Calculation of Fiber Optic Liquid Level Sensor

Article Overview

Fiber optic liquid level sensors measure liquid height by converting optical signal changes into level readings, with sensitivity and linearity determined by fiber configuration, refractive index, and mechanical deformation.

Principles of Operation

Fiber optic liquid level sensors operate by detecting changes in light intensity, reflection, or wavelength caused by the liquid's presence. Common types include:

o Reflective optical fiber sensors: Use an incident fiber and receiving fibers with a reflective diaphragm; the reflected light intensity varies with liquid level, allowing calculation of height based on optical power changes (sensitivity can reach 8 nW/cm over 0-5 m range) .
o Plastic optical fiber (POF) sensors: Employ U-bent fibers and photodetectors; the optical intensity decreases linearly with liquid height due to scattering losses, and voltage output from the photodetector is used to calculate liquid level .
o Fiber Bragg grating (FBG) sensors: Measure strain induced in gratings embedded in a diaphragm; wavelength shifts correspond to hydrostatic pressure changes, providing highly linear and sensitive readings (e.g., 98 pm/cm for water) .

Key Calculation Parameters

o
Sensitivity (S): Change in optical signal per unit liquid height. For reflective sensors, S depends on fiber diameter, spacing, and optical path; for FBG sensors, S depends on diaphragm elasticity and fiber material .

o
Optical Path and Geometry: The distance between incident and receiving fibers, fiber bending radius, and diaphragm thickness affect the reflected or transmitted light intensity, which must be calibrated to liquid height .

o
Refractive Index Effects: The liquid's refractive index alters light propagation and reflection. Accurate calculation requires considering the refractive index contrast between fiber core, cladding, and liquid .

o
Environmental Factors: Temperature, vibration, and liquid flow rate can influence measurements. Compensation can be achieved using multi-sensor arrays or calibration curves .

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Calculation Example

For a reflective optical fiber sensor:
o Measure baseline optical power P0 with empty container.
o Measure reflected power PL at liquid height L .
o Sensitivity S=?P?L=PL-P0L .
o Liquid level can then be calculated as L=PL-P0S , adjusting for temperature or vibration effects if necessary . For FBG-based sensors:
o Measure wavelength shift ?? of each grating.
o Convert to strain using fiber calibration: ?=??/?0 .
o Relate strain to hydrostatic pressure: P=?.E (E = Young's modulus of diaphragm).
o Calculate liquid height: L=P/(?g) , where ? is liquid density and g is gravity .

Advanced Techniques

o Multiplexing: Multiple sensors can be interrogated using a single optical source, with deep neural networks or signal processing algorithms used to resolve overlapping signals and improve accuracy .
o Calibration: Empirical calibration with known liquid heights is essential to account for non-linearities, optical losses, and environmental variations . By combining these principles, one can design a fiber optic liquid level sensor system with high sensitivity, linearity, and robustness suitable for industrial applications such as fuel storage, chemical processing, or water monitoring.

Abstract In this paper, we present a polymer optical fiber (POF) Bragg grating (FBG) to measure liquid level based on

Sensitivity levels of 1.4 and 3.3 mV/mm were achieved for water level fluctuations below and above 45 cm,

The large number types of sensors with the various principles have been used for the liquid level measurement.

In this article, a simple intensity-modulated fiber optic sensor for liquid level measurement is presented. The sensor

The results demonstrate that this fiber optic level sensor is not only easy-to-make, cost-effective and robust but also

This chapter reports optical fiber-based sensors for liquid-level detection in aerospace environment. It discusses preliminary

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An innovative fiber optic liquid level sensor based on a peanut-shaped fiber structure has been designed and fabricated for use in

The measurement principle is simple: the liquid level is calculated from the hydrostatic pressure exerted by

Innovators at NASA"s Armstrong Flight Research Center have developed a highly accurate method for measuring liquid levels and

In this paper, a novel liquid level sensing system is proposed to enhance the capacity of the

Download scientific diagram | Schematic of a liquid level sensor, whose working principle is based on frustrated total internal

Abstract and Figures A simple fiber optic technique is developed for the remote measurement of the liquid level. It

We describe a fiber-optic system to measure the liquid level inside a container. The technique is based on the extraction of the

This study introduces a cost-effective solution and sensor arrays for the multipoint liquid-level measuring sensor

We present a fiber-optic liquid level sensor that is conducted by a combination of optical interferometry and lever principle. The

This article presents a portable optical fiber sensor (OFS) design for continuous liquid level measurement, fabricated using two

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