

PATCH ANTENNA ARRAY FOR THE TIME REVERSAL MICROWAVE HYPERTHERMIA

Trefná H., Persson M.

Department of Signal and Systems, Chalmers University of Technology, Göteborg, Sweden

Introduction

The E-field distribution of the applicator can be driven by changing amplitude and phase at the feed-points of the individual antennas. The E-field is typically focused by optimizing the SAR or the temperature distributions in the treated area. The time reversal method offers the another approach. The wave front of the source is propagated through the patient model from a virtual antenna placed in the tumour of the patient. The simulated radiated field is then "measured" using the computer models of the surrounding antenna system. The real antenna system is then transmitting the field in a time reversed order. It is the invariance of the wave equation under time-reversal in lossless media that enables optimal refocusing of the time-reversed signal at the original source.

In this paper, we investigate an antenna array design for time reversal based microwave hyperthermia. Our previous results, conducted in 2-D realistic anatomy models of neck and breast, have shown that the algorithm focuses EM energy better at high frequencies hence these fit well to treatment of small tumours. The level of absorbed energy is also strongly dependent on size of treated area through penetration depth of EM waves, thus selection of the frequency depends on treated area sizes as well as tumour volume. For this reason the broadband techniques is used in the patch antenna design.

Methods and Results

The proposed applicator is immersed in the matching liquid and consists of 8 to 12 identical triangular patch elements. The triangular patch antenna is chosen as the applicator element. By placing shorting wall the edge of a triangular patch antenna with a V-shaped slot, two resonant modes can be excited simultaneously and they can be coupled together to achieve the broadband operation. Two different models, with and without V-shaped slot respectively, are presented.

The matching liquid reduces hot spots and increases the impedance matching between biological tissue and the applicator. The relative permittivity ϵ_r of the matching liquid strongly affects the operating frequency of the antenna. Thus by changing of this parameter it is possible to tune the applicator to required optimal frequency. Both operating frequency and bandwidth of proposed models are similar, whereas SAR distributions on the surface of the phantom have different shapes. The bandwidth of the single element achieves 50%. The center frequency variates according to relative permittivity ϵ_r of the matching liquid from 350 MHz to 700 MHz for $\epsilon_r = 78$ and $\epsilon_r = 30$.

Conclusions

SAR distributions of both applicators are calculated for phantom and realistic anatomy model of the Head and Neck region. The results are compared with the applicator consisting of dipole elements. The performance indices show that application is encouraging for treatment of all tumour volumes and positions in this region. In comparison with the dipole applicator, the proposed applicator offers more favourable SAR distribution in the treated area. The single patch element may also be individually mounted in a planar array and can be use for the superficial hyperhermia.