UNIVERSITI PUTRA MALAYSIA

MITIGATION OF RAIN ATTENUATION IN EQUATORIAL REGION FOR MEASAT-2 AND MEASAT-3 USING ORBITAL DIVERSITY

HALID BIN AGIL

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By

HALID BIN AGIL

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Master of Science

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Master of Science

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Chairman : Harlisya binti Harun, PhD

Faculty : Engineering

Rain is the main contributor towards signal attenuation for satellites operating above 3 GHz, and its effect becomes significant at 10 GHz and above. This causes satellite signal to experience degradation, and to some extent, signal cut-off. A tropical area such as Malaysia faces heavy rainfall throughout the year, and thus the satellite's signal attenuation would occur frequently. This effect is undesirable for satellite services such as those provided by MEASAT satellites, as clients and customers demand for uninterrupted transmissions.

Orbital diversity (OD) is seen to be a viable method to mitigate rain attenuation. It employs multiple satellites transmitting identical signal streams toward a mutual ground station. Although orbital diversity has been studied with great interest in regions such as Europe, there is little information of OD research in tropical regions,

particularly in Malaysia. Therefore, this thesis proposed an analysis of an OD system in Malaysian climate using MEASAT satellites.

An OD simulation model has been setup using parameters from MEASAT-2, MEASAT-3, and MEASAT Satellite Control Centre in Pulau Langkawi. It involved a rain attenuation prediction for each satellite, based on the ITU-R recommended rain attenuation model, signal gain prediction, and diversity gain prediction. The simulation model has been programmed in MATLAB environment. The results are obtained in numerical figures and graphs.

The performance of the OD system is dependent upon the operating frequency and the satellite's elevation angle. The simulation has shown that rain attenuation increases exponentially with the increase of frequency. Therefore, the signal gain decreases in an inverse exponential manner, particularly for individual signals of MEASAT-2 and MEASAT-3. Using signal combination, an OD signal can achieve a signal boost of up to 2.3 times the individual signal gain. With this significant finding, the OD is proposed to mitigate rain attenuation in Malaysia.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PELEGAAN REDAMAN HUJAN DI DALAM KAWASAN KHATULISTIWA UNTUK MEASAT-2 DAN MEASAT-3 MENGGUNAKAN KEPELBAGAIAN ORBIT

Oleh

HALID BIN AGIL

JULAI 2012

Pengerusi : Harlisya binti Harun, PhD

Fakulti : Kejuruteraan

Hujan adalah penyumbang utama kepada kemerosotan isyarat untuk satelit-satelit yang beroperasi melebihi frekuensi 3 GHz, dan kesannya menjadi ketara pada frekuensi 10 GHz dan ke atas. Ini menyebabkan kemerosotan pada isyarat satelit, dan pada tahap tertentu, isyarat tersebut akan terputus. Kawasan tropika seperti Malaysia mengalami taburan hujan lebat sepanjang tahun, dan ini menyebabkan kemerosotan pada isyarat satelit kerap berlaku. Ini memberikan kesan yang tidak diingini ke atas perkhidmatan-perkhidmatan satelit seperti yang dibekalkan oleh satelit-satelit MEASAT, kerana permintaan pelanggan adalah terhadap penghantaran tanpa gangguan.

Kepelbagaian orbit (OD) adalah satu kaedah untuk melegakan redaman hujan. Ia menggunakan pelbagai satelit yang menghantar aliran-aliran isyarat yang serupa ke

arah satu stesen bumi bersama. Walaupun kaedah OD telah dikaji dengan minat yang mendalam di rantauan seperti di Eropah, hanya terdapat sedikit maklumat tentang penyelidikan OD di rantauan tropikal, terutamanya di Malaysia. Oleh sebab itu, tesis ini mencadangkan satu analisis sebuah sistem OD dalam iklim di Malaysia menggunakan satelit-satelit MEASAT.

Satu model simulasi OD telah disediakan menggunakan parameter-parameter daripada MEASAT-2, MEASAT-3, dan Pusat Kawalan Satelit MEASAT di Pulau Langkawi. Ia melibatkan ramalan redaman dari hujan untuk setiap satelit, berdasarkan model redaman hujan yang disyorkan oleh ITU-R, ramalan gandaan isyarat, dan ramalan gandaan kepelbagaian. Model simulasi tersebut telah diprogram dalam persekitaran MATLAB. Keputusan simulasi telah diperolehi di dalam berangka dan graf.

Prestasi OD bergantung kepada frekuensi operasi dan sudut dongakan. Simulasi telah menunjukkan bahawa redaman hujan meningkat secara eksponen dengan meningkatnya frekuensi. Oleh itu, gandaan isyarat berkurang secara eksponen songsang terutamanya untuk isyarat individu MEASAT-2 dan MEASAT-3. Dengan menggunakan kombinasi isyarat, suatu isyarat OD mampu mengalami peningkatan sehingga 2.3 kali ganda berbanding gandaan isyarat individu. Dengan penemuan penting ini, OD telah dicadangkan untuk melegakan redaman hujan di Malaysia.

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I certify that a Thesis Examination Committee has met on 20 July 2012 to conduct the final examination of Halid bin Agil on his thesis entitled "Mitigation of Rain Attenuation in Equatorial Region for MEASAT-2 and MEASAT-3 Using Orbital Diversity" in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the Master of Science.

Members of the Examination Committee were as follows:

Mohd Ramly bin Mohd Ajir, PhD
Associate Professor Lt. Col
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Rizal bin Zahari, PhD
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Faizal bin Mustapha, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Norbahiah Misran, PhD
Professor
Faculty of Engineering and Built Environment
Universiti Kebangsaan Malaysia
(External Examiner)

SEOW HENG FONG, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 22 November 2012

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the Master of Science.

Members of the Supervisory Committee were as follows:

Harlisya binti Harun, PhD
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Abd. Rahim bin Abu Talib, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Renuganth s/o Varatharajoo, PhD
Professor Dr.-Ing. Ir.
Faculty of Engineering
Universiti Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

HALID BIN AGIL

Date: 20 July 2012

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