OPTICAL INTERNETWORKING FORUM

Very Short Reach (VSR) OC-192 Interface Using 1310 Wavelength and 4dB and 11dB Link Budgets

OIF-VSR4-05.0

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Working Group: **Physical and Link Layer (PLL) Working Group**

TITLE: Very Short Reach (VSR) OC-192 Interface Using 1310 Wavelength and 4dB and 11dB Link Budgets

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Abstract: This is an Implementation Agreement for a Serial 1310 Very Short Reach (VSR) interface which includes both 4dB and 11dB optical link budgets, which covers distances from 2m to 600m. The 11dB option can be deployed in an optical network where the optical path includes a passive (transparent) Photonic Cross-connect (PXC), patch panels and up to 600m of single mode fibre.

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4 Document Revision History

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Baseline document adopted at the August, 2000 OIF meeting.

OIF2000.147.2 November, 2000
Revised document containing comment resolution from straw ballot, and minor editorial changes.

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Added 12dB option column into table 2, extracted from ITU G.693

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Changes to 12dB option column into table 3 and definition of eye mask.

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Changes to 12dB option column into table 3 and use of G.693 eye mask.

OIF2002.206.01 July 9thth 2002
Changes to Table 3 on Chromatic Dispersion. Added note 6 regarding amount of dispersion in link. Changed spelling error on OptronX.

5 Introduction

This technical document describes and offers detailed specifications for a Serial OC-192 Very Short Reach (VSR) optical interface that provides additional flexibility and advantages in the design of interoperable central office (CO) equipment. The serial OC-192 VSR interface described in this document provides a robust and cost effective solution to meet the desire to reduce the cost of interconnecting network elements and other CO equipment over shorter distances.

The parameter specifications for this VSR interface are based on a laser operating in the 1310nm region, transmitting at approximately 10Gb/s (OC-192/OC-192c), with a target distance of 600 meters on Single-Mode Fiber (SMF). This specification references the range of application models defined by the OIF for 10Gb/s VSR. Two different optical link budgets with maximum attenuation of 4dB and 11dB are defined, which collectively meet all the requirements of all the application models. The 11dB link is specifically intended for application through a photonic crossconnect (PXC).

6 Applications

Serial OC-192 VSR Interfaces may be used to provide interconnection of Dense Wavelength Division Multiplexing (DWDM) terminals, Photonic Cross-Connects (PXC), SONET/SDH Add Drop Multiplexers (ADM), Routers and other networking elements that are all co-located, or located within short distances of each other, as in a central office.

Currently, in many central offices, interconnection between network elements may only require fiber links of several hundred meters. Optical transmitters/receivers compliant to the Serial VSR OC-192 interface spec proposed in this contribution provide a cost-effective solution covering these distances (<600m), as opposed to using interface specifications intended for longer distance applications (20km-80km) which require more costly optical transmitters and receivers.

Examples of applications that could benefit from a more cost effective serial VSR solution are listed below and shown in Figure 1:

A. Router to PXC
B. Transport Equipment (SONET) to PXC
C. PXC to DWDM
D. Transport to DWDM
E. Router to DWDM
F. DWDM to DWDM
G. PXC Transparency—Router/Transport to DWDM

The reference models for OC192 VSR were defined in OIF2000.317 and are summarized in table 1 below. It is intended that all reference models can be addressed with the Optical link budgets included in this Implementation agreement.

Table 1. OC192 VSR Reference models

Ref Model #	Link description	Link specification
1	2m to between 50m and 100m intra-office direct connection, no patch panel or junction boxes	4dB
2	2m to 300m intra-office inter-connection, with 0-2 patch panels	4dB
3	2m to 600m intra-office inter-connection, with 0-2 patch panels	4dB
4	2m to 600m intra-office inter-connection with exactly one PXC in the interconnect, and 0-4 junction boxes	11dB

Reference model 1 is a simple direct point to point connection between 2 equipments.

Reference models 2, 3 have up to 2 patch panels, with up to 600m of fibre. A typical arrangement is shown in fig. 1.

Figure 1. Reference model for applications 2, 3

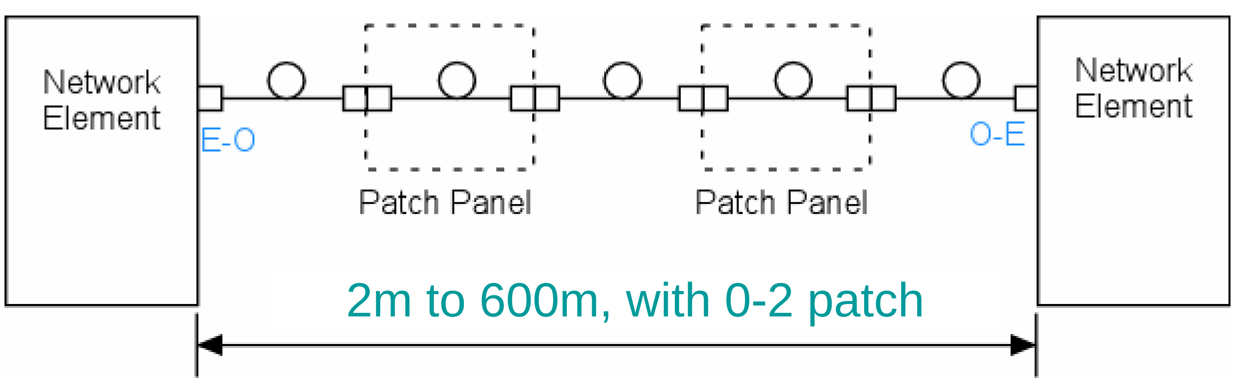
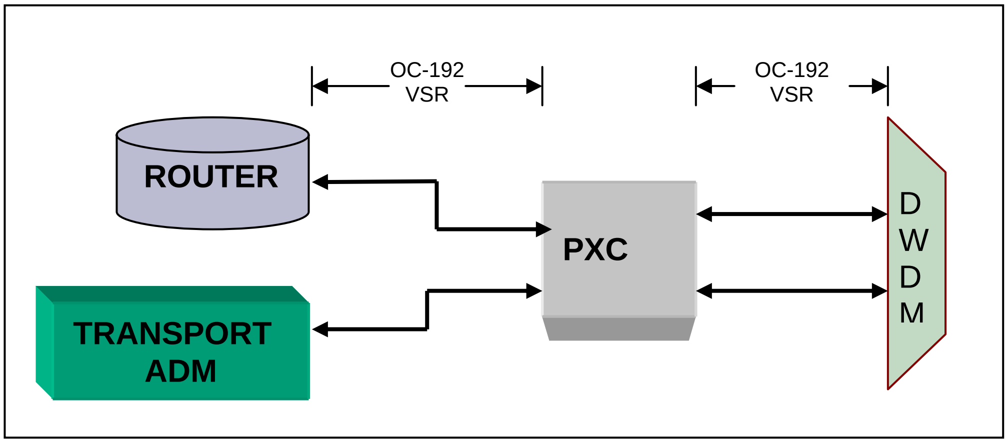


Figure 2 below shows typical interfaces relating to application nos 1, 2, 3.

Figure 2. Applications for OC192 VSR Interfaces Ref Models 1 - 3



Reference model 4 defines a VSR link through a transparent Photonic Crossconnect. A typical arrangement is shown in figures 3 and 4 below.

Figure 3. Reference model for application 4

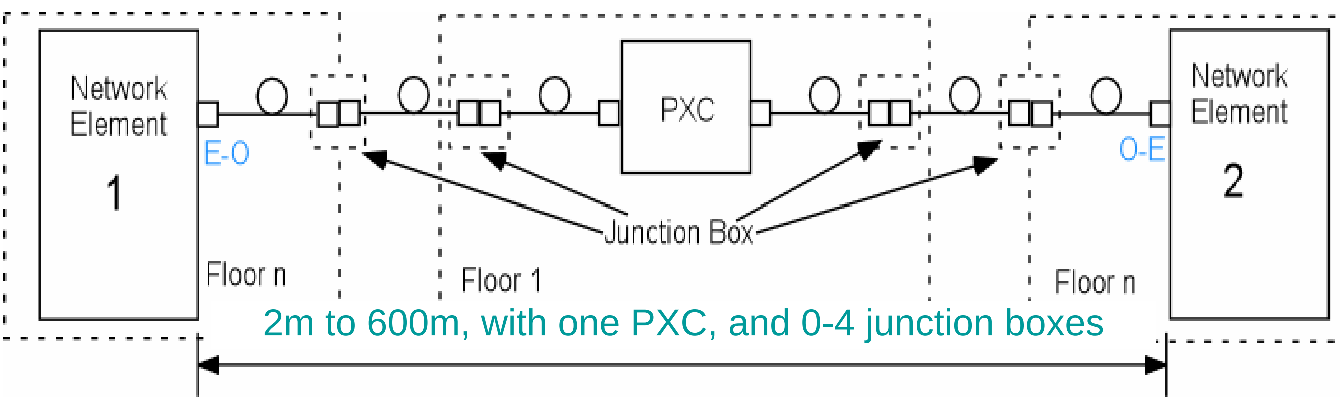
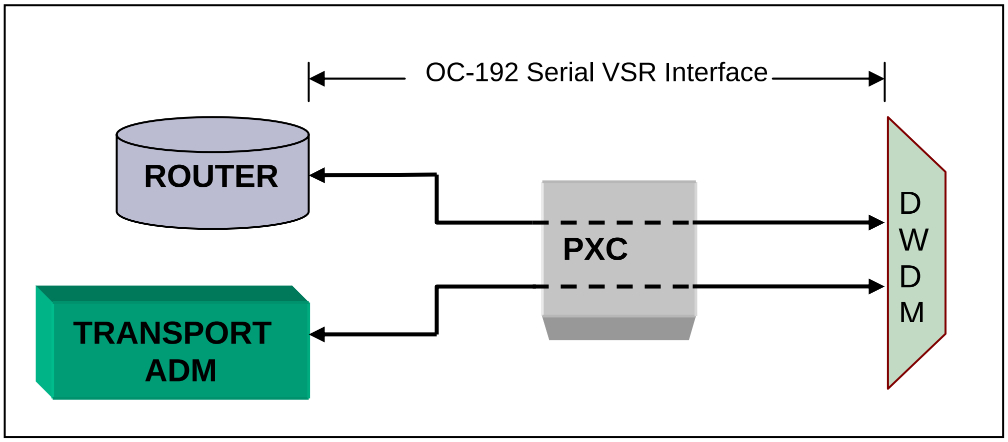


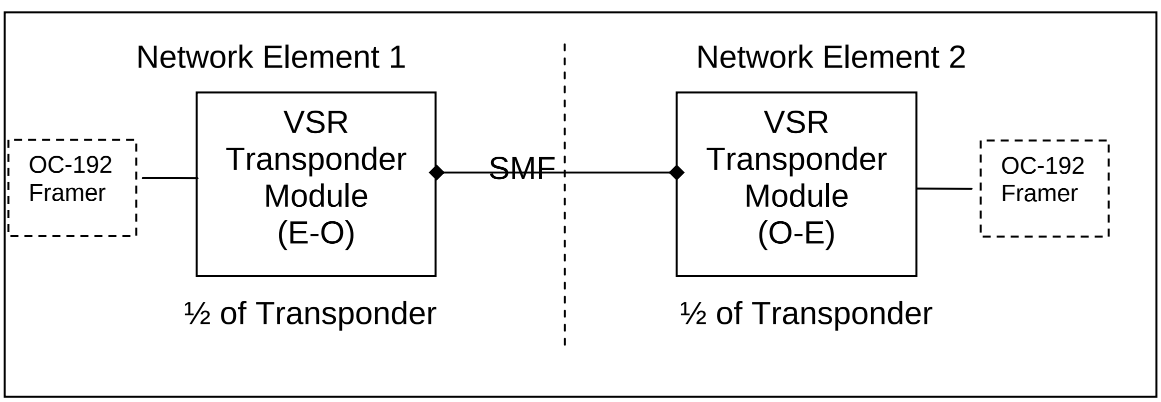
Figure 4. Application for OC192 VSR Interface Ref Model 4



7 Functional Description

A way to realize an optical interface compliant to the VSR interface specification proposed in section 6 is an optical transponder device which generates and receives a single 10Gbit/s data-stream and is designed to work on standard single-mode fiber. This solution incorporates the SERDES (Mux/Demux) and transceiver devices into a single module, with a SONET compliant OC-192 Framer used externally. The transponder described in Figures 1 through Figure 6 does not preclude the possible integration of the components (i.e. Framer and SERDES) at a later date, but instead offers one possible implementation that meets the parameter specification as shown in Table 2.

Figure 5. High level implementation of OC192 VSR



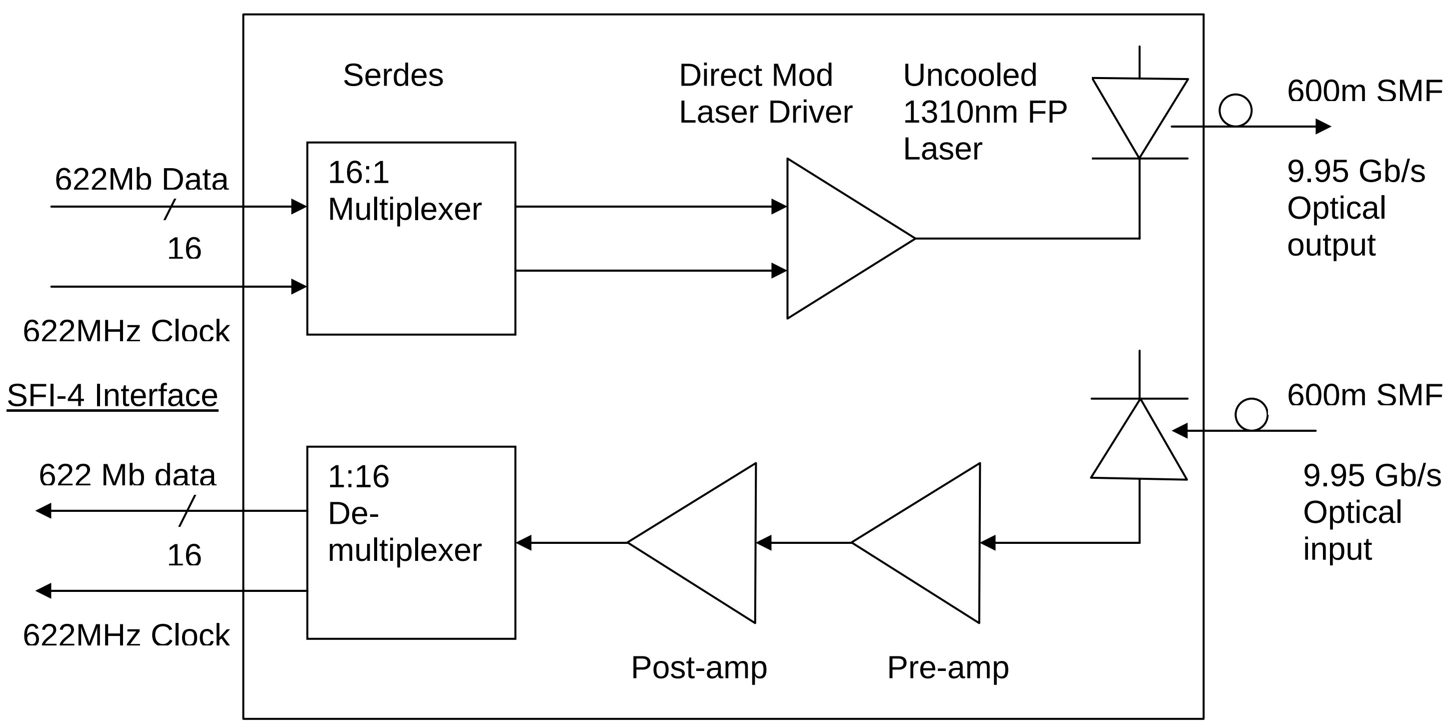
The transmit direction includes an electrical multiplexer, laser driver and the 1310 nm laser with spectral characteristics appropriate to link lengths of 600m. The 16:1 multiplexer receives the data and clock from an external OC-192 Framer. The output of the multiplexer is a data stream framed in a SONET/SDH compliant OC-192 (9.95Gb/s) manner, along with the clock. The multiplexer function usually includes a clock synthesis PLL, which generates a low jitter clock from an external reference. A direct modulation laser driver uses both the clock and 9.95Gb/s data signal from the mux to drive a laser, such as an uncooled 1310 nm Fabry-Perot laser, which places the 9.95Gb/s optical output on Single Mode Fiber (SMF).

The receive direction includes a PIN Photodetector, pre-amplifier, post-amplifier and electrical demultiplexer which delivers the 16 data outputs and clock from the Deserializer. The demultiplexer function conventionally includes the clock and data recovery.

Both transmit and receive portions of the OC-192 VSR serial transponder proposal are shown in Figure 6.

It is important to note that the OC-192 transponder modules, as shown in Figure 6, are fully compliant with the SFI-4 electrical I/O specifications (at SERDES interface). Use of a Fabry-Perot laser to achieve the proposed VSR parameter specification in this contribution does not preclude the use of other technologies or lasers to achieve the same performance criteria, allowing for new technologies in the future that may also yield significant cost savings with the serial approach.

Figure 6. Serial VSR Transponder Module – Detailed Implementation



8 Optical Interface Specifications

The optical interface specifications, as shown in Table 2 are derived from ITU-T specifications for STM-64 Optical Interfaces. The 4dB link budget is copied from G.693. The 11dB Link budget is modified from that defined in G.693. Since work has already been done in this area, the optical physical layer parameters are listed below with a reference to the ITU-T G.691 and G.693 recommendations.

It should be noted that the distance of 600 m is not limited by the power budget of 4 dB, but by the worst case transmitter rms spectral width of 3 nm, which in combination with a wide operating wavelength range of 1260 – 1360 nm, creates a worst case dispersion limit of 600 m on standard single-mode fiber. The above mentioned spectral characteristics are chosen to allow Fabry Perot Lasers to be manufactured at lowest cost.

Table 3 provides the necessary optical parameter requirements for a serial OC-192 VSR interface on SMF. The ITU-T and other standards bodies (for example IEC) have approved and accepted recommendations that cover measurement of optical parameters (i.e. jitter, eye-mask, extinction ratio), terminology, and detailed descriptions of all the optical parameters contained within this recommendation. Rather than reproduce this work, the proposed serial VSR parameter specification will be included in detail in Table 3, with a reference for additional information that directs the user to the series of ITU-T recommendations (G.691 and G.693 in particular) on optical physical layer interfaces.

Jitter specifications will be as defined in ITU G.783.

8.1 Eye Pattern Masks

The transmitted pulse shape for both the 4 dB and 11 dB links are specified in the form of a mask shape as in fig. 7 below. Parameters specifying the eye mask are defined in table 2. This eye mask for the 4 dB link is as defined in G.693. The eye mask for the 11 dB link is also from G.693. Eye mask measurements are made with a fourth order Bessel Thomson filter as defined in G.691 and G.693.

Figure 7. Eye diagram mask for optical transmit signal

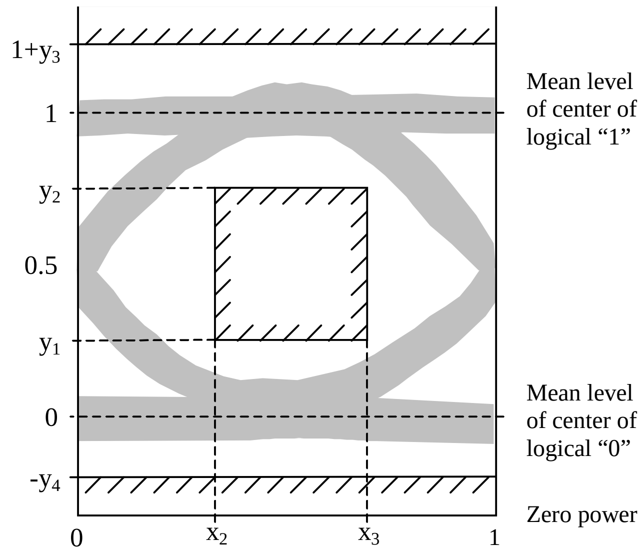


Table 2. Eye mask parameters

	VSR link
$x_3 – x_2$	0.2
y_1	0.25
y_2	0.75
y_3	0.4
y_4	0.25

Note: x2 and x3 of the rectangular eye mask need not be equidistant with respect to the vertical axes at 0UI and 1UI.

Table 3. Serial OC-192 1310nm VSR Optical Parameter Interface Specifications

Application	Unit	4dB VSR	11dB VSR
ITU Reference		G.693 VSR600-2R1	
Transmitter Characteristics			
Source type		MLM	MLM
Operating wavelength range	nm	1260-1360	1260 – 1360
Mean launched power (note 5)			
- maximum	dBm	-1	+2
- minimum	dBm	-6	-1
Special characteristics			
- maximum RMS width (σ)	nm	3	3
- maximum –20 dB width	nm	NA	NA
- minimum SMSR	dB	NA	NA
Minimum EX	dB	6	6
Main Optical Path Characteristics			
Fiber type		Single Mode	Single Mode
Attenuation range			
- maximum	dB	4	11
- minimum	dB	0	0
Chromatic dispersion (note 4,6)			
- maximum	ps/nm	3.8	3.8
Maximum DGD	ps	30	30
Min ORL of cable plant at MPI-S, including any connectors	dB	14	14
Maximum discrete reflectance between MPI-S and MPI-R	dB	-27	-27
Receiver Characteristics			
Minimum sensitivity (BER of $1*10^{-12}$) (note 5)	dBm	-11	-13
Minimum overload	dBm	-1	2
Maximum optical path penalty	dB	1	1
Maximum reflectance of receiver, measured at MPI-R	dB	-14	-14

Notes:
1. Optical parameters are derived from Table 3 in ITU-T recommendation G.693.
2. In the case that passive optical devices in the main optical path introduce additional chromatic dispersion, the achievable link distance may be reduced. Alternatively an application with a higher chromatic dispersion tolerance may be used to overcome this restriction.
3. The Serdes function, clocking scheme and synchronization method should comply with SFI-4 and are all defined in OIF199.102.8
4. Refer to ITU-T G.691 and 693 for other relevant optical parameter criteria (e.g. reference points)
5. A value of 12dB link loss and 1dB path penalty is highly desirable and should be adopted when the TX/RX technology matures and/or optical cross connects insertion loss improves
6. Chromatic dispersion is not added through the Optical Cross Connect Switch. The dispersion is a result of the 600m of SLM fiber as indicated in the application model shown in Figure 3.

Appendix A. List of companies belonging to the OIF at time of approval

Accelerant Networks
Accelight Networks
Actel
Acterna Eningen GmbH
ADC Telecommunications
Aeluros
Agere Systems
Agilent Technologies
Agility Communications
Alcatel
All Optical Networks, Inc.
Altamar Networks
Altera
Alvesta Corporation
AMCC
America Online
Ample Communications
Analog Devices
ANDO Corporation
Anritsu
Aralight
ASTRI
AT&T
Atrica Inc.
Avici Systems
Axiowave Networks
Bandwidth9
Bay Microsystems
Big Bear Networks
Bit Blitz Communications
Blaze Network Products
Blue Sky Research
Bookham Technology
Booz-Allen & Hamilton
Broadcom
Cable & Wireless
Cadence Design Systems
Calient Networks
Calix Networks
Caspian Networks
Celion Networks
Centellax
Centillium Communications
Ceyba
Chiaro Networks
Chunghwa Telecom Labs
Ciena Communications
Cisco Systems
Coherent Telecom
Conexant

CoreOptics
Coriolis Networks
Corrigent Systems
Cortina Systems
Corvis Corporation
Cypress Semiconductor
Data Connection
Department of Defense
DeriveIt
E2O Communications
ELEMATICS
Elisa Communications
Emcore
Equant Telecommunications SA
Equipe Communications
Ericsson
ETRI
Extreme Networks
EZChip Technologies
Fiberhome Telecommunications
Fiberspace
Finisar Corporation
Flextronics
Force 10 Networks
France Telecom
Free Electron Technology
Fujikura
Fujitsu
Furukawa Electric Technologies
Galazar Networks
General Dynamics
Glimmerglass Networks
Harris Corporation
Harting Electro-Optics GmbH
Helix AG
Hi/fn
Hitachi
Huawei Technologies
IBM Corporation
Ignis Optics
Industrial Technology Research Institute
Infineon Technologies
Infinera
Innovance Networks
Inphi
Integrated Device Technology
Intel
Internet Machines
Interoute
Intune Technologies, Ltd.
Iolon
Japan Telecom

JDS Uniphase
Jennic
Juniper Networks
KDDI R&D Laboratories
Kirana Networks
KT Corporation
Larscom
Lattice Semiconductor
LSI Logic
Lucent
Lumentis
LuxN
LYNX - Photonic Networks
Mahi Networks
Marconi Communications
MathStar
Maxim Integrated Products
MergeOptics GmbH
Meriton
Metro-OptiX
Mintera
Mitsubishi Electric Corporation
Multilink Technology Corporation
Multiplex
MultiWave Networks
Myrica Networks
Mysticom
National Semiconductor
Nayna Networks
NEC
NetTest
Network Elements
NIST
Nortel Networks
NTT Corporation
NurLogic Design
OpNext
Optical Datacom
Optillion
Optium
Optix Networks
Optobahn
OptronX
PacketLight Networks
Parama Networks
Paxonet Communications
Peta Switch Solutions
PhotonEx
Photuris, Inc.
Phyworks
Picarro
Pine Photonics Communications

PMC Sierra
Polaris Networks, Inc.
Princeton Optronics
Procket Networks
Quake Technologies
Qwest Communications
RedClover Networks
RF Micro Devices
RHK
Sandia National Laboratories
Santec Corporation
Santel Networks
Santur
SBC
Siemens
Sierra Monolithics
Silicon Access Networks
Silicon Labs
Silicon Logic Engineering
Sky Optix
Solidum
Southampton Photonics
Spirent Communications
StrataLight Communications
Stratos Lightwave
Sumitomo Electric Industries
Sun Microsystems
Sycamore Networks
TDK Semiconductor
Tektronix
Telcordia Technologies
Telecom Italia Lab
Tellabs
Tellium
Tenor Networks
TeraBurst Networks
TeraConnect
Teradiant Networks, Inc.
Texas Instruments
T-Networks, Inc.
Toshiba Corporation
Transpectrum
Transpera Networks
TriQuint Semiconductor
Tropic Networks Inc.
Tsunami Photonics
T-Systems Nova
Turin Networks
US Conec
Velio Communications
Velocium (TRW)
Verizon

Vitesse Semiconductor
VSK Photonics
W.L. Gore & Associates
Wavecrest Corporation
Wavium AB
West Bay Semiconductor
Xanoptix
Xelerated
Xignal Technologies
Xilinx
Xindium
Xlight Photonics
Zagros Networks
Zarlink Semiconductor