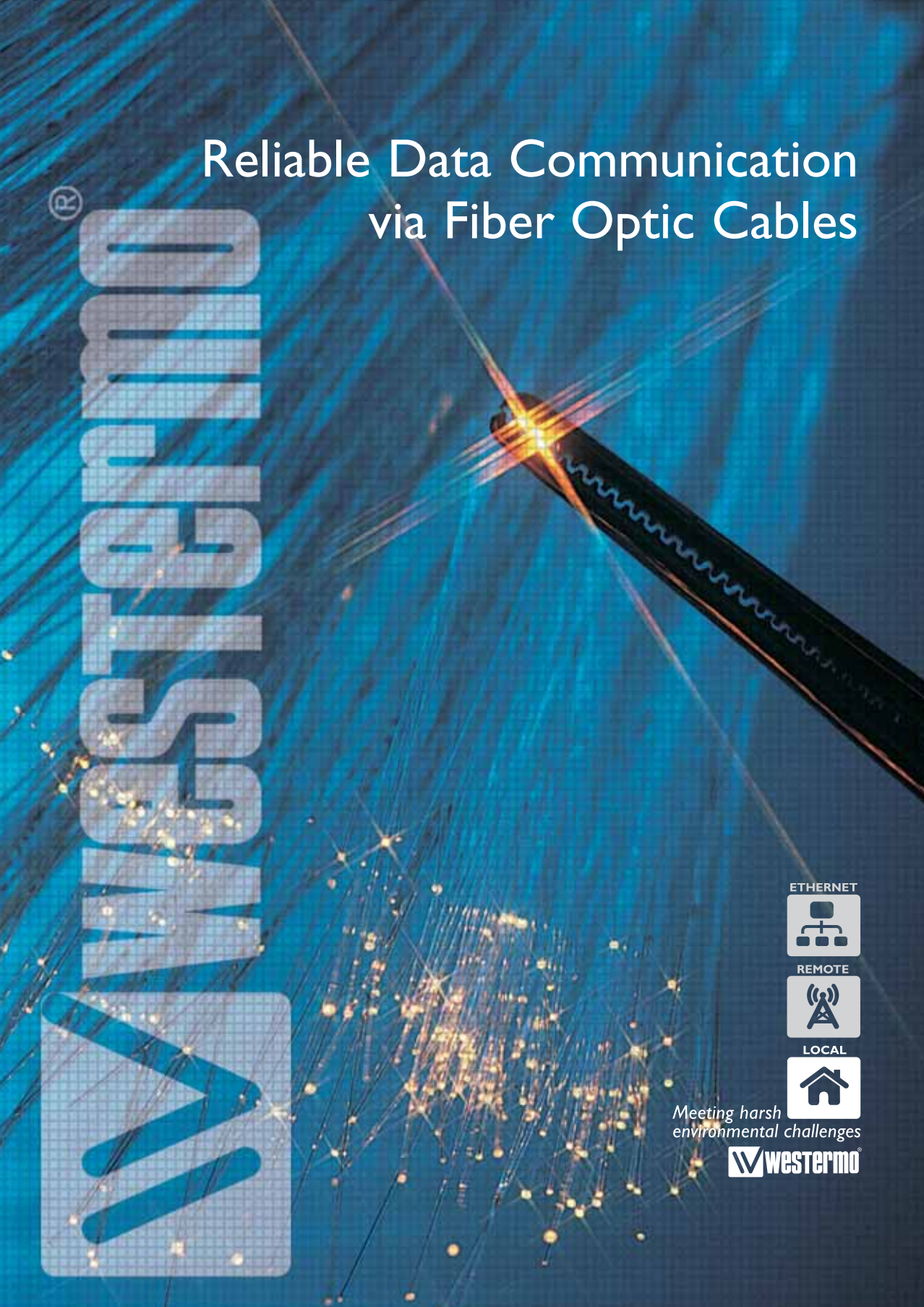
Reliable Data Communication via Fiber Optic Cables



Fiber Optic Communications

Fiber optics (optical fibres) are long, thin strands of very pure glass about the diameter of a human hair. They carry much more information than conventional copper wire and one of the advantages of fiber cable is that it is completely insensitive to electromagnetic interference (EMI). It is therefore ideal for installations in harsh industrial environments. It provides reliable transmission and high data transfer capacity over long distances. For example, almost all telephone long-distance lines (cross country) are fiber optic cables.

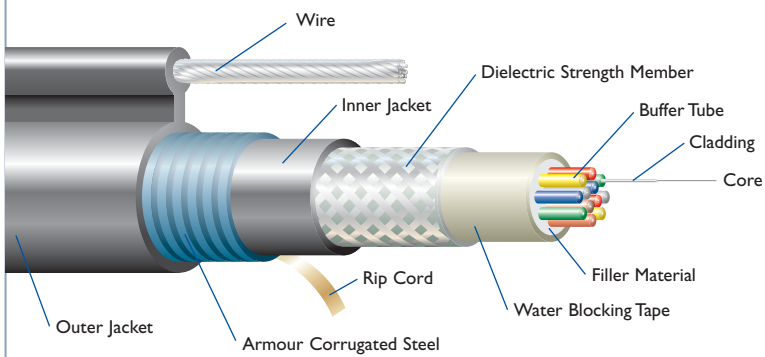
Advantages with Fiber Optic Cables vs. copper wire

- **Speed:** Operates at high data-rates – up into the gigabits.
- **Bandwidth:** Large data carrying capacity.
- **Distance:** Longer ranges without needing to be amplified or boosted.
- **Immunity:** Insensitive to electromagnetic interference (EMI).

Fiber cables

There are a lot of different fiber optic cable types available on the market to meet different installation requirements. Internal grade cable is constructed to be flexible and lightweight and it may be coated to meet fire protection codes. External grade cable is constructed to withstand immersion in water, exposure to ultraviolet rays and attack by rodents and birds.

Fiber optic cable is constructed in several layers. The actual glass fiber consists of a central glass core that is surrounded by a layer called cladding of a different refractive index. This causes the light to travel in a controlled path along the entire length of the glass core. The glass fiber can be placed in a "tight" or "loose" buffer tube array, which is a protective covering that protects the fiber from sustaining damage. It also prevents light from escaping the assembly, and
is often color-coded for identification purposes. This allows for the neces sary management of fibers due to the normally high counts contained within a cable. Tight-buffered cable is generally used in horizontal interior installations. The loose buffer tube array allows the glass fibre to "float" with considerable movement. As the fiber cable is installed (in conduit, directly buried, or placed on a pole) the glass fibers are not subjected to the forces of the pulling tension and therefore sustain minimal damage or distortion from stretching.

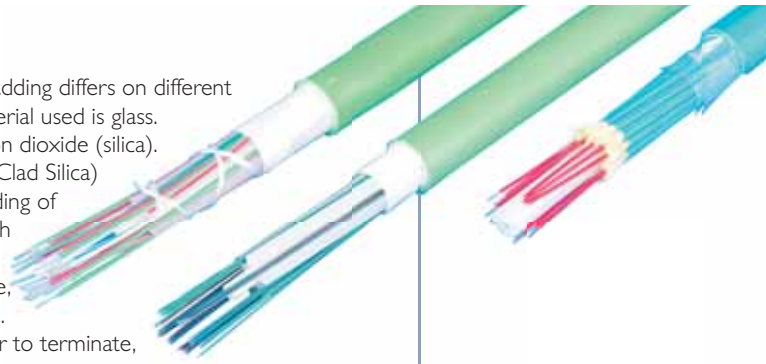


Example of a fiber optic cable

Produced by:
Westermo Teleindustri AB
Photo:
Studio Roland AB
Eskilstuna, Sweden
Fotosearch Stock Photography
Future Images Bank
Tele & Datanät AB
Örebro, Sweden
BildN
Västerås, Sweden
Illustrations:
Visual Information Sweden AB
Eskilstuna, Sweden
Printed by:
Eskilstuna Offset AB
Sweden 2007
Specifications are subject to change without notice due to continuous product develop ment and improvement.

Material

The material used for the core and cladding differs on different types of fiber. The most common material used is glass. The glass used is extremely pure, silicon dioxide (silica). Other types of cable are PCS (Plastic Clad Silica) with a core of glass and an outer cladding of plastic, or a plastic fiber cable with both the core and outer cladding of plastic. Glass cable gives the best performance, but is more complicated to terminate. Plastic fiber on the other hand is easier to terminate, but offers very short transmission distances.

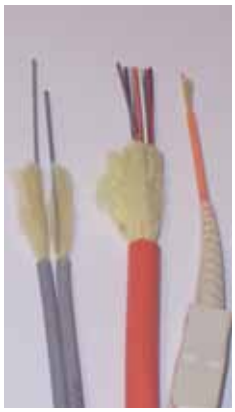


Type of Fibre Optic Cable

There are three types of fibre optic cables:

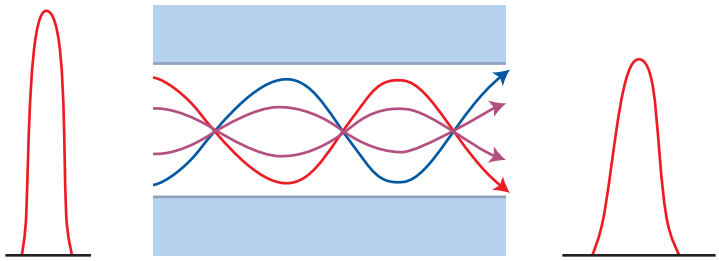
- Plastic fibers have a large core (0.04 inches or 1 mm diameter) and transmit visible red light (wavelength = 650 nm) from LEDs.

  Distances up to 20–50 meters (65.6 – 164.0 ft). (Not possible to use with the ODW-series).
- Multimode fibers have cores about 2.5×10^{-3} inches or 62.5 microns in diameter and transmit infrared light (wave length = 850 to 1300 nm) from light emitting diodes (LEDs). Distances up to 5 km (3.1 mi) are possible.
- Singlemode fibers have small cores (about 3.5×10^{-4} inches or 9 microns in diameter) and transmit infrared laser light (wavelength = 1300 to 1550 nanometers). Distances up to 80 km (50 mi) are possible with the ODW-series.



Multimode

A multimode cable has a relatively large diameter core (50 to 400 microns where 62.5 is the most common one) and a total diameter of 125 microns. Multimode cables are available in two categories; these are graded index and step index. In a step index fiber, as modes reflect through the cable, some have to travel further than others and in doing so the light pulse will spread. This is one disadvantage, which means the fiber has a lower bandwidth. The solution to this problem is graded index. In these cables the refractive index reduces gradually from the core's centre towards the cladding. This means that a light beam travelling mainly in the center of the cable. This means higher bandwidth and lower attenuation.



Transmitted light pulse

Light paths in multimode graded index fiber

Received light pulse

Singlemode

A singlemode cable has a small core (3 to 10 microns where 9 microns is the most common) that forces the light to follow a more linear single path down the cable, as opposed to the multipath reflections of multimode cables. The singlemode cable has the highest bandwidths and distance ratings.

Transmitted light pulse

Light path in singlemode fiber

Received light pulse

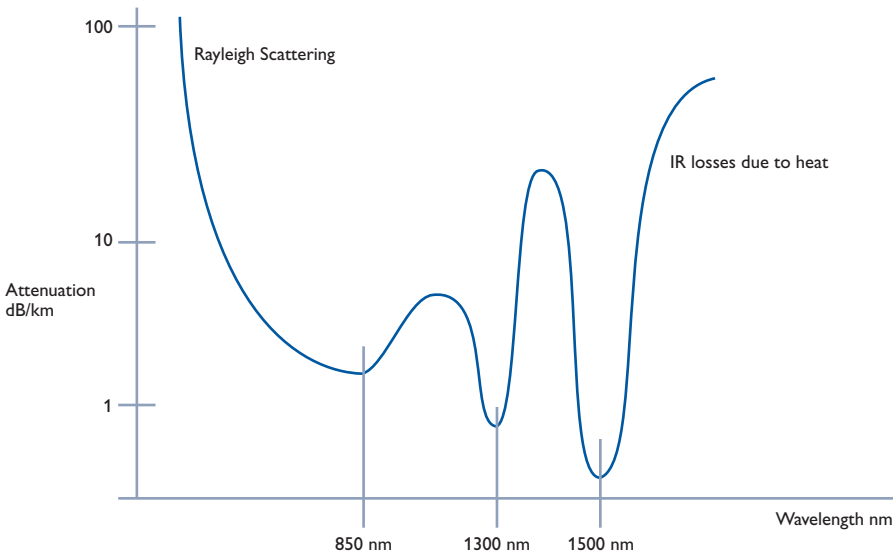
Attenuation / Wavelength

The attenuation in the cable depends on several parameters where wavelength, material and pureness are three important factors.

The attenuation is measured in dB/km and can vary from 0.4 (singlemode) up to 1000 dB/km (plastic).

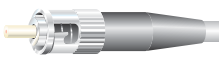
The common wavelength is 650 nm on plastic, 820 – 1300 nm on multimode and 1300 – 1550 nm on singlemode cables.

Light Attenuation in Glass Fiber at different wavelengths

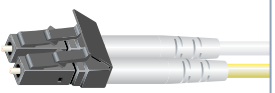


Summary of fiber types

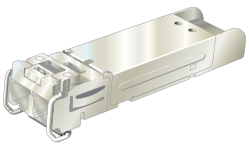
Material	Type	Core/Outer casing	Attenuation (dB/km)	Field of application
Plastic	Multimode Step index	200–600 / 450– 1000 µm	330-1000	Very short distances
Glass (silicon) core plastic	Multimode Step index	200–600/350–900 µm	4-15	Short distances
Glass	Multimode Step index	50–400/125–440 µm	4-15	Short distances
Glass	Multimode Graded index	30–100/100–140 µm	2-10	Medium distances
Glass	Singlemode	3–10/50–125 µm	0,4-5	Long distances



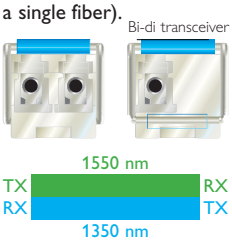
ST-Connector
Simplex connector used for single- or multimode cables on LR-01 and LR-11.



LC-Connector
Duplex connector used for single- or multimode cables on the ODW-series.



LC-Transceiver
The transceiver used in the ODW-series is an SFP-transceiver (Small Form-Factor Pluggable), which offers a flexible configuration. Its also available as a Bi-directional transceiver (full duplex on a single fiber).



Bi-directional transceivers offer the possibility of full duplex communication on a single fiber using different wavelength.

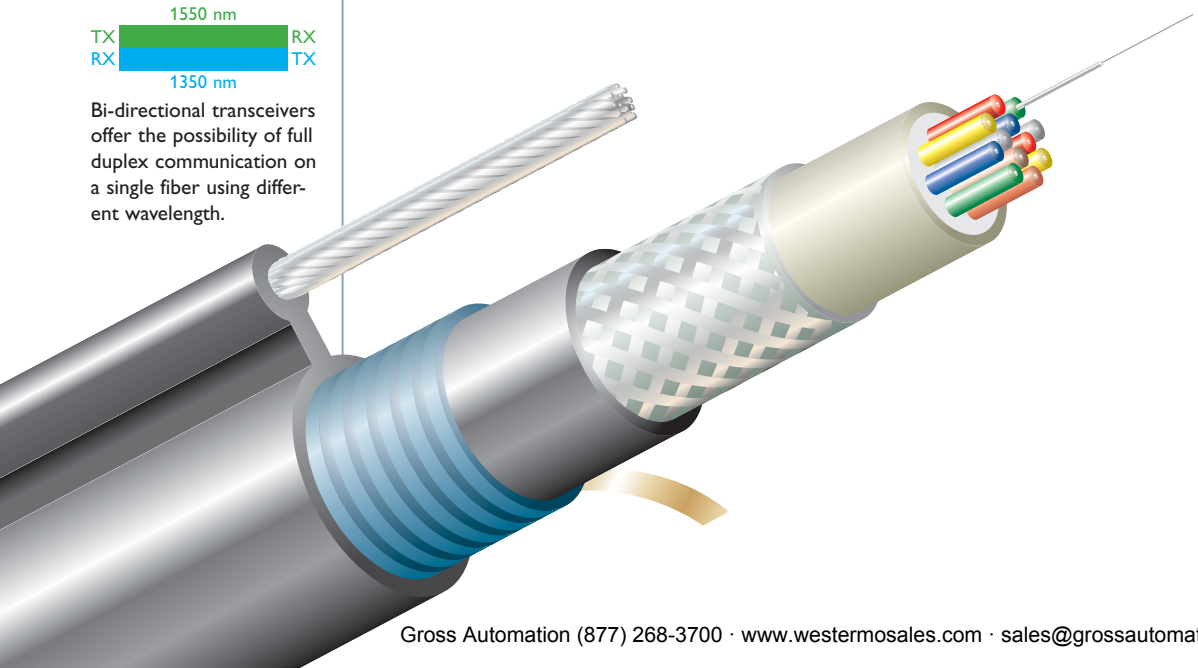
Transceivers and Connectors

Fiber optic transceivers usually include both a transmitter and a receiver in the same component. These are arranged in parallel so that they can operate independently of each other. Both the receiver and the transmitter have their own circuitry so that they can handle transmissions in both directions.

The ODW-series has LC-connectors and the LR-series has ST-connectors.

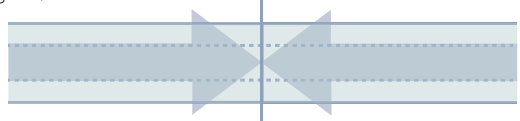
Termination / Patch Panels

There are many different ways to terminate fiber cables. One simple procedure called "crimp and cleave" is to crimp the connector on to the fiber (this requires special pliers) and then cleave the fiber very carefully. Another more reliable procedure is to use an epoxy to bond the fiber into the connector; connectors are available with the adhesive already in the connector. The connector is then heated with the help of a special oven for around 1 minute; the fiber is inserted in the connector and is then allowed to cool. These two terminating methods both require equipment to prepare the fiber before mounting the connector and to polish the fiber after the cable is terminated. In systems where connection points are frequently changed the epoxy bonded connectors may be beneficial, as this gives a more durable termination. In larger systems a patch panel is often used at the center of the installation. From the patch panel a short patch cable is used to connect to the fiber optic equipment. The patch cable can for example be terminated with an ST-connector at one end and an LC-connector



Light loss in splices and connectors

Connector and splice loss is caused by a number of factors. Loss is minimised when the two fiber cores are identical and perfectly aligned, the connectors or splices are properly finished and no dirt is present.



Only the light that is coupled into the receiving fiber's core will propagate, all the rest of the light effectively becomes the connector or splice loss.

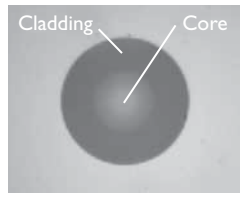
Typical splice loss and connector loss values are:

Mechanical:	0.2 dB
Fusion:	0.1 dB
Connector:	0.2 – 0.4 dB

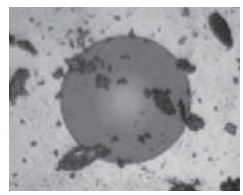
The end finish of the fiber must be properly polished to minimise loss. A rough surface will scatter light and dirt can scatter and absorb light. Since the optical fiber is so small, typical airborne dirt can be a major source of loss.

The pictures show a multimode cable 200x magnification where the upper picture is clean, the one in the middle has dust particles and the one below is contaminated with liquid.

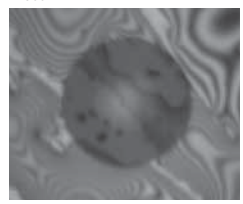
Whenever connectors are not terminated, they should be covered to protect the end of the ferrule from dirt. One should never touch the end of the ferrule, since the oils on one's skin causes the fiber to attract dirt. Before connection and testing, it is advisable to clean connectors with lint free wipes moistened with isopropyl alcohol.



Clean



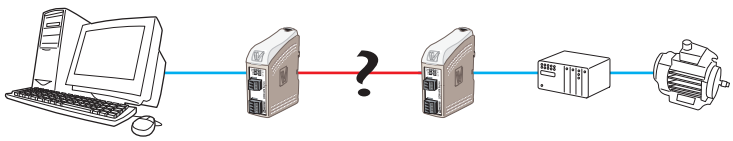
Dust



Liquid

Calculate Transmission Distances

The communication range of a system is dependent on the transmission output, the sensitivity of the receiver and the loss that arises in terminations and cable splices. In order to calculate this range a fiber budget is stated, which is the difference between the transmitter output power and receiver sensitivity, both these values have a typical value and a minimum level. We have chosen to document both these values. We do this because there can be large variations in the manufacturers' specifications; this applies mainly to singlemode fibre.



Example:

There is an installation to be made between two sites with a distance of 4 km (2.5 mi).
What type of cable is necessary to be used, multimode or singlemode?

A typical attenuation value on a 62.5/125 multimode cable is approx. 1.5 dB/km (1310 nm).

The worst-case optical power budget on MM-LC2 is 11 dB (see table on page 19). There are no splices or patch cables so there is only need to consider the loss in both connectors (approx. 0.3 dB in each).

The calculation would be as follows:

Optical power budget in LC2 system 11dB
Loss in connectors 0.3 dB x 2 =0.6 dB
Attenuation in cable 1.5 dB/km
Transmission distance 11 dB – 0.6 dB =10.4 dB / 1.5 dB = 6.9 km (4.2 mi).

This indicates it is possible to use a multimode cable in this installation.

Note: In multimode systems the bandwidth also needs to be considered in some cases.
The maximum transmission range is reduced at very high data-rates. The transceivers we use are classed LC-2 (2 km 1.2 mi) however this is only relevant at gigabit speeds. With the modulation we use in our fibre optic modems (ODW) this bandwidth limitation is not an issue.

The ODW-series:

The natural choice for Reliable Fibre Optic Applications in Harsh Environments

The ODW-series are our new industrial designed fiber optic modems. The ODW-series offers better performance then our previous fiber optic modems.

- Higher data rates
- Longer distances
- Extended Temperature range
- Flexible Fiber Transceiver configuration
- Bi-Directional Fiber Optic Transceivers
  (Full duplex on a single fibre, max range 60 km 37 mi)
- Redundant Power Supply
- Re-Timing and data synchronisation virtually no limit to units in a multidrop or ring application*

All these features together with the advantages of using fiber optic cable such as: total immunity towards electrical interference makes the ODW-series the perfect data communication solution in extreme harsh environments.

* Based on a maximum ring transit time of 10 ms (2000 km 1243 mi) – some protocols may require faster response times – please check with Westermo for larger applications.

- Automatic data rate detection and re-timing
- All PROFIBUS DP data rates up to 12 Mbit/s
- 9-position D-sub PROFIBUS DP connection
- Redundant power supply inputs
- Status interface for fault indication
- Fiber link fault indication (Red)
- Design for harsh environments
- –40 to +158°F operating temperature

ODW-611

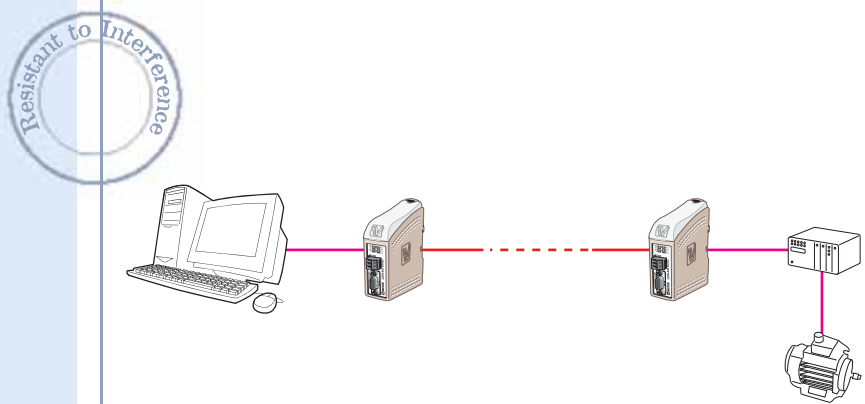
PROFIBUS DP
Point-to-point applications

The ODW-611 is a fiber optic modem designed for point-to-point fiber optic connections between PROFIBUS DP networks. The ODW-611 is designed for harsh industrial usage as well as road or railway installations meeting industrial level EMC specifications and having a wide operating temperature range.

The maximum distance of the fiber link depends on selected transceiver and fiber type. Fiber distances up to 80 km (50 miles) are possible using singlemode fiber.

The ODW-611 is able to automatically detect the data rate of the connected PROFIBUS DP network and hence needs minimal configuration prior to use. The unit also has a re-timing function that eliminates the problem of jitter and hence ensures reliable communications in all situations.

The ODW-611 can also be used in start/end points in a multidrop application together with ODW-612.



ODW-612

PROFIBUS DP

Redundant ring or multidrop applications

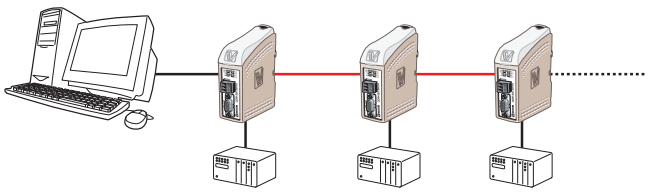
The ODW-612 is a fiber optic modem that can be used to create either redundant ring or multidrop fiber optic solutions for devices with PROFIBUS DP interfaces.

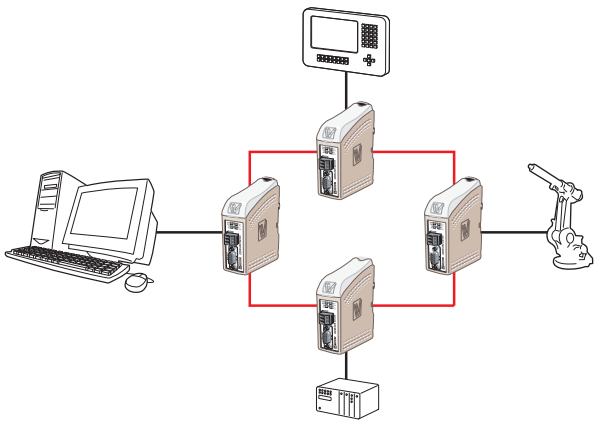
The ODW-612 is designed for harsh industrial usage as well as road or railway installations meeting industrial level EMC specifications and having a wide operating temperature range.

The maximum distance of a fiber link depends on selected transceiver and fiber type. Fiber distances up to 80 km (50 miles) are possible on each leg of the ring meaning huge rings over 1000 km (621.4 miles) in circumference could be created.

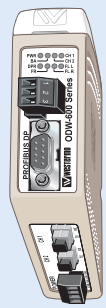
The ODW-612 is able to automatically detect the data rate of the connected PROFIBUS DP device and hence needs minimal configuration prior to use. The unit also has a re-timing function that eliminates the problem of jitter and hence ensures reliable communications in all situations.

The unit has LED indication to display fault conditions as well as relay contacts that can be connected to a PLC or similar device to allow network problems to be diagnosed at a central point. It is possible to use the ODW-611 at start/end points in a multidrop application together with ODW-612.





- Automatic data rate detection and re-timing
- All PROFIBUS DP data rates up to 12 Mbit/s
- 9-position D-sub PROFIBUS DP connection
- Redundant power supply input
- Status interface for fault indication
- Fiber link fault indication (Red)
- Design for harsh environments
- –40 to +140°F operating temperature



- Re-timing
- Data rate up to 250 kbit/s
- 9-position D-sub connector
- Redundant power supply inputs
- Status interface for fault indication
- Fiber link fault indication (Red)
- Design for harsh environments
- –40 to +158°F operating temperature

ODW-621

RS-232
Point-to-point applications

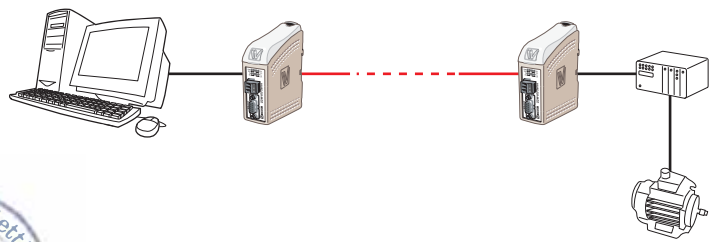
The ODW-621 is designed for point-to-point applications between devices with an RS-232 interface. The ODW-621 is designed for harsh industrial usage as well as road or railway installations meeting industrial level EMC specifications and having a wide operating temperature range.

The maximum distance of the fibre link depends on selected transceiver and fiber type. Fibre distances up to 80 km (50 miles) are possible using singlemode fiber.

The unit also has a re-timing function that eliminates the problem of jitter and hence ensures reliable communications in all situations.

It is possible to use the ODW-621 in conjunction with the ODW-631 to provide protocol conversion from RS-232 to RS-422/485 at either end of the optical link.

The ODW-621 can also be used in start/end points in a multidrop application together with ODW-632 / 622.



DIP-switch Settings

ODW-622

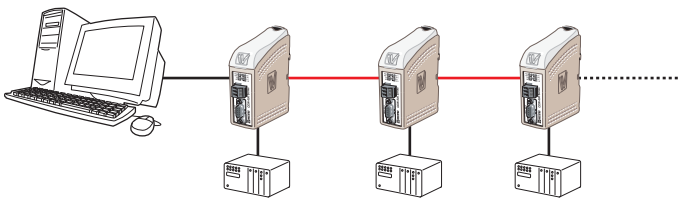
RS-232
Redundant ring or multidrop applications

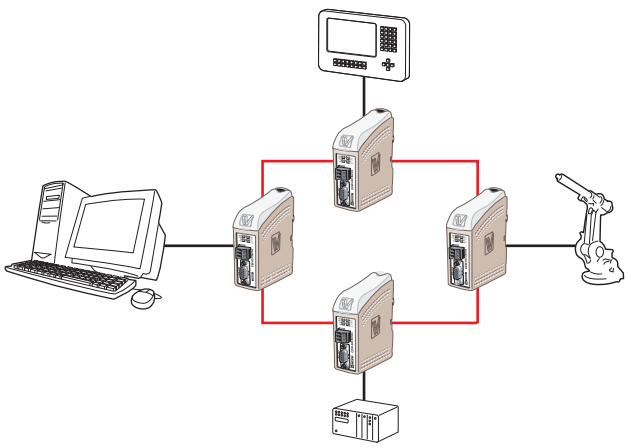
The ODW-622 can be used to create either redundant ring or multidrop solutions for devices with RS-232 interfaces. The ODW-622 is designed for harsh industrial usage as well as road or railway installations meeting industrial level EMC specifications and having a wide operating temperature range.

The maximum distance of a fiber link depends on selected transceiver and fiber type. Fiber distances up to 80 km (50 miles) are possible on each leg of the ring meaning huge rings over 1000 km (621.4 miles) in circumference could be created.

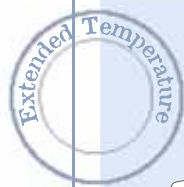
The unit also has a re-timing function that eliminates the problem of jitter and hence ensures reliable communications in all situations. The unit has LED indication to display fault conditions as well as relay contacts that can be connected to a PLC or similar device to allow network problems to be diagnosed at a central point.

It is possible to mix ODW-622 with ODW-632 in a network and hence have both RS-232 and RS-422/485 devices in the same network. It is possible to use the ODW-621 or ODW-631 at start/end points in a multidrop application together with ODW-622.





- Re-timing
- Data rate up to 250 kbit/s
- 9-position D-sub connector
- Redundant power supply input
- Status interface for fault indication
- Fiber link fault indication (Red)
- Design for harsh environments
- –40 to +140°F operating temperature



- Re-timing
- Data rate up to 1.5 Mbit/s
- 4-position screw terminal connector
- Switch selectable failsafe/termination
- 2- and 4- wire applications
- Redundant power supply inputs
- Status interface for fault indication
- Fiber link fault indication (Red)
- Design for harsh environments
- –40 to +158°F operating temperature

ODW-631

RS-422/485
Point-to-point applications

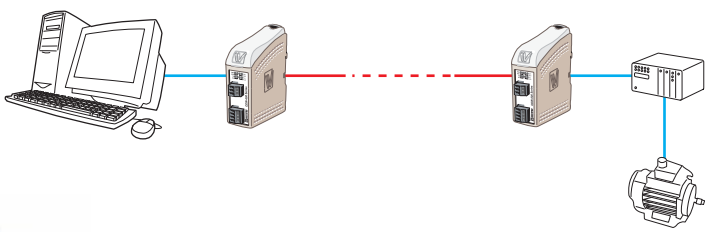
The ODW-631 is designed for point-to-point connections between RS-422/485 networks or devices. The ODW-631 is designed for harsh industrial usage as well as road or railway installations meeting industrial level EMC specifications and having a wide operating temperature range.

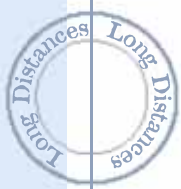
The maximum distance of the fibre link depends on selected transceiver and fibre type. Fibre distances up to 80 km (50 miles) are possible using singlemode fibre.

The unit also has a re-timing function that eliminates the problem of jitter and hence ensures reliable communications in all situations.

It is possible to use the ODW-631 in conjunction with the ODW-621 to provide protocol conversion from RS-232 to RS-422/485 as well as the fibre optic link.

The ODW-631 can also be used in start/end points in a multidrop application together with ODW-632 / 622.





ODW-632

RS-422/485
Redundant ring or multidrop applications

The ODW-632 can be used to create either redundant ring or multidrop solutions for devices with RS-422/485 interfaces.

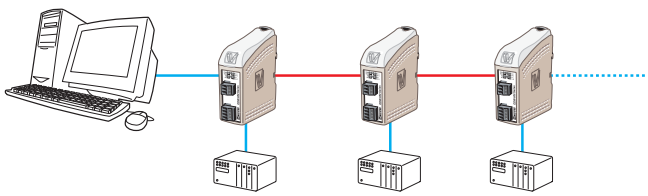
The ODW-632 is designed for harsh industrial usage as well as road or railway installations meeting industrial level EMC specifications and having a wide operating temperature range.

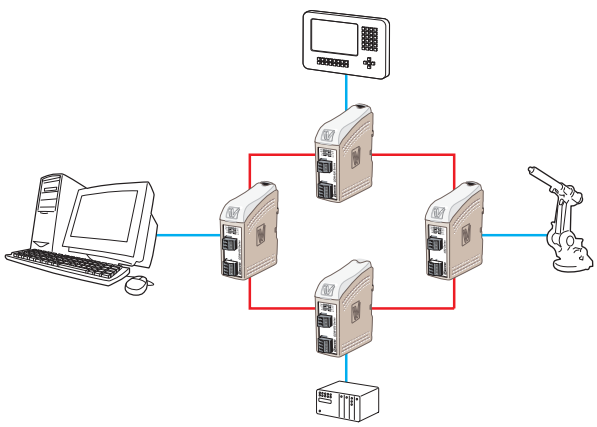
The maximum distance of a fibre link depends on selected transceiver and fibre type. Fiber distances up to 80 km (50 miles) are possible on each leg of the ring meaning huge rings over 1000 km (621.4 miles) in circumference could be created.

The unit also has a re-timing function that eliminates the problem of jitter and hence ensures reliable communications in all situations. The unit has LED indication to display fault conditions as well as relay contacts that can be connected to a PLC or similar device to allow network failures to be diagnosed at a central point.

It is possible to mix ODW-632 with ODW-622 in a network and hence have both RS-232 and RS-422/485 devices in the same network. It is possible to use the ODW-631 or ODW-621 at start/end points in a multidrop application together with ODW-632.

- Re-timing
- Data rate up to 1.5 Mbit/s
- 4-position screw terminal connector
- 2- or 4- wire applications
- Switch selectable termination or failsafe
- Redundant power supply input
- Status interface for fault indication
- Fiber link fault indication (Red)
- Design for harsh environments
- –40 to +158°F operating temperature





ODW-Series

Technical data

Power	
Rated voltage	12 to 48 VDC 24 VAC
Operating voltage	10 to 60 VDC 20 to 30 VAC*
Rated current	**ODW-611/621/631** 300 mA @ 12 VDC 150 mA @ 24 VDC 75 mA @ 48 VDC
	ODW-612/622/632 400 mA @ 12 VDC 200 mA @ 24 VDC 100 mA @ 48 VDC
Rated frequency	DC: 0 Hz AC: 48 to 62 Hz
Inrush current I^2t	0.2 A^2s
Startup current**	1.0 A_{peak}
Polarity	Polarity independent
Redundant power input	Yes
Isolation to	Serial port and Status port
Connection	Detachable screw terminal
Connector size	0.2 – 2.5 mm^2 (AWG 24-12)
Shielded cable	Not required

* Not available on ODW-611/612 ** External supply current capability for proper startup

Status	
Port type	Signal relay, changeover contacts
Rated voltage	Up to 48 VDC
Operating voltage	Up to 60 VDC
Contact rating	500 mA @ 48 VDC
Contact resistance	< 50 mΩ
Isolation to	Serial port and Power port
Connection	Detachable screw terminal
Connector size	0.2 – 2.5 mm^2 (AWG 24 – 12)
Shielded cable	Not required

LC-connectors SFP (Small Form-Factor Pluggable)			
LC-2 Multimode	up to 5 km (3.1 mi)	LC-40 Singlemode	up to 40 km (25 mi)
LC-15 Singlemode	up to 15 km (9.3 mi)	LC-80 Singlemode	up to 80 km (50 mi)

RS-232	
Electrical specification	EIA RS-232
Data rate	300 bit/s – 250 kbit/s
Data format	9 – 12 bits (Protocol dependent mode) Arbitrary (Transparent mode)
Protocol	Start-bit followed by 8 – 11 bits (Protocol dependent mode) Arbitrary (Transparent mode)
Re-timing	Yes (Protocol dependent mode)
Deviation, Input data rate	Byte: 4%; Bit 49% (Protocol dependent mode)
Transmission range	15 m
Isolation to	Status and Power port
Connection	9-pin D-sub female (DCE)
Shielded cable	Not required, except when installed in railway applications as signalling and telecommunications apparatus and located close to rails*
Conductive housing	Isolated to all other circuits and housings

* To minimise the risk of interference, a shielded cable is recommended when the cable is located inside 3 m boundary to the rails and connected to this port.
The cable shield should be properly connected (360°) to an earthing point within 1 m from this port.
This earthing point should have a low impedance connection to the conductive enclosure of the apparatus cabinet, or similar, where the unit is built-in. This conductive enclosure should be connected to the earthing system of an installation and may be directly connected to the protective earth.

RS-422/485	
Electrical specification	EIA RS-485, 2-wire (PROFIBUS DP) or EIA RS-422, 4-wire twisted pair
Data rate	300 bit/s – 1.5 Mbit/s, RS-422/485 9 600 kbit/s – 12 Mbit/s, PROFIBUS DP
Data format	9 – 12 bits (Protocol dependent mode) Arbitrary (Transparent mode)
Protocol	Start-bit followed by 8 – 11 bits (Protocol dependent mode) Arbitrary (Transparent mode), RS-422/485 PROFIBUS DP (RS-485)
Re-timing	Yes (Protocol dependent mode, RS-422/485)
Deviation, Input data rate	Byte: 4%; Bit 49% (Protocol dependent mode)
Turning time (2-wire RS-485)	One t_{bit} t_{bit} = 1 / Baud rate (Baud rate in bit/s) In accordance with EN 50 170, PROFIBUS DP
Transmission range	< 1200 m, depending on data rate and cable type (EIA RS-485)
Settings	120 Ω termination and failsafe biasing 680 Ω, RS-422/485 None, external termination and failsafe biasing, PROFIBUS DP
Protection	Installation Fault Tolerant (up to ±60 V)
Isolation to	Status and Power port
Connection	Detachable screw terminal, RS-422/485 9-pin D-sub female, PROFIBUS DP
Connector size	0.2 – 2.5 mm^2 (AWG 24 – 12)
Shielded cable	Not required

Type tests and environmental conditions for the ODW-series

Electromagnetic Compatibility			
Phenomena	**Test**	**Description**	**Level**
ESD	EN 61000-4-2	Enclosure contact	± 6 kV
		Enclosure air	± 8 kV
RF field AM modulated	IEC 61000-4-3	Enclosure	20 V/m 80% AM (1 kHz), 80 – 2000 MHz
RF field 900 MHz	ENV 50204	Enclosure	20 V/m pulse modulated 200 Hz, 900 ± 5 MHz
Fast transient	EN 61000-4-4	Signal ports	± 2 kV
		Power ports	± 2 kV
Surge	EN 61000-4-5	Signal ports unbalanced	± 2 kV line to earth, ± 2 kV line to line
		Signal ports balanced	± 2 kV line to earth, ± 1 kV line to line
		Power ports	± 2 kV line to earth, ± 2 kV line to line
RF conducted	EN 61000-4-6	Signal ports	10 V 80% AM (1 kHz), 0.15 – 80 MHz
		Power ports	10 V 80% AM (1 kHz), 0.15 – 80 MHz
Power frequency magnetic field	EN 61000-4-8	Enclosure	100 A/m, 50 Hz, 16.7 Hz & 0 Hz
Pulse Magnetic field	EN 61000-4-9	Enclosure	300 A/m, 6.4 / 16 µs pulse
Voltage dips and interruption	EN 61000-4-11	AC power ports	10 & 5 000 ms, interruption 10 & 500 ms, 30% reduction 100 & 1 000 ms, 60% reduction
Mains freq. 50 Hz	EN 61000-4-16	Signal ports	100 V 50 Hz line to earth
Mains freq. 50 Hz	SS 436 15 03	Signal ports	250 V 50 Hz line to line
Voltage dips and interruption	EN 61000-4-29	DC power ports	10 & 100 ms, interruption 10 ms, 30% reduction 10 ms, 60% reduction +20% above & –20% below rated voltage
Radiated emission	EN 55022	Enclosure	Class B
	FCC part 15		Class A
Conducted emission	EN 55022	AC power ports	Class B
	FCC part 15	AC power ports	Class A
	EN 55022	DC power ports	Class B
Dielectric strength	EN 60950	Signal port to all other isolated ports	2 kVrms 50 Hz 1min
		Power port to other isolated ports	3 kVrms 50 Hz 1min 2 kVrms 50 Hz 1min (@ rated power < 60V)
Environmental			
Temperature		Operating	–40 to +158°F
		Storage & Transport	–40 to +158°F
Humidity		Operating	5 to 95% relative humidity
		Storage & Transport	5 to 95% relative humidity
Altitude		Operating	6562 ft / 70 kPa
Service life		Operating	10 year
Vibration	IEC 60068-2-6	Operating	.3 in., 5 – 8 Hz 2 g, 8 – 500 Hz
Shock	IEC 60068-2-27	Operating	15 g, 11 ms
Packaging			
Enclosure	UL 94	PC / ABS	Flammability class V-1
Dimension W x H x D			1.4 x 4.8 x 4.7 in.
Weight			0.26 kg
Degree of protection			IP 21
Cooling	IEC 529	Enclosure	Convection
Mounting			Horizontal on 1.4 in. DIN-rail

Optical Power Budget for the ODW-series

The maximum supported link lengths as specified in table below should only been seen as indicative. The allowed link length is calculated from the Optical Power Budget (OPB), the available optical power for a fiber optic link, and the attenuation of the fiber, comprising losses due to in-line connectors, splices, optical switches and a margin for link aging (typical 1.5 dB for 1300 nm).

The worst-case Optical Power Budget (OPB) in dB for a fiber optic link is determined by the difference between the minimum transmitter output optical power and the lowest receiver sensitivity.

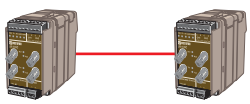
FX (Fiber)	SM-LC80	SM-LC40	SM-LC15	MM-LC2
Fiber connector	LC duplex	LC duplex	LC duplex	LC duplex
Fiber type	Singlemode 9/125 µm	Singlemode 9/125 µm	Singlemode 9/125 µm	Multimode, 62.5/125 and 50/125 µm
Wavelength	1550 nm	1310 nm	1310 nm	1310 nm
Transmitter Output optical power min/max	–5/0 dBm**	–5/0 dBm**	–15/–8 dBm**	–20/–14 dBm*
Receiver Input sensitivity, max	–34 dBm	–34 dBm	–31 dBm	–31 dBm
Receiver Input optical power, max	–5 dBm***	–3 dBm***	–8 dBm	–8 dBm
Optical power budget, worst-case	29 dB	29 dB	16 dB	11 dB
Bit error rate (BER)	< 1 x 10^{-10}	< 1 x 10^{-10}	< 1 x 10^{-10}	< 2.5 x 10^{-10}
Transceiver type	Small Form-Factor Pluggable (SFP) Multi-Sourcing Agreement (MSA) compliant			
Laser class	Class 1, IEC 825-1 Accessible Emission Limit (AEL)			

* Output power is power coupled into a 62.5/125 µm multimode fiber

** Output power is power coupled into a 9/125 µm singlemode fiber

*** The use of attenuation is recommended on short fibre lengths. 5dB (SM-LC80) and 3dB (SM-LC40)

Power budget for the LR-series



Minimum budget			
Fiber	**820 nm**		**Singlemode**
50/125	10.7 dB		
62,5/125	14.5 dB		
100/140	20.6 dB		
9/125			6.3 dB
Typical Budget			
50/125	16.6 dB		
62,5/125	18.6 dB		
100/140	25.9 dB		
9/125			12.3 dB

”Min. budget” states the minimum guaranteed power budget.
Experience shows however that the typical value is in the range of the indicated ”Typ. budget”.

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REV 2.0-2007-09