UNIVERSITI TEKNOLOGI MARA

INVESTIGATION ON STIMULATED BRILLOUIN SCATTERING (SBS) IN THE GENERATION OF SELF-SEEDED MULTIPLE WAVELENGTH BRILLOUIN ERBIUM FIBER LASER (BEFL)

MOHD RUZALEH NURDIK

Thesis submitted in fulfillment
of the requirements for the degree of
Master of Science

Faculty of Applied Sciences

March 2014

AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

Name of Student	:	Mohd Ruzaleh Nurdik
Student ID No.	:	2008792225
Programme	:	Master of Science
Faculty	:	Faculty of Applied Sciences
Thesis Title	:	Investigation on Stimulated Brillouin Scattering (SBS) in the Generation of Self-seeded Multiple Wavelength Brillouin Erbium Fiber Laser (BEFL)
Signature of Student	:	
Date	:	March 2014

ABSTRACT

Erbium-doped Fiber Laser (EDFL) configured into ring cavity system shows better performance compare to linear cavity fiber laser system. Ring cavity fiber laser has the advantage of higher efficiency, higher output power, and higher signal-to-noise ratio (SNR). Thus, the ring cavity laser configuration is preferred to be employed in the self-seeded Brillouin Erbium Fiber Laser (BEFL) system to generate the self-seeded multiple Brillouin Stokes.The Brillouin Fiber Laser (BFL) has been investigated in single and double ring cavity system to produce maximum number of Stokes signals. For a single cavity system, 7 and 9 Stokes signals were produced compare to 2 Stokes signals before enhancing at Brillouin pump (BP) source and configured an S-Shape in the cavity, respectively. In a double ring cavity BFL, 5 Stokes signals were generated and when configuration was enhanced by Erbium Doped Fiber Amplifier (EDFA) in the cavity, 8 Stokes signals were achieved. The BEFL which is the hybrid of BFL and EDFL shows improvement on the stokes generated when enhanced by EDFA where 14 Stokes were obtained. The optimization of BP power as lower as 2 dBm was able to produce a maximum 17 Stokes signals. This thesis focuses on the exploitation of non linear effects in Single-Mode Fiber (SMF), mainly the Stimulated Brillouin Scattering (SBS) in generating self-seeded multiple wavelength BEFL in double ring cavity. More than 67 multiple wavelengths self-seeded with 0.088 nm lines spacing were generated in 5.64 nm wavelength range from 1528.19 to 1533.83 nm and centered at 1531.01 nm. The signal to noise ratio of the spectrum is more than 16 dB. The injected 980 nm laser diodes (LDs) were set to optimum powers of 100 mW for pumping two erbium doped fibers in the two lasers cavities. The multiwavelength self-seeded has a good potential application in wavelength division multiplexing (WDM) especially in Dense Wavelength Division Multiplexing (DWDM) for data transmission in communications system.

ACKNOWLEDGEMENTS

First and foremost, my deepest gratitude is for ALLAH S.W.T. Alhamdulillah, all praises to ALLAH for the strength and His blessing in completing this thesis.

Special appreciation goes to my supervisor, Prof. Dr. Mohd Kamil Abd. Rahman for his supervision and constant support. With his enthusiasm, inspiration and great effort to explain things clearly and simply make this research fun for me. I really appreciate the opportunity given to me to do this research in Photonics Laboratory, FSG, UiTM Shah Alam.

And also, my acknowledgement goes to UiTM Sabah Campus Rector, Datuk Dr Hj Abd Kadir Hj Rosline for giving me permission and opportunity to do my research in Photonics Laboratory, FSG, UiTM, Shah Alam.

To all lab members, thank you for providing a fun enviroment which we learn together.

But not least, my deepest gratitude goes to my beloved parent, Mr. Nurdik Hj Surdin and Mrs. Jasrah Basilir and also my wife, Mrs. Hasnah Marusin my daugther, Siti Yunisah and my son, Mohammad Noor Hafizun for their endless loves, prayers and encouragements.

I dedicate this work to Allah, the most Gracious and the most Merciful and Prophet Muhammad, the Messenger of Allah.

CHAPTER ONE
INTRODUCTION

1.1 INTRODUCTION

Today's communications are based on transmitting information from one place to another. It can be achieved by sending pulses of light known as optical signal through an optical fiber. The large quantity of data can be carried by optical fiber and makes it the first choice for the telecommunication system. The first fiber optic communication system was introduced in 1973, and operated at 1.3 μm, at a bit rate of 45 Mbps [1]. Later, the bandwidth and the capacity of information increased until 1990s, when internet applications were introduced. In the year 2001, optical transmission speed reached 10 Tbit/s means extra bandwidth capacity is required to provide the services in telephone, audio and video communications [2].

1.2 TELECOMMUNICATION SYSTEM

The basic telecommunication system using fiber optics is shown in Figure 1.1. Basically there are three components involved in this system. The first component is transmitter which converts electrical to optical signal. The fiber optics is responsible for carrying the optical signal to the receivers. Then, the receivers reconvert the optical signal to the original data.

The most common devices used as transmitter in fiber optics communications are semiconductor lasers or laser diodes (LDs) and light-emitting diodes (LEDs). Both light sources have different usage and advantages, depending on the applications. For example LDs are more suitable for transmission of signals over long distances but LEDs are widely used for short transmission. The operating wavelength and power for light source, bandwidth range and modulated for the