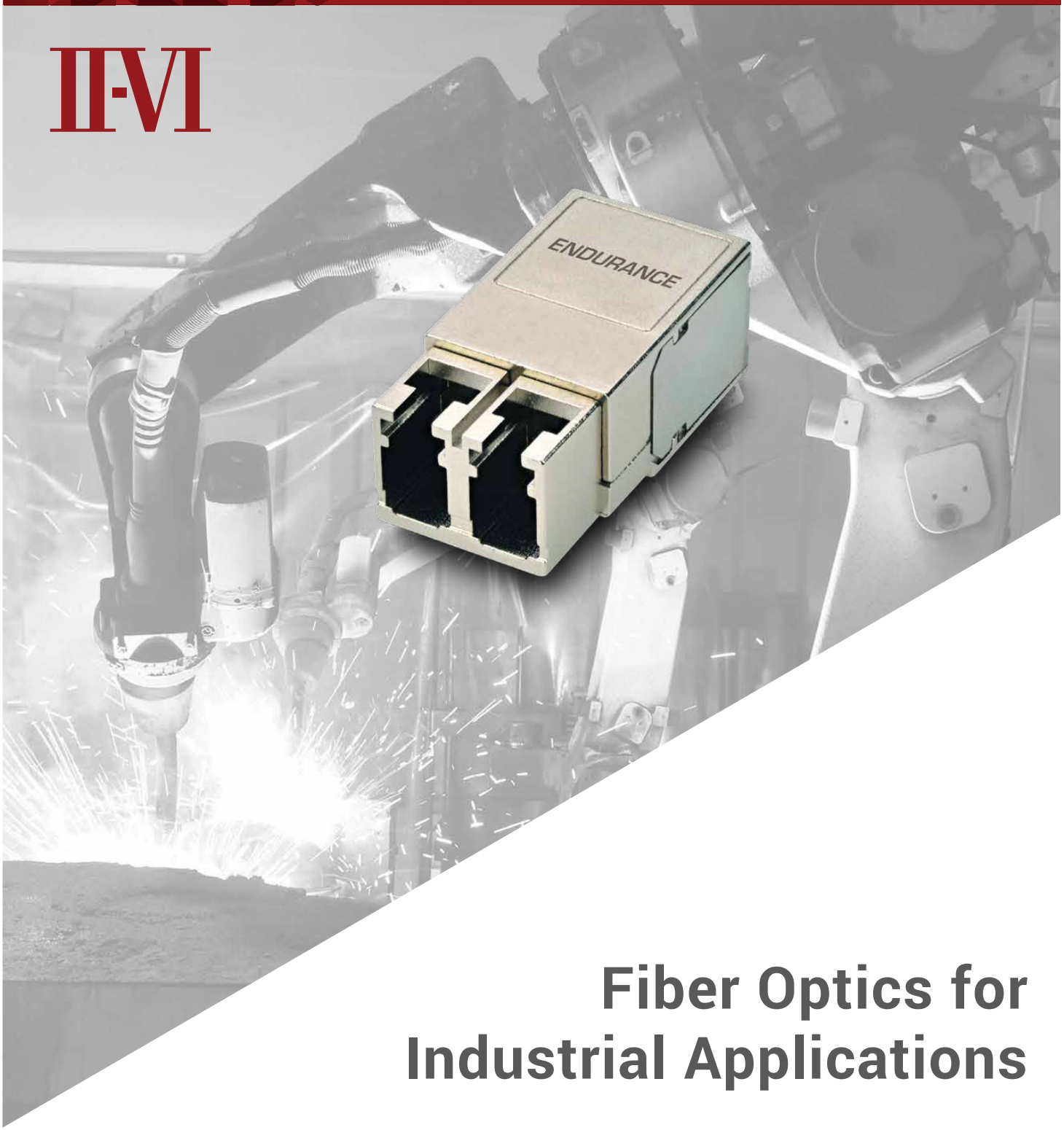
MATERIALS THAT MATTER

II-VI



Fiber Optics for Industrial Applications

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1/2020

Fiber Optics for Industrial Applications

The Industrial Internet, also known as Industry 4.0, is bringing greater speed and efficiency to industries such as factory automation, rail transportation, power generation, oil and gas development, and health care delivery. An enormous amount of data is collected, transported, and analyzed - all which requires a vast number of high-bandwidth interconnections between a myriad of nodes such as machines, sensors, facilities, computers, data centers, and people. Industrial Ethernet is becoming the communication standard to network all of these devices.

Fiber optic communication solutions provide high data rates, long distances, galvanic isolation, low flammable media, and good electromagnetic compatibility (EMC). As the world's largest fiber optic components and subsystem manufacturer, II-VI is best positioned to provide the Fast Ethernet and Gigabit Ethernet solutions to interconnect the Industrial Internet.

Evolution of Industrial Fiber Optics

Today, industrial communications are dominated by copper connections along with fiber optic links utilizing Light Emitting Diodes (LEDs) at low bit rates and short distances. With the rise of the Industrial Internet, communication links will need to support higher data

rates such as Fast Ethernet (125 Mb/s) and Gigabit Ethernet (1 Gb/s). Distances for these links may span meters to hundreds of meters (Short- Reach) and even kilometers (Long-Reach). LED fiber optic technology cannot support the higher data rates at these link distances. Laser sources such as Vertical-Cavity Surface-Emitting Lasers (VCSELs) and

Distributed Feedback (DFBs) satisfy these new requirements while being cost competitive with LED solutions.

Since interconnections in industrial applications will be more critical, the availability of fiber optic links will be very important. II-VI has shipped 175 million fiber optic transceivers with VCSELs with a failure rate of less than 10 parts per million. II-VI transceivers have patented digital diagnostic functions that provide early warning if a fiber optic link will go down. This enables maintenance to be dispatched before a data link fails.

Comparison of Fiber Optic Characteristics

Characteristic	Industrial Legacy	Industrial Internet
Protocol	Proprietary	Ethernet (Industrial)
Data Rate	12 Mb/s	125 Mb/s, 1 Gb/s
Link Distances	Meters	Hundreds of Meters, Kilometers
Link Reliability	Moderate	High
Flexibility	Low	High
Cost	Low	Low
Source	LED	Laser (VCSEL and DFB)
Digital Diagnostics	None	Yes
Form-Factors	Discrete Tx and Rx Modules Board-Mounted Transceivers	Pluggable Transceivers Compact Board-Mount Transceivers Active Optical Cables
Power Consumption	Medium	Low

Fiber Optics for Industrial Applications

Endurance® Rugged, Compact Laser Transceivers

II-VI's Endurance® transceiver provides two-way optical data links at data rates for Fast Ethernet, Gigabit Ethernet and 10 Gigabit Ethernet. It interoperates with standard SFP/SFP+ pluggable modules and contains 2-wire serial communication interface for digital control and diagnostics.

The Endurance transceiver operates at a wide temperature range, from -40°C to 85°C, and comes with an optional conformal coating (resistant to corrosive environments). It mounts directly to the Printed Circuit Board to handle excessive shock and vibration. Endurance is qualified to military specifications for long- term aging, salt spray, and vibration.

At half the length of Small-Form Factor (SFF) modules, the Endurance transceiver saves space on Printed Circuit Boards and allows multiple modules to be mounted side-by-side for high-density edge port counts.

SFP/SFP+ Pluggable Transceivers

II-VI's Small-Form Factor Pluggable (SFP) transceivers provide tremendous flexibility for industrial applications. Common equipment can be designed with generic SFP ports and later the optimal transceiver can be installed for the application. This reduces R&D investments and streamlines operations.

II-VI has the broadest SFP/SFP+ portfolio in the industry to accommodate data rates from Fast Ethernet to 10 Gigabit Ethernet, and distances from meters to kilometers. There is also an SFP option for RJ45 copper links.

SFPwire® Active Optical Cable

II-VI's SFPwire® AOC is a rugged fiber optic cable with SFP+ transceivers directly attached eliminating optical interfaces and providing an even lower cost solution for data links. The transceiver ends plug into standard SFP ports on industrial Ethernet equipment.

The SFPwire AOC also operates at data rates from Fast Ethernet to 10 or 25 Gigabit Ethernet. Various standard cable lengths are available from 1 meter to 30 meters.

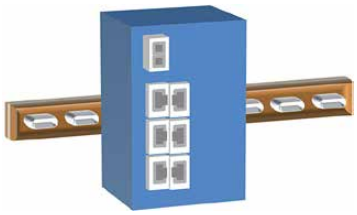
Several of II-VI's Active Optical Cables, including SFPwire, feature the Connectivity Diagnostics® (CD) suite of tools, which helps data center technicians quickly and intuitively find specific modules in a sea of sockets using a visual indicator.

Fiber Optics for Industrial Applications

Example of II-VI Products in Industrial Ethernet

Endurance® Rugged, Compact Laser Transceivers

Industrial Ethernet Switch modules that mount on DIN railings on the factory floor, have embedded Endurance laser transceivers to provide the optical interface. The transceiver's rugged form-factor is qualified for shock, vibration, and hazardous environments. These switch modules are small and power efficient due to the Endurance transceiver. With the multi data rate capabilities, Switch modules operate at Fast Ethernet and can transition up to Gigabit Ethernet as more bandwidth is required. This equipment fully interoperates with SFP/SFP+ transceivers on the other end of the link.



Endurance Laser Transceiver

SFP/SFP+ Laser Transceiver

SFP Copper Transceiver

Link Details:

Fiber Type:	Glass, Single-mode
Data Rate:	Fast Ethernet (125 Mb/s), Gigabit Ethernet (1 Gb/s), or 10 GbE (10 Gb/s)
Laser type:	1310nm Distributed Feedback (DFB)
Distance:	10 kilometers (at Gigabit Ethernet and 10 Gigabit Ethernet)

SFP/SFP+ Pluggable Transceivers

The Industrial Ethernet backbone platform is designed with open SFP/SFP+ ports. Depending on the fiber distances and/or data rate required for each link, the factory can choose the optimal SFP/SFP+ transceivers. For some very short links, the factory utilizes a copper SFP with a standard RJ45 interface.

With the patented digital diagnostic capabilities on the transceivers, the Ethernet Switch can monitor the link characteristics, such as receive optical input power, and provide early warning alarms to maintenance if it starts to deteriorate.

Selection Guide

Application	Suggested II-VI Products
Industrial backbone / Station level	**Endurance**®: FTE8501 (Short-Reach), FTE8511 (Short-Reach), FTE1411 (Long-Reach) **SFP**: FTLF8519P3BTL (Short-Reach), FTLF1318P3BTL (Long-Reach), FCLF852xP2BTL (copper) **SFP+**: FTLX8574D3BNV (Short-Reach), FTLX1475D3BNV (Long-Reach) **SFF**: FTLF8519F2GTL (Short-Reach)
Factory floor / Bay level	**Endurance**®: FTE8501 (Short-Reach), FTE8511 (Short-Reach), FTE1411 (Long-Reach)
Industrial Patch Cables	**SFPWire**®: FCBG110SD1Cxx (1 meter to 30 meters, 10G without CD), FCBG110SD1Cxx-1V (1 meter to 30 meters, 10G with CD), FCBG125SD1Cxx (1 meter to 30 meters, 25G without CD), FCCG125SD1Cxx (1 meter to 30 meters, 10G with CD)
Fieldbus upgrade to Industrial Ethernet	**Endurance**®: FTE8501 (Short-Reach), FTE8511 (Short-Reach), FTE1411 (Long-Reach) **SFF**: FTLF8519F2GTL (Short-Reach)