Analysis and design of phased patch array with a MoM solver

Yuanhao Wang, Alexander Nietsch, Michael Berens and Wolfgang Mathis
Institut für Theoretische Elektrotechnik
Leibniz University Hanover
Appelstrasse 9 A, D-30167 Hanover, Germany

***Abstract*—In this paper a MoM (method of moment) Solver with a graphical user interface for phased patch arrays will be presented, in which suitable analysis for the design can be produced. A patch antenna array was designed with this solver. The results are shown here.**

***Index Terms*—antenna, MoM, phased array, patch array.**

I. Introduction

Due to its high gain and controllability of the direction of propagation a phased patch antenna array is suitable for UHF RFID applications in logistic industries. Such a phased array antenna is discussed e.g. in [1]. It consists of four patch antennas and is associated with three Wilkinson couplers. A sketch of the phased array is shown in Fig. 1. The elements are connected with micro strip lines. It operates in the frequency range of 867 MHz. The array antenna has a gain of 12.1 dB and utilizes a phase shifter which switches the main-beam between $\pm 30^\circ$, with a HPBW (Half-Power Beam Width) of approximately 90° (Fig. 2). This paper presents a graphical user interface for phased patch array simulations to produce a suitable analysis for their design. This graphical user interface can be extended to other models of phased arrays with patch antennas. The graphical user interface of the phased array is based on simulation results from a MoM (method of moment) solver implemented in MATLAB. The MoM solver relies on the RWG (Rao-Wilton-Glisson) edge elements [2].

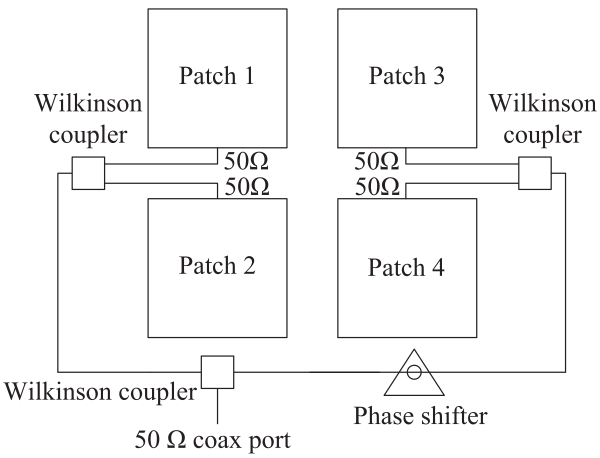

Fig. 1. a simplified sketch of the phased array in [1]

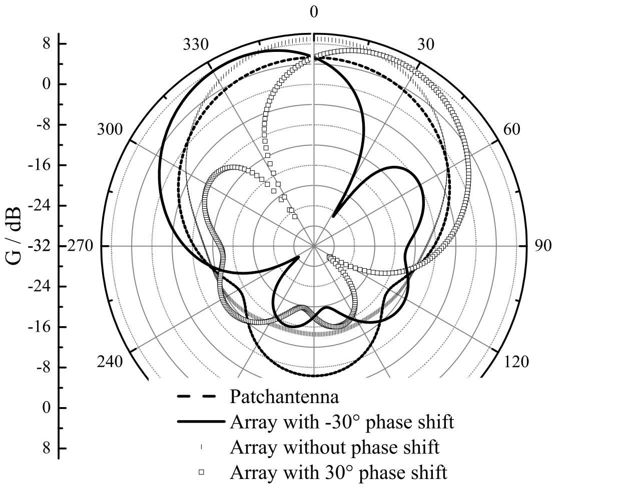

Fig. 2. comparison between a single patch antenna and a phased patch array on vertical chart ($\phi = 0^\circ$)

After a discretization of the antenna array we get the impedance matrix $[Z]$ via

$$[Z][I] = [U] \tag{1}$$

$$\text{with} \qquad [I] = \begin{bmatrix} i_1 \\ . \\ . \\ . \\ i_n \end{bmatrix} \qquad \text{and} \qquad [U] = \begin{bmatrix} E_1\Delta l_1 \\ . \\ . \\ . \\ E_n\Delta l_n \end{bmatrix}.$$

The grid variables in (1) are $[I]$ and $[E]$. They can be calculated with the electric field equation

$$E = -j\omega A - \nabla\Phi \tag{2}$$

with the boundary condition $n \times E^s = -n \times E^i$. E^s is the scattered electric field derived of surface current and E^i is the field from the outside. The magnetic vector potential A and the scalar potential Φ in (2) can be solved with

$$A(r) = \frac{\mu}{4\pi}\int_s J\frac{e^{-jkR}}{R}dS \tag{3}$$

and

$$\Phi(r) = \frac{1}{4\pi\varepsilon}\sigma\frac{e^{-jkR}}{R} \tag{4}$$

if we utilize the charge conservation equation

$$\text{div} J = -j\omega\sigma \quad (5)$$

the surface charge density σ can be solved.

The front end consists of an area for geometrical design (Fig. 3) and another area for the setup of calculations and the results (Fig. 4). The properties of antenna arrays with different array numbers and positions can be investigated. An advantage of this frontend is that we can setup every single parameter which could influence the antenna properties. For example the geometry of the patch, the number of discretization steps and the phase shift between the array elements can be adjusted individually. Also in the calculation area in Fig. 4, the results of the simulation are retrieved individually. For example the radiation pattern in 2D and 3D, the reflectance factor over frequency and the Hansen-Woodyard model [3], which is shown in Fig. 4. The setting options simplify the optimization of antenna array and accelerate the design process. In the final version of the paper we will discuss in more detail different antenna arrays for logistic applications and their simulation as well as their measurement performances.

REFERENCES

[1] M. Abbak and I. Tekin, "Rfid coverage extension using microstrip-patch antenna array [wireless corner]," *Antennas and Propagation Magazine, IEEE*, vol. 51, no. 1, pp. 185–191, 2009.

[2] S. Rao, D. Wilton, and A. Glisson, "Electromagnetic scattering by surfaces of arbitrary shape," *Antennas and Propagation, IEEE Transactions on*, vol. 30, no. 3, pp. 409–418, 1982.

[3] S. Makarov, *Antenna and EM modeling with Matlab*. New York: Wiley-Interscience, 2002.

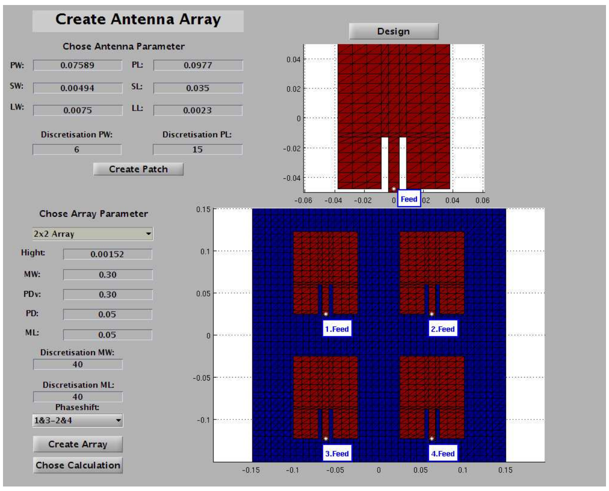

Fig. 3. design area of the solver

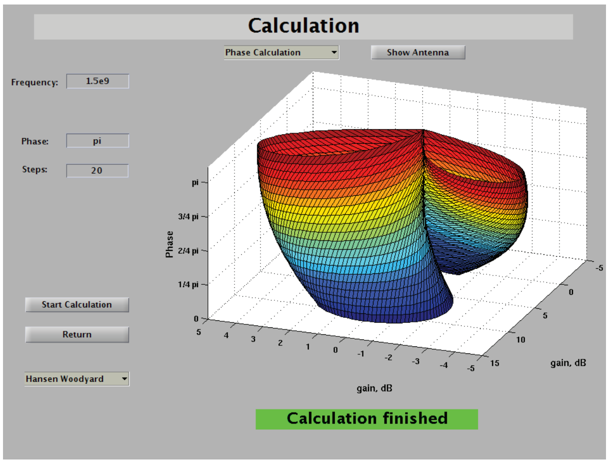

Fig. 4. calculation area of the solver

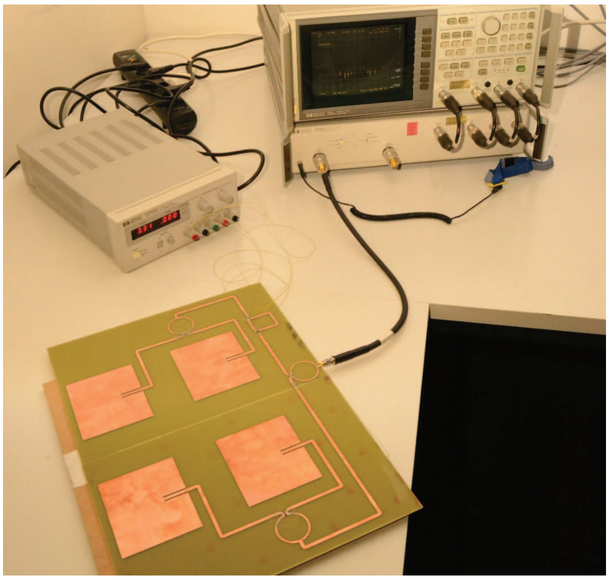

Fig. 5. the measurement of S parameters for patch antenna array