WHITE PAPER

The touch-sensing HMI in wearable and IoT devices

How the latest CAPSENSE™ touch-sensing technology enables new power- and space-saving designs

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Touch-sensing HMI design: consumer demands and market pressures

The touch-sensing human-machine interface (HMI) in wearable devices is a key element of their consumer appeal, providing a responsive, intuitive way to interact via touch buttons and sliders in devices such as earbuds and smart glasses, or via a small touchscreen in a smart watch.

Competition in the market for these types of wearable device continually drives innovation. Manufacturers battle for superiority in two features that particularly matter to consumers:

- Battery run-time between charges (the ‘recharge cycle time’)
- Form factor – OEMs have to balance comfort, convenience, and the abundance of features such as sensors with the demand for a sleek and attractive design

This market pressure affects design decisions about the touch HMI: with every new generation of a wearable product, manufacturers want to achieve substantial improvements in the touch system’s:

- Average power consumption, to conserve the battery’s energy
- Impact on the device’s mechanical design and form factor. The goal is to improve touch sensor functionality and features while reducing size and weight of the product
- Liquid tolerance, to maintain high performance in the presence of rain, sweat, etc.

And any such improvements must of course do nothing to detract from the device’s pleasing user experience.

To enable manufacturers to achieve these two goals, Infineon has introduced a new touch-sensing controller, the PSoC™ 4000T, for any type of wearable device, as well as small IoT devices. Based on the new 5th generation of Infineon’s famous CAPSENSE™ capacitive sensing technology, the PSoC™ 4000T reduces average power consumption by 10x com-pared to the previous generation PSoC™ touch controller for wearable devices. It also enables designers shrink size of touch sensors and denser placement of components around a smaller touch-sensing element without compromising performance thanks to a 10x higher signal-to-noise ratio (SNR).

At the same time, new multi-sense capability enables a single sensor to perform multiple sensing functions – not only touch buttons and sliders, but also force, proximity, and touchscreen sensing. And improvements to the touch technology result in very high liquid tolerance, giving superior touch-sensor performance in the presence of liquids such as rain or sweat.

This white paper describes the Infineon engineering breakthroughs that have produced these dramatic improvements.

Wearable devices: the big challenges facing the touch HMI design team

Market demand requires the designers of the touch HMI in wearable devices to cut power consumption and reduce size, while adding touch-sensor capabilities and maintaining an excellent user experience, including in the presence of liquids.

Let’s look at the factors that affect each of these challenges.

1 The power challenge

1.1 Why always on touch sensing drains battery power

While most other functions in a wearable device such as a smart watch can be turned off for long periods of time between episodes of user activity, the touch-sensing HMI is required to be always on. The user's touch interactions are randomly timed – there is no pattern that enables the device to know in advance when the user is going to touch it. So, it has to continuously scan for the entire time that the device is powered up consuming power by HMI subsystem. The always on touch HMI is an important factor power consumption in both low-power mode, because it is continuously scanning and Active mode in which touch sub-system burning significant power in short time, and is therefore a substantial contributor to total power consumption. Any saving in the touch system's power consumption can result in a worthwhile extension to recharge cycle time.

1.2 Understanding the operation and architecture of the touch-sensing controller

The touch HMI is normally the most commonly used method for waking up a wearable device from its sleep state. To conserve power, devices have a low-power touch detect function which runs in the device's deep sleep mode: here, it scans at a low refresh rate sufficient only to detect any kind of touch event. In this mode, the user might have to momentarily press and hold (rather than simply touching) a button to wake the system.
On detecting a touch, the HMI wakes the device, and at the same time switches to an active mode in which it operates at a faster refresh rate, and supports all the device's touch-sensing functions.

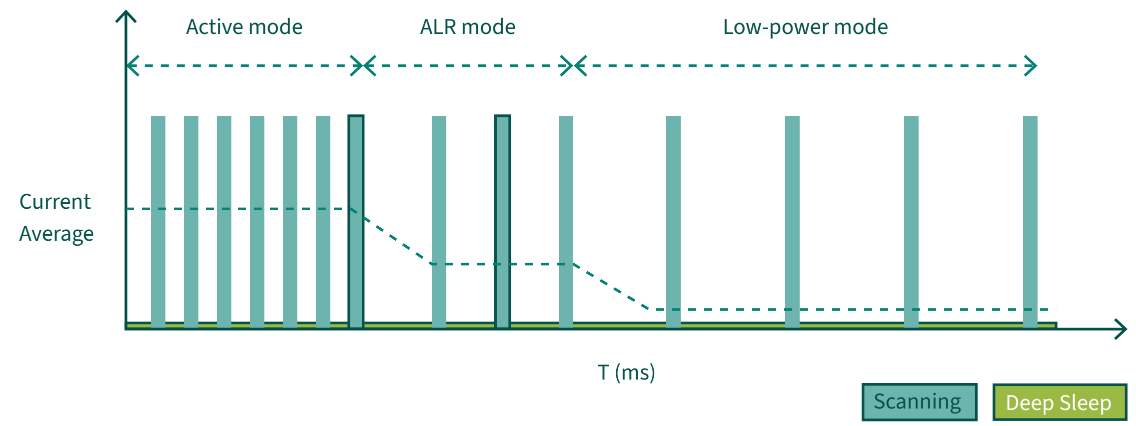


Figure 1 Reducing the refresh rate in touch detect mode reduces average power consumption.

Above is decode old method to optimize power consumption and power saved greatly depends on how slow the sensors can be refreshed; therefore, it is always a tradeoff between power consumption and quick response to user touches. In addition, today's touch HMI systems consume substantial amounts of power consumption because of architecture limitation. To understand why this is, it is worth studying the process for performing a scan of a touch sensor. Every commercial touch-sensing controller has a microcontroller-like architecture: the block diagram of the PSoC™ 4000 series of touch controllers from Infineon shown in Figure 1 provides a typical example. Its architecture consists of:

- A CPU supported by non-volatile and volatile memory resources
- An analog front end (AFE) which interfaces to the touch sensing element and other sensors
- Digital logic functions
- I/Os

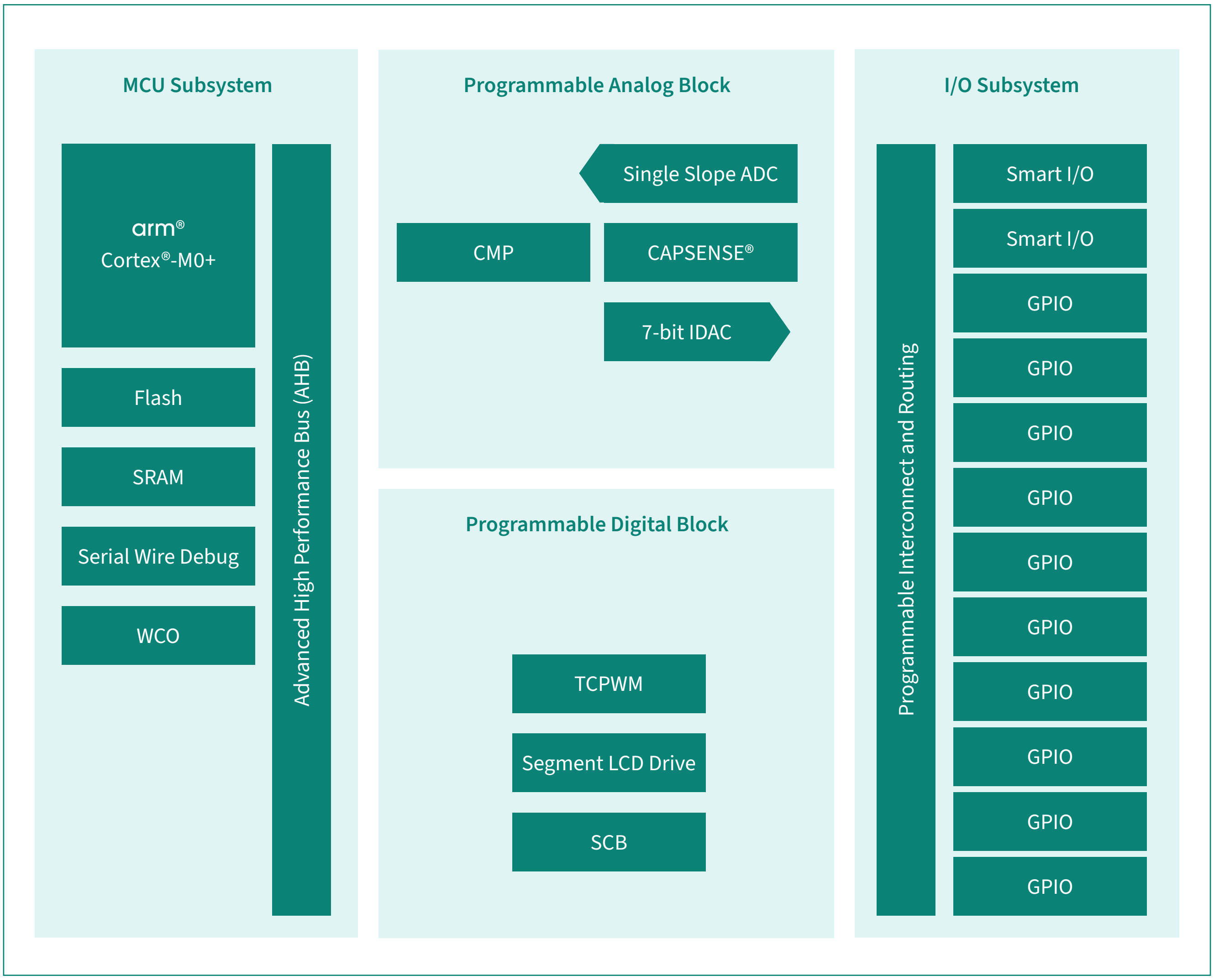


Figure 2 Block diagram of the PSoC™ 4000 series touch controllers from Infineon.

In most touch controllers – as we shall see, the PSoC™ 4000T is different – scanning operations always require the operation of the CPU, to initialize the touch-sensing system, configure the sensing element, scan the sensors, and process the results to determine whether a touch event has occurred.
Unfortunately, the CPU and its associated memory resources are heavy power consumers.
So the 'low-power' touch detect function does indeed consume less average power than active mode touch sensing because the refresh rate is reduced, so fewer scans occur each second (see Figure 2). But the power consumed by each scanning operation is high in both the touch detect and active modes, because of the involvement of the CPU.

2 The size challenge

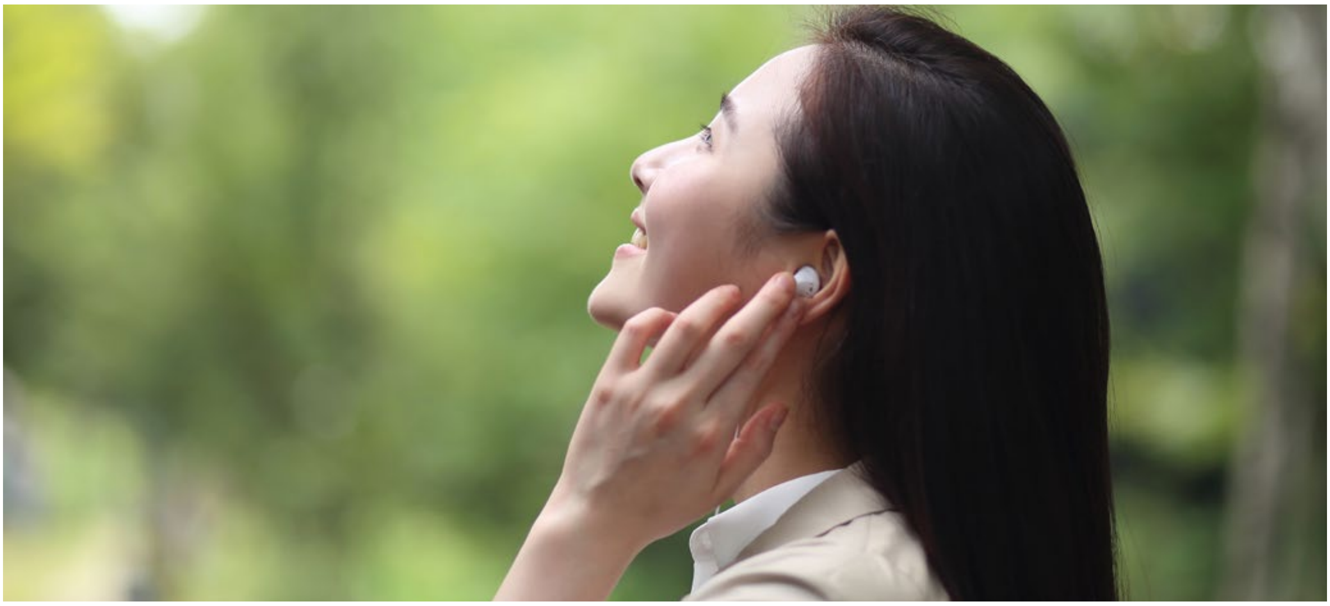
2.1 Trading off sensor size against responsiveness and accuracy

The sensitivity of a touch-sensing element or button is proportional to its area. This means that the accuracy of a touch HMI's responses can be enhanced by increasing the size of the touch sensor. Increasing sensitivity also increases the signal-to-noise ratio (SNR), leading to improved rejection of false touch events attributable to noise or interference. Noise sources can include RF emissions produced by a smart watch's display or by a Bluetooth® or other radio antenna. Interference can also be produced by water, sweat or other liquid on the surface of the device. High sensitivity and the ability to reject interference from liquids – known as liquid tolerance - have a strong impact on the user experience. Producing high sensitivity by increasing the touch sensor's size, however, reduces the device manufacturer's freedom to optimize the mechanical design of the device.

Device manufacturers are also seeking to gain competitive advantage by adding new touch-sensor features to improve the user experience even more: these features include force sensing, and proximity sensing – for instance to wake the device up when it detects a finger close by, before it has touched it. Some devices also require the touch sensor to support both touch buttons and touch sliders and touchscreen functionality.

The challenge for the device OEM is to provide this wide range of features without increasing the overall size of the device – and while also achieving high sensitivity and high liquid tolerance.

The solution can be found in a single touch controller which integrates all these capabilities.



2.2 5th generation CAPSENSE™ technology: a solution to the challenges of power and size

The CAPSENSE™ technology that underpins the operation of touch-sensing controllers from Infineon has set the benchmark for performance and usability since its first generation was introduced in 2002. The fourth generation of CAPSENSE™ technology, which was first implemented in PSoC™ touch controllers in 2017, featured many innovations including inductive sensing capability for the first time.

The year 2022 saw the introduction of the latest, 5th generation. This brought in a major architectural innovation: ratiometric sensing.

There is another CAPSENSE™ innovation in the new PSoC™ 4000T touch-sensing controller for wearable devices: Ultra-low power Always on sensing (MSCLP) and Multi-sense sensing technologies.

This integrates multiple touch-sensing methods – self-capacitance sensing, mutual capacitance sensing, and inductive sensing – into a single chip, supporting the implementation of touch, force and proximity sensing with a single chip. MSCLP also enables a capability called Ultra-low power Always on sensing where PSoC™ 4000T microcontroller can be in Deepsleep state yet perform touch sensing optimizing the power.

Together, these innovations provide a solution to the problems of power and size that wearable device manufacturers face.

Solving the power challenge: autonomous capacitive sensor scanning

2.3 Always on sensing function greatly extends touch controller’s time in Deep Sleep state

The MSCLP is a new, dedicated hardware block implemented in the PSoC™ 4000T controller. Its system resources include a 1kB SRAM, high-frequency clock, and reference voltage generator, sufficient to perform scanning operations of up to 16 sensor elements and support multiple sensing methods. The MSCLP can also process the results to determine whether a touch event has occurred. (Detailed processing of results to precisely locate and interpret a touch event or a series of touch events requires the intervention of the controller’s Arm® Cortex®-M0+ CPU, which runs when the device is in active mode.)

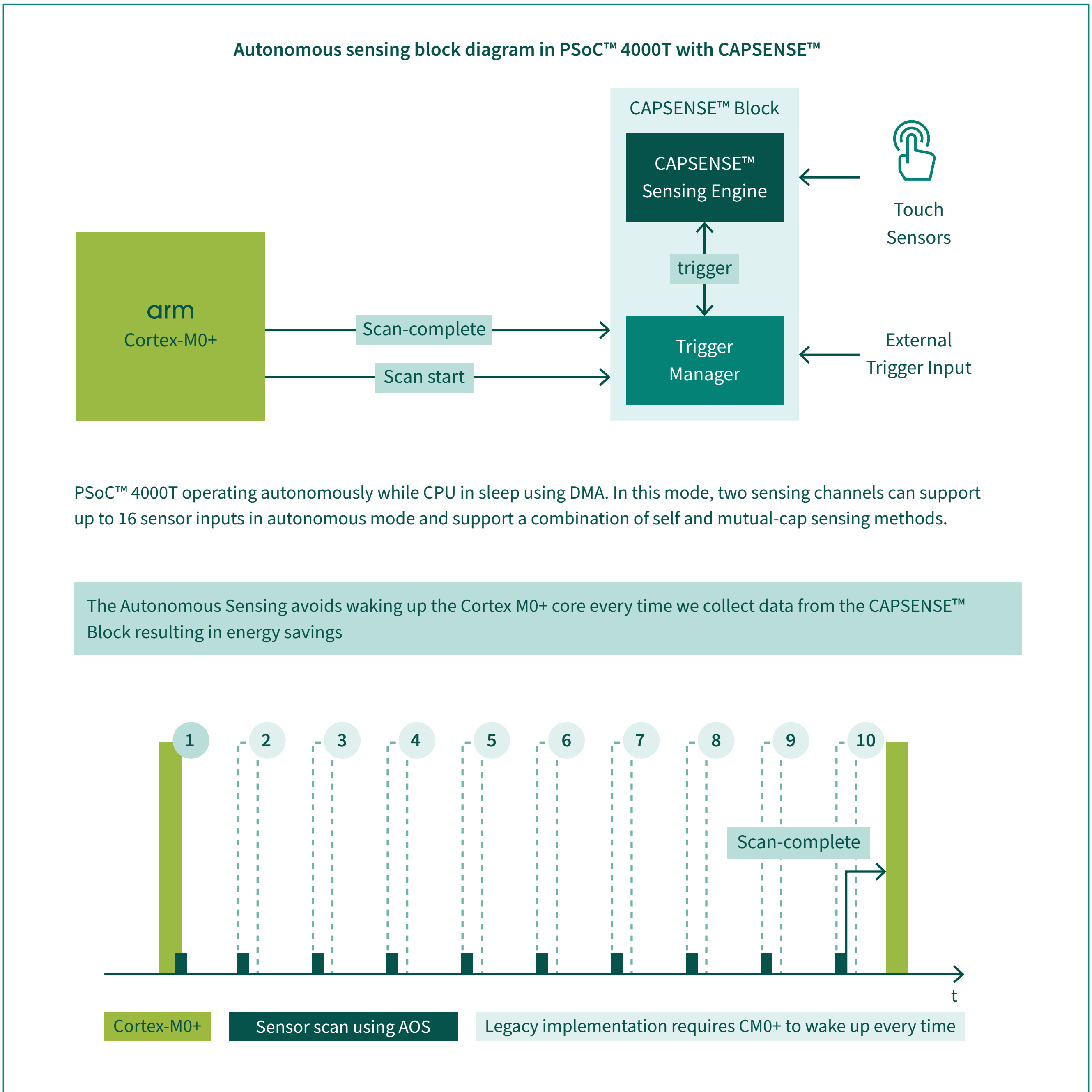


Figure 3 Average current is higher in active mode than in low-power mode because the CPU processes results in active mode. Note that the CPU remains in its deep sleep state at all stages in active mode except when processing scan results.

The MSCLP, controlled by middleware hosted in the PSoC™ 4000T, is the basis of the AOS function: in AOS mode, the MSCLP performs sensor scanning autonomously, without any involvement by the CPU. Since the CPU and its associated memory resources draw a much higher operating current than the MSCLP block does, use of the AOS mode produces substantial savings in the average power consumption of the touch HMI system (see Figure 3).

Demonstration designs developed by Infineon have shown that a smart watch's touchscreen HMI based on the PSoC™ 4000T can run on just 360 µW in active mode, and 11 µW in wake-on-touch (WoT) mode. A four-sensor touch slider in an earbud can run on 160 µW in active mode.

Table 1 Power consumption comparison

Power	Fourth-generation CAPSENSE™	PSoC™ 4000T (Fifth-geneartion CAPSENSE™ with LP)	Condition
Wake on Touch (Lowest power)	50 µA	6 µA[1]	10 buttons ganged to a total of 40 pF with shield enabled. Shield Cp = 39 pF Refresh rate = 16 Hz. Sensitivity = 0.4 pF.
Active – High refresh rate (Active power, Four sensor Hearable HMI)	800 µA	90 µA	4 buttons, each with electrode Cp = 5 pF with shield enabled. Shield Cp = 39 pF. Refresh rate = 128 Hz. Sensitivity = 0.4 pF.
Active – High refresh rate (Active power)	2000 µA	200 µA	13 buttons, eacht with electrode Cp = 5 pF with shield enabled. Shield Cp = 39 pF. Refresh rate = 128 Hz. Sensitivity = 0.7 pF.

Figure 4 A comparison of the operating current drawn by a fourth-generation CAPSENSE™ touch controller, which does not have AOS capability, and a PSoC™ 4000T operating in AOS mode with no involvement of the CPU in scanning operations.

2.4 How to deploy AOS mode for maximum power savings

The AOS function can be deployed in any power state of the PSoC™ 4000T and this can be done by choosing this sensing method in in drop down list in CAPSENSE™ Middleware configurator.
In active mode, the user is interacting with the device via the touch HMI, and requires instant interpretation of all touch events. When the AOS mode is deployed with the PSoC™ 4000T active, the MSCLP block autonomously reads each sensor configuration, initiates scanning, and saves the result to SRAM for the CPU's middleware to read and process after full-frame scanning is completed. As Figure 4 shows, in this mode of operation, the CPU remains in its Deep Sleep state while the MSCLP performs sensor configuration, initiation and scanning, and only wakes up to process the results.
In low-power modes, the MSCLP block autonomously reads each sensor configuration, initiates scanning of the same frame at a low refresh rate, and processes the result to detect whether a touch event has occurred. Here, the CPU is not required to initiate scanning or process the results. This means that the PSoC™ device can be kept in deep sleep mode continuously until woken up after detection of a touch event.

2.5 Use case examples of the CAPSENSE™ low-power operation

To illustrate the application of the new low-power capability in 5th generation CAPSENSE™ technology, consider a smart watch's touchscreen: the display is a high-power consumer, so needs to be turned off when not in active use to conserve battery energy.
The PSoC™ 4000T with 5th generation CAPSENSE™ technology could support a WoT function, in which the MSCLP scans a reduced number of sensors at a low refresh rate and processes the results without CPU intervention. A low-power interrupt is generated by the MSCLP hardware only when there is user activity, or when a timeout occurs.
This means that the smart watch, which spends 96% of the time on average in low-power mode, could extend the power savings because in low-power mode the PSoC™ 4000T's CPU will be turned off and chip remains in Deepsleep state until a user touch is detected.
Additional power savings can be achieved in active mode that all sensors can be scanned in Autonomous mode where CPU is off and chip is Deepsleep state during the scanning of all sensors – thus saving power in Active mode and wake up CPU only at the end of last sensor scanning so that CPU can process the data. This allows touch controller to run both standby mode and Active mode touch sensing operation in highly power efficient manner.

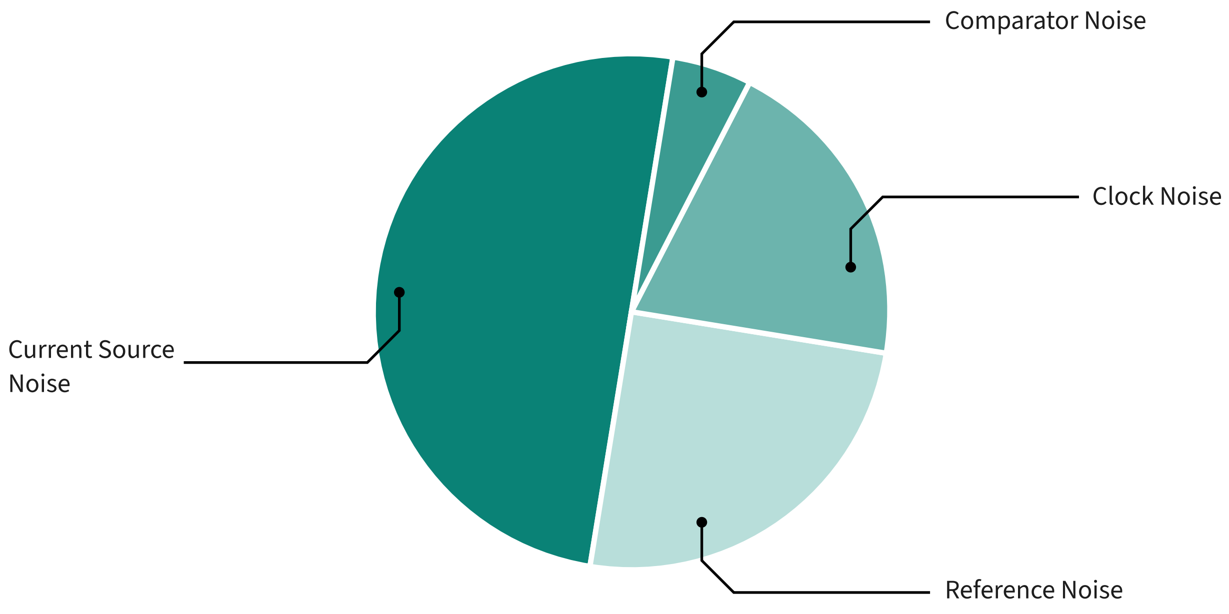
2.6 Dramatically increased SNR enables operation with smaller sensors to save space

As explained above, signal is proportional to the area of the touch sensor. Touch-sensing HMI systems in small devices that have a controller with a low SNR can compromise a product's design because of the large minimum size of sensor required to provide adequate accuracy and responsiveness to touches.

The PSoC™ 4000T solves the SNR problem in space-constrained touch HMIs thanks to the introduction of a new architecture in the 5th generation CAPSENSE™ technology.

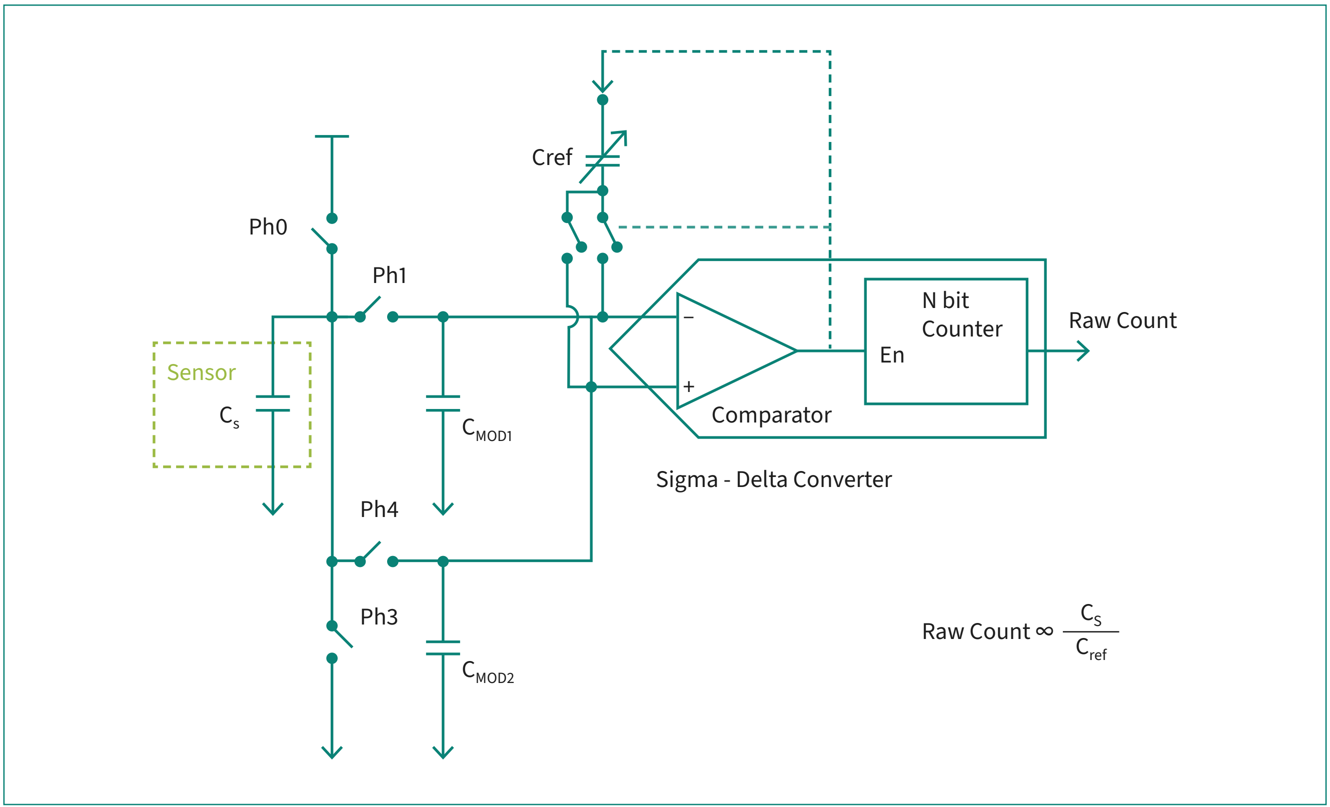
The classic topology for the sense converter circuit in a touch-sensing controller is single-ended. The single-ended circuit configuration relies on an internal reference voltage. This means that the touch sensor output is prone to error generated by the internal reference when it is exposed to voltage or current noise, to clock jitter or drift, or to other low-frequency internal or external noise sources. The diagram illustrates the effect of the various types of noise encountered in typical single-ended capacitance-to-digital converters.

Noise Pareto



By contrast, Infineon's 5th generation CAPSENSE™ technology uses a differential configuration for the sensing front-end coupled with a ratiometric sensing architecture, in which the sensor output is simply a ratio of the sensor capacitance to the reference capacitance. This ratiometric sensing architecture eliminates the need for internal references in the sensing circuits, and thus removes this source of error. At the same time, the differential sensing front-end removes low-frequency external noise from the sensor output.

Benefiting in addition from a valuable reduction in comparator noise in its delta-sigma modulator design, the 5th generation CAPSENSE™ technology provides a substantial increase in SNR and a much-reduced noise floor (for a sensor with capacitance of 8pF) of less than 100aF– some 10 times better than 4th generation CAPSENSE™ devices can achieve.



2.7 Real-world benefits to device designers

The low noise floor and the resulting high SNR are the attributes of 5th generation CAPSENSE™ technology that enable PSoC™ 4000T-based touch HMIs to operate reliably with a smaller sensor.

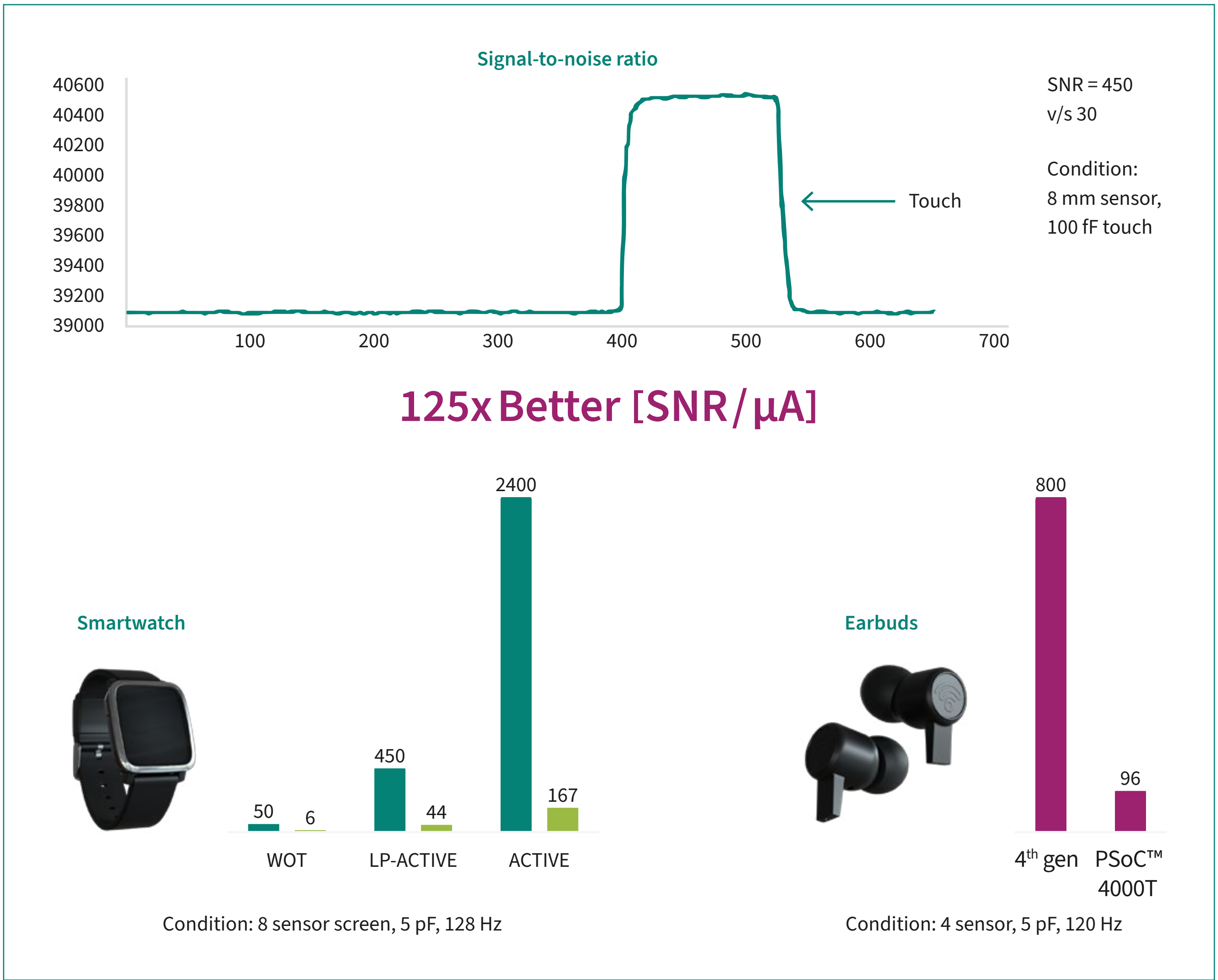
In real-world products, this allows the designer to maintain high touch-sensing performance with a small sensor element. In a product such as an earbud, this gives the designer scope to reduce the overall size of the product, making it sleeker and more discreet – a valuable product enhancement for premium products.

In designs for other products such as fitness tracker wristbands, the space released by the replacement of a large touch-sensing element with a smaller element can be used to provide new features that add extra value to the product.

The PSoC™ 4000T's high SNR also gives the freedom to mount system noise sources such as an RF antenna close to the touch sensor without impairing the user experience.

Figure below shows two real-world examples of advantage of SNR and power consumption improvements. A case study is made with a smartwatch touchscreen which has 10 sensors and another touch sensor HMI design on Earbuds which has 4 sensors by retrofitting existing products in the market with PSoC™ 4000T, the analysis shows SNR was improved to 450 from 30 in current design and Active power reduced from 167uA from 2400uA in product in the market today.

For net SNR achieved for each unit for current consumed, we can see the PSoC™ 4000T based solution provides 125x better performance compared to products in the market today, helping to improve the battery life while improving the reliability of touch sensors.



Solving the size challenge: new multi-sense capability

2.8 Integration of touch, force and proximity sensing in a single chip

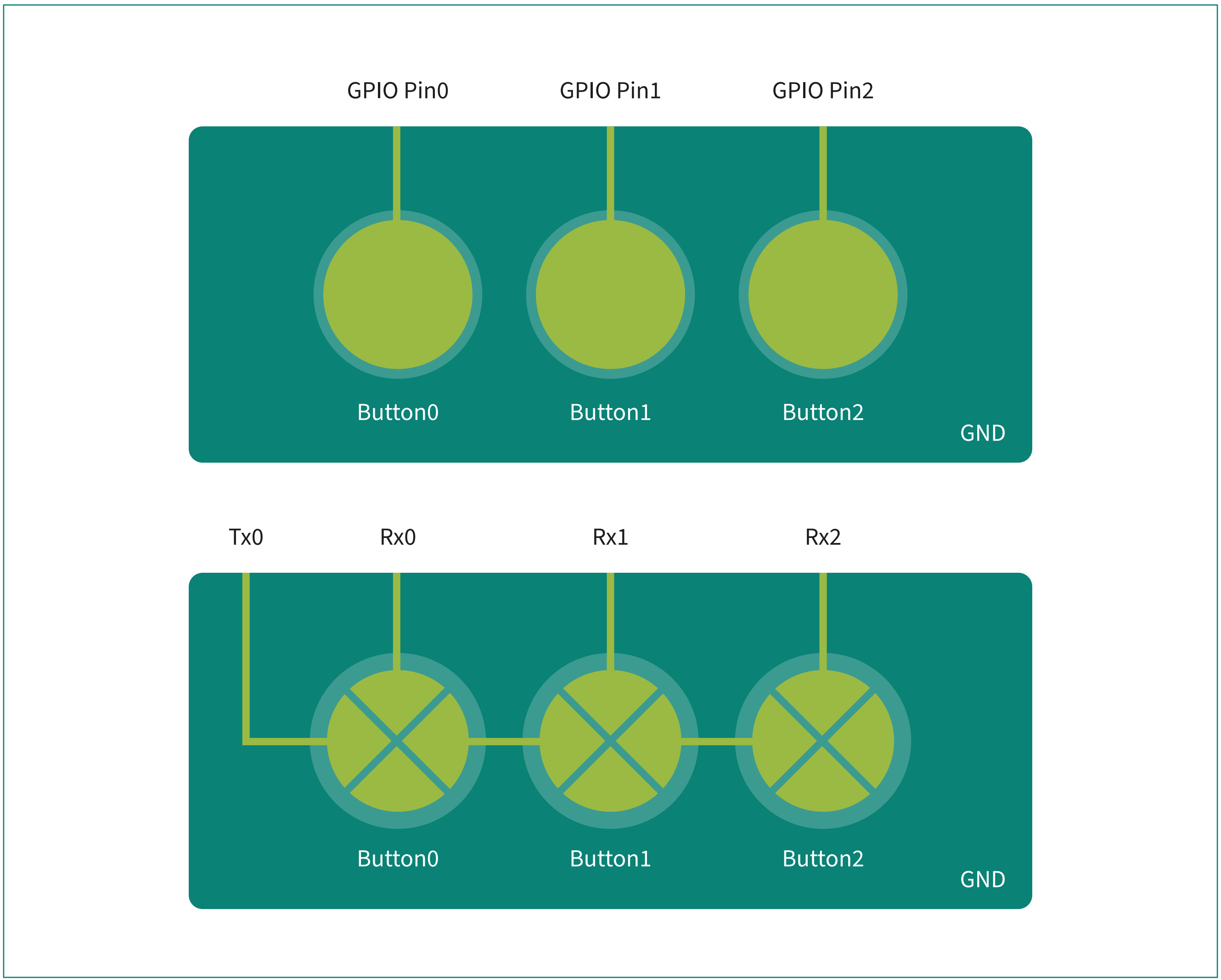
Conventional touch-sense controllers on the market today implement familiar functions, such as touch-sense buttons, sliders, and touchscreens.

But the function of the user interface can be enhanced by the provision of additional touch-sensing functions, including force sensing and proximity sensing. The 5th generation CAPSENSE™ technology enables these sensing functions to be integrated in the same PSoC™ 4000T controller that also performs button, slider and touchscreen functions.

The multiple sensor modalities supported in the 5th generation CAPSENSE™ technology are self-capacitance, mutual capacitance and inductive sensing – all implemented in a single chip.

The PSoC™ 4000T uses a patented CAPSENSE™ sigma delta (CSD) method for self-capacitance sensing, and CAPSENSE™ crosspoint ratiometric (CSX-RM) for mutual-capacitance scanning. The CSD-RM and CSX-RM touch sensing methods provide the industry's best-in-class SNR. These sensing methods are a combination of hardware and firmware techniques.

Support for both CSD-RM and CSX-RM methods in the PSoC™ 4000T gives designers the flexibility to choose different ways to implement touch-sensing features such as touch buttons. The upper image shows a button implementation using CSD-RM, while the lower image shows an implementation for the same buttons using the CSX-RM method.



The different techniques have complementary strengths and weaknesses. For instance, the CSX-RM method is recommended when implementing a matrix of touch buttons. A PSoC™ 4000T supports CSX capability for this button configuration.
A proximity sensor, which can detect a hand at a distance of several centimeters to tens of centimeters depending on the sensor construction, has different requirements from an array of touch buttons. Self-capacitance is the recommended method of sensing for a proximity application. This capability too is integrated into the same PSoC™ 4000T that also supports a matrix of touch buttons.

Likewise, the provision of inductive sensing capability via the MSCLP block enables a device to perform various other sensor functions with the same PSoC™ 4000T device. These additional functions are:
– Accessory detection/identification, for instance of watch bands
– Foreign object detection in wireless charging
– Hermetically sealed force sensing touch buttons
– Touch sensing over metal
– Rotary encoders

2.9 Use case example: integration eliminates discrete proximity sensing sub-system

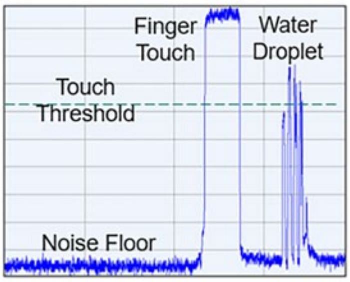
The multi-sense capability in 5th generation CAPSENSE™ technology enables wearable device OEMs to provide more features in less space.
For instance, proximity sensing may be used in a smart watch as a wake-up method, bringing the display to life when the user's finger approaches the screen. In smartphones, proximity sensing is implemented with an infrared (optical) sensor system consisting of an infrared LED, infrared photodiode, and analog front end. An infrared proximity sensor module combining all of these elements would typically occupy a board footprint of 2 mm × 2 mm.
The PSoC™ 4000T with MSCLP technology enables this device and all its supporting components to be eliminated: the proximity sensing functionality can be provided within the similar form factor, with the only impact on the hardware design being the configuration of the touch-sensing element to provide the higher electric field strength required for proximity sensing (compared to touch buttons).

Solving the liquid interference challenge

2.10 Superior liquid tolerance maintains touch sensor performance in presence of rain or sweat

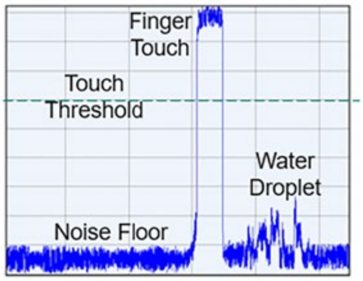
In a capacitive-sensing application design, false sensing of touch or proximity events can occur when a film of liquid, or liquid droplets, are lying on the sensor surface.
The CSD sensing method supported in 5th generation CAPSENSE™ technology can compensate for the variation in the raw sensor count attributable to the presence of liquid, and provide for reliable capacitive sensor operation. To compensate for changes in raw count due to mist, moisture, and humidity changes, the CAPSENSE™ technology continuously adjusts the baseline of the sensor to prevent false triggers.
Detailed design guidelines provided by Infineon give comprehensive advice on the way to implement a liquid-tolerant PSoC™ 4000T-based design: in summary, if the application requires tolerance to liquid droplets, implement a driven shield signal and shield electrode. If the application requires tolerance to streaming liquids as well as liquid droplets, implement a driven shield signal and shield electrode and a guard sensor. These methods are fully explained in application note AN85951 published by Infineon.

Raw count without a shield electrode



The Raw Count generated by a water droplet exceeds the touch threshold, causing a false touch

Raw count with a shield electrode



The Raw Count generated by a water droplet is below the touch threshold; therefore, there is no false touch

CAPSENSE™ works under liquids

CAPSENSE™ buttons even work under spaghetti sauce

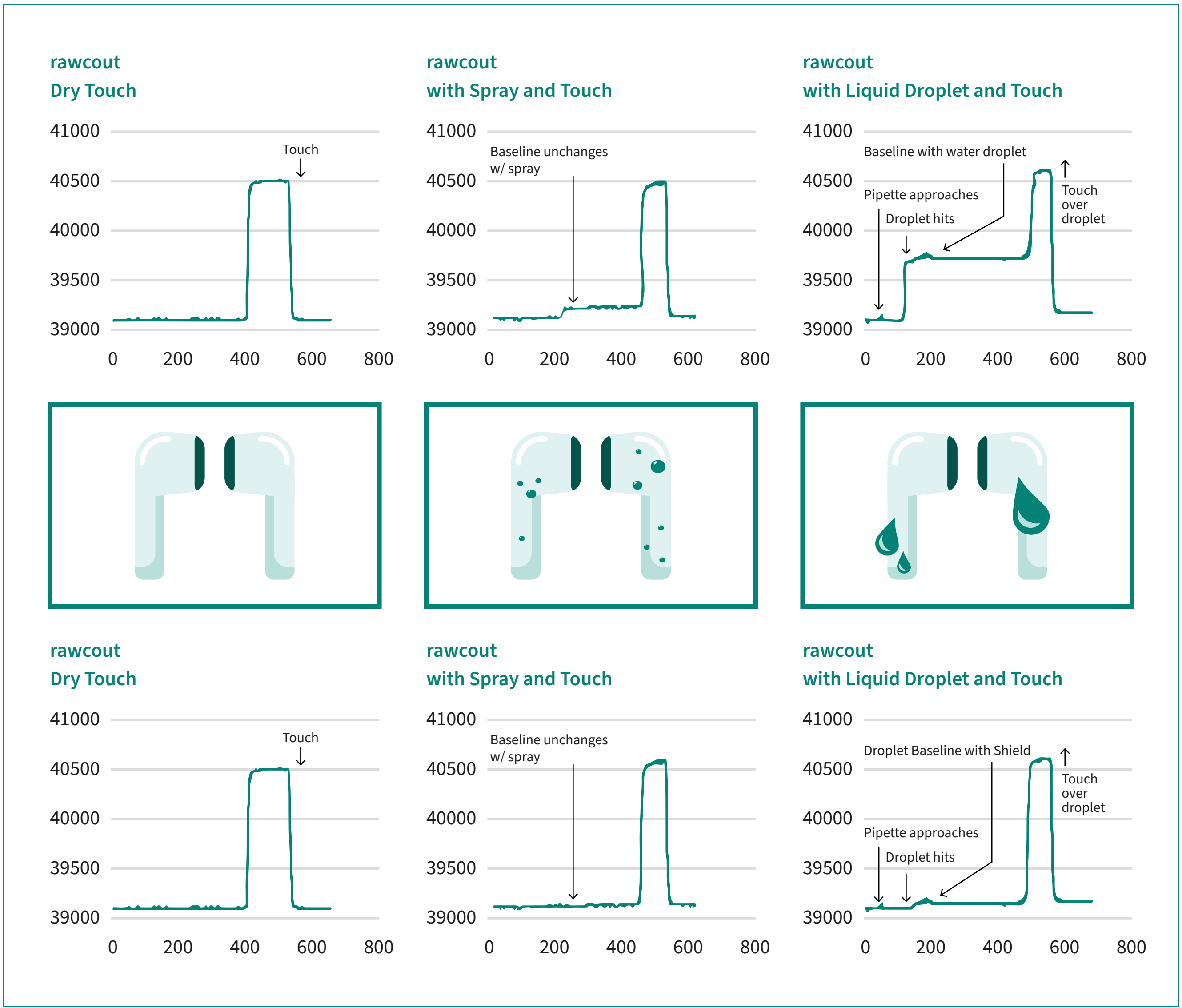
2.11 Use case examples: touch sensing functionality maintained when exercising

Conductive liquids such as water or sweat readily fall on wearable devices such as smart watches, smart glasses, or fitness tracker wristbands, as these products are often used outdoors or when exercising.

The user might not be able to wipe the surface clean of liquid when exercising, because sweat is present everywhere, including on hands and fingers.

The ability of the PSoC™ 4000T to maintain touch-sensing capability when sweat is lying on the touch sensing surface makes the device more usable and convenient, saving the user from the need to find a towel or other absorbent material to clean the surface every time that they want to interact with it.

Figure below shows a real-world examples of improved liquid tolerance performance of PSoC™ 4000T. A case study is made with a touch sensor HMI design on Earbuds which has 4 sensors by retrofitting existing products in the market with PSoC™ 4000T, the analysis shows the current technology in the market loses about 60% signal in worse case liquid presence while PSoC™ 4000T manages the limit signal loss to less than 10% – enabling the touch HMI function reliably even in the presence of sweat droplets.



2.12 PSoC™ 4000T: more than a touch-sensing controller

The primary function for which the PSoC™ 4000T is intended to be used is as the controller of a touch-button or touch-screen HMI in wearable and small IoT devices. Based on the foundation of the programmable PSoC™ architecture, the PSoC™ 4000T has a configurable AFE that can be adapted to suit the requirements of multiple applications.

This means that OEM design teams can use the same controller across multiple products, such as a smart watch, earbuds, activity tracker and smart speaker. The choice of the PSoC™ 4000T increases design productivity, because it enables re-use of IP from one design to another. Engineers who have become familiar with the PSoC™ 4000T and its development environment avoid the need to learn to use different controllers for different products.

With its 5^{th} generation CAPSENSE™ technology, Infineon also introduced a new MSC (Multi-Sense Converter) hardware block. As its name suggests, this MSC block in the PSoC™ 4000T can handle multiple sensor modalities: it can implement inductive as well as self-capacitance and mutual-capacitance touch sensing. Its flexible analog front-end is also capable of directly interfacing to other analog sensors in addition to capacitive sensors.

In addition, the flexibility of the PSoC™ 4000T provides scope to integrate a ‘wear detect’ function, simplifying the system design and reducing component count.

2.13 Capacitive method for wear detect and proximity sensing

The wear detect function is a power-saving measure that enables a wearable device such as earbuds or smart glasses to automatically switch to a power-down mode when not in use. A common method for implementing the wear detect function – the same applies to proximity sensing, as described above – is infrared (optical) proximity sensing. This method has two substantial drawbacks, however:

- The need to accommodate an additional optical sensing system alongside a capacitive touch-sensing system compromises the mechanical design of space-constrained products such as earbuds or smart glasses. The proximity sensor's transmitter/receiver module adds to the bill-of-materials cost and increases component count.
- Infrared proximity sensors are plagued by reliability problems caused by contamination of the sensor window, attenuating or completely blocking infrared light transmission, and by interference from sunlight and other external sources.

A PSoC™ 4000T can perform capacitive proximity sensing for the wear detect function alongside the touch HMI function, requiring the addition only of very low-cost and small sensor elements for the proximity function. Such a capacitive proximity sensing implementation is immune to the contamination and interference problems that impair the performance of infrared proximity sensors.
The same wear detect firmware can be applied across multiple products based on the PSoC™ 4000T.
For products that have a wear detect function, then, use of the PSoC™ 4000T for both the touch HMI and wear detection saves space, reduces cost and simplifies the design.

2.14 Capacitive method for liquid level sensing

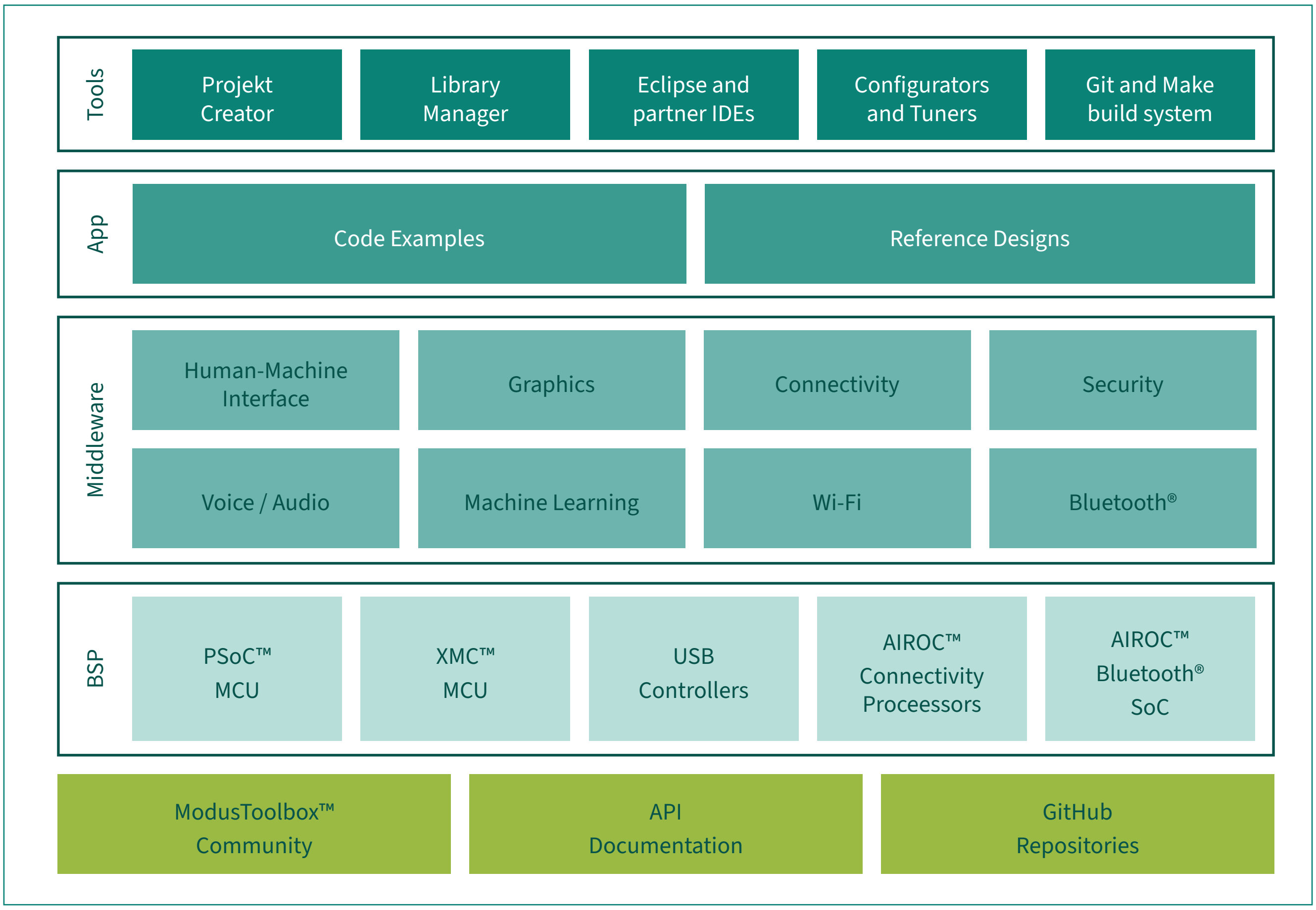
Capacitive sensing techniques can also be used to sense the level of liquids in a vessel or tank. A product that uses the PSoC™ 4000T for touch sensing control of the human-machine interface can add liquid level sensing capability interfaced to the PSoC™ 4000T without the need for any additional components except the sensor element in the tank.
This could be implemented, for instance, in an iron for pressing clothes, where the touch sensing HMI provides buttons or sliders for activating functions and turning the iron on and off, and the liquid level sensor can alert the user when the water tank (for steam iron functionality) is about to run dry. All of these functions can be implemented with a single PSoC™ 4000T.

2.15 CAPSENSE™ technology backed by comprehensive hardware and software resources

This white paper has described the ways in which the 5th generation CAPSENSE™ capacitive sensing technology in the PSoC™ 4000T enables manufacturers of wearable and small IoT devices to increase recharge cycle time and reduce the size of the touch-sensing system.
Designers who as a result wish to explore the potential for implementing CAPSENSE™ technology in their designs will find that Infineon supplies a rich set of development resources to support them. Development of CAPSENSE™-based systems is backed by the ModusToolbox development platform (see below). ModusToolbox software is a modern, extensible development environment supporting a wide range of Infineon microcontroller devices, including the PSoC™ products. Provided as a collection of development tools, libraries, and embedded runtime assets, it provides a flexible and comprehensive development experience.
The ModusToolbox package includes desktop programs that enable:

- The creation of new embedded applications
- The management of software components
- Configuration of device peripherals and middleware
- Compiling, programming, and debugging

ModusToolbox runtime software includes an extensive collection of GitHub-hosted repositories comprised of code examples, board support packages, middleware, and application support.



The ModusToolbox platform's support for HMI development includes software supporting the creation of touch-sensing buttons and sliders, and of touchscreen interfaces. The ModusToolbox platform also enables development of other capacitive sensing functions such as proximity sensing.

2.16 Scalable system design

Thanks to the ModusToolbox platform, CAPSENSE™ applications are easily portable from one PSoC™ controller to another, providing for scalability of HMI applications across broad families of product designs.
For wearable and IoT device designs based on the PSoC™ 4000T, designers can evaluate the hardware and the ModusToolbox development environment with the PSoC™ 4000T Pioneer development kit (part number CY8CKIT-040T), an easy-to-use and inexpensive development platform which features the PSoC™ 4000 device family with up to 16KB Flash and 2KB SRAM. The kit is supplied with:

- Trackpad shield board
- 6 jumper wires
- Quick Start Guide
- USB cable

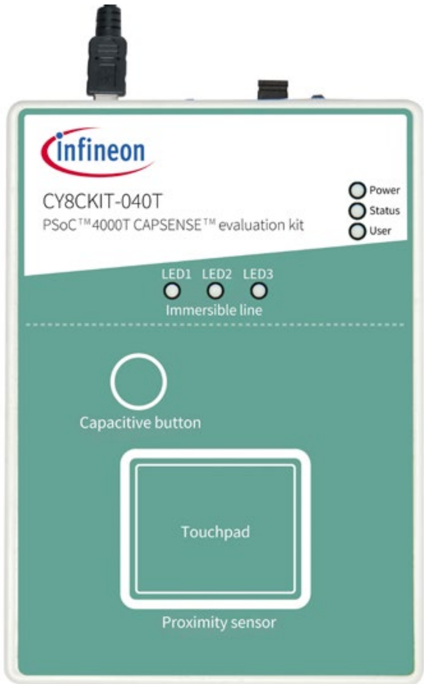


Figure 5 The CY8C-040T Pioneer development kit's PSoC™ 4000 controller board

Technical documentation supporting development from concept to production
Infineon supplies comprehensive and helpful documents for those who want to design touch HMIs. They guide the user from concept through to production, and help them to overcome various system-level challenges in creating a robust touch HMI for a product.

- CAPSENSE™ capacitive sensing overview web page
- Getting started with CAPSENSE™, application note AN6846
- CAPSENSE™ Configurator Guide as part of ModusToolbox
- PSoC™ 4 and PSoC™ 6 MCU CAPSENSE™ design guide

Code examples are available via GitHub.
Developers can find help via the Infineon Developer Community.

Author:
Vibheesh Bharathan, Senior Manager, IoT Compute and Wireless at Infineon Technologies

Vibheesh Bharathan is a dynamic marketeer with strong engineering background in system design and semiconductor fields. Vibheesh Bharathan is a Product Marketing Manager responsible for Touch sensing technology portfolio of MCU product line at Infineon Technologies AG. He has over 15 years of experience in technical and business roles and enjoys technology and business development.

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