J.M. Dailey, M.J. Power, R.P. Webb, and R.J. Manning, "All-Optical Modulation Converter for On-Off Keying to Duobinary and Alternate-Mark Inversion at 42.6 Gbps", *CLEO/Europe 2011*, Munich, Germany, May 22-26, 2011, Paper CI4.1.

http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5943121

All-Optical Modulation Converter for On-Off Keying to Duobinary and Alternate-Mark Inversion at 42.6 Gbps

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Advanced modulation formats have become increasingly important as telecoms engineers strive for improved tolerance to both linear and nonlinear fibre-based transmission impairments. Two important modulation schemes are Duobinary (DB) and Alternate-mark inversion (AMI) [1] where transmission enhancement results from auxiliary phase modulation. As advanced modulation formats displace Return-to-zero On-Off Keying (RZ-OOK), inter-modulation converters will become increasingly important. If the modulation conversion can be performed at high bitrates with a small number of operations per bit, then all-optical techniques may offer lower energy consumption compared to optical-electronic-optical approaches. In this paper we experimentally demonstrate an all-optical system incorporating a pair of hybrid-integrated semiconductor optical amplifier (SOA)-based Mach-Zehnder interferometer (MZI) gates which translate RZ-OOK to RZ-DB or RZ-AMI at 42.6 Gbps. This scheme includes a wavelength conversion to arbitrary output wavelength and has potential for high-level photonic integration, scalability to higher bitrates, and should exhibit regenerative properties [2].

AMI can be generated using a one-bit delay-and-subtract operation which we have previously numerically demonstrated using an XOR gate like that shown in Fig. 1 [3]. DB can also be produced with a delay-and-subtract operation if an inverted copy of the input data is used at one of the XOR inputs. The two outputs of the Dual-Output Wavelength Converter, the first gate shown in Fig. 1, can be independently optimized to produce either (data, data) or (data, inv-data) for AMI or DB conversion, respectively.

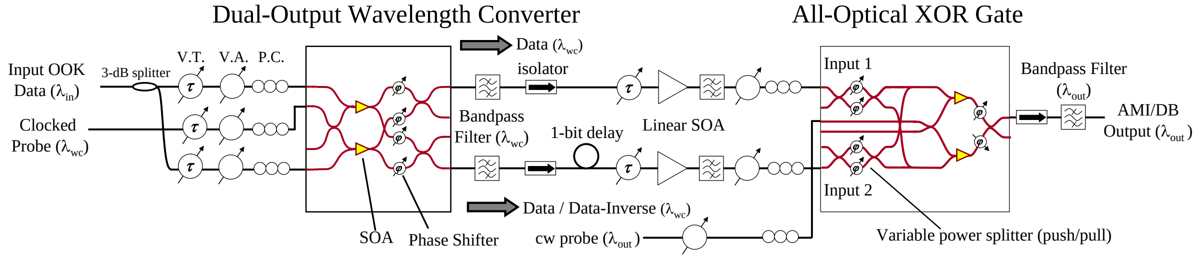

Fig. 1. Detailed experimental setup. V.T., V.A., and P.C. are variable time delay, variable attenuator and polarization controller, respectively.

We demonstrate in our experimental results below that the signal output spectral features are well-matched with the expected modulation format spectral characteristics. We also show clear and open eyes for each output. The input RZ-OOK signal is a 42.6 Gbps sequence modulated with a standard 2^7-1 PRBS and the measured XOR output spectra are plotted below in Figs. 2a and 2b. Fig. 2a shows the output DB spectrum (black line) plotted with the OOK output spectrum (gray line) produced by turning off one of the XOR gate inputs. Likewise, Fig. 2b shows the AMI spectrum (black line) plotted alongside the OOK spectrum (gray line). The OOK spectrum in both figures displays the expected carrier and sideband peaks at integer multiples of the bitrate, B. The smaller bump-like features between the peaks result from the short PRBS pattern. The DB spectrum exhibits characteristic nulls at frequencies $f = \pm$ (n+1/2)B (n=0,1,2,…), while the AMI spectrum shows the expected nulls at f = nB. Carrier suppressions are ~6.4 dB (DB) & ~17 dB (AMI) with respect to the OOK carrier. Output eye extinction ratios are 14 dB (OOK) & 12 dB (DB) and 12 dB (OOK) & 13 dB (AMI).

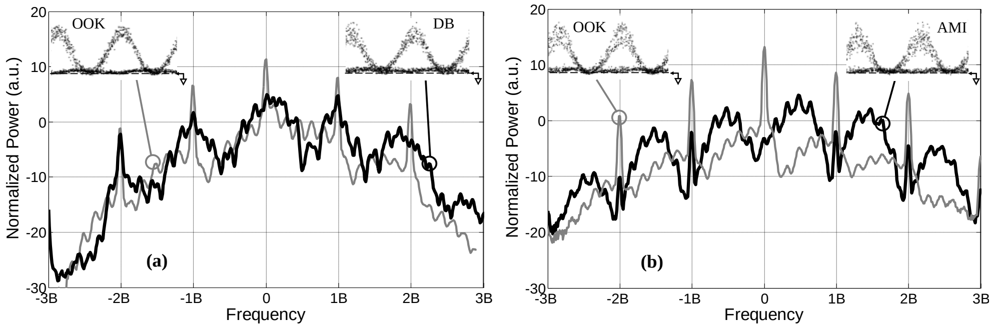

Fig. 2. (a) The DB (black) and OOK (gray) output spectra. (b)The AMI (black) and OOK (gray) output spectra. The frequency axes are centred at the cw carrier and normalized to the bitrate, B.

This work was funded by the Science Foundation Ireland under grant 06/IN/1969 and the hybrid gates were produced by CIP Technologies.

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