IBM Optical Communications Technology

Serial 12.5 Gbaud, 10 km SMF Link with Clock and Data Recovery IC

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Features of Serial PMD

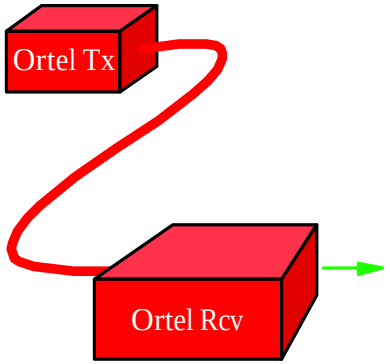
- **Low Cost**
  - High Speed ICs (SiGe and CMOS) are Less Expensive than OE Chips
  - Uncooled Optics for LAN spans
- **Adapt Technology from Multiple, Existing Suppliers**
  - Transceivers developed by many suppliers
  - Capitalize on high BW MMF's; & existing SMF cable suppliers
  - Multiple IC Foundries
  - Extensions of Existing Standard Serial Package Technology
- **User Familiarity with TDM**
  - 1 GbE, FCS
- **Can use existing LAN installation methodology / infrastructure**

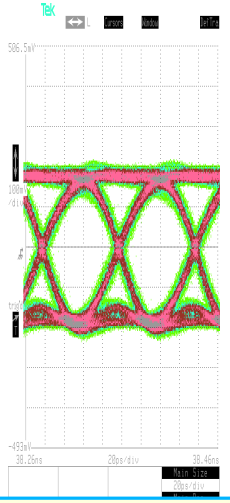
Objectives of These Presentations

- **IBM Presentation**
  - Demonstration of a serial optical link prototype exceeding the requirements of 10 GbE, 10 km, LAN, PHY
  - Relates this link technology to Extensions of the 1 GbE Tables of Link and Transmitter / Receiver Specifications
- **Ortel Presentation**
  - Presents Data Supporting Manufacturability

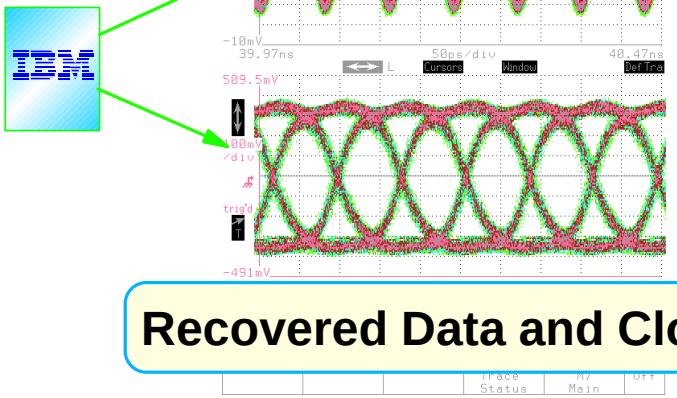
Link Demonstration

- ✓ Stressed the 12.5Gbd/10km option: operated at 13 Gbd, 14 km
- ✓ Ortel Transmitter and Receiver Modules
- ✓ IBM SiGe Clock & Data Recovery IC





Receiver Output 'eye"



Recovered Data and Clock

Link Components

- Transmitter
  - Ortel DFB laser with isolator
  - Driven by Pattern Generator with 2^7-1
  - 5 bias conditions tested, near I_{th} for high extinction and to stress jitter
  - 12.5 Gbaud and 13.0 Gbaud tested
- Receiver
  - Ortel PD with preamp
  - External AC coupled post-amp for 200 mV_{pp} to CDR IC
- Clock and data recovery IC (CDR)
  - SiGe BiCMOS from IBM Foundry,
  - f_t> 45 GHz (HBT), 0.5 mm (CMOS)
  - Single chip CDR , 3.3-3.6 V
  - Designed for 12.5 Gbaud

Long Wavelength Transmitter Characteristics

(extension of IEEE 802.3z Table 38.7)

Description	Current Link Stressed Measurements	Tentative Spec.	Unit
Signaling speed	13.0	12.5	GBd
Wavelength	1310	1290-1325	nm
τ_{rise}/τ_{fall} (20-80%)	14.6 ps / 31 ps	25	ps
Spectral width	0.30	0.5	nm, cw
Launch power (max)	+1.9	+2	dBm, avg.
Launch power (min)		-4	dBm, avg.
Extinction Ratio(min)	10	6	dB
RIN	-132.6	-140	dB/Hz
SMSR	40.2	30	dB

Long Wavelength Receiver Characteristics

(extension of IEEE 802.3z Table 38.8)

Description	Current Link Stressed Measurements	Tentative Spec.	Unit
Signaling Speed	13.0	12.5	GBd
Wavelength	1310	1290-1325	nm
Receiver power (max)	+1.9	+2	dBm,avg
Receiver power (min)	-16 @ BER 10^{-12}	-14	dBm,avg
Return loss	40	26	dBm

Worst case link power budget & penalties

(extension of IEEE 802.3z Table 38.9)

Long Wavelength

Description	Current Link Measurement	Tentative Spec. SMF-DFB	Unit
Modal Bandwidth	N/A	N/A	MHz*km
Link power budget	17.9	10	dB
Operating distance	14	10	km
Channel insertion loss	5.3	7	dB
Link power penalties	-	2.7	dB
Unallocated margin	-	0.3	dB

Link Jitter Budget

(extension of IEEE 802.3z Table 38-10)

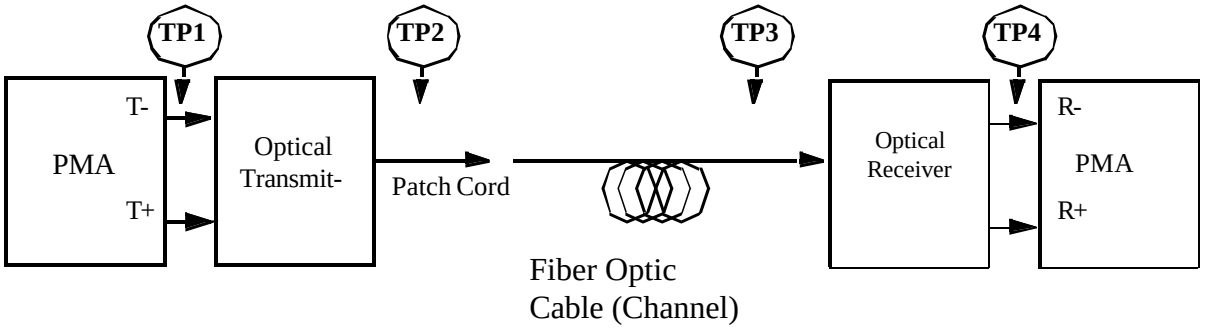


Table 38-10,802.3z	Deterministic Jitter, UI	Total Jitter, UI
TP1	0.1	0.24
TP1 to TP2	0.1	0.287
TP2	0.2	0.431
TP2 to TP3	0.05	0.170
TP3	0.25	0.510
TP3 to TP4	0.212	0.332
TP4	0.462	0.749

- Does jitter just scale according to UI?
- Initial measurements made on one link at 12.5 Gbaud.

Link Jitter Budget (cont.)

(extension of IEEE 802.3z Table 38-10)

	Deterministic Jitter Scaled from 1GbE (psec)	Deterministic Jitter measured (psec)	1 s of RJ (psec)
@ TP1	8	7	1.7
@ TP2	16	20.4	1.9
@ TP3	20	21.7	2
@ TP4	37	18.7	2.1

- DJ,RJ difficult to measure/correlate to TP's, but overall RJ,TJ looks manageable.
- Link driven close to I_{th} to enhance jitter
- Used 2^7-1 run length (~8B/10B)
  - Might be worse at 10 Gbaud and with long run length codes
- Jitter Budget allocation to be resolved by 802.3ae sub-group

Implications of Link Demonstration

- 10 Gigabit/sec links with **12.5 Gbaud signaling rates are feasible**
  - Allows robust codes for reliable link operation
  - Compatible with 1 GbE and FCS standards.
- Optical Transceiver Products From Current Production can be adapted to 10 GbE LAN Requirements
  - Elimination of cooling allows migration to smaller, lower power, lower cost Transceiver Modules
- SiGe BiCMOS From Foundry can provide CDR function as IC
  - All high speed functions ?
  - In single IC?

☛ **This Demonstration Supports the Serial PMD Group Claim of a Volume Manufacturable, Low Cost PHY Technology**