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A 3-9 GHz UWB High-Gain Conformal End-Fire Vivaldi Antenna Array

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***Abstract*—A novel conformal Vivaldi antenna array with two elements is designed to achieve 3-9 GHz ultra-wideband (UWB) high-gain end-fire radiation. By employing a flexible printed circuit and two Vivaldi antenna elements, this conformal antenna array has a wide bandwidth and low cross-polarization levels. In addition, a feeding network provides a co-phase equal amplitude excitation of the array to create the required high-gain end-fire radiation within the operating band. Simulated reflection coefficient illustrates that an impedance bandwidth of 102.5% is obtained from 3.06 GHz to 9.5 GHz with $|S_{11}|$ < -10 dB. Within the operating band, the range of realized gain is 8.81-15.18 dBi, and stable end-fire radiation patterns are maintained.**

***Index Terms*—conformal, high gain, end-fire, ultra-wideband (UWB), Vivaldi antenna array.**

I. Introduction

Vivaldi antenna first proposed in 1979 [1] has received a great amount of interest and has been employed in radars, remote sensing systems, and satellite communications [2] thanks to its end-fire radiation, simple structure, and broadband operation [3]. However, the gain of a Vivaldi antenna element is not ideal. Therefore, the array structures are utilized to optimize the gain of Vivaldi antenna. The conventional Vivaldi antennas were mainly used in planar antenna arrays. Since the resonant frequency of Vivaldi radiating elements is determined by the element aperture dimension, Vivaldi arrays are difficult to miniaturize [3]. To improve the gain of Vivaldi antenna arrays and miniaturize the arrays, much efforts including arc-shaped slots, regular slot edge structures, and dielectric lenses [4]–[6], were made to design a high-performance Vivaldi antenna array. Nevertheless, these methods suffer from large size and complex structure, which are not desirable in modern wireless systems. Therefore, it is of great importance to achieve a miniaturized high-gain Vivaldi antenna array.

In this paper, a 3-9 GHz ultra-wideband (UWB) high-gain end-fire conformal Vivaldi antenna array with two elements is proposed. As is well-known, conformal antennas can be constructed in a special shaped package while realizing miniaturization and maintaining stable radiation characteristics [7]. Hence, the two-element Vivaldi antenna array is fitted on the outer surface of an air cylinder with a small diameter of 37.5 mm, and its radiation characteristics are studied in this paper. The proposed antenna is constructed on a flexible printed circuit (FPC), which make it easy to be mounted on a curved surface. Besides, to feed the proposed array, a T-junction in-phase feeding network is utilized to provide co-phase equal amplitude excitation. Compared to the traditional planar Vivaldi antenna array, the proposed conformal design has a much smaller size and higher gain, while maintaining broadband and stable end-fire radiation performance. Moreover, thanks to its large bandwidth, high gain, and compact structure, the proposed antenna array is suitable to be used in radar, communication, and remote sensing systems.

II. Vivaldi Antenna Array Design

The proposed conformal Vivaldi antenna array is fed by a T-junction microstrip feeding network, as shown in Fig. 1. To maintain the maximum flexibility of the proposed antenna, the antenna is designed on a 0.26 mm thin FPC substrate. In this way, the antenna can be very easily integrated into complex and space-limited applications. Moreover, the planar two-element Vivaldi antenna array can be fitted on the outer surface of the cylinder, which greatly reduces the size of planar Vivaldi antenna array.

The geometry of the designed Vivaldi array is illustrated in Fig. 1(b). Vivaldi array is printed on the bottom layer of a FPC substrate with a relative dielectric constant of 3.1 and a loss tangent of 0.008. In addition, a feeding network is constructed on the top layer of substrate, as shown in Fig. 1(c). This feeding network consists of a microstrip-to-slot transition structure and a T-junction power divider. Both the microstrip-to-slot transition and the circular slot etched on the bottom layer are adjusted to obtain good impedance matching. Moreover, the T-junction power divider is utilized to provide in-phase equal amplitude feed for the Vivaldi antenna array.

III. Simulation Results and Discussions

The proposed antenna is simulated and optimized by Ansoft HFSS. The optimized geometry parameters of the proposed antenna are listed in Table I. Fig. 2 shows the reflection coefficient and realized gain of the proposed antenna array. As shown, the proposed two-element Vivaldi antenna features a nearly 102.5% impedance bandwidth from 3.06 to 9.5 GHz. Moreover, the conformal Vivaldi antenna array has also high

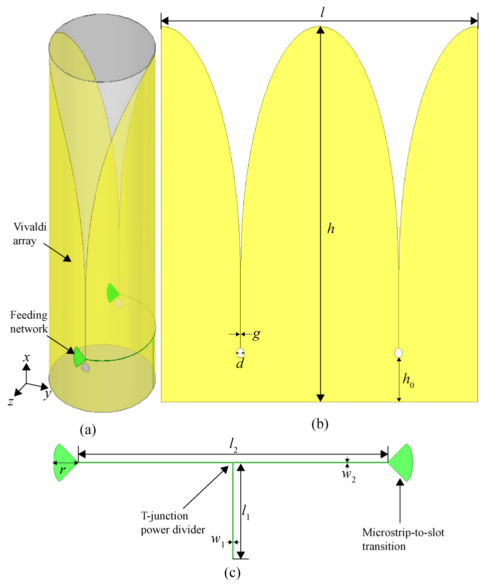

Fig. 1. Geometry of the proposed conformal Vivaldi antenna array. (a) 3D view, (b)Vivaldi antenna array, (c) Feeding network.

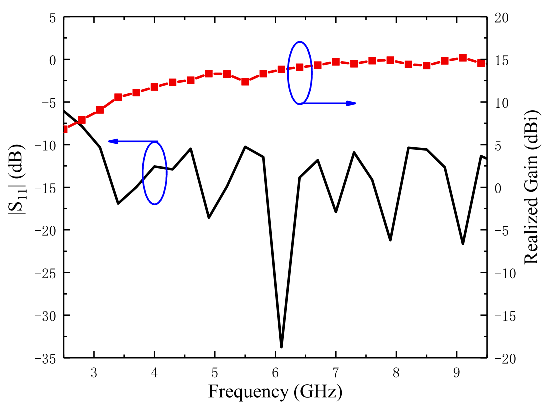

Fig. 2. $|S_{11}|$ and realized gain for the two-element conformal Vivaldi antenna array.

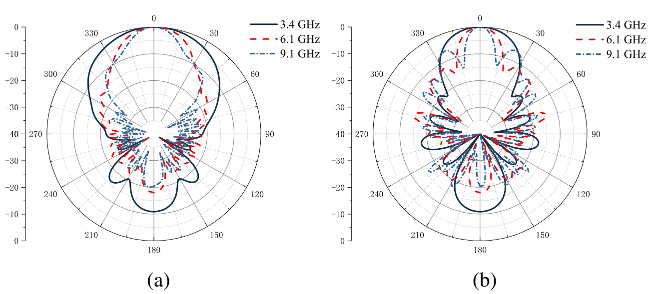

Fig. 3. Simulated radiation patterns of the proposed antenna at 3.4, 6.1, 9.1 GHz, respectively. (a) *E*-plane (*XOY*-plane). (b) *H*-plane (*XOZ*-plane).

gain of above 8.81 dBi within the operating frequency band. In particular, the peak gain of the proposed antenna is 15.18 dBi at 9.1 GHz, which is far greater than the reported peak gains generated by a planar Vivaldi antenna array with four elements [8].

TABLE I
PARAMETERS OF THE PROPOSED VIVALDI ANTENNA ARRAY (UNIT: MM)

l_1	l_2	l	h	h_0	w_1	w_2	g	d	r
36	117.6	235.6	230	27	0.49	0.245	0.2	6	9.37

The simulated *E*- and *H*-planes radiation patterns at 3.4, 6.1, 9.1 GHz are illustrated in Figs. 3(a) and 3(b) , respectively. The observed radiation pattern of the proposed conformal Vivaldi antenna array has the expected end-fire radiation. Moreover, the radiation patterns remain unchanged throughout the entire operating bandwidth. However, the side-lobe level increases greatly in the *H*-plane at 9.1 GHz, which is a result of the increased electrical distance between the antenna elements.

IV. CONCLUSION

A novel UWB high-gain conformal end-fire Vivaldi antenna array is proposed in this paper. By utilizing two Vivaldi antenna elements and a co-phase feeding network, a simultaneous 3-9 GHz UWB and high gain performance is achieved. Simulated results show a low reflection coefficient, for the whole frequency range of 3.06-9.5 GHz with $|S_{11}|$ <-10 dB, and the peak gain increases to 15.18 dBi at 9.1 GHz. Moreover, the end-fire radiation characteristics of the proposed array are maintained over the entire operating frequency range.

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