Phase-shifted photonic analog-to-digital conversion system with 40GS/s sampling rate

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Abstract:

A phase-shifted photonic analog-to-digital conversion system is experimentally demonstrated with 40GS/S sampling rate. A 2.5GHz sinusoid signal is quantized and the effective number of bits of 3.41 is obtained.

Introduction:

The analog-to-digital converters (ADCs) are the key devices in a wide range of applications. Due to high-speed sampling rate and broad bandwidth, using photonic technology in ADC has attracted researchers' interest for almost three decades [1]. To exploit the potential of photonic ADC, the phase-shifted photonic quantization scheme has been proposed recently [2-3], which can realize higher resolution with only one electro-optic modulator (EOM).

In this letter, a phase-shifted photonic ADC system with 40GS/s sampling rate is presented, which is based on polarization interferometer structure. 2.5GHz sinusoid signal is quantized with 4×10GS/s time- and wavelength- interleaved sampling pulses.

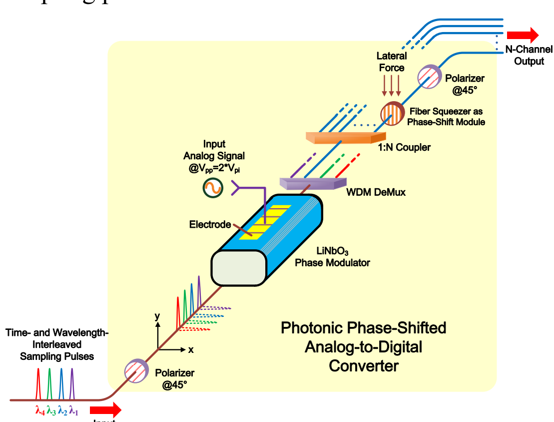

Fig. 1 Schematic setup of phase-shifted photonic ADC system based on polarization interference.

Principle and experiment setup:

Fig. 1 shows the phase-shifted photonic ADC scheme. The sampling pulses are 4×10GS/s time- and wavelength- interleaved pulse train (shown in Fig. 2), in which the sampling rate for each wavelength is 10GS/s, and the time interval between adjacent wavelengths is 25ps. In this way, the sampling rate could be remarkably improved by multiplexing more wavelengths. Through a polarizer, sampling optical pulses are launched with 45degree into the x and y axes of phase modulator by which the phase difference between x and y directions will linearly change with the voltage of electrical analog signal. After passing through the phase modulator, the time- and wavelength- interleaved pulse train is de-multiplexed by a WDM DeMux. For each wavelength, the optical pulses are divided into N channels. In each channel, a fiber squeezer is used to produce stress-induced birefringence between x and y directions, which will make a fixed $(i\text{-}1)\times\pi/N$ phase shift between two polarizations, where i stands for the *ith*-output channel. Then two polarizations are made to interfere through a polarizer as in-line analyzer whose transmission axis is ±45 degree relative to the x and y axes. The output pulse train could be detected by a photodetector and observed in oscilloscope.

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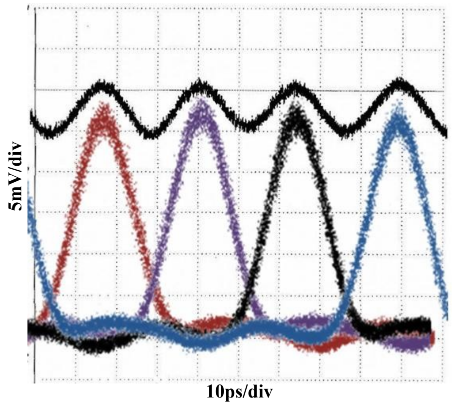

Fig. 2 4×10GS/s time- and wavelength-interleaved sampling pulses. The pulse trains corresponding to different wavelengths are shown in different colors, and the upper trace is the waveform of the multiplexed 4×10GS/s sampling pulses.

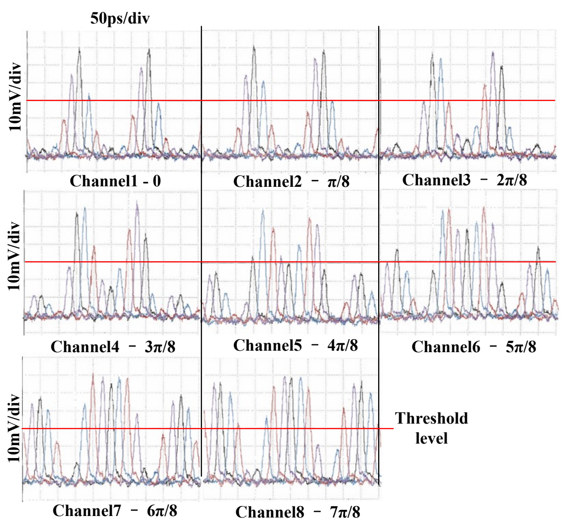

Fig. 3 The observed output optical pulses of the four wavelengths are superimposed on one trace for 8 output channels. The red line is the level to threshold the pulses.

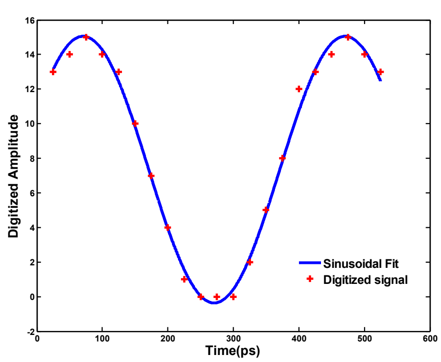

Fig. 4 The digitized value to 2.5GHz sinusoid signal (red dots) and sinusoidal fit result (blue line).

Experiment results:

In our experiment, the input electrical analog signal is 2.5GHz sinusoid wave with $V_{pp} = 2V_{\pi}$ (V_{π} is the half-wave voltage of the phase modulator), and the output channel number for each wavelength is 8, corresponding to a resolution of 4 bits. The bandwidth of input analog signal is only limited by the $LiNbO_3$ phase modulator. The received optical pulses of the four wavelengths with the same phase shift are superimposed on one trace as shown in Fig. 3, where different colors represent different wavelengths. Half of the maximum output is set as the threshold. According to quantization results, the curve-fit sinusoid signal is calculated and shown in Fig. 4, achieving an effective number of bits (ENOB) of 3.41.

Conclusions:

A phase-shifted photonic ADC system using time- and wavelength- interleaved pulse train with a sampling rate of 4×10GS/s is proposed and experimentally demonstrated. The ENOB of 3.41 is achieved by quantizing a 2.5GHz sinusoid signal. Using this method, the sampling rate could be extended to even up to 100 gigahertz.

(This work was supported by the National Natural Science Foundation of China (60607008) and by the National High Technology Research and Development Program of China (2007AA01Z271).)

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