All-Optical Clock Recovery using Stimulated Brillouin Scattering

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Outline

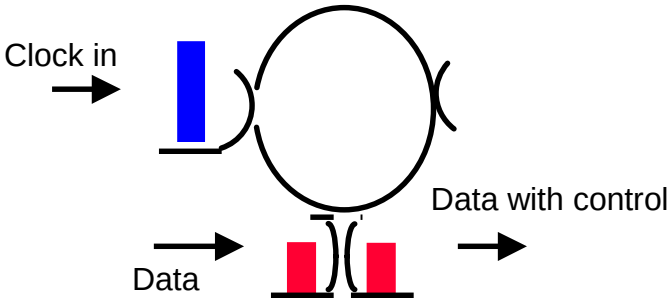
- Various clock recovery techniques
- Stimulated Brillouin optical clock recovery
- Experimental results to date
- Concluding remarks

Why All-Optical Clock Recovery?

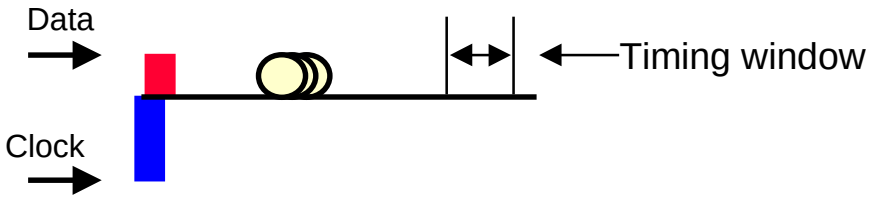
Transparent optical networks will require optical switches for:

- Synchronization between traffic and switches.
- Demultiplexing time channels in OTDM systems.

Nonlinear Optical Loop Mirror



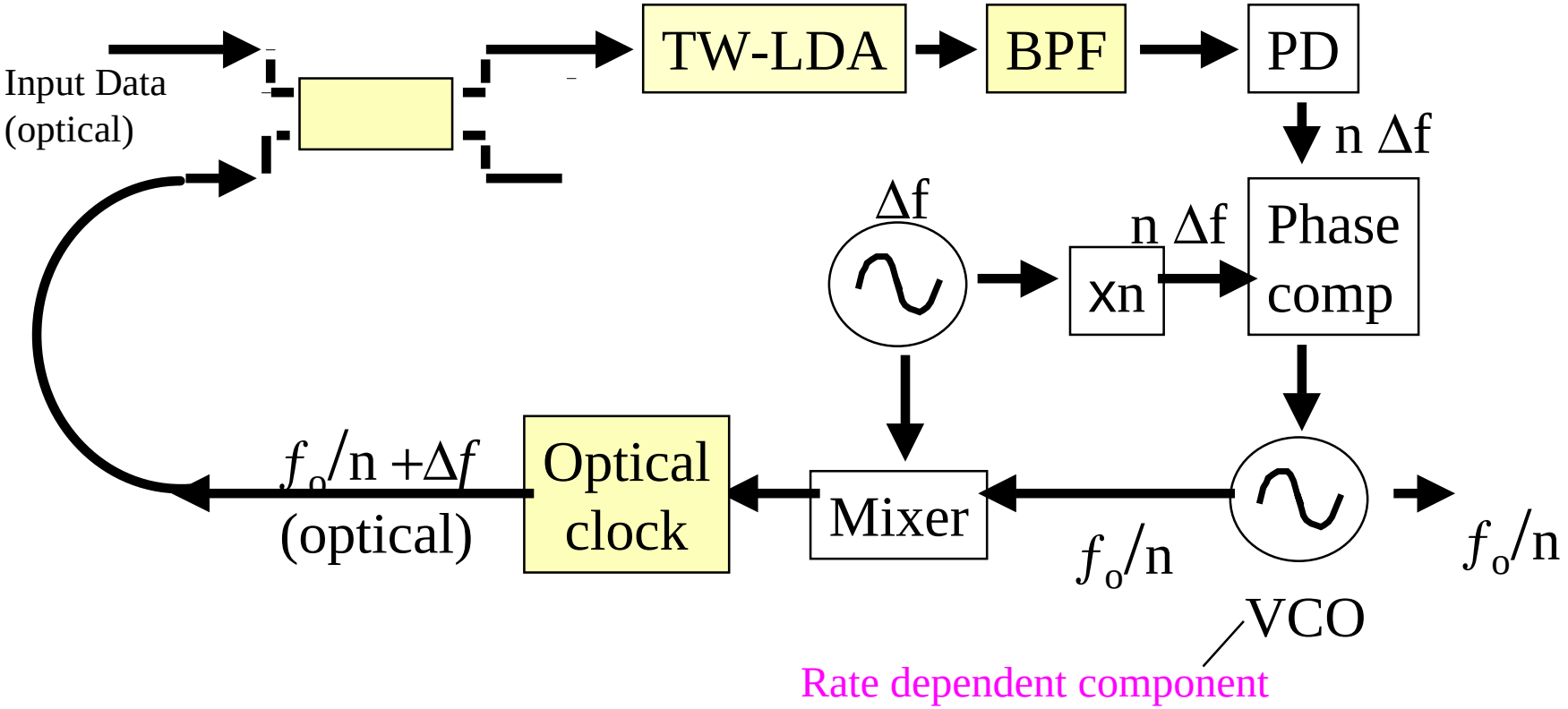
Soliton Dragging Logic Gate



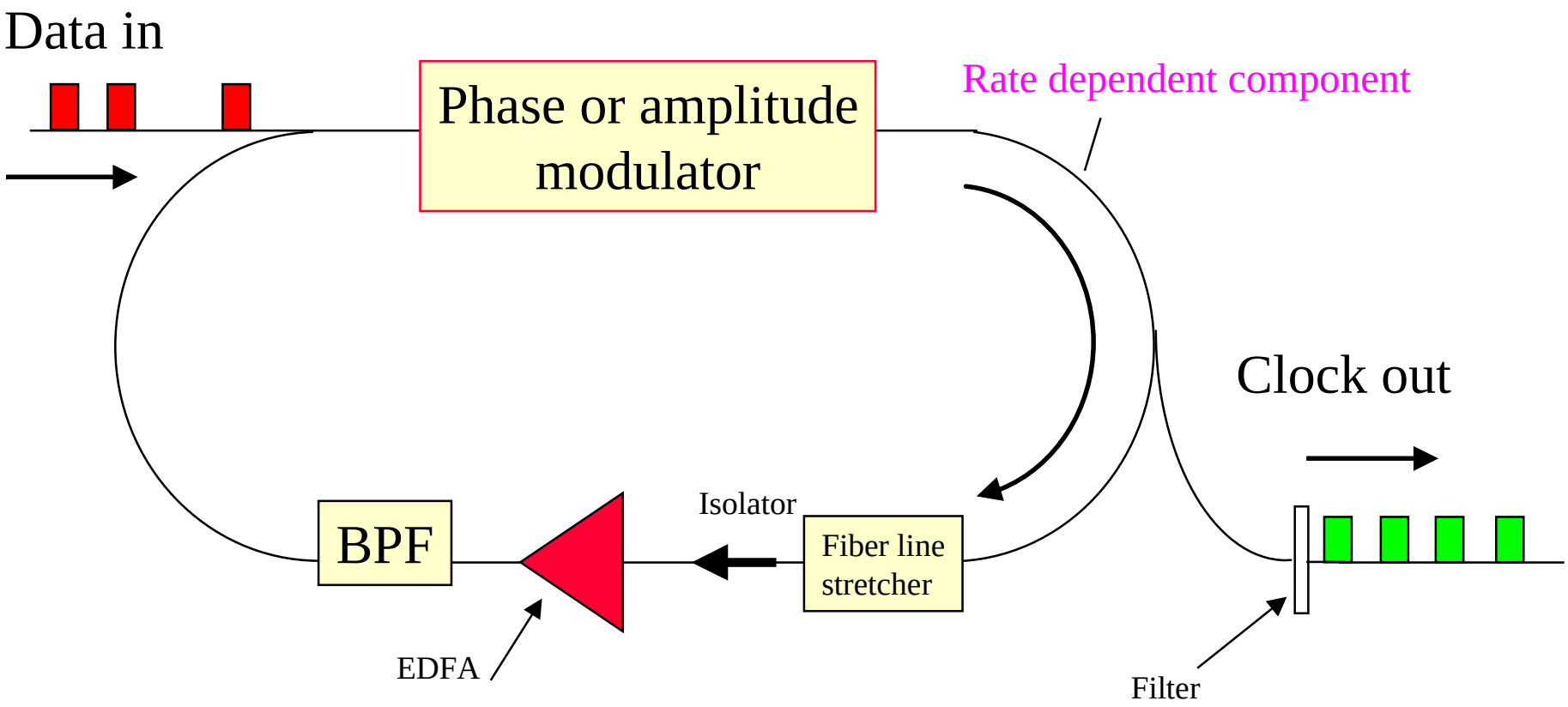
Methods of Optical Clock Recovery

- Opto-electronic phase locked loops
- Mode-locked lasers
- Self-pulsations in laser diodes
- Optical tank circuits
  - Fabry-Perot filters and resonators
  - Stimulated Brillouin scattering (SBS)

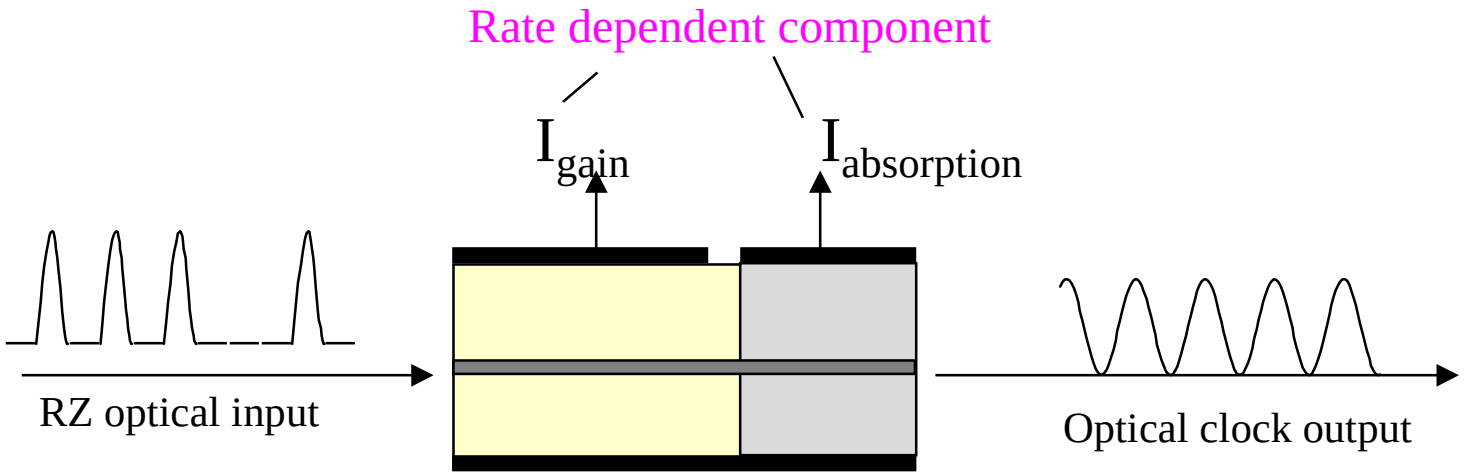
Opto-Electronic Clock Recovery



Optical Clock Recovery-Fiber Mode Locked Ring Laser

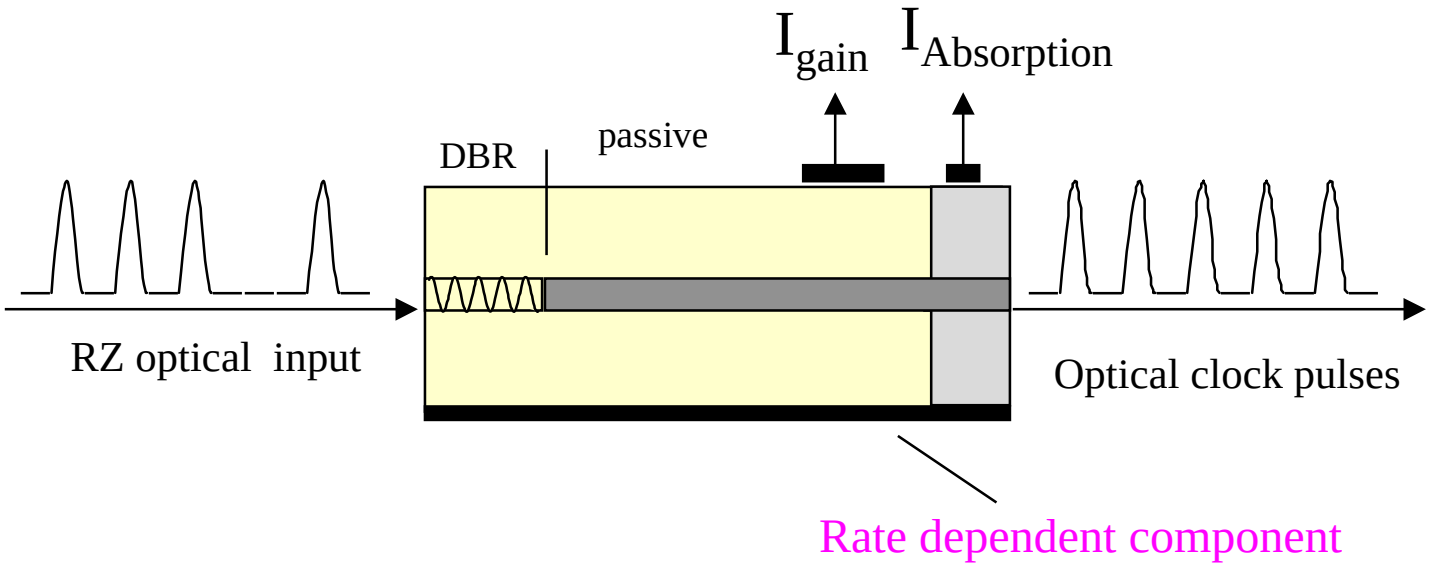


Optical Clock Recovery using Self-Pulsating Diode Laser

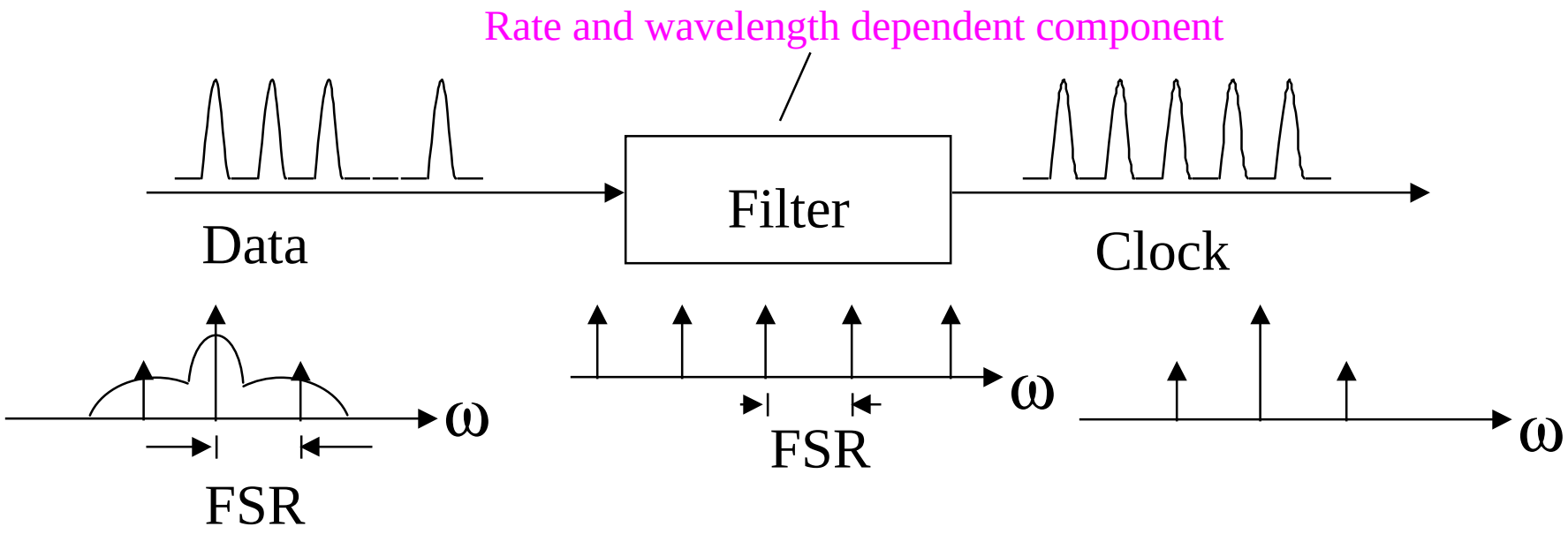


- The self-pulsation frequency of the amplifier locks to the input bit rate
- Bit-rate dependent

Optical Recovery using Mode-locked Multi-segment Semiconductor Laser

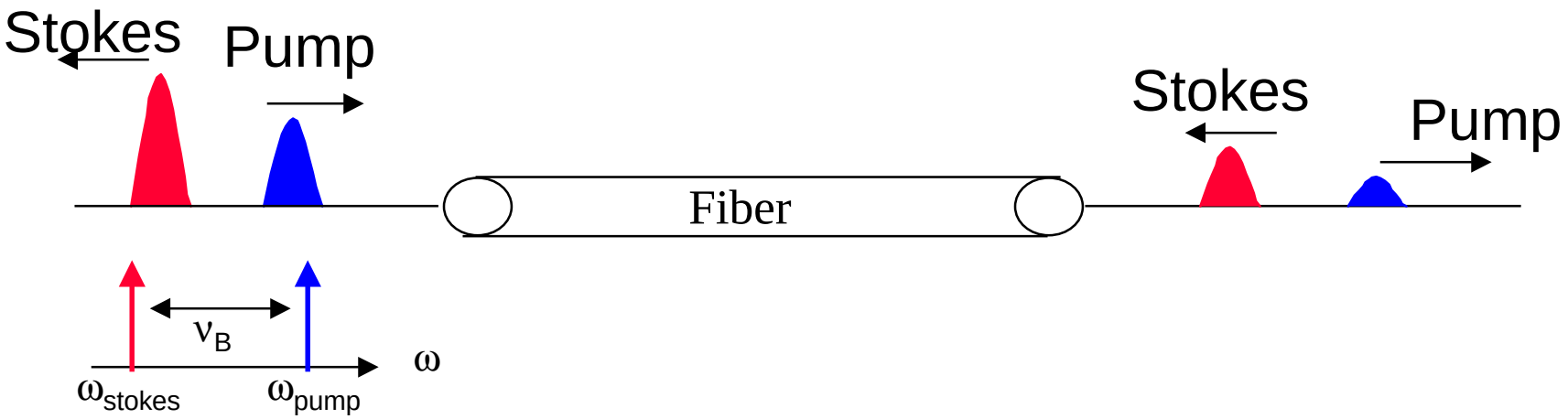


Optical Tank Circuits

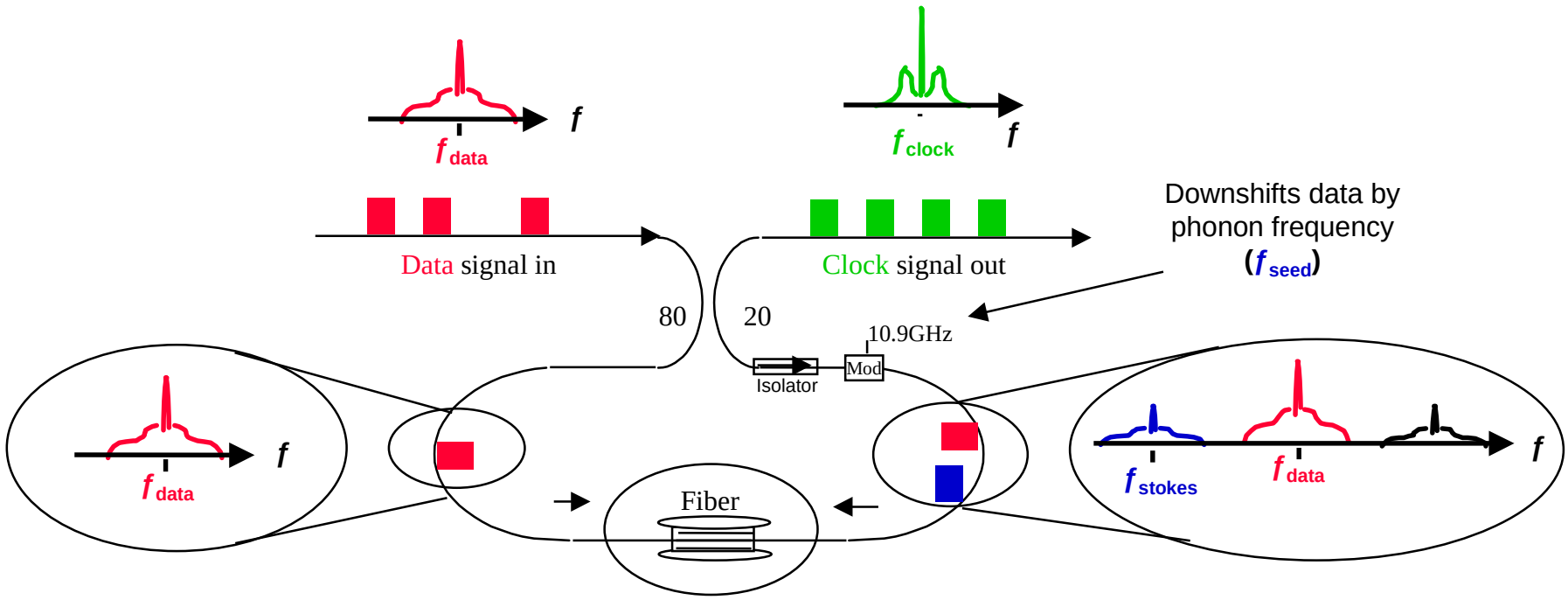


Stimulated Brillouin Scattering

The pump creates a forward propagating acoustic grating. The pump scatters off this grating with a downward Doppler shift.



Brillouin Optical Clock Recovery



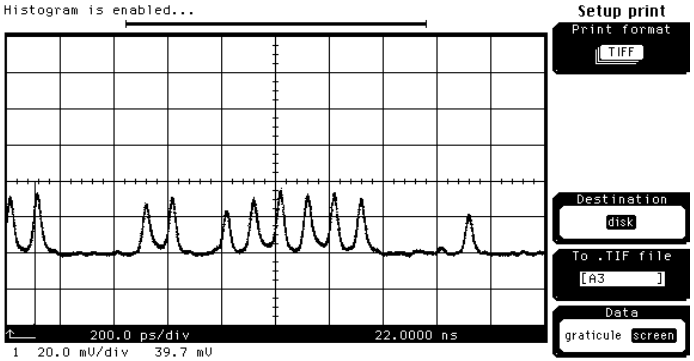
Stokes wave provides amplification

Advantages of Brillouin Clock Recovery

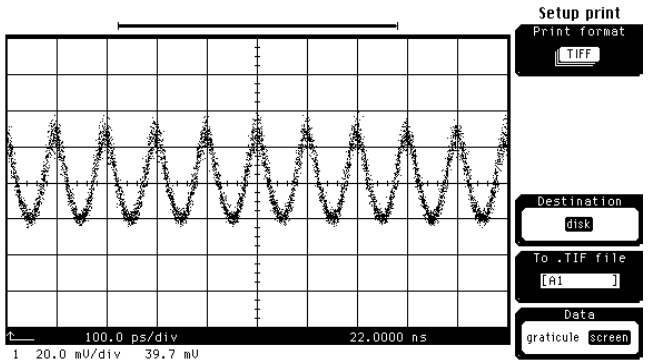
- Bit-rate insensitive
- Clock output is stable through long periods of zeros (170 at 10 GB/s)
- Wavelength independent

Experimental Results

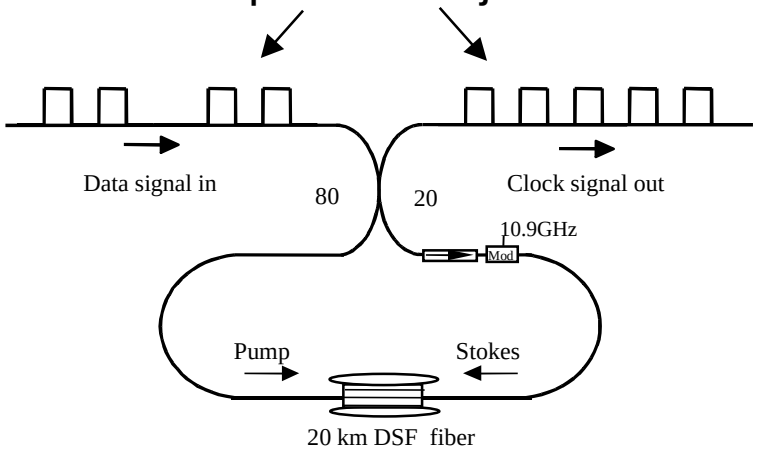
Data in



Output clock



1.2 ps relative jitter



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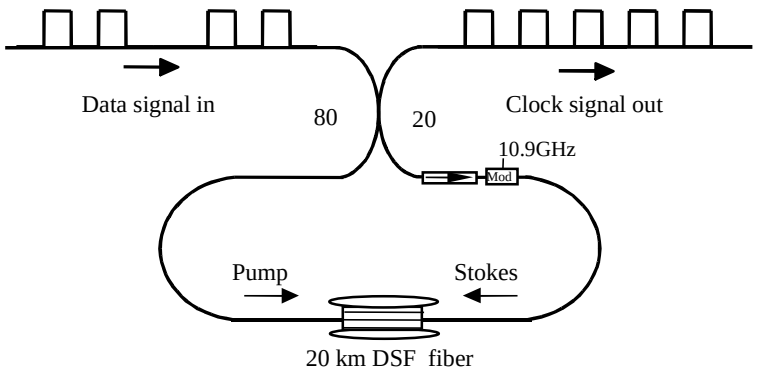
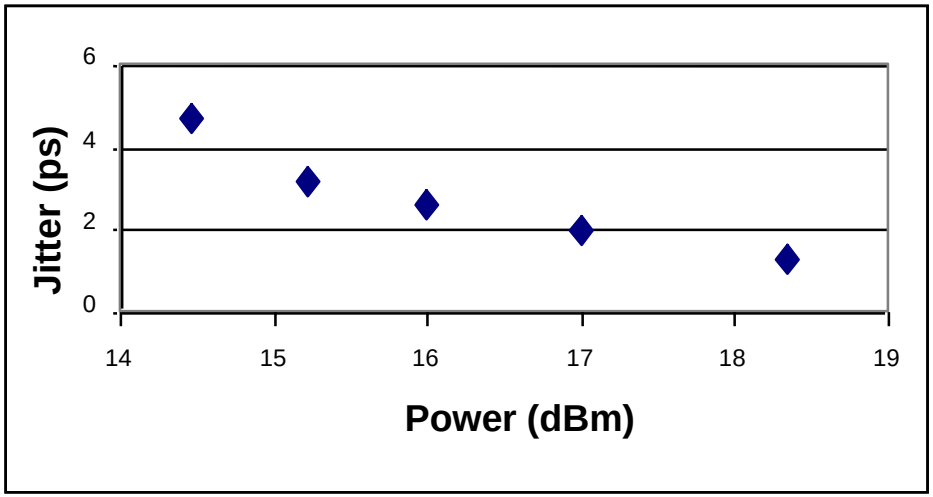
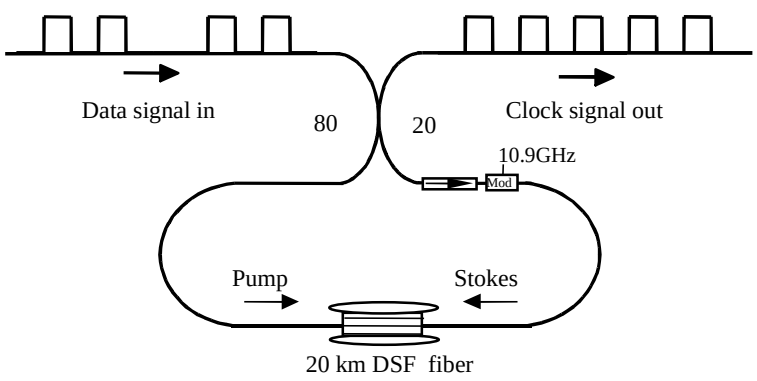
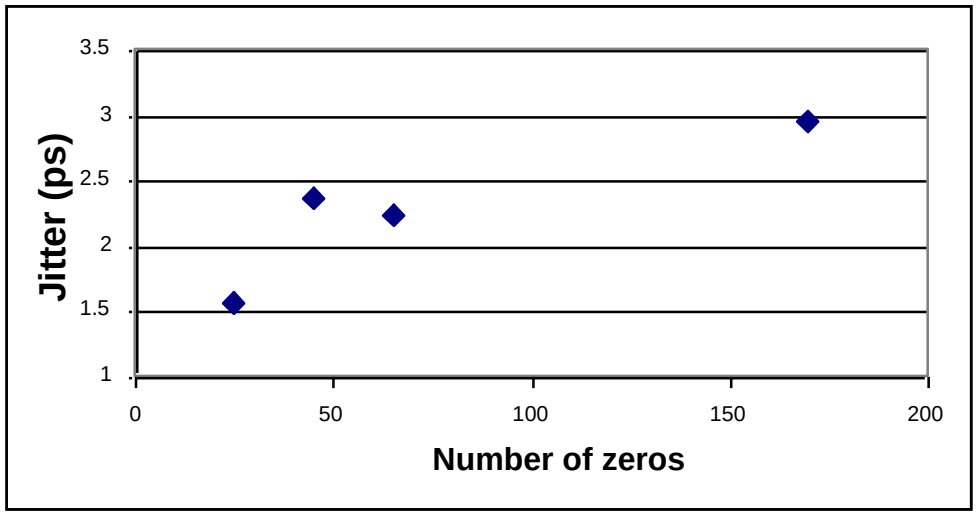
Jitter vs. Signal Power





Jitter vs. Number of Zeros





Conclusions

- An all-optical Brillouin Clock has been demonstrated
- Compatible with all-optical networks
  - Bit-rate independent
  - Wavelength independent
  - Not limited by electronic speeds