

Modified Compact Antipodal Vivaldi Antenna for 4–50-GHz UWB Application

Jian Bai, Shouyuan Shi, and Dennis W. Prather, *Senior Member, IEEE*

Abstract—A novel way capable of improving low-frequency performance of Vivaldi antennas is presented in this paper. Traditional Vivaldi antennas are modified via introducing the loading structure, i.e., circular-shape-load or slot-load, to match the termination. This modified antenna has been demonstrated to have the impedance bandwidth of over 25:1. It also exhibits symmetric radiation patterns in both the E - and H -plane in addition to the gain varying from 3 to 12 dBi in the measurement bandwidth of 4–50 GHz.

Index Terms—RF photonics, ultra-wideband (UWB), Vivaldi antenna.

I. INTRODUCTION

ULTRA-WIDEBAND (UWB) as an alternative to narrow-band technology, has been utilized in some specific applications, e.g., biomedical detection, pulse communication, and ground penetrating radar, since its emergence [1]–[7]. Recently, RF photonics technology [8], [9] has drawn considerable attention because of its advantage over traditional systems, with the capability of offering extreme power efficiency, information capacity, frequency agility, and spatial beam diversity. A hybrid RF photonics communication system utilizing optical links and an RF transducer at the antenna potentially provides ultra-high-bandwidth data transmission, i.e., over 100 GHz. To build an ultra-wide-bandwidth antenna array is an attractive application of RF photonics technology. This requires an RF aperture, i.e., antenna, to be compact and conveniently integrated with an opto-electronic circuit in addition to ultra-wide bandwidth.

The Vivaldi antenna [10] is one of the best candidates due to its planar structure, low profile, light weight, and ultra-wide bandwidth. The Vivaldi tapered slot antenna (TSA) generally consists of two different structures, i.e., coplanar [11] and antipodal [12] geometry. Coplanar Vivaldi antennas usually offer wideband performance typical two octaves. This limitation is mainly imposed by the feeding transitions, e.g., microstrip-to-slotline, to work as the feeding balun used in coplanar Vivaldi antennas. For instance, in this structure, a microstrip fan-shaped stub produces very high radiation loss and even distorts radiation patterns at a high frequency range.

Manuscript received July 01, 2010; revised December 29, 2010; accepted January 08, 2011. Date of publication March 03, 2011; date of current version April 08, 2011. This work was supported by the Office of Naval Research under Contract N00014-07-C-0765.

The authors are with the Department of Electrical and Computer Engineering, University of Delaware, Newark, DE 19716 USA (e-mail: jbai@udel.edu; sshi@ee.udel.edu; dprather@ee.udel.edu).

Color versions of one or more of the figures in this paper are available online at <http://ieeexplore.ieee.org>.

Digital Object Identifier 10.1109/TMTT.2011.2113970

Compared with a coplanar Vivaldi antenna, an antipodal one, however, can achieve much wider bandwidth, i.e., $>10:1$, owing to some natural UWB feeding transitions, e.g., microstrip-to-parallel stripline. One drawback involved in antipodal Vivaldi antennas is relatively high cross polarization. Langley *et al.* [13] presented a balanced antipodal configuration capable of lowering the cross polarization. The design criteria and performance of conventional Vivaldi antennas have been reported [14], [15]. The bandwidth of Vivaldi antennas is generally proportional to their length and aperture. Therefore, the antenna becomes bulky when UWB performance is desired. Some modifications were implemented on coplanar Vivaldi antennas to attain compact configuration [12], [13], [16]–[24]. A corrugated aperture edge is applied to mitigate the sidelobe level as the width of the antenna outer edge decreases [16], [17]. Numerical techniques are employed in order to optimize antenna geometrical parameters [19]. On the other hand, a dual exponentially tapered slots antenna (DETSA) is achieved by modifying the antipodal Vivaldi antenna to minimize the size for UWB operation. However, the radiation patterns of the DETSA lack directivity and stability [20]. Thus far, there has been rarely reported compact Vivaldi antennas with over 25:1 impedance bandwidth to meet the requirements of an UWB antenna array fed with an RF-photonics system.

In this paper, we propose two modified antipodal Vivaldi antennas, which are terminated by two different kinds of loadings, i.e., circular-shape-load and slot-load, to match the termination of a traditional Vivaldi antenna. Although the physical mechanisms of two loads, which enable the antenna to radiate below the cutoff frequency, are different, either of them are able to mitigate the restriction on the antenna length and aperture, thereby offering more compact antenna configuration for a particular UWB operation. Both antennas are simulated with 3-D High Frequency Structure Simulator (HFSS) based on the finite-element method (FEM). All the measurements are implemented on the Agilent PNA Network Analyzer E8361C.

In Section II, extensive parametric studies are implemented to optimize the antenna impedance bandwidth and the geometry. In Section III, both antennas are fabricated to perform the measurements of S -parameter, radiation pattern, and gain for validation. The physical mechanism of the loading impacts on the antenna performance is elaborated. Lastly, a conclusion is presented in Section IV.

II. ANTENNA DESIGN AND PARAMETRIC STUDY

A. Circular-Shape-Loaded Vivaldi Antenna

Fig. 1(a) shows the geometry of a conventional Vivaldi antenna designed on a 10-mil substrate with a dielectric constant of

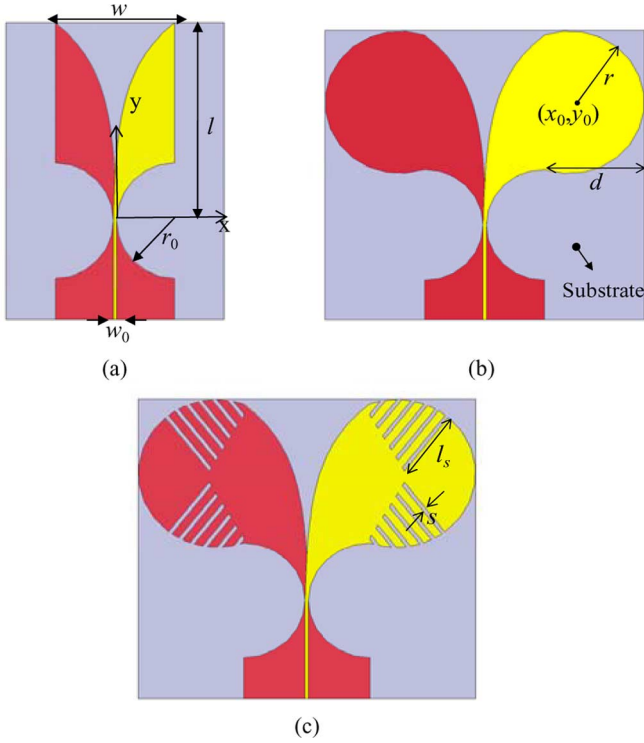


Fig. 1. (a) Conventional Vivaldi antenna. (b) Circular-shape-loaded Vivaldi antenna. (c) Slot-loaded Vivaldi antenna. Red (in online version) is the bottom layer, yellow (in online version) is the top layer, and blue (in online version) is the substrate.

2.3. In the design of an antipodal Vivaldi antenna, two arms metallized on either side of the substrate are flared in the opposite direction to form a tapered slot. To improve the impedance characteristics, the exponentially tapered slot is typically defined as

$$x = \begin{cases} w_0 - 0.5w_0 \exp(\alpha y) & \text{top layer} \\ -w_0 + 0.5w_0 \exp(\alpha y) & \text{bottom layer} \end{cases} \quad (1)$$

where w_0 is the width of the feeding microstrip, and α is the rate of exponential transition, which can be determined by

$$\alpha = \frac{1}{l} \ln \left(\frac{w_0 + 0.5w}{0.5w_0} \right) \quad (2)$$

where l is the effective radiation length and w is the aperture size. The antipodal configuration allows for a natural transition from microstrip feeding, thereby providing an UWB characteristics, as well as lower radiation loss at high frequency than the microstrip-to-slotline transition used in coplanar Vivaldi antennas. A circular taper with radius of r_0 is used to microstrip ground to achieve the transition from microstrip to parallel strip line. An optimal radius of $r_0 = 11.6$ mm is used. For a given tapered slot length of $l = 40$ mm and aperture of $w = 24$ mm, α needs to be optimized for an ideal bandwidth. The antenna cutoff wavelength can be defined [15] by

$$\lambda_c = 2w. \quad (3)$$

As a result, the lower cutoff frequency is about 7 GHz here. In other words, the current aperture and length of this conventional

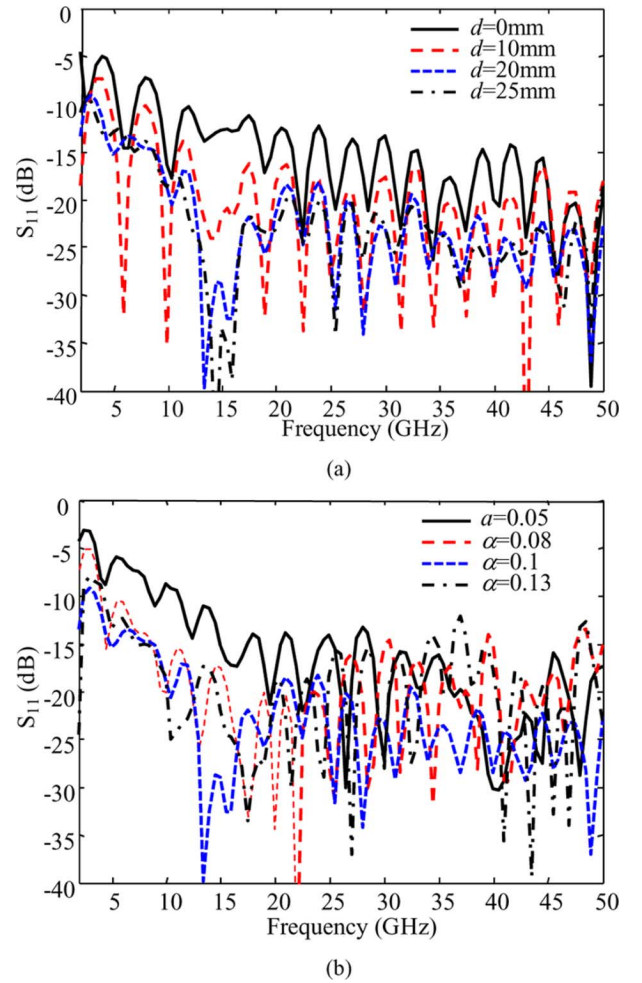


Fig. 2. (a) Simulated return loss of circular-shape-loaded Vivaldi antenna with $\alpha = 0.1$ and varies d of 0, 10, 20, and 25 mm. (b) Simulated return loss with $d = 20$ mm and varies α of 0.05, 0.08, 0.1, 0.13.

TABLE I
GEOMETRIC PARAMETERS FOR THE ANTENNA

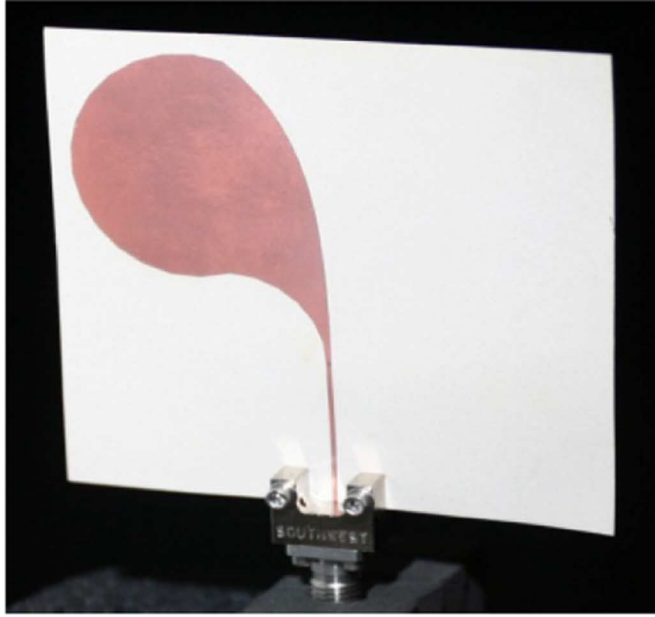
w_0	r_0	l	w	α	d	s
0.675mm	11.6mm	40mm	24mm	0.1	20mm	0.9mm

TABLE II
RESONANT FREQUENCY INCURRED BY THE SLOT-LOAD

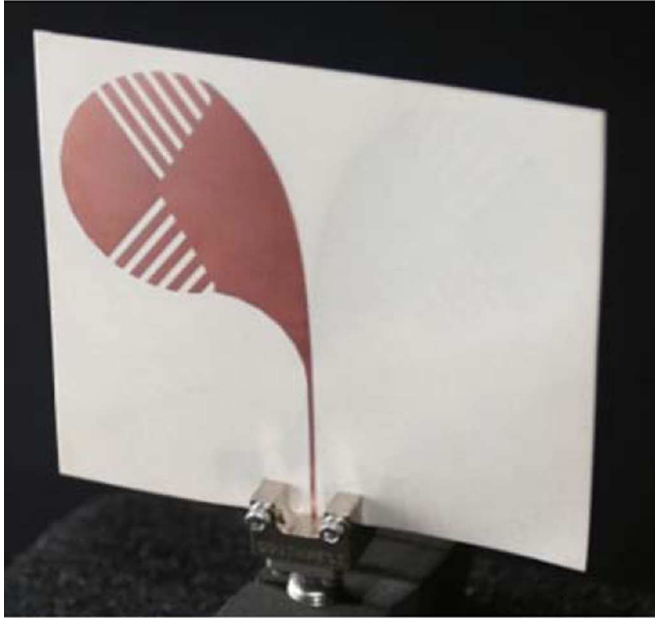
Finger Lengths (mm)	Calculated f_0 (GHz)	Simulated f_0 (GHz)	Measured f_0 (GHz)
13.7	4.3	4.3	4.3
12.7	4.7	4.7	5.0
11.3	5.2	5.2	5.8
9.6	6.2	6.0	6.2
7.4	8.0	7.5	7.5
4.5	13.0	13.5	13.0

Vivaldi antenna has to be approximately enlarged three times to reach the lower cutoff frequency of 2 GHz.

To further improve the bandwidth while making the antenna compact, the circular-shape-loaded Vivaldi antenna, as shown in Fig. 1(b), is proposed. This antenna is attained by adding a circular-shape-load on each arm of the conventional one. The outer



(a)



(b)

Fig. 3. (a) Fabricated circular-shape-loaded Vivaldi antenna. (b) Fabricated slot-loaded antenna.

edge of circular load matches the conventional Vivaldi antenna. The overall extension distance d , circle center (x_0, y_0) , and radius of r are related by

$$r = \frac{\left[\frac{(l - r_0)^2}{4} + d^2 \right]}{2d} \quad (4)$$

$$\begin{cases} x_0 = r_0 + \frac{d - r}{2} \\ y_0 = r_0 + \frac{(l - r_0)}{2} \end{cases} \quad (5)$$

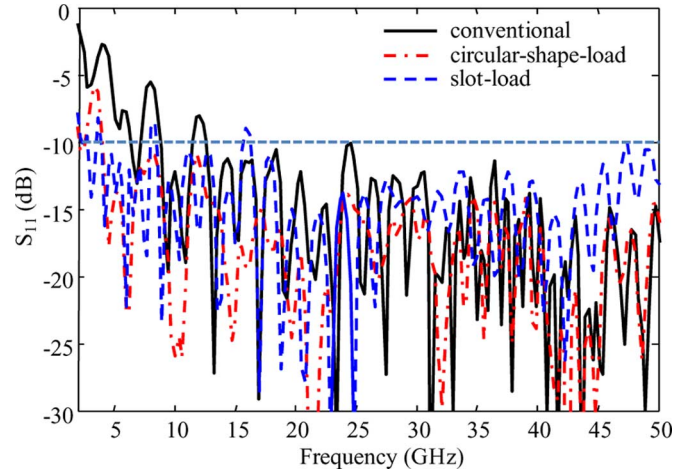


Fig. 4. Measured return loss, respectively, of the conventional, circular-shape-loaded, and slot-loaded Vivaldi antenna.

Based on our previous discussion, the parameter d along with α is to be optimized under the criteria of achieving the widest bandwidth and compact geometry through a parametric study. First, by maintaining α constant, we investigate return loss by varying d . Fig. 2(a) is the simulated return loss with $\alpha = 0.1$ and d varying from 0, 10, 20, and 25 mm, respectively, illustrating the impedance bandwidth to be dramatically expanded by applying the load. Without the load ($d = 0$), the lowest operating frequency with return loss less than -10 dB is about 9 GHz. By increasing d , this frequency can be lowered to about 4 GHz. However, it is also observed that the return loss has no noticeable change at d above 20 mm. In addition, we keep d constant and vary α to study impedance characteristics. Fig. 2(b) shows the simulated return loss with d of 20 mm and α , respectively, of 0.05, 0.08, 0.1, and 0.13. As we see from the figure, return loss decreases as α increases from 0.05 to 0.1, and then increases when α is above 0.1. Therefore, $\alpha = 0.1$ and $d = 20$ mm is found to offer the UWB performance and compact configuration with a circular-shaped load. All of the geometrical parameter values are listed in Table I.

B. Slot-Loaded Vivaldi Antenna

The antenna impedance bandwidth at low frequency can be further increased. In addition, the radiation pattern can be improved and tailored to achieve high directivity. To achieve this, the slot-loaded antenna, as shown in Fig. 1(c), is proposed. Such an antenna is designed by properly introducing slots on the optimized circular-shape-load. Extensive numerical studies on the slot orientation have been performed, and it concludes that the orientation of the slots chosen about 45° respective to y -axis provides the better directivity. The slot-load basically gives rise to two-folded effects on the performance of the circular-shape-loaded antenna. First, due to the change of the current flow, i.e., the current distributes along the “fingers” instead of the circular edge, actually producing more directive radiation pattern than the circular-shape-loaded Vivaldi antenna. Secondly, loaded slots will change the return loss of the circular-shape-loaded Vivaldi antenna, particularly at relative the low- and high-frequency range. This is because the circular-shape-load is mainly characterized as a resistor, whereas

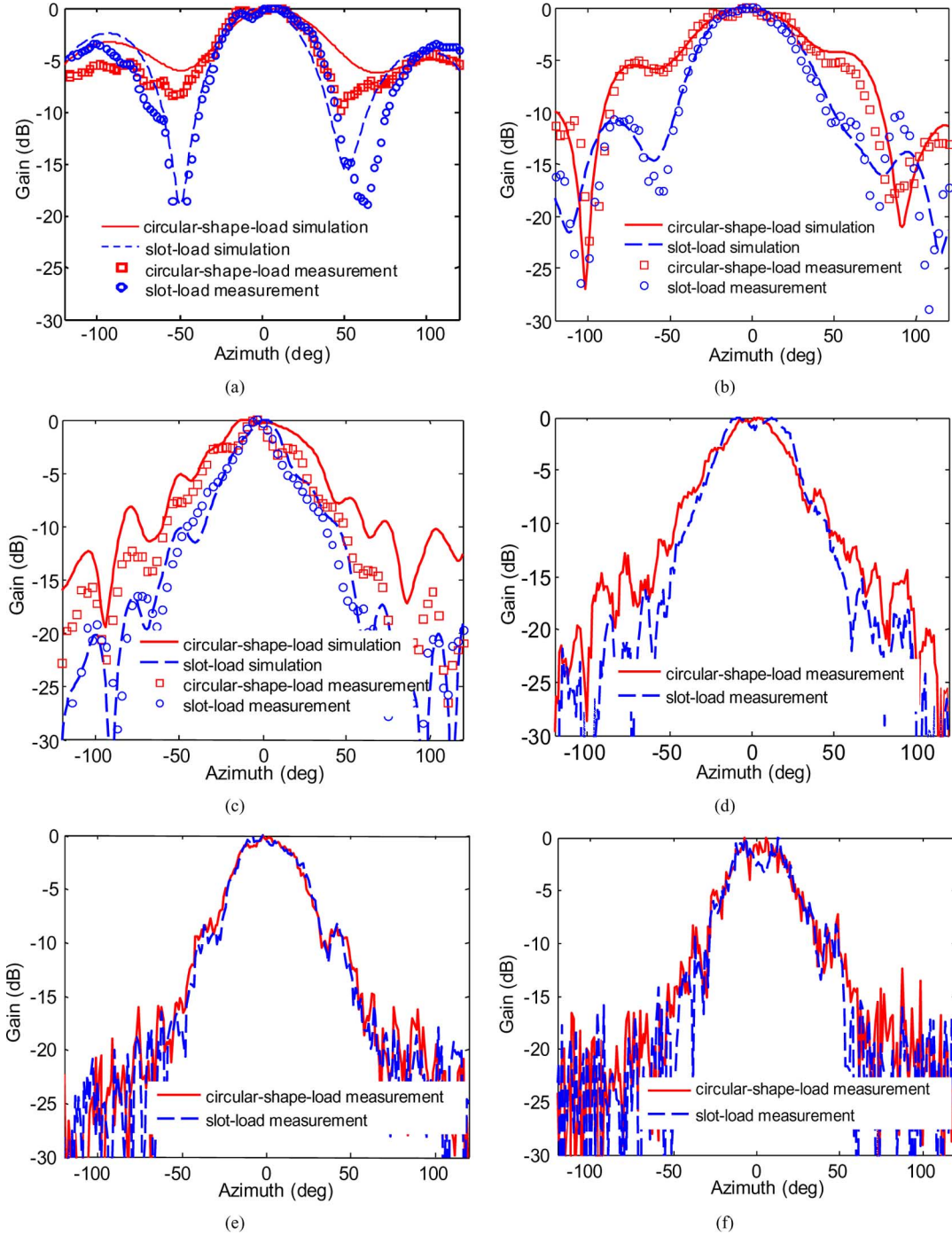


Fig. 5. Simulated and measured radiation patterns of circular-shape-loaded and slot-loaded Vivaldi antenna at: (a) 4 GHz, (b) 10 GHz, and (c) 20 GHz. Measured results at: (d) 30 GHz, (e) 40 GHz, and (f) 50 GHz.

the slot-load is more like an *RLC* resonator. The resonant wavelength of each finger can be approximately estimated by

$$\lambda_0 = \frac{4l_s}{\sqrt{\frac{1 + \epsilon_r}{2}}} \quad (6)$$

where l_s is the length of each finger and ϵ_r is the dielectric constant of the substrate. In order to achieve a wideband performance, multiple slots with varied lengths are used to merge these resonances. The gradually increased length of the six fin-

gers on each load is listed in Table II. Slot width of s does not apparently impact return loss, except for the resonances slightly shifted toward the lower frequency as s decreases. This phenomenon similarly exists in all dipole antennas. By the parametric study, the slot width of s is chosen as 0.9 mm to achieve a good impedance bandwidth. The design parameters for the slot-loaded antenna are listed in Tables I and II.

III. MEASURED RESULT AND DISCUSSION

The antenna is fabricated with standard lithography technology on a 10-mil-thick Rogers Duroid 5880 substrate, and

then is attached on a piece of Eccostock SH8 (polyurathane) foam with very low loss and dielectric constant in order to keep the antenna stable during measurement. The antennas are fed through a 2.4-mm coaxial adaptor capable of working from dc to 50 GHz. Fig. 3 shows the fabricated circular-shape-loaded and slot-loaded Vivaldi antenna. The measured return loss of the modified and conventional Vivaldi antennas is compared in Fig. 4. It can be seen that at the low frequency, i.e., 2–8 GHz, the slot-loaded Vivaldi antenna demonstrates the best wide-band performance in terms of impedance bandwidth with a return loss less than -10 dB, except at a few frequencies. The results are also in agreement with the simulation. The return loss of the slot-loaded Vivaldi antenna becomes larger than that of the other two antennas, as seen from the figure, at the high frequency, i.e., 40–50 GHz, which is attributed to a rising mismatch with large reactance involved in the slot-load. In summary, the achievable impedance bandwidth of the conventional, circular-shape-loaded, and slot-loaded Vivaldi antennas with geometrical parameters in Table I are about 9–50, 4–50, and 2–50 GHz, all with the typical return loss less than -10 dB and the maximum less than -8 dB. Therefore, the antennas with the optimized loads, i.e., circular-shape-load and slot-load, can dramatically improve the impedance bandwidth and achieve compact geometry.

The physical mechanism of the circular-shape-loaded Vivaldi antenna with the capability of radiating below the cutoff frequency of the conventional Vivaldi antenna can be explained as follows. Surface current on the metallization layers is primarily confined to the metallization edges of the radiating flares. At high frequencies, the longer electric length of the tapered slot allows sufficient radiation and thereby a small amount of current remains at the end of the flare. However, for low frequencies, the flare length in terms of wavelength is much shorter. As a result, the current on the flare is less efficiently radiated. In addition, the remaining current at the end of the flare can even cause the radiation pattern to be distorted. In the circular-shape-loaded Vivaldi antenna, the current path is smoothly extended longer along the circular curve, and is thereby capable of providing symmetric radiation at the ultra-wide bandwidth. The slot-loaded Vivaldi antenna can radiate below the cutoff frequency, however, because the “fingers” at the end of the flare induce resonances. As a result, the slot-loaded antenna behaves like a resonant antenna with multiple resonant frequencies at low frequency instead of a traveling-wave antenna at high frequency. As mentioned above, the fundamental resonances of the slots can be evaluated according to (6). It is worth examining the impact of the loaded slots on the return loss. Table II offers the comparison of the calculated resonant frequencies with the simulated and measured results. Good agreement between them allows accurate design to improve the impedance characteristic at low frequency.

Fig. 5 shows the measured E -plane (xoy -plane) radiation patterns of both modified Vivaldi antennas at five frequencies in the range of 4–50 GHz. The measured results are also compared with simulations at 4, 10, and 20 GHz for validation. The comparison at higher frequency is not implemented due to limited computer memory and time. As seen from the figure, the measured E -plane patterns are in good agreement with the simulated results. In addition, the slot-loaded antenna displays better

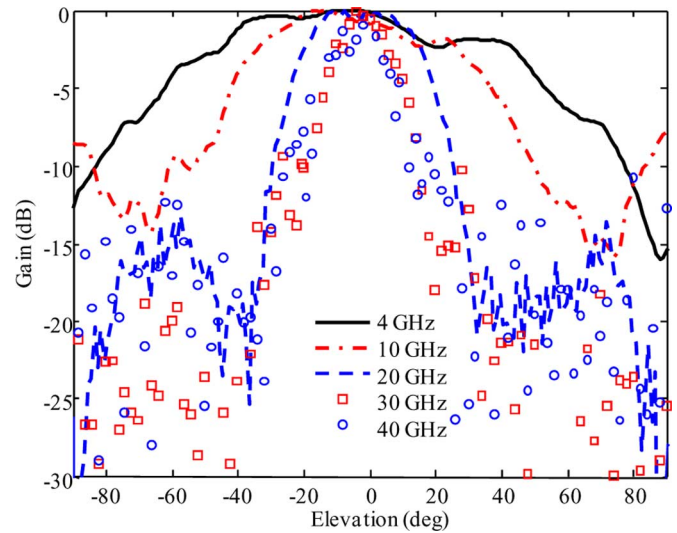


Fig. 6. Measured H -plane radiation patterns of the slot-loaded antenna.

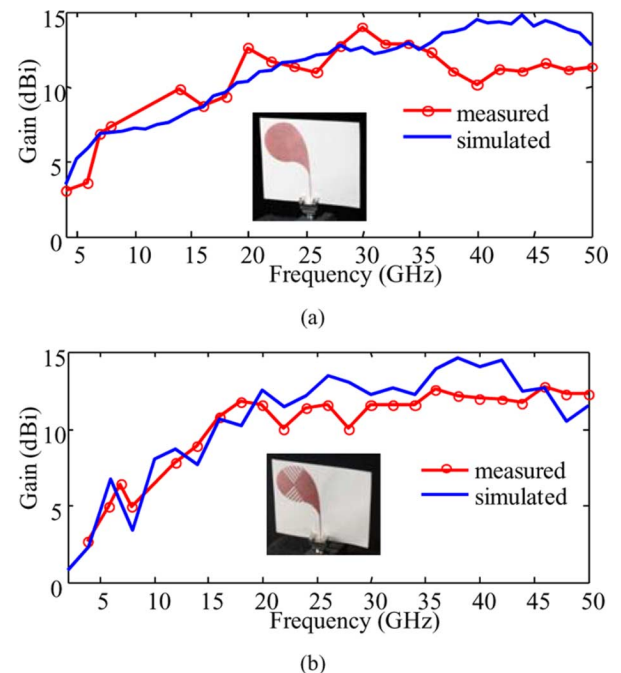


Fig. 7. Measured versus simulated gain. (a) Circular-shape-loaded and (b) slot-loaded Vivaldi antenna.

directivity in terms of smaller half-power beamwidth (HPBW) and sidelobes, especially at frequencies lower than 30 GHz. At higher frequencies, the radiation patterns of both antennas tend to be identical because most power has already been radiated before arriving at the loading structures. Fig. 6 shows the measured H -plane radiation patterns of the slot-loaded antenna at 4, 10, 20, 30, and 40 GHz, respectively. Through examining Figs. 5 and 6, we found the pattern beamwidths in both the E - and H -plane are wider at low frequencies and then narrow to a constant beamwidth as the frequency increases to above 30 GHz.

The gain of the two antennas is slightly different, as shown in Fig. 7, and varies between 3–12 dBi over 4–50 GHz. The discrepancy between the simulation and measurement is due to ohmic and substrate loss, surface roughness of fabrication, and

other factors, which are very difficult to be predicted, but significant at high frequency. The measured results of the gain and radiation patterns at the frequency below 4 GHz are not available here due to the measurement system capability of 4–50 GHz. According to the simulated result, as shown in Fig. 7(b), the gain of the slot-loaded Vivaldi antenna at 2 GHz is expected to be about 1 dBi. The cross-polarization of the modified Vivaldi antenna is generally similar to the traditional one and has maximum -15 dB in the operating bandwidth. It can be further lowered, if necessary, using a balanced antipodal structure.

IV. CONCLUSION

This paper presents two UWB compact Vivaldi antennas. By introducing two different loading structures, i.e., circular-shape-load and slot-load, both antennas have UWB performance of more than 46 GHz. Loading structures mitigate the requirement of bandwidth on the antenna length and aperture, resulting in a compact structure for the antenna. It is worth pointing out that the slot-loaded Vivaldi antenna can have wider bandwidth by manipulating the slot length and width to create a lower frequency resonance to be merged. In summary, the circular-shape-loaded Vivaldi antenna is characterized as lower return loss, while the slot-loaded Vivaldi antenna exhibits nearly 2-GHz wider impedance bandwidth with typical return loss less than -10 dB, except only a few frequencies, which could cause a problem. The slot-loaded Vivaldi antenna is allowed to possess the radiation pattern with suppressed sidelobe and higher directivity in a particular spectrum range. The beam patterns of modified Vivaldi antennas are symmetric in both E - and H -plane and become stable when frequency is larger than 30 GHz. In addition, the modified Vivaldi antenna is characterized of compact geometry, symmetric and directive radiation pattern in antenna plane (xy -plane), and convenient integration with opto-electronic circuits, therefore being suitable for realizing an UWB antenna array fed with an RF-photonics system. One more thing to be noted is the loading method employed in this paper theoretically differs from other techniques utilized to optimize impedance characteristics, e.g., DETSA, which is through a modified tapered slot and flare. Therefore, our loading method can be applied together with a dual exponential taper to possibly achieve a more miniaturized configuration and wider bandwidth.

REFERENCES

- [1] D. G. Leeper, "Ultra-wideband—The next step in short-range wireless," in *IEEE Radio Freq. Integr. Circuits Symp. Dig.*, Jun. 2003, pp. 493–496.
- [2] G. R. Aiello, "Challenges for ultra-wideband (UWB) CMOS integration," in *IEEE Radio Freq. Integr. Circuits Symp. Dig.*, Jun. 2003, pp. 497–500.
- [3] G. R. Aiello and G. D. Rogerson, "Ultra-wideband wireless systems," *IEEE Microw. Mag.*, vol. 4, pp. 36–47, Jun. 2003.
- [4] K. S. Siwiak, "Ultra-wide band radio: Introducing a new technology," in *Proc. IEEE Veh. Technol. Conf.*, May 2001, vol. 2, pp. 1088–1093.
- [5] I. Craddock, "Wideband antennas for biomedical imaging," in *Ultra-Wideband Antennas and Propagation for Communications, Radar and Imaging*, First ed. Hoboken, NJ: Wiley, 2006, ch. 20, pp. 437–448.

- [6] Y. Yang, Y. Wang, and A. E. Fathy, "Design of compact Vivaldi antenna arrays for UWB see through wall applications," *Progr. Elektromagn. Res.*, vol. PIER 82, pp. 401–418, 2008.
- [7] M. H. Shenouda and E. C. Fear, "Ultra-wideband antenna design for breast tumor detection," in *Abstracts URSI North Amer. Radio Sci. Meeting*, 2006, p. 1.
- [8] K. Garenaux, T. Merlet, M. Alouini, J. Lopez, N. Vojdani, and R. Boula-Picard, "Recent breakthroughs in RF photonics for radar systems," *IEEE Aerosp. Electron. Syst. Mag.*, vol. 22, no. 2, pp. 3–8, Feb. 2007.
- [9] C. A. Schuetz, J. Murakowski, G. J. Scheider, and D. W. Prather, "Radiometric millimeter-wave detection via optical upconversion and carrier suppression," *IEEE Trans. Microw. Theory Tech.*, vol. 53, no. 4, pp. 1732–1738, Apr. 2005.
- [10] P. J. Gibson, "The Vivaldi aerial," in *Proc. 9th Eur. Microw. Conf.*, Brighton, U.K., Jun. 1979, pp. 101–105.
- [11] S. Sugawara, Y. Maita, K. Adachi, K. Mori, and K. Mizuno, "A mm-wave tapered slot antenna with improved radiation pattern," in *IEEE MTT-S Int. Microw. Symp. Dig.*, 1997, pp. 959–959.
- [12] E. Gazit, "Improved design of the Vivaldi antenna," *Proc. Inst. Elect. Eng.—Microw., Antennas, Propag.*, vol. 135, no. 2, pp. 89–92, 1988.
- [13] J. D. S. Langley, P. S. Hall, and P. Newham, "Balanced antipodal Vivaldi antenna for wide bandwidth phased arrays," *Proc. Inst. Elect. Eng.—Microw. Antennas Propag.*, vol. 143, no. 2, pp. 97–102, Apr. 1996.
- [14] K. S. Yngvesson, "The tapered slot antenna—A new integrated element for millimeter-wave application," *IEEE Trans. Microw. Theory Tech.*, vol. 37, no. 2, pp. 365–374, Feb. 1989.
- [15] K. S. Yngvesson, "Endfire tapered slot antennas on dielectric substrates," *IEEE Trans. Antennas Propag.*, vol. AP-33, no. 12, pp. 1392–1400, Dec. 1985.
- [16] S. Sugawara, Y. Maita, K. Adachi, K. Mori, and K. Mizuno, "A mm-wave tapered slot antenna with improved radiation pattern," in *IEEE MTT-S Int. Microw. Symp. Dig.*, 1997, pp. 959–959.
- [17] J. Bai, S. Shi, and D. W. Prather, "A modified antipodal Vivaldi antenna with improved bandwidth and radiation pattern," in *Abstract Progr. Elektromagn. Res. Symp.*, Cambridge, U.K., Jul. 2010, p. 349.
- [18] E. Gullanton, J. Y. Dauvignac, C. Pichot, and J. Cashman, "A new design tapered slot antenna for ultra-wideband applications," *Microw. Opt. Technol. Lett.*, vol. 19, no. 4, pp. 286–289, Dec. 1998.
- [19] H. Oraizi and S. Jam, "Optimum design of tapered slot antenna profile," *IEEE Trans. Antennas Propag.*, vol. 51, no. 9, pp. 1987–1995, Sep. 2003.
- [20] A. Z. Hood, T. Karacolak, and E. Topsakal, "A small antipodal Vivaldi antenna for ultra-wide-band applications," *IEEE Antennas Wireless Propag. Lett.*, vol. 7, pp. 656–660, 2008.
- [21] H. Loui, J. P. Weem, and Z. Popovic, "A dual-band dual-polarized nested Vivaldi slot array with multilevel ground Plane," *IEEE Trans. Antennas Propag.*, vol. 51, no. 9, pp. 2168–2175, Sep. 2003.
- [22] J. B. Rizk and G. M. Rebeiz, "Millimeter-wave Fermi tapered slot antennas on micromachined silicon substrates," *IEEE Trans. Antennas Propag.*, vol. 50, no. 3, pp. 379–383, Mar. 2002.
- [23] H. Y. Xu, H. Zhang, J. Wang, and L. X. Ma, "A new tapered slot antenna with symmetrical and stable radiation pattern," *Progr. Elektromagn. Res. Lett.*, vol. 5, pp. 35–43, 2008.
- [24] S. Sugawara, Y. Maita, K. Adachi, K. Mori, and K. Mizuno, "Characteristics of a millimeter-wave tapered slot antenna with corrugated edges," in *IEEE MTT-S Int. Microw. Symp. Dig.*, 1998, pp. 533–536.



Jian Bai received the B.S. and M.S. degrees in electrical engineering and radio physics from Xidian University, Xi'an, China, in 2005 and 2008, respectively, and is currently working toward the Ph.D. degree in electrical engineering at the University of Delaware, Newark.

His research interests include UWB microwave and millimeter-wave antennas, phased arrays, and the integration with opto-electronic systems, metamaterials, and their applications.



Shouyuan Shi received the B.S., M.S., and Ph.D. degrees from Xidian University, Xi'an, China, in 1991, 1994, and 1997, respectively, all in electrical engineering.

He is currently an Associate Professor with the Department of Electrical and Computer Engineering, University of Delaware, Newark. His research interests include electromagnetic numerical modeling, electromagnetic imaging, antenna design, RF microphotonics, microoptics and nanophotonics, left-hand material, and photonic crystals and their

applications.



Dennis W. Prather (M'97–SM'08) is currently the College of Engineering Distinguished Professor with the Department of Electrical and Computer Engineering, University of Delaware, Newark, where he established the Laboratory for Nano- and Integrated-Photonic Systems. The focus of this laboratory is on both the theoretical and experimental aspects of active and passive nanophotonic elements and their integration into opto-electronic subsystems. To achieve this, this laboratory develops and refines computational electromagnetic tools for

both the analysis and synthesis of photonic devices in addition to developing nanofabrication and integration processes necessary for their integration into functional subsystems. Devices of particular interest include subwavelength structures, photonic crystal devices, diffractive optical elements, and optical waveguides for application in next-generation opto-electronic systems. He has authored or coauthored over 350 scientific papers and ten books/book chapters. He holds over 40 patents.

Dr. Prather is a Fellow of the Society of Photo-Instrumentation Engineers (SPIE) and the Optical Society of America (OSA).