The aim of this educational kit is to provide users a complete overview and comprehensive knowledge of a fiber optic field and familiarize them with fiber optic interferometry. The educational kit proposes characterization and study of features and behavior of basic types of interferometers like Michelson, Mach-Zehnder, Fabry-Perot and ring interferometer.

The training kit also enables observing of an optical interference, wavelength shift of a DFB laser diode, Doppler effect, measurement of a disk rotation speed and measurement of thermal expansion of a silica fiber.

Thanks to wide range of practical experiments the students can make complete investigation of the basics of interferometry in various applications. The modular presentation of the kit allows users to realize also many types of complex experiments.

**COMPONENTS INCLUDED:**

| 1 | DFB laser diode @ 1550 nm, 1 mW, modulation 1 MHz |
| 2 | Optical attenuators |
| 1 | Detector: InGaAs photodiode (BW > 10 MHz) |
| 1 | Fiber optic heater |
| 1 | Optical isolator |
| 1 | Fringe counter |
| 2 | Fiber optic couplers 2x2, 50/50 |
| 1 | Rotating disk for Doppler effect |
| 2 | Gold mirrored fiber ends |
| 8 | Patchcords E2000/APC Diamond connectors |
FIBER OPTIC INTERFEROMETRY
TRAINING KIT

USER MANUAL:
The educational kit is completed by the comprehensive and detailed training and teaching manual for theoretical and practical familiarization with a given topic.

Each manual is divided into two parts – theoretical and practical part. First part is focused on detailed description of a given topic and also includes necessary mathematical instrument for high level educated users. For better understanding of studied topic the support graphics are used in the manual. In the end of this part the theoretical exercises allow to users proving of their achieved knowledge.

The second part is devoted to practical utilization of the training kit through a number of experiments, which correspond to each of the topics of the theoretical part of the manual.

CONTENT OF THE MANUAL:

- **Theoretical part**
  - Optical fibers
  - Photodetectors – semiconductors
  - Semiconductors optical emitters
  - Interferometry
  - Tutorials
- **Practical part**
  - Practical experiments with results

THEORETICAL PART:

**Optical fibers**
In this chapter a few fundamental notions concerning optical fibers are given. After having briefly described an optical fiber, interpretation of guidance by geometrical optics is given. Then propagation in a step index and gradient fiber is analyzed. Then the two phenomena that limit the performance of an optical fiber is recalled, that is attenuation and dispersion. Finally the process of fiber fabrication is described.

**Photodetectors - semiconductors**
Firstly the nature of a material known as semiconductor is examined as well as the different modes of transport of the charges can be found in this chapter, concerning theoretical description of a photodetector. Than a look at physical mechanisms used in PN junction diode is given. Finally the two main types of optical detectors are described: PIN photodiode and APD photodiode.
FIBER OPTIC INTERFEROMETRY
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Semiconductor optical emitters
This chapter describes the main physics of semiconductor emitters (commonly called Light Emitting Diodes LED) which can emit near to the UV, the visible or the near infra-red (wavelength between 0.3 and 2 µm). However the manual is restricted to the spectral domain of the diodes destined to the optical fiber telecommunications industry, that is to say, those emitting around 0.85 µm, 1.3 µm and 1.55 µm, which are the three telecom bands of minimum absorption of optical fibers. This restriction doesn’t limit a description of the processes in optical light sources. A large part of this description is reserved for laser diodes, as these are imposed in the telecommunications industry due to the better quality parameters.

Interferometry
The final chapter of the theoretical part of the manual concerns a description of basic features of interference and interferometry. The conditions and general principles of the optical interference origination are explained to users, as well as principles of superposition of two or more monochromatic and polychromatic waves of different parameters and description of basic interfere devices are provided. A large part of this chapter is devoted to characterization of properties and a principle of operation of various types of interferometers, like Fabry-Perot, Mach-Zehnder, Michelson, etc. Final part concerns a description of Doppler effect and an implementation of this effect in practice.

THEORETICAL EXERCISES:

The end of the theoretical part of the manual is devoted to exercising of the above mentioned chapters. Simple and complex exercises are used for this purpose. The structure of each of the theoretical exercises provides the better understanding of a given topic.

Structure of the theoretical exercises:
• Exercise task
• Exercise questions
• Theoretical basics
• Exercises results:
  o Calculated results
  o Graphical output, if is requested
  o Answers to asked questions

List of the topics of the theoretical exercises:

Optical fibers
  Number of modes
  Bandwidth of a singlemode fiber
  Optical loss budget
  Dispersion in a multimode optical fiber
  Dispersion in a singlemode optical fiber
Passive components
- Isolator depending on polarization
- Polarization insensitive isolator

Semiconductors
- Electrical field and potential at the interface of a PN junction
- Profile of the mobile charges densities and of the currents along a polarized PN junction
- Amplification factor in an avalanche photodiode

Laser diodes
- Yield of a laser diode

Interferometry
- Basics of interferometry
- Lloyd’s mirror
- Amplitude division interferometer: Michelson interferometer

PRACTICAL PART:

The second part is devoted to practical utilization of the training kit through the experiments, which correspond to each of the topics of the theoretical part of the manual. Thanks user manual, optical patchcords and components of given training kit is allowed to users realize various setups, configurations and measurements. Thereby users can prove their achieved knowledge by study of the theoretical part of the manual.

User is not limited only to experiments recommended in the corresponding manual of training kit, but can interconnect components from different educational kits. User is able to assemble and test complex experiments that way.

Each practical experiment includes the complete list of results and measurements for proving of the correctness of measured and calculated data. These results allows to users, or supervisor, to show up possible mistakes of setup, interconnection or defective component very easily and quickly.

Structure of the practical experiments:
- Experiment task, arrangement
- Aims of the experiment
- Summary of the theoretical basics
- Component adjustment, operation
- Experiment results:
  - Measured and calculated results
  - Graphical output, if is requested
  - Conclusion and experiment evaluation

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List of practical experiments

1. Measurement of attenuator parameters
   The experiment provides to users possibility to measure the attenuation coefficient of the fibered attenuators. It also shows if the attenuators are symmetric or not.

2. Measurement of optical isolator parameters
   Users can measure the basic features of optical isolator.

3. Measurement of optical coupler parameters
   Experiment is focused on measurement of the coupling coefficient, the insertion losses and the coupler’s directivity and shows that the couplers are symmetric.

4. Characterization of a laser diode and a photodetector
   The goal of this experiment is to measure the characteristics of DFB laser diode emitting at 1.55 \( \mu \text{m} \), to analyze the spectrum of DFB laser diode and to estimate the sensitivity of the detector.

5. Measurement of thermal dilatation
   The experiment concerns study and comparison the Michelson, Mach-Zehnder, Fabry-Perot and ring fiber interferometers. Also the measurement of the thermal dilatation of SMF-28 optical fiber is required.

6. Wavelength shift of a laser diode
   The aim of this experiment is to measure the wavelength shift of DFB laser source, the response of a semiconductor laser to a modulation of its optical frequency.

7. Measurement of velocity by the Doppler effect
   The task of this experiment is a study of Doppler effect and its implementation for measurement of speed of a rotating disk.