3:30pm-4:00pm (Invited)
ThT1

High Speed TDM Systems

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Abstract:

We will describe recent worldwide developments in high speed time division multiplexed (TDM) components, links and switches. Advances in component technology and remaining critical problems for 40 Gbit/s transmission will be discussed.

Summary:

In the telecommunication networks, the growth of existing and new services will create a large increase of traffic flow in the near future. The range of services are very diverse in terms of required channel capacity, channel occupancy and connection duration. In this heterogeneous environment, the Asynchronous Transfer Mode (ATM) for network operation is a key technique for multiplexing and routing of these signals. While the optical fibers with their virtually unlimited bandwidth are used for transmission, routing and multiplexing are usually performed electrically. However, the future high speed networks should reach beyond the possibilities of today's electronic switch implementations and photonic technologies will play an essential role also in routing and switching.

In terms of speed, optical systems have rapidly expanded in capacity from early systems at 55Mbit/s in 1978 to present commercial systems at 10 Gbit/s, a quadrupling of capacity every five to six years. The cost per bit/s has fallen by more than an order of magnitude while the capacity has increased by a factor of 100, resulting in an explosion of fiber optic systems and services. The reason for higher speed TDM is simply that the cost typically increases as the square root of bit rate for TDM systems while the cost of a WDM system increases slightly faster than the total bit rate (N different wavelength systems cost N times as much as one system with additional costs for splitting, combining and stabilization). The other important reason relates back to switching systems and the relative ease with which TDM systems can be switched while maintaining synchronization, zero packet loss, and other system control functions.

Although optically multiplexed data rates have reached 400 Gbit/s [1], highest reported electronically multiplexed data rate is 40 Gbit/s [2]. Effort has been done to implement receivers at 40 Gbit/s as well [3-5]. Single channel 40 Gbit/s systems based on electronic TDM are presently under development at various laboratories. A 40 Gbit/s link is presently being developed by UCSB and Rockwell Science Center. This system is based on a mode-locked semiconductor laser with a GaAs/AlGaAs traveling wave Mach-Zehnder electro-optic modulator (Fig.1)[6]. This modulator with electrical bandwidth exceeding 40 GHz, has a switching voltage of 16V and an extinction ratio of 22.6 dB. The best receiver sensitivity is obtained using optical preamplification. In our link we are using an optical receiver with a p-i-n photodetector and a microwave traveling-wave amplifier. Fig. 2 shows the measured transimpedance of this receiver which has a 35 GHz bandwidth and 42-46 dBΩ transimpedance. Fig. 3 shows the output eye-diagram of our electronic 4:1 multiplexer at 30 Gbit/s. Our multiplexer and demultiplexer are working error-free at 30 Gbit/s at 2^{31}-1 pseudo random sequences.

References:

[1] Kawanishi, S.; Takara, H.; Morioka, T.; Kamatani, O.; and others. "400 Gbit/s TDM transmission of 0.98 ps pulses over 40 km employing dispersion slope compensation" OFC 96, paper PD23.

[2] Kuwano, S.;Takachio, N.;Iwashita, K. and others,"160 Gbit/s (4chx40Gbit/s electrically multiplexed data) WDM transmission over 320 km dispersion shifted fiber", OFC 96, paper PD25.

[3] Sano, E.; Yoneyama, M.; Yamahata, S.; Matsuoka, Y., "23 GHz bandwidth monolithic photoreceiver compatible with InP/InGaAs double-heterojunction bipolar transistor fabrication process". Electronics Letters, 24 Nov. 1994, vol.30, (no.24):2064-5.

[4] Lunardi, L.M.; Chandrasekhar, S.; Gnauck, A.H.; Burrus, C.A., "20-Gb/s monolithic p-i-n/HBT photoreceiver module for 1.55- μm applications.", IEEE Photonics Technology Letters, Oct. 1995, vol.7, (no.10):1201-3.

[5] Petersen, A.K.; Reynolds, T.; et al. "3MHz-30GHz traveling-wave optical front-end receiver.", Proceedings of Optical Fiber Communication conference, pp.157-8, SanDiego CA, Feb. 95.

[6] Spickermann, R.; Dagli, N.; Peters, M.G., "GaAs/AlGaAs electro-optic modulator with bandwidth >40 Ghz.", Electronics Letters, 25 May 1995, vol.31, (no.11):915-16.

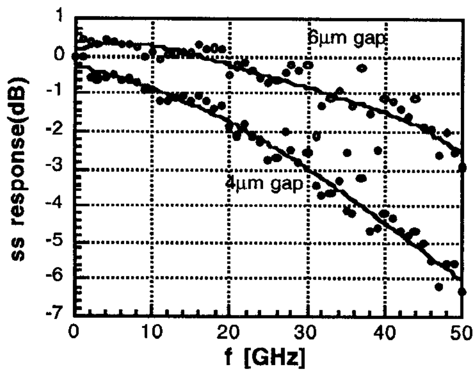

Figure 1 Small signal response for GaAs/AlGaAs traveling-wave Mach-Zehner electro-optic modulators fabricated at UCSB.

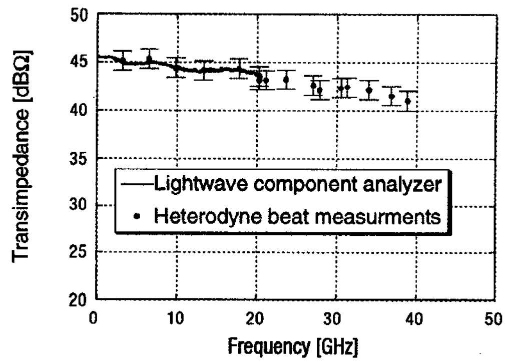

Figure 2 Packaged optical receiver with pin detector and wide-band traveling-wave amplifier.

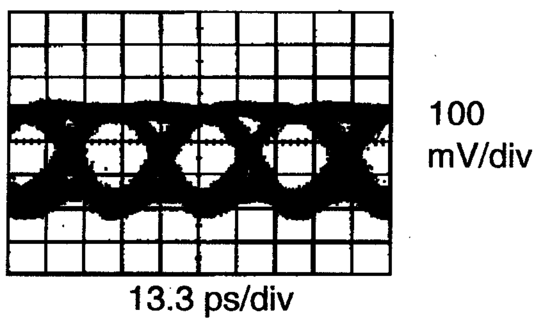

Figure 3 Measured output eye diagram of 4:1 electronic multiplexer at 30 Gbit/s. The multiplexer was fabricated by Rockwell Science Center in AlGaAs/GaAs HBT technology.