BEAMFORMING NETWORK USING SWITCH LINE PHASE SHIFTER

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ABSTRACT

The rapid progresses in radio technology is creating new and improve service at lower cost, which results in increases in air-time usage the number of subscribers. Wireless revenues are currently growing between 20% and 30% per year, and these broad trends are likely to continue for several years. Wireless system designer are faced with a number of challenges one of them is interference. In indoor wireless communication environments, however, reflections from walls, the floor, or the ceiling cause many signal propagation paths and delays, consequently degrading the received signal quality and receiver performance. One of possible solutions is a beamforming technique to direct antenna's main beam towards a transmitter and to direct nulls towards interference or multipath signal directions, such that incoming signals from reflection paths are suppressed while increasing the antenna gain for a desired signal direction. This project shows the steps of designing beamforming network by implement an active component. It was designed to operate at 2.4GHz for WLAN application. The switch line phase shifter is chosen as way to build a beamforming network. This was designed to provide four different progressive phase shifts -45^{o}, $+135^{o}$, -135^{o}, $+45^{o}$ that coupled to an antenna array. It is made up from two 90^{0} hybrid coupler, eight phase shifters and eights PIN diode each component is designed and simulated using Agilent ADS software and fabricated on FR4 board. This network is then combined with linear antenna arrays with the aim to produce four independent beams at four different directions. The obtained results shows that 4 beams are generated by rectangular patch antenna array, it is produced half power beam width for each beams about 30^{o} and manage to cover 120^{o} area. Finally, it can be concluded that the objective of this project to design beamforming was achieved.

ABSTRAK

Perkembangan yang pesat dalam teknologi radio telah mencipta sesuatu yang baru dan penambahbaikan perkhidmatan pada kos yang rendah, menghasilkan peningkatan dalam penggunaan dan jumlah pengguna pada masa kini. Pendapatan daripada pengunaan sistem wayarles meningkat antara 20% dan 30% setiap tahun, dan tren ini dijangka terus meningkat untuk beberapa tahun. Pereka sistem wayarles menghadapi beberapa cabaran dan diantaranya ialah gangguan. Dalam persekitaran komunikasi wayarles tertutup, pantulan daripada dinding, lantai atau siling menyebabkan perambatan isyarat menjadi lengah mengakibatkan penurunan kualiti isyarat penerima dan prestasi penerima. Satu daripada penyelesaiannya adalah menggunakan teknik *Beamforming* untuk mengarahkan alur utama antena kearah pemancar dan sifar kearah gangguan atau isyarat atau dari pelbagai arah, iaitu isyarat yang datang dari pantulan akan direndahkan disamping menambah gandaan antena pada isyarat yang dikehendaki. Projek ini menunjukkan kaedah rekabentuk rangkaian *Beamforming* dengan menggabungkan bersama beberapa komponen aktif. Ia telah direka pada frekuansi 2.4 GHz untuk disesuaikan dengan aplikasi *'WLAN'*. Suis garis penganjak fasa dipilih untuk membina rangkaian *Beamforming*. Ia direkabentuk untuk menghasilkan empat nilai anjakan fasa progesif yang berbeza iaitu -45°, +135°, -135°, +45° yang digandingkan dengan antena tatasusun. Ia diperbuat daripada dua komponen gandingan hibrid 90°, lapan penganjak fasa dan lapan PIN diode dimana setiap komponen direka dan disimulasi menggunakan perisian Agilent ADS dan difabrikasi ke atas papan litar FR4. Rangkaian ini kemudiannya digabung dengan antena tatasusun dengan tujuan untuk menghasilkan empat alur yang bebas pada setiap arah. Keputusan yang diperolehi menunjukkan 4 alur dijana daripada antenna tampal tatasusun, ia menghasilkan kuasa separuh alur dimana setiap alur adalah 30^0 dan berkebolehan untuk menutupi kawasan 120^0. Akhir sekali, dapat disimpulkan bahawa objektif projek ini untuk merekabentuk *Beamforming* tercapai.

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

This dissertation proposes the development of beamforming network using switch line phase shifter. In this first chapter, the background of the project is discussed providing the problem statement, objective, scope of the study and project contribution.

1.1 Project Background

The radio age began over 100 years ago with the invention of the radio telegraph by Guglielmo Marconi and the wireless industry is now set rapid growth. The rapid progresses in radio technology is creating new and improve service at lower cost, which results in increases in air-time usage and the number of subscribers. Wireless revenues are currently growing between 20% and 30% per year, and these broad trends are likely to continue for several years.

Multiple access wireless communications is being deployed for both fixed and mobile application. In fixed application, the wireless network provides voice and data for fixed subscribers. Mobile networks offering voice and data services can be divided into two classes: high mobility, to serve high speed vehicle-borne user, and low mobility, to serve pedestrian user. Wireless system designer are faced with a number of challenges. These include the limited availability of radio frequency spectrum and complex time-varying wireless environment (fading and multipth) [1]. Multipath is a condition which arises when transmitted signal undergoes reflection from various obstacles in the propagation environment which cause the multiple signals arrive from different directions [2]. The result is degradation in signal quality when they are combined at the receiver due to the phase mismatch. Co-channel interference arises due to frequency reuse in wireless channels. When multiple antennas are used, the differentiation between the spatial signatures of the desired signal and co-channel signal can be exploited to reduce the interference. [1]. The solution can be solved by using smart antenna system. Smart antenna can increase the coverage and capacity of a system. In multipath channels they can increase the maximum data rate and mitigate fading due to cancellation of multipath components. Adaptive antenna can also be used for direction finding, with application including emergency services and vehicular traffic monitoring [1].

The smart antenna system used beamforming to create the radiation pattern of the antenna array by adding constructively the phase of the signal in the direction of the targets. The beamforming has two types. It described in chapter 2.

As the implementation of beamforming network in smart antenna system for wireless LAN. So far, most studies had done on the simulation to observe the performance of beamforming network by using butler matrix [3], [5], [10]. It has been proven that the butler matrix is capable to give constant phase (β) with different input [4, 5].

With the motivation gained from the simulation that has been done in literature [6-9], this project aims to produce physical implementation of beamforming network by using Switched Line phase shifter.

1.2 Problem Statement

By applying beamforming network by using passive component, it is suffering from the massive structure involved. This disadvantage can be overcome by using beamforming network using Switched Line phase shifter. Thus far, a few studies have been done on the beamforming network using butler matrix [3-4]. Which are in terms of passive beamforming and using switch stage before beamforming network. The main task here is to design a beamforming network using Switched Line phase shifter so that it will give the same result, but with small size and design switch to control which port will radiate.

1.3 Objective

The objective of this research is to design, simulate, fabricate and measured the active Beamforming network at 2.4 GHz using switched line phase shifter.

1.4 Scope of Study.

The first part of this study is to understand the concept of smart antenna as well as beamforming network. The function of the phase shifter as well as switch line phase shifter.

The second part of the study, the beamforming is designed and simulated .At this stage, the fundamental of phase shifter, switch line phase shifter was explained. After that, the antenna array and beamforming is connected and simulated.

The third part is the fabrication and measurement of the design. At this stage, related equipment such as UV Light Equipment, Spectrum Analyzer, and Signal Generator at 2.4 GHz are expected to be used for measurement set up.

The last part of the study is the analysis part. It is expected that during the study, the measured result and the theoretical should be compared and observed.

1.5 Project Contribution

The application of beamforming is not limited to the smart antenna system only, but also can be implemented in most communication system. Most studies have been done on the improvement of beamforming network [4-5],[10-11]. This dissertation will give a basic idea about the integration active elements in beamforming network and the performance is compared with passive Beamforming network. Previous works show that the Beamforming network using butler matrix has a bigger size compared to active Beamforming network.

1.6 Organization of Thesis

The thesis is divided into five chapters. The first chapter is Introduction, which provides information regarding the project background, objectives, scope of project, project contribution and the layout of the thesis.

The second chapter is literature review. In this chapter, the concept of smart antennas, beamforming network, related previous works are thoroughly explained, concept of phase shifter and switch line phase shifter.

The third chapter is methodology, in which the methods employed in this project will be explained. The design procedures and simulation results for this project will be presented in detail. The simulation results and subsequent analysis will be discussed. Prototype fabrication and measurement setup are also presented.

Results and analysis of the measurement is presented in Chapter 4. The comparison between simulations, measurement and computation result have been explained in this chapter.

The last chapter is conclusion and future work. This chapter will conclude the findings of the project and provide recommendations for future work.

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