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CPW-Fed Compact Printed Circular Disk Ultra - wideband Antenna with band notch characteristic

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***Abstract*— The proposed coplanar waveguide fed compact printed circular disk Ultra-wideband antenna is printed on the glass epoxy FR-4 dielectric substrate with thickness of 1.6 mm, relative permittivity of 4.4 and loss tangent of 0.025. One SRR is cut in the radiating circular patch in order to obtain the desired band-rejection around 5.76 GHz frequencies. The overall dimension of this antenna is 40 mm x 34 mm. The proposed UWB printed antenna is very promising due to its remarkably small size, simple fabrication, and easy integration with compact RF front ends.**

***Index Terms*— Band- notched function, split ring resonator (SRR), coplanar waveguide (CPW), ultra wide band (UWB) antenna.**

I. Introduction

The evolution of wireless communication has revolutionized our life styles. Through the evolutionary process of development, various technologies have been developed for these applications. In order to support high data rates on short-ranges, new promising technologies such as the ultra wide band (UWB) transmission scheme are used. Similar to spread spectrum, UWB communications transmit in such a way which does not interfere with conventional narrowband and carrier wave used in the same frequency band. Ultra-wideband is a technology for transmitting information spread over a large bandwidth (more than 500 MHz). The regulatory is settings by the Federal Communications Commission (FCC) in the United States to provide an efficient use of radio bandwidth while enabling high-data-rate personal area network (PAN) wireless connectivity, longer-range, low-data-rate applications, and radar and imaging systems[1]-[4]. There exist some narrow bands for other communication systems, such as WiMAX operating in the 3.3 GHz to 3.7 GHz band, IEEE 802.11a (WLAN) operating in the 5.15 GHz to 5.825 GHz band, ITU8 operating at 8 GHz to 8.4 GHz and downlink of X-band satellite communication systems at 7.25 GHz to 7.75 GHz. They may cause communication interference with the UWB system. To overcome this problem, various UWB antennas with a band-notched function have been developed not only to mitigate the potential interference but also to remove the requirement of an extra bandstop filter in the system .The simple and most commonly used approach is to incorporate various shapes and sizes of slots into the main radiator.

Two different slot resonators, are embedded into the arc shaped ground plane of the circular disk patch antennas in order to obtain the desired band-rejection around 5.8 GHz [6]. A C-shaped and a modified π shaped slots are etched in the patch to produce two notched bands at the center frequencies of 3.5 and 5.5 GHz in the UWB region [7]. An antenna consists of part of a circular patch and two modified ground planes [8]. Here two symmetrical slots are etched from the ground plane to implement the notched band at 5.5 GHz. The other notched band at 3.5 GHz is obtained by etching a split ring slot in the radiator. By etching two C-shaped slots in the elliptical radiation Element the dual band-notched characteristics at 3.9 GHz and 5.5 GHz are achieved [9]. An antenna consists of a circular patch and a multiple ground plane, here two U-shaped slots are inserted in circular patch and by adjusting the dimensions of the slots, the antenna can reach a frequency band-width from 2.9 GHz to 15.6 GHz for voltage standing wave ratio (VSWR) < 2 and have two notched bands from 3.38 GHz to 4.08 GHz and 5.15 GHz to 6.15 GHz [10].

This paper present a coplanar waveguide fed compact printed circular disk Ultra-wideband antenna with band notch characteristic. The simulated impedance bandwidth is observed from 2.78 GHz to 12.23 GHz which covers the whole UWB frequency band from 3.1 GHz to 10.6 GHz. The VSWR is less than 2 observed over the UWB operating frequency range.

II. ANTENNA DESIGN

A. *Basic Antenna Design*

The geometry of a coplanar waveguide fed compact printed circular disk Ultra-wideband antenna is as shown in Fig.1. The proposed antenna is printed on the glass epoxy FR-4 dielectric substrate with thickness of 1.6 mm, relative permittivity of 4.4 and loss tangent of 0.025. A circular patch with radius of 10 mm is printed on the top side of the glass epoxy FR-4 dielectric substrate, a CPW feed line along with the coplanar ground plane is printed on the same side of the glass epoxy FR-4 dielectric substrate. The feed line of width 3 mm and a gap of 0.30 mm between the CPW feed line and the coplanar ground plane is provided to achieve 50 ohm characteristic impedance. The overall dimension of this antenna is 40 mm x 34 mm. There is a gap of 0.30 mm between the partial ground plane and CPW-fed line. A sub-miniaturized type-A (SMA) connector is connected to the port of the CPW feed line.

The simulation of this proposed antenna is carried out with the CST Microwave Studio package which is based on the finite integration technique for electromagnetic computation. The simulated return loss (S1,1) curve as the function of frequency is as shown in Fig.3.The simulated impedance bandwidth is observed from 2.78 GHz to 12.23 GHz which covers the whole UWB frequency band from 3.1 GHz to 10.6

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GHz. The simulated voltage standing wave ratio (VSWR) as the function of frequency is as shown in Fig.2. The VSWR is less than 2 observed over the UWB operating frequency range. By changing the gap 'h' between the circular disk and coplanar ground plane, the operating impedance bandwidth may be changed and tunes the impedance bandwidth. The simulated impedance bandwidths of the proposed antennas are observed from 3.10 GHz to 13.62 GHz which covers the whole ultra-wideband frequency band, for VSWR is less than 2.

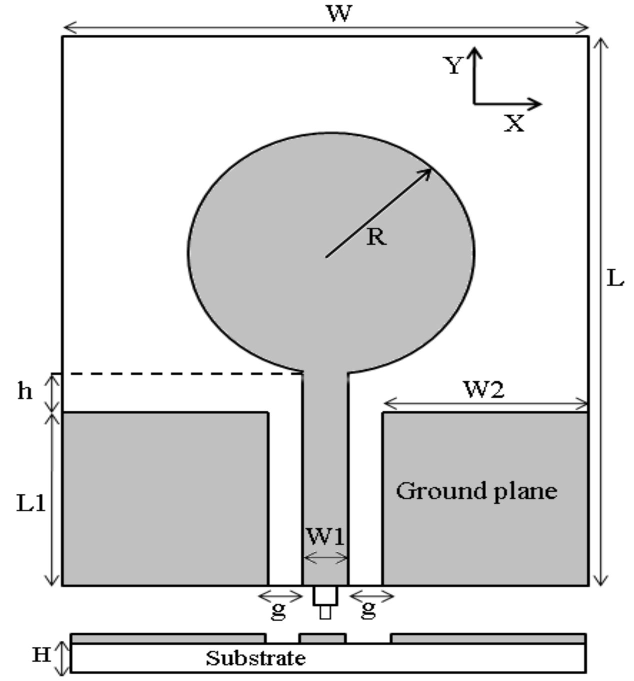


Fig.1 Geometry of the CPW-fed compact printed circular disk ultra-wideband antenna

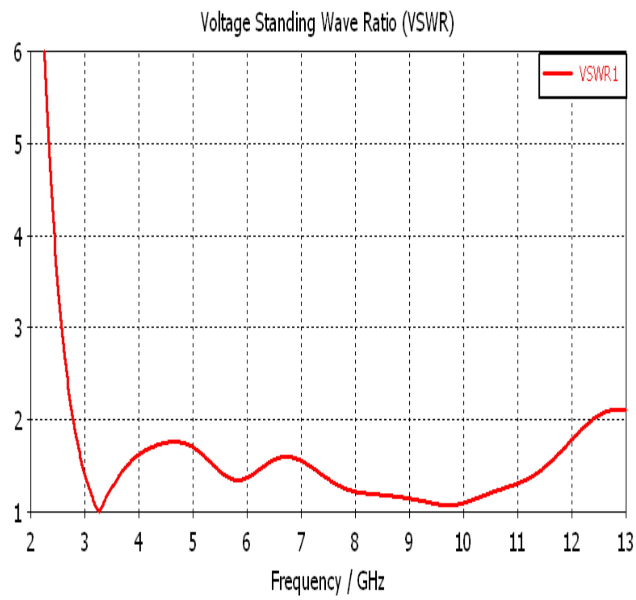


Fig.2 Simulated VSWR curve with frequency of CPW-fed compact printed circular disk ultra-wideband antenna

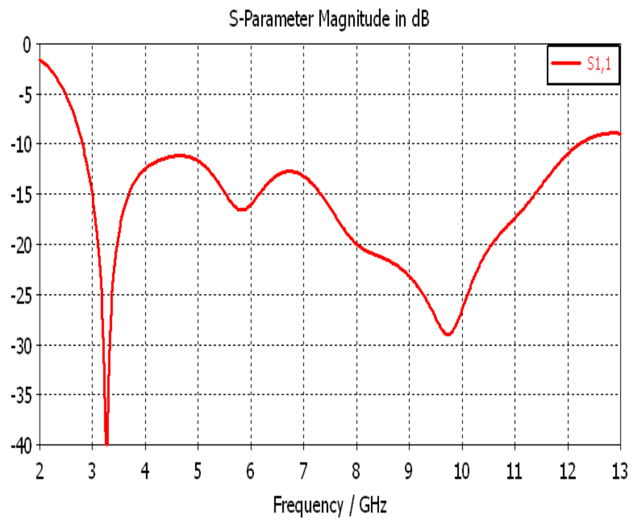


Fig.3 Simulated return loss (S11) curve with frequency of CPW-fed compact printed circular disk ultra-wideband antenna

B. Band-notched Antenna

To avoid interference between UWB and IEEE 802.11a WLAN systems, CPW-fed UWB antennas with frequency band-notched characteristics are desirable. In the next section, a CPW fed UWB antenna with split ring resonator (SRR) is reported. The proposed antenna is printed on the same material as specified in the previous section. It consists of one split ring resonator (SRR) on radiating patch and also CPW feed line to achieve 50 ohm characteristic impedance. The optimal dimensions of the designed antenna are as follows:

L=40mm, Lf=13.2mm, Lg=12.4mm, R=10mm, W=10mm, cw=5mm, g=0.4mm, g1=-0.2mm, h=11.6mm, x1=1.1mm and y1=1.5mm.

It is observed that the key parameters that have the impact on the band-notched characteristic are,gap of srr1 in x direction 'g1', width of srr arm in x direction 'x1', lower shift of srr1 in y direction 'y1'. By adjusting these parameters, the suitable band-notched frequency and notched impedance bandwidth may be achieved. Split Ring Resonator (SRR) is a small sized high Q resonator which can be used to produce Band Notched characteristics in a planar antenna. In a SRR, two similar split rings are coupled by means of a strong distributed capacitance in the region between the rings. A SRR consisting of a pair of concentric annular rings with splits at the opposite ends is considered in this project to implement the band notch characteristics. The resonant frequency of SRR is given by [10]:-

$\omega_o = [\,2/\,(\pi r L_e C_o)]^{1/2}$

Where $r = (r_1+r_2)/2$ is the average radius of the SRR, r_1=Outer radius, r_2=Inner radius, L_e= Equivalent Inductance, C_0= Capacitance per unit length between the two rings.

Fig.4 shows the Circular radiating patch with single notch band characteristics, where a SRR is designed on radiating patch to notch 5.76 GHz frequency. Increasing the length of the slots, which is similar to increasing the inductor value and the capacitor value, has the effect of decreasing the center frequency and bandwidth [9].

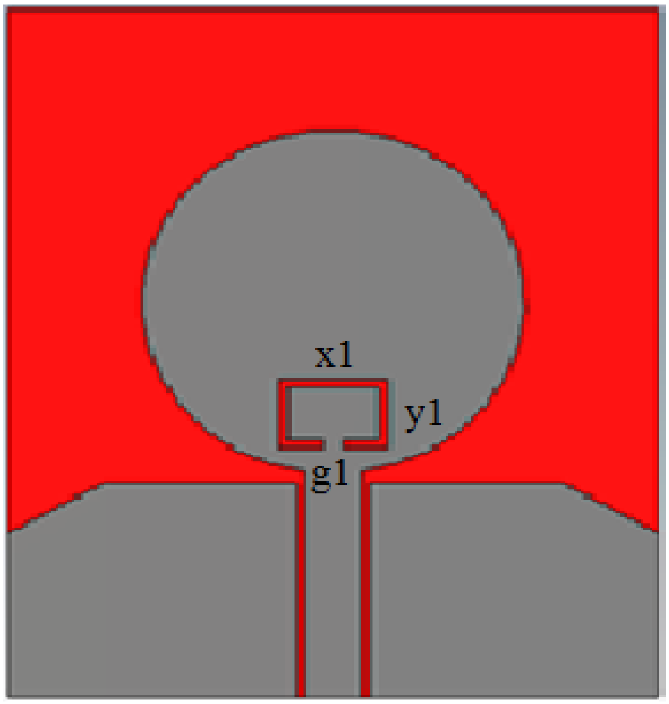


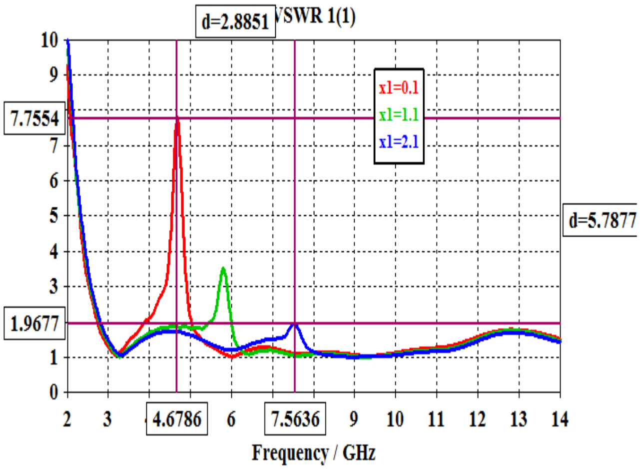
Fig.4 Circular radiating patch with single notch band characteristics

III. RESULTS AND DISCUSSION

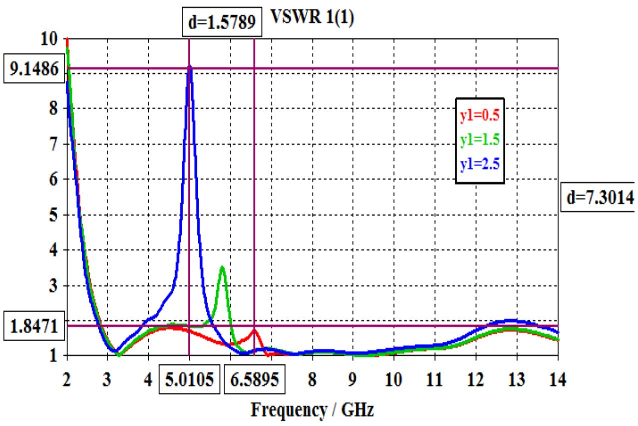
The effects of the geometrical parameter on VSWR curve of antenna performance

Three parts of the proposed CPW-fed antenna effects its performance,which are following: (1) x1 : width of srr arm in x direction, (2) y1: lower shift of srr1 in y direction and (3) g1:gap of srr in x direction.Fig 5(a) & 5(b) gives the simulated VSWR curves of the antenna as a function of frequency for different values of x 1& y1 with fixed other optimized parameter of the patch respectivly . Fig shows that as we vary the value of x1=0.1,1.1,2.1 mm, the centre frequency of the notched band varied from 4.678 to 7.563 GHz .It can be seen that the VSWR of the centre frequency of the notch band is decreased.It can be seen that when as we vary y1=0.5,1.5 and 2.5 mm,the centre frequency of notch band is decreased from 6.589 to 5.010 GHz.

Fig.6 shows the Vector current distributions and Fig.7 shows the Magnitude current distributions at 5.76 GHz notch frequency. Fig. 8 shows the Simulated VSWR curve v/s frequency of the proposed compact printed CPW-fed UWB antenna with dual band-notched characteristics. The notched frequency is 5.76 GHz with VSWR>2. It is observed from fig. 9 of Simulated reflection coefficient (S11) curve v/s frequency of the proposed compact printed CPW-fed UWB antenna with single band-notched characteristics that notched band 5.15 GHz to 5.825 GHz.



(a)



(b)

Fig.5 Relations between the VSWR and dimensions of the proposed antenna(in millimeter): (a) variation of x1 with fixed other optimized dimensions and (b) variation of y1 with fixed other optimized dimensions.

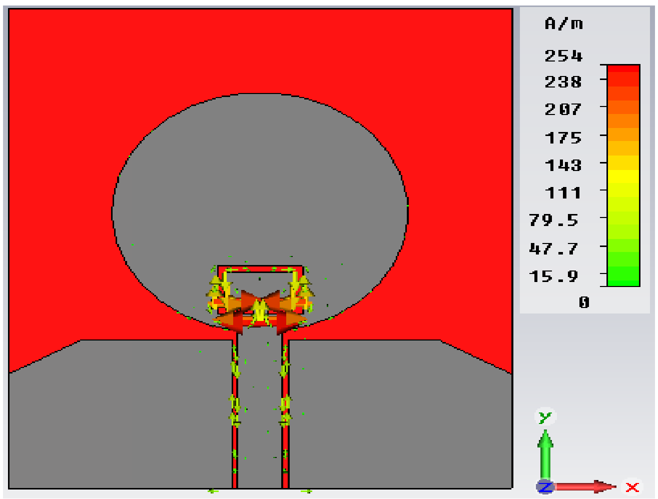


Fig.6 Vector current distributions at 5.76 GHz notch frequency

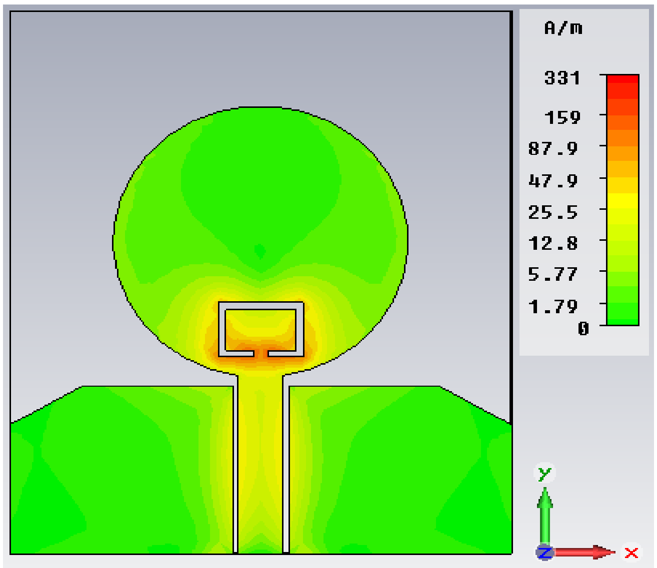


Fig.7 Magnitude current distributions at 5.76 GHz notch frequency

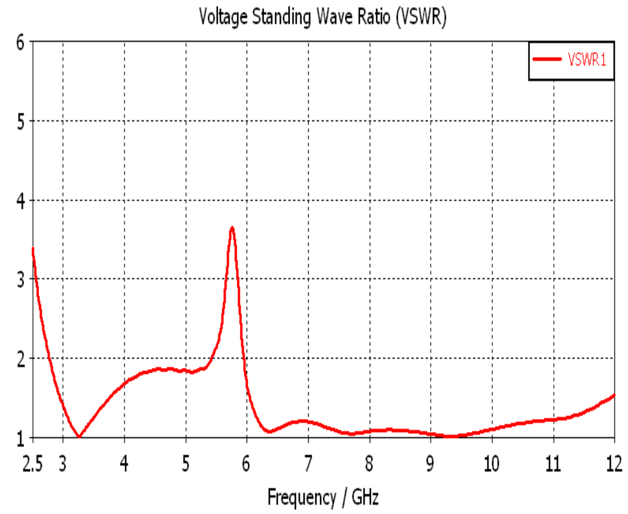


Fig.8 Simulated VSWR curve v/s frequency of the proposed compact printed CPW-fed circular disc UWB antenna with single band-notched characteristics.

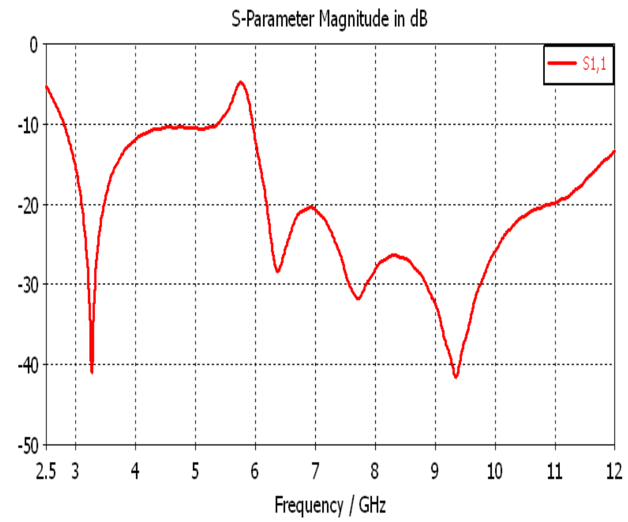


Fig.9 Simulated S-parameter curve v/s frequency of the proposed compact printed CPW-fed circular disc UWB antenna with single band-notched characteristics

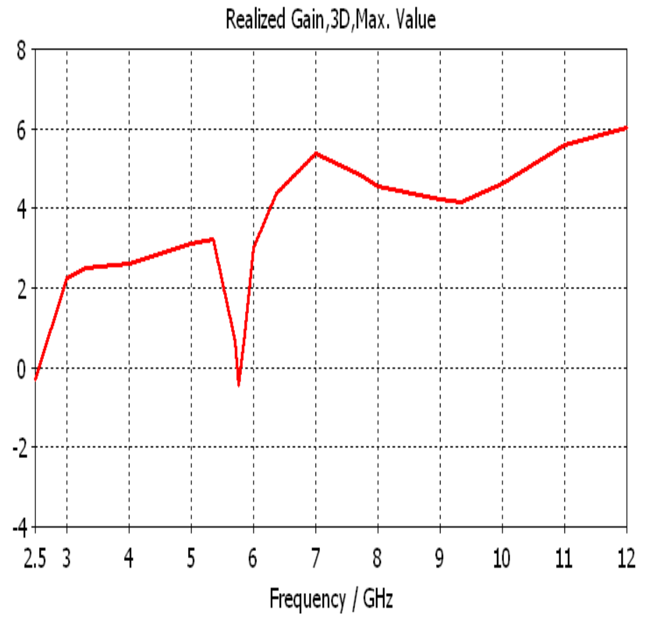


Fig.10 Simulated realized gain curve v/s frequency of the compact printed CPW-fed circular disc UWB antenna with single band-notched characteristic.

Fig.10 shows the Simulated realized gain curve v/s frequency of the proposed compact printed CPW-fed UWB antenna with single band-notched characteristics that notched band 5.15 GHz to 5.825 GHz.

Finally, it is necessary to investigate the radiation pattern, as the antenna's performance depends on its impedance. Bandwidth as well as radiation bandwidth. The radiation patterns shown in Fig.11(a) & (b) are simulated at four different frequencies, respectively.

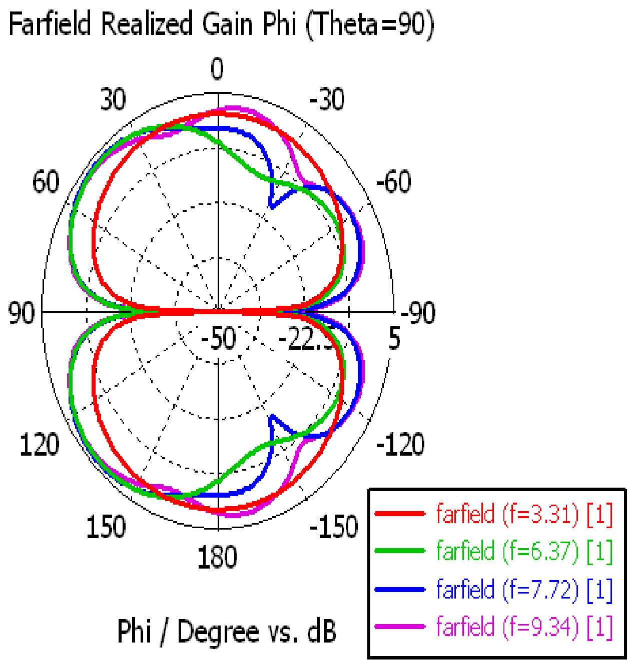


Fig.11(a) E-plane radiation Patterns at different frequencies

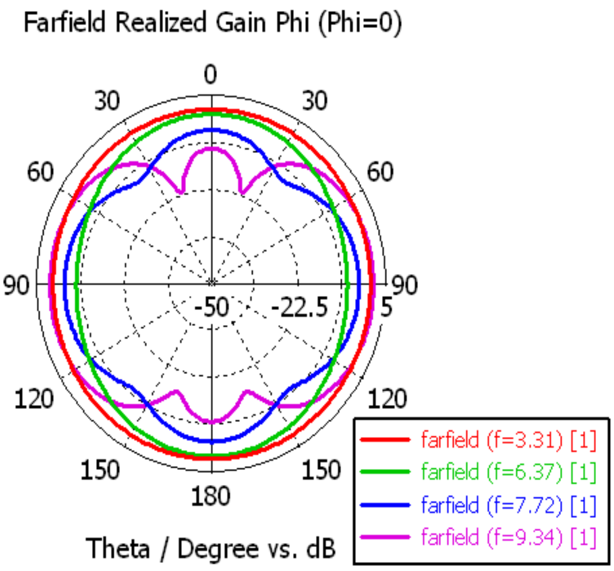


Fig 11(b) H-plane radiation Patterns at different frequencies

IV. CONCLUSION

Simulated results of proposed antenna with band-notched characteristics show the simulated reflection coefficient (S11 < -10 dB) curve as the function of frequency of the proposed compact printed CPW-fed circular disk UWB antenna with band-notched characteristics. The simulated impedance bandwidth of the proposed antenna is observed from 2.78 GHz to 12.23 GHz which covers the ultra-wideband frequency band, for VSWR is less than 2. The antenna notch the IEEE 802.11a WLAN band with center frequency 5.76 GHz, for VSWR is greater than 2.The results show that the proposed antenna has good impedance matching, nearly omni-directional radiation pattern, and flatness gain in the operating band. Thus this antenna is a good candidate for portable UWB application.

REFERENCES

[1] Constantines Balanis. “Antenna Theory: Analysis and Design”. 3rd edition Willey, 2005.

[2] R Garg, P. Bhartia, Bahl, “Microstrip Antenna Design Handbook”. London: Artech House, 2001.

[3] “First Report and Order, Revision of Part 15 of the Commission’s Rule Regarding Ultra-Wideband Transmission systems FCC 02-48, ”*Federal Communication Commission*, 2002.

[4] K.S.Yee,"Numerical Solution of Initial Boundary Value Problems Involving Maxwell’s Equations in Isotropic Media", *IEEE transaction on Antenna and Propagation*, Vol. AP-14, pg. 302-307, 1966.

[5] Yuan Dan Dong, Wei Hong, Senior Member *IEEE*, Zhen Qi Kuai, and Ji Xin Chen, " Analysis of Planar Ultra wide band Antennas With On-Ground Slot Band-Notched Structures ", *IEEE Transactions On Antennas And Propagation,* Vol. 57, Issue 7,Pg. 1886-1893, July 2009.

[6] Zhen Hong ,Yong-Chang Jiao ,Bin Yang ,Wei Zhang," CPW-fed ultra wideband antenna with 3.5/5.5 GHz dual band-notched characteristics", *Proceedings of International Conference on Microwave Technology & Computational Electromagnetics (ICMTCE)*,Pg. 327-330 ,ISBN 978-1-4244-8556-7, 22-25 May 2011.

[7] Zhi-An Zheng, Qing-Xin Chu, “A CPW-Fed Ultra wideband Antenna with Dual Notched Bands’’ ,*Proceedings of IEEE International Conference on Ultra-Wideband ICUWB*, ISBN 9781-4244-2931-8 , 9-11 Sept. 2009.

[8] Zheng Mei, Guang Fu, Jin-Gang Gong, Qiao Li, Jian Wang, “ Printed Monopole UWB Antenna with Dual Band-Notched Characteristics’’, *Proceedings of 2010 IEEE International Conference on Ultra-Wideband (ICUWB2010), Vol.2*, 978-1-4244-5306-1, 20-23 Sept. 2010.

[9] Yang Cui, Wei Wang, Hua Zhang, Weidong Zhang, Peng Fei, “A Printed Circular Disc Monopole Antenna with Dual Band-Notched Characteristic for UWB Applications’’, *9th International Symposium on Antennas Propagation and EM Theory (ISAPE),* ISBN 978-1-4244-6906-2, Nov. 29-Dec. 2 2010.

[10] Santasri Koley, Suvadeep Choudhury,”An Integrated Planar Bluetooth and UWB Monopole Antenna with Dual
Notched Bands Based on Etched Slot on the Patch and Split Ring Resonators on the Ground Plane’’, *Proceedings of Third IEEE International Conference on Advanced Computing & Communication Technologies,* Pg142–145,ISSN 2327-0632,ISBN 978-0-7695-4941-5,6-7 April 2013.

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