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RECTANGULAR SLOT MICROSTRIP ANTENNA WITH L SHAPED GROUND FOR ULTRA WIDEBAND APPLICATIONS

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***Abstract*—The given paper presents a compact microstrip fed rectangular monopole antenna for ultra-wideband communication. The basic antenna consists of rectangular shaped slot on ground plane, which achieved UWB frequency band operation from 2.9-11.2GHz.The proposed antenna is designed using low cost FR-4 substrate of dielectric constant 4.4, loss tangent of 0.02 and thickness of 1.6mm.CADFEKO suite (7.0) is used for simulation and optimization with stable radiation patterns. The designed antenna has efficiency above 80% and provides an excellent bandwidth of 8.3GHz (117.73%) which satisfied UWB requirement for VSWR<2.Parametric study is carried out for different parameters of UWB antenna.**

Keywords—***ultra wideband; federal communication commission; slot antenna.***

I. INTRODUCTION

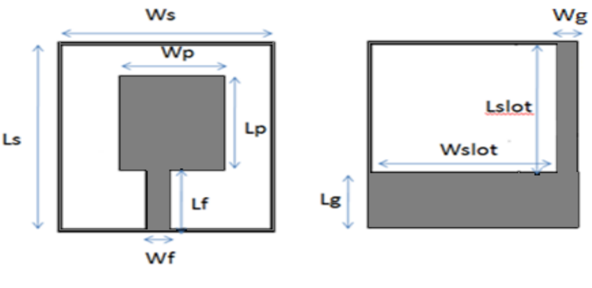
According to FCC UWB is a very encouraging technology that have a huge unlicensed bandwidth of 7.5GHz ranging from 3.1GHz to10.6GHz [1].UWB communication system has been favorable and studied in the college and industry, due to various advantages such as high data transmission rate, low cost, ease of integration and also low transmitting power consumption as compared to other. In ultra-wideband communication different types of antennas were used. Slot antenna is favorable which satisfy demand of UWB. Different shapes of slot such as rectangle, circle, elliptical, beveled, tapered has been used for enhancing wide impedance bandwidth. Narrow the slot lowers the frequency variation. Higher the slot then higher frequency variation in resonant frequency.

In [2], an inverted T-shaped conductor backed plane was used inside rectangular shaped slot on bottom layer which acquired UWB span from 3.04 to 10.87GHz.A rectangular radiating patch was etched on front side of substrate in [3] and tapered slot was cut from bottom side of substrate on ground plane, achieved an over -10dB frequency bandwidth from 3.04 to 10.87GHz.Differential wide slot UWB antenna is presented in [4].Four corners of ground plane are truncated to improve gain and radiation pattern. Inverted T shaped slot was cut in the square radiating patch and inverted T shaped conductor backed plane was used in [5].CPW –fed was used [6].In that corners of rectangular tunning stub was beveled and also two semicircular slots were etched to improve UWB BW. To achieve wide impedance bandwidth of small planar antenna number of experiments has been carried by researchers [7-9].

In this letter, a design of compact rectangular slot is proposed. To increase bandwidth of UWB antenna wide rectangular slot is cut from the L-shaped ground plane. Simulated results show reflection coefficient < -10dB from 2.9 to 11.2GHz.The given antenna is simple in structure.

II. ANTENA DESIGN

Fig.1 consists of rectangular shaped patch of dimension 12 x 16 x 1.6 mm^3 is etched on the one side of FR-4 substrate having relative permittivity of 4.4 and loss tangent of 0.02.



(a) Top view

(b) Bottom view

Fig.1 Geometry of proposed antenna

The feed width of offset micro strip line can be calculated by using (1), so as to achieve 50Ω characteristic impedance [10][11].

$$z=\frac{377}{\sqrt{er}[(w/t)+2} \quad (1)$$

Here, *er* is the dielectric constant of 4.4, *w* is width of feedline, *t* is the thickness of 1.6mm and *z* is the characteristic impedance.

Feedwidth is inversely proportional to impedance of an antenna. To achieve wide impedance bandwidth, a wide rectangular slot is cut on bottom side of ground and formed L-shaped ground plane. The width and length of rectangular slot is chosen as 31.5mm and 26.5mm so as to obtain good result over entire UWB. The optimized parameter for given

UWB antenna as Ws=33mm, Ls=35.5mm, Wp=12mm, Lp=16mm, Wf=2.8mm, Lf=10.25mm, Wg=1.5mm, Lg=9mm, Wslot=31.5mm, Lslot=26.5mm.Simulation is carried out on CADFEKO (7.0) EM simulation software [12].

A. Evolution of UWB Antenna

Basic rectangular monopole antenna with full ground provide impedance Bandwidth of 0.14GHz(1.98%) from 6.975-7.115GHz as show in Fig.2.It is observed that 1.98% impedance BW is very small as compared to Ultra-wideband impedance BW. In order to achieve the wide impedance bandwidth over entire UWB a rectangular shaped slot is cut from the full ground plane which formed U-shaped ground plane. After forming U-shaped ground bandwidth is increased from 3.4 to 10.31GHz.So still total UWB is not achieved. Hence a wide rectangular shaped slot is cut from full ground formed partial ground plane, which has impedance BW from 3.3-10.9GHz.So here is also still UWB lower frequency band is not achieved. Then wide rectangular slot is cut from full ground plane in such a way that it form L-shaped ground plane. So new acceptable impedance BW is from 2.9-11.2GHz (117.73%).

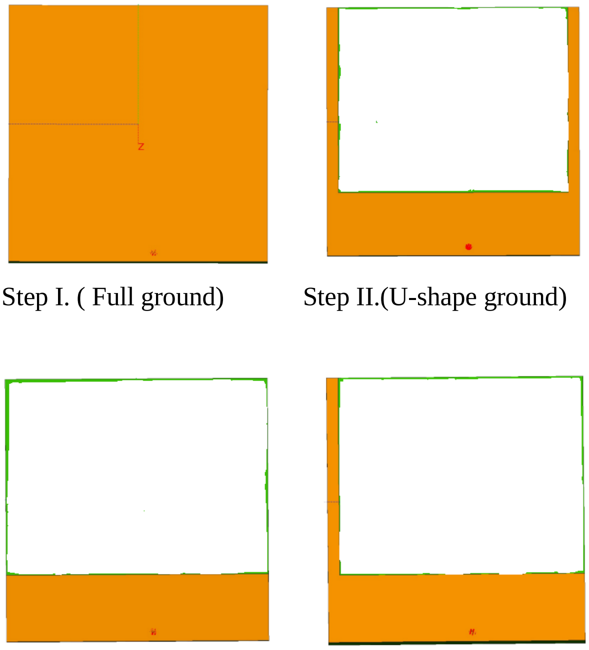
Percentage of bandwidth can be calculated by using (2) and (3)

$$\%Bandwidth=\frac{(Fh-Fl)}{fc} \quad (2)$$

Where,

$$Fc=\frac{Fl+Fh}{2} \quad (3)$$

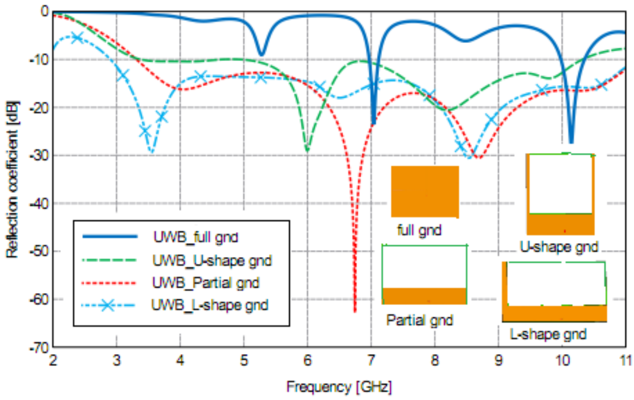
Here, *Fh* is higher frequency operation of UWB antenna in GHz,*Fl* is lower frequency operation of UWB antenna in GHz and *Fc* is a centre frequency of UWB antenna in GHz.



Step I. (Full ground) Step II.(U-shape ground)

Step III.(Partial ground) Step IV.(L-shape ground)

(a)



(b)

Fig.2 (a) Evolution of UWB antenna (b) Simulated reflection coefficient for different ground plane

III. STIMULATION RESULTS AND DISCUSSION

The overall performance of UWB antenna depends on number of parameters such as width (Wg) and length (Lg) of L-shaped ground plane, width (Wp) and length (Lp) of patch and feedwidth (Wf).Hence, further parametric study is carried out.

Fig.3 represents the simulated results for different values of width of ground such as Wg=1, 1.5 and 2mm.For all these values of Wg antenna resonates for entire ultra-wideband. But for Wg=1.5mm, return loss is maximum for lower and higher frequency of operation. Hence optimum results are obtained for Wg=1.5mm.

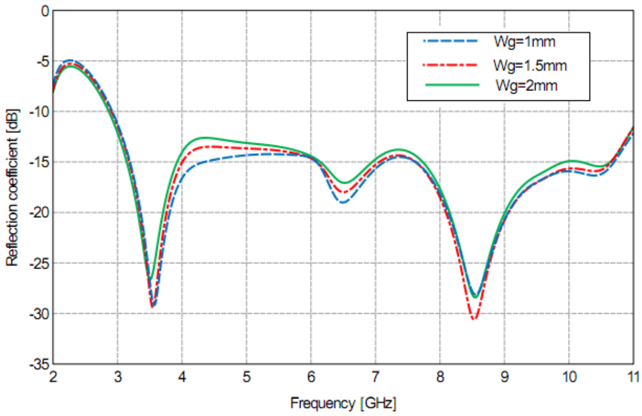


Fig.3 Return loss vs. frequency graph for different width of ground plane

The effect of ground length(Lg) is presented in Fig.4 .It shows simulated results for different values of length of ground such as Lg=8,9 and 10mm.For Lg=8mm total UWB is not achieved at higher frequency range. For Lg=10mm return loss is very poor at 4.3GHz frequency. Only for Lg=9mm we achieved satisfied UWB.

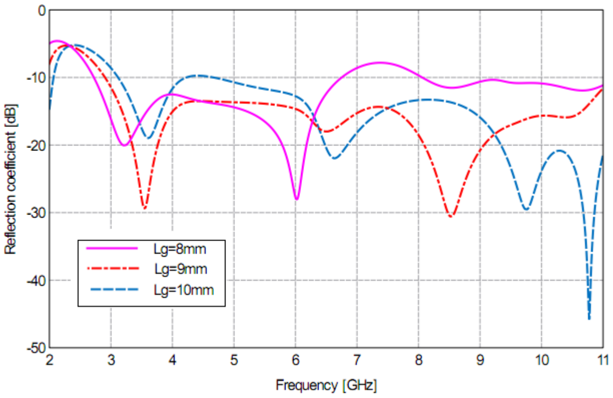


Fig.4 Return loss vs. frequency graph for different length of ground plane

Fig.5 shows return loss for different length of patch. For Lp=15mm and Lp=17mm return loss is maximum at lower and higher frequency band as compared to Lp=16mm,but there impedance bandwidth start from 3Ghz.So Lp=16mm is best optimized result whose reflection coefficient< -10dB is from 2.9-11.2GHz.

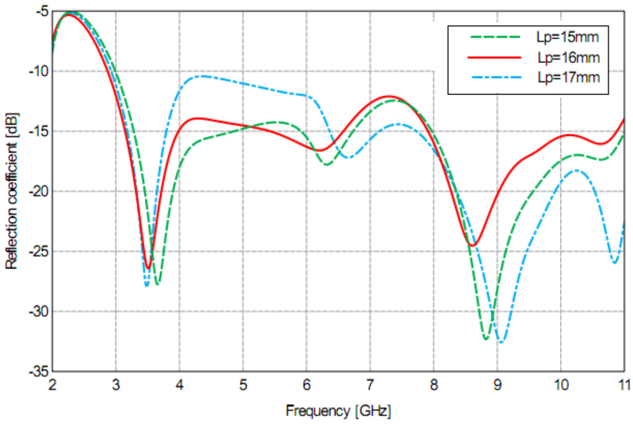


Fig.5 Return loss vs. frequency graph for different length of patch

Fig.6 shows return loss for different width of patch. For Wp=11mm return loss is not maximum at lowest and highest frequency band and for Wp=13mm impedance BW is not up to 11GHz frequency band. Only for Wp=12mm return loss is maximum at higher frequency band and achieve a wide impedance BW up to 11.2GHz.So the optimum results are obtained for Wp=12mm.

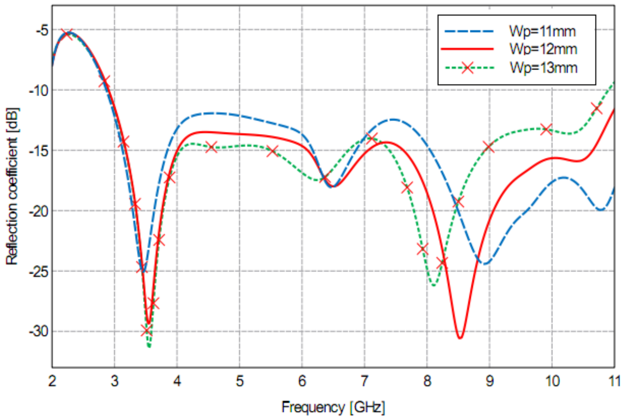


Fig.6 Return loss vs. frequency graph for different width of patch

Fig.7 shows reflection coefficient for different width of feedline. Here only for Wf=2.8mm return loss is maximum as compared to Wf=2.7mm and Wf=2.9mm.Hence, optimized results are obtained for Wf=2.8mm.

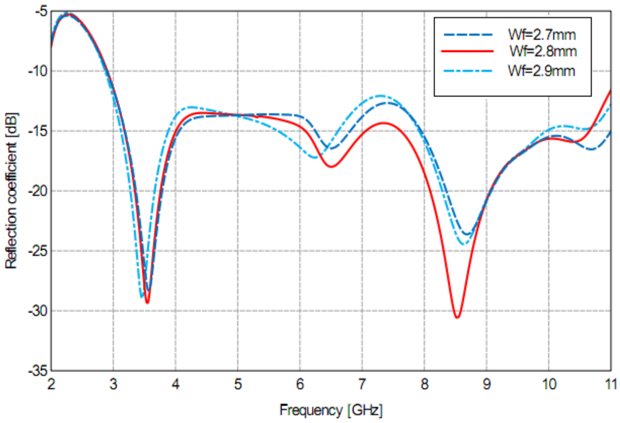


Fig.7 Return loss vs. frequency graph for different width of feedline (Wf)

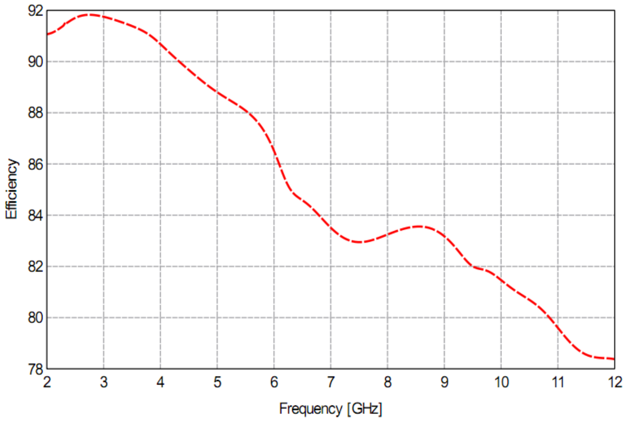


Fig.8 Efficiency vs. frequency graph of proposed UWB antenna

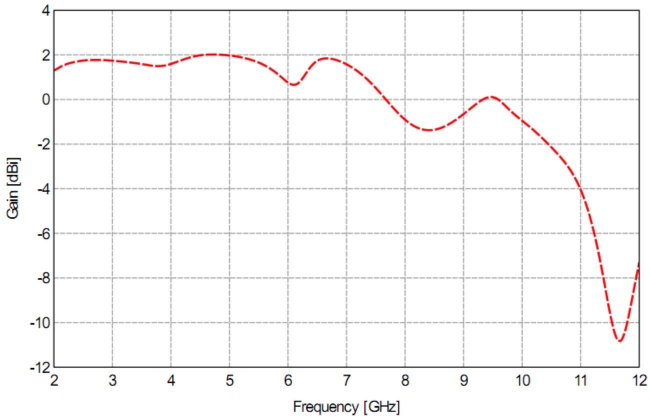


Fig.9 Gain vs. frequency graph of proposed UWB antenna

As show in Fig.8 efficiency is 91% at 3.1GHz and 80% at 10.6GHz.So the average efficiency is 85.5%.It decreases at higher frequency range due to dielectric losses. Gain is maximum i.e.2dBi at 4.5GHz.Fig.10 shows surface current distribution at 5.6GHz.Current distribution is more along the offset microstrip feed line and L-shaped ground plane. Current distribution is less along rectangular slot.

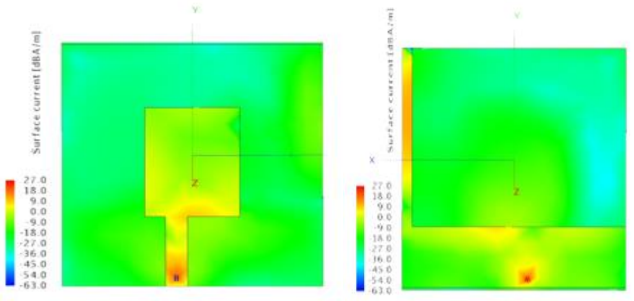
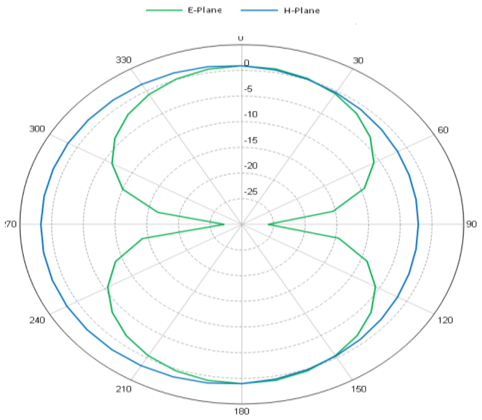
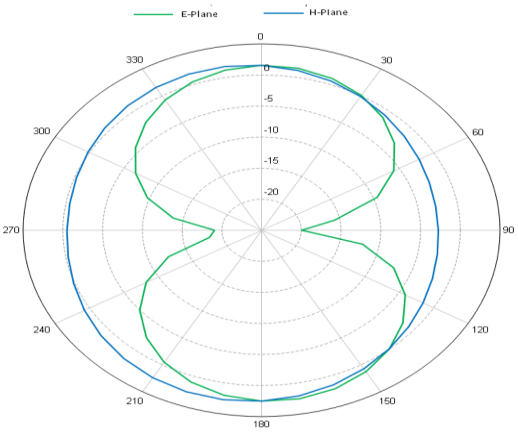


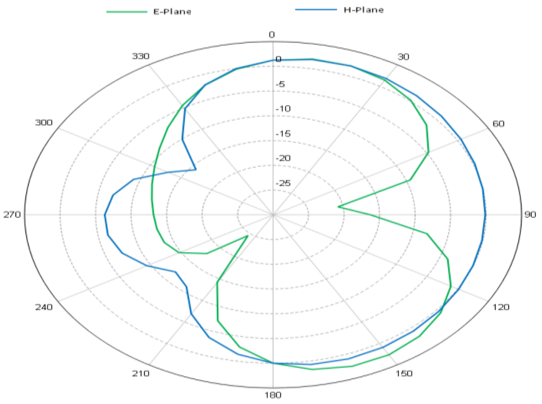
Fig.10 Surface current distribution of UWB antenna at 5.6GHz



At 3.2GHz



At 5GHz



At 8.6GHz

Fig.11 Simulated radiation pattern in E-plane and H-plane at 3.2, 5 and 8.6GHz

Fig.11 shows that proposed antenna has co-polarized field nearly omnidirectional in H-plane (Φ=0°) and bidirectional radiation patterns in E-plane (Φ=90°).Radiation pattern at 8.6GHz is distorted due to reduction in efficiency at this frequency range.

IV. CONCLUSIONS

The UWB antenna is simple in structure and satisfied UWB need for VSWR<2.Large Impedance bandwidth is achieved from 2.9 to 11.2GHz (117.73%) using wide rectangular shaped slot on ground plane. Stable radiation patterns are obtained by EM simulation software CADFEKO suite (7.0).It is observed that radiation patterns are nearly omnidirectional in H-plane and bidirectional in E-plane for UWB frequency band. Efficiency of antenna is above 80% for entire operating band. Hence the given antenna is best choice for personal wireless communication.

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