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Published in:
Technical Digest Optical Fiber Communication Conference 2003

Publication date:
2003

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):

This work was partially funded by the Defense Advanced Research Projects Agency (DARPA) and Air Force Research Laboratory under agreement number F30602-00-2-0543, by the National Science Foundation under grant number ANI-998665, and by the support of OIDA and Fire Technologies.

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A Novel Optical Labeling Scheme Using a FSK Modulated DFB Laser Integrated with an EA Modulator

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The feasibility of an optical FSK labeling scheme is demonstrated. An optical signal consisting of a 10Gb/s payload and a 312Mb/s label was generated, and its performance was evaluated in an 88km transmission link.

1. Introduction

All optical label switching implements the packet routing and forwarding functions of multistep label switching (MPLS) directly in the optical layer, which is a promising technology for next-generation wavelength division multiplexing (WDM) networks. Several optical labeling methods have been proposed and demonstrated as possible solutions [1], in which the label is attached by time multiplexing or subcarrier multiplexing with the data payload. The optical label can also be achieved by angle modulation that is orthogonal to the intensity-modulated payload [2]. In direct detection systems, the label information can be modulated using either the differential-phase-shift-keying (DPSK) or frequency-shift-keying (FSK) format. The feasibility of the optical DPSK label scheme was experimentally validated [3]. However, this scheme imposes stringent requirements on the laser linewidth. The scheme of combined FSK/ASK modulation was demonstrated to be more applicable in practical networks [4]. In this paper, we report the construction of a novel optical FSK transmitter and investigation of the optical FSK labeled signal's performance. The generated signal consists of a 10Gbps intensity modulated payload and a 312Mbps FSK format label, whose performance was evaluated in a 88km standard single-mode-fiber (SMF) transmission link.

2. Operation Principle of the Optical FSK Transmitter

The optical FSK transmitter plays an important role in optical labeling. The label information is impressed upon the frequency of the optical carrier through FSK modulation, while keeping its amplitude unaffected. Thus the optically labeled packet can be achieved when the payload information is modulated on the amplitude of the carrier. An optical FSK signal can be generated simply by directly modulating the frequency of the DFB or DBR laser diodes [5]. However, the drive current variation also results in a simultaneous intensity modulation of the emitted light. As for the optical labeling, such residual intensity modulation has a detrimental effect on the optical packet transport. Therefore, label information is added. To overcome this problem, we propose a novel optical FSK label generation scheme based on a commercially available integrated DFB laser/
signal, thus achieving the FSK demodulation. The demodulated label was received by an electrical receiver with 1.8 GHz bandwidth. Fig. 5 shows the eye-diagrams of the payload and label.

Fig. 5 (a) Eye-diagram of optically labeled signal

Fig. 5 (b) Eye-diagram of received payload (electrical)

In the labeling scheme used, interference is introduced between the payload and label through the intermodulation distortion, as indicated in Fig. 5(c). The intensity modulation depth of the payload and label and the extinction ratio of payload in the back-to-back case can be achieved by nearly 6dB extinction ratio. Fig. 6(b) shows the transmission performance of the signal with 6dB extinction ratio. The transmission penalties for label and payload are 2.0dB and 1.0dB respectively.

Fig. 6 (a) Payload and label receiver sensitivity versus extinction ratio of the payload

Fig. 6 (b) BER performance of the optically labeled signal

4. Conclusions

We have proposed a novel optical FSK label generation scheme based on a commercially available integrated DFB laser/EA modulator. An optically labeled signal consisting of a 10Gb/s payload and a 312Mb/s label was generated. Both payload and label data could be recovered error free after transmission over 88km SMF, validating the feasibility of the optical FSK labeling scheme.

References


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Murphy 1

Access Networks 1

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Whatever Happened to Fiber-to-the-Home? (invited)

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The early vision of FTTH, which promised abundant, ubiquitous, and future-proof bandwidth to consumers, has largely remained unrealized nearly 20 years after its birth. We discuss the historical, competitive, economic, and service reasons for this and prospects for the future.

Introduction

The vision of Fiber-to-the-Home (FTTH) was developed in the 1980's to satisfy the perceived need for future consumer applications. Optical fiber, it was felt, would permit high bandwidth transport, remove "bottlenecks" as video-rich services were developed, enable upgrades, and permit passive multiplexing that would remove remote powering costs. Various aspects of its history have been reviewed [1-3]. In today's terms, applications such as telephony and video-on-demand were to be carried over a 40-MHz universal carrier at OC-3 rates [1]. Proposals included an optical version of the telephony loop (each fiber carrying one house's circuit) to passive optical networks (PONS) with an optical splitter delivering light (and bandwidth) to several optical network units (ONUs). For Fiber-to-the-Curb (FTTC), the ONUs served several homes. In the nearly two decades since the FTTH vision was established, economic, regulatory, and technological forces have frustrated the vision's intended universal implementation.

The Recent Past

Fig. 1 shows some of the structural forces at work. The two major consumer communications today are broadcast television and telephony, which have nearly opposite characteristics. TV is a passive imperative entertainment delivered as a one-way service requiring high bandwidth. Telephony is personal communication that requires a two-way symmetric, low-bandwidth connection. We apparently value communication more than "content" [4] because the cost of information on phone calls exceeds that of entertainment by 6 or 7 orders of magnitude. TV's infrastructure is largely coaxial cable, Multiple System Operators (MSOs) as service providers, whereas telephony is largely delivered over twisted wire pairs by incumbent Local Exchange Carriers (ILECs). The two-way nature and quality of telephony makes aggregation, multiplexing, and switching essential, and thus the telephone and TV physical networks look quite different. Both the MSOs and the ILECs have, over time, created efficient networks, and they can be viewed as vertically integrated, delivery networks that deliver their services. Both entities saw potential markets in the intermediate area of Fig. 1, labeled "Data," which could provide personalized entertainment, be consumed as an end in itself, or enhance communications services. This seemed a natural extension for the ILECs, since these services required point-to-point connections, while regulatory and technical reasons prevented MSOs from entering. This space was intended for FTTH: the services would need more bandwidth than the copper plant allowed, and would need new architecture, but revenues from new services such as Video on Demand (VOD) were expected to support a fiber build-out [1].

Developments in the 1980s, however, changed the landscape dramatically. Advances in linear lightwave technology enabled CATV links with cascaded amplifiers to be replaced with high bandwidth, high fidelity optical analog transmission links to local offices. The "pushing fiber deeper" approach became known as Hybrid Fiber-Coax (HFC), which, with its ability to shrink serving areas sizes [5], began to look like the telco's FTTH plans, would permit the MSOS to carry data (albeit on a shared medium). This would crowd into the telco's vision and could lead to competition in that new space. Meanwhile, technical advances in data compression reduced the information needed to carry video by nearly two orders of magnitude, and new modems with a variety of Digital Subscriber Loop (xDSL) formats were developed to carry data and video over copper pairs. Furthermore, graphical interfaces made world-wide web traffic explode (making that central area in Fig. 1 look more attractive), launched the dot-com boom and CLEC threats. Technical advances also made Satellite TV a credible threat to cable, and Wireless phones a threat to landlines. Thus, technical progress and regulatory relaxations set the stage for that middle area to be actively contested, while putting pressure on each market. What does the future hold?

Prospects for the Future

Overriding all of the plans, of course, is the need for the network to make money for its owner; early advocates estimated that the customer's willingness to pay for phone and VOD services would support a cost of $1500 per subscriber for infrastructure [1], which is still a reasonable guess today. Much activity in 60 and standards groups such as the Full Service Access Network (FSAN) in the First Mile (EFM) activities support the vision, and vendors are within striking range of these costs. Furthermore, there are several large trials run by ILECs (dating back to the 1980's), and some MSO trials have recently begun, so the players are developing technological experiences to be used for a massive FTTH rollout [6]. We believe that a major deployment is unlikely for the foreseeable future for several reasons:

First, the cost calculations require essentially monopoly conditions. The major cost of the FTTH network is in the installation of ubiquitous distribution fiber that permits a drop to any potential customer. This fixed cost of passing every customer must be borne by that fraction of customers who actually subscribe. For example, if the market is 25%, then the effective cost per customer is nearly 4 times the