

An ultra-wideband horizontally polarized omnidirectional connected Vivaldi array antenna

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Abstract -An omnidirectional horizontally polarized antenna with an ultra-wideband impedance and radiation bandwidth is proposed in this paper. The connected Vivaldi antenna array is firstly applied to realize a UWB horizontally polarized antenna with good omnidirectional radiation properties. The designed antenna exhibits a relative impedance bandwidth of 163.17% for $|S_{11}| < -10\text{dB}$ (1.45-14.3GHz). Meanwhile, good omnidirectional radiation patterns with a gain variation of less than 1.5dB has been obtained within the frequency band of 1.45-12GHz (156.88%).

Index Terms — HP Omnidirectional antenna, Vivaldi antenna, connected array antenna.

1. Introduction

Horizontally polarized omnidirectional antennas are frequently used in indoor and urban wireless communication systems for their merits of full coverage of surrounding environment [1]. In many literatures, alford loop antennas are used to obtain HP omnidirectional antenna [2,3]. But this kind of antennas has a relatively narrow bandwidth. To improve the operating bandwidth, parasitic strips and capacitive loading are added to the annularly distributed dipole arrays [4]. To further enhance the bandwidth of HP omnidirectional antenna, tight coupling mechanism is utilized to obtain a very broad bandwidth. In [5], 12 tightly coupled dipoles are arranged on a circular substrate to generate good omnidirectional radiation patterns and a wide bandwidth of up to 61%.

In this paper, the connected Vivaldi antenna array, which is another form of tight coupling mechanism, is applied to design a UWB omnidirectional antenna. 24 connected Vivaldi antenna elements are distributed along a circular substrate to realize omnidirectional performance and obtain broad operating band simultaneously. Three main advantages have been obtained for an HP omnidirectional antenna using connected array mechanism: 1) lower operating frequency can be achieved to realize antenna miniaturization; 2) ultra-wide impedance bandwidth can be obtained using Vivaldi antenna elements; 3) good HP omnidirectional radiation properties can be realized applying the symmetrical elements distribution. The relative impedance bandwidth for $|S_{11}| < -10\text{dB}$ is 163.17%. Meanwhile good omnidirectional horizontal radiation pattern with a gain variation of less than 1.5dB is also obtained across a relative bandwidth of over 156.88%.

2. Antenna design

Fig.1 illustrates the geometry of the proposed antenna. It can be seen that 24 connected Vivaldi antenna elements are printed on the upper side of an FR4 substrate, which has a relative permittivity of 4.4 and a loss tangent of 0.02. The antenna elements are fed by a microstrip-to-slot transition structure on the other side of the substrate, which can help obtain good impedance match. The whole antenna is fed by a 1-to-24 power divider, which is indicated in the middle of the circular substrate. The length of the longest open cut of the Vivaldi element is $d=20\text{mm}$. The radius of the whole substrate is $R1=66\text{mm}$ and radius for the feeding network is $R2=26\text{mm}$.

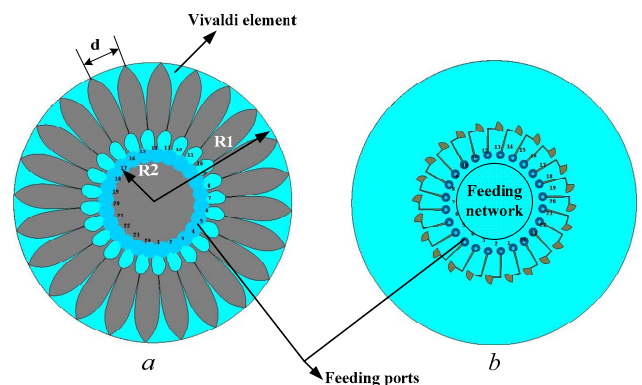


Fig. 1. Geometry of the proposed antenna (a) front view (b) back view.

3. Results and discussion

It is well known that the lower operating frequency for a Vivaldi antenna is determined by the length of the longest open cut. The length in the designed antenna element is chosen to be about 20mm, which indicate that the lowest operating frequency of the individual Vivaldi element will be around 7.5GHz. The analytical results agree well with the simulation results in Fig.2. Fig.3 illustrates the S-parameters of the antenna elements when they are in a connected circular array. The results show that the lower frequency is improved to be around 1.5GHz, which help obtain considerable antenna miniaturization.

The radiation patterns at different frequencies are given in Fig.4. It can be observed that good omnidirectional radiation patterns are obtained within a very broad bandwidth. The peak antenna gains are over 1.2dB within the operating band.

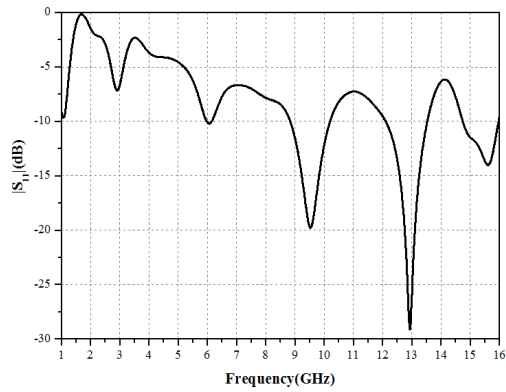


Fig. 2. Simulated $|S_{11}|$ against frequency of the individual Vivaldi antenna.

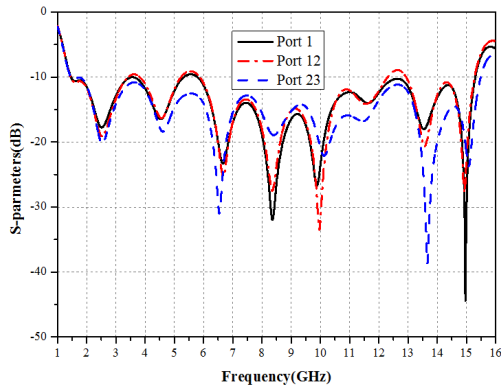


Fig. 3. Simulated S-parameters versus frequency of the proposed antenna.

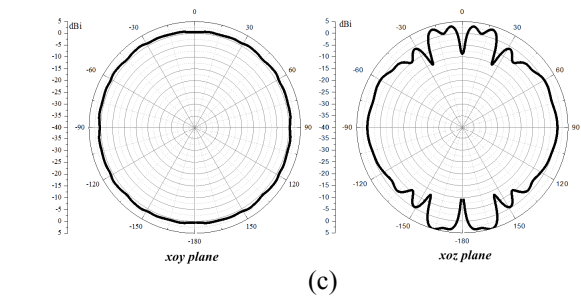
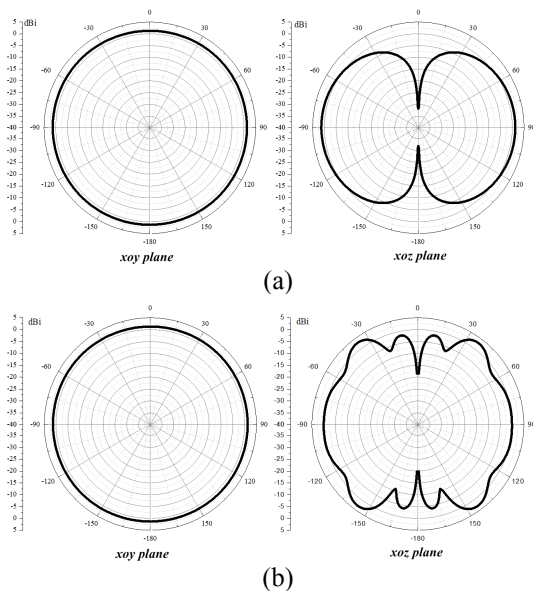


Fig. 4. Simulated radiation pattern at different frequencies (a) 1.5GHz (b) 6GHz (c) 12GHz.

4. Conclusion

A UWB HP omnidirectional antenna is designed using the connected Vivaldi antenna array. Good omnidirectional performance is obtained with the symmetrical element distributions. Broad impedance bandwidth and relatively small antenna size are attributed to the connected array mechanism. Both wideband impedance bandwidth and radiation properties have been obtained simultaneously.

References

- [1] K. Wei, Z. Zhang, Z. Feng, and M.F. Iskander, "Periodic leaky-wave antenna array with horizontally polarized omnidirectional pattern," *IEEE Trans. Antennas Propagat.*, vol. 60, no.7, pp. 3165-3173, Jul. 2012.
- [2] C. C. Lin, L. C. Kuo, and H.R. Chuang, "A horizontally polarized omnidirectional printed antenna for WLAN applications," *IEEE Trans. Antennas Propagat.*, vol. 54, no.11, pp. 3551-3556, Nov. 2006.
- [3] C. H. Ahn, S. W. Oh, and K. Chang, "A dual-frequency omnidirectional antenna for polarization diversity of MIMO and wireless communication applications," *IEEE Antennas Wireless Propag. Lett.*, vol. 8, pp. 966-970, 2009.
- [4] G. G. Zhang, H. Zhang, Z. L. Yuan, and Z. M. Wang, "A novel broadband E-plane omnidirectional planar antenna," *J. Electromagn. Waves Appl.*, vol. 24, pp. 663-670, 2010.
- [5] Z. D. Wang, Y. Z. Yin, X. Yang and J. J. Wu, "Design of a wideband horizontally polarized omnidirectional antenna with mutual coupling method," *IEEE Trans. Antennas Propagat.*, vol. 63, no. 7, pp. 3311-3316, Jul. 2015.