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### What is "[Embedded - Microcontrollers](#)"?

"[Embedded - Microcontrollers](#)" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

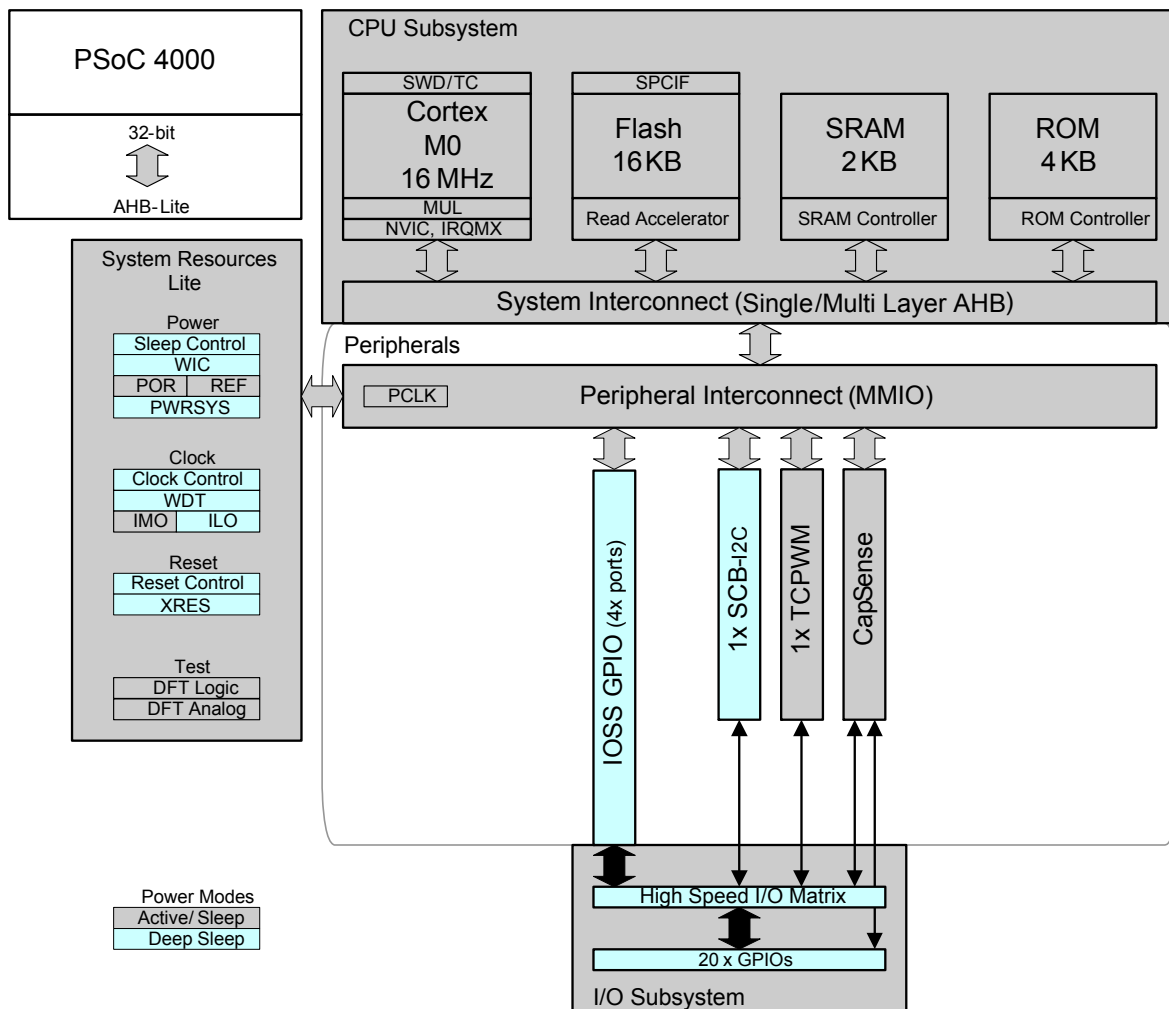
### Applications of "[Embedded - Microcontrollers](#)"

#### Details

Product Status	Active
Core Processor	ARM® Cortex®-M0
Core Size	32-Bit Single-Core
Speed	16MHz
Connectivity	I <sup>2</sup> C
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	20
Program Memory Size	16KB (16K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	2K x 8
Voltage - Supply (Vcc/Vdd)	1.71V ~ 5.5V
Data Converters	D/A 1x7b, 1x8b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	24-UFQFN Exposed Pad
Supplier Device Package	24-QFN (4x4)
Purchase URL	<a href="https://www.e-xfl.com/product-detail/infineon-technologies/cy8c4014lqi-412t">https://www.e-xfl.com/product-detail/infineon-technologies/cy8c4014lqi-412t</a>

## Contents

<b>Functional Definition .....</b>	<b>5</b>	Digital Peripherals .....	19
CPU and Memory Subsystem .....	5	Memory .....	20
System Resources .....	5	System Resources .....	20
Analog Blocks .....	6	<b>Ordering Information.....</b>	<b>23</b>
Fixed Function Digital .....	6	Part Numbering Conventions .....	23
GPIO .....	6	<b>Packaging.....</b>	<b>25</b>
Special Function Peripherals.....	6	Package Outline Drawings .....	26
<b>Pinouts .....</b>	<b>7</b>	<b>Acronyms .....</b>	<b>30</b>
<b>Power .....</b>	<b>12</b>	<b>Document Conventions .....</b>	<b>32</b>
Unregulated External Supply.....	12	Units of Measure .....	32
Regulated External Supply .....	12	<b>Revision History .....</b>	<b>33</b>
<b>Development Support .....</b>	<b>13</b>	<b>Sales, Solutions, and Legal Information .....</b>	<b>34</b>
Documentation .....	13	Worldwide Sales and Design Support.....	34
Online .....	13	Products .....	34
Tools.....	13	PSoC® Solutions .....	34
<b>Electrical Specifications .....</b>	<b>14</b>	Cypress Developer Community.....	34
Absolute Maximum Ratings.....	14	Technical Support .....	34
Device Level Specifications.....	14		
Analog Peripherals .....	17		

**Figure 2. Block Diagram**


PSoC 4000 devices include extensive support for programming, testing, debugging, and tracing both hardware and firmware.

The ARM Serial-Wire Debug (SWD) interface supports all programming and debug features of the device.

Complete debug-on-chip functionality enables full-device debugging in the final system using the standard production device. It does not require special interfaces, debugging pods, simulators, or emulators. Only the standard programming connections are required to fully support debug.

The PSoC Creator IDE provides fully integrated programming and debug support for the PSoC 4000 devices. The SWD interface is fully compatible with industry-standard third-party tools. The PSoC 4000 family provides a level of security not possible with multi-chip application solutions or with microcontrollers. It has the following advantages:

- Allows disabling of debug features
- Robust flash protection
- Allows customer-proprietary functionality to be implemented in on-chip programmable blocks

The debug circuits are enabled by default and can only be disabled in firmware. If they are not enabled, the only way to re-enable them is to erase the entire device, clear flash protection, and reprogram the device with new firmware that enables debugging.

Additionally, all device interfaces can be permanently disabled (device security) for applications concerned about phishing attacks due to a maliciously reprogrammed device or attempts to defeat security by starting and interrupting flash programming sequences. All programming, debug, and test interfaces are disabled when maximum device security is enabled. Therefore, PSoC 4000, with device security enabled, may not be returned for failure analysis. This is a trade-off the PSoC 4000 allows the customer to make.

## Functional Definition

### CPU and Memory Subsystem

#### CPU

The Cortex-M0 CPU in the PSoC 4000 is part of the 32-bit MCU subsystem, which is optimized for low-power operation with extensive clock gating. Most instructions are 16 bits in length and the CPU executes a subset of the Thumb-2 instruction set. This enables fully compatible, binary, upward migration of the code to higher performance processors, such as the Cortex-M3 and M4. It includes a nested vectored interrupt controller (NVIC) block with eight interrupt inputs and also includes a Wakeup Interrupt Controller (WIC). The WIC can wake the processor from the Deep Sleep mode, allowing power to be switched off to the main processor when the chip is in the Deep Sleep mode. The CPU subsystem also includes a 24-bit timer called SYSTICK, which can generate an interrupt.

The CPU also includes a debug interface, the serial wire debug (SWD) interface, which is a 2-wire form of JTAG. The debug configuration used for PSoC 4000 has four breakpoint (address) comparators and two watchpoint (data) comparators.

#### Flash

The PSoC 4000 device has a flash module with a flash accelerator, tightly coupled to the CPU to improve average access times from the flash block. The low-power flash block is designed to deliver zero wait-state (WS) access time at 16 MHz.

#### SRAM

Two KB of SRAM are provided with zero wait-state access at 16 MHz.

#### SROM

A supervisory ROM that contains boot and configuration routines is provided.

### System Resources

#### Power System

The power system is described in detail in the section on [Power on page 12](#). It provides an assurance that voltage levels are as required for each respective mode and either delays mode entry (for example, on power-on reset (POR)) until voltage levels are as required for proper functionality, or generates resets (for example, on brown-out detection). The PSoC 4000 operates with a single external supply over the range of either 1.8 V  $\pm$ 5% (externally regulated) or 1.8 to 5.5 V (internally regulated) and has three different power modes, transitions between which are managed by the power system. The PSoC 4000 provides Active, Sleep, and Deep Sleep low-power modes.

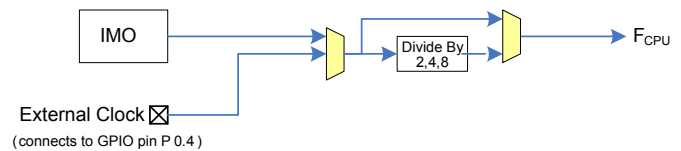
All subsystems are operational in Active mode. The CPU subsystem (CPU, flash, and SRAM) is clock-gated off in Sleep mode, while all peripherals and interrupts are active with instantaneous wake-up on a wake-up event. In Deep Sleep mode, the high-speed clock and associated circuitry is switched off; wake-up from this mode takes 35  $\mu$ S.

#### Clock System

The PSoC 4000 clock system is responsible for providing clocks to all subsystems that require clocks and for switching between different clock sources without glitching. In addition, the clock system ensures that there are no metastable conditions.

The clock system for the PSoC 4000 consists of the internal main oscillator (IMO) and the internal low-frequency oscillator (ILO) and provision for an external clock.

**Figure 3. PSoC 4000 MCU Clocking Architecture**



The  $F_{CPU}$  signal can be divided down to generate synchronous clocks for the analog and digital peripherals. There are four clock dividers for the PSoC 4000, each with 16-bit divide capability. The 16-bit capability allows flexible generation of fine-grained frequency values and is fully supported in PSoC Creator.

#### IMO Clock Source

The IMO is the primary source of internal clocking in the PSoC 4000. It is trimmed during testing to achieve the specified accuracy. The IMO default frequency is 24 MHz and it can be adjusted from 24 to 48 MHz in steps of 4 MHz. The IMO tolerance with Cypress-provided calibration settings is  $\pm$ 2% (24 and 32 MHz).

#### ILO Clock Source

The ILO is a very low power, 40-kHz oscillator, which is primarily used to generate clocks for the watchdog timer (WDT) and peripheral operation in Deep Sleep mode. ILO-driven counters can be calibrated to the IMO to improve accuracy.

#### Watchdog Timer

A watchdog timer is implemented in the clock block running from the ILO; this allows watchdog operation during Deep Sleep and generates a watchdog reset if not serviced before the set timeout occurs. The watchdog reset is recorded in a Reset Cause register, which is firmware readable.

#### Reset

The PSoC 4000 can be reset from a variety of sources including a software reset. Reset events are asynchronous and guarantee reversion to a known state. The reset cause is recorded in a register, which is sticky through reset and allows software to determine the cause of the reset. An XRES pin is reserved for external reset on the 24-pin package. An internal POR is provided on the 16-pin and 8-pin packages. The XRES pin has an internal pull-up resistor that is always enabled. Reset is Active Low.

#### Voltage Reference

The PSoC 4000 reference system generates all internally required references. A 1.2-V voltage reference is provided for the comparator. The IDACs are based on a  $\pm$ 5% reference.

## Analog Blocks

### Low-power Comparators

The PSoC 4000 has a low-power comparator, which uses the built-in voltage reference. Any one of up to 16 pins can be used as a comparator input and the output of the comparator can be brought out to a pin. The selected comparator input is connected to the minus input of the comparator with the plus input always connected to the 1.2-V voltage reference. This comparator is also used for CapSense purposes and is not available during CapSense operation.

### Current DACs

The PSoC 4000 has two IDACs, which can drive any of up to 16 pins on the chip. These IDACs have programmable current ranges.

### Analog Multiplexed Buses

The PSoC 4000 has two concentric independent buses that go around the periphery of the chip. These buses (called amux buses) are connected to firmware-programmable analog switches that allow the chip's internal resources (IDACs, comparator) to connect to any pin on Ports 0, 1, and 2.

## Fixed Function Digital

### Timer/Counter/PWM (TCPWM) Block

The TCPWM block consists of a 16-bit counter with user-programmable period length. There is a capture register to record the count value at the time of an event (which may be an I/O event), a period register that is used to either stop or auto-reload the counter when its count is equal to the period register, and compare registers to generate compare value signals that are used as PWM duty cycle outputs. The block also provides true and complementary outputs with programmable offset between them to allow use as dead-band programmable complementary PWM outputs. It also has a Kill input to force outputs to a predetermined state; for example, this is used in motor drive systems when an over-current state is indicated and the PWM driving the FETs needs to be shut off immediately with no time for software intervention.

### Serial Communication Block (SCB)

The PSoC 4000 has a serial communication block, which implements a multi-master I<sup>2</sup>C interface.

**I<sup>2</sup>C Mode:** The hardware I<sup>2</sup>C block implements a full multi-master and slave interface (it is capable of multi-master arbitration). This block is capable of operating at speeds of up to 400 kbps (Fast Mode) and has flexible buffering options to reduce interrupt overhead and latency for the CPU. It also supports EZI<sup>2</sup>C that creates a mailbox address range in the memory of the PSoC 4000 and effectively reduces I<sup>2</sup>C communication to reading from and writing to an array in memory. In addition, the block supports an 8-deep FIFO for receive and transmit which, by increasing the time given for the CPU to read data, greatly reduces the need for clock stretching caused by the CPU not having read data on time.

The I<sup>2</sup>C peripheral is compatible with the I<sup>2</sup>C Standard-mode and Fast-mode devices as defined in the NXP I<sup>2</sup>C-bus specification and user manual (UM10204). The I<sup>2</sup>C bus I/O is implemented with GPIO in open-drain modes.

The PSoC 4000 is not completely compliant with the I<sup>2</sup>C spec in the following respect:

- GPIO cells are not overvoltage tolerant and, therefore, cannot be hot-swapped or powered up independently of the rest of the I<sup>2</sup>C system.
- Fast-mode minimum fall time is not met in Fast Strong mode; Slow Strong mode can help meet this spec depending on the Bus Load.

## GPIO

The PSoC 4000 has up to 20 GPIOs. The GPIO block implements the following:

- Eight drive modes:
  - Analog input mode (input and output buffers disabled)
  - Input only
  - Weak pull-up with strong pull-down
  - Strong pull-up with weak pull-down
  - Open drain with strong pull-down
  - Open drain with strong pull-up
  - Strong pull-up with strong pull-down
  - Weak pull-up with weak pull-down
- Input threshold select (CMOS or LVTTTL).
- Individual control of input and output buffer enabling/disabling in addition to the drive strength modes
- Selectable slew rates for dV/dt related noise control to improve EMI

The pins are organized in logical entities called ports, which are 8-bit in width (less for Ports 2 and 3). During power-on and reset, the blocks are forced to the disable state so as not to crowbar any inputs and/or cause excess turn-on current. A multiplexing network known as a high-speed I/O matrix is used to multiplex between various signals that may connect to an I/O pin.

Data output and pin state registers store, respectively, the values to be driven on the pins and the states of the pins themselves.

Every I/O pin can generate an interrupt if so enabled and each I/O port has an interrupt request (IRQ) and interrupt service routine (ISR) vector associated with it (4 for PSoC 4000).

The 28-pin and 24-pin packages have 20 GPIOs. The 16-pin SOIC has 13 GPIOs. The 16-pin QFN and the 16-ball WLCSP have 12 GPIOs. The 8-pin SOIC has 5 GPIOs.

## Special Function Peripherals

### CapSense

CapSense is supported in the PSoC 4000 through a CSD block that can be connected to up to 16 pins through an analog mux bus via an analog switch (pins on Port 3 are not available for CapSense purposes). CapSense function can thus be provided on any available pin or group of pins in a system under software control. A PSoC Creator component is provided for the CapSense block to make it easy for the user.

Shield voltage can be driven on another mux bus to provide water-tolerance capability. Water tolerance is provided by driving the shield electrode in phase with the sense electrode to keep the shield capacitance from attenuating the sensed input. Proximity sensing can also be implemented.

The CapSense block has two IDACs, which can be used for general purposes if CapSense is not being used (both IDACs are available in that case) or if CapSense is used without water tolerance (one IDAC is available).

## Pinouts

All port pins support GPIO. Ports 0, 1, and 2 support CSD CapSense and analog multiplexed bus connections. TCPWM functions and Alternate Functions are multiplexed with port pins as follows for the five PSoC 4000 packages.

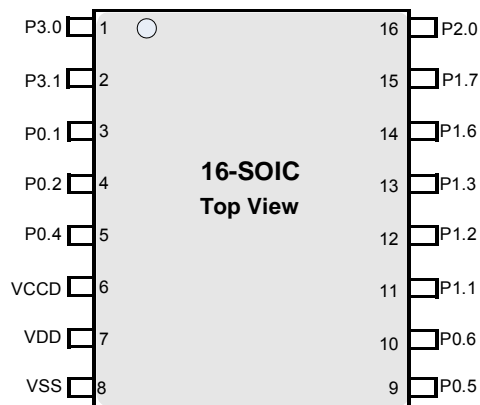
**Table 1. Pin Descriptions**

28-Pin SSOP		24-Pin QFN		16-Pin QFN		16-Pin SOIC		8-Pin SOIC		TCPWM Signals	Alternate Functions
Pin	Name	Pin	Name	Pin	Name	Pin	Name	Pin	Name		
20	VSS										
21	P0.0/TRIN0	1	P0.0/TRIN0							TRIN0: Trigger Input 0	
22	P0.1/TRIN1/CMPO_0	2	P0.1/TRIN1/CMPO_0	1	P0.1/TRIN1/CMPO_0	3	P0.1/TRIN1/CMPO_0			TRIN1: Trigger Input 1	CMPO_0: Sense Comp Out
23	P0.2/TRIN2	3	P0.2/TRIN2	2	P0.2/TRIN2	4	P0.2/TRIN2			TRIN2: Trigger Input 2	
24	P0.3/TRIN3	4	P0.3/TRIN3							TRIN3: Trigger Input 3	
25	P0.4/TRIN4/CMPO_0/EXT_CLK	5	P0.4/TRIN4/CMPO_0/EXT_CLK	3	P0.4/TRIN4/CMPO_0/EXT_CLK	5	P0.4/TRIN4/CMPO_0/EXT_CLK	2	P0.4/TRIN4/CMPO_0/EXT_CLK	TRIN4: Trigger Input 4	CMPO_0: Sense Comp Out, External Clock, CMOD Cap
26	VCC	6	VCC	4	VCC	6	VCC	3	VCC		
27	VDD	7	VDD	6	VDD	7	VDD	4	VDD		
28	VSS	8	VSS	7	VSS	8	VSS	5	VSS		
1	P0.5	9	P0.5	5	VDDIO	9	P0.5				
2	P0.6	10	P0.6	8	P0.6	10	P0.6				
3	P0.7	11	P0.7								
4	P1.0	12	P1.0								
5	P1.1/OUT0	13	P1.1/OUT0	9	P1.1/OUT0	11	P1.1/OUT0	6	P1.1/OUT0	OUT0: PWM OUT 0	
6	P1.2/SCL	14	P1.2/SCL	10	P1.2/SCL	12	P1.2/SCL				I2C Clock
7	P1.3/SDA	15	P1.3/SDA	11	P1.3/SDA	13	P1.3/SDA				I2C Data
8	P1.4/UND0	16	P1.4/UND0							UND0: Underflow Out	
9	P1.5/OVF0	17	P1.5/OVF0							OVF0: Overflow Out	
10	P1.6/OVF0/UND0/nOUT0/CMPO_0	18	P1.6/OVF0/UND0/nOUT0/CMPO_0	12	P1.6/OVF0/UND0/nOUT0/CMPO_0	14	P1.6/OVF0/UND0/nOUT0/CMPO_0	7	P1.6/OVF0/UND0/nOUT0/CMPO_0	nOUT0: Complement of OUT0, UND0, OVF0 as above	CMPO_0: Sense Comp Out, Internal Reset function <sup>[1]</sup>

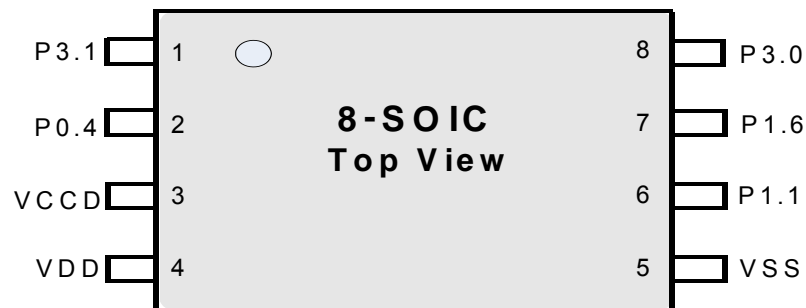
**Note**

1. Must not have load to ground during POR (should be an output).

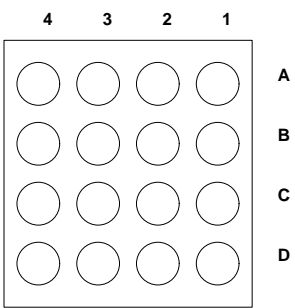
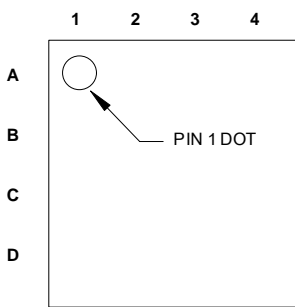
**Figure 7. 16-Pin SOIC Pinout**



**Figure 8. 8-Pin SOIC Pinout**



**Table 2. 16-ball WLCSP Pin Descriptions and Diagram**

Pin	Name	TCPWM Signal	Alternate Functions	Pin Diagram
B4	P3.2	OUT0:PWMOUT0	—	<div>Bottom View</div>  <div>Top View</div> 
C3	P0.2/TRIN2	TRIN2:Trigger Input 2	—	
C4	P0.4/TRIN4/CMPO_0/ EXT_CLK	TRIN4:Trigger Input 4	CMPO_0: Sense Comp Out, Ext. Clock, CMOD Cap	
D4	VCCD	—	—	
D3	VDD	—	—	
D2	VSS	—	—	
C2	VDDIO	—	—	
D1	P0.6	—	—	
C1	P1.1/OUT0	OUT0:PWMOUT0	—	
B1	P1.2/SCL	—	I <sup>2</sup> C Clock	
A1	P1.3/SDA	—	I <sup>2</sup> C Data	
A2	P1.6/OVF0/UND0/nO UT0/CMPO_0	nOUT0:Complement of OUT0, UND0, OVF0	CMPO_0: Sense Comp Out, Internal Reset function <sup>[3]</sup>	
B2	P1.7/MATCH/ EXT_CLK	MATCH: Match Out	External Clock	
A3	P2.0	—	—	
B3	P3.0/SDA/SWD_IO	—	I <sup>2</sup> C Data, SWD I/O	
A4	P3.1/SCL/SWD_CLK	—	I <sup>2</sup> C Clock, SWD Clock	

**Note**

3. Must not have load to ground during POR (should be an output).



## Power

The following power system diagrams (Figure 9 and Figure 10) show the set of power supply pins as implemented for the PSoC 4000. The system has one regulator in Active mode for the digital circuitry. There is no analog regulator; the analog circuits run directly from the  $V_{DD}$  input. There is a separate regulator for the Deep Sleep mode. The supply voltage range is either 1.8 V  $\pm$ 5% (externally regulated) or 1.8 V to 5.5 V (unregulated externally; regulated internally) with all functions and circuits operating over that range.

The  $V_{DDIO}$  pin, available in the 16-pin QFN package, provides a separate voltage domain for the following pins: P3.0, P3.1, and P3.2. P3.0 and P3.1 can be I<sup>2</sup>C pins and the chip can thus communicate with an I<sup>2</sup>C system, running at a different voltage (where  $V_{DDIO} \leq V_{DD}$ ). For example,  $V_{DD}$  can be 3.3 V and  $V_{DDIO}$  can be 1.8 V.

The PSoC 4000 family allows two distinct modes of power supply operation: Unregulated External Supply and Regulated External Supply.

### Unregulated External Supply

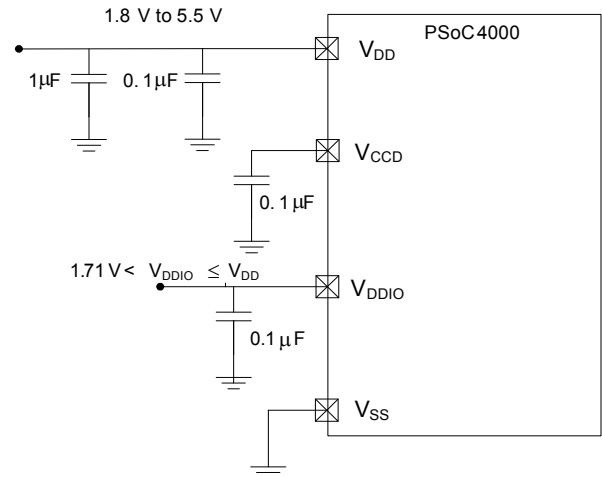
In this mode, the PSoC 4000 is powered by an external power supply that can be anywhere in the range of 1.8 to 5.5 V. This range is also designed for battery-powered operation. For example, the chip can be powered from a battery system that starts at 3.5 V and works down to 1.8 V. In this mode, the internal regulator of the PSoC 4000 supplies the internal logic and the  $V_{CCD}$  output of the PSoC 4000 must be bypassed to ground via an external capacitor (0.1  $\mu$ F; X5R ceramic or better).

Bypass capacitors must be used from  $V_{DD}$  to ground. The typical practice for systems in this frequency range is to use a capacitor in the 1- $\mu$ F range, in parallel with a smaller capacitor (0.1  $\mu$ F, for example). Note that these are simply rules of thumb and that, for critical applications, the PCB layout, lead inductance, and the bypass capacitor parasitic should be simulated to design and obtain optimal bypassing.

An example of a bypass scheme follows ( $V_{DDIO}$  is available on the 16-QFN package).

**Figure 9. 16-pin QFN Bypass Scheme Example - Unregulated External Supply**

Power supply connections when  $1.8 \leq V_{DD} \leq 5.5$  V



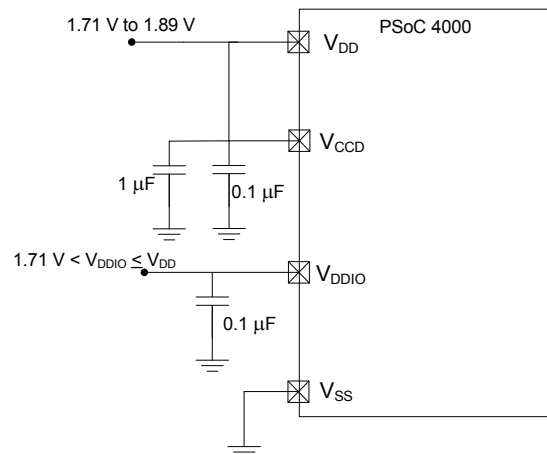
### Regulated External Supply

In this mode, the PSoC 4000 is powered by an external power supply that must be within the range of 1.71 to 1.89 V; note that this range needs to include the power supply ripple too. In this mode, the  $V_{DD}$  and  $V_{CCD}$  pins are shorted together and bypassed. The internal regulator should be disabled in the firmware. Note that in this mode  $V_{DD}$  ( $V_{CCD}$ ) should never exceed 1.89 in any condition, including flash programming.

An example of a bypass scheme follows ( $V_{DDIO}$  is available on the 16-QFN package).

**Figure 10. 16-pin QFN Bypass Scheme Example - Regulated External Supply**

Power supply connections when  $1.71 \leq V_{DD} \leq 1.89$  V



## Development Support

The PSoC 4000 family has a rich set of documentation, development tools, and online resources to assist you during your development process. Visit [www.cypress.com/go/psoc4](http://www.cypress.com/go/psoc4) to find out more.

### Documentation

A suite of documentation supports the PSoC 4000 family to ensure that you can find answers to your questions quickly. This section contains a list of some of the key documents.

**Software User Guide:** A step-by-step guide for using PSoC Creator. The software user guide shows you how the PSoC Creator build process works in detail, how to use source control with PSoC Creator, and much more.

**Component Datasheets:** The flexibility of PSoC allows the creation of new peripherals (components) long after the device has gone into production. Component data sheets provide all of the information needed to select and use a particular component, including a functional description, API documentation, example code, and AC/DC specifications.

**Application Notes:** PSoC application notes discuss a particular application of PSoC in depth; examples include brushless DC motor control and on-chip filtering. Application notes often include example projects in addition to the application note document.

**Technical Reference Manual:** The Technical Reference Manual (TRM) contains all the technical detail you need to use a PSoC device, including a complete description of all PSoC registers. The TRM is available in the Documentation section at [www.cypress.com/psoc4](http://www.cypress.com/psoc4).

### Online

In addition to print documentation, the Cypress PSoC forums connect you with fellow PSoC users and experts in PSoC from around the world, 24 hours a day, 7 days a week.

### Tools

With industry standard cores, programming, and debugging interfaces, the PSoC 4000 family is part of a development tool ecosystem. Visit us at [www.cypress.com/go/psoccreator](http://www.cypress.com/go/psoccreator) for the latest information on the revolutionary, easy to use PSoC Creator IDE, supported third party compilers, programmers, debuggers, and development kits.

## Electrical Specifications

### Absolute Maximum Ratings

**Table 3. Absolute Maximum Ratings**<sup>[4]</sup>

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
SID1	V <sub>DD_ABS</sub>	Digital supply relative to V <sub>SS</sub>	-0.5	—	6	V	
SID2	V <sub>CCD_ABS</sub>	Direct digital core voltage input relative to V <sub>SS</sub>	-0.5	—	1.95	V	
SID3	V <sub>GPIO_ABS</sub>	GPIO voltage	-0.5	—	V <sub>DD</sub> +0.5	V	
SID4	I <sub>GPIO_ABS</sub>	Maximum current per GPIO	-25	—	25	mA	
SID5	I <sub>GPIO_injection</sub>	GPIO injection current, Max for V <sub>IH</sub> > V <sub>DD</sub> , and Min for V <sub>IL</sub> < V <sub>SS</sub>	-0.5	—	0.5	mA	Current injected per pin
BID44	ESD_HBM	Electrostatic discharge human body model	2200	—	—	V	
BID45	ESD_CDM	Electrostatic discharge charged device model	500	—	—	V	
BID46	LU	Pin current for latch-up	-140	—	140	mA	

### Device Level Specifications

All specifications are valid for -40 °C ≤ T<sub>A</sub> ≤ 85 °C and T<sub>J</sub> ≤ 100 °C, except where noted. Specifications are valid for 1.71 V to 5.5 V, except where noted.

**Table 4. DC Specifications**

Typical values measured at V<sub>DD</sub> = 3.3 V and 25 °C.

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
SID53	V <sub>DD</sub>	Power supply input voltage	1.8	—	5.5	V	With regulator enabled
SID255	V <sub>DD</sub>	Power supply input voltage (V <sub>CCD</sub> = V <sub>DD</sub> )	1.71	—	1.89	V	Internally unregulated supply
SID54	V <sub>DDIO</sub>	V <sub>DDIO</sub> domain supply	1.71	—	V <sub>DD</sub>	V	
SID55	C <sub>EFC</sub>	External regulator voltage bypass	—	0.1	—	μF	X5R ceramic or better
SID56	C <sub>EXC</sub>	Power supply bypass capacitor	—	1	—	μF	X5R ceramic or better
<b>Active Mode, V<sub>DD</sub> = 1.8 to 5.5 V</b>							
SID9	I <sub>DD5</sub>	Execute from flash; CPU at 6 MHz	—	2.0	2.85	mA	
SID12	I <sub>DD8</sub>	Execute from flash; CPU at 12 MHz	—	3.2	3.75	mA	
SID16	I <sub>DD11</sub>	Execute from flash; CPU at 16 MHz	—	4.0	4.5	mA	
<b>Sleep Mode, V<sub>DD</sub> = 1.71 to 5.5 V</b>							
SID25	I <sub>DD20</sub>	I <sup>2</sup> C wakeup, WDT on. 6 MHz	—	1.1	—	mA	
SID25A	I <sub>DD20A</sub>	I <sup>2</sup> C wakeup, WDT on. 12 MHz	—	1.4	—	mA	
<b>Deep Sleep Mode, V<sub>DD</sub> = 1.8 to 3.6 V (Regulator on)</b>							
SID31	I <sub>DD26</sub>	I <sup>2</sup> C wakeup and WDT on	—	2.5	8.2	μA	

#### Note

4. Usage above the absolute maximum conditions listed in Table 1 may cause permanent damage to the device. Exposure to Absolute Maximum conditions for extended periods of time may affect device reliability. The Maximum Storage Temperature is 150 °C in compliance with JEDEC Standard JESD22-A103, High Temperature Storage Life. When used below Absolute Maximum conditions but above normal operating conditions, the device may not operate to specification.

**Table 4. DC Specifications (continued)**

 Typical values measured at  $V_{DD} = 3.3\text{ V}$  and  $25\text{ }^{\circ}\text{C}$ .

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
<b>Deep Sleep Mode, <math>V_{DD} = 3.6</math> to <math>5.5\text{ V}</math> (Regulator on)</b>							
SID34	$I_{DD29}$	I <sup>2</sup> C wakeup and WDT on	–	2.5	12	μA	
<b>Deep Sleep Mode, <math>V_{DD} = V_{CCD} = 1.71</math> to <math>1.89\text{ V}</math> (Regulator bypassed)</b>							
SID37	$I_{DD32}$	I <sup>2</sup> C wakeup and WDT on	–	2.5	9.2	μA	
<b>XRES Current</b>							
SID307	$I_{DD\_XR}$	Supply current while XRES asserted	–	2	5	mA	

**Table 5. AC Specifications**

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
SID48	$F_{CPU}$	CPU frequency	DC	–	16	MHz	$1.71 \leq V_{DD} \leq 5.5$
SID49 <sup>[5]</sup>	$T_{SLEEP}$	Wakeup from Sleep mode	–	0	–	μs	
SID50 <sup>[5]</sup>	$T_{DEEPSLEEP}$	Wakeup from Deep Sleep mode	–	35	–	μs	

#### GPIO

**Table 6. GPIO DC Specifications (referenced to  $V_{DDIO}$  for 16-Pin QFN  $V_{DDIO}$  pins)**

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
SID57	$V_{IH}$ <sup>[6]</sup>	Input voltage high threshold	$0.7 \times V_{DD}$	–	–	V	CMOS Input
SID58	$V_{IL}$	Input voltage low threshold	–	–	$0.3 \times V_{DD}$	V	CMOS Input
SID241	$V_{IH}$ <sup>[6]</sup>	LVTTL input, $V_{DD} < 2.7\text{ V}$	$0.7 \times V_{DD}$	–	–	V	
SID242	$V_{IL}$	LVTTL input, $V_{DD} < 2.7\text{ V}$	–	–	$0.3 \times V_{DD}$	V	
SID243	$V_{IH}$ <sup>[6]</sup>	LVTTL input, $V_{DD} \geq 2.7\text{ V}$	2.0	–	–	V	
SID244	$V_{IL}$	LVTTL input, $V_{DD} \geq 2.7\text{ V}$	–	–	0.8	V	
SID59	$V_{OH}$	Output voltage high level	$V_{DD} - 0.6$	–	–	V	$I_{OH} = 4\text{ mA}$ at $3\text{ V } V_{DD}$
SID60	$V_{OH}$	Output voltage high level	$V_{DD} - 0.5$	–	–	V	$I_{OH} = 1\text{ mA}$ at $1.8\text{ V } V_{DD}$
SID61	$V_{OL}$	Output voltage low level	–	–	0.6	V	$I_{OL} = 4\text{ mA}$ at $1.8\text{ V } V_{DD}$
SID62	$V_{OL}$	Output voltage low level	–	–	0.6	V	$I_{OL} = 10\text{ mA}$ at $3\text{ V } V_{DD}$
SID62A	$V_{OL}$	Output voltage low level	–	–	0.4	V	$I_{OL} = 3\text{ mA}$ at $3\text{ V } V_{DD}$
SID63	$R_{PULLUP}$	Pull-up resistor	3.5	5.6	8.5	kΩ	
SID64	$R_{PULLDOWN}$	Pull-down resistor	3.5	5.6	8.5	kΩ	
SID65	$I_{IL}$	Input leakage current (absolute value)	–	–	2	nA	$25\text{ }^{\circ}\text{C}$ , $V_{DD} = 3.0\text{ V}$
SID66	$C_{IN}$	Input capacitance	–	3	7	pF	

#### Notes

5. Guaranteed by characterization.
6.  $V_{IH}$  must not exceed  $V_{DD} + 0.2\text{ V}$ .

**Table 11. Comparator AC Specifications (Guaranteed by Characterization)**

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
SID336 <sup>[8]</sup>	T <sub>COMP1</sub>	Response Time High Bandwidth mode, 50-mV overdrive	–	–	90	ns	
SID337 <sup>[8]</sup>	T <sub>COMP2</sub>	Response Time Low Power mode, 50-mV overdrive	–	–	110	ns	

### CSD

**Table 12. CSD and IDAC Block Specifications**

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
<b>CSD and IDAC Specifications</b>							
SYS.PER#3	VDD_RIPPLE	Max allowed ripple on power supply, DC to 10 MHz	–	–	±50	mV	VDD > 2V (with ripple), 25 °C T <sub>A</sub> , Sensitivity = 0.1 pF
SYS.PER#16	VDD_RIPPLE_1.8	Max allowed ripple on power supply, DC to 10 MHz	–	–	±25	mV	VDD > 1.75V (with ripple), 25 °C T <sub>A</sub> , Parasitic Capacitance (C <sub>P</sub> ) < 20 pF, Sensitivity ≥ 0.4 pF
SID.CSD#15	VREFHI	Reference Buffer Output	1.1	1.2	1.3	V	
SID.CSD#16	IDAC1IDD	IDAC1 (8-bits) block current	–	–	1125	µA	
SID.CSD#17	IDAC2IDD	IDAC2 (7-bits) block current	–	–	1125	µA	
SID308	V <sub>CSD</sub>	Voltage range of operation	1.71	–	5.5	V	1.8 V ±5% or 1.8 V to 5.5 V
SID308A	VCOMPIDAC	Voltage compliance range of IDAC	0.8	–	V <sub>DD</sub> – 0.8	V	
SID309	IDAC1 <sub>DNL</sub>	DNL for 8-bit resolution	–1	–	1	LSB	
SID310	IDAC1 <sub>INL</sub>	INL for 8-bit resolution	–3	–	3	LSB	
SID311	IDAC2 <sub>DNL</sub>	DNL for 7-bit resolution	–1	–	1	LSB	
SID312	IDAC2 <sub>INL</sub>	INL for 7-bit resolution	–3	–	3	LSB	
SID313	SNR	Ratio of counts of finger to noise. Guaranteed by characterization	5	–	–	Ratio	Capacitance range of 9 to 35 pF, 0.1 pF sensitivity
SID314	IDAC1 <sub>CRT1</sub>	Output current of IDAC1 (8 bits) in high range	–	612	–	µA	
SID314A	IDAC1 <sub>CRT2</sub>	Output current of IDAC1(8 bits) in low range	–	306	–	µA	
SID315	IDAC2 <sub>CRT1</sub>	Output current of IDAC2 (7 bits) in high range	–	304.8	–	µA	
SID315A	IDAC2 <sub>CRT2</sub>	Output current of IDAC2 (7 bits) in low range	–	152.4	–	µA	
SID320	IDAC <sub>OFFSET</sub>	All zeroes input	–	–	±1	LSB	
SID321	IDAC <sub>GAIN</sub>	Full-scale error less offset	–	–	±10	%	
SID322	IDAC <sub>MISMATCH</sub>	Mismatch between IDACs	–	–	7	LSB	
SID323	IDAC <sub>SET8</sub>	Settling time to 0.5 LSB for 8-bit IDAC	–	–	10	µs	Full-scale transition. No external load.
SID324	IDAC <sub>SET7</sub>	Settling time to 0.5 LSB for 7-bit IDAC	–	–	10	µs	Full-scale transition. No external load.
SID325	CMOD	External modulator capacitor.	–	2.2	–	nF	5-V rating, X7R or NP0 cap.

## Memory

**Table 16. Flash DC Specifications**

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID173	V <sub>PE</sub>	Erase and program voltage	1.71	–	5.5	V	

**Table 17. Flash AC Specifications**

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID174	T <sub>ROWWRITE</sub> <sup>[11]</sup>	Row (block) write time (erase and program)	–	–	20	ms	Row (block) = 64 bytes
SID175	T <sub>ROWERASE</sub> <sup>[11]</sup>	Row erase time	–	–	13	ms	
SID176	T <sub>ROWPROGRAM</sub> <sup>[11]</sup>	Row program time after erase	–	–	7	ms	
SID178	T <sub>BULKERASE</sub> <sup>[11]</sup>	Bulk erase time (16 KB)	–	–	15	ms	
SID180 <sup>[12]</sup>	T <sub>DEVPROG</sub> <sup>[11]</sup>	Total device program time	–	–	7.5	seconds	
SID181 <sup>[12]</sup>	F <sub>END</sub>	Flash endurance	100 K	–	–	cycles	
SID182 <sup>[12]</sup>	F <sub>RET</sub>	Flash retention. T <sub>A</sub> ≤ 55 °C, 100 K P/E cycles	20	–	–	years	
SID182A <sup>[12]</sup>		Flash retention. T <sub>A</sub> ≤ 85 °C, 10 K P/E cycles	10	–	–	years	

## System Resources

### Power-on Reset (POR)

**Table 18. Power On Reset (PRES)**

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID.CLK#6	SR_POWER_UP	Power supply slew rate	1	–	67	V/ms	At power-up
SID185 <sup>[12]</sup>	V <sub>RISEIPOR</sub>	Rising trip voltage	0.80	–	1.5	V	
SID186 <sup>[12]</sup>	V <sub>FALLIPOR</sub>	Falling trip voltage	0.70	–	1.4	V	

**Table 19. Brown-out Detect (BOD) for V<sub>CCD</sub>**

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID190 <sup>[12]</sup>	V <sub>FALLPPOR</sub>	BOD trip voltage in active and sleep modes	1.48	–	1.62	V	
SID192 <sup>[12]</sup>	V <sub>FALLDPSLP</sub>	BOD trip voltage in Deep Sleep	1.11	–	1.5	V	

### Notes

11. It can take as much as 20 milliseconds to write to Flash. During this time the device should not be Reset, or Flash operations will be interrupted and cannot be relied on to have completed. Reset sources include the XRES pin, software resets, CPU lockup states and privilege violations, improper power supply levels, and watchdogs. Make certain that these are not inadvertently activated.

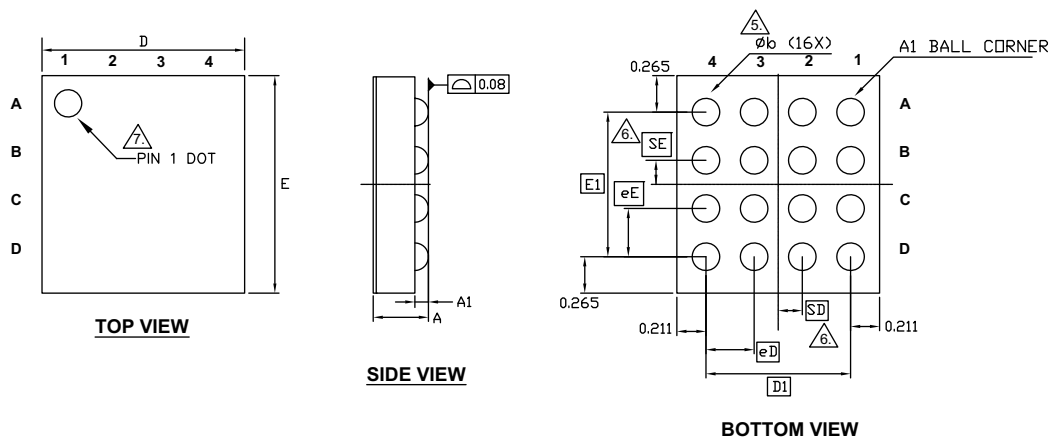
12. Guaranteed by characterization.



The Field Values are listed in the following table:

Field	Description	Values	Meaning
CY8C	Cypress prefix		
4	Architecture	4	PSoC 4
A	Family	0	4000 Family
B	CPU speed	1	16 MHz
		4	48 MHz
C	Flash capacity	3	8 KB
		4	16 KB
		5	32 KB
		6	64 KB
		7	128 KB
DE	Package code	SX	SOIC
		LQ	QFN
		PV	SSOP
		FN	WLCSP
F	Temperature range	I	Industrial
XYZ	Attributes code	000-999	Code of feature set in specific family



**Figure 16. 16-Ball WLCSP 1.47 x 1.58 x 0.4 mm**


SYMBOL	DIMENSIONS		
	MIN.	NOM.	MAX.
A	-	-	0.42
A1	0.089	0.099	0.109
D	1.447	1.472	1.497
E	1.554	1.579	1.604
D1	1.05 BSC		
E1	1.05 BSC		
MD	4		
ME	4		
N	16		
Ø b	0.17	0.20	0.23
eD	0.35 BSC		
eE	0.35 BSC		
SD	0.18 BSC		
SE	0.18 BSC		

**NOTES:**

- ALL DIMENSIONS ARE IN MILLIMETERS.
- SOLDER BALL POSITION DESIGNATION PER JEP95, SECTION 3, SPP-020.
- "e" REPRESENTS THE SOLDER BALL GRID PITCH.
- SYMBOL "MD" IS THE BALL MATRIX SIZE IN THE "D" DIRECTION. SYMBOL "ME" IS THE BALL MATRIX SIZE IN THE "E" DIRECTION. N IS THE NUMBER OF POPULATED SOLDER BALL POSITIONS FOR MATRIX SIZE MD X ME.
- DIMENSION "b" IS MEASURED AT THE MAXIMUM BALL DIAMETER IN A PLANE PARALLEL TO DATUM C.
- "SD" AND "SE" ARE MEASURED WITH RESPECT TO DATUMS A AND B AND DEFINE THE POSITION OF THE CENTER SOLDER BALL IN THE OUTER ROW. WHEN THERE IS AN ODD NUMBER OF SOLDER BALLS IN THE OUTER ROW, "SD" OR "SE" = 0. WHEN THERE IS AN EVEN NUMBER OF SOLDER BALLS IN THE OUTER ROW, "SD" = eD/2 AND "SE" = eE/2.
- A1 CORNER TO BE IDENTIFIED BY CHAMFER, LASER OR INK MARK METALIZED MARK, INDENTATION OR OTHER MEANS.
- "+" INDICATES THE THEORETICAL CENTER OF DEPOPULATED SOLDER BALLS.
- JEDEC SPECIFICATION NO. REF. : N/A.

002-18598 \*\*

## Acronyms

**Table 31. Acronyms Used in this Document**

Acronym	Description
abus	analog local bus
ADC	analog-to-digital converter
AG	analog global
AHB	AMBA (advanced microcontroller bus architecture) high-performance bus, an ARM data transfer bus
ALU	arithmetic logic unit
AMUXBUS	analog multiplexer bus
API	application programming interface
APSR	application program status register
ARM®	advanced RISC machine, a CPU architecture
ATM	automatic thump mode
BW	bandwidth
CAN	Controller Area Network, a communications protocol
CMRR	common-mode rejection ratio
CPU	central processing unit
CRC	cyclic redundancy check, an error-checking protocol
DAC	digital-to-analog converter, see also IDAC, VDAC
DFB	digital filter block
DIO	digital input/output, GPIO with only digital capabilities, no analog. See GPIO.
DMIPS	Dhrystone million instructions per second
DMA	direct memory access, see also TD
DNL	differential nonlinearity, see also INL
DNU	do not use
DR	port write data registers
DSI	digital system interconnect
DWT	data watchpoint and trace
ECC	error correcting code
ECO	external crystal oscillator
EEPROM	electrically erasable programmable read-only memory
EMI	electromagnetic interference
EMIF	external memory interface
EOC	end of conversion
EOF	end of frame
EPSR	execution program status register
ESD	electrostatic discharge

**Table 31. Acronyms Used in this Document** *(continued)*

Acronym	Description
ETM	embedded trace macrocell
FIR	finite impulse response, see also IIR
FPB	flash patch and breakpoint
FS	full-speed
GPIO	general-purpose input/output, applies to a PSoC pin
HVI	high-voltage interrupt, see also LVI, LVD
IC	integrated circuit
IDAC	current DAC, see also DAC, VDAC
IDE	integrated development environment
I <sup>2</sup> C, or IIC	Inter-Integrated Circuit, a communications protocol
IIR	infinite impulse response, see also FIR
ILO	internal low-speed oscillator, see also IMO
IMO	internal main oscillator, see also ILO
INL	integral nonlinearity, see also DNL
I/O	input/output, see also GPIO, DIO, SIO, USBIO
IPOR	initial power-on reset
IPSR	interrupt program status register
IRQ	interrupt request
ITM	instrumentation trace macrocell
LCD	liquid crystal display
LIN	Local Interconnect Network, a communications protocol.
LR	link register
LUT	lookup table
LVD	low-voltage detect, see also LVI
LVI	low-voltage interrupt, see also HVI
LVTTTL	low-voltage transistor-transistor logic
MAC	multiply-accumulate
MCU	microcontroller unit
MISO	master-in slave-out
NC	no connect
NMI	nonmaskable interrupt
NRZ	non-return-to-zero
NVIC	nested vectored interrupt controller
NVL	nonvolatile latch, see also WOL
opamp	operational amplifier
PAL	programmable array logic, see also PLD

**Table 31. Acronyms Used in this Document** *(continued)*

Acronym	Description
PC	program counter
PCB	printed circuit board
PGA	programmable gain amplifier
PHUB	peripheral hub
PHY	physical layer
PICU	port interrupt control unit
PLA	programmable logic array
PLD	programmable logic device, see also PAL
PLL	phase-locked loop
PMDD	package material declaration data sheet
POR	power-on reset
PRES	precise power-on reset
PRS	pseudo random sequence
PS	port read data register
PSoC®	Programmable System-on-Chip™
PSRR	power supply rejection ratio
PWM	pulse-width modulator
RAM	random-access memory
RISC	reduced-instruction-set computing
RMS	root-mean-square
RTC	real-time clock
RTL	register transfer language
RTR	remote transmission request
RX	receive
SAR	successive approximation register
SC/CT	switched capacitor/continuous time
SCL	I <sup>2</sup> C serial clock
SDA	I <sup>2</sup> C serial data
S/H	sample and hold
SINAD	signal to noise and distortion ratio
SIO	special input/output, GPIO with advanced features. See GPIO.
SOC	start of conversion
SOF	start of frame
SPI	Serial Peripheral Interface, a communications protocol
SR	slew rate
SRAM	static random access memory
SRES	software reset
SWD	serial wire debug, a test protocol

**Table 31. Acronyms Used in this Document** *(continued)*

Acronym	Description
SWV	single-wire viewer
TD	transaction descriptor, see also DMA
THD	total harmonic distortion
TIA	transimpedance amplifier
TRM	technical reference manual
TTL	transistor-transistor logic
TX	transmit
UART	Universal Asynchronous Transmitter Receiver, a communications protocol
UDB	universal digital block
USB	Universal Serial Bus
USBIO	USB input/output, PSoC pins used to connect to a USB port
VDAC	voltage DAC, see also DAC, IDAC
WDT	watchdog timer
WOL	write once latch, see also NVL
WRES	watchdog timer reset
XRES	external reset I/O pin
XTAL	crystal

## Document Conventions

### Units of Measure

**Table 32. Units of Measure**

Symbol	Unit of Measure
°C	degrees Celsius
dB	decibel
fF	femto farad
Hz	hertz
KB	1024 bytes
kbps	kilobits per second
Khr	kilohour
kHz	kilohertz
kΩ	kilo ohm
ksps	kilosamples per second
LSB	least significant bit
Mbps	megabits per second
MHz	megahertz
MΩ	mega-ohm
Msps	megasamples per second
μA	microampere
μF	microfarad
μH	microhenry
μs	microsecond
μV	microvolt
μW	microwatt
mA	milliampere
ms	millisecond
mV	millivolt
nA	nanoampere
ns	nanosecond
nV	nanovolt
Ω	ohm
pF	picofarad
ppm	parts per million
ps	picosecond
s	second
sps	samples per second
sqrtHz	square root of hertz
V	volt

## Revision History

Description Title: PSoC <sup>®</sup> 4: PSoC 4000 Family Datasheet Programmable System-on-Chip (PSoC <sup>®</sup> ) Document Number: 001-89638				
Revision	ECN	Orig. of Change	Submission Date	Description of Change
*B	4348760	WKA	05/16/2014	New PSoC 4000 datasheet.
*C	4514139	WKA	10/27/2014	Added 28-pin SSOP pin and package details. Updated $V_{REF}$ spec values. Updated conditions for SID174. Updated SID.CSD#15 values and description. Added spec SID339.
*D	4617283	WKA	01/09/2015	Corrected Development Kits information and PSoC Creator Example Project figure. Corrected typo in the ordering information table. Updated 28-pin SSOP package diagram.
*E	4735762	WKA	05/26/2015	Added 16-ball WLCSP pin and package details.
*F	5466193	WKA	10/07/2016	Updated <a href="#">Table 30</a> . Updated 8-pin SOIC package diagram. Updated the template.
*G	5685079	TSEN	04/05/2017	Updated 16-ball WLCSP package details.