BEAMFORMING NETWORK DESIGN BY USING BLASS MATRIX

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To beloved father and mother

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ABSTRACT

This project is to design Blass Matrix beamforming network. Blass Matrix is the method where to solve the problem multiple transmission line and the interferences also to increase the capacity channel. With the growing technology of wireless local area network (WLAN), the demand for wireless communication to increase its capacity increases as well. As the number of users increase, the co-channel interference fading also increases. This reduces the transmission quality in wireless systems and limits their performances. The beamforming network is a network that controls the phases and amplitudes of the excitation current for smart antennas. A signal processor will control which port of the beamforming network is used to feed or receive signals while the beamforming network will feed the signal to an array of antennas. The Blass matrix enables the beamforming network to be explained through a matrix expression. The Blass matrix is simple and easy to fabricate. The design components included hybrid coupler and phase shifter. This project used the Microwave Office 2006 to simulate and design the hybrid coupler and Blass Matrix beamforming network. At the end, the design has been fabricated on the FR4 board microstrip. The magnitude of design Blass Matrix for port 1 noticed that different between each port were more less -3dB. The phase different was more less 10° for each output when referred to the port 1. The size of the layout was 28.59 cm in length and 18.66 cm in width.

ABSTRAK

Projek ini adalah untuk mereka jaringan pembentuk alur Matriks Blass. Matriks Blass adalah satu kaedah dimana untuk menyelesaikan masalah garis penghantaran yang banyak dan interferences juga meningkatkan kapasiti rangkaian. Dengan perkembangan kemajuan dalam teknologi jaringan setempat wayarles (WLAN), keperluan untuk komunikasi wayarles meningkatkan kapasiti turut meningkat. Apabila bilangan pelanggan bertambah, pemudaran interferens saluran sama turut bertambah. Ini akan menyebabkan penurunan dalam kualiti pemancaran dalam sistem wayarles dan seterusnya menghadkan kebolehan sistem. Jaringan pembentuk alur adalah jaringan yang mengawal fasa dan amplitud arus pengujaan untuk antena bijak. Satu pemproses isyarat akan mengawal pemilihan pangkalan yang akan digunakan oleh jaringan untuk menghantar atau menerima isyarat manakala jaringan pembentuk alur akan menyuap isyarat kepada satu rangkaian antena. Matriks Blass membolehkan jaringan pembentuk alur diterangkan melalui ekspresi matriks. Matriks Blass mudah difahami dan difabrikasi. Komponen yang terlibat untuk mereka Matriks Blass adalah pengganding hibrid dan anjakan fasa. Projek ini menggunakan Microwave Office 2006 untuk simulasi rekaan pengganding hibrid dan jaringan pembentuk alur Matriks Blass. Di akhir sekali, rekaan ini akan difabrikasi di atas papan FR4 microstrip. Magnitud pada rekaan Matrik Blass untuk port 1 menyatakan bahawa perbezaan antara setiap port adalah lebih kurang -3dB. Beza fasa setiap keluaran pada port 1 adalah lebih kurang 10°. Saiz rekaan Matrix Blass adalah panjangnya 28.59 cm dan lebarnya 18.66 cm.

CONTENTS

LIST OF TABLE

LIST OF FIGURE

LIST OF ABBREVIATIONS

MIMO	Multiple Input Multiple Output
WLAN	Wireless Local Area Network
CDMA	Code Division Multiple Access
BER	Bit Error Ratio
RF	Radio Frequency
WAP	Wireless Application Protocol
BFN	Beamforming Network
SNR	Signal Noise Ratio
LBMBFN	Lossy Blass Matrix Beamforming Network
ULA	Uniform Linear Array
BMBFN	Blass Matrix Beamforming Network
PCB	Printed Circuit Board
EM	Electromagnetic
UV	Ultra Violet
$^\circ$	Degree
c	Coupling Coefficient
Z_o	Impedance
C	Coupling
D	Directivity
I	Isolation
50Ω	Characteristic Impedance
w	Wavelength
H	Height

ε_{eff}	Effective Dielectric
λ_g	Waveguide
l	Length
3D	Three Dimensions
mm	Millimeter
dB	decibel
cm	centimeter
MHz	Megahertz

LIST OF APPENDIX

CHAPTER I

INTRODUCTION

1.1 Project background

As the demands and services of wireless communications increase explosively, the methods to increase the channel capacity of wireless communications have been greatly demanded to efficiently use the limited radio resource. Smart antenna technology seems to be a good candidate to resolve the issue.

The topic of multi-beam smart antenna array has been receiving much attention due to its wide range of applications. Different multi-beam antenna prototypes are implemented for the applications in base stations to improve the quality of transmission and enhance the cellular capacity, range, and coverage because the antenna array is capable of pointing to desired targets automatically in real time. Moreover, the multipath fading and interferences phenomenon in communications systems can be solved using switched beam antenna array for rejecting interference signals and increasing desired signal level.

In many antenna array applications, the need for multiple beams has arisen. In modern cellular satellite mobile systems, for instance, signals coming from mobile stations towards the base station change their directions continuously. A smart antenna system consists of three main parts, the antenna array, the beam forming network and the signal processor.

The beamforming network is the network that controls the amplitude and phases of the signal that is radiated by the antenna array. There are many ways to implement the beamforming network, including microwave lenses, waveguides. Many types of matrix networks can be used to feed the antenna arrays, for example Butler matrix, Blass matrix, Nolen Matrix, tapped delay-line-matrix, RC matrix, and mixer matrix. In this project, the Blass matrix concept will be used to design a beamforming network that feeds the antenna array. This is because it is the most simple and only used hybrid coupler to implement a beamforming network [1].

1.2 Objective

The objective of this project is to develop, design, simulate and fabricate the beamforming network by using 4x4 Blass Matrix at 2.4GHz using microwave office. The Blass Matrix was design by using microstrip board (FR4).

1.3 Problem statement

There are three main problems can be solving from this method and there are multiple transmission signal where the signal can transmit for many channel. Then, multiple input multiple output (MIMO) is one of the techniques which is new and widely explore by the researchers. MIMO concept can achieve by implement Beam-forming Network into the system. When using two microwave in the same time and the frequencies same so that the signal will redundant. This will lead the interference. It is also to increase network capacity [1].

1.4 Scope of Work

The implementation of this project requires understanding the concept of beam forming network for smart antenna system. The beamforming network will be design by using Blass Matrix method. The Blass Matrix beamforming network will design and simulate using microwave office software. The Butler matrix will then be fabricated. The results obtained from the fabricated beamforming network would be analyzed and compared with the simulation results. This project would cover designing a beamforming network that operates at 2.4 GHz for wireless local area network (WLAN) applications.

1.5 Report Structure

The beamforming network is the network that controls the amplitude and phases of the signal that is radiated by the antenna array. There are many ways to implement the beamforming network, including microwave lenses, waveguides. Many types of matrix networks can be used to feed the antenna arrays, for example Butler matrix, Blass matrix, Nolen Matrix, tapped delay-line-matrix, RC matrix, and mixer matrix.The objective of this project to design the Blass Matrix Beamforming Network where 4x4 input and output at 2.4 GHz. This project using Microwave Office to design the circuit and fabricate using FR4 board microstrip. There are three problems can be solving from this method and there are multiple, multiple input multiple output (MIMO) is one of the techniques which is new and widely explore by the researchers. MIMO concept can achieve by implement Beam-forming Network into the system and lastly when using two microwave in the same time and the frequencies same so that the signal will redundant. This will lead the interference. It is also to increase network capacity. The implementation of this project requires understanding the concept of beam forming network for smart antenna system. The beamforming network will be design by using Blass Matrix method. For the report structure, explain about the summary of the contents at Chapter 1.

CHAPTER II

LITERATURE REVIEW

2.1 MIMO (Multiple Input Multiple Output)

Multiple-input multiple-output (MIMO) antenna techniques can achieve huge capacity gains without requiring extra bandwidth. The primary challenges to apply the MIMO techniques lines in the implementation complexity and the possible side effect of reliability performance degradation. Many research efforts, especially the physical layer techniques, have been reported in the literature to resolve these issues. Differently, this talk provides a network perspective to implement the MIMO techniques in wireless scheduling systems [2]. MIMO (Multiple-Input Multiple-Output) technique [3-6] have been developed to increase the spectral efficiency. MIMO can obtain the spatial diversity gain by using channel matrices for recovering transmitted data streams of CDMA BSs. Presented MIMO does not requires space-time coding, receivers only decode by multiplying the transposed channel matrices to received data vectors.

However, for general application scenes, the row vectors of MIMO channels' matrix are not orthogonal each other, the MIMO system can only keep the channel matrix to nonsingular, which leads to great co-channel interference existing in the spatial MIMO channels allocated to mobile stations, and the caused BER degradation cannot satisfy the communication specifications. The MIMO channels are not highly independent in practical situations, which lead to a great channel interference for the spatial multiplexing scheme. To solve the problem, the only way of the presented MIMO CDMA systems is to increase the number of antennas of the transmitters and receivers of CDMA systems, while it will increase the implementation complexity and cost of CDMA systems also [7].

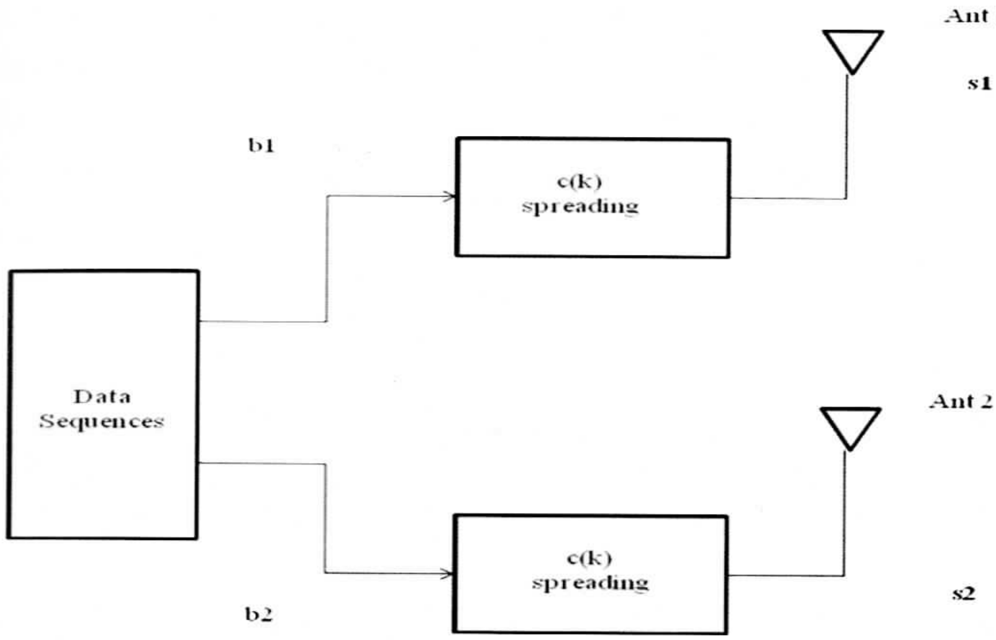

Figure 2.1: Block Diagram of the MIMO transmitter for downlink transmission

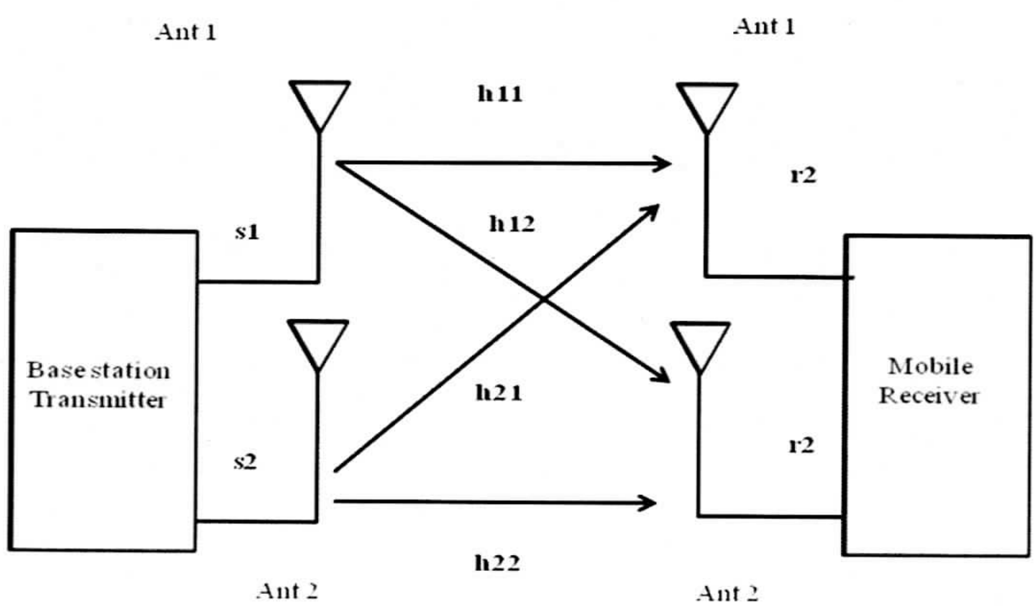

Figure 2.2: The MIMO channel

2.2 Smart Antenna

As demand for wireless communications continues to grow, wireless operators face increasing network capacity challenges. Smart antenna technology currently provides a viable solution to capacity-strained networks and lends itself to the migration to high speed networks. The primary advantages of using smart antennas in wireless networks are to increase the number of voice calls and the amount of data throughput, to avoid interference and to ease network management [8]. A basic understanding of smart antenna technology provides an explanation of the application of smart antennas in wireless communications.

The basic principle behind smart antennas is to control or reduce interference. Typically, this is accomplished through the use of narrow beams at the base site, both on the forward and reverse links. A smart antenna system combines multiple antenna elements with signal processing capability to optimise its radiation pattern and reception pattern in response to the signal environment [8]. The transmit and receive patterns are automatically updated as the subscriber moves through the cell or as signal conditions change.

Smart antennas use an array of antenna elements connected to either an analogue or digital combining network. The size of the array and the number of elements determine the maximum gain and minimum beamwidth of the antenna array. Smart antennas form beams by adjusting the amplitudes and phases of the signals received from each of the antenna elements so that, when added together, they form the desired beam. This process is called beamforming [8]. Beamformers can create a wide range of beams: scanned beams, multiple beams, shaped beams, and beams with steered nulls. There are two primary classes of smart antenna systems, switched beam systems and adaptive systems.

2.2.1 Switched-beam Smart Antenna Systems

Switched-beam systems consist of multiple narrow beams, the best of which is used to serve the subscriber as it moves through the coverage of the cell. Adaptive systems can form a number of different patterns that are adjusted to track the subscriber user [8]. Switched-beam systems are more economical to implement, requiring only a static beamforming network, RF switch and control. A separate beam selection is continuously made for each subscriber unit as it moves through the cell's coverage area. Figure 2.3 shows the structure of a switched multiple-beam antenna.

This method is considered as an extension of the current sectorization scheme. The switched-beam approach further subdivides the macro-sectors into several micro-sectors [9]. Each micro-sector contains a predetermined, fixed beam pattern, with the greatest gain placed in the centre of the beam. When a mobile user is in the vicinity of a micro-sector, the switched-beam system selects the beam containing the strongest signal.

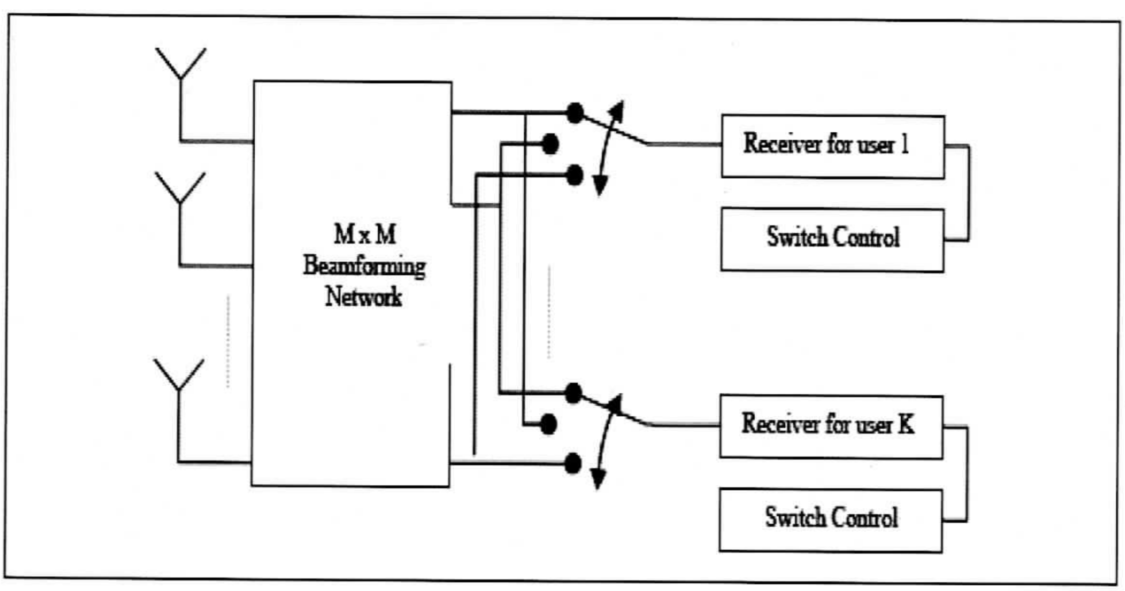

Figure 2.3: The structure of a switched multiple-beam antenna [9]