Photonics
5c Fiber optic refractometer

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- 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

- **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

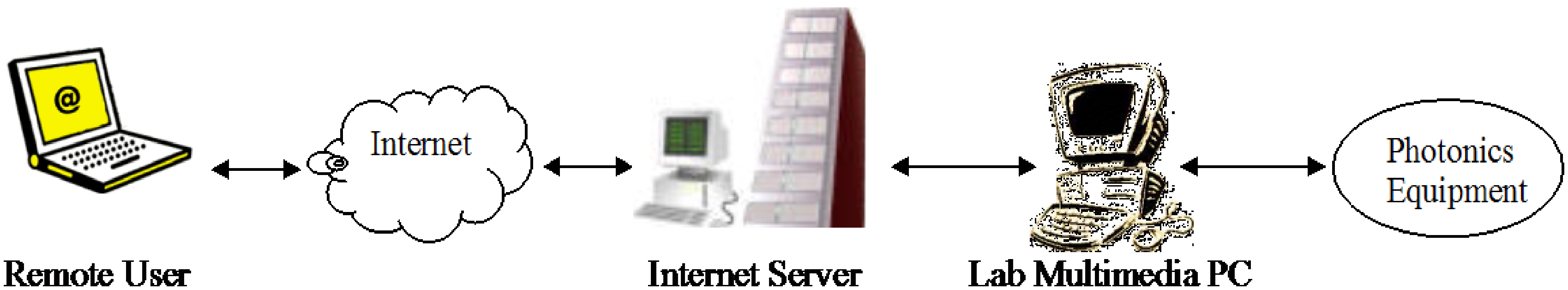
- **CAD and CAE analysis tools**
- **Multimedia GUI design**
  - **System supervisor GUI**
  - **Teacher (tutor, supervisor) GUI**
  - **Student GUI**
  - **Browser GUI**

3. System architecture design

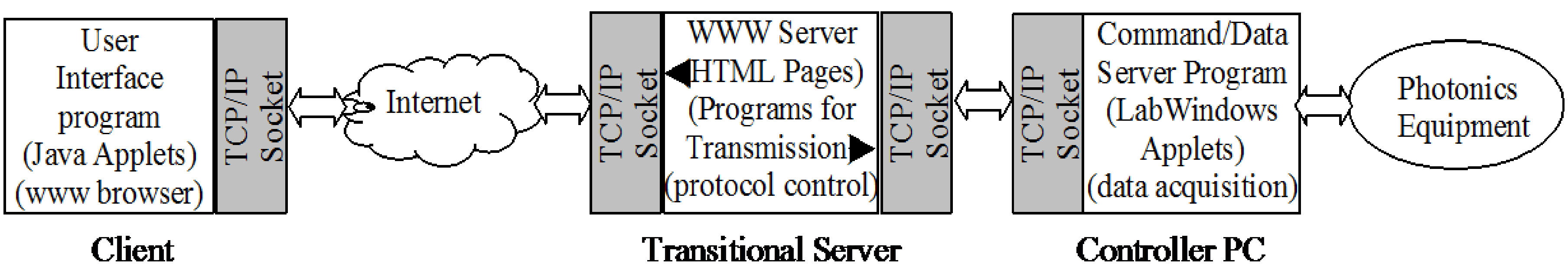
- **Hardware structure**
  - **Remote Users**
  - **Internet Server**
  - **Laboratory Multimedia PC**
  - **Photonics Equipment**
- **Software structure**
  - **Client (Java Applets)**
  - **Transitional Server (HTML Pages)**
  - **Controller PC (LabWindows Applets)**

Web-controlled laboratory architecture

A) Hardware Structure

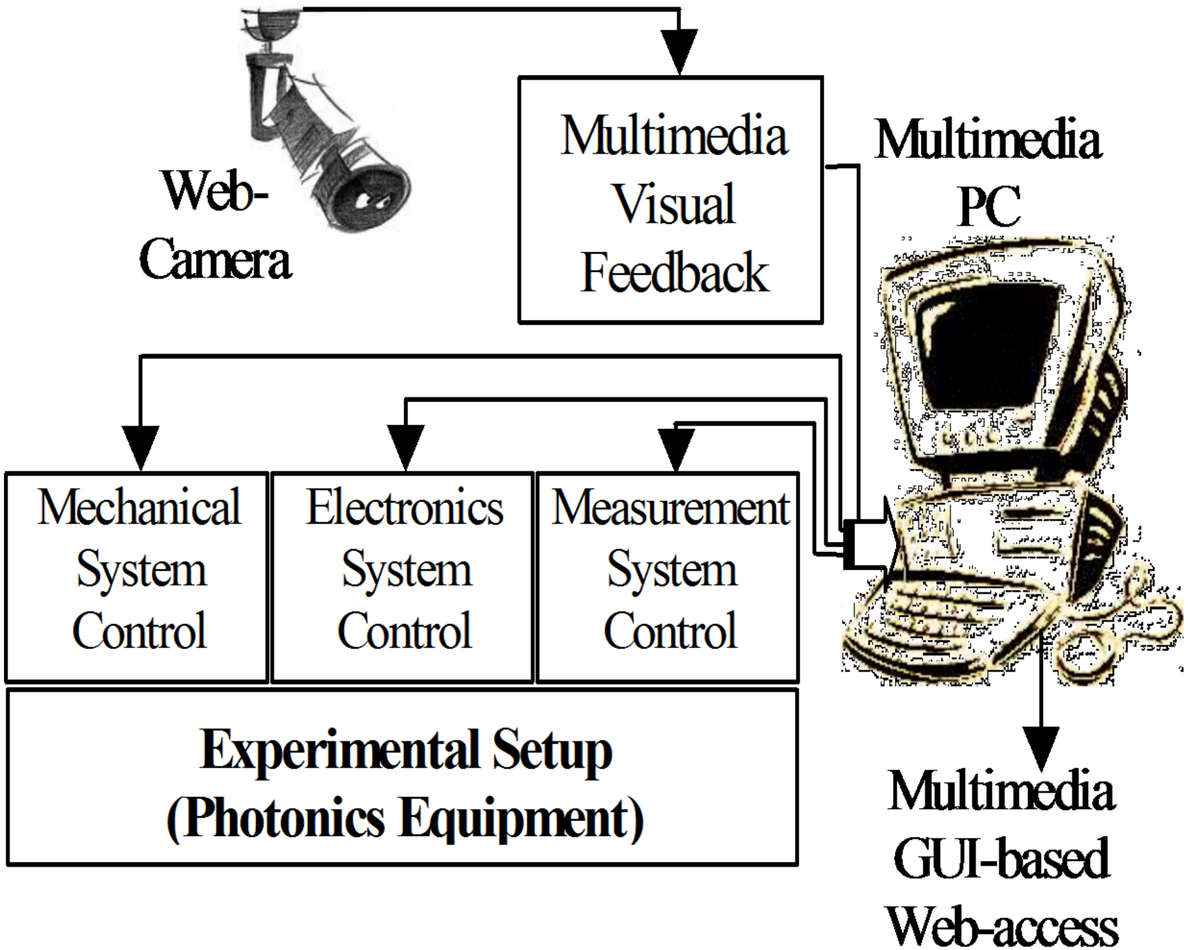


B) Software Structure



- **Present state – two equipments**
  - **Fiber Optic Refractometer**
  - **Optical Fiber Connection Test Bench**
- **Experimental set-up is controlled trough 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, petrocheical
  - Plastic
  - Food
  - Etc…

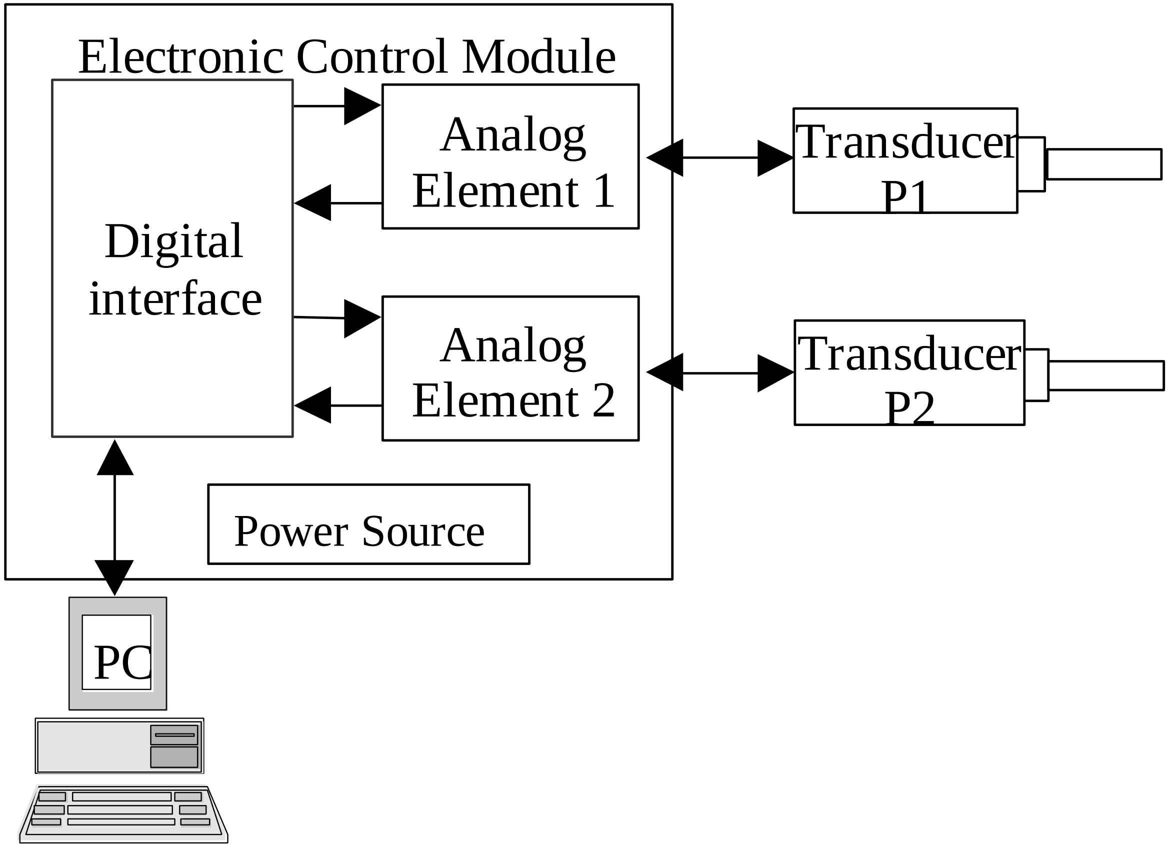
Measurement

- 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

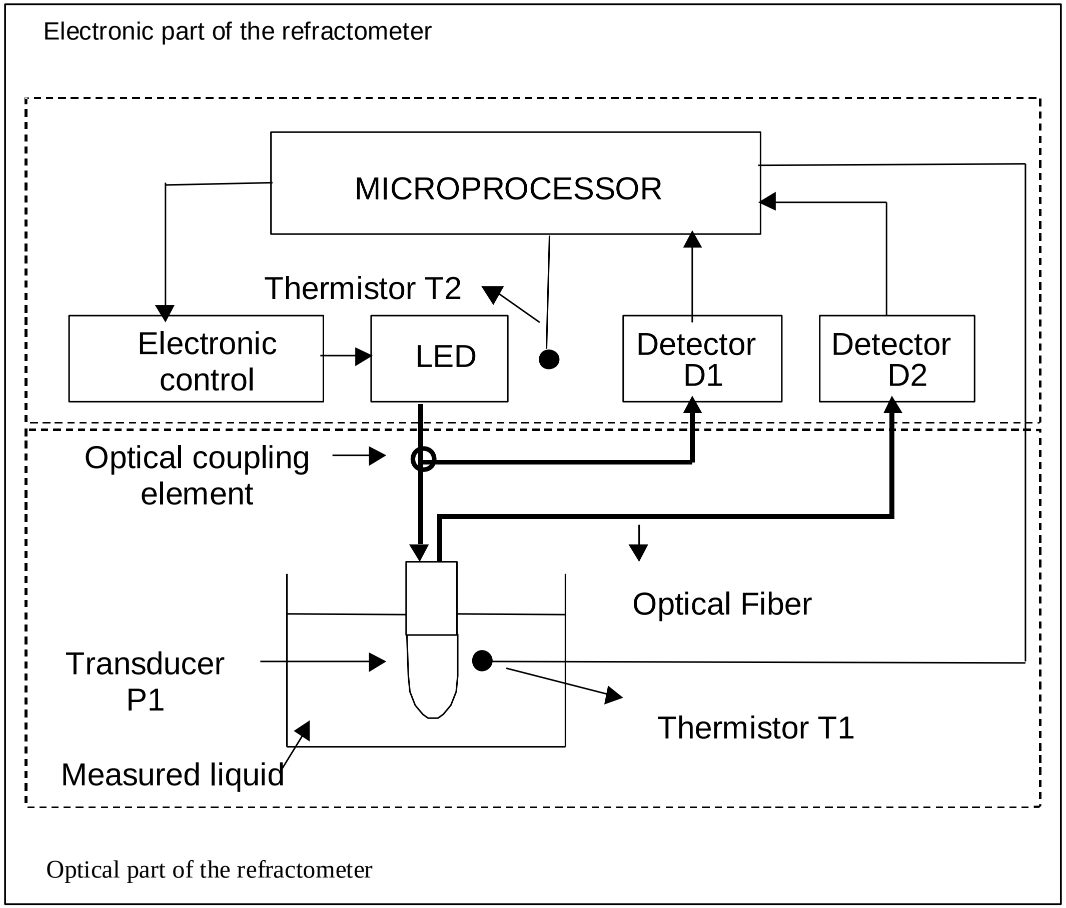
Fiber optic refractometer basic parameters

- 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

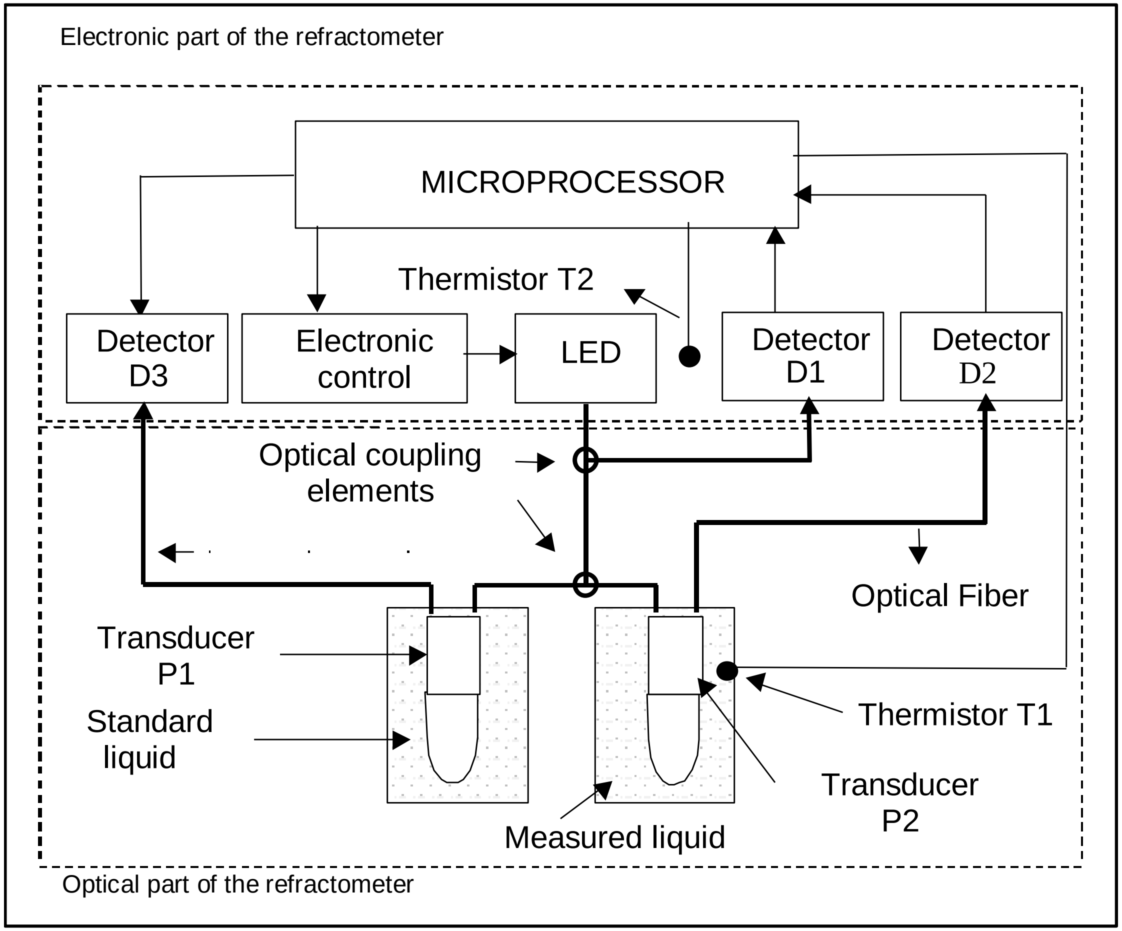
Fiber Optic Refractometer



Basic fiber optic refractometer

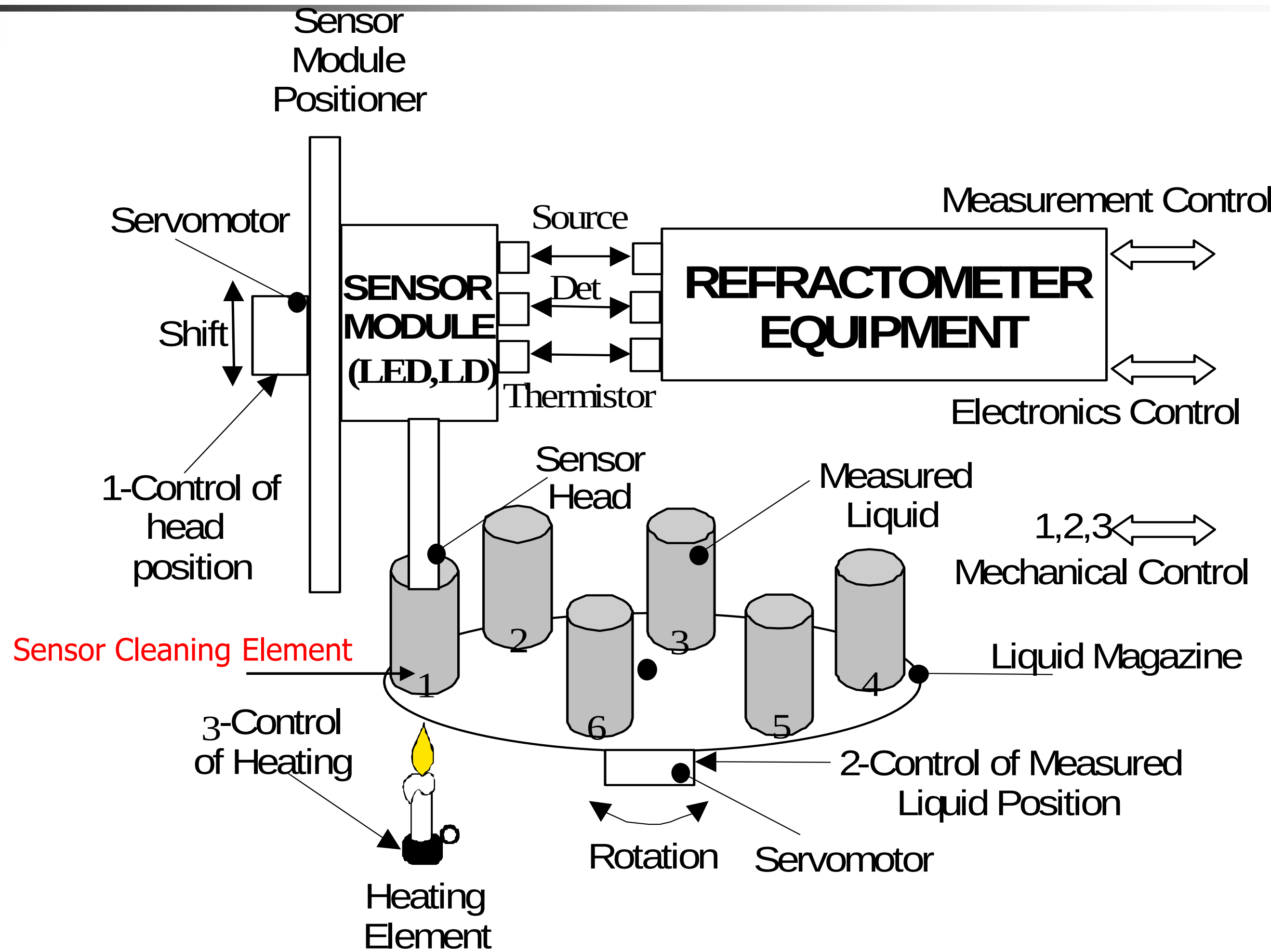


Differential fiber optic refractometer

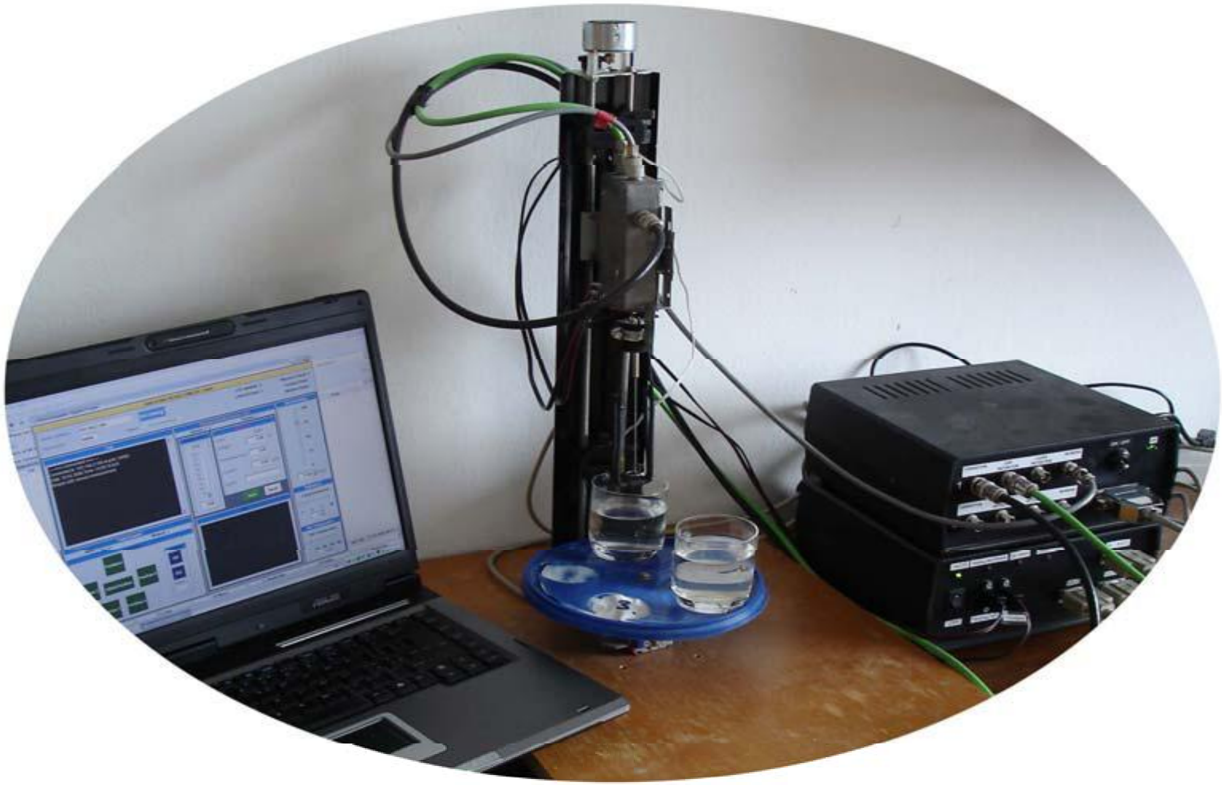


- **Web-Controlled Fiber Optic Refractometer**
  - **Sensor Module**
  - **Sensor Module Positioner**
  - **Liquid Magazine:**
    - **Rotation**
    - **Heating**
    - **Cleaning**
  - **Refractometer Equipment**
  - **Visual Interface (Camera Feedback)**
  - **Base Multimedia PC (Digital Interface)**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

Interactive web-controlled fiber optic refractometer instrument

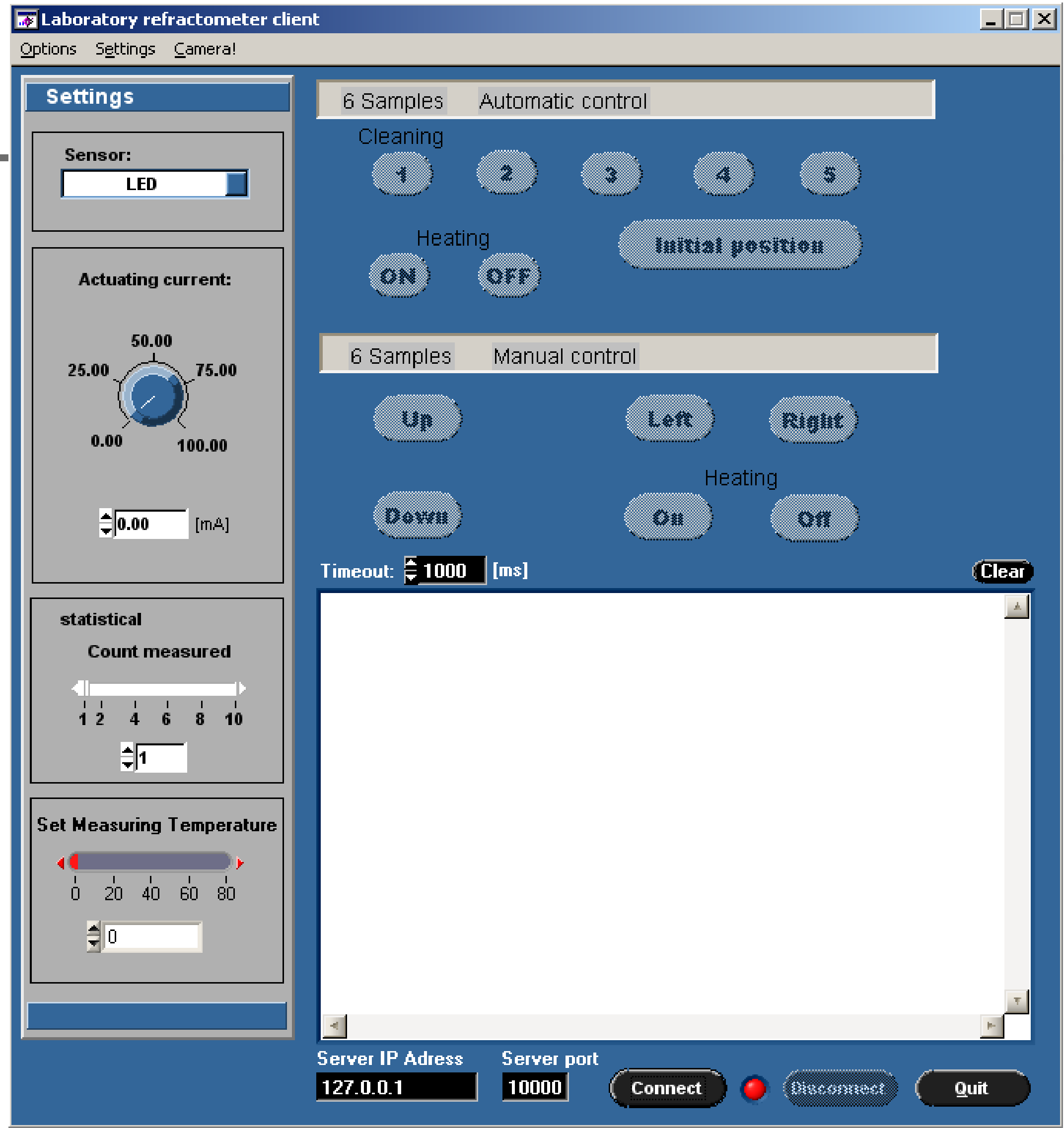


Web-based multimedia laboratory system

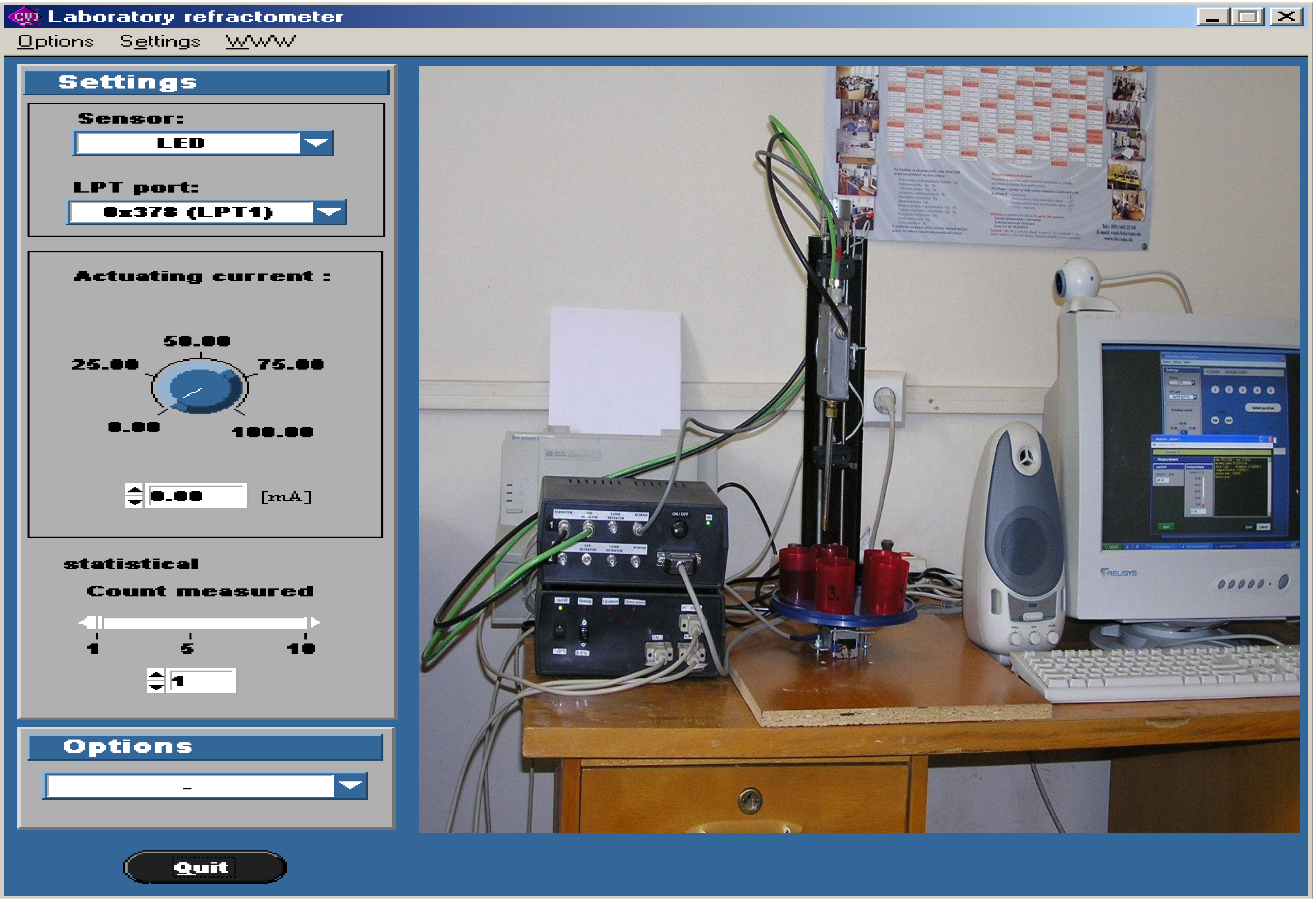


- Developed multimedia GUI
  - **Control the various parts of the instrument**
  - **Support control remote measurements using standard Internet Protocol (TCP/IP) procedures through WWW browser**
  - **Control and monitor refractive index of various liquids**
  - **Measurement of dependence of refractive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

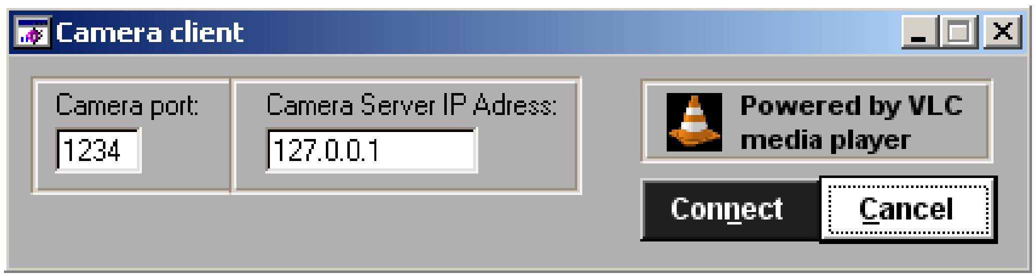
Basic control window of the refractometer



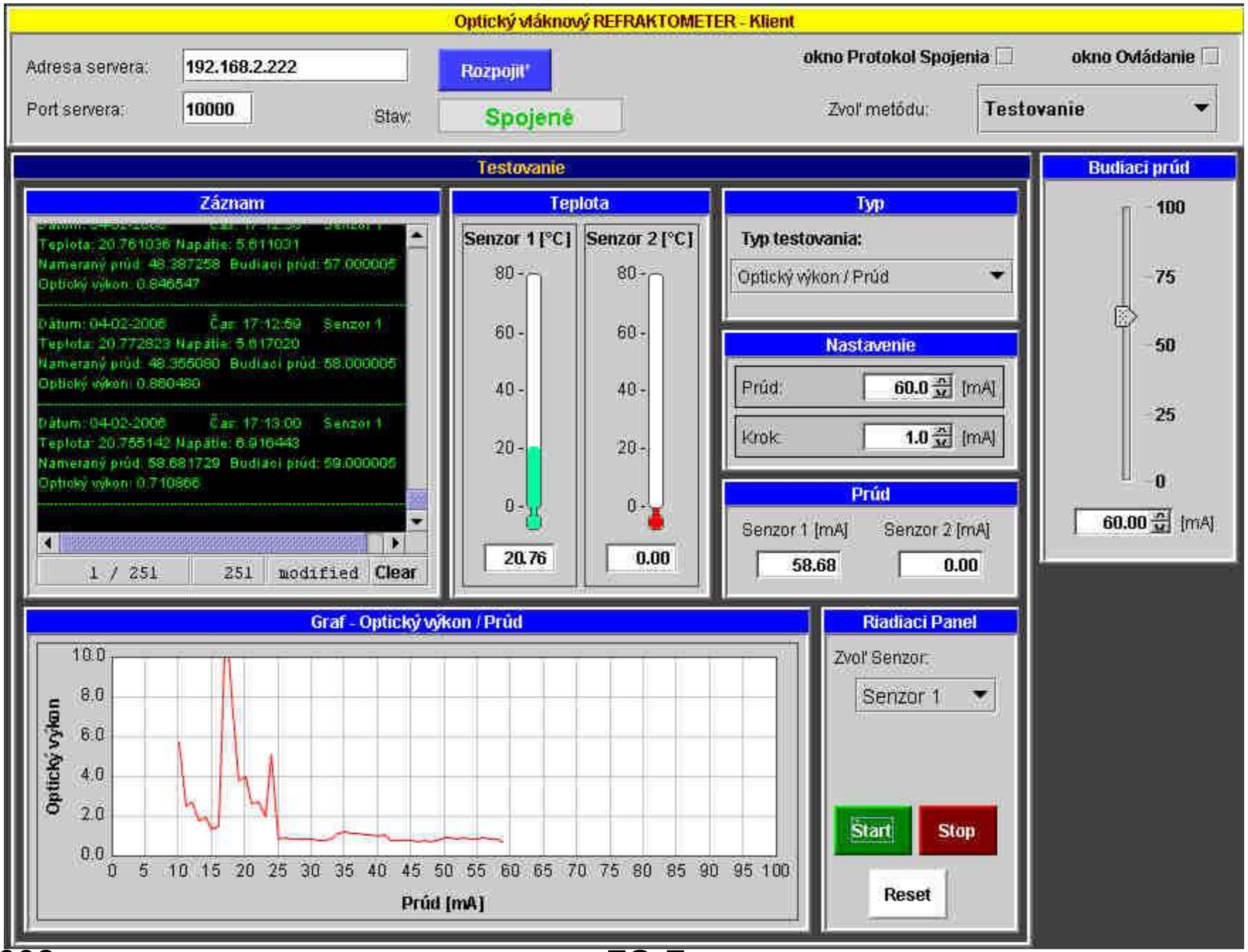
WWW control window of the refractometer



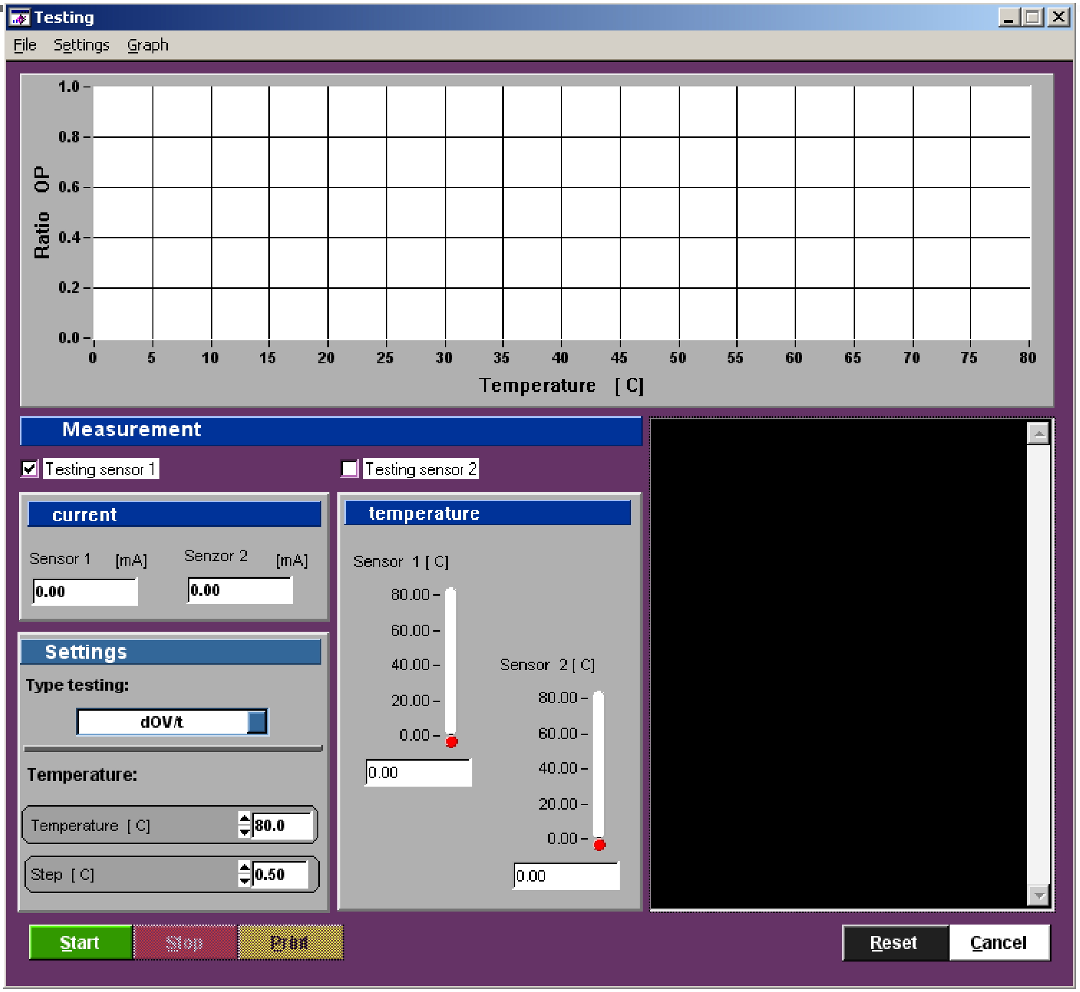
Window of the camera client and VLC media player



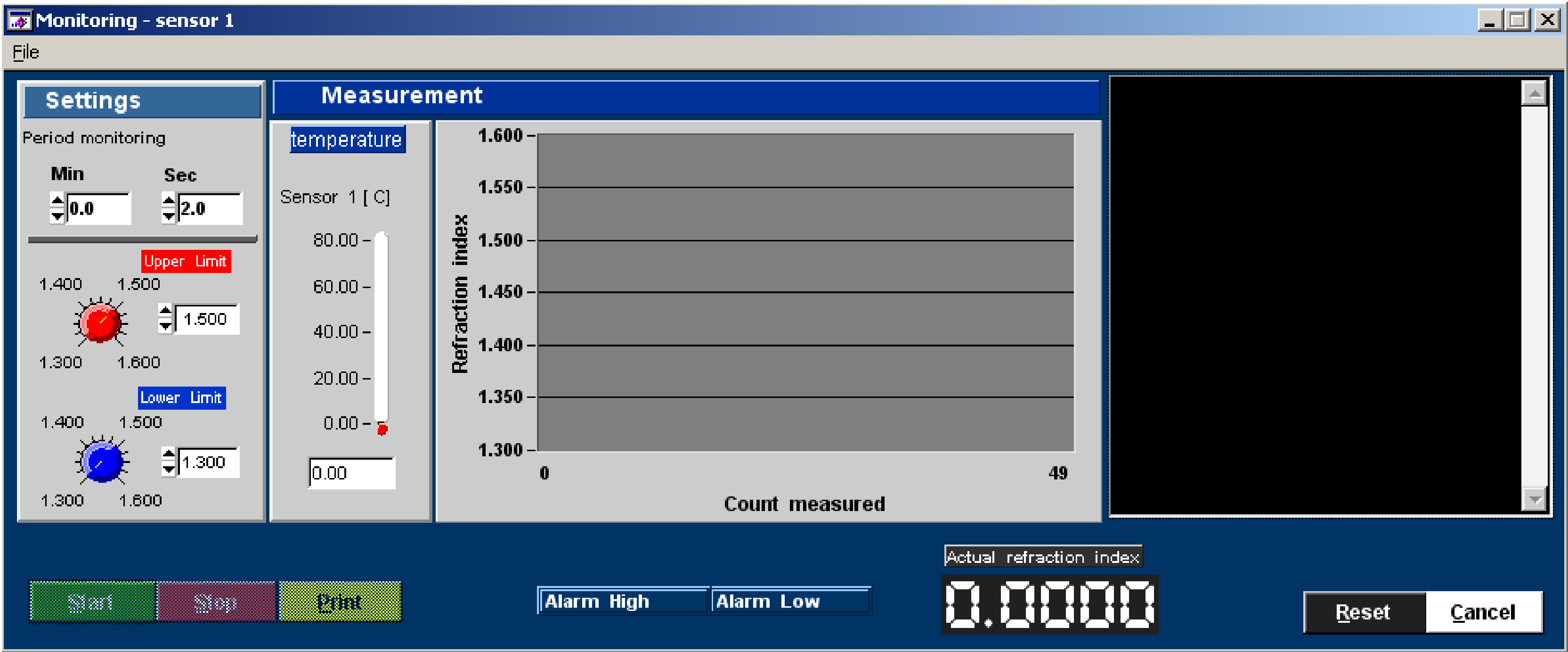
Main control window of the fiber optic refractometer (Measurements)



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

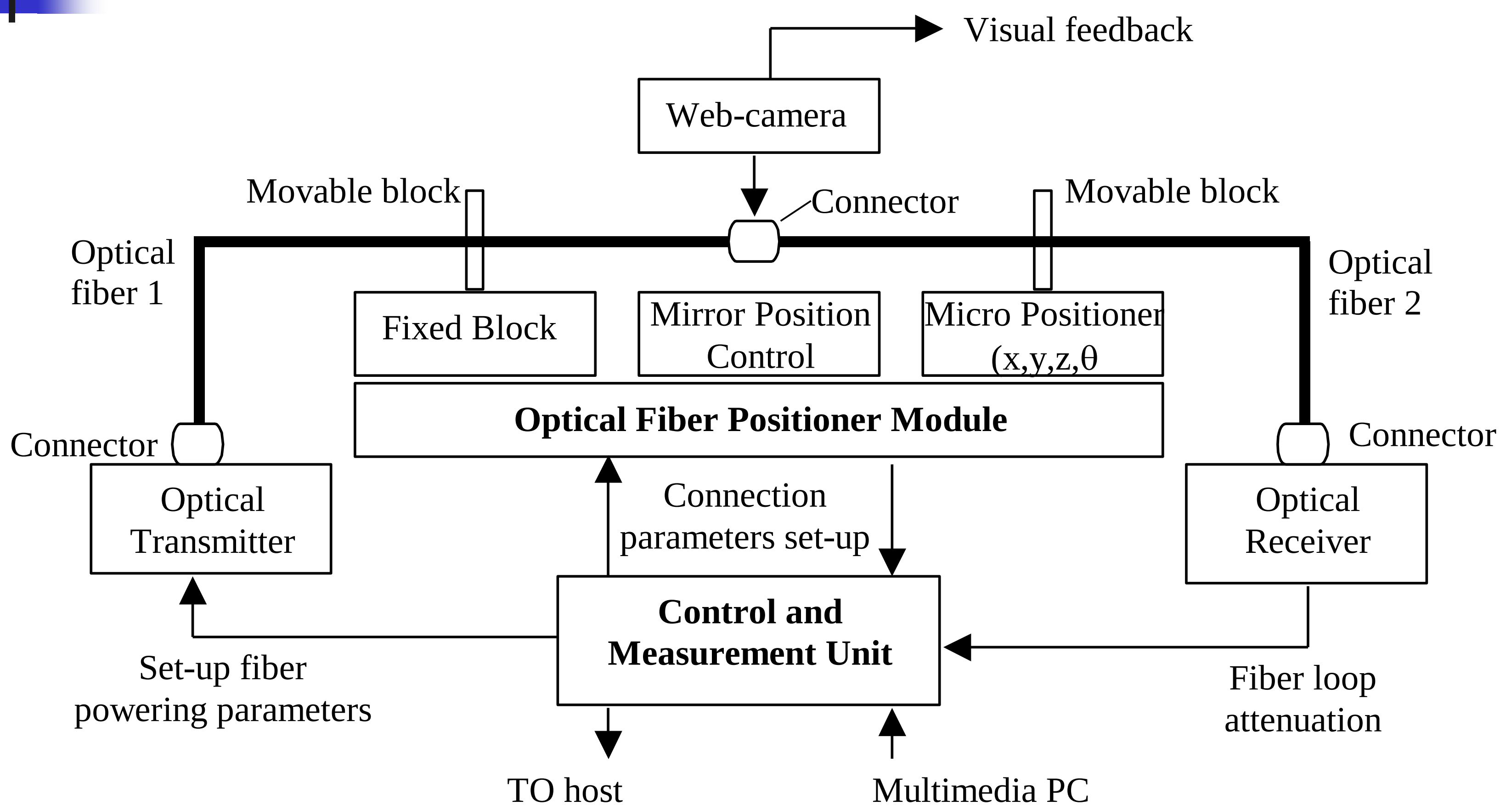
Optical fiber links – requirement for jointing transmission medium - Fiber

Fiber – fiber connections
- Fiber splices
- Fiber connectors

- Optical loss caused by two phenomenona
  - **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

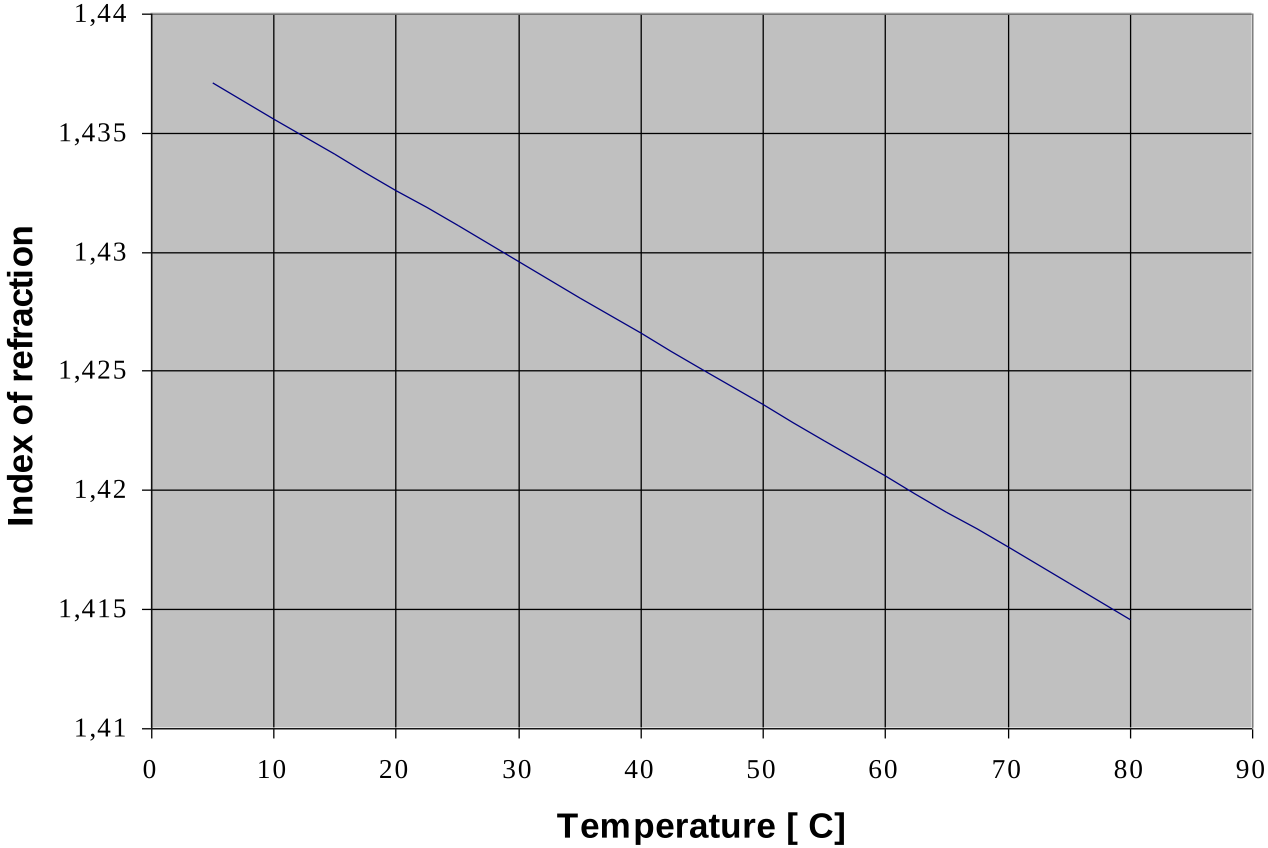
Interactive web-controlled fiber optic connection test bench



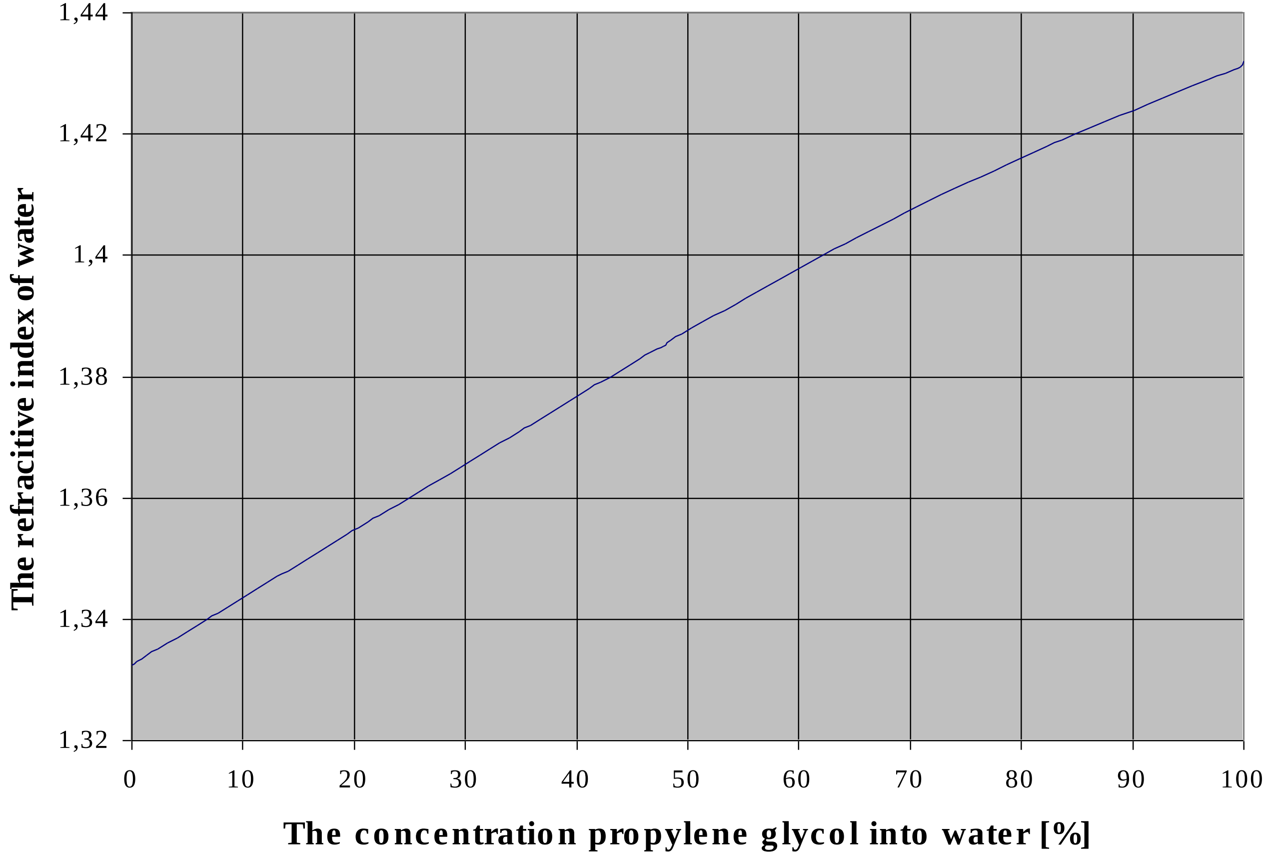
6. Experiments and Results

- **Basic Laboratory Experiments**
  - Dependence of refractive index of propylene glycol and water on temperature
    - dn/dt for water in the range 15 to 30ºC is 0.0001 per degree ºC
    - dn/dt for propylene glycol is 0.0003 per degree ºC
  - 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 (ºC)



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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