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Characterisation and optimisation of a dual-channel picosecond gain-switched DFB laser system for use as a pump–probe source ☆

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Abstract

The output characteristics of a dual-channel gain-switched laser system are studied with respect to the gain-switch frequency and power. InGaAsP laser diodes operating at 1548 and 1549 nm are gain-switched at 1 GHz and the spectral and temporal profiles of the pulses are investigated. The development of a pump–probe system with the use of in-line amplifiers and amplified spontaneous emission filtering is detailed.

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Keywords: DFB; Gain-switching; Picosecond; Pump–probe system

1. Introduction

In order to increase the amount of data transmitted through a telecommunications system that employs WDM and TDM either the number of wavelength channels or the individual channel rates need to be increased. Increasingly both approaches need to be used, as there is a finite bandwidth available in silica fibre. High-speed sources are obviously crucial for systems running at 10 Gbit/s rates and there are a variety of solutions available. Also at high channel rates it is important to have short pulses as in TDM the pulsewidth of the signal pulses sets the upper limit on the bit rate. From the viewpoint of nonlinear optical switching, short pulses are advantageous as higher peak powers lead to shorter interaction length requirements and a reduction of the size of the switch.

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This sets out a challenge for a dual-channel system that could provide a pump and signal channel output at different wavelengths with the shortest possible pulse widths at high repetition rates. The pulse to pulse jitter also has to be minimal to enable complete switching as the overlap between a signal pulse and a pump (or gate) pulse determines the proportion of the signal that is switched.

In order to assess the performance of new and novel optical fibres for nonlinear optical switching applications a high-speed dual-wavelength short pulse source was required. The design chosen was a dual-channel gain-switched distributed feedback (DFB) laser system. DFBs were chosen for their high side-mode suppression and wavelength stability and fibre amplifiers were used to achieve high peak powers. A description is now given of the system design and the principles of operation of each of the stages used. Finally the characteristics of this system is described for the suitability of nonlinear optical experiments.

The dual picosecond source consisted of two synchronised RF generators driving two InGaAsP DFB laser units. The overall system design is shown in Fig. 1. Temperature controls on the DFB unit allow the peak wavelength to be finely tuned. The HP8648B and Agilent 8648C RF signal generators are synchronised using a 10-MHz signal that also triggers the detection system. Gain-switching involves the modulation of a laser diode held just below the threshold current. The initial DC level, the applied AC frequency and magnitude determine the form of the optical pulse produced. The optical pulse shape can be broadened or compressed and the pulse can also be delayed by a suitable selection of these parameters [1]. Any semiconductor laser is sensitive to back reflections coupled into the cavity and particularly when there are multiple inline amplifiers in the system. Counter propagating optical power can be significant. To eliminate this a polarisation insensitive optical isolator is used. The process of gain-switching produces pulses that are considerably chirped because of temporal refractive index variations occurring during pulse generation. The chirp induced is negative which corresponds to a frequency shift of the leading and trailing edges to the blue and red, respectively. Since red-shifted components travel faster than blue-shifted components in the normal (or positive) dispersion regime,

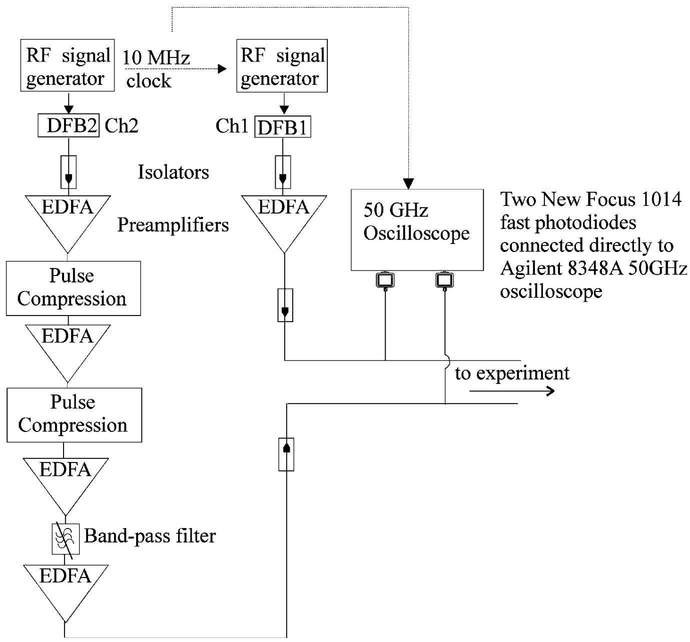

Fig. 1. Configuration used in the pump–probe experiments.