如何打造强大、智能、易于使用的HMI应用

CapSense® 电容式感应 与 MagSense™ 电感式感应

Harris Chan 高级现场应用工程师

日程

- 赛普拉斯公司及创新技术简介
- CapSense 与 MagSense 的对比
- 手把手实验: MagSense 电感式感应
- PSoC® MCU 发展路线图
- 入门参考资料

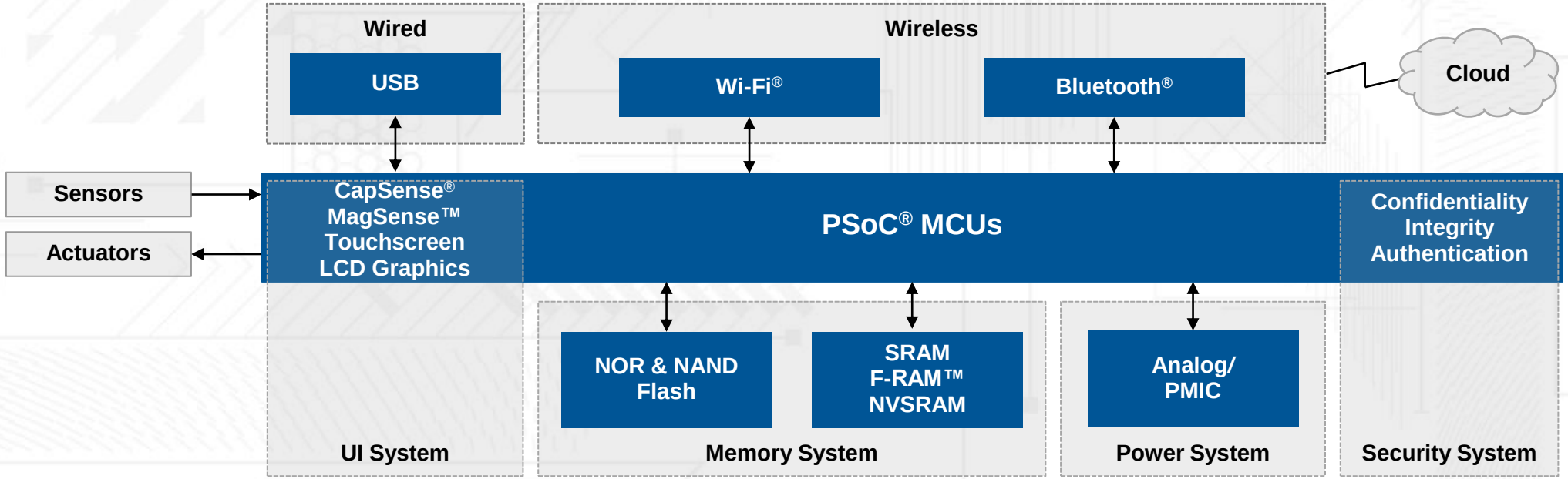
Cypress' Industry-Leading Portfolio of Embedded Solutions

- **Wireless radio standards and combinations**
  - Wi-Fi (802.11ac, 802.11bgn), Bluetooth (BR, EDR, BLE)
  - Advanced coexistence algorithms for multi-radio (Wi-Fi + Bluetooth) platforms
- **Broad portfolio of Arm®-based MCUs**
  - PSoC 4: Arm Cortex® M0 and M0+ devices ideal for HMI, sensor hubs, and other mixed-signal subsystems
  - PSoC 6: Most-flexible, lowest-power, dual-core Arm Cortex-M4 and M0+ MCU—purpose-built for the IoT
- **Robust development tools and ecosystem partners**
  - WICED® IoT platform provides turnkey wireless connectivity
  - PSoC Creator™ IDE speeds system configuration and design
  - ModusToolbox™ Software Suite unifies MCU and wireless development environments

ModusToolbox™

PSoC® Creator™ Integrated Design Environment

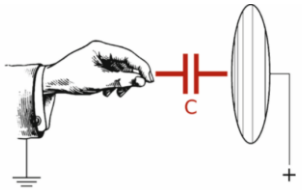
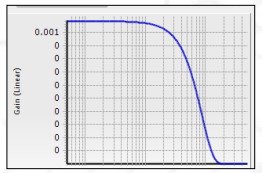
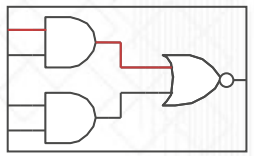
WICED by CYPRESS



CYPRESS EMBEDDED IN TOMORROW™

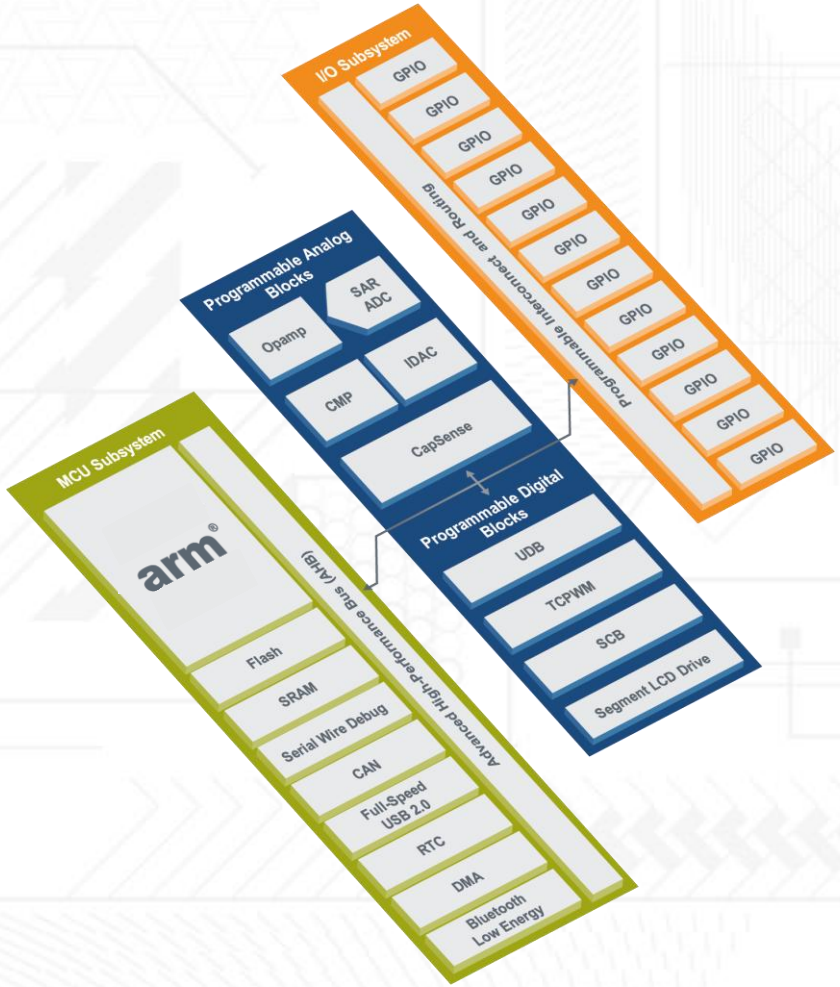
Cypress' Innovation

Cypress MCUs have been at the heart of industrial, consumer and automotive revolutions, offering game changing technologies and altering the way products evolve.

	Wireless technologies built for the IoT. Secure, design-ready products		CapSense solutions. Elegant, reliable, flexible and easy-to-use
	Hardware-based TEE, root-of-trust isolation, and secure data storage		MagSense enables integrated contact-less metal detection
	Programmable Analog Blocks let you interface with nearly any sensor		Integrated array of small, fast, low-power programmable digital blocks
	Ultra low power technologies enable industry-leading power consumption		

PSoC : Your Problem Solver on Chip

Ultimate Mixed-Signal Flexibility



- **CapSense / MagSense**
  - Industry-leading capacitive and inductive sensing solutions
  - Touch, metal detection, proximity sensing and liquid-sensing applications
- **Programmable Analog Blocks**
  - Customize analog front end to interface to analog sensors
  - Comprised of ADC, DAC, opamps and comparators
- **Programmable Digital Blocks**
  - Configurable SCB and TCPWM blocks for digital peripherals
  - Programmable UDB blocks for digital glue logic
- **Wired and Wireless Connectivity**
  - Wired connectivity interface such as CAN and USB
  - Wireless connectivity such as Bluetooth Low Energy
- **Security**
  - Implements cryptographic algorithms including ECC and AES with an integrated hardware coprocessor
  - Provides secure, internal storage for firmware, applications, and secure assets such as cryptographic keys

Make It Smarter **Make It Connected** **Make It Easy to Use** **Make It Secure**

Capacitive and Inductive Sensing

Enhancing User Interfaces

Cypress has changed the face of industrial design in consumer electronics, cars, and white goods, with its industry-leading CapSense and MagSense solutions. CapSense and MagSense solutions provide robust, intelligent, and easy-to-use sensing functionality to your design.

Touch Buttons: 2003

LG Chocolate
(First Generation)

Cypress's CapSense research and development begins with buttons and sliders

Liquid Tolerance: 2008

Whirlpool Dishwasher
(Second Generation)

CapSense algorithms offer Liquid Tolerance, Proximity Sensing and improved noise immunity

SmartSense: 2010

HP TouchSmart Printer
(Third Generation)

SmartSense™ Auto-tuning revolutionizes CapSense design by removing manual tuning

1B Units Shipped: 2013

Samsung Galaxy Note 3
(Third Generation)

One billionth CapSense controller shipped with stylus-activated buttons

PSoC 4 S-Series: 2016

PSoC 4 S-Series
(Fourth Generation)

Cypress introduces its fourth-generation CapSense solution that offers superior touch-sensing performance with low power consumption

PSoC 4700 Family: 2018

PSoC 4700 Family
(Sense AnyThing)

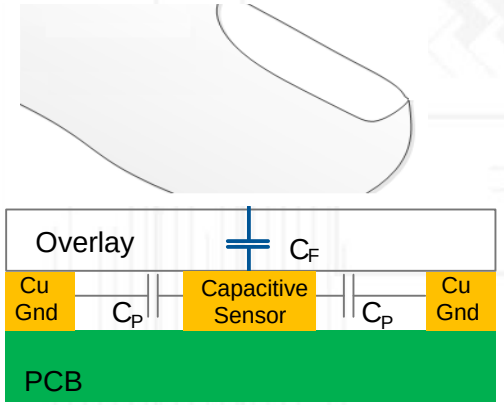
Cypress introduces its MagSense inductive sensing solution that offers superior metal detection performance with low power consumption

Senzei™ Capacitive and Inductive Sensing

Enhancing User Interfaces

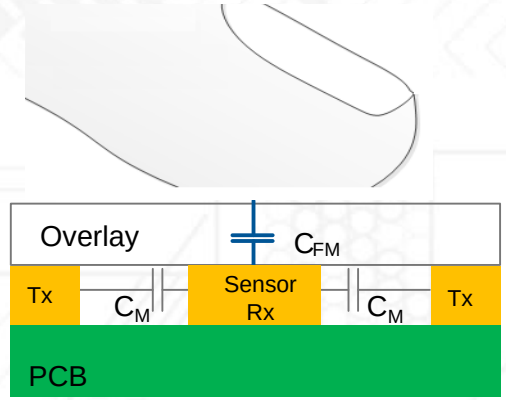
- Senzei suite of sensing solutions
  - CapSense is the industry's leading self- and mutual-capacitive sensing solution for touch buttons and sliders, proximity detection, and liquid-level sensing
  - MagSense senses minute deflections or movements of metal, enabling sleek and futuristic user interfaces with metallic overlays
  - MagSense and CapSense can co-exist, even as one sensor, and provides a fool-proof solution that can not only detect any kind of object but also rejects false touches caused due to stress, wear and tear, or environmental changes

Self-Capacitive Sensing



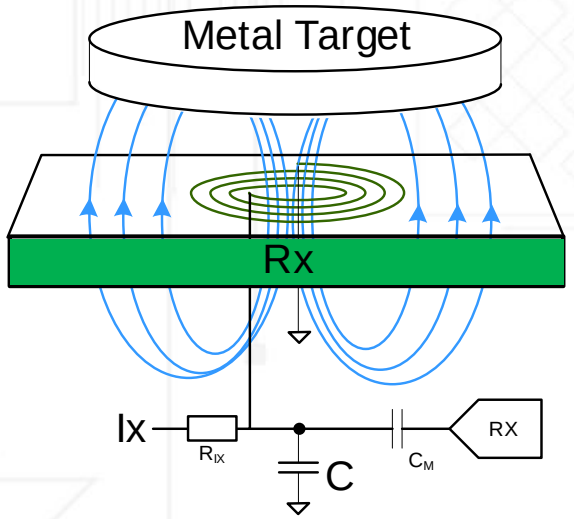
$C_{CSD} = 2C_P + C_F$

Mutual-Capacitive Sensing



$C_{CSX} = 2C_M – C_{FM}$

Inductive Sensing

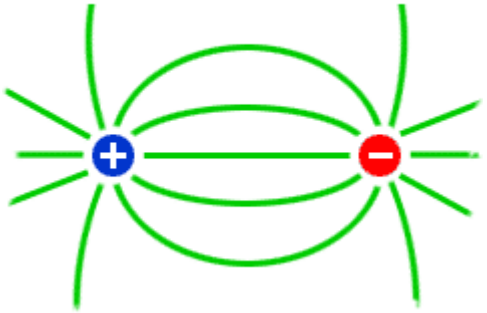


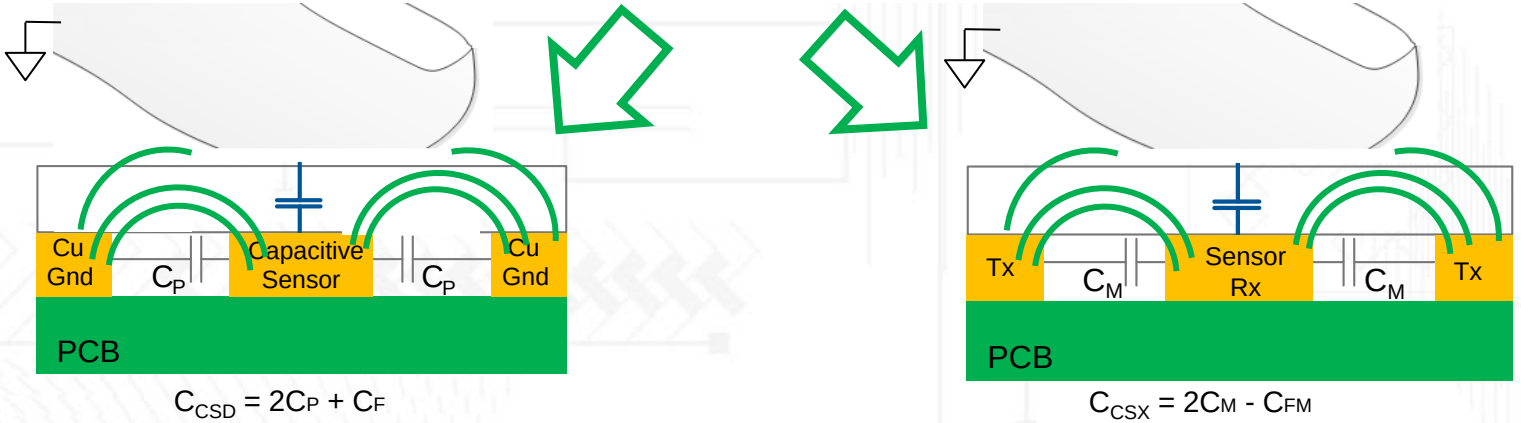
CapSense Capacitive Sensing vs. MagSense Inductive Sensing

CapSense Capacitive-Sensing

Source: Electric Field Lines

Between two voltage potentials





$C_{CSD} = 2C_P + C_F$

C_F = Capacitance added by a finger touch

$C_{CSX} = 2C_M - C_{FM}$

C_{FM} = Mutual-Cap reduction due to finger touch

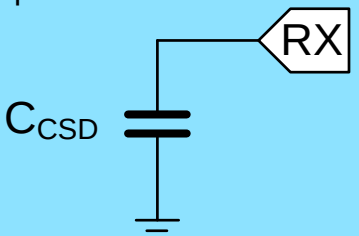
CapSense Capacitive-Sensing

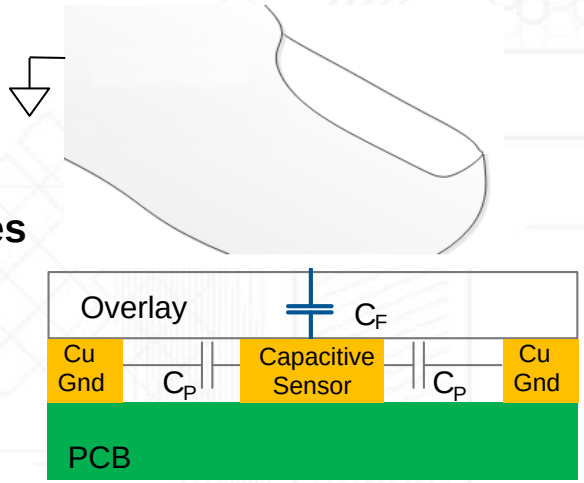
- **Self Capacitive Sensing (CapSense CSD)**
  - Self capacitive sensing occurs when one node of the capacitor is sensed.
  - The second node of the capacitor is at a fixed potential (usually ground).

- **CapSense CSD operation**
  - The self-capacitance sensor is formed between the sensor electrode and neighboring ground lines (C_P).
  - The total capacitance **without** a touch: $C_{CSD} = 2C_P$
  - The total capacitance **with** a touch: $C_{CSD} = 2C_P + C_F$
  - C_F is the capacitance between the sensor and the grounded finger and **increases** the capacitance with a touch.
  - **Note:** The finger appears to be *grounded* because of the large capacitance between the human body and earth.

Self Capacitance Sensing (CSD)

We have access to only one node of the capacitor.





$C_{CSD} = 2C_P + C_F$

C_F = Capacitance added by a finger touch

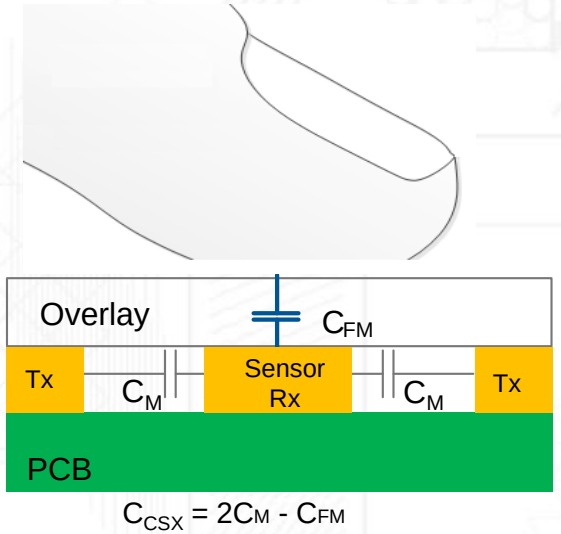
CapSense Capacitive-Sensing

- **Mutual Capacitive Sensing (CapSense CSX)**
  - Mutual capacitive sensing occurs when there is access to **both** nodes of the capacitor.
  - A transmit (TX) signal is driven onto one node and received at the other.
  - A change in capacitance is detected as a change in signal at the receiver (RX).

- **CapSense CSX operation**
  - The mutual capacitance sensor is formed between the sensor RX electrode and the sensor TX electrodes (C_M).
  - The total capacitance **without** a touch: $C_{CSD} = 2C_M$
  - The total capacitance **with** a touch: $C_{CSD} = 2C_M - C_F$
  - C_F is the capacitance between the sensor and the grounded finger and **decreases** the capacitance with a touch because it steals TX-RX field lines reducing C_M.
  - **Note:** Mutual capacitance **decreases** with a touch while self-capacitance **increases** with a touch.

Mutual Capacitance Sensing (CSX)

We have access to **both** nodes of the capacitor.



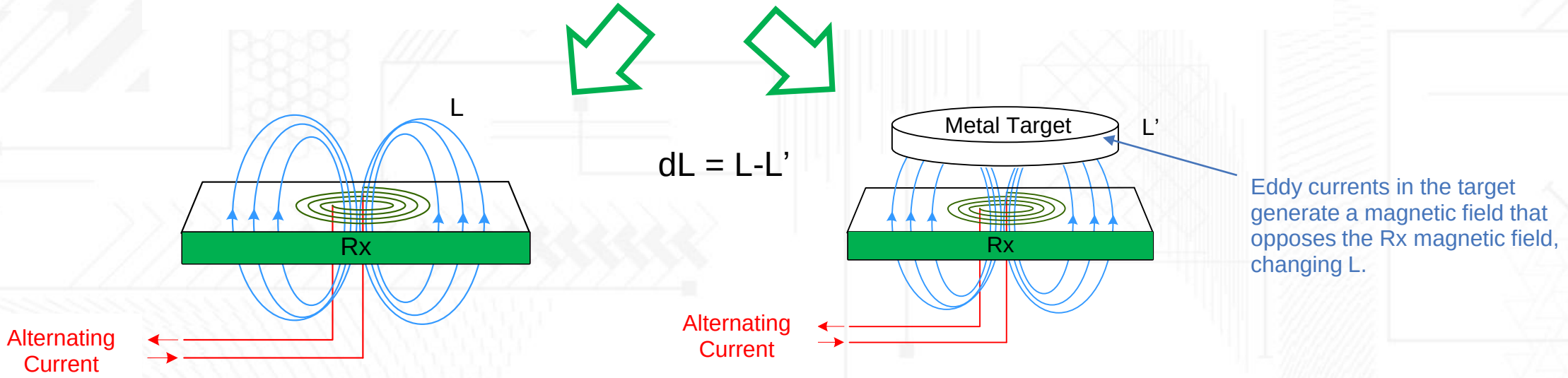
$C_{CSX} = 2C_M - C_{FM}$

C_{FM} = Mutual-Cap reduction due to finger touch

MagSense Inductive-Sensing

- Driving an AC signal into an Inductive Coil creates a magnetic field
- Moving a metal target close to the field induces eddy currents in the target, changing the field.

Source: Magnetic Field Lines



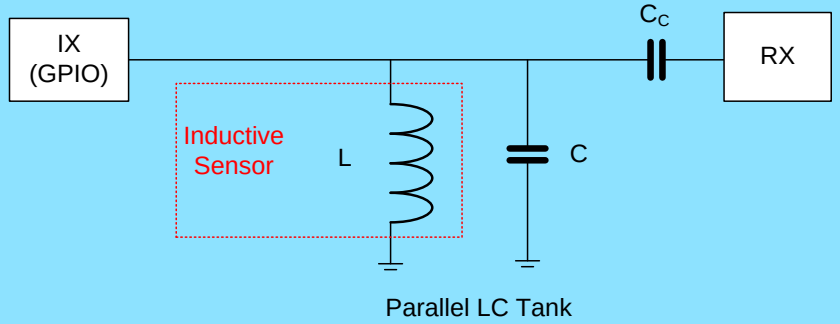
MagSense Inductive-Sensing

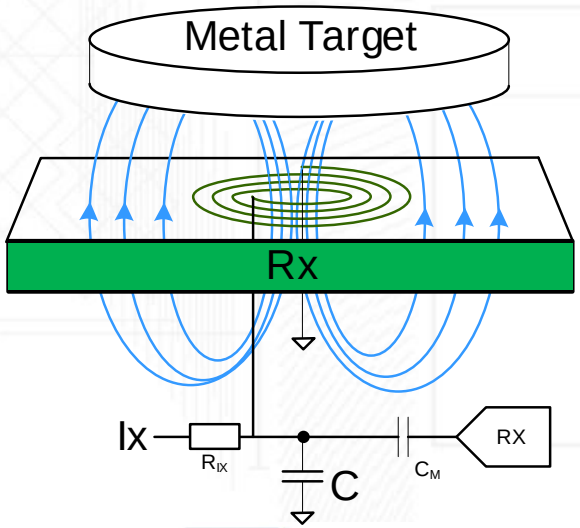
- **Inductive-sensing (MagSense)**
  - The sensor forms a parallel LC tank that is excited at it's resonant frequency and the resulting signal is coupled into the RX through C_C.
  - A change in L causes an amplitude change in the LC tank signal.

- **MagSense ISX operation**
  - The parallel resonant tank formed by the sensor L and a discrete C produces a sine wave when excited by LX.
  - The magnetic field lines from the inductive sensor induces **eddy currents** in the metal target that oppose the sensor magnetic field lines, reducing the effective inductance (L) of the sensor.
  - This reduction in L manifests itself as a reduction in the **amplitude** of the sine wave produced by the LC tank.
  - **Note:** Inductive-sensing detects a change in **magnetic field** while capacitive-sensing detects a change in **electric field**.

Inductive Sensing (ISX)

The sensor forms a parallel LC tank that is excited by a signal (IX).
The tank signal is then AC coupled into the RX.

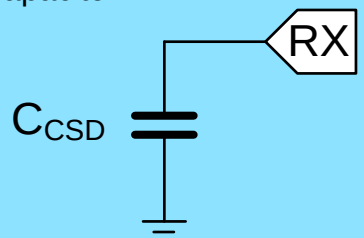


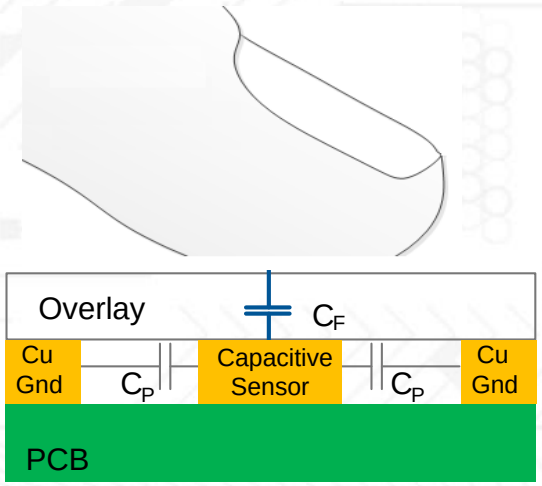


CapSense and MagSense Summary

Self Capacitance Sensing (CSD)

We have access to only one node of the capacitor.



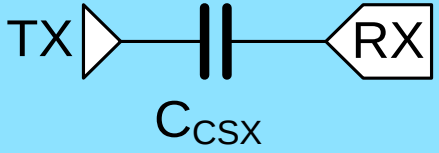


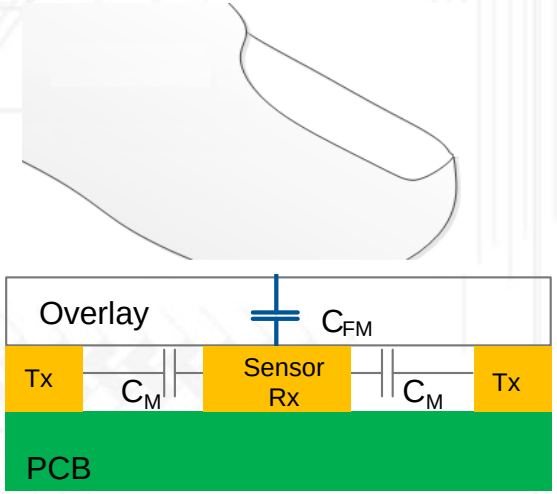
$C_{CSD} = 2C_P + C_F$

C_F = Capacitance added by a finger touch

Mutual Capacitance Sensing (CSX)

We have access to **both** nodes of the capacitor.



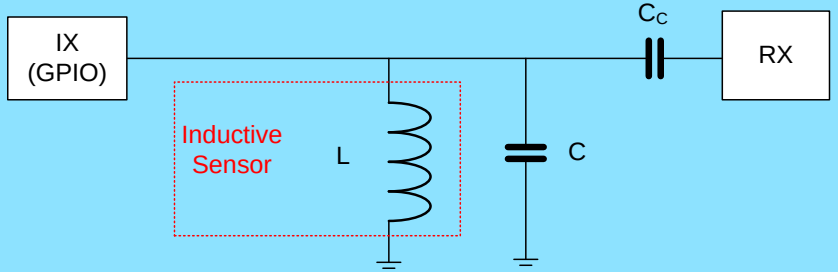


$C_{CSX} = 2C_M - C_{FM}$

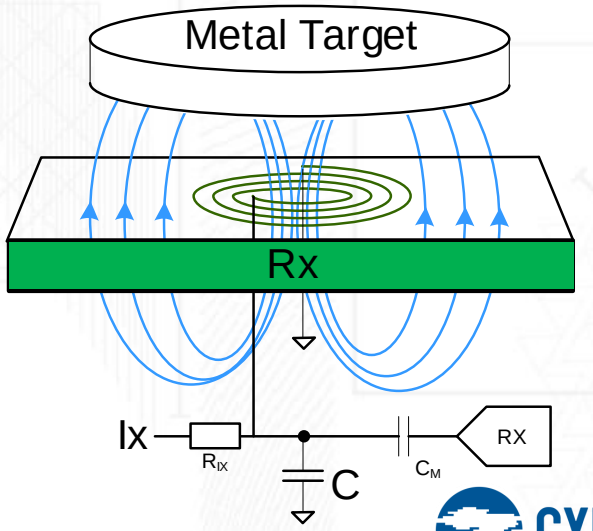
C_{FM} = Mutual-Cap reduction due to finger touch

Inductive Sensing (ISX)

The sensor forms a parallel LC tank that is excited by a signal (IX).
The tank signal is then AC coupled into the RX.



Parallel LC Tank



CapSense Use Cases

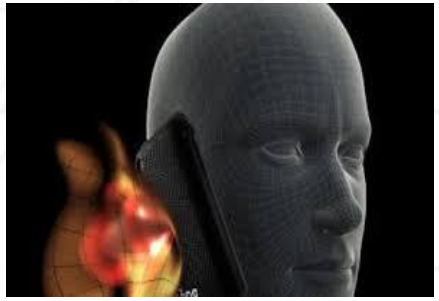
CapSense Buttons

CapSense Slider

Capacitive Trackpad

Proximity Detection

Capacitive Liquid Level Sense



Specific Absorption Rate

Capacitive Force sensing

Absolute Capacitance sensing

MagSense Use Cases

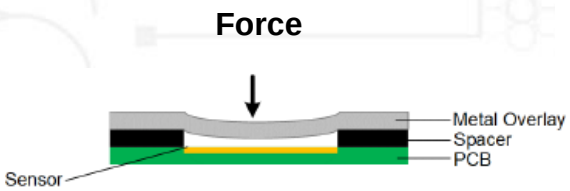
MagSense Metal Buttons

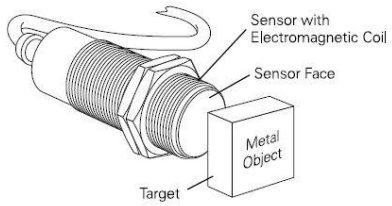
MagSense Metal Proximity

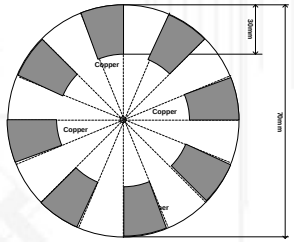
MagSense Rotary

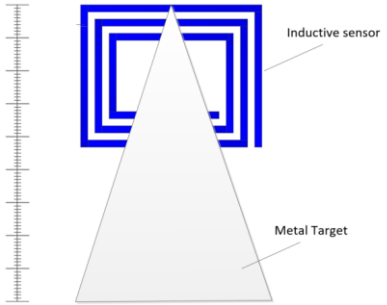
MagSense Linear Transducer

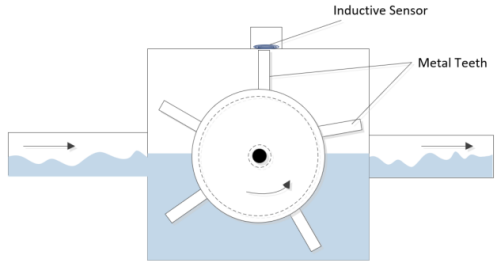
MagSense Flow Meter

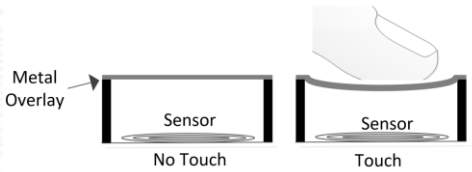












CapSense vs. MagSense Comparison

	CapSense Capacitive sensing	MagSense Inductive sensing
Advantages	• Provides hybrid sensing (mutual and self capacitive-sensing methods) to enable advanced features such as proximity sensing, hover and glove touch, liquid tolerance • Delivers multi-touch sensing capabilities (> 2 touch) • Enables a low-cost system • Enables ease-of design into an application	• Provides robustness and reliability in harsh environment and surroundings • Enables a fully water-proof system • Enables underwater capabilities • Provides proximity sensing, glove touch • Provides reliable force sensing
Disadvantages	• Not fully water-proof, but is liquid tolerant (rejects water) • Easily affected by environment and surroundings • Tuning can be difficult	• Complex HW design • Complex HW design results in lower yield • Tuning can be difficult

Hands-On

MOUSER ELECTRONICS

CYPRESS®
EMBEDDED IN TOMORROW™

PSoC MCU Roadmap

CapSense® and MagSense® Portfolio

Configurable CapSense	Programmable CapSense	MagSense
	CY8C4000 (new) 24 Buttons, Sliders 16 – 32 KB Flash Proximity, Liquid Tolerance SmartSense™ Auto-tuning	**CY8C47xx (new)** 16 Channels, 16 – 32 KB Flash, CapSense, MagSense
	CY8C4000S 36 Buttons, Sliders 16 – 32KB Flash Proximity, Liquid Tolerance SmartSense™ Auto-tuning **CY8C4100S (Plus)** 54 Buttons, Sliders 16 – 128KB Flash Proximity, Liquid Tolerance SmartSense™ Auto-tuning	
CY8CMBR3002 2 Buttons, 2 LEDs SmartSense_EMCplus **CY8CMBR301x** 2-16 Buttons, 2 Sliders Proximity, Liquid Tolerance SmartSense_EMCplus™[3]	**CY8C4000** 16 Buttons, Sliders 8 – 16KB Flash Proximity, Liquid Tolerance SmartSense™ Auto-tuning **CY8C4100** 36 Buttons, Sliders 16 – 32KB Flash Proximity, Liquid Tolerance SmartSense™ Auto-tuning **CY8C4100M** 54 Buttons, Sliders 32 – 128 KB Flash Proximity, Liquid Tolerance SmartSense™ Auto-tuning **CY8C4200L** 94 Buttons, Sliders 64 – 256 KB Flash Proximity, Liquid Tolerance SmartSense™ Auto-tuning	**CY8C47xxS** 16 Channels, 16 – 32 KB Flash, CapSense, MagSense
CY8CMBR20xx **2**-16 Buttons, 10 LEDs SmartSense Auto-tuning	**CY8C20xxx** 25 Buttons, 6 Sliders 8 – 32 KB Flash SmartSense Auto-tuning **CY8C21xxx** 31 Buttons, 6 Sliders 16 - 32KB Flash Proximity, Liquid Tolerance SmartSense™ Auto-tuning	

Performance

Integration

[1] Standard products that are configured for target applications with a graphical user interface
[2] Microcontroller-based products that can be freely programmed to implement additional functions
[3] SmartSense Electromagnetic Compatible = SmartSense Auto-tuning + high noise immunity

	Concept	Development	Sampling	Production
Status				
Availability			QQYY	QQYY

PSoC 6 Arm Cortex-M4 MCUs for IoT

Ultra-Low-Power | Built-in Security | High-Performance

D+C

Production | Concept | Sampling | Development

	Features and Flash →				
PSoC 64 Secure MCU with Root-of-Trust	S: Q319 CY8C64x5	CY8C64x6	CY8C64x7	MP: Q420 CY8C64x8	MP: Q420 CY8C64xA
PSoC 63 Integrated BLE		CY8C63x6	CY8C63x7	CY8C63x8	CY8C63xA
PSoC 62 Dual-Core M0+/M4	S: Q319 CY8C62x5	CY8C62x6	CY8C62x7	MP: Q419 CY8C62x8	MP: Q419 CY8C62xA
PSoC 61 Single-Core M4	S: Q319 CY8C61x5	CY8C61x6	CY8C61x7	MP: Q419 CY8C61x8	MP: Q419 CY8C61xA
	512KB Flash/256KB SRAM CAN-FD	512KB Flash/128KB SRAM Opamps, VDAC, UDBs	1MB Flash/288KB SRAM Opamps, VDAC, UDBs	1MB Flash/512KB SRAM	2MB Flash/1MB SRAM

CYPRESS EMBEDDED IN TOMORROW™

Getting Started

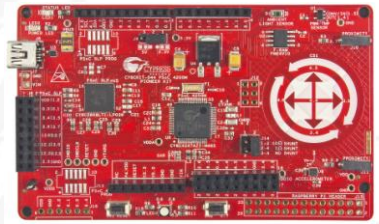
MOUSER ELECTRONICS

CYPRESS®
EMBEDDED IN TOMORROW™

PSoC 4 Development Kits

Make It Smarter

Intelligent Analog Kits



[$25 PSoC 4 M-Series Pioneer Kit (CY8CKIT-044)]

[$10 PSoC 4100PS Prototyping Kit (CY8CKIT-147)]

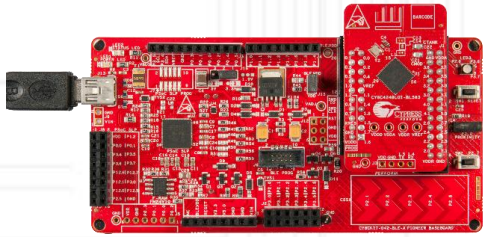
Make It Connected

Bluetooth® Low Energy (BLE) Kits

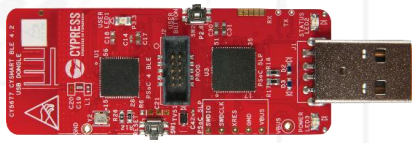
[CY8CKIT-143-A]

[CY8CKIT-141]

PSoC 4 BLE Modules* with PCB or external antenna



[$49 PSoC 4 BLE Pioneer Kit (CY8CKIT-042-BLE-A)]



[$20 CySmart BLE USB Dongle (CY5677)]

* Modules can be used independently or with PSoC Pioneer kits

Make It Easy to Use

HMI Kits for Capacitive Sensing

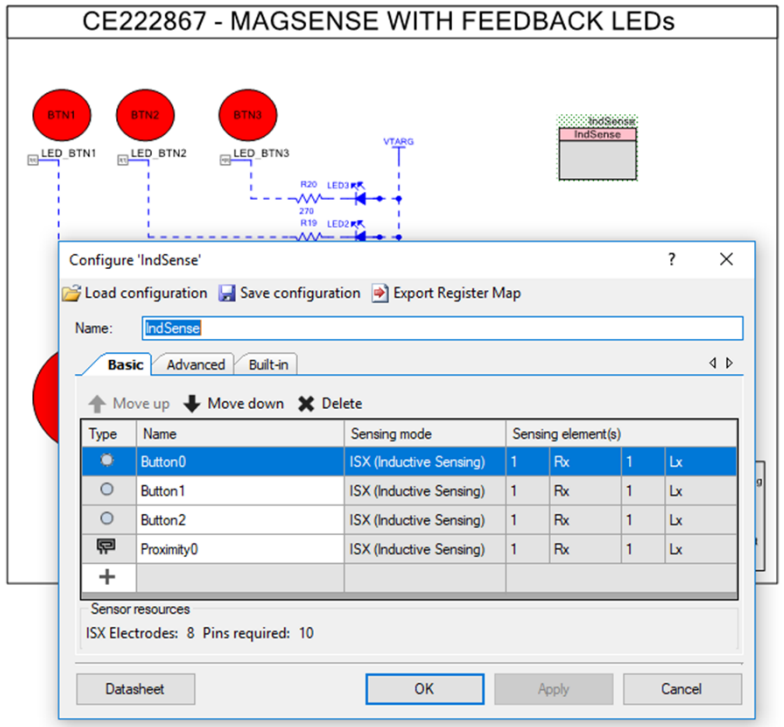
[$15 PSoC 4000S Prototyping Kit (CY8CKIT-145-40xx)]

[$20 CapSense Proximity Shield (CY8CKIT-024)]
(Used with PSoC 4 Pioneer Kits)

PSoC 4 Kit Selector: [www.cypress.com/psoc4kits]

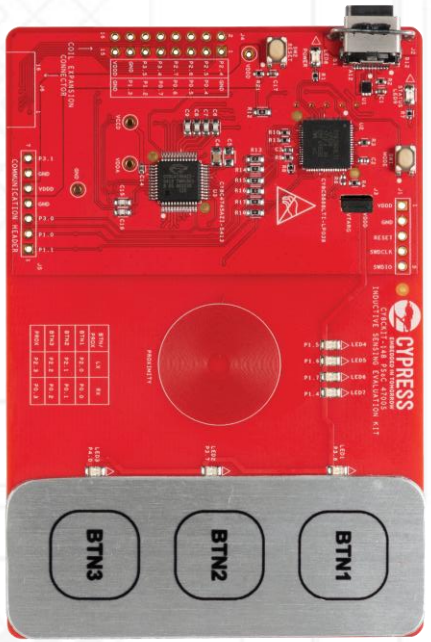
Getting Started With PSoC® 4700

1. **Download the PSoC Creator IDE software**



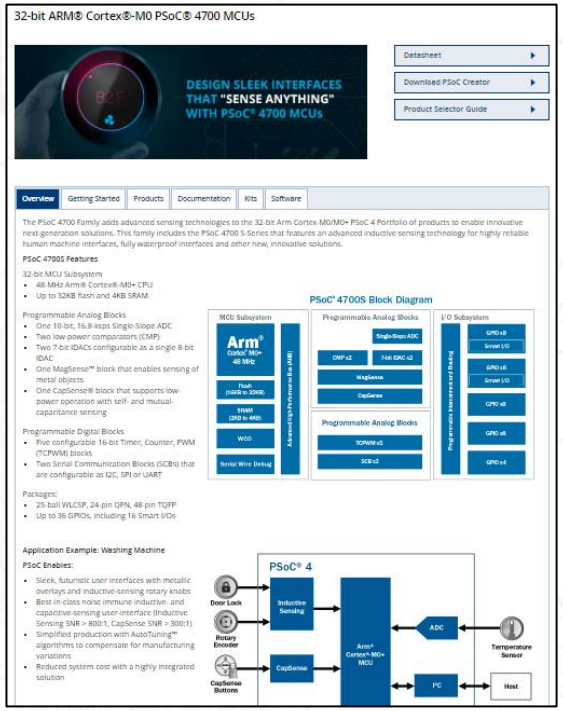
PSoC Creator IDE with Graphical Front Ends
www.cypress.com/Creator

2. Purchase a PSoC 4700 kit



PSoC 4700 Inductive Sensing Evaluation Kit

3. **Visit the PSoC 4700 Product Page and review datasheets, design guide and code examples**



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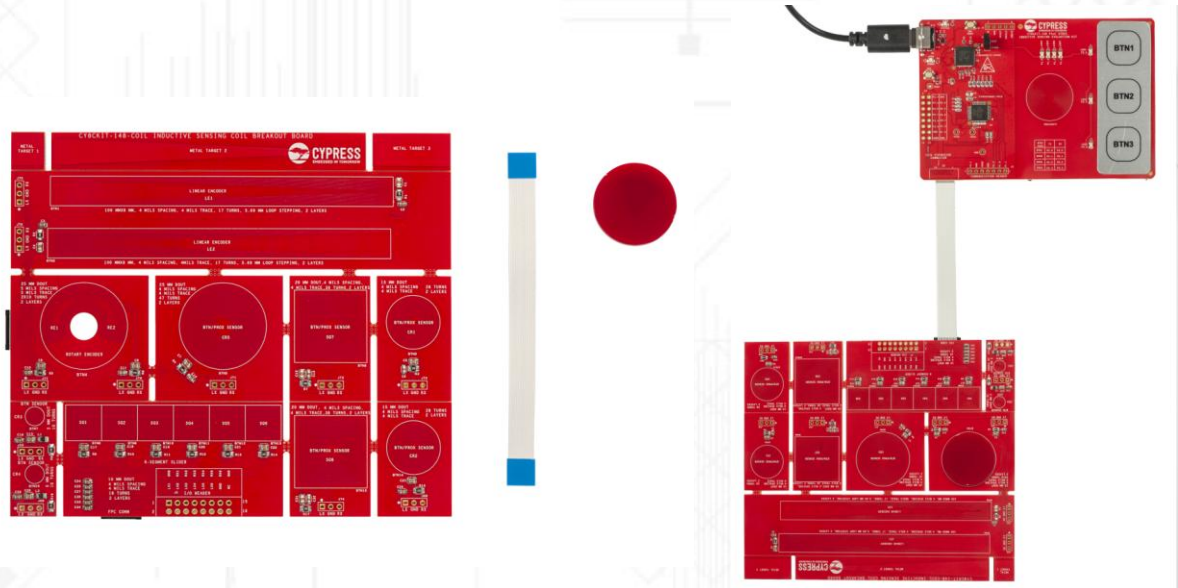
CY8CKIT-148-COIL Inductive Sensing Breakout Board

- CY8CKIT-148-COIL Inductive Sensing Breakout Board features the following:
  - Snap-able metal targets
    - 1x Linear Metal Target
    - 2x rectangular metal targets
    - 1x Rotary Encoder target
  - Snap-able coils
    - 2x Linear Encoders
    - 1x Rotary Encoder
    - 1x 6-Segment Button Slider
    - 2x 20mm Square Coils
    - 1x 25mm Circular Coil
    - 2x 15mm Circular Coils
    - 2x 5mm Circular Coils

CY8CKIT-148-COIL Inductive Sensing Breakout Board image

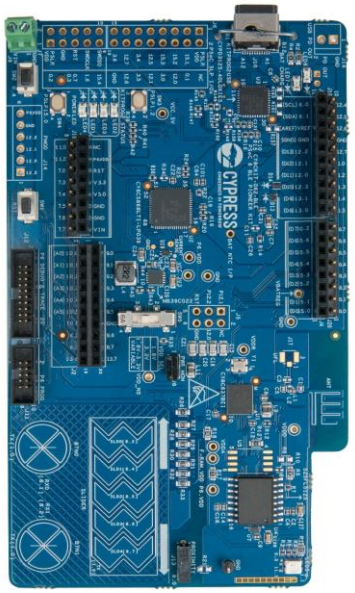


Getting Started with PSoC 6 MCUs

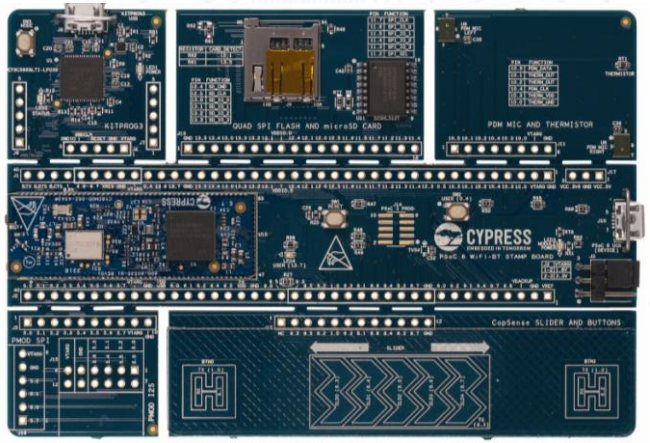
- **Visit the PSoC 6 Product Page and review datasheets, application notes, technical reference manuals, and watch videos**
- **Purchase the PSoC 6 BLE Pioneer Kit, PSoC 6 WiFi-BT Pioneer Kit, or PSoC 6 Wi-Fi BT Prototyping Kit**
- **Join the PSoC 6 Community to interact with us**
- **PSoC 6 BLE Pioneer Kit provides:**
  - Capacitive-sensing CapSense slider and buttons and 512Mb QSPI NOR flash memory
  - Compatible form factor with Arduino® shields and Digilent® Pmod™ daughter cards
- **PSoC 6 WiFi-BT Pioneer Kit provides:**
  - Capacitive-sensing CapSense slider and buttons and 512Mb QSPI NOR Flash memory
  - Compatible form factor with Arduino shields and Digilent Pmod daughter cards
  - Murata LBEE5KL1DX-TEMP Module (CYW4343W) that provides IEEE 802.11a/b/g/n WLAN + Bluetooth
- **PSoC 6 Wi-Fi BT Prototyping Kit provides:**
  - Snappable peripherals: Capacitive-sensing CapSense slider and buttons, Digilent Pmod interface, 512Mb QSPI NOR flash, uSD card, PDM-PCM microphone, thermistor
  - Bread-board compatible form-factor
  - Murata LBEE5KL1DX-TEMP Module (CYW4343W) that provides IEEE 802.11a/b/g/n WLAN + Bluetooth

$99 PSoC 6 WiFi-BT Pioneer Kit (CY8CKIT-062-WiFi-BT)

$75 PSoC 6 BLE Pioneer Kit (CY8CKIT-062-BLE)



$30 PSoC 6 Wi-Fi BT Prototyping Kit (CY8CPROTO-062-4343W)



Getting Started

1. **Download the PSoC Creator IDE**
2. **Purchase any of Cypress CapSense/MagSense Eval Kits:**

PSoC 4700 MCU Inductive Sensing Eval Kit (CY8CKIT-148)

PSoC 4 MCU Kits w/ CapSense:

- → PSoC 4 BLE Pioneer Kit (CY8CKIT-042-BLE-A)
- → PSoC 4000S Prototyping Kit (CY8CKIT-145-40XX)
- → PSoC 4 M-Series (Intelligent Analog) Pioneer Kit (CY8CKIT-044)
- → CapSense Liquid Level Sensing Shield (for use w/ PSoC 4 Kits (CY8CKIT-022)
- → CapSense Proximity Shield (for use w/ PSoC 4 Kits (CY8CKIT-024)

PSoC 6 MCU Kits w/ CapSense:

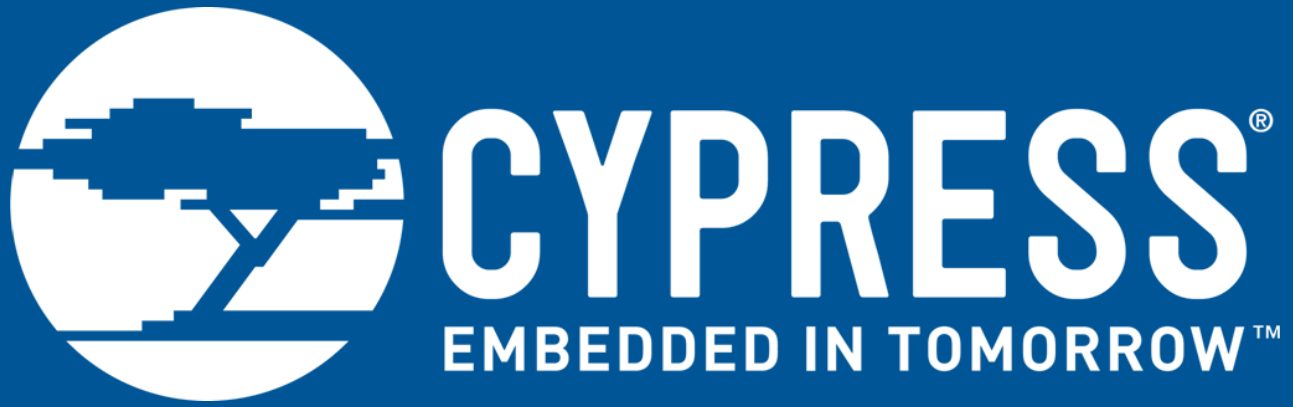
- → PSoC 6 BLE Pioneer Kit (CY8CKIT-062-BLE)
- → PSoC 6 WiFi-BT Pioneer Kit (CY8CKIT-062-WIFI-BT)
- → PSoC 6 WiFi-BT Prototyping Kit (CY8CPROTO-062-4343W)

3. **Join the Cypress Developer Community (CDC)**
4. **Start your design with any of the kits above and resources to the right. Interact with our engineers on the CDC if you need help!**

References and Links

- **Product Pages**
  - PSoC 4 MCU Family Page
  - PSoC 6 MCU Family Page
  - Cypress Sensing Technologies Page
  - PSoC MCU Roadmap
  - PSoC MCU Development Kits Selector
- **Cypress Developer Community (CDC)**
  - PSoC 4 Community
  - PSoC 6 Community
  - Cypress Sensing Technologies Community
- **App Notes/Datasheets/Technical Docs**
  - PSoC 6 MCU Datasheets
  - PSoC 4 MCU Datasheets
  - PSoC 4 and PSoC 6 MCU CapSense Design Guide App Note
  - Getting Started With CapSense App Note
  - PSoC 4 Low-Power CapSense Design Guide
  - PSoC 4 Capacitive Liquid Level Sensing App Note
  - Proximity Sensing With CapSense App Note
  - Inductive Sensing Design Guide
  - All Cypress CapSense/MagSense Resources

扫码关注赛普拉斯官方微信，获取更多信息和帮助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