EFFICIENT FDTD SIMULATION OF PASSIVE ANTENNA ARRAYS

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***Abstract* – This paper describes the analysis of large waveguide fed phased patch antenna arrays using an FDTD based field solver. A feature of the arrays considered here is the use of sequentially rotated elements, which requires special design measures. Therefore, the calculation of the far fields of the array based on FDTD-simulations is described, and different models for coupling are investigated. Special algorithms, which increase the simulation speed on modern processors, are introduced. A novel signal estimation technique is used to obtain accurate results of resonant antenna structures within short simulation time.**

1 INTRODUCTION

The basic antenna element considered here consists of a circularly polarised patch element, fed by a circular waveguide via an elliptical slot. All patches of the array have a truncated square shape, and can be separately steered in amplitude and phase. The schematic of a single patch element is displayed in figure 1.

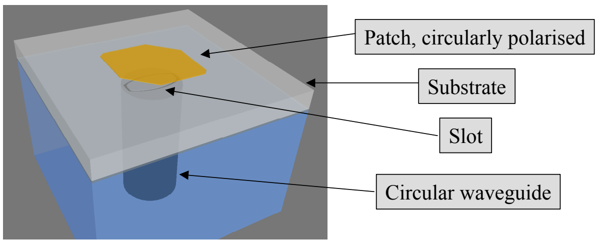

Figure 1: Layout of the basic element.

The single elements will be sequentially rotated as indicated in figure 2, in order to improve the axial ratio. The patches are not only rotated spatially 90° with respect to each other, but also fed with a 90° phase shift. Normally, the sequential rotation principle is used to generate circular polarisation from linearly polarised patch elements [1]. Yet, the use of sequentially rotated circularly polarised elements enhances the polarisation behaviour of the array [2], and suppresses the generation of grating lobes. The array will be composed of approximately 4,000 elements, arranged in subgroups of 4 rotated patches. The operation band is 29.5 GHz - 30 GHz, and the element spacing is approximately 5 mm (about half a wavelength at 29.7 GHz). The beam of the array can be steered and formed electronically by applying different amplitudes and phases to the antenna elements by employing the Digital Beam Forming (DBF technique). The maximum scan angle is 60° with respect to boresight. Because the bandwidth is an uncritical parameter in the design, all radiation patterns given in this paper will be determined for 29.7 GHz, the centre frequency of the band.

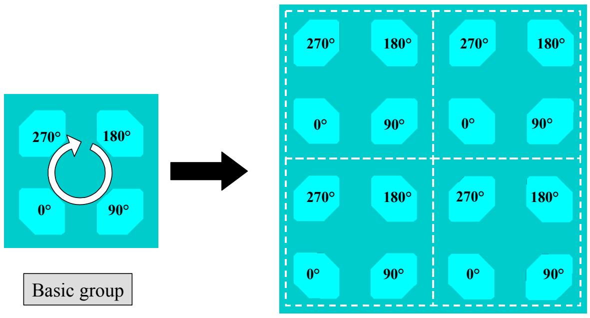

Figure 2: Patches arranged according to the sequential rotation principle.

Due to the size of the array, simulation time and memory capacities become critical issues. The new processor generations like Pentium III/Pentium IV and Athlon have extensions that allow multiple floating point operations within one processor cycle. This paper shows how these extensions can be used very efficient to speed up Finite Difference Time Domain simulations. A processor and structure dependent assembler code is created automatically for each simulation, which can reduce the simulation time by more than a factor of four.
The presented signal estimation technique allows the calculation of accurate frequency domain signals from resonant time signals, which can be even truncated. Standard Autoregressive Signal Processing is very sensitive to the model system's order, instabilities can occur and make the model unusable [3]. To overcome this drawback, a mixed DFT/AR (DAR) method is presented using frequency domain AR evaluation, which is insensitive to instable poles of the AR model.

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