



WHITEPAPER

A Differentiated HMI Solution using Capacitive Touch Sensing Technology

Edition: v1.0
Date: 06/2023

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Capacitive sensing is a popular interfacing alternative to switches and knobs in consumer electronics, industrial and automotive front panel applications. IoT devices span across consumer, industrial, and business applications. All these applications can benefit from a sleek user interface, with product-differentiating features such as a touch display, buttons/sliders, proximity sensing, and intelligent touch switches for smart homes. For the best user experience, touch displays may also need to be able to support gesture recognition, water resistance, wrist detection, and gloved touch. Each of these features can be implemented using capacitive sensing technology in a manner that enables intuitive ways for users to interact with the product.



Figure 1 Touch enabled Home Appliance (Example)

1 CAPSENSE™ Basics

CAPSENSE™ is an Infineon's capacitive touch sensing technology. It works by measuring changes in the capacitance between a plate (the sensor) and its environment to detect the presence of a finger on or near a touch surface. A typical capacitive sensor consists of a copper pad of proper dimensions on the surface of a PCB, where a nonconductive overlay serves as the touch surface for the button. There are two types of sensing methods commonly used in capacitive touch sensing applications.

2 Self-Capacitive Sensing (CSD)

CSD – CAPSENSE™ Sigma-Delta is Infineon's preoperatory self-capacitance sensing method. A sensor is nothing but a conductive object connected to a PSoC MCU pin. Sensor can be constructed using a copper pad on PCB, transparent materials such as ITO or silver-oxide printed on glass for Touchscreens, it could be even conductive paint printed in non-conductive material or even as simple as a wire. The high-performance touch sensing engine measures capacitance of electrode w.r.t ground. The algorithms in touch firmware library identifies touch pattern and user interactions. Self-cap sensing is used in interface that support one finger operation such as buttons, slider, proximity sensor and touchscreen with one finger operation.

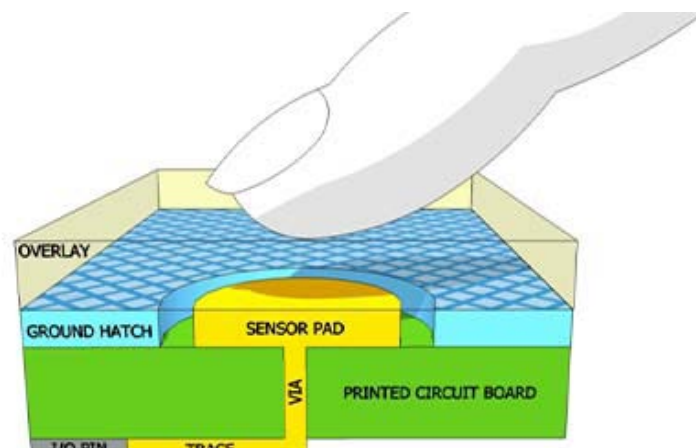


Figure 2 Self-Capacitive Sensing (CSD) Method

3 Mutual-Capacitive Sensing (CSX)

CSX – is Infineon’s preoperatory mutual-capacitance sensing method. As the name suggests, Mutual-capacitance works by measuring the capacitance between two electrodes, the transmit (Tx) and receive (Rx) electrodes. When a finger is placed between the Tx and Rx electrodes, the CM decreases. Because of the reduction in CM, the charge received on the Rx electrodes also decreases. The capacitive-sensing system measures the amount of charge received on the Rx electrode to detect a touch/no touch condition. Example of an application that benefits from mutual-cap is touchscreen that can simultaneously detect multiple finger touches.

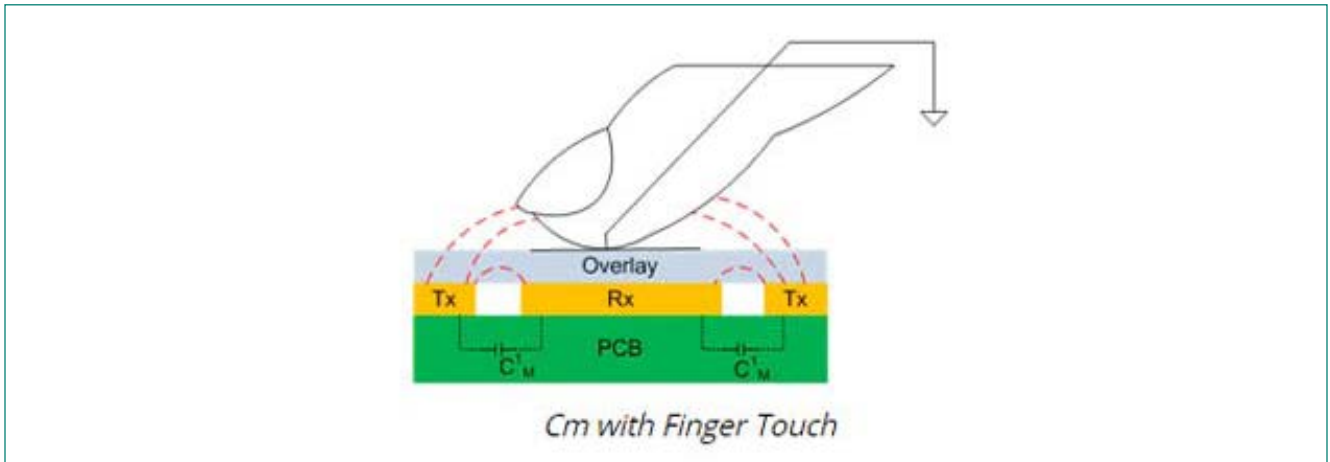


Figure 3 Mutual-Capacitive Sensing (CSD) Method

4 Challenges in designing a Robust Touch HMI Solution

Building a robust and reliable capacitive sensing system gives many challenges to an embedded designer. Detecting a finger touch on touch panel requires measuring capacitance in range of femto farads. There are several noise sources that can affect the measurement, hinder the operation and create false touch detection. These noise sources include but not limited environmental factors, liquid presents, metal objects, dust, moisture, wet, extreme temperatures or electrical noise such as conducted and radiated noises from other equipment. The touch interface must reliably work in all these conditions, should meets the EMC & EMI and regulatory requirements.

A good reliable touch HMI design should consider Robustness, Response Rate, Low Power and Aesthetics & Form Factor.

5 Robustness

Infineon offers a high performance, robust solution with high immunity to various noise sources and it works reliably in harsh operating conditions. The high immunity from external noise sources is built into silicon hardware and the extensive firmware algorithms that hides this silicon complexity and gives a reliable Capacitive Touch sensing solution. Some of the important parameters that helps provide robust solution includes:

- **Signal to noise ratio:** This is the most important specification for a design. A high SNR is indicative of a highly reliable touch interface. Infineon’s advanced sensing algorithms provides reliable performance even in noisy environments with Signal-to-Noise Ratio (SNR) of $> 100:1$.
- **Robust Liquid Tolerance:** Touch sensing must work reliably in presence of water droplets, rain, mist and other liquids and protect from false touches even under streaming water. Infineon’s capacitive sensing with drive shield electrode guards the sensor from liquids. The hybrid sensing (ability to perform multiple types of measurements – self-capacitance, mutual-capacitance and inductive sensing) enables further safe guard against complex failure conditions by making decision logics based on data from multiple sensing methods on same interfaces. This is very useful and important for outdoor equipment and as well as Home appliance in which users can spill liquid or clean the panel with soap or wet cloths etc.

- **EMC/EMI Compliance:** The sensor operating frequency plays an important role noise emission from HMI interface as well as high immunity from external electrical noise sources. Infineon provides several solutions. Spread Spectrum Clock (SSC) and Pseudo random sequencer (PRS) are two methods in which operating clock is spread over a wider range of frequency thus attenuate the noise emission at specific frequencies. This clock spread also protects sensing system is not sensitive to interference from specific frequencies and its harmonics. The Multi-Frequency Scan (MFS) is a method of performing multiple “micro” scan in using multiple narrow band frequencies. This method helps to provide robust performance against both high frequencies conducted and radiated noise sources and is comes handy in meeting EMC/EMI regulatory requirements. This is very important for touch interface on industrial equipment as it is expected to reliability work in harsh noisy conditions.
- **Operating Conditions:** The touch sensing interface works by measuring capacitance of touch sensors which may be sensitive to environmental factors such as humidity and temperature around the sensors. High immunity from such factors surrounding touch sensor is important for equipment that are subjected to changing surroundings such as Cooktop (fast change in temperature). The Capacitive touch sensing solutions implements relative measurement to detect user interaction on sensors to overcome this challenge.

As the product becoming smaller and smarter more components are packed into small form factors and this is why high immunity to noise from other electronics components and RF transmitters are important for good HMI interface. Thanks to Infineon’s proprietary sensing method for providing world’s best noise protection in Capacitive HMI solutions for almost decades now.

6 Response rate

Response rate indicates how quickly the touch HMI can react to a user interaction. For a smoother user experience, a simple touch button interface detecting on or off status requires about 40 Hz report rate. A slider interface or touch-screen interface that detects and tracks finger positions as well as detect Gesture requires response rate about between 60 to 120 Hz for smooth user experience.

Infineon touch solution provides higher than 120 Hz report rate enabling smoother user interface designs. This is achieved using a high-performance delta-sigma architecture-based capacitance digital converter and using multiple capacitance to digital converters to sense multiple sensors in parallel to each other in some touch controllers.

7 Low power

In most products, the touch HMI interface will be active always active including in standby mode of the product as users may use touch interface to wake the product up from standby mode. This emphasis an increased focus on need for low power touch solution, especially for battery powered designs.

Optimizing average power consumption of touch system requires little more than selecting a chip that has lowest datasheet power specs. Selecting a touch controller that offers response rate higher than required for the product helps to put chip in Deepsleep power domain for portion time while maintaining the required response rate. Features and flexibility such as ganged sensing and hybrid sensing allows to optimize scan duration in standby mode and put controller in Deepsleep power domain for longer duration without affecting user interface functionality. The ganged sensing method allows to combine multiple sensors together inside chip and sense it as on giant touch or proximity sensor capable of sensing a touch or proximity event on any of the sensor with shorter scan time. Hybrid sensing allows to scan sensors or ganged sensor using sensing method that uses lowest average power consumption to detect a touch in standby mode. Flexibility

to operation sensing subsystem in Sleep or Deepsleep mode where unused peripherals of touch controller can be turned off useful to optimize average power consumption further. Therefore, one must carefully select a controller with features and flexibility to optimize overall touch HMI power consumption to achieve best results.

8 Form Factor and Aesthetics

Today's customers don't need a product that just fine, they want unique solutions and great aesthetics. For example, Smart Thermostat is not more a just equipment, is a beautiful piece of art in living room wall. These products require everything to be elegant including an HMI interface. It is worth to note many successful products that emerged in last decade has great touch HMI and aesthetics. As the IoT product becoming smaller and smaller with more components packed into small form factors, it is challenging to design a touch interface with limited space available on the product.

Designing a small form factor touch interface demands a high-performance touch sensing system that can detect a touch signal as small as femto-farads, enhanced immunity to defend various noise challenges a tightly packed company design may pose, flexibility to support wide ranges of sensor designs and a scalable hardware and software architecture. One can find all of these in Infineon's touch sensing solution as result of 2 decades of technology innovation.

9 CAPSENSE™ enabled PSoC MCUs

Infineon's capacitive touch technology is offered mainly under 3 variants:

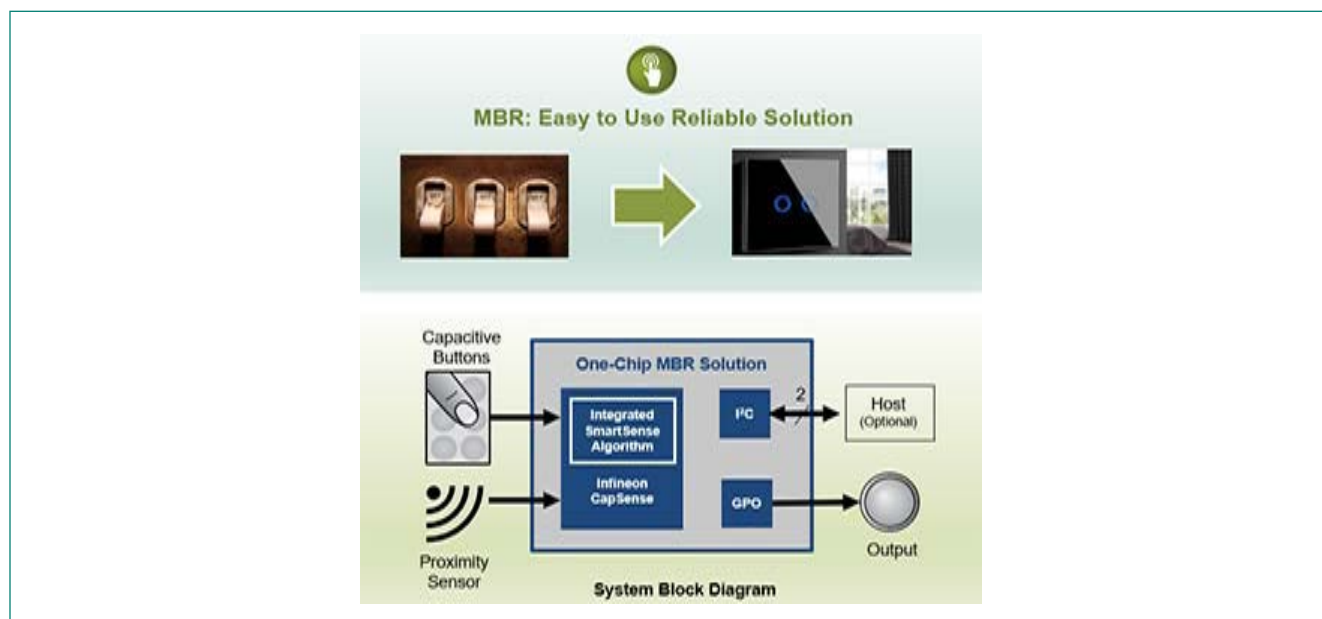


Figure 4 MBR – Configurable Touch Controllers

MBR devices a configurable CAPSENSE™ controller that does not require firmware development or manual tuning, that allows to quickly and easily replace mechanical buttons with sleek & reliable touch user interface. This is one of the easiest and quickest way to implement a touch interface a product, even with beginner who does not have prior experience with capacitive sensing can quickly and easily complete the design.

PSoC 4 MCU device family is Infineon's programmable MCU with touch interface. Programmability gives greater flexibility to implement complex interfaces and fine tune performance of touch interface.

The programmable analog and digital blocks in PSoC 4 devices allow to customize your analog-front-end, enabling you to easily integrate intelligent analog sensors into your application. Programmable wired communication (USB, CAN, I2C, SPI, UART) and wireless communication (BLE) integrated into some PSoC 4 devices simplifies RF design and interfacing with external devices. PSoC 4 simplifies complex HMI interfaces such as capacitive and inductive sensing enabling sleek, robust, and easy-to-use interfaces.

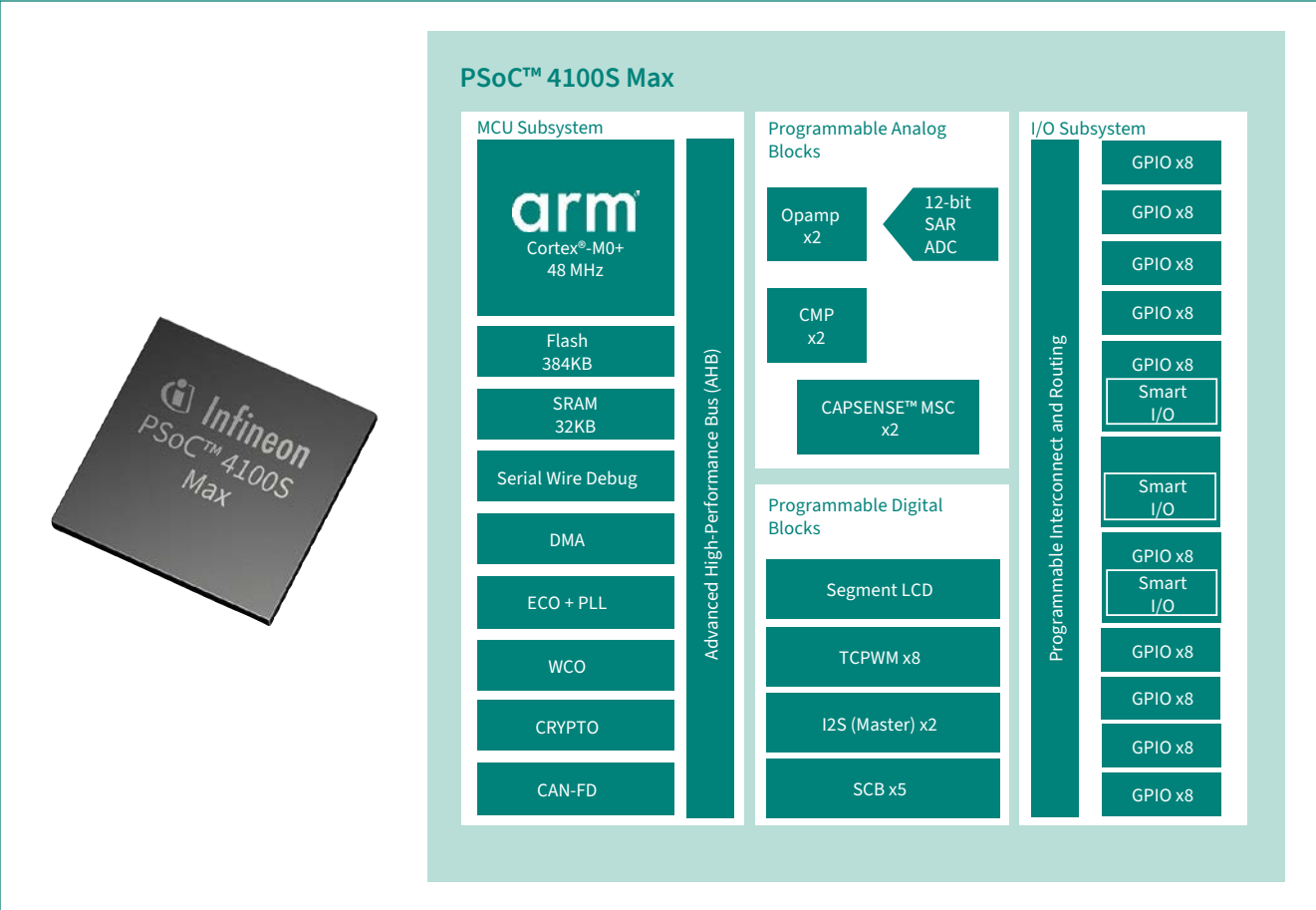


Figure 5

Figure below shows Touch HMI enabled PSoC 4 CAPSENSE™ portfolio which have more capabilities in addition to touch sensing, that makes them suitable for HMI Plus Sensor or System controller and many more. For example, Integrated CAPSENSE™ + Analog Front End (AFE) + Digital Peripherals makes them ideal for low memory footprint applications (i.e. Housekeeping MCUs).

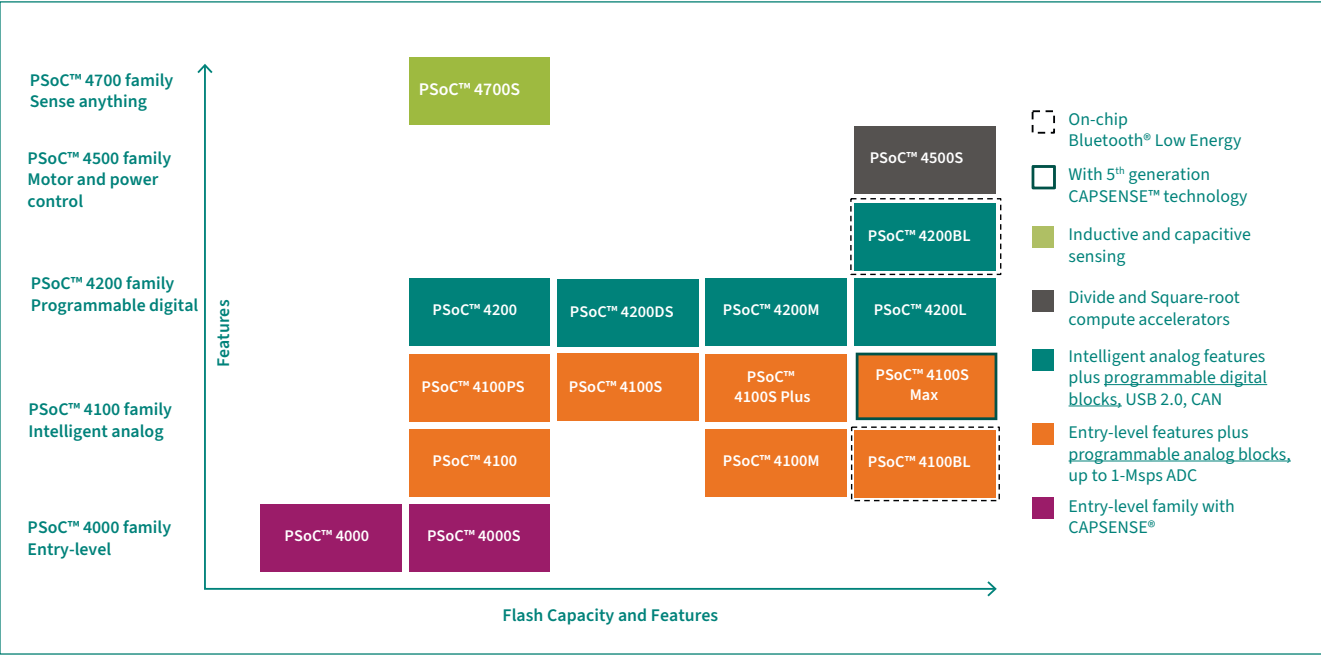


Figure 6 PSoC 6 MCU – Purpose Built IoT Host Controllers

PSoC 6 MCU (www.cypress.com/psoc6) device family from Infineon has lot more than HMI interface. It is purpose built dual core application processor for IoT applications. This device is suitable for Embedded IoT applications providing touch HMI, wireless connectivity, security, graphics and lot more.

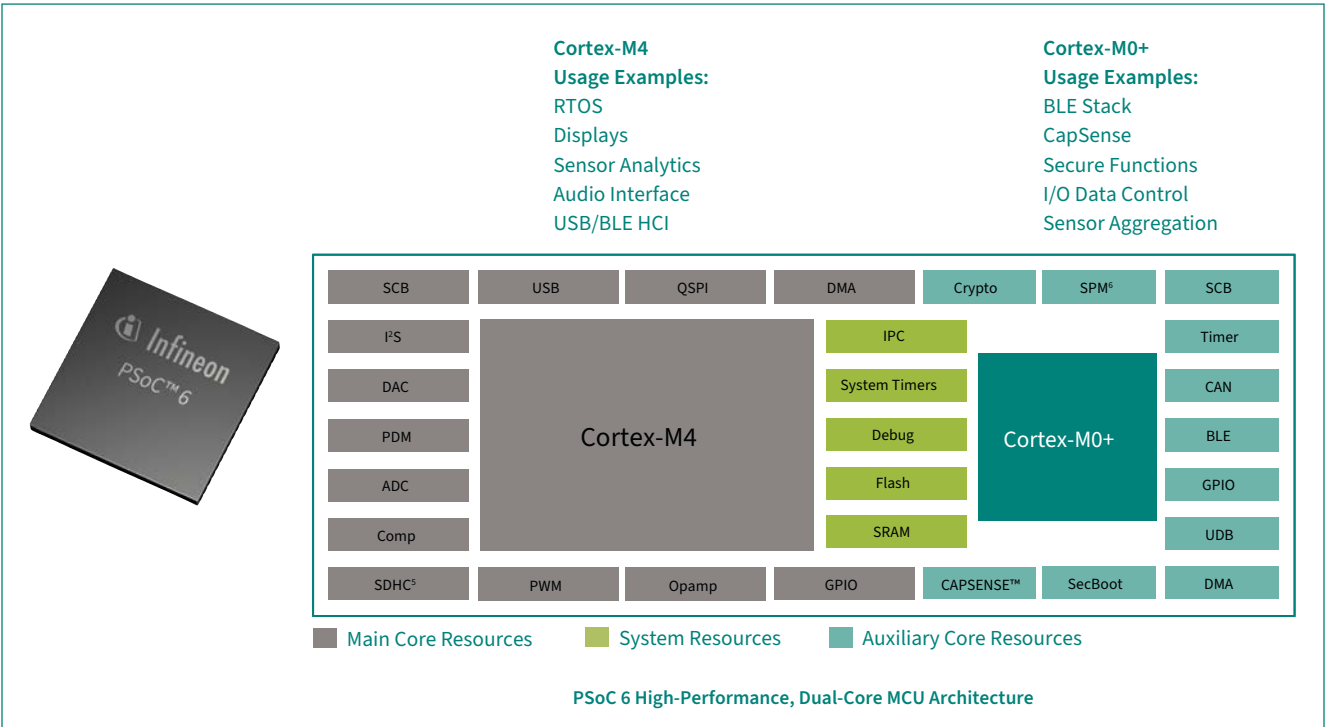


Figure 7



Figure 8

Key features of PSoC 6 MCU are 150-MHz and 100-MHz dual-core Arm® Cortex®-M4 and Arm Cortex-M0+ ultra-low-power 40-nm architecture. Industry-leading ultra-low-power design that consumes as little as 22-µA/MHz in active power mode. Best-in-class Wi-Fi connectivity options enabled with ModusToolbox and cloud services support like Amazon Web Services and Integrated, hardware-based ‘Secure Execution Environment (SEE)’ with secure data storage.

10 Comprehensive Software Solution with Intuitive GUI interface (ModusToolbox)

Implementing a robust touch embedded system requires a great silicon and an easy use software solution, that is why Infineon provides a state-of-the-art touch library with Modus toolbox IDE, that enables quick implementation of a touch interface with few API calls on CAPSENSE™ enabled programmable MCUs.

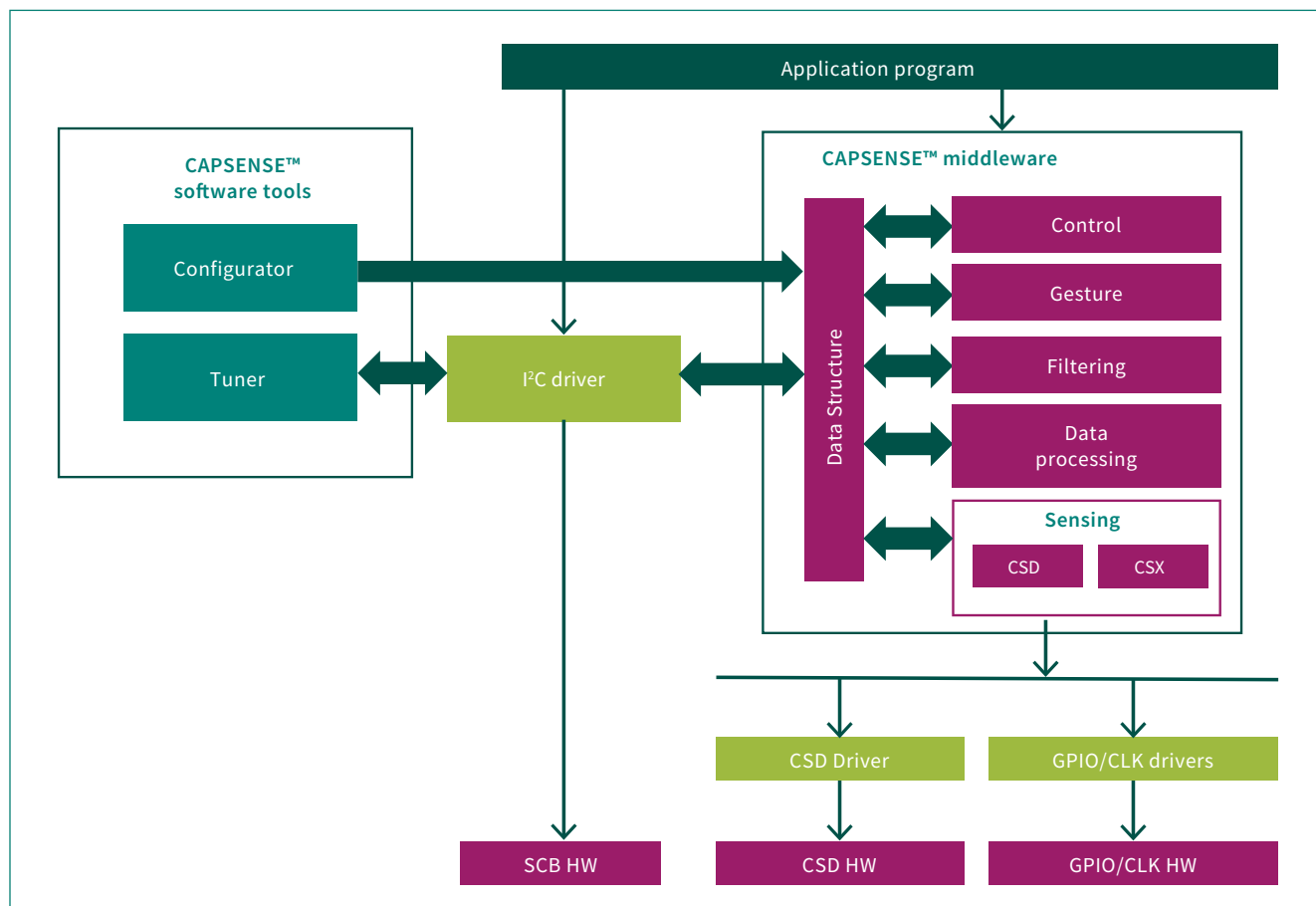


Figure 9 CAPSENSE™ Solution in ModusToolbox

CAPSENSE™ Middleware Touch Firmware library provides set of APIs to quickly implement robust touch user interface of end product. Additionally, a graphical interface-based wizard to customize firmware library and create interfaces, widgets and configure that suite each application. The Tuner Software tool is a real-time performance analysis software tool providing tuning, testing, validation and debugging support I2C, UART, Bluetooth interface capabilities.

11 References

Read Infineon CAPSENSE™ Design Guides

Comprehensive and ideal documents for those who want to design touch HMI. It guides from concept through production and helps to overcome various system level challenges in create robust touch HMI for your product.

[CAPSENSE™ Capacitive-Sensing Overview Web Page](#)

[Getting Started With CAPSENSE™ Application Note](#)

[ModusToolbox CAPSENSE™ Configurator Guide](#)

[PSoC 4 and PSoC 6 MCU CAPSENSE™ Design Guide](#)

Start with a Code Example

Start and complex code examples for CAPSENSE™ touch HMI solutions

[Code Examples for ModusToolbox Software on GitHub](#)

Reach out to us on the Cypress Developer Community for help!

PSoC MCU Dev Kits in 3 Flavors

You can evaluate PSoC MCUs with a variety of Dev Kits. There are fully featured “Pioneer” Kits which provide enhanced functionalities such as on-board sensors, CAPSENSE™, on-board wireless and Arduino® shields to add displays, external sensors, and more.

All CAPSENSE™ Dev Kits can be viewed [here](#)

About the Author



Vibheesh Bharathan A dynamic marketer with strong engineering background in system design and semiconductor fields. Vibheesh Bharathan is a Senior 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. Vibheesh can be reached at Vibheesh.Bharathan@Infineon.com



Jaya Kathuria Bindra Works as Director Applications Engineering at Infineon Technologies where she is managing the Embedded Applications Group and Solutions Development using the PSoC and WiFi/BT platform. She has 17+ years of experience in the Semiconductor Industry. She earned her MBA credential from IIM, Bangalore and holds a bachelor's degree in Electronics Engineering from the Kurukshetra University. Jaya can be reached at Jaya.Bindra@Infineon.com



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Published by
Infineon Technologies AG
Am Campeon 1-15, 85579 Neubiberg
Germany

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Public

Date: 06/2023

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