1x2 optical packet switch using all-optical header processing


A 1x2 all-optical packet switch is presented. The header processing is implemented by using a SLALOM structure and an optical flip-flop memory is used to store the processed header bits. The packets are switched in wavelength by using cross-gain modulation. Experimental results are presented.

Introduction: The need to produce an optical packet switch has been well documented [1, 2]. Approaches to all-optical header processing have been described in the literature [3]. We present (on a proof of concept basis) a 1x2 all-optical packet switch. All the processing steps related to both the header and the payload are executed in the optical domain. In our approach, the data-packets consist of non-return-to-zero amplitude-modulated data bits. The header information is implemented at an effectively lower bit rate than the payload. The payload is Manchester encoded. This data format ensures that header processing can be implemented by using a SLALOM configuration [4]. The processed header information can be stored in an optical flip-flop memory that drives a wavelength converter to switch the packet's wavelength.

Operating principle: The all-packet switch is implemented using the structure shown in Fig. 1. The optical power of an optical packet arriving at the packet switch is split into two equal parts. Half of the optical power of the packet is delayed and injected into a wavelength converter. The other half of the optical power is fed into the header processor.

The packet structure is shown in Fig. 1. We distinguish packets with two kinds of headers. The first header (header 1) consists of a repeated hexadecimal FFOFF00 pattern. The second header (header 2) consists of a repeated hexadecimal 0000000 pattern. Packets with alternating headers were used throughout the experiments. The packet's payload is Manchester encoded to avoid repetition of the header in the payload.

For the first stage of the optical header processing, the packet is fed into a SLALOM structure. Suppose that a packet with header 1 enters the SLALOM. It is shown in [4] that the two-pulse correlation principle of SLALOM causes a correlation pulse to appear at the SLALOM's output. The high bit rate payload is suppressed because the SOA is driven in saturation [4]. The SLALOM's output is then passed through an optical threshold function to differentiate more strongly between the correlation pulse and the suppressed payload. The threshold function operation principle is similar to that of the optical flip-flop memory that is described later. The threshold function increases the contrast between the correlation pulse and the suppressed payload from 3dB at the output of the SLALOM to over 25dB. The output of the threshold function is then amplified by an EDFA and filtered. If a packet with header 2 enters the SLALOM structure, then no correlation pulse is formed and consequently no pulse is generated by the header-processing block [3].

The output of the header processor produces an optical pulse when there is a packet containing header 1, indicating that the packet should be routed to wavelength \( \lambda_1 \). The optical power of the pulse is split into two. One half of the pulse is sent directly to the packet switch at input. The packet switch at input is coupled in packet switch at input. The packet format is given.

The time between two packets was 17.5 ps. Repetition of the packet was repeated for a duration of 7.5 ps. The payload consists of a data stream of 35 ps of Manchester encoded pseudo-randomly generated bits. Header and payload were separated by a guard band of 5 ps. The time between two packets was 17.5 ps. Repetition of the header pattern was necessary to make the optical flip-flop changes faster [5]. This was due to the large laser cavities, which had long round-trip time. Integration of the flip-flop memory into an optical chip would overcome this problem. All the couplers used in the experiment were 50/50 couplers except those couplers used in the flip-flop. Their coupling ratios are given in Fig. 1. The fibre Bragg gratings in the threshold function formed wavelength-selective

Fig. 1 Experimental setup to demonstrate 1x2 all-optical packet switch

Traffic from network is coupled in packet switch at input. The packet format is given.

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mirrors at 1555.8 and 1558.43 nm. The optical flip-flop memory was implemented using Fabry-Perot filters as wavelength-selective elements operating at 1549.26 and 1552.52 nm, corresponding to wavelengths $\lambda_1$ and $\lambda_2$, respectively. The SOAs were manufactured by JDS Uniphase and employ a strained bulk active region. The component lasers had low intrinsic modulation bandwidths, which was much slower, with the header length needing to be of the order of microseconds. This was due to the particular implementation of the optical threshold function and flip-flop used in the experiment. The lasers used to form these functions were constructed from standard commercially available fibre pigtailed components having cavity lengths of many metres. Thus the component lasers had low intrinsic modulation bandwidths, which limited the speed of the threshold function and the flip-flop. However, integrated versions of these functions using lasers with cavity lengths of less than a millimetre could attain speeds in the GHz range, allowing high header data rates and short packet lengths. In principle, this concept can be extended to a 1xN switch since a SLALOM structure can be used to recognise more complicated header patterns [4].

Discussion: The packet payload data rate of the switch was 2.5 Gbit/s, which was only limited by the wavelength converter, and could potentially reach 100 Gbit/s [7]. The header data rate was much slower, with the header length needing to be of the order of microseconds. This was due to the particular implementation of the optical threshold function and flip-flop used in the experiment. The lasers used to form these functions were constructed from standard commercially available fibre pigtailed components having cavity lengths of many metres. Thus the component lasers had low intrinsic modulation bandwidths, which limited the speed of the threshold function and the flip-flop. However, integrated versions of these functions using lasers with cavity lengths of less than a millimetre could attain speeds in the GHz range, allowing high header data rates and short packet lengths. In principle, this concept can be extended to a 1xN switch since a SLALOM structure can be used to recognise more complicated header patterns [4].

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References

50 GHz spaced 40 Gbit/s × 25 WDM transmission over 480 km using bandlimited RZ signals

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50 GHz spaced 40 Gbit/s × 25 WDM transmission over 480 km has been successfully demonstrated using bandlimited RZ signals and an SMF-based dispersion-flattened transmission line. What the authors believe is the longest distance transmission for a spectral efficiency of 0.8 bit/s/Hz was achieved without using polarisation demultiplexing.

Introduction: A higher channel bit rate, such as 40 Gbit/s, is preferable for terrestrial WDM transmission systems, since the number of terminals can be significantly reduced. In addition, to increase the aggregate capacity with a finite transmission bandwidth, a higher spectral efficiency is indispensable. So far, the highest spectral efficiency reported at a 40 Gbit/s channel bit rate has been 0.8 bit/s/Hz, which was demonstrated in 186 km NRZ transmission with polarisation demultiplexing of the adjacent WDM channels at the receiver [1]. In practical conditions, however, the use of such an automated polarisation-demultiplexer may introduce too much complexity and cost increase. Without using polarisation demultiplexing, the highest reported spectral efficiency in 40 Gbit/s-based WDM transmission has been 0.64 bit/s/Hz, demonstrated in 300 km NRZ transmission [2].

In this Letter, we present experimental results of 50 GHz spaced 40 Gbit/s × 25 WDM transmission over 480 km using bandlimited RZ signals and an SMF-based dispersion-flattened transmission line without using polarisation demultiplexing. The achieved spectral efficiency was 0.8 bit/s/Hz with just passive optical components, and the transmission distance was more than double the length of that reported previously with polarisation multiplexing [1].