DIGITAL BEAMFORMING IMPLEMENTATION OF SWITCH-BEAM SMART ANTENNA SYSTEM BY USING INTEGRATED DIGITAL SIGNAL PROCESSOR AND FIELD-PROGRAMMABLE GATE ARRAY

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ABSTRACT

Smart antenna technologies are emerging as an innovative way to meet the growing demand for more powerful, cost-effective and highly efficient wireless systems. If this system is implemented successfully, it could significantly improve the performance of wireless systems in terms of data rates, coverage and range. The best near-term application opportunities for smart antennas are wireless local area networks (WLANs), mobile DBS, WiMax, and cellular areas. The application targeted for this research is WiMax. Regardless of the application, hardware implementation of smart antenna is very challenging and complicated. Therefore, our focus is just on the beamforming and sidelobe cancellation for the WiMax downlink transmission. In downlink, we try to form and steer the beam according to the user location. Also, for more antenna radiation pattern optimization, the sidelobe cancellation is performed base on the chebyshev algorithm. In this respect, the system is firstly modeled by MATLAB software. After modeling, the algorithm is implemented in DSP. By using the Hardware-In-Loop facility of DSP, the comparison between hardware implementation and software modeling is performed. The results indicate that the digital beamforming and sidelobe cancellation are successfully implemented. At the next stage of the project, the signal management should be done before transmission to the expansion board. This management is necessary, in order to make data suitable for expansion board. After signal management the channels need to be split into sixteen antenna array elements by a means of FPGA board. To do so, the verilog code is written for programming the FPGA base on the signal which is come from DSP. The simulation results and measurement show that channels separation and synchronization is done successfully. By doing abovementioned procedure, the digital beamforming and sidelobe cancellation are implemented in baseband frequency.

ABSTRAK

Teknologi antena pintar telah muncul sebagai satu inovasi untuk memenuhi permintaan sistem tanpa wayar yang berkuasa tinggi, kos berpatutan dan berkecekapan tinggi yang sekarang semakin meningkat. Sekiranya sistem ini berjaya dilaksanakan, ianya dapat memperbaiki perlakuan sistem tanpa wayar dari segi kadaran data, liputan dan julatnya. Peluang penggunaan antenna pintar untuk masa terdekat ini adalah di rangkaian kawasan tempatan tanpa wayar (WLANs), DBS bergerak, WiMax dan kawasan bersel. Sasaran penyelidikan hanya tertumpu kepada WiMax. Di sebalik penggunaanya yang begitu meluas, pelaksanaan perkakasan untuk antena pintar adalah sangat mencabar dan rumit. Oleh itu, fokus kajian hanya melibatkan pembentukan alur dan pembatalan cuping sisi (sidelobe). bagi penghantaran sambungan hujung WiMax. Bergantung kepada penempatan pengguna, alur dibentuk dan dipandu untuk membolehkan sambungan hujung dibuat.. Juga, untuk mendapatkan bentuk sinaran antena yang optimum, pembatalan cuping sisi dilakukan berdasarkan kepada algoritma chebyshev. Pada mulanya, perisian MATLAB digunakan untuk mendapatkan model bagi sistem tersebut dan seterusnya algoritma dilakukankan dalam DSP. Dengan menggunakan kemudahan perkakasan ‘in-loop’ yang ada pada DSP, perbandingan antara pelaksanaan perkakasan dan pemodelan perisian dibuat. Keputusan menunjukkan bahawa pembentukan alur digit dan pembatalan cuping sisi berjaya dilaksanakan. Peringkat seterusnya bagi projek ini ialah memastikan bahawa pengurusan isyarat dibuat sebelum signal ini dihantar ke papan pengembangan. Ini adalah perlu untuk membolehkan data yang sesuai sahaja yang akan di hantar ke papan pengembangan tersebut. Setelah itu, saluran perlu dipisahkan kepada enam belas unsur tatasusunan antenna menggunakan papan FPGA. Untuk tujuan tersebut, kod verilog telah digunakan dalam pengaturcaraan FPGA berdasarkan isyarat yang diterima dari DSP. Keputusan penyelakuan dan pengukuran menunjukkan bahawa pemisahan saluran dan peyegerakan telah berjaya dibuat. Dengan melakukan prosedur yang telah dinyatakan di atas, pembetukan alur digit dan pembatalan cuping sisi boleh dilaksanakan dalam frekuensi jalur dasar.

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CHAPTER 1

INTRODUCTION

I. Introduction

The demand of smart antenna for mobile communications is increased recently and the main purpose for applying smart antennas is feasibility for increasing in capacity and efficiency. The application of smart-antenna arrays has been suggested for mobile-communication systems, to overcome the problem of limited channel bandwidth, satisfying a growing demand for a large number of mobiles on communications channels. Smart antennas, when used appropriately, help in improving the system performance by increasing channel capacity and spectrum efficiency, extending range coverage, steering multiple beams to track many mobiles, and compensating electronically for aperture distortion. They also reduce delay spread, multipath fading, co-channel interference, system complexity, bit error rate (BER).

1.2 Objectives

The project has three objectives. The first one is implementation of the digital beamforming by using the digital signal processor. More precisely, the first objective

is aim to implement the switched beam smart antenna for downlink transmission. According to the algorithm, the beam can steer from 0 to 180 degree in azimuth angle base on user direction with any resolution. Second objective of the project is to manage the processed signals in DSP board after digital beamforming and sidelobe cancellation to transmit them to the expansion board. Third and main objective of the project is to design and implementation of baseband channel separation and synchronization by using FPGA board.

1.3 Scope of works

The project involves both of software modeling and hardware implementation. It can be defined as three phases; in the first phase of the project the TMS320C6713B DSP board is used for beamforming. C and Code Composer Studio software is applied for programming this board. Also MATLAB software is chosen for modeling because of some facilities which is provided a Link for Code Composer Studio Development Tools which is let to use MATLAB functions to communicate with Code Composer Studio and with information stored in memory and registers on a target. With this links the transferring information to and from Code Composer Studio. In the second phase of the project FPGA board is applied for performing the channel separation and synchronization and Quartus II software is used for programming this board. In the third phase of the project integration of DSP and FPGA is done by programming the EDMA and McBSP of DSP.

1.4 Thesis outline

This thesis is organized as follows. In Chapter 2, background information and basic principle in smart antenna system is explained. In addition, a brief introduction about switch-beam smart antenna is given. In Chapter 3, digital beamforming by using

DSP board is fundamentally discussed. Moreover, the hardware structure of DSP board shortly reviewed. Also, the model for beamforming is illustrated. In Chapter 4, after FPGA hardware description, channel separation for the project is explained. In this respect, FPGA programming and pin assignment are reviewed. In Chapter 5, integration of DSP and FPGA is discussed and also the model of system which is used in this project is given. In Chapter 6, simulation results for digital beamforming and the channel separation are discussed. In this chapter a comparison between hardware and software simulation results is made between DSP and MATLAB software. At the end of this chapter, final conclusion of the work is presented, and some possible future works are suggested.

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