muvrlabs

Permittivity Sensor & Measurement Circuit Datasheet

Abstract

This document provides the specifications and operating details of a permittivity sensor (interdigitated capacitive sensor) and its accompanying measurement circuit. The sensor detects ion concentration in DI water by measuring changes in permittivity. A shielding cap is placed over the sensor to minimize external interference. The circuit integrates a capacitive measurement IC, a microcontroller, and a DAC, delivering a 0 V to 5 V output corresponding to the sensed permittivity.

Contents

1 Introduction

The permittivity sensor described in this datasheet is an interdigitated capacitive structure designed to detect changes in the dielectric properties of deionized (DI) water. Ion concentrations in water alter its permittivity, allowing the sensor to quantitatively measure these changes. The sensor includes a shielding cap to reduce interference from external electromagnetic fields and improve measurement stability.

The measurement circuit uses an integrated capacitive measurement IC for high-accuracy capacitance-to-digital conversion. A microcontroller then processes the digital data and uses a DAC (digital-to-analog converter) to generate a 0 V to 5 V output. This output can be interfaced with standard data-acquisition systems or analog inputs of industrial controllers.

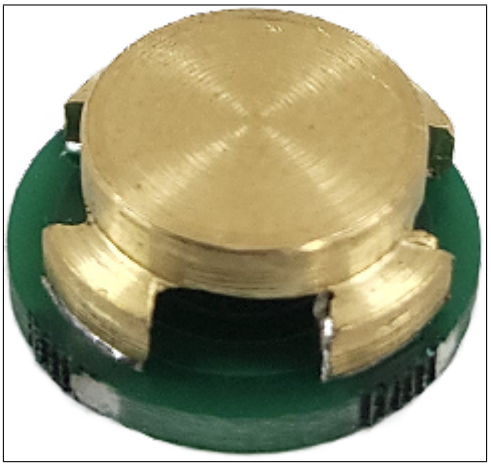


Figure 1: Permittivity Sensor (IDT) with shield

2 Features

- **Sensor Type:** Interdigitated capacitive sensor for permittivity measurement.
- **Shielding Cap:** Reduces external interference and noise.
- **Measurement Range:** 200uM to 5mM concentration of NaCl in DI water.
- **Output Range:** 0 V to 5 V (analog).
- **Integrated Circuitry:** Capacitive measurement IC + microcontroller + DAC.
- **Communication Protocol:** I^2C and UART.
- **Operating Voltage:** 5 V single supply (for both sensor circuit and DAC output).

3 Functional Block Diagram

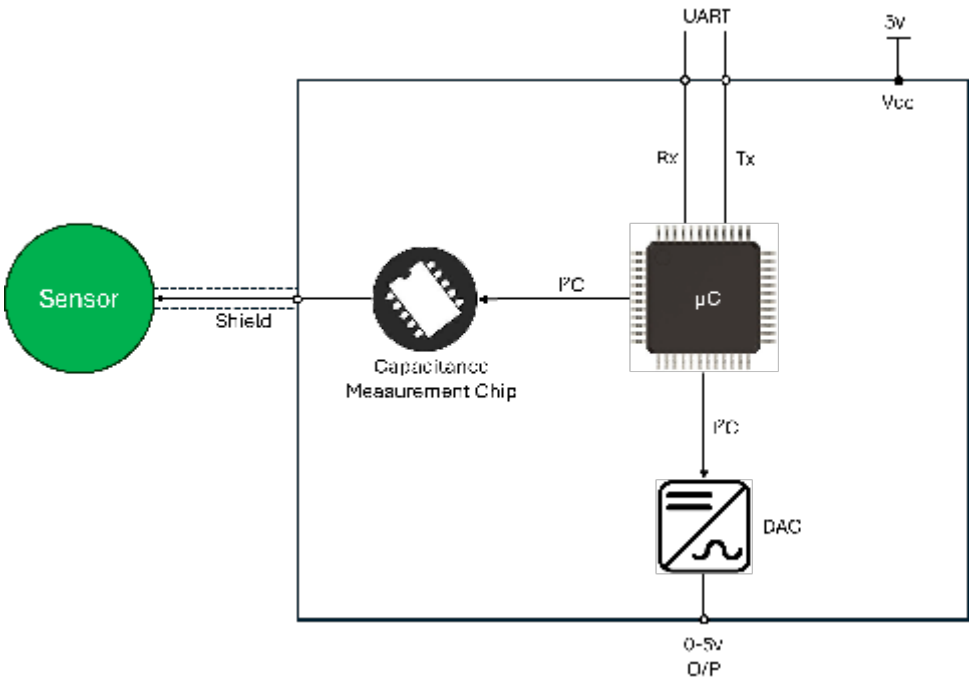


Figure 2: Block Diagram of the Permittivity Sensor Measurement Circuit

Figure 2 illustrates the primary functional blocks:

1. **Permittivity Sensor (IDT)**: Senses dielectric changes in DI water.
2. **Capacitive Measurement IC**: Converts small changes in sensor capacitance to digital values.
3. **Microcontroller**: Reads data from the measurement IC and controls the DAC.
4. **DAC Output**: Provides a 0 V to 5 V output corresponding to sensor readings.

4 Pinout and Connections

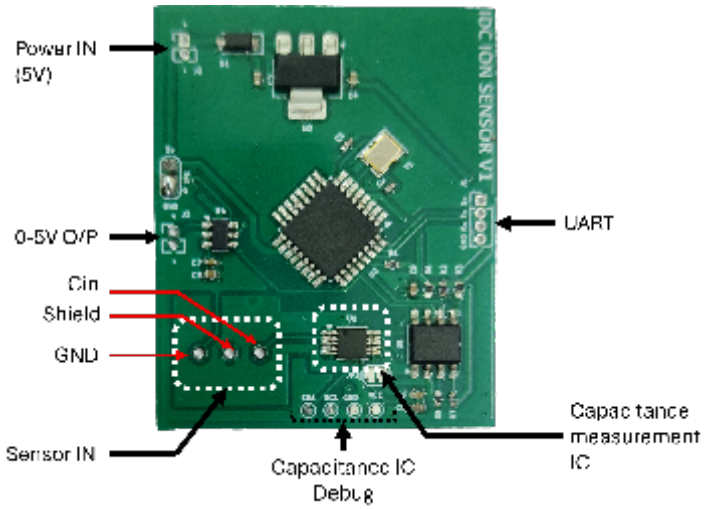


Figure 3: Pinout Diagram for the Measurement Circuit

4.1 Pin Descriptions

Pin	Name	Description
1	Power IN	5V supply input
2	O/P	0-5V analog output
3	Cin	Sensor I/P
4	Shield	Shielding for sensor
5	GND	Sensor ground
6	UART	For debugging and digital O/P
7	Capacitance IC debug	For optional debug or configuration (*Reserved*)

Table 1: Pinout and Signal Descriptions

4.2 Recommended Operating Conditions

Parameter	Value	Unit
Supply Voltage (VDD)	5 ± 0.5	V
Sensor Excitation Voltage	~3.3	V (typ)
Output Voltage Range	$0 - 5$	V

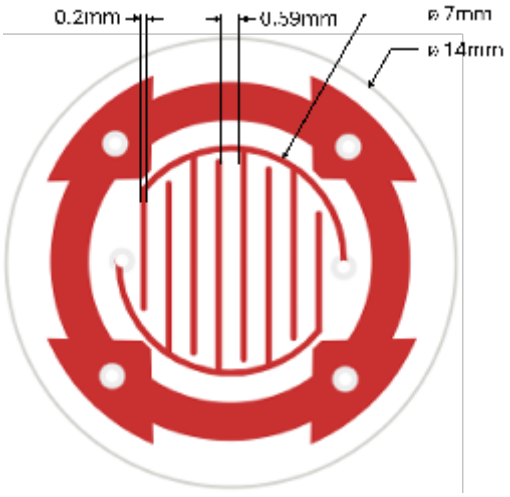
Table 2: Recommended Operating Conditions

4.3 Electrical Characteristics

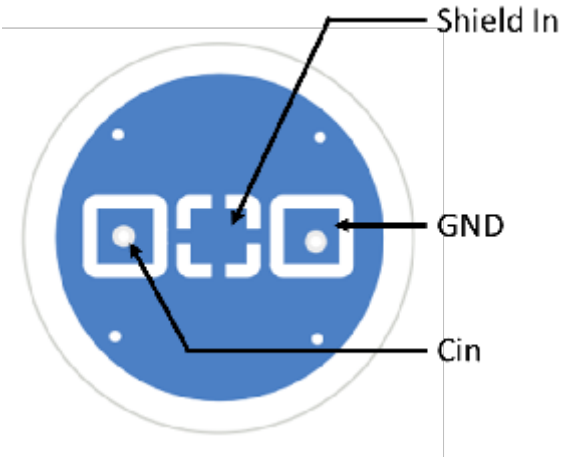
Parameter	Min	Typ	Max
Supply Current	–	10 mA	15 mA
DAC Resolution	–	12-bit	–
Measurement IC Resolution	–	16-bit	–
Sensor Capacitance Range	–	10 pF	100 pF (extended)

Table 3: Typical Electrical Characteristics (at 25 °C, VDD = 5 V)

5 Mechanical Dimensions



Dimensions of the Interdigitated Capacitive Sensor



Pin-out of Sensor

Sensor Dimensions:

- Overall Sensor Diameter: 14 mm
- Sensor Electode Diameter: 7 mm
- Interdigitated Finger Width: 0.2 mm
- Gap Between Fingers: 0.59 mm

6 Operation and Calibration

6.1 Measurement Principle

The permittivity sensor operates by measuring changes in capacitance formed between interdigitated electrodes when immersed in DI water. As ion concentration in the water changes, the dielectric constant changes accordingly, altering the capacitance. The measurement IC converts these changes to a digital reading which is processed by the microcontroller.

6.2 Calibration Procedure

1. **Reference Calibration:** Place sensor in pure DI water (baseline). Record the DAC output or digital reading.
2. **Known Ion Concentration:** Immerse sensor in a solution with a known ion concentration. Record the corresponding output.
3. **Mapping Curve:** Generate a calibration curve or table mapping ion concentration to the measured permittivity (DAC output).
4. **Firmware Adjustments:** Update microcontroller firmware with calibration data to ensure accurate readings in subsequent measurements.

7 Preliminary Studies

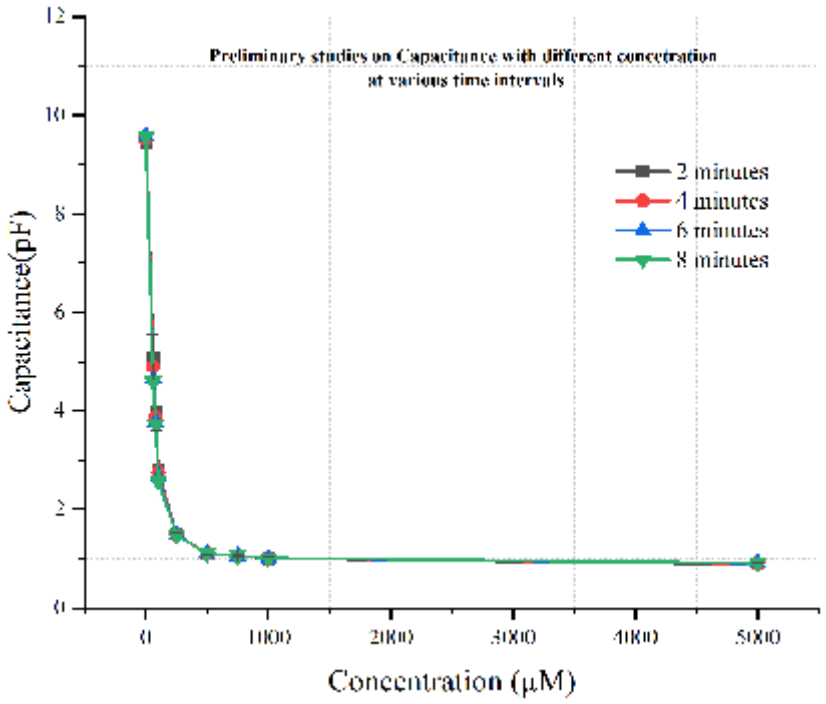


Figure 5: Preliminary studies on capacitance change for different concentrations at various time intervals