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FACULTY OF ENGINEERING
Electronics and Communication Engineering Department

Design and Analysis of Advanced MIMO Techniques for the Next Generating Wireless Communication Systems

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STATEMENT

This dissertation is submitted as a partial fulfillment of the degree of Doctor of Philosophy in Electrical Engineering (Electronics and Communications Engineering) Faculty of Engineering, Ain Shams University.

The work included in this thesis was carried out by the author at the Electronics and Communications Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis was submitted for a degree or a qualification at any other university or institution.

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ABSTRACT

Design and Analysis of Advanced MIMO Techniques for the Next Generating Wireless Communication Systems

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Demands on broadband data service are increasing dramatically each year. Following terrestrial trends, satellite communication systems have moved from the traditional TV broadcasting to provide interactive broadband services even to urban users. The cellular and land-line networks are mainly designed to deliver broadband services to metropolitan and large urban centers. However, the High Throughput Satellite (HTS) technology has the advantage of covering these demands over wide geographically regions, including areas without backbone connectivity (maritime, aeronautic, rural, etc..) in addition to high dense populated areas with an existing communication infrastructure, as an alternative competitive solution. However, to stay competitive with economical terrestrial solutions in urban areas, it is necessary to reduce the cost per transmitted bit by increasing the capacity of the satellite systems.

Geostationary HTS is an evolution of the conventional spacecraft and it is a satellite system that uses a large number of geographically spot beams distributed over a specified service area. Present HTS technology employs the frequency reuse technique to the spot beam approach in order to support high overall throughput. The current design can increase the satellite capacity to be in hundreds of gigabits per second (Gbps) compared to a few Gbps for Fixed Satellite Services (FSS) satellites.

This dissertation takes the challenge of achieving higher capacities - towards Terabits/s HTS - by developing a new methodology that based on applying an Orthogonal-CDMA technique on the multibeam HTS system. Consequently, the proposed design can efficiently utilize the overall satellite bandwidth for each spot beam while the present technology limits the spot beam bandwidth to a portion of the available satellite bandwidth, depending on the frequency reuse factor. Therefore, the proposed approach can achieve a superior satellite capacity due to the huge increase in the supported data rates per beam and then, it preserves a higher throughput gain for each user in any spot beam. Moreover, the offered design in the thesis mitigates the Co-channel Interference (CCI) which currently limit the performance of the existing technology. Therefore, the proposed idea can efficiently outperform the present frequency reuse technology, providing a higher system capacity and multiple times of the current throughput, which approaches Terabits/s.

The contribution of this thesis focuses on three main topics: 1) design of a new resource allocation methodology based on an orthogonal coding technique for the satellite multibeam configuration to efficiently enhance the capacity of next generation HTS systems, 2) provide a coding design realization proposal with a maximum number of codes and minimum number of bits, and 3) developing models for both capacity enhancement and performance investigation under realistic channel conditions.

The new resource allocation strategy in this dissertation is launched under a title called *Coded Beam High Throughput Satellite* (CB-HTS). It proposes orthogonal coding designs over a multi-spot-beam antenna, which can be realized by using a feed horn array per satellite reflector, acts as a massive MIMO configuration. The designed orthogonal coding scheme has the capability to isolate spot beams and preserves polarization resource for further capacity increase as well. For a prototype system that covers Europe with broadband service, as numerical results demonstrate, the proposed methodology introduces a significant performance gain and throughput enhancement over the existing state-of-art schemes in terms of bit error rate performance, user data rates, traffic channels, system throughput and capacity, by coding all user data that belongs to a specific beam with an orthogonal sequence and exploiting the polarization duality transmission. The proposed CB-HTS has compatibility with the existing system using traditional user access inside beams using Digital Video Broadcasting standards (DVB-S2/DVB-S2X). The system performance is investigated under different parameters of both standards. In addition, a performance comparison is presented. Finally, some open topics are highlighted as the possible future research directions.

Key Words: High-Throughput Satellites; Multibeam satellites; Coded-Beams HTS; Walsh coding; CDMA Satellites**.**

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TABLE OF CONTENTS

List of Figures xi

List of Tables xiv

List of Abbreviations xv

List of Symbols xviii

CHAPTER 1 Introduction

1.1 Introduction 1

1.2 Previous Work 1

1.3 Problem Statement 3

1.4 Accomplishment and Contribution 3

1.5 Thesis Organization 4

CHAPTER 2 High Throughput Satellite Technology

2.1 Introduction 5

2.2 Broadband Satellite Systems 5

2.2.1 Multibeam Satellite Systems 7

2.2.2 Interference Management Techniques in Broadband Satellite Systems 9

2.2.2.1 Solutions in the Forward Link 9

2.2.2.2 Solutions in the Return Link 11

2.3 Characterization of Terabit/s Satellite, the Next Generation of HTS Systems 13

2.3.1 System Definition 14

2.3.1.1 Regulatory matters 14

2.3.1.2 Frequency plan 15

2.3.1.3 User beams and gateways 16

2.3.1.4 Air Interface performances 16

2.3.1.5 Payload architecture 16

2.3.1.6 Platform and launchers envelope 17

2.3.1.7 System performance analysis: capacity and availability 17

2.3.2 Main Challenges 17

2.3.2.1 Challenge 1 - Bandwidth scarcity 18

2.3.2.2 Challenge 2 – Large gateway network....18
2.3.2.3 Challenge 3 – Large payload mass footprint; 18
2.3.2.4 Challenge 4 - Adequacy of the provided capacity to the user needs....19
2.4 Code Division Multiple Accessing in satellite communication systems....19
2.4.1Popular CDMA Spreading Codes....21
2.4.1.1 Orthogonal Walsh Codes....21
2.4.1.2 Gold Codes....22
2.4.1.3 Kasami Codes....22
2.4.2CDMA Capacity....23
2.5 Higher Dimensional Hadamard Matrices....24
2.5.1 Higher Dimensional orthogonal design....25
2.5.2 Example of Higher Dimensional Hadamard matices....26
2.6 Summary....28
CHAPTER 3 The Proposed System of Coded-Beams High Throughput Satellites
3.1 Introduction....29
3.2 Motivation to Coded-Beams High Throughput Satellite....29
3.3 Coded-Beams High Throughput Satellite System....31
3.4 Analysis of CB-HTS resource allocation system Throughput capabilites....35
3.5 CB-HTS Numerical Results and Analysis....38
3.5 Summary....41
CHAPTER 4 Capacity Enhancement For CB-HTS System
4.1 Introduction....42
4.2 Problem Outline....42
4.3 General description of the technical characteristics of the CB-HTS with DVB-S2 and DVB-S2X extensions standard....44
4.4 Standards and parameters used in High Throughput Satellite....45
4.5 Optimal parameter values for Coded Beam Satellite data rates and number of channels based on DVB-S2/S2X parameters....48
4.5.1 Results Investigation for Proposed CB-HTS satellite with Standard DVB-S2....48
4.5.2 Results Investigation for Proposed CB-HTS satellite with Standard DVB-S2X....52

4.5.3 Demonstration of the Numerical results of the Proposed CB-HTS satellite....57

4.6 Comparison of proposed Coded Beam Satellite data rates and number of channels based on DVB-S2/S2X parameters with state-of-the art 63

4.6.1 Investigation of supported number of channels by the Proposed CB-HTS satellite.....63

4.6.2 Number of supported channels comparison for Proposed CB-HTS satellite with Standard DVB-S2 and [84].....64

4.7 Summary.....66

CHAPTER 5 Analysis And Performance Assessment of CB-HTS System A Path Toward Terahertz Communications

5.1 Introduction.....67

5.2 System Model.....68

5.3 Numerical Results and Analysis.....72

5.3.1 Results Investigation for Proposed CB-HTS satellite using Standard DVB-S2 as users multiple access technique 72

5.3.1.1 Traffic per beam offered by proposed CB-HTS satellite system using DVB-S2 standard as users multiple access technique 72

5.3.1.2 Performance of proposed CB-HTS satellite system using DVB-S2 standard as users multiple access technique 74

5.3.2 Results Investigation for Proposed CB-HTS satellite using Standard DVB-S2X as users multiple access technique 76

5.3.2.1 Traffic per beam offered by proposed CB-HTS satellite system using DVB-S2X standard as users multiple access technique 76

5.3.2.2 Performance of proposed CB-HTS satellite system using DVB-S2X standard as users multiple access technique 78

5.3.3 Signal to interference plus noise Investigation of the Proposed CB-HTS satellite.....80

5.4 Summary.....80

CHAPTER 6 Coclusion and Future Work

6.1 Conclusions.....81

6.2 Suggestion for Future Work.....83

APPENDIX.....85

EXTRACTED PAPER.....95

REFERENCES.....96

LIST OF FIGURES

Page

Figure 2.1: Architecture of a traditional broadband satellite system. 7

Figure2.2: The schematic of the multibeam satellite antennas that generate multiple spot beams 8

Figure 2.3: Architecture of a multibeam satellite system with 4-color reuse scheme 10

Figure 2.4: Fractional Frequency Reuse Scheme[18]. 12

Figure 2.5: Frequency plan for typical [24]. 17

Figure 2.6: A functional display of the CDMA process [31]. 22

Figure 2.7: 2^3 Hadamard matrix of propriety (2.2.2) and a three-dimensional matrix of propriety (2.2.3) (a) proper. (b)Improper.[46]. 28

Figure 2.8: Paley cube of dimension 3, ■minus one , □ plus one [46]. 29

Figure 3.1: Illustration of a cluster with coded beams. 31

Figure 3.2: Functional block diagram of CB-HTS system based on DVB-S2 System. 34

Figure 3.3: User beam layout . 38

Figure 4.1: Generic block diagram of the forward link of Coded-Beam broadband HTS satellite system based on DVB-S2 and DVB-S2X extensions 45

Figure 4.2: Frequency Plan – coded-beams HTS system with the two Scenarios 47

Figure 4.3: Data rate [MBps] of 1050 MHz CB-HTS satellite with Standard DVB-S2 , QPSK modulation and Normal FEC frame size for different filter roll-off factors and FEC rates. 49

Figure 4.4: Data rate [MBps] of 1050 MHz CB-HTS satellite with Standard DVB-S2, QPSK modulation and short FEC frame size for different filter roll-off factors and FEC rates. 49

Figure 4.5: Data rate [MBps] of 1050 MHz coded-beam Satellite with Standard DVB-S2 , QPSK modulation for Normal vs. Short FEC frame size with different filter roll-off factor and FEC rate. 50

Figure 4.6: Data rate [MBps] of 1050 MHz CB-HTS satellite with Standard DVB-S2 and normal FEC frame size for different filter roll-off factors , MODCODEs 51

Figure 4.7: Data rate [MBps] of 1050 MHz CB-HTS satellite with Standard DVB-S2 and short FEC frame size for different filter roll-off factors , MODCODEs and FEC frame size 51

Figure 4.8: Spectral efficiency [Bit/s/Hz] of 1050 MHz CB-HTS satellite with Standard DVB-S2 and QPSK modulation for different FEC frame size. 52

Figure 4.9: Spectral efficiency [Bit/s/Hz] of 1050 MHz CB-HTS satellite with Standard DVB-S2 and modulation of 8PSK,16-APSK and 32-APSK for different FEC frame size 52

Figure 4.10: Data rate [MBps] of 1050 MHz CB-HTS satellite with Standard DVB-S2X , QPSK and 8APSK modulation and Normal FEC frame size for different filter roll-off factors, and FEC rate. 53

Figure 4.11: Data rate [MBps] of 1050 MHz CB-HTS satellite with Standard DVB-S2X ,16APSK modulation and Normal FEC frame size for different filter roll-off factors, and FEC rate. 54

Figure 4.12: Data rate [MBps] of 1050 MHz CB-HTS satellite with Standard DVB-S2X with higher order modulation and Normal FEC frame size for different filter roll-off factors and FEC rate. 55

Figure 4.13: Data rate [MBps] of 1050 MHz CB-HTS satellite with Standard DVB-S2X and Short FEC frame size for different filter roll-off factors and MODCODEs 55

Figure 4.14: Spectral efficiency [Bit/s/Hz] of 1050 MHz CB-HTS satellite with Standard DVB-S2X ,Normal FEC frame size ,for QPSK,8-APSK and 16-APSK modulation of different FEC rates. 56

Figure 4.15: Spectral efficiency [Bit/s/Hz] of 1050 MHz CB-HTS satellite with Standard DVB-S2X ,Normal FEC frame size ,for APSK modulation of order 4,5,6,7,8 with different FEC rates. 56

Figure 4.16: Spectral efficiency [Bit/s/Hz] of 1050 MHz CB-HTS satellite with Standard DVB-S2X ,Short FEC frame size for different filter roll-off factors , MODCODEs. 57

Figure 4.17: Number of supported SDTV using MPEG-2 encoding for proposed scheme, scenario I with values obtained in [84] with the DVB-S2 Standard. 64

Figure 4.18: Number of supported SDTV using MPEG-4 encoding for proposed scheme, scenario I with values obtained in [84] with 65

the DVB-S2 Standard.

Figure 4.19: Number of supported HDTV using MPEG-2 encoding for proposed scheme, scenario I with values obtained in [84] with the DVB-S2 Standard. 65

Figure 4.20: Number of supported HDTV USING MPEG-4 encoding for proposed scheme, scenario I with values obtained in [84] with the DVB-S2 Standard. 66

Figure 4.21: Number of supported UHDDTV using HEVC encoding for proposed scheme, scenario I with values obtained in [84] with the DVB-S2 Standard 66

Figure 5.1: CB-HTS strategy, outer orthogonal coding resource management and inner multiple accessing technique. 68

Figure 5.2: Uplink spectrum organization for CB-HTS strategy, B sat is the total satellite bandwidth available in each beam 69

Figure 5.3: Uplink spectrum organization for dual-polarized CB-HTS strategy, V and H are the vertical and horizontal polarization respectively. 71

Figure 5.4: Offered Traffic channels per sub-band (Lc) by CB-HTS satellite with Standard DVB-S2 versus E_b/N_o, for different modulation techniques and Normal FEC frame size. 73

Figure 5.5: Offered Traffic channels per sub-band (Lc) by CB-HTS satellite with Standard DVB-S2 versus Eb/No, for different modulation techniques and Short FEC frame size. 73

Figure 5.6: BER versus E_b/N_o of 1050 MHz CB-HTS satellite with Standard DVB-S2 and QPSK modulation for different filter roll-off factor of 0.35 and comparing Normal and Short FEC frame size 75

Figure 5.7:BER versus E_b/N_o of 1050 MHz CB-HTS satellite with Standard DVB-S2 ,Normal Frame size and modulation of QPSK, 8PSK, 16-APSK and 32-APSK using roll-off rate of 0.2. 75

Figure 5.8: Offered Traffic channels per sub-band (Lc) by CB-HTS satellite with Standard DVBS2X versus E_b/N_o, for different MODCODEs and Normal FEC frame size. 77

Figure 5.9: Offered Traffic channels per sub-band (Lc) by CB-HTS satellite with Standard DVB-S2X versus E_b/N_o and roll-off rate of 0.2 , for different MODCODEs and Short FEC frame size. 78

Figure 5.10: BER versus E_b/N_o of 1050 MHz CB-HTS satellite with Standard DVB-S2X and QPSK modulation for different filter roll-off factor of 0.05 and comparing Normal and Short FEC frame 79

Figure 5.11. BER versus E_b/N_o of 1050 MHz CB-HTS satellite with Standard DVB-S2X ,short frame size and modulation of BPSK, QPSK, 8PSK, and 16-APSK using roll-off rate of 0.05. 79