White paper

Long-distance surveillance

Fiber-optic communication in network video

AXIS COMMUNICATIONS

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1. Introduction

In network video, copper cables (twisted-pair) have traditionally been used to connect the camera with the control center or the recording unit. In long-range surveillance installations, however, fiber-optic cabling can be a more cost-efficient alternative. Even though it is more expensive per meter, the superior transmission characteristics of a fiber-optic cable reduces the need for expensive signal amplifiers along the way, and makes it possible to transmit more data at a time.

This white paper explains what fiber-optic communication is and how it can be used in network video. It also outlines how the Axis product line is designed to support fiber-optic communication.

2. What is fiber-optic communication?

In fiber-optic communication, light signals are transmitted through glass fibers.

2.1 Light reflections within a strand of glass

The fibers inside a fiber-optic cable are flexible, transparent strands of very pure glass or plastic. The core of a fiber is radially enclosed by another transparent material with slightly different characteristics, the cladding. This structure makes the fiber function as a "light pipe", so that light that enters the core at one end can emerge from the other end, even when the fiber is bent or twisted. For stability and protection, the core and cladding are normally enclosed by several protective coatings, as seen in Figure 1.

Figure 1. Fiber-optic strands bundled together in a protective outer cover.

Whenever the light inside the fiber hits the boundary between the core and the cladding, the light will bounce in a controlled manner and essentially continue forward, bouncing back and forth between the "walls" (see Figure 2). It is as if the cladding was lined with mirrors. Hardly any light is absorbed by the cladding, which is why the fiber can carry the light across great distances with nearly preserved intensity.

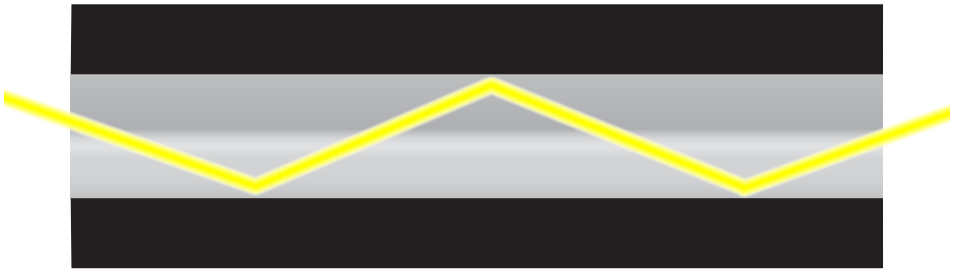

Figure 2. Inside a fiber-optic strand of glass or plastic the light bounces back and forth off the core/cladding boundary, continuing through the core.

2.2 Single-mode and multi-mode fibers

Fibers come in two types, suitable for different light sources and different transmission distances.

Single-mode fibers have thin cores, about 8 µm in diameter, and transmit infrared laser light (wavelength = 1,300 to 1,550 nm). They are usually made of glass. Single-mode fibers support only one propagation path, or mode, and are used for communication links longer than 1 km. They are typically used in 10-/100-Mbit/s network connections spread out over extended areas.

Multi-mode fibers have a larger core diameter, typically 50–100 µm, and transmit infrared LED (light-emitting diode) light (wavelength = 850 to 1,300 nm). They are usually made of plastic-clad silica or plastic. Multi-mode fibers support many propagation paths, or modes. They are used for short-distance communication links (up to 5 km), and for applications where high power must be transmitted.

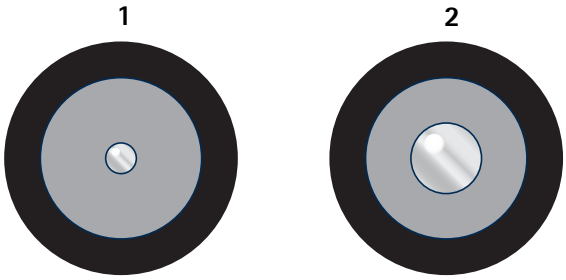

Figure 3. A single-mode fiber to the left (1), and a multi-mode fiber to the right (2).

2.3 Duplex and simplex transmission

You can transmit either two signals (full duplex) or just one signal (simplex) through one fiber-optic strand.

With duplex transmission, the transmitted signal and the received signal travel through the same strand. This means that in each fiber-optic strand there are two rays of light, traveling in opposite directions at the same time (see top part of Figure 4). In simplex transmission, there is only one ray of light traveling through each fiber strand. The received signal must then travel through a second strand (see lower part of Figure 4). Duplex transmission requires only half the number of fiber strands to transmit the same amount of data compared with simplex transmission.

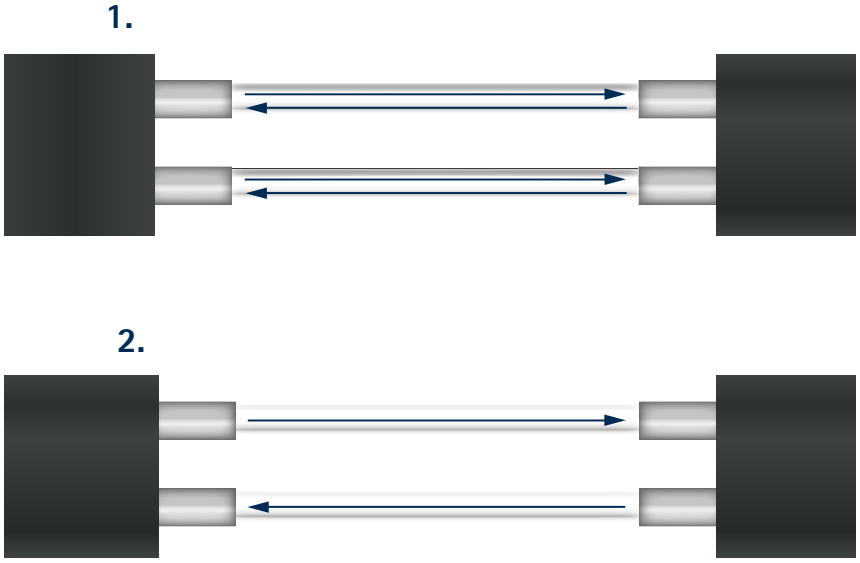

Figure 4. Showing the principles of duplex transmission (1) and simplex transmission (2).

3. Why use fiber-optic communication?

The most common purposes of using fiber-optic connections are illumination, communication, and medical or industrial endoscopy where many fibers are bundled together to transmit an image.

For telecommunications, such as network video, the light traveling through the fiber is, of course, not just random light, but rather data streams encoded as light signals. Fiber-optic connections have been used for data transmission since the 1970s, but the techniques for both transmitting of the data and for manufacturing of the fiber-optic equipment have advanced drastically over the years.

3.1 Long-range installations at low cost

As we have seen, a fiber-optic cable can carry a signal across great distances with only very low attenuation. For a twisted-pair copper cable to be able to carry a signal across the same distance, the signal would have to be amplified at several instances along the way. This could be done using so-called repeaters, but these are rather costly. This is why fiber-optic cables can be a cost-efficient solution at long distances, even though they are more expensive per meter than copper cables.
The maximum length of a fiber-optic cable ranges from 10 km to 70 km, depending on the type of fiber. The maximum length of a twisted-pair copper cable is 100 m. Depending on the type of fiber-optic cables used, data rates can range up to 10,000 Mbit/s.

The cost-efficiency of fiber-optic installations is also due to the slenderness of the fibers. This means that more fibers can be bundled into a given-diameter cable. This allows more data to go over the same cable, and makes fiber-optic cables ideal for carrying digital information.

3.2 No electrical interference

Transmission through twisted-pair copper cables is susceptible to electromagnetic interference (EMI). This is when external electromagnetic fields affect the current in the cable, and may cause substantial problems with data loss. Fiber-optic cables, however, are immune to such interference. Also, the signal in one fiber does not interfere with those in other fibers in the same cable.

Because the signal in a fiber-optic cable does not give rise to any electromagnetic field outside of the fiber, there is no signal leakage. This means that the transmission cannot be tapped, or accessed by unauthorized people.

4. Fiber-optic communication in network video

Axis offers a range of network video products that support fiber-optic communication. The key component in connecting a surveillance system with a fiber-optic cable is the SFP (Small Form Factor Pluggable) module. Other components are media converters and network cameras with integrated SFP slots.

4.1 Overview of fiber-based network video system

Figure 5 shows an example of a video surveillance system where a fiber-optic cable connects the sending side with the receiving side.

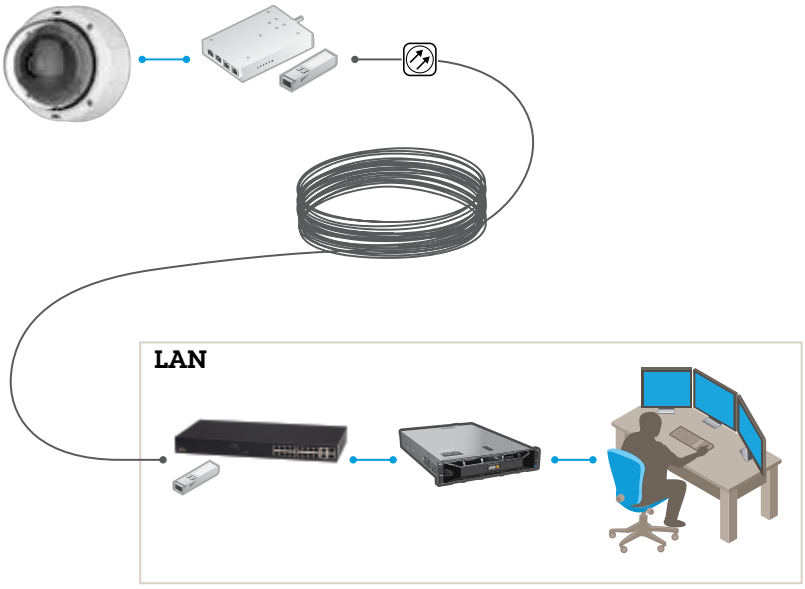

Figure 5. A network video system with a fiber-optic cable between the sending side (at the top) and the receiving side (at the bottom).

4.1.1 Sending side

On the sending side of the system is a network camera (in this case AXIS Q3615-VE Network Camera) which provides video data to be transmitted. The camera is connected to a media converter switch (AXIS T8604 Media Converter Switch), which has an SFP slot. An Axis SFP module (AXIS T8612 SFP Module LC.SX) is inserted into the slot, converting the electrical data signal from the camera into a light signal.

4.1.2 Fiber-optic cable

Because of its special light-propagating characteristics, the fiber-optic cable can carry the signal over a long distance without any considerable reduction of the light intensity.

4.1.3 Receiving side

At the other end of the fiber-optic cable is another Axis SFP module, which converts the light signal back to an electrical signal. The SFP module sits in the SFP slot of an Axis network switch (AXIS T8516 PoE+ Network Switch) that connects the signal to an Axis video recorder (storage unit), and the local server at the control center.

4.2 The components that enable a fiber-based network video system

Axis offers a wide range of products to enable the use of fiber-optic cables. The transmission distance you can achieve with fiber-optic cables will vary depending on which type of SFP module, which type of fiber-optic cable, and which LAN devices you use.

4.2.1 SFP modules

An SFP module (as can be seen in Figure 6) is a transceiver, meaning that it is a transmitter and a receiver combined into one module. Also functioning as a cable adapter, the SFP module is the key component in connecting fiber-optic cables with twisted-pair copper cables. The SFP module is inserted in the SFP slot of a network camera, a media converter switch, a network switch, or a video encoder.

Figure 6. AXIS T8612 SFP Module LC.SX

Axis SFP modules support duplex transmission, which means that they are optimal for simultaneous, bidirectional data transfer. Axis offers SFP modules for both multimode and single-mode fiber-optic cables. Different SFP modules carry different bandwidths, from 100 Mbit/s up to 10 Gbit/s. Axis recommends 1 Gbit/s for most applications.

The form factor and electrical interface of the SFP modules are not standardized by any official standards body, but rather are specified by a multi-source agreement (MSA) between different manufacturers. You should choose modules according to manufacturers' recommendations. The Axis products that support fiber-optic connections are equipped with corresponding SFP slots, supporting the SFP modules that comply with the MSA.

4.2.2 Media converters

A media converter, such as AXIS T8604 Media Converter Switch (see Figure 7), can be used to connect any Axis network video camera to a fiber-optic cable. The media converter has slots for twisted-pair copper cabling from the camera and slots for SFP modules for the fiber-optic connection. Several cameras, with one media converter each, can be connected in a bus setup (daisy-chain network) to one network switch.

Figure 7. AXIS T8604 Media Converter Switch

4.2.3 Network cameras

Any Axis network video camera can be connected to a fiber-optic cable using a media converter switch with an SFP slot. Even analog cameras can be directly connected to a fiber-optic cable, using AXIS Q7424-R Video Encoder. Axis also offers network cameras with integrated SFP slots, which means that no media converter is needed. One example is AXIS Q1659 Network Camera (see Figure 8).

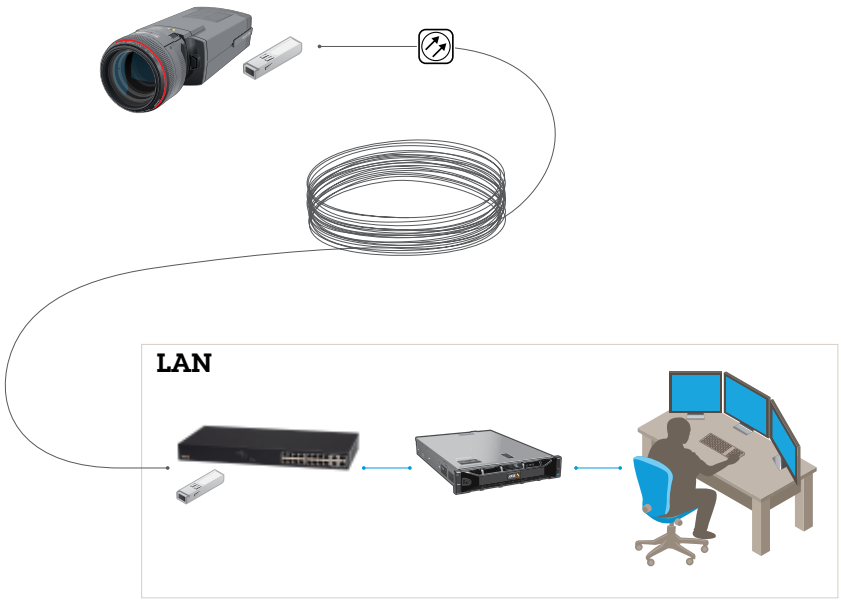

Figure 8. A network video system using AXIS Q1659 Network Camera and an SFP module on the sending side. No media converter switch is needed since the camera has an integrated SFP slot.

4.2.4 Video encoders

AXIS Q7424-R Video Encoder has an SFP slot, which means that it can be used to encode your far-distant analog cameras directly over fiber-optic cables.

4.2.5 Network switches

AXIS T8516 PoE+ Network Switch connects your network-based devices for overview and management of your surveillance system. SFP slots enable the use of fiber-optic cables with the switch.

4.2.6 Fiber-optic cables

Different kinds of fiber-optic cables are suitable for different distances and data rates. Fiber-optic cables are often color coded, indicating multi-mode or single-mode as well as other characteristics.

5. Conclusion

Fiber-optic communication is a technique that can be used to transmit data streams, encoded as light signals traveling through thin strands of glass or plastic. At long transmission distances, fiber-optic cables are a cost-efficient complement to twisted-pair copper cables. Axis offers a range of products that enable fiber-based network video, and the SFP module is a key component.

6. Acronyms and abbreviations

EMI	Electromagnetic interference
LAN	Local area network
LC	Lucent connector
LED	Light-emitting diode
MSA	Multi-source agreement
PTZ	Pan, tilt, and zoom
SFP	Small form-factor pluggable

7. Useful links

Axis Communications – 'Fiber-optic cables':
www.axis.com/technologies/fiber-optics

70469/EN/R1/1704

About Axis Communications

Axis offers intelligent security solutions that enable a smarter, safer world. As the market leader in network video, Axis is driving the industry by continually launching innovative network products based on an open platform - delivering high value to customers through a global partner network. Axis has long-term relationships with partners and provides them with knowledge and ground-breaking network products in existing and new markets.

Axis has more than 2,600 dedicated employees in more than 50 countries around the world, supported by a global network of over 90,000 partners. Founded in 1984, Axis is a Sweden-based company listed on NASDAQ Stockholm under the ticker AXIS.

For more information about Axis, please visit our website www.axis.com.

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