual band micro strip antenna whose notch bands centered at WLAN and WIMAX is

electronically reconfigured on an individual bases. Defecting method is used for band rejection operations. P-I-N diodes incorporated within the defected ground structure are used to electronically manage the individual notch band without affecting characteristics of other and overall performance. The proposed technique provided the explanation to the problem occurred in reconfigurable antennas which provide only one frequency band at a time. In addition, the proposed structure used P-I-N diodes. There is no need of any dc bias line for PIN diodes, etched on the dielectric substrate. So it avoided the problems associated by means of dc effects. The antenna is energized using CPW structure to increase the impedance. P-I-N diodes controlled the surface currents paths along the slits, are used to switch two rejection bands either on or off state. Feeding of the antenna is accomplished by etching a coplanar waveguide on the dielectric substrate. The antenna radiates omni directionally in the H-plane. Antenna has simple configuration and it is fabricate with low cost.

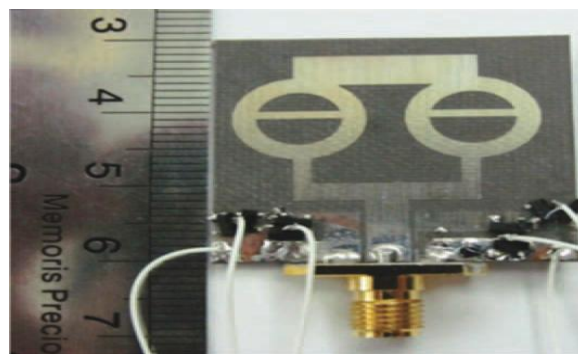


Figure 3: Reconfigurable ultra wide band Antenna with Dual notch band [18]

[19] A.A. Kalteh et al. proposed ultra wide band reconfigurable antenna with single notch band or dual notch band function to eliminate interference from C band satellite communications, IEEE802.11a and HIPERLAN/2 WLAN systems. Circular ring resonator is used to excite the antenna. A single notch band or dual notch band characteristic is obtained using semi rounded parasitic strip placed over the circular ring and a T shaped stub is placed near the inside edge of circular ring. The antenna reconfigurability is achieved by P-I-N diode. The antenna generated a single or dual notch band to separate and block interfering signal in the C-band and/or WLAN frequency bands by altering the ON/OFF conditions of the P-I-N diodes. The antenna defined omni directional pattern in the H plane and bi directional pattern in E plane.

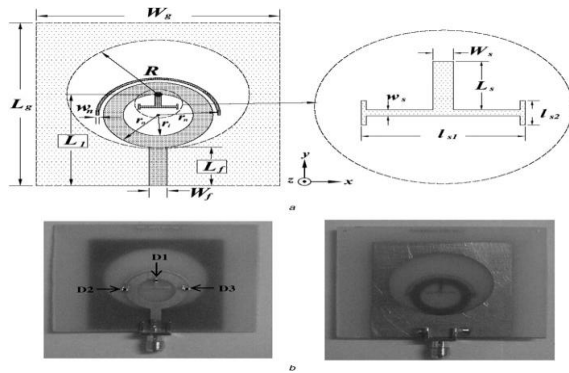


Figure 4: Reconfigurable ultra wide band Antenna [19]

[20] Zohur et al. presented reconfigurable antenna operating in the United States Public Safety bands. It operated in two modes with central frequencies of 718 MHz and 4960 MHz. Single RF MEMS switch is utilized to accomplish reconfigurability between the modes that empowers changing the length of the current, in this manner the resonance frequency is changed. The deliberate band width of the antenna is 2.6% and 7.6% at 718 MHz and 4960 MHz, respectively.

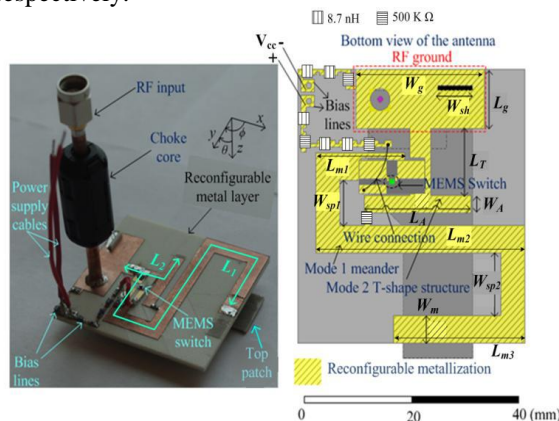


Figure 5: RF MEMS Reconfigurable two band Antenna [20]

[21] Nasrin Tasouji et al. presented a novel printed ultra wideband (UWB) slot antenna with reconfigurable band notched characteristics. The proposed antenna has a customized rectangular radiation patch on which a round shaped and three rectangular shaped slots are impressed. Moreover bandwidth of 3.12 to 12.51 GHz is given by -10 dB return loss. It is obtained by cutting two slits of triangular shape, on a modified ground plane. Single and dual band notch characteristics are generated by two P-I-N diodes, these are mounted across the circular slot. The proposed antenna has reconfigurable single notch band of 3.12 GHz to 3.84 GHz for Wi-MAX with first diode is on and 5 GHz to

6.07 GHz for WLAN when second diode is on. Also, dual bands of 3.12 GHz to 3.82 GHz and 4.9 GHz to 6.06 GHz are rejected from complete frequency range when both diodes are in on state at the same time. The proposed antenna operated in three ranges and it is suitable in a variety of wireless systems. The design structure controlled the width of notched frequencies and also the position. The proposed structure is less complex and has better functionality. A circular slot having three arms etched on the patch to improve bandwidth from 3.12 GHz to 12.51 GHz.

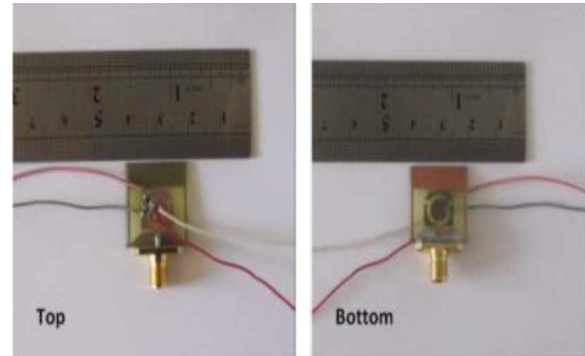


Figure 6: Reconfigurable band notched Ultra wideband slot Antenna [21]

[25] Sarang Pendharker et al. proposed optically controlled frequency reconfigurable microstrip patch antenna. Proposed antenna designs used optical loading of a stub on a patch which is used to change its resonant frequency. In the proposed antenna design, the switch is not a part of the radiating element in direct way but it is used to dynamically change the effective stub impedance connected to a patch.

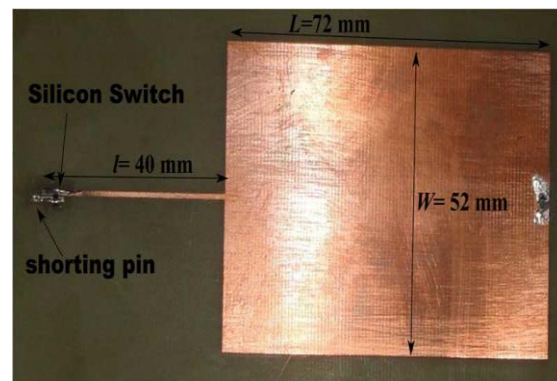


Figure 7: Optically Controlled Frequency Reconfigurable Microstrip patch Antenna [25]

[29] Bahareh Badamchi et al. proposed a compact reconfigurable ultra wide band antenna. In the given antenna, two notches of symmetrical shape are etched

on the feed line. These are used to excite an additional resonance which is useful to obtain UWB characteristic. Reconfigurable single and dual Notch bands are obtained with cutting two slots on the radiating patch along with two P-I-N diodes. The proposed antenna is made able of showing four diverse operations of ultra wide band spectrum by altering the bias states of the P-I-N diodes. It showed ultra wide band spectrum with rejection of the WLAN band, ultra wide band spectrum with single rejection of the Wi-MAX and C band spectrum and ultra wide band spectrum with dual notch band of the WLAN, the Wi-MAX and the C band. The designed structure has a small size of  $20 \times 20 \text{ mm}^2$  and good radiation behavior in the ultra wide band spectrum along with reconfigurable notch bands of 3.15 GHz to 3.85 GHz and 5.43 GHz to 6.1 GHz which rejected the interference with the Wi-MAX, the C band and the WLAN systems respectively. Wider and improved impedance bandwidth particularly at the higher frequency band is achieved with cutting of two modified notches on the feed line. The fabricated antenna showed frequency range of 2.5 GHz to 10.6 GHz with voltage standing wave  $< 2$  along with notch bands of 3.15 GHz to 3.85 GHz and 5.43 GHz to 6.1 GHz.

rejected band is controlled by changing capacitance range from 0.3 pF to 2 pF of varactor diode.

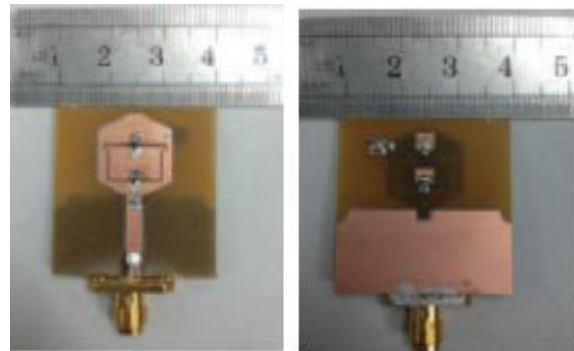


Figure 8: Reconfigurable dual notch band UWB Antenna [33]

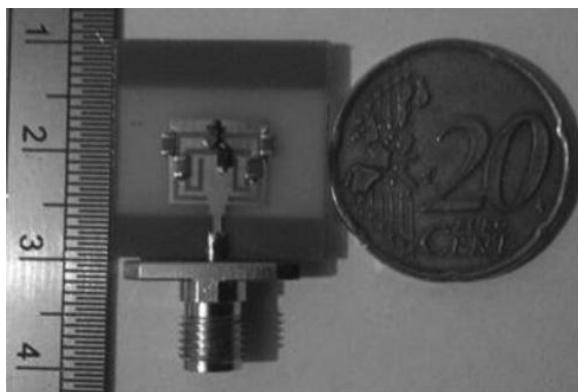


Figure 8: Reconfigurable microstrip slot Antenna [29]

[33] Si Yan Chen et al. proposed a reconfigurable dual notch band ultra wide band antenna. The antenna provided impedance bandwidth from 3 GHz to 11 GHz with dual notch band centered at 3 GHz and 5 GHz, respectively. The frequency of notch band can be tunable within a certain range by varying the voltage on the varactor diodes in the U shaped slots. The proposed antenna removed Wi-MAX/WLAN band and other related frequency bands in the range of 3 GHz to 6 GHz, based on actual application scenarios. Two different lengths of U shaped slots are etched in radiation patch to create two different notch bands. The frequency of the

[34] Babu lal Sharma et al. proposed a defected ground structure antenna with radiating patch of rectangular shape. Reconfigurability for proposed structure is achieved by using P-I-N diodes. During off condition, the antenna provided wide single band (3.6 GHz to 4.2 GHz) for downlink satellite communication in C band and having resonant frequency at 3.99 GHz. When diode is in on condition, the antenna provided two bands of 3.3 GHz to 3.5 GHz for Wi-MAX application with resonant frequency at 3.4 GHz and 4.4 GHz to 4.8 GHz for INSAT with resonant frequency at 4.6 GHz. The antenna was simulated with CST microwave studio. In off condition return loss was -23.45 dB with bandwidth of 621 MHz. When diode is in on condition resonant frequencies are calculated at 3.46 GHz with return loss of -14.40 dB and 4.64 GHz with return loss of -21.89 dB and bandwidth of 268.4 MHz, 406.7 MHz respectively.

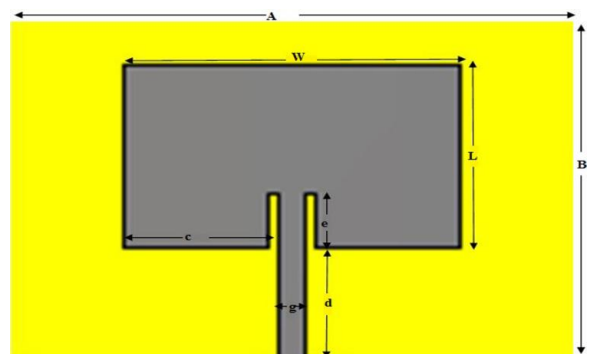


Figure 9: Frequency Reconfigurable microstrip patch Antenna for S band Application (front view) [34]

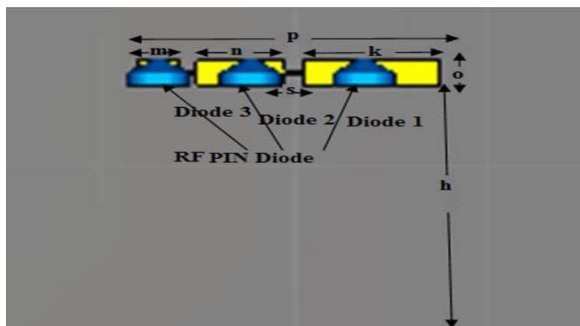


Figure 10: Frequency Reconfigurable microstrip patch Antenna for S band application (back view) [34]

[36] Nishant kumar et al. proposed a reconfigurable antenna with selective frequency for application of cognitive radio. Reconfigurability is obtained by using P-I-N diodes. These are used in defected microstrip structure T slot filter. The proposed antenna defined band width of 3.0 GHz to 10 GH. The proposed structure patch is a grouping of two semi circular patches. For every case reflection coefficient is figured, it keeps up not exactly - 10 dB throughout the operating frequency. The reconfigurability is achieved by using filters in feed line. Filters can be reconfigured by using DC bias .The presented antenna defined good omni directional radiation pattern ,that remain about unchanged in different cases and radiation efficiency of more than 70% in each case. Antenna is simulated using CST Microwave Studio software.

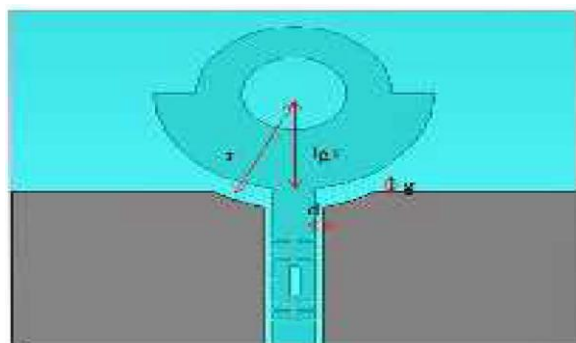


Figure 11: Microstrip Antenna with Frequency Reconfigurable for Cognitive Radio Applications.

Tunable components advantages/ disadvantages

**MEMS advantages**

Consumes slight or about no DC power, large bandwidth, Diminished insertion loss, excellent isolation, very high linearity, small power losses,

**MEMS disadvantages**

Poor reliability because of mechanical movement inside the switch (0.2 to 100  $\mu$ s), sluggish switching speed, discrete tuning, and inadequate lifecycle, require elevated control voltage (50 to 100V),

**PIN Diode advantages**

Wants very little driving voltage, elevated tuning speed (1 to 100 ns), and high power handling ability, very reliable because there is no moving part, inexpensive.

**PIN Diode disadvantages**

Desires elevated DC bias current in on state which consume a major amount of DC power, nonlinear performance, poor quality factor, discrete tuning

**Varactor advantages**

The current flow through the varactor is small compared to P-I-N diode and MEMS, constant tuning

**Varactor disadvantages**

Nonlinear behavior and include small dynamic range

### 3. INFERENCES DRAWN OUT OF LITERATURE REVIEW

The main advantage of UWB antenna is that they are able to utilize the whole UWB spectrum and when an interfering signal appears, the antenna can change its configuration in order to produce a band- notch function which eliminates the interference with the coexisting system. The frequency range for UWB system is from 3.1 GHz to 10.6 GHz. The WLAN operating in frequency bands (5.15 GHz to 5.35 and 5.725 GHz to 5.875 GHz) will cause interference to the existing wireless communication systems. So the UWB antenna with a band stop performance is required to generate the frequency band notch function.

Modified planar monopoles with H-shaped conductor blacked plane, inverted U slot, hook shaped DGS, A planar monopole antenna with two L shape slots, inverted L slit at the edge of the radiator are used to achieve frequency notching.

UWB planar monopole antenna is designed to obtain triple notch band of 3.3 to 3.9 GHz, 5.2 to 5.35 GHz, 5.8 to 6.0 GHz to reduce interference from C band, Wi-MAX and WLAN respectively.

UWB antenna is designed with single notch band of 5.13 to 6.1 GHz to overcome problem of interference

from dedicated short range communication system and WLAN.

Reconfigurable notch band antenna is designed for the notch band which covers 3.3 GHz to 3.6 GHz band for Wi-MAX and 5.15 to 5.825 GHz band for WLAN. Reconfigurability is achieved using switches on the ring shaped in to patch. The disadvantage is reconfigurable notch band is realized with selecting state of switch properly.

Reconfigurable dual notch band antenna is designed with notch band of 3.12 to 3.82 GHz and 4.9 to 6.06 GHz for Wi-MAX and WLAN respectively. Reconfigurability is achieved using P-I-N diode.

Single notch band UWB antenna is designed to reject frequency of WLAN (5.2 / 5.8 GHz). Reconfigurability is achieved using varactor diode because of compact size on printed circuit board. There is problem of proper selection of parameters of diode and dc effects.

Triple notch band antenna is designed with notch bands of 3.3 to 3.67 GHz for Wi-MAX, 4.9 to 5.8 GHz for WLAN and 7.9 to 8.4 GHz for satellite service band.

UWB antenna is designed with stop band from 4.74 to 6.22 GHz for wireless body area network.

Reconfigurable antenna is not designed for narrow band rejection of Bluetooth and Wi-Fi (2.4 GHz to 2.483 GHz), Wi-Fi (2.4 GHz to 2.5 GHz, 5.1 GHz to 5.35 GHz and 5.725 GHz to 5.825 GHz) and Wi-MAX (3.2 GHz to 3.6 GHz).

Reconfigurable antenna is achieved through the use of microwave switches, such as MEMS or P-I-N diodes. The latter being the more popular choice. The reason for this is that MEMS switches are more expensive, afford lower reliability and require a higher bias voltage compared to P-I-N diodes. Pin diodes, on the other hand, are based on more mature technology and are thus more readily available.

#### 4. CONCLUSION

Asia pacific region (India, China) used frequency bands of 2.3, 2.5, 3.3, 3.5, 5.8 GHz for Wi-max. Two bands of (2.4 to 2.5 GHz and 5.725 to 5.825 GHz) are mainly used for Wi-Fi. Bluetooth, IEEE 802.15.1 used frequency band at 2.4 GHz (2.4 to 2.483 GHz). Ultra wide band have the required bandwidth to accommodate future wireless traffic with improved energy efficiency. Electromagnetic interference (EMI) from Bluetooth, Wi-Fi (2.4 GHz to 2.483 GHz), Wi-Fi (5.1 GHz to 5.825 GHz), Wi-MAX (3.2 GHz to 3.6 GHz) and X band for down link satellite communication in the 7.25 to 7.75 GHz. restricts the use of entire ultra wide band all the time. Thus reconfigurable antenna is required to notch the

interference to improve the performance of ultra wide band antenna.

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