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Vivaldi Antenna for Wall Imaging Through Microwave

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Abstract: Vivaldi antenna is an exponentially tapered slot antenna (ETSA), is easy to fabricate and can provide wide bandwidth. In this research work design of a TSA has been discussed which is Vivaldi antenna for UWB frequency using FR4 substrate which has permittivity of 4.4. In this design of Vivaldi antenna the UWB frequency cover from 1.2 to 4.8 GHz. This design is simulated by the CST software. For TWI the return loss S11 should be below -10dB, which is very easily obtained in this design.

Keywords: UWB, Vivaldi antenna, FR4 substrate, TWI, ETSA.

1. INTRODUCTION

Rapidly developing technology of satellite based remote sensing, wireless communication and radar has led to the electronic systems using ultra-wide band (UWB). Any radio technology using signals with a spectrum occupying a bandwidth either greater than 20% of the centre frequency or a bandwidth greater than 500 MHz is defined as UWB technology. Ultra-wide band technology requires antennas with broad bandwidth and minimum distortion of received and radiated signal pulses. Moreover ultra-wide band airborne applications have strict requirements on the size of antenna to be used due to the limited space. Vivaldi antennas are a different type of tapper slot antenna having. exponential flare shape. It was first presented in 1979 by Gibson. In his first paper, he state that the antenna has ideally unlimited instantaneous bandwidth. Vivaldi antenna is also a special type of traveling wave antenna of the surface-type with the capability of producing broadband end fire radiation.
However, the visible light has a limited spectrum in terms of wavelength, which extends from 400nm- 750nm. These wavelengths can allow a transparent view through very few materials such as glass, air or clean water. On the other hand, there are electromagnetic waves with larger wavelengths and frequencies in the range of gigahertz (GHz) which can penetrate most of the visually opaque materials such as wall, metal, plastic, plywood etc. This frequency range falls in the microwave spectrum which extends from 300MHz to 300GHz. Thus microwave imaging provides us an innovative technique to see and identify the target behind the walls. Figure 1 shows the application of TWI.

Figure.1: Few Application of Through Wall Imaging

2. ULTRA WIDE BAND VIVALDI ANTENNA

The Vivaldi antenna is a member of class of a periodic continuously scaled travelling wave antenna structures. Vivaldi antenna gives significant advantages of efficiency, high gain, wide bandwidth and simple geometry. The Vivaldi antenna, having an exponentially tapered slot profile, is a type of tapered slot antenna. ETSA is discussed below with its typical characteristics. The EM waves propagate down the tapered path of the antenna. A part of antenna where the distance between the conductors is relatively small, propagating waves is tightly bounded. Part of antenna where the distance between the conductors is relatively large, propagating waves is loosely bounded and start to leave

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the antenna for propagation. This is possible only when the distance between the conductors is greater than half wave length.

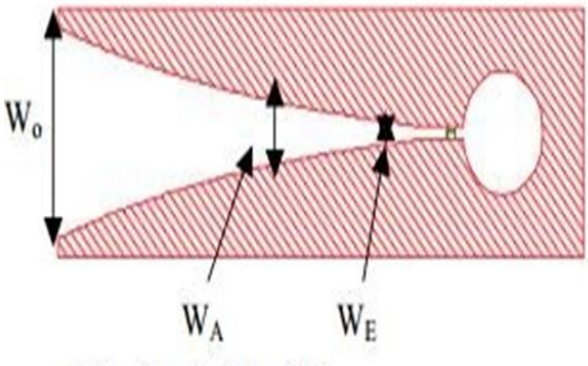

Figure 2: Vivaldi antenna

In figure $W_E$is the input slot line width, W_A is slot width at radiated area, W_O is output slot width.
According to the figure propagating area defined by $W_E<W<W_A$ and radiating region defined as $W_A<W<W_O$.
The exponential taper profile is determined by the opening rate and two point's $p_1(x_1, y_1)$ and $p_2(x_2, y_2)$

The resulting exponential relation explains the taper section

$$y = c_1 e^{Rx} + c_2 \qquad (1)$$

Where,

$$c_1 = \frac{y_2 - y_1}{e^{Rz_2} - e^{Rz_2}} \qquad c_2 = \frac{y_1 e^{Rz_2} - y_2 e^{Rz_2}}{e^{Rz_2} - e^{Rz_2}}$$

c_1, c_2 are constants and R the opening rate of the exponential taper. Note that (x_1, y_1) and (x_2, y_2) are the coordinates of the origin and end of flare curve, respectively and the taper length $L = x_2 - x_1$. An exponentially tapered slot line rather than an elliptically antipodal tapering structure was exploited to make the antenna simulation easier. We are using FR4 substrate of dielectric constant of 4.4. Effective thickness of the dielectric substrate (t_{eff}) defined as follows

$$t_{eff}/\lambda_0 = (\sqrt{\varepsilon_r}-1)t/\lambda_0 \quad (2)$$

Where, λ_0 is the free space wavelength at the center frequency, t is the thickness and ε_r is the dielectric constant of the substrate.
The essential criteria for a TSA to possess travelling wave antenna characteristics is [11]

$$0.005 \leq t_{eff}/\lambda_0 \leq 0.03 \qquad (3)$$

A simple arithmetic calculation shows that for the given thickness, the antenna can operate in the frequency range of 0.9 to 5.5 GHz. But, it is designed for the frequency range of 1.2-4.8 GHz only.
The characteristic impedance of a slot line increases with increasing slot width, so the width of slot line must be selected to be as small as possible to achieve an impedance value close to 50Ω. The width, characteristic impedance and guided wavelength of slotline are calculated with procedures suggested in.
The stripline feed used in a Vivaldi antenna is either connected directly to the transmitter/ receiver circuitry or is fed by a coaxial cable attached to a connector. The stripline width and guided wavelength is calculated using formulas given in equation 1 & 2. Hence the antenna parameters calculated are given in Table I.

Table 1 – List of Final Antenna Parameters

Design Parameter	**Value**
Substrate Material	FR-4
Substrate Thickness	0.7 mm
Micro stripcouplerlength	16.667 mm
Micro stripcouplerwidth	0.7958 mm
Micro striptaperlength	37.63124 mm
Antenna Length	14 cm
Antenna Width	9 cm

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Micro striptaper width	2.853630690 mm
Flarelength	263.55mm
Taperfactor	12
Flareheight	147.994mm

3. SIMULATION AND RESULT ANALYSIS

Parametric study of Vivaldi antennas has been conducted for its design with given specifications. The effect of each parameter is investigated performing simulations with CST Microwave studio. The antenna is made to work in the frequency range of 1.2GHz-4.8GHz, return loss below -10db and 50 ohm characteristic impedance in the feeding section. Figure 3 shows the Vivaldi antenna on CST tool.

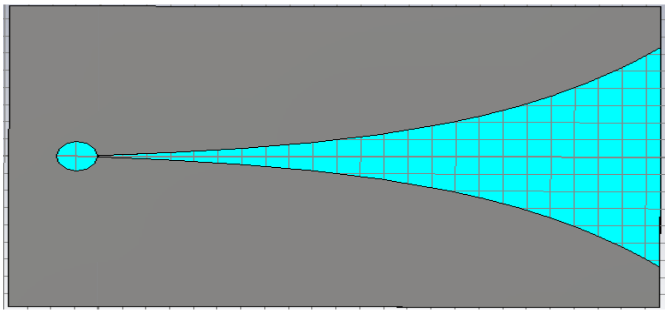

Figure 3(a): Front View of Vivaldi antenna

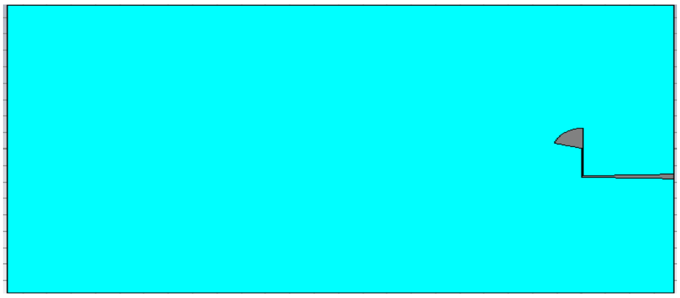

Figure 3(b): Back view of Vivaldi antenna

The striplines are extended along a finite length and terminated after the stripline to slotline transition. A short circuit is achieved soldering or using an open circuited quarter wavelength stub usually in order to reflect incident waves back to the transition. A radial stub is used which also helps to increase the bandwidth. An acceptable return loss response is achieved using an open circuited stripline of length 16.66 mm. Figure 4 shows the strip line to slot line transition.

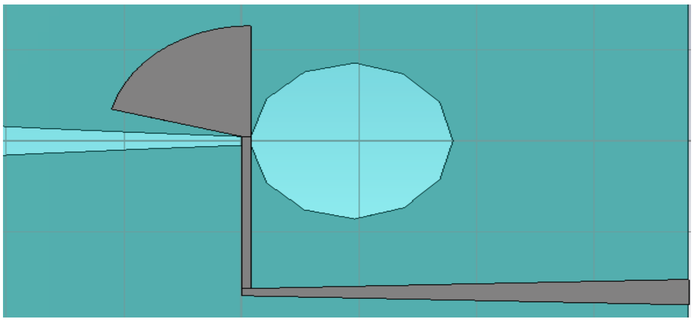

Figure 4: Stripline to Slot line Transition

The S_{11} plot of the antenna was obtained using a VNA. The frequency range was set from 1-6 GHz. Though the antenna was designed to work in the frequency range of 1.2-4.8 GHz, it displayed a S_{11} value well below-10 dB at all the frequencies between 1-6 GHz. Deepest trough, i.e. the minimum value of S11 was obtained at 2.41 GHz with a value of -37dB. The data was exported in ASCII format to a floppy drive. The screenshot of S-parameter has been shown in following figure 5.

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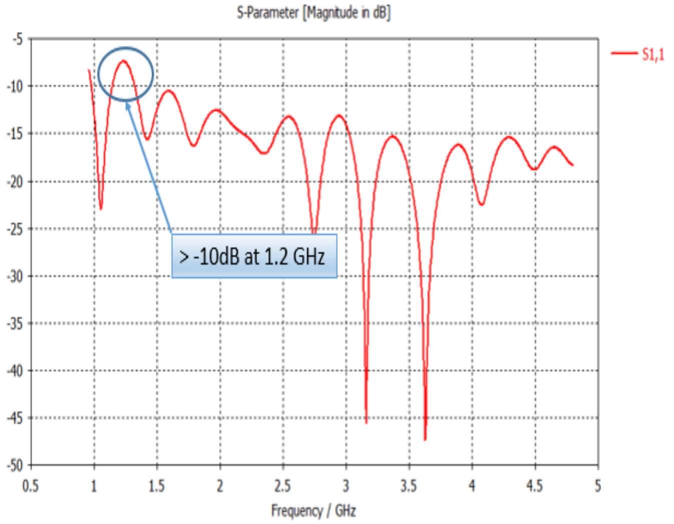

Figure 5: S_{11} plot of the antenna

The radiation pattern in far field region at 3 different frequencies of 2.48, 3.51 and 4.54 GHz has been shown respectively. The general trend shows end fire antenna radiation pattern in 90° direction and gradually decreasing angular width with increasing frequencies.

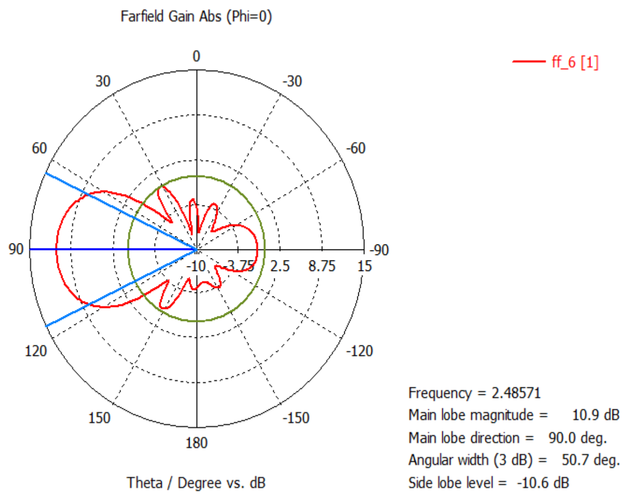

Figure 6 (a): Radiation Pattern at frequency 2.48 GHz

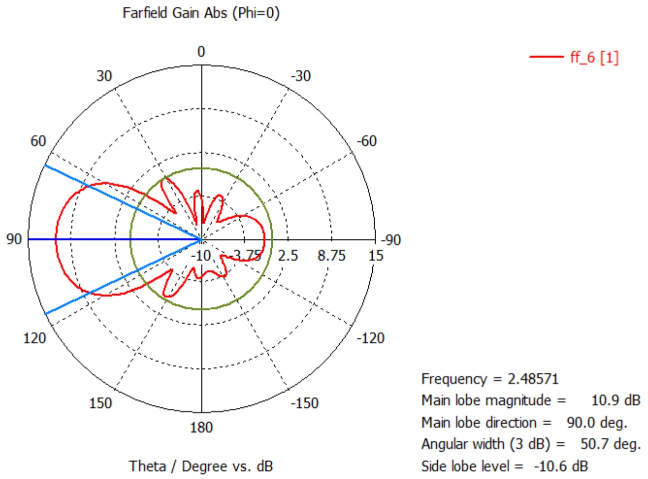

Figure 6 (b): Radiation Pattern at frequency 3.5GHz

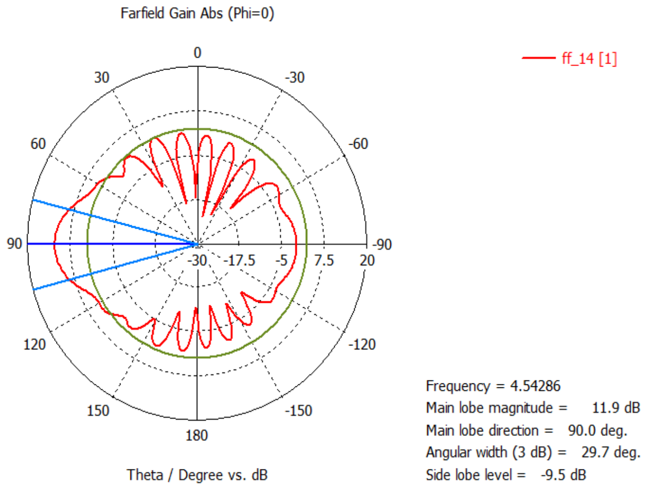

Figure 6 (c): Radiation Pattern at frequency 4.54 GHz

4. CONCLUSION

In this paper a design of Vivaldi antenna which is suitable for through wall imaging applications was presented. The antenna is designed to work in the frequency range of 1.2 GHz-4.8 GHz. It was then simulated on CST Microwave studio & radiation pattern, and return loss were obtained.

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REFERENCES

[1] P.J. Gibson. "The Vivaldi aerial." Proceedings of the 9th European Microwave Conference, pages 101–105, 1979.
[2] Gazit.E. "Improved Design of the Vivaldi Antenna." Proc.IEE, 1988, 135H, pp.89-90.
[3] Mehdipour, A., K. M-Aghdam, and R. FarajiDana, "Completed dispersion analysis of Vivaldi antenna for ultra wideband applications," Progress In Electromagnetics Research, PIER 77, 85–96, 2007.
[4] M. C. Greenberg, K. L.Virga, and C. L. Hammond, "Performance characteristics of the dual exponentially tapered slot antenna (DETSA) for wireless communications applications," IEEE Trans. Veh. Technol, vol.52, no. 2, pp. 305–312, Mar. 2003
[5] Janaswamy, R. and D. H. Schaubert, "Analysis of the tapered slot antenna," IEEE Trans. Antennas Propagation., Vol. AP-35, 1058– 1064, Sept. 1987.
[6] Stockbroeckx, B. and A. V. Vorst, "Copolar and cross-polar radiation of Vivaldi antenna on dielectric substrate," IEEE Trans. Antennas Propagat., Vol. 48, 19–25, Jan. 2000.
[7] Greenberg, M. C., L. Virga, and C. L. Hammond, "Performance characteristics of the dual exponentially tapered slot antenna for wireless communication application," IEEE Trans. on Vehicular Technology, Vol. 52, 305–310, Mar. 2003.
[8] Kim, S. G. and K. Chang, "Ultra wideband 8 to 40 GHz beam scanning phased array using antipodal exponentially-tapered slot antennas," IEEE MTT-S Digest, 1757–1760, 2004.
[9] Schaubert, D. H. and T.-H. Choi, "Wideband Vivaldi arrays for large aperture antennas," Perspectives on Radio Astronomy: Technologies for Large Antenna Array, 49–58, 1999.
[10] Langley, J. D. S., P. S. Hall, and P. Newham, "Balanced antipodal Vivaldi antenna for wide bandwidth phased arrays," Proc. IEEE Antennas Propagation, Vol. 143, 97–102, Apr. 1996.
[11] N.Vignesh, G.A.Sathish Kumar, R.Brindha, "Design and Development of a Tapered Slot Vivaldi Antenna for Ultra-Wide Band Application", International Journal of Advanced Research in Computer Science and Software Engineering, vol. 4, issue 5, May 2014, ISSN: 2277 128X.
[12] Online Available: http://en.wikipedia.org/wiki/Particleswarmoptimization.

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