Fiber Optic Sensor Liquid Level Model

Article Overview

Fiber optic sensors (FOS) for liquid level measurement use optical fibers to detect liquid height with high precision, employing configurations such as reflective fibers, fiber Bragg gratings, and Fabry-Perot cavities.

Sensor Configurations and Models

1. Reflective Optical Fiber Sensors These sensors use an incident fiber to transmit light toward a reflective surface and receiving fibers to detect reflected light. The liquid level is inferred from changes in the reflection spectrum caused by the displacement of a diaphragm or reflective sheet. Sensitivity depends on parameters such as fiber diameter, spacing, optical path length, and diaphragm thickness. Wide-range reflective sensors can maintain linear output over 0-5 m with minimal influence from temperature, vibration, or fluid type, achieving relative measurement errors as low as 3.2% . 2. Fiber Bragg Grating (FBG) Sensors FBG-based sensors detect liquid levels by monitoring shifts in the Bragg wavelength caused by changes in the refractive index when the fiber is submerged. Variants include etched chirped FBGs, which improve sensitivity. These sensors can be multiplexed along a single fiber to measure multiple points simultaneously. Advanced models integrate deep neural networks (DNNs) to resolve cross-talk between sensors and enhance prediction accuracy compared to conventional machine learning methods like random forests or support vector machines . 3. Fabry-Perot and Multimode Interference Sensors Fabry-Perot cavities and multimode interference configurations modulate the optical signal based on liquid immersion depth. These intrinsic FOS designs allow direct measurement of the liquid level without external modulation devices, providing high resolution and safety in hazardous environments .

Commercial Fiber Optic Units

o KEYENCE FU-95Z and FU-94C: These units are designed for industrial liquid detection, offering compact fiber units capable of detecting various liquids. They are optimized for sensitivity and can be integrated into automated systems for real-time monitoring .
o NASA Armstrong FOSS: Originally developed for cryogenic fuel monitoring, this system uses fiber Bragg sensors along a single fiber with a resistive heater to detect the liquid-gas interface with 1/4-inch precision. The system measures cooling rates of the fiber in liquid versus gas to determine the exact liquid level .

Modeling Approaches

o Theoretical Models: Reflective fiber sensors are modeled using optical path analysis, considering incident and receiving fiber geometry, diaphragm elasticity, and reflection coefficients. These models predict sensor output as a function of liquid height and environmental factors .
o Machine Learning Models: For multiplexed FBG sensors, DNNs are employed to accurately predict liquid levels at multiple points, overcoming cross-talk and non-linearities in the sensor response .

Key Advantages

o High accuracy and resolution, suitable for industrial and aerospace applications.
o Safe for explosive or hazardous environments due to intrinsic optical sensing.
o Capable of continuous, real-time monitoring over wide ranges.
o Multiplexing allows multiple measurement points with a single fiber, reducing cost and complexity. Fiber optic liquid level sensors combine precision, safety, and adaptability, making them ideal for applications ranging from chemical processing to cryogenic fuel monitoring. Advanced models integrate machine learning and multiplexing to enhance performance and enable multi-point measurements.

The article deals with the use of intensity-based fiber optic sensors for the level measurement. Two types of optical fiber

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

Design and construction of an optical fiber sensor for liquid level detection are reported. This sensor operates based

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

In this work, a novel optical fiber sensor capable of measuring both the liquid level and its refractive index is designed,

To be more specific, in response to the fourth industrial revolution, the sensing system is also being required to

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

Abstract An intensity-based fiber-optic liquid-level gauge for continuous measurement is described. The sensing

To achieve accurate, continuous, and online monitoring of liquid levels over a wide range, we investigate a liquid level

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

Fiber Optic Sensor Liquid Level Model

The fiber-optic level measurement systems from Opsens Solutions are based on pressure measurement

A novel optical liquid level sensor based on macro-bending coupling of fiber is proposed. Two plastic fibers are twisted

Abstract This study presents a fiber optic liquid level sensor (FOLLS) by acquiring information from the amplitude of

FU-95Z, Liquid-level-detection Fiber Unit in FS-N40 series by KEYENCE America.

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

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

Web: https://www.supremeacademicresearch.co.za