

Stefan Balling, Marko Hennhöfer, Gerd Sommerkorn, Ralf Stephan

# Broadband Dual Polarized Antenna Arrays for Mobile Communication Applications

## ABSTRACT

This paper presents a novel rectangular antenna array for 3G mobile communication systems. The array consists of 32 dual polarization-sensitive radiators and operates at 2 GHz, covering the uplink and downlink bands of the UMTS standard. Design issues and the resulting electrical performance of the antenna array are discussed.

## INTRODUCTION

The growing demand for mobile communication services requires an effective use of the available channel capacity. This can be achieved by applying smart antennas, which form multiple-input multiple-output (MIMO) systems and offer a more effective utilization of frequency resources. 3G and 4G mobile radio systems will take advantage of the full spatial and temporal structure of the mobile radio channel including direction and polarization information [1]. An important tool for practical investigations of the wave propagation is the MIMO channel sounder described in [2].

As a communication system of particular interest, the UTRA (UMTS Terrestrial Radio Access) [1] system has been chosen. UMTS (Universal Mobile Telecommunication System) provides high data rates at the mobile terminals for future video and internet applications. The UMTS FDD (Frequency Division Duplex) mode is characterized by two 60 MHz bands (uplink and downlink) with a duplex distance of 190 MHz. Suitable antenna arrays therefore have to cope with a total bandwidth of 250 MHz.

## DIRECTION SENSITIVE ANTENNA ARRAY OF VIVALDI AERIALS

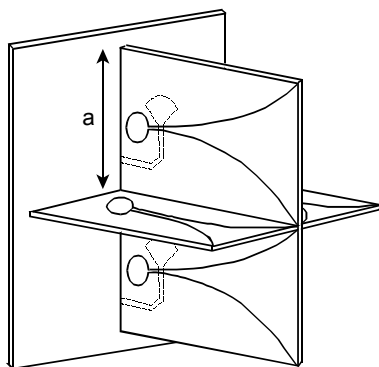


Fig. 1 Two horizontal and two vertical Vivaldi elements of the array

Uniform rectangular arrays (URA) are well suited to cover a complete half space. They consist of identical antenna elements, which are arranged in an equally spaced rectangular shaped grid. An antenna array for channel sounding applications has to deliver all antenna ports separately, to enable subsequent signal processing. This can be achieved by sequentially measuring all active antenna elements. The path to the active antenna is chosen electronically by a switching matrix, and the unused elements are terminated. The magnitudes and phases at all antenna ports are then processed at the IF level to resolve parameters, such as the directions-of-arrival and time delays. With respect to the simplicity of the direction-

finding algorithms and the calibration procedure, it is preferable to use antenna elements with identical radiation patterns. To achieve this, all antennas have to be uniform including their next neighbours. Next to the elements at the margins of the rectangle, therefore, e.g. two rows respectively columns of passively terminated dummy antennas have to be added. The number of antenna elements increases further if the array has to be able to distinguish between horizontal and vertical polarization (Fig. 1), so that every grid point has to contain two radiators (one for each polarization). The spacing between the elements depends on the wavelength of the signal and should not exceed half a wavelength for the maximum frequency.



Fig. 2: Dual polarized Vivaldi array

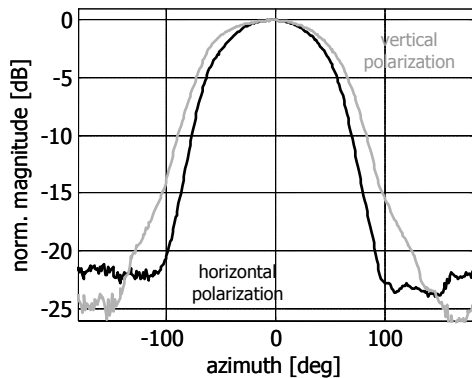


Fig. 4: Horizontal radiation pattern of the single Vivaldi element

The URA consists of Vivaldi elements ([3], [4]) (Fig. 2). These broadband antennas are formed by a tapered slotline and radiate in the plane of the slotline structure. Within the frequency range of 1.8 - 2.2 GHz, the Vivaldi array (Fig. 3) has a 3-dB beam-width of 112° vertical and 99° horizontal. Fig. 3 shows the typical radiation diagram of a single Vivaldi radiator of the URA. The isolation between both polarization planes amounts to 20 dB.

## DISCUSSION

Directive antenna arrays for 3G communication systems offer promising technologies for increased channel capacity. The arrangement of the Vivaldi antennas within the array has a strong influence on the electrical behaviour of each individual radiator. Especially the maximum antenna dimension (“a” in Fig. 1) given by the distance between the rows and columns of the grid is critical. The limitation of half a wavelength for the lateral antenna dimension reduces the bandwidth of the Vivaldi antenna drastically, and the shadowing effects of the neighbouring antennas limit the beam-width of the radiators. Despite these limitations the presented Vivaldi antenna array covers a bandwidth of 400 MHz and has a broadband characteristic that is difficult to achieve with resonant antenna principles like patch antennas.

### References:

- [1] Nabar, R. U.; Bölcskei, H.; Ercog, V.; Gesbert, D.; Paulraj, A. J.: Performance of multi-antenna signaling techniques in the presence of polarization diversity, *IEEE Trans. Signal Processing* (Special Issue on "Signal Processing Techniques for Space-Time-Coded Transmissions"), 2002, to appear.
- [2] Thomä, R.S.; Hampicke, D.; Richter, A.; Sommerkorn, G.; Trautwein, U., "MIMO Vector Channel Sounder Measurement for Smart Antenna System Evaluation," *European Transactions on Telecommunications ETT*, Vol. 12, No. 5, pp. 427-438, Sept. 2001.
- [3] Gibson, P.J.; *The Vivaldi Aerial*, Proc. 9th European Microwave Conf., Brighton, UK, Sept. 1979, pp. 101-105
- [4] Lee, K.F.; Chen, W.: *Advances in Microstrip and Printed Antennas*, Kapitel 9, John Wiley & Sons, Inc., New York, 1997

### Authors:

Stefan Balling, Marko Hennhöfer, Gerd Sommerkorn, Ralf Stephan  
 Ilmenau University of Technology, Institute of Communications and Measurement Engineering, P.O.B. 100565  
 98693 Ilmenau, Germany  
 Phone: +49 3677 691585  
 Fax: +49 3677 691586