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Multi-Sense Sensing – A Path to Design Optimization

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***Abstract*— Infineon's PSOC™ analog coprocessor simplifies the design of sensor-based systems by providing a scalable and reconfigurable architecture that integrates programmable analog front-end devices (AFEs) and a signal processing engine (32-bit Arm® Cortex®-M0+) that can calibrate and tune the AFE in software. The PSOC™ analog coprocessor enables designs to send aggregated, preprocessed, and formatted sensor data over serial communication interfaces to host processors.**

Keywords*— HMI, transducers, sensor technologies, PSOC, MCU, CAPSENSE,. TCPWMs, design for manufacturing.

I. Introduction

Instead of developing separate devices for different types of measurement, a multi-sensor system combines different transducers, including capacitive, inductive, and liquid sensors, into a single system. Capacitive sensors, for example, work by detecting changes in electrical capacitance caused by conductive or dielectric materials. This technology is commonly used in human-machine interface (HMI) applications, such as touch screens, touch buttons, proximity sensors, and devices that measure humidity or liquid levels [1].

Inductive sensors generate an alternating magnetic field and detect changes caused by conductive materials in the tested object. This technology is well suited for touch-sensitive HMIs on metal surfaces and sensors designed to operate in harsh environments where traditional sensors can suffer from interference. Inductive transducers can be found in home appliances, industrial automation, and position-tracking applications. In other words, inductive sensing is a non-contact method that uses electromagnetic fields to determine conductive materials' presence, position, or properties. When a current flows through a coil, it creates a magnetic field. Eddy currents are induced on its surface when a conductive object, such as metal, enters this field. These currents create an opposing field that alters the primary electromagnetic field. The sensor detects these changes and converts them into data about the object's presence, distance, or composition [2]. The magnitude of the effect depends on factors such as conductivity, size, and proximity to the coil (Fig. 1).

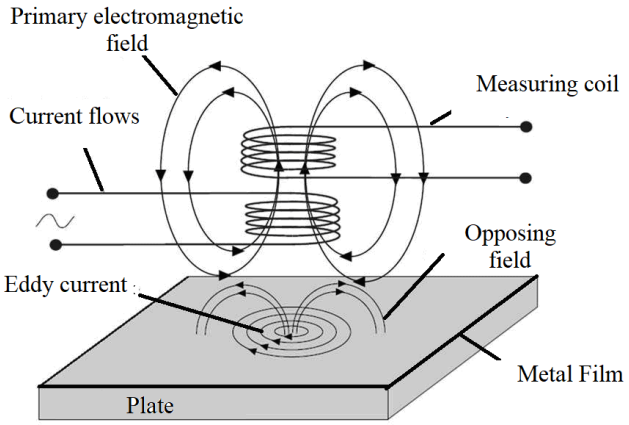

Fig. 1. Field coupling between sensor and metal or conductive target

Liquid sensors detect various properties of a liquid, such as its presence, level, flow, or composition. Different technologies, including capacitive, ultrasonic, optical, and conductive sensors, can be used depending on the application. The main advantage of this approach is its ability to operate without direct contact, using different algorithms to increase accuracy, linearize the shape of the tanks, and increase cost-effectiveness.

II. Advantages of an Integrated Multi-Sensor

Combining these three sensor technologies in a single device provides numerous advantages. One of the key advantages is increased accuracy and reliability. The different measurement methods complement each other, compensating for individual shortcomings. For example, a capacitive sensor is very effective for detecting touch and liquid levels

but is less suitable for metal objects, an area where an inductive sensor is better.

Another advantage is the reduction in system complexity and cost. Integrating multiple measurement methods into a single MCU eliminates the need for separate sensors and controllers, resulting in reduced component count, power consumption, and manufacturing costs. Embedded sensor technology helps reduce system size by replacing multiple standalone components and simplifying hardware. For example, a household washing machine can use a single PSOC 4 microcontroller to sense the water level in the tank, implement sensor control functions on the metal front panel, and manage general system control functions [3].

This technology is widely used in various fields, including industrial automation, home appliances, and medical equipment. Energy efficiency is another significant advantage, as a single low-power microcontroller optimizes power consumption.

PSOC 4 series review

Having already introduced the PSOC 4 microcontroller, let us look at its features. This device features a high-performance, low-power capacitive sensor solution with high signal-to-noise ratio (SNR), water resistance, and versatile multi-sensor capabilities for improved quality and reliability. These MCUs, part of the series, are built on the Arm Cortex-M0+ processor core and feature advanced HMI functionality. A key differentiator is its Multi-Sense feature, which includes 5th-generation CAPSENSE technology for capacitive and inductive liquid-level sensing and detection. The new version of CAPSENSE has 10 times better SNR, as well as 10 times lower power consumption than previous generations.

The MCU's inductive sensing capability based on a differential and proportional-metric sensor architecture provides broad sensor inductance and operating frequency flexibility. At the same time, its liquid-level measurement function provides accurate measurements without the need for direct contact with the liquid. This ensures optimal performance in noisy environments and the ability to distinguish between liquid types while filtering out foam and residue.

PSOC 4 consist of Programmable Analog Blocks. Configure analog interface to interface with any analog sensor using programmable analog blocks consisting of op amps, comparators, ADCs, and DACs that provide complex analog signal flows. PSOC™ 4 can also eliminate the need for external analog components, saving time and money.

Programmable digital blocks consist of universal digital blocks (UDBs), serial communication blocks (SCBs), and timer/counter/pulse-width modulators (TCPWMs). These blocks can be configured to configure custom digital interfaces, state machines, and custom logic functions. Wired and Wireless Connectivity

The PSOC™ 4 portfolio offers wired connectivity interfaces such as CAN and USB. Bluetooth® low energy is also available for wireless connectivity. With a built-in antenna matching balun, the PSOC™ 4 Bluetooth® Low Energy simplifies RF board design and reduces PCB footprint. With sample projects, development kits, and complete Bluetooth® Low Energy profiles and APIs, we can get Bluetooth® Low Energy up and running in minutes.

Easy migration path

For those already working with previous versions of PSOC 4, such as the PSOC 4000 and 4000S, upgrading to the new PSOC 4000T or PSOC 4100T Plus is simple. Its software and package compatibility ensures a smooth migration path, allowing developers to leverage previous developments while improving functionality [4].

By using Infineon's PSOC 4 together with the sensor development tools available in ModusToolbox, engineers can create high-performance sensor-based applications. These tools feature an intuitive graphical user interface and pre-configured sensor libraries, streamlining real-time setup, configuration, and tuning without the need for extensive coding. Additionally, built-in auto-tuning algorithms optimize performance across a variety of environments, simplifying sensor calibration and deployment (Fig. 2).

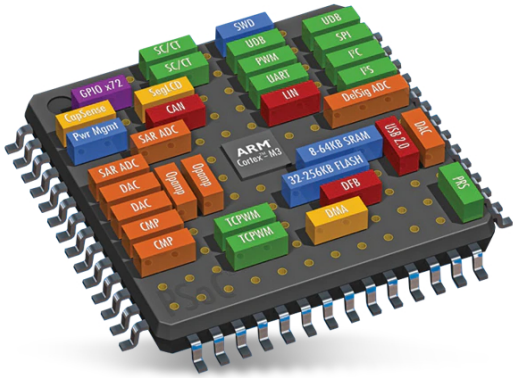

Fig. 2. PSOC 4 Multi-Sense series MCU structure

Ultimately, the Infineon PSOC 4 Multi-Sense MCU represents a significant advancement in multi-sensor technology, saving time and money while improving user experience. Its robust performance and efficiency give OEMs a competitive advantage by enabling high-performance, low-power HMI designs

REFERENCES

[1] Hardware for Providing Smart Farming Technologies./Liudmyla Sviderska. MC&FPGA 2023.DOI: 10.35598/mcfpga.2023.003.

[2] Improvement in Wireless Sensor Networks: From Technology Integration to Network Management / Evhen Horbenko, Maria Piataikina Information Systems and Technology 2023, Kharkiv, Ukraine.

[3] https://www.infineon.com/cms/en/product/promopages/Multi-Sense/

[4] https://www.infineon.com/cms/en/design-support/tools/sdk/modustoolbox-software/.