Strip silicon waveguide for code synchronization in all-optical analog-to-digital conversion based on lumped time-delay compensation scheme
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Analog-to-digital converter (ADC) as an important part of communication system needs to satisfy the requirements of the rapid development of ultra-wide-band applications such as advanced Radar system, high speed optical communication, etc.[1-3] The electrical ADC whose sample rate and art resolution are several giga-sample per second (GSa/s) and 10 bit respectively cannot meet the requirements of ultra-wide-band applications.[1-3] All-optical ADC has attracted much attention because it can cope with the problems in electrical field, meanwhile achieve appropriate quantization resolution and sampling rate. Optical quantization could be realized by soliton self-frequency shift (SSFS), higher-order soliton fission, cross-phase modulation (XPM) effects, etc. Optical quantization utilizing SSFS effect is a promising option among the above schemes because of its ultrafast response speed and sampling rate transparency. During the process of frequency shift, time delays between optical pulses with different peak powers occur inherently, leading to the non-synchronization of the quantized optical pulses and coding error. The multiple optical time-delay lines (TDLs) are utilized to compensate time-delay in the previous schemes whose disadvantages are complicated and expensive.

We propose a lumped time-delay compensation scheme based on the SSFS for all-optical analog-to-digital conversion. A strip silicon waveguide is designed and used to compensate for the entire time delays of the optical pulses after the SSFS module instead of the corresponding TDLs. The simulation results show that the strip silicon waveguide can compensate for the time-delay accurately with the full width at half maximum (FWHM) variation less than 2.52 ps. The proposed scheme can support a maximum supportable sampling rate (MSSR) of 50.45 GSa/s with no coding error. When a spectral compression module can be added by utilizing a span of high nonlinear fiber (HNLF) after the SSFS module, a potential 3-bit resolution can be realized since the total wavelength range is only 22 nm. The lumped time-delay compensation scheme utilizing the large dispersion strip silicon waveguide instead of the multiple TDLs reduce the structure complexity in practical applications, which conforms to the trend of integration and miniaturization of all-optical ADC.