

Frequency Shifting in SOAs For All-Optical Wavelength Routing

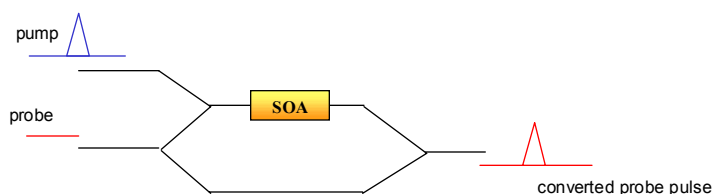
J. M. Dailey, T. L. Koch

Goals

- Utilize the frequency shift capability of SOA for all-optical signal routing
- Demonstrate > 40 Gb/s *multi-channel* routing
- Develop model for nonlinearities in SOA including electron transport, hot carrier dynamics, spectral hole-burning effects, etc

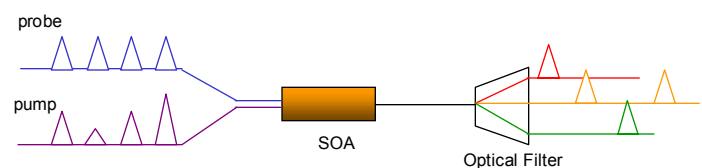
Interferometric setups are commonly used in wavelength conversion

- High intensity pump saturates the SOA, causing a *phase shift* in the upper arm
- Interferometer unbalances and probe pulse is produced



We are investigating *direct* wavelength conversion using RZ data

- High amplitude pump pulse rapidly depletes gain in amplifier
- Rapid gain change produces rapid index change
- Pulse is *frequency shifted* to appropriate filter channel



Invoke typical assumptions on alpha factor and linearized gain

$$n_R^{B-B} = -\alpha \frac{\lambda}{4\pi} g(N)$$

$$g(N) \approx a \cdot (N - N_t)$$

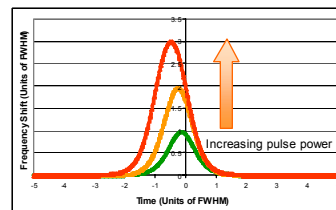
Frequency shift is function of input photon flux

Solving non-linear equations using rate equation approach results in equation for frequency shift

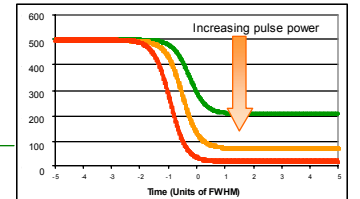
$$\delta\alpha(t) = -\dot{\phi} = -\frac{\alpha}{2} \frac{av_g}{v_g} \frac{S_0(t - \frac{L}{v_g}) \cdot (G_0 - 1)}{1 + G_0(e^F - 1)}$$

$$F \equiv av_g \int_{-\infty}^{t - \frac{L}{v_g}} S_0(t') dt'$$

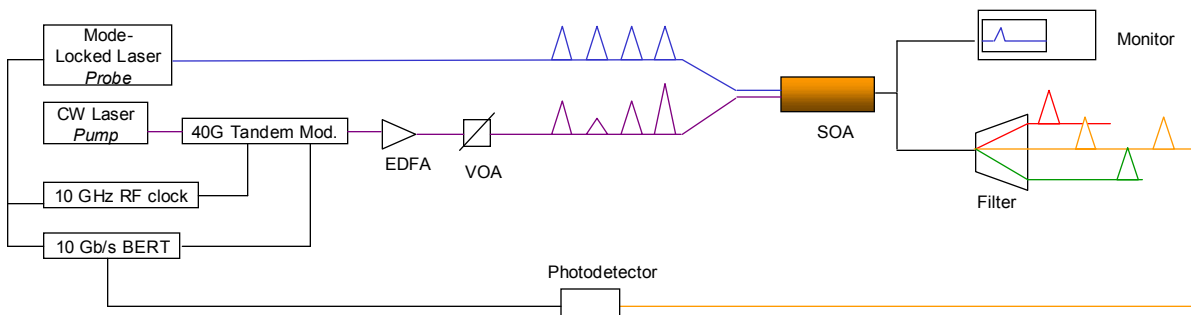
Pulse Shift



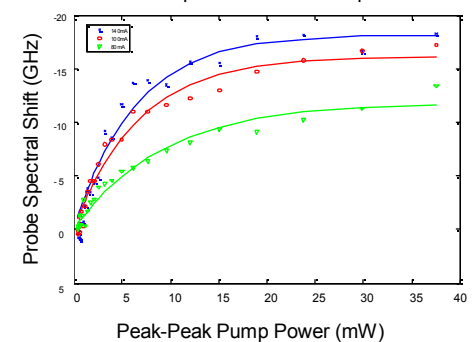
SOA Gain Evolution



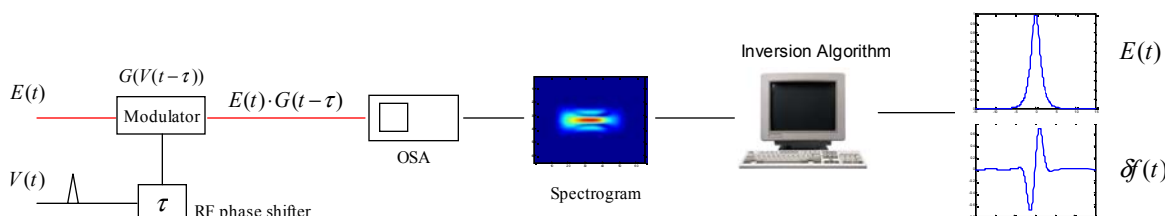
Experimental Setup



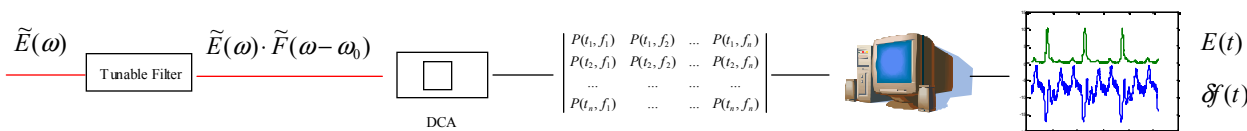
Probe Spectral Shift vs Pump Power



Amplitude and Phase Measurements at Picosecond Time Scales



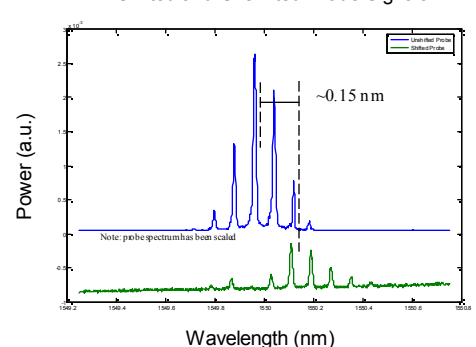
- This technique is similar to FROG, but no non-linear elements are used to obtain spectrogram
- An iterative "Principal Component Generalized Projections" algorithm is used to invert the spectrogram



→ Time resolved spectroscopy

- 20 ps (~25 GHz), transform limited pulses are input to the amplifier
- As current bias increases, gain increases and larger frequency shifts are possible

Shifted and Unshifted Probe Signals



- Due to gain loss at high pump power, the shifted probe spectrum is significantly diminished