Customer Training Workshop: Introduction to PSoC 4

Featuring the PSoC 4 M-Series Pioneer Kit

Replace Legacy 8-/16-Bit Platforms With the World’s Most Flexible 32-Bit ARM® Cortex®-M0 One-Chip Solution
Workshop Objectives

By the end of this workshop, you will
Understand the PSoC® 4 Programmable System-on-Chip architecture
Learn how to use Cypress’s solutions and integrated development environment (IDE) to implement:
  Digital designs with PSoC 4
  CapSense® touch-sensing user interface designs with PSoC 4
  One-chip, sensor-based system designs with PSoC 4
## Workshop Agenda

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<th>Topic</th>
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<td>0:15 (10 min)</td>
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<td>35</td>
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<tr>
<td>4:00</td>
<td></td>
<td>End of workshop</td>
</tr>
</tbody>
</table>

1 PSoC 3, PSoC 4 and PSoC 5 Integrated Design Environment (IDE) software that installs on your PC

2 A PSoC 4 with up to 128KB flash, 55 I/Os, Direct Memory Access, 2x CAN, 12 Programmable Analog Blocks and 16 Programmable Digital Blocks

3 A firmware development tool by Micrium that installs on your PC and helps debug system designs
Set Up and Install Software

Required software and initial steps
Copy the contents of the provided USB drive onto your laptop and install the software listed in the table below. Follow the on-screen instructions to complete the installation in approximately 15 minutes.

<table>
<thead>
<tr>
<th>Software</th>
<th>Version</th>
<th>File Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSoC Creator 1 Installer</td>
<td>3.2</td>
<td>“PSoCCreatorSetup_3.2_es100”</td>
</tr>
<tr>
<td>Micrium µC/Probe 2</td>
<td>3.5 (or newer)</td>
<td>“Micrium-uC-Probe-Setup-Release-3.5.15.300.exe”</td>
</tr>
<tr>
<td>PSoC 4 M-Series 3 Pioneer Kit Installer</td>
<td>1.0 (or newer)</td>
<td>“CY8CKIT044PIONEERKITSetupOnlyPackage_RevSS.exe”</td>
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<tr>
<td>PSoC 4 M-Series 3 Lab Exercise Files</td>
<td>1.0</td>
<td>“PSoC_4_M-Series_Workshop.zip”</td>
</tr>
</tbody>
</table>

Required hardware:
PSoC 4 M-Series 3 Pioneer Kit (CY8CKIT-044), shown at right.

Raise your hand if you need help!

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1 PSoC 3, PSoC 4 and PSoC 5 Integrated Design Environment (IDE) software that installs on your PC
2 A firmware development tool by Micrium that installs on your PC and helps debug system designs
3 A PSoC 4 with up to 128KB flash, 55 I/Os, Direct Memory Access, 2x CAN, 12 Programmable Analog Blocks and 16 Programmable Digital Blocks
**PSoC Terms**

**PSoC**
PSoC is the world’s only programmable embedded system-on-chip integrating an MCU core, Programmable Analog Blocks, Programmable Digital Blocks, Programmable Interconnect and Routing and CapSense.

**Programmable Analog Block**
A hardware block that is configured using PSoC Components to create Analog Front Ends (AFEs), among other capabilities. Includes Continuous Time Blocks, analog-to-digital converters (ADCs) and digital-to-analog converters (DACs).

**Continuous Time Block (CTB)**
A Programmable Analog Block that is used to implement continuous time analog circuits such as opamps and programmable gain amplifiers (PGAs).

**Programmable Digital Block**
A hardware block that is configured using PSoC Components to implement custom digital peripherals and glue logic. Includes Universal Digital Blocks, Serial Communication Blocks (SCBs) and TCPWMs.

**Universal Digital Block (UDB)**
A PSoC Programmable Digital Block that contains: two programmable logic devices (PLDs), one programmable data path with an arithmetic logic unit (ALU), one status register and one control register. Configured in PSoC Creator using PSoC Components, or the graphical state machine editor or Verilog code.

**Serial Communication Block (SCB)**
A PSoC Programmable Digital Block that is configurable as a UART, SPI or I²C interface.

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1. Connects the Programmable Analog Blocks, Programmable Digital Blocks and I/Os
2. Free embedded ICs represented by an icon in PSoC Creator software
3. Timer, counter, pulse-width modulator (PWM)
4. PSoC 3, PSoC 4 and PSoC 5 Integrated Design Environment (IDE) software that installs on your PC
**PSoc Terms**

**Timer, Counter, PWM (TCPWM) Block**
A PSoc **Programmable Digital Block** that is configurable as a 16-bit timer, counter, PWM or quadrature decoder.

**CapSense®**
Cypress’s third-generation touch-sensing user interface solution that “just works” in noisy environments and in the presence of water.
The industry’s No. 1 solution in sales by 4x over No. 2

**Programmable Interconnect and Routing**
Connects the Programmable Analog Blocks, Programmable Digital Blocks and I/Os.
Enables flexible connections of internal analog and digital signals to internal buses and external I/Os.

**PSoc Creator™**
PSoc 3, PSoc 4 and PSoc 5 Integrated Design Environment (IDE)
Software that installs on your PC that allows:
- Concurrent hardware and firmware design of PSoc systems, or
- PSoc hardware design followed by export to popular IDEs

**Components**
Free **embedded ICs** represented by an icon in PSoc Creator software.
Used to **integrate multiple ICs** and system interfaces into one **PSoc**
Dragged and dropped as icons to design systems in PSoc Creator.

**Component Configuration Tools**
Simple graphical user interfaces in PSoc Creator embedded in each Component.
Used to customize Component parameters.
PSoC Terms

PSoC 4
A PSoC with an ARM® Cortex®-M0 MCU

PSoC 4 “Base-Series”
A PSoC 4 with up to 32KB flash, 36 I/Os, 8 Programmable Analog Blocks and 10 Programmable Digital Blocks
The original PSoC 4 family introduced in 2013 with over 2 million units in the field

PSoC 4 M-Series
A PSoC 4 with up to 128KB flash, 55 I/Os, DMA¹, 2x CAN², 12 Programmable Analog Blocks and 16 Programmable Digital Blocks

PSoC 4 L-Series
A PSoC 4 with up to 256KB flash, 98 I/Os, DMA¹, 2x CAN², USB, 13 Programmable Analog Blocks and 20 Programmable Digital Blocks

PSoC 4 BLE
A PSoC 4 with up to 256KB flash, 36 I/Os, 10 Programmable Analog Blocks, 10 Programmable Digital Blocks and an integrated BLE⁴ radio with a royalty-free BLE⁴ Protocol Stack

IDAC³ Component used to create custom Analog Front Ends

Component Icon

Component Configuration Tool

¹ Direct Memory Access
² Controller Area Network
³ Current-output digital-to-analog converter
⁴ Bluetooth Low Energy wireless solution designed for short-range, low-power wireless applications
Additional Terms

**Analog Front End (AFE)**
An analog signal-conditioning circuit that uses opamps, filters and comparators to interface to an analog-to-digital converter (ADC)

**Coprocessor**
A specialized hardware block designed to offload compute-intensive tasks, such as signal processing or communication interfaces, from the main processor
Simplifies the application firmware design in the main processor by moving functions to specialized hardware blocks

**Direct Memory Access (DMA)**
A method to transfer data directly between memory and input/output subsystems
Allows fast data transfers, bypassing the CPU during the read/write operation

**Controller Area Network (CAN)**
A serial communication standard designed to provide highly reliable communication between devices

**CapSense Gesture Pad**
A set of capacitive sensors designed in a pattern on a PCB to implement touch-based swipe and circular gestures, as shown to the right

**Micrium® µC/Probe™**
A firmware development tool by Micrium that installs on your PC and helps debug system designs
A free 30-day Professional Edition License is available with the purchase of a PSoC 4 M-Series Pioneer Kit

Swipe Gesture
Circular Gesture
Introduction to PSoC 4

DEMO #1: PSoC CREATOR OVERVIEW
Demo #1: PSoC Creator Overview

Objectives:
Learn about the PSoC Creator workflow:
- Create a new project
- Find 100s of example projects
- Place and configure a Component
- Open a datasheet
- Assign signals to pins
- Build and debug a design

Software tool:
PSoC Creator

A Heart Rate Monitor Example Project in PSoC Creator
Introduction to PSoC 4

LAB #1: PSoC 4 M-SERIES PIONEER KIT OVERVIEW AND BLINKING LED
$25 PSoC 4 M-Series Pioneer Kit (CY8CKIT-044)
Is form-factor compatible with the Arduino™ and Raspberry Pi hobbyist kit ecosystems
Features a CapSense Gesture Pad and proximity\(^1\) headers
Includes on-board sensors such as an ambient light sensor, an accelerometer and a PWM temperature sensor
Contains a PSoC 5 for programming and debugging

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\(^1\) A method to detect the presence of approaching objects without a physical touch
\(^2\) Ferroelectric RAM with an I\(^2\)C serial interface
Lab #1: Blinking LED

Objectives:
Learn how to use PSoC Creator to implement and debug PSoC designs
Implement a simple blinking LED design

Software tool:
PSoC Creator

Component:
Pin Component (configured as a digital output)
Introduction to PSoC 4

PSoC 4 ARCHITECTURE
PSoC 4 Architecture

PSoC 4 One-Chip Solution

MCU Subsystem

ARM Cortex-M0
48 MHz

Flash (64KB to 128KB)

SRAM (8KB to 16KB)

Serial Wire Debug

CAN x2

Real-Time Control

DMA

Advanced High-Performance Bus (AHB)

Programmable Analog Blocks

Opamp x4

12-bit SAR ADC
1 Msps

Low-Power Comparator x6

CapSense

8-bit IDAC1 x2

7-bit IDAC1 x2

Programmable Digital Blocks

UDB2 x4

TCPWM3 x8

SCB4 x4

Segment LCD Drive

Programmable Interconnect/Routing

GPIO x8

GPIO x8

GPIO x8

GPIO x8

GPIO x8

GPIO x7

1 Current-output digital-to-analog converter
2 Universal Digital Block
3 Timer, Counter, PWM block
4 Serial Communication Block; programmable as I²C/SPI/UART
Programmable Digital Blocks Used for Coprocessors and Serial Interfaces

PSoC 4 implements Coprocessors and serial interfaces without increasing cost, size or power with:

Universal Digital Blocks (UDBs) that can be configured as:
- Timing-critical Coprocessors that simplify firmware and interrupt handling by replacing “bit-banging” firmware
- Custom serial communication interfaces for emerging standards that replace external glue logic ICs (e.g., Microwire)
- Serial Communication Blocks that can be configured as serial communication interfaces like I²C, UART, SPI or LIN
- TCPWM Blocks that can be configured as timers, counters, PWMs or quadrature decoders

Three Design Methods Used to Create Custom Digital Logic Using UDBs in PSoC Creator

1. Use digital logic Components in the PSoC Creator schematic…
2. Or the graphical state machine editor…
3. Or Verilog code in the code editor…

To program the UDB

1. A technique using firmware to directly control the state of I/Os
2. A serial communication interface based on a subset of the SPI protocol
3. Programmable logic device (12C4 = 12 inputs with 4 combinatorial outputs)
4. A technique used to combine elements of a UDB to form wider elements
5. Product term: A logical conjunction of Boolean inputs
6. A programmable element of a UDB that contains an arithmetic logic unit
Programmable Analog Blocks Used for Custom AFEs and Sophisticated UIs

PSOC 4 enables custom AFE designs and sophisticated UIs without increasing cost, size or power with:

A differential 1-Msps, 12-bit SAR ADC and high-performance opamps with ±1-mV-input offset voltage and 6-MHz gain bandwidth that offer discrete analog performance

A 1- to 55-channel analog multiplexer that can be used to create custom AFE designs

A 5-V input voltage that provides over 50% more analog input signal range than 3.3-V input voltages in most ARM® Cortex®-M0 MCUs

A CapSense hardware block for sophisticated, capacitive touch-sensing user interfaces with advanced features such as proximity sensing¹, water tolerance² and SmartSense™ AutoTuning³

PSOC 4 M-Series Programmable Analog Blocks

CapSense Component With Configuration Tool in PSOC Creator

1 A method to detect the presence of approaching objects without a physical touch

2 The ability of a capacitive sensing solution to work in the presence of water droplets or mist

3 A Cypress algorithm that automatically sets parameters for optimal performance after the design phase and continuously compensates for system, manufacturing and environmental changes

4 Current-output digital-to-analog converter
Programmable Interconnect and Routing Enables Flexible Hardware Designs

**PSoC 4 enables flexible hardware designs with:**
Programmable Interconnect and Routing that connects internal analog and digital signals to any I/O
Programmable I/Os that support:
- Eight drive modes\(^1\) to interface with a variety of analog and digital peripherals such as analog and digital sensors
- MCU interrupts on the rising edge, falling edge or both edges of a digital input signal

**PSoC Creator simplifies designs by:**
Providing Pin Components to configure the programmable I/Os
Automatically routing signals between the system bus, Programmable Analog Blocks, Programmable Digital Blocks and I/Os

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### Pin Components in PSoC Creator

- **Analog_Pin**
- **Digital_Input_Pin**
- **Digital_Output_Pin**
- **Digital_Bidirectional_Pin**

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### Pin Component Configuration Tool

**PSoC Creator Design Using Programmable I/Os and Routing to Provide Internal Test Signals to the System Bus**

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1 The eight drive modes are: Strong Drive, Open-Drain High Drive, Open-Drain Low Drive, Resistive Pull-up, Resistive Pull-down, Resistive Pull-up/down, High-Impedance Digital, High-Impedance Analog. Refer to the product datasheet for more information on these modes.
### PSoC® 4 Portfolio

**ARM® Cortex®-M0 | CapSense®**

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<th>PSOC MCU</th>
<th>Intelligent Analog</th>
<th>Programmable Digital</th>
<th>Programmable Analog</th>
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<td>PSoC 4100</td>
<td>PSoC 4200</td>
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#### Performance

<table>
<thead>
<tr>
<th>Series</th>
<th>M = M-Series</th>
<th>L = L-Series</th>
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<tbody>
<tr>
<td>BL = BLE-Series</td>
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</tbody>
</table>

#### Integration

- **Status Availability**
  - Production
  - Sampling
  - Development
  - Concept

1. Flash KB/ SRAM KB
2. Comparator
3. Analog-to-digital converter
4. Serial Communication Block; programmable as I2C/SPI/UART
5. Current-output digital-to-analog converter
6. Timer, counter, PWM block
7. Bluetooth Low Energy
8. Universal Digital Block
9. Controller Area Network

#### Technology Features

- **CY8C4128-BL**
  - 24 MHz, 256K/32K1, 36 I/O, CMP2, Opamp, ADC3, SCB4, IDAC5, TCPWM6, BLE7

- **CY8C4127-M**
  - 24 MHz, 128K/16K1, 51-55 I/O, CMP2, Opamp, ADC3, SCB4, IDAC5, TCPWM6, CAN9

- **CY8C4126-M**
  - 24 MHz, 64K/8K1, 38-51 I/O, CMP2, Opamp, ADC3, SCB4, IDAC5, TCPWM6

- **CY8C4125**
  - 24 MHz, 32K/4K1, 22-36 I/O, CMP2, Opamp, ADC3, SCB4, IDAC5, TCPWM6

- **CY8C4014**
  - 16 MHz, 16K/2K1, 5-20 I/O, CMP2, PC, IDAC5, TCPWM6

- **CY8C4013**
  - 16 MHz, 8K/2K1, 5-13 I/O, CMP2, PC, IDAC5, TCPWM6

- **CY8C4014**
  - 16 MHz, 16K/2K1, 5-20 I/O, CMP2, PC, IDAC5, TCPWM6

- **CY8C4013**
  - 16 MHz, 8K/2K1, 5-13 I/O, CMP2, PC, IDAC5, TCPWM6

- **CY8C4124**
  - 24 MHz, 16K/4K1, 22-36 I/O, CMP2, Opamp, ADC3, SCB4, IDAC5, TCPWM6

- **CY8C4245**
  - 48 MHz, 32K/4K1, 22-36 I/O, CMP2, Opamp, ADC3, SCB4, IDAC5, TCPWM6, UDB8

- **CY8C4246-M**
  - 48 MHz, 64K/8K1, 38-55 I/O, CMP2, Opamp, ADC3, SCB4, IDAC5, TCPWM6, UDB8

- **CY8C4247-M**
  - 48 MHz, 128K/16K1, 51-55 I/O, CMP2, Opamp, ADC3, SCB4, IDAC5, TCPWM6, UDB8, CAN9

- **CY8C4247-L**
  - 48 MHz, 128K/16K1, 38-59 I/O, CMP2, Opamp, ADC3, SCB4, IDAC5, TCPWM6, UDB8, CAN9, USB

- **CY8C4248-L**
  - 48 MHz, 256K/32K1, 53-98 I/O, CMP2, Opamp, ADC3, SCB4, IDAC5, TCPWM6, UDB8, CAN9, USB

- **CY8C4247-BL**
  - 48 MHz, 128K/16K1, 38-59 I/O, CMP2, Opamp, ADC3, SCB4, IDAC5, TCPWM6, UDB8, BLE7

- **CY8C4248-BL**
  - 48 MHz, 256K/32K1, 53-98 I/O, CMP2, Opamp, ADC3, SCB4, IDAC5, TCPWM6, BLE7

- **CY8C44x6**
  - 48 MHz, 64K/16K1
  - Concept Only
  - Contact Sales

- **CY8C44x5**
  - 48 MHz, 32K/8K1
  - Concept Only
  - Contact Sales

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**Note:**
- **Q215:** Query 215
- **Q315:** Query 315
- **NEW:** New release
- **IDAC:** Integrated Digital Analog Converter
- **TCPWM:** Time-Triggered Pulse Width Modulation
- **SCB:** Serial Communication Block
- **UDB:** Universal Digital Block
- **BLE:** Bluetooth Low Energy
- **USB:** Universal Serial Bus
- **CAN:** Controller Area Network
- **98 I/O:** 98 I/O pins
- **57 I/O:** 57 I/O pins
Introduction to PSoC 4

DEMO #2: MICRIUM µC/PROBE
Objectives:
Learn about the Micrium µC/Probe Tool and workflow:
- Create a new project
- Place and map Micrium virtual controls and indicators to the internal registers and memory locations in a PSoC 4 device
- Debug a PSoC 4 design by monitoring internal PSoC 4 registers

Software tools:
Micrium µC/Probe
PSoC Creator

Micrium µC/Probe Debug Tool Enables Visual Debugging of Systems

A design created in PSoC Creator…

Is graphically debugged with Micrium µC/Probe

1 Graphical representation of firmware parameters using buttons, gauges, charts and numeric indicators
SESSION BREAK

Introduction to PSoC 4
Introduction to PSoC 4

LAB #2: DIGITAL SYSTEM DESIGN
Lab #2: Digital System Design

Objectives:
Measure the ambient temperature of the PWM temperature sensor using a TMP05\textsuperscript{1} Component that is implemented using UDBs
Implement a breathing LED using the TCPWM and XOR Digital Logic Components
Debug a system design with the Micrium \textit{µC/Probe} Tool

Software tools:
PSoc Creator
Micrium \textit{µC/Probe}

Components:
TMP05\textsuperscript{1} Component
TCPWM Component
XOR Component

\textsuperscript{1} A digital temperature sensor that generates a pulse-modulated signal based on the temperature
Introduction to PSoC 4

LAB #3: CapSense TOUCH-SENSING DESIGN
CapSense Touch Sensing

CapSense replaces mechanical buttons
A capacitive sensor is used to measure the change in capacitance between a pin and ground
CapSense algorithms and analog circuitry convert the measured capacitance to a raw count
A finger touch increases the capacitance of the system, which in turn increases the raw count
An increase in the raw count above a user-defined threshold registers a touch

Refer to the Getting Started With CapSense Guide for details on CapSense algorithms

Capacitive Sensor
Without a Finger Touch

\[ C_X = 2C_P \]

\( C_X \) = Total Capacitance on the capacitive sensor node
\( C_P \) = Parasitic capacitance

Capacitive Sensor
With a Finger Touch

\[ C_X = 2C_P + C_F \]

\( C_F \) = Capacitance added by a finger touch
\( C_F \) is dependent on the overlay material, overlay thickness and the dimensions of the finger (typical = 9mm) and sensor capacitances

CapSense algorithms use analog circuits to convert the capacitance to raw count, which is compared to the user-defined threshold to record a touch
SmartSense Auto-tuning sets, monitors and continuously maintains optimal capacitive sensor performance

Reduces design effort by eliminating manual tuning (of baseline and threshold values) after the design phase
Adapts to manufacturing variations in PCB, overlay and paint that degrade touch-sensing performance
Adapts to changes in system environment due to RF noise sources
Allows a platform design approach that uses different overlays, button shapes and trace lengths with the same electronics

SmartSense Auto-tuning Cuts Design Cycle Time

Steps eliminated through Auto-tuning functionality

SmartSense Auto-tuning eliminates time-consuming manual tuning and the design iterations caused by it
CapSense Touch Sensing Enables Sophisticated User Interfaces

**PSoC 4 tracks finger movements and touch-based gestures in two dimensions**
Swipe gestures track up, down, left and right finger movements
Circular gestures track clockwise and counter-clockwise finger movements
Refer to the [PSoC 4 M-Series Pioneer Kit Guide](#) for details on touch-based gestures

**CapSense maintains touch accuracy even in wet conditions**
Refer to the [Getting Started With CapSense Guide](#) for details on liquid tolerance

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**CapSense Gestures on the PSoC 4 M-Series Pioneer Kit (CY8CKIT-044)**

- **Swipe Gesture: Up/Down**
- **Swipe Gesture: Left/Right**
- **Circular Gesture: Clockwise/Counter-Clockwise**

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The PSoC 4 M-Series Pioneer Kit provides a platform to implement touch-based gestures rapidly
Lab #3: CapSense Touch-Sensing Design

Objectives:
Adjust the RGB LED color and intensity using three TCPWM Components
Implement CapSense touch-based gestures using the CapSense Gesture Pad

Software tool:
PSoC Creator

Components:
TCPWM Components
CapSense CSD Component

Lab 3: Block Diagram

PSoc 4 M-Series Pioneer Kit

PSoc 4 M-Series

ARM® Cortex®-M0
TCPWM x3
CapSense
P0[6], P2[6], P6[5]
P3[4-5], P4[4-6]
CapSense Gesture Pad
RGB LED

CapSense CSD Component Icon
TCPWM Component Icon
Introduction to PSoC 4

LAB #4: SENSOR-BASED SYSTEM DESIGN
Sensor-Based System Design

Fitness monitors are examples of sensor-based system designs
Fitness monitors can have up to 8 or more analog and digital sensors to track activities
To learn more about fitness monitors, download our Wearables Solutions Catalog

Fitness monitors require:
A heart rate monitor
Activity monitoring and a step counter
A touch-based user interface
Maximum battery life
A low system BOM cost

Designing a fitness monitor requires:
AFEs with opamps and an ADC to amplify, buffer and capture heart rate signals
An accelerometer to capture changes in motion
A touch-sensing IC to detect touches and gestures
ICs with low-power modes to minimize system power consumption

PSoc 4 delivers a low-cost, single-chip solution for today’s sensor-based system designs

Up3 Fitness Monitor by Jawbone
The newest Jawbone Up3 features a heart rate monitor and a touch-sensing interface to mobile devices

Microsoft Band Fitness Monitor
The new Microsoft Band includes a state-of-the-art heart rate monitor and a touch-sensing interface to mobile devices
PSoC 4 Integrates AFEs, Digital Logic and an MCU

Multiple AFE ICs, a CPLD IC and a legacy MCU…

Are integrated using **Components** in **PSoC Creator**…

And **rapidly prototyped** to create a **one-chip solution**…

That can be **changed in software** without costly PCB spins.

Instrumentation Amplifier

Dual-Channel Opamp

Complex Programmable Logic Device (CPLD)

MSP430® MCU

16-Bit MCU

$25 PSoC 4 M-Series Pioneer Kit (CY8CKIT-044)
PSoC 4 Delivers Five Flexible, Easy-to-Use Low-Power Modes

<table>
<thead>
<tr>
<th>Power Mode</th>
<th>Current Consumption</th>
<th>Code Execution</th>
<th>Digital Peripherals Available</th>
<th>Analog Peripherals Available</th>
<th>Clock Sources Available</th>
<th>Wake-Up Sources</th>
<th>Wake-Up Time</th>
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<tbody>
<tr>
<td>Active</td>
<td>2.2 mA @ 6 MHz</td>
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<td>All</td>
<td>All</td>
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<tr>
<td>Sleep</td>
<td>1.3 mA</td>
<td>No</td>
<td>All</td>
<td>All</td>
<td>All</td>
<td>Any interrupt source</td>
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<tr>
<td>Deep-Sleep</td>
<td>1.3 μA</td>
<td>No</td>
<td>WDT(^1), LCD(^2), I(^2)C/SPI</td>
<td>Comparator, opamps, POR(^3), BOD(^4)</td>
<td>WCO(^5), 32-kHz ILO(^6)</td>
<td>Comparator, GPIO(^7), WDT, SCB(^8)</td>
<td>25 μs</td>
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<tr>
<td>Hibernate</td>
<td>150 nA</td>
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<td>No</td>
<td>Comparator, POR, BOD</td>
<td>No</td>
<td>Comparator, GPIO</td>
<td>2 ms</td>
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<tr>
<td>Stop</td>
<td>20 nA</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Wake-Up pin, XRES(^9)</td>
<td>2 ms</td>
</tr>
</tbody>
</table>

**PSoC 4 has best-in-class low-power modes**

Consumes the lowest current in Stop mode with I/O-state retention
Retains SRAM data in Hibernate mode
Retains complete system status, as well as opamp and comparator functionality, in Deep-Sleep mode
Immediate wake-up from Sleep mode, unlike some 8-/16-bit MCUs

**PSoC Creator simplifies power optimization**

Provides APIs to switch easily between low-power modes
Provides APIs to control the power of PSoC Components

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1. Watchdog timer
2. Liquid crystal display
3. Power-on-reset
4. Brownout-detect
5. 32-kHz watch crystal oscillator
6. 32-kHz internal low-speed oscillator
7. General-purpose input/output
8. Serial Communication Block
9. External reset

---

PSoC 4 Current Consumption in Different Power Modes

![Current Consumption Chart](chart.png)
Lab #4: Sensor-Based System Design

Objectives
Measure ambient light intensity using an ambient light sensor
Control the LED intensity based on the ambient light intensity

Software tools
PSOC Creator
Micrium µC/Probe

Components
SAR ADC Component
Opamp Component

Lab 4: Block Diagram

PSOC 4 M-Series Pioneer Kit

1 Trans-impedance amplifier using PSOC 4 Programmable Analog Blocks
Introduction to PSoC 4
WRAP-UP
References and Links

Product Webpages:
- PSoC 4 Product webpage: [www.cypress.com/PSoC4](http://www.cypress.com/PSoC4)
- PSoC 4100 datasheet: [www.cypress.com/go/cy8c41datasheet](http://www.cypress.com/go/cy8c41datasheet)
- PSoC 4200 datasheet: [www.cypress.com/go/cy8c42datasheet](http://www.cypress.com/go/cy8c42datasheet)
- PSoC 4100M datasheet: [www.cypress.com/PSoC4100MDatasheet](http://www.cypress.com/PSoC4100MDatasheet)
- PSoC 4200M datasheet: [www.cypress.com/PSoC4200MDatasheet](http://www.cypress.com/PSoC4200MDatasheet)
- PSoC 4 BLE datasheet: [www.cypress.com/PSoC4BLEDatasheet](http://www.cypress.com/PSoC4BLEDatasheet)
- PSoC 4 M-Series Pioneer Kit: [www.cypress.com/CY8CKIT-044](http://www.cypress.com/CY8CKIT-044)
- PSoC Creator IDE: [www.cypress.com/PSoCCreator](http://www.cypress.com/PSoCCreator)
- Micrium µC/Probe: [www.micrium.com/tools/ucprobe](http://www.micrium.com/tools/ucprobe)

Application Notes:
- *Getting Started With PSoC 4* (AN79953): [www.cypress.com/go/AN79953](http://www.cypress.com/go/AN79953)
- *PSoC 4 Low-Power Modes and Power Reduction Techniques* (AN86233): [www.cypress.com/go/AN86233](http://www.cypress.com/go/AN86233)
- *PSoC 4 and PSoC 5LP ARM® Cortex® Code Optimization* (AN89610): [www.cypress.com/go/AN89610](http://www.cypress.com/go/AN89610)
- *PSoC 4100/4200 Hardware Design Considerations* (AN88619): [www.cypress.com/go/AN88619](http://www.cypress.com/go/AN88619)
- *Designing PSoC Creator™ Components With UDB Datapaths* (AN82156): [www.cypress.com/go/AN82156](http://www.cypress.com/go/AN82156)

Design Guides:
Cypress Resources

PSoC Product webpage: www.cypress.com/PSoC
Cypress Roadmap: www.cypress.com/Roadmap
Kits: www.cypress.com/kits
Support: www.cypress.com/support
Workshops: www.cypress.com/workshops
Cypress Online Store: www.cypress.com/store
Developer Community & Forums: www.cypress.com/forums
App Notes: www.cypress.com/AppNotes

Cypress PSoC 4 M-Series Solutions: www.cypress.com/PSoC4

Cypress’s PSoC 4 M-Series webpage is your one-stop-shop for everything, including product datasheets, development kits, app notes, software downloads, example projects and demo videos.
Workshop Objectives Recap

You should now:
Understand the architecture of the PSoC 4 Programmable System-on-Chip
Know how to use the PSoC Creator IDE and the PSoC 4 M-Series Pioneer Kit to design with PSoC 4, to implement:
  Digital designs with PSoC 4
  CapSense touch-sensing user interface designs with PSoC 4
  One-chip, sensor-based system designs with PSoC 4

Please help us improve this workshop by completing our feedback form
Introduction to PSoC 4

APPENDIX
**Applications**
User interface for home appliances
Digital and analog sensor hub
MCU and discrete analog replacement

**Features**

**32-bit MCU Subsystem**
- 24-MHz ARM® Cortex®-M0 CPU
- Up to 32KB flash and 4KB SRAM

**CapSense® with SmartSense™ Auto-tuning**
- Cypress Capacitive Sigma-Delta™ (CSD) controller
- CapSense supported on up to 36 pins

**Programmable Analog Blocks**
- Two comparators (CMP)
- Two opamps, programmed as PGAs, CMPs, filters, etc.
- One 12-bit, 1-MspS SAR ADC
- Two IDACs (2x 8-bit, 2x 7-bit)

**Programmable Digital Blocks**
- Four programmable 16-bit TCPWM blocks
- Two SCBs: I²C master or slave, SPI master or slave, or UART

**Packages:** 28-pin SSOP, 40-pin QFN, 44-pin TQFP, 48-pin LQFP

**Collateral**
Datasheet: PSoC 4100 datasheet

**Availability**
- Sampling: Now
- Production: Now

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1 Successive approximation register
2 Current-output digital-to-analog converter
3 Timer, counter, PWM block
4 Serial Communication Block, programmable as I²C/SPI/UART
**Introduction to PSoC 4 Customer Training Workshop with PSoC 4 M-Series**

**Owner:** JFMD  
**Tech lead:** PMAD

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**Applications**

- User interface for home appliances
- Digital and analog sensor hub
- MCU and discrete analog replacement

**Features**

**32-bit MCU Subsystem**
- 48-MHz ARM® Cortex®-M0 CPU
- Up to 32KB flash and 4KB SRAM

**CapSense® with SmartSense™ Auto-tuning**
- Cypress Capacitive Sigma-Delta™ (CSD) controller
- CapSense supported on up to 36 pins

**Programmable Analog Blocks**
- Two comparators (CMP)
- Two opamps, programmed as PGAs, CMPs, filters, etc.
- One 12-bit, 1-Mmps SAR\(^1\) ADC
- Two IDACs\(^2\) (2x 8-bit, 2x 7-bit)

**Programmable Digital Blocks**
- Four Universal Digital Blocks (UDBs\(^3\)): custom digital peripherals
- Four programmable 16-bit TCPWM\(^4\) blocks
- Two SCBs\(^5\): I\(^2\)C master or slave, SPI master or slave, or UART

**Packages:** 28-pin SSOP, 40-pin QFN, 44-pin TQFP, 48-pin LQFP

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**Collateral**

- Datasheet: [PSoC 4200 datasheet](#)

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**Availability**

- Sampling: Now
- Production: Now

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**Applications**

Sports and fitness monitors, wearable electronics, medical devices, home automation solutions, game controllers, sensor-based low-power systems for the Internet of Things (IoT)

**Features**

**32-bit MCU subsystem**
- 24-MHz ARM® Cortex®-M0 CPU
- Up to 256KB flash and 32KB SRAM

**Programmable Analog Blocks**
- Four opamps, configurable as PGAs, comparators, filters, etc.
- One 12-bit, 1-Msps SAR ADC

**CapSense® with SmartSense™ Auto-tuning**
- One Cypress Capacitive Sigma-Delta™ (CSD) controller with touchpad capability

**Programmable Digital Blocks**
- Four configurable TCPWM blocks: 16-bit timer, counter or PWM
- Two configurable serial communication blocks (SCBs):
  - I²C master or slave, SPI master or slave, or UART

**Packages**
- 56-pin QFN, 68-pin CSP

**Bluetooth Smart connectivity with Bluetooth 4.1**
- 2.4-GHz BLE radio with integrated Balun

**Collateral**

Datasheet: [PSoC 4100 BLE datasheet](#)

**Availability**

Sampling: Now
Production: Now

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1 Successive approximation register
2 Timer, counter, PWM block
3 Serial Communication Block, programmable as I²C/SPI/UART
Introduction to PSoC 4 Customer Training Workshop with PSoC 4 M-Series

**Applications**
Sports and fitness monitors, wearable electronics, medical devices, home automation solutions, game controllers, sensor-based low-power systems for the Internet of Things (IoT)

**Features**

**32-bit MCU subsystem**
48-MHz ARM® Cortex®-M0 CPU
Up to 256KB flash and 32KB SRAM

**Programmable Analog Blocks**
Four opamps, configurable as PGAs, comparators, filters, etc.
One 12-bit, 1-Msps SAR\(^1\) ADC

**CapSense\(^\circledR\) with SmartSense™ Auto-tuning**
One Cypress Capacitive Sigma-Delta™ (CSD) controller with touchpad capability

**Programmable Digital Blocks**
Four Universal Digital Blocks (UDBs\(^2\)):
custom digital peripherals
Four configurable TCPWM\(^3\) blocks: 16-bit timer, counter or PWM
Two configurable serial communication blocks (SCBs\(^4\)):
I\(^2\)C master or slave, SPI master or slave, or UART

**Packages**
56-pin QFN, 68-pin CSP

**Bluetooth Smart connectivity with Bluetooth 4.1**
2.4-GHz BLE radio with integrated Balun

**Collateral**
Datasheet: [PSoC 4200 BLE datasheet](#)

**Availability**
Sampling: Now
Production: Now

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1 Successive approximation register
2 Universal Digital Block
3 Timer, counter, PWM block
4 Serial Communication Block, programmable as I\(^2\)C/SPI/UART

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[Image of a diagram showing the PSoC 4 BLE One-Chip Solution with blocks for MCU Subsystem, Programmable Analog Blocks, Programmable Digital Blocks, Advanced High-Performance Bus (AHB), BLE System, Flash, SRAM, Serial Wire Debug, and I/O Subsystem.]
Applications
User interface and host processor for home appliances
Digital and analog sensor hub
MCU and discrete analog replacement

Features

32-bit MCU Subsystem
24-MHz ARM® Cortex®-M0 CPU with a DMA controller and RTC
Up to 128KB flash and 16KB SRAM
Up to 55 GPIOs supporting analog, digital and CapSense interfaces

CapSense® With SmartSense™ Auto-tuning
Cypress Capacitive Sigma-Delta™ (CSD) controller

Programmable Analog Blocks
Six comparators (CMP)
Four opamps, programmable as PGAs, CMPs, filters, etc.
One 12-bit, 1-Msps SAR1 ADC
Four IDACs2 (2x 8-bit, 2x 7-bit)

Programmable Digital Blocks
Eight programmable 16-bit TCPWM3 blocks
Four SCBs4: I2C master or slave, SPI master or slave, or UART

Two Controller Area Network (CAN) Controllers

Packages: 48-pin LQFP, 64-pin TQFP (0.8-mm pitch),
64-pin TQFP (0.5-mm pitch), 68-pin QFN

Datasheet: PSoC 4100M datasheet

Availability
Sampling: Now
Production: Q2 2015

Notes:
1 Successive approximation register
2 Current-output digital-to-analog converter
3 Timer, counter, PWM block
4 Serial Communication Block, programmable as I2C/SPI/UART
Applications
User interface and host processor for home appliances
Digital and analog sensor hub
LED control and communication for lighting systems

Features
32-bit MCU Subsystem
48-MHz ARM® Cortex®-M0 CPU with a DMA controller and RTC
Up to 128KB flash and 16KB SRAM
Up to 55 GPIOs supporting analog, digital and CapSense interfaces

CapSense® With SmartSense™ Auto-tuning
Cypress Capacitive Sigma-Delta™ (CSD) controller

Programmable Analog Blocks
Six comparators (CMP)
Four opamps, programmable as PGAs, CMPs, filters, etc.
One 12-bit, 1-Msps SAR ADC
Four IDACs2 (2x 8-bit, 2x 7-bit)

Programmable Digital Blocks
Four Universal Digital Blocks (UDBs3): custom digital peripherals
Eight programmable 16-bit TCPWM4 blocks
Four SCBs5: I2C master or slave, SPI master or slave, or UART

Two Controller Area Network (CAN) Controllers

Packages: 48-pin LQFP, 64-pin TQFP (0.8-mm pitch),
64-pin TQFP (0.5-mm pitch), 68-pin QFN

Datasheet: PSoC 4200M datasheet

Availability
Sampling: Now
Production: Q2 2015

Notes:
1 Successive approximation register
2 Current-output digital-to-analog converter
3 Universal Digital Block
4 Timer, counter, PWM block
5 Serial Communication Block, programmable as I2C/SPI/UART