

# Elektrotechniek



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## Finite antenna arrays: an eigencurrent approach

### Antenna arrays

On April 30, 1904, Christian Hülsmeier patented his 'Telemobiloskop', which became the first operational radar system for detecting ships through the transmission and reception of electromagnetic waves. Nowadays, radar systems are widely used, e.g. to control air traffic, to measure vehicle speeds, and to detect and track objects like ships and airplanes. Often, the transmit/receive unit of such a system is an array composed of separate antennas, their number varying from a dozen to many hundreds. An example is shown in Figure 1. Since the development of antenna arrays is complex and costly, designs from simulations are made prior to the development.

### Simulations

At present, brute-force numerical approaches applied to a large array are still far too computationally expensive. Therefore, an array is often considered as an infinite periodic structure, where symmetry is used to restrict the analysis to a single antenna of the array. This approach, however, cannot completely describe the characteristic electromagnetic behavior of antenna arrays. In particular, it cannot predict the occurrence of standing-wave phenomena that limits their bandwidth severely. In this thesis, we propose an approach that describes the characteristic behavior of finite arrays accurately. Besides the prediction of standing-wave phenomena, the approach can indicate how these phenomena can be reduced for the entire scan range of the array.

### Eigencurrents

In the proposed approach, we describe the behavior of an array by its 'eigenvibrations' or eigencurrents. These eigencurrents are the eigenfunctions of the impedance operator that relates the currents on the separate antennas to their excitation fields. From a physical point of view, the eigencurrents are standing waves of the array. The concept of eigencurrent appears extremely useful for the design, because eigencurrents are one-to-one related to properties of the array, like sum patterns, difference patterns, grating lobes, modulated impedance oscillations, and impedance variations attributed to surface waves. Besides a physical interpretation, the approach with eigencurrents leads to rapidly executable simulations; for, although the performance parameters of an array vary as a function of the geometry parameters, the eigencurrents vary hardly. Moreover, eigencurrents of (large) arrays are approximated as compositions of a small number of eigencurrents of the individual antennas in an array.

### Test cases

The eigencurrent approach was tested for the canonical examples of line arrays of rectangular or ring-shaped microstrips. However, the approach is suitable for other types of elements and array geometries as well. Figure 2 shows an example of a test for a line array of rectangular microstrips. Clearly, the standing-wave nature of the element impedances is observed.



Figure 1. An antenna array on a test tower of Thales in Hengelo.

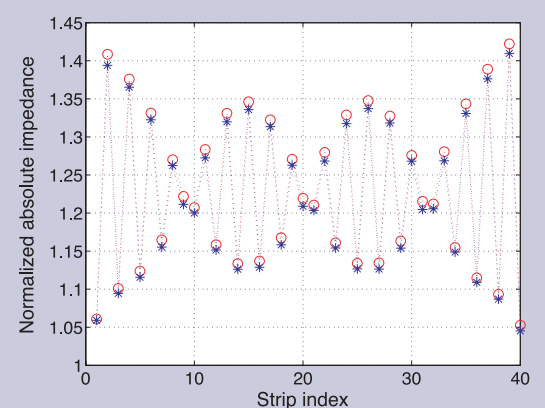


Figure 2. The element impedances of a line array of 40 rectangular microstrips (blue: moment method, red: eigencurrent approach).