UNIVERSITI PUTRA MALAYSIA

FIBER VIBRATION SENSOR MULTIPLEXING DEPLOYING KS CODE IN SAC-OCDMA WITH DIRECT DECODING TECHNIQUE

TAIWO AMBALI ABIOLA

FK 2014 12

FIBER VIBRATION SENSOR MULTIPLEXING DEPLOYING KS CODE IN SAC-OCDMA WITH DIRECT DECODING TECHNIQUE

By

TAIWO AMBALI ABIOLA

Thesis submitted to the School of Graduate Studies, University Putra Malaysia, in fulfillment of the degree of Masters of Science

June 2014

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

FIBER VIBRATION SENSOR MULTIPLEXING DEPLOYING KS CODE IN SAC-OCDMA WITH DIRECT DECODING TECHNIQUE

By

TAIWO AMBALI ABIOLA

June 2014

Chair: Makhfudzah Mokhtar, PhD

Faculty: Engineering

The advent of fiber optic vibration sensors has provided a way of achieving distributed sensing for remote vibration monitoring without being limited by electromagnetic effects and others which are hurdles faced in the conventional electrical sensors. Among the techniques that have been introduced for distributed vibration sensing are Time Division Multiplexing (TDM), Wavelength Division Multiplexing (WDM) and Optical Code Division Multiple Access (OCDMA). Some of these techniques are either not suitable for real time vibration monitoring due to low scanning speed or high cost of the required light source. OCDMA, which is known to be effect in providing information security, also has challenges with Multiple Access Interference (MAI) which makes it difficult to differentiate the correct signals from the interfering ones.

Fiber vibration sensor multiplexing using Khazani-Syed (KS) code in Spectral Amplitude Coding Optical Code Division Multiplex (SAC/OCDMA) with direct decoding was investigated in this work. This was done in order to eliminate the MAI effects with less cost and complexity. The proposed work was carried out using a simulation tool to compare KS codes with Optical Orthogonal Code (OOC) and Modified Quadratic Congruence (MQC) codes while laboratory experiment was used to implement and compare the system based on the two decoding techniques and as well as with simplified WDM.

The results show that the proposed system exhibits low noise level and capable of eliminating MAI when compared with complimentary decoding counterpart while still demonstrating low cost and complexity of achieving distributed vibration sensing over OOC and MQC codes. In addition, it demonstrates

optimal performance as the received power level of up to 3.2 dB is measured above WDM based system.

Therefore, the proposed system presents a better alternative for quasi distributed vibration monitoring. The range of frequency measured from 0 Hz to 401 Hz shows its suitability for structures that exhibit low frequency such has remote bridge, transformer, and pipeline vibration monitoring.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia adalah bagi memenuhi syarat keperluan untuk ijazah Sarjana Sains

PEMULTIPLEKS PENDERIA GETARAN GENTIAN MENGGUNAKAN KOD KS DI DALAM SAC-OCDMA DAN PENYAHKODAN SECARA TERUS

Oleh

TAIWO AMBALI ABIOLA

June 2014

Pengerusi: Makhfudzah Mokhtar, PhD

Fakulti: Engineering

Kehadiran penderia getaran gentian optik telah menyediakan satu kaedah untuk mencapai penderiaan getaran teragih bagi kawalan getaran jauh tanpa dihalang oleh kesan elektromagnetik dan lain-lain yang sering menimbulkan masalah kepada penderia elektronik yang sedia ada. Antara teknik pemultipleksan yang telah diperkenalkan untuk penderiaan getaran teragih adalah pemultipleksan pembahagian masa (TDM), pemultipleksan pembahagian jalur gelombary (WDM) dan pemultipleksan pembahagian kod optik (OCDMA). Walaubagaimanapun, terdapat beberapa teknik yang tidak sesuai untuk diaplikasikan untuk kawalan getaran masa nyata kerana kelajuan pengimbasan yang rendah. Teknik OCDMA pula mempunyai cabaran dalam Akses Pelbagai Gangguan (MAI) yang menjadikannya sukar untuk membezakan isyarat dari hingar.

Penderia getaran gentian yang menggunakan kod Khazani-Syed (KS) di dalam SAC/OCDMA dan penyahkodan secara terus telah dikaji di dalam kajian ini. Kaedah ini telah digunakan kerana ia mampu untuk menghilangkan Interferens Akses Pelbagai (MAI) dengan kos yang lebih rendah dan mudah. Dengan menggunakan alat simulasi, perbandingan di antara kod KS dengan OOC dan MQC telah dilakukankan. Eksperimen bagi membandingkan sistem yang menggunakan kedua dua teknik ini juga telah dijalankan dan eksperimen dengan menggunakan sistem WDM termudah juga telah dilakukan.

Hasil daripada keputusan telah menunjukkan bahawa sistem berdasarkan teknik yang dicadangkan telah menghasilkan aras hingar yang rendah dan mampu memusnahkan MAI dengan kos yang lebih rendah dan mudah untuk menghasilkan penderia getaran teragih berbanding kod OOC dan MQC. Tambahan pula, ia menunjukkan prestasi yang optimal apabila nilai kuasa yang diterima melebihi sehingga 3.2 dB daripada sistem berasaskan sistem WDM.

Oleh yang demikian, sistem yang telah dicadangkan menunjukkan prestasi yang lebih sesuai untuk kawalan getaran kuasi teragih. Julat frekuensi yang diukur dari 0 Hz ke 401 Hz telah menunjukkan kesesuaian sistem untuk struktur yang berfrekuensi rendah seperti sistem kawalan jambatan penderiaan jauh, transformer, dan pemantauan getaran saluran paip.

ACKNOWLEDEGEMENTS

All praises and adorations are to Almighty Allah, the eternal who has made my research work a successful one.

My heartfelt gratitude goes to my supervisor, Dr Makhfudzha Mokhtar, for the kindhearted relationship she established with me right from the time of my arrival in UPM. The same is extended to the committee members in persons of Dr M.H Yaacob and Dr R.Z.K Shabudin. I pray to Almighty Allah to reward you all in abundance.

I must commend the efforts of my examiners in persons of Prof. Mohd Adzir Mahdi, Prof. Madya Dr. Salasiah Hitam, and my external examiner, Prof. Ir. Azhar Rashid including the Chairman, Dr. Sharifah Mumtazah for their guidance during and after my VIVA VOCE. May Almighty Allah reward you all abundantly.

The unquantifiable contribution of my family members starting from my immediate elder brother, Alhaji Sulaiman, who personally took the responsibility of sponsoring my study in Malaysia deserved an inimitable appreciation. Also the rest of my family who have in one way or the other contributed either financial or through moral words of advice. May Allah grant you your entire requests.

I must commend the support of my colleagues in the lab, friends in the hostel, and members of the college 12 mosque for you love throughout the study. I pray Almighty God will see you through in your various endeavors.

I pray for my late parents for their immeasurable contribution to my life right from my childhood till their demise. May Allah overlook their shortcomings and guide them to the Paradise.

Last but not the least, I would like to thank the Ministry of Science, Technology and Innovation, Malaysia (Science fund: 5450698) for their contribution in the aspect of funding this research work. Thanks you all

I certify that a Thesis Examination Committee has met on 11 June 2014 to conduct the final examination of Taiwo Ambali Abiola on his thesis entitled "Fiber Vibration Sensor Multiplexing Deploying KS Code in SAC/OCDMA with Direct Decoding Technique" in accordance with the Universities and University Colleges 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 Thesis Examination Committee were as follows:

Sharifah Mumtazah Syed Ahmad Abdul Rahman, PhD
Senior Lecturer
Faculty of Engineering
University Putra Malaysia
(Chairman)

Mohd Adzir bin Mahdi, PhD
Professor
Faculty of Engineering
University Putra Malaysia
(Internal Examiner)

Salasiah Binti Hitam, PhD
Associate Professor
Faculty of Engineering
University Putra Malaysia
(Internal Examiner)

Hairul Azhar Abdul Rashid, PhD
Professor Ir
Multimedia University
Malaysia
(External Examiner)

_____

NORITAH OMAR, PhD
Associate Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 21 July 2014

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Masters of Science. The members of the Supervisory Committee were as follows:

Makhfudzah Binti Mokhtar, PhD
Lecturer
Faculty of Engineering
University Putra Malaysia
(Chairman)

Mohd Hanif Bin Yaacob, PhD
Lecturer
Faculty of Engineering
University Putra Malaysia
(Member)

Ratna Kalos Zakiah Binti Sahbudin, PhD
Lecturer
Faculty of Engineering
University Putra Malaysia
(Member)

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

Date:

DECLARATION

Declaration by graduate student

I hereby confirm that:

- this thesis is my original work;
- quotations, illustrations and citations have been duly referenced;
- this thesis has not been submitted previously or currently for any degree at any other institutions;
- intellectual property from the thesis and copyright of thesis are fully-own by Universiti Putra Malaysia, as according to the University Putra Malaysia (Research) Rules 2012;
- written permission must be obtained from supervisor and the office of Dean Vice-Chancellor (Research and Innovation) before thesis is published (in the form of written, printed or in electronic form) including books, journals, modules, proceedings, popular writings seminar papers manuscripts, posters, reports, lecture notes, learning modules or any other materials as stated the Universiti Putra Malaysia (Research) rules 2012;
- There is no plagiarism or data falsification/ fabrication in the thesis, and scholarly integrity is upheld as according to the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012-2013) and the University Putra Malaysia (Research) Rules 2012. The thesis has undergone plagiarism detection software.

Signature: _____ Date: _____

Name and Matric No.: _____

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in the Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012 – 2013) are adhered to.

Signature: _____	Signature: _____
Name of Chairman of Supervisory Committee: _____	Name of Member of Supervisory Committee: _____
Signature: _____	Signature: _____
Name of Member of Supervisory Committee: _____	Name of Member of Supervisory Committee: _____

TABLE OF CONTENTS