Extended-Wavelength Receivers for Forward Compatibility

Jack Jewell

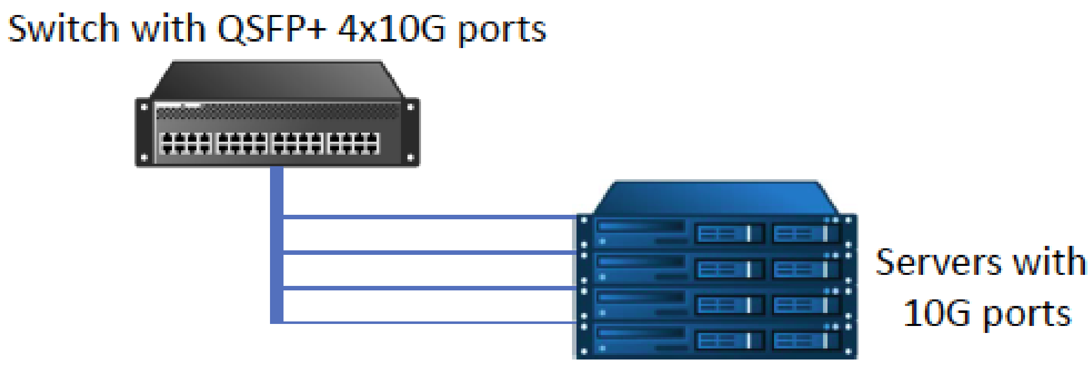
CommScope

MMF Ad Hoc, May 30, 2013

Background: 40G ↔ 4X10G, 400G ↔ 4X100G

40G Observations

- Four lanes of 10G was extremely useful
  - Not everything required a 40G pipe
  - Ability to use break-out cables provided a level of "backwards compatibility"

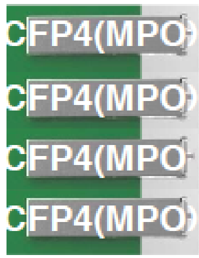


from booth_400_01_0513

Background: 40G ↔ 4X10G, 400G ↔ 4X100G

High Density 100GE or Early Adopter 400GE Common Module on MMF

4 x CAUI-4
(16 x 25G NRZ)



Summary on 400GE

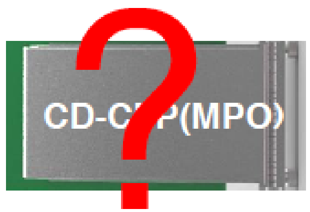
Leverage of mature PMD from previous Ethernet rate

Early adopter 400GE by reusing 100G module and parallel cabling, SMF or MMF

Possible common module for 400GE and high-density (4-port) 100GE

- Implementation persists as high-density support of previous speed of Ethernet (e.g., 4 x 100GE) for industry investment protection

CDAUI-16
(16 x 25G NRZ)



No density increase over the use of four CFP4 modules.

CDAUI-16
(16 x 25G NRZ)

Courtesy, Mark Bugg, Molex

High-density 100GE or 400GE common module.

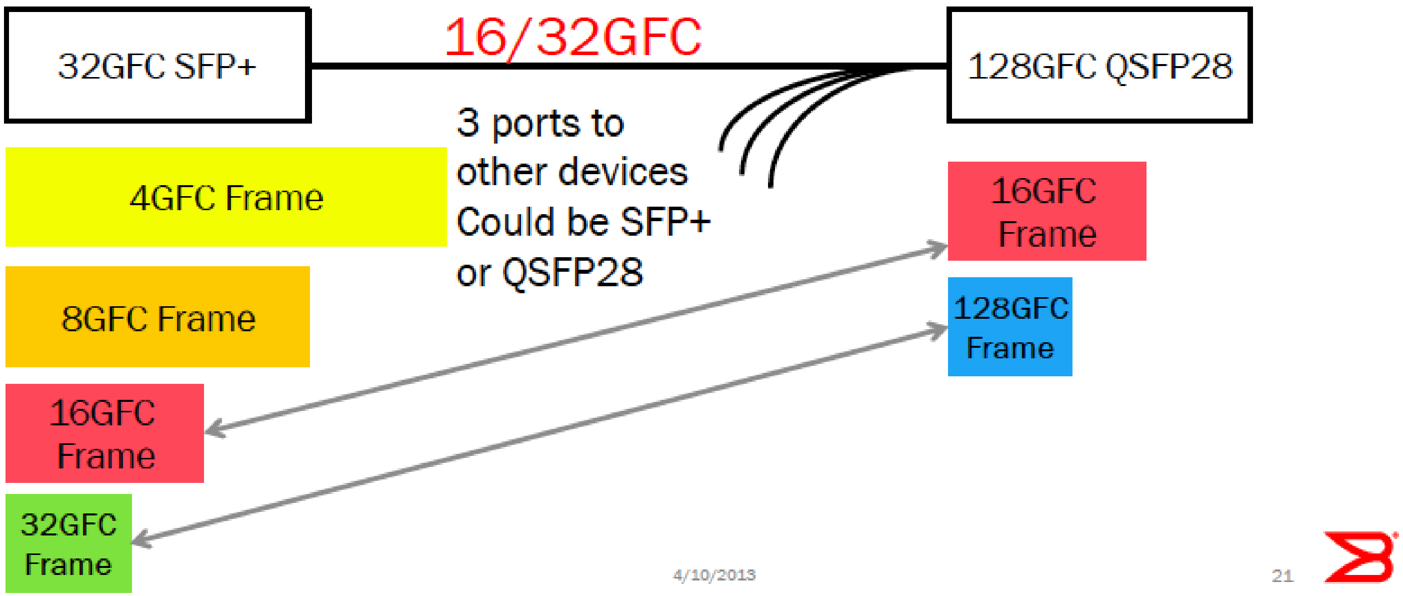
10 400 Gb/s Ethernet Study Group Victoria BC, Canada, May 2013

from maki_400_01_0513

Background: 128GFC ↔ 4X32GFC

32GFC Transmitter Training

- QSFP28 will only support 16GFC and 32GFC when it is connected to a 32GFC SFP+



from 13-162v1-128G32Gnegotiation – Scott Kipp – T11.2

Background: Higher Speed VCSELs → InGaAs

- 25Gb/s 850nm VCSELs rumored to use InGaAs quantum well active material, rather than GaAs
  - Compressive strain leads to higher speed, lower threshold
  - But addition of Indium leads to longer wavelength, so keeping at 850nm implies very thin wells and/or InAlGaAs
  - Thus the benefits of InGaAs at 850nm are limited
- VCSELs at 900-1200nm can use much more Indium, without compromising, and achieve higher performance
- Directly-modulated VCSEL products at 40-56Gb/s are more feasible at ~900-1200nm than at 850nm
  - and <u>better</u> at ~900-1200nm

Advantages of Longer Wavelength

- VCSEL related
  - Higher speed (from higher differential gain)
  - Lower operating current density
  - Higher reliability
  - Improved thermal dissipation (GaAs in mirrors better than AlGaAs)
  - Higher temperature stability (higher well/barrier offset)
  - Single-mode emission at larger aperture (lower current density)
  - More binary-material content (GaAs replaces AlGaAs)
- Fiber related
  - Lower chromatic dispersion
  - Higher potential modal bandwidth (fewer modal groups; needs wavelength optimization to realize)
- Other
  - Higher eyesafe power
  - Higher Rx responsivity (lower photon energy; 1mW at 1060nm has about 1dB more photons/sec as 1mW at 850nm)

InGaAs VCSELs

- 950-1200nm InGaAs VCSELs are **NOT** "1310nm VCSELs"
  - Extending VCSEL wavelength to 1310nm region must incorporate Nitrogen into the active material ➔ loss in performance
- 950-1200nm InGaAs VCSELs better than "850nm VCSELs"
  - Adding Indium into the active material ➔ improved performance, as outlined in previous slide

Issue: GaAs Photodetector limit ~860nm

- Interoperability between imminent 840-860nm MMF TRx's and future 840-1200nm MMF TRx's requires the imminent TRx's to have Receivers sensitive over the 840-1200nm region.
- Problem: For wavelengths much above 860nm GaAs is transparent. "Your GaAs is glass"
- Solution: Specify imminent MMF Rx's to operate over 840-1200nm, which implies use of InGaAs photodetectors optimized for this region.
- Slight modifications to standard InGaAs PIN's
  - Replace most of InP top layer (absorbing below ~930nm) with InAlAs or InAlGaAs (transparent above 840nm) – straightforward
  - Make antireflection coating broadband - easy

"Dual-Channel" PIN Photodiode Product

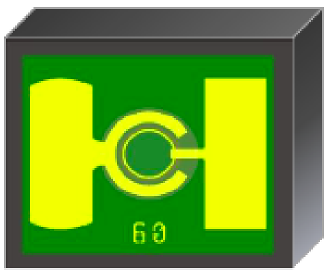
- GaAs PIN photodiodes have typical responsivity ~0.6 A/W
- This 10Gb/s product made for optical USB/Thunderbolt

10Gbps DualBand InGaAs PIN Photodiode

P/N: DO122_60um_OUSB

GCS™ Known Good Die

DATASHEET



Introduction

This high-performance product is a front side illuminated InGaAs PIN photodiode chip that features a large 60μm detection window, and two large flexible wire-bonding pads. This product has low capacitance, high respsonsivity, low dark current and excellent reliability, with GCS proprietary design specially tailored for meeting the performance requirement for 10Gbps receiver for dual bands at 850nm and 1310nm used for Light Peak Optical USB application with a multi-mode fiber.

SPECIFICATIONS (T=25C°)

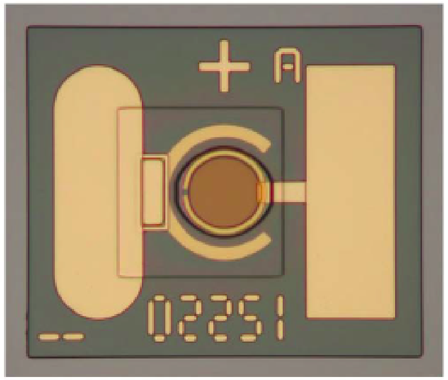
	Conditions	Min.	Typical	Max.	Unit	Notes
Bandwidth	-5V	8	10	-	GHz	
Wavelength range		-	850/1310	-	nm	
Capacitance	-5 V	-	0.22	0.25	pF	
Responsivity	@1310 nm	0.85	-	-	A/W	
Responsivity	@850 nm	0.5	-	-	A/W	
Dark current	-5V	-	1	5	nA	
Reverse breakdown	-20V	-	-	1	μA	

"Dual-Channel" PIN Photodiodes

PDCS60T-USB
10Gb/s InGaAs Photodiode

Enablence

PDCS60T-USB is a high speed, dual wavelength photodiode chip that combines a large aperture with a high speed of response and allows operation at both 850 and 1310 nm wavelengths. The top-illuminated p-i-n photodiode structure has a 60 µm optical aperture allowing easy alignment to single mode as well as multimode fibers. Despite the large aperture, the photodiode has a low capacitance and can be used for applications up to 10 Gb/s. The photodiode is manufactured with a dual wavelength AR coating, offering an excellent responsivity at both 850 nm and 1310 nm and is therefore highly suitable for optical USB or Light Peak interfaces. The chip is available with a pad metallization optimized for wire-bonding.



Optical USB/Thunderbolt

SPECIFICATIONS

Parameter	Sym	U_R	Min	Typ	Max	Unit
Responsivity λ = 850 nm λ = 1310 nm	R	2.5 V	0.46 0.75	0.85		A/W

Recommendation

- Tx: Keep upper value of Lane wavelength (range) at 860nm
- Rx: Replace upper value of Lane wavelengths (range) from 860 to 1200nm

Table 95–6—100GBASE-SR4 transmit characteristics

Description	Value	Unit
Signaling rate, each lane (range)	25.78125 ± 100 ppm	GBd
Lane wavelength (range)	840 to 860	nm

keep 860

Table 95–7—100GBASE-SR4 receive characteristics

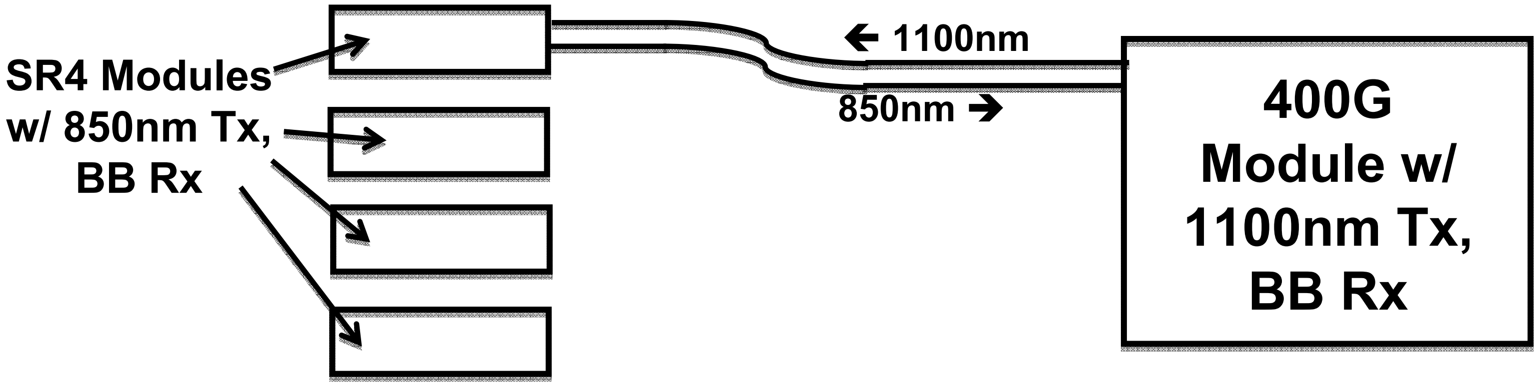
Description	Value	Unit
Signaling rate, each lane (range)	25.78125 ± 100 ppm	GBd
Lane wavelengths (range)	840 to 860	nm

change to 1200

from P802.3bm-D1p0

One Scenario: Choose Optimal VCSEL λ

- E.g. choose 1100nm
- For OM3/4 MMF, specify the reach, accounting for improved speed, reduced chromatic dispersion, higher power, higher Rx responsivity, reduced modal bandwidth
- Specify a significantly-longer reach for MMF tuned for 1100nm, accounting for the VCSEL improvements
- Effort would be undertaken in a future standard



Other Scenarios (Economically Feasible?)

- 400G modules (at 8 X 50G) back compatibility with 2 100G SR4 modules using rate switching, analogously to Fibre-Channel
- CWDM
- Bi-directional transmission

- Effort(s) would be undertaken in future standards

Summary and Closing Perspectives

- MMF / VCSEL platform has delivered optical links at ~1/2 the cost/power of SMF links ever since 1GbE and 1GFC
- Proposed extension of Rx wavelength would
  - incur small-incremental cost
  - help VCSELs out of the “850nm rut” to satisfy future needs, e.g. 56Gb/s lane rates over ~100m
  - enable future higher-performing modules (e.g. 400GbE at 25 or 50Gb/s lane rates) to be back-compatible with 100G-SR4