WATER LEVEL OPTICAL SYSTEM FOR INTEGRATING COMPTENCES

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ABSTRACT

This paper reports a short project designed and carried out for laboratory work of graduate and post graduate disciplines with the main focus on integrating physical and engineering competences.

A plastic optical fiber liquid level sensor is presented. The sensor is a low cost solution to be used in the measurement on the monitoring of groundwater or levels of precipitation in meteorological stations. A periodic indentation on the polymeric fiber was made removing the protective coating and part of the fiber core, disturbing the propagation of optical signal. Each indentation induces an increase in the optical signal loss. The amount of radiation loss depends on the external environment surrounding the indentation and the dimensions of the grooves. Thus, any external disturbance to the surrounding environment produces a measurable effect on the signal optical power at the fiber output. A sensitivity of 13.5±0.05 mV/groove was estimated for the implemented sensor. This level sensor may provide a practical solution to implement the physics teaching in order to acquire competencies in this area.

Keywords*:* Plastic Optical Fiber; Level sensor; Optical signal.

Summary

Water level optical sensor was tested for teaching the basic principles and applications in order to acquire competencies in POF based sensors and related technology. The sensor can be used in the measurement on the monitoring of groundwater or levels of precipitation in meteorological stations.

Introduction

In the latest years, polymeric optical fiber (POF) has been studied and used for the control of liquid levels due to its main properties. An importance arises in how these properties are taught.

Nowadays, the main technologies used for liquid level measurement, are the capacitive, ultrasonic or hydrostatic (Simon, 1993; Fraden, 2010), but the optical technologies are also gaining place among those sensors, due to its properties like the immunity to electromagnetic interference, the possibility of remote sensing, the inexistence of electrical signal at the sensor head and the compactness.

POF are already being used in numerous types of sensors, such as physical sensors (elongation, acceleration or pressure) (Peters, 2010; Antunes *et al.*, 2013), chemical (Bartlett *et al.*, 2000; Zubia, & Arrue, 2001), biosensors (Varriale *et al.*, 2013) or fiber Bragg sensors (Antunes *et al.*, 2007; Cátia *et al.*, 2011).

The basic principle of this sensor is a periodic indentation (grooves) on the polymeric fiber core. The presence of the groove in the core of an optical fiber cause a disturbance on the propagation of the optical signal, thereby interacting with the environment surrounding the fiber. The transmitted optical power loss will change if the refractive index (RI) of the liquid fulfilling the grooves is different from the RI of the POF core. So, the optical signal power measured at the fiber output is dependent on the RI of the liquid around the fiber. Taking into account that the liquid refractive index doesn´t changed during the measurements, each time a groove is fulfilled, the transmitted optical power will increase. Using a POF fiber with grooves perpendicularly to the liquid surface, when the liquid rises it will sequentially fulfill each groove, and consequently increase the transmitted optical power. The amount of radiation lost to the outside depends on the dimensions of the grooves and its depth.

In this work, we present a level sensor based on POF´s that combine the optical technology properties with the lower cost of the interrogation technique, providing a practical solution to implement the physics teaching in order to acquire competencies in this area.

This level sensor was already tested on the 3rd OPTICWISE Training School on Optical Wireless Communications, in April 2014, in University of Aveiro.

Experimental system

The sensor was implemented with a large diameter core (1 mm) plastic optical fiber, with typical attenuation 0.22 dB/m, from Avago Technologies (HFBR-RUS100Z), with 10 grooves, spaced 4 cm.

The monitoring system includes an optical power source and receiver, a light emitting diode (IF-E92B 430-nm blue LED) and a photodiode (IFD91), from Industrial Fiber Optics. The data acquisition was performed with a 12 bit resolution Analog to Digital Converter (ADC) from National Instruments (USB6008). Scheme of the plastic optical fiber with grooves and the experimental setup block diagram is shown in Figure 1.

An optical fiber 2 m long was connected to the optical source and to the receiver for the sensor head preparation. The grooves were sliced on the fiber with a depth to half of the core diameter. The implemented sensor was tested by measuring the distilled water level in a cylindrical glass reservoir, with a maximum height of 40 cm. The POF was fixed to a PVC (Polyvinyl chloride) tube which remains fixed and strained along the reservoir containing the water.

Usually, level sensors can be classified into two groups, continuous and discrete. Continuous level sensors can measure the level within a specified resolution, while discrete sensors can only specify whether the level is below or above a threshold. Moreover, if the predicted costs for the discrete sensors are kept reduced, is possible to use a large array of sensors to emulate a quasi-continuous sensor. This level sensor that we present here can be classified as discrete. However, it can be deployed as a quasi-continuous solution, because is a low cost solution which can be employed with multiplexing techniques (Hopenfeld, 2006).

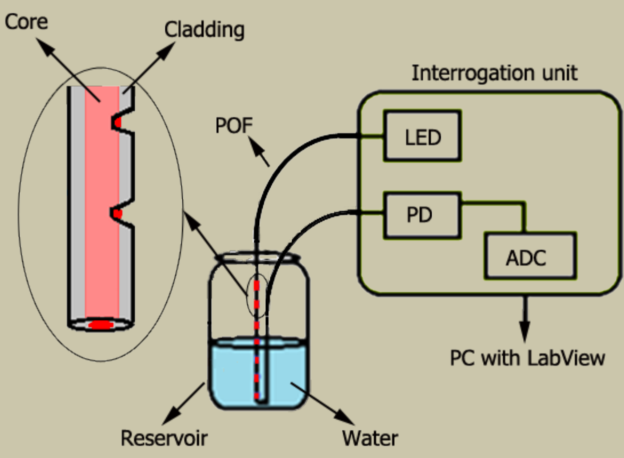

Fig. 1. Scheme of the plastic optical fiber with grooves and the experimental setup block diagram.

Experimental results

It is observed that as water is added in the reservoir the transmitted signal optical power increases and the optical losses decreases. The sensitivity of the sensor, in this case by linear fit to the data of Figure 2 a) and b), is 13.5±0.05 mV per each groove and 0.253±0.005 dB/groove, respectively. The resolution of the sensor is related to the distance between the produced grooves. Nevertheless, it can be improved if we decrease the distance between grooves. The measuring range of the proposed sensor depends on several factors, such as the length of the POF (due to the optical attenuation) and the number and depth of the grooves, the optical power emitted by the LED and the minimum detectable optical power of the photodetector.

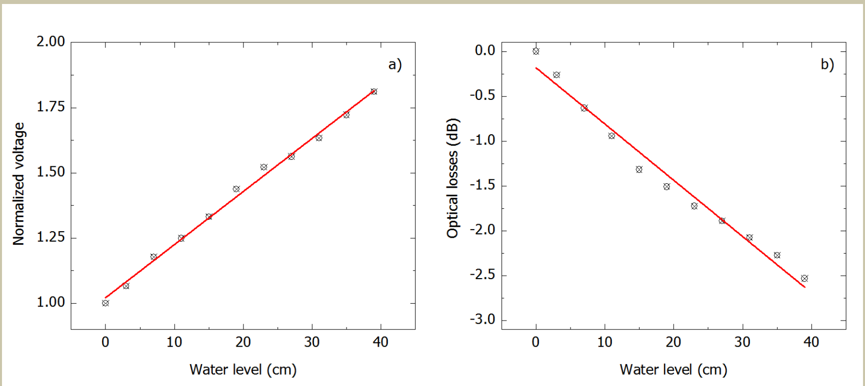

Fig. 22 a) Normalized voltage with the water level variation. b) Optical losses with water level variation. The dots represent the experimental data and the lines represents the linear fit (correlation factor > 0.9952 for a) and correlation factor > 0.9799 for b)).

Discussion and Conclusion

This paper reports a short project designed and carried out for laboratory work of graduate and post graduate disciplines with the main focus on integrating physical and engineering competences. A polymeric optical fiber intensity based level sensor was presented. A sensitivity of 13.5±0.05 mV/groove was estimated for the tested version. The number of grooves and the distance between them define the sensing resolution. Moreover, the sensor sensitivity and resolution can be adapted for different applications.

Some possible applications of this sensor are in the monitoring of groundwater tablet levels, soil moisture monitoring and levels of precipitation in meteorological stations. This level sensor may prove to be a viable alternative/solution to existing electronic sensors, due to the production lower cost.

This short project has received a positive feedback from the students. In their opinion this project is a simple and interactive way to acquire competencies in POF based sensors and related technology.

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