

General Description

PSoC® 4 is a scalable and reconfigurable platform architecture for a family of mixed-signal programmable embedded system controllers with an ARM® Cortex™-M0 CPU. It combines programmable and reconfigurable analog and digital blocks with flexible automatic routing. The PSoC 4200 product family, based on this platform, is a combination of a microcontroller with digital programmable logic, high-performance analog-to-digital conversion, opamps with Comparator mode, and standard communication and timing peripherals. The PSoC 4200 products will be fully upward compatible with members of the PSoC 4 platform for new applications and design needs. The programmable analog and digital sub-systems allow flexibility and in-field tuning of the design.

Features

32-bit MCU Sub-system

- 48-MHz ARM Cortex-M0 CPU with single cycle multiply
- Up to 32 kB of flash with Read Accelerator
- Up to 4 kB of SRAM

Programmable Analog

- Two opamps with reconfigurable high-drive external and high-bandwidth internal drive, Comparator modes, and ADC input buffering capability
- 12-bit, 1-Msps SAR ADC with differential and single-ended modes; Channel Sequencer with signal averaging
- Two current DACs (IDACs) for general-purpose or capacitive sensing applications on any pin
- Two low-power comparators that operate in Deep Sleep mode

Programmable Digital

- Four programmable logic blocks called universal digital blocks, (UDBs), each with 8 Macrocells and data path
- Cypress-provided peripheral component library, user-defined state machines, and Verilog input

Low Power 1.71-V to 5.5-V Operation

- 20-nA Stop Mode with GPIO pin wakeup
- Hibernate and Deep Sleep modes allow wakeup-time versus power trade-offs

Capacitive Sensing

- Cypress CapSense Sigma-Delta (CSD) provides best-in-class SNR (>5:1) and water tolerance
- Cypress-supplied software component makes capacitive sensing design easy
- Automatic hardware tuning (SmartSense™)

Segment LCD Drive

- LCD drive supported on all pins (common or segment)
- Operates in Deep Sleep mode with 4 bits per pin memory

Serial Communication

- Two independent run-time reconfigurable serial communication blocks (SCBs) with reconfigurable I²C, SPI, or UART functionality

Timing and Pulse-Width Modulation

- Four 16-bit timer/counter pulse-width modulator (TCPWM) blocks
- Center-aligned, Edge, and Pseudo-random modes
- Comparator-based triggering of Kill signals for motor drive and other high-reliability digital logic applications

Up to 36 Programmable GPIOs

- Any GPIO pin can be CapSense, LCD, analog, or digital
- Drive modes, strengths, and slew rates are programmable

Five different packages

- 48-pin TQFP, 44-pin TQFP, 40-pin QFN, 35-ball WLCSP, and 28-pin SSOP package
- 35-ball WLCSP package is shipped with I²C Bootloader in Flash

Extended Industrial Temperature Operation

- -40 °C to + 105 °C operation

PSoC Creator Design Environment

- Integrated Development Environment (IDE) provides schematic design entry and build (with analog and digital automatic routing)
- Applications Programming Interface (API) component for all fixed-function and programmable peripherals

Industry-Standard Tool Compatibility

- After schematic entry, development can be done with ARM-based industry-standard development tools

More Information

Cypress provides a wealth of data at www.cypress.com to help you to select the right PSoC device for your design, and to help you to quickly and effectively integrate the device into your design. For a comprehensive list of resources, see the knowledge base article [KBA86521, How to Design with PSoC 3, PSoC 4, and PSoC 5LP](#). Following is an abbreviated list for PSoC 4:

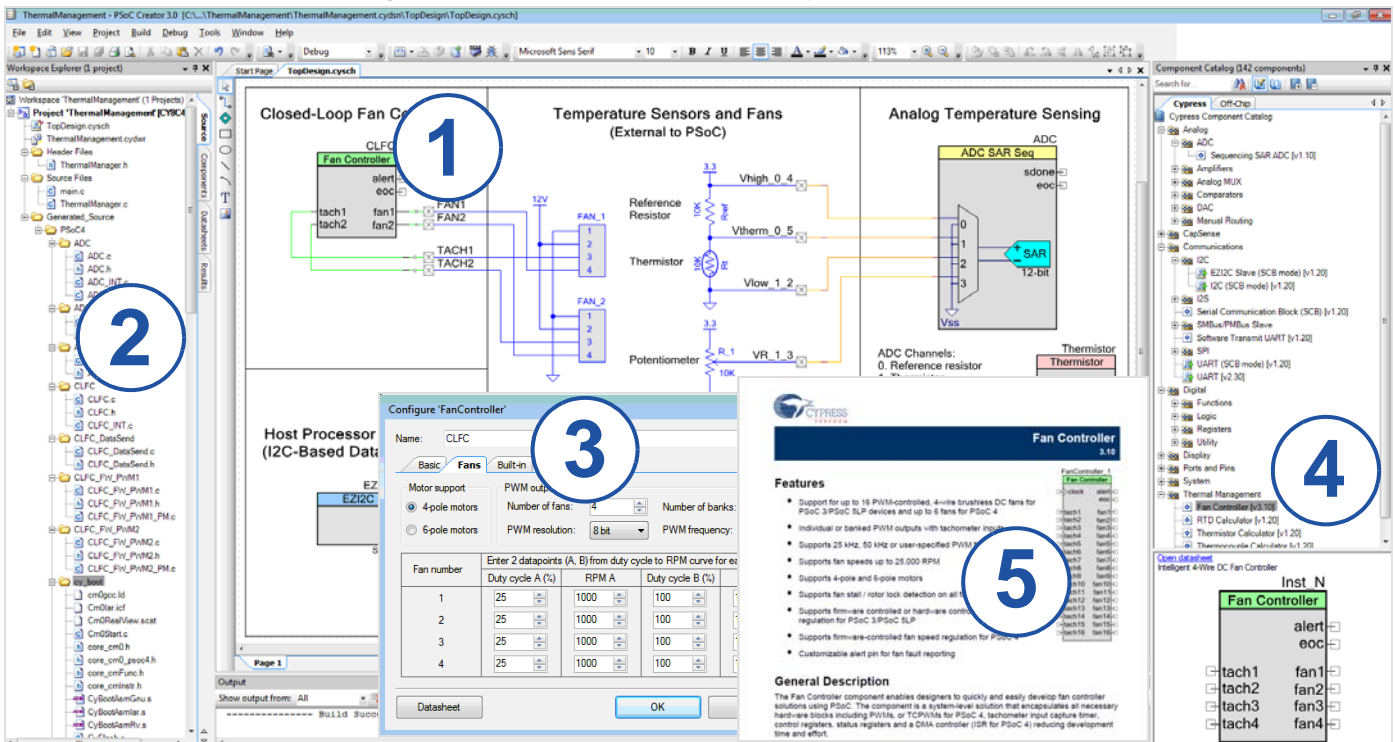
- Overview: [PSoC Portfolio](#), [PSoC Roadmap](#)
 - Product Selectors: [PSoC 1](#), [PSoC 3](#), [PSoC 4](#), [PSoC 5LP](#)
In addition, PSoC Creator includes a device selection tool.
 - Application notes: Cypress offers a large number of PSoC application notes covering a broad range of topics, from basic to advanced level. Recommended application notes for getting started with PSoC 4 are:
 - [AN79953: Getting Started With PSoC 4](#)
 - [AN88619: PSoC 4 Hardware Design Considerations](#)
 - [AN86439: Using PSoC 4 GPIO Pins](#)
 - [AN57821: Mixed Signal Circuit Board Layout](#)
 - [AN81623: Digital Design Best Practices](#)
 - [AN73854: Introduction To Bootloaders](#)
 - [AN89610: ARM Cortex Code Optimization](#)
 - [AN90071: CY8CMBRxxx CapSense Design Guide](#)
 - Technical Reference Manual (TRM) is in two documents:
 - [Architecture TRM](#) details each PSoC 4 functional block.
 - [Registers TRM](#) describes each of the PSoC 4 registers.
 - Development Kits:
 - [CY8CKIT-042](#), PSoC 4 Pioneer Kit, is an easy-to-use and inexpensive development platform. This kit includes connectors for Arduino™ compatible shields and Digilent® Pmod™ daughter cards.
 - [CY8CKIT-049](#) is a very low-cost prototyping platform. It is a low-cost alternative to sampling PSoC 4 devices.
 - [CY8CKIT-001](#) is a common development platform for any one of the PSoC 1, PSoC 3, PSoC 4, or PSoC 5LP families of devices.
- The [MiniProg3](#) device provides an interface for flash programming and debug.

PSoC Creator

[PSoC Creator](#) is a free Windows-based Integrated Design Environment (IDE). It enables concurrent hardware and firmware design of PSoC 3, PSoC 4, and PSoC 5LP based systems. Create designs using classic, familiar schematic capture supported by over 100 pre-verified, production-ready PSoC Components; see the [list of component datasheets](#). With PSoC Creator, you can:

1. Drag and drop component icons to build your hardware system design in the main design workspace
2. Codesign your application firmware with the PSoC hardware, using the PSoC Creator IDE C compiler
3. Configure components using the configuration tools
4. Explore the library of 100+ components
5. Review component datasheets

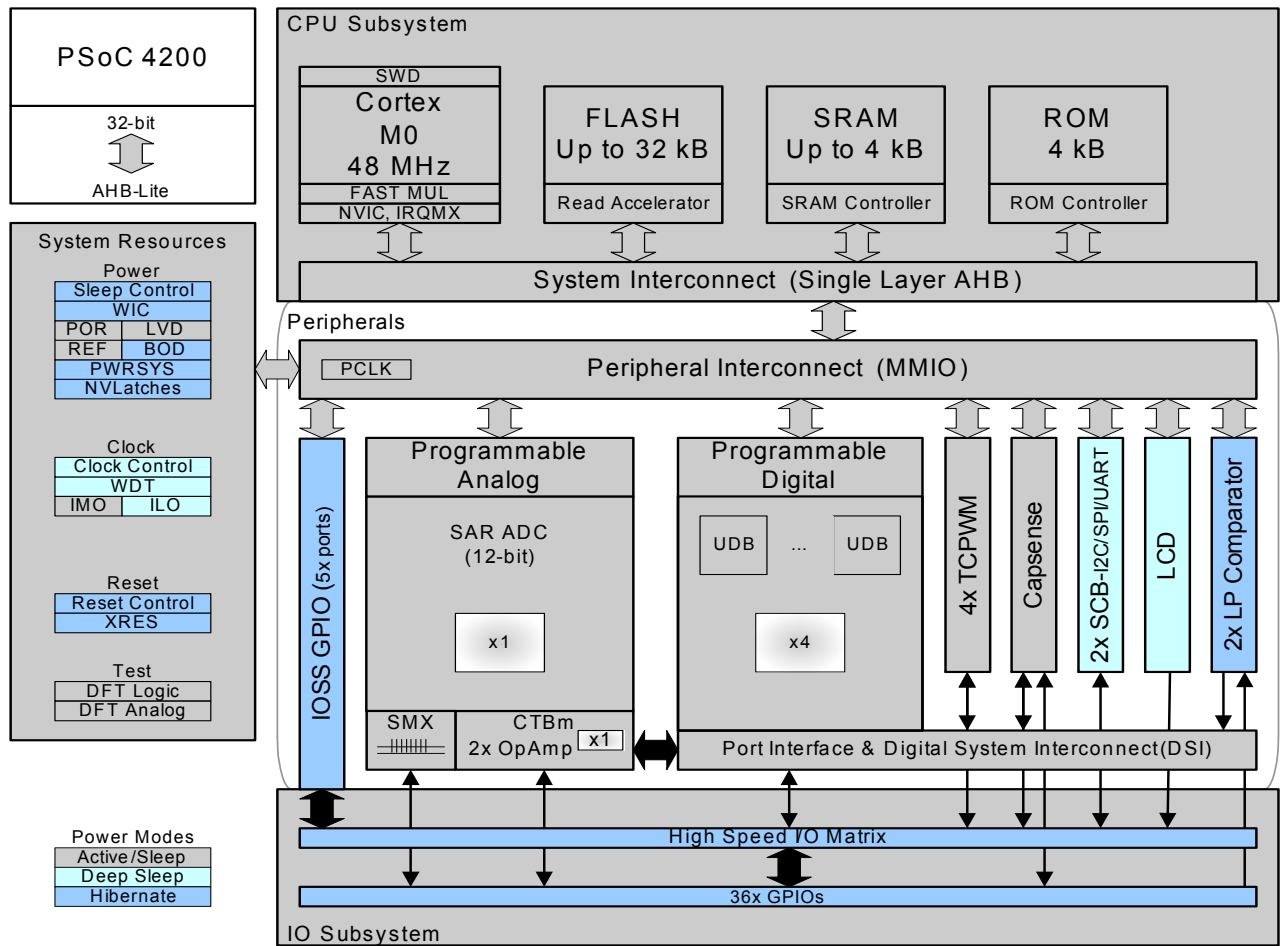
Figure 1. Multiple-Sensor Example Project in PSoC Creator



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Figure 2. Block Diagram



The PSoC 4200 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 4200 devices. The SWD interface is fully compatible with industry-standard third-party tools. With the ability to disable debug features, with very robust flash protection, and allowing customer-proprietary functionality to be implemented in on-chip programmable blocks, the

PSoC 4200 family provides a level of security not possible with multi-chip application solutions or with microcontrollers.

The debug circuits are enabled by default and can only be disabled in firmware. If 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. Because all programming, debug, and test interfaces are disabled when maximum device security is enabled, PSoC 4200 with device security enabled may not be returned for failure analysis. This is a trade-off the PSoC 4200 allows the customer to make.

Functional Definition

CPU and Memory Subsystem

CPU

The Cortex-M0 CPU in PSoC 4200 is part of the 32-bit MCU subsystem, which is optimized for low-power operation with extensive clock gating. It mostly uses 16-bit instructions and 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, thus enabling upward compatibility. The Cypress implementation includes a hardware multiplier that provides a 32-bit result in one cycle. It includes a nested vectored interrupt controller (NVIC) block with 32 interrupt inputs and also includes a Wakeup Interrupt Controller (WIC). The WIC can wake the processor up 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 Cortex-M0 CPU provides a Non-Maskable Interrupt (NMI) input, which is made available to the user when it is not in use for system functions requested by the user.

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 4200 has four break-point (address) comparators and two watchpoint (data) comparators.

Flash

The PSoC 4200 device has a flash module with a flash accelerator, tightly coupled to the CPU to improve average access times from the flash block. The flash block is designed to deliver 1 wait-state (WS) access time at 48 MHz and with 0-WS access time at 24 MHz. The flash accelerator delivers 85% of single-cycle SRAM access performance on average. Part of the flash module can be used to emulate EEPROM operation if required.

The PSoC 4200 Flash supports the following flash protection modes at the memory subsystem level:

- **Open: No Protection.** Factory default mode in which the product is shipped.
- **Protected: User may change from Open to Protected.** This mode disables Debug interface accesses. The mode can be set back to Open but only after completely erasing the Flash.
- **Kill: User may change from Open to Kill.** This mode disables all Debug accesses. The part cannot be erased externally, thus obviating the possibility of partial erasure by power interruption and potential malfunction and security leaks. This is an irrevocable mode.

In addition, row-level Read/Write protection is also supported to prevent inadvertent Writes as well as selectively block Reads. Flash Read/Write/Erase operations are always available for internal code using system calls.

SRAM

SRAM memory is retained during Hibernate.

SROM

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

System Resources

Power System

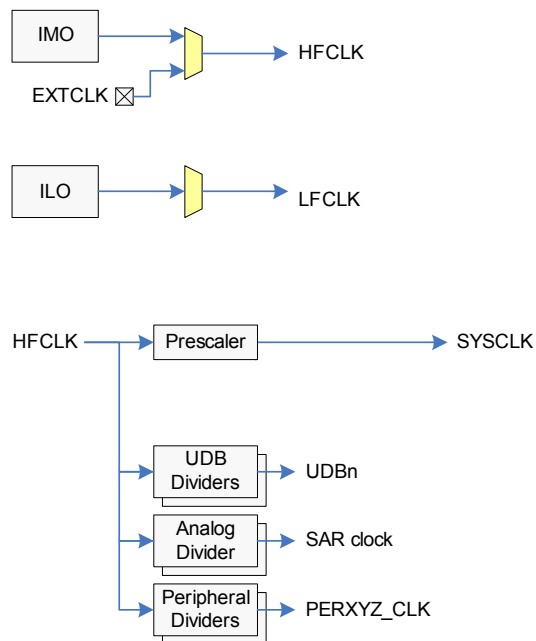
The power system is described in detail in the section [Power on page 16](#). It provides assurance that voltage levels are as required for each respective mode and either delay mode entry (on power-on reset (POR), for example) until voltage levels are as required for proper function or generate resets (brown-out detect (BOD)) or interrupts (low-voltage detect (LVD)). The PSoC 4200 operates with a single external supply over the range of 1.71 to 5.5 V and has five different power modes, transitions between which are managed by the power system. The PSoC 4200 provides Sleep, Deep Sleep, Hibernate, and Stop low-power modes.

Clock System

The PSoC 4200 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 no metastable conditions occur.

The clock system for PSoC 4200 consists of the internal main oscillator (IMO) and the internal low-power oscillator (ILO) and a provision for an external clock.

Figure 3. PSoC 4200 MCU Clocking Architecture



The HFCLK signal can be divided down (see [PSoC 4200 MCU Clocking Architecture](#)) to generate synchronous clocks for the UDBs, and the analog and digital peripherals. There are a total of 12 clock dividers for PSoC 4200, each with 16-bit divide capability; this allows eight to be used for the fixed-function blocks and four for the UDBs. The analog clock leads the digital clocks to allow analog events to occur before digital clock-related noise is generated. The 16-bit capability allows a lot of flexibility in generating fine-grained frequency values and is fully supported in PSoC Creator. When UDB-generated pulse interrupts are used, SYSCLK must equal UDBCLK.

IMO Clock Source

The IMO is the primary source of internal clocking in PSoC 4200. It is trimmed during testing to achieve the specified accuracy. Trim values are stored in nonvolatile latches (NVL). Additional trim settings from flash can be used to compensate for changes. The IMO default frequency is 24 MHz and it can be adjusted between 3 MHz to 48 MHz in steps of 1 MHz. The IMO tolerance with Cypress-provided calibration settings is $\pm 2\%$.

ILO Clock Source

The ILO is a very low-power oscillator, which is primarily used to generate clocks for peripheral operation in Deep Sleep mode. ILO-driven counters can be calibrated to the IMO to improve accuracy. Cypress provides a software component, which does the calibration.

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 timeout occurs. The watchdog reset is recorded in the Reset Cause register.

Reset

PSoC 4200 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 to avoid complications with configuration and multiple pin functions during power-on or reconfiguration. The XRES pin has an internal pull-up resistor that is always enabled.

Voltage Reference

The PSoC 4200 reference system generates all internally required references. A 1% voltage reference spec is provided for the 12-bit ADC. To allow better signal to noise ratios (SNR) and better absolute accuracy, it is possible to bypass the internal reference using a GPIO pin or to use an external reference for the SAR.

Analog Blocks

12-bit SAR ADC

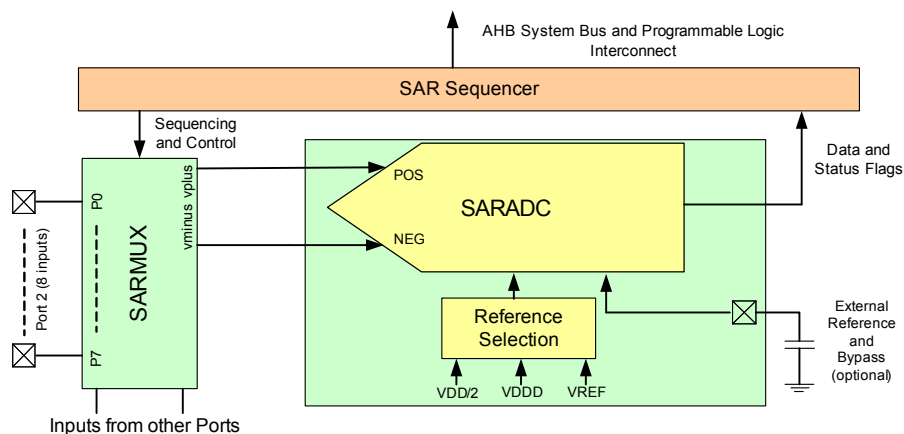
The 12-bit 1-Msps SAR ADC can operate at a maximum clock rate of 18 MHz and requires a minimum of 18 clocks at that frequency to do a 12-bit conversion.

The block functionality is augmented for the user by adding a reference buffer to it (trimmable to $\pm 1\%$) and by providing the choice (for the PSoC-4200 case) of three internal voltage references: V_{DD} , $V_{DD}/2$, and V_{REF} (nominally 1.024 V) as well as an external reference through a GPIO pin. The sample-and-hold (S/H) aperture is programmable allowing the gain bandwidth requirements of the amplifier driving the SAR inputs, which determine its settling time, to be relaxed if required. System performance will be 65 dB for true 12-bit precision providing appropriate references are used and system noise levels permit. To improve performance in noisy conditions, it is possible to provide an external bypass (through a fixed pin location) for the internal reference amplifier.

The SAR is connected to a fixed set of pins through an 8-input sequencer. The sequencer cycles through selected channels autonomously (sequencer scan) and does so with zero switching overhead (that is, aggregate sampling bandwidth is equal to 1 Msp whether it is for a single channel or distributed over several channels). The sequencer switching is effected through a state machine or through firmware driven switching. A feature provided by the sequencer is buffering of each channel to reduce CPU interrupt service requirements. To accommodate signals with varying source impedance and frequency, it is possible to have different sample times programmable for each channel. Also, signal range specification through a pair of range registers (low and high range values) is implemented with a corresponding out-of-range interrupt if the digitized value exceeds the programmed range; this allows fast detection of out-of-range values without the necessity of having to wait for a sequencer scan to be completed and the CPU to read the values and check for out-of-range values in software.

The SAR is able to digitize the output of the on-board temperature sensor for calibration and other temperature-dependent functions. The SAR is not available in Deep Sleep and Hibernate modes as it requires a high-speed clock (up to 18 MHz). The SAR operating range is 1.71 V to 5.5 V.

Figure 4. SAR ADC System Diagram



Two Opamps (CTBm Block)

PSoC 4200 has two opamps with Comparator modes which allow most common analog functions to be performed on-chip eliminating external components; PGAs, voltage buffers, filters, trans-impedance amplifiers, and other functions can be realized with external passives saving power, cost, and space. The on-chip opamps are designed with enough bandwidth to drive the S/H circuit of the ADC without requiring external buffering.

Temperature Sensor

PSoC 4200 has one on-chip temperature sensor This consists of a diode, which is biased by a current source that can be disabled to save power. The temperature sensor is connected to the ADC, which digitizes the reading and produces a temperature value using Cypress supplied software that includes calibration and linearization.

Low-power Comparators

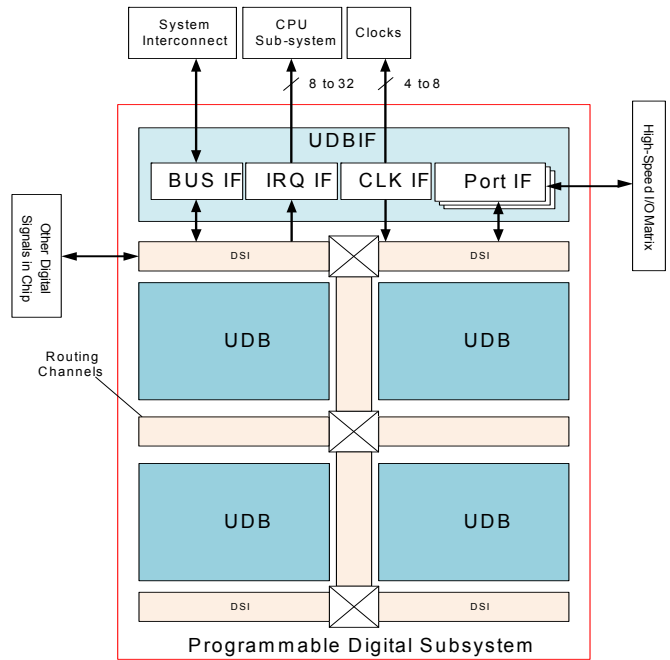
PSoC 4200 has a pair of low-power comparators, which can also operate in the Deep Sleep and Hibernate modes. This allows the analog system blocks to be disabled while retaining the ability to monitor external voltage levels during low-power modes. The comparator outputs are normally synchronized to avoid metastability unless operating in an asynchronous power mode (Hibernate) where the system wake-up circuit is activated by a comparator switch event.

Programmable Digital

Universal Digital Blocks (UDBs) and Port Interfaces

PSoC 4200 has four UDBs; the UDB array also provides a switched Digital System Interconnect (DSI) fabric that allows signals from peripherals and ports to be routed to and through the UDBs for communication and control. The UDB array is shown in the following figure.

Figure 5. UDB Array

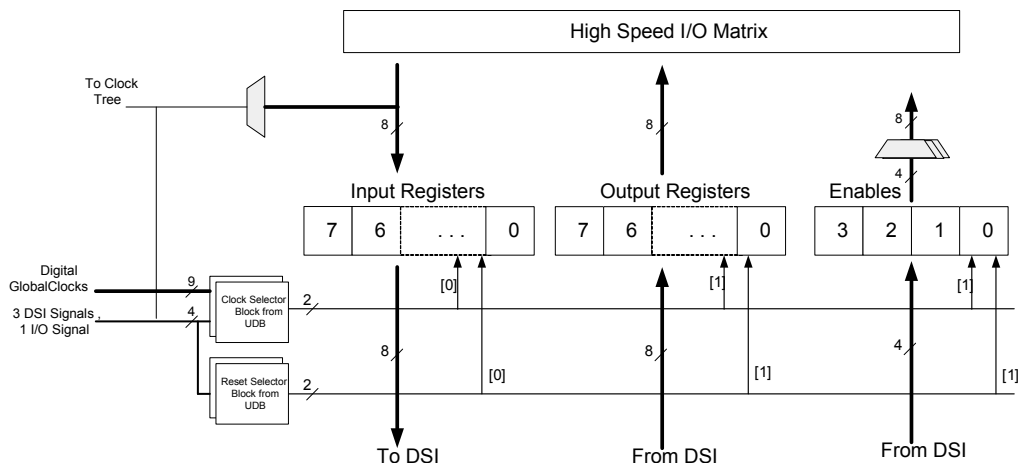


UDBs can be clocked from a clock divider block, from a port interface (required for peripherals such as SPI), and from the DSI network directly or after synchronization.

A port interface is defined, which acts as a register that can be clocked with the same source as the PLDs inside the UDB array. This allows faster operation because the inputs and outputs can be registered at the port interface close to the I/O pins and at the edge of the array. The port interface registers can be clocked by one of the I/Os from the same port. This allows interfaces such as SPI to operate at higher clock speeds by eliminating the delay for the port input to be routed over DSI and used to register other inputs (see Figure 6).

The UDBs can generate interrupts (one UDB at a time) to the interrupt controller. The UDBs retain the ability to connect to any pin on the chip through the DSI.

Figure 6. Port Interface



Fixed Function Digital

Timer/Counter/PWM Block (TCPWM)

The TCPWM block consists of four 16-bit counters 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 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 which are used as PWM duty cycle outputs. The block also provides true and complementary outputs with programmable offset between them to allow use as deadband programmable complementary PWM outputs. It also has a Kill input to force outputs to a pre-terminated state; for example, this is used in motor drive systems when an overcurrent state is indicated and the PWMs driving the FETs need to be shut off immediately with no time for software intervention.

Serial Communication Blocks (SCB)

PSoC 4200 has two SCBs, which can each implement an I²C, UART, or SPI interface.

I²C Mode: The hardware I²C block implements a full multi-master and slave interface (it is capable of multimaster arbitration). This block is capable of operating at speeds of up to 1 Mbps (Fast Mode Plus) and has flexible buffering options to reduce interrupt overhead and latency for the CPU. The FIFO mode is available in all channels and is very useful in the absence of DMA.

The I²C peripheral is compatible with the I²C Standard-mode, Fast-mode, and Fast-Mode Plus devices as defined in the NXP I²C-bus specification and user manual (UM10204). The I²C bus I/O is implemented with GPIO in open-drain modes. The I²C bus uses open-drain drivers for clock and data with pull-up resistors on the bus for clock and data connected to all nodes. The required Rise and Fall times for different I²C speeds are guaranteed by using appropriate pull-up resistor values depending on VDD, Bus Capacitance, and resistor tolerance. For detailed information on how to calculate the optimum pull-up resistor value for your design, refer to the UM10204 I²C bus specification and user manual (the latest revision is available at www.nxp.com).

PSoC 4200 is not completely compliant with the I²C spec in the following respects:

- GPIO cells are not overvoltage-tolerant and, therefore, cannot be hot-swapped or powered up independently of the rest of the I²C system.
 - Fast-Mode Plus has an I_{OL} specification of 20 mA at a V_{OL} of 0.4 V. The GPIO cells can sink a maximum of 8-mA I_{OL} with a V_{OL} maximum of 0.6 V.
 - Fast mode and Fast-Mode Plus specify minimum Fall times, which are not met with the GPIO cell; Slow strong mode can help meet this spec depending on the Bus Load.
 - When the SCB is an I²C master, it interposes an IDLE state between NACK and Repeated Start; the I²C spec defines Bus free as following a Stop condition so other Active Masters do not intervene but a Master that has just become activated may start an Arbitration cycle.
- When the SCB is in I²C slave mode, and Address Match on External Clock is enabled (EC_AM = 1) along with operation in the internally clocked mode (EC_OP = 0), then its I²C address must be even.
- UART Mode:** This is a full-feature UART operating at up to 1 Mbps. It supports automotive single-wire interface (LIN), infrared interface (IrDA), and SmartCard (ISO7816) protocols, all of which are minor variants of the basic UART protocol. In addition, it supports the 9-bit multiprocessor mode that allows addressing of peripherals connected over common RX and TX lines. Common UART functions such as parity error, break detect, and frame error are supported. An 8-deep FIFO allows much greater CPU service latencies to be tolerated. Note that hardware handshaking is not supported. This is not commonly used and can be implemented with a UDB-based UART in the system, if required.
- SPI Mode:** The SPI mode supports full Motorola SPI, TI SSP (essentially adds a start pulse used to synchronize SPI Codecs), and National Microwire (half-duplex form of SPI). The SPI block can use the FIFO.

GPIO

PSoC 4200 has 36 GPIOs. The GPIO block implements the following:

- Eight drive strength 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.
- Hold mode for latching previous state (used for retaining I/O state in Deep Sleep mode and Hibernate 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. 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. Pin locations for fixed-function peripherals are also fixed to reduce internal multiplexing complexity (these signals do not go through the DSI network). DSI signals are not affected by this and any pin may be routed to any UDB through the DSI network.

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 (5 for PSoC 4200 since it has 4.5 ports).

Special Function Peripherals

LCD Segment Drive

PSoC 4200 has an LCD controller which can drive up to four commons and up to 32 segments. It uses full digital methods to drive the LCD segments requiring no generation of internal LCD voltages. The two methods used are referred to as digital correlation and PWM.

Digital correlation pertains to modulating the frequency and levels of the common and segment signals to generate the highest RMS voltage across a segment to light it up or to keep the RMS signal zero. This method is good for STN displays but may result in reduced contrast with TN (cheaper) displays.

PWM pertains to driving the panel with PWM signals to effectively use the capacitance of the panel to provide the integration of the modulated pulse-width to generate the desired LCD voltage. This method results in higher power consumption but can result in better results when driving TN displays. LCD operation is supported during Deep Sleep refreshing a small display buffer (4 bits; 1 32-bit register per port).

CapSense

CapSense is supported on all pins in PSoC 4200 through a CapSense Sigma-Delta (CSD) block that can be connected to any pin through an analog mux bus that any GPIO pin can be connected to via an Analog switch. CapSense function can thus be provided on any pin or group of pins in a system under software control. A 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.

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).

WLCSP Package Bootloader

The WLCSP package is supplied with an I²C Bootloader installed in flash. The bootloader is compatible with PSoC Creator bootloadable project files and has the following default settings:

- I²C SCL and SDA connected to port pins P4.0 and P4.1 respectively (external pull-up resistors required)
- I²C Slave mode, address 8, data rate = 100 kbps
- Single application
- Wait two seconds for bootload command
- Other bootloader options are as set by the PSoC Creator Bootloader Component default
- Occupies the bottom 4.5 KB of flash

For more information on this bootloader, see the following Cypress application note:

[AN73854](#) - Introduction to Bootloaders

Note that a PSoC Creator bootloadable project must be associated with *.hex* and *.elf* files for a bootloader project that is configured for the target device. Bootloader *.hex* and *.elf* files can be found at <http://www.cypress.com/?rID=78632>. The factory-installed bootloader can be overwritten using JTAG or SWD programming.

Pinouts

The following is the pin-list for the PSoC 4200 (44-TQFP, 40-QFN, 28-SSOP, and 48-TQFP). Port 2 comprises of the high-speed Analog inputs for the SAR Mux. P1.7 is the optional external input and bypass for the SAR reference. Ports 3 and 4 contain the Digital Communication channels. All pins support CSD CapSense and Analog Mux Bus connections.

| 44-TQFP | | 40-QFN | | 28-SSOP | | 48-TQFP | | Alternate Functions for Pins | | | | | Pin Description |
|---------|------|--------|------|---------|------|---------|------|------------------------------|-------------|-----------------|-----------------|--------------------|--|
| Pin | Name | Pin | Name | Pin | Name | Pin | Name | Analog | Alt 1 | Alt 2 | Alt 3 | Alt 4 | |
| 1 | VSS | – | – | – | – | – | – | – | – | – | – | – | Ground |
| 2 | P2.0 | 1 | P2.0 | – | – | 2 | P2.0 | sarmux.0 | – | – | – | – | Port 2 Pin 0: gpio, lcd, csd, sarmux |
| 3 | P2.1 | 2 | P2.1 | – | – | 3 | P2.1 | sarmux.1 | – | – | – | – | Port 2 Pin 1: gpio, lcd, csd, sarmux |
| 4 | P2.2 | 3 | P2.2 | 5 | P2.2 | 4 | P2.2 | sarmux.2 | – | – | – | – | Port 2 Pin 2: gpio, lcd, csd, sarmux |
| 5 | P2.3 | 4 | P2.3 | 6 | P2.3 | 5 | P2.3 | sarmux.3 | – | – | – | – | Port 2 Pin 3: gpio, lcd, csd, sarmux |
| 6 | P2.4 | 5 | P2.4 | 7 | P2.4 | 6 | P2.4 | sarmux.4 | tcpwm0_p[1] | – | – | – | Port 2 Pin 4: gpio, lcd, csd, sarmux, pwm |
| 7 | P2.5 | 6 | P2.5 | 8 | P2.5 | 7 | P2.5 | sarmux.5 | tcpwm0_n[1] | – | – | – | Port 2 Pin 5: gpio, lcd, csd, sarmux, pwm |
| 8 | P2.6 | 7 | P2.6 | 9 | P2.6 | 8 | P2.6 | sarmux.6 | tcpwm1_p[1] | – | – | – | Port 2 Pin 6: gpio, lcd, csd, sarmux, pwm |
| 9 | P2.7 | 8 | P2.7 | 10 | P2.7 | 9 | P2.7 | sarmux.7 | tcpwm1_n[1] | – | – | – | Port 2 Pin 7: gpio, lcd, csd, sarmux, pwm |
| 10 | VSS | 9 | VSS | – | – | – | – | – | – | – | – | – | Ground |
| – | – | – | – | – | – | 10 | NC | – | – | – | – | – | No Connect |
| – | – | – | – | – | – | 11 | NC | – | – | – | – | – | No Connect |
| 11 | P3.0 | 10 | P3.0 | 11 | P3.0 | 12 | P3.0 | – | tcpwm0_p[0] | scb1_uart_rx[0] | scb1_i2c_scl[0] | scb1_spi_mosi[0] | Port 3 Pin 0: gpio, lcd, csd, pwm, scb1 |
| 12 | P3.1 | 11 | P3.1 | 12 | P3.1 | 13 | P3.1 | – | tcpwm0_n[0] | scb1_uart_tx[0] | scb1_i2c_sda[0] | scb1_spi_miso[0] | Port 3 Pin 1: gpio, lcd, csd, pwm, scb1 |
| 13 | P3.2 | 12 | P3.2 | 13 | P3.2 | 14 | P3.2 | – | tcpwm1_p[0] | – | swd_io[0] | scb1_spi_clk[0] | Port 3 Pin 2: gpio, lcd, csd, pwm, scb1, swd |
| – | – | – | – | – | – | 15 | VSSD | – | – | – | – | – | Ground |
| 14 | P3.3 | 13 | P3.3 | 14 | P3.3 | 16 | P3.3 | – | tcpwm1_n[0] | – | swd_clk[0] | scb1_spi_ssel_0[0] | Port 3 Pin 3: gpio, lcd, csd, pwm, scb1, swd |
| 15 | P3.4 | 14 | P3.4 | – | – | 17 | P3.4 | – | tcpwm2_p[0] | – | – | scb1_spi_ssel_1 | Port 3 Pin 4: gpio, lcd, csd, pwm, scb1 |
| 16 | P3.5 | 15 | P3.5 | – | – | 18 | P3.5 | – | tcpwm2_n[0] | – | – | scb1_spi_ssel_2 | Port 3 Pin 5: gpio, lcd, csd, pwm, scb1 |
| 17 | P3.6 | 16 | P3.6 | – | – | 19 | P3.6 | – | tcpwm3_p[0] | – | – | scb1_spi_ssel_3 | Port 3 Pin 6: gpio, lcd, csd, pwm, scb1 |
| 18 | P3.7 | 17 | P3.7 | – | – | 20 | P3.7 | – | tcpwm3_n[0] | – | – | – | Port 3 Pin 7: gpio, lcd, csd, pwm |
| 19 | VDDD | – | – | – | – | 21 | VDDD | – | – | – | – | – | Digital Supply, 1.8 - 5.5V |
| 20 | P4.0 | 18 | P4.0 | 15 | P4.0 | 22 | P4.0 | – | – | scb0_uart_rx | scb0_i2c_scl | scb0_spi_mosi | Port 4 Pin 0: gpio, lcd, csd, scb0 |
| 21 | P4.1 | 19 | P4.1 | 16 | P4.1 | 23 | P4.1 | – | – | scb0_uart_tx | scb0_i2c_sda | scb0_spi_miso | Port 4 Pin 1: gpio, lcd, csd, scb0 |
| 22 | P4.2 | 20 | P4.2 | 17 | P4.2 | 24 | P4.2 | csd_c_mod | – | – | – | scb0_spi_clk | Port 4 Pin 2: gpio, lcd, csd, scb0 |
| 23 | P4.3 | 21 | P4.3 | 18 | P4.3 | 25 | P4.3 | csd_c_sh_tank | – | – | – | scb0_spi_ssel_0 | Port 4 Pin 3: gpio, lcd, csd, scb0 |
| – | – | – | – | – | – | 26 | NC | – | – | – | – | – | No Connect |
| – | – | – | – | – | – | 27 | NC | – | – | – | – | – | No Connect |

| 44-TQFP | | 40-QFN | | 28-SSOP | | 48-TQFP | | Alternate Functions for Pins | | | | | Pin Description |
|---------|-----------|--------|-----------|---------|-----------|---------|-----------|------------------------------|-------------|-----------------|-----------------|--------------------|--|
| Pin | Name | Pin | Name | Pin | Name | Pin | Name | Analog | Alt 1 | Alt 2 | Alt 3 | Alt 4 | |
| 24 | P0.0 | 22 | P0.0 | 19 | P0.0 | 28 | P0.0 | comp1_inp | – | – | – | scb0_spi_ssel_1 | Port 0 Pin 0: gpio, lcd, csd, scb0, comp |
| 25 | P0.1 | 23 | P0.1 | 20 | P0.1 | 29 | P0.1 | comp1_inn | – | – | – | scb0_spi_ssel_2 | Port 0 Pin 1: gpio, lcd, csd, scb0, comp |
| 26 | P0.2 | 24 | P0.2 | 21 | P0.2 | 30 | P0.2 | comp2_inp | – | – | – | scb0_spi_ssel_3 | Port 0 Pin 2: gpio, lcd, csd, scb0, comp |
| 27 | P0.3 | 25 | P0.3 | 22 | P0.3 | 31 | P0.3 | comp2_inn | – | – | – | – | Port 0 Pin 3: gpio, lcd, csd, comp |
| 28 | P0.4 | 26 | P0.4 | – | – | 32 | P0.4 | – | – | scb1_uart_rx[1] | scb1_i2c_scl[1] | scb1_spi_mosi[1] | Port 0 Pin 4: gpio, lcd, csd, scb1 |
| 29 | P0.5 | 27 | P0.5 | – | – | 33 | P0.5 | – | – | scb1_uart_tx[1] | scb1_i2c_sda[1] | scb1_spi_miso[1] | Port 0 Pin 5: gpio, lcd, csd, scb1 |
| 30 | P0.6 | 28 | P0.6 | 23 | P0.6 | 34 | P0.6 | – | ext_clk | – | – | scb1_spi_clk[1] | Port 0 Pin 6: gpio, lcd, csd, scb1, ext_clk |
| 31 | P0.7 | 29 | P0.7 | 24 | P0.7 | 35 | P0.7 | – | – | – | wakeup | scb1_spi_ssel_0[1] | Port 0 Pin 7: gpio, lcd, csd, scb1, wakeup |
| 32 | XRES | 30 | XRES | 25 | XRES | 36 | XRES | – | – | – | – | – | Chip reset, active low |
| 33 | VCCD | 31 | VCCD | 26 | VCCD | 37 | VCCD | – | – | – | – | – | Regulated supply, connect to 1µF cap or 1.8V |
| – | – | – | – | – | – | 38 | VSSD | – | – | – | – | – | Digital Ground |
| 34 | VDDD | 32 | VDDD | 27 | VDD | 39 | VDDD | – | – | – | – | – | Digital Supply, 1.8 - 5.5V |
| 35 | VDDA | 33 | VDDA | 27 | VDD | 40 | VDDA | – | – | – | – | – | Analog Supply, 1.8 - 5.5V, equal to VDDD |
| 36 | VSSA | 34 | VSSA | 28 | VSS | 41 | VSSA | – | – | – | – | – | Analog Ground |
| 37 | P1.0 | 35 | P1.0 | 1 | P1.0 | 42 | P1.0 | ctb.oa0.inp | tcpwm2_p[1] | – | – | – | Port 1 Pin 0: gpio, lcd, csd, ctb, pwm |
| 38 | P1.1 | 36 | P1.1 | 2 | P1.1 | 43 | P1.1 | ctb.oa0.inm | tcpwm2_n[1] | – | – | – | Port 1 Pin 1: gpio, lcd, csd, ctb, pwm |
| 39 | P1.2 | 37 | P1.2 | 3 | P1.2 | 44 | P1.2 | ctb.oa0.out | tcpwm3_p[1] | – | – | – | Port 1 Pin 2: gpio, lcd, csd, ctb, pwm |
| 40 | P1.3 | 38 | P1.3 | – | – | 45 | P1.3 | ctb.oa1.out | tcpwm3_n[1] | – | – | – | Port 1 Pin 3: gpio, lcd, csd, ctb, pwm |
| 41 | P1.4 | 39 | P1.4 | – | – | 46 | P1.4 | ctb.oa1.inm | – | – | – | – | Port 1 Pin 4: gpio, lcd, csd, ctb |
| 42 | P1.5 | – | – | – | – | 47 | P1.5 | ctb.oa1.inp | – | – | – | – | Port 1 Pin 5: gpio, lcd, csd, ctb |
| 43 | P1.6 | – | – | – | – | 48 | P1.6 | ctb.oa0.inp_alt | – | – | – | – | Port 1 Pin 6: gpio, lcd, csd |
| 44 | P1.7/VREF | 40 | P1.7/VREF | 4 | P1.7/VREF | 1 | P1.7/VREF | ctb.oa1.inp_alt ext_vref | – | – | – | – | Port 1 Pin 7: gpio, lcd, csd, ext_ref |

Notes:

1. tcpwm_p and tcpwm_n refer to tcpwm non-inverted and inverted outputs respectively.
2. P3.2 and P3.3 are SWD pins after boot (reset).

The following is the pin-list for the PSoC 4200 (35-WLCSP).

| 35-Ball CSP | | Alternate Functions for Pins | | | | | Pin Description |
|-------------|------|------------------------------|-------------|-----------------|-----------------|--------------------|--|
| Pin | Name | Analog | Alt 1 | Alt 2 | Alt 3 | Alt 4 | |
| D3 | P2.2 | sarmux.2 | – | – | – | – | Port 2 Pin 2: gpio, lcd, csd, sarmux |
| E4 | P2.3 | sarmux.3 | – | – | – | – | Port 2 Pin 3: gpio, lcd, csd, sarmux |
| E5 | P2.4 | sarmux.4 | tcpwm0_p[1] | – | – | – | Port 2 Pin 4: gpio, lcd, csd, sarmux, pwm |
| E6 | P2.5 | sarmux.5 | tcpwm0_n[1] | – | – | – | Port 2 Pin 5: gpio, lcd, csd, sarmux, pwm |
| E3 | P2.6 | sarmux.6 | tcpwm1_p[1] | – | – | – | Port 2 Pin 6: gpio, lcd, csd, sarmux, pwm |
| E2 | P2.7 | sarmux.7 | tcpwm1_n[1] | – | – | – | Port 2 Pin 7: gpio, lcd, csd, sarmux, pwm |
| E1 | P3.0 | – | tcpwm0_p[0] | scb1_uart_rx[0] | scb1_i2c_scl[0] | scb1_spi_mosi[0] | Port 3 Pin 0: gpio, lcd, csd, pwm, scb1 |
| D2 | P3.1 | – | tcpwm0_n[0] | scb1_uart_tx[0] | scb1_i2c_sda[0] | scb1_spi_miso[0] | Port 3 Pin 1: gpio, lcd, csd, pwm, scb1 |
| D1 | P3.2 | – | tcpwm1_p[0] | – | swd_io[0] | scb1_spi_clk[0] | Port 3 Pin 2: gpio, lcd, csd, pwm, scb1, swd |
| B7 | VSS | – | – | – | – | – | Ground |
| C1 | P3.3 | – | tcpwm1_n[0] | – | swd_clk[0] | scb1_spi_ssel_0[0] | Port 3 Pin 3: gpio, lcd, csd, pwm, scb1, swd |
| C2 | P3.4 | – | tcpwm2_p[0] | – | – | scb1_spi_ssel_1 | Port 3 Pin 4: gpio, lcd, csd, pwm, scb1 |
| B1 | P4.0 | – | – | scb0_uart_rx | scb0_i2c_scl | scb0_spi_mosi | Port 4 Pin 0: gpio, lcd, csd, scb0 |
| B2 | P4.1 | – | – | scb0_uart_tx | scb0_i2c_sda | scb0_spi_miso | Port 4 Pin 1: gpio, lcd, csd, scb0 |
| A2 | P4.2 | csd_c_mod | – | – | – | scb0_spi_clk | Port 4 Pin 2: gpio, lcd, csd, scb0 |
| A1 | P4.3 | csd_c_sh_tank | – | – | – | scb0_spi_ssel_0 | Port 4 Pin 3: gpio, lcd, csd, scb0 |
| C3 | P0.0 | comp1_inp | – | – | – | scb0_spi_ssel_1 | Port 0 Pin 0: gpio, lcd, csd, scb0, comp |
| A5 | P0.1 | comp1_inn | – | – | – | scb0_spi_ssel_2 | Port 0 Pin 1: gpio, lcd, csd, scb0, comp |
| A4 | P0.2 | comp2_inp | – | – | – | scb0_spi_ssel_3 | Port 0 Pin 2: gpio, lcd, csd, scb0, comp |
| A3 | P0.3 | comp2_inn | – | – | – | – | Port 0 Pin 3: gpio, lcd, csd, comp |
| B3 | P0.4 | – | – | scb1_uart_rx[1] | scb1_i2c_scl[1] | scb1_spi_mosi[1] | Port 0 Pin 4: gpio, lcd, csd, scb1 |
| A6 | P0.5 | – | – | scb1_uart_tx[1] | scb1_i2c_sda[1] | scb1_spi_miso[1] | Port 0 Pin 5: gpio, lcd, csd, scb1 |
| B4 | P0.6 | – | ext_clk | – | – | scb1_spi_clk[1] | Port 0 Pin 6: gpio, lcd, csd, scb1, ext_clk |
| B5 | P0.7 | – | – | – | wakeup | scb1_spi_ssel_0[1] | Port 0 Pin 7: gpio, lcd, csd, scb1, wakeup |
| B6 | XRES | – | – | – | – | – | Chip reset, active low |
| A7 | VCCD | – | – | – | – | – | Regulated supply, connect to 1µF cap or 1.8V |
| C7 | VDD | – | – | – | – | – | Supply, 1.8 - 5.5V |
| C4 | P1.0 | ctb.0a0.inp | tcpwm2_p[1] | – | – | – | Port 1 Pin 0: gpio, lcd, csd, ctb, pwm |
| C5 | P1.1 | ctb.0a0.inm | tcpwm2_n[1] | – | – | – | Port 1 Pin 1: gpio, lcd, csd, ctb, pwm |
| C6 | P1.2 | ctb.0a0.out | tcpwm3_p[1] | – | – | – | Port 1 Pin 2: gpio, lcd, csd, ctb, pwm |

| 35-Ball CSP | | Alternate Functions for Pins | | | | | Pin Description |
|-------------|---------------|------------------------------|-------------|-------|-------|-------|--|
| Pin | Name | Analog | Alt 1 | Alt 2 | Alt 3 | Alt 4 | |
| D7 | P1.3 | ctb.oa1.out | tcpwm3_n[1] | – | – | – | Port 1 Pin 3: gpio, lcd, csd, ctb, pwm |
| D4 | P1.4 | ctb.oa1.inm | – | – | – | – | Port 1 Pin 4: gpio, lcd, csd, ctb |
| D5 | P1.5 | ctb.oa1.inp | – | – | – | – | Port 1 Pin 5: gpio, lcd, csd, ctb |
| D6 | P1.6 | ctb.oa0.inp_alt | – | – | – | – | Port 1 Pin 6: gpio, lcd, csd |
| E7 | P1.7/VR EF | ctb.oa1.inp_alt ext_vref | – | – | – | – | Port 1 Pin 7: gpio, lcd, csd, ext_ref |

Descriptions of the Pin functions are as follows:

VDDD: Power supply for both analog and digital sections (where there is no V_{DDA} pin).

VDDA: Analog V_{DD} pin where package pins allow; shorted to V_{DDD} otherwise.

VSSA: Analog ground pin where package pins allow; shorted to VSS otherwise

VSS: Ground pin.

VCCD: Regulated Digital supply (1.8 V \pm 5%).

Port Pins can all be used as LCD Commons, LCD Segment drivers, or CSD sense and shield pins can be connected to AMUXBUS A or B or can all be used as GPIO pins that can be driven by firmware or DSI signals.

The following packages are supported: 48-pin TQFP, 44-pin TQFP, 40-pin QFN, and 28-pin SSOP.

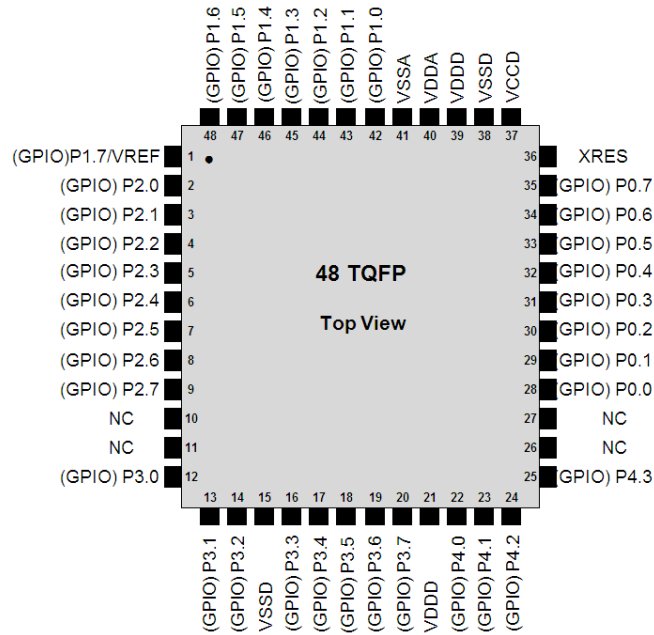
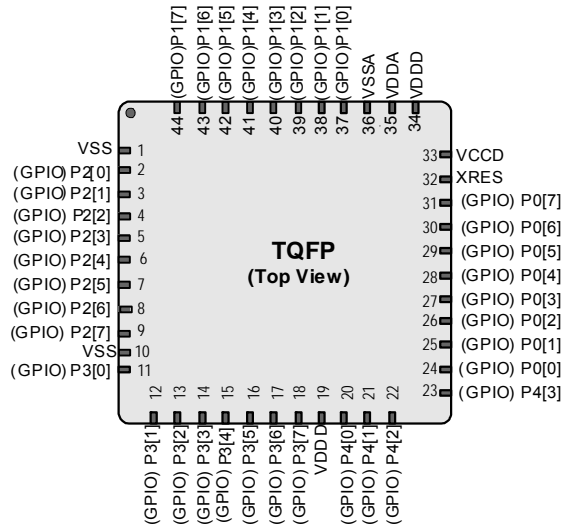
Figure 7. 48-Pin TQFP Pinout

Figure 8. 44-pin TQFP Part Pinout


Figure 9. 40-Pin QFN Pinout

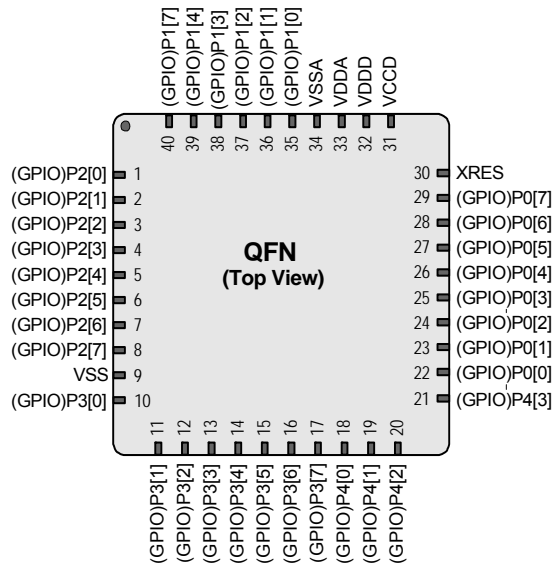


Figure 10. 35-Ball WLCSP

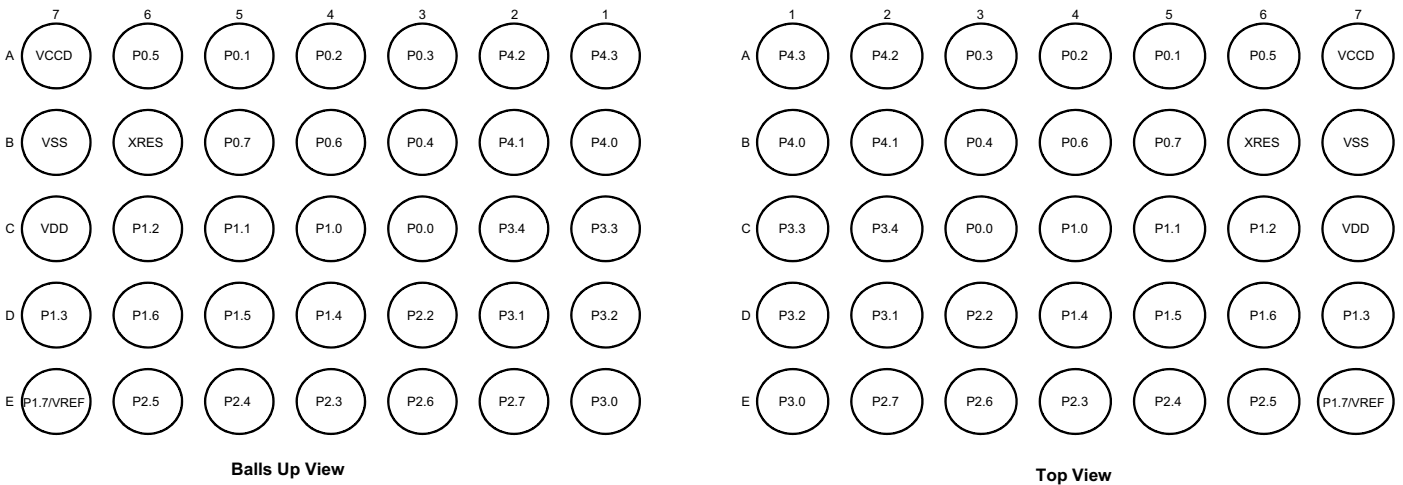
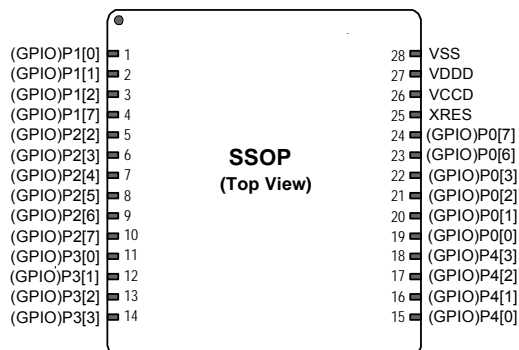


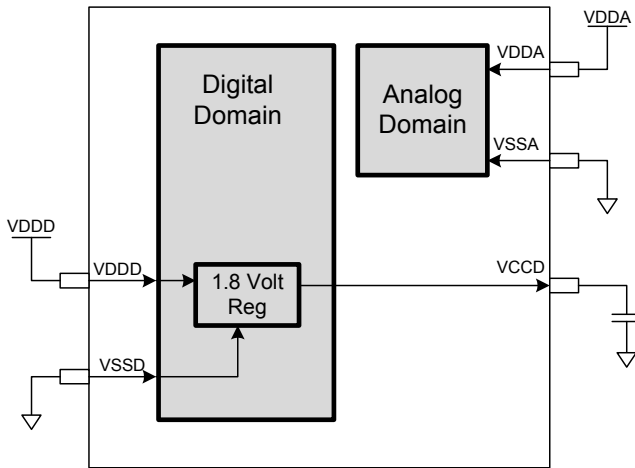
Figure 11. 28-Pin SSOP Pinout



Power

The following power system diagrams show the minimum set of power supply pins as implemented for the PSoC 4200. 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_{DDA} input. There are separate regulators for the Deep Sleep and Hibernate (lowered power supply and retention) modes. There is a separate low-noise regulator for the bandgap. The supply voltage range is 1.71 to 5.5 V with all functions and circuits operating over that range.

Figure 12. PSoC 4 Power Supply



The PSoC 4200 family allows two distinct modes of power supply operation: Unregulated External Supply and Regulated External Supply modes.

Unregulated External Supply

In this mode, PSoC 4200 is powered by an external power supply that can be anywhere in the range of 1.8 V to 5.5 V. This range is also designed for battery-powered operation, for instance, 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 PSoC 4200 supplies the internal logic and the V_{CCD} output of PSoC 4200 must be bypassed to ground via an external capacitor (in the range of 1 μF to 1.6 μF ; X5R ceramic or better).

V_{DDA} and V_{DDD} must be shorted together; the grounds, V_{SSA} and V_{SS} must also be shorted together. Bypass capacitors must be used from V_{DDD} to ground, typical practice for systems in this frequency range is to use a capacitor in the 1- μF range in parallel with a smaller capacitor (0.1 μF 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.

Figure 13. 48-TQFP Package Example

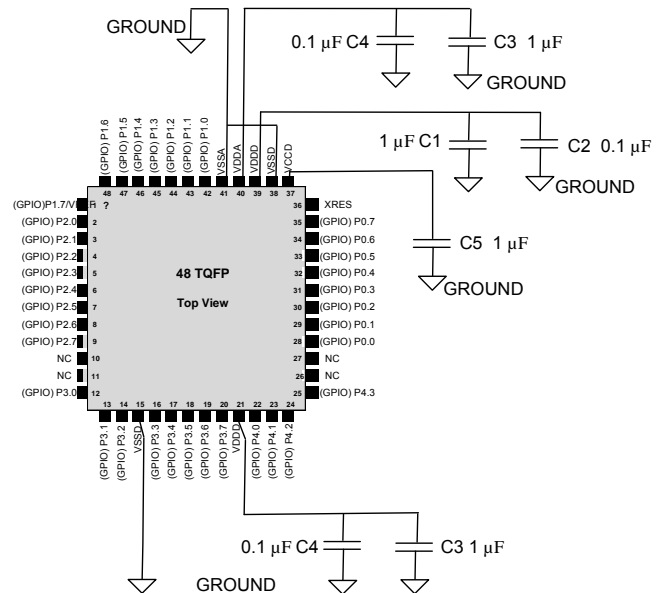
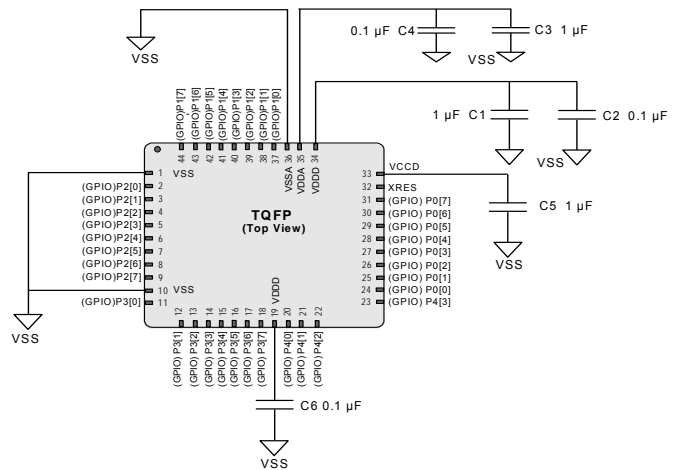


Figure 14. 44-TQFP Package Example



| Power Supply | Bypass Capacitors |
|------------------------------|--|
| $V_{DDD}-V_{SS}$ | 0.1- μF ceramic at each pin (C2, C6) plus bulk capacitor 1 μF to 10 μF (C1). Total capacitance may be greater than 10 μF . |
| $V_{DDA}-V_{SSA}$ | 0.1- μF ceramic at pin (C4). Additional 1 μF to 10 μF (C3) bulk capacitor. Total capacitance may be greater than 10 μF . |
| $V_{CCD}-V_{SS}$ | 1- μF ceramic capacitor at the V_{CCD} pin (C5) |
| $V_{REF}-V_{SSA}$ (optional) | The internal bandgap may be bypassed with a 1- μF to 10- μF capacitor. Total capacitance may be greater than 10 μF . |

Note It is good practice to check the datasheets for your bypass capacitors, specifically the working voltage and the DC bias specifications. With some capacitors, the actual capacitance can decrease considerably when the DC bias (V_{DDA} , V_{DDD} , or V_{CCD})

is a significant percentage of the rated working voltage. V_{DDA} must be equal to or higher than the V_{DDD} supply when powering up.

Figure 15. 40-pin QFN Example

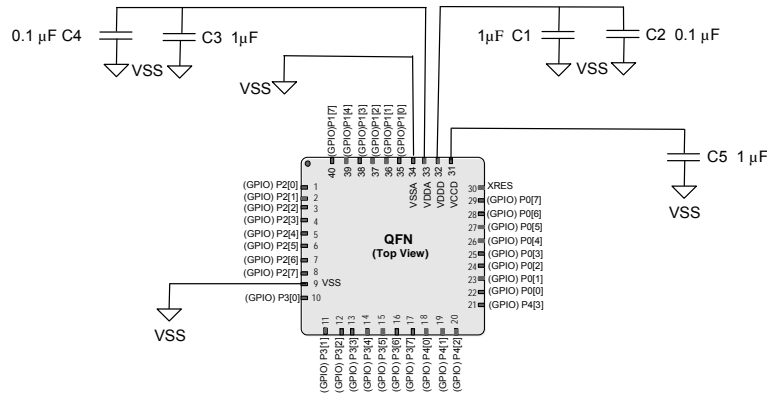
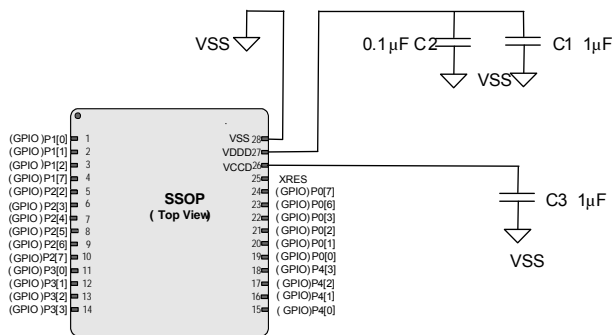


Figure 16. 28-SSOP Example



Regulated External Supply

In this mode, PSoC 4200 is powered by an external power supply that must be within the range of 1.71 V to 1.89 V ($1.8 \pm 5\%$); note that this range needs to include power supply ripple too. In this mode, V_{CCD} , V_{DDA} , and V_{DDD} pins are all shorted together and bypassed. The internal regulator is disabled in firmware.

Development Support

The PSoC 4200 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 to find out more.

Documentation

A suite of documentation supports the PSoC 4200 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.

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 4200 family is part of a development tool ecosystem. Visit us at 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 1. Absolute Maximum Ratings^[1]

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|----------|-----------------------------|--|------|-----|----------------------|-------|--|
| SID1 | V _{DDD_ABS} | Digital supply relative to V _{SSD} | -0.5 | - | 6 | V | Absolute max |
| SID2 | V _{CCD_ABS} | Direct digital core voltage input relative to V _{SSD} | -0.5 | - | 1.95 | V | Absolute max |
| SID3 | V _{GPIO_ABS} | GPIO voltage | -0.5 | - | V _{DD} +0.5 | V | Absolute max |
| SID4 | I _{GPIO_ABS} | Maximum current per GPIO | -25 | - | 25 | mA | Absolute max |
| SID5 | I _{GPIO_injection} | GPIO injection current, Max for V _{IH} > V _{DDD} , and Min for V _{IL} < V _{SS} | -0.5 | - | 0.5 | mA | Absolute max, 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 | -200 | - | 200 | mA | |

Device Level Specifications

All specifications are valid for -40 °C ≤ TA ≤ 105 °C and TJ ≤ 125 °C, except where noted. Specifications are valid for 1.71 V to 5.5 V, except where noted.

Table 2. DC Specifications

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---|------------------|---|------|------|------|-------|----------------------------------|
| SID53 | V _{DD} | Power Supply Input Voltage (V _{DDA} = V _{DDD} = V _{DD}) | 1.8 | - | 5.5 | V | With regulator enabled |
| SID255 | V _{DDD} | Power Supply Input Voltage unregulated | 1.71 | 1.8 | 1.89 | V | Internally unregulated supply |
| SID54 | V _{CCD} | Output voltage (for core logic) | - | 1.8 | - | V | |
| SID55 | CEFC | External Regulator voltage bypass | 1 | 1.3 | 1.6 | μF | X5R ceramic or better |
| SID56 | CEXC | Power supply decoupling capacitor | - | 1 | - | μF | X5R ceramic or better |
| Active Mode, V_{DD} = 1.71 V to 5.5 V. Typical Values measured at V_{DD} = 3.3 V | | | | | | | |
| SID9 | IDD4 | Execute from Flash; CPU at 6 MHz | - | - | 2.8 | mA | |
| SID10 | IDD5 | Execute from Flash; CPU at 6 MHz | - | 2.2 | - | mA | T = 25 °C |
| SID12 | IDD7 | Execute from Flash; CPU at 12 MHz, | - | - | 4.2 | mA | |
| SID13 | IDD8 | Execute from Flash; CPU at 12 MHz | - | 3.7 | - | mA | T = 25 °C |
| SID16 | IDD11 | Execute from Flash; CPU at 24 MHz | - | 6.7 | - | mA | T = 25 °C |
| SID17 | IDD12 | Execute from Flash; CPU at 24 MHz | - | - | 7.2 | mA | |
| SID19 | IDD14 | Execute from Flash; CPU at 48 MHz | - | 12.8 | - | mA | T = 25 °C |
| SID20 | IDD15 | Execute from Flash; CPU at 48 MHz | - | - | 13.8 | mA | |
| Sleep Mode, V_{DD} = 1.7 V to 5.5 V | | | | | | | |
| SID25 | IDD20 | I ² C wakeup, WDT, and Comparators on. 6 MHz. | - | 1.3 | 1.8 | mA | V _{DD} = 1.71 to 5.5 V. |
| SID25A | IDD20A | I ² C wakeup, WDT, and Comparators on. 12 MHz | - | 1.7 | 2.2 | mA | V _{DD} = 1.71 to 5.5 V. |

Note

- 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 2. DC Specifications (continued)

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/ Conditions |
|--|-----------|--|-----|-----|------|-------|--------------------------------|
| Deep Sleep Mode, V_{DD} = 1.8 V to 3.6 V (Regulator on) | | | | | | | |
| SID31 | IDD26 | I ² C wakeup and WDT on. | – | 1.3 | – | μA | T = 25 °C |
| SID32 | IDD27 | I ² C wakeup and WDT on. | – | – | 45 | μA | T = 85 °C |
| Deep Sleep Mode, V_{DD} = 3.6 V to 5.5 V | | | | | | | |
| SID34 | IDD29 | I ² C wakeup and WDT on | – | 1.5 | 15 | μA | Typ. at 25 °C. Max at 85 °C. |
| Deep Sleep Mode, V_{DD} = 1.71 V to 1.89 V (Regulator bypassed) | | | | | | | |
| SID37 | IDD32 | I ² C wakeup and WDT on. | – | 1.7 | – | μA | T = 25 °C |
| SID38 | IDD33 | I ² C wakeup and WDT on | – | – | 60 | μA | T = 85 °C |
| Deep Sleep Mode, +105 °C | | | | | | | |
| SID33Q | IDD28Q | I ² C wakeup and WDT on. Regulator Off. | – | – | 135 | μA | V _{DD} = 1.71 to 1.89 |
| SID34Q | IDD29Q | I ² C wakeup and WDT on. | – | – | 180 | μA | V _{DD} = 1.8 to 3.6 |
| SID35Q | IDD30Q | I ² C wakeup and WDT on. | – | – | 140 | μA | V _{DD} = 3.6 to 5.5 |
| Hibernate Mode, V_{DD} = 1.8 V to 3.6 V (Regulator on) | | | | | | | |
| SID40 | IDD35 | GPIO and Reset active | – | 150 | – | nA | T = 25 °C |
| SID41 | IDD36 | GPIO and Reset active | – | – | 1000 | nA | T = 85 °C |
| Hibernate Mode, V_{DD} = 3.6 V to 5.5 V | | | | | | | |
| SID43 | IDD38 | GPIO and Reset active | – | 150 | – | nA | T = 25 °C |
| Hibernate Mode, V_{DD} = 1.71 V to 1.89 V (Regulator bypassed) | | | | | | | |
| SID46 | IDD41 | GPIO and Reset active | – | 150 | – | nA | T = 25 °C |
| SID47 | IDD42 | GPIO and Reset active | – | – | 1000 | nA | T = 85 °C |
| Hibernate Mode, +105 °C | | | | | | | |
| SID42Q | IDD37Q | Regulator Off | – | – | 19.4 | μA | V _{DD} = 1.71 to 1.89 |
| SID43Q | IDD38Q | | – | – | 17 | μA | V _{DD} = 1.8 to 3.6 |
| SID44Q | IDD39Q | | – | – | 16 | μA | V _{DD} = 3.6 to 5.5 |
| Stop Mode | | | | | | | |
| SID304 | IDD43A | Stop Mode current; V _{DD} = 3.3 V | – | 20 | 80 | nA | Typ. at 25 °C. Max at 85 °C. |
| Stop Mode, +105 °C | | | | | | | |
| SID304Q | IDD43AQ | Stop Mode current; V _{DD} = 3.6 V | – | – | 5645 | nA | |
| XRES current | | | | | | | |
| SID307 | IDD_XR | Supply current while XRES asserted | – | 2 | 5 | mA | |

Table 3. AC Specifications

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/ Conditions |
|----------|-------------------------|--------------------------------------|-----|-----|-----|-------|--|
| SID48 | F _{CPU} | CPU frequency | DC | – | 48 | MHz | 1.71 ≤ V _{DD} ≤ 5.5 |
| SID49 | T _{SLEEP} | Wakeup from sleep mode | – | 0 | – | μs | Guaranteed by characterization |
| SID50 | T _{DEEPSLEEP} | Wakeup from Deep Sleep mode | – | – | 25 | μs | 24 MHz IMO. Guaranteed by characterization |
| SID51 | T _{HIBERNATE} | Wakeup from Hibernate and Stop modes | – | – | 2 | ms | Guaranteed by characterization |
| SID52 | T _{RESETWIDTH} | External reset pulse width | 1 | – | – | μs | Guaranteed by characterization |

GPIO

Table 4. GPIO DC Specifications

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/ Conditions |
|----------|-----------------|--|-----------------------|-----|----------------------|------------|--|
| SID57 | $V_{IH}^{[2]}$ | Input voltage high threshold | $0.7 \times V_{DD3}$ | – | – | V | CMOS Input |
| SID58 | V_{IL} | Input voltage low threshold | – | – | $0.3 \times V_{DD3}$ | V | CMOS Input |
| SID241 | $V_{IH}^{[2]}$ | LVTTL input, $V_{DD3} < 2.7$ V | $0.7 \times V_{DD3}$ | – | – | V | |
| SID242 | V_{IL} | LVTTL input, $V_{DD3} < 2.7$ V | – | – | $0.3 \times V_{DD3}$ | V | |
| SID243 | $V_{IH}^{[2]}$ | LVTTL input, $V_{DD3} \geq 2.7$ V | 2.0 | – | – | V | |
| SID244 | V_{IL} | LVTTL input, $V_{DD3} \geq 2.7$ V | – | – | 0.8 | V | |
| SID59 | V_{OH} | Output voltage high level | $V_{DD3} - 0.6$ | – | – | V | $I_{OH} = 4$ mA at 3-V V_{DD3} |
| SID60 | V_{OH} | Output voltage high level | $V_{DD3} - 0.5$ | – | – | V | $I_{OH} = 1$ mA at 1.8-V V_{DD3} |
| SID61 | V_{OL} | Output voltage low level | – | – | 0.4 | V | $I_{OL} = 4$ mA at 1.8-V V_{DD3} |
| SID62 | V_{OL} | Output voltage low level | – | – | 0.6 | V | $I_{OL} = 8$ mA at 3-V V_{DD3} |
| SID62A | V_{OL} | Output voltage low level | – | – | 0.4 | V | $I_{OL} = 3$ mA at 3-V V_{DD3} |
| SID63 | R_{PULLUP} | Pull-up resistor | 3.5 | 5.6 | 8.5 | k Ω | |
| SID64 | $R_{PULLDOWN}$ | Pull-down resistor | 3.5 | 5.6 | 8.5 | k Ω | |
| SID65 | I_{IL} | Input leakage current (absolute value) | – | – | 2 | nA | 25 °C, $V_{DD3} = 3.0$ V |
| SID65A | I_{IL_CTBM} | Input leakage current (absolute value) for CTBM pins | – | – | 4 | nA | |
| SID66 | C_{IN} | Input capacitance | – | – | 7 | pF | |
| SID67 | V_{HYSTTL} | Input hysteresis LVTTL | 25 | 40 | – | mV | $V_{DD3} \geq 2.7$ V. Guaranteed by characterization |
| SID68 | $V_{HYSCMOS}$ | Input hysteresis CMOS | $0.05 \times V_{DD3}$ | – | – | mV | Guaranteed by characterization |
| SID69 | I_{DIODE} | Current through protection diode to V_{DD}/V_{SS} | – | – | 100 | μ A | Guaranteed by characterization |
| SID69A | I_{TOT_GPIO} | Maximum Total Source or Sink Chip Current | – | – | 200 | mA | Guaranteed by characterization |

Note

 2. V_{IH} must not exceed $V_{DD3} + 0.2$ V.

Table 5. GPIO AC Specifications

(Guaranteed by Characterization)

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/ Conditions |
|----------|----------------------|---|-----|-----|------|-------|--|
| SID70 | T _{RISEF} | Rise time in fast strong mode | 2 | – | 12 | ns | 3.3-V V _{DDD} , Clload = 25 pF |
| SID71 | T _{FALLF} | Fall time in fast strong mode | 2 | – | 12 | ns | 3.3-V V _{DDD} , Clload = 25 pF |
| SID72 | T _{RISES} | Rise time in slow strong mode | 10 | – | 60 | ns | 3.3-V V _{DDD} , Clload = 25 pF |
| SID73 | T _{FALLS} | Fall time in slow strong mode | 10 | – | 60 | ns | 3.3-V V _{DDD} , Clload = 25 pF |
| SID74 | F _{GPIOUT1} | GPIO Fout; 3.3 V ≤ V _{DDD} ≤ 5.5 V. Fast strong mode. | – | – | 33 | MHz | 90/10%, 25-pF load, 60/40 duty cycle |
| SID75 | F _{GPIOUT2} | GPIO Fout; 1.7 V ≤ V _{DDD} ≤ 3.3 V. Fast strong mode. | – | – | 16.7 | MHz | 90/10%, 25-pF load, 60/40 duty cycle |
| SID76 | F _{GPIOUT3} | GPIO Fout; 3.3 V ≤ V _{DDD} ≤ 5.5 V. Slow strong mode. | – | – | 7 | MHz | 90/10%, 25-pF load, 60/40 duty cycle |
| SID245 | F _{GPIOUT4} | GPIO Fout; 1.7 V ≤ V _{DDD} ≤ 3.3 V. Slow strong mode. | – | – | 3.5 | MHz | 90/10%, 25-pF load, 60/40 duty cycle |
| SID246 | F _{GPIOIN} | GPIO input operating frequency; 1.71 V ≤ V _{DDD} ≤ 5.5 V | – | – | 48 | MHz | 90/10% V _{IO} |

XRES

Table 6. XRES DC Specifications

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/ Conditions |
|----------|----------------------|---|------------------------|-----|------------------------|-------|--------------------------------|
| SID77 | V _{IH} | Input voltage high threshold | 0.7 × V _{DDD} | – | – | V | CMOS input |
| SID78 | V _{IL} | Input voltage low threshold | – | – | 0.3 × V _{DDD} | V | CMOS input |
| SID79 | R _{PULLUP} | Pull-up resistor | 3.5 | 5.6 | 8.5 | kΩ | |
| SID80 | C _{IN} | Input capacitance | – | 3 | – | pF | |
| SID81 | V _{HYSXRES} | Input voltage hysteresis | – | 100 | – | mV | Guaranteed by characterization |
| SID82 | I _{DIODE} | Current through protection diode to V _{DDD} /V _{SS} | – | – | 100 | μA | Guaranteed by characterization |

Table 7. XRES AC Specifications

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/ Conditions |
|----------|-------------------------|-------------------|-----|-----|-----|-------|--------------------------------|
| SID83 | T _{RESETWIDTH} | Reset pulse width | 1 | – | – | μs | Guaranteed by characterization |

Analog Peripherals
Opamp
Table 8. Opamp Specifications

(Guaranteed by Characterization)

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/ Conditions |
|----------|--------------------------|--|-------|------|------------------------|---------|---------------------------|
| | I _{DD} | Opamp block current. No load. | – | – | – | – | |
| SID269 | I _{DD_HI} | Power = high | – | 1100 | 1850 | μA | |
| SID270 | I _{DD_MED} | Power = medium | – | 550 | 950 | μA | |
| SID271 | I _{DD_LOW} | Power = low | – | 150 | 350 | μA | |
| | GBW | Load = 20 pF, 0.1 mA. V _{DDA} = 2.7 V | – | – | – | – | |
| SID272 | GBW_HI | Power = high | 6 | – | – | MHz | |
| SID273 | GBW_MED | Power = medium | 4 | – | – | MHz | |
| SID274 | GBW_LO | Power = low | – | 1 | – | MHz | |
| | I _{OUT_MAX} | V _{DDA} ≥ 2.7 V, 500 mV from rail | – | – | – | – | |
| SID275 | I _{OUT_MAX_HI} | Power = high | 10 | – | – | mA | |
| SID276 | I _{OUT_MAX_MID} | Power = medium | 10 | – | – | mA | |
| SID277 | I _{OUT_MAX_LO} | Power = low | – | 5 | – | mA | |
| | I _{OUT} | V _{DDA} = 1.71 V, 500 mV from rail | – | – | – | – | |
| SID278 | I _{OUT_MAX_HI} | Power = high | 4 | – | – | mA | |
| SID279 | I _{OUT_MAX_MID} | Power = medium | 4 | – | – | mA | |
| SID280 | I _{OUT_MAX_LO} | Power = low | – | 2 | – | mA | |
| SID281 | V _{IN} | Charge pump on, V _{DDA} ≥ 2.7 V | –0.05 | – | V _{DDA} – 0.2 | V | |
| SID282 | V _{CM} | Charge pump on, V _{DDA} ≥ 2.7 V | –0.05 | – | V _{DDA} – 0.2 | V | |
| | V _{OUT} | V _{DDA} ≥ 2.7 V | – | – | – | – | |
| SID283 | V _{OUT_1} | Power = high, I _{load} =10 mA | 0.5 | – | V _{DDA} – 0.5 | V | |
| SID284 | V _{OUT_2} | Power = high, I _{load} =1 mA | 0.2 | – | V _{DDA} – 0.2 | V | |
| SID285 | V _{OUT_3} | Power = medium, I _{load} =1 mA | 0.2 | – | V _{DDA} – 0.2 | V | |
| SID286 | V _{OUT_4} | Power = low, I _{load} =0.1mA | 0.2 | – | V _{DDA} – 0.2 | V | |
| SID288 | V _{OS_TR} | Offset voltage, trimmed | 1 | ±0.5 | 1 | mV | High mode |
| SID288A | V _{OS_TR} | Offset voltage, trimmed | – | ±1 | – | mV | Medium mode |
| SID288B | V _{OS_TR} | Offset voltage, trimmed | – | ±2 | – | mV | Low mode |
| SID290 | V _{OS_DR_TR} | Offset voltage drift, trimmed | –10 | ±3 | 10 | μV/°C | High mode. TA ≤ 85 °C |
| SID290Q | V _{OS_DR_TR} | Offset voltage drift, trimmed | 15 | ±3 | 15 | μV/°C | High mode. TA ≤ 105 °C |
| SID290A | V _{OS_DR_TR} | Offset voltage drift, trimmed | – | ±10 | – | μV/°C | Medium mode |
| SID290B | V _{OS_DR_TR} | Offset voltage drift, trimmed | – | ±10 | – | μV/°C | Low mode |
| SID291 | CMRR | DC | 70 | 80 | – | dB | V _{DD} = 3.6 V |
| SID292 | PSRR | At 1 kHz, 100-mV ripple | 70 | 85 | – | dB | V _{DD} = 3.6 V |
| | Noise | | – | – | – | – | |
| SID293 | V _{N1} | Input referred, 1 Hz - 1GHz, power = high | – | 94 | – | μVrms | |
| SID294 | V _{N2} | Input referred, 1 kHz, power = high | – | 72 | – | nV/rtHz | |
| SID295 | V _{N3} | Input referred, 10kHz, power = high | – | 28 | – | nV/rtHz | |

Table 8. Opamp Specifications

(Guaranteed by Characterization) (continued)

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/ Conditions |
|----------|------------------|--|-----|------|-----|------------|------------------------|
| SID296 | V_{N4} | Input referred, 100kHz, power = high | – | 15 | – | nV/rtHz | |
| SID297 | Cload | Stable up to maximum load. Performance specs at 50 pF. | – | – | 125 | pF | |
| SID298 | Slew_rate | Cload = 50 pF, Power = High, $V_{DDA} \geq 2.7$ V | 6 | – | – | V/ μ s | |
| SID299 | T_op_wake | From disable to enable, no external RC dominating | – | 300 | – | μ s | |
| SID299A | OL_GAIN | Open Loop Gain | – | 90 | – | dB | Guaranteed by design |
| | Comp_mode | Comparator mode; 50 mV drive, Trise = Tfall (approx.) | – | – | – | | |
| SID300 | T _{PD1} | Response time; power = high | – | 150 | – | ns | |
| SID301 | T _{PD2} | Response time; power = medium | – | 400 | – | ns | |
| SID302 | T _{PD3} | Response time; power = low | – | 2000 | – | ns | |
| SID303 | Vhyst_op | Hysteresis | – | 10 | – | mV | |

Comparatorr
Table 9. Comparator DC Specifications

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/ Conditions |
|----------|----------------------|---|-----|----------|------------------|---------|--|
| SID85 | V _{OFFSET2} | Input offset voltage, Common Mode voltage range from 0 to $V_{DD}-1$ | – | – | ± 4 | mV | |
| SID85A | V _{OFFSET3} | Input offset voltage. Ultra low-power mode ($V_{DDD} \geq 2.2$ V for Temp < 0 °C, $V_{DDD} \geq 1.8$ V for Temp > 0 °C) | – | ± 12 | – | mV | |
| SID86 | V _{HYST} | Hysteresis when enabled, Common Mode voltage range from 0 to $V_{DD}-1$. | – | 10 | 35 | mV | Guaranteed by characterization |
| SID87 | V _{ICM1} | Input common mode voltage in normal mode | 0 | – | $V_{DDD} - 0.1$ | V | Modes 1 and 2. |
| SID247 | V _{ICM2} | Input common mode voltage in low power mode ($V_{DDD} \geq 2.2$ V for Temp < 0 °C, $V_{DDD} \geq 1.8$ V for Temp > 0 °C) | 0 | – | V_{DDD} | V | |
| SID247A | V _{ICM3} | Input common mode voltage in ultra low power mode | 0 | – | $V_{DDD} - 1.15$ | V | |
| SID88 | CMRR | Common mode rejection ratio | 50 | – | – | dB | $V_{DDD} \geq 2.7$ V. Guaranteed by characterization |
| SID88A | CMRR | Common mode rejection ratio | 42 | – | – | dB | $V_{DDD} < 2.7$ V. Guaranteed by characterization |
| SID89 | I _{CMP1} | Block current, normal mode | – | – | 400 | μ A | Guaranteed by characterization |
| SID248 | I _{CMP2} | Block current, low power mode | – | – | 100 | μ A | Guaranteed by characterization |
| SID259 | I _{CMP3} | Block current, ultra low power mode ($V_{DDD} \geq 2.2$ V for Temp < 0 °C, $V_{DDD} \geq 1.8$ V for Temp > 0 °C) | – | 6 | 28 | μ A | Guaranteed by characterization |

Table 9. Comparator DC Specifications (continued)

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|----------|------------------|----------------------------------|-----|-----|-----|-------|--------------------------------|
| SID90 | Z _{CMP} | DC input impedance of comparator | 35 | – | – | MΩ | Guaranteed by characterization |

Table 10. Comparator AC Specifications

(Guaranteed by Characterization)

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|----------|--------------------|--|-----|-----|-----|-------|--------------------|
| SID91 | T _{RESP1} | Response time, normal mode | – | – | 110 | ns | 50-mV overdrive |
| SID258 | T _{RESP2} | Response time, low power mode | – | – | 200 | ns | 50-mV overdrive |
| SID92 | T _{RESP3} | Response time, ultra low power mode (V _{DD} ≥ 2.2 V for Temp < 0 °C, V _{DD} ≥ 1.8 V for Temp > 0 °C) | – | – | 15 | μs | 200-mV overdrive |

Temperature Sensor

Table 11. Temperature Sensor Specifications

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|----------|----------------------|-----------------------------|-----|-----|-----|-------|--------------------|
| SID93 | T _{SENSACC} | Temperature sensor accuracy | –5 | ±1 | +5 | °C | –40 to +85 °C |

SAR ADC

Table 12. SAR ADC DC Specifications

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|----------|-----------|------------------------------------|-----------------|-----|------------------|-------|---|
| SID94 | A_RES | Resolution | – | – | 12 | bits | |
| SID95 | A_CHNIS_S | Number of channels - single ended | – | – | 8 | | 8 full speed |
| SID96 | A-CHNKS_D | Number of channels - differential | – | – | 4 | | Diff inputs use neighboring I/O |
| SID97 | A-MONO | Monotonicity | – | – | – | | Yes. Based on characterization |
| SID98 | A_GAINERR | Gain error | – | – | ±0.1 | % | With external reference. Guaranteed by characterization |
| SID99 | A_OFFSET | Input offset voltage | – | – | 2 | mV | Measured with 1-V V _{REF} . Guaranteed by characterization |
| SID100 | A_ISAR | Current consumption | – | – | 1 | mA | |
| SID101 | A_VINS | Input voltage range - single ended | V _{SS} | – | V _{DDA} | V | Based on device characterization |
| SID102 | A_VIND | Input voltage range - differential | V _{SS} | – | V _{DDA} | V | Based on device characterization |
| SID103 | A_INRES | Input resistance | – | – | 2.2 | KΩ | Based on device characterization |
| SID104 | A_INCAP | Input capacitance | – | – | 10 | pF | Based on device characterization |
| SID106 | A_PSRR | Power supply rejection ratio | 70 | – | – | dB | |
| SID107 | A_CMRR | Common mode rejection ratio | 66 | – | – | dB | Measured at 1 V |

Table 12. SAR ADC DC Specifications (continued)

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|----------|-----------|----------------------------|------|-----|------|-------|--|
| SID111 | A_INL | Integral non linearity | -1.7 | - | +2 | LSB | $V_{DD} = 1.71$ to 5.5, 1 Msps, $V_{ref} = 1$ to 5.5. |
| SID111A | A_INL | Integral non linearity | -1.5 | - | +1.7 | LSB | $V_{DDD} = 1.71$ to 3.6, 1 Msps, $V_{ref} = 1.71$ to V_{DDD} . |
| SID111B | A_INL | Integral non linearity | -1.5 | - | +1.7 | LSB | $V_{DDD} = 1.71$ to 5.5, 500 Ksps, $V_{ref} = 1$ to 5.5. |
| SID112 | A_DNL | Differential non linearity | -1 | - | +2.2 | LSB | $V_{DDD} = 1.71$ to 5.5, 1 Msps, $V_{ref} = 1$ to 5.5. |
| SID112A | A_DNL | Differential non linearity | -1 | - | +2 | LSB | $V_{DDD} = 1.71$ to 3.6, 1 Msps, $V_{ref} = 1.71$ to V_{DDD} . |
| SID112B | A_DNL | Differential non linearity | -1 | - | +2.2 | LSB | $V_{DDD} = 1.71$ to 5.5, 500 Ksps, $V_{ref} = 1$ to 5.5. |

Table 13. SAR ADC AC Specifications

(Guaranteed by Characterization)

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|----------|-----------|--|-----|-----|-----|-------|--------------------|
| SID108 | A_SAMP_1 | Sample rate with external reference bypass cap | - | - | 1 | Msp | |
| SID108A | A_SAMP_2 | Sample rate with no bypass cap. Reference = V_{DD} | - | - | 500 | Ksps | |
| SID108B | A_SAMP_3 | Sample rate with no bypass cap. Internal reference | - | - | 100 | Ksps | |
| SID109 | A_SNR | Signal-to-noise and distortion ratio (SINAD) | 65 | - | - | dB | $F_{IN} = 10$ kHz |
| SID113 | A_THD | Total harmonic distortion | - | - | -65 | dB | $F_{IN} = 10$ kHz. |

CSD

Table 14. CSD Specifications

| Spec ID# | Parameter | Description | Min | Typ | Max | Units | Details/ Conditions |
|------------|--------------|--|------|-------|---------|-------|---|
| SID.CSD#16 | IDAC1IDD | IDAC1 (8 bits) block current | – | – | 1125 | μA | |
| SID.CSD#17 | IDAC2IDD | IDAC2 (7 bits) block current | – | – | 1125 | μA | |
| SID308 | VCS | Voltage range of operation | 1.71 | – | 5.5 | V | |
| SID308A | Vcompidac | Voltage compliance range of IDAC for S0 | 0.8 | – | VDD-0.8 | V | |
| SID309 | IDAC1 | DNL for 8-bit resolution | –1 | – | 1 | LSB | |
| SID310 | IDAC1 | INL for 8-bit resolution | –3 | – | 3 | LSB | |
| SID311 | IDAC2 | DNL for 7-bit resolution | –1 | – | 1 | LSB | |
| SID312 | IDAC2 | INL for 7-bit resolution | –3 | – | 3 | LSB | |
| SID313 | SNR | Ratio of counts of finger to noise, 0.1-pF sensitivity | 5 | – | – | Ratio | Capacitance range of 9 to 35 pF, 0.1-pF sensitivity |
| SID314 | IDAC1_CRT1 | Output current of Idac1 (8 bits) in High range | – | 612 | – | uA | |
| SID314A | IDAC1_CRT2 | Output current of Idac1 (8 bits) in Low range | – | 306 | – | uA | |
| SID315 | IDAC2_CRT1 | Output current of Idac2 (7 bits) in High range | – | 304.8 | – | uA | |
| SID315A | IDAC2_CRT2 | Output current of Idac2 (7 bits) in Low range | – | 152.4 | – | uA | |
| SID320 | IDACOFFSET | All zeroes input | – | – | ±1 | LSB | |
| SID321 | IDACGAIN | Full-scale error less offset | – | – | ±10 | % | |
| SID322 | IDACMISMATCH | Mismatch between IDACs | – | – | 7 | LSB | |
| SID323 | IDACSET8 | Settling time to 0.5 LSB for 8-bit IDAC | – | – | 10 | μs | Full-scale transition. No external load. |
| SID324 | IDACSET7 | 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. |

Digital Peripherals

The following specifications apply to the Timer/Counter/PWM peripherals in the Timer mode.

Timer/Counter/PWM

Table 15. TCPWM Specifications

(Guaranteed by Characterization)

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|--------------|-----------|--|------|-----|-----|-------|--|
| SID.TCPWM.1 | ITCPWM1 | Block current consumption at 3 MHz | – | – | 45 | μA | All modes (Timer/Counter/PWM) |
| SID.TCPWM.2 | ITCPWM2 | Block current consumption at 12 MHz | – | – | 155 | μA | All modes (Timer/Counter/PWM) |
| SID.TCPWM.2A | ITCPWM3 | Block current consumption at 48 MHz | – | – | 650 | μA | All modes (Timer/Counter/PWM) |
| SID.TCPWM.3 | TCPWMFREQ | Operating frequency | – | – | Fc | MHz | Fc max = Fcpu. Maximum = 24 MHz |
| SID.TCPWM.4 | TPWMENEXT | Input Trigger Pulse Width for all Trigger Events | 2/Fc | – | – | ns | Trigger Events can be Stop, Start, Reload, Count, Capture, or Kill depending on which mode of operation is selected. |
| SID.TCPWM.5 | TPWMEXT | Output Trigger Pulse widths | 2/Fc | – | – | ns | Minimum possible width of Overflow, Underflow, and CC (Counter equals Compare value) trigger outputs |
| SID.TCPWM.5A | TCRES | Resolution of Counter | 1/Fc | – | – | ns | Minimum time between successive counts |
| SID.TCPWM.5B | PWMRES | PWM Resolution | 1/Fc | – | – | ns | Minimum pulse width of PWM Output |
| SID.TCPWM.5C | QRES | Quadrature inputs resolution | 1/Fc | – | – | ns | Minimum pulse width between Quadrature phase inputs. |

I^2C

Table 16. Fixed I²C DC Specifications

(Guaranteed by Characterization)

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|-------------------|---|-----|-----|-----|-------|--------------------|
| SID149 | I _{I2C1} | Block current consumption at 100 kHz | – | – | 50 | μA | |
| SID150 | I _{I2C2} | Block current consumption at 400 kHz | – | – | 135 | μA | |
| SID151 | I _{I2C3} | Block current consumption at 1 Mbps | – | – | 310 | μA | |
| SID152 | I _{I2C4} | I ² C enabled in Deep Sleep mode | – | – | 1.4 | μA | |

Table 17. Fixed I²C AC Specifications

(Guaranteed by Characterization)

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|-------------------|-------------|-----|-----|-----|-------|--------------------|
| SID153 | F _{I2C1} | Bit rate | – | – | 1 | Mbps | |

LCD Direct Drive

Table 18. LCD Direct Drive DC Specifications

(Guaranteed by Characterization)

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|-----------------------|---|-----|-----|------|-------|-------------------------------------|
| SID154 | I _{LCDLOW} | Operating current in low power mode | – | 5 | – | μA | 16 × 4 small segment disp. at 50 Hz |
| SID155 | C _{LCDCAP} | LCD capacitance per segment/common driver | – | 500 | 5000 | pF | Guaranteed by Design |
| SID156 | LCD _{OFFSET} | Long-term segment offset | – | 20 | – | mV | |
| SID157 | I _{LCDOP1} | PWM Mode current. 5-V bias. 24-MHz IMO. 25 °C | – | 0.6 | – | mA | 32 × 4 segments. 50 Hz |
| SID158 | I _{LCDOP2} | PWM Mode current. 3.3-V bias. 24-MHz IMO. 25 °C | – | 0.5 | – | mA | 32 × 4 segments. 50 Hz |

Table 19. LCD Direct Drive AC Specifications

(Guaranteed by Characterization)

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|------------------|----------------|-----|-----|-----|-------|--------------------|
| SID159 | F _{LCD} | LCD frame rate | 10 | 50 | 150 | Hz | |

Table 20. Fixed UART DC Specifications

(Guaranteed by Characterization)

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|--------------------|---|-----|-----|-----|-------|--------------------|
| SID160 | I _{UART1} | Block current consumption at 100 Kbits/sec | – | – | 55 | μA | |
| SID161 | I _{UART2} | Block current consumption at 1000 Kbits/sec | – | – | 312 | μA | |

Table 21. Fixed UART AC Specifications

(Guaranteed by Characterization)

| Spec ID | Parameter | Description | Min | Typ | Max | Units |
|---------|-------------------|-------------|-----|-----|-----|-------|
| SID162 | F _{UART} | Bit rate | – | – | 1 | Mbps |

SPI Specifications

Table 22. Fixed SPI DC Specifications

(Guaranteed by Characterization)

| Spec ID | Parameter | Description | Min | Typ | Max | Units |
|---------|-------------------|---|-----|-----|-----|-------|
| SID163 | I _{SPI1} | Block current consumption at 1 Mbts/sec | – | – | 360 | μA |
| SID164 | I _{SPI2} | Block current consumption at 4 Mbts/sec | – | – | 560 | μA |
| SID165 | I _{SPI3} | Block current consumption at 8 Mbts/sec | – | – | 600 | μA |

Table 23. Fixed SPI AC Specifications

(Guaranteed by Characterization)

| Spec ID | Parameter | Description | Min | Typ | Max | Units |
|---------|------------------|---|-----|-----|-----|-------|
| SID166 | F _{SPI} | SPI operating frequency (master; 6X oversampling) | – | – | 8 | MHz |

Table 24. Fixed SPI Master Mode AC Specifications

(Guaranteed by Characterization)

| Spec ID | Parameter | Description | Min | Typ | Max | Units |
|---------|------------------|--|-----|-----|-----|-------|
| SID167 | T _{DMO} | MOSI valid after Sclock driving edge | – | – | 15 | ns |
| SID168 | T _{DSI} | MISO valid before Sclock capturing edge. Full clock, late MISO Sampling used | 20 | – | – | ns |
| SID169 | T _{HMO} | Previous MOSI data hold time with respect to capturing edge at Slave | 0 | – | – | ns |

Table 25. Fixed SPI Slave Mode AC Specifications

(Guaranteed by Characterization)

| Spec ID | Parameter | Description | Min | Typ | Max | Units |
|---------|----------------------|---|-----|-----|------------------------------|-------|
| SID170 | T _{DMI} | MOSI valid before Sclock capturing edge | 40 | – | – | ns |
| SID171 | T _{DSO} | MISO valid after Sclock driving edge | – | – | 42 + 3 × T _{scbclk} | ns |
| SID171A | T _{DSO_ext} | MISO valid after Sclock driving edge in Ext. Clock mode | – | – | 48 | ns |
| SID172 | T _{HSO} | Previous MISO data hold time | 0 | – | – | ns |
| SID172A | T _{SSELSCK} | SSEL Valid to first SCK Valid edge | 100 | – | – | ns |

Memory

Table 26. Flash DC Specifications

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|-----------------|---------------------------|------|-----|-----|-------|--------------------|
| SID173 | V _{PE} | Erase and program voltage | 1.71 | – | 5.5 | V | |

Table 27. Flash AC Specifications

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|--|--|-------|-----|-----|---------|--------------------------------|
| SID174 | T _{ROWWRITE} ^[3] | Row (block) write time (erase and program) | – | – | 20 | ms | Row (block) = 128 bytes |
| SID175 | T _{ROWERASE} ^[3] | Row erase time | – | – | 13 | ms | |
| SID176 | T _{ROWPROGRAM} ^[3] | Row program time after erase | – | – | 7 | ms | |
| SID178 | T _{BULKERASE} ^[3] | Bulk erase time (32 KB) | – | – | 35 | ms | |
| SID180 | T _{DEVPROG} ^[3] | Total device program time | – | – | 7 | seconds | Guaranteed by characterization |
| SID181 | F _{END} | Flash endurance | 100 K | – | – | cycles | Guaranteed by characterization |
| SID182 | F _{RET} | Flash retention. T _A ≤ 55 °C, 100 K P/E cycles | 20 | – | – | years | Guaranteed by characterization |
| SID182A | | Flash retention. T _A ≤ 85 °C, 10 K P/E cycles | 10 | – | – | years | Guaranteed by characterization |
| SID182B | F _{RETQ} | Flash retention. T _A ≤ 105 °C, 10 K P/E cycles, ≤ three years at T _A ≥ 85 °C | 10 | – | 20 | years | Guaranteed by characterization |

Note

- 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.

System Resources

Power-on-Reset (POR) with Brown Out

Table 28. Imprecise Power On Reset (IPOR)

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|-----------------------|----------------------|------|-----|------|-------|--------------------------------|
| SID185 | V _{RISEIPOR} | Rising trip voltage | 0.80 | – | 1.45 | V | Guaranteed by characterization |
| SID186 | V _{FALLIPOR} | Falling trip voltage | 0.75 | – | 1.4 | V | Guaranteed by characterization |
| SID187 | V _{IPORHYST} | Hysteresis | 15 | – | 200 | mV | Guaranteed by characterization |

Table 29. Precise Power On Reset (POR)

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|------------------------|--|------|-----|-----|--------|--|
| SID190 | V _{FALLPPOR} | BOD trip voltage in active and sleep modes | 1.64 | – | – | V | Full functionality between 1.71 V and BOD trip voltage is guaranteed by characterization |
| SID192 | V _{FALLDPSLP} | BOD trip voltage in Deep Sleep | 1.4 | – | – | V | Guaranteed by characterization |
| BID55 | Svdd | Maximum power supply ramp rate | – | – | 67 | kV/sec | |

Voltage Monitors

Table 30. Voltage Monitors DC Specifications

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|--------------------|--------------------------|------|------|------|-------|--------------------------------|
| SID195 | V _{LVI1} | LVI_A/D_SEL[3:0] = 0000b | 1.71 | 1.75 | 1.79 | V | |
| SID196 | V _{LVI2} | LVI_A/D_SEL[3:0] = 0001b | 1.76 | 1.80 | 1.85 | V | |
| SID197 | V _{LVI3} | LVI_A/D_SEL[3:0] = 0010b | 1.85 | 1.90 | 1.95 | V | |
| SID198 | V _{LVI4} | LVI_A/D_SEL[3:0] = 0011b | 1.95 | 2.00 | 2.05 | V | |
| SID199 | V _{LVI5} | LVI_A/D_SEL[3:0] = 0100b | 2.05 | 2.10 | 2.15 | V | |
| SID200 | V _{LVI6} | LVI_A/D_SEL[3:0] = 0101b | 2.15 | 2.20 | 2.26 | V | |
| SID201 | V _{LVI7} | LVI_A/D_SEL[3:0] = 0110b | 2.24 | 2.30 | 2.36 | V | |
| SID202 | V _{LVI8} | LVI_A/D_SEL[3:0] = 0111b | 2.34 | 2.40 | 2.46 | V | |
| SID203 | V _{LVI9} | LVI_A/D_SEL[3:0] = 1000b | 2.44 | 2.50 | 2.56 | V | |
| SID204 | V _{LVI10} | LVI_A/D_SEL[3:0] = 1001b | 2.54 | 2.60 | 2.67 | V | |
| SID205 | V _{LVI11} | LVI_A/D_SEL[3:0] = 1010b | 2.63 | 2.70 | 2.77 | V | |
| SID206 | V _{LVI12} | LVI_A/D_SEL[3:0] = 1011b | 2.73 | 2.80 | 2.87 | V | |
| SID207 | V _{LVI13} | LVI_A/D_SEL[3:0] = 1100b | 2.83 | 2.90 | 2.97 | V | |
| SID208 | V _{LVI14} | LVI_A/D_SEL[3:0] = 1101b | 2.93 | 3.00 | 3.08 | V | |
| SID209 | V _{LVI15} | LVI_A/D_SEL[3:0] = 1110b | 3.12 | 3.20 | 3.28 | V | |
| SID210 | V _{LVI16} | LVI_A/D_SEL[3:0] = 1111b | 4.39 | 4.50 | 4.61 | V | |
| SID211 | LVI_IDD | Block current | – | – | 100 | μA | Guaranteed by characterization |

Table 31. Voltage Monitors AC Specifications

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|----------------------|---------------------------|-----|-----|-----|-------|--------------------------------|
| SID212 | T _{MONTRIP} | Voltage monitor trip time | – | – | 1 | μs | Guaranteed by characterization |

SWD Interface
Table 32. SWD Interface Specifications

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|--------------|---|--------|-----|-------|-------|---------------------------------------|
| SID213 | F_SWDCLK1 | $3.3\text{ V} \leq V_{DD} \leq 5.5\text{ V}$ | – | – | 14 | MHz | SWDCLK \leq 1/3 CPU clock frequency |
| SID214 | F_SWDCLK2 | $1.71\text{ V} \leq V_{DD} \leq 3.3\text{ V}$ | – | – | 7 | MHz | SWDCLK \leq 1/3 CPU clock frequency |
| SID215 | T_SWDI_SETUP | $T = 1/f$ SWDCLK | 0.25*T | – | – | ns | Guaranteed by characterization |
| SID216 | T_SWDI_HOLD | $T = 1/f$ SWDCLK | 0.25*T | – | – | ns | Guaranteed by characterization |
| SID217 | T_SWDO_VALID | $T = 1/f$ SWDCLK | – | – | 0.5*T | ns | Guaranteed by characterization |
| SID217A | T_SWDO_HOLD | $T = 1/f$ SWDCLK | 1 | – | – | ns | Guaranteed by characterization |

Internal Main Oscillator
Table 33. IMO DC Specifications

(Guaranteed by Design)

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|-------------------|---------------------------------|-----|-----|------|-------|--------------------|
| SID218 | I _{IMO1} | IMO operating current at 48 MHz | – | – | 1000 | μA | |
| SID219 | I _{IMO2} | IMO operating current at 24 MHz | – | – | 325 | μA | |
| SID220 | I _{IMO3} | IMO operating current at 12 MHz | – | – | 225 | μA | |
| SID221 | I _{IMO4} | IMO operating current at 6 MHz | – | – | 180 | μA | |
| SID222 | I _{IMO5} | IMO operating current at 3 MHz | – | – | 150 | μA | |

Table 34. IMO AC Specifications

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|-------------------------|--------------------------------------|-----|-----|-----|-------|--|
| SID223 | F _{IMOTOL1} | Frequency variation from 3 to 48 MHz | – | – | ±2 | % | ±3% if T _A > 85 °C and IMO frequency < 24 MHz |
| SID226 | T _{STARTIMO} | IMO startup time | – | – | 12 | μs | |
| SID227 | T _{JITRMSIMO1} | RMS Jitter at 3 MHz | – | 156 | – | ps | |
| SID228 | T _{JITRMSIMO2} | RMS Jitter at 24 MHz | – | 145 | – | ps | |
| SID229 | T _{JITRMSIMO3} | RMS Jitter at 48 MHz | – | 139 | – | ps | |

Internal Low-Speed Oscillator
Table 35. ILO DC Specifications

(Guaranteed by Design)

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|----------------------|---------------------------------|-----|-----|------|-------|--------------------------------|
| SID231 | I _{ILO1} | ILO operating current at 32 kHz | – | 0.3 | 1.05 | μA | Guaranteed by Characterization |
| SID233 | I _{ILOLEAK} | ILO leakage current | – | 2 | 15 | nA | Guaranteed by Design |

Table 36. ILO AC Specifications

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|------------------------|--------------------------|-----|-----|-----|-------|---|
| SID234 | T _{STARTILO1} | ILO startup time | – | – | 2 | ms | Guaranteed by characterization |
| SID236 | T _{ILODUTY} | ILO duty cycle | 40 | 50 | 60 | % | Guaranteed by characterization |
| SID237 | F _{ILOTRIM1} | 32 kHz trimmed frequency | 15 | 32 | 50 | kHz | Max ILO frequency is 70 kHz if T _A > 85 °C |

Table 37. External Clock Specifications

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|------------|---|-----|-----|-----|-------|--------------------------------|
| SID305 | ExtClkFreq | External Clock input Frequency | 0 | – | 48 | MHz | Guaranteed by characterization |
| SID306 | ExtClkDuty | Duty cycle; Measured at V _{DD/2} | 45 | – | 55 | % | Guaranteed by characterization |

Table 38. UDB AC Specifications

(Guaranteed by Characterization)

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|------------------------------------|---------------------------|---|-----|-----|-----|-------|--------------------|
| Datapath performance | | | | | | | |
| SID249 | F _{MAX-TIMER} | Max frequency of 16-bit timer in a UDB pair | – | – | 48 | MHz | |
| SID250 | F _{MAX-ADDER} | Max frequency of 16-bit adder in a UDB pair | – | – | 48 | MHz | |
| SID251 | F _{MAX_CRC} | Max frequency of 16-bit CRC/PRS in a UDB pair | – | – | 48 | MHz | |
| PLD Performance in UDB | | | | | | | |
| SID252 | F _{MAX_PLD} | Max frequency of 2-pass PLD function in a UDB pair | – | – | 48 | MHz | |
| Clock to Output Performance | | | | | | | |
| SID253 | T _{CLK_OUT_UDB1} | Prop. delay for clock in to data out at 25 °C, Typ. | – | 15 | – | ns | |
| SID254 | T _{CLK_OUT_UDB2} | Prop. delay for clock in to data out, Worst case. | – | 25 | – | ns | |

Table 39. Block Specs

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|------------------------|---|-----|-----|-----|---------|---|
| SID256* | T _{WS48} * | Number of wait states at 48 MHz | 1 | – | – | | CPU execution from Flash. Guaranteed by characterization |
| SID257 | T _{WS24} * | Number of wait states at 24 MHz | 0 | – | – | | CPU execution from Flash. Guaranteed by characterization |
| SID260 | V _{REFSAR} | Trimmed internal reference to SAR | –1 | – | +1 | % | Percentage of V _{bg} (1.024 V). Guaranteed by characterization |
| SID262 | T _{CLKSWITCH} | Clock switching from clk1 to clk2 in clk1 periods | 3 | – | 4 | Periods | . Guaranteed by design |

* T_{WS48} and T_{WS24} are guaranteed by Design

Table 40. UDB Port Adaptor Specifications

(Based on LPC Component Specs, Guaranteed by Characterization -10-pF load, 3-V V_{DDIO} and V_{DDD})

| Spec ID | Parameter | Description | Min | Typ | Max | Units | Details/Conditions |
|---------|-------------------------|---------------------------------------|-----|-----|-----|-------|--------------------|
| SID263 | T _{LCLKDO} | LCLK to output delay | – | – | 18 | ns | |
| SID264 | T _{DINLCLK} | Input setup time to LCLK rising edge | – | – | 7 | ns | |
| SID265 | T _{DINLCLKHLD} | Input hold time from LCLK rising edge | 5 | – | – | ns | |
| SID266 | T _{LCLKHIZ} | LCLK to output tristated | – | – | 28 | ns | |
| SID267 | T _{FLCLK} | LCLK frequency | – | – | 33 | MHz | |
| SID268 | T _{LCLKDUTY} | LCLK duty cycle (percentage high) | 40 | – | 60 | % | |

Ordering Information

The PSoC 4200 part numbers and features are listed in the following table.

Table 41. PSoC 4200 Family Ordering Information

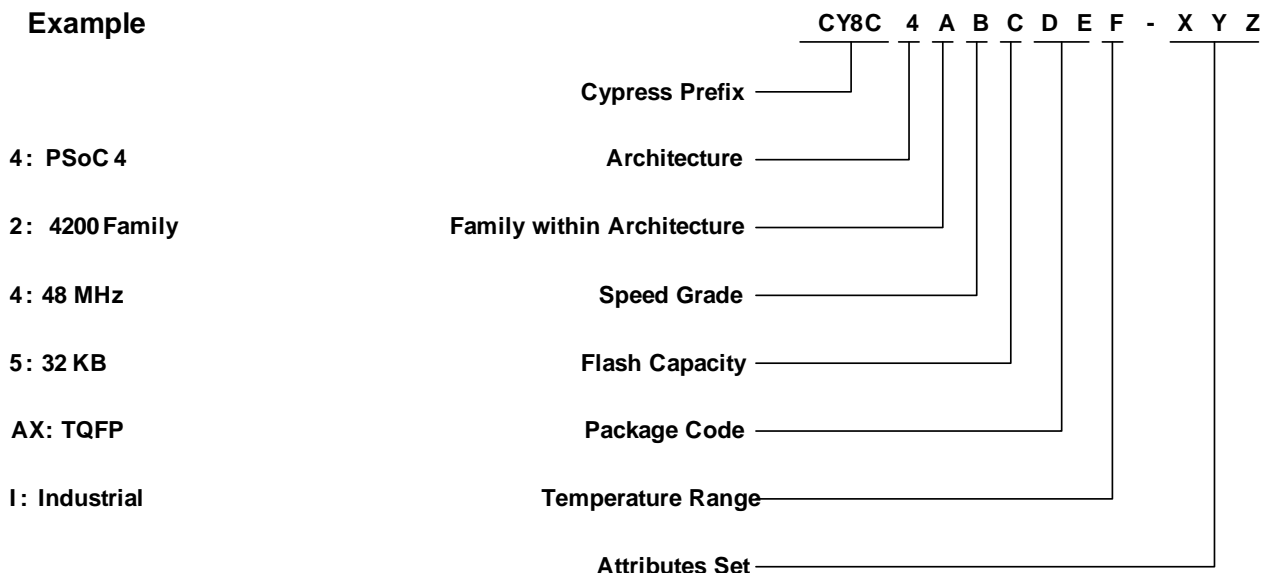
| Family | MPN | Features | | | | | | | | | | | | Package | | | | |
|-----------------|--------------------|---------------------|------------|-----------|-----|---------------|----------|------------------|----------------|----------------|--------------|------------|------|---------|----------|--------|---------|---------|
| | | Max CPU Speed (MHz) | Flash (KB) | SRAM (KB) | UDB | Op-amp (CTBm) | CapSense | Direct LCD Drive | 12-bit SAR ADC | LP Comparators | TCPWM Blocks | SCB Blocks | GPIO | 28-SSOP | 35-WLCSP | 40-QFN | 44-TQFP | 48-TQFP |
| 4200 | CY8C4244PVI-432 | 48 | 16 | 4 | 2 | 1 | - | - | 1 Msps | 2 | 4 | 2 | 24 | √ | | | | |
| | CY8C4244PVI-442 | 48 | 16 | 4 | 2 | 1 | √ | √ | 1 Msps | 2 | 4 | 2 | 24 | √ | | | | |
| | CY8C4244PVQ-432 | 48 | 16 | 4 | 2 | 1 | - | - | 1 Msps | 2 | 4 | 2 | 24 | √ | | | | |
| | CY8C4244PVQ-442 | 48 | 16 | 4 | 2 | 1 | √ | √ | 1 Msps | 2 | 4 | 2 | 24 | √ | | | | |
| | CY8C4244FNI-443 | 48 | 16 | 4 | 2 | 2 | √ | √ | 1 Msps | 2 | 4 | 2 | 31 | | √ | | | |
| | CY8C4244LQI-443 | 48 | 16 | 4 | 2 | 2 | √ | √ | 1 Msps | 2 | 4 | 2 | 34 | | | √ | | |
| | CY8C4244AXI-443 | 48 | 16 | 4 | 2 | 2 | √ | √ | 1 Msps | 2 | 4 | 2 | 36 | | | | √ | |
| | CY8C4244LQQ-443 | 48 | 16 | 4 | 2 | 2 | √ | √ | 1 Msps | 2 | 4 | 2 | 34 | | | √ | | |
| | CY8C4244AXQ-443 | 48 | 16 | 4 | 2 | 2 | √ | √ | 1 Msps | 2 | 4 | 2 | 36 | | | | √ | |
| | CY8C4244AZI-443 | 48 | 16 | 4 | 2 | 2 | √ | √ | 1 Msps | 2 | 4 | 2 | 36 | | | | | √ |
| | CY8C4245AXI-473 | 48 | 32 | 4 | 4 | 2 | - | - | 1 Msps | 2 | 4 | 2 | 36 | | | | √ | |
| | CY8C4245AXQ-473 | 48 | 32 | 4 | 4 | 2 | - | - | 1 Msps | 2 | 4 | 2 | 36 | | | | √ | |
| | CY8C4245AZI-473 | 48 | 32 | 4 | 4 | 2 | - | - | 1 Msps | 2 | 4 | 2 | 36 | | | | | √ |
| | CY8C4245PVI-482 | 48 | 32 | 4 | 4 | 1 | √ | √ | 1 Msps | 2 | 4 | 2 | 24 | √ | | | | |
| | CY8C4245PVQ-482 | 48 | 32 | 4 | 4 | 1 | √ | √ | 1 Msps | 2 | 4 | 2 | 24 | √ | | | | |
| | CY8C4245FNI-483(T) | 48 | 32 | 4 | 4 | 2 | √ | √ | 1 Msps | 2 | 4 | 2 | 31 | | √ | | | |
| | CY8C4245LQI-483 | 48 | 32 | 4 | 4 | 2 | √ | √ | 1 Msps | 2 | 4 | 2 | 34 | | | √ | | |
| | CY8C4245AXI-483 | 48 | 32 | 4 | 4 | 2 | √ | √ | 1 Msps | 2 | 4 | 2 | 36 | | | | √ | |
| | CY8C4245LQQ-483 | 48 | 32 | 4 | 4 | 2 | √ | √ | 1 Msps | 2 | 4 | 2 | 34 | | | √ | | |
| | CY8C4245AXQ-483 | 48 | 32 | 4 | 4 | 2 | √ | √ | 1 Msps | 2 | 4 | 2 | 36 | | | | √ | |
| CY8C4245AZI-483 | 48 | 32 | 4 | 4 | 2 | √ | √ | 1 Msps | 2 | 4 | 2 | 36 | | | | | √ | |

Part Numbering Conventions

PSoC 4 devices follow the part numbering convention described in the following table. All fields are single-character alphanumeric (0, 1, 2, ..., 9, A,B, ..., Z) unless stated otherwise.

The part numbers are of the form CY8C4ABCDEF-XYZ where the fields are defined as follows.

Example



The Field Values are listed in the following table.

| Field | Description | Values | Meaning |
|-------|----------------------------|---------|--|
| CY8C | Cypress Prefix | | |
| 4 | Architecture | 4 | PSoC 4 |
| A | Family within architecture | 1 | 4100 Family |
| | | 2 | 4200 Family |
| B | CPU Speed | 2 | 24 MHz |
| | | 4 | 48 MHz |
| C | Flash Capacity | 4 | 16 KB |
| | | 5 | 32 KB |
| DE | Package Code | AX, AZ | TQFP |
| | | LQ | QFN |
| | | PV | SSOP |
| | | FN | WLCSP |
| F | Temperature Range | I | Industrial |
| | | Q | Extended Industrial |
| XYZ | Attributes Code | 000-999 | Code of feature set in specific family |

Packaging

Table 42. Package Characteristics

| Parameter | Description | Conditions | Min | Typ | Max | Units |
|-----------------|---------------------------------------|------------|-----|-------|-----|---------|
| T _A | Operating ambient temperature | | -40 | 25.00 | 105 | °C |
| T _J | Operating junction temperature | | -40 | - | 125 | °C |
| T _{JA} | Package θ_{JA} (28-pin SSOP) | | - | 66.58 | - | °C/Watt |
| T _{JA} | Package θ_{JA} (35-ball WLCSP) | | - | 28.00 | - | °C/Watt |
| T _{JA} | Package θ_{JA} (40-pin QFN) | | - | 15.34 | - | °C/Watt |
| T _{JA} | Package θ_{JA} (44-pin TQFP) | | - | 57.16 | - | °C/Watt |
| T _{JA} | Package θ_{JA} (48-pin TQFP) | | - | 67.30 | - | °C/Watt |
| T _{JC} | Package θ_{JC} (28-pin SSOP) | | - | 26.28 | - | °C/Watt |
| T _{JC} | Package θ_{JC} (35-ball WLCSP) | | - | 00.40 | - | °C/Watt |
| T _{JC} | Package θ_{JC} (40-pin QFN) | | - | 2.50 | - | °C/Watt |
| T _{JC} | Package θ_{JC} (44-pin TQFP) | | - | 17.47 | - | °C/Watt |
| T _{JC} | Package θ_{JC} (48-pin TQFP) | | - | 27.60 | - | °C/Watt |

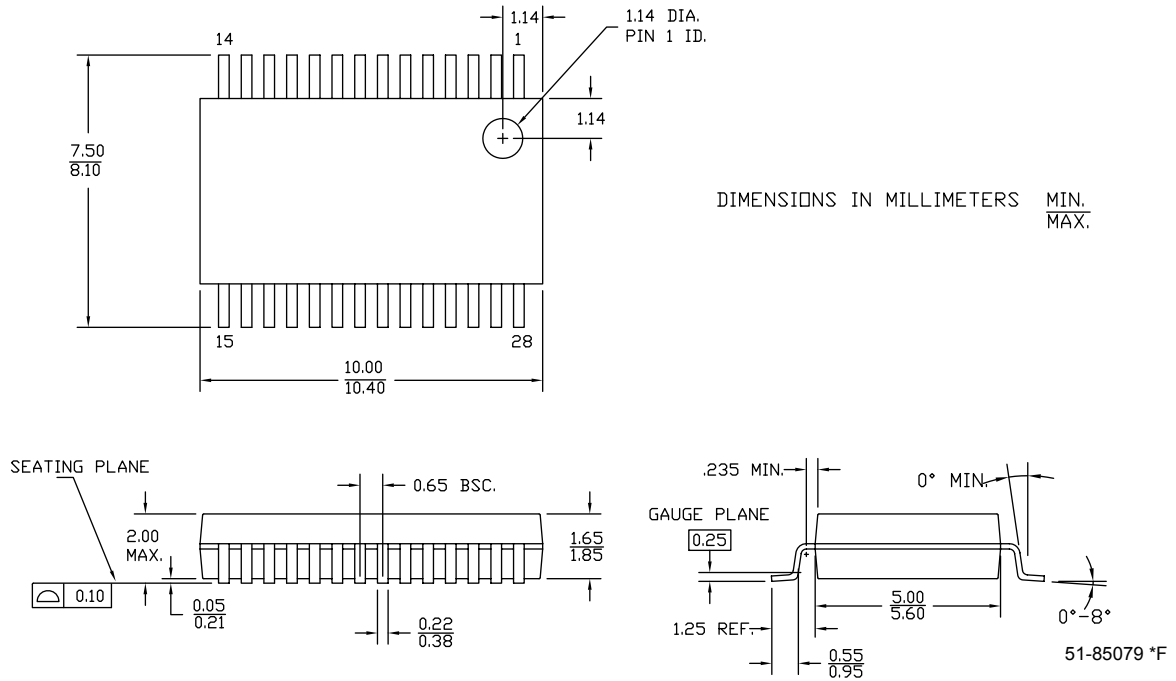
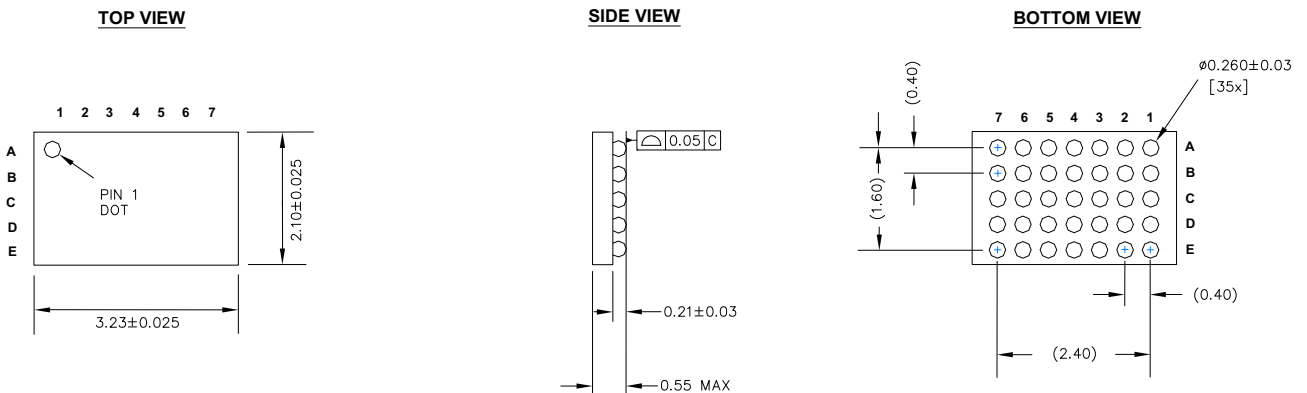
Table 43. Solder Reflow Peak Temperature

| Package | Maximum Peak Temperature | Maximum Time at Peak Temperature |
|---------------|--------------------------|----------------------------------|
| 28-pin SSOP | 260 °C | 30 seconds |
| 35-ball WLCSP | 260 °C | 30 seconds |
| 40-pin QFN | 260 °C | 30 seconds |
| 44-pin TQFP | 260 °C | 30 seconds |
| 48-pin TQFP | 260 °C | 30 seconds |

Table 44. Package Moisture Sensitivity Level (MSL), IPC/JEDEC J-STD-2

| Package | MSL |
|---------------|-------|
| 28-pin SSOP | MSL 3 |
| 35-ball WLCSP | MSL 3 |
| 40-pin QFN | MSL 3 |
| 44-pin TQFP | MSL 3 |
| 48-pin TQFP | MSL 3 |

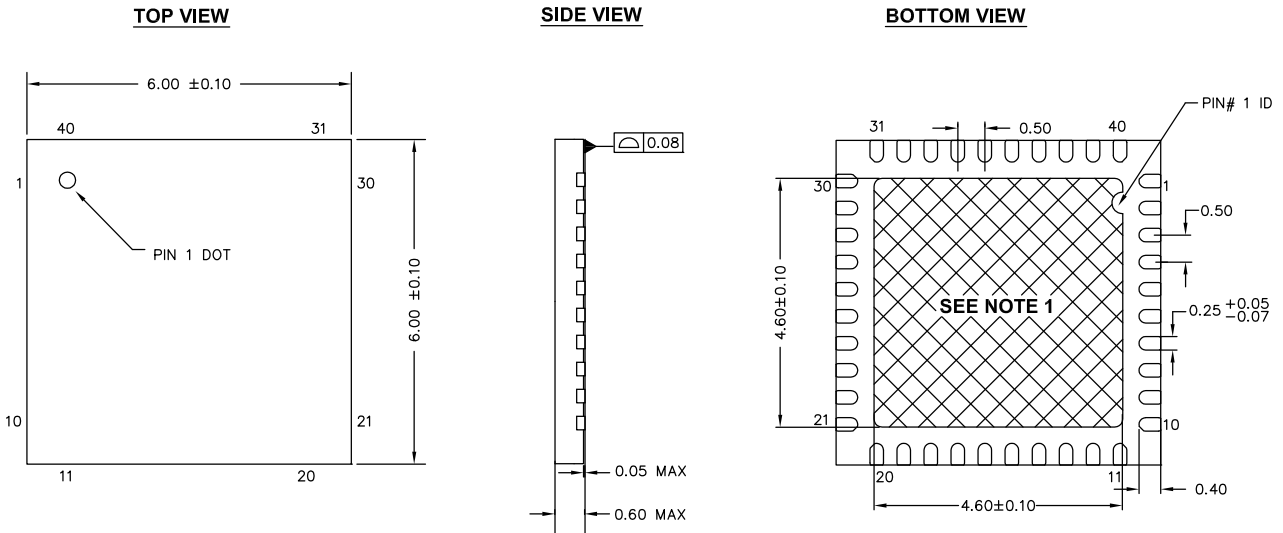
PSoC 4 CAB Libraries with Schematics Symbols and PCB Footprints are on the Cypress web site at http://www.cypress.com/cad-resources/psoc-4-cad-libraries?source=search&cat=technical_documents.

Figure 17. 28-pin (210-mil) SSOP Package Outline

Figure 18. 35-ball WLCSP Package Outline

NOTES:

1. REFERENCE JEDEC PUBLICATION 95, DESIGN GUIDE 4.18
2. ALL DIMENSIONS ARE IN MILLIMETERS

001-93741 **

Figure 19. 40-pin QFN Package Outline



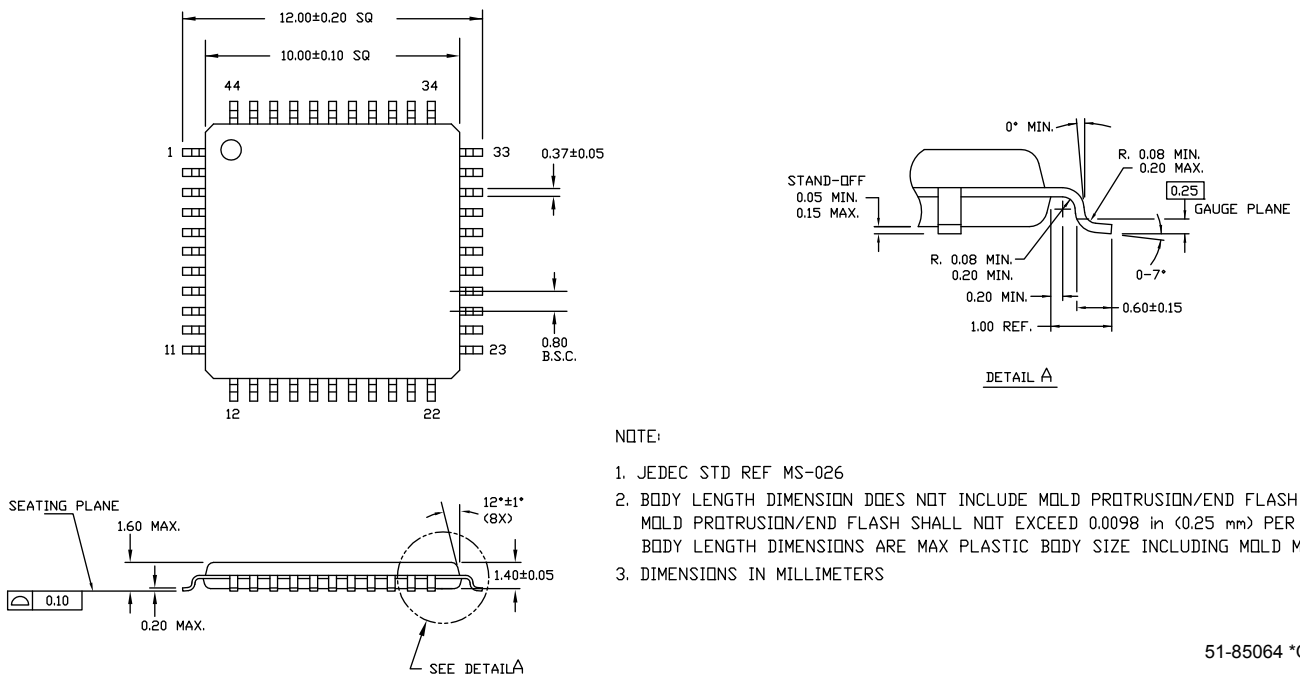
NOTES:

1. HATCH AREA IS SOLDERABLE EXPOSED PAD
2. REFERENCE JEDEC # MO-248
3. PACKAGE WEIGHT: 68 ±2 mg
4. ALL DIMENSIONS ARE IN MILLIMETERS

001-80659 *A

The center pad on the QFN package should be connected to ground (VSS) for best mechanical, thermal, and electrical performance. If not connected to ground, it should be electrically floating and not connected to any other signal.

Figure 20. 44-pin TQFP Package Outline

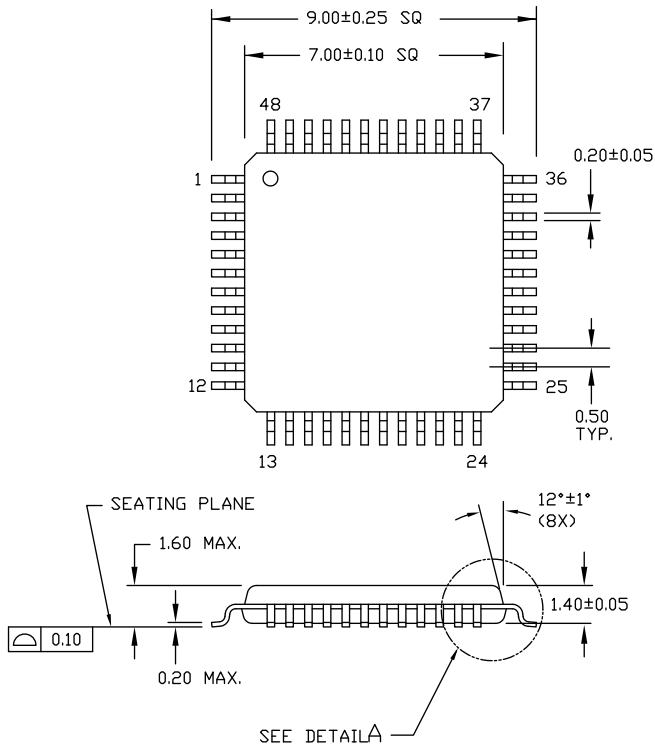


NOTE:

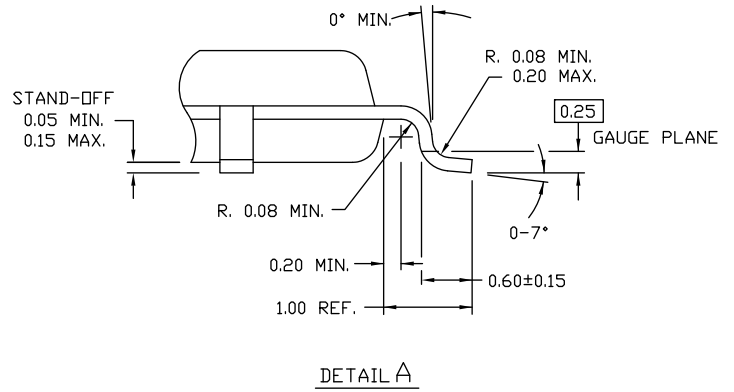
1. JEDEC STD REF MS-026
2. BODY LENGTH DIMENSION DOES NOT INCLUDE MOLD PROTRUSION/END FLASH
MOLD PROTRUSION/END FLASH SHALL NOT EXCEED 0.0098 in (0.25 mm) PER SIDE
BODY LENGTH DIMENSIONS ARE MAX PLASTIC BODY SIZE INCLUDING MOLD MISMATCH
3. DIMENSIONS IN MILLIMETERS

51-85064 *G

Figure 21. 48-Pin TQFP Package Outline



DIMENSIONS ARE IN MILLIMETERS



51-85135 *C

Acronyms

Table 45. 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 45. 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 ² 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 45. 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 ² C serial clock |
| SDA | I ² 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 45. 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 46. 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® 4: PSoC 4200 Family Datasheet Programmable System-on-Chip (PSoC®) Document Number: 001-87197 | | | | |
|--|---------|-----------------|-----------------|--|
| Revision | ECN | Orig. of Change | Submission Date | Description of Change |
| *B | 4108562 | WKA | 08/29/2013 | Added clarifying note about the XRES pin in the Reset section. Updated UDB Array diagram. Added a link reference to the PSoC 4 TRM. Updated the footnote in Absolute Maximum Ratings . Updated Sleep Mode IDD specs in DC Specifications . Updated Comparator DC Specifications Updated SAR ADC AC Specifications Updated LCD Direct Drive DC Specifications Updated the number of GPIOs in Ordering Information . |
| *C | 4568937 | MKEA/ WKA | 11/19/2014 | Added More Information and PSoC Creator sections. Added 48-pin TQFP pin and package details. Added SID308A spec details. Updated Ordering Information . |
| *D | 4617283 | WKA | 01/08/2015 | Corrected typo in the ordering information table. Updated 28-pin SSOP package diagram. |
| *E | 4643655 | WKA | 04/29/2015 | Added 35 WLCSP pinout and package detail information. Updated CSD specifications. |
| *F | 5287114 | WKA | 06/09/2016 | Added reference to AN90071 in the More Information section. Updated Flash section with details of flash protection modes. Added notes in the Pinouts section. Updated 40-pin QFN and 28-pin SSOP pin diagrams. Added PSoC 4 Power Supply diagram. Updated the Bypass Capacitors column in the Power Supply table. Updated values for SID32, SID34, SID38, SID269, SID270, SID271. Added SID299A. Updated Comparator Specifications. Updated TCPWM Specifications. Updated values for SID149, SID160, SID171. Updated Conditions for SID190. Added BID55. Removed Conditions for SID237. Added reference to PSoC 4 CAB Libraries with Schematics Symbols and PCB Footprints in the Packaging section. |
| *G | 5327384 | WKA | 06/28/2016 | Removed capacitor connection for Pin 15 in Figure 13. |
| *H | 5702140 | GNKK | 04/19/2017 | Updated the Cypress logo and copyright information. |
| *I | 5738586 | WKA | 05/16/2017 | Updated max value of SID61. |
| *J | 5795966 | WKA | 07/10/2017 | Changed Pin 33 name in 40-pin QFN Pinout from VDDD to VDDA to correct typo; pinout table is correct and not changed. Removed reference to swd_io[1] and swd_clk[1]. Corrected 44-TQFP Package Example . |

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