Preface

The Plastic Optical Fiber (POF) provides benefits compared to glass fiber. The best known POF is the step-index (SI) PMMA POF with a core diameter of 1 mm. It is simpler and less expensive than glass fibers. Large-core POF has greater flexibility and resilience to bending, shock, vibration, and it is easier in handling and connecting. The transmission windows of the POF are in the visible range. These advantages make POF very attractive for use in short-range communication and within in-building networks.

The cheap standard PMMA SI-POF has the lowest bandwidth and the highest attenuation among multimode fibers. This small bandwidth limits the maximum data rate which can be transmitted through POF. To overcome the problem of its high transmission loss, very sensitive receivers must be used to increase the transmitted length over POF. The POF's limited bandwidth problem can be decreased by using multilevel signaling like Multilevel Pulse Amplitude Modulation (M-PAM) or Discrete Multi Tone (DMT). Another method is to use equalization techniques to reduce the effect of limited bandwidth.

This book presents integrated optical receivers fabricated with a low-cost Si process and having a good performance with multilevel modulation. These receivers achieve a good transmission performance over standard PMMA SI-POF (higher sensitivity and higher data rate transmission over longer POF length). Also, fully integrated optical receivers with an integrated POF equalizer achieving free of error 1.25 Gbit/s transmission over 50 m SI-POF will be introduced.

In the design of the multilevel signaling optical receiver a linear transimpedance amplifier with an automatic gain control and no limiting amplifiers are used to have equally spaced output signal voltage levels. For many applications it is desirable to integrate the photodiode with a transimpedance amplifier and the post amplifiers into the same chip. Placing the transimpedance amplifier adjacent to the photodiode improves the performance by reducing lead capacitance and sensitivity to interference, thereby giving higher speed and lower noise. A further advantage is the reduction of the external circuitry required. Hence, overall cost and PCB board size can be reduced.

Experiments regarding the application of M-PAM over the SI-POF channel are presented using the integrated optical receivers introduced. The presented receivers are able to receive a free of error signal at a data rate of 1 Gbit/s over 20 m SI-POF, 400 Mb/s over 50 m SI-POF, and 170 Mbit/s over 115 m of SI-POF. All of the reached results are free of errors ($<10^{-8}$), were obtained in real time and have a data rate-length product of 20 Gb/s m.

A single-chip optical receiver with an integrated equalizer is used to achieve a high performance gigabit transmission over step-index plastic optical fiber (SI-POF). The integrated equalizer can compensate for different POF lengths up to 50 m. The integrated optical receiver is fabricated in a low-cost silicon 0.6 μm BiCMOS technology and has a power consumption of 100 mW. Real-time transmission at data rates of 1.8 Gbit/s over 20 m SI-POF and 1.25 Gbit/s over 50 m SI-POF with high sensitivities and BER of 10^{-9} is achieved.

This book has eight chapters and is organized as follows:

In the beginning of this book in Chap. 1, the motivation for optical communication over step index plastic optical fibers and the use of fully integrated optical receiver technology are discussed.

Chapter 2 provides the description of different multilevel signaling modulation formats and gives a brief comparison between multilevel and binary signaling. We motivate the importance of the multilevel signaling when the system frequency response has a certain roll-off. Some issues of the different methods to generate and decode the M-PAM are introduced. The calculation of symbol error rate for M-PAM and BER for binary signal will be provided.

In Chap. 3 different types of equalizations are described. Preequalization, post-equalization, electronics and analogue equalization are compared. The implementation of different kinds of equalizers is also discussed in this chapter. Performance comparison between different types of equalization techniques for high-speed communication over SI-POF will be addressed.

The first part of Chap. 4 explains the importance and benefits of PMMA SI-POF compared to copper wire and glass fiber. The main applications of PMMA SI-POF will be introduced. The characteristics of PMMA SI-POF like frequency response, bending loss and coupling loss will be discussed. The next sections in Chap. 4 will be about the available light sources for PMMA POF and how to minimize the effects of POF modal dispersion. The last section contains the state of the art for high speed transmission systems over standard SI-POF.

Chapter 5 provides the theoretical background of silicon PIN photodiodes. The design of large-area integrated PIN photodiode in silicon BiCMOS technology will be described. A brief comparison between this photodiode design example and other photodiode designs will be introduced.

Chapter 6 discusses the theory of transimpedance amplifiers (TIAs). A detailed analysis for the frequency response and noise of transimpedance amplifiers are shown. Different TIA topologies and their performance will be discussed. The end of the chapter contains a discussion about two types of post amplifiers, limiting amplifiers and automatic gain control amplifiers.

The first part of Chap. 7 discusses the circuit structure of the multilevel signaling integrated optical receiver and its importance. The next sections give circuit descriptions and experimental results for the fabricated integrated optical receivers with different bandwidth and different sensitivities. The experimental results for binary, 4-PAM and 8-PAM signal transmission over PMMA SI-POF lengths from 10 m to 115 m are also included.

Chapter 8 gives circuit descriptions and experimental results for the integrated adjustable POF equalizer. Fully integrated optical receivers with integrated equalizer will be introduced. The experimental results for equalized signals over different SI-POF lengths are also included for data rates up to 1.25 Gbit/s. A comparison to recently published results of integrated POF equalizers will be presented at the end of the chapter.

Chapter 9 compares receivers and transmission results of multilevel signaling and of binary modulation. This chapter finally draws some conclusions.

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