The Development of Vivaldi Antenna at 12 GHz for Communication Application

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ABSTRACT: Vivaldi antennas are usually ultra-wide band antennas and can be used with both multi-band and impulse technologies. Comparing to others planar antenna, Vivaldi antenna has high gain due to their tapered slot design regardless with the compact size. Therefore, a compact exponential tapered slot Vivaldi antenna is presented at 12 GHz, designed on low cost FR4 substrate of thickness 1.6mm for 5G application. Proposed antenna produces return loss, S_{11} -13.427 dB, gain 16.37 dB and bandwidth, BW 1 GHz.

Keywords: *Vivaldi antenna, return loss, radiation pattern, gain and directivity*

1. INTRODUCTION

The development of cellular network have been started recently. Its new standardization generation is finalized in 2016 and the commercial availability of equipment is realized in the early of 2020s[1].

Nowadays, the rapid development in wireless communications and the great number of commercial and military application, requirement of the new types of antenna which can support at higher bit rates. According to the U.S. Federal Communication Commission (FCC), UWB refer to radio technology with a signal bandwidth exceeding the lesser of 500MHz or 20% of the arithmetic centre frequency.

High gain antenna is crucial in wireless communication. Ridge horn antenna is able to produce high gain but the bulky size comparing to patch antenna will limit the suitability of the antenna. Vivaldi antennas are planar antennas that have high gain due to their tapered slot design and fit into smaller spaces than a ridge horn antenna because of plane characteristic [2].

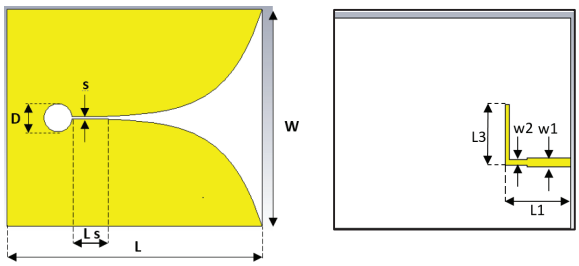
This project is focus on developing the Vivaldi antenna to improve the variations of the basic of parameter such as return loss (S_{11}), gain, radiation pattern, gain and directivity at the operating frequency.

2. METHDOLOGY

The antenna design parameter of Vivaldi antenna is be simulated by using CST software. The optimization of antenna's parameters can improve the performance of the Vivaldi antenna. Antenna is designed at operating frequency of 12 GHz.

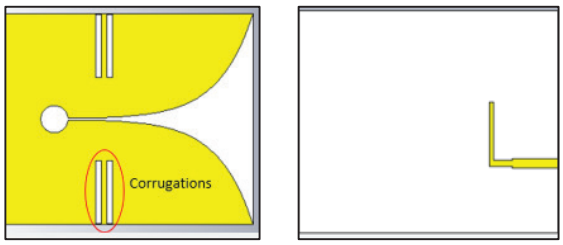
Figure 1 shows the optimized Vivaldi antenna designed. The antenna is fabricated on FR4 substrate with thickness 1.6mm and permittivity, ε_r of 4.3.

Vivaldi antenna is selected as it provides wide impedance bandwidth, stable radiation pattern, and gain characteristic. The geometrical configuration of the proposed antenna (Antenna 1 and Antenna 2) is shown in Figure 1 and Figure 2. As shown in Figure2, the tapered corrugation is used to enhancement of radiation in the end-fire directing [3][4]. It is used to achieve the optimize antenna regarding their return loss, gain, radiation pattern, and directivity.



(a) (b)

Figure 1 Antenna 1 (a) top and (b) bottom view (D=diameter, W=width, s=slot, Ls=slotline, L1/L2=feeding line length, w1/w2=feeding line width)



(a) (b)

Figure 2 Antenna 2 (a) top and (b) bottom view

The tapered profile of the antenna is given as,

$$y = ce^{K_a x}$$

where, c is constant and K_a is opening rate which is given by,

$$c = \frac{s}{2}$$

$$K_a = \frac{1}{La} ln\left(\frac{Wa}{s}\right)$$

where, La, Wa and s are aperture length, aperture width, and width of slot origin.

3. RESULT AND DISCUSSION

Figure 3 shows the comparison of return loss (S_{11})

at 12GHz between Antenna 1 and Antenna 2. At the 12GHz, the return loss of Antenna 1 is -12.744dB, while Antenna 2 is -13.427dB.

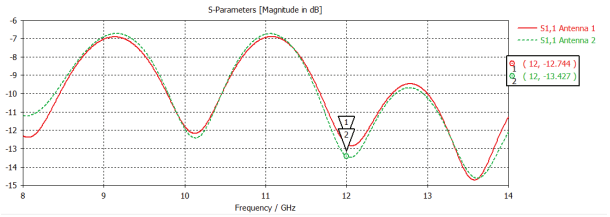


Figure 3 Return loss, S_{11} for Antenna 1 and Antenna 2

Figure 4 and Figure 5 presents the radiation pattern of Antenna 1 and Antenna 2 respectively. The antenna gain at 12 GHz for Antenna 1 is 3.48 dB. The radiation efficiency is -2.342 dB and total efficiency is -2.579 dB.

While, the Figure 5 shows the gain is 3.65 dB at 12 GHz. Then, radiation efficiency is -2.295 dB and total efficiency -2.497 dB.

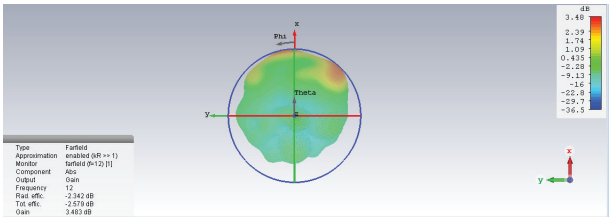


Figure 4 Radiation pattern of Antenna 1

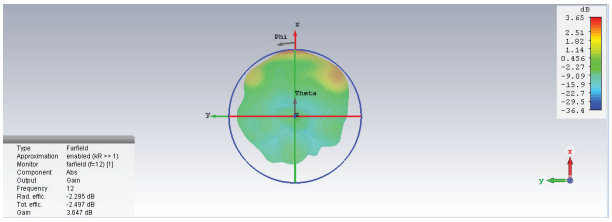
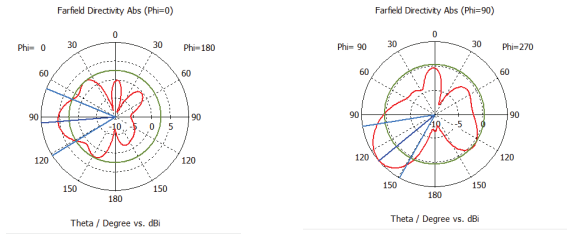
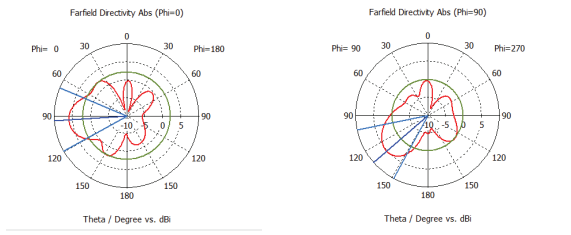


Figure 5 Radiation pattern of Antenna 2



(a) (b)

Figure 6 (a) E-plane and (b) H-plane of Antenna 1



(a) (b)

Figure 7 (a) E-plane and (b) H-plane of Antenna 2

Figure 6 and Figure 7 show the farfield directivity for Antenna 1 and Antenna 2 respectively. Both antennas have good directivity of E-plane and H-plane.

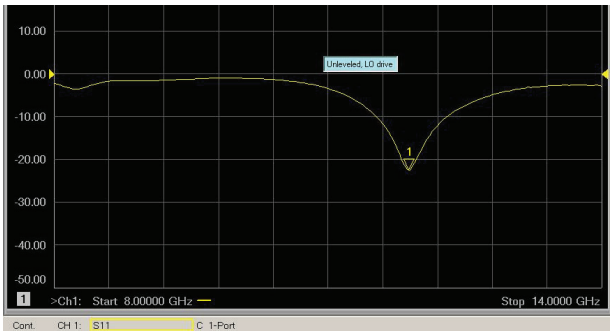


Figure 8 The measurement of return loss

As shown in Figure 8, measurement of the return loss is -22.47dB at 12 GHz. Over range might be affected the return loss of antenna or limitation error during measurement.

The gain obtained for simulation is 3.65 dB at 12 GHz while for measurement result 16.37 dB at 11.886 dB, which are both results, are good for both performance. However, there several factors during the measurement process due to limitation of frequency range which is from 1 Ghz to 12 GHz. The different ffrequency range was used which is 8 Ghz to 14Ghz during simulation. That the main cause the measurement performance had obtained higher gain.

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REFERENCES

[1] A. A. Khan et al., “Investigation On The Performance Of Low-Profile Insensitiantenna With Improved Radiation Characteristics For The Future 5g Applications,” vol. 58, no. 9, pp. 2148–2151, 2016.

[2] Ahmad Hatami, Afsaneh Saee Arezomand and Ferdows B. Zarrabi, “Phase center controlling in Vivaldi antenna: review and development of the story,” Journal of Computational Electronics , vol. 19, pp. 736-749, 2020

[3] A.Balaji, J.Karthi, V.Chinnammal, C.Malarvizhi, S.Vanaja, “A Unique Technique to Improve the Performance of Antipodal Vivaldi Antenna for Microwave Imaging Application”, IOP Conf. Series: Materials Science and Engineering, doi:10.1088/1757-899X/1055/1/012100, 2021

[4] Chareonsiri, Yosita, Thaiwirot, Wanwisa and Akkaraekthalin, Prayoot. "Design of Ultra-Wideband Tapered Slot Antenna by Using Binomial Transformer with Corrugation" Frequenz Journal, vol. 71, no. 5-6, 2017, pp. 251-260.