Working Group: Physical and Link Layer Working Group

TITLE: Very Short Reach (VSR) OC-192 four fiber Interface Based on Parallel Optics

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This proposed specification is similar to work being performed at the Fibre Channel, Infiniband and IEEE 802.3ae working groups. The IEEE 802.3ae working group has a baseline standard protocol which is compatible with this proposed specification. The Fibre Channel and Infiniband have both specified the use of parallel fiber interconnects over short distance fiber links.

5.19.1 Overlaps
5.19.2 Unique viewpoints

6 Introduction

This technical document describes a functional low-cost SONET/SDH OC-192 interface for very short reach (VSR) applications.

The VSR interface utilizes four 2.5 Gbps vertical cavity surface emitting lasers (VCSEL) and a 4 fiber cable to transmit the OC-192 frame over 'very short' distances of up to 300m. The four fiber solution leverages the low cost parallel fiber VCSEL based technology currently being deployed in many optical backplane applications for digital crossconnect systems, terabit routers and terabit switches. Four fiber solutions are also being specified in the ANSI Fibre Channel standard and the Infiniband Industrial consortium. These applications and the VSR OC-192 applications have very similar optical power and jitter link budgets. The four fiber VSR OC-192 solution will map the OC-192 frame onto the parallel optical link with no bandwidth expansion and no overwriting of the SONET overhead bytes to maintain compatibility with SONET OC-192 overhead processors and framers.

The target performance of the four fiber VSR interface is to transmit the OC-192 data over 300m of 50 μm-core multimode (MM) ribbon fiber cable.

This document defines the functions for mapping from the OC-192 framer interface to the parallel optical interface. It also defines the optical interface. The electrical interface from the framer conforms to the common electrical interface defined in the ratified OIF99.102 proposal.

6.1 Application

The application of the OC-192 VSR interface is to interconnect co-located equipment. Due to the short distances, use of interfaces designed to achieve longer distances, results in unnecessary cost and complexity. Examples of equipment that is often co-located within a central office and often interconnected are:

1. Routers,
2. Dense Wavelength Division Multiplexer (DWDM) terminals, and
3. SONET/SDH Add-Drop Multiplexers (ADMs).

7 Functional Overview

The OC-192 VSR is a bi-directional interface. A schematic of the VSR interface functional block diagram is illustrated in Figure 1.

7.1 Transmit Direction

- The "converter" device receives a 16-bit 622 Mb/s LVDS electrical signal from the OC-192 framer chip as defined in OIF99.102.
- The transmit data interface is source synchronous (i.e. the required 2.5 Gb/s high-speed data is synchronous with the 622MHz clock received from the OC-192 framer chip).
- The 16 bit parallel bus shall be mapped onto 4 parallel channels.
- Each channel contains OC-192 scrambled data demultiplexed into four channels. No additional scrambling or descrambling is performed by the converter device. Each individual channel will have 48 A1A2 SONET framing bytes (identical to an OC-48 data stream)
  - The A1A2 boundary is used to de-skew the four channels at the receiver.
- The 4 channels are forwarded to the parallel optics transmitter that transmits the data along the 4 optical fibers in the ribbon fiber at a bit rate of 2.488 Gb/s per channel. The interface to the optical fiber is the MTP® (MPO) connector[1].

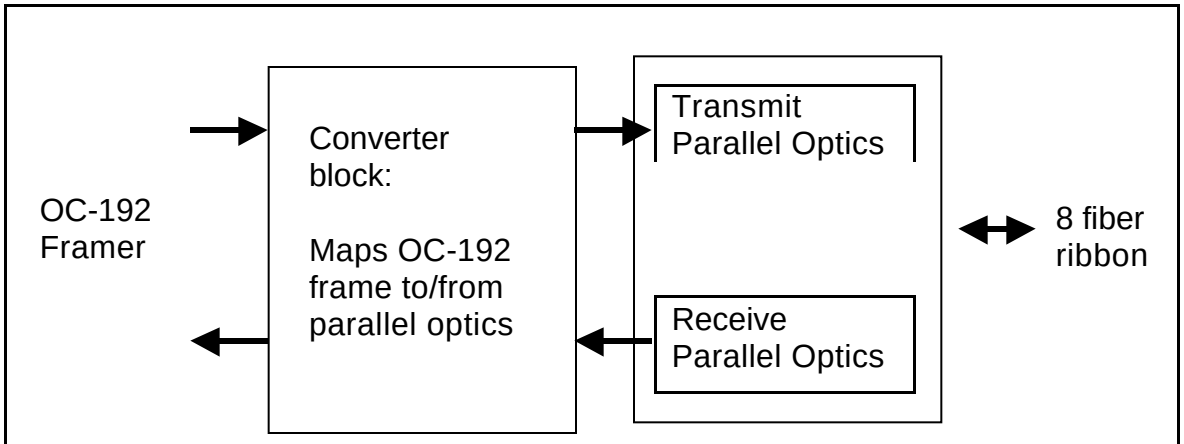


Figure 1: Functional block diagram of OC-192 four fiber VSR interface

[1] The MTP is a registered trademark of US Conec

7.2 The Receive Direction

- The parallel optical interface receives 4 optical signals from the fiber ribbon cable.
  - Each channel shall operate at 2.488 Gb/s.
  - The parallel optics receiver converts the signal to an electrical equivalent.
- The receive portion of the SERDES shall perform clock and data recovery on each channel.
- It will also de-skew the individual channels, by using the A1A2 boundary, to compensate for any inter-channel skew that may occur due to propagation delay differences between the channels.
- The “converter” shall recombine the 4 channels of data to a 16-bit wide data bus operating at 622 Mb/s. It shall not overwrite or replace any of the SONET framing or overhead bytes.
- The SERDES shall provide a 16-bit parallel 622 Mb/s LVDS signal for connection to the OC-192 framer chip retimed with a 622 MHz output clock.

7.3 Auto-Detection of Fiber Ribbon Cable Crossover

- The “converter” shall not auto-detect whether the fiber ribbon cable has a crossover. The ribbon fiber shall be constructed to avoid any crossovers of the fibers. Link polarity is to be maintained through the use of keyed adapters. The keyed concept enables the use of point to point, multiple interconnnect or crossconnected links.

7.4 Loss of Synchronization

- The “converter” shall detect a loss of synchronization (LOSyn) on any single channel within the 4 data channels, and indicate a loss of sync condition.

7.5 Fiber Ribbon (See Figure 5)

- The fiber ribbon shall be eight 50µm multimode optical fibers as specified by ANSI TIA/EIA-455-30B.
- Each fiber shall carry a separate channel.

7.6 OC192 Mapping to Data Channels

- The OC-192 frame shall be striped 2 bytes at a time across the 4 data channels.
- The first 2 bytes of the OC-192 frame shall be transmitted on channel 0, and the striping continues across the channels as shown.
- At the receiver, once the channels have been re-aligned, the reverse mapping shall re-assemble the OC-192 frame

7.7 Channel Encoding and Frame Delimiting (see Figure 4 & Table 1)

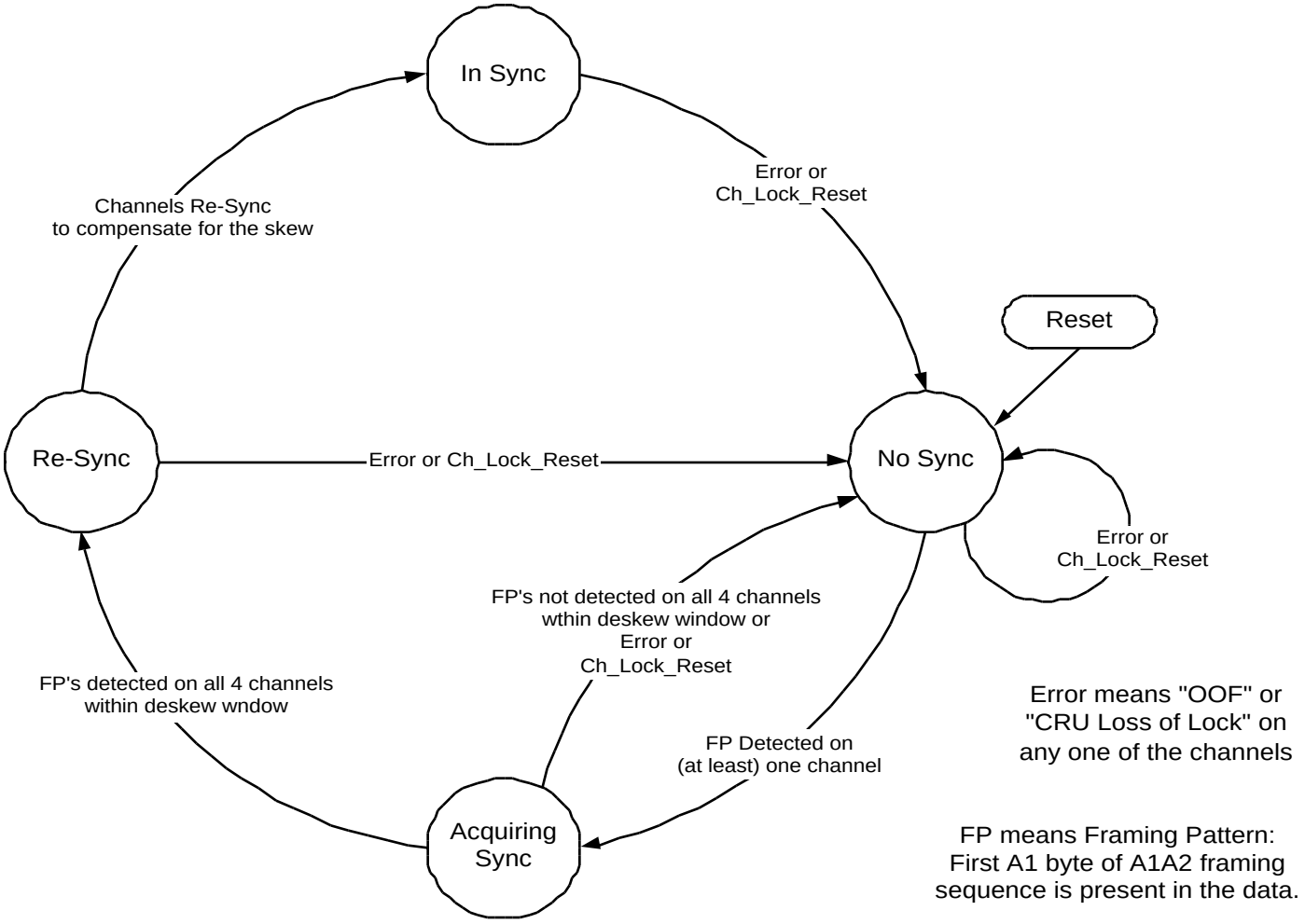
- Each channel shall maintain the original scrambled codes generated by the OC-192 framer.
  - The SONET/SDH A1A2 byte boundary shall be used for frame alignment and channel deskew.
  - The receiver has skew tolerance of at least 10 ns (typical inter-channel skew on a ribbon cable is 10 ps/m).

- The receiver in the converter shall use an algorithm to find the frame delimiters that is robust to local bit errors that may affect an individual frame delimiter.

7.8 Loss of Synchronization (LOSyn)

- Loss of synchronization (LOSyn) is a state that shall exist when a channel is considered to be not operating
- The LOSyn algorithm shall be based on looking for A1A2 boundaries.

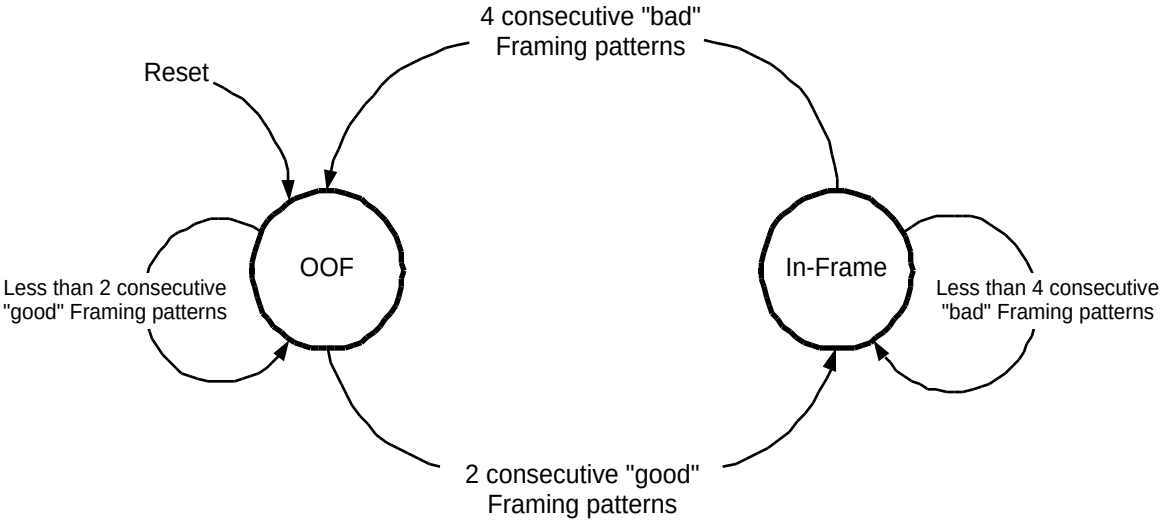
Figure 2: LOS State Machine



7.9 Out Of Frame State Machine

The Out of Frame (OOF) state machine is used by individual channels to indicate frame alignment. The OOF state machine searches the incoming data streams for the A1-A2 byte boundary with the correct 125 us separation.

Figure 3: OOF State Machine



8 Interface Specifications

There are two interface specifications: The electrical interface to the OC-192 framer and the optical interface to the parallel ribbon fiber.

8.1 Electrical Interface

This interface shall be compatible with the OIF contribution OIF99.102. No further details will be given in this document.

8.1.1 Jitter budget

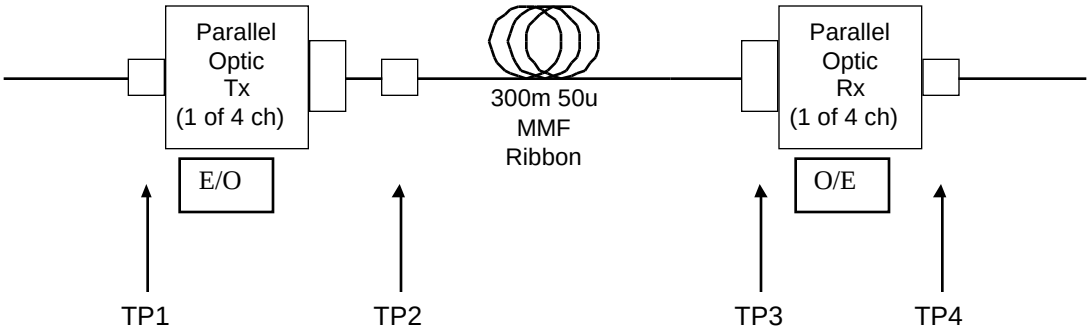


Figure 4: Jitter test points

Compliance point		TP1	TP2	TP3	TP4
Jitter Budget	TJ (UI)	0.27	0.46	0.52	0.73
	TJ (ps)	108	184	208	292
	DJ (ps)	28	76	76	122

Table 1: Jitter budget

8.2 Optical Interface

- The OC-192 VSR optical interface shall meet the specifications given in Table 2

- The interface will transmit on 50µm multimode ribbon fiber. The target distances are shown in Table 3.

Parameter	Min.	Max	Units
Transmit[1,2]			
P_{out}	-8	See footnote[3]	dBm
λ_c	830	860	nm
Extinction ratio	6		dB
$\Delta\lambda_{rms}$		0.85	nm
T_{rise}/T_{fall} (20-80%)		140	ps
RIN		-116	dB/Hz
Receive [4]			
P_{in}	-16[5]	-3	dBm
λ_c	830	860	nm
Return loss	12		dB
Signal detect – asserted[6]		-16.5/-22	dBm
Signal detect-de-asserted	-24/-31		dBm
Signal detect hysteresis	0.5/2		dB

Table 2: Optical Interface Specifications

Notes:
1. All specifications are per channel and at the end of a 2m patchcord
2. In the event of accidental transmitter to transmitter connection, no damage shall occur that will prevent the continued operation of the transmitter module within specification.
3. Output power for combined channels will be compliant with FDA Class 1 and IEC Class 3A eye safety requirements (all channels aggregated).
4. All receiver specifications are per channel.
5. Receiver sensitivity shall be such that the BER ≤ 10^{-12} with the minimum optical power and worst case extinction ratio including the optical path penalty (includes 1.5dB loss for connectors).
6. Signal detect signal is asserted when all channels are active. Signal is de-asserted when one or more channel's power drops below threshold.

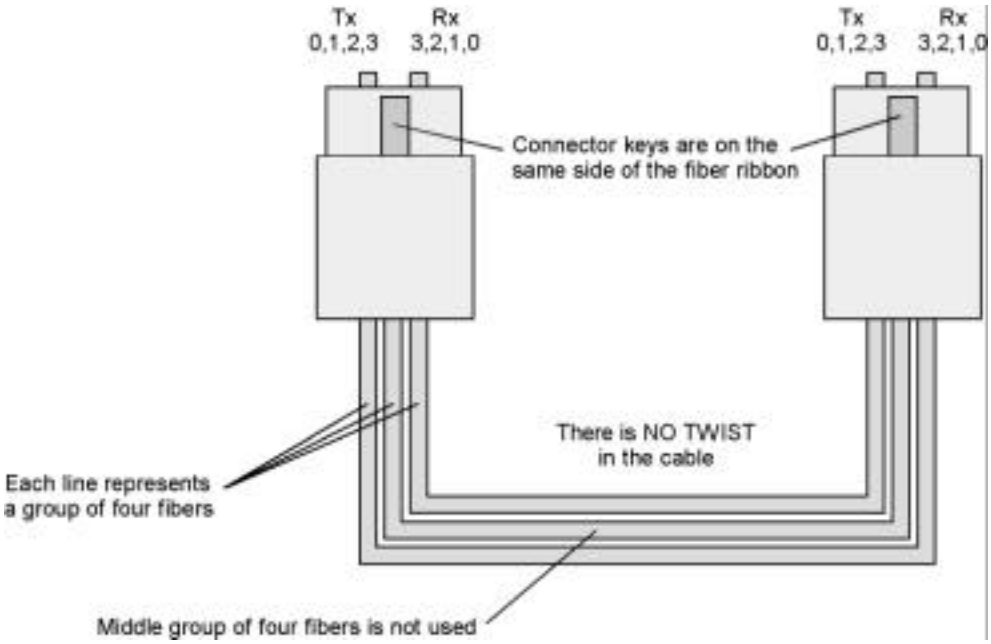


Figure 5: Connector/Fiber ribbon Orientation

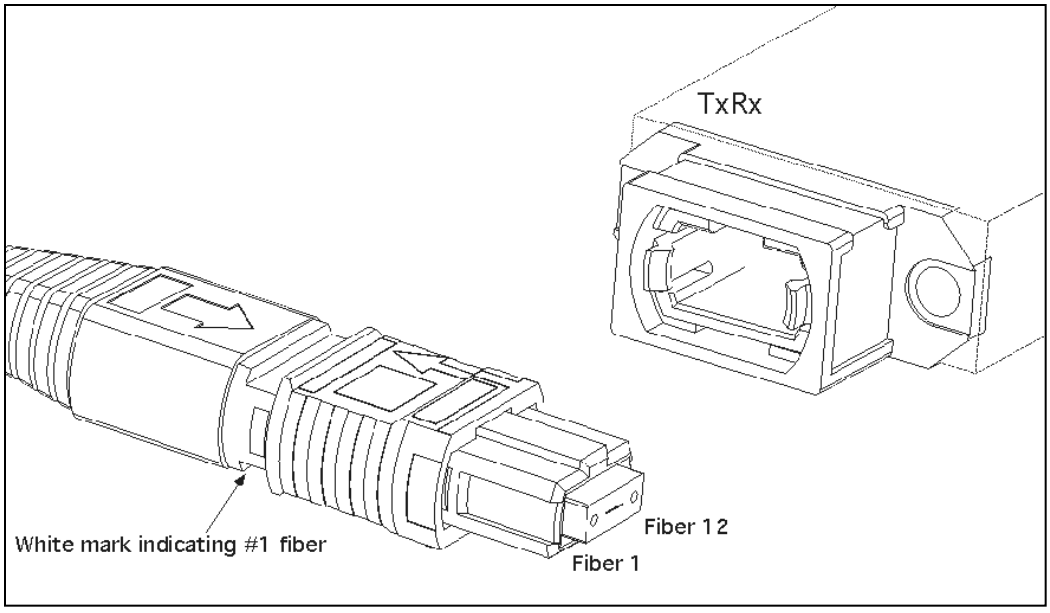


Figure 6: MTP Connector Interface
Note: Middle 4 fibers are unused
Note: Receptacle contains male guide pins
Note: Receptacle key location (top or bottom) may be vendor specific but must guarantee correct fiber orientation per fig. 5.

Fiber Effective Modal bandwidth[3]	Target Distance
500 MHz.km[1]	300m

Table 3: Target Distance

Notes:

1. Work is currently underway in TIA FO2.2 to standardize multimode fiber characterization with laser launches. For reference see:
   Draft FOTP203: Launched Power Distribution Measurement Procedure for Graded-Index Multimode Fiber Transmitters
   Draft FOTP xxx: Restricted launch requirements for Multimode Fiber bandwidth measurements

2. Advanced fiber under study to achieve >500m distances. Launch conditions currently under study by TIA FO2.1.

8.3 Optical connector

· The optical connector shall be the MTPä (MPO).

Connector references:

1. IEC 61754-7 Fiber Optic Connector Interfaces - Part 7: Type MPO Connector Family
2. EIA/TIA-604-5 "Fiber optic Connector Intermateability Standard" (FOCIS 5)
3. JIS C 5891-1993
4. HIPPI 6400-OPT (final stages of approval, MTP has been adopted)

Appendix A. Companies belonging to the OIF at time of document approval.

Accelerant Networks
Accelight Networks
Acorn Networks
AdventNet
Aerie Networks
Agilent Technologies
Agility Communications
Alcatel
Algety Telecom
Alidian Networks
All Optical Networks, Inc.
Allegro Networks
Altera
Alvesta Corporation
Amber Networks
AMCC
Amkor Technology
Ample Communications
Analog Devices
ANDO Corporation
AON Networks
Appian Communications
Applied Innovation
Aralight
Artel Video Systems
Astral Point Communications
AT&T
Atoga Systems
Avici Systems
Axiowave Networks
Axsun Technologies
Bandwidth9
Bay Microsystems
Bellsouth Telecommunications
Big Bear Networks
Blaze Network Products
Bravida Corp
BrightLink Networks
Broadcom
BT
Cable & Wireless
Calient Networks
Calix Networks
Caspian Networks
Catamaran Communications

Celion Networks
Celox Networks
Cenix
Centerpoint Broadband Technologies
Chiaro Networks
China Advanced Info-Optical Network
Chorum Technologies
Cidra
Cielo Communications
CIENA Communications
Cinta Corporation
Cisco Systems
Clifton Microsystems
Cognet Microsystems
Computer & Communications Research Labs
Conexant
ConnectCom MicroSystems
Continuum Networks
Coriolis Networks
Corning Incorporated
Corrigent Systems
CORVIS Corporation
CPlane
CSELT
CyOptics
Cypress Semiconductor
Cyras Systems
Dark Matter Network Technologies
Data Connection
Deutsche Telekom
DigiLens
Ditech
Dynarc
E2O Communications
ECI Telecom
Edgeflow
Elisa Communications
Emperative
Enron Broadband Services
Entridia
Equipe Communications
Ericsson
ETRI
Extreme Networks

Ezchip
Fast-Chip
FCl
Finisar Corporation
Force 10 Networks
Foundry Networks
Fujikura
Fujitsu
Fujitsu
Furukawa Electric
Technologies
G2 Networks
Gazillion Bits
Gemfire
General Dynamics
Genoa
Glimmerglass Networks
Global Crossing North
American Networks
Gore & Associates
Gotham Networks
Gtran
GTS Network Services
Helix AG
Hi/fn
Hitachi
Honeywell
Huawei Technologies
Hyperchip
IBM Corporation
Ilotron
Infineon Technologies
Information
Management Systems
Informed Diagnostics
Inc.
Innovance Networks
Inphi
Integral Access
Intel
Internet Machines
Iolon
IPOptical
Iris Labs
Ironbridge Networks
Jasmine Networks
JDS Uniphase
Jedai Broadband
Networks
Jennic
Juniper Networks

KDD R&D Laboratories
KereniX
Kestrel Solutions
Korea Telecom
Kromos Technology
Lambda Crossing
LANCAST
Lara Networks, Inc.
Laurel Networks
Level 3 Communications
LightLogic
LSI Logic
Lucent Technologies
Luminous Networks
Luxcore
LuxN
LYNX - Photonic Networks
Mahi Networks
Maple Optical Systems
Marconi Communications
Mayan Networks
Memlink
Metro-OptiX
MicroOptical Devices
Mintera
Mitel Corporation
Mitsubishi Electric Corporation
Multilink Technology Corporation
Nanovation
National Security Agency, US. Dept of Defense
Native Networks
Nayna Networks
NEC
NEL America, Inc.
Net Insight
Net-Hopper Systems
NetPlane
Network Associates
Network Elements
Network Photonics
New Focus
NewPort Communications
NIST
Nokia

Nortel Networks
nSerial
Ntechra
NTT Corporation
NurLogic Design, Inc.
Ocular Networks
OKI Electric Industry
ON Semiconductor
Onex Communications
ONI Systems
Opthos
Optical Switch Corp.
Opticalwave Networks
Optivera
Optix Networks
Optobahn
OptronX
Panstera
Parama Networks
Paxonet Communications
Photonami Inc.
PhotonEx
Photuris, Inc.
PicoLight
Pine Photonics Communications
Pluris
PMC Sierra
Point Reyes Networks
Princeton Networks
Procket Networks
Quake Technologies
Quantum Bridge
Redback Networks
Redfern Broadband Networks
Reversi Networks
RHK
Sandia National Laboratories
Santec Corporation
Scientific Atlanta
SDL
Seneca Networks
Siemens
Silicon Access
SITA Equant
Solidum Systems Corporation
Solinet Systems

Sorrento Networks
SpectraSwitch
Sphera Optical Networks
Spirent Communications
Sprint
Stratos Lightwave
Sumitomo Electric Industries
Sycamore Networks
Syntera Communications
T-Networks, Inc.
TDK Semiconductor
Tektronix
Telcordia Technologies
TELE-WORX
Tellabs
Tellium
Tenor Networks
TeraBeam Networks
TeraBurst Networks
TeraOp
Terawave Communications
Texas Instruments
Toshiba Corporation
Transparent Optical
TranSwitch Corporation
Trellis Photonics
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Vivace Networks
Wavium AB
West Bay Semiconductor Inc.
White Rock Networks
Williams Communications
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