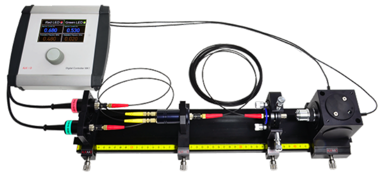
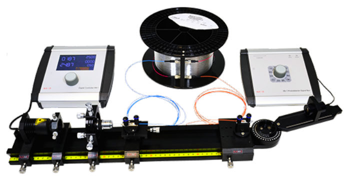
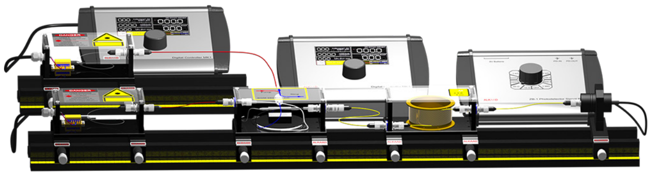
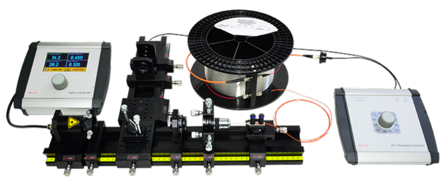
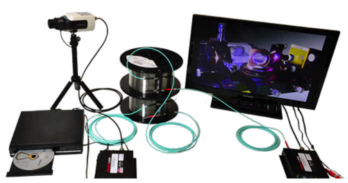
LT - Telecommunication



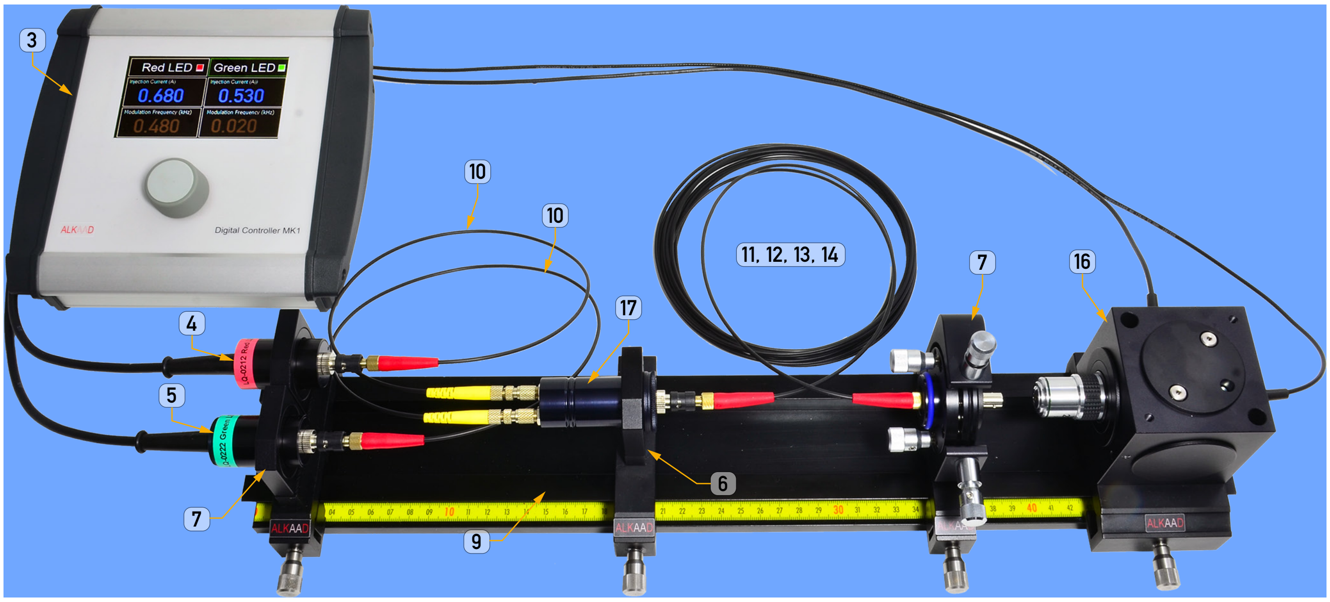








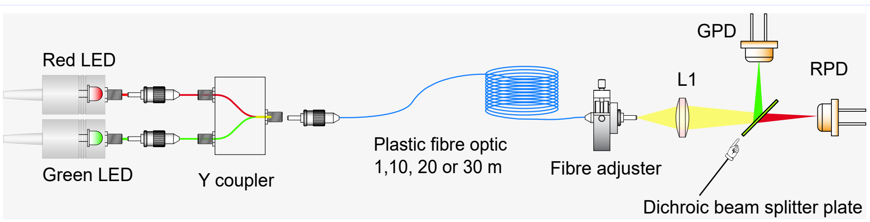
LT-0100 Plastic Optical Fibre (POF)



Plastic Fibre Handling
Dichroic Beam Splitter
Data Transmission
LED Transmitter
LED Modulation
Losses in Plastic Fibre
Si Photodetector Receiver
Fibre Y Coupler

A plastic fibre is an equivalent to optical multimode glass fibres. Whereas glass fibre are used for long distance and high speed data transmission, plastic fibres are commonly used for local area networks for data and signal transmission. Nowadays the transmission losses with 12 dB / 50 m of these fibres are significantly higher than those of the glass fibres. A lot of effort is undertaken to remove this disadvantage, since the manufacturing and installation costs of plastic fibres are comparably low. For signal transfer at short distances optical plastic fibre play an important role. Especially in harsh environments for example high voltage power stations, signal transfer via light and plastic fibre can be performed almost free of noise. The light transfer in all plastic fibres is achieved by using a plastic core which is coated with a material to obtain a step index profile. Typical diameters are 1 mm for the core which simplifies the coupling of light compared to glass fibres significantly. Also the preparation process, the cutting of the fibre can be done with a simple cutter blade instead of using special cleaving tools as it is the case for glass fibres.

The goal of this experimental system is to teach and train the handling with and the signal transmission via optical plastic fibre. As transmitter a green and red LED is used to demonstrate independent dual wavelength data transmission in a single fibre. The radiation of the LED is coupled by means of a Y coupler into the fibre. The light at the exit of the fibre passes a dichroic beam splitter plate which is coated in such a way that the green radiation will be totally reflected whereas the red radiation is transmitted. Two photo detectors convert the light signal into electrical signals which are amplified by the receiver module and can be displayed on a two channel oscilloscope for further investigation. The transmitter unit contains two independent drivers for both the LED as well as internal modulators.



The light of the fibre coupled red and the green fibre coupled LED is merged by an also fibre coupled Y coupler and is available at the fibre output jack. The power and modulation of each LED is independently controlled.

Appearing emission spectrum

By changing the individual power of the LED the merged light appears in a spectral range from green via yellow to red. After passing the plastic fibre optics the light is guided by means of the fibre adjuster to the lens L1, which focuses the light onto the photodetector GPD (green) and RPD (red). The dichroic beam splitter plate separates the green and red part of the incident light.

To measure the spectral absorption of the fibre different length of fibres are used. By combining the 10 m, 20 m and 30 m a variety of 10,20,30,40,50 and 60 m can be achieved.

LT-0100 POF - Plastic Fibre Optics consisting of:

Item	*Code*	*Qty.*	*Description*	*Details page*
1	CA-0450	2	BNC connection cable 1 m	130 (28)
2	CA-0610	1	Plastic fibre connector mounting set	130 (31)
3	DC-0030	1	Dual channel LED transmitter and receiver	121 (3)
4	LQ-0212	1	Red LED in C25 with fibre jack	119 (8)
5	LQ-0222	1	Green LED in C25 with fibre jack	120 (11)
6	MM-0020	1	Mounting plate C25 on carrier MG20	93 (1)
7	MM-0480	1	Four axes kinematic plastic fibre mount	97 (33)
8	MM-0560	1	Two mounting plates C25 on MG20	98 (39)
9	MP-0150	1	Optical Bench MG-65, 500 mm	93 (8)
10	OC-2500	2	Plastic optical fibre ST/FSMA, length 0.25 m	109 (101)
11	OC-2502	1	Plastic optical fibre ST/ST, length 1 m	109 (102)
12	OC-2510	1	Plastic optical fibre ST, length 10 m	109 (103)
13	OC-2520	1	Plastic optical fibre ST, length 20 m	109 (104)
14	OC-2530	1	Plastic optical fibre ST, length 30 m	110 (105)
15	OC-2590	2	ST-POF coupler	110 (106)
16	OM-0070	1	Dichroitic beam splitter unit on MG65	111 (9)
17	OM-0920	1	POF Y coupler in C25	117 (45)
18	UM-LT01	1	Manual Plastic Fibre Optics	

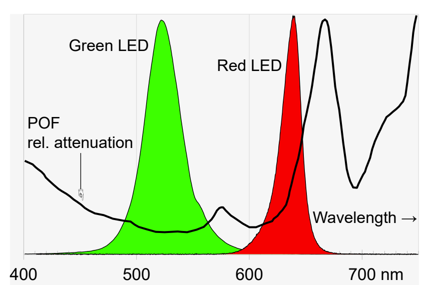


Fig. 3.1: Spectral emission of the LED and the relative POF attenuation

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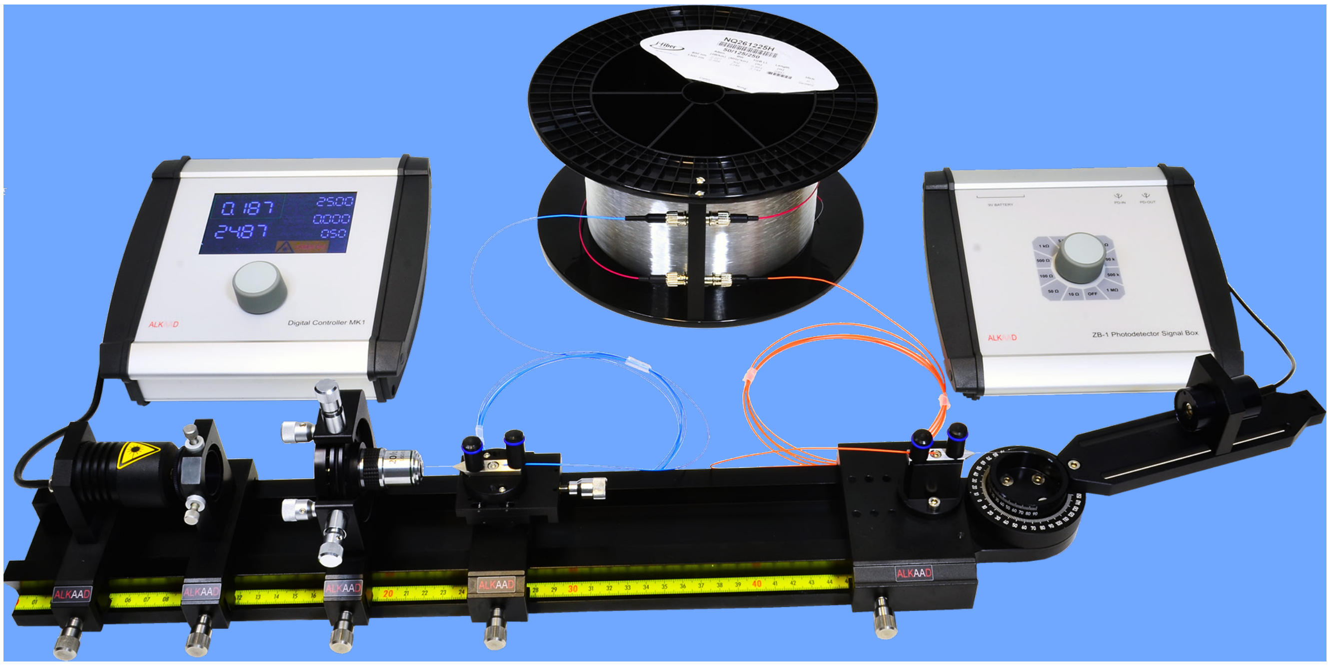
LT-0200 Glass Fibre Optics



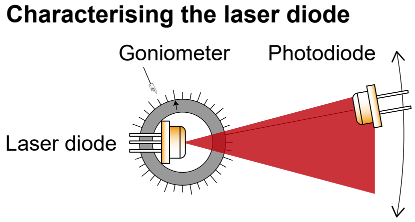
Introduction Keywords

Fibre stripping
Coupling Light to Fibre
Cut of wavelength
Fibre cleaving and cutting
Signal transfer
Speed of Light
Diode Laser Characterisation
Numerical Aperture of Fibre

The basic idea to use guided light for data communication was published in 1939 by H. Buchholz in his paper „Die Quasioptik der Ultrakurzwellenleiter“ (The quasi optical behaviour of ultra short wave guides). However it took more than 20 years to develop first realistic technical solutions mainly encouraged by the first available diode lasers in 1962. These new light sources are ideally suited as transmitter because of their ability to be modulated and in addition, as we know today, they can be produced in large numbers at low prices. Nowadays the world wide communication is based on fibre optics combined with laser diodes and the development in this area belongs to the most exciting ones in this century. In 1977 based on the experience and results rapid investigation in other fields than communications were initiated, leading for example in the development of fibre gyros for navigation purposes of air planes. In principle this new technology does not require a new understanding of the physics because the related phenomena are well known and can be considered as a combination of classical optics and lasers. However for the realisation a lot of technical problems had to been solved. In the fibres mainly used in communication the light is guided within a „glass tunnel“ with a diameter of 9 µm only. The necessary mechanical components as well the production process of the fibres itself were subject of comprehensive developments. Considerable efforts today are undertaken to reduce fibre transmission losses by using so called active fibres and in the realisation of integrated optical devices for distributing and receiving signals. The field of fibre optics is still expanding and of high common interest. Therefore this experiment is considered as a introduction to this important technology.
The trainees are introduced firstly to prepare a bare optical fibre in such a way that suitable end faces are obtained. This process of fibre stripping and cleaving is a recurrent practice either in research labs or telecommunication. By means of collimation optics the beam of the diode laser is made almost parallel before it enters the microscope objective which focuses the light into the multimode fibre. By observing the output at the exit of the fibre the coupling efficiency is optimised by adjusting the precise mounts. Once a strong signal has been obtained the numerical aperture of the fibre is measured by means of the photodetector mounted to the pivot arm. In a next step the photodetector is connected to an oscilloscope and the injection current of the diode laser is modulated. Both the diode laser signal and fibre output are displayed on the scope and the time of flight becomes apparent and can be measured. From this measurement either the speed of light or the length of the fibre is determined.

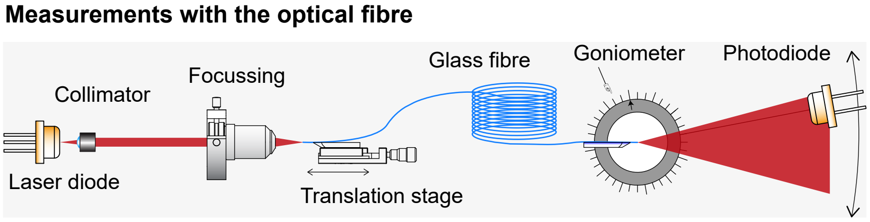
How it works

Characterising the laser diode



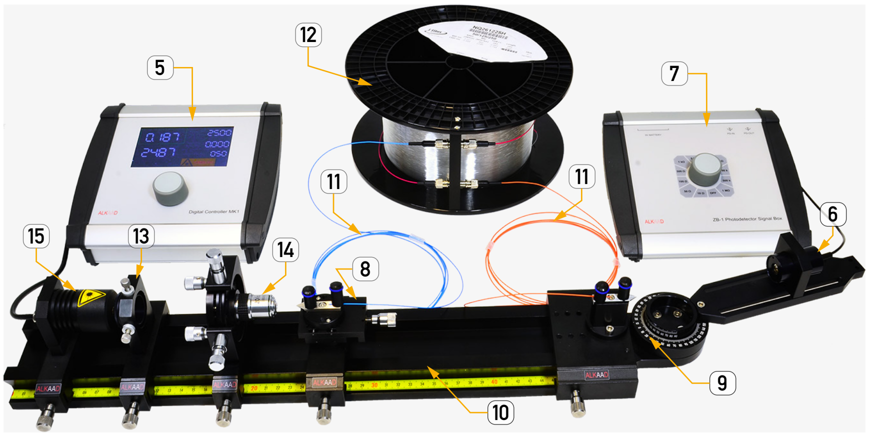
The light of the diode laser is characterised by measuring the output power versus the injection current and the spatial intensity distribution by using the provided photodetector which is mounted onto a pivot arm.

Measurements with the optical fibre



By means of collimation optics the beam of the diode laser is made almost parallel before it enters the microscope objective which focuses the light into the multimode fibre. By observing the output at the exit of the fibre the coupling efficiency is optimised by adjusting the precise mounts. Once a strong signal has been obtained the numerical aperture of the fibre is measured by means of the photodetector mounted to the pivot arm. In a next step the photodetector is connected to an oscilloscope and the injection current of the diode laser is modulated. Both the diode laser signal and fibre output are displayed on the oscilloscope and the time of flight becomes apparent and can be measured. From this measurement either the speed of light or the length of the fibre is determined.

Description of the components



The light of the laser diode (15) is collimated (13) and launched by means of a precise adjustable objective (14) into the fibre which is placed on top of a fibre chuck which is fixed to the translation stage (8). This allows the precise positioning to the focus of the laser light. The fibre is connected via so called fibre pigtails with the drum of 1000 or 2000 m multimode fibre (12). The end of the fibre is placed on top of the fixed fibre chuck of the goniometer (9). A photodetector (6) is attached to the goniometer arm and measures the emerging output power of the fibre. The photo current is converted with the junction box (7) into a voltage and is measured either by a digital voltmeter or oscilloscope. The controller (5) stabilises and displays the temperature and injection current of the laser diode plus the modulation of the injection current.

Details

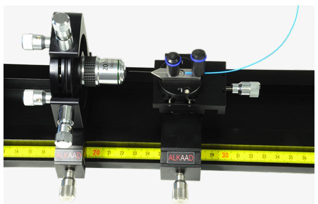


Fig. 3.5: Coupling light to fibre

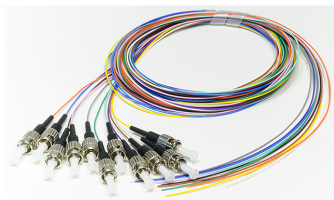


Fig. 3.7: Set of fibre pigtails (11)

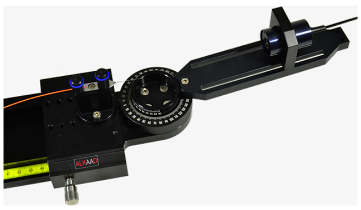


Fig. 3.6: Measuring spatial distribution

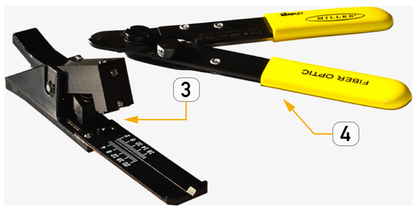


Fig. 3.8: Fibre preparation tools

A fibre is called pigtailed, when one end is bare and the other has a fibre connector (Fig. 3.7). The use of such fibre interfaces has the advantage that the training of the fibre preparation will not affect the main fibre (12). It has furthermore the advantage that without the need for realignment other fibre drums can be connected or connected into series to extend the overall length. It allows also to measure the fibre attenuation, however including the connector losses. To prepare the fibre for operation a flat and clean surface of the fibre face is needed. Firstly the plastic cover and cladding is removed by the so called Miller's pliers (4) and secondly scratched and broken by the fibre breaking tool (3). This practical work gives the students important skills to work in the exciting world of fibre telecommunication.

Measurement examples

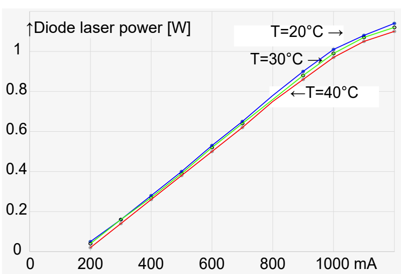


Fig. 3.2: Output power versus injection current

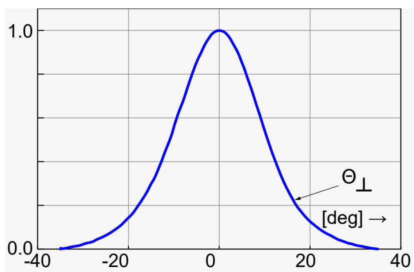


Fig. 3.3: Laser diode angular power distribution

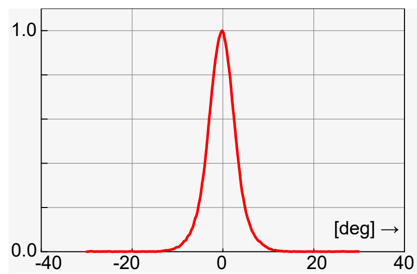


Fig. 3.4: Intensity distribution at fibre exit to determine the numerical aperture

LT-0200 Glass Fibre Optics consisting of:

Item	*Code*	*Qty.*	*Description*	*Details page*
1	CA-0060	1	Infrared display card 0.8 -1.4 µm	127 (10)
2	CA-0450	2	BNC connection cable 1 m	130 (28)
3	CA-0620	1	Optical fibre scriber and breaker	130 (32)
4	CA-0630	1	Adjustable plastic cover stripper	131 (34)
5	DC-0040	1	Diode laser controller MK1	121 (4)
6	DC-0120	1	Si-PIN Photodetector, BPX61 with connection leads	123 (15)
7	DC-0380	1	Photodetector Junction Box ZB1	125 (31)
8	MM-0490	1	Translation stage with bare fibre holder	97 (34)
9	MM-0494	1	Rotation stage with bare fibre mount	97 (35)
10	MP-0150	1	Optical Bench MG-65, 500 mm	93 (8)
11	OC-2040	1	Set of 10 ST pigtailed MM fibre	107 (87)
12	OC-2450	1	Multimode fibre 1000 m, 50/125 µm, ST panel jacks	109 (99)
13	OM-0620	1	Collimating optics on carrier MG20	114 (30)
14	OM-0950	1	MO coupling optics, 4 axes kinematic mount	117 (46)
15	OM-L500	1	Diode laser module 808 nm on C20	118 (56)
16	UM-LT02	1	Manual Glass Fibre Optics	
	Option (order separately)			
17	OC-2440	1	Singlemode fibre, 1000 m, 9/125 µm, ST panel jacks	109 (98)
18	OC-2460	1	Multimode fibre, 2000 m 50/125 µm, ST panel jacks	109 (100)
	Required Option (order separately)			
19	CA-0200	1	Oscilloscope 100 MHz digital, two channel	129 (19)

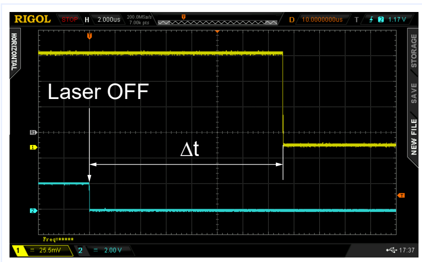
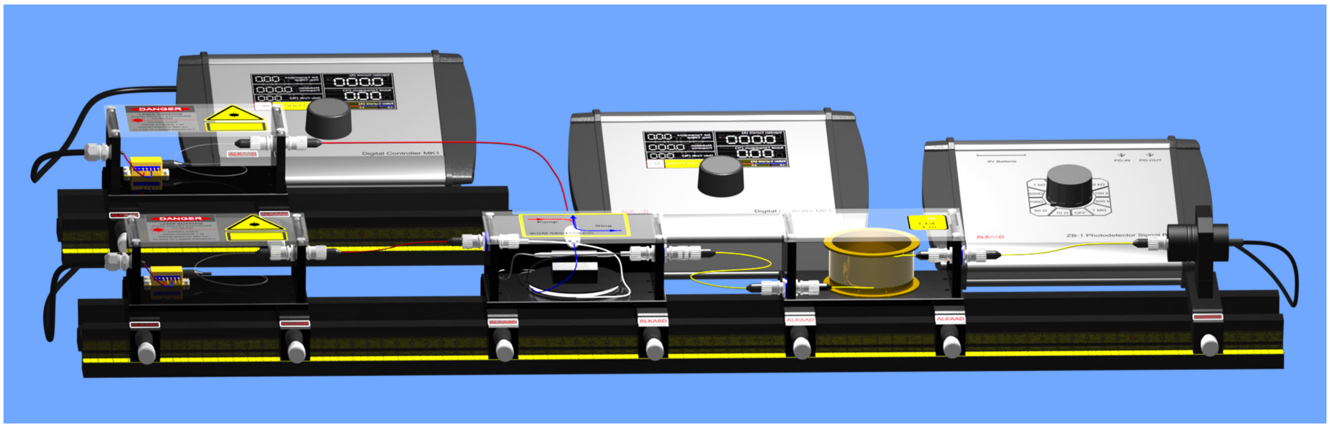


Fig. 3.9: Measurement of the time of flight

The facility to modulate the injection current of the diode laser makes it possible to measure the time of flight Δt of a laser pulse via 1000m, 2000 m or 3000 m of fibre. With the known length of the fibre even the speed of light can be determined and the index of refraction of the fibre calculated.

LT-0300 Erbium doped Fibre Amplifier (EDFA)



Keywords

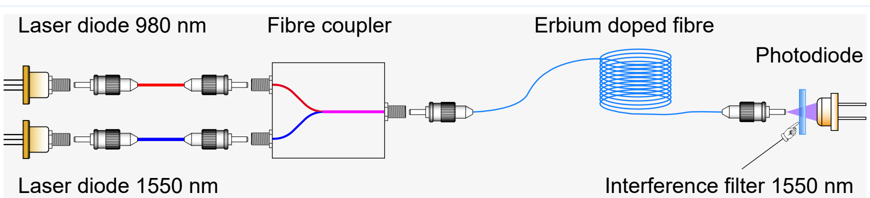
Optical Amplifier
Coupling light to fibre
Lifetime of Excited State
Optical Pumping
Signal Amplification
Fibre Laser Spiking
Erbium doped optical Amplifier
Fibre Laser

Introduction

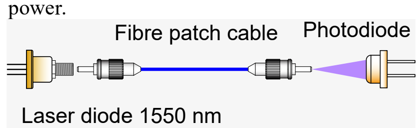
The success of the optical communication would not have been perfect without the invention of optical amplifier. A lot of effort has been invested in reducing the losses in optical fibres. However the residual losses limiting a maximum distance of around 80 km for a single mode fibre before the signal becomes to weak for detection. In principle the weak light could be amplified by an electronic amplifier and fed again into the fibre. However, this foils the extraordinary high bandwidth of optical fibre and a pure optically working amplifier is required. The concept of optical amplification is part of each laser and optical amplification is a well established technology. The genius underlying concept is the combination with an optical fibre and amplifier in one piece which has been realized in the erbium doped fibre amplifier (EDFA). The EDFA consists of an optical fibre which is doped with a defined concentration of Erbium atoms. By means of a coupler the light of a pump source is fed into the fibre exciting the erbium atoms which are acting now as amplifier. The pump wavelength is typically 980 nm and the amplification takes place around 1500 nm, the same range as the optical communication signal. Due to the coherence of the amplification process the amplified stream of photons are indistinguishable with respect to the incoming ones. What a great idea!

This experiment is designed to avoid time consuming adjustments procedures to launch the light of two diode laser into the amplifying EDFA fibre. As fibre coupled system each component can viewed to enhance the understanding of the EDFA concept. It starts with the pump laser diode emitting a wavelength of 980 nm. The pump radiation is coupled via a single mode fibre beam Y coupler into the Erbium doped fibre (EDF). The EDF has a length of about 16 metre and is coiled up on a drum. As signal source a laser diode emitting at 1550 nm is used. Its radiation passes the same fibre coupler is also launched into the EDF. At the output end of the EDFA an InGaAs detector is used for the detection of the 980 nm radiation as well as for the detection of the 1550 nm radiation respectively. A variety of measurements are carried out like the characterization of the two diode lasers. The injection current of each laser can be set independently by two controllers. In a next experiment the 980 nm radiation is coupled into the EDF and the created fluorescence is detected and monitored on an oscilloscope. The controller allows the modulated operation of the diode laser in such a way that the fluorescence decay the excited erbium atoms are displayed and the life time determined. By a further increase of the power of the pump diode laser the EDFA turns into a fibre laser which dynamic behaviour like distinctive spiking. Finally the 1550 nm radiation is fed into the EDFA and the gain is measured as function of the pump power.

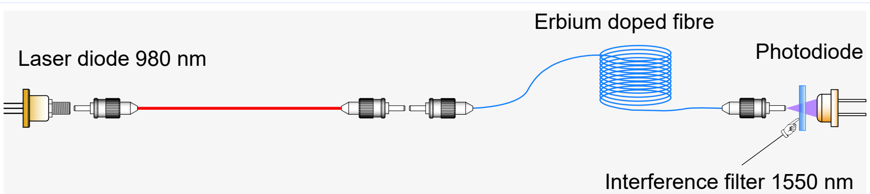
How it works



The experiment uses two laser diodes, one emits a wavelength of 980 nm with a power of 300 mW and serves as pump source. The other emits a wavelength of 1550 nm with lower power around 5 mW and serves as signal source. Both diode laser are fibre coupled and are connected via single mode patch cables to the fibre coupler. The pump as well as the signal wave enter the Erbium doped fibre and the signals leaving the fibre are detected by a InGaAs photodetector. In order to detect only the 1550 nm radiation a laser line or interference filter is placed in front of the photodetector. Each diode laser has its own controller to set the individual injection current for the measurement of the EDFA as function of the pump and the signal power.



In such case, the laser diode is directly coupled to the photodiode by means of fibre patch cable and the photocurrent is converted by means of the provided junction box into a linear voltage.



This setup uses only the pump diode laser to characterize the Erbium doped fibre in terms of measuring the lifetime of the excited state and even to perform some fibre laser experiments. For this purpose the 980 nm laser diode is directly coupled to the Erbium doped fibre. A photodiode monitors the output of the EDFA fibre. It will be a mixture of not absorbed pump power of 980 nm and the created fluorescence of 1550 nm. Of special interest is the 1550 nm radiation and therefore a line filter is placed in front of the photodiode.

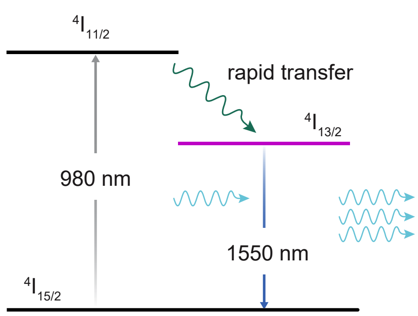
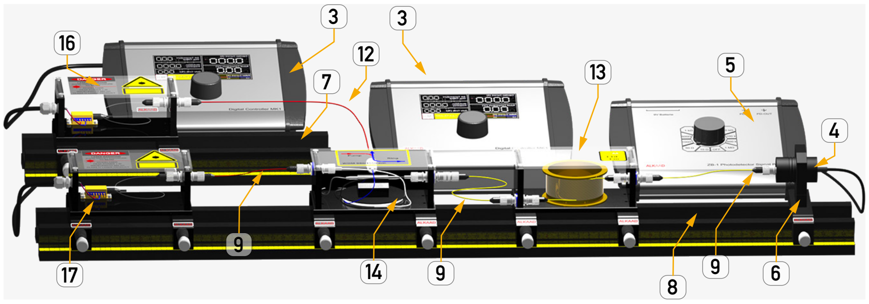


Fig. 3.10: EDFA amplification process

Description of the components



The amplifying medium is a 16 m long Erbium doped fibre which is coiled up on a drum (13) and terminated with single mode ST fibre panel jacks. The pump laser source (17) consists of a 980 nm laser diode in a so called butterfly housing which also contains a Peltier element to control the temperature of the laser chip. The radiation is available at a single mode ST fibre panel jack. By means of single mode fibre patch cables (12 and 9) both laser sources are connected to the wavelength division multiplexer (14, WDM). The combined radiation enters via a single mode patch cable the Erbium doped fibre (13). The output of the fibre is connected via a patch cable to the photodetector (4) which is connected to the junction box (5) where the detected photocurrent is converted into a voltage and can be displayed on an oscilloscope. Each laser diode has its own controller (3) which maintains the set values for the injection current and temperature.

Measurements

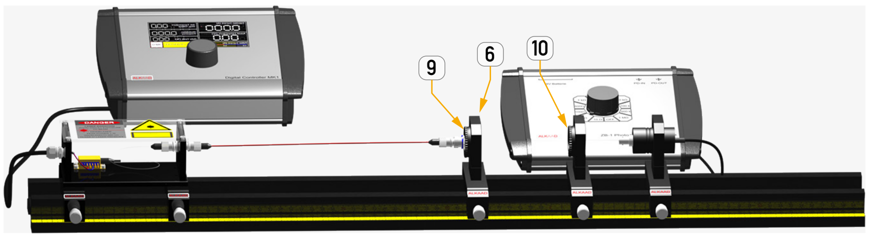
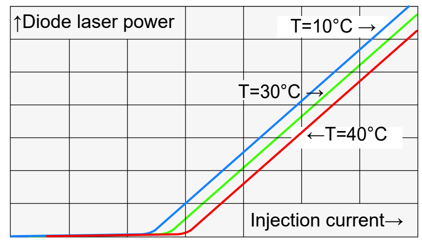


Fig. 3.11: Setup to characterize the individual diode laser modules



Pump laser power versus injection current and temperature

In first experiments the characteristics of the diode laser modules are measured. These are mainly the output power versus the injection current with the temperatures as parameter.

Laser operation and Gain Measurements

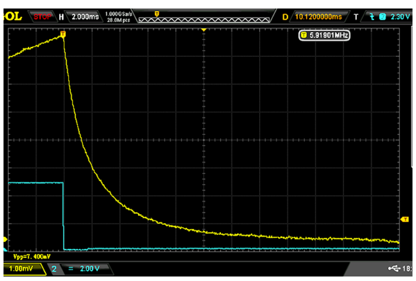


Fig. 3.12: Lifetime of the excited state

For the measurement for the lifetime of the excited state (Fig. 3.12) and the fibre laser operation (Fig. 3.13) only the pump laser (17) is connected to the Erbium doped fibre. The full setup is chosen to measure the gain of the EDFA.

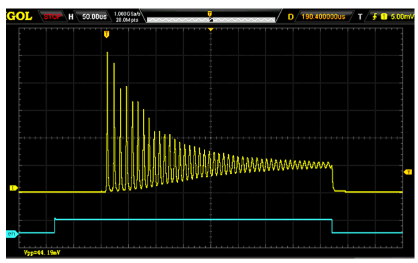


Fig. 3.13: Spiking of the Erbium laser

The gain is measured as a function of the pump power with the for signal strength of the 1550 nm radiation as parameter. If the pump power exceeds a certain value, the EDFA start to work as laser and falsifies the gain measurement.

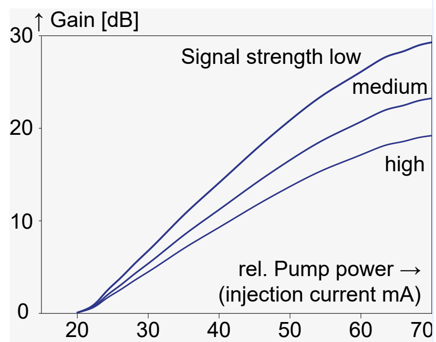


Fig. 3.14: Gain versus pump power and signal strength, small signal and large signal amplification, gain saturation

LT-0300 Erbium doped Fibre Amplifier EDFA consisting of:

Item	*Code*	*Qty.*	*Description*	*Details page*
1	CA-0060	1	Infrared display card 0.8 -1.4 µm	127 (10)
2	CA-0450	3	BNC connection cable 1 m	130 (28)
3	DC-0040	2	Diode laser controller MK1	121 (4)
4	DC-0164	1	InGaAs Photodetector ST with connection leads	124 (19)
5	DC-0380	1	Photodetector Junction Box ZB1	125 (31)
6	MM-0020	3	Mounting plate C25 on carrier MG20	93 (1)
7	MP-0130	1	Optical Bench MG-65, 300 mm	93 (7)
8	MP-0150	1	Optical Bench MG-65, 500 mm	93 (8)
9	OC-0430	1	Fibre jacket in C25 mount	100 (21)
10	OC-0760	1	Laser line filter 1550 nm in C25 mount	103 (42)
11	OC-2010	3	ST/ST SM Fibre patch cable, length 0.25 m	107 (84)
12	OC-2020	1	ST/ST SM Fibre patch cable, length 1 m	107 (85)
13	OC-2230	1	Erbium doped fibre unit, ST terminated, length 16 m	108 (94)
14	OC-2300	1	SM-WDM coupler 980/1550 nm unit ST terminated	108 (94)
15	OM-0540	1	Diode laser module 980 nm, ST fibre connector	113 (23)
16	OM-0550	1	Diode laser module 1550 nm, ST fibre connector	113 (24)
17	UM-LT03	1	Manual EDFA	
	Required Option (order separately)			
18	CA-0200	1	Oscilloscope 100 MHz digital, two channel	129 (19)

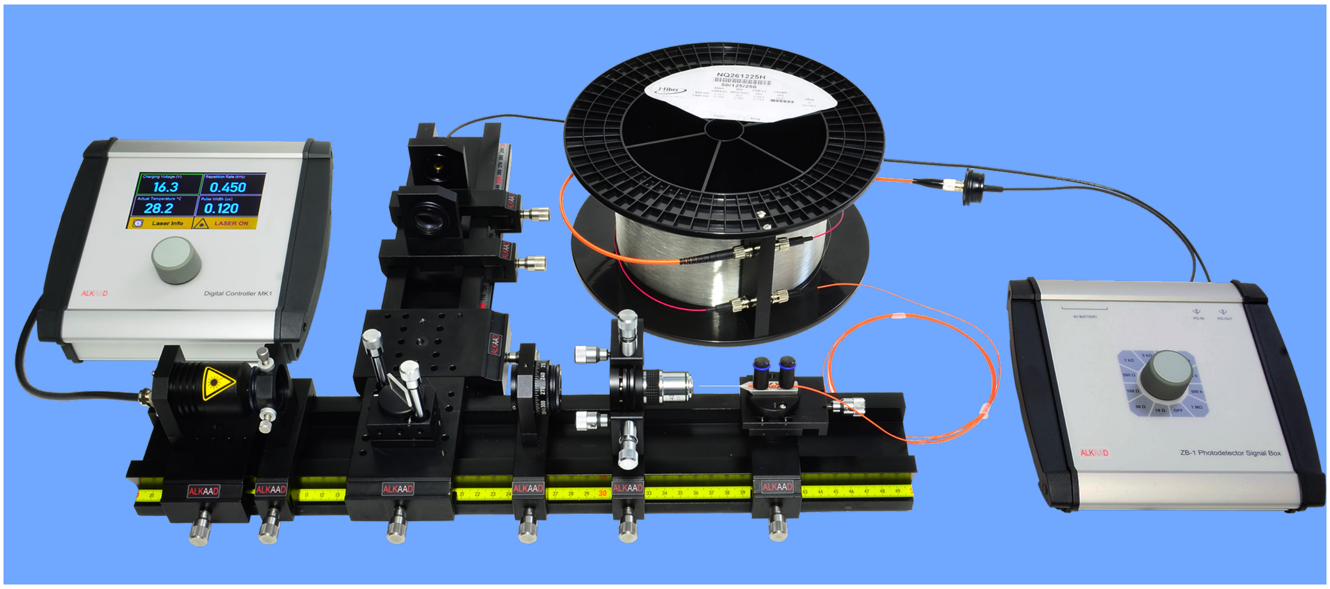
Highlights

Advanced and top level ★★★ experiments

Outstanding features for an all fibre coupled Erbium doped fibre amplifier

Intended institutions and users:
- Physics Laboratory
- Telecommunication
- Engineering department
- Electronic department
- Biophotonics department
- Chemistry department

LT-0400 Optical Time Domain Reflectometer



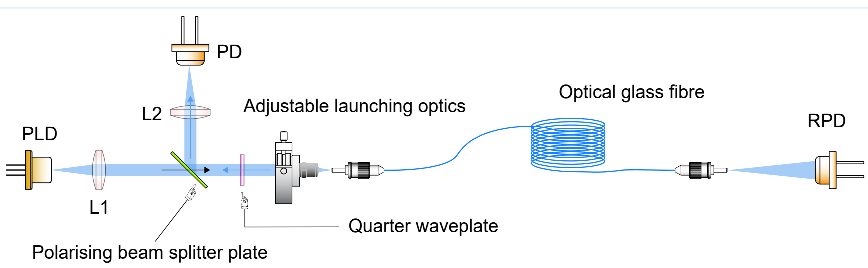
Keywords

Pulsed Laser Diode
Fibre cutting
Losses of Fibres
Light Echoes
Optical Fibre
Speed of Light
Losses of Connectors
Fibre Stripping
Length of Fibre
Fast Photo Detector

Introduction

The whole worldwide communication is based on fibre optical networks encompassing the entire world and is extremely important in view of economical and security aspects. Meanwhile fibre optical networks lines already terminating at homes thus forming a complex structure. The proper working and condition is of vital mutual interest of the provider and customer. Fibre lines can be damaged during road works, earth movements and even by late effects of production imperfections. Whatever the reason of the malfunction of communication networks are, the problems needs to be solved as soon as possible. This is the moment of the mission of the "Optical Time Reflectometry" (OTDR). An OTDR is an opto-electronics instrument that uses time-domain reflectometry to characterize and locate faults in optical fibres. The underlying idea is to send a short pulse into the fibre and "listening" to any echoes coming back from it. At each fibre imperfection, especially at the face of a broken fibre a lot of light is reflected or scattered back into the fibre. From the time of flight of the input pulse and the occurrence of the echoes the distance to the faulty position is found and the service repair team can then do their job.
However, the OTDR covers more possibilities, it is the only device which can measure the attenuation or losses of an optical fibre non-destructively. Such losses in optical fibres can be caused by several reasons, mainly due to optical and mechanical imperfections during the manufacturing process, or by extra mechanical stress on the fibres like unspecified bending or tension.
These days OTDR devices form a small and compact and an indispensable tool in optical fibre communication. The aim of this experiment is to set up an OTDR in such a way that the trainees can identify, align and control the required components like the pulsed diode laser, coupling light into the fibre via a polarising beam splitter. The path of the returning light is bent due to its changed polarisation at the beam splitter cube towards the fast photodetector. The returned light intensity carries the information about the losses by an exponential decay in time, upward peaks for reflections and downward peaks for losses at joints caused either by splices or connectors. The experiment comes with two drums carrying each 1000 m of optical fibre. The fibres are interconnected via two ST patch cable whereby one end of each fibre is left as it is to teach fibre stripping and cutting.

How it works



Main reasons for losses in optical fibre are mechanical cracks, unavoidable scatter centres due to the production process and reflections (see Fig. 3.15). These three imperfections creating backward oriented scatter light, where by optical connectors acting as a photon sink.

The idea of an OTDR is to detect this back scattered light and analyse its amplitude and temporal behaviour. For this purpose the pulse of the laser diode (PLD) is launched via a polarising beam splitter plate into the optical fibre. The polarisation of the back scattered is changed so that it will be reflected at the beam splitter towards the detector. The quarter waveplate further enhances the right polarisation in order to get most of the back scattered light which anyhow has a very small power. This requires highly sensitive photodiodes and fast amplifier.

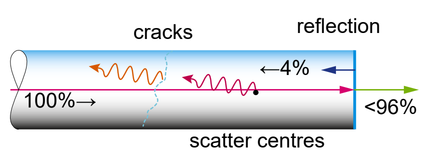
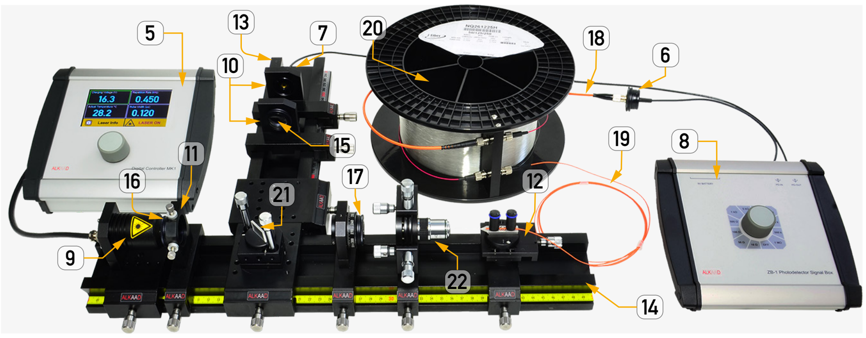


Fig. 3.15: Losses in optical fibre

Within this experiment an extra photodetector as alignment aid is used. It serves as indicator for the coupling efficiency of the laser light into the fibre. Further more in first experiments the time of flight inside the fibre can be measured with this photodetector as well.



The light of the pulsed diode laser (9) is collimated (11) to an almost parallel beam and guided via the polarising beam splitter (21), the quarter wave plate (17) and the launching optics into the fibre (20) under test. The fibre drum is connected via a pigtailed fibre patch cable to the adjustable fibre holder (12). The exit of the fibre drum is connected via a patch cable (18) to the photodetector (6). The junction box (8) converts the photocurrent into a voltage which is displayed on an oscilloscope. The adjustable launching optics and the translation stage of (12) is used to couple the light into the fibre while observing the signal of the photodetector (6) on the oscilloscope. Once the optimum settings has ben achieved, the signal of the photodiode (7) is monitored, which represents the intensity of the back scattered light as shown in (Fig. 3.16).

Details

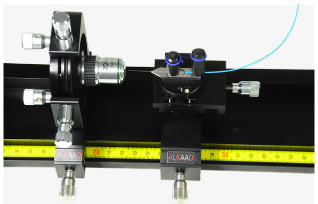


Fig. 3.18: Coupling light to fibre

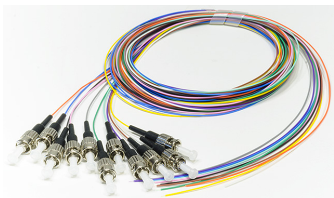


Fig. 3.19: Set of fibre pigtails (11)

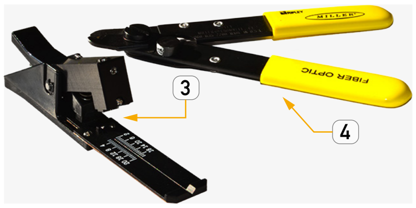


Fig. 3.20: Fibre preparation tools

A fibre is called pigtailed, when one end is bare and the other has a fibre connector Fig. 3.18. The use of such fibre interfaces has the advantage that the training of the fibre preparation will not affect the main fibre (19). It has furthermore the advantage that without the need for realignment other fibre drums can be connected or connected into series to extend the overall length. It allows also to measure the fibre attenuation, however including the connector losses. To prepare the fibre for operation a flat and clean surface of the fibre face is needed. Firstly the plastic cover and cladding is removed by the so called Miller's pliers (4) and secondly scratched and broken by the fibre breaking tool (3). This practical work gives the students important skills to work in the exciting world of fibre telecommunication.

Kea measurements

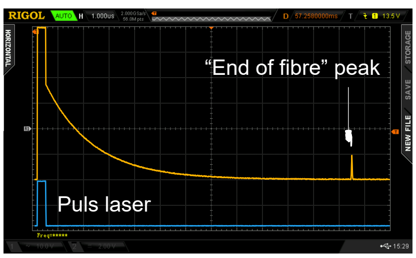


Fig. 3.16: OTDR back scatter signal

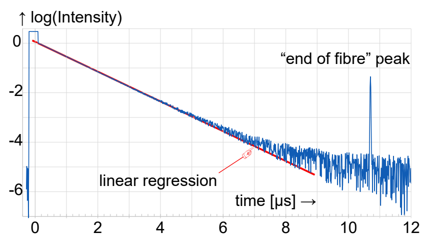


Fig. 3.17: Logarithmic representation of the back scatter signal

The Fig. 3.17 shows the evaluation of the data from the scope (Fig. 3.16). To obtain the losses of the fibre it is necessary to scale the Y-axis in logarithmic units. This provides a linear range of the applied linear regression from which the slope of it represents the losses of the fibre. Since the intensity at the end of the response is very low, the noise floor dominates the signal and due to the logarithm of small values the noise is even enhanced in this representation. The "end of fibre" peak finally gives the length of the fibre and from this we gain the desired losses as dB/ km.

LT-0400 OTDR - Optical Time Domain Reflectometer consisting of:

Item	*Code*	*Qty.*	*Description*	*Details page*
1	CA-0060	1	Infrared display card 0.8 -1.4 µm	127 (10)
2	CA-0450	2	BNC connection cable 1 m	130 (28)
3	CA-0620	1	Optical fibre scriber and breaker	130 (32)
4	CA-0630	1	Adjustable plastic cover stripper	131 (34)
5	DC-0050	1	Pulsed laser diode controller MK1	122 (6)
6	DC-0124	1	Si-PIN Photodetector with ST jack and connection leads	123 (16)
7	DC-0220	1	SiPIN Photodetector, ultrafast with amplifier	124 (23)
8	DC-0384	1	Photodetector junction box w. amplifier	126 (32)
9	LQ-0350	1	Pulsed diode laser in housing	120 (15)
10	MM-0020	2	Mounting plate C25 on carrier MG20	93 (1)
11	MM-0090	1	XY adjuster on MG20	94 (8)
12	MM-0490	1	Translation stage with bare fibre holder	97 (34)
13	MP-0130	1	Optical Bench MG-65, 300 mm	93 (7)
14	MP-0150	1	Optical Bench MG-65, 500 mm	93 (8)
15	OC-0060	1	Biconvex lens f=60 mm in C25 mount	99 (5)
16	OC-0170	1	Collimator 808 nm in C25 mount	99 (13)
17	OC-0840	1	Quarter-wave plate in C25 mount	101 (24)
18	OC-2030	1	ST/ST MM Fibre patch cable, length 1 m	107 (86)
19	OC-2040	1	Set of 10 ST pigtailed MM fibre	107 (87)
20	OC-2450	2	Multimode fibre 1000 m, 50/125 µm, ST panel jacks	109 (99)
21	OM-0020	1	Adjustable beam splitter on tee-piece MG65	110 (3)
22	OM-0950	1	MO coupling optics, 4 axes kinematic mount	117 (46)
23	UM-LT04	1	Manual OTDR	
	Required Option (order separately)			
24	CA-0200	1	Oscilloscope 100 MHz digital, two channel	129 (19)

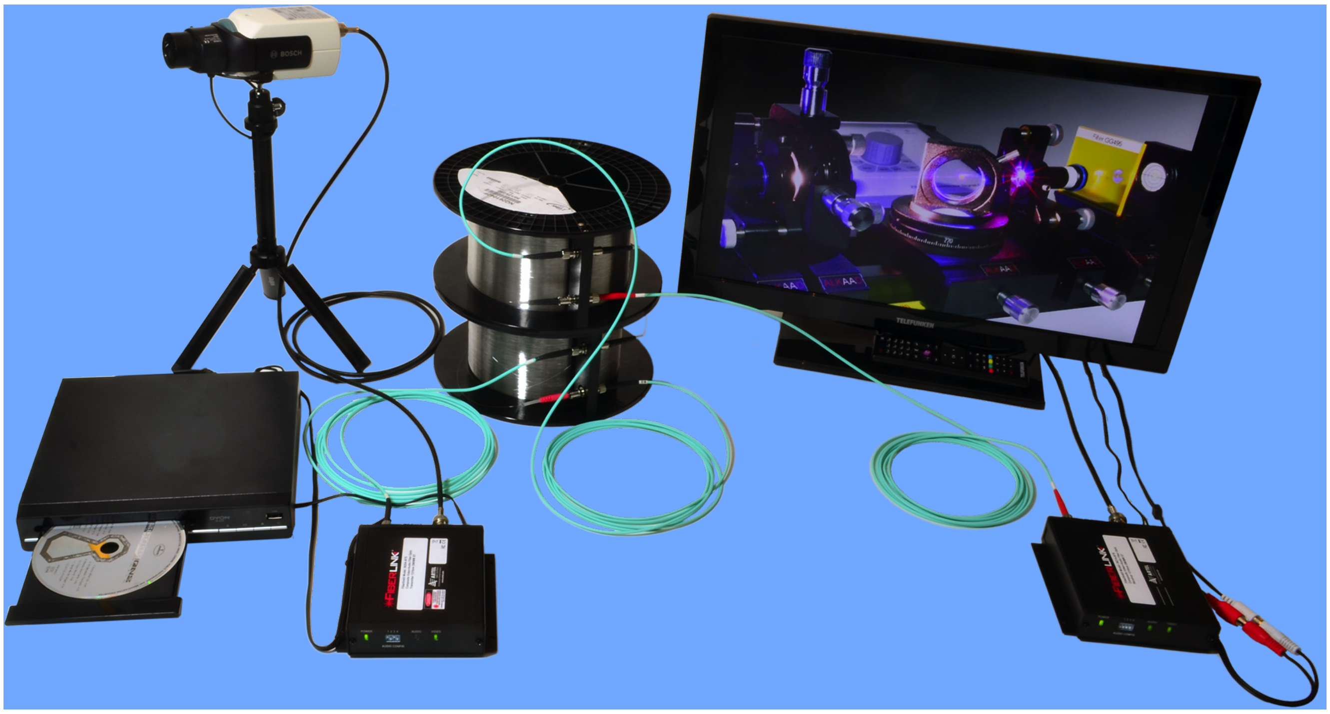
Highlights

Advanced and top level ★★★ experiments

Outstanding features for an open frame Optical domain Reflectometer. A rich variety of professional adjustment tasks

Intended institutions and users:
- Physics Laboratory
- Telecommunication Engineering
- Engineering department
- Electronic department

LT-0500 Video and Audio Transmission



Laser Telecom

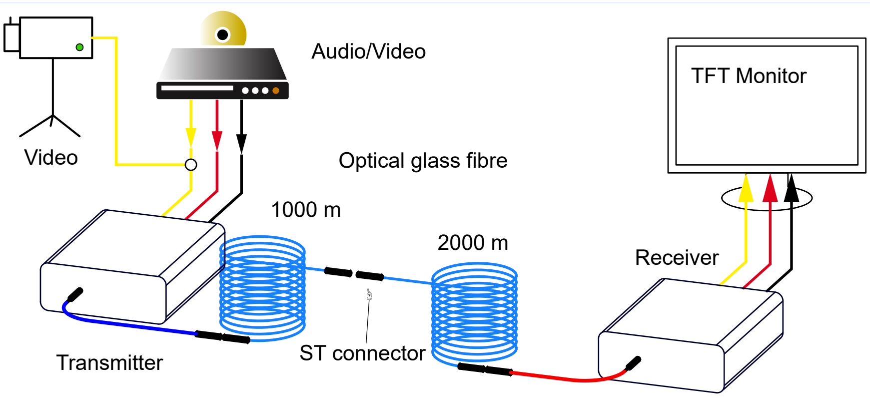
Keywords

Optical Glass Fibre | **Fibre Transmitter** | **Fibre Receiver**
CCD Camera | **Audio Source** | **Signal Transfer via 1+2 km Optical Fibre**
Optical Signal Detection | **Photodetector** | **Fibre Attenuation**

Introduction

This experiment comprises two drums of multimode fibre with one 1000 m and two 2000 m long multimode fibre. With this set data transmission segments can be realized with a length of 1000 m, 2000 m and 3000. The fibre drums are equipped with ST fibre jacks and by means of the provided fibre patch cable they can be interconnected. As signal sources a colour CCD Video camera and a CD - Player as audio source are used. They are connected to the fibre transmitter which converts the electronic signals into digital optical signals which are guided via the optical fibre to the optical receiver where the signals converted back to electronic audio as well as video signal. These signals are connected to a regular TV to watch the transmitted video as well as listen to the simultaneously transmitted audio. The optical signals having a wavelength of 1.3 µm and are detected in addition by the optional fast InGaAs photodetector. The amplitude can be shown on an oscilloscope and the amplitude measured for the 3 different length of the data segment. For each measurement the input and output power is measured and from this relation the fibre attenuation calculated.

How it works



The video signal (yellow lines) is generated either by the CCD camera (2) or by the DVD player (3), whereby the DVD player provides the audio stereo signal (red and black). The video and audio signals are converted by the transmitter (7) to modulated optical signals and made available at a ST panel jack. Optical glass fibre (5, 6) with a length of 1000 m and 2000 m are coiled to a drum and provided with ST panel jacks. The optical connection between the transmitter and the first fibre segment is established by means of a ST fibre patch cable. In the same way the two fibre segments are linked to each other and connected to the receiver. The optical signal is converted back to the video as well as audio signal and are connected via standard BNC and cynch connection cable to the TFT monitor.

LT-0500 Fibre Video & Audio Transmission consisting of:

Item	*Code*	*Qty.*	*Description*	*Details page*
1	CA-0100	1	Flat panel TV	128 (13)
2	CA-0130	1	Colour CCD Camera on tripod	128 (16)
3	CA-0140	1	DVD player with music DVD	128 (17)
4	OC-2020	3	ST/ST SM Fibre patch cable, length 1 m	107 (85)
5	OC-2450	1	Multimode fibre 1000 m, 50/125 µm, ST panel jacks	109 (99)
6	OC-2460	1	Multimode fibre, 2000 m 50/125 µm, ST panel jacks	109 (100)
7	OM-2100	1	Audio & Video upto fibre transmitter	117 (51)
8	OM-2200	1	Audio & Video from fibre receiver	118 (52)
9	UM-LT05	1	Manual Video & Audio transmission	
	Option (order separately)			
10	CA-0200	1	Oscilloscope 100 MHz digital, two channel	129 (19)
11	DC-0210	1	InGaAs Photodetector, ultrafast with amplifier 120 MHz	124 (22)

Highlights

Basic experiment ★★
High technology value
Intended institutions and users:
- Physics Laboratory
- Engineering department
- Electronic department
- Telecommunication department
- Biophotonics department
- Physics education in Medicine

LT-0600 Fibre Optics Workshop Basic

Fibre Stripping | **Fibre Breaking** | **Fibre to Ferrule Bonding**
Fibre Connector | **Fibre Hand Polishing** | **Fibre inspection microscope**

Before a glass fibre can be used in real application outside the laboratories, it has to be fixed to a connector. The entire process of stripping, cleaving, cementing and polishing the entrance window of the fixed fibre is termed as preparing of the fibre. Stripping means the removal of the protective plastic cladding of the fibre. This is done by so called Miller pliers. Cleaving means the defined breaking of the fibre in such a way that the face of it is perpendicular and of optical quality after the process. This can be achieved by slightly scratching the fibre by means of a ceramic or diamond blade when it is bent and exposed to a defined force in direction of the fibre axis. For this process a variety of tools are available. In a next step the fibre is supplied with a connector. For a particular fibre the right connector must be chosen. The ready cut fibre is dipped in one component of a two compound glue and inserted into the ferrule of the connector which already is filled with the second compound of the glue. After a short while the fibre is bonded to the ceramic ferrule of the connector. The protruding fibre is scratched and removed. The connector is now ground and polished. By means of a fibre inspection microscope the connector is inspected if the face of the fibre has the desired optical quality. In this workshop the hand grinding and polishing of optical fibre is introduced and trained. This method is useful in research labs or other places with occasional requirements.

Notes:

The followings steps are performed during the process:

1. Plastic cover removal
   Requires the Millers's pliers (3)
2. Cleaning
   Requires one sheet of (9) and some drops of isopropyl alcohol (10)
3. Filling ferrule with adhesive
   The syringe (11) is filled with the bond liquid (6) and applied to the ferrule. The fibre is dipped into the activator liquid (6) and gently pushed into the ferrule. In a few seconds the adhesive is hardened and is ready for scribing and breaking.
4. Scribing and breaking the fibre
   This is the most sensitive part of the entire process. After applying the scribing tool (2) and breaking the protruding fibre, only a fraction of a millimetre should remain. For safety reasons the remaining fibre splint must be disposed using the tweezers (12) into the trash can (13)
5. Polishing the fibre
   For this step the acrylic plate (7), the polishing disk (8), the polishing film (4) and some drops of isopropyl alcohol (10) are required. The polishing starts with the so called "air polishing". In one hand the polishing film is held and with the other hand the connector tip is slightly polished in circular movements. This removes peaks and other irregularities due to the breaking of the fibre. Thereafter the polishing film is fixed with some drops of alcohol to the acrylic plate and the final polishing starts. This should not take longer than 5 minutes.
6. Inspection of the fibre
   From time to time the connector face is cleaned and inspected with microscope. Once a clear image without digs and scratches is visible, the fibre is ready.

LT-0600 Fibre Optics Workshop Basic consisting of:

Item	*Code*	*Qty.*	*Description*	*Details page*
1	CA-0600	1	Fibre inspection microscope	130 (30)
2	CA-0625	1	Fibre scriber, tungsten carbide	131 (33)
3	CA-0630	1	Adjustable plastic cover stripper	131 (34)
4	CA-0640	1	One step polishing film 2 µm, set of 50	131 (35)
5	CA-0672	1	ST - connector multimode, Set of 60	131 (36)
6	CA-0710	1	Two part anaerobic epoxy for 150 connectors	131 (38)
7	CA-0726	1	Acrylic plate 230 x 140 x 3 mm	131 (38)
8	CA-0728	1	Fiber Optic Polishing Disc for ST, SC, FC	131 (39)
9	CA-0730	1	Cleaning wipes dry - 280 wipes per box	131 (40)
10	CA-0732	1	Dispenser bottle. Isopropyl alcohol	131 (41)
11	CA-0740	10	Epoxy Syringe	131 (42)
12	CA-0742	1	Fibre splint tweezers	132 (43)
13	CA-0744	1	Fibre optic scrap trash can	132 (44)
14	OC-2410	1	Multimode fibre 1000 m 50/125 µm	109 (97)
15	UM-LT07	1	Manual Fibre optics Workshop	