UNIVERSITI PUTRA MALAYSIA

ANALYSIS AND FABRICATION OF FUSED FIBER OPTIC COUPLERS FOR COMMUNICATION SYSTEMS

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MASTER OF SCIENCE
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ANALYSIS AND FABRICATION OF FUSED FIBER OPTIC COUPLERS FOR COMMUNICATION SYSTEMS

By

AHMAD ZAKI BIN HAJI SHAARI

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

April 2006
DEDICATION

*In the name of Allah, Most Gracious and Most Merciful*

*For the sake of seeking knowledge*
Optical couplers such as fused optical fiber coupler are widely used in the network communication systems as either splitters or combiners. There are not much of theories available to describe the core and cladding interaction model inside fused coupler’s region. In this study, suitable Models for analysis of core to cladding guidance interaction using BPM_CAD simulation are created. While core guidance occurs in between core ratios 1 to 0.65, cladding guidance does support propagation at certain core ratio lower than 0.65 with slightly different results between various Models. The Models are also able to generate low excess losses in both the simulated core guidance and cladding guidance.

Excess loss in real fused couplers depends on their elongations, which can be controlled through certain set-up parameters such as torch head positions and motor speed. The effects of changing hydrogen flowrate and
torch head positions do not have direct relationship with the insertion loss of WDM coupler, hence scientifically, the conclusion of fusion temperature effect on coupling cannot be made. Some design parameters are found out to confirm quite well with the parameters found from fabrication. This has been demonstrated through theoretical pulling signatures for various fused couplers.

Besides examining 1 x 2 fused couplers, the study on triangular shape arrangement of 1 x 3 monolithic star couplers do indicate that equal couplings in all output ports are possible if correct Intertwined Method of twisting fibers is used. The same technology used in fabricating fused coupler, is used to fabricate lattice filter, which has channel spacing 2.84 nm or 178 GHz. Generally, all the studies are carried out at most levels including theory, simulation and experiment. These findings or data are analyzed to show the relationship between them and they are also discussed in details in this thesis.
Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

ANALISA DAN FABRIKASI PENGGANDING GENTIAN OPTIK TERLAKUR UNTUK SISTEM KOMUNIKASI

Oleh

AHMAD ZAKI BIN HAJI SHARRI

April 2006

Pengerusi: Profesor Madya Mohd Adzir Mahdi, PhD

Fakulti: Kejuruteraan

Pengganding optik, seperti pengganding gentian optik terlakur, telah digunakan secara meluas didalam sistem komunikasi rangkaian sebagai pembahagi atau penggabung. Tidak terdapat banyak kajian teori dilakukan mengenai model interaksi pergerakan terurus teras ke cladding didalam pengganding terlakur. Dalam kajian ini, model-model tertentu telah dicipta untuk analisa interaksi pergerakan terurus teras ke cladding dengan menggunakan perisian simulasi BPM_CAD. Didapati, pergerakan terurus cladding memang berlaku pada model tertentu jika nisbah diameter teras kurang dari 0.65 manakala pergerakan terurus teras berlaku pada nisbah diameter teras diantara 1 dan 0.65. Walaupun begitu, terdapat sedikit ketidaksamaan diantara model-model tersebut. Model-model juga berjaya menghasilkan lesapan lebihan yang kecil bagi kedua-dua simulasi pergerakan terurus teras dan cladding.

Selain kajian keatas pengganding terlakur 1 x 2, kajian juga dilakukan keatas pengganding terlakur 1 x 3 berbentuk susunan tigasegi yang boleh mengeluarkan kuasa penggandingan sama diantara ketiga-tiga arah keluaran ports jika Cara Intertwined yang betul diguna pakai bila melilitkan gentian-gentian optik berkenaan. Kajian keatas Lattice Filter juga dibuat dengan menggunakan teknologi yang sama untuk pembuatan pengganding terlakur tersebut. Didapati Lattice Filter berkenaan mempunyai ruangan saluran sebanyak 2.84 nm. Secara amnya, semua kajian yang dijalankan melibatkan teori, simulasi dan uji kaji. Kesemua penemuan atau data dianalisa untuk mencari perhubungan diantara kesemua parameter-parameter berkenaan dan dibincang secara menyeluruh didalam tesis ini.
I would like to express my appreciation and deep gratitude to my supervisor
Associate Professor Mohd Adzir Mahdi and my co-supervisor Associate
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guidance and patience towards completion of this research work. My
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My special thanks are also to all my colleagues and staffs from IMEN,
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Thanks you very much to my wife for your support and understanding. And
to my two children (Ismail and Hanisah Safiah) who I love so much. My
indebtedness is to all family members especially my beloved mother,
brothers and sisters.
I certify that an Examination Committee has met on 20 April 2006 to conduct the final examination of Ahmad Zaki Bin Haji Shaari on his Master of Science thesis entitled “Analysis and Fabrication of Fused Fiber Optic Couplers for Communication Systems” in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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**Date:**  
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Date: 10 AUG 2006
DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not previously or concurrently submitted for any other degree at UPM or other institutions.

AHMAD ZAKI BIN HAJI SHAARI

Date: 1/3/2006
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<td>BPM</td>
<td>Beam Propagation Method</td>
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<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
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<td>CH</td>
<td>Photodetector</td>
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<td>CMT</td>
<td>Coupled Mode Theory</td>
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<td>CPU</td>
<td>Central Processing Unit</td>
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<td>CR</td>
<td>Coupling Ratio</td>
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<td>CW</td>
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<td>CWDM</td>
<td>Coarse Wavelength Division Multiplexing</td>
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<td>EL</td>
<td>Excess Loss</td>
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<td>FBT</td>
<td>Fused Biconical Taper</td>
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<td>FTP</td>
<td>Flame Torch Position</td>
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<td>Fiber to the Home</td>
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<td>IL</td>
<td>Insertion Loss</td>
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<td>ITU</td>
<td>International Telecommunication Union</td>
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<tr>
<td>LM</td>
<td>Lower Modes</td>
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<td>MFD</td>
<td>Mode Field Diameter</td>
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<td>MZI</td>
<td>Mach Zehnder Interferometer</td>
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<tr>
<td>OLT</td>
<td>Optical Line Terminal</td>
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<td>ONU</td>
<td>Optical Network Unit</td>
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<td>Optical Spectrum Analyzer</td>
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<td>PL</td>
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