

**SEMICONDUCTOR OPTICAL AMPLIFIER (SOA)  
FOR PHOTONIC SIGNAL PROCESSING**

**LATTY SHAZANA BT ISMAIL**

**SCHOOL OF MICROELECTRONIC ENGINEERING  
UNIVERSITI MALAYSIA PERLIS**

**2011**

© This item is protected by original copyright

## ACKNOWLEDGEMENT

First of all, I would like to show my gratitude and prayer to Allah S.W.T for awarded me a good health during my final year project period. Without their blessing this project would not be success.

I would like to extend my sincere gratitude to my final year project supervisor Dr Mohamad Halim B Abd. Wahid, for his guidance towards the progress of this thesis. Throughout him has been patiently monitoring my progress and guided me in making the right direction and offering encouragement. Obviously the progress I had now will be uncertain without his assistance.

Most of all, I am very grateful to those who involve directly or indirectly to this final year project and thanks you for willing to spend time with me and giving me a lot of priceless suggestion and knowledge.

Last but not least, special thanks for my parents and friends for their unfulfilling encouragement support they have given me over the years.

## **APPROVAL AND DECLARATION SHEET**

**This report titled “Semiconductor optical amplifier (SOA) for photonic signal processing” is prepared and submitted by Latty Shazana Bt Ismail (081030299) and has been found satisfactory in term of scope, quality and presentation as partial fulfillment of the requirement for Bachelor of Engineering (Electronic Engineering) University Malaysia Perlis, (UniMAP).**

**Checked and Approved by**

---

**(Dr Mohamad Halim B Abd Wahid)**

**Project Supervisor**

**School of Electronic Engineering**

**University Malaysia Perlis**

**May 2011**

## **Semiconductor optical amplifier (SOA) for photonic signal processing.**

### **ABSTRAK**

Projek ini memaparkan ciri-ciri penguat optik semikonduktor dalam pemrosesan isyarat fotonik. Data- data yang berdasarkan ciri-ciri yang dianalisis adalah untuk aplikasi yang berpotensi dalam sistem fotonik seperti pensuisan dan penjana isyarat. Dengan menggunakan perisian Optisystem, ciri-ciri SOA dimodelkan dan mensimulasikan dengan memvariasikan parameter yang digunakan dalam SOA seperti arus , gandaan kuasa dan suhu. Kajian ini dapat membantu dalam merancang dan merekacipta aplikasi fotonik. Prestasi litar akan dapat dipertingkatkan dengan menggunakan parameter yang betul dan tepat dalam litar yang direkacipta. Dengan mengeksplorasi ciri-ciri SOA, ianya akan membantu perancang untuk memahami lebih lanjut tentang perilaku litar yang mereka perlukan untuk merekacipta litar menggunakan peranti SOA.

# **SEMICONDUCTOR OPTICAL AMPLIFIER (SOA) FOR PHOTONIC SIGNAL PROCESSING.**

## **ABSTRACT**

This project presents the characteristic of semiconductor optical amplifier in photonic signal processing. The characterization data is analyzed for potential application in photonic systems such as switching and signal generators. Using Optisystem, the characteristic is modeled and simulated by varying the parameter used in SOA such as current, gain and temperature. This characterization model will help in designing the application in photonic. Performance wise will be enhanced by employing correct parameters in the design. By exploring the properties, it will help the designer to understand more on the behavior of the circuit that they need to design using this SOA device.

© This item is protected by original copyright

## TABLE OF CONTENTS

	<b>Page</b>
<b>ACKNOWLEDGMENT</b>	i
<b>APPROVAL AND DECLARATION</b>	ii
<b>ABSTRAK</b>	ii
<b>ABSTRACT</b>	iv
<b>TABLE OF CONTENTS</b>	v
<b>LIST OF FIGURES</b>	vii
<b>LIST OF TABLES</b>	ix
<b>CHAPTER 1 INTRODUCTION</b>	
1.0 Project Background	1
1.0.1 Optical Amplifier	1
1.0.2 Semiconductor optical amplifier	1
1.0.3 History of SOA	2
1.1 Basic Concept	2
1.1.1 Optical Gain	3
1.1.2 Gain Coefficient	3
1.1.3 Rate Equation Approach	3
1.2 Objective	5
1.3 Problem statement	5
1.4 Project Outline	6
<b>CHAPTER 2: LITERATURE REVIEW</b>	
2.0 Introduction	7
2.1 Summarization SOA gain recovery wavelength dependence: simulation and measurement using a single-color pump-probe technique	7
2.2 Summarization on Gain recovery in semiconductor optical amplifiers	9

2.3	Summarization SOA output characteristics: effect of amplifier length and injected carrier density	10
2.4	Summarization Application of Semiconductor Optical Amplifiers in High Speed All-Optical NRZ to RZ Format Conversion	11

## CHAPTER 3 METHDODOLOGY & RESULTS

3.0	Designing circuit	13
3.0.1	CW Laser	13
3.0.2	Non Return Zero (NRZ) pulse generator	14
3.0.3	March- Zehnder Modulator	14
3.1	Gain Saturation	15
3.1.1	Theory	15
3.1.2	Methodology	16
3.2	Temperature Gain Dependency	17
3.2.1	Theory	17
3.2.2	Methodology	18
3.3	Current Gain Dependency	19
3.3.1	Theory	19
3.3.2	Methodology	20
3.4	Length & Wavelength Gain Dependency	21
3.4.1	Theory	21
3.4.1.1	Length	21
3.4.1.2	Wavelength	22
3.4.2	Methodology	24
3.5	Gain Recovery Time	25
3.5.1	Theory	25
3.5.2	Methodology	26

## **CHAPTER 4: RESULTS & DISCUSSION (SOA CHARACTERIZATION)**

4.0	SOA Characteristic	27
4.1	Gain Saturation	27
4.2	Temperature Dependency	29
4.3	Current Dependency	30
4.4	Gain Recovery Wavelength Dependency	31
4.5	Gain Recovery Time	32

## **CHAPTER 5: RESULTS & DISCUSSION (CSRZ GENERATION)**

5.0	Appllication of SOA	34
5.1	Carrier Suppress Return to Zero	35
5.2	Methodology	36
5.2.1	Generation of Input Data Circuit	36
5.2.2	Generation of Control Circuit	37
5.2.3	Generation of SOA Fiber Loop Mirror Circuit	37
5.3	Analysis On Current Dependence on Output Performance	38
5.4	Results	40

## **CHAPTER 6: CONCLUSION**

6.0	Introduction	41
6.1	Conclusion	41
6.2	Commercialization Potential	43

## **REFERENCE**

## **APPENDIX**



## LIST OF FIGURES

<b>Figure</b>	<b>Page</b>
Figure 1.1: Three Level System	3
Figure 1.2 : Four Level System	4
Figure. 2.1: Schematic diagram of the experimental setup. ODL	8
Figure 2.2: Measurement Setup	9
Figure 2.3: NRZ to RZ format conversion based on XPM in SOA	11
Figure 2.4: NRZ to RZ format conversion based on XPolM in SOA	11
Figure 3.1: Gain Saturation Output Power	15
Figure 3.2: Schematic diagram of SOA gain saturation	16
Figure 3.3: Injection carrier density as a function of temperature	17
Figure 3.4: Schematic diagram for temperature effect on SOA performance	18
Figure 3.5: Gain function of current in SOA	19
Figure 3.6: Schematic Diagram on Gain recovery current variation	20
Figure 3.7: Length vs Gain for variation active layer thickness	21
Figure 3.8: Measured SOA chip gain versus wavelength	23
Figure 3.9: Schematic Diagram of wavelength gain recovery	24
Figure3.10: Measured gain and phase dynamics for 10 GHz and 40 Ghz repetition rate	25
Figure 3.11: Schematic Diagram on Time Recovery	26
Figure 4.1: Gain Saturation Output Power	28
Figure 4.2: Temperature variations and its effect on SOA performance	29
Figure 4.3: Gain output for different current input	30
Figure 4.4: Wavelength gain recovery with variation of probe length	31

Figure 4.5:	Gain Recovery Time with variation of injection current	32
Figure 5.1:	RZ Input Signal Circuit	36
Figure 5.2:	Control circuit	37
Figure 5.3:	Fiber loop mirror circuit	37
Figure 5.4:	Analysis on Performance based on SOA current	38
Figure 5.5:	Eye diagram	39
Figure 5.6 :	CSRZ Spectrum	39
Figure 5.7:	CSRZ output performance based on variation injection current	40

#### LIST OF TABLES

Table		Page
5.1	Results of CSRZ performance wise.	43