All-Optical Clock Recovery and Regeneration Using Self-Pulsing Gain-Coupled DFB Lasers

Guifang Li
School of Optics/CREOL
University of Central Florida
li@creol.ucf.edu
(407) 823-6811

Outline and Motivation

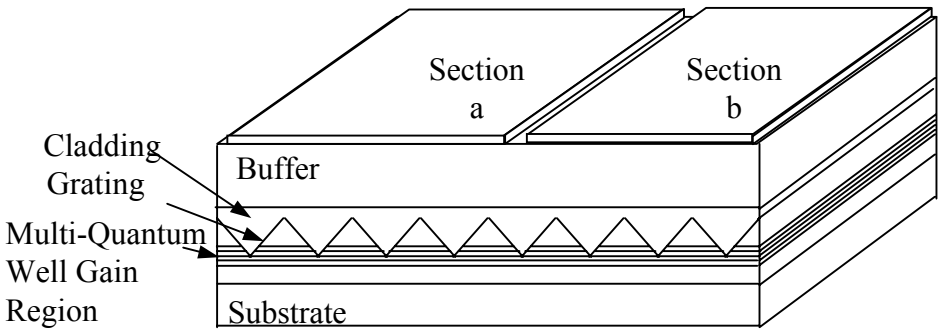
Motivation

- Clock Recovery provides retiming function for optical 3R.
- Clock Recovery provides synchronization function for optical packet switching.
- Ultrafast clock recovery for variable-bit-rate burst-mode receivers.

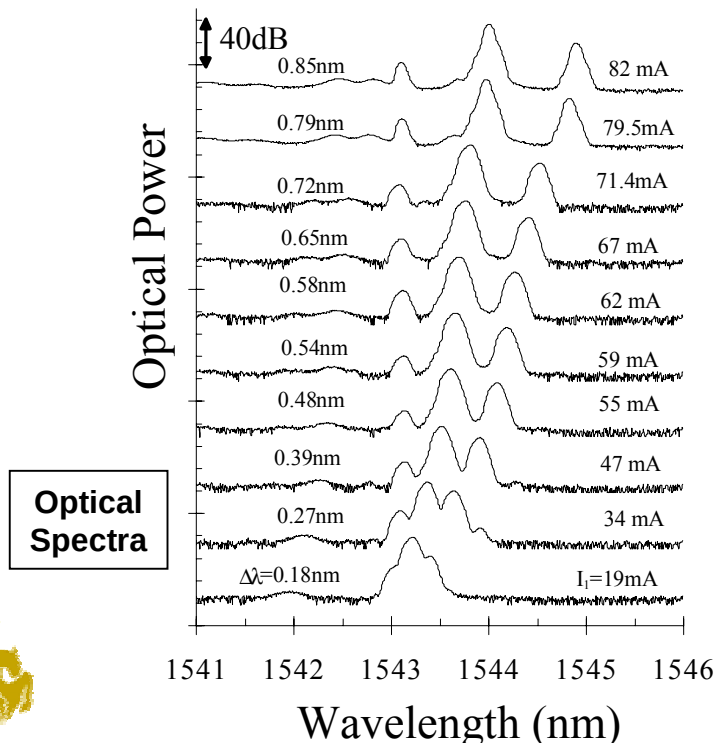
Outline

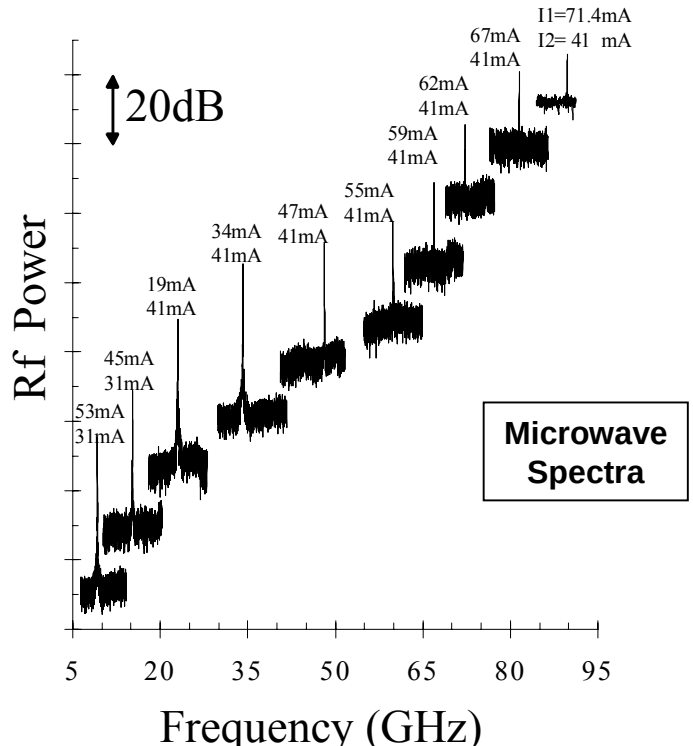
- Self-Pulsing Two-Section Gain-Coupled DFB
- Modes of Clock Recovery Operation
- Performance: Speed Limit, Lock-up Time and Hold Time
- Future Work: Chip-Scale 3R (2 Active Components)

Two-Section Gain-Coupled DFB Lasers: Device Structure & Performance

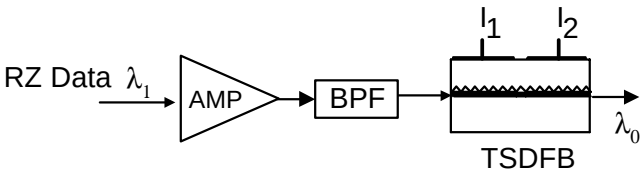
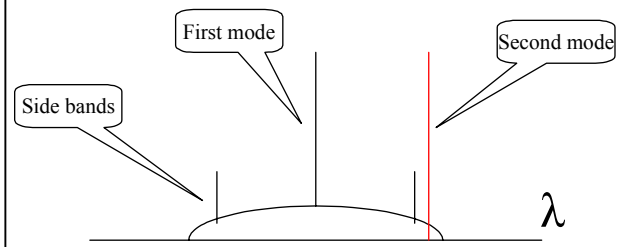
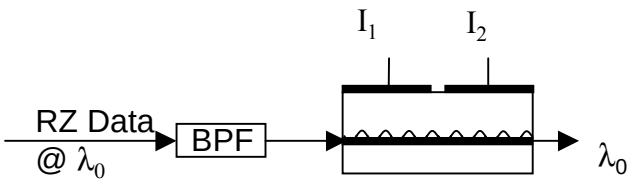
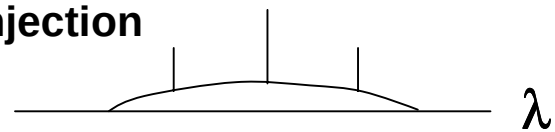
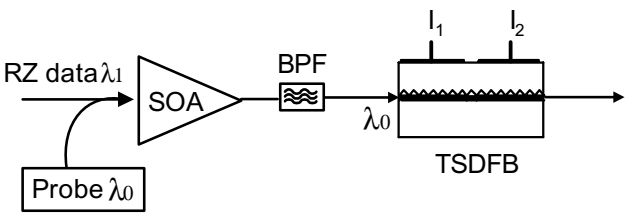


- Two section share one substrate
- Electrically isolated contacts for each section
- Gain Coupling lead to
  - (> 40 dB SMSR in single-section DFB)
  - Relative independent operation in two section
- Proper design/operation lead to self pulsing: Periodic output with DC bias for both sections

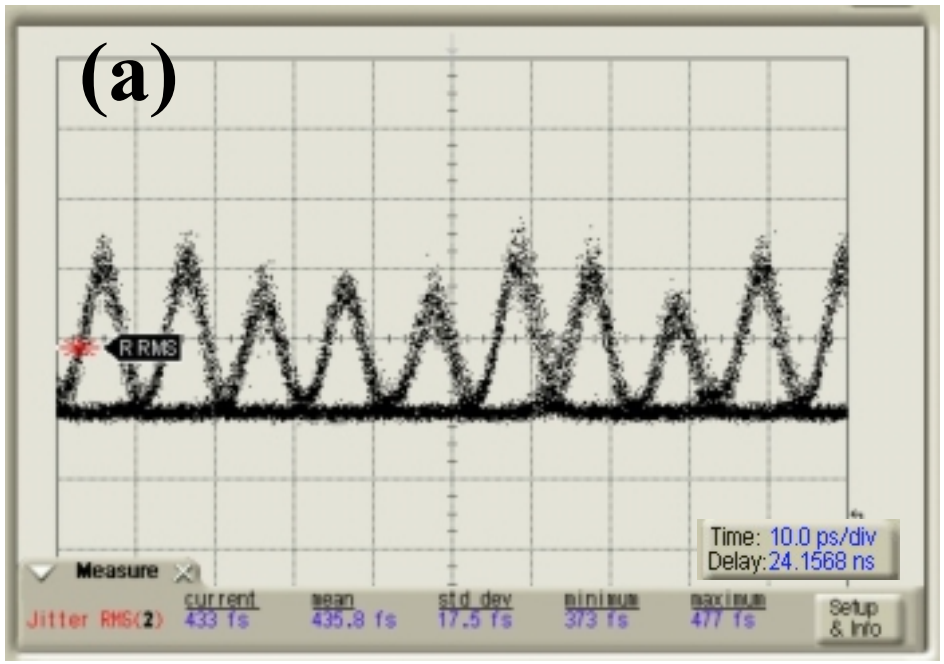


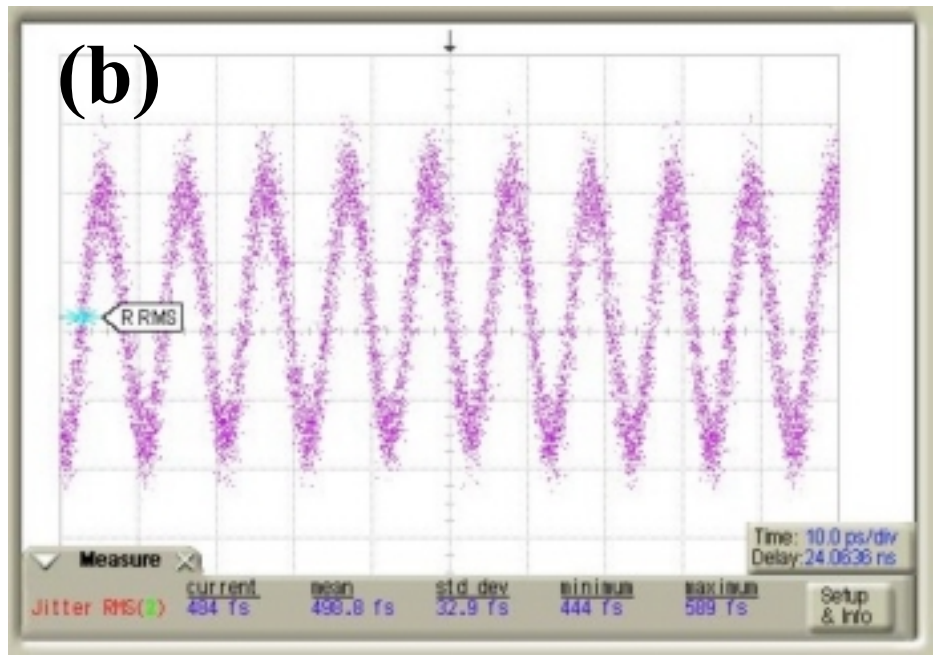


Clock Recovery: Modes of Operation

Circuitry	Mechanism	Advantages/Disadvantage
 **Incoherent**		• Wavelength Insensitive • Potentially Polarization Insensitive • High injection power • Jitter
 **coherent**	**TS DBF** **Injection** 	• High sensitivity < -13 dBm • Low jitter • Wavelength and polarization insensitive
	Wavelength Conversion Followed by Coherent Clock Recovery	**Combines the advantages of both** • **Wavelength and polarization insensitive** • **Low jitter**

100 Gb/s Clock Recovery: Time-Domain Waveform and Jitter

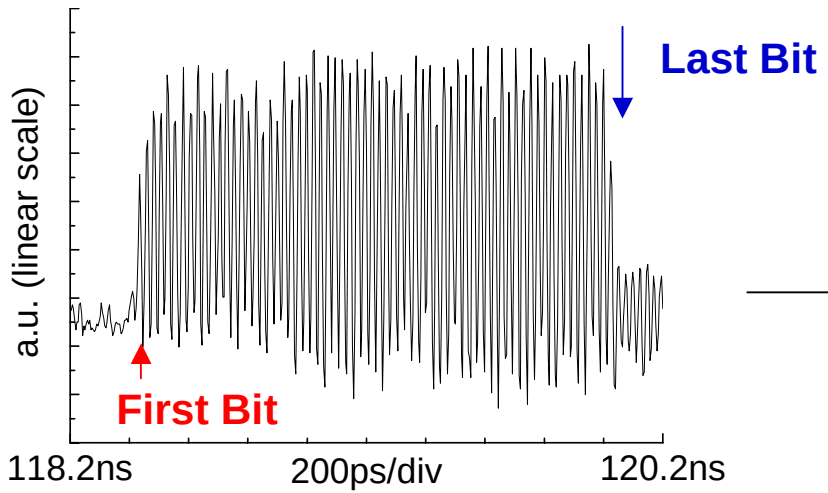


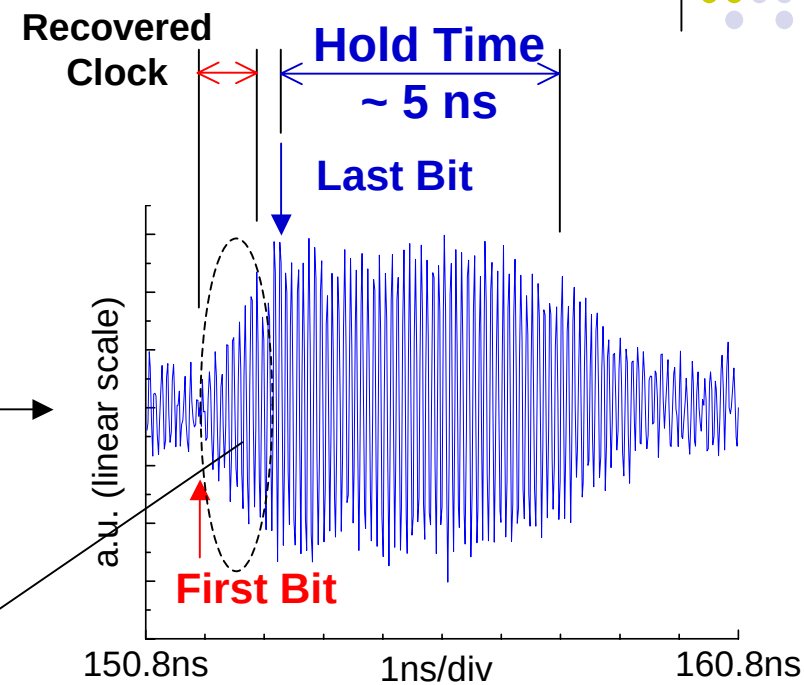


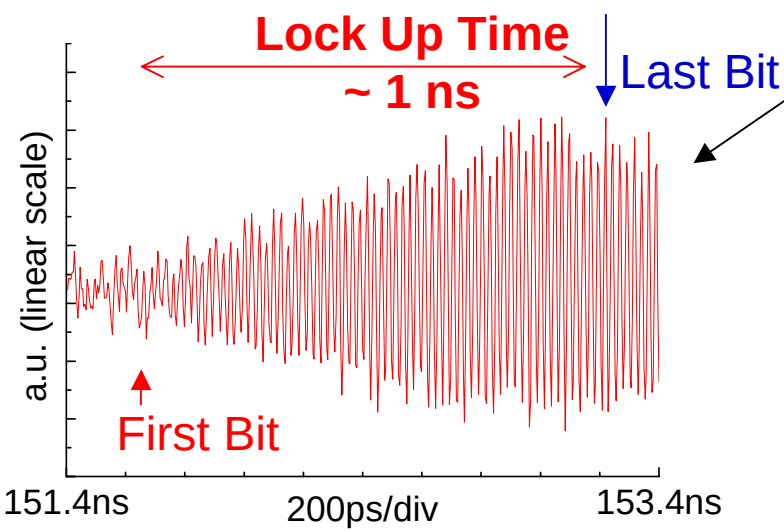
Input Data Pattern: 2^{31}-1 PRBS
Input Power: -7 dBm
Intrinsic Jitter of CR Circuitry: <200 fs

Lock up and Hold Time @ 40Gb/s

Input Data Pattern:
64 bits of 1's followed by 1984 Bits of 0's

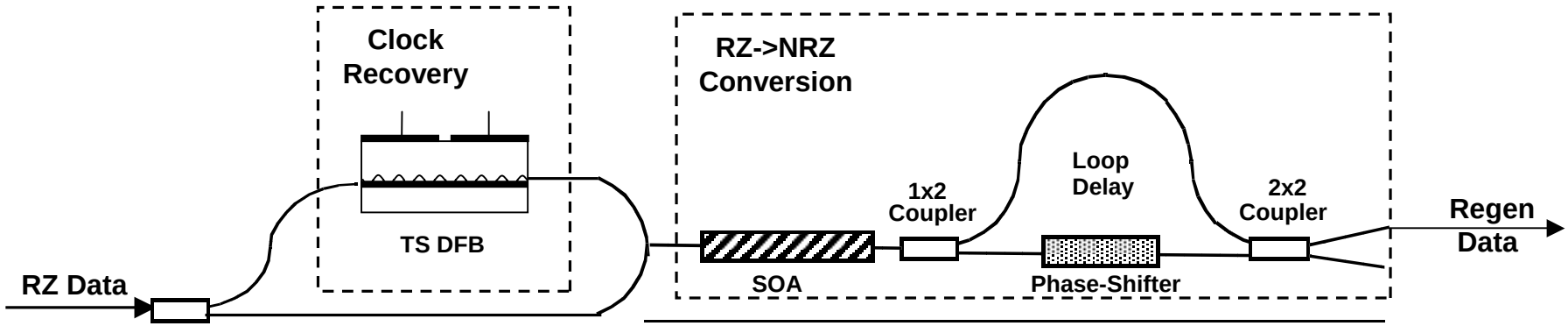




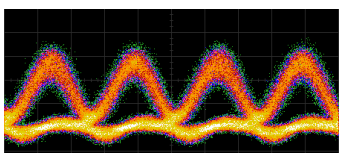


- ***Variable Rates up to at least 100 Gb/s.***
- ***Ultrafast Lock-Up Time (1 ns) and Long Hold Time (5 ns) for Optical Packet Switching and Burst-mode receiver***
- ***Wavelength and Polarization Insensitive***
- ***Low Jitter 2-3%***
- ***Frequency locking range: > 100 MHz***
- ***High Sensitivity & Large Dynamic***
- ***Simplicity & Compactness for Chip Scale Integration***

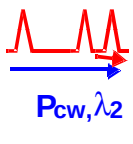
Future Work: Chip-Scale 3R using CR + RZ to NRZ Format Conversion

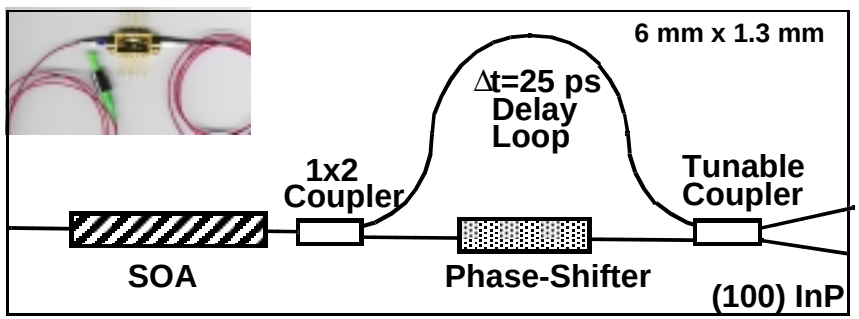


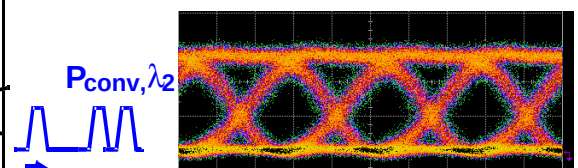
Courtesy: Juerg Leuthold
Lucent Technologies



40 Gb/s RZ Data





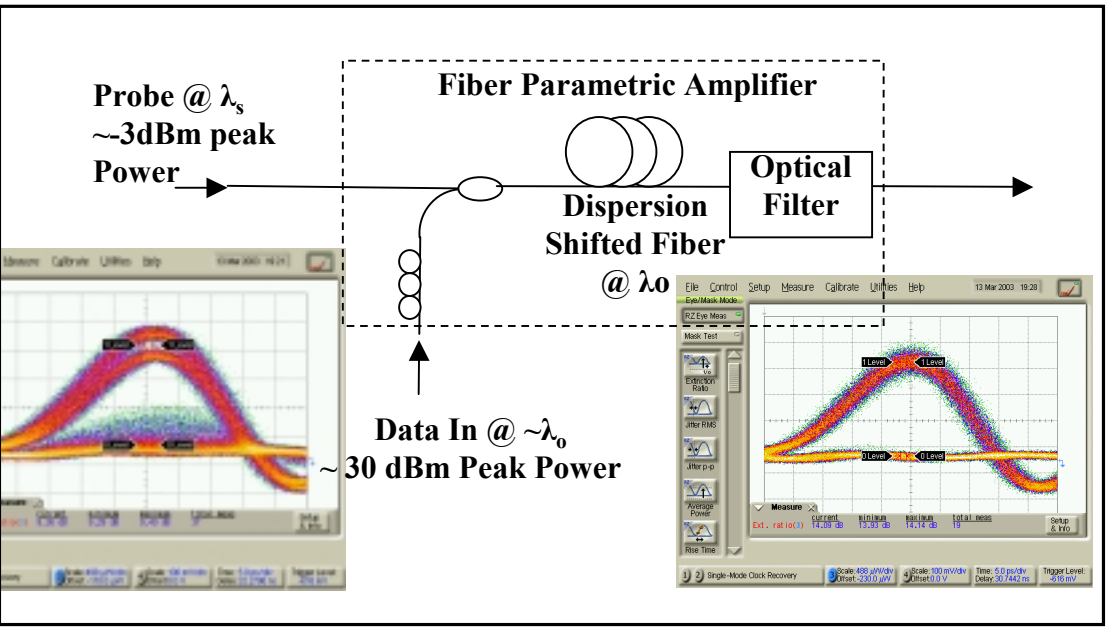


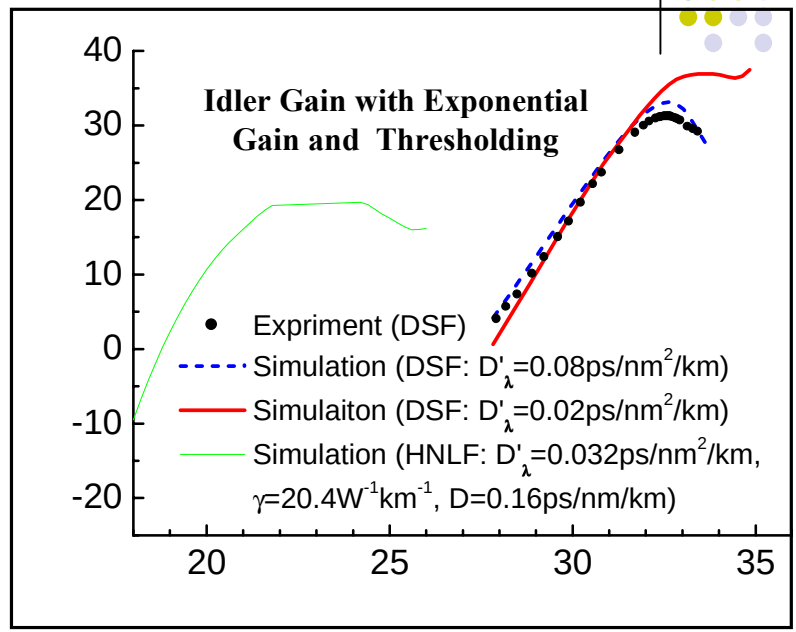
40 Gb/s NRZ Data

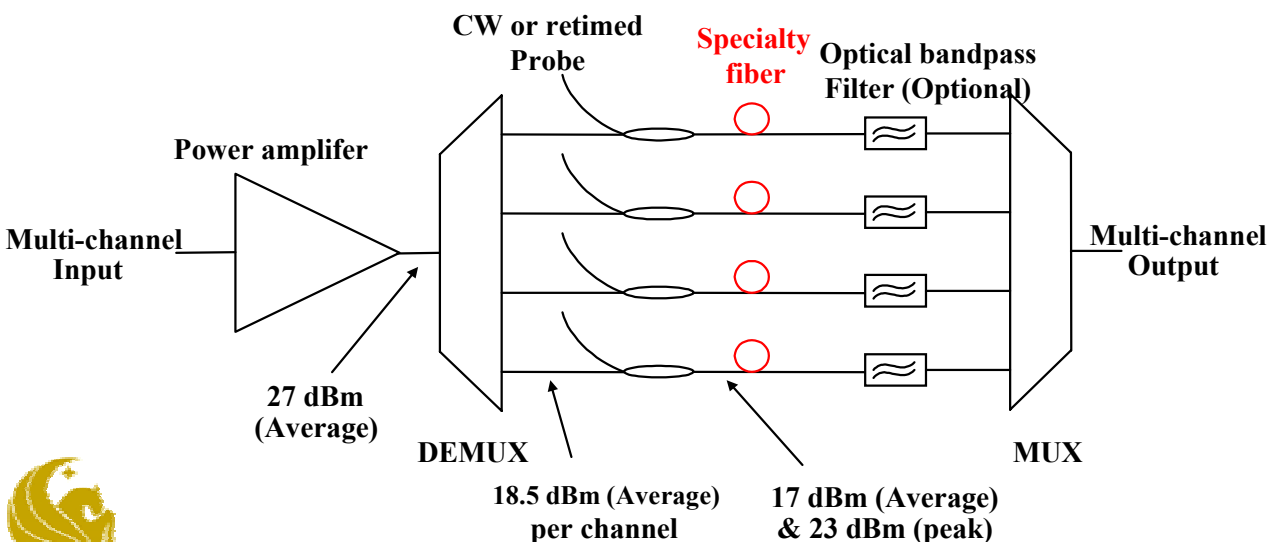
RZ to NRZ Conversion

- Use combined effects of XPM and XGM
- Transition Bit by XPM
- Subsequent bits by both XPM and XGM
- Up to 100 Gb/s have been demonstrated

Multi-Wavelength 2R Regenerator







Cost Comparision

Optical:

27 dBm EDFA: <$20,000

Per Channel: <$5,000, Independent Of Bit Rate

OEO:

40 Gb/s E-O Modulator: $10,000

40 Gb/s Modulator Driver: $10,000

Per Channel: $20,000