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II ELECTRONICS AND INFORMATION TECHNOLOGY

MODELLING AND ANALYSIS OF VIVALDI ANTENNA STRUCTURE DESIGN FOR BROADBAND COMMUNICATION SYSTEMS

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Abstract

An antipodal Vivaldi antenna with a compact parasitic patch to overcome radiation performance degradations in the high-frequency band is proposed. For this purpose, a double asymmetric trapezoidal parasitic patch is designed and added to the aperture of an antipodal Vivaldi antenna. The proposed antenna has a peak gain greater than 7 dBi over the frequency range of 6–90 GHz.

Key Words: Antipodal Vivaldi Antenna, High Gain, Parasitic Antenna, Ultra-Wideband Antenna.

Vivaldi's antenna is designed for all conditions. It is performed on a thin flexible substrate, which makes it easy to fit on various surfaces. Thus, this antenna can be used in different conditions.

There is a patent for a two-element receiving section of a Vivaldi antenna for use on aircraft. Such use is possible because the antenna easily takes a streamlined shape. Besides, the Vivaldi antenna is ideal for aircraft, since it operates at speeds with a Mach number of up to 2.

Using the Vivaldi antenna model, we can evaluate its far-field radiation pattern and impedance.

Our model imitates the real design of the Vivaldi antenna through the use of a thin dielectric substrate. A conical slit is applied over this substrate, and the base plane is formed by an ideal electrical conductor. We construct the conical gap curves using the exponential function e0.044x. The slit itself resembles a pipe with a wide end, the edges of which, curving, converge into a narrow line. However, unlike the pipe, the narrow end connects to the annular hole, and the wide end extends outward, as shown below.

The reverse side of the substrate is a shorted 50-Ohm microstrip supply line, which, when modelling, was taken as an ideal electrical conductor. To excite the antenna, a port located on the line was used.

The opening aerial geometry is defined as

$$W^{max} = \frac{c}{2f_{min}\sqrt{\varepsilon_r}}$$

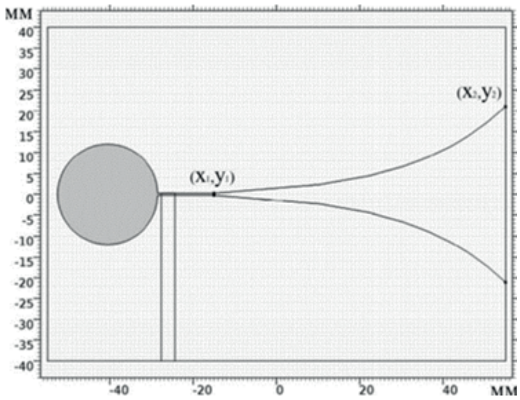


Fig. 1. The geometric dimensions of the antenna

$$W^{min} = \frac{c}{2f_{max}\sqrt{\varepsilon_r}}$$

where c is the propagation velocity of an electromagnetic wave in a vacuum; fmin and / f max - minimum and maximum operating frequencies of the antenna; er is the electrical permeability of the substrate material.

The equation of the exponential form of the aperture was given by the formula

$$y = C_1 e^{Rx} + C_2$$

where C; and C2 - const, are chosen so that the opening passes through the points with coordinates (xx yy) and (x2, y2), indicated in Fig. 2 and defined as

$$C_1 = \frac{y_2 - y_1}{e^{Rx_2} - e^{Rx_1}}$$

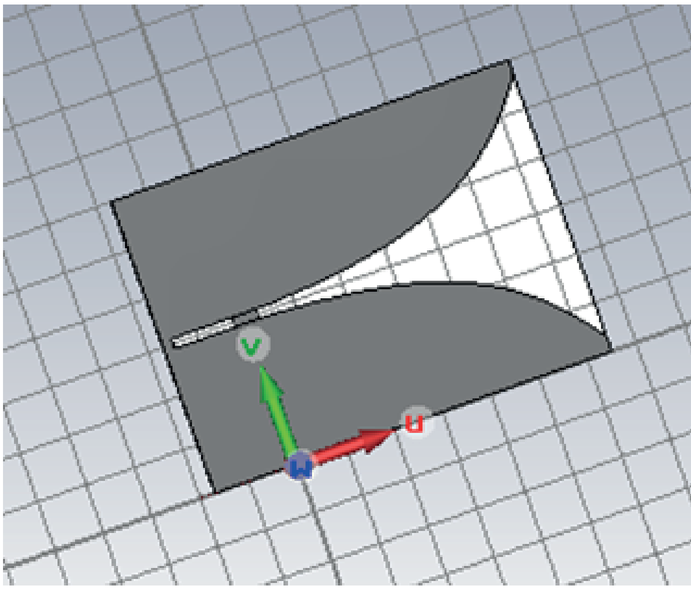
$$C_2 = \frac{y_1 e^{Rx_2} - y_2 e^{Rx_1}}{e^{Rx_2} - e^{Rx_1}}$$

The resulting electric field of the antenna in the far zone is defined as the sum of the contribution to the electric field of each approximated area:

$$E(\theta,\varphi) = \sum^{N} E_n(\theta,\varphi)$$

where E (0, <p) is the contribution of the nth approximated portion of the guide structure of the antenna in the electric field of the far zone.

The design of the AP element was performed using computer simulation in the CST Studio Suite. As the dielectric substrate, "Rogers 4003C" material was chosen with a substrate thickness of 1.524 mm, a copper layer thickness of 0.035 mm and a dielectric constant of 8 = 2.3. The Vivaldi antenna model made in the CST Studio suite program is presented in Figure 2.



Parameter List

Nam /	Value	Description	Type
ext	0.1		None
h	0.2		None
k	4.83		Undefined
MW	0.25		None
QWM	0.9		None
QWS	0.75		None
r	1.1		None
s	0.05		None
sl	1		None
subw	3		None
TL	3		None

Fig. 2. The physical model of the antenna made in CST.

Figure 3 shows the 3D pattern of the antenna at 70 GHz. Also, thanks to the model, we can see the return loss of a 5G Vivaldi antenna (Figure 4). We know that the Vivaldi antenna pattern faces the wide end of its conical slit. Our model confirms that the radiation pattern in the far zone has exactly this shape.

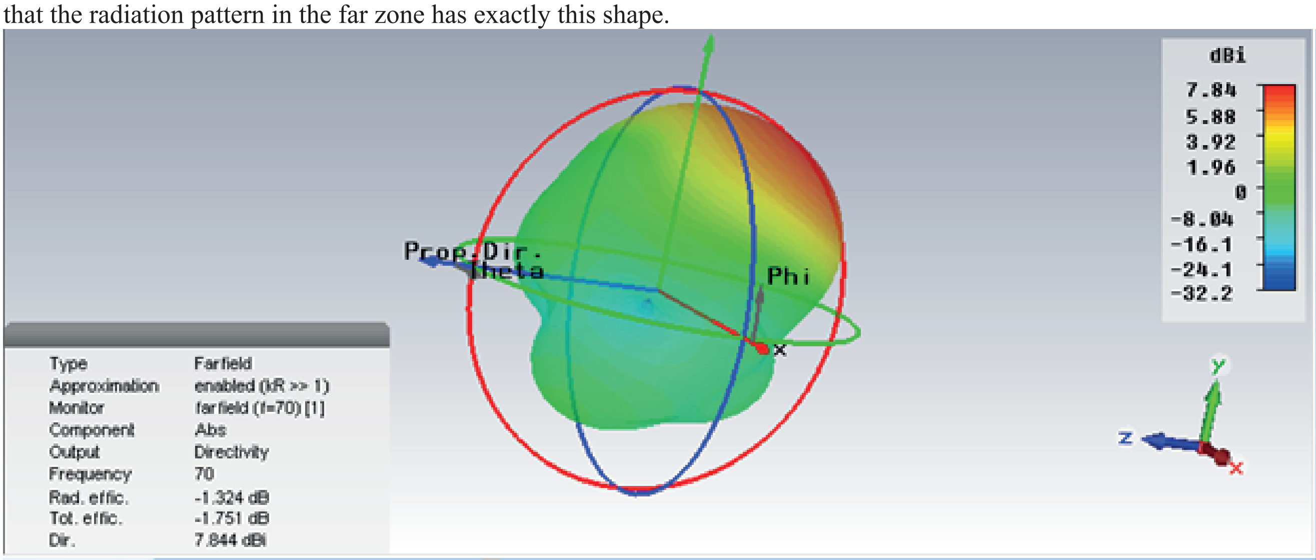


Fig. 3. 3D pattern of the Vivaldi antenna at 70 GHz.

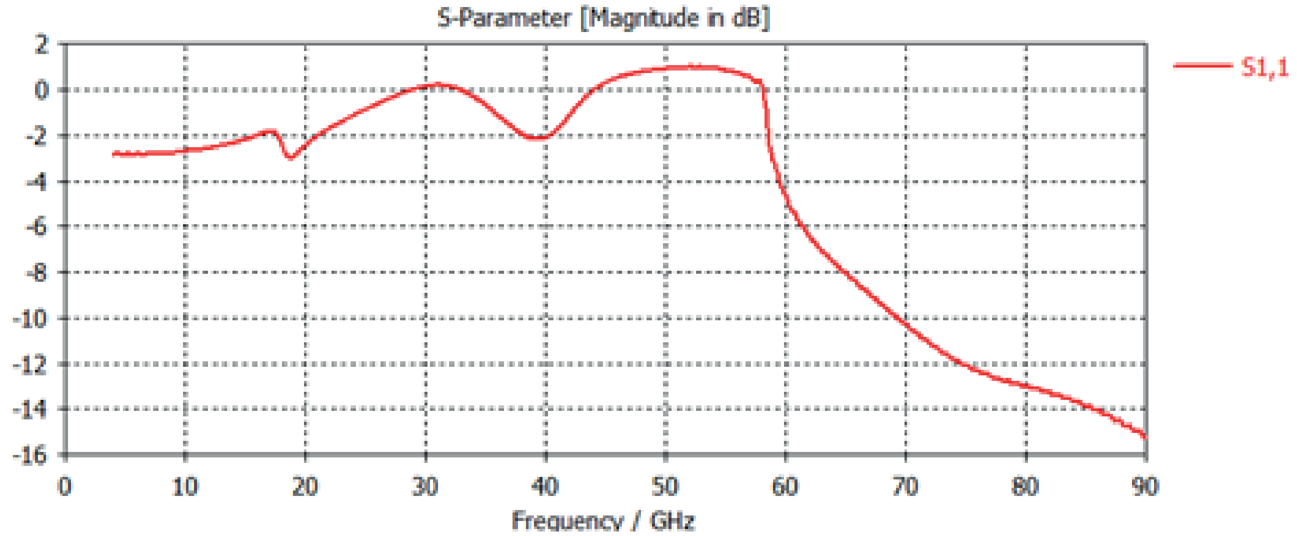


Fig. 4. The return loss of the Vivaldi antenna at 70 GHz.

Conclusion

In this paper, the designs of a Vivaldi antenna with various sizes were presented. The simulation and fabrication result of 6 different sizes have been shown. Vivaldi antenna is a wideband antenna.

Thus a compact triband Vivaldi antenna for the use in high-frequency Wi-Fi applications, radar, geostationary satellite applications with a gain of about 2-7dBi has been designed. These advantages make the improved Vivaldi antenna valuable in many future wireless communication applications.

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