Chapter 3
Application of Space-Time Signal Processing and Active Control Algorithms for the Suppression of Electromagnetic Fields

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ABSTRACT

Several studies have been conducted on the effects of radiation on the human body. This has been especially important in the case of radiation from hand held mobile phones. The amount of radiation emitted from most mobile phones is very small, but given the close proximity of the phone to the head it might be possible for the radiation to cause harm. The suggested approach involves the use of adaptive active control algorithms and a full space-time processing system setup (i.e. multiple antennas at both the transmitter and receiver side or MIMO), with the objective of reducing the possibly harmful electromagnetic radiation emitted by hand held mobile phones. Simulation results show the possibility of using the adaptive control algorithms and MIMO antenna system to attenuate the electromagnetic field power density.

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BACKGROUND AND INTRODUCTION

There have been several studies done, with conflicting results, on the effects of cell-phone radiation on the human body (Christensen, Schüz, Kosteljanetz, Poulsen, Thomsen & Johansen, 2004; Lai, 1998; Sienkiewicz & Kowalczuk, 2005). The amount of radiation emitted from most cell phones is very minute. However, given the close proximity of the phone to the head, it is entirely possible for the radiation to cause harm. If you want to be on the safe side, the easiest way to minimize the radiation you are exposed to is to position the antenna as far from your head as possible. Utilizing a hands-free kit, a car-kit antenna or a cell phone whose antenna is even a couple of inches farther from the head can do this most effectively. This chapter makes a contribution to that discussion by proposing a new approach employing adaptive active control algorithms combined with a Multiple-Input Multiple-Output (MIMO) antenna system to suppress the electromagnetic field at a certain volume in space. In addition, this system can be applied to other applications such as heavy electric machinery (electric engines, generators) and power lines or when performing maintenance and testing on high power radio transmitters (e.g., broadcasting or radar).

Active methods for attenuating acoustic pressure fields have been successfully used in many applications. In this chapter we investigate if these methods can be applied to an electromagnetic field in an attempt to lower the power density at a specified volume in space.

The cancelling out of a signal can be achieved by employing the principle of superposition. For example, if two signals are superimposed, they will add either constructively or destructively. The objective of our study is to investigate the possibility of applying adaptive active control algorithms with the goal of reducing the electromagnetic field power density at a specific volume using the superposition principle and MIMO antenna system. Initially, the application we evaluate is a model of a mobile phone equipped with one ordinary transmitting antenna and a number of actuator-antennas which purpose is to cancel out the electromagnetic field at a specific volume in space (e.g. at the human head) (Hult & Mohammed, 2004, 2005) using power level information obtained by an sensor antenna array. Later, we investigate the effects of the size and number of MIMO antenna elements on the performance of the system (Hult & Mohammed, 2004).

It is worth stressing at this point that the purpose of this MIMO system is not to improve the capacity or quality of transmission between the mobile unit and base station, but to predict the channel response or sense the radiated field which can then be controlled by using the active control algorithms. For this purpose, a class of algorithms called Filtered-X (Widrow, 1985; Johansson, 2000; Kuo, 1996), which are well known from the area of acoustic noise cancellation are employed and evaluated to assess their behaviour and performance in this electromagnetic type of environment. By constraining these adaptive algorithms we also try to make the total output power level transmitted by the antenna elements, locked to a predefined value. This power constraint is achieved through the use of a quadratic constraint on the active control algorithms (Hult & Mohammed, 2004).

The modelling of the antenna elements and the electromagnetic field calculations are performed using the simulation package FEMLAB (currently COMSOL Multiphysics) (COMSOL, 2006a, 2006b). This software is also used in combination with MATLAB to implement and test the adaptive algorithms used to control the electromagnetic field.

THE MODEL

The FEM Model

The application used in this chapter is a three-dimensional (3D) model of a physical system consisting of eight vertical antenna elements and of