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Slot line Fed Directional UWB Antenna for Microwave Imaging

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Abstract-
Ultrawideband microwave imaging is a promising technique for cancer detection. This paper illustrates a slot line fed UWB antenna which has been designed for microwave imaging. Here Slotline feed technique has been used to increase the directivity.The antenna has a wide bandwidth which is obtained by merging three resonant frequencies. The designed antenna has an operational bandwidth of 3.3-11.01Ghz.The measured peak gain is about 6.7dBi. Return loss, radiation pattern, surface current distribution and gain has been simulated. From the radiation pattern, it is clear that antenna offers a highly directive radiation pattern and can be used for microwave imaging. A parametric study is carried out in order to optimize the performances of the antenna.

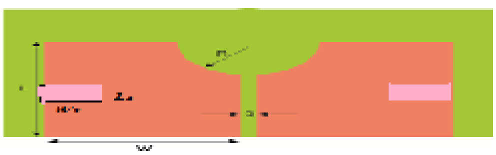
***Index terms*-Microwave imaging, UWB, slotline, OES**

I. INTRODUCTION

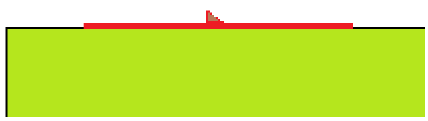
According to the definition of FCC, the UWB is with wide spectrum. Therefore the main challenge is to develop low cost UWB systems for commercial and military applications.UWB microwave imaging is a technique for biomedical applications such as cancer detection. Even though x-ray mammography is the most effective method used for cancer detection it has its own limitations. One of the limitations is that approximately 30% of the tumors are missed by the mammogram and it is also giving high rate of false positives.

Microwave imaging is a viable alternative to x-ray mammography. The main underlying principle of this technique is the significant contrast in the dielectric properties of the normal and cancerous tissues. The capability for penetrating waves into human body through UWB makes microwave technology an attractive technology for microwave imaging. Illuminating tissues with UWB, scattered fields can be measured by applying an array of antenna.Antenna is the key element in microwave imaging that radiates and receives signals. For an accurate imaging high gain, planar, compact and directional antennas are required. Most of the antennas presented in literature exhibit omnidirectional pattern with low gain [2]. The unipolar and Vivaldi antenna satisfies the requirements of high gain, bandwidth and impulse response [3–5]. But they have large size. Coaxial monopole antenna[6] is attractive for microwave imaging because of its size and shape. But because of the mismatch of the coupling medium and human body it produces false positives. Ridge pyramidal horn antenna is another type of antenna that can be used for microwave imaging. The drawbacks of this antenna are that antenna efficiency is not mentioned and co-polarization and cross-polarization is also not mentioned. The modified Bow-tie antenna was introduced for Ground Penetrating Radar (GPR) applications in the frequency region of 0.5 − 5 GHz[13] . Compared to earlier versions of planar resistor - loaded antennas the above mentioned antenna has improved radiation efficiency and low level of late time ringing. The antenna exhibit input impedance of 100 Ω in the spectrum of the exciting pulse, for matching to a 100 Ω twin semi rigid line employed as feed system . However, from the results it can be clearly seen that the input impedance was not actually matched to 100 Ω. This would have resulted high mismatch in reflection coefficient parameter in the interested frequency region .Some of the proposed antennas have a non-planar structure; whereas others has a low gain and low efficiency.

Therefore this article addresses the shortcomings by designing,a slotlinefed antenna(30x15)which has a circular slot on the top edge. The antenna is designed using Ansoft HFSS. The proposed antenna provides a nearly directional radiation patterns with peak gain of 6.7dBi.This proposed antenna can provide a wider impedance bandwidth of 3.3-11.01GHz. Details of the proposed antenna are described and the simulated results for the obtained performance are presented and discussed as well.



a.



b.

Figure 1.(a).Proposed Design,(b).Top View

II. ANTENNA DESIGN

Fig.1 illustrates the geometry of the proposed antenna . The antenna is derived from an OES by removing a semicircle of radius R from the top edge of the OES with centre of the semicircle lies in the intersection of middle point of the slot along X axis and upper edge of the OES. The basic idea of derivation of this antenna structure came from the Vivaldi antennas in which there is an exponential tapering of both the conducting strips. Here in this structure the tapering is not an exponential one but circular. The size of the proposed structure is also found to be very compact when compared to that of existing structures.

It consists of a slotline of metallic strip dimension L × W from the top of which a semicircle of radius R is removed and from the sides of which rectangular slots of size Ls X Ws are removed. The antenna is fabricated on commercially available FR4 substrate having relative dielectric constant ε_r=4.4, height h=1.6mm and loss tangent tanδ=0.02. The dimensional parameters of the antenna are L=10mm, W=13mm, R=4.18mm, Ls=2mm, Ws=3mm and g=0.3mm. The overall dimension of the antenna is 10mm × 26.3mm × 1.6mm. The introduction of a semicircular slot at the top edge of the OES will introduce an additional resonance near the initial resonant frequency. This resonance is due to the creation of a new surface current path through the either sides of the slot and through flared and upper edges of the structure. The introduction of a rectangular slot at the end of the patch also introduces two additional resonances. Thus three resonances are obtained within the entire region of operation.

The antenna is modeled and optimized using high frequency structure simulator. The parametric analysis is carried out using HFSS in which the numerical analysis is based on finite element method. The parametric study helps to optimize the antenna parameters before the antenna is manufactured and tested experimentally. Various antenna parameters has been considered for optimizing the antenna's performance. Some of the parameters are diameter of the semi-circular slot, length and width of the rectangular patch.

From the parametric analysis of the antenna performed, it is able to develop the design equation of the semicircular slot ultra wideband antenna. The developed design equations are validated for different substrates with different dielectric constant and are also discussed.

Table 1:physical characteristics of different substrates

	Antenna a	Antenna b	Antenna c
Laminate	Rogers 5880	Roger RO3006	Rogers6010LM
Nh(mm)	1.57	1.28	0.635
$\varepsilon\varepsilon_r$	2.2	6.15	10.2
$\varepsilon\varepsilon_{re}$	1.6	3.575	5.6
(g(mm)	0.1	0.65	0.775

Table 2:Dimensions of the proposed antenna for different substrates

Parameter(mm)	Antenna a	Antenna b	Antenna c
L	13	8.64	6.9
W	18	12.1	9.67
R	5.68	3.8	3.04
L_s	3.89	2.08	2.6
W_s	3	1.73	1.38

III.RESULTS AND DISCUSSION

A. Reflection Coefficient

Figure.2 shows the simulated return loss of the manufactured antenna. From the figure it is clear that the antenna offers a large 2:1 VSWR bandwidth starting from 3.3 GHz to 11.01 GHz. This large bandwidth enables the antenna as a potential candidate for operating in FCC specified ultra wideband range. This heavy bandwidth is obtained by merging three resonances centered at 3.8 GHz, 7.54 GHz and 10.46 GHz. On the cases of antenna, it is very necessary to study about the distribution of energy radiated by the structure towards the surrounding space. The simulated three dimensional radiation pattern of the antenna at three resonances are shown in Fig 3.

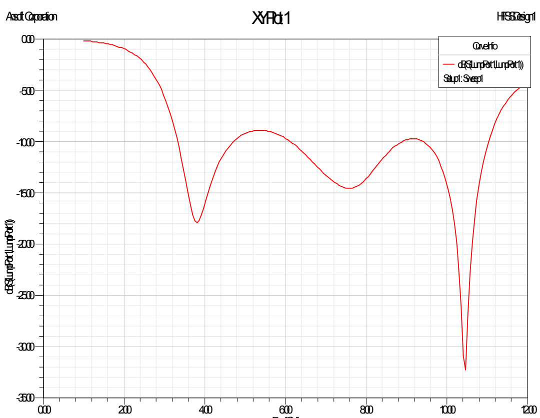


Figure 2. Return loss

B.Radiation Pattern

The spatial distribution of electromagnetic energy by the proposed antenna at 3.8 GHz is shown in Fig.3.(a). From the figure it is clear that the antenna offer an apple shaped pattern similar to a dipole antenna. Three dimensional radiation pattern of the antenna at second resonance ie at 7.54 GHz is shown in Fig3.(b). From the figure it is clear that the antenna offers a directive radiation pattern at this frequency with beam maxima pointed towards the positive Y direction. A high amount of back suppression is noticed in this pattern. This can be explained from the surface current pattern of the antenna given in Fig.6. From the current pattern it is clear that the current is maximum at the curved edges of the antenna and at all other parts the current is minimum. Thus the other parts of the radiating structure will acts as a suppressor of backward power. The simulated 3 dimensional radiation pattern of the antenna at third resonance is shown in Fig.3(c). From the figure it is clear that the antenna offers a highly directive radiation pattern at this frequency. This is also due to the suppression of electromagnetic energy by the lower parts of the antenna. Only the upper edges of the antenna take part in radiation at this frequency. This can be verified from the current distribution of the antenna .

(a)

(b)

(c)

Figure 3.three dimensional radiation pattern of the antenna (a)3.805GHz (b)7.54GHz (c)10.46GHz

C. Parametric Analysis

To get the reason for resonance and to get further insight to the radiation mechanism, parametric analysis is very necessary. The variation of reflection co-efficient of the antenna with L is shown in Fig.4(a). From the figure it is clear that all the resonances are affected by L. The variation of reflection co efficient of the antenna with W is shown in Fig.4(b). From the figure it is clear that all the three resonances are affected by this parameter. There is a considerable down shift for all the resonant frequencies with W. This is due to the increase in current path length of the antenna. The variation of reflection co efficient of the antenna with radius R of the semicircle is shown in Fig 4(c). From the figure it is clear, for small values of R, the antenna acts as a single band antenna with moderate band width. The variation of reflection coefficient of the antenna with substrate height h is shown in Fig.4(d) . From the figure it is clear that all the resonances are unaffected by the height of the substrate. The matching is slightly affected by the parameter h. This may be due to the variation of input impedance of the antenna with h. by the parameter h.

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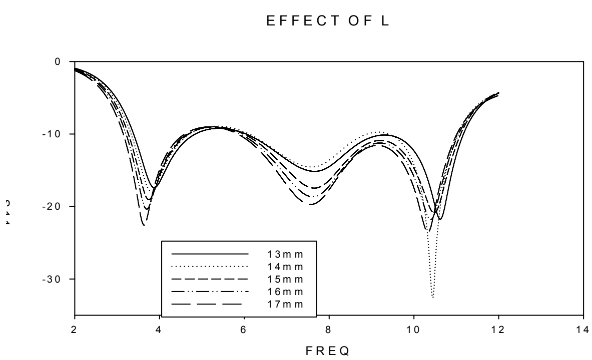
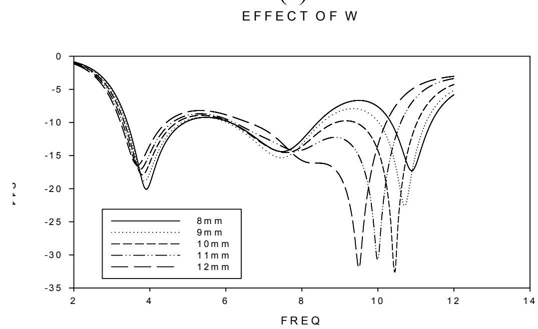
The two dimensional radiation pattern of the antenna in the two principal planes at different frequencies including the three resonances are given in Fig.5. E and H plane radiation patterns of the antenna at first resonance ie at 3.805 GHz is shown in Fig.5.(a). From the figure it is clear that the antenna offer an omnidirectional pattern similar to a dipole at this frequency.The two dimensional radiation pattern of the antenna at second resonance ie at 7.54 GHz is shown in Fig.5(b).From the figure it is clear that the antenna exhibits a highly directional behavior at this frequency. Principal plane patterns of the antenna at 10 GHz is shown in Fig.5(c). From the figure it is clear that at this frequency also the antenna is slightly directive towards the plus Y direction.

Simulated surface current distributions of the antenna at the three resonating frequencies are shown in Fig.6.



(a)



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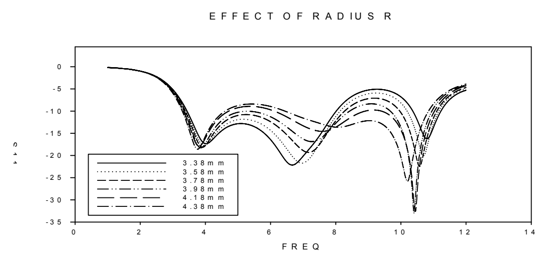
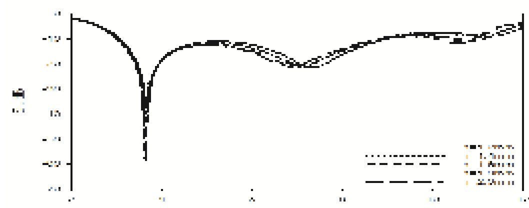
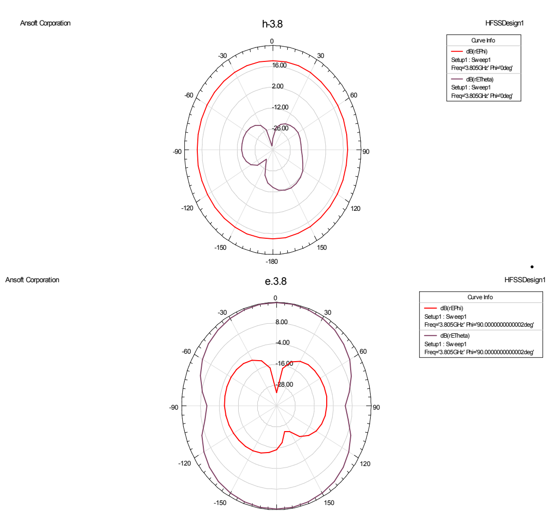


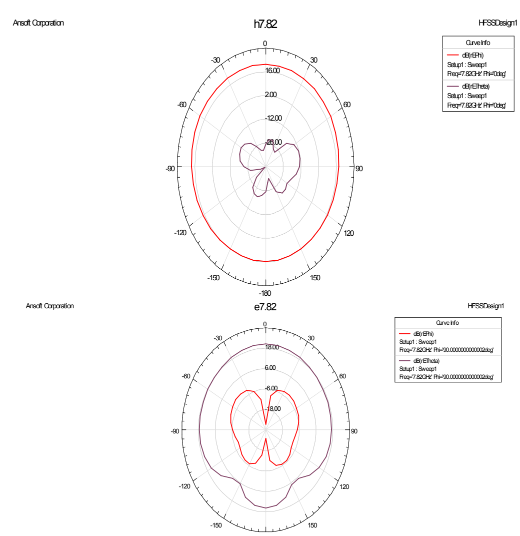


(d)

Figure.4.(a)variation of L,(b)Variation of W,(c)variation of R,(d)Variation of H



(a)



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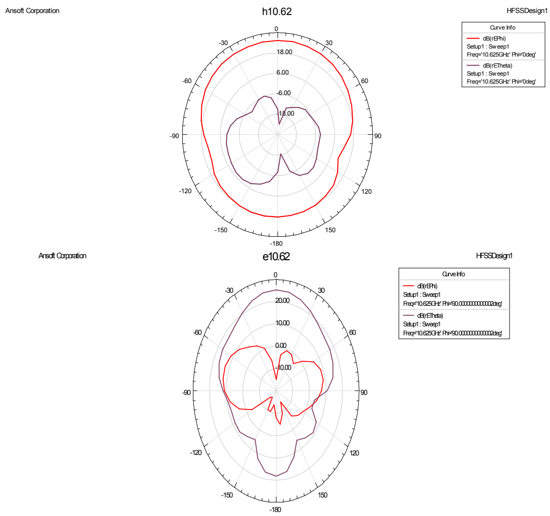

(c)

Figure.5.radiation pattern at(a)f=3.805GHz (b) f=7.54GHz (c)f=10.46GHz

V.CONCLUSION

In this paper, a compact directional UWB antenna has been presented. The effect of various antenna parameters was discussed. The operational bandwidth achieved a minimum return loss of 10dB.The proposed antenna is planar, compact and also provides a directional radiation pattern.

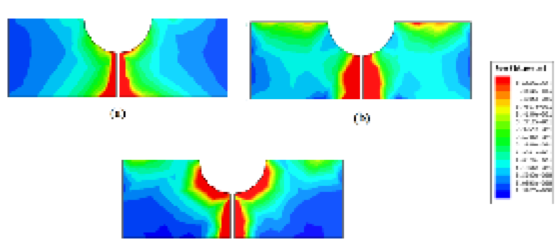

Figure.6.surface current distribution(a)f=3.805GHz(b)f=7.54GHz(c)f=10.46 GHz

REFERENCES

[1] Jui-Han Luand Chih-HsuanYeh," Planar Broadband Arc-Shaped Monopole Antenna for UWB System", *IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION,* VOL. 60, NO. 7,pp.3091-3095 JULY 2012

[2] J. Liang, C. C. Chiau, X. Chen, and C. G. Parini, "Printed circular disc monopole antenna for ultrawidebandapplications,"*Electronics Letters*, vol. 40, no. 20, pp. 1246–1247, 2004.

[3] J. D. S. Langley, P. S. Hall, and P. Newham, "Balanced antipodal Vivaldi antenna for wide bandwidth phased arrays," *IEEE Proceedings: Microwaves, Antennas and Propagation*, vol. 143,no. 2, pp. 97–102, 1996.

[4] E. Guillanton, J. Y. Dauvignac, Ch. Pichot, and J. Cashman, "A new design tapered slot antenna for ultra-wideband applications,"*Microwave and Optical Technology Letters*, vol. 19, no. 4,pp. 286–289, 1998.

[5] M. Chiappe and G. L. Gragnani, "Vivaldi antennas for microwave imaging: theoretical analysis and design considerations,"*IEEE Transactions on Instrumentation and Measurement*,vol. 55, no. 6, pp. 1885–1891, 2006

[6] Colleen J. Fox, Paul M. Meaney, Fridon Shubitidze, Lincoln Potwin, and Keith D.Paulsen.,"Characterization of an implicitly resistively-loaded monopole antenna in lossy liquid media" *International Journal of Antennas and Propagation*, pp-1 –4,2008.

[7] Xu Li, S. C. Hagness, M. K. Choi, and D.W. Van derWeide, "Numerical and experimental investigation of an ultrawideband ridged pyramidal horn antenna with curved launching plane for pulse radiation." *Antennas and Wireless Propagation Letters, IEEE*, 2(1):259–262,2003.

[8] Amin M Abbosh and Marek E Bialkowski," design of uwb planar antenna for microwave imaging systems", IEEE International Conference on Signal Processing and Communications,pp-1-4,2007.

[10]Aaron Zachary Hood, *Tutku Karacolak, and* Erdem Topsakal*,"* A Small Antipodal Vivaldi Antenna for Ultrawide-Band Applications", *IEEE ANTENNAS AND WIRELESS PROPAGATION ,* VOL. 7,pp.656-660, 2008

[11]. Li, S. K. Davis, S. C. Hagness, D. W. van der Weide, and B. D.Van Veen, "Microwave imaging via space-time beamforming:Experimental investigation of tumor detection in multilayer breastphantoms," IEEE Trans. Microw. Theory Tech., vol. 52, no. 8, pp.1856-1865, 2004.

[12]E.C. Fear, S.C. Hagness, P.M. Meaney, M. Okoniewski and M.A.Stuchly, "Enhancing breast tumor detection with near-fieldimaging," IEEE Microwave Magazine, pp48-56, March 2002.

[13] A.A.Lestari, E. Bharata, A. B. Suksmono, A. Kurniawan, A. G. Yarovoy, and L. P.Ligthart." A modified bow-tie antenna for improved pulse radiation". *Antennas and Propagation, IEEE Transactions on*, 58(7):2184 –2192, July 2010.

[14] C. Shannon, E. Fear, and M. Okoniewski," Dielectric-filled slotline bowtie antenna for breast cancer detection," Electronics Letters, Vol.4 1, No.7, pp. 3 88-390, 2005.