Project TOPDESS
Fiber optic refractometer
System for local concentration measurement
Concentration of binary mixtures are measured by means of evaluation of refractive index of the liquid through optical fiber sensor.

This device is compact (200 mm x 150 mm x 80 mm)

The light which is provided by a laser diode @1550 nm splits with a “X-split” junction
(It has two detectors. The first one shows the signal and the second one is the feedback control of the power used for the measurement. The laser light splits 90:10.)

Acquisition and control software are done with user interface (NI and PC card).
Fiber Optic (FO) refractometer is an optical sensor to measure the real-time refractive index \(n\) of the liquid based on Fresnel equations of the reflected and transmitted light at the interface between the liquid medium \(n_x\) and the fiber optic’s tip \(n_f\) which is:

\[
\frac{I_R}{I_0} \propto \left(\frac{n_f - n_x}{n_f + n_x}\right)^2
\]

Where:

- \(I_R\) is the reflected light from the sensor
- \(I_0\) is the laser source signal.
Hardware 1 _ electronics

1. Input current (laser)
2. This board is the current generator
3. Detector 2 (reference port-10% arm)
4. Detector 1 (measurement signal port)
5. * Sensor (90% arm)
6. This port is to amplify the diod
7. ** X-splitter
8. This board is the demodulator

* and ** are shown in more detail in next slides
Hardware 2 _ X-split

1550 nm, 50 mW, E Pin Code, SM Fiber-Pigtailed Laser Diode, FC/PC

**High Speed InGaAs Photodiodes**

Coupling ratio 90:10

90% of power

10% of power

Connectors FC/PC
## SINGLE-MODE OPTICAL FIBER SPECIFICATION

<table>
<thead>
<tr>
<th>Optical fiber type</th>
<th>9/125 OS2 (ITU G.652D)</th>
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</thead>
<tbody>
<tr>
<td>Core diameter</td>
<td>9.0 ± 0.4 µm @ 1310 nm</td>
</tr>
<tr>
<td></td>
<td>10.1 ± 0.5 µm @ 1550 nm</td>
</tr>
<tr>
<td>Cladding diameter</td>
<td>125 ± 0.7 µm</td>
</tr>
<tr>
<td>Primary coating diameter</td>
<td>242 ± 7 µm</td>
</tr>
<tr>
<td>Cladding Non-Circularity</td>
<td>≤ 0.7%</td>
</tr>
<tr>
<td>Concentricity error core/cladding</td>
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<td>Attenuation typical/max λ=1310 nm</td>
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<td>Group Index @ 1310 nm</td>
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<tr>
<td>Cable cut-off wavelength</td>
<td>λ₀ ≤ 1260 nm</td>
</tr>
<tr>
<td>Zero-dispersion wavelength λ₀</td>
<td>1304 – 1324 nm</td>
</tr>
<tr>
<td>Slope at λ₀</td>
<td>S₀ ≤ 0.092 psi/(nm²-Km)</td>
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**Fiber optic sensor**

- **Hardware**: 3 _ fiber optic sensor
- **Optical fiber type**: 9/125 OS2 (ITU G.652D)
- **Core diameter**: 9.0 ± 0.4 µm @ 1310 nm, 10.1 ± 0.5 µm @ 1550 nm
- **Cladding diameter**: 125 ± 0.7 µm
- **Primary coating diameter**: 242 ± 7 µm
- **Cladding Non-Circularity**: ≤ 0.7%
- **Concentricity error core/cladding**: ≤ 0.5 µm
- **Concentricity error cladding/coating**: ≤ 12 µm
- **Attenuation typical/max λ=1310 nm**: 0.31 – 0.35 dB/Km
- **Attenuation typical/max λ=1550 nm**: 0.20 – 0.24 dB/Km
- **Attenuation typical/max λ=1625 nm**: 0.21 – 0.26 db/Km
- **Group Index @ 1310 nm**: 1.467
- **Group Index @ 1550 nm**: 1.4682
- **Chromatic @ 1550 nm**: ≤ 18 ps/(nm-Km)
- **Chromatic @ 1625 nm**: ≤ 22 ps/(nm-Km)
- **Cable cut-off wavelength**: λ₀ ≤ 1260 nm
- **Zero-dispersion wavelength**: 1304 – 1324 nm
- **Slope at λ₀**: S₀ ≤ 0.092 psi/(nm²-Km)
- **PMD**: ≤ 0.1 psi/Km
Thanks to the signal acquisition and using the mentioned Fresnel equation it is possible to evaluate the refractive index of the liquid. Refractive index is a concentration (C)-dependent parameter, which means direct and linear relation between \( n \) and \( C \) let us measure contribution of each liquid.
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