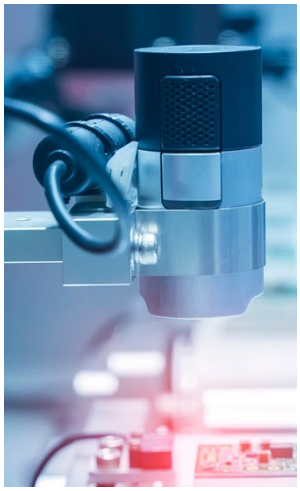
New Optical Interface Enhances Industrial Machinery

The rise of smart factories and industry 4.0 has been powered by several technological advancements including fiber optics. The development of lower cost and more robust fiber optic cables/connectors and transceivers has enabled the technology to expand beyond traditional telecom and datacom applications and into the factory. Fiber optics provide high speed data transmission and bandwidth required for machine vision applications that provide imaging-based automatic inspection and analysis, as well as robot guidance. There are many different types of fiber optic connector options available, and selecting the right one for your application can be difficult. In machine vision systems, a fiber optic system must not only deliver high signal integrity and durability, but also reliability and ease of use. In addition, many machine vision camera systems have size constraints. The following is a brief overview of current fiber optic cables and connectors and an introduction to the next generation connectivity solution for machine vision applications.

Fiber Optic Market Growth

A recent Research and Markets study estimates that the fiber optics market size in 2019 was USD 4.3 billion, with projections of reaching USD 6.9 billion by 2024. This increase is due to optical networks displacing copper networks as the preferred solution based on lower costs and faster data rates. Fiber optic technology continues to evolve to meet increased demand for greater speed and efficiency extending into areas where copper cannot go.



Machine Vision Standards

When designing a machine vision system, it is important to reference camera-to-computer interface standards. Standards help define networking based interfaces like Gigabit Ethernet, bus-based designs such as USB3 Vision, and point-to-point protocols such as Camera Link, Camera Link HS (CLHS) and CoaXPress (CXP). These camera-to-computer interface standards are documented by the AIA, and more information can be found at https://www.visiononline.org/

Fiber Versus Copper

Fiber optics offer many inherent advantages compared to copper cabling:

- Faster transmission speeds over greater distances without signal degradation
- Lower power consumption
- Less heat generation
- Impervious against interferences (EMC)

However, until recently, fiber optic solutions were not a preferred method of data transfer in machine vision. There are several key reasons:

- Size: the required fiber optic interface was previously not compact enough to be integrated into a camera housing
- Ease-of-use: the perception that fiber optic is fragile and difficult to install was once true. Rugged and highly durable fiber optics are now widely available
- Cost: fiber optics were historically more expensive than copper

Advancements to fiber optic transceiver technologies has addressed previous application concerns.

Fiber Optic Technology Overview

Fiber optic cables consist of one or many thin strands of glass protected by a flexible sheath. Typically, a strength member of Kevlar or other high strength element protects the optical content. Unlike standard copper cabling/connector systems that use electrical pulses to transmit data signals, fiber optics use pulses of light. This is accomplished via optical transceivers. Optical transceivers are wavelength-specific lasers that convert electrical data signals from data switches into optical signals. Fiber optics can transmit signals over longer distances with less signal loss compared to traditional electrical cabling & connectors. Fiber optics also offer superior transmission speeds and signal bandwidth enhanced with color wavelength multiplexing. One drawback of standard optical fiber cabling technology is that it does not support power transmission unless cables are manufactured with parallel copper elements.

There are two general categories of fiber optic cable technologies being widely deployed. Glass optical fiber and plastic optical fiber. Plastic optical fiber is used for short distances with network speeds that tend to be in the Mbyte/sec category. Glass optical fiber is used for medium and long distances with network speeds that tend to be in the Gbyte/sec category. When selecting glass fiber optics for machine vision applications, transmission distances and data rates must be taken into consideration. Machine vision applications with shorter camera-to-computer distances are manageable with plastic optical fiber. However, the majority of modern machine vision applications incorporate glass fiber optics.

Fiber optic connectors can be divided into different types according to the pin end surface of the connector. They can be divided into Physical Contact (PC), Ultra Physical Contact (UPC), and Angled Physical Contact (APC). Depending on the transmission media, fiber optics can be divided into single mode or multimode types. Single mode fiber enables one type of light mode to be transmitted at a time, while multimode fiber can support the propagation of multiple light modes at once. The differences between single mode and multimode fiber mainly lies in the fiber core diameter (the waveguide along which the optical signal is carried), wavelength and light source, bandwidth, color sheath, distance and cost. While single mode fiber offers higher bandwidth, multimode cables are more cost-effective.

Optical fiber connector performance can be expressed by two data points: insertion loss and return loss. Measurements of these parameters are defined in IEC standard 61753-1.

The standard gives five grades for insertion loss ranging from A (best) to D (worst) and M for multimode, while return loss is graded from 1 (best) to 5 (worst).

Most optical fiber connectors are spring-loaded plugs (male connectors) that feature a protruding ceramic, metal or plastic ferrule that holds and aligns fibers to ensure optimal waveguide core alignment. The spring loaded connectors inherently press the fibers “end faces” together when connectors are mated. By removing any airgap between the optical waveguides, signal loss is minimized and return loss is maximized to prevent noise being returned to laser sources. A connector shell brings these “plugs” together with a screw-on or snap-in mating adaptor used to mate two spring-loaded plugs.

Fiber Optic Transceivers & Connectors

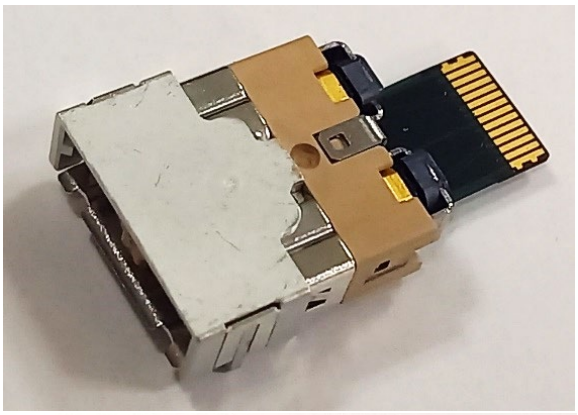
Optical fiber connectors couple and align transceivers so that light can pass through the fiber cores with minimum return loss or insertion loss. Transceiver modules can be classified into different groups based on their connector types. Today, there are four main types of fiber optic module connectors used in conjunction with optical transceivers: SC, LC, MPO, and ST.

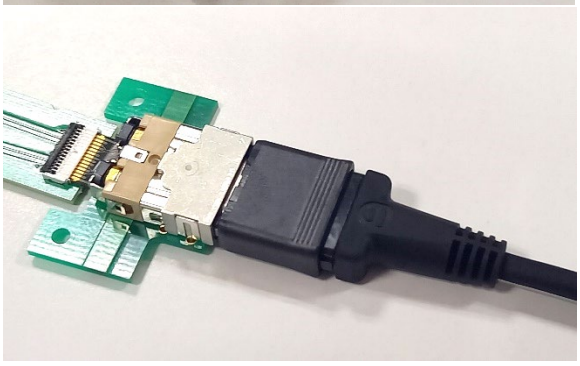
Connector	Description	Form Factors
SC	Subscriber Connector (snap-in connector)	GBIC, X2, XENPAK, some QSFP (40G) and CFP (100G)
LC	Lucent Connector (small form-factor version of the SC connector)	SFP, SFP+, XFP
MPO	Multi-fiber Push-On (commonly 12 or 24 fibers per)	Some QSFP (40G) and CFP (100G)
ST	Straight Tip Connector (bayonet mount connector)	Not used on optical transceivers, but popular at optical patch panels

Low-profile LC connectors have emerged as a preferred method for connectivity in machine vision applications, mainly because they are a small form factor (SFP) that use a 1.25 mm ceramic ferrule, which is half the size of the SC connector. The push/pull LC connector uses a latch for secure mating and is easy to terminate in high density applications.

Next-gen Optical Transceivers

New multimode fiber optic transceivers and connectors have emerged offering even more space-savings and design flexibility for machine vision applications. Compared to SFP+ connectors, modern transceivers offer space savings up to 90%. The smaller transceiver allows fiber optic solutions to be implemented in tighter spaces, often where conventional fiber optic hardware is not viable. Miniature transceivers, like EOC Type from Yokowo, ease integration into machine vision camera housings.

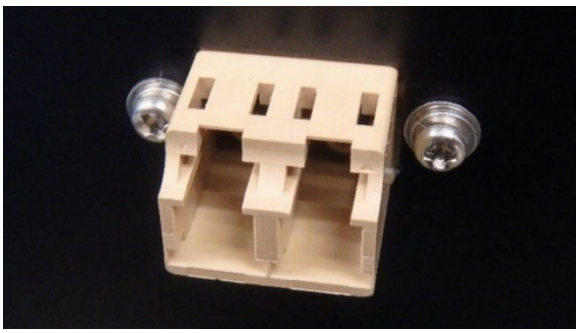


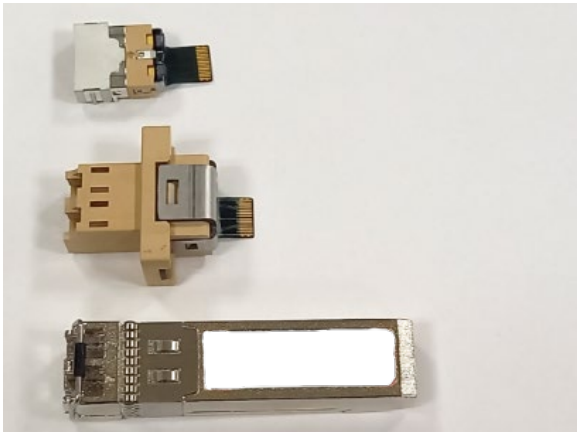


EOC Type Transceiver Fixed onto PCB

At 1/10th the size of traditional SFP+ transceivers, EOC Type multimode optical transceivers combine high speed data transmission up to 300m at 12.5 Gbps with power transmission of 3.3V. Combining signal and power in one hybrid solution further simplifies machine vision system design, lowering the cost, and enabling a smaller, lighter solution. These unique transceivers also lower power consumption, requiring only 150mW compared to traditional optical transceiver solutions.

The hybrid EOC Type optical transceivers reduce power consumption, which in turn reduces heat generation within the machine vision housing. This is vital as waste heat can degrade machine vision image quality if not properly dissipated away from temperature sensitive electronics. The modern transceivers themselves offer a wide operating temperature of -40℃ to 85℃.





Space and Cost Saving LC Type Transceiver

At about 1/3 the size of traditional SFP+ transceivers, LC Type multimode transceivers from Yokowo are compatible with LC connectors. This offers more cost savings as installers can use existing LC optical cables.

Utilizing a PC contact, Yokowo transceiver can also achieve a high transmission speeds 50Gps when used with Yokowo connectors (unidirectional transmission). Transceivers also offer low power consumption of 150mW to reduce heat in the machine vision system.

The transceiver solutions from Yokowo are available with several cable options including vertical screw type, horizontal screw type and no screw type. Samples are available upon request.

Conclusion

Fiber optic cables combine small size with high speed data transfer and bandwidth capabilities to meet modern machine vision application demands. Yokowo's miniature fiber optic transceivers and connectors now combine signal and power transmission to simplify design and installation. The user-friendly fiber optic solutions reduce power consumption and heat generation, simplifying machine vision designs. The advanced transceivers also reduce the total cost of ownership, and ensure all the benefits of fiber optic systems are realized.

Product Information

yokowoconnector.com