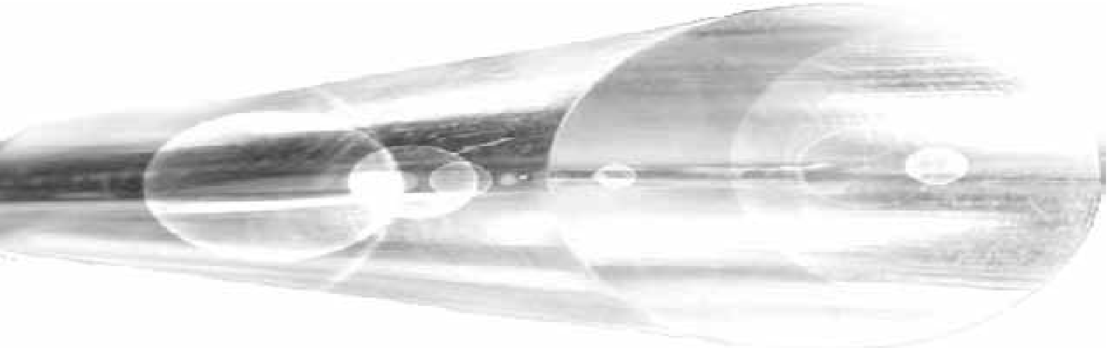
OPTO FIBRES

DEMONSTRATION KIT



Users guide

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Introduction

For several decades we have been aware of the ability to transfer information using light frequencies. Major expansion of and advancements in fibre optics began taking place after 1966, being signified by the use of new technology and materials.

The development is on-going and specifically related to optimising the refraction index profile of the fibre itself. Recently developed materials are utilised as carrier and protection elements. The development of tools related to fibre optics, such as semi-conducting lasers and sensors has also advanced significantly.

The main advantages of systems utilising optical fibres are the following:

- transfer capacity,
- lower losses,
- greater number of transfer channels,
- lower overall cost per channel/km,
- receiver and transmitter being galvanicly separated,
- robustness in terms of sustainability against outer electromagnetic fields,
- larger span between amplifiers,
- savings on use of non-ferrous metals , the prices of which constantly increase, and the production of which is high in energy consumption.

The following are some disadvantages of optical transfer systems:

- more stringent requirements in following the technological procedures,
- higher cost of inter-operation check-ups.

These inadequacies are gradually being eliminated by increasing the share of automated manufacturing facilities at production level.

With regard to the practical use of systems with optical cables it is necessary to point out the increased precautions that need to be taken into account when installing cables. Attention should be paid to mechanical strain put on the cables (it is essential not to exceed the maximum allowable forces, to maintain sufficient radius of curvature, and prevent damage to the coating of the cable), and to ensure appropriate cable connection quality.

The following mistakes should try to be avoided when connecting cables:

- mutual displacement of the axes of the cables,
- tilt of the axes of the cables,
- non-perpendicularity of the connecting ends with respect to the axis of the cable,
- insufficient smoothness and cleanliness of the cable ends to be connected.

Optical systems are capable of transferring signals in digital or in analogue form. Some of the main areas in which transfer systems with optical cables are used as follows:

- measuring equipment,
- computer networks,
- control of technological procedures,
- communications links between telephone exchange offices,
- industrial conglomerates,
- remote data transfer.

Development in this field is proceeding at a fast pace and it is anticipated that in the near future links between fibre optics and other related fields will expand and give rise to exciting new opportunities in the realms of science.

Set contents

Main panels, pic. 2

The set consists of two main panels each with a 5 V stabiliser and detachable 9 V plug. These panels are mutually non-interchangeable; one of them serves as the assembly of the transmitter (`TX Board`), the other of the receiver (`RX Board`). They carry three plug-in slots for direct connectors, into which other components of the set can be plugged in. There are Measurement Points (`MP`) between the connectors that facilitate voltage monitoring at selected points of the chosen arrangement. Also located on the main panels are the optical transmitter connector and the receiver connector, to which the polymer optical fibre (1 mm diameter) can be attached.

Transmitter modules

Potentiometer, pic. 19 (`POT.`)[*]

The potentiometer has a linear resistance range capable of setting the DC voltage from 0 V to 5 V. It is used to determine transmission path parameters and to adjust the reference signal level.

Low Frequency generator, pic. 20 (`LF GEN.`)

This generates a sine signal with a frequency of about 1 kHz and an amplitude swing of 1.4 V (i.e., U_{ef} = 0.5 V), which is super-imposed on the DC voltage of +2 V. The Wien cell is used within the positive feedback of the operation amplifier. The amplitude of the signal is stabilised by the diode gate within the circuit of the negative feedback.

Microphone amplifier, pic. 18 (`MIC.AMP.`)

This facilitates acquiring the sound signal as input and amplifying it to the appropriate level. It is possible to adjust amplification within the range of 1 – 1000 using the module's trimmer. The output signal is super-imposed on the DC voltage of +2V.

[*] The abbreviations of the modules' names are written down in the parentheses. These abbreviations are printed on the rear sides of the modules.

Analogue transmitter, pic. 16 (ANAL.TX)

This module transforms the analogue voltage signal into the current signal, which feeds the optical transmitter on the main panel. The circuit is constructed by means of a controlled current source and the output current is linearly dependent on the input voltage. The level of signal is indicated on the module by the brightness of the red LED diode.

Digital transmitter, pic. 14 (DIG.TX)

This module consists of four Smith "drop-down" circuits, two of which shape the input signal, while the other two generate the testing signal with a frequency of about 1 kHz. Moving the sliding switch on the panel determines whether the input signal or the testing oscillator is selected as the modulation source. Input to the module is controlled by protection diodes. Output status is indicated by the red LED diode.

Serial TxD, pic. 11 (RS232 – Tx)

This module transforms the signal from the serial port (± 12V) to TTL voltage level (0 – 5V). It is using MAX-232 for the signal conversion.

Receiver Modules

Analogue receiver, pic. 15 (ANAL.RX)

This module transforms the current from the optical receiver on the main panel into the analogue DC voltage. The level of signal is indicated by the brightness of the green LED diode. The sensitivity of the module can be modified by the input trimmer, so that the output voltage of the module is at the same level as the input voltage of the analogue transmitter. This ensures that attenuation changes along the transmission path are compensated for. These changes are caused by random damping of optical fibre connections and by using optical fibres of various lengths.

Digital receiver, pic. 13 (DIG.RX)

The signal from the optical receiver on the main panel is transmitted to the digital receiver. The decision level, which determines output status, can be altered by the trimmer. The digital receiver status is indicated by the green LED diode.

Low frequency amplifier + speaker, pic. 17 (`LF.AMP`)

This module processes the signal from the analogue receiver. It is used when the low frequency generator panel, the microphone amplifier or another source of sound signal is set up. The module contains a potentiometer for loudness (volume) regulation, an amplifier, and a miniature speaker. While using the microphone amplifier at the transmitter side and using the low frequency amplifier at the receiver side, it is important to position both set-ups sufficiently far apart from each other and to set the amplification level so that acoustic feedback is avoided.

Serial RxD, pic. 12 (`RS232 – Rx`)

This module transforms the signal from TTL (0 – 5V) to the serial ports (± 12V) voltage level. It is using MAX-232 for the signal conversion.

Other parts

Optical components, pic. 1

The set consists of three 1 mm diameter polymer optical fibres 2 m, 3 m, 5 m long, one 2 mm outside-diameter jacketed optical fibre 3 m long, and one U-probe 1 m long. The fibres have a step profile of refractive index.

Power supply, pic. 4

Power is supplied by two universal adaptors which are connected to the main boards. Feed voltage is 9 V.

Measuring device, pic. 3

The universal Multimeter is included in the set. The Multimeter enables measurement of voltage tension between measuring points `GND` and `MP1` or `MP2` on the main boards.

Mechanical fibre holders, pic. 5

The holders are fixed to the calliper. This combination is useful for the demonstration of losses caused by an imperfect fibre-fibre bond.

Emeries, pic. 8

Three fine emeries purple, yellow and white are included to file and smooth cut fibre ends.

Plastic tube, pic. 7

The plastic tube is used in the Tyndall's experiment.

Force plates, pic. 6

Two separate metal plates with 3 holes and holders. The force plates are used in the dynamometer experiment.

Bending cylinders, pic. 9

The bending cylinders are used in the attenuation measurement.

Data cable, pic. 10

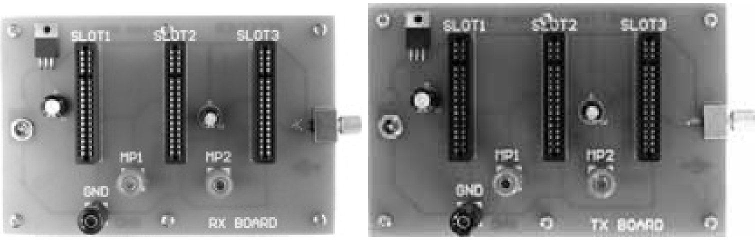
Two data cabels are used to connect the Serial TxD and Serial RxD modul to the transmitter and receiver computer.

CD medium

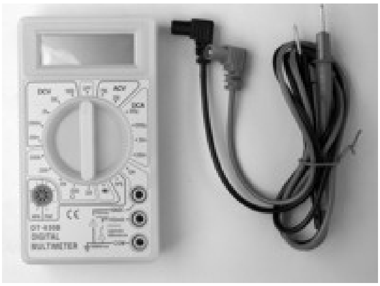
The CD contains instalation of the comunication software OptoSerial-RxD, TxD for the Transfer of Digital Signal experiment.

Photo of parts

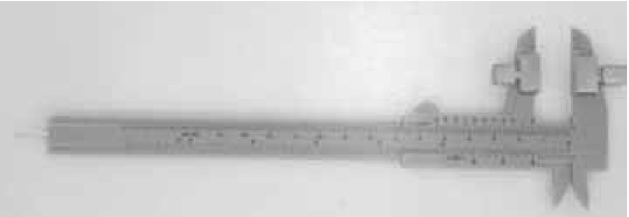

Picture 1: Optical components (not jacketed, jacketed fibre, U-porbe)

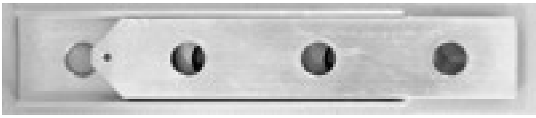


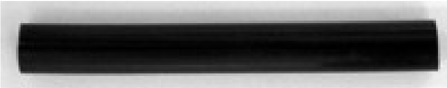
Picture 2: Main panels (RxD, TxD board)


Picture 3: Measuring device

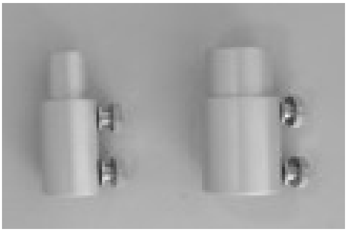

Picture 4: Power supply


Picture 5: Mechanical fibre holders

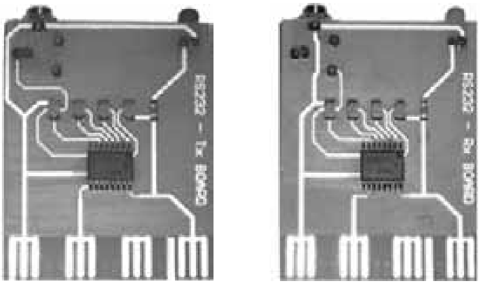

Picture 6: Force plates


Picture 7: Plastic tube

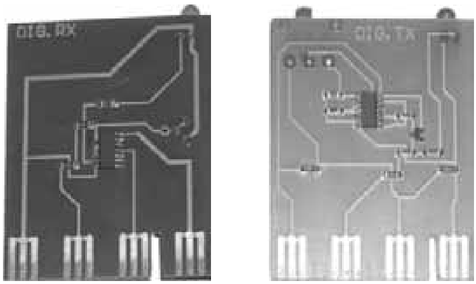

Picture 8: Emeries


Picture 9: Bending cylinders

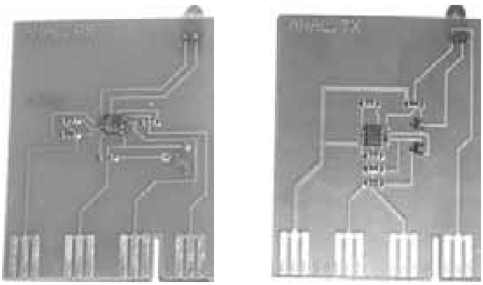

Picture 10: Data cabel



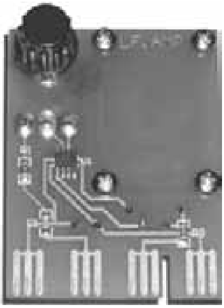
Picture 11, 12: RS232 – Tx, Rx

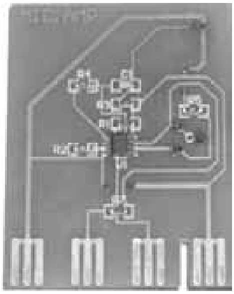


Picture 13, 14: Digital receiver – transmitter

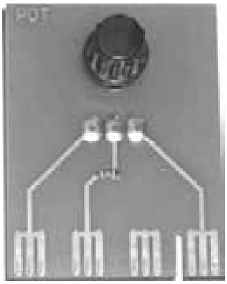


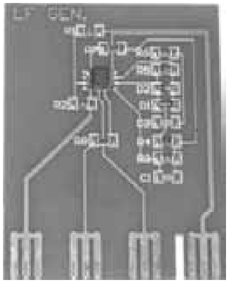
Picture 15, 16: Analogue receiver – transmitter





Picture 17, 18: Low frequency amplifier – Microphone amplifier





Picture 19, 20: Potentiometer – Low Frequency generator

Recommendations

Some general principles are valid during experiments, to ensure that devices function properly. It is advised that they are remembered and adhered to.

1. The laboratory where experiments take place should be dark. Background light could damage the photodiode of the receiver or cause its saturation.
2. Never touch unprotected conductive metal parts of modules. This could cause a discharge and the fine electrical parts could be damaged.
3. Adapters should be inserted into the electricity socket after being connected to the main panel.
4. The black connector of the Multimeter should be connected to `GND` point first.
5. The U-probe must be and clean and dry when changing the liquid.
6. The reference voltage level can be adjusted by the potentiometer. Be careful not to set it to the extreme position.
7. Do not cause undue stress to the optical fibres by excessive mechanical force. The shape changes are mostly irreversible.
8. Upon completion of the experiment return all components to the portable case.

The following set of experiments should help you to acquaint yourself with the basics of fibre optics. There are, of course, many more experiments which can be undertaken with our set. We welcome any ideas and suggestions that you might have which could help us to refine our fibre optics set. In the meantime, we hope that you enjoy using this set.

Basic overview of fibre optic cables

Fibre optic cable functions as a "light guide," guiding the light introduced at one end of the cable through to the other end. The light source can either be a light-emitting diode (LED) or a laser. The light source is pulsed on and off, and a light-sensitive receiver on the other end of the cable converts the pulses back into the digital ones and zeros of the original signal.

Even laser light shining through a fibre optic cable is subject to loss of strength, primarily through dispersion and scattering of the light, within the cable itself. The faster the laser fluctuates, the greater is the risk of dispersion. Light strengtheners, called repeaters, may be necessary to refresh the signal in certain applications.

While fibre optic cable itself has become cheaper over time - an equivalent length of copper cable cost less per foot but not in capacity. Fibre optic cable connectors and the equipment needed to install them are still more expensive than their copper counterparts.

There are two types of fibre optic cable commonly used:

- single mode
- multi mode and plastic optical fibre (POF)

Single Mode (Figure 1) cable is a single stand of glass fibre with a diameter of 8.3 to 10 microns that has one mode of transmission. Single Mode Fibre with a relatively narrow diameter, through which only one mode can propagate typically 1310 or 1550nm. Carries higher bandwidth than multimode fibre, but requires a light source with a narrow spectral width. Single-mode fibre gives you a higher transmission rate and up to 50 times more distance than multimode, but it also costs more. Single-mode fibre has a much smaller core than multimode. The small core and single light-wave virtually eliminate any distortion that could result from overlapping light pulses, providing the least signal attenuation and the highest transmission speeds of any fibre cable type. Single-mode optical fibre is an optical fibre in which only the lowest order bound mode can propagate at the wavelength of interest typically 1300 to 1320nm.

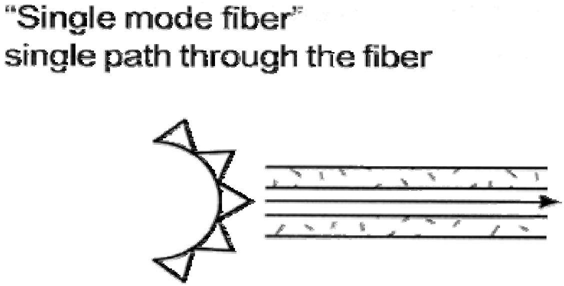


Figure 1: Single mode fibre

Multimode cable and plastic optical fibres (POF) (Figure 2) are made of glass fibres, with common diameters in from 50 to 100 micron for the light carry component (the most common size is 62.5). POF is a newer plastic-based cable which promises performance similar to glass cable on very short runs, but at a lower cost. Multimode fibre gives you broad bandwidth at high speeds over medium distances. Light waves are dispersed into numerous paths, or modes, as they travel through the cable's core typically 850 or 1300nm. Typical multimode fibre core diameters are 50, 62.5, and 100 micrometers. However, in long cable runs (longer than 3000 feet [914.4 m]), multiple paths of light can cause signal distortion at the receiving end, resulting in an unclear and incomplete data transmission.

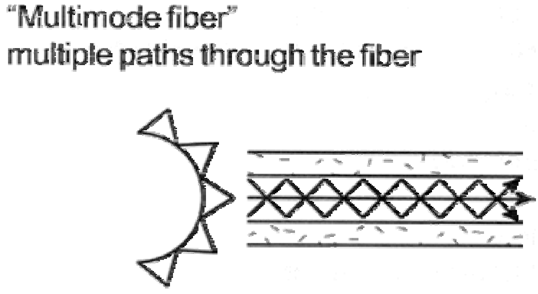


Figure 2: Multimode fibre

NOTICE:

1. Prepare the optic fibre fairly following instructions in experiment #1 before each of experiments.
2. For each experiment use only neccessary long piece of fibre, because the longer it is, the bigger the loss is.
3. Remember that the fibre gets worn off or destroyed while performing some of experiments e.g. #3 & #4. So take care to not destroy whole fibre for the first time.
4. Values measured in the experiments are only approximate and they should vary for each repeating of experiment. It depends on a number of circumstances like preparing of the fibre, its length, deflection etc.

Experiment No 1: Preparation of optical fibres

Introduction

As it was mentioned before, careful attention has to be paid to the fibres bond during optical transmission system building. Imperfect worked fibres bonds are responsible for large losses in the whole system. This is the reason why fibres must be prepared before starting experiments. In this experiment the proper cutting of fibre will be demonstrated (Figure 3).

Objective

Preparing the fibres before experiments so any losses after connecting connectors will be as low as possible.

Principle of light propagation in optical fibres

Optical fibres consist of a core, a cladding and a protective coating. The core diameter is usually about 5 to 50 µm. The cladding can be of a diameter up to hundreds of µm. The core and the cladding are necessary for light propagation, whereas the coating has a protective function against mechanical and chemical damage.

The Snell Law of refraction controls propagation inside a fibre. Light is subject to total reflection on the core-cladding border. The refractive index of the core n_1 is higher then that of the cladding, n_2. Light is propagated, in terms of geometrical optics, only through the core of the fibre. The cladding has an important role in this process, because through the division of the two indices one of the main parameters of the fibre can be defined as the *numerical aperture* (Figure 3)

$$\mathrm{NA} = \sin\alpha = \sqrt{n_1^2 - n_2^2}$$

The numerical aperture is a sine of the maximum incidence light angle entering the fibre and fulfilling total reflection requisites. It is also the maximum angle of the light cone leaving the fibre at the other end, until the output cut is planar and perpendicular to the fibre axis.

Equipment

Optical fibres, scalpel or sharp knife*, mechanical holders of fibres (fixed on the calliper), emery papers

Procedure

1. Cut the end of the fibre accurately by applying steady pressure to the knife.
2. Fix the end of the fibre to the mechanical holder (fixed on the calliper). Let about 0.1 mm of the end overhang the plane of the holder.
3. Lay down the emery on flat and solid field and keep trying to grind the fiber only vertically. Grinding not uprightly should cause creation of a number of various fields at the end of fibre.
4. Resurface the end of the fibre with the purple emery, then polish it with the yellow and finally with the white emery.
5. Repeat the procedure for every fibre.

The fibres are prepared to be used for light transmission with lower losses.

Exercises

1. Try to derive the formula for numeric aperture.
2. What should be the maximum value of the refractive index of the core if the index of the cladding equalled to 1? (in the case of a fibre without cladding, it consists of a core only)

* Not contained in this kit

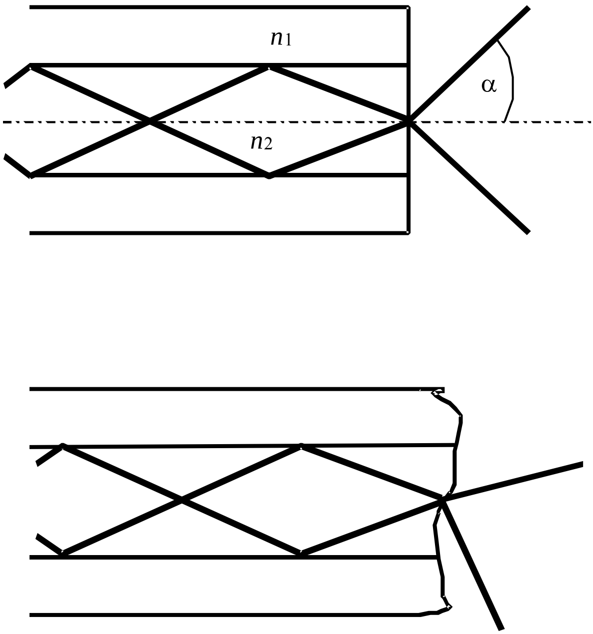


Figure 3 Well and badly cut fibre. The radiation angle is limited by the numerical aperture, therefore when the fibre is cut badly, the angle is unlimited.

Experiment No.2: Tyndall's Light Guiding Experiment

Introduction

The modern-day technology of fibre optics starts back in the days when inventors and scientists were trying their best to bend the light around corners. It isn't exactly clear why anyone would want to do that, but a lot of people, even a hundred years ago, were unwilling to accept that light travel was confined to straight lines. They tried many different devices like mirrors and special tubes, but none received much attention until John Tyndall came along. In 1870, before members of the prestigious British Royal Society, Tyndall demonstrated how to guide a light beam through a falling stream of water. His method is shown in Figure 4. The tank of water had a horizontal pipe extending out one side which allowed water to flow out in an arc to a collection pan on the floor. A bright light was directed into the pipe and the light rays traveled within the water until they were broken up by the turbulence of the water hitting the collection pan.

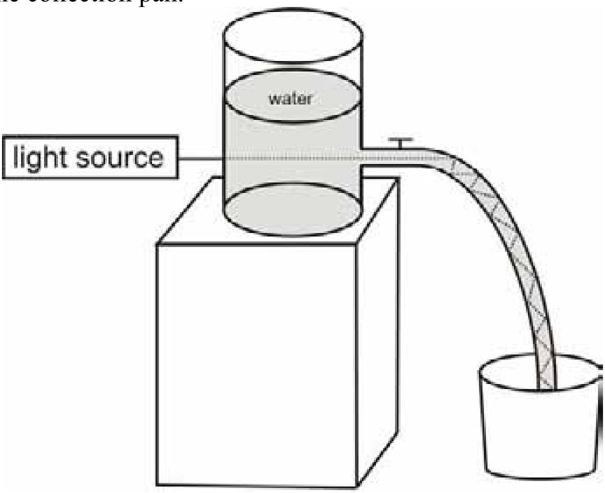


Figure 4: John Tyndall's light guiding experiment

Objective

Demonstration of the Tyndall’s light guiding experiment.

Equipment

Main transmitter panel, analogue transmitter, optical fibre, plastic tube, 2x empty plastic bottle (min. size 1,5 liter or 0,5 galon)*, sticking plaster*, scalpel or sharp knife*, bucket*, water

THIS EXPERIMENT CAN BE REALIZED IN MANY WAYS. THE FOLLOWING METHOD IS ONLY PRINCIPIAL AND YOU SHOULD TAKE IT LIKE A TIP FOR THE REALIZATION. IT DEPENDS ONLY ON YOUR POSSIBILITIES AND EQUIPMENT.

Procedure

1. Fill up one empty plastic bottle with water.
2. Insert the analogue transmitter into `Slot 3`, as given in Figure 7.
3. Connect the prepared optical fibre to the transmitter.
4. Take other empty bottle and using knife cut a hole (approximately twice of the size of the optical fibre diameter) on the plastic bottle and cover it with a sticking plaster.
5. Using knife make a hole on the opposite side of the sticking plaster. The hole should be so big, that you can stick the plastic tube through it.
6. Stick the plastic tube in to the bottle (you can tighten it with plaster). Push the optical fibre from the transmitter through the other sticking plaster to the bottle.
7. Guide the optical fibre through the bottle to the plastic tube.
8. Put down the bucket in front of the table, and place the plastic bottle at the edge of the table so the plastic tube is over the table and bucket is under the tube Figure 5.

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* Not contained in this kit

9. Darken the room and connect the power sources of the main transmitter panels to the power.

10. Start pouring water carefully from one bottle to the other one (try not to pour water on the electronics). Observe the light beam after it leaves the end of the plastic tube end and the stream of water. Do you see the light in the water stream? The light will leave the plastic tube and follow, or be guided by the stream of water to the bottom of the bucket. For better effect you can to the water few drops of milk.

Advices for better effect

- choose a tube with smaller diameter
- take care to have appropriate strong water stream
- the angle of deflection have to be sufficient
- the bucket shouldn't be too deep; for better efect you can insert an object to see the light beam better
- on supplied CDrom you can find video which shows another tip for the experiment demonstration

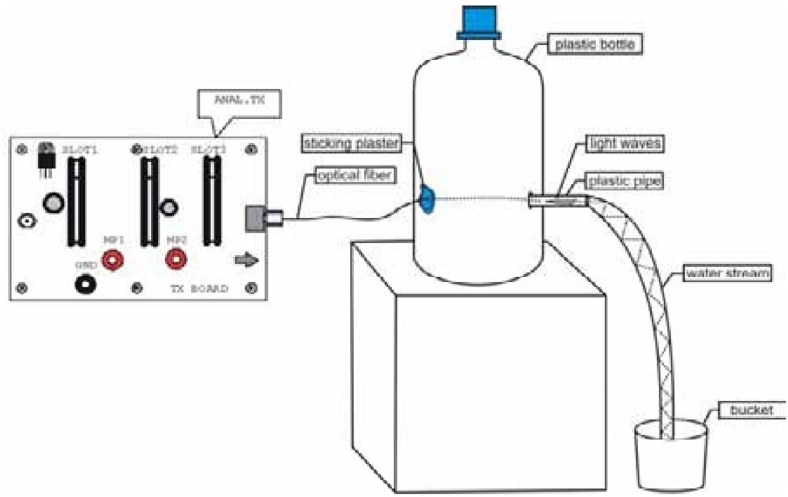

Figure 5: The set-up diagram of the Tyndall's experiment

Questions

1. Describe where do you see the light, once the stream of water is in motion?
2. How does the light get down to the bottom of the bucket?
3. Where is visible the majority of the light?

Experiment No.3: Measurement of attenuation caused by the bend of a fibre

Introduction

When bending a fibre, the incidence angles of beams at the boundary between the core and the cladding of a fibre changes, consequently some beams get emitted from the fibre. A bent fibre results in losses caused by emittance and an increase in attenuation, because the angle of incidence decreases at the points with a too small curvature radius and the condition of total reflection is not achieved (Figure 6). It is therefore necessary to maintain a sufficiently large curvature radius of a fibre when installing the cable nets.

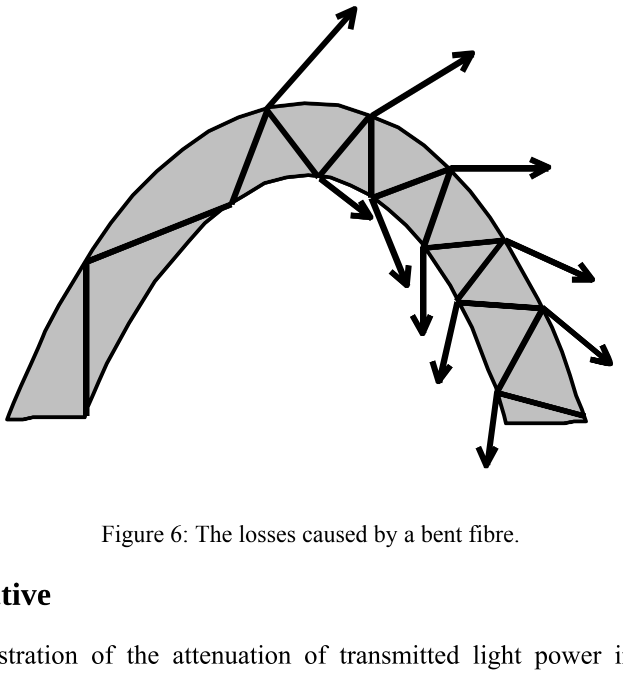

Figure 6: The losses caused by a bent fibre.

Objective

Demonstration of the attenuation of transmitted light power increase caused by a bent fibre.

Equipment

Main transmitter panel, main receiver panel, analogue receiver, analogue transmitter, potentiometer, optical fibre, Multimeter, bending cylinders

Procedure

1. Insert the analogue transmitter into `Slot 3` and the potentiometer into `Slot 2` of the main transmitter panel, following the order as given in Figure 7.
2. Connect the main transmitter panel to the main receiver panel by using the optical fibre.
3. Insert the analogue receiver into `Slot 3` of the main receiver panel.
4. Connect the Multimeter to the main receiver panel; plug it into the ground (`GND`) and to the measuring point `MP2`.
5. Connect the power sources of both the main receiver and the main transmitter panels to the power.
6. Measure the emitted power P_0. (Set the reference level by the potentiometer to appropriate level)
7. Coil one turn onto the bending cylinder of a diameter 1 cm, 1.5 cm, 2 cm and 2.5 cm and measure the transferred power P_x.
8. Repeat point 7 for up to five turns. The optical fibre must fit the bending cylinder tightly.
9. Calculate the additional attenuation from the formula

$$A = 10 \log \frac{P_0}{P_x}$$

10. Make a graph of the dependence of the attenuation on the radius of the cylinders at five coiled turns.

Questions

1. What is the influence of the number of turns on the losses caused by bending?

2. What is the influence of the radius of a cylinder on the losses caused by bending?

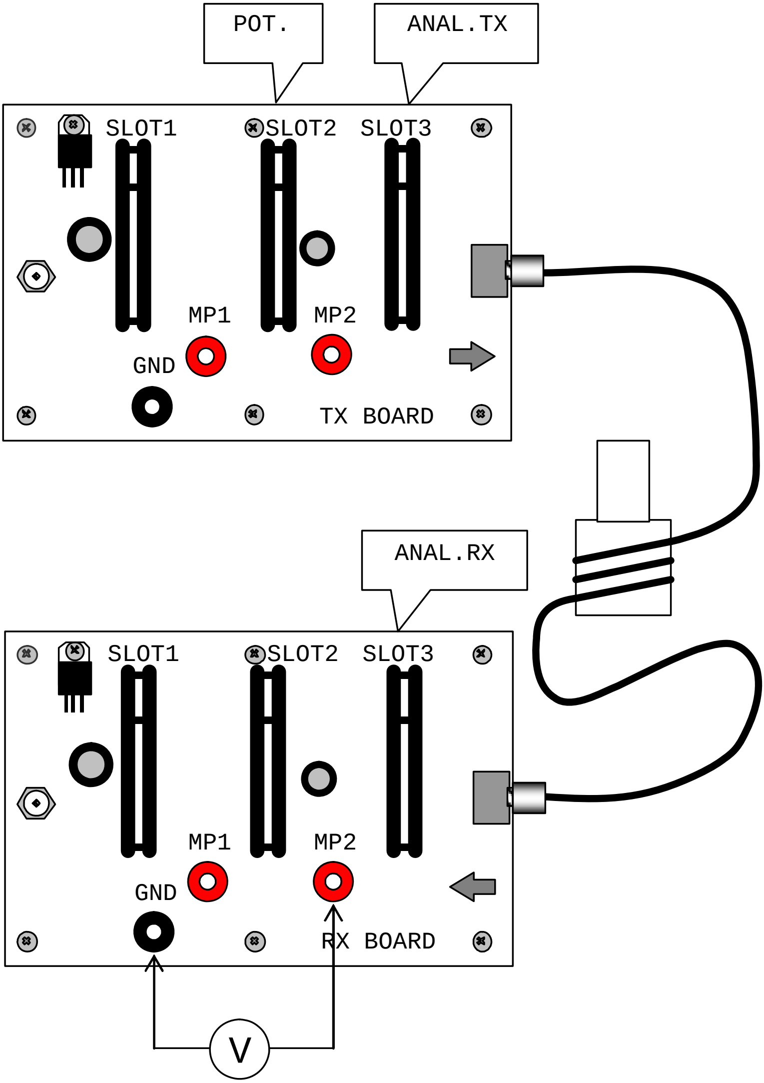

Figure 7: The set-up diagram of the experiment of attenuation caused by a bend.

Experiment No.4: Optical fibre based dynamometer

Introduction

In the previous experiment you verified the fact that the attenuation of a fibre is dependent on its deformation. This effect can be used in the construction of a dynamometer. Such device could measure the force applied on the fibre cable or it can be used for measurement of the heaviness.

Objective

Demonstration of the dynamometer based on bent fibre.

Equipment

Main transmitter panel, main receiver panel, analogue receiver, analogue transmitter, potentiometer, jacket optical fibre, Multimeter, force plates, weights*

Procedure

1. Insert the analogue transmitter into `Slot 3` and the potentiometer into `Slot 2` of the main transmitter panel, following the order as given in Figure 8.
2. Insert the analogue receiver into `Slot 3` of the main receiver panel.
3. Tow the optical fibre thorough the force plate holes as shown in Figure 8.
4. Connect the main transmitter panel to the main receiver panel by using the optical fibre.

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* Not contained in this kit. You can use a bottle filled with water instead of weights.

5. Connect the Multimeter to the main receiver panel; plug it into the ground (`GND`) and to the measuring point `MP2`.
6. Connect the power sources of both the main receiver and the main transmitter panels to the power.
7. Measure the emitted power P_0. (Set the reference level by the potentiometer card to appropriate level.)
8. Hang up one side of the first force plate and put a weight to the other side of the second plate. Check the emitted power P_x .
9. Calculate the power difference between P_x and P_0. Try this experiment with different weights. Always adjust the power to the same level as the first measured P_0 was when switching the weights. Avoid using weights that are too heavy or too light. Use weights which voltage difference is between 0.1 V – 0.5 V. Try not to change the position and the bending level of the optical fibres between measurements.

NOTE:

The fibre can get worn off during the experiment and you may not reach the initial reference level if you set the potentiometer at maximal level at the beginning of the experiment. To avoid this, begin with lower weights. You can destroy the fibre using too heavy weights.

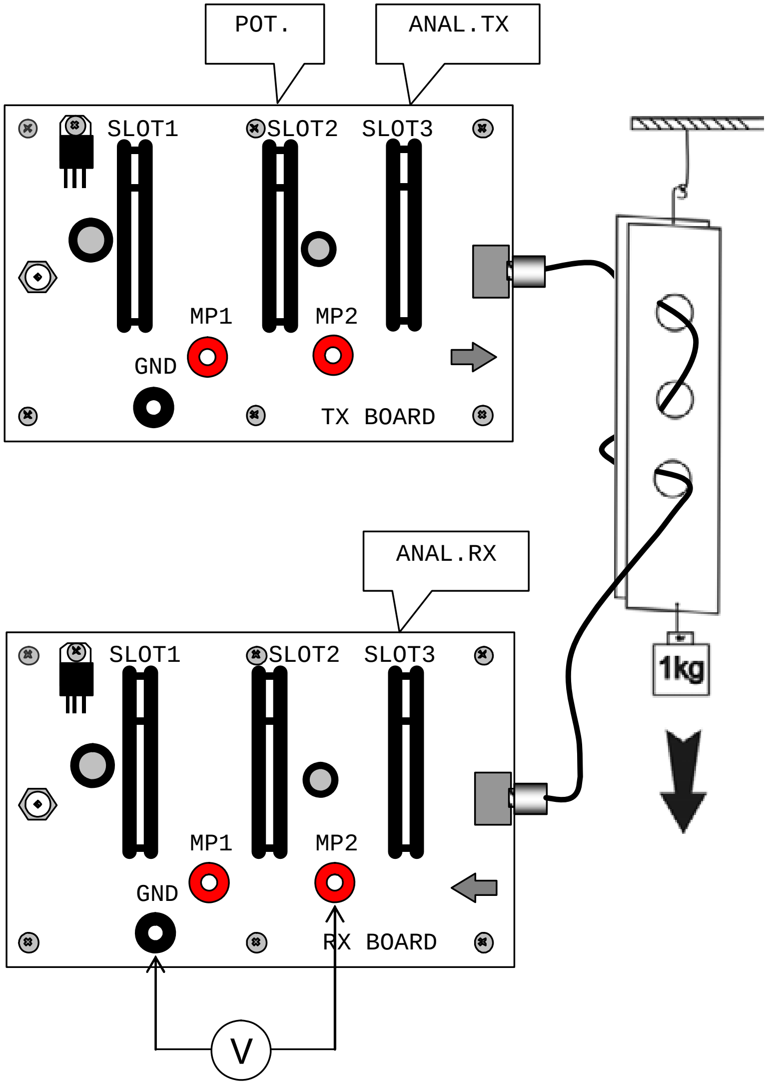

Figure 8 : The set-up diagram of the dynamometer experiment

Questions

1. Calculate the size of the force applied to the optical fibre using different weights. Compare your calculation results with a mechanical dynamometer.

2. How would you calculate the weight of an unknown sample (X kg) using 1 kg weight and the optical fibre dynamometer?
   Hint: $1:d_1 = X:d_2,$ where $d_1=abs(PX_1 - P0_1)$, $d2=abs(PX_2-P0_2)$

3. Try to check the linearity of the system, by calibration with different weight standards and suggest an optimal calibration equation.

4. It's also possible to measure weight with the method shown on the picture Figure 9? Try this experiment.

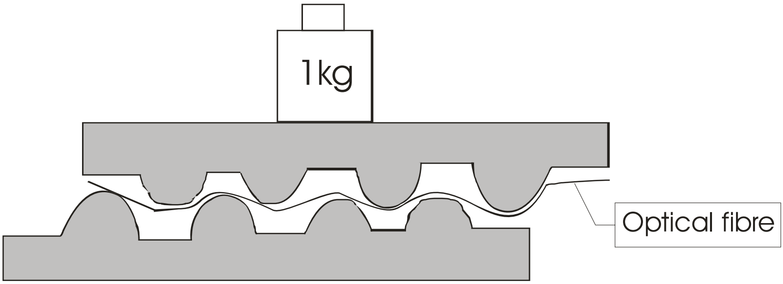

Figure 9: Weight measurement

Experiment No.5: Sensor of a liquid surface

Introduction

Using the optical fibre bent in 180 degrees (U-shaped) on a very small radius of curvature, it is possible to vividly demonstrate the tie-out of an optical wave by submersing it in a liquid matter with the refraction index having a value close to the refraction index of the fibre itself. Light is emitted through the fibre at the point of the bend, because the condition for total reflection is not satisfied (Figure 6). The loss increases when the refraction index of the surrounding environment approaches the refraction index of the fibre. If the power of transferred light is measured, the type of environment in the vicinity of the sensor can be determined.

Equipment

U-shaped fibre (so-called ‘U-probe’), main receiver panel, main transmitter panel, potentiometer, analogue transmitter, analogue receiver, beak*, water and sugared water, ehtylalcohole

Objective

Demonstration of the operation of the water liquid sensor.

Procedure

1. Insert the analogue transmitter into `Slot 3` and the potentiometer into `Slot 2` of the main transmitter panel (Figure 10).
2. Connect the main transmitter panel to the main receiver panel by the U-shaped fibre. You have to prepare the fibre as in experiment no. 1.
3. Insert the analogue receiver into `Slot 3` of the main receiver panel.
4. Connect the Multimeter to the main receiver panel; plug it into the ground (`GND`) and into the measuring point `MP2`.

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* Not contained in this kit

5. Connect the power sources of both the main receiver and the main transmitter panels to the power.
6. The reference level has to be set by the potentiometer at appropriate level.
7. Measure the emitted power, which is proportional to the voltage in `MP2`, using the Multimeter, when the U-probe is
   a) not submersed (power P_0)
   b) submersed in water (power P_w)
   c) submersed in ethylacohole (power P_e)
   d) when sensor is submersed in a water-sugar solution (power P_s)

   Ensure that the U-probe is dry before changing the liquid.
8. Calculate the attenuation for the U-shaped fibre in the case of submersion in water and in ethylalcohol according to the formula :

$$A = 10 \log \frac{P_0}{P_e}$$

Questions

1. How and why is the attenuation for water different from the one for ethylalcohol?
2. Why does the power of emittance decrease when the U-probe is submersed in liquid?
3. What is the relationship between the sensitivity of the U-probe and the value of the refraction index of the environment in which the sensor is submersed?

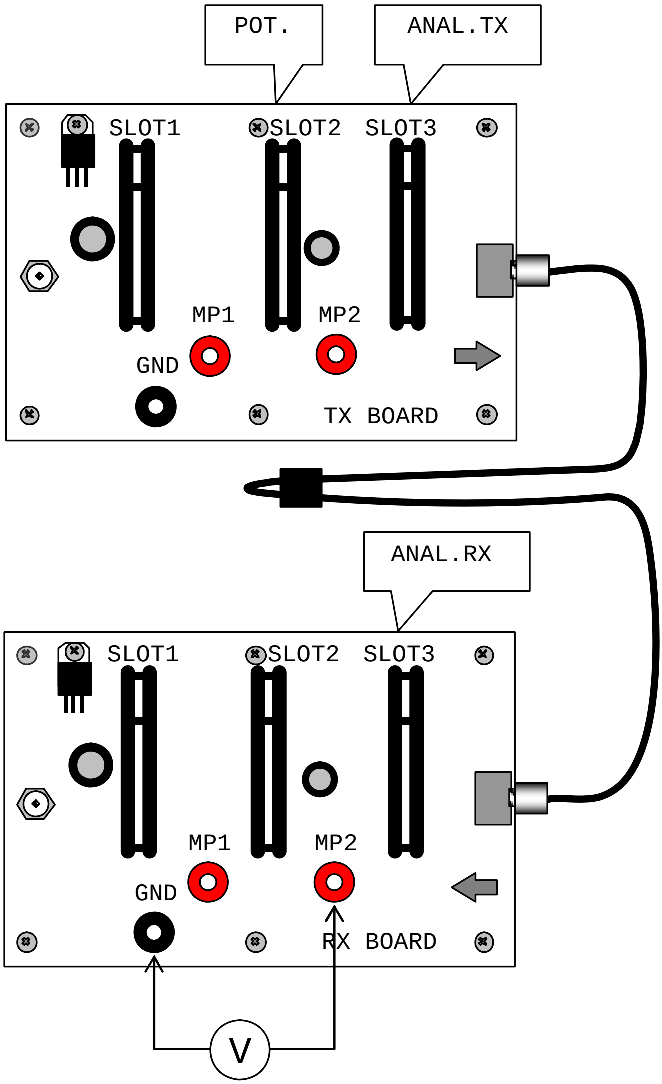

Figure 10 The set-up diagram of the U-probe experiment

Experiment No.6: Transmission sensor

Introduction

The transmission sensor facilitates detection of changes in the optical signal between two separate optical ends. Sometimes we refer to it as an optical gate. It is used as a counter of the amount of transferred objects, as a detector of speed and movement.

Objective

Demonstration of the principle of a transmission sensor.

Means

main transmitter panel, main receiver panel, analogue receiver, analogue transmitter, digital receiver, potentiometer, jacketed optical fibre, mechanical holder of the optical fibres with a calliper, Multimeter

Procedure

1. Insert the analogue transmitter into `Slot 3` and the potentiometer into `Slot 2` of the main transmitter panel (
2. Figure 11).
3. Insert the analogue receiver into `Slot 3` of the main receiver panel.
4. Connect the main transmitter panel to the main receiver panel by the optical fibres, the other ends of which are fitted into the mechanical holders of optical fibres which are in turn fitted into the calliper.
5. Connect the Multimeter to the main receiver panel; plug it into the ground (`GND`) and into the measuring point `MP2`.
6. Connect the power sources of both the main receiver and the main transmitter panels to the power.
7. Set the ends of fibres 5 mm apart in the mechanical holder and set the appropriate signal level by the potentiometer on the main transmitter panel.

8. Pass a diaphragm through the space between the separated ends of fibres while observing the change in the transferred power.
9. Switch off the power on the main receiver panel. Replace the analogue receiver in the main receiver panel with the digital receiver.
10. Set the signal level by the potentiometer of the main transmitter panel to get “zero” (the green diode lights) when the diaphragm is between the ends of the fibres, and to get “one” when the diaphragm is absent. By doing so we have set up a counter which records the number of objects passing through the space between the fibres.

Questions

1. In what manner could the transmission sensor be used for measuring speed, or alternate movement (the investigated object may be provided with ticks)?
2. How could the transmission sensor be used as a passing objects counter?

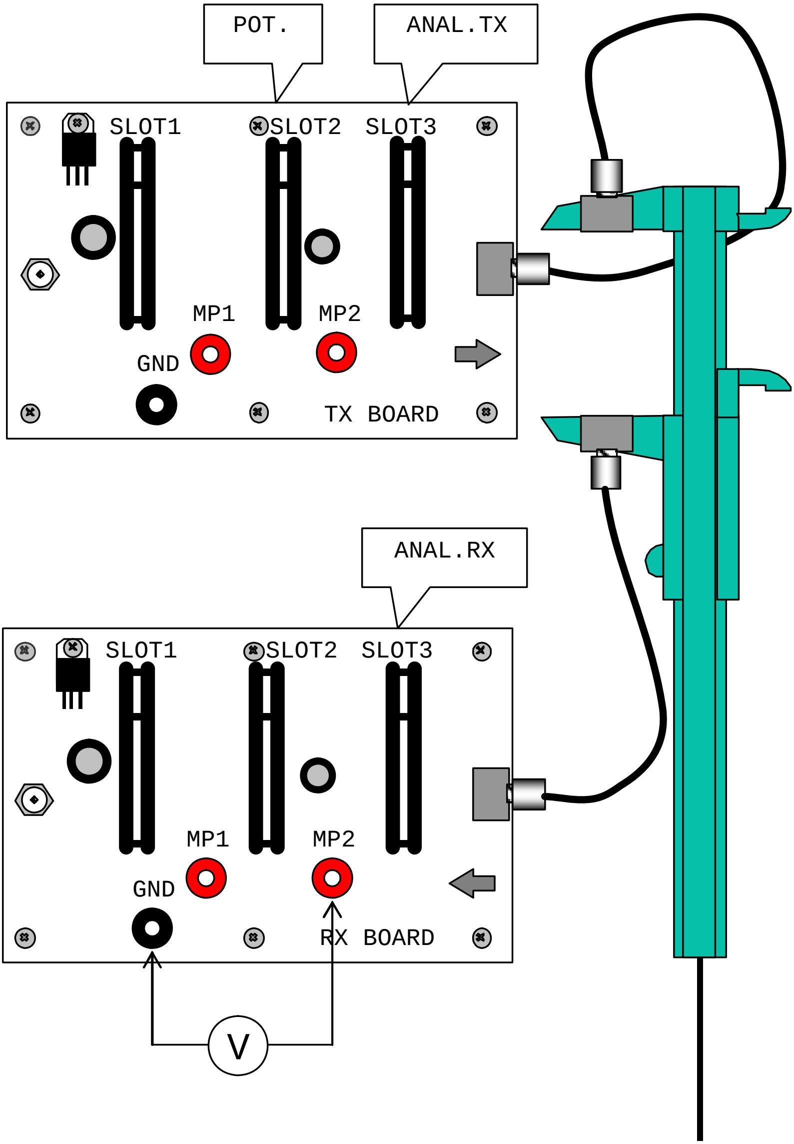

Figure 11 The set-up diagram of the transmission sensor.

Experiment No.7: Measurement of attenuation caused by an imperfect fibre-fibre bond

Introduction

The optical signal is attenuated along its entire path during the transfer. The losses which arise in the optical cable depend on the type of cable and on its length. The unit for evaluating losses in the cable is dB/m; it represents the attenuation of a 1 m long cable. Optical connectors and connections are additional sources of losses during transfer of an optical signal. When connecting optical cables, it is important that the axes of the fibres are aligned, and that the front sides fit each other well in longitudinal as well as latitudinal direction.

Objective

The demonstration of the influence of an insufficient fibre-fibre bond on attenuation, when increasing the separation of the fibres.

Equipment

Main transmitter panel, main receiver panel, analogue receiver, analogue transmitter, potentiometer, jacketed optical fibres, mechanical holder of the optical fibres with a calliper, Multimeter

Procedure

1. Insert the analogue transmitter into `Slot 3` and the potentiometer into `Slot 2` of the main transmitter panel (Figure 12).
2. Insert the analogue receiver into `Slot 3` of the main receiver panel.
3. Connect the main transmitter panel to the main receiver panel using the optical fibres, the other ends of which are fitted into the mechanical holders of optical fibres which are in turn fitted into the calliper.
4. Connect the Multimeter to the main receiver panel; plug it into the ground (`GND`) and into the measuring point `MP2`.
5. Connect the power sources of both the main receiver and the main transmitter panels to the power.

6. Position the ends of fibres fitted in the mechanical holder to a distance until you still have signal and set the appropriate signal level by the potentiometer on the main transmitter panel.
7. Gradually bring the fibres towards each other measuring the level of transferred power P_x at each 1 mm interval. Make an effort to prevent crosswise shift of the fibres during the measurement.
8. Denote the measured transferred power at zero separation of fibres as P_0.
9. Calculate the attenuation from the formula:

$$A = 10 \log \frac{P_0}{P_x}$$

10. Make a graph of the dependence of the transferred power on the distance between the ends of the fibres and the dependence of the attenuation on the same distance.

Questions

1. What are the main sources of attenuation during the transfer of an optical signal?
2. What is the contribution of an imperfect treatment of the fibre end to the losses?
3. Why do we need to bond fibres?

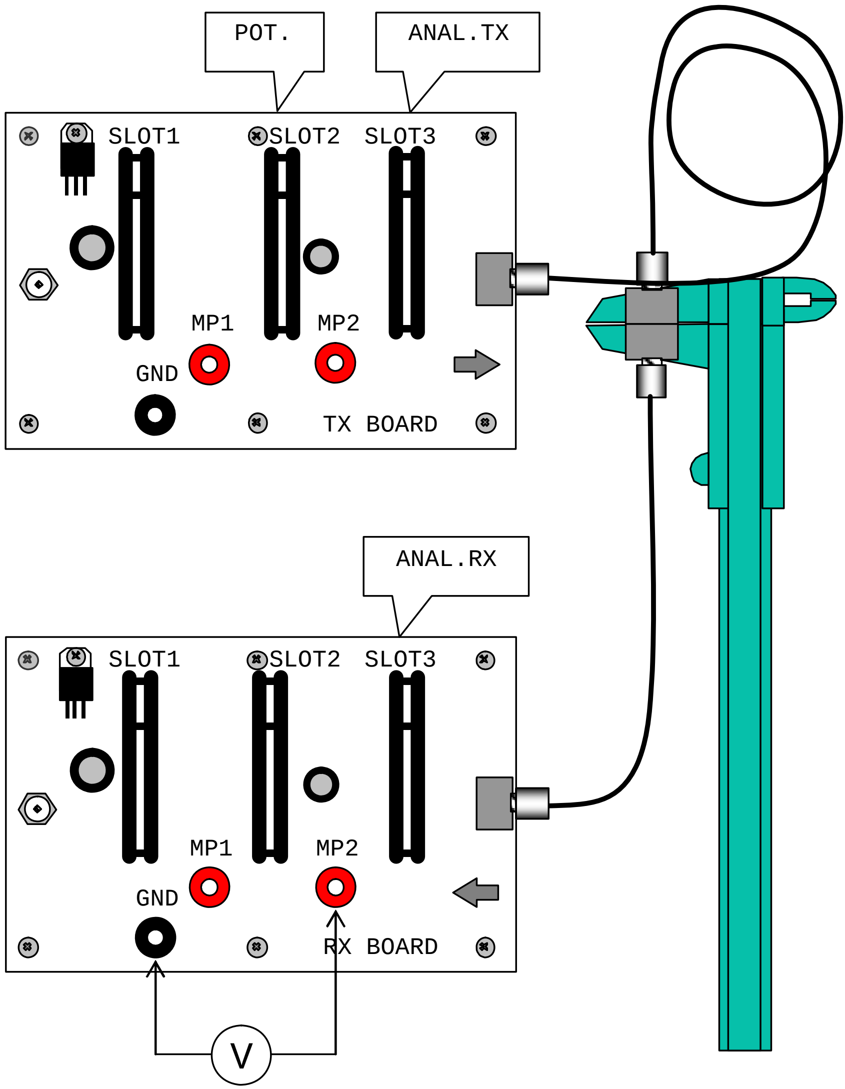

Figure 12: The set-up diagram of the measurement of attenuation caused by an imperfect fibre-fibre bond.

Experiment No. 8: Distance sensor

Introduction

In the previous experiment you verified the fact that the attenuation of a divided fibre depended on the distance between the two ends. This effect can be used in the construction of a distance sensor. A sensor of this kind could cause another device to turn on or off when the fibre ends reach a certain distance.

Objective

Demonstration of the distance detector principle.

Equipment

Main transmitter panel, main receiver panel, digital receiver, transmitter, module with the potentiometer, jacketed optical fibre, mechanical holder of the optical fibres with a calliper, Multimeter

Procedure

1. Insert the analogue transmitter into `Slot 3` and the potentiometer into `Slot 2` of the main transmitter panel (Figure 13).
2. Insert the digital receiver into `Slot 3` of the main receiver panel.
3. Connect the main transmitter panel with the main receiver panel by the optical fibres, the other ends of which are fitted into the mechanical holders of optical fibres which are in turn fitted into the calliper.
4. Connect the Multimeter to the main receiver panel; plug it into the ground (`GND`) and into the measuring point `MP2`.
5. Connect the power sources of both the main receiver and the main transmitter panels to the power.
6. Position the ends of fibres 10 mm apart in the mechanical holders.
7. Adjust the power on the transmitter side by the potentiometer so that the digital receiver shows “zero” (the green LED diode light shows)

for distances shorter than 10 mm and “one” (the green LED diode light does not show) for distances longer than 10 mm.

8. You have created a distance sensor, which is able to turn off or on another device in the event of the calliper arms approaching.

Questions

1. What is the practical use of distance sensor?
2. Try to calculate the most convenient switch distance of fibres in accordance with your previous measurement.

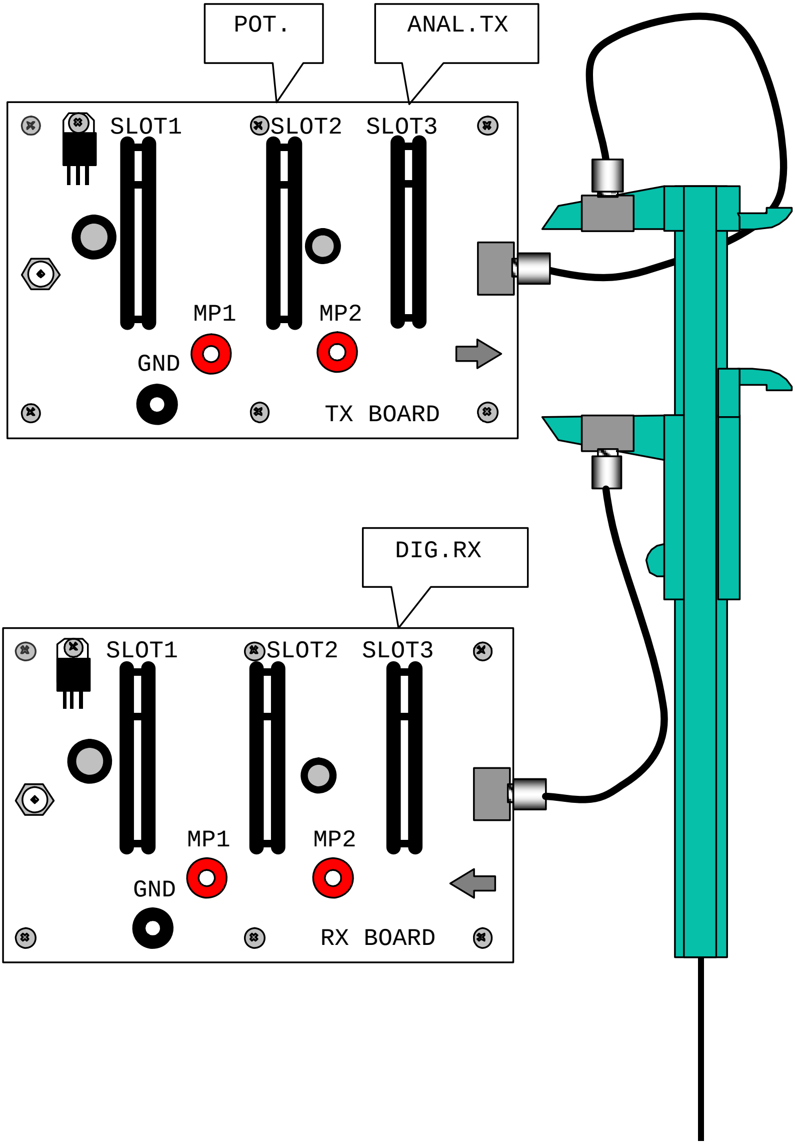

Figure 13: The setup diagram of a distance sensor.

Experiment No.9: The transfer of an audio signal (sound) by an optical cable

Introduction

Signals of frequencies within the range of 15 Hz to 20 kHz are audible to people and they are referred to as audio signals. In order to transfer sound via optical cable we must provide a microphone for the transformation of the audio signal into an electrical signal. This electrical signal is transformed further into an optical signal. After the signal is transferred via the optical cable, it is transformed in a receiver through the electrical signal back into sound using a speaker.

Objective

The demonstration of the principle of sound transfer by an optical fibre and the use of this principle in practise.

Equipment

Main transmitter panel, main receiver panel, analogue receiver, analogue transmitter, low frequency generator, microphone amplifier, potentiometer, optical fibre, oscilloscope*

Procedure

1. Insert the analogue transmitter into `Slot 3`, the potentiometer into `Slot 1`, and the low frequency generator into `Slot 2` of the main transmitter panel (Figure 14).
2. Insert the analogue receiver into `Slot 3` of the main receiver panel.
3. Connect the main transmitter pannel and main receiver pannel with optic fibre.

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* Not contained in this kit

4. Connect the input of the oscilloscope to `GND` and `MP 2` on the main receiver panel. (Set the sensitivity to 1 V/tick, set the time frame to approximately 2,5 ms/tick.)
5. Plug the power sources of both the main receiver and the main transmitter panels to the power.
6. Monitor the time variations of the signal coming from the receiver module on the oscilloscope.
7. By adjusting the potentiometer the range of output voltage can be determined. Set the signal to be in the middle of the linear range using the potentiometer.

Demonstration of the transfer of sound

1. Replace the low frequency generator with the microphone amplifier on the main transmitter panel.
2. Insert the low frequency amplifier into `Slot 2` on the main receiver panel.
3. Position both the set-ups as far as possible from each other to prevent acoustic feedback.
4. Set the volume (loudness) using the potentiometer on the `LF.AMP.` slightly below the level of the origin of the acoustic feedback (high-pitched sound).
5. The system is now ready to transfer acoustic signals (speech, music, ...).

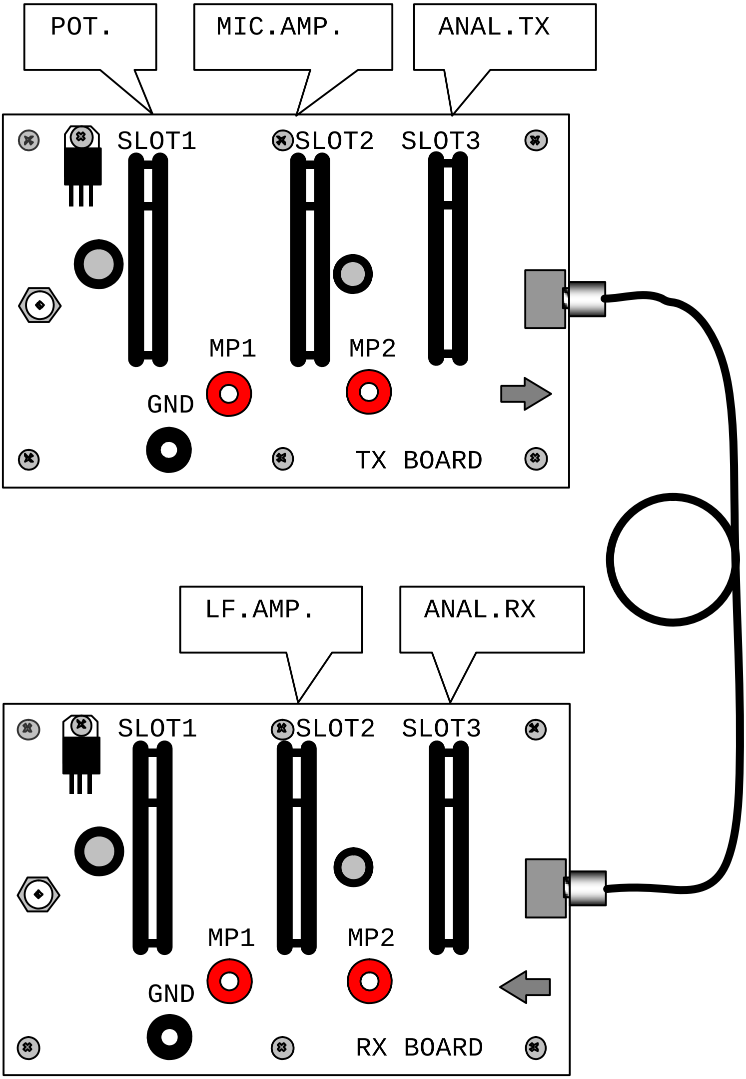

Figure 14 A set-up diagram of a device for sound transmission.

Experiment No.10: The transfer of digital signal by an optical fibre

Introduction

Optical fibres are a key component of modern communications network, largely because of the high speed of communications and virtually error-free transmission they offer. In many cases the data is in digital form already - such as the output from the readout system of a CD (compact disc) player or a network card. In order to transfer digital signal via optical cable we must provide a transformation further into an optical signal. After the signal is transferred via the optical cable, it is transformed in a receiver through the electrical signal back into digital signal. With the next experiment we will demonstrate how can be data transferred from one computer to another with the help of optical cable. For this experiment you will need two computers with CD-ROM and serial port. The experiment is using as asynchronous serial transmission through serial ports with no flow control.

Objective

Demonstration of digital communication by an optical fibre.

Equipment

Main transmitter panel, main receiver panel, digital receiver, digital transmitter, serial RxD, serial TxD, jacketed optical fibre, 2 data cables, CD-medium, 2 computers with serial (RS232) ports, CD-ROM and equipped with one of the following operating systems: Windows 9x/NT/2000/Xp

Setting up the hardware

1. Insert the digital transmitter into `Slot 3` and the serial TxD into `Slot 2` of the main transmitter panel. Set the switch on the digital transmitter to the left position (the black part should be further from the red diode, Figure 15).

2. Insert the digital receiver into `Slot 3` and the serial RxD into `Slot 2` of the main receiver panel.
3. Connect the main transmitter panel to the main receiver panel by using the jacketed optical fibre.
4. Connect the power sources of both the main receiver and the main transmitter panels to the power.
5. Adjust the trimmer on the digital receiver so that the receiver shows "zero" (the green LED diode light is off). Than start turning slowly the trimmer to the opposite position till the receiver shows "one" (the green LED diode light is on). Stop turning immediately after the diode flashes on. Repeat this step before you try higher connection speed.
6. With the data cabel connect the transmitter computer's serial port and the serial TxD modul. Make sure the cabel's jack conenctor is fitted properly to the modul.
7. With the data cabel connect the receiver computer's serial port and the serial RxD modul. Make sure the cabel's jack conenctor is fitted properly to the modul.

Setting up the software

1. Insert the installation CD to the transmitter computer and install the OptoSerial-TxD program.
2. Insert the installation CD to the receiver computer and install the OptoSerial-RxD program.
3. Run both programs on both computers from the desktop (Figure 16, Figure 17).
4. Select the first port in the OptoSerial-RxD program on the receiver computer, and press the connect button. If you receive "*Failed to open com port*" message in the connection status message box, then switch off the program*, run it again and choose a different port. Repeat the procedure till you receive message: "*Waiting for connection...*".

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* hint: you can switch off the program by pressing ESC

5. Select the first port in the OptoSerial-TxD program on the transmitter computer, and repeat the same procedure as was described before with the receiver computer. Repeat it till you receive a message saying: “*Ready to send*”.
6. Now check the receiver computer’s connection status, it should say: ”*Ready to receive*”.
7. Now check the OptoSerial-TxD program. Type in any text to the message edit field and press the send button.
8. Now check the OptoSerial-RxD program. You should see your message displayed in the received messages list box.
9. Try to change the transmission speed on both sides, and create new connection. Watch the flashing speed of red and green led diode.

Troubleshooting

1. If any of the programs reports “*Failed to open com port*“ message for all the com port’s check the serial port setup in the computers CMOS setup. If it is still not working try to close all running programs on the computer which could use the com ports.
2. If you can’t get ”*Ready to receive*” message on the receiver computer, try to adjust the trimmer on the digital receiver board. If this does not help, you can try to exchange the digital receiver and digital transmitter boards for analogue receiver and analogue transmitter board. Be sure to use a good prepared optical fibre. The transmissions voltage level measured in the measuring point MP2 on the main receiver board should not be lover than 1 V.
3. If you can not transmit data, check the transmission speed in the program. It must be the same on the transmissions and receivers side. Be sure to run and press the connect button on the receivers side first.

Questions

1. How is the asynchronous serial transmission working through serial ports?

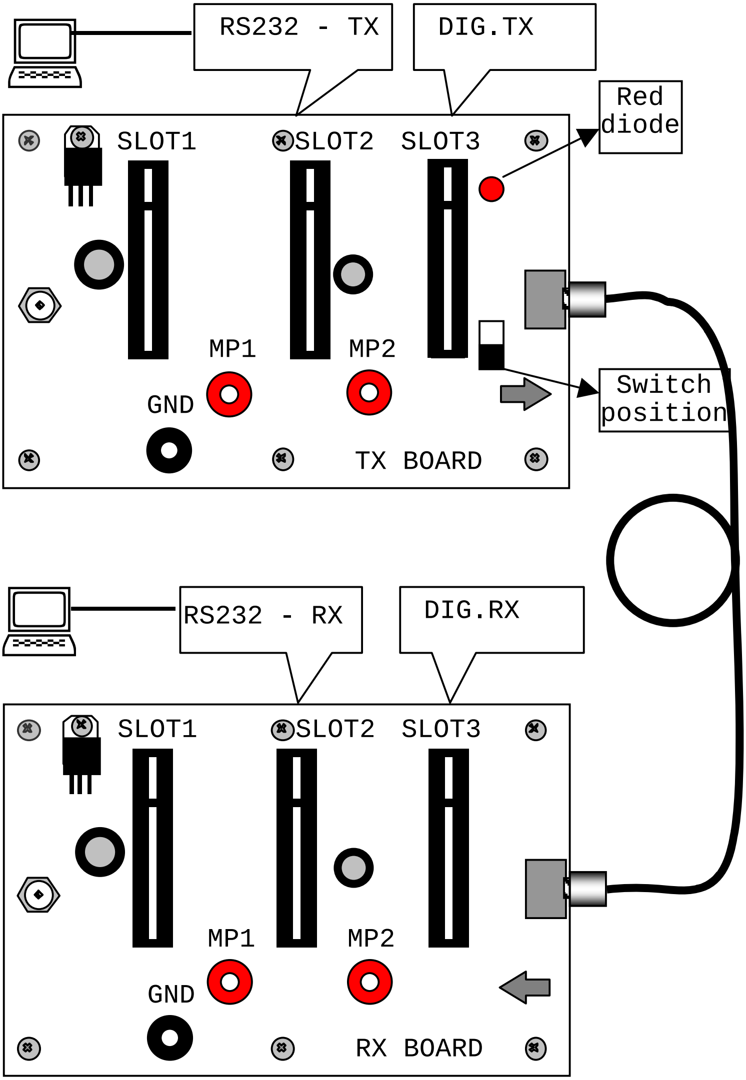

Figure 15: A set-up diagram of device for data transmission.

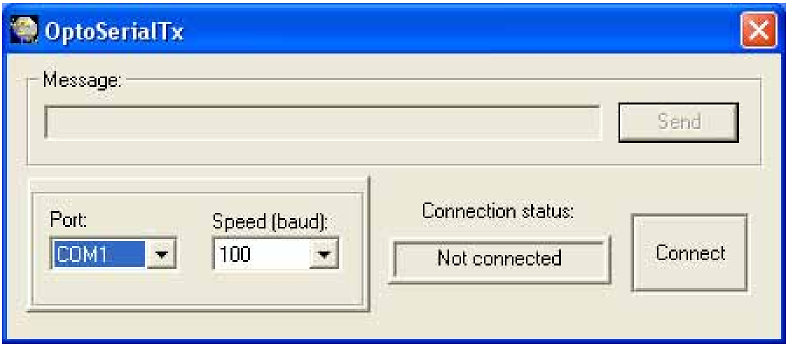

Figure 16: OptoSerial-TxD program (on the transmitter computer)

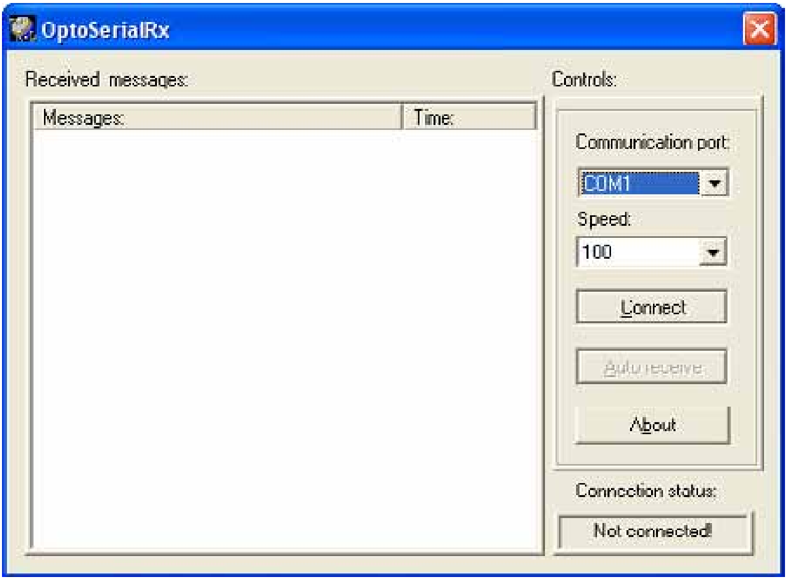

Figure 17: OptoSerial-RxD program (on the receiver computer)