Group: 5

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Objective

The primary objective of the ultrasonic leak detection system is to provide a highly sensitive and accurate method for detecting water leaks, including those that involve very low flow rates, such as individual drops of water. This system aims to overcome the limitations of traditional leak detectors, which often rely on mechanical impellers or surface sensing technologies that cannot detect small leaks until significant water damage has occurred.

Scope

The scope of this project encompasses the development, testing, and validation of an ultrasonic leak detection solution using Texas Instruments' ultrasonic sensing technology. It includes:

- Designing and configuring the ultrasonic sensing subsystem (USS) integrated with low-energy accelerators and MSP microcontrollers.
- Utilizing Jiakang 2-MHz transducers for high-resolution leak detection measurements.
- Creating a 3D-printed test fixture to facilitate experimentation with different pipe geometries.
- Providing demo source code and schematics to support developers in accelerating the development of ultrasonic sensing applications.
- Evaluating the performance of the system under various conditions to ensure reliability and accuracy.

IC Technology

The ultrasonic leak detection system leverages Texas Instruments' MSP430FR6043 microcontroller, which integrates a sophisticated ultrasonic sensing subsystem (USS). Key components of the IC technology include:

- A programmable pulse generator (PPG) for precise ultrasonic excitation.
- A high-speed sigma-delta analog-to-digital converter (ADC) with a programmable gain amplifier (PGA) for capturing ultrasonic waveforms.
- Low-energy accelerator (LEA) to process captured waveforms with minimal power consumption.
- Cross-correlation based algorithm for determining ultrasonic time of flight with high accuracy.
- Integration of the USS with a low-power microcontroller to enable autonomous operation with an average current consumption of less than 3 µA per measurement.

Significance

The significance of this ultrasonic leak detection system lies in its ability to detect small leaks that traditional mechanical meters cannot. This capability is crucial for preventing water damage in residential and commercial properties by identifying leaks early, thereby reducing repair costs and conserving water. Utility companies benefit from this technology as it allows for more accurate water metering and billing, ultimately improving water management and conservation efforts.

Novelty

The novelty of the ultrasonic leak detection system is highlighted by several innovative features:

- **High Sensitivity:** The system can detect individual drops of water at very low flow rates, providing much higher resolution compared to traditional mechanical sensors.
- **Advanced Sensing Technology:** The cross-correlation based approach for determining ultrasonic time of flight offers superior accuracy over threshold-based techniques.

- **Low Power Consumption:** With an average current consumption of less than 3 µA per measurement, the system is highly energy-efficient, making it suitable for long-term deployment in battery-operated devices.
- **Autonomous Operation:** The integration of the USS with a low-power microcontroller allows for autonomous operation, reducing the need for frequent maintenance and manual intervention.
- **3D-Printed Test Fixture:** The use of a 3D-printed fixture for testing different pipe geometries demonstrates the system's adaptability and flexibility in various installation scenarios.