TSTCNN). Fig. 1 shows the BER of the first user against the near-far-ratio (NFR = E_i/E_1, i = 2,3,4,5) with the signal-to-noise-ratio (SNR) of user 1 being fixed at 8dB. It can be seen from Fig. 1 that the TSTCNN detector outperforms the HNN detector over the NFR range. When the NFR is low, the TCNN detector has poor performance. As the NFR increases, the performance of both the TCNN detector and the TSTCNN detector approach that of the optimum detector closely. In Fig. 2, the average BERs of these detectors are plotted against SNR with all users having the same power. From this Figure, it can be seen that the performance of the TSTCNN detector tracks that of the optimum detector, while the performances of the HNN and TCNN detectors are obviously interference limited with the increase in SNR.

Conclusion: A time-varying scaling-parameter transiently chaotic neural network has been developed for multiuser detection in DS/CDMA systems. Compared with the HNN detector and TCNN detector, it has much better performance. The performance of the TSTCNN detector can closely approximate that of the optimum detector.

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All-optical clock recovery from NRZ data with simple NRZ-to-PRZ converter based on self-phase modulation of semiconductor optical amplifier

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The feasibility of all-optical clock recovery (CR) from non-return-to-zero (NRZ) data with a simple NRZ-to-pseudo-RZ (PRZ) converter based on the self-phase modulation (SPM) of a semiconductor optical amplifier (SOA) is empirically presented. The SPM induces a frequency chirp at every leading edge of the NRZ data passing through the SOA. The SPM-induced chirp component is extracted by an optical grating bandpass filter and then transformed to PRZ data with a low polarisation dependency of ~0.7dB. By transmitting the PRZ data into a mode-locked Er-doped fibre laser, all-optical CR has been achieved at 2.5Gbit/s.

Introduction: All-optical clock recovery (CR) will be one of the key technologies in future all-optical communication networks. Various techniques for realising all-optical CR have been proposed and demonstrated. Most of these techniques are limited to all-optical CR from a return-to-zero (RZ) data format, which is relatively easier than all-optical CR from a non-return-to-zero (NRZ) data format because each pulse in RZ data has its own clock component. However, the NRZ data format is actually widely used in current lightwave systems because of its bandwidth efficiency. Nevertheless, demonstrations of all-optical CR from NRZ data are rare owing to implementational difficulties and, in particular, the rapid progress of electronic CR technology.

All-optical CR from NRZ data was first demonstrated in [1]. However, in this case 3.2Gbit/s NRZ 1010... regular data were used. Recently, all-optical CR from NRZ pseudo-random data using a nonlinear loop clock generator and a modelocked figure-eight laser has been successfully demonstrated in [2]. In this Letter, we present a demonstration of all-optical CR from NRZ data based on the self-phase modulation (SPM) of an SOA. The SPM is used in extracting a pseudo-RZ (PRZ) signal from the NRZ data. The NRZ-to-PRZ converter combined with a modelocked Er-doped fibre laser [3] shows stable CR operation under normal experimental conditions.

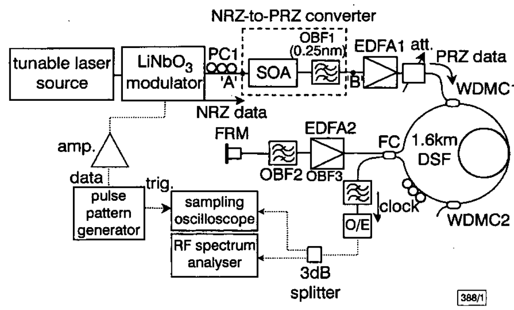

Fig. 1 *Experimental setup*

EDFA: erbium-doped fibre amplifier; Att: optical attenuator; PC: polarisation controller; OBF: optical bandpass filter; SOA: semiconductor optical amplifier; DSF: dispersion-shifted fibre; WDMC: wavelength division multiplexing coupler; FRM: Faraday rotating mirror; FC: fixed coupler
——— optical
·········· electrical

Operation: In [1], when optical NRZ data enter into a semiconductor optical amplifier (SOA), an overshoot at the leading edge of the NRZ data is normally generated owing to the gain depletion of the SOA. The overshoot produces a clock component from the NRZ data. However, because the NRZ modulation signal component still also exists within the output signal of the SOA, the suppression ratio between the clock component and the modulation component is very low. Therefore, to obtain an output with a higher suppression ratio, an NRZ-to-PRZ conversion is required.

The proposed NRZ-to-PRZ converter based on the SPM of an SOA has a simple structure, which is composed of an SOA and a narrow-bandwidth grating filter. After optical NRZ data of wavelength of λ pass through the SOA, the wavelength near the leading-edge of the NRZ data is red-chirped to $\lambda+\Delta\lambda$ together with the overshoot [4]. The physical mechanism for the spectral shift is the SPM occurring as the result of index nonlinearities induced by gain saturation of the SOA [5]. The wavelength-shifted components are selected by the grating-filter, the centre wavelength of which is set to $\lambda+\Delta\lambda$. The PRZ signal is generated at every leading edge of NRZ data and then enters into the modelocked fibre laser to produce an optical clock. The NRZ-to-PRZ converter is very stable with a simple structure and is insensitive to the polarisation of input pulses if the SOA used in the experiment is of the polarisation insensitive type.

Experiments: Fig. 1 shows an experimental setup for the proposed scheme. An NRZ data sequence is generated by modulating the CW output of a tunable laser diode (HP8168F) with an $LiNbO_3$ electro-optic modulator driven by a pattern generator. The PRZ signal is generated from the above-mentioned NRZ-to-PRZ converter (dotted box in Fig. 1) based on the SPM of an SOA, and then injected into the modelocked fibre laser. The modelocked fibre laser cavity consists of a nonlinear optical loop mirror (NOLM), an Er-doped fibre pumped with a 1480nm laser diode, an optical bandpass filter OBF2, and a Faraday rotating mirror (FRM) [3].

Fig. 2*a* and *b* show the measured waveforms and the RF spectrum of the input NRZ data, respectively. The length of the pseudorandom binary sequence of the input signal is 2^{23}–1 at 2.5Gbit/s (λ = 1535.78nm). The NRZ data contain very little well-defined sequential clock information at this data rate, as shown in Fig. 2*b*. The temporal waveform of the converted PRZ signal is shown in Fig. 2*c*. The amplitudes of the PRZ bit stream are uneven owing to leading-edge slope differences of NRZ data and pattern effects of the SOA. The clock components generated from the NRZ-to-PRZ conversion can be seen in the RF spectrum of the PRZ data, as shown in Fig. 2*d*. The oscilloscope trace shown in Fig. 2*e* represents the recovered output clock signal from the modelocked fibre laser. From the corresponding RF spectrum, as shown in Fig. 2*f*, the clock-to-modulation component ratio (CMR) is enhanced by ~10dB compared to that of the PRZ signal in Fig. 2*d*. The SOA (a carrier lifetime of ~320ps, Alcatel 1901) in this experiment is of the polarisation insensitive type (~0.6dB) based on low tensile bulk GaInAsP and is driven at an operating bias current of 198mA. The optical mean power at point 'A' and point 'B' in Fig. 1 is –0.25dBm (NRZ data) and –13.8dBm (PRZ data), respectively. The PRZ signal from EDFA1 is amplified to 7.63dBm and then injected into the modelocked fibre laser. Here, the centre wavelength of the grating filter (OBF1, which has a bandwidth of 0.25nm at –3dB, JDS FITEL TB9226) is set to 1535.97nm. When the polarisation of the NRZ data at the SOA input is fully stirred by manipulating the PC1, the intensity variation of the PRZ data is ~0.7dB.

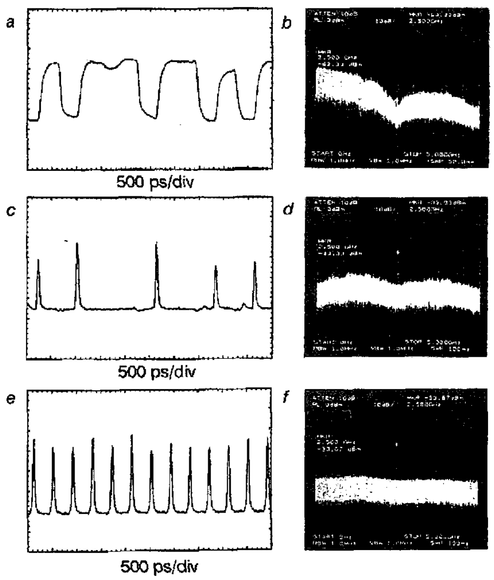

Fig. 2 *Measured oscilloscope traces and RF spectra*

a Waveform of input NRZ data
b RF spectrum of input NRZ data
c Waveform of converted PRZ data
d RF spectrum of converted PRZ data
e Waveform of recovered clock signal
f RF spectrum of recovered clock signal

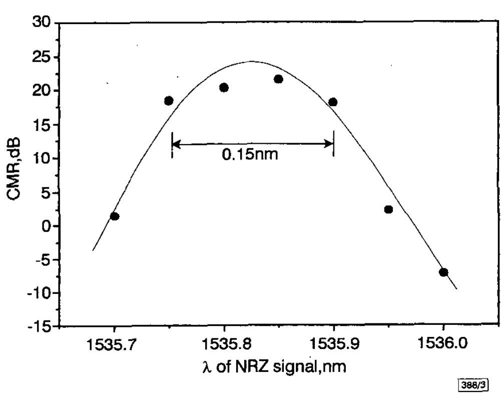

Fig. 3 *CMR against wavelength of NRZ signal when centre wavelength of OBF1 is fixed to 1536.5nm*

To investigate the sensitivity to the wavelength of the NRZ signal, we measured the CMR according to the NRZ wavelength change while the centre wavelength of the grating filter was fixed at 1536.5nm. For a wavelength variation of 0.15nm (~18.75GHz), a CMR of > 18dB was obtained, as shown in Fig. 3. In a WDM transmission system, it is simple to lock the frequency of a DFB-LD within 10MHz [6]. Hence, the proposed method has significant applications in WDM networks.

Conclusion: We have proposed and successfully demonstrated the feasibility of all-optical clock recovery based on the SPM of an SOA. The SPM-induced chirp is used for the NRZ-to-PRZ conversion. The conversion has the advantage of stable polarisation-independent all-optical processing (~0.7dB). Moreover, because it can be realised using a compact device, on-chip operation will be possible in the near future. Although the experiment has been conducted for 2.5Gbit/s NRZ data, the scheme may be applied to all-optical CR at much higher repetition rates (~100Gbit/s) with an SOA having a much shorter lifetime. Recently, we have successfully conducted the NRZ-to-PRZ conversion at 10Gbit/s using the same experiment. If the carrier lifetime reduction technique [7] is introduced, more improvement may also be possible.

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Cross-coupled MZI configuration for wavelength selective switching

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A novel optical device for wavelength selective switching is proposed. The device is based on a cross-coupled MZI (CCMZI) with wavelength-dependent cross-coupling. The analysis is based on mode propagation theory. SiO_2/Si is presently the most promising technology for realising this kind of device.

Introduction: Photonic WDM-based systems [1] require different kinds of WDM-device. For (de)multiplexing and fixed add/drop-mux functionality concepts have already been implemented with a satisfactory system performance, e.g. arrayed waveguide grating (AWG) based demultiplexers [2] and add/drop multiplexing [3]. On the other hand, there are few principles that provide wavelength selective switch (WSS) functionality if we consider compact