

Photonics

5c Fiber optic refractometer



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Content

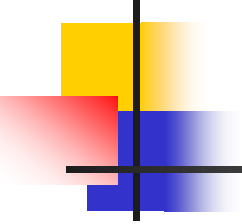
- Introduction
- Web-Controlled Fiber Optic Refractometer
- Web-Controlled Fiber Optic Connection Test Bench
- Experiments and Results
- Conclusions



1. Introduction

- **Virtual Laboratories**

- Creating a Virtual laboratory
- Creating a Web-controlled laboratory equipment

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- **Traditional solutions:**
 - **Web-based courseware**
 - **Virtual laboratories (CAD, CAE multimedia package)**
 - **Good learning in engineering**
 - **Mixture of theoretical and/or simulation**
 - **Practical experiments**
 - **Photonics**
 - **Expensive instruments**
 - **Limited time resources**



2. Applied Photonics courseware

- **CAD and CAE analysis tools**
- **Multimedia GUI design**
 - **System supervisor GUI**
 - **Teacher (tutor, supervisor) GUI**
 - **Student GUI**
 - **Browser GUI**



3. System architecture design

- **Hardware structure**

- Remote Users
- Internet Server
- Laboratory Multimedia PC
- Photonics Equipment

- **Software structure**

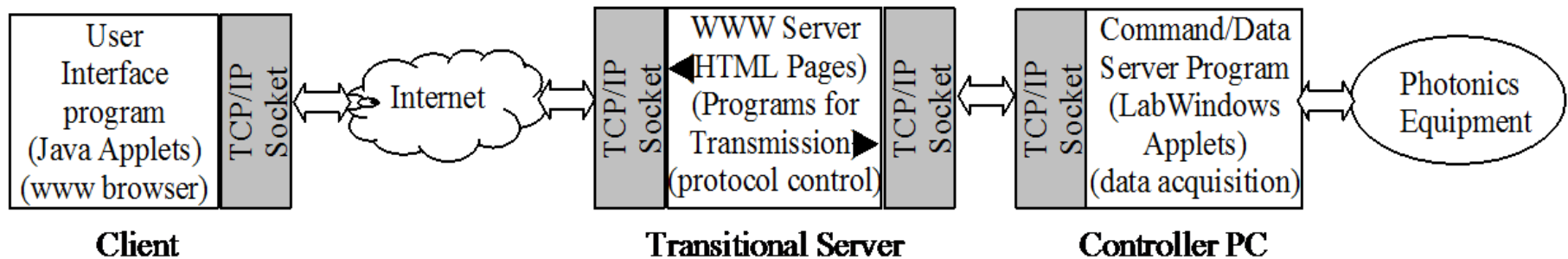
- Client (Java Applets)
- Transitional Server (HTML Pages)
- Controller PC (LabWindows Applets)

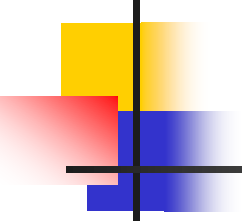
Web-controlled laboratory architecture

A) Hardware Structure

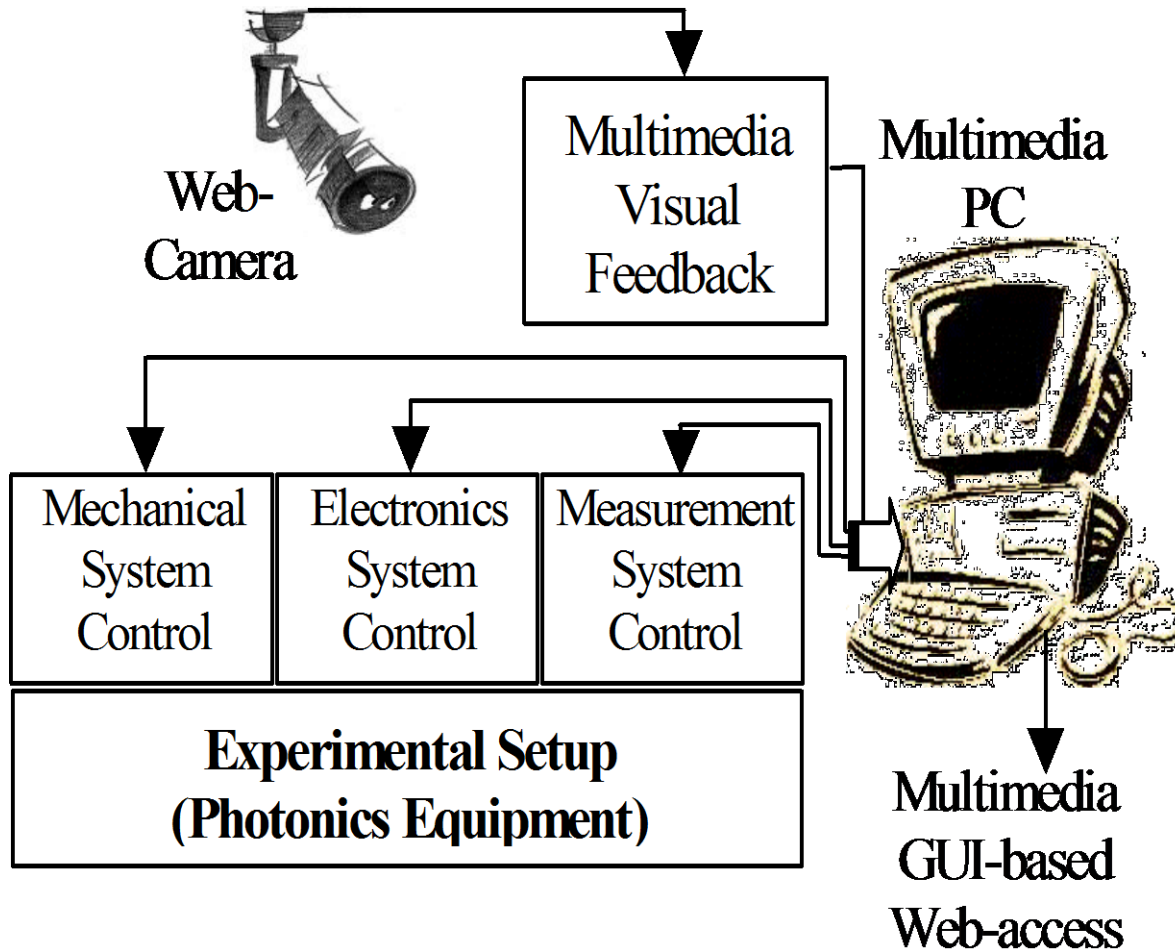


B) Software Structure



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- **Present state – two equipments**
 - **Fiber Optic Refractometer**
 - **Optical Fiber Connection Test Bench**
 - **Experimental set-up is controlled through three data acquisition systems**
 - **Mechanical**
 - **Electronics**
 - **Measurement**

Web-based multimedia laboratory module





4. Web-Controlled Fiber Optic Refractometer

■ Refractometers

(liquid refractive index measurements)

- Prismatic elements
- Linear photodetector array
- **Fiber optic**

■ Fiber Optic Refractometer

- **Basic**
- **Differential**



■ Refractometer applications

- Medical
- Pharmaceutical
- Industrial fluid
- Chemical, petrochemical
- Plastic
- Food
- Etc...

□ Measurement

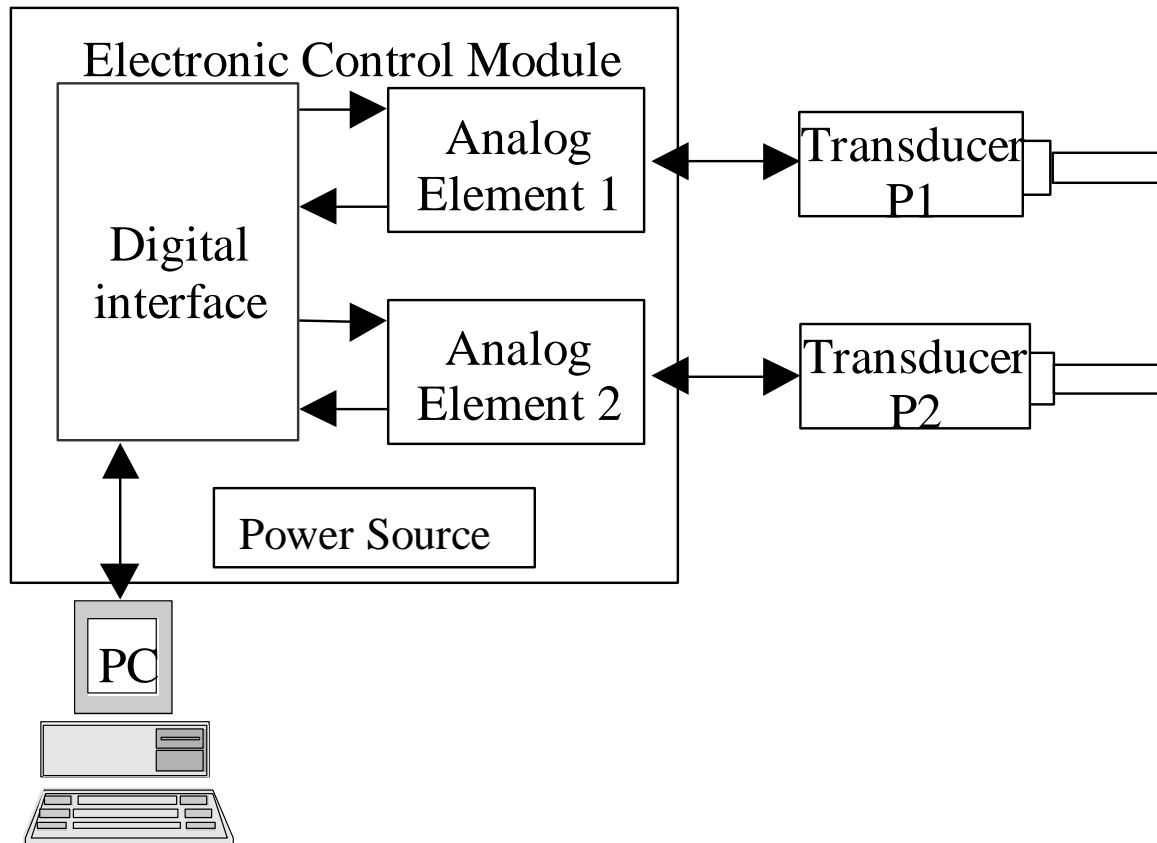
- Concentration of aqueous solutions
- Sugar in fruits, soft drinks, syrups
- Salinity of aquariums, food products
- Freezing point of coolants
- Charge status of acid batteries
- Serum protein
- Urine specific gravity



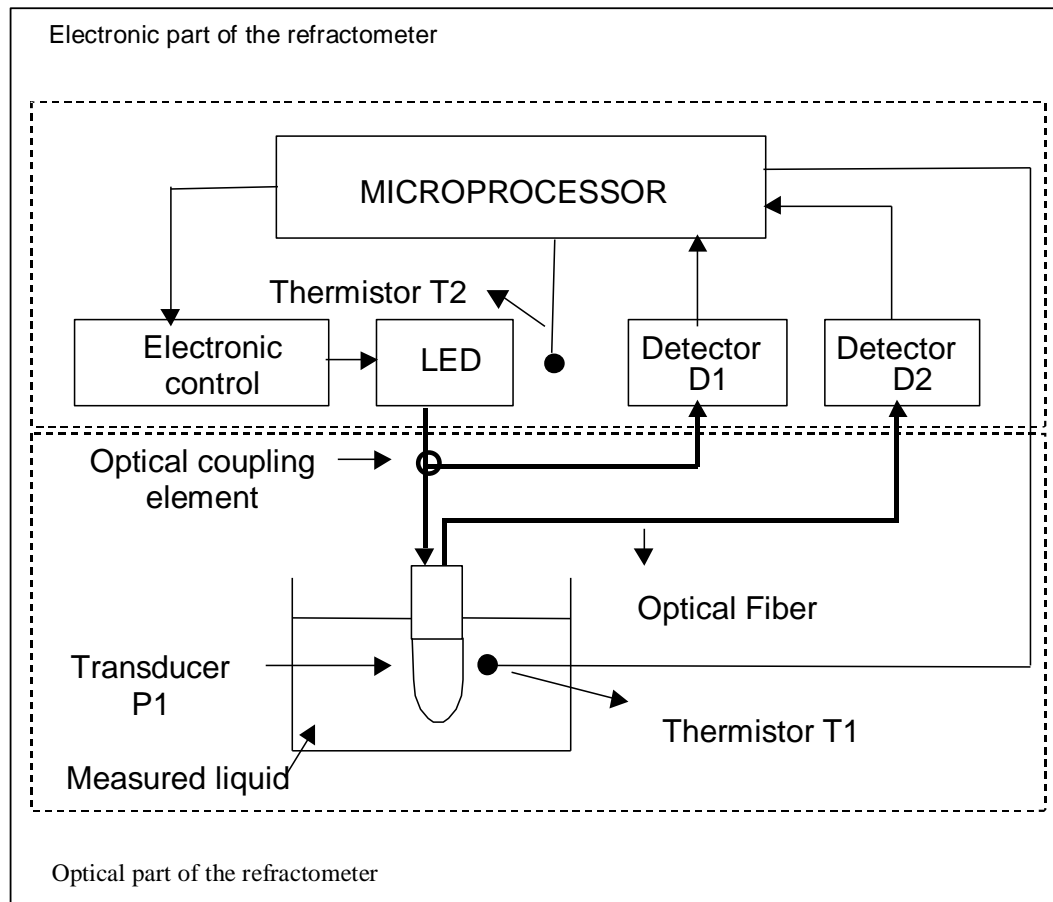
Fiber optic refractometer basic parameters

- **Index of refraction 1,3 – 1,6**
- **Change in refractive index of the order 5 to 10**
- **Catheter type probe – diameter 5 – 1 mm, or 250 – 300 μm**
- **Extremely rugged transducer elements**
- **Small probe type**
 - **inserted on top of containers or in flow line**
- **Smart data acquisition**
- **Versatile sensory systems**

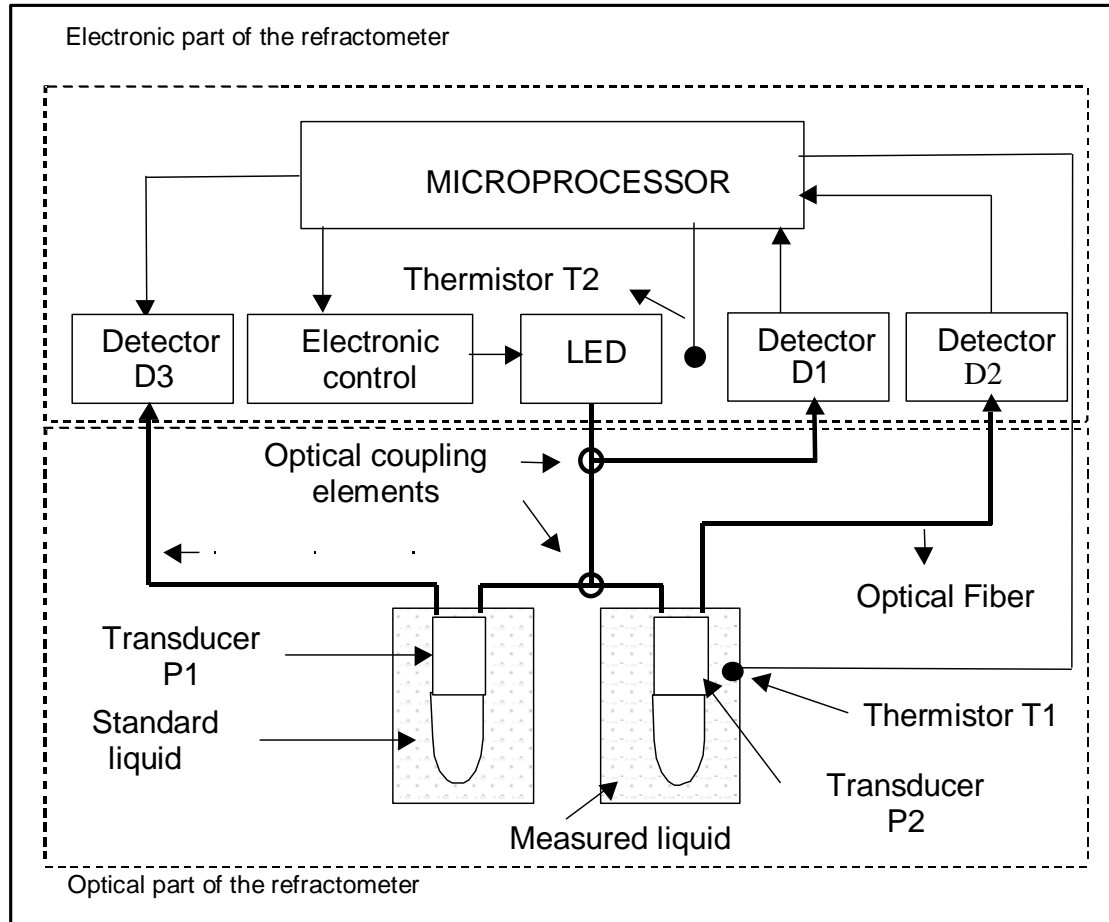
Fiber Optic Refractometer



Basic fiber optic refractometer



Differential fiber optic refractometer

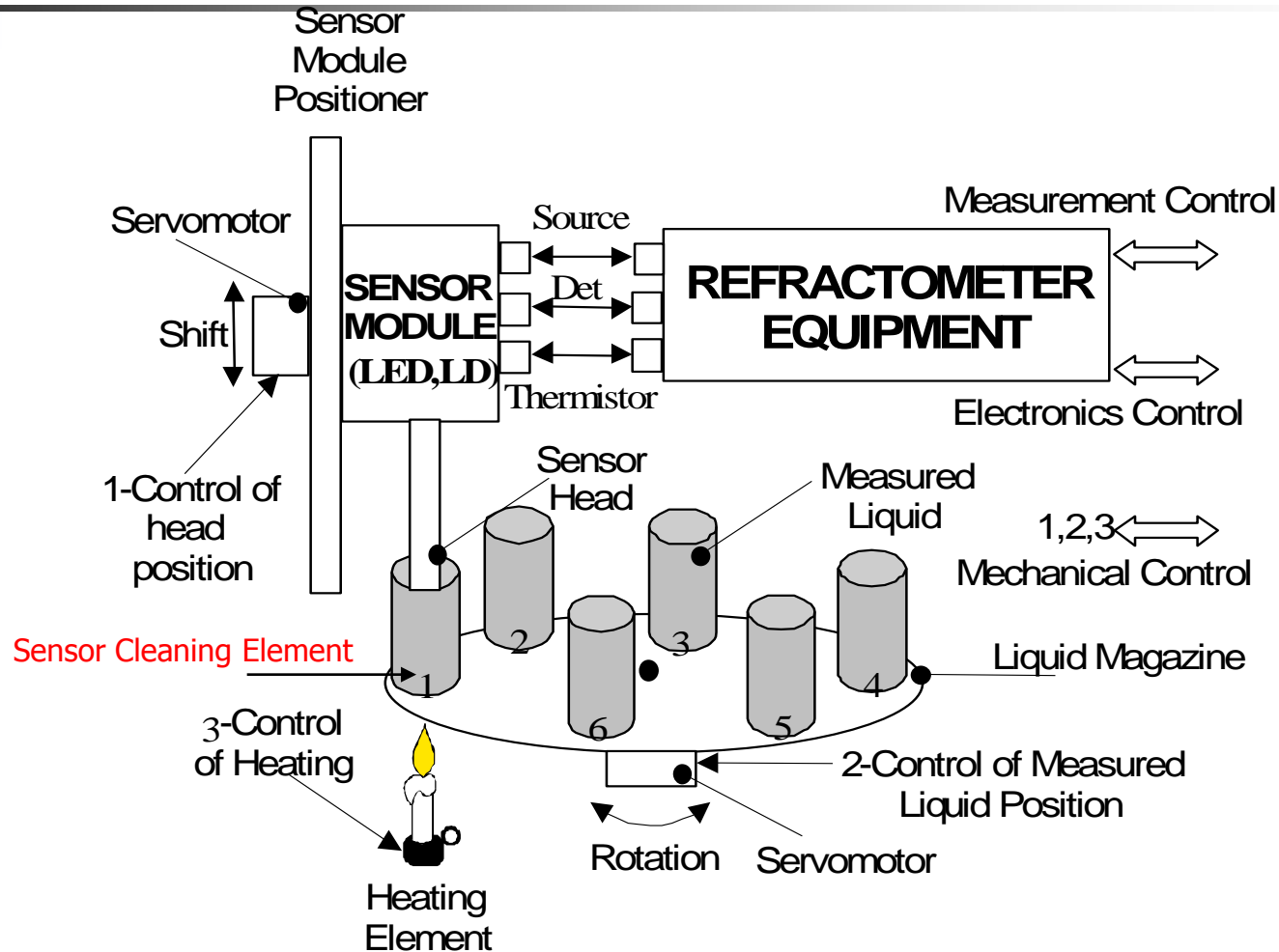




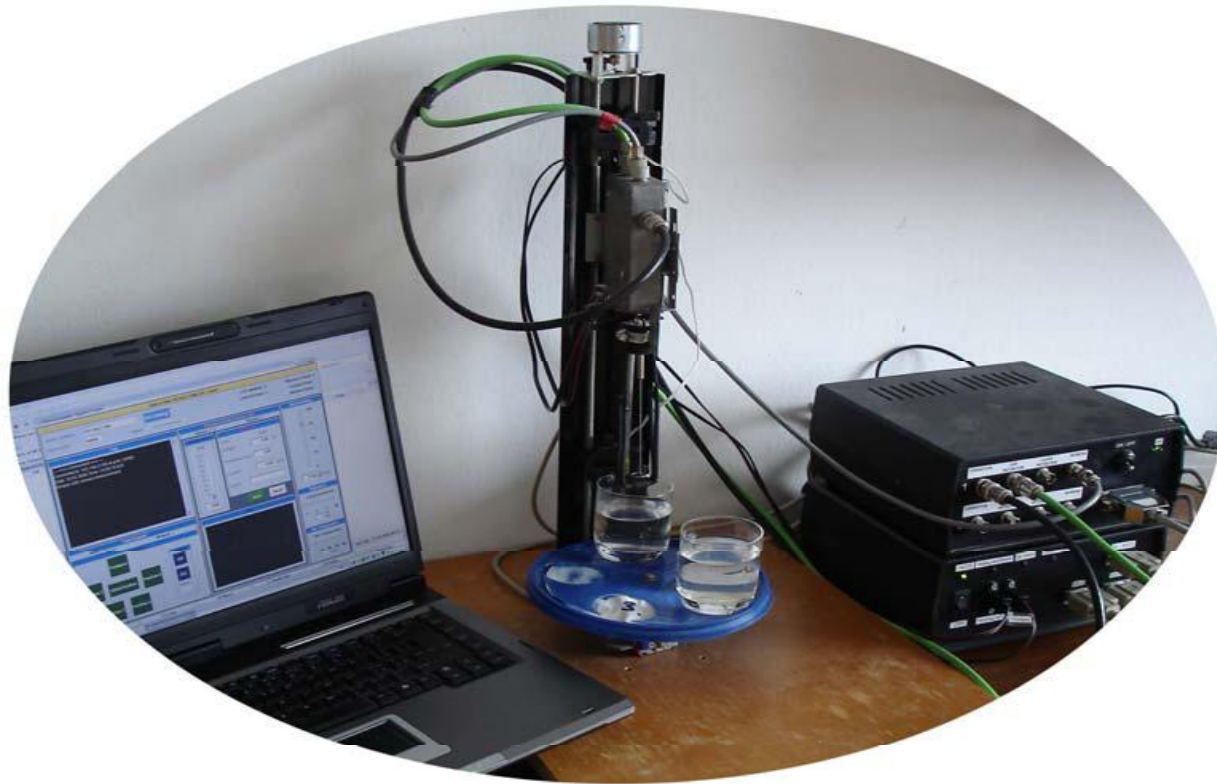
■ **Web-Controlled Fiber Optic Refractometer**

- **Sensor Module**
- **Sensor Module Positioner**
- **Liquid Magazine:**
 - **Rotation**
 - **Heating**
 - **Cleaning**
- **Refractometer Equipment**
- **Visual Interface (Camera Feedback)**
- **Base Multimedia PC (Digital Interface)**
- **Server**
- **User PCs**

Interactive web-controlled fiber optic refractometer instrument



Web-based multimedia laboratory system

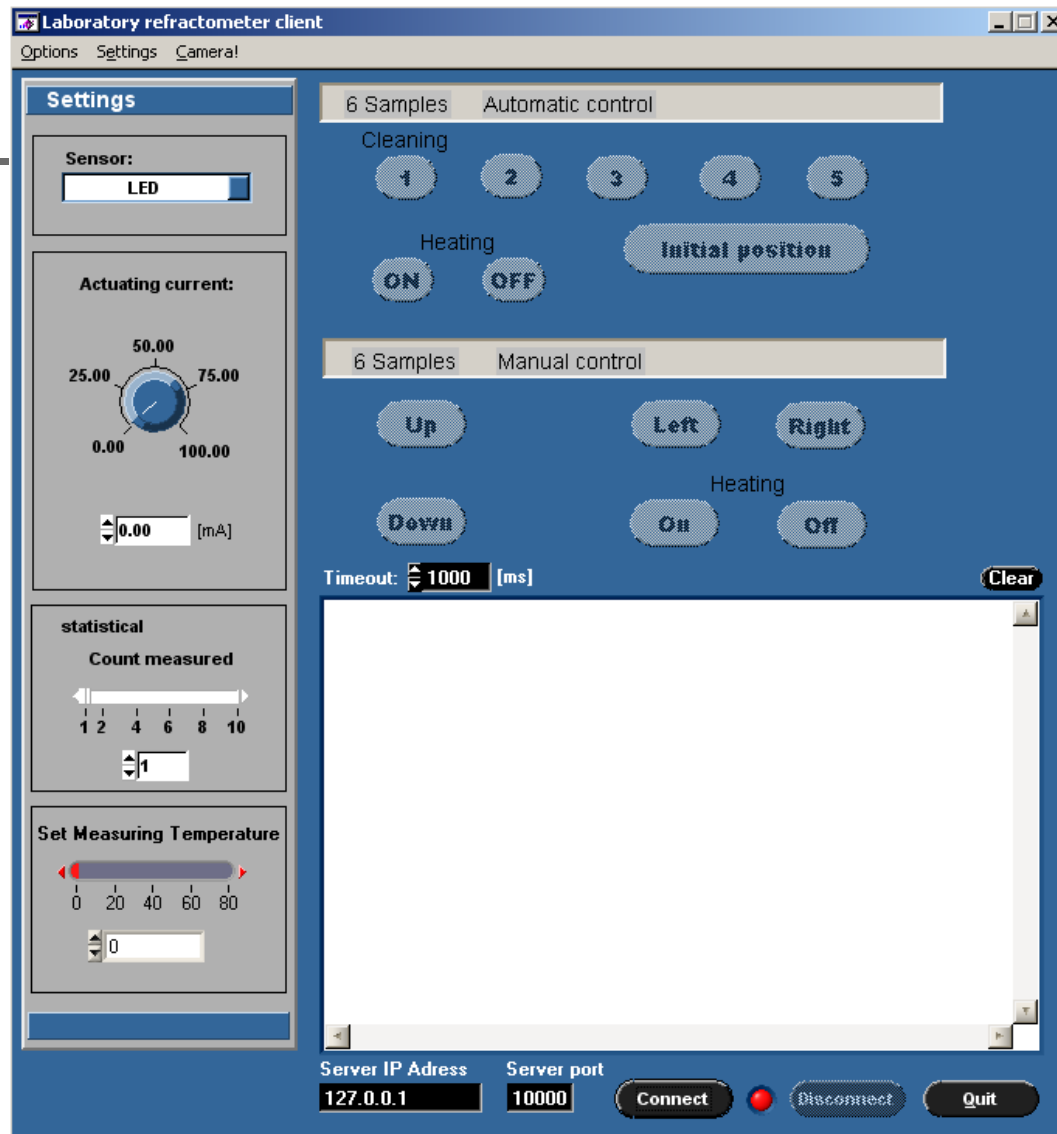




- **Developed multimedia GUI**

- **Control the various parts of the instrument**
- **Support control remote measurements using standard Internet Protocol (TCP/IP) procedures through WWW browser**
- **Control and monitor refractive index of various liquids**
- **Measurement of dependence of refractive index on temperature**
- **Measurement of dependence of refractive index on concentration**
- **Liquid type determination**

Basic control window of the refractometer



WWW control window of the refractometer

The image displays the 'Laboratory refractometer' software interface and its physical implementation. The software window, titled 'Laboratory refractometer', features a menu bar with 'Options', 'Settings', and 'WWW'. The 'Settings' panel includes a 'Sensor:' dropdown menu set to 'LED', an 'LPT port:' dropdown menu set to '0x378 (LPT1)', and an 'Actuating current:' section with a circular gauge ranging from 0.00 to 100.00 mA and a digital display showing 0.00 mA. Below this is a 'statistical' section with a 'Count measured' slider set to 1. The 'Options' panel is currently empty. A 'Quit' button is located at the bottom of the window.

The photograph shows the physical setup on a wooden desk. A computer monitor displays the software interface. To the left of the monitor, a black power supply unit and a black interface box are connected to the refractometer. The refractometer itself is a vertical black metal stand with a glass cell at the top, supported by a blue base with three red cylindrical weights. A white webcam is mounted on top of the monitor. A keyboard and a blue speaker are also visible on the desk. A poster is pinned to the wall behind the desk.

Window of the camera client and VLC media player



Main control window of the fiber optic refractometer (Measurements)

Optický vláknový REFRAKTOMETER - Klient

Adresa servera: Rozpojit' okno Protokol Spojenia okno Ovládanie
Port servera: Stav: **Spojené** Zvoľ metódu: **Testovanie**

Testovanie

Záznam

```
04-02-2006 17:12:59 Senzor 1
Teplota: 20.761036 Napätie: 5.611031
Nameraný prúd: 48.387258 Budiaci prúd: 57.000005
Optický výkon: 0.646547

-----

04-02-2006 17:12:59 Senzor 1
Teplota: 20.772923 Napätie: 5.617020
Nameraný prúd: 48.355090 Budiaci prúd: 58.000005
Optický výkon: 0.880480

-----

04-02-2006 17:13:00 Senzor 1
Teplota: 20.755142 Napätie: 6.916443
Nameraný prúd: 68.681729 Budiaci prúd: 59.000005
Optický výkon: 0.710866
```

1 / 251 251 modified Clear

Teplota

Senzor 1 [°C] Senzor 2 [°C]

20.76 0.00

Typ

Typ testovania:
Optický výkon / Prúd

Nastavenie

Prúd: [mA]
krok: [mA]

Prúd

Senzor 1 [mA] Senzor 2 [mA]
58.68 0.00

Budiaci prúd

100
75
50
25
0

[mA]

Graf - Optický výkon / Prúd

Optický výkon

Prúd [mA]

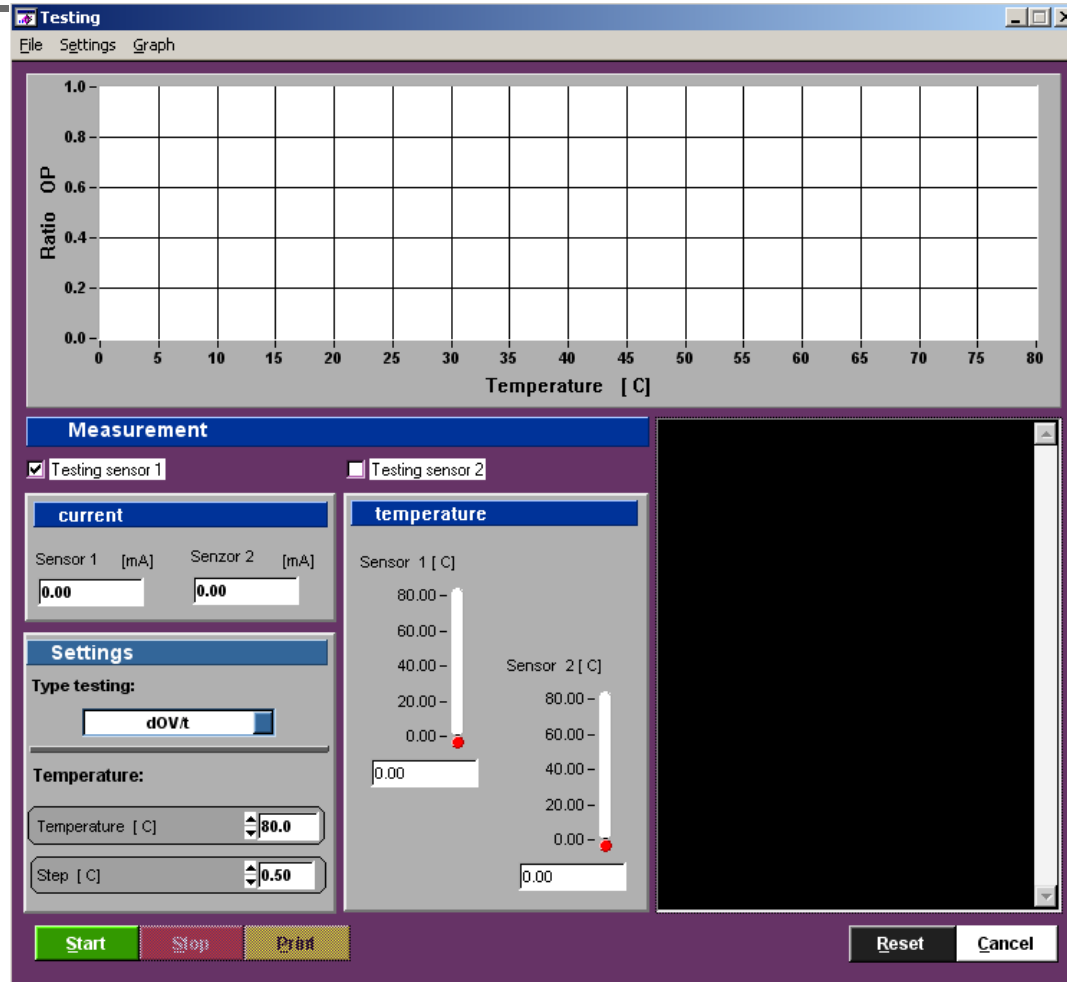
Riadiaci Panel

Zvoľ Senzor:
Senzor 1

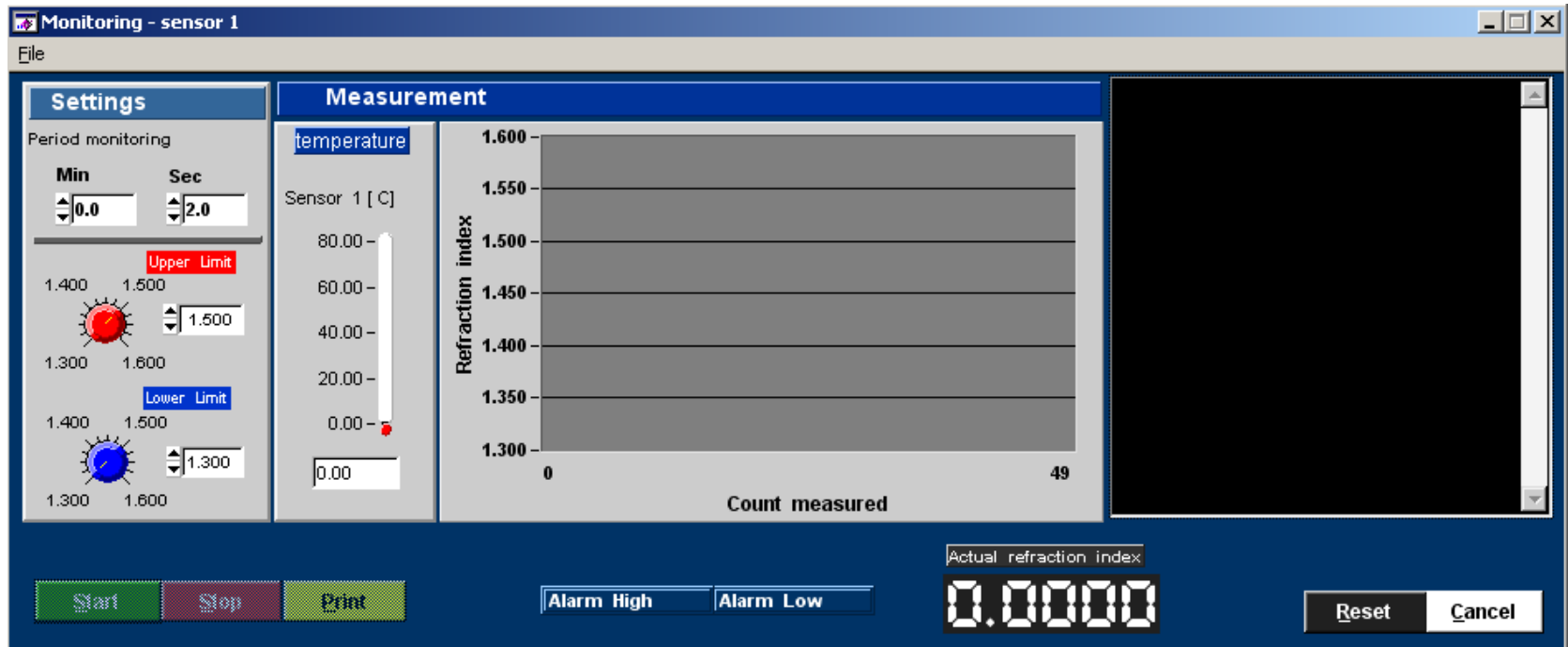
Start **Stop**

Reset

Main control window of the fiber optic refractometer (Testing)



Main control window of the fiber optic refractometer (Monitoring)



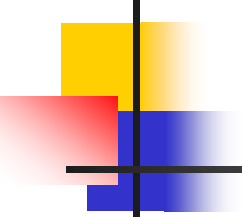
5. Web-Controlled Fiber Optic Connection Test Bench



Optical fiber links – requirement for jointing transmission medium - Fiber

Fiber – fiber connections

- **Fiber splices**
- **Fiber connectors**

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- Optical loss caused by **two phenomena**
 - **Fresnel reflection**
 - **Misalignment of the jointed fibers**
 - Equipment can measure misalignment introduced fiber joint insertion loss for
 - Various separation between the fibers (longitudinal misalignment)
 - Offset perpendicular to the fiber core axes (lateral / radial / axial misalignment)
 - Angle between the core axes (angular misalignment)



- **Optical losses depend upon**

- **Fiber type**

- **Core diameter**

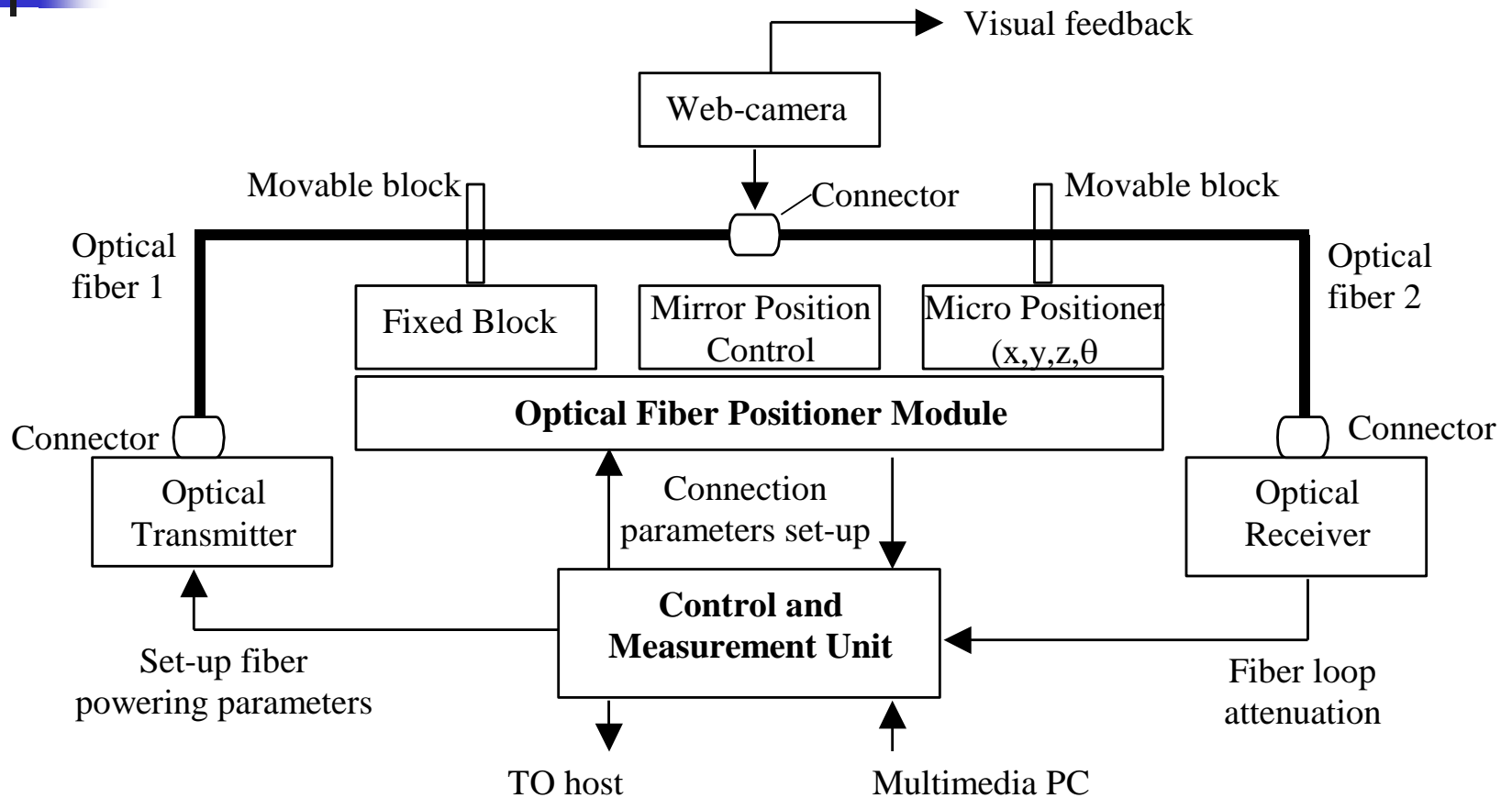
- **Optical wavelength and the distribution of the optical power between the propagation modes**

- **Present experimental set-up:** the fiber type, core diameter and used optical wavelength are fixed

- Developed instrument use simple **plastic step index multimode optical fiber** with large numerical aperture

- Visual feedback: using simple web-camera used for control of fiber positions in two perpendicular planes

Interactive web-controlled fiber optic connection test bench





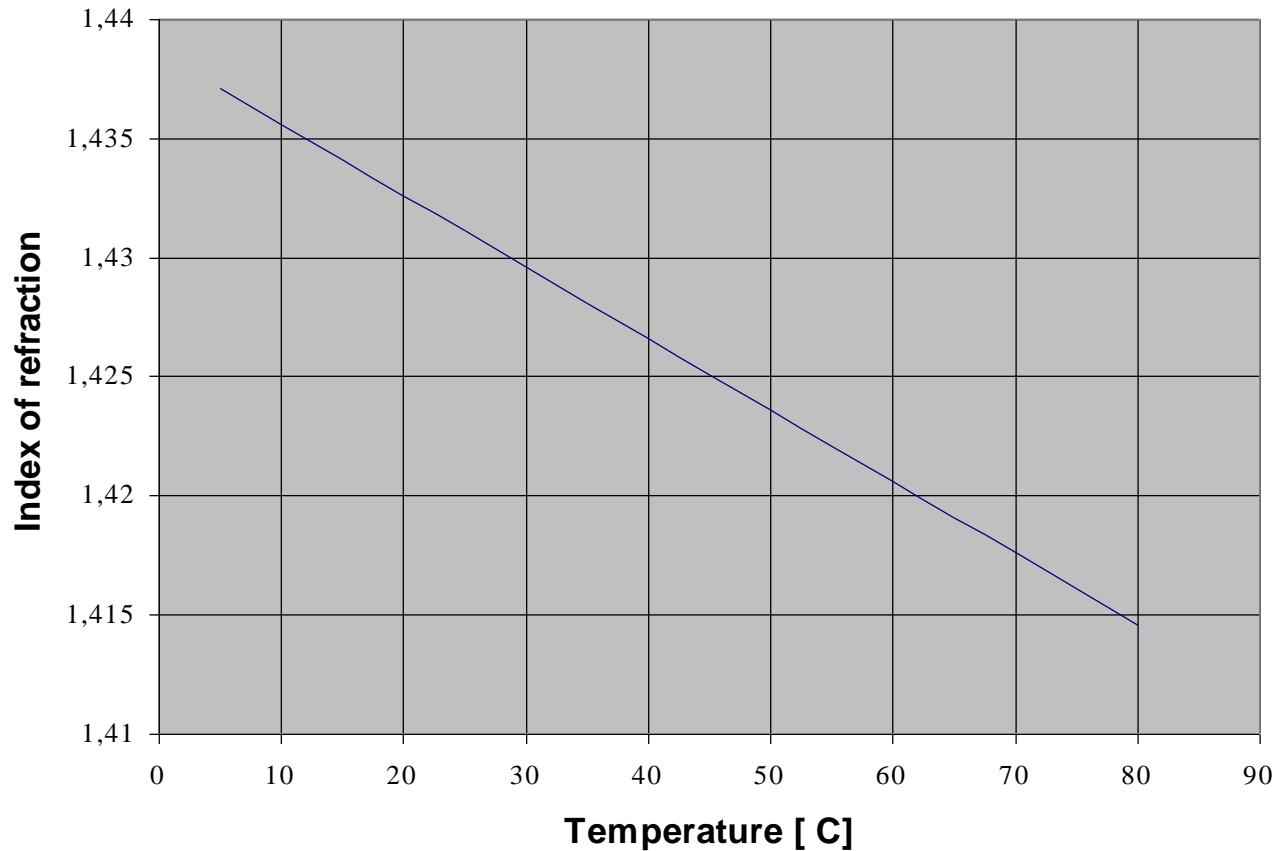
6. Experiments and Results

■ **Basic Laboratory Experiments**

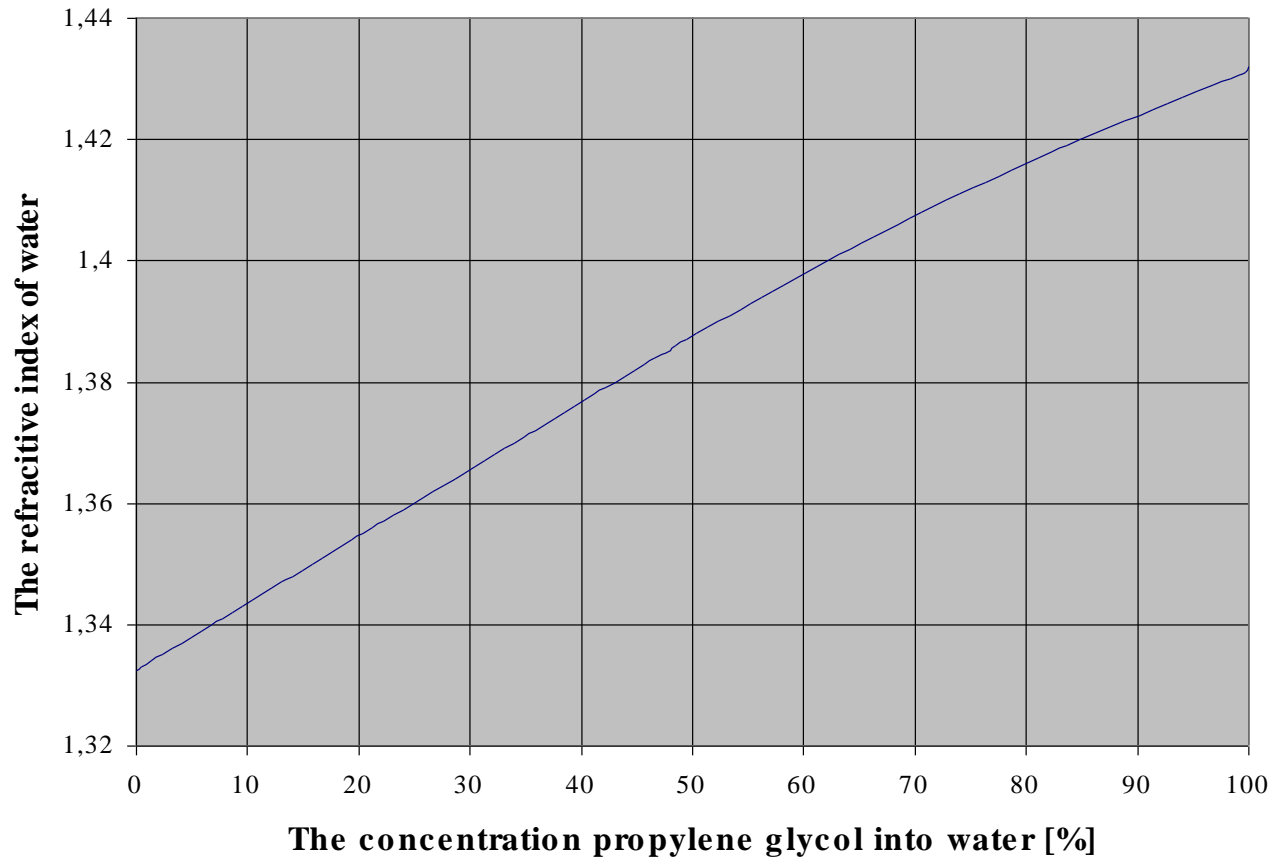
- Dependence of refractive index of propylene glycol and water on temperature
 - dn/dt for water in the range 15 to 30°C is 0.0001 per degree °C
 - dn/dt for propylene glycol is 0.0003 per degree °C
- Dependence of refractive index of water propylene glycol solution on propylene concentration
 - for glycol/water solutions one could assume a linear dependence of dn/dt , that is, for example assume $dn/dt = 0.0002$ for a 50% solution

■ **Measurements of petrochemical products**

Refractive index of propylene glycol vs. temperature (°C)



Refractive index of water vs. propylene glycol concentration





Result of petrochemical products measurements

| Petrochemical products | Refractive index | Temperature (°C) |
|------------------------|------------------|------------------|
| Water | 1.3333 | 21 |
| Synthetic alcohol | 1.3620 | 21 |
| Propylen glycol | 1.4268 | 21 |
| Mobil VS-200 | 1.4399 | 21 |
| Mobil motor 5W-50 | 1.4678 | 21 |
| Oil drive | 1.4757 | 21 |
| Madit drive | 1.4828 | 21 |

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