WAVE-PROPAGATION FROM MEDICAL IMPLANTS
- INFLUENCE OF BODY SHAPE ON RADIATION PATTERN

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Abstract -**The influence of a patient's body shape and position on the radiation pattern from an implanted radio transmitter has been simulated. Simulations and comparisons have been made with different body shapes (male, female and child) and different arm positions. It can be concluded from the results that the difference between different body shapes are at least as large as the influence of a patients arm movements.**
Keywords - Radio wave propagation, Medical, MICS

I. MEDICAL IMPLANT COMMUNICATION

A. Pacemaker communication

Implanted pacemakers are today routinely used for correction of heart arrhythmias [1]. A modern pacemaker is programmable from the outside in order to set parameters such as pace rhythm, output levels, sensitivity for motion etc. Data is also recorded and stored in the pacemaker for later retrieval. This data may consist of performance data, battery status and measurements of the intracardiac ECG of the patient. Today the communication link used is a magnetic coupling between two coils: one inside the pacemaker and one placed at the chest of the patient. This link has two main drawbacks: the outside coil must be placed on the correct spot with relative high precision and the transmission speed is slow. A wireless link operating at RF frequencies would give a higher transmission speed and a simpler interface.
The new standard Medical Implant Communications Service (MICS) for communication with medical implants is tailored for this use. It uses the 403-405 MHz band [2]. This band is previously utilized by weather balloons and is now shared between the two applications. This gives very stringent demands on the medical application, as this should not impede on the metrological use. Output power is thus set to a maximum of 25 μW EIRP and the maximum bandwidth used is set to 300kHz.

B. Transmission through the human body

In order to design establish a reliable communication channel between two points there are a number of variables that have to be known. One fundamental parameter is to accurately know the radio channel. There are well-known channel-models that describe the conditions outside the human body such as those found in a hospital, as this case is no different from classic mobile communication channels. What we today have very limited knowledge of is the transmission channel from the implant to the free air space surrounding the patient.
The human body is not a good media in which to transmit an electromagnetic wave. It has a high electric conductivity which gives rise to a large path loss within the body.

II. SIMULATIONS

In the simulations presented below the impact of the patients body shape and the position of the arms are investigated.

The shapes of the phantoms are taken from the "Poser" program [3], and represent fairly realistic human body shapes. The positions of all the mannequins limbs and joints are adjustable in the program. Eight different positions of the arms were generated this way, which can be seen in figure 2. There are also different sexes and ages available. Three were chosen for this simulation: one male, one female and a young boy.

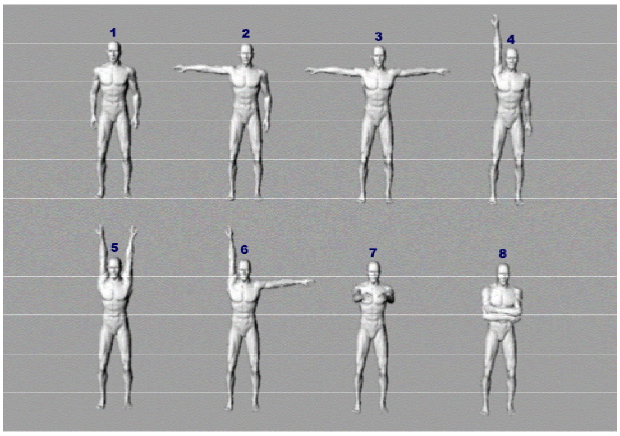

Figure 2. The eight different arm positions that were simulated.

These phantoms were transferred to the SEMCAD FDTD-simulator [4]. The phantoms were transferred as hollow shells. In the simulator these were then filled with a homogenous matter with the same electrical properties as muscles. The electrical properties were taken from the parametric model of C. Gabriel [5]. A simplified pacemaker with a wire antenna was placed inside the mannequin, in the medial line towards the front of the

phantom. The pacemaker was placed at the base of the neck, with the antenna pointing in the inferior direction (i.e. downwards when the phantom is viewed as standing up). The antenna was simulated as a perfectly conducting wire without any isolation. The length of the wire was 40 cm. This is the approximate actual length of a pacemaker lead. A wire antenna in a conductive medium has a logarithmic damping of the currents along the wire and a relative good electrical matching. The damping is due to losses to the surrounding media, as shown in [6]. The pacemaker was simulated as a perfectly conducting short cylinder.
The discretization was non-uniform with a maximum voxel size of 1/10 of a wavelength at all places.

III. RESULTS

A. Arm Positions

The far-field of the system was studied. As can be seen in figure 3 the influence of arm movements is very limited when the arms are not placed in front of the body were the greatest currents on the body surface are.
The gain in the upper half of the frontal half-sphere is –28dBi +0/-10dB depending on arm position.

B. Phantom size and sex

The difference between the three different body shapes simulated can be viewed in figure 4. The variation in the upper half of the frontal half-sphere is equivalent to the variation shown in figure 3, when the arm positions of the male phantom were adjusted.

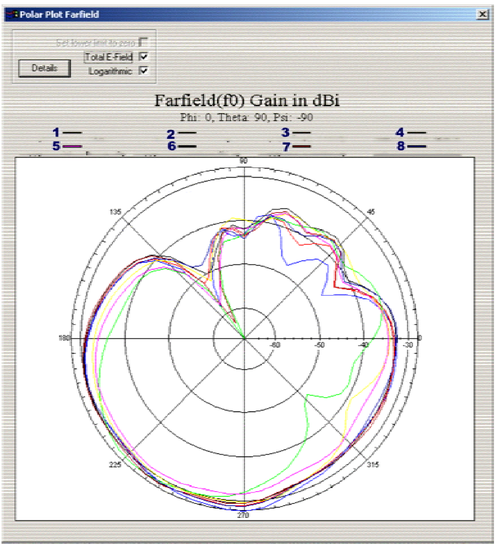

Figure 3. Plot of the gain patterns from the phantom for the eight arm positions in the sagittal plane. Superior of the phantom at 180^{O}, anterior at 270^{O}.

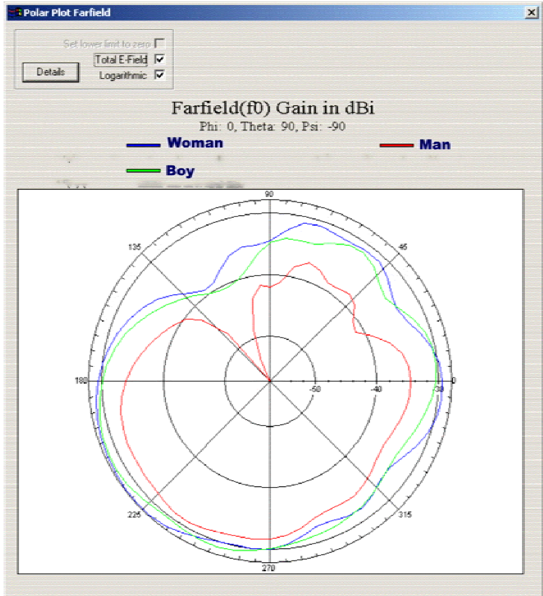

Figure 4. Plot of the gain patterns for three different phantoms in the sagittal plane. Superior of the phantoms at 180^{O}, anterior at 270^{O}.

IV. DISCUSSION

These are the early results from our simulations of the influence of the humans shape on a radio link from the inside to the outside. They show that the overall shape of the patient with the implant is as important as the position of the patients limbs. When calculating the link budget for MICS systems care must be taken not only to take account for the variability of the patients posture, but also for the variability in the physical built of the patient.

ACKNOWLEDGMENT

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REFERENCES

[1] J. G. Webster, ed., "*Design of Cardiac Pacemakers*", IEEE Press 1995, ISBN 0-7803-1134-5
[2] Code of Federal Regulations, USA, Title 47 Telecommunication, Part 95,
[3] POSER, Curious Labs Inc. 655 Capitola Road, Suite 200, Santa Cruz, CA 95062
[4] SEMCAD, Schmid & Partner Engineering AG, Zeughausstrasse 43, 8004 Zurich, Switzerland
[5] C. Gabriel. *Compilation of the Dielectric Properties of Body Tissues at RF and Microwave Frequencies*, Final report for the period 15 December 1994 – 14 December 1995, Prepared for AFOSR
[6] R. W. P. King and G. S. Smith, *Antennas in Matter*, the MIT Press, Cambridge, 1981