Demonstration of a 10 Gb/s Channel-Tunable Mode-Locked Laser Transmitter for OTDM Networks

W. Hung, L.K. Chen, F. Tong, K.-P. Ho, L. Y. Chan, T. Shimizu*, and H. Yokoyama*
Dept. of Information Engineering, The Chinese University of Hong Kong,
Shatin, N.T., Hong Kong (whung@ie.cuhk.edu.hk)
*Optoelectronics and High Frequency Device Research Laboratory, NEC Corporation, Japan

Abstract: A hybrid mode-locked laser transmitter was demonstrated to generate 10-GHz repetition rate optical short pulses that can be easily tuned to different TDM channels. The transient of the lasers during the channel-tuning period was investigated.

Introduction In a bit-interleaved OTDM network, a channel-tunable transmitter or receiver that can tune its channel to a particular time slot is essential [1]-[4]. In this paper, we demonstrate a new channel-tunable 10-Gb/s transmitter based on a hybrid mode-locked semiconductor laser diode (MLLD) capable of generating 2.6 ps optical pulses [5]. Channel tuning is achieved by tuning the phase of the RF sinusoidal signal that drives the saturable absorption (SA) section of the MLLD. The transient effect of the mode-locking process by the phase change of the driving signal during the channel-tuning period is also investigated.

Operation Principle Mode-Locked lasers are very attractive and commonly used for short pulses generation. An active mode-locked laser requires a sinusoidal modulation signal with a frequency equal to one of the harmonics of the laser cavity modes. After mode-locked, the optical pulses generated are synchronized with the phase of the driving RF signal. If the phase of the driving signal is adjusted, optical pulses will be generated at different time. Thus optical pulse streams at different time slots with very short pulse width can be generated easily.

One parameter that is of major concern to network design is the duration of the channel-tuning time for the network's medium access control. During that transient, no data can be sent, thus deteriorating network capacity. It is desirable to have a mode-locked device with a short transient period. As the MLLD has a shorter cavity round trip time than that of fiber lasers because of the much shorter cavity length (4.2mm), the channel-tuning transient will be shorter, making it a better choice of channel-tunable transmitter.

Though the turn-on transient of active mode-locked lasers has been investigated [6], the transient effect due to the tuning of the RF driving signal has not been discussed. To observe the channel-tuning transient, we switch the phase of the driving signal alternatively between two phases. If the transient effect is periodic, we then can obtain the information of the channel-tuning characteristics of the mode-locked laser from a digital sampling oscilloscope. The minimum guard time that has to be reserved for channel-tuning is then can be decided.

Experiment A tunable transmitter for a 40-Gb/s network with a 10-Gb/s per channel data rate is demonstrated in Fig. 1. In the channel selection part, there are 4 different possible paths that can be selected by the two electronic switches. Different paths with different lengths give rise to different phase shift of the 10-GHz sinusoidal signal. The signal is then fed into the SA section of the MLLD. Optical pulse streams that are tuned to channel 1, 3 and 4 (with 0, 50, and 75 ps delays) are shown in Fig. 2. This demonstrated the feasibility of generating a tunable-delay mode-locked pulse stream for OTDM networks.

To study the channel-tuning transient, an experimental setup illustrated in Fig. 3 is used. It consists of two stages. The first stage is responsible for generating RF sinusoidal signals with

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periodic phase changes as shown in the inset. The RF signals are then fed into the SA section of the MLLD in the second stage. Fig. 4 shows the oscilloscope trace of the MLLD output. The transient is found to be < 2 ns (20 pulses) for this device. During phase changes, the amplitude of the pulse train gradually subsides and rebuilds again. The amplitude of the mode-locked pules in one phase is higher than that in the other as the amplitude of the electronic driving signals in the two phases are slightly different due to the unequal attenuation in the two delay paths. The details of the pulses generated are shown in the insect of Fig. 4. The left trace is the optical pules generated in phase 1 and the right is for phase 2. The relative delay of the two traces is 20 ps (1/5 of the bit period).

Summary A 10 Gbit/s channel-tunable transmitter for OTDM networks is demonstrated by tuning the phase of the driving RF signal to a hybrid mode-locked laser. The corresponding transient for this transmitter is found to be ~2 ns (20 pulses). This work is supported in part by RGC-CUHK4170/97E project.

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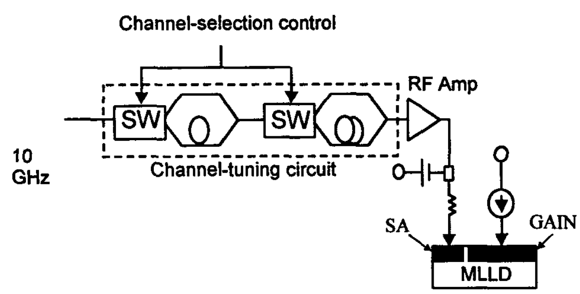

Fig. 1. The channel-tunable transmitter. SW - RF switch., SA – MLLD saturable absorber section, GAIN – MLLD gain section.

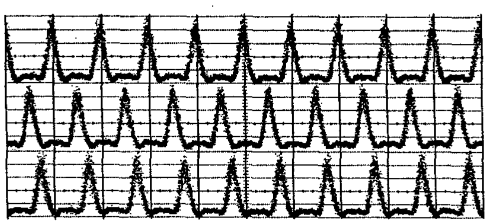

Fig. 2. 10Gb/s Optical pulse streams at channels 1, 3 and 4. 100ps/div

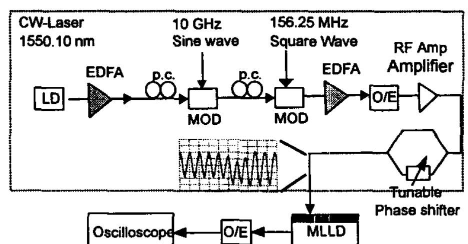

Fig. 3. Experimental setup for transient study LD-laser diode, p.c.-polarization controller, MOD-Mach Zehnder modulator, O/E-optical to-electrical conversion, MLLD-mode locked laser diode.

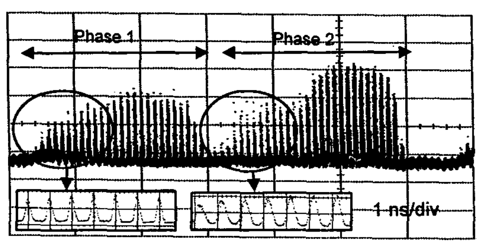

Fig. 4. Transient of the optical pulses driven by alternatively phase change sinusoidal signal.