



AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

Electronics and Communications Department

Interference Analysis and Mitigation Techniques for Multiple Cognitive Systems in Ka-band

A Thesis submitted in partial fulfillment of the requirements of
a Master of Science degree in Electrical Engineering
Electronics Engineering and Electrical Communications Department
by

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Faculty of Engineering Ain Shams University
Electronics and Communication Engineering
Department

Thesis title: **”Interference Analysis and Mitigation
Techniques for Multiple Cognitive Systems in Ka-band”**

Submitted by: **Mohamed Mustafa Elmohamady Mustafa**

Degree: **Master of Science in Electrical Engineering**

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Statement

This thesis is submitted as a partial fulfillment of Master of Science in Electrical Engineering, Faculty of Engineering, Ain shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

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Signature

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Date: ../../2018

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Abstract

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Abstract

Cognitive Radio applications in satellite communications become a challenging and promising research owing to limitations over the available spectrum. Broadband satellite services continuously call for extra band resources, especially in Ka-band. The coexistence among multiple systems including two satellites systems and terrestrial networks sharing the band (17.7 - 18.1 GHz) is proposed. Co-operative and Non co-operative spectrum sensing approaches are investigated using Energy Detection and Matched Filter techniques to detect harmful interferences over both Gaussian and Rayleigh fading channels. An independent

dipole chain is used to perform energy detection at the cognitive receiver. Hard fusion AND, OR and MAJORITY rules are employed to optimize individual cognitive users sensing decisions. Then exploitation of 3D beamforming is provided using both constrained (3-Dimension Minimum Variance Distortionless Response (3D MVDR) and 3-Dimension Linearly Constrained Minimum Variance (3D LCMV)) and Least Mean Square (LMS) based techniques. Moreover, Adaptable variable step size LMS (AVSS-LMS) is proposed to mitigate harmful interferences. AVSS-LMS shows the ability to speed up the processing time than others compared techniques. Spatial filtering is designed based on Focal Plane Array Reflector (FPAR) that suits satellite receiving terminals. Finally, simulation and analytical results are used to provide a comparative performance evaluation of cooperative and non cooperative sensing techniques over Gaussian and Rayleigh fading channels. Also, Real link parameters and measurements from Nilesat (The Egyptian Satellite Company) are considered in calculations. In addition, 3D Beamforming performance evaluation and enhancements are provided through simulation.

Keywords: Cognitive Radio Communications, Cognitive Radio Cycle, Energy Detection, Matched Filter, Probability of Detection, Probability of False Alarm, Co-operative Sensing, Enabling Techniques, 3D MVDR and 3D LCMV Beamforming, LMS, AVSS-LMS.

Thesis Summary

The thesis is divided into six chapters as listed below:

Chapter 1

In this chapter a brief introduction is presented about spectrum efficiency and cognitive radio. It illustrates the motivation points and our contributions in cognitive radio applications within satellite ka-band. The chapter ends with an organization for the rest of thesis.

Chapter 2

It presents the cognitive radio networks in general. In addition, cognitive radio cycle stages are explained. Then, Ka-band importance is revealed by listing most of ka-band satellites and services that occupy this band.

Chapter 3

This chapter introduces the cognitive radio applications in satellite Ka-band represented in CoRaSat project. Also, the applied spectrum awareness and enabling techniques are defined.

Chapter 4

This chapter proposes a new co-existence model including multiple cognitive radio systems. Spectrum awareness and enabling techniques are discussed through a framework. Matched filter and energy detection techniques are considered in spectrum sensing. Cooperative detection is applied using fusion rules to increase the detection accuracy. Constrained and Unconstrained Beamforming techniques are considered for spatial filtering.

Chapter 5

It explores the proposed framework performance evaluation through simulation results. Advantages of using Matched Filter over Energy detection in the spectrum sensing are shown with numerical results. Also, co-operative detection enhancements over individual detection are explained. Finally, beamforming convergence speed and SINR enhancements using LMS and AVSS-LMS beamforming are investigated.

Chapter 6

It starts with the thesis conclusion and ends with a discussion for the available future work.

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