

Contents

1	Introduction	1
1.1	Why Do We Need Optical Communication?	1
1.1.1	Existing and Emerging Applications	1
1.1.2	The Advantages of Optical Communication	4
1.2	What are Integrated Optical Receivers?	6
1.3	Overview of Existing Literature	8
1.3.1	Non-CMOS Implementations	8
1.3.2	CMOS Implementations Without an Integrated Photodiode	10
1.3.3	CMOS Implementations with an Integrated Photodiode	12
1.4	Summary of the Research	13
1.5	Outline of the Thesis	14
2	Optical Communication—A High-Level Perspective	15
2.1	The Communication Model	15
2.2	Properties of Binary Data	16
2.2.1	Random Binary Data	16
2.2.2	Pseudo-random Binary Data	18
2.3	The Laser Diode	19
2.4	Optical Fiber	23
2.4.1	Silica Fiber	23
2.4.2	Plastic Fiber	25
2.5	Optical Receiver Fundamentals	26
2.5.1	Bandwidth Versus Bit Rate	27
2.5.2	Noise Versus Bandwidth	29
2.5.3	Bit Error Ratio Versus Noise	33
2.6	Conclusion	38

3	From Light to Electric Current—The Photodiode	41
3.1	Working Principle	41
3.1.1	Carrier Generation and Recombination	41
3.1.2	Collecting the Generated Carriers	47
3.2	Photodiodes in CMOS	55
3.2.1	Magnitude and Speed of the Photocurrent	56
3.2.2	Speed Improvement Techniques	63
3.2.3	The Photodiode Parasitics	68
3.2.4	The Reflection Coefficient of CMOS	70
3.3	Conclusion	76
4	From Current to Voltage—The Transimpedance Amplifier	77
4.1	Important Specifications	77
4.2	Comparison of TIA Topologies	82
4.2.1	Open-Loop Topologies	82
4.2.2	Closed-Loop Topologies	88
4.3	Design Considerations of a Shunt-Shunt Feedback TIA	100
4.3.1	Design of the Voltage Amplifier	100
4.3.2	Design of the Feedback Network	113
4.3.3	The Capacitance-Relieved TIA	117
4.4	TIA Designs	123
4.4.1	A Differential Shunt-Shunt Feedback TIA	123
4.4.2	A Shunt-Shunt Feedback TIA for POF-Applications	129
4.4.3	A Capacitance-Relieved TIA for POF-Applications	132
4.5	Conclusion	134
5	Increasing the Speed—The Equalizer	137
5.1	Operation Principle	137
5.2	Circuit Techniques	141
5.2.1	A Source-Degenerated Amplifier	141
5.2.2	A Common-Source Amplifier with an Inductive Load	143
5.3	Equalizer Designs	146
5.3.1	A Differential Equalizer with Differential Source Degeneration	146
5.3.2	A Single-Ended Equalizer with Active Inductors	149
5.4	Conclusion	152
6	Towards a Rail-to-Rail Voltage—The Post Amplifier	153
6.1	A Limiting Amplifier or an AGC Amplifier?	153
6.2	Important Specifications	155
6.3	Broadband Circuit Techniques	162
6.3.1	Multistage Amplifier	162
6.3.2	Negative Impedance Converter	166
6.3.3	Other Techniques	169

6.4	Offset Compensation	170
6.5	Post Amplifier Designs	176
6.5.1	A 4-stage Limiting Amplifier	176
6.5.2	A Limiting Amplifier with Negative Miller Capacitors and Active Offset Compensation	179
6.6	Conclusion	182
7	Chip Implementations	185
7.1	A New FOM for Integrated Optical Receivers	186
7.2	A 4.5-Gbit/s Optical Receiver with an Integrated Photodiode in 130-nm CMOS	187
7.2.1	The Chip	187
7.2.2	Measurement Setup	190
7.2.3	Measurement Results	191
7.3	A 5.5-Gbit/s Optical Receiver with a Speed-Enhanced Photodiode in 130-nm CMOS	195
7.3.1	The Chip	195
7.3.2	Measurement Setup	198
7.3.3	Measurement Results	198
7.4	A POF Receiver with a 1-mm Diameter Integrated Photodiode in 180-nm CMOS	201
7.4.1	The Chip	201
7.4.2	Measurement Setup	203
7.4.3	Measurement Results	204
7.5	A Low Power and Area Efficient Limiting Amplifier in 90-nm CMOS	206
7.5.1	The Chip	206
7.5.2	Measurement Setup	208
7.5.3	Measurement Results	209
7.6	Conclusion	212
8	Conclusions	213
8.1	General Conclusions	213
	References	215
	Index	221

High-Speed Optical Receivers with Integrated
Photodiode in Nanoscale CMOS

Tavernier, F.; Steyaert, M.

2011, XIV, 226 p., Hardcover

ISBN: 978-1-4419-9924-5