



**AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING**

Electronics and Communication Engineering Department

**Performance Analysis of MIMO Hybrid Satellite
Terrestrial Multi-Relay Networks over Fading
Channels**

A Thesis

**Submitted in Partial Fulfillment of the Requirements
For the Degree of Doctor of Philosophy in Electrical Engineering
(Electronics and Communication Engineering)**

Submitted By

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Supervised By

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Doctor of Philosophy in Electrical Engineering
(Electronics and Communications Engineering)
Faculty of Engineering, Ain Shams University, 2019

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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

Performance Analysis of MIMO Hybrid Satellite Terrestrial Multi-Relay Networks over Fading Channels

by

ABDEL RAHMAN HASSAN GABER SWALEM

**DOCTOR OF PHILOSOPHY IN ELECTRICAL ENGINEERING THESIS AIN
SHAMS UNIVERSITY**

The high-speed access development led to increase the demand of new services, more frequently audio and video media for communication purposes. Due to the advantages of satellite wide coverage, the satellite communications networks are suitable for medium filling white zones and gray areas, while the terrestrial Networks cannot be covered. Accordingly to the new term called Hybrid Satellite Terrestrial Networks (HSTNs), many communication technologies are assumed to be important increasingly in all sectors to achieve daily people's demands.

In the last decade, cooperative communications researchers has been improved, producing advanced technologies based on optimal communication strategies. The word cooperation has been used for multiple context such as; transmitter cooperation, and relay cooperation. However, in this dissertation, the proposed hybrid satellite communication system will exploit the cooperation of nodes to increase the boundary of the communication performance such as; decreasing the probability of error, decreasing the outage probability, and increasing the capacity of the whole system. This calibration of the cooperation communication system with the hybrid satellite terrestrial networks will lead us to a new definition for the hybrid networks so called Hybrid satellite Terrestrial Cooperative Networks (HSTCNs).

This dissertation mainly contributes in analyzing the performance of dual-hop amplify-and-forward (AF) cooperative code-division multiple-access (CDMA) systems which is presented over independent non identical (i.n.i.) Shadowed-Rician fading for Satellite links; and Nakagami-m fading channel for Terrestrial links. Multiple transmission cooperative protocols for transmission between the Source node (S), Relay node (R), and Destination node (D) are investigated. The analysis of performance in this dissertation will be evaluated for probability of error (P_e), outage

probability (P_{out}), and ergodic Capacity (C_e) for both Downlink and Uplink full duplex channels proposed HSTCNs.

The contribution of this thesis focuses on four main topics: 1) the performance analysis of applying CDMA communication in the downlink HSTCNs using multiple relays with orthogonal and non orthogonal codes for i.n.i channels, 2) the performance analysis of adding non identical Multiple Input Multiple Output (MIMO) antennas configuration at all communication nodes in the downlink HSTCNs, 3) the performance analysis of applying CDMA communication in the uplink HSTCNs using multiple relays with orthogonal and non orthogonal codes for i.n.i channels, and 4) the performance analysis of adding non identical MIMO antennas configuration at all communication nodes in the downlink HSTCNs.

The total signal-to-noise ratio (SNR) was used to derive a novel closed form expression for the moment-generating-function (MGF), as well as the n^{th} moment Function will be derived using the expectation of the total end-to-end Signal-to-noise ratio for: proposed downlink utilizing single antenna at all communication nodes in the HSTCNs, downlink utilizing different MIMO antennas configuration at all communication nodes in the HSTCNs, uplink utilizing single antenna at all communication nodes in the HSTCNs, and different MIMO antennas configuration for all communication nodes in the uplink HSTCNs. The performance analysis is acquired using the MGF derived for the proposed system for Direct Sequence Code Division Multiple Access (DS – CDMA) utilizing either non orthogonal codes (PN codes) or orthogonal codes (Walsh Codes).

Analytical performance analysis results are confirmed by determining a comparison with Monte Carlo simulations. The analytical as well as Monte Carlo simulation shows exact match at low and high SNR. The results mainly show that utilizing cooperative relay communication systems will intensely increase the performance, utilizing MIMO antennas at the nodes, as well as exploiting CDMA systems.

Key Words: *Amplify-and-forward protocol (AF), Code-division multiple-access (CDMA), outage probability, hybrid satellite-terrestrial cooperative system, land mobile satellite (LMS) channel, Shadowed-Rician fading, Ergodic capacity, Multiple Input Multiple Output (MIMO), Uplink channels.*

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Every challenging work needs self-efforts as well as guidance from those are very close to your hearts:

My humble effort I dedicatee to;

- The soul of my father who always wished to be with me on that day. He always supported and encouraged me to believe in myself. Thank you, Dad. You left such finger prints on my life. You shan't be forgotten.
- To my mother who taught me to trust in ALLAH believe in hardwork and that so much could be done with little. Thank you Mum for your endless support and devotion.
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