A Digital-Baseband/SCM-Control Fiber Link with Novel Differential Integrated Optic Transmitter and Microwave/Optical Direct Detection Receiver

R. Gaudino[††], S. Han[†], M. Shell[†], M. D. Vaughn[†], D. J. Blumenthal[†] and J. Laskar[†]

[†]School of Electrical and Computer Engineering
Georgia Institute of Technology
Atlanta, GA 30332-0250
Tel: 404-894-5168
Fax: 404-894-4700
Email: danb@ee.gatech.edu

[††]Dipartimento di Elettronica
Politecnico di Torino
Corso Duca degli Abruzzi, 24, 10129 Torino, Italy

I. Introduction

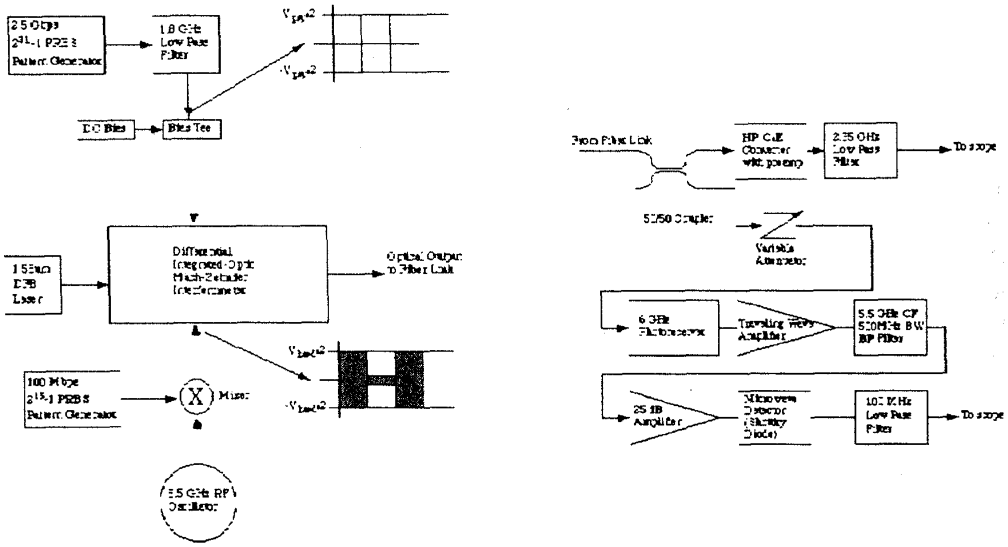
Fiber-optic networks offer the potential to support very wideband, flexible communications for future analog and digital applications. Optical subcarrier multiplexing (OSCM) allows parallel data channels to be transmitted on an optical fiber using a single optical source. One application of OSCM is out-of-band signaling in optical fibers where the data channel is transmitted at baseband and the control channel multiplexed onto an RF subcarrier. The control channel is easily recovered by following photodetection with a microwave bandpass filter. Digital information transmitted on the microwave subcarrier can be used to setup end-to-end connections in a circuit switched network, handle contention resolution [1], and transmit headers in packet-based networks [2, 3,4].

In this paper we present the results of an OSCM digital-baseband/SCM-control link that utilizes a novel transmitter architecture [5] and a microwave/optical direct detection receiver. The transmitter is based on a differentially driven Mach-Zehnder integrated optic modulator. The modulator is used to optoelectronically combine the baseband and subcarrier signal onto the optical carrier. The receiver is based on a simple pin photodetection followed by a traveling wave amplifier, band pass filter and Schottky barrier diode for envelope detection.

II. Link Architecture

The transmitter consists of two data sources, one for digital baseband and the other for the digital control channel. A novel optoelectronic technique is used to combine the baseband data with the microwave subcarrier control, reducing the transmitter complexity and alleviating the need for an electronic summing circuit which introduces excess resistive loss. As shown in Figure

1a, one arm of a differential input integrated-optic Mach-Zehnder interferometer modulator is driven by DC biased baseband data and the other arm of the interferometer is driven by the microwave subcarrier control data. Differential driving of the two interferometer arms acts to combine the baseband and subcarrier multiplexed signal onto the optical output of a DFB semiconductor laser.



(a) (b)

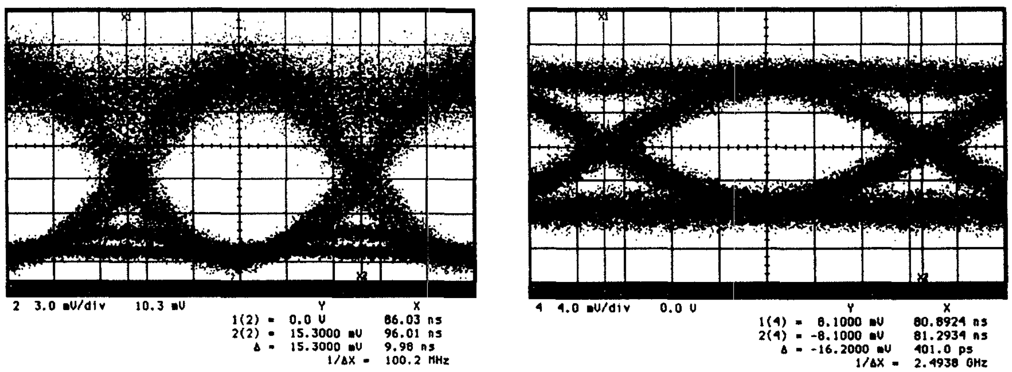
Figure 1. Layout of (a) differentially driven transmitter for optoelectronically combining baseband data and SCM control onto single optical channel and (b) Direct detection microwave/optical receiver for recovery of baseband and SCM control channels.

The baseband and control channel receivers each detects a portion of the optical power determined by the network architecture requirements. Illustrated in Figure 1b, a fiber splitter is used to tap a portion of the optical signal for the subcarrier receiver and output the remaining signal to the baseband receiver. The baseband receiver consists of a simple optical-to-electrical (O/E) converter and a low pass filter to pass the digital baseband and reject the subcarrier channel. The subcarrier receiver consists of an O/E converter followed by a broadband traveling wave amplifier to improve receiver sensitivity. A band pass filter centered at the subcarrier frequency is used to reject the baseband data and a microwave envelope detector followed by a low pass filter to select digital baseband data and reduce noise implements direct detection of the control data channel.

III. Experimental Results

For the 2.5 Gbps baseband link, an on-off-keyed (OOK) pseudorandom bit stream (PRBS) with variable amplitude is generated using a bit-error-rate (BER) tester followed by a 1.8 GHz low pass filter to reduce very high frequency components and to allow addition of a variable bias voltage. The OSCM control channel is generated by upconverting a 100 Mbps OOK control channel to a 5.5 GHz subcarrier using a synthesized signal generator and a microwave mixer. The extinction ratio between the "0" and "1" states at the mixer output was measured to be greater than 30 dB. The baseband and subcarrier signals are applied to independent arms of an $LiNbO_3$ Mach Zehnder modulator, with a $V\pi$ = 3.0Volts and a 3dB modulation bandwidth equal to 6 GHz. Results of a 12.5 Gbps baseband link with the control channel multiplexed on an 18 GHz RF subcarrier will be presented at the conference.

The EOM output power is split to the baseband/OSCM receivers using a 4:1 splitting ratio with the received optical powers measured to be -10.4 dBm for the baseband and -16.4 dBm for the control channel. The baseband signal is detected using an HP11982A lightwave converter, then filtered and displayed on an oscilloscope to display the resulting eye-diagram. The control data signal is detected by following a photodiode with a traveling wave amplifier and bandpass filter with center frequency of 5.5 GHz and 3 dB bandwidth f_{3dB} =500 MHz. The electronic subcarrier signal is further amplified and incoherently detected using a Schottky diode followed by a low-pass filter with corner frequency f_{3dB} = 100 MHz to recover the digital control data. The resulting experimental eye-diagram for the 2.5 Gbps baseband and control data receiver outputs are shown in Figures 2a and 2b respectively. A photograph of the direct detection microwave/optical receiver is shown in figure 3.



(a) (b)

Figure 2. Recovered eye diagrams for (a) the SCM header channel using microwave/optical direct detection and (b) for the baseband channel.

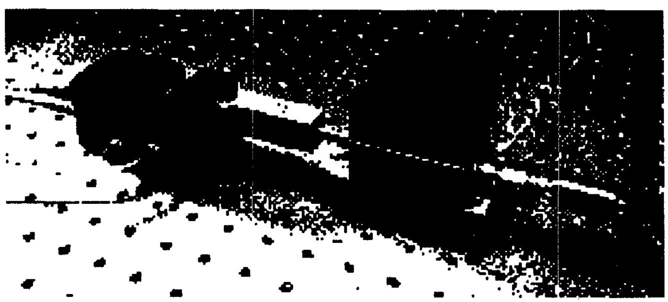


Figure 3. Direct detection microwave/optical SCM receiver. From left to right: photodetector, TWA, bandpass filter, RF amplifier, Schottky barrier diode and low pass filter.

IV. Summary

We have experimentally demonstrated a baseband digital/SCM control fiber link that uses a novel transmitter and microwave/optical direct detection receiver. The transmitter utilizes a differentially driven Mach Zehnder interferometer modulator to optoelectronically combine the AC and DC electronic signals thereby simplifying the transmitter design with minimal impact on performance and functionality. The receiver utilizes a schottky barrier diode to direct detect the subcarrier multiplexed control signal and optical direct detection to recover both the baseband and SCM control channels. Experimental 2.5 Gbps baseband and 100 Mbps control on a 5.5 GHz subcarrier are shown. Results for a 10 Gbps baseband and 100 Mbps control on an 18 GHz subcarrier will be presented at the conference. The receiver architecture greatly simplifies this type of link over coherent SCM links and shows great promise towards integration.

Acknowledgments

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