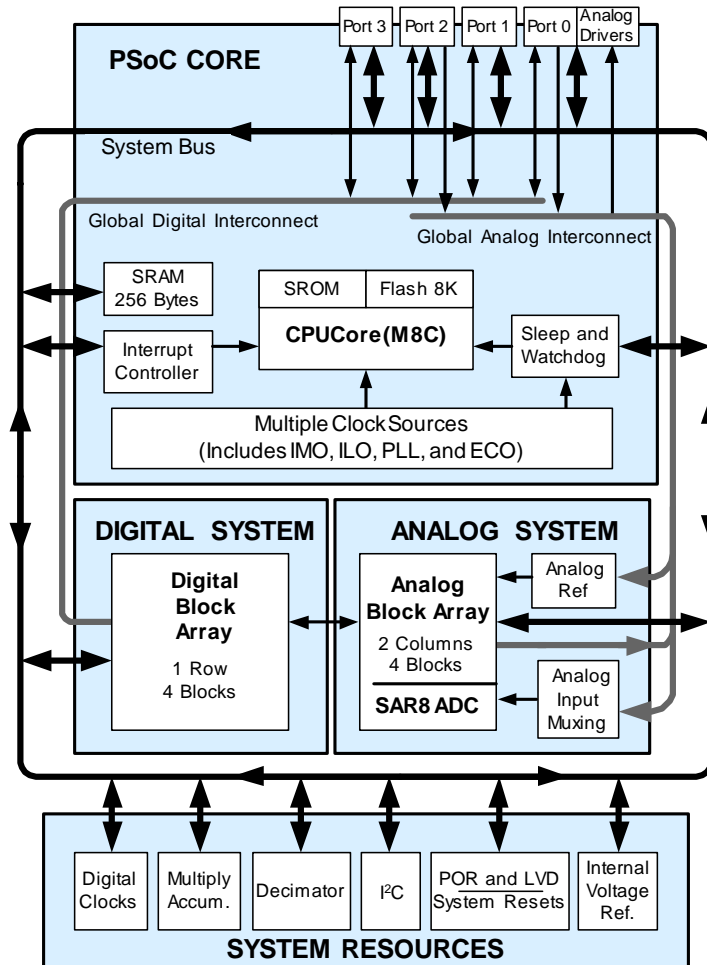


Features

- Powerful Harvard-architecture processor
 - M8C processor speeds to 24 MHz
 - 8 × 8 multiply, 32-bit accumulate
 - low Power at High Speed
 - 3.0 to 5.25 V operating voltage
 - industrial temperature range: -40 °C to +85 °C
- Advanced peripherals (PSoC[®] Blocks)
 - Four Rail-to-Rail analog PSoC blocks provide:
 - Up to 14-bit ADCs
 - Up to 8-bit DACs
 - Programmable gain amplifiers
 - Programmable filters and comparators
 - Four digital PSoC blocks provide:
 - 8- to 32-bit timers and counters, 8- and 16-bit pulse-width modulators (PWMs)
 - CRC and PRS modules
 - Full-duplex UART
 - Multiple SPI masters or slaves
 - Connectable to all GPIO Pins
 - Complex peripherals by combining blocks
 - High speed 8-bit SAR ADC optimized for motor control
- Precision, programmable clocking
 - Internal ±5% 24/48 MHz oscillator
 - High accuracy 24 MHz with optional 32 kHz crystal and PLL
 - Optional external oscillator, up to 24 MHz
 - Internal oscillator for watchdog and sleep
- Flexible on-chip memory
 - 8K flash program storage 50,000 erase/write cycles
 - 256 bytes SRAM data storage
 - In-System Serial Programming (ISSP)
 - Partial flash updates
 - Flexible protection modes
 - EEPROM emulation in flash
- Programmable pin configurations
 - 25 mA sink on all GPIO
 - Pull-up, pull-down, high Z, strong, or open drain drive modes on all GPIO
 - Up to eight Analog Inputs on GPIO plus two additional analog inputs with restricted routing
 - Two 30 mA analog outputs on GPIO
 - Configurable interrupt on all GPIO
- Additional system resources
 - I²C slave, master, and multi-master to 400 kHz
 - Watchdog and sleep timers
 - User-configurable low voltage detection
 - Integrated supervisory circuit
 - On-chip precision voltage reference
- Complete development tools
 - Free development Software (PSoC Designer™)
 - Full-featured In-Circuit Emulator and programmer
 - Full speed emulation
 - Complex breakpoint structure
 - 128KB trace memory

Block Diagram



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 “How to Design with PSoC® 1, PowerPSoC®, and PLC – KBA88292”. Following is an abbreviated list for PSoC 1:

- Overview: PSoC Portfolio, PSoC Roadmap
- Product Selectors: [PSoC 1](#), [PSoC 3](#), [PSoC 4](#), [PSoC 5LP](#)
- In addition, PSoC Designer 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 1 are:
 - [Getting Started with PSoC® 1 – AN75320](#)
 - [PSoC® 1 - Getting Started with GPIO – AN2094](#)
 - [PSoC® 1 Analog Structure and Configuration – AN74170](#)
 - [PSoC® 1 Switched Capacitor Analog Blocks – AN2041](#)
 - [Selecting Analog Ground and Reference – AN2219](#)

Note: For CY8C24633 devices related Application note please click [here](#).

- Development Kits:
 - [CY3210-PSocEval1](#) supports all PSoC 1 Mixed-Signal Array families, including automotive, except CY8C25/26xxx devices. The kit includes an LCD module, potentiometer, LEDs, and breadboarding space.
 - [CY3214-PSocEvalUSB](#) features a development board for the CY8C24x94 PSoC device. Special features of the board include USB and CapSense development and debugging support.

Note: For CY8C24633 devices related Development Kits please click [here](#).

The [MiniProg1](#) and [MiniProg3](#) devices provide interfaces for flash programming and debug.

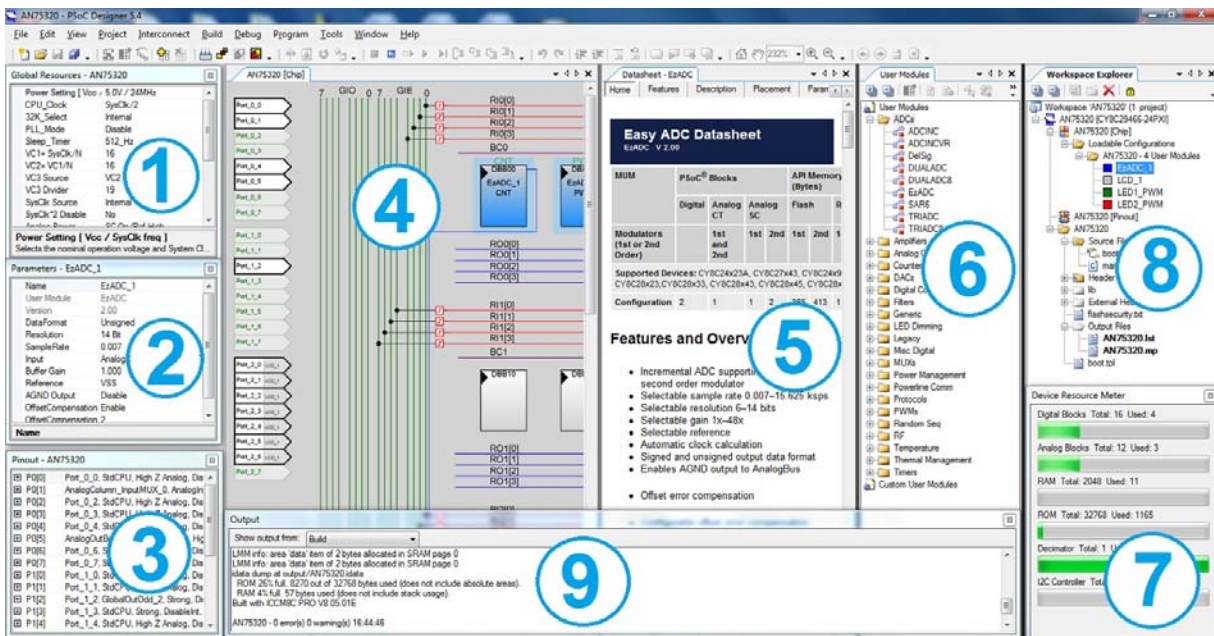
PSoC Designer

[PSoC Designer](#) is a free Windows-based Integrated Design Environment (IDE). Develop your applications using a library of pre-characterized analog and digital peripherals in a drag-and-drop design environment. Then, customize your design leveraging the dynamically generated API libraries of code. [Figure 1](#) shows PSoC Designer windows. **Note:** This is not the default view.

1. **Global Resources** – all device hardware settings.
2. **Parameters** – the parameters of the currently selected User Modules.
3. **Pinout** – information related to device pins.
4. **Chip-Level Editor** – a diagram of the resources available on the selected chip.
5. **Datasheet** – the datasheet for the currently selected UM
6. **User Modules** – all available User Modules for the selected device.
7. **Device Resource Meter** – device resource usage for the current project configuration.
8. **Workspace** – a tree level diagram of files associated with the project.
9. **Output** – output from project build and debug operations.

Note: For detailed information on PSoC Designer, go to PSoC® Designer > Help > Documentation > Designer Specific Documents > IDE User Guide.

Figure 1. PSoC Designer Layout



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PSoC Functional Overview

The PSoC family consists of many programmable system-on-chip with on-chip controller devices. These devices are designed to replace multiple traditional MCU-based system components with one, low cost single-chip programmable device. PSoC devices include configurable blocks of analog and digital logic, as well as programmable interconnects. This architecture allows the user to create customized peripheral configurations that match the requirements of each individual application. Additionally, a fast CPU, flash program memory, SRAM data memory, and configurable I/O are included in a range of convenient pinouts and packages.

The PSoC architecture, as illustrated in the [Block Diagram](#), is comprised of four main areas: PSoC core, digital system, Analog system, and system resources. Configurable global buses allows all the device resources to be combined into a complete custom system. The PSoC CY8C24x33 family can have up to three I/O ports that connect to the global digital and analog interconnects, providing access to four digital blocks and four analog blocks.

The PSoC Core

The PSoC core is a powerful engine that supports a rich feature set. The core includes a CPU, memory, clocks, and configurable general purpose I/O (GPIO).

The M8C CPU core is a powerful processor with speeds up to 24 MHz, providing a four MIPS 8-bit Harvard-architecture microprocessor. The CPU utilizes an interrupt controller with 11 vectors, to simplify programming of real time embedded events. Program execution is timed and protected using the included sleep and watch dog timers (WDT).

Memory encompasses 8 KB of flash for program storage, 256 bytes of SRAM for data storage, and up to 2 KB of EEPROM emulated using the flash. Program flash uses four protection levels on blocks of 64 bytes, allowing customized software IP protection.

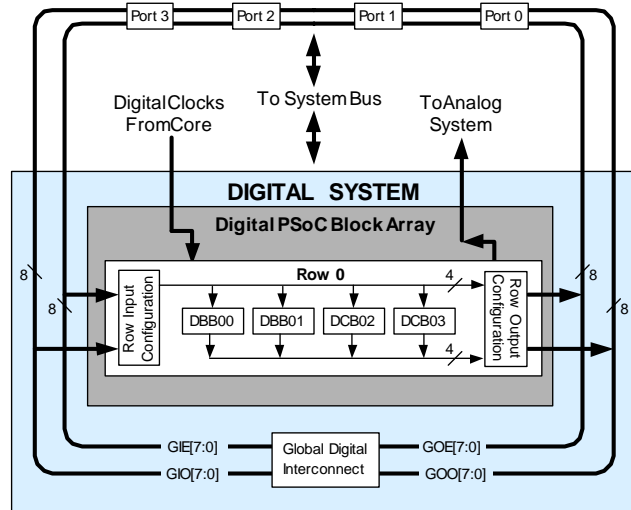
The PSoC device incorporates flexible internal clock generators, including a 24 MHz internal main oscillator (IMO) accurate to ±5% over temperature and voltage. The 24 MHz IMO can also be doubled to 48 MHz for use by the digital system. A low power 32 kHz internal low speed oscillator (ILO) is provided for the sleep timer and WDT. If crystal accuracy is desired, the ECO (32.768 kHz external crystal oscillator) is available for use as a real time clock (RTC) and can optionally generate a crystal-accurate 24 MHz system clock using a PLL. The clocks, together with programmable clock dividers (as a system resource), provide the flexibility to integrate almost any timing requirement into the PSoC device.

PSoC GPIOs provide connection to the CPU, digital and analog resources of the device. Each pin's drive mode may be selected from eight options, allowing great flexibility in external interfacing. Every pin also has the capability to generate a system interrupt on high level, low level, and change from last read.

The Digital System

The Digital System is composed of four digital PSoC blocks. Each block is an 8-bit resource that can be used alone or combined with other blocks to form 8-, 16-, 24-, and 32-bit peripherals, which are called user module references.

Figure 2. Digital System Block Diagram



Digital peripheral configurations include those listed below.

- PWMs (8- and 16-bit)
- PWMs with dead band (8- and 16-bit)
- Counters (8- to 32-bit)
- Timers (8- to 32-bit)
- UART 8 bit with selectable parity (up to 1)
- SPI master and slave (up to 1)
- I²C slave and master (1 available as a system resource)
- Cyclical redundancy checker/generator (8- to 32-bit)
- IrDA (up to 1)
- Pseudo random sequence generators (8- to 32-bit)

The digital blocks are connected to any GPIO through a series of global buses that route any signal to any pin. The buses also allow signal multiplexing and performing logic operations. This configurability frees your designs from the constraints of a fixed peripheral controller.

Digital blocks are provided in rows of four, where the number of blocks varies by PSoC device family. This allows the optimum choice of system resources for your application. Family resources are shown in [Table 1 on page 7](#).

The Analog System

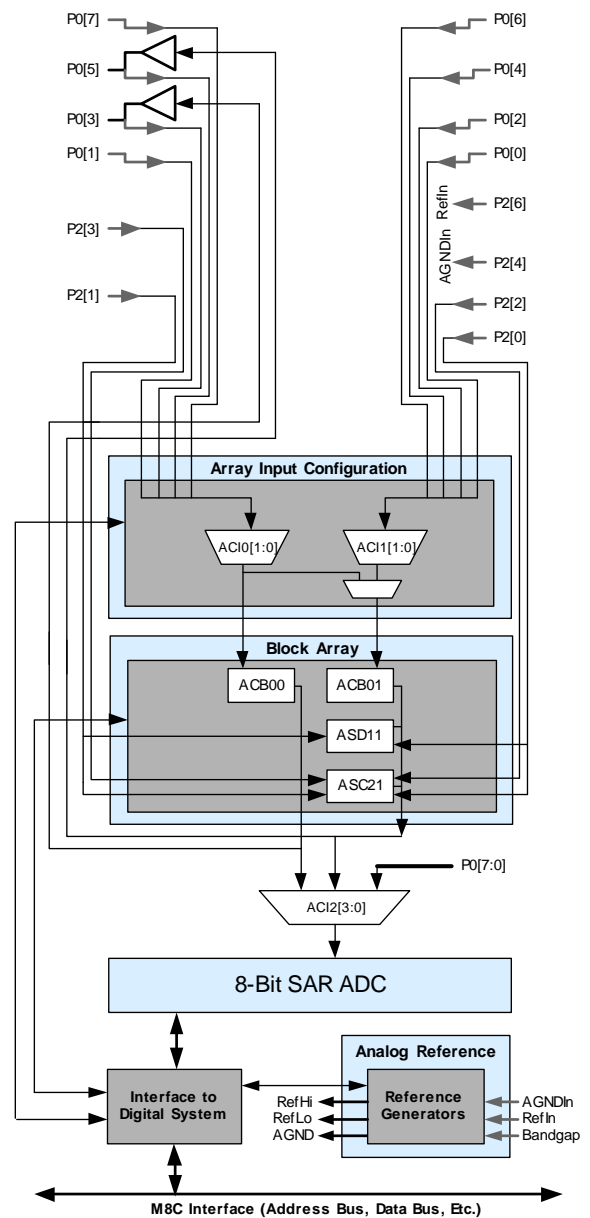
The analog system is composed of an 8-bit SAR ADC and four configurable blocks. The programmable 8-bit SAR ADC is an optimized ADC that runs up to 300 Ksps, with monotonic guarantee. It also has the features to support a motor control application.

Each analog block is comprised of an opamp circuit allowing the creation of complex analog signal flows. Analog peripherals are very flexible and can be customized to support specific application requirements. Some of the more common PSoC analog functions (most available as user modules) are listed below.

- Filters (2 and 4 pole band pass, low-pass, and notch)
- Amplifiers (up to two, with selectable gain to 48x)
- Instrumentation amplifiers (1 with selectable gain to 93x)
- Comparators (up to two, with 16 selectable thresholds)
- DACs (up to two, with 6- to 9-bit resolution)
- Multiplying DACs (up to 2, with 6- to 9-bit resolution)
- High current output drivers (two with 30 mA drive as a core resource)
- 1.3 V reference (as a system resource)
- DTMF dialer
- Modulators
- Correlators
- Peak detectors
- Many other topologies possible

Analog blocks are arranged in a column of three, which includes one continuous time (CT) and two switched capacitor (SC) blocks. The analog column 0 contains the SAR8 ADC block rather than the standard SC blocks.

Figure 3. Analog System Block Diagram



Additional System Resources

System resources, some of which have been previously listed, provide additional capability useful to complete systems. Additional resources include a multiplier, decimator, low voltage detection, and power on reset. Brief statements describing the merits of each system resource are presented below.

- Digital clock dividers provide three customizable clock frequencies for use in applications. The clocks can be routed to both the digital and analog systems. Additional clocks can be generated using digital PSoC blocks as clock dividers.
- A multiply accumulate (MAC) provides a fast 8-bit multiplier with 32-bit accumulate, to assist in both general math as well as digital filters.
- The decimator provides a custom hardware filter for digital signal processing applications including the creation of Delta Sigma ADCs.
- The I²C module provides 100 and 400 kHz communication over two wires. Slave, master, and multi-master modes are all supported.
- Low-voltage detection (LVD) interrupts can signal the application of falling voltage levels, while the advanced power-on reset (POR) circuit eliminates the need for a system supervisor.
- An internal 1.3 V reference provides an absolute reference for the analog system, including ADCs and DACs.

PSoC Device Characteristics

Depending on your PSoC device characteristics, the digital and analog systems can have 16, 8, or 4 digital blocks and 12, 6, or 3 analog blocks. The following table lists the resources available for specific PSoC device groups.

Table 1. PSoC Device Characteristics

| PSoC Part Number | Digital I/O | Digital Rows | Digital Blocks | Analog Inputs | Analog Outputs | Analog Columns | Analog Blocks | SRAM Size | Flash Size | SAR ADC |
|------------------|-------------|--------------|----------------|---------------|----------------|----------------|-----------------------------|-----------|------------|---------|
| CY8C29x66 | up to 64 | 4 | 16 | up to 12 | 4 | 4 | 12 | 2 K | 32 K | No |
| CY8C28xxx | up to 44 | up to 3 | up to 12 | up to 44 | up to 4 | up to 6 | up to 12 + 4 ^[1] | 1 K | 16 K | Yes |
| CY8C27x43 | up to 44 | 2 | 8 | up to 12 | 4 | 4 | 12 | 256 | 16 K | No |
| CY8C24x94 | up to 56 | 1 | 4 | up to 48 | 2 | 2 | 6 | 1 K | 16 K | No |
| CY8C24x23A | up to 24 | 1 | 4 | up to 12 | 2 | 2 | 6 | 256 | 4 K | No |
| CY8C23x33 | up to 26 | 1 | 4 | up to 12 | 2 | 2 | 4 | 256 | 8 K | Yes |
| CY8C22x45 | up to 38 | 2 | 8 | up to 38 | 0 | 4 | 6 ^[1] | 1 K | 16 K | No |
| CY8C21x45 | up to 24 | 1 | 4 | up to 24 | 0 | 4 | 6 ^[1] | 512 | 8 K | Yes |
| CY8C21x34 | up to 28 | 1 | 4 | up to 28 | 0 | 2 | 4 ^[1] | 512 | 8 K | No |
| CY8C21x23 | up to 16 | 1 | 4 | up to 8 | 0 | 2 | 4 ^[1] | 256 | 4 K | No |
| CY8C20x34 | up to 28 | 0 | 0 | up to 28 | 0 | 0 | 3 ^[1,2] | 512 | 8 K | No |
| CY8C20xx6 | up to 36 | 0 | 0 | up to 36 | 0 | 0 | 3 ^[1,2] | up to 2 K | up to 32 K | No |

Notes

1. Limited analog functionality.
2. Two analog blocks and one CapSense®.

Development Tools

PSoC Designer™ is the revolutionary integrated design environment (IDE) that you can use to customize PSoC to meet your specific application requirements. PSoC Designer software accelerates system design and time to market. Develop your applications using a library of precharacterized analog and digital peripherals (called user modules) in a drag-and-drop design environment. Then, customize your design by leveraging the dynamically generated application programming interface (API) libraries of code. Finally, debug and test your designs with the integrated debug environment, including in-circuit emulation and standard software debug features. PSoC Designer includes:

- Application editor graphical user interface (GUI) for device and user module configuration and dynamic reconfiguration
- Extensive user module catalog
- Integrated source-code editor (C and assembly)
- Free C compiler with no size restrictions or time limits
- Built-in debugger
- In-circuit emulation
- Built-in support for communication interfaces:
 - Hardware and software I²C slaves and masters
 - Full-speed USB 2.0
 - Up to four full-duplex universal asynchronous receiver/transmitters (UARTs), SPI master and slave, and wireless

PSoC Designer supports the entire library of PSoC 1 devices and runs on Windows XP, Windows Vista, and Windows 7.

PSoC Designer Software Subsystems

Design Entry

In the chip-level view, choose a base device to work with. Then select different onboard analog and digital components that use the PSoC blocks, which are called user modules. Examples of user modules are analog-to-digital converters (ADCs), digital-to-analog converters (DACs), amplifiers, and filters. Configure the user modules for your chosen application and connect them to each other and to the proper pins. Then generate your project. This prepopulates your project with APIs and libraries that you can use to program your application.

The tool also supports easy development of multiple configurations and dynamic reconfiguration. Dynamic reconfiguration makes it possible to change configurations at run time. In essence, this lets you to use more than 100 percent of PSoC's resources for an application.

Code Generation Tools

The code generation tools work seamlessly within the PSoC Designer interface and have been tested with a full range of debugging tools. You can develop your design in C, assembly, or a combination of the two.

Assemblers. The assemblers allow you to merge assembly code seamlessly with C code. Link libraries automatically use absolute addressing or are compiled in relative mode, and linked with other software modules to get absolute addressing.

C Language Compilers. C language compilers are available that support the PSoC family of devices. The products allow you to create complete C programs for the PSoC family devices. The optimizing C compilers provide all of the features of C, tailored to the PSoC architecture. They come complete with embedded libraries providing port and bus operations, standard keypad and display support, and extended math functionality.

Debugger

PSoC Designer has a debug environment that provides hardware in-circuit emulation, allowing you to test the program in a physical system while providing an internal view of the PSoC device. Debugger commands allow you to read and program and read and write data memory, and read and write I/O registers. You can read and write CPU registers, set and clear breakpoints, and provide program run, halt, and step control. The debugger also lets you to create a trace buffer of registers and memory locations of interest.

Online Help System

The online help system displays online, context-sensitive help. Designed for procedural and quick reference, each functional subsystem has its own context-sensitive help. This system also provides tutorials and links to FAQs and an Online Support Forum to aid the designer.

In-Circuit Emulator

A low-cost, high-functionality in-circuit emulator (ICE) is available for development support. This hardware can program single devices.

The emulator consists of a base unit that connects to the PC using a USB port. The base unit is universal and operates with all PSoC devices. Emulation pods for each device family are available separately. The emulation pod takes the place of the PSoC device in the target board and performs full-speed (24 MHz) operation.

Designing with PSoC Designer

The development process for the PSoC device differs from that of a traditional fixed-function microprocessor. The configurable analog and digital hardware blocks give the PSoC architecture a unique flexibility that pays dividends in managing specification change during development and lowering inventory costs. These configurable resources, called PSoC blocks, have the ability to implement a wide variety of user-selectable functions. The PSoC development process is:

1. Select [user modules](#).
2. Configure user modules.
3. Organize and connect.
4. Generate, verify, and debug.

Select User Modules

PSoC Designer provides a library of prebuilt, pretested hardware peripheral components called “user modules.” User modules make selecting and implementing peripheral devices, both analog and digital, simple.

Configure User Modules

Each user module that you select establishes the basic register settings that implement the selected function. They also provide parameters and properties that allow you to tailor their precise configuration to your particular application. For example, a PWM User Module configures one or more digital PSoC blocks, one for each eight bits of resolution. Using these parameters, you can establish the pulse width and duty cycle. Configure the parameters and properties to correspond to your chosen application. Enter values directly or by selecting values from drop-down menus. All of the user modules are documented in datasheets that may be viewed directly in PSoC Designer or on the Cypress website. These [user module datasheets](#) explain the internal operation of the user module and provide performance specifications. Each datasheet describes the use of each user module parameter, and other information that you may need to successfully implement your design.

Organize and Connect

Build signal chains at the chip level by interconnecting user modules to each other and the I/O pins. Perform the selection, configuration, and routing so that you have complete control over all on-chip resources.

Generate, Verify, and Debug

When you are ready to test the hardware configuration or move on to developing code for the project, perform the “Generate Configuration Files” step. This causes PSoC Designer to generate source code that automatically configures the device to your specification and provides the software for the system. The generated code provides APIs with high-level functions to control and respond to hardware events at run time, and interrupt service routines that you can adapt as needed.

A complete code development environment lets you to develop and customize your applications in C, assembly language, or both.

The last step in the development process takes place inside PSoC Designer's Debugger (accessed by clicking the Connect icon). PSoC Designer downloads the HEX image to the ICE where it runs at full-speed. PSoC Designer debugging capabilities rival those of systems costing many times more. In addition to traditional single-step, run-to-breakpoint, and watch-variable features, the debug interface provides a large trace buffer. It lets you to define complex breakpoint events that include monitoring address and data bus values, memory locations, and external signals.

Pinouts

The PSoC CY8C24633 is available in 28-pin SSOP and 56-pin SSOP OCD packages. Refer to the following information for details. Every port pin (labeled with a “P”), except V_{SS} , V_{DD} , and XRES in the following tables and illustrations, is capable of Digital I/O.

28-Pin Part Pinout

The 28-pin part is for the CY8C24633 PSoC device.

Table 2. 28-Pin Part Pinout (SSOP)

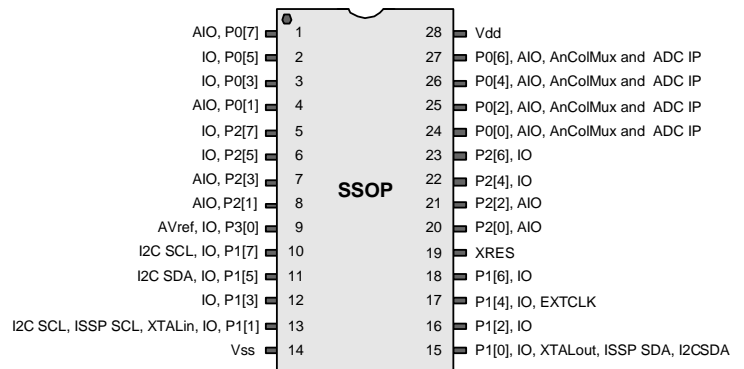
| Pin No. | Digital | Analog | Pin Name | Description |
|---------|---------|--------|----------------------|---|
| 1 | I/O | I | P0[7] | Analog col mux IP and ADC IP |
| 2 | I/O | I/O | P0[5] | Analog col mux IP and column O/P and ADC IP |
| 3 | I/O | I/O | P0[3] | Analog col mux IP and column O/P and ADC IP |
| 4 | I/O | I | P0[1] | Analog col mux IP and ADC IP |
| 5 | I/O | | P2[7] | GPIO |
| 6 | I/O | | P2[5] | GPIO |
| 7 | I/O | I | P2[3] | Direct switched capacitor input |
| 8 | I/O | I | P2[1] | Direct switched capacitor input |
| 9 | I/O | AVref | P3[0] ^[3] | GPIO/ADC Vref (optional) |
| 10 | I/O | | P1[7] | I ² C SCL |
| 11 | I/O | | P1[5] | I ² C SDA |
| 12 | I/O | | P1[3] | GPIO |
| 13 | I/O | | P1[1] ^[4] | GPIO, Xtal input, I2C SCL, ISSP SCL |
| 14 | Power | | Vss | Ground pin |
| 15 | I/O | | P1[0] ^[4] | GPIO, Xtal output, I2C SDA, ISSP SDA |
| 16 | I/O | | P1[2] | GPIO |
| 17 | I/O | | P1[4] | GPIO, external clock IP |
| 18 | I/O | | P1[6] | GPIO |
| 19 | | | XRES | External reset |
| 20 | I/O | I | P2[0] | Direct switched capacitor input |
| 21 | I/O | I | P2[2] | Direct switched capacitor input |
| 22 | I/O | | P2[4] | GPIO |
| 23 | I/O | | P2[6] | GPIO |
| 24 | I/O | I | P0[0] | Analog Col Mux IP and ADC IP |
| 25 | I/O | I | P0[2] | Analog Col Mux IP and ADC IP |
| 26 | I/O | I | P0[4] | Analog Col Mux IP and ADC IP |
| 27 | I/O | I | P0[6] | Analog Col Mux IP and ADC IP |
| 28 | Power | | Vdd | Supply voltage |

LEGEND A = Analog, I = Input, and O = Output

Notes

- Even though P3[0] is an odd port, it resides on the left side of the pinout.
- ISSP pin, which is not High Z at POR.

Figure 4. CY8C24633 PSoC Device



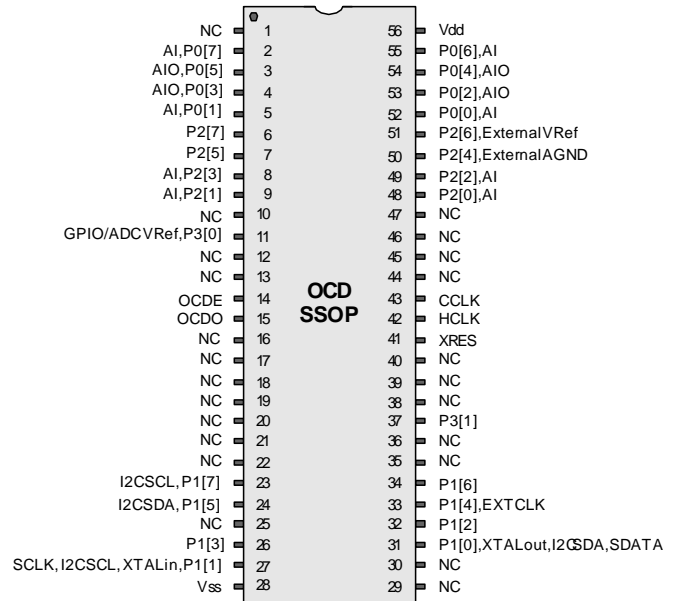
56-Pin Part Pinout

The 56-pin OCD (on-chip debug) part is for the CY8C24633 (CY8C24033) PSoC device.

Note OCD parts are only used for in-circuit debugging. OCD parts are NOT available for production.

Table 3. 56-Pin OCD Part Pinout (SSOP)

| Pin No. | Name | Description |
|---------|--------------------|--|
| 1 | NC | No internal connection |
| 2 | P0[7] | Analog column mux input: AI |
| 3 | P0[5] | Analog column mux input and column output: AIO |
| 4 | P0[3] | Analog column mux input and column output: AIO |
| 5 | P0[1] | Analog column mux input: AI |
| 6 | P2[7] | |
| 7 | P2[5] | |
| 8 | P2[3] | Direct switched capacitor block input: AI |
| 9 | P2[1] | Direct switched capacitor block input: AI |
| 10 | NC | No internal connection |
| 11 | P3[0] | GPIO/ADC Vref (optional) |
| 12 | NC | No internal connection |
| 13 | NC | No internal connection |
| 14 | OCDE | OCD even data I/O |
| 15 | OCDO | OCD odd data output |
| 16 | NC | No internal connection |
| 17 | NC | No internal connection |
| 18 | NC | No internal connection |
| 19 | NC | No internal connection |
| 20 | NC | No internal connection |
| 21 | NC | No internal connection |
| 22 | NC | No internal connection |
| 23 | P1[7] | I2C Serial Clock (SCL) |
| 24 | P1[5] | I2C Serial Data (SDA) |
| 25 | NC | No internal connection |
| 26 | P1[3] | |
| 27 | P1[1] ⁵ | Crystal (XTALin), I2C Serial Clock (SCL) |
| 28 | Vss | Ground connection |
| 29 | NC | No internal connection |
| 30 | NC | No internal connection |
| 31 | P1[0] ⁵ | Crystal (XTALout), I2C Serial Data (SDA) |
| 32 | P1[2] | |
| 33 | P1[4] | Optional External Clock Input (EXTCLK) |
| 34 | P1[6] | |
| 35 | NC | No internal connection |
| 36 | NC | No internal connection |
| 37 | P3[1] | GPIO |
| 38 | NC | No internal connection |
| 39 | NC | No internal connection |
| 40 | NC | No internal connection |
| 41 | XRES | Active high pin reset with internal pull down |
| 42 | HCLK | OCD high speed clock output |
| 43 | CCLK | OCD CPU clock output |
| 44 | NC | No internal connection |
| 45 | NC | No internal connection |
| 46 | NC | No internal connection |
| 47 | NC | No internal connection |
| 48 | P2[0] | Direct switched capacitor block input: AI |
| 49 | P2[2] | Direct switched capacitor block input: AI |
| 50 | P2[4] | External Analog Ground (AGND) |
| 51 | P2[6] | External Voltage Reference (VRef) |
| 52 | P0[0] | Analog column mux input: AI |
| 53 | P0[2] | Analog column mux input and column output: AIO |
| 54 | P0[4] | Analog column mux input and column output: AIO |
| 55 | P0[6] | Analog column mux input: AI |
| 56 | Vdd | Supply voltage |

Figure 5. CY8C24033 OCD PSoC Device


Not For Production

| Pin No. | Name | Description |
|---------|-------|--|
| 44 | NC | No internal connection |
| 45 | NC | No internal connection |
| 46 | NC | No internal connection |
| 47 | NC | No internal connection |
| 48 | P2[0] | Direct switched capacitor block input: AI |
| 49 | P2[2] | Direct switched capacitor block input: AI |
| 50 | P2[4] | External Analog Ground (AGND) |
| 51 | P2[6] | External Voltage Reference (VRef) |
| 52 | P0[0] | Analog column mux input: AI |
| 53 | P0[2] | Analog column mux input and column output: AIO |
| 54 | P0[4] | Analog column mux input and column output: AIO |
| 55 | P0[6] | Analog column mux input: AI |
| 56 | Vdd | Supply voltage |

LEGEND A = Analog, I = Input, O = Output.

Note

5. ISSP pin, which is not High Z at POR.

Register Reference

This section lists the registers of the CY8C24633 PSoC device by using mapping tables, in offset order.

Register Conventions

The register conventions specific to this section are listed in the following table.

| Convention | Description |
|------------|------------------------------|
| R | Read register or bit(s) |
| W | Write register or bit(s) |
| L | Logical register or bit(s) |
| C | Clearable register or bit(s) |
| # | Access is bit specific |

Register Mapping Tables

The PSoC device has a total register address space of 512 bytes. The register space is referred to as I/O space and is divided into two banks, Bank 0 and Bank 1. The XIO bit in the Flag register (CPU_F) determines which bank the user is currently in. When the XIO bit is set to 1, the user is in Bank 1.

Note In the following register mapping tables, blank fields are reserved and should not be accessed.

Table 4. Register Map Bank 0 Table: User Space

| Name | Addr (0,Hex) | Access | Name | Addr (0,Hex) | Access | Name | Addr (0,Hex) | Access | Name | Addr (0,Hex) | Access |
|----------|--------------|--------|------------|--------------|--------|----------|--------------|--------|-----------------------|--------------|--------|
| PRT0DR | 00 | RW | | 40 | | | 80 | | | C0 | |
| PRT0IE | 01 | RW | | 41 | | | 81 | | | C1 | |
| PRT0GS | 02 | RW | | 42 | | | 82 | | | C2 | |
| PRT0DM2 | 03 | RW | | 43 | | | 83 | | | C3 | |
| PRT1DR | 04 | RW | | 44 | | ASD11CR0 | 84 | RW | | C4 | |
| PRT1IE | 05 | RW | | 45 | | ASD11CR1 | 85 | RW | | C5 | |
| PRT1GS | 06 | RW | | 46 | | ASD11CR2 | 86 | RW | | C6 | |
| PRT1DM2 | 07 | RW | | 47 | | ASD11CR3 | 87 | RW | | C7 | |
| PRT2DR | 08 | RW | | 48 | | | 88 | | | C8 | |
| PRT2IE | 09 | RW | | 49 | | | 89 | | | C9 | |
| PRT2GS | 0A | RW | | 4A | | | 8A | | | CA | |
| PRT2DM2 | 0B | RW | | 4B | | | 8B | | | CB | |
| PRT3DR | 0C | RW | | 4C | | | 8C | | | CC | |
| PRT3IE | 0D | RW | | 4D | | | 8D | | | CD | |
| PRT3GS | 0E | RW | | 4E | | | 8E | | | CE | |
| PRT3DM2 | 0F | RW | | 4F | | | 8F | | | CF | |
| | 10 | | | 50 | | | 90 | | | D0 | |
| | 11 | | | 51 | | | 91 | | | D1 | |
| | 12 | | | 52 | | | 92 | | | D2 | |
| | 13 | | | 53 | | | 93 | | | D3 | |
| | 14 | | | 54 | | ASC21CR0 | 94 | RW | | D4 | |
| | 15 | | | 55 | | ASC21CR1 | 95 | RW | | D5 | |
| | 16 | | | 56 | | ASC21CR2 | 96 | RW | I ² C_CFG | D6 | RW |
| | 17 | | | 57 | | ASC21CR3 | 97 | RW | I ² C_SCR | D7 | # |
| | 18 | | | 58 | | | 98 | | I ² C_DR | D8 | RW |
| | 19 | | | 59 | | | 99 | | I ² C_MSCR | D9 | # |
| | 1A | | | 5A | | | 9A | | INT_CLR0 | DA | RW |
| | 1B | | | 5B | | | 9B | | INT_CLR1 | DB | RW |
| | 1C | | | 5C | | | 9C | | | DC | |
| | 1D | | | 5D | | | 9D | | INT_CLR3 | DD | RW |
| | 1E | | | 5E | | | 9E | | INT_MSK3 | DE | RW |
| | 1F | | | 5F | | | 9F | | | DF | |
| DBB00DR0 | 20 | # | AMX_IN | 60 | RW | | A0 | | INT_MSK0 | E0 | RW |
| DBB00DR1 | 21 | W | | 61 | | | A1 | | INT_MSK1 | E1 | RW |
| DBB00DR2 | 22 | RW | | 62 | | | A2 | | INT_VC | E2 | RC |
| DBB00CR0 | 23 | # | ARF_CR | 63 | RW | | A3 | | RES_WDT | E3 | W |
| DBB01DR0 | 24 | # | CMP_CR0 | 64 | # | | A4 | | DEC_DH | E4 | RC |
| DBB01DR1 | 25 | W | ASY_CR | 65 | # | | A5 | | DEC_DL | E5 | RC |
| DBB01DR2 | 26 | RW | CMP_CR1 | 66 | RW | | A6 | | DEC_CR0 | E6 | RW |
| DBB01CR0 | 27 | # | SARADC_DL | 67 | RW | | A7 | | DEC_CR1 | E7 | RW |
| DCB02DR0 | 28 | # | | 68 | | | A8 | | MUL0_X | E8 | W |
| DCB02DR1 | 29 | W | SARADC_C0 | 69 | # | | A9 | | MUL0_Y | E9 | W |
| DCB02DR2 | 2A | RW | SARADC_C1 | 6A | RW | | AA | | MUL0_DH | EA | R |
| DCB02CR0 | 2B | # | | 6B | | | AB | | MUL0_DL | EB | R |
| DCB03DR0 | 2C | # | TMP_DR0 | 6C | RW | | AC | | ACC0_DR1 | EC | RW |
| DCB03DR1 | 2D | W | TMP_DR1 | 6D | RW | | AD | | ACC0_DR0 | ED | RW |
| DCB03DR2 | 2E | RW | TMP_DR2 | 6E | RW | | AE | | ACC0_DR3 | EE | RW |
| DCB03CR0 | 2F | # | TMP_DR3 | 6F | RW | | AF | | ACC0_DR2 | EF | RW |
| | 30 | | ACB00CR3 | 70 | RW | RDIORI | B0 | RW | | F0 | |
| | 31 | | ACB00CR0 | 71 | RW | RDIOSYN | B1 | RW | | F1 | |
| | 32 | | ACB00CR1 | 72 | RW | RDI0IS | B2 | RW | | F2 | |
| | 33 | | ACB00CR2 | 73 | RW | RDI0LT0 | B3 | RW | | F3 | |
| | 34 | | ACB01CR3 | 74 | RW | RDI0LT1 | B4 | RW | | F4 | |
| | 35 | | ACB01CR0 | 75 | RW | RDI0RO0 | B5 | RW | | F5 | |
| | 36 | | ACB01CR1 * | 76 | RW | RDI0RO1 | B6 | RW | | F6 | |
| | 37 | | ACB01CR2 * | 77 | RW | | B7 | | CPU_F | F7 | RL |
| | 38 | | | 78 | | | B8 | | | F8 | |
| | 39 | | | 79 | | | B9 | | | F9 | |
| | 3A | | | 7A | | | BA | | | FA | |
| | 3B | | | 7B | | | BB | | | FB | |
| | 3C | | | 7C | | | BC | | | FC | |
| | 3D | | | 7D | | | BD | | | FD | |
| | 3E | | | 7E | | | BE | | CPU_SCR1 | FE | # |
| | 3F | | | 7F | | | BF | | CPU_SCR0 | FF | # |

Blank fields are reserved. # Access is bit specific.

Table 5. Register Map Bank 1 Table: Configuration Space

| Name | Addr (1,Hex) | Access | Name | Addr (1,Hex) | Access | Name | Addr (1,Hex) | Access | Name | Addr (1,Hex) | Access |
|---------|--------------|--------|------------|--------------|--------|-------------|--------------|--------|-----------|--------------|--------|
| PRT0DM0 | 00 | RW | | 40 | | | 80 | | | C0 | |
| PRT0DM1 | 01 | RW | | 41 | | | 81 | | | C1 | |
| PRT0IC0 | 02 | RW | | 42 | | | 82 | | | C2 | |
| PRT0IC1 | 03 | RW | | 43 | | | 83 | | | C3 | |
| PRT1DM0 | 04 | RW | | 44 | | ASD11CR0 | 84 | RW | | C4 | |
| PRT1DM1 | 05 | RW | | 45 | | ASD11CR1 | 85 | RW | | C5 | |
| PRT1IC0 | 06 | RW | | 46 | | ASD11CR2 | 86 | RW | | C6 | |
| PRT1IC1 | 07 | RW | | 47 | | ASD11CR3 | 87 | RW | | C7 | |
| PRT2DM0 | 08 | RW | | 48 | | | 88 | | | C8 | |
| PRT2DM1 | 09 | RW | | 49 | | | 89 | | | C9 | |
| PRT2IC0 | 0A | RW | | 4A | | | 8A | | | CA | |
| PRT2IC1 | 0B | RW | | 4B | | | 8B | | | CB | |
| PRT3DM0 | 0C | RW | | 4C | | | 8C | | | CC | |
| PRT3DM1 | 0D | RW | | 4D | | | 8D | | | CD | |
| PRT3IC0 | 0E | RW | | 4E | | | 8E | | | CE | |
| PRT3IC1 | 0F | RW | | 4F | | | 8F | | | CF | |
| | 10 | | | 50 | | | 90 | | GDI_O_IN | D0 | RW |
| | 11 | | | 51 | | | 91 | | GDI_E_IN | D1 | RW |
| | 12 | | | 52 | | | 92 | | GDI_O_OU | D2 | RW |
| | 13 | | | 53 | | | 93 | | GDI_E_OU | D3 | RW |
| | 14 | | | 54 | | ASC21CR0 | 94 | RW | | D4 | |
| | 15 | | | 55 | | ASC21CR1 | 95 | RW | | D5 | |
| | 16 | | | 56 | | ASC21CR2 | 96 | RW | | D6 | |
| | 17 | | | 57 | | ASC21CR3 | 97 | RW | | D7 | |
| | 18 | | | 58 | | | 98 | | | D8 | |
| | 19 | | | 59 | | | 99 | | | D9 | |
| | 1A | | | 5A | | | 9A | | | DA | |
| | 1B | | | 5B | | | 9B | | | DB | |
| | 1C | | | 5C | | | 9C | | | DC | |
| | 1D | | | 5D | | | 9D | | OSC_GO_EN | DD | RW |
| | 1E | | | 5E | | | 9E | | OSC_CR4 | DE | RW |
| | 1F | | | 5F | | | 9F | | OSC_CR3 | DF | RW |
| DBB00FN | 20 | RW | CLK_CR0 | 60 | RW | | A0 | | OSC_CR0 | E0 | RW |
| DBB00IN | 21 | RW | CLK_CR1 | 61 | RW | | A1 | | OSC_CR1 | E1 | RW |
| DBB00OU | 22 | RW | ABF_CR0 | 62 | RW | | A2 | | OSC_CR2 | E2 | RW |
| | 23 | | AMD_CR0 | 63 | RW | | A3 | | VLT_CR | E3 | RW |
| DBB01FN | 24 | RW | | 64 | | | A4 | | VLT_CMP | E4 | R |
| DBB01IN | 25 | RW | | 65 | | | A5 | | | E5 | |
| DBB01OU | 26 | RW | AMD_CR1 | 66 | RW | | A6 | | | E6 | |
| | 27 | | ALT_CR0 | 67 | RW | | A7 | | | E7 | |
| DCB02FN | 28 | RW | | 68 | | SARADC_TRS | A8 | RW | IMO_TR | E8 | W |
| DCB02IN | 29 | RW | | 69 | | SARADC_TRCL | A9 | RW | ILO_TR | E9 | W |
| DCB02OU | 2A | RW | | 6A | | SARADC_TRCH | AA | RW | BDG_TR | EA | RW |
| | 2B | | | 6B | | SARADC_C2 | AB | # | ECO_TR | EB | W |
| DCB03FN | 2C | RW | TMP_DR0 | 6C | RW | SARADC_LCR | AC | RW | | EC | |
| DCB03IN | 2D | RW | TMP_DR1 | 6D | RW | | AD | | | ED | |
| DCB03OU | 2E | RW | TMP_DR2 | 6E | RW | | AE | | | EE | |
| | 2F | | TMP_DR3 | 6F | RW | | AF | | | EF | |
| | 30 | | ACB00CR3 | 70 | RW | RDI0RI | B0 | RW | | F0 | |
| | 31 | | ACB00CR0 | 71 | RW | RDI0SYN | B1 | RW | | F1 | |
| | 32 | | ACB00CR1 | 72 | RW | RDI0IS | B2 | RW | | F2 | |
| | 33 | | ACB00CR2 | 73 | RW | RDI0LT0 | B3 | RW | | F3 | |
| | 34 | | ACB01CR3 | 74 | RW | RDI0LT1 | B4 | RW | | F4 | |
| | 35 | | ACB01CR0 | 75 | RW | RDI0RO0 | B5 | RW | | F5 | |
| | 36 | | ACB01CR1 | 76 | RW | RDI0RO1 | B6 | RW | | F6 | |
| | 37 | | ACB01CR2 * | 77 | RW | | B7 | | CPU_F | F7 | RL |
| | 38 | | | 78 | | | B8 | | | F8 | |
| | 39 | | | 79 | | | B9 | | | F9 | |
| | 3A | | | 7A | | | BA | | FLS_PR1 | FA | RW |
| | 3B | | | 7B | | | BB | | | FB | |
| | 3C | | | 7C | | | BC | | | FC | |
| | 3D | | | 7D | | | BD | | | FD | |
| | 3E | | | 7E | | | BE | | CPU_SCR1 | FE | # |
| | 3F | | | 7F | | | BF | | CPU_SCR0 | FF | # |

Blank fields are reserved. # Access is bit specific.

Electrical Specifications

This section presents the DC and AC electrical specifications of the CY8C24633 PSoC device. For the most up to date electrical specifications, confirm that you have the most recent data sheet by going to the web at <http://www.cypress.com/psoc>.

Specifications are valid for $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$ and $T_J \leq 100\text{ }^{\circ}\text{C}$, except where noted.

Refer to [Table 22](#) for the electrical specifications on the IMO using SLIMO mode.

Figure 6. Voltage versus CPU Frequency

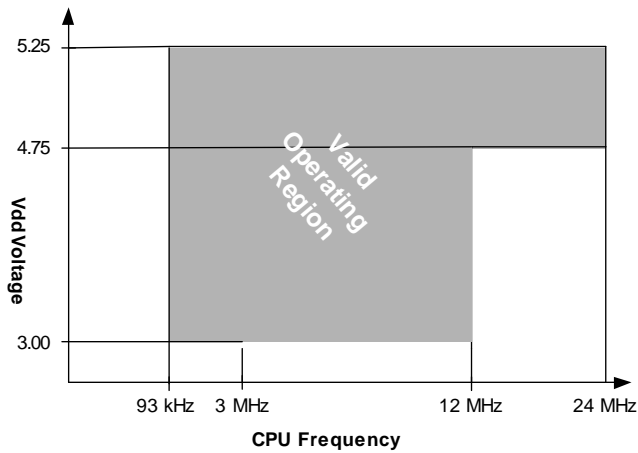
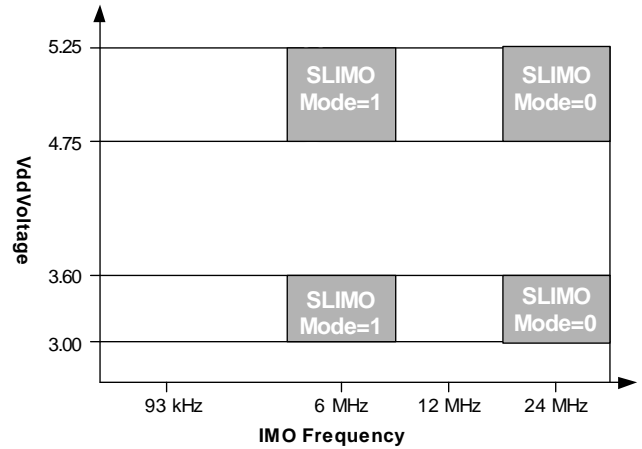


Figure 5a. IMO Frequency Trim Options



Absolute Maximum Ratings
Table 6. Absolute Maximum Ratings

| Symbol | Description | Min | Typ | Max | Units | Notes |
|-----------------------|---|-----------------------|-----|-----------------------|-------|--|
| T _{STG} | Storage temperature | -55 | 25 | +100 | °C | Higher storage temperatures reduce data retention time. Recommended storage temperature is +25 °C ± 25 °C. Extended duration storage temperatures above 65 °C degrade reliability. |
| T _{BAKETEMP} | Bake temperature | – | 125 | See package label | °C | |
| T _{BAKETIME} | Bake time | See package label | – | 72 | hours | |
| T _A | Ambient temperature with power applied | -40 | – | +85 | °C | |
| V _{dd} | Supply voltage on V _{dd} Relative to V _{ss} | -0.5 | – | +6.0 | V | |
| V _{IO} | DC input voltage | V _{ss} - 0.5 | – | V _{dd} + 0.5 | V | |
| V _{IOZ} | DC voltage applied to Tri-state | V _{ss} - 0.5 | – | V _{dd} + 0.5 | V | |
| I _{MIO} | Maximum current into any port pin | -25 | – | +50 | mA | |
| ESD | Electro static discharge voltage | 2000 | – | – | V | Human Body Model ESD. |
| LU | Latch up current | – | – | 200 | mA | |

Operating Temperature
Table 7. Operating Temperature

| Symbol | Description | Min | Typ | Max | Units | Notes |
|----------------|----------------------|-----|-----|------|-------|--|
| T _A | Ambient temperature | -40 | – | +85 | °C | |
| T _J | Junction temperature | -40 | – | +100 | °C | The temperature rise from ambient to junction is package specific. See Thermal Impedances by Package on page 41 . The user must limit the power consumption to comply with this requirement. |

DC Electrical Characteristics

DC Chip-Level Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 8. DC Chip-Level Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|---------------------|--|------|------|------|-------|--|
| V _{DD} | Supply voltage | 3.0 | – | 5.25 | V | See Table 18 on page 27. |
| I _{DD} | Supply current | – | 5 | 8 | mA | Conditions are V _{DD} = 5.0 V, T _A = 25 °C, CPU = 3 MHz, SYSCLK doubler disabled, VC1 = 1.5 MHz, VC2 = 93.75 kHz, VC3 = 93.75 kHz, analog power = off. SLIMO mode = 0. IMO = 24 MHz. |
| I _{DD3} | Supply current | – | 3.3 | 6.0 | mA | Conditions are V _{DD} = 3.3 V, T _A = 25 °C, CPU = 3 MHz, SYSCLK doubler disabled, VC1 = 1.5 MHz, VC2 = 93.75 kHz, VC3 = 93.75 kHz, analog power = off. SLIMO mode = 0. IMO = 24 MHz. |
| I _{SB} | Sleep (Mode) current with POR, LVD, sleep timer, and WDT. ^[6] | – | 3 | 6.5 | μA | Conditions are with internal slow speed oscillator, V _{DD} = 3.3 V, $-40\text{ }^{\circ}\text{C} \leq T_A \leq 55\text{ }^{\circ}\text{C}$, analog power = off. |
| I _{SBH} | Sleep (Mode) current with POR, LVD, sleep timer, and WDT at high temperature. ^[6] | – | 4 | 25 | μA | Conditions are with internal slow speed oscillator, V _{DD} = 3.3 V, $55\text{ }^{\circ}\text{C} < T_A \leq 85\text{ }^{\circ}\text{C}$, analog power = off. |
| I _{SBXTL} | Sleep (Mode) current with POR, LVD, sleep timer, WDT, and external crystal. ^[6] | – | 4 | 7.5 | μA | Conditions are with properly loaded, 1 μW max, 32.768 kHz crystal. V _{DD} = 3.3 V, $-40\text{ }^{\circ}\text{C} \leq T_A \leq 55\text{ }^{\circ}\text{C}$, analog power = off. |
| I _{SBXTLH} | Sleep (Mode) current with POR, LVD, sleep timer, WDT, and external crystal at high temperature. ^[6] | – | 5 | 26 | μA | Conditions are with properly loaded, 1 μW max, 32.768 kHz crystal. V _{DD} = 3.3 V, $55\text{ }^{\circ}\text{C} < T_A \leq 85\text{ }^{\circ}\text{C}$, analog power = off. |
| V _{REF} | Reference voltage (Bandgap) | 1.28 | 1.30 | 1.33 | V | Trimmed for appropriate V _{DD} . V _{DD} > 3.0 V. |

Note

6. Standby current includes all functions (POR, LVD, WDT, sleep time) needed for reliable system operation. This should be compared with devices that have similar functions enabled.

DC GPIO Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 9. 5V and 3.3V DC GPIO Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|------------------|-----------------------------------|-----------------------|-----|------|-------|--|
| R _{PU} | Pull-up resistor | 4 | 5.6 | 8 | kΩ | |
| R _{PD} | Pull-down resistor | 4 | 5.6 | 8 | kΩ | |
| V _{OH} | High output level | V _{dd} - 1.0 | – | – | V | I _{OH} = 10 mA, V _{dd} = 4.75 to 5.25 V (maximum 40 mA on even port pins (for example, P0[2], P1[4]), maximum 40 mA on odd port pins (for example, P0[3], P1[5])). 80 mA maximum combined IOH budget. |
| V _{OL} | Low output level | – | – | 0.75 | V | I _{OL} = 25 mA, V _{dd} = 4.75 to 5.25 V (maximum 100 mA on even port pins (for example, P0[2], P1[4]), maximum 100 mA on odd port pins (for example, P0[3], P1[5])). 100 mA maximum combined IOH budget. |
| I _{OH} | High level source current | 10 | – | – | mA | |
| I _{OL} | Low level sink current | 25 | – | – | mA | |
| V _{IL} | Input low level | – | – | 0.8 | V | V _{dd} = 3.0 to 5.25. |
| V _{IH} | Input high level | 2.1 | – | – | V | V _{dd} = 3.0 to 5.25. |
| V _H | Input Hysteresis | – | 60 | – | mV | |
| I _{IL} | Input leakage (absolute value) | – | 1 | – | nA | Gross tested to 1 μA. |
| C _{IN} | Capacitive load on pins as input | – | 3.5 | 10 | pF | Package and pin dependent. Temp = 25°C. |
| C _{OUT} | Capacitive load on pins as output | – | 3.5 | 10 | pF | Package and pin dependent. Temp = 25°C. |

DC Operational Amplifier Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

The operational amplifier is a component of both the analog continuous time PSoC blocks and the analog switched Cap PSoC blocks. The guaranteed specifications are measured in the analog continuous Time PSoC block. Typical parameters apply to 5 V at 25°C and are for design guidance only.

Table 10. 5 V DC Operational Amplifier Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|----------------|---|----------------|------|----------------|--------------------------------|---|
| $V_{OSO A}$ | Input offset voltage (absolute value) | – | 1.6 | 10 | mV | |
| | Power = Low, opamp bias = high | – | 1.3 | 8 | mV | |
| | Power = high, opamp bias = high | – | 1.2 | 7.5 | mV | |
| $TCV_{OSO A}$ | Average input offset voltage drift | – | 7.0 | 35.0 | $\mu\text{V}/^{\circ}\text{C}$ | |
| $I_{EBO A}$ | Input leakage current (Port 0 Analog Pins) | – | 20 | – | pA | Gross tested to 1 μA . |
| $C_{INO A}$ | Input capacitance (port 0 analog pins) | – | 4.5 | 9.5 | pF | Package and pin dependent. Temp = 25 °C. |
| $V_{CMO A}$ | Common mode voltage range | 0.0 | – | V_{dd} | V | The common-mode input voltage range is measured through an analog output buffer. The specification includes the limitations imposed by the characteristics of the analog output buffer. |
| | Common Mode Voltage Range (high power or high opamp bias) | 0.5 | – | $V_{dd} - 0.5$ | V | |
| $G_{OLO A}$ | Open loop gain | – | – | – | dB | Specification is applicable at high power. For all other bias modes (except high power, high opamp bias), minimum is 60 dB. |
| | Power = low, opamp bias = high | 60 | – | – | dB | |
| | Power = high, opamp bias = high | 80 | – | – | dB | |
| $V_{OHIGHO A}$ | High output voltage swing (internal signals) | – | – | – | V | |
| | Power = low, opamp bias = high | $V_{dd} - 0.2$ | – | – | V | |
| | Power = high, opamp bias = high | $V_{dd} - 0.5$ | – | – | V | |
| $V_{OLOWO A}$ | Low output voltage swing (internal signals) | – | – | – | V | |
| | Power = low, opamp bias = high | – | – | 0.2 | V | |
| | Power = high, opamp bias = high | – | – | 0.5 | V | |
| $I_{SO A}$ | Supply current (including associated AGND buffer) | – | – | – | μA | |
| | Power = low, opamp bias = high | – | 300 | 400 | μA | |
| | Power = medium, opamp bias = low | – | 600 | 800 | μA | |
| | Power = medium, opamp bias = high | – | 1200 | 1600 | μA | |
| | Power = high, opamp bias = high | – | 4600 | 6400 | μA | |
| $PSRR_{O A}$ | Supply voltage rejection ratio | 52 | 80 | – | dB | $V_{SS} \leq VIN \leq (V_{dd} - 2.25)$ or $(V_{dd} - 1.25\text{ V}) \leq VIN \leq V_{dd}$. |

Table 11. 3.3 V DC Operational Amplifier Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|----------------|--|--|--|--|--|---|
| $V_{OSO A}$ | Input offset voltage (absolute value) Power = low, opamp bias = high Power = medium, opamp bias = high Power = high, opamp bias = high | – – – | 1.65 1.32 – | 10 8 – | mV mV mV | Power = high, opamp bias = high setting is not allowed for 3.3 V V_{DD} operation. |
| $TCV_{OSO A}$ | Average input offset voltage drift | – | 7.0 | 35.0 | $\mu V/^{\circ}C$ | |
| $I_{EBO A}$ | Input leakage current (port 0 analog pins) | – | 20 | – | pA | Gross tested to 1 μA |
| $C_{INO A}$ | Input capacitance (port 0 analog pins) | – | 4.5 | 9.5 | pF | Package and pin dependent. Temp = 25 $^{\circ}C$ |
| $V_{CMO A}$ | Common mode voltage range | 0.2 | – | $V_{DD} - 0.2$ | V | The common-mode input voltage range is measured through an analog output buffer. The specification includes the limitations imposed by the characteristics of the analog output buffer. |
| $G_{OLO A}$ | Open loop gain power = low, ppamp, Opamp bias = low Power = medium, opamp bias = low Power = high, opamp bias = low | 60 60 80 | – – – | – – – | dB dB dB | Specification is applicable at low Opamp bias. For high opamp bias mode (except high power, high opamp bias), minimum is 60 dB. |
| $V_{OHIGHO A}$ | High output voltage swing (internal signals) Power = low, opamp bias = low Power = medium, opamp bias = low Power = high, opamp bias = low | $V_{DD} - 0.2$ $V_{DD} - 0.2$ $V_{DD} - 0.2$ | – – – | – – – | V V V | Power = high, opamp bias = high setting is not allowed for 3.3 V V_{DD} operation. |
| $V_{OLOWO A}$ | Low output voltage swing (internal signals) Power = low, opamp bias = low Power = medium, opamp bias = low Power = high, opamp bias = low | – – – | – – – | 0.2 0.2 0.2 | V V V | Power = high, opamp bias = high setting is not allowed for 3.3 V V_{DD} operation. |
| $I_{SO A}$ | Supply current (including associated AGND buffer) Power = low, opamp bias = low Power = low, opamp bias = high Power = medium, opamp bias = low Power = medium, opamp bias = high Power = high, opamp bias = low Power = high, opamp bias = high | – – – – – – | 150 300 600 1200 2400 – | 200 400 800 1600 3200 – | μA μA μA μA μA μA | Power = high, opamp bias = high setting is not allowed for 3.3 V V_{DD} operation. |
| $PSRR_{O A}$ | Supply voltage rejection ratio | 64 | 80 | – | dB | $V_{SS} \leq V_{IN} \leq (V_{DD} - 2.25)$ or $(V_{DD} - 1.25 V) \leq V_{IN} \leq V_{DD}$ |

DC Low Power Comparator Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40^{\circ}C \leq T_A \leq 85^{\circ}C$, or 3.0 V to 3.6 V and $-40^{\circ}C \leq T_A \leq 85^{\circ}C$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 $^{\circ}C$ and are for design guidance only.

Table 12. DC Low Power Comparator Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|--------------|--|-----|-----|--------------|---------|-------|
| V_{REFLPC} | Low power comparator (LPC) reference voltage range | 0.2 | – | $V_{dd} - 1$ | V | |
| I_{SLPC} | LPC supply current | – | 10 | 40 | μA | |
| V_{OSLPC} | LPC voltage offset | – | 2.5 | 30 | mV | |

DC Analog Output Buffer Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 13. 5 V DC Analog Output Buffer Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|---------------|--|--|------------|--|--------------------------------|--|
| C_L | Load capacitance | – | – | 200 | pF | This specification applies to the external circuit that is being driven by the analog output buffer. |
| V_{OSOB} | Input offset voltage (absolute value) | – | 3 | 12 | mV | |
| TCV_{OSOB} | Average input offset voltage drift | – | +6 | – | $\mu\text{V}/^{\circ}\text{C}$ | |
| V_{CMOB} | Common-mode input voltage range | 0.5 | – | $V_{dd} - 1.0$ | V | |
| R_{OUTOB} | Output resistance Power = low Power = high | – – | 1 1 | – – | W W | |
| $V_{OHIGHOB}$ | High output voltage swing (Load = 32Ω to $V_{dd}/2$) Power = low Power = high | $0.5 \times V_{dd} + 1.1$ $0.5 \times V_{dd} + 1.1$ | – – | – – | V V | |
| V_{OLOWOB} | Low output voltage swing (Load = 32Ω to $V_{dd}/2$) Power = low Power = high | – – | – – | $0.5 \times V_{dd} - 1.3$ $0.5 \times V_{dd} - 1.3$ | V V | |
| I_{SOB} | Supply current including bias cell (no load) Power = low Power = high | – – | 1.1 2.6 | 5.1 8.8 | mA mA | |
| $PSRR_{OB}$ | Supply voltage rejection ratio | 52 | 64 | – | dB | $V_{OUT} > (V_{dd} - 1.25)$. |

Table 14. 3.3 V DC Analog Output Buffer Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|---------------|--|--|------------|--|--------------------------------|--|
| C_L | Load capacitance | – | – | 200 | pF | This specification applies to the external circuit that is being driven by the analog output buffer. |
| V_{OSOB} | Input offset voltage (absolute value) | – | 3 | 12 | mV | |
| TCV_{OSOB} | average input offset voltage drift | – | +6 | – | $\mu\text{V}/^{\circ}\text{C}$ | |
| V_{CMOB} | Common-mode input voltage range | 0.5 | – | $V_{dd} - 1.0$ | V | |
| R_{OUTOB} | Output resistance Power = low Power = high | – – | 1 1 | – – | W W | |
| $V_{OHIGHOB}$ | High output voltage swing (Load = 1 k Ω to $V_{dd}/2$) Power = low Power = high | $0.5 \times V_{dd} + 1.0$ $0.5 \times V_{dd} + 1.0$ | – – | – – | V V | |
| V_{OLOWOB} | Low output voltage swing (Load = 1 k Ω to $V_{dd}/2$) Power = low Power = high | – – | – – | $0.5 \times V_{dd} - 1.0$ $0.5 \times V_{dd} - 1.0$ | V V | |
| I_{SOB} | Supply current including bias cell (No Load) Power = low Power = high | – – | 0.8 2.0 | 2.0 4.3 | mA mA | |
| $PSRR_{OB}$ | Supply voltage rejection ratio | 52 | 64 | – | dB | $V_{OUT} > (V_{dd} - 1.25)$. |

DC Analog Reference Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

The guaranteed specifications are measured through the analog continuous time PSoC blocks. The power levels for AGND refer to the power of the analog continuous Time PSoC block. The power levels for RefHi and RefLo refer to the analog reference control register. The limits stated for AGND include the offset error of the AGND buffer local to the analog continuous time PSoC block. reference control power is high.

Table 15. 5-V DC Analog Reference Specifications

| Reference ARF_CR [5:3] | Reference Power Settings | Symbol | Reference | Description | Min | Typ | Max | Units |
|------------------------|--|--------------------|-----------|---|----------------------------|----------------------------|----------------------------|-------|
| 0b000 | RefPower = high Opamp bias = high | V _{REFHI} | Ref High | V _{DD} /2 + Bandgap | V _{DD} /2 + 1.136 | V _{DD} /2 + 1.288 | V _{DD} /2 + 1.409 | V |
| | | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.138 | V _{DD} /2 + 0.003 | V _{DD} /2 + 0.132 | V |
| | | V _{REFLO} | Ref Low | V _{DD} /2 - Bandgap | V _{DD} /2 - 1.417 | V _{DD} /2 - 1.289 | V _{DD} /2 - 1.154 | V |
| | RefPower = high Opamp bias = low | V _{REFHI} | Ref High | V _{DD} /2 + Bandgap | V _{DD} /2 + 1.202 | V _{DD} /2 + 1.290 | V _{DD} /2 + 1.358 | V |
| | | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.055 | V _{DD} /2 + 0.001 | V _{DD} /2 + 0.055 | V |
| | | V _{REFLO} | Ref Low | V _{DD} /2 - Bandgap | V _{DD} /2 - 1.369 | V _{DD} /2 - 1.295 | V _{DD} /2 - 1.218 | V |
| | RefPower = medium Opamp bias = high | V _{REFHI} | Ref High | V _{DD} /2 + Bandgap | V _{DD} /2 + 1.211 | V _{DD} /2 + 1.292 | V _{DD} /2 + 1.357 | V |
| | | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.055 | V _{DD} /2 | V _{DD} /2 + 0.052 | V |
| | | V _{REFLO} | Ref Low | V _{DD} /2 - Bandgap | V _{DD} /2 - 1.368 | V _{DD} /2 - 1.298 | V _{DD} /2 - 1.224 | V |
| | RefPower = medium Opamp bias = low | V _{REFHI} | Ref High | V _{DD} /2 + Bandgap | V _{DD} /2 + 1.215 | V _{DD} /2 + 1.292 | V _{DD} /2 + 1.353 | V |
| | | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.040 | V _{DD} /2 - 0.001 | V _{DD} /2 + 0.033 | V |
| | | V _{REFLO} | Ref Low | V _{DD} /2 - Bandgap | V _{DD} /2 - 1.368 | V _{DD} /2 - 1.299 | V _{DD} /2 - 1.225 | V |
| 0b001 | RefPower = high Opamp bias = high | V _{REFHI} | Ref High | P2[4]+P2[6] (P2[4] = V _{DD} /2, P2[6] = 1.3 V) | P2[4] + P2[6] - 0.076 | P2[4] + P2[6] - 0.021 | P2[4] + P2[6] + 0.041 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | - |
| | | V _{REFLO} | Ref Low | P2[4]-P2[6] (P2[4] = V _{DD} /2, P2[6] = 1.3 V) | P2[4] - P2[6] - 0.025 | P2[4] - P2[6] + 0.011 | P2[4] - P2[6] + 0.085 | V |
| | RefPower = high Opamp bias = low | V _{REFHI} | Ref High | P2[4]+P2[6] (P2[4] = V _{DD} /2, P2[6] = 1.3 V) | P2[4] + P2[6] - 0.069 | P2[4] + P2[6] - 0.014 | P2[4] + P2[6] + 0.043 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | - |
| | | V _{REFLO} | Ref Low | P2[4]-P2[6] (P2[4] = V _{DD} /2, P2[6] = 1.3 V) | P2[4] - P2[6] - 0.029 | P2[4] - P2[6] + 0.005 | P2[4] - P2[6] + 0.052 | V |
| | RefPower = medium Opamp bias = high | V _{REFHI} | Ref High | P2[4]+P2[6] (P2[4] = V _{DD} /2, P2[6] = 1.3 V) | P2[4] + P2[6] - 0.072 | P2[4] + P2[6] - 0.011 | P2[4] + P2[6] + 0.048 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | - |
| | | V _{REFLO} | Ref Low | P2[4]-P2[6] (P2[4] = V _{DD} /2, P2[6] = 1.3 V) | P2[4] - P2[6] - 0.031 | P2[4] - P2[6] + 0.002 | P2[4] - P2[6] + 0.057 | V |
| | RefPower = medium Opamp bias = low | V _{REFHI} | Ref High | P2[4]+P2[6] (P2[4] = V _{DD} /2, P2[6] = 1.3 V) | P2[4] + P2[6] - 0.070 | P2[4] + P2[6] - 0.009 | P2[4] + P2[6] + 0.047 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | - |
| | | V _{REFLO} | Ref Low | P2[4]-P2[6] (P2[4] = V _{DD} /2, P2[6] = 1.3 V) | P2[4] - P2[6] - 0.033 | P2[4] - P2[6] + 0.001 | P2[4] - P2[6] + 0.039 | V |

Table 15. 5-V DC Analog Reference Specifications (continued)

| Reference ARF_CR [5:3] | Reference Power Settings | Symbol | Reference | Description | Min | Typ | Max | Units |
|---------------------------------------|--|--------------------|--|--|----------------------------|----------------------------|----------------------------|-------|
| 0b010 | RefPower = high Opamp bias = high | V _{REFHI} | Ref High | V _{DD} | V _{DD} - 0.121 | V _{DD} - 0.003 | V _{DD} | V |
| | | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.040 | V _{DD} /2 | V _{DD} /2 + 0.034 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.006 | V _{SS} + 0.019 | V |
| | RefPower = high Opamp bias = low | V _{REFHI} | Ref High | V _{DD} | V _{DD} - 0.083 | V _{DD} - 0.002 | V _{DD} | V |
| | | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.040 | V _{DD} /2 - 0.001 | V _{DD} /2 + 0.033 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.004 | V _{SS} + 0.016 | V |
| | RefPower = medium Opamp bias = high | V _{REFHI} | Ref High | V _{DD} | V _{DD} - 0.075 | V _{DD} - 0.002 | V _{DD} | V |
| | | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.040 | V _{DD} /2 - 0.001 | V _{DD} /2 + 0.032 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.003 | V _{SS} + 0.015 | V |
| RefPower = medium Opamp bias = low | V _{REFHI} | Ref High | V _{DD} | V _{DD} - 0.074 | V _{DD} - 0.002 | V _{DD} | V | |
| | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.040 | V _{DD} /2 - 0.001 | V _{DD} /2 + 0.032 | V | |
| | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.002 | V _{SS} + 0.014 | V | |
| 0b011 | RefPower = high Opamp bias = high | V _{REFHI} | Ref High | 3 × Bandgap | 3.753 | 3.874 | 3.979 | V |
| | | V _{AGND} | AGND | 2 × Bandgap | 2.511 | 2.590 | 2.657 | V |
| | | V _{REFLO} | Ref Low | Bandgap | 1.243 | 1.297 | 1.333 | V |
| | RefPower = high Opamp bias = low | V _{REFHI} | Ref High | 3 × Bandgap | 3.767 | 3.881 | 3.974 | V |
| | | V _{AGND} | AGND | 2 × Bandgap | 2.518 | 2.592 | 2.652 | V |
| | | V _{REFLO} | Ref Low | Bandgap | 1.241 | 1.295 | 1.330 | V |
| | RefPower = medium Opamp bias = high | V _{REFHI} | Ref High | 3 × Bandgap | 2.771 | 3.885 | 3.979 | V |
| | | V _{AGND} | AGND | 2 × Bandgap | 2.521 | 2.593 | 2.649 | V |
| | | V _{REFLO} | Ref Low | Bandgap | 1.240 | 1.295 | 1.331 | V |
| RefPower = medium Opamp bias = low | V _{REFHI} | Ref High | 3 × Bandgap | 3.771 | 3.887 | 3.977 | V | |
| | V _{AGND} | AGND | 2 × Bandgap | 2.522 | 2.594 | 2.648 | V | |
| | V _{REFLO} | Ref Low | Bandgap | 1.239 | 1.295 | 1.332 | V | |
| 0b100 | RefPower = high Opamp bias = high | V _{REFHI} | Ref High | 2 × Bandgap + P2[6] (P2[6] = 1.3 V) | 2.481 + P2[6] | 2.569 + P2[6] | 2.639 + P2[6] | V |
| | | V _{AGND} | AGND | 2 × Bandgap | 2.511 | 2.590 | 2.658 | V |
| | | V _{REFLO} | Ref Low | 2 × Bandgap - P2[6] (P2[6] = 1.3 V) | 2.515 - P2[6] | 2.602 - P2[6] | 2.654 - P2[6] | V |
| | RefPower = high Opamp bias = low | V _{REFHI} | Ref High | 2 × Bandgap + P2[6] (P2[6] = 1.3 V) | 2.498 + P2[6] | 2.579 + P2[6] | 2.642 + P2[6] | V |
| | | V _{AGND} | AGND | 2 × Bandgap | 2.518 | 2.592 | 2.652 | V |
| | | V _{REFLO} | Ref Low | 2 × Bandgap - P2[6] (P2[6] = 1.3 V) | 2.513 - P2[6] | 2.598 - P2[6] | 2.650 - P2[6] | V |
| | RefPower = medium Opamp bias = high | V _{REFHI} | Ref High | 2 × Bandgap + P2[6] (P2[6] = 1.3 V) | 2.504 + P2[6] | 2.583 + P2[6] | 2.646 + P2[6] | V |
| | | V _{AGND} | AGND | 2 × Bandgap | 2.521 | 2.592 | 2.650 | V |
| | | V _{REFLO} | Ref Low | 2 × Bandgap - P2[6] (P2[6] = 1.3 V) | 2.513 - P2[6] | 2.596 - P2[6] | 2.649 - P2[6] | V |
| RefPower = medium Opamp bias = low | V _{REFHI} | Ref High | 2 × Bandgap + P2[6] (P2[6] = 1.3 V) | 2.505 + P2[6] | 2.586 + P2[6] | 2.648 + P2[6] | V | |
| | V _{AGND} | AGND | 2 × Bandgap | 2.521 | 2.594 | 2.648 | V | |
| | V _{REFLO} | Ref Low | 2 × Bandgap - P2[6] (P2[6] = 1.3 V) | 2.513 - P2[6] | 2.595 - P2[6] | 2.648 - P2[6] | V | |

Table 15. 5-V DC Analog Reference Specifications (continued)

| Reference ARF_CR [5:3] | Reference Power Settings | Symbol | Reference | Description | Min | Typ | Max | Units |
|------------------------|--|--------------------|-----------|---|-----------------|-------------------------|-------------------------|-------|
| 0b101 | RefPower = high Opamp bias = high | V _{REFHI} | Ref High | P2[4] + Bandgap (P2[4] = V _{DD} /2) | P2[4] + 1.228 | P2[4] + 1.284 | P2[4] + 1.332 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | – |
| | | V _{REFLO} | Ref Low | P2[4] – Bandgap (P2[4] = V _{DD} /2) | P2[4] – 1.358 | P2[4] – 1.293 | P2[4] – 1.226 | V |
| | RefPower = high Opamp bias = low | V _{REFHI} | Ref High | P2[4] + Bandgap (P2[4] = V _{DD} /2) | P2[4] + 1.236 | P2[4] + 1.289 | P2[4] + 1.332 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | – |
| | | V _{REFLO} | Ref Low | P2[4] – Bandgap (P2[4] = V _{DD} /2) | P2[4] – 1.357 | P2[4] – 1.297 | P2[4] – 1.229 | V |
| | RefPower = medium Opamp bias = high | V _{REFHI} | Ref High | P2[4] + Bandgap (P2[4] = V _{DD} /2) | P2[4] + 1.237 | P2[4] + 1.291 | P2[4] + 1.337 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | – |
| | | V _{REFLO} | Ref Low | P2[4] – Bandgap (P2[4] = V _{DD} /2) | P2[4] – 1.356 | P2[4] – 1.299 | P2[4] – 1.232 | V |
| | RefPower = medium Opamp bias = low | V _{REFHI} | Ref High | P2[4] + Bandgap (P2[4] = V _{DD} /2) | P2[4] + 1.237 | P2[4] + 1.292 | P2[4] + 1.337 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | – |
| | | V _{REFLO} | Ref Low | P2[4] – Bandgap (P2[4] = V _{DD} /2) | P2[4] – 1.357 | P2[4] – 1.300 | P2[4] – 1.233 | V |
| 0b110 | RefPower = high Opamp bias = high | V _{REFHI} | Ref High | 2 × Bandgap | 2.512 | 2.594 | 2.654 | V |
| | | V _{AGND} | AGND | Bandgap | 1.250 | 1.303 | 1.346 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.011 | V _{SS} + 0.027 | V |
| | RefPower = high Opamp bias = low | V _{REFHI} | Ref High | 2 × Bandgap | 2.515 | 2.592 | 2.654 | V |
| | | V _{AGND} | AGND | Bandgap | 1.253 | 1.301 | 1.340 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.006 | V _{SS} + 0.02 | V |
| | RefPower = medium Opamp bias = high | V _{REFHI} | Ref High | 2 × Bandgap | 2.518 | 2.593 | 2.651 | V |
| | | V _{AGND} | AGND | Bandgap | 1.254 | 1.301 | 1.338 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.004 | V _{SS} + 0.017 | V |
| | RefPower = medium Opamp bias = low | V _{REFHI} | Ref High | 2 × Bandgap | 2.517 | 2.594 | 2.650 | V |
| | | V _{AGND} | AGND | Bandgap | 1.255 | 1.300 | 1.337 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.003 | V _{SS} + 0.015 | V |
| 0b111 | RefPower = high Opamp bias = high | V _{REFHI} | Ref High | 3.2 × Bandgap | 4.011 | 4.143 | 4.203 | V |
| | | V _{AGND} | AGND | 1.6 × Bandgap | 2.020 | 2.075 | 2.118 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.011 | V _{SS} + 0.026 | V |
| | RefPower = high Opamp bias = low | V _{REFHI} | Ref High | 3.2 × Bandgap | 4.022 | 4.138 | 4.203 | V |
| | | V _{AGND} | AGND | 1.6 × Bandgap | 2.023 | 2.075 | 2.114 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.006 | V _{SS} + 0.017 | V |
| | RefPower = medium Opamp bias = high | V _{REFHI} | Ref High | 3.2 × Bandgap | 4.026 | 4.141 | 4.207 | V |
| | | V _{AGND} | AGND | 1.6 × Bandgap | 2.024 | 2.075 | 2.114 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.004 | V _{SS} + 0.015 | V |
| | RefPower = medium Opamp bias = low | V _{REFHI} | Ref High | 3.2 × Bandgap | 4.030 | 4.143 | 4.206 | V |
| | | V _{AGND} | AGND | 1.6 × Bandgap | 2.024 | 2.076 | 2.112 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.003 | V _{SS} + 0.013 | V |

Table 16. 3.3-V DC Analog Reference Specifications

| Reference ARF_CR [5:3] | Reference Power Settings | Symbol | Reference | Description | Min | Typ | Max | Units |
|---------------------------------------|--|--------------------|------------------------------|---|----------------------------|----------------------------|----------------------------|-------|
| 0b000 | RefPower = high Opamp bias = high | V _{REFHI} | Ref High | V _{DD} /2 + Bandgap | V _{DD} /2 + 1.170 | V _{DD} /2 + 1.288 | V _{DD} /2 + 1.376 | V |
| | | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.098 | V _{DD} /2 + 0.003 | V _{DD} /2 + 0.097 | V |
| | | V _{REFLO} | Ref Low | V _{DD} /2 - Bandgap | V _{DD} /2 - 1.386 | V _{DD} /2 - 1.287 | V _{DD} /2 - 1.169 | V |
| | RefPower = high Opamp bias = low | V _{REFHI} | Ref High | V _{DD} /2 + Bandgap | V _{DD} /2 + 1.210 | V _{DD} /2 + 1.290 | V _{DD} /2 + 1.355 | V |
| | | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.055 | V _{DD} /2 + 0.001 | V _{DD} /2 + 0.054 | V |
| | | V _{REFLO} | Ref Low | V _{DD} /2 - Bandgap | V _{DD} /2 - 1.359 | V _{DD} /2 - 1.292 | V _{DD} /2 - 1.214 | V |
| | RefPower = medium Opamp bias = high | V _{REFHI} | Ref High | V _{DD} /2 + Bandgap | V _{DD} /2 + 1.198 | V _{DD} /2 + 1.292 | V _{DD} /2 + 1.368 | V |
| | | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.041 | V _{DD} /2 | V _{DD} /2 + 0.04 | V |
| | | V _{REFLO} | Ref Low | V _{DD} /2 - Bandgap | V _{DD} /2 - 1.362 | V _{DD} /2 - 1.295 | V _{DD} /2 - 1.220 | V |
| RefPower = medium Opamp bias = low | V _{REFHI} | Ref High | V _{DD} /2 + Bandgap | V _{DD} /2 + 1.202 | V _{DD} /2 + 1.292 | V _{DD} /2 + 1.364 | V | |
| | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.033 | V _{DD} /2 | V _{DD} /2 + 0.030 | V | |
| | V _{REFLO} | Ref Low | V _{DD} /2 - Bandgap | V _{DD} /2 - 1.364 | V _{DD} /2 - 1.297 | V _{DD} /2 - 1.222 | V | |
| 0b001 | RefPower = high Opamp bias = high | V _{REFHI} | Ref High | P2[4]+P2[6] (P2[4] = V _{DD} /2, P2[6] = 0.5 V) | P2[4] + P2[6] - 0.072 | P2[4] + P2[6] - 0.017 | P2[4] + P2[6] + 0.041 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | - |
| | | V _{REFLO} | Ref Low | P2[4]-P2[6] (P2[4] = V _{DD} /2, P2[6] = 0.5 V) | P2[4] - P2[6] - 0.029 | P2[4] - P2[6] + 0.010 | P2[4] - P2[6] + 0.048 | V |
| | RefPower = high Opamp bias = low | V _{REFHI} | Ref High | P2[4]+P2[6] (P2[4] = V _{DD} /2, P2[6] = 0.5 V) | P2[4] + P2[6] - 0.066 | P2[4] + P2[6] - 0.010 | P2[4] + P2[6] + 0.043 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | - |
| | | V _{REFLO} | Ref Low | P2[4]-P2[6] (P2[4] = V _{DD} /2, P2[6] = 0.5 V) | P2[4] - P2[6] - 0.024 | P2[4] - P2[6] + 0.004 | P2[4] - P2[6] + 0.034 | V |
| | RefPower = medium Opamp bias = high | V _{REFHI} | Ref High | P2[4]+P2[6] (P2[4] = V _{DD} /2, P2[6] = 0.5 V) | P2[4] + P2[6] - 0.073 | P2[4] + P2[6] - 0.007 | P2[4] + P2[6] + 0.053 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | - |
| | | V _{REFLO} | Ref Low | P2[4]-P2[6] (P2[4] = V _{DD} /2, P2[6] = 0.5 V) | P2[4] - P2[6] - 0.028 | P2[4] - P2[6] + 0.002 | P2[4] - P2[6] + 0.033 | V |
| | RefPower = medium Opamp bias = low | V _{REFHI} | Ref High | P2[4]+P2[6] (P2[4] = V _{DD} /2, P2[6] = 0.5 V) | P2[4] + P2[6] - 0.073 | P2[4] + P2[6] - 0.006 | P2[4] + P2[6] + 0.056 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | - |
| | | V _{REFLO} | Ref Low | P2[4]-P2[6] (P2[4] = V _{DD} /2, P2[6] = 0.5 V) | P2[4] - P2[6] - 0.030 | P2[4] - P2[6] | P2[4] - P2[6] + 0.032 | V |
| 0b010 | RefPower = high Opamp bias = high | V _{REFHI} | Ref High | V _{DD} | V _{DD} - 0.102 | V _{DD} - 0.003 | V _{DD} | V |
| | | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.040 | V _{DD} /2 + 0.001 | V _{DD} /2 + 0.039 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.005 | V _{SS} + 0.020 | V |
| | RefPower = high Opamp bias = low | V _{REFHI} | Ref High | V _{DD} | V _{DD} - 0.082 | V _{DD} - 0.002 | V _{DD} | V |
| | | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.031 | V _{DD} /2 | V _{DD} /2 + 0.028 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.003 | V _{SS} + 0.015 | V |
| | RefPower = medium Opamp bias = high | V _{REFHI} | Ref High | V _{DD} | V _{DD} - 0.083 | V _{DD} - 0.002 | V _{DD} | V |
| | | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.032 | V _{DD} /2 - 0.001 | V _{DD} /2 + 0.029 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.002 | V _{SS} + 0.014 | V |
| | RefPower = medium Opamp bias = low | V _{REFHI} | Ref High | V _{DD} | V _{DD} - 0.081 | V _{DD} - 0.002 | V _{DD} | V |
| | | V _{AGND} | AGND | V _{DD} /2 | V _{DD} /2 - 0.033 | V _{DD} /2 - 0.001 | V _{DD} /2 + 0.029 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.002 | V _{SS} + 0.013 | V |
| 0b011 | All power settings Not allowed at 3.3 V | - | - | - | - | - | - | - |

Table 16. 3.3-V DC Analog Reference Specifications (continued)

| Reference ARF_CR [5:3] | Reference Power Settings | Symbol | Reference | Description | Min | Typ | Max | Units |
|------------------------|--|--------------------|-----------|---|-----------------|-------------------------|-------------------------|-------|
| 0b100 | All power settings Not allowed at 3.3 V | – | – | – | – | – | – | – |
| 0b101 | RefPower = high opamp bias = high | V _{REFHI} | Ref High | P2[4] + Bandgap (P2[4] = V _{DD} /2) | P2[4] + 1.211 | P2[4] + 1.285 | P2[4] + 1.348 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | – |
| | | V _{REFLO} | Ref Low | P2[4] – Bandgap (P2[4] = V _{DD} /2) | P2[4] – 1.354 | P2[4] – 1.290 | P2[4] – 1.197 | V |
| | RefPower = high opamp bias = low | V _{REFHI} | Ref High | P2[4] + Bandgap (P2[4] = V _{DD} /2) | P2[4] + 1.209 | P2[4] + 1.289 | P2[4] + 1.353 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | – |
| | | V _{REFLO} | Ref Low | P2[4] – Bandgap (P2[4] = V _{DD} /2) | P2[4] – 1.352 | P2[4] – 1.294 | P2[4] – 1.222 | V |
| | RefPower = medium opamp bias = high | V _{REFHI} | Ref High | P2[4] + Bandgap (P2[4] = V _{DD} /2) | P2[4] + 1.218 | P2[4] + 1.291 | P2[4] + 1.351 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | – |
| | | V _{REFLO} | Ref Low | P2[4] – Bandgap (P2[4] = V _{DD} /2) | P2[4] – 1.351 | P2[4] – 1.296 | P2[4] – 1.224 | V |
| | RefPower = medium opamp bias = low | V _{REFHI} | Ref High | P2[4] + Bandgap (P2[4] = V _{DD} /2) | P2[4] + 1.215 | P2[4] + 1.292 | P2[4] + 1.354 | V |
| | | V _{AGND} | AGND | P2[4] | P2[4] | P2[4] | P2[4] | – |
| | | V _{REFLO} | Ref Low | P2[4] – Bandgap (P2[4] = V _{DD} /2) | P2[4] – 1.352 | P2[4] – 1.297 | P2[4] – 1.227 | V |
| 0b110 | RefPower = high opamp bias = high | V _{REFHI} | Ref High | 2 × Bandgap | 2.460 | 2.594 | 2.695 | V |
| | | V _{AGND} | AGND | Bandgap | 1.257 | 1.302 | 1.335 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.01 | V _{SS} + 0.029 | V |
| | RefPower = high opamp bias = low | V _{REFHI} | Ref High | 2 × Bandgap | 2.462 | 2.592 | 2.692 | V |
| | | V _{AGND} | AGND | Bandgap | 1.256 | 1.301 | 1.332 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.005 | V _{SS} + 0.017 | V |
| | RefPower = medium opamp bias = high | V _{REFHI} | Ref High | 2 × Bandgap | 2.473 | 2.593 | 2.682 | V |
| | | V _{AGND} | AGND | Bandgap | 1.257 | 1.301 | 1.330 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.003 | V _{SS} + 0.014 | V |
| | RefPower = medium opamp bias = low | V _{REFHI} | Ref High | 2 × Bandgap | 2.470 | 2.594 | 2.685 | V |
| | | V _{AGND} | AGND | Bandgap | 1.256 | 1.300 | 1.332 | V |
| | | V _{REFLO} | Ref Low | V _{SS} | V _{SS} | V _{SS} + 0.002 | V _{SS} + 0.012 | V |
| 0b111 | All power settings Not allowed at 3.3 V | – | – | – | – | – | – | |

DC Analog PSoC Block Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 17. DC Analog PSoC Block Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|-----------------|---------------------------------------|-----|------|-----|-------|-------|
| R _{CT} | Resistor unit value (continuous time) | – | 12.2 | – | kΩ | |

DC POR and LVD Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Note The bits PORLEV and VM in the table below refer to bits in the VLT_CR register.

Table 18. DC POR and LVD Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|--|--|--|--|--|--------------------------------------|---|
| V _{PPOR0} V _{PPOR1} V _{PPOR2} | V _{dd} Value for PPOR Trip PORLEV[1:0] = 00b PORLEV[1:0] = 01b PORLEV[1:0] = 10b | – | 2.36 2.82 4.55 | 2.40 2.95 4.70 | V V V | V _{dd} must be greater than or equal to 2.5 V during startup, reset from the XRES pin, or reset from watchdog. |
| V _{LVD0} V _{LVD1} V _{LVD2} V _{LVD3} V _{LVD4} V _{LVD5} V _{LVD6} V _{LVD7} | V _{dd} Value for LVD Trip VM[2:0] = 000b VM[2:0] = 001b VM[2:0] = 010b VM[2:0] = 011b VM[2:0] = 100b VM[2:0] = 101b VM[2:0] = 110b VM[2:0] = 111b | 2.40 2.85 2.95 3.06 4.37 4.50 4.62 4.71 | 2.45 2.92 3.02 3.13 4.48 4.64 4.73 4.81 | 2.51 ^[7] 2.99 ^[8] 3.09 3.20 4.55 4.75 4.83 4.95 | V V V V V V V V | |

Notes

7. Always greater than 50 mV above V_{PPOR} (PORLEV=00) for falling supply.
8. Always greater than 50 mV above V_{PPOR} (PORLEV=01) for falling supply.

DC Programming Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 19. DC Programming Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|-----------------------|---|-----------------------|-----|------------------------|-------|--|
| V _{DDP} | V _{DD} for programming and erase | 4.5 | 5 | 5.5 | V | This specification applies to the functional requirements of external programmer tools |
| V _{DDL} | Low V _{DD} for verify | 3.0 | 3.1 | 3.2 | V | This specification applies to the functional requirements of external programmer tools |
| V _{DDHV} | High V _{DD} for verify | 5.1 | 5.2 | 5.3 | V | This specification applies to the functional requirements of external programmer tools |
| V _{DDIWRITE} | Supply voltage for flash write operation | 3.0 | – | 5.25 | V | This specification applies to this device when it is executing internal flash writes |
| I _{DDP} | Supply current during programming or verify | – | 5 | 25 | mA | |
| V _{ILP} | Input low voltage during programming or verify | – | – | 0.8 | V | |
| V _{IHP} | Input high voltage during programming or verify | 2.1 | – | – | V | |
| I _{ILP} | Input current when applying V _{ilp} to P1[0] or P1[1] during programming or verify | – | – | 0.2 | mA | Driving internal pull-down resistor. |
| I _{IHP} | Input Current when applying V _{ihp} to P1[0] or P1[1] During Programming or Verify | – | – | 1.5 | mA | Driving internal pull-down resistor. |
| V _{OLV} | Output low voltage during programming or verify | – | – | V _{ss} + 0.75 | V | |
| V _{OHV} | Output high voltage during programming or verify | V _{dd} - 1.0 | – | V _{dd} | V | |
| Flash _{ENPB} | Flash endurance (per block) | 50,000 ^[9] | – | – | – | Erase/write cycles per block. |
| Flash _{ENT} | Flash endurance (total) ^[10] | 1,800,000 | – | – | – | Erase/write cycles. |
| Flash _{DR} | Flash data retention | 10 | – | – | Years | |

Notes

9. The 50,000 cycle flash endurance per block will only be guaranteed if the flash is operating within one voltage range. Voltage ranges are 2.4 V to 3.0 V, 3.0 V to 3.6 V, and 4.75 V to 5.25 V.

10. A maximum of 36 x 50,000 block endurance cycles is allowed. This can be balanced between operations on 36x1 blocks of 50,000 maximum cycles each, 36x2 blocks of 25,000 maximum cycles each, or 36x4 blocks of 12,500 maximum cycles each (to limit the total number of cycles to 36x50,000 and that no single block ever sees more than 50,000 cycles).

For the full industrial range, use a temperature sensor user module (FlashTemp) and feed the result to the temperature argument before writing. Refer to the flash APIs Application Note AN2015 at <http://www.cypress.com> under Application Notes for more information.

DC I²C Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 20. DC I²C Specifications^[11]

| Symbol | Description | Min | Typ | Max | Units | Notes |
|----------------------------------|------------------|-----------------------|-----|------------------------|-------|-----------------------------------|
| V _{IL} I ₂ C | Input low level | – | – | 0.3 × V _{DD} | V | 3.0 V ≤ V _{DD} ≤ 3.6 V |
| | | – | – | 0.25 × V _{DD} | V | 4.75 V ≤ V _{DD} ≤ 5.25 V |
| V _{IH} I ₂ C | Input high level | 0.7 × V _{DD} | – | – | V | 3.0 V ≤ V _{DD} ≤ 5.25 V |

SAR8 ADC DC Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 21. SAR8 ADC DC Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|----------------------|---|------|-----|------|-------|--|
| V _{ADCVREF} | Reference voltage at pin P3[0] when configured as ADC reference voltage | 3.0 | – | 5.25 | V | The voltage level at P3[0] (when configured as ADC reference voltage) should always be maintained to be less than chip supply voltage level on V _{dd} pin. V _{ADCVREF} < V _{dd} . |
| I _{ADCVREF} | Current when P3[0] is configured as ADC V _{REF} | 3 | – | – | mA | |
| INL | R-2R integral non-linearity ^[12] | -1.2 | – | +1.2 | LSB | The maximum LSB is over a sub-range not exceeding 1/16 of the full-scale range. |
| DNL | R-2R differential non-linearity ^[13] | -1 | – | +1 | LSB | Output is monotonic. |

Notes

11. All GPIOs meet the DC GPIO V_{IL} and V_{IH} specifications found in the DC GPIO Specifications sections. The I²C GPIO pins also meet the above specs.
12. At the 7F and 80 points, the maximum INL is 1.5 LSB.
13. For the 7F to 80 transition, the DNL specification is waived.

AC Electrical Characteristics

AC Chip-Level Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 22. 5V and 3.3V AC Chip-Level Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|--------------------------------------|---|-------|--------|----------------------------|-------|---|
| F _{IMO24} | Internal main oscillator frequency for 24 MHz | 22.8 | 24 | 25.2 ^[14,15,16] | MHz | Trimmed for 5 V or 3.3 V operation using factory trim values. See Figure 5b on page 15. SLIMO mode = 0. |
| F _{IMO6} | Internal main oscillator frequency for 6 MHz | 5.5 | 6 | 6.5 ^[14,15,16] | MHz | Trimmed for 5 V or 3.3 V operation using factory trim values. See Figure 5b on page 15. SLIMO mode = 1. |
| F _{CPU1} | CPU frequency (5 V nominal) | 0.093 | 24 | 24.6 ^[14,15] | MHz | SLIMO mode = 0. |
| F _{CPU2} | CPU frequency (3.3 V nominal) | 0.093 | 12 | 12.3 ^[15,16] | MHz | SLIMO mode = 0. |
| F _{48M} | digital psoc block frequency | 0 | 48 | 49.2 ^[14,15,17] | MHz | Refer to the Table 27 on page 36 . |
| F _{24M} | Digital PSoC block frequency | 0 | 24 | 24.6 ^[15,17] | MHz | |
| F _{32K1} | Internal low speed oscillator frequency | 15 | 32 | 75 | kHz | |
| F _{32K2} | External crystal oscillator | – | 32.768 | – | kHz | Accuracy is capacitor and crystal dependent. 50% duty cycle. |
| F _{32K_U} | Internal low speed oscillator untrimmed frequency | 5 | – | 100 | kHz | |
| F _{PLL} | PLL frequency | – | 23.986 | – | MHz | Is a multiple (x732) of crystal frequency. |
| DC _{ILO} | Internal low speed oscillator duty cycle | 20 | 50 | 80 | % | |
| T _{PLLSLEW} | PLL Lock time | 0.5 | – | 10 | ms | |
| T _{PLLSLEWSLOW} | PLL Lock time for low gain setting | 0.5 | – | 50 | ms | |
| T _{OS} | External crystal oscillator startup to 1% | – | 1700 | 2620 | ms | |
| T _{OSACC} | External crystal oscillator startup to 100 ppm | – | 2800 | 3800 | ms | The crystal oscillator frequency is within 100 ppm of its final value by the end of the T _{OSACC} period. Correct operation assumes a properly loaded 1 uW maximum drive level 32.768 kHz crystal. 3.0 V ≤ V _{dd} ≤ 5.5 V, $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$. |
| T _{XRST} | External reset pulse width | 10 | – | – | μs | |
| DC _{24M} | 24 MHz duty cycle | 40 | 50 | 60 | % | |
| Step _{24M} | 24 MHz trim step size | – | 50 | – | kHz | |
| F _{out48M} | 48 MHz output frequency | 46.8 | 48.0 | 49.2 ^[14,16] | MHz | Trimmed. Utilizing factory trim values. |
| F _{MAX} | Maximum frequency of signal on row input or row output. | – | – | 12.3 | MHz | |
| T _{RAMP} | Supply ramp time | NA | – | – | μs | |
| SR _{POWER_UP} | Power supply slew rate | – | – | 250 | V/ms | |
| T _{POWERUP} | Time from End of POR to CPU Executing Code | – | 16 | 100 | ms | |
| t _{jit_IMO} ^[18] | 24 MHz IMO cycle-to-cycle jitter (RMS) | – | 200 | 700 | ps | |
| | 24 MHz IMO long term N cycle-to-cycle jitter (RMS) | – | 300 | 900 | ps | N = 32 |
| | 24 MHz IMO period jitter (RMS) | – | 100 | 400 | ps | |
| t _{jit_PLL} ^[18] | 24 MHz IMO cycle-to-cycle jitter (RMS) | – | 200 | 800 | ps | |
| | 24 MHz IMO long term N cycle-to-cycle jitter (RMS) | – | 300 | 1200 | ps | N = 32 |
| | 24 MHz IMO period jitter (RMS) | – | 100 | 700 | ps | |

Notes

- 14. 4.75V < Vdd < 5.25V.
- 15. Accuracy derived from Internal Main Oscillator with appropriate trim for Vdd range.
- 16. 3.0V < Vdd < 3.6V.
- 17. See the individual user module data sheets for information on maximum frequencies for user modules.
- 18. Refer to Cypress Jitter Specifications application note, [Understanding Datasheet Jitter Specifications for Cypress Timing Products – AN5054](#) for more information.

Figure 7. PLL Lock Timing Diagram

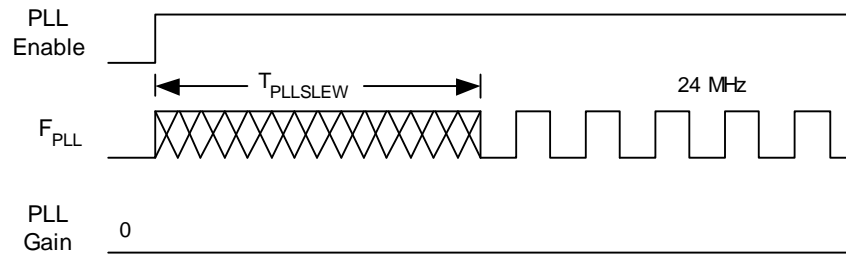


Figure 8. PLL Lock for Low Gain Setting Timing Diagram

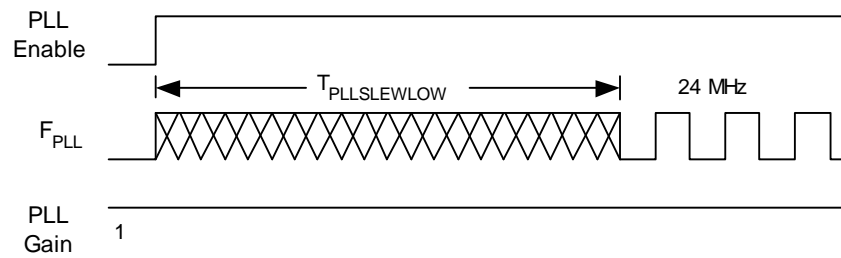
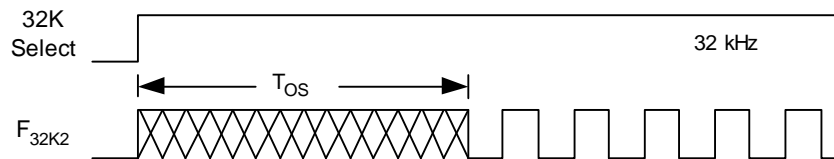


Figure 9. External Crystal Oscillator Startup Timing Diagram



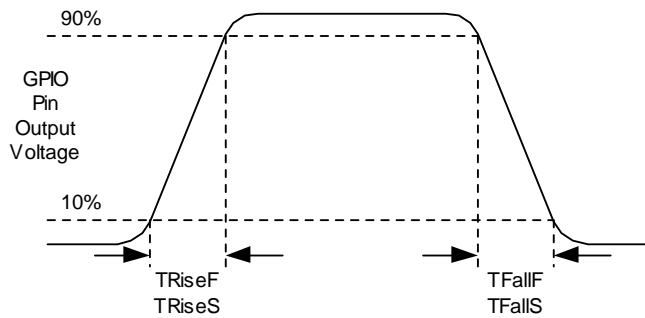
AC GPIO Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75V to 5.25V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 23. 5 V and 3.3 V AC GPIO Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|-------------|--|-----|-----|-----|-------|--|
| F_{GPIO} | GPIO operating frequency | 0 | – | 12 | MHz | Normal strong mode |
| T_{RiseF} | Rise time, normal strong mode, $C_{load} = 50\text{ pF}$ | 3 | – | 18 | ns | $V_{dd} = 4.5\text{ to }5.25\text{ V}$, 10% - 90% |
| T_{FallF} | Fall time, normal strong mode, $C_{load} = 50\text{ pF}$ | 2 | – | 18 | ns | $V_{dd} = 4.5\text{ to }5.25\text{ V}$, 10% - 90% |
| T_{RiseS} | Rise time, slow strong mode, $C_{load} = 50\text{ pF}$ | 10 | 27 | – | ns | $V_{dd} = 3\text{ to }5.25\text{ V}$, 10% - 90% |
| T_{FallS} | Fall time, slow strong mode, $C_{load} = 50\text{ pF}$ | 10 | 22 | – | ns | $V_{dd} = 3\text{ to }5.25\text{ V}$, 10% - 90% |

Figure 10. GPIO Timing Diagram



AC Operational Amplifier Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Settling times, slew rates, and gain bandwidth are based on the Analog continuous time PSoC block.

Power = high and opamp bias = high is not supported at 3.3 V.

Table 24. 5 V AC Operational Amplifier Specifications

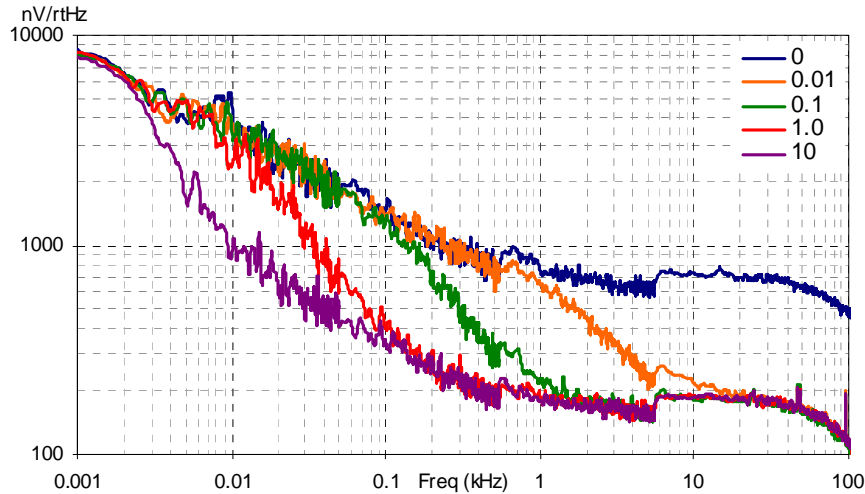
| Symbol | Description | Min | Typ | Max | Units | Notes |
|-------------------|---|------|-----|------|------------------|-------|
| T _{ROA} | Rising settling time from 80% of ΔV to 0.1% of ΔV (10 pF load, unity gain) | | | | | |
| | Power = low, opamp bias = Low | – | – | 3.9 | μs | |
| | Power = medium, opamp bias = high | – | – | 0.72 | μs | |
| T _{SOA} | Falling settling time from 20% of ΔV to 0.1% of ΔV (10 pF load, unity gain) | | | | | |
| | Power = low, opamp bias = low | – | – | 5.9 | μs | |
| | Power = medium, opamp bias = high | – | – | 0.92 | μs | |
| SR _{ROA} | Rising slew rate (20% to 80%)(10 pF load, unity gain) | | | | | |
| | Power = low, opamp bias = low | 0.15 | – | – | V/ μs | |
| | Power = medium, opamp bias = high | 1.7 | – | – | V/ μs | |
| SR _{FOA} | Falling slew rate (20% to 80%)(10 pF load, unity gain) | | | | | |
| | Power = low, opamp bias = low | 0.01 | – | – | V/ μs | |
| | Power = medium, opamp bias = high | 0.5 | – | – | V/ μs | |
| BW _{OA} | Gain bandwidth product | | | | | |
| | Power = low, opamp bias = low | 0.75 | – | – | MHz | |
| | Power = medium, opamp bias = high | 3.1 | – | – | MHz | |
| | Power = high, opamp bias = high | 5.4 | – | – | MHz | |

Table 25. 3.3 V DC Operational Amplifier Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|-----------------|--|--|--|--|--|---|
| $V_{OSO A}$ | Input offset voltage (absolute value) Power = low, opamp bias = high Power = medium, opamp bias = high Power = high, opamp bias = high | – – – | 1.65 1.32 – | 10 8 – | mV mV mV | Power = high, opamp bias = high setting is not allowed for 3.3 V V_{DD} operation. |
| $TCV_{OSO A}$ | Average input offset voltage drift | – | 7.0 | 35.0 | $\mu V/^{\circ}C$ | |
| $I_{EBO A}$ | Input leakage current (port 0 analog pins) | – | 20 | – | pA | Gross tested to 1 μA |
| $C_{INO A}$ | Input capacitance (port 0 analog pins) | – | 4.5 | 9.5 | pF | Package and pin dependent. Temp = 25 $^{\circ}C$ |
| $V_{CMO A}$ | Common mode voltage range | 0.2 | – | $V_{DD} - 0.2$ | V | The common-mode input voltage range is measured through an analog output buffer. The specification includes the limitations imposed by the characteristics of the analog output buffer. |
| $G_{OLO A}$ | Open loop gain Power = low, opamp bias = low Power = medium, opamp bias = low Power = high, opamp bias = low | 60 60 80 | – – – | – – – | dB dB dB | Specification is applicable at low opamp bias. For high opamp bias mode (except high power, high Opamp bias), minimum is 60 dB. |
| $V_{OHIGHO A}$ | High output voltage swing (internal signals) Power = low, opamp bias = low Power = medium, opamp bias = low Power = high, opamp bias = low | $V_{DD} - 0.2$ $V_{DD} - 0.2$ $V_{DD} - 0.2$ | – – – | – – – | V V V | Power = high, opamp bias = high setting is not allowed for 3.3 V V_{DD} operation. |
| $V_{OLO W O A}$ | Low output voltage swing (internal signals) Power = low, opamp bias = low Power = medium, opamp bias = low Power = high, opamp bias = low | – – – | – – – | 0.2 0.2 0.2 | V V V | Power = high, opamp bias = high setting is not allowed for 3.3 V V_{DD} operation. |
| $I_{SO A}$ | Supply current (including associated AGND buffer) Power = low, opamp bias = low Power = low, opamp bias = high Power = medium, opamp bias = low Power = medium, opamp bias = high Power = high, opamp bias = low Power = high, opamp bias = high | – – – – – – | 150 300 600 1200 2400 – | 200 400 800 1600 3200 – | μA μA μA μA μA μA | Power = high, opamp bias = high setting is not allowed for 3.3 V V_{DD} operation. |
| $PSRR_{O A}$ | Supply voltage rejection ratio | 64 | 80 | – | dB | $V_{SS} \leq V_{IN} \leq (V_{DD} - 2.25)$ or $(V_{DD} - 1.25 V) \leq V_{IN} \leq V_{DD}$ |

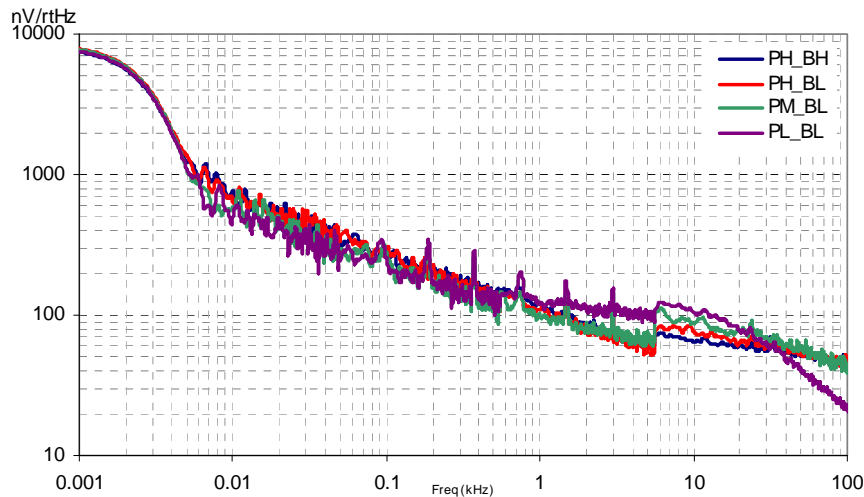
When bypassed by a capacitor on P2[4], the noise of the analog ground signal distributed to each block is reduced by a factor of up to 5 (14 dB). This is at frequencies above the corner frequency defined by the on-chip 8.1k resistance and the external capacitor.

Figure 11. Typical AGND Noise with P2[4] Bypass



At low frequencies, the opamp noise is proportional to 1/f, power independent, and determined by device geometry. At high frequencies, increased power level reduces the noise spectrum level.

Figure 12. Typical Opamp Noise



AC Low Power Comparator Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 26. AC Low Power Comparator Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|------------|-------------------|-----|-----|-----|---------------|--|
| T_{RLPC} | LPC response time | – | – | 50 | μs | $\geq 50\text{ mV}$ overdrive comparator reference set within V_{REFLPC} . |

AC Digital Block Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 27. 5-V and 3.3-V AC Digital Block Specifications

| Function | Description | Min | Typ | Max | Unit | Notes |
|-------------------|--|--------------------|-----|------|------|---|
| All functions | Block input clock frequency | | | | | |
| | $V_{DD} \geq 4.75\text{ V}$ | – | – | 49.2 | MHz | |
| | $V_{DD} < 4.75\text{ V}$ | – | – | 24.6 | MHz | |
| Timer | Input clock frequency | | | | | |
| | No capture, $V_{DD} \geq 4.75\text{ V}$ | – | – | 49.2 | MHz | |
| | No capture, $V_{DD} < 4.75\text{ V}$ | – | – | 24.6 | MHz | |
| | With capture | – | – | 24.6 | MHz | |
| | Capture pulse width | 50 ^[19] | – | – | ns | |
| Counter | Input clock frequency | | | | | |
| | No enable input, $V_{DD} \geq 4.75\text{ V}$ | – | – | 49.2 | MHz | |
| | No enable input, $V_{DD} < 4.75\text{ V}$ | – | – | 24.6 | MHz | |
| | With enable input | – | – | 24.6 | MHz | |
| | Enable input pulse width | 50 ^[19] | – | – | ns | |
| Dead Band | Kill pulse width | | | | | |
| | Asynchronous restart mode | 20 | – | – | ns | |
| | Synchronous restart mode | 50 ^[19] | – | – | ns | |
| | Disable mode | 50 ^[19] | – | – | ns | |
| | Input clock frequency | | | | | |
| | $V_{DD} \geq 4.75\text{ V}$ | – | – | 49.2 | MHz | |
| | $V_{DD} < 4.75\text{ V}$ | – | – | 24.6 | MHz | |
| CRCPRS (PRS Mode) | Input clock frequency | | | | | |
| | $V_{DD} \geq 4.75\text{ V}$ | – | – | 49.2 | MHz | |
| | $V_{DD} < 4.75\text{ V}$ | – | – | 24.6 | MHz | |
| CRCPRS (CRC Mode) | Input clock frequency | – | – | 24.6 | MHz | |
| SPIM | Input clock frequency | – | – | 8.2 | MHz | The SPI serial clock (SCLK) frequency is equal to the input clock frequency divided by 2. |
| SPIS | Input clock (SCLK) frequency | – | – | 4.1 | MHz | The input clock is the SPI SCLK in SPIS mode. |
| | Width of SS_negated between transmissions | 50 ^[19] | – | – | ns | |
| Transmitter | Input clock frequency | | | | | The baud rate is equal to the input clock frequency divided by 8. |
| | $V_{DD} \geq 4.75\text{ V}$, 2 stop bits | – | – | 49.2 | MHz | |
| | $V_{DD} \geq 4.75\text{ V}$, 1 stop bit | – | – | 24.6 | MHz | |
| | $V_{DD} < 4.75\text{ V}$ | – | – | 24.6 | MHz | |
| Receiver | Input clock frequency | | | | | The baud rate is equal to the input clock frequency divided by 8. |
| | $V_{DD} \geq 4.75\text{ V}$, 2 stop bits | – | – | 49.2 | MHz | |
| | $V_{DD} \geq 4.75\text{ V}$, 1 stop bit | – | – | 24.6 | MHz | |
| | $V_{DD} < 4.75\text{ V}$ | – | – | 24.6 | MHz | |

Note

19. 50 ns minimum input pulse width is based on the input synchronizers running at 24 MHz (42 ns nominal period).

AC Analog Output Buffer Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 28. 5 V AC Analog Output Buffer Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|-------------------|---|------|-----|-----|-------|-------|
| T _{ROB} | Rising settling time to 0.1%, 1 V step, 100 pF load | – | – | 2.5 | μs | |
| | Power = low Power = high | – | – | 2.5 | μs | |
| T _{SOB} | Falling settling time to 0.1%, 1 V step, 100 pF load | – | – | 2.2 | μs | |
| | Power = low Power = high | – | – | 2.2 | μs | |
| SR _{ROB} | Rising slew rate (20% to 80%), 1V step, 100 pF load | 0.65 | – | – | V/μs | |
| | Power = low power = High | 0.65 | – | – | V/μs | |
| SR _{FOB} | Falling slew rate (80% to 20%), 1V step, 100 pF load | 0.65 | – | – | V/μs | |
| | Power = low Power = high | 0.65 | – | – | V/μs | |
| BW _{OB} | Small signal bandwidth, 20 mV _{pp} , 3db bw, 100 pF load | 0.8 | – | – | MHz | |
| | Power = low Power = high | 0.8 | – | – | MHz | |
| BW _{OB} | Large signal bandwidth, 1V _{pp} , 3db bw, 100 pF load | 300 | – | – | kHz | |
| | Power = low Power = high | 300 | – | – | kHz | |

Table 29. 3.3 V AC Analog Output Buffer Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|-------------------|---|-----|-----|-----|-------|-------|
| T _{ROB} | Rising settling time to 0.1%, 1 V step, 100 pF load | – | – | 3.8 | μs | |
| | Power = low Power = high | – | – | 3.8 | μs | |
| T _{SOB} | Falling settling time to 0.1%, 1V Step, 100 pF load | – | – | 2.6 | μs | |
| | Power = low power = High | – | – | 2.6 | μs | |
| SR _{ROB} | Rising slew rate (20% to 80%), 1V step, 100 pF load | 0.5 | – | – | V/μs | |
| | Power = Low Power = High | 0.5 | – | – | V/μs | |
| SR _{FOB} | falling slew rate (80% to 20%), 1V step, 100 pF load | 0.5 | – | – | V/μs | |
| | Power = low Power = high | 0.5 | – | – | V/μs | |
| BW _{OB} | Small signal bandwidth, 20 mV _{pp} , 3dB BW, 100 pF load | 0.7 | – | – | MHz | |
| | Power = low Power = high | 0.7 | – | – | MHz | |
| BW _{OB} | Large signal bandwidth, 1V _{pp} , 3dB BW, 100 pF load | 200 | – | – | kHz | |
| | Power = low Power = high | 200 | – | – | kHz | |

AC External Clock Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 30. 5V AC External Clock Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|---------------------|------------------------|-------|-----|------|-------|-------|
| F _{OSCEXT} | Frequency | 0.093 | – | 24.6 | MHz | |
| – | High period | 20.6 | – | 5300 | ns | |
| – | Low period | 20.6 | – | – | ns | |
| – | Power Up IMO to Switch | 150 | – | – | μs | |

Table 31. 3.3V AC External Clock Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|---------------------|---|-------|-----|------|-------|-------|
| F _{OSCEXT} | Frequency with CPU clock divide by 1 ^[20] | 0.093 | – | 12.3 | MHz | |
| F _{OSCEXT} | Frequency with CPU clock divide by 2 or greater ^[21] | 0.186 | – | 24.6 | MHz | |
| – | High period with CPU clock divide by 1 | 41.7 | – | 5300 | ns | |
| – | Low period with CPU clock divide by 1 | 41.7 | – | – | ns | |
| – | Power up IMO to switch | 150 | – | – | μs | |

Notes

20. Maximum CPU frequency is 12 MHz at 3.3 V. With the CPU clock divider set to 1, the external clock must adhere to the maximum frequency and duty cycle requirements.

21. If the frequency of the external clock is greater than 12 MHz, the CPU clock divider must be set to 2 or greater. In this case, the CPU clock divider ensures that the fifty percent duty cycle requirement is met.

AC Programming Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 32. AC Programming Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|---------------------------|--|-----|-----|-----|-------|---|
| T _{RSCLK} | Rise time of SCLK | 1 | – | 20 | ns | |
| T _{FSCLK} | Fall time of SCLK | 1 | – | 20 | ns | |
| T _{SSCLK} | Data set up time to falling edge of SCLK | 40 | – | – | ns | |
| T _{HSCLK} | Data hold time from falling edge of SCLK | 40 | – | – | ns | |
| F _{SCLK} | Frequency of SCLK | 0 | – | 8 | MHz | |
| T _{ERASEB} | Flash erase time (Block) | – | 20 | – | ms | |
| T _{WRITE} | Flash block write time | – | 80 | – | ms | |
| T _{DSCLK} | Data out delay from falling edge of SCLK | – | – | 45 | ns | V _{dd} > 3.6 |
| T _{DSCLK3} | Data out delay from falling edge of SCLK | – | – | 50 | ns | 3.0 ≤ V _{dd} ≤ 3.6 |
| T _{ERASEALL} | Flash erase time (Bulk) | – | 20 | – | ms | Erase all blocks and protection fields at once. |
| T _{PROGRAM_HOT} | Flash block erase + flash block write time | – | – | 200 | ms | 0 °C ≤ T _J ≤ 100 °C |
| T _{PROGRAM_COLD} | Flash block erase + flash block write time | – | – | 400 | ms | –40 °C ≤ T _J ≤ 0 °C |

SAR8 ADC AC Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

Table 33. SAR8 ADC AC Specifications

| Symbol | Description | Min | Typ | Max | Units | Notes |
|-------------------|---------------------------|-----|-----|-----|-------|-------|
| Freq ₃ | Input clock frequency 3 V | – | – | 3.0 | MHz | |
| Freq ₅ | Input clock frequency 5 V | – | – | 3.0 | MHz | |

AC I²C Specifications

The following table lists guaranteed maximum and minimum specifications for the voltage and temperature ranges: 4.75 V to 5.25 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, or 3.0 V to 3.6 V and $-40\text{ }^{\circ}\text{C} \leq T_A \leq 85\text{ }^{\circ}\text{C}$, respectively. Typical parameters apply to 5 V and 3.3 V at 25 °C and are for design guidance only.

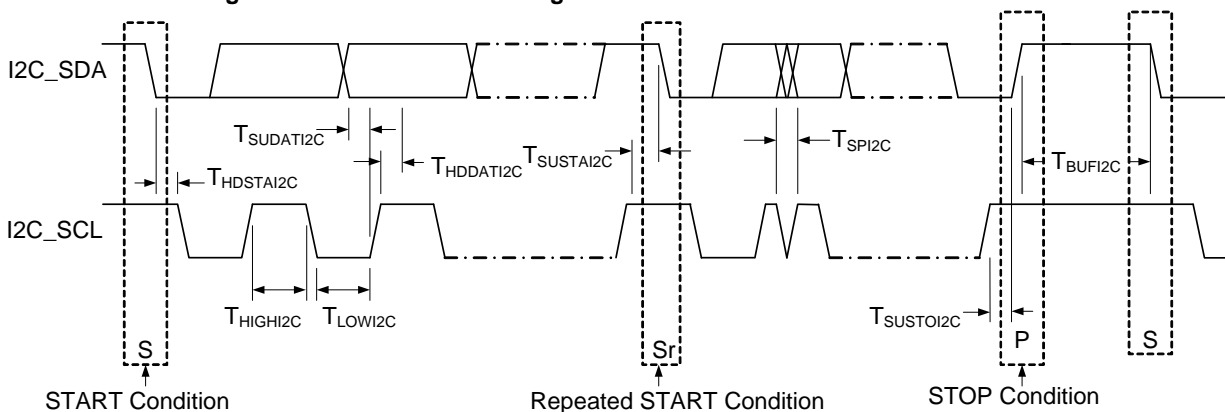
Table 34. AC Characteristics of the I²C SDA and SCL Pins for V_{dd} > 3.0 V

| Symbol | Description | Standard-Mode | | Fast-Mode | | Units | Notes |
|------------------------|--|---------------|-----|---------------------|-----|-------|-------|
| | | Min | Max | Min | Max | | |
| F _{SCL I2C} | SCL clock frequency | 0 | 100 | 0 | 400 | kHz | |
| T _{HDSTA I2C} | Hold time (repeated) START condition. After this period, the first clock pulse is generated. | 4.0 | – | 0.6 | – | μs | |
| T _{LOW I2C} | LOW period of the SCL Clock | 4.7 | – | 1.3 | – | μs | |
| T _{HIGH I2C} | HIGH period of the SCL Clock | 4.0 | – | 0.6 | – | μs | |
| T _{SUSTA I2C} | Set-up time for a repeated START Condition | 4.7 | – | 0.6 | – | μs | |
| T _{HDDAT I2C} | Data hold time | 0 | – | 0 | – | μs | |
| T _{SUDAT I2C} | Data set-up time | 250 | – | 100 ^[22] | – | ns | |
| T _{SUSTO I2C} | Set-up time for STOP Condition | 4.0 | – | 0.6 | – | μs | |
| T _{BUFI2C} | Bus free time between a stop and start condition | 4.7 | – | 1.3 | – | μs | |
| T _{SPI2C} | Pulse width of spikes are suppressed by the input filter. | – | – | 0 | 50 | ns | |

Table 35. AC Characteristics of the I²C SDA and SCL Pins for V_{dd} < 3.0 V (Fast-Mode Not Supported)

| Symbol | Description | Standard-Mode | | Fast-Mode | | Units | Notes |
|------------------------|--|---------------|-----|-----------|-----|-------|-------|
| | | Min | Max | Min | Max | | |
| F _{SCL I2C} | SCL clock frequency | 0 | 100 | – | – | kHz | |
| T _{HDSTA I2C} | Hold time (repeated) START condition. After this period, the first clock pulse is generated. | 4.0 | – | – | – | μs | |
| T _{LOW I2C} | LOW period of the SCL Clock | 4.7 | – | – | – | μs | |
| T _{HIGH I2C} | HIGH period of the SCL Clock | 4.0 | – | – | – | μs | |
| T _{SUSTA I2C} | Set-up Time for a Repeated START Condition | 4.7 | – | – | – | μs | |
| T _{HDDAT I2C} | Data hold time | 0 | – | – | – | μs | |
| T _{SUDAT I2C} | Data set-up time | 250 | – | – | – | ns | |
| T _{SUSTO I2C} | Set-up time for STOP Condition | 4.0 | – | – | – | μs | |
| T _{BUFI2C} | Bus free time between a STOP and START Condition | 4.7 | – | – | – | μs | |
| T _{SPI2C} | Pulse width of spikes are suppressed by the input filter. | – | – | – | – | ns | |

Figure 13. Definition for Timing for Fast-/Standard-Mode on the I²C Bus



Note

22. A Fast-Mode I2C-bus device can be used in a Standard-Mode I2C-bus system, but the requirement T_{SUDAT I2C} ≥ 250 ns must then be met. This is automatically the case if the device does not stretch the LOW period of the SCL signal. If such device does stretch the LOW period of the SCL signal, it must output the next data bit to the SDA line t_{max} + T_{SUDAT I2C} = 1000 + 250 = 1250 ns (according to the Standard-Mode I2C-bus specification) before the SCL line is released.

Thermal Impedances

Table 36. Thermal Impedances by Package

| Package | Typical θ_{JA} ^[23] |
|-------------|---------------------------------------|
| 28-pin SSOP | 95 °C/W |
| 56-pin SSOP | 67 °C/W |

Capacitance on Crystal Pins

Table 37. Typical Package Capacitance on Crystal Pins

| Package | Package Capacitance | |
|-------------|---------------------|----------------|
| 28-pin SSOP | 2.8 pF | |
| 56-pin SSOP | Pin 27 0.33 pF | Pin 31 0.35 pF |

Solder Reflow Peak Temperature

Following is the minimum solder reflow peak temperature to achieve good solderability.

Table 38. Solder Reflow Peak Temperature

| Package | Maximum Peak Temperature | Time at Maximum Peak Temperature |
|-------------|--------------------------|----------------------------------|
| 28-pin SSOP | 260 °C | 30 s |
| 56-pin SSOP | 260 °C | 30 s |

Ordering Information

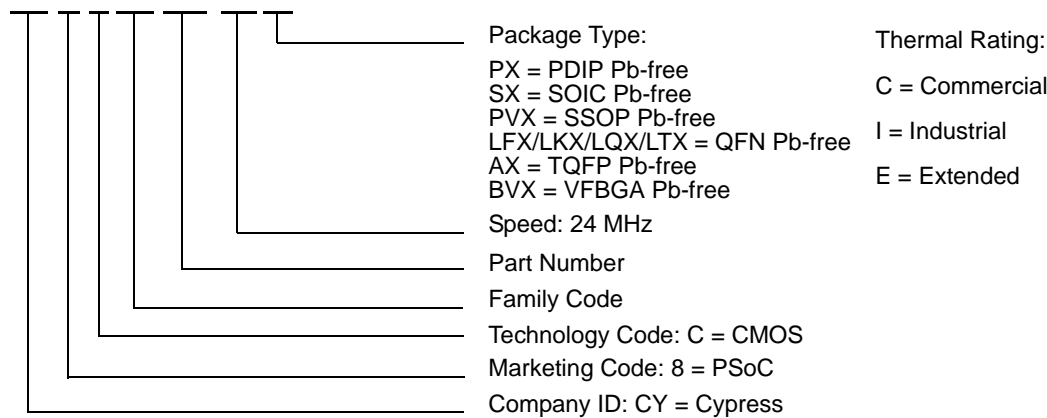
The following table lists the CY8C24633 PSoC device family key package features and ordering codes .

Table 39. CY8C24x33 PSoC Device Family Key Features and Ordering Information

| Package | Ordering Code | Flash (Kbytes) | RAM (Bytes) | Temperature Range | Digital Blocks (Rows of 4) | Analog Blocks (Columns of 3) | Digital I/O Pins | Analog Inputs | Analog Outputs | XRES Pin |
|---------------------------------------|----------------------------------|----------------|-------------|-------------------|----------------------------|------------------------------|------------------|---------------|----------------|----------|
| 28-Pin (210 Mil) SSOP | CY8C24633-24PVXI | 8 | 256 | -40 °C to +85 °C | 4 | 4 | 25 | 12 | 2 | Yes |
| 28-Pin (210 Mil) SSOP (Tape and Reel) | CY8C24633-24PVXIT | 8 | 256 | -40 °C to +85 °C | 4 | 4 | 25 | 12 | 2 | Yes |
| 56-Pin OCD SSOP | CY8C24033-24PVXI ^[24] | 8 | 256 | -40 °C to +85 °C | 4 | 4 | 24 | 12 | 2 | Yes |

Ordering Code Definitions

CY 8 C 24 XXX-SP XX



Notes

23. $T_j = T_A + \text{POWER} \times \theta_{JA}$

24. This part may be used for in-circuit debugging. It is NOT available for production.

Packaging Information

This section illustrates the packaging specifications for the CY8C24633 PSoC device, along with the thermal impedances for each package, solder reflow peak temperature, and the typical package capacitance on crystal pins.

Figure 14. 28-Pin (210-Mil) SSOP

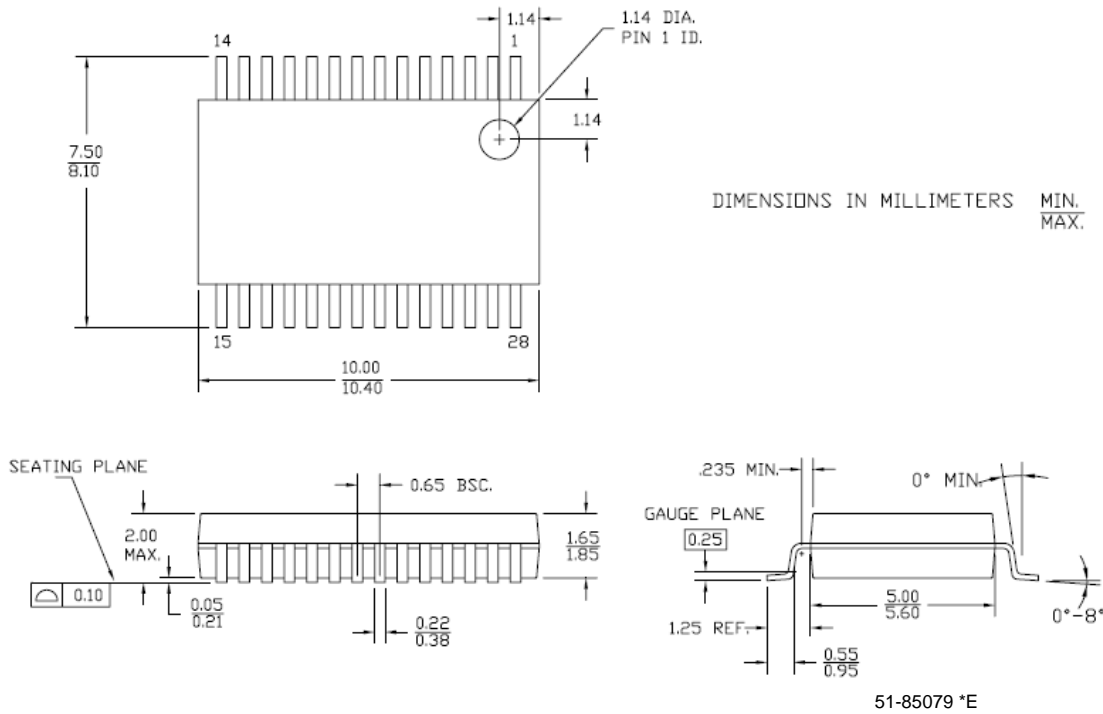
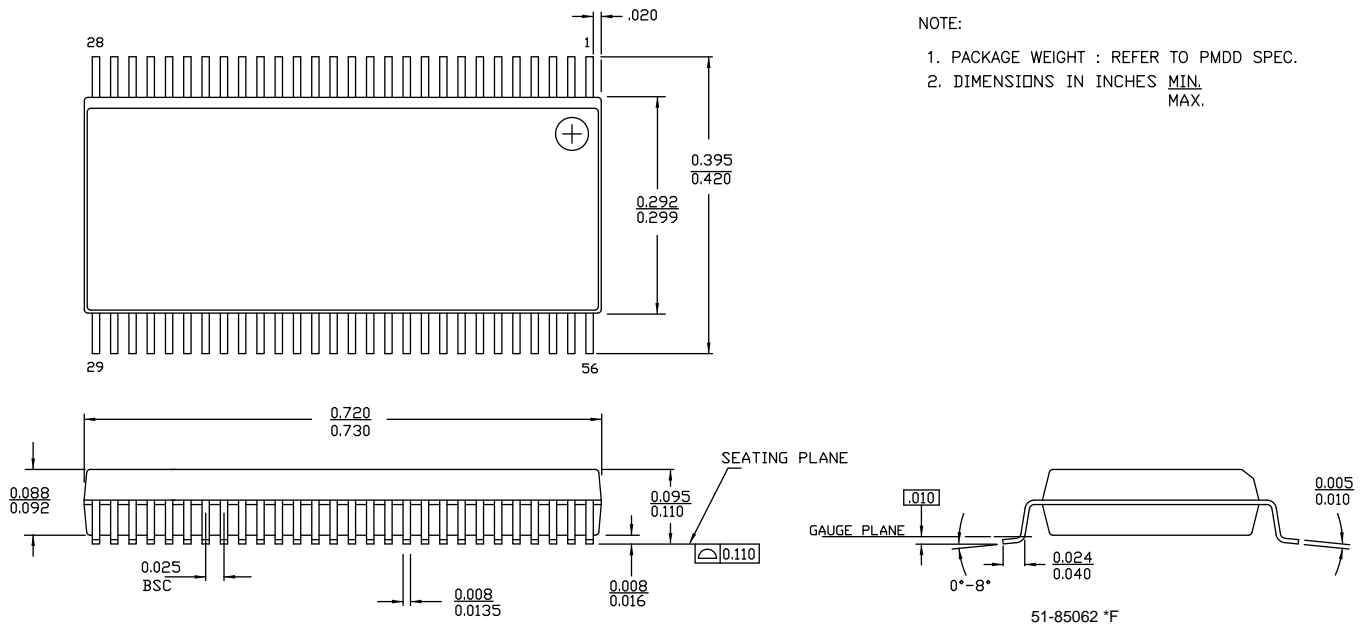


Figure 15. 56-Pin (300-Mil) SSOP



Acronyms

Acronyms Used

Table 40 lists the acronyms that are used in this document.

Table 40. Acronyms Used in this Datasheet

| Acronym | Description | Acronym | Description |
|---------|---|---------|---|
| AC | alternating current | MIPS | million instructions per second |
| ADC | analog-to-digital converter | OCD | on-chip debug |
| API | application programming interface | PCB | printed circuit board |
| CPU | central processing unit | PGA | programmable gain amplifier |
| CRC | cyclic redundancy check | PLL | phase-locked loop |
| CT | continuous time | POR | power on reset |
| DAC | digital-to-analog converter | PPOR | precision power on reset |
| DC | direct current | PRS | pseudo-random sequence |
| DNL | differential nonlinearity | PSoC® | Programmable System-on-Chip |
| DTMF | dual-tone multi-frequency | PWM | pulse width modulator |
| ECO | external crystal oscillator | RTC | real time clock |
| EEPROM | electrically erasable programmable read-only memory | SAR | successive approximation |
| GPIO | general purpose I/O | SC | switched capacitor |
| ICE | in-circuit emulator | SLIMO | slow IMO |
| IDE | integrated development environment | SMP | switch mode pump |
| ILO | internal low speed oscillator | SOIC | small-outline integrated circuit |
| IMO | internal main oscillator | SPI™ | serial peripheral interface |
| INL | integral nonlinearity | SRAM | static random access memory |
| I/O | input/output | SROM | supervisory read only memory |
| IrDA | infrared data association | SSOP | shrink small-outline package |
| ISSP | in-system serial programming | UART | universal asynchronous receiver / transmitter |
| LPC | low-power comparator | USB | universal serial bus |
| LVD | low-voltage detect | WDT | watchdog timer |
| MAC | multiply-accumulate | XRES | external reset |
| MCU | microcontroller unit | | |

Reference Documents

Design Aids – Reading and Writing PSoC® Flash – [AN2015](#) (001-40459)

Document Conventions

Units of Measure

Table 41 lists the units of measures.

Table 41. Units of Measure

| Symbol | Unit of Measure | Symbol | Unit of Measure |
|--------|-----------------------|--------|-------------------------|
| kB | 1024 bytes | ms | millisecond |
| dB | decibels | ns | nanosecond |
| °C | degree Celsius | ps | picosecond |
| pF | picofarads | μV | microvolts |
| kHz | kilohertz | mV | millivolts |
| MHz | megahertz | nV | nanovolts |
| LSB | least significant bit | V | volts |
| kΩ | kilo-ohm | μW | microwatts |
| μA | microamperes | W | watt |
| mA | milliamperes | mm | millimeter |
| nA | nanoamperes | mVpp | millivolts peak-to-peak |
| pA | pikoamperes | ppm | parts per million |
| μs | microsecond | % | percent |

Numeric Conventions

Hexadecimal numbers are represented with all letters in uppercase with an appended lowercase 'h' (for example, '14h' or '3Ah'). Hexadecimal numbers may also be represented by a '0x' prefix, the C coding convention. Binary numbers have an appended lowercase 'b' (for example, '01010100b' or '01000011b'). Numbers not indicated by an 'h' or 'b' are decimals.

Glossary

| | |
|---|---|
| active high | <ol style="list-style-type: none"> 1. A logic signal having its asserted state as the logic 1 state. 2. A logic signal having the logic 1 state as the higher voltage of the two states. |
| analog blocks | The basic programmable opamp circuits. These are switched capacitor (SC) and continuous time (CT) blocks. These blocks can be interconnected to provide ADCs, DACs, multi-pole filters, gain stages, and much more. |
| analog-to-digital (ADC) | A device that changes an analog signal to a digital signal of corresponding magnitude. Typically, an ADC converts a voltage to a digital number. The digital-to-analog (DAC) converter performs the reverse operation. |
| API (Application Programming Interface) | A series of software routines that comprise an interface between a computer application and lower level services and functions (for example, user modules and libraries). APIs serve as building blocks for programmers that create software applications. |
| asynchronous | A signal whose data is acknowledged or acted upon immediately, irrespective of any clock signal. |
| Bandgap reference | A stable voltage reference design that matches the positive temperature coefficient of VT with the negative temperature coefficient of VBE, to produce a zero temperature coefficient (ideally) reference. |
| bandwidth | <ol style="list-style-type: none"> 1. The frequency range of a message or information processing system measured in hertz. 2. The width of the spectral region over which an amplifier (or absorber) has substantial gain (or loss); it is sometimes represented more specifically as, for example, full width at half maximum. |

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| bias | <ol style="list-style-type: none">1. A systematic deviation of a value from a reference value.2. The amount by which the average of a set of values departs from a reference value.3. The electrical, mechanical, magnetic, or other force (field) applied to a device to establish a reference level to operate the device. |
| block | <ol style="list-style-type: none">1. A functional unit that performs a single function, such as an oscillator.2. A functional unit that may be configured to perform one of several functions, such as a digital PSoC block or an analog PSoC block. |
| buffer | <ol style="list-style-type: none">1. A storage area for data that is used to compensate for a speed difference, when transferring data from one device to another. Usually refers to an area reserved for IO operations, into which data is read, or from which data is written.2. A portion of memory set aside to store data, often before it is sent to an external device or as it is received from an external device.3. An amplifier used to lower the output impedance of a system. |
| bus | <ol style="list-style-type: none">1. A named connection of nets. Bundling nets together in a bus makes it easier to route nets with similar routing patterns.2. A set of signals performing a common function and carrying similar data. Typically represented using vector notation; for example, address[7:0].3. One or more conductors that serve as a common connection for a group of related devices. |
| clock | The device that generates a periodic signal with a fixed frequency and duty cycle. A clock is sometimes used to synchronize different logic blocks. |
| comparator | An electronic circuit that produces an output voltage or current whenever two input levels simultaneously satisfy predetermined amplitude requirements. |
| compiler | A program that translates a high level language, such as C, into machine language. |
| configuration space | In PSoC devices, the register space accessed when the XIO bit, in the CPU_F register, is set to '1'. |
| crystal oscillator | An oscillator in which the frequency is controlled by a piezoelectric crystal. Typically a piezoelectric crystal is less sensitive to ambient temperature than other circuit components. |
| cyclic redundancy check (CRC) | A calculation used to detect errors in data communications, typically performed using a linear feedback shift register. Similar calculations may be used for a variety of other purposes such as data compression. |
| data bus | A bi-directional set of signals used by a computer to convey information from a memory location to the central processing unit and vice versa. More generally, a set of signals used to convey data between digital functions. |
| debugger | A hardware and software system that allows the user to analyze the operation of the system under development. A debugger usually allows the developer to step through the firmware one step at a time, set break points, and analyze memory. |
| dead band | A period of time when neither of two or more signals are in their active state or in transition. |
| digital blocks | The 8-bit logic blocks that can act as a counter, timer, serial receiver, serial transmitter, CRC generator, pseudo-random number generator, or SPI. |
| digital-to-analog (DAC) | A device that changes a digital signal to an analog signal of corresponding magnitude. The analog-to-digital (ADC) converter performs the reverse operation. |
| duty cycle | The relationship of a clock period high time to its low time, expressed as a percent. |

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| emulator | Duplicates (provides an emulation of) the functions of one system with a different system, so that the second system appears to behave like the first system. |
| external reset (XRES) | An active high signal that is driven into the PSoC device. It causes all operation of the CPU and blocks to stop and return to a pre-defined state. |
| flash | An electrically programmable and erasable, non-volatile technology that provides users with the programmability and data storage of EPROMs, plus in-system erasability. Non-volatile means that the data is retained when power is off. |
| Flash block | The smallest amount of Flash ROM space that may be programmed at one time and the smallest amount of Flash space that may be protected. A Flash block holds 64 bytes. |
| frequency | The number of cycles or events per unit of time, for a periodic function. |
| gain | The ratio of output current, voltage, or power to input current, voltage, or power, respectively. Gain is usually expressed in dB. |
| I ² C | A two-wire serial computer bus by Philips Semiconductors (now NXP Semiconductors). I2C is an Inter-Integrated Circuit. It is used to connect low-speed peripherals in an embedded system. The original system was created in the early 1980s as a battery control interface, but it was later used as a simple internal bus system for building control electronics. I2C uses only two bi-directional pins, clock and data, both running at +5V and pulled high with resistors. The bus operates at 100 kbits/second in standard mode and 400 kbits/second in fast mode. |
| ICE | The in-circuit emulator that allows users to test the project in a hardware environment, while viewing the debugging device activity in a software environment (PSoC Designer). |
| input/output (I/O) | A device that introduces data into or extracts data from a system. |
| interrupt | A suspension of a process, such as the execution of a computer program, caused by an event external to that process, and performed in such a way that the process can be resumed. |
| interrupt service routine (ISR) | A block of code that normal code execution is diverted to when the M8C receives a hardware interrupt. Many interrupt sources may each exist with its own priority and individual ISR code block. Each ISR code block ends with the RETI instruction, returning the device to the point in the program where it left normal program execution. |
| jitter | <ol style="list-style-type: none"> 1. A misplacement of the timing of a transition from its ideal position. A typical form of corruption that occurs on serial data streams. 2. The abrupt and unwanted variations of one or more signal characteristics, such as the interval between successive pulses, the amplitude of successive cycles, or the frequency or phase of successive cycles. |
| low-voltage detect (LVD) | A circuit that senses V _{DD} and provides an interrupt to the system when V _{DD} falls lower than a selected threshold. |
| M8C | An 8-bit Harvard-architecture microprocessor. The microprocessor coordinates all activity inside a PSoC by interfacing to the Flash, SRAM, and register space. |
| master device | A device that controls the timing for data exchanges between two devices. Or when devices are cascaded in width, the master device is the one that controls the timing for data exchanges between the cascaded devices and an external interface. The controlled device is called the slave device. |
| microcontroller | An integrated circuit chip that is designed primarily for control systems and products. In addition to a CPU, a microcontroller typically includes memory, timing circuits, and IO circuitry. The reason for this is to permit the realization of a controller with a minimal quantity of chips, thus achieving maximal possible miniaturization. This in turn, reduces the volume and the cost of the controller. The microcontroller is normally not used for general-purpose computation as is a microprocessor. |

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| mixed-signal | The reference to a circuit containing both analog and digital techniques and components. |
| modulator | A device that imposes a signal on a carrier. |
| noise | 1. A disturbance that affects a signal and that may distort the information carried by the signal. The random variations of one or more characteristics of any entity such as voltage, current, or data. |
| oscillator | A circuit that may be crystal controlled and is used to generate a clock frequency. |
| parity | A technique for testing transmitting data. Typically, a binary digit is added to the data to make the sum of all the digits of the binary data either always even (even parity) or always odd (odd parity). |
| phase-locked loop (PLL) | An electronic circuit that controls an oscillator so that it maintains a constant phase angle relative to a reference signal. |
| pinouts | The pin number assignment: the relation between the logical inputs and outputs of the PSoC device and their physical counterparts in the printed circuit board (PCB) package. Pinouts involve pin numbers as a link between schematic and PCB design (both being computer generated files) and may also involve pin names. |
| port | A group of pins, usually eight. |
| power on reset (POR) | A circuit that forces the PSoC device to reset when the voltage is lower than a pre-set level. This is one type of hardware reset. |
| PSoC® | Cypress Semiconductor's PSoC® is a registered trademark and Programmable System-on-Chip™ is a trademark of Cypress. |
| PSoC Designer™ | The software for Cypress' Programmable System-on-Chip technology. |
| pulse width modulator (PWM) | An output in the form of duty cycle which varies as a function of the applied measurand |
| RAM | An acronym for random access memory. A data-storage device from which data can be read out and new data can be written in. |
| register | A storage device with a specific capacity, such as a bit or byte. |
| reset | A means of bringing a system back to a know state. See hardware reset and software reset. |
| ROM | An acronym for read only memory. A data-storage device from which data can be read out, but new data cannot be written in. |
| serial | 1. Pertaining to a process in which all events occur one after the other. Pertaining to the sequential or consecutive occurrence of two or more related activities in a single device or channel. |
| settling time | The time it takes for an output signal or value to stabilize after the input has changed from one value to another. |
| shift register | A memory storage device that sequentially shifts a word either left or right to output a stream of serial data. |
| slave device | A device that allows another device to control the timing for data exchanges between two devices. Or when devices are cascaded in width, the slave device is the one that allows another device to control the timing of data exchanges between the cascaded devices and an external interface. The controlling device is called the master device. |

| | |
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| SRAM | An acronym for static random access memory. A memory device allowing users to store and retrieve data at a high rate of speed. The term static is used because, after a value has been loaded into an SRAM cell, it remains unchanged until it is explicitly altered or until power is removed from the device. |
| SROM | An acronym for supervisory read only memory. The SROM holds code that is used to boot the device, calibrate circuitry, and perform Flash operations. The functions of the SROM may be accessed in normal user code, operating from Flash. |
| stop bit | A signal following a character or block that prepares the receiving device to receive the next character or block. |
| synchronous | 1. A signal whose data is not acknowledged or acted upon until the next active edge of a clock signal. A system whose operation is synchronized by a clock signal. |
| tri-state | A function whose output can adopt three states: 0, 1, and Z (high-impedance). The function does not drive any value in the Z state and, in many respects, may be considered to be disconnected from the rest of the circuit, allowing another output to drive the same net. |
| UART | A UART or universal asynchronous receiver-transmitter translates between parallel bits of data and serial bits. |
| user modules | Pre-build, pre-tested hardware/firmware peripheral functions that take care of managing and configuring the lower level Analog and Digital PSoC Blocks. User Modules also provide high level API (Application Programming Interface) for the peripheral function. |
| user space | The bank 0 space of the register map. The registers in this bank are more likely to be modified during normal program execution and not just during initialization. Registers in bank 1 are most likely to be modified only during the initialization phase of the program. |
| V_{DD} | A name for a power net meaning “voltage drain.” The most positive power supply signal. Usually 5 V or 3.3 V. |
| V_{SS} | A name for a power net meaning “voltage source.” The most negative power supply signal. |
| watchdog timer | A timer that must be serviced periodically. If it is not serviced, the CPU resets after a specified period of time. |

Document History Page

| Document Title: CY8C24633, PSoC® Programmable-System-on-Chip Document Number: 001-20160 | | | | |
|--|---------|-----------------|-----------------|---|
| Rev. | ECN No. | Orig. of Change | Submission Date | Description of Change |
| ** | 1411003 | HMT | See ECN | New spec. Separate device from 001-14643. |
| *A | 1648723 | HMT | See ECN | Update SAR ADC electrical specs. Update INL, DNL, and VOL specs. Finetune specs. Add 56 SSOP package capacitance data. Change title. Make data sheet Final. |
| *B | 2763970 | POA / AESA | 09/16/2009 | Update Getting Started, Development Tools, and Designing with PSoC Designer sections. |
| *C | 2871212 | JHU / HMT | 02/04/2010 | <ul style="list-style-type: none"> ■ Add Table of Contents. ■ Update DC GPIO, AC Chip-Level, and AC Programming Specifications as follows: <ul style="list-style-type: none"> □ Add IOH, IOL. Existing parameter. Previously only in “Notes” section of VOH/VOL. Now added as a separate line item for ease of location in data sheet. □ Add Flash Endurance Note regarding the programming and verifying Flash should be in the same voltage range. Added to clarify Flash behavior for the customer. □ Add F32K_U to clarify minimum ILO frequency out before the part boots up. □ Add DCILO upon request from a few customers. □ Add TPOWERUP, typical amount of time taken by PSoC to begin executing code out of Flash after powerup. Added to clarify PSoC behavior at startup for customer. □ Revise FIMO6 limits. No impact to form, fit, function, or customer application. □ Revise TRAMP from 0 to NA. Replace TRAMP (time) with SRPOWER_UP to accurately define the powerup requirement. □ Add SRPOWER_UP, change from no limitation to limitations based on test equipment ratings, to which the part will now be tested. □ Add TPROGRAM_HOT of maximum time it takes to erase and program a block when die temperature is >0°C. Added to clarify Flash behavior to the customer. □ Add TPROGRAM_COLD of maximum time it takes to erase and program a block over the full temperature range (–40°C to 85°C). Added to clarify Flash behavior to the customer. □ Revise TWRITE to align with recommended values for third party programmers. Data sheet now matches the typical value as recommended. ■ Update copyright and Sales, Solutions, and Legal Information URLs. ■ Update 28-Pin SSOP package diagram. |
| *D | 3115813 | NJF | 12/20/10 | <p>Updated PSoC Device Characteristics table . Added DC I²C Specifications table. Added Tjit_IMO specification, removed existing jitter specifications. Updated DC Analog Reference Specifications and 3.3 V DC operational amplifier specifications tables. Updated Units of Measure, Acronyms, Glossary, and References sections. Updated solder reflow specifications. No specific changes were made to AC Digital Block Specifications table and I²C Timing Diagram. They were updated for clearer understanding. Updated Figure 10 since the labelling for y-axis was incorrect. Added ordering code definitions.</p> |
| *E | 3284078 | SHOB | 07/29/10 | <p>Updated Getting Started, Development Tools, and Designing with PSoC Designer Updated Solder Reflow Peak Temperature table. Removed reference to obsolete Application Note AN2012.</p> |
| *F | 3598339 | LURE / XZNG | 04/24/2012 | Changed the PWM description string from “8- to 32-bit” to “8- and 16-bit”. |

Document History Page (continued)

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| Rev. | ECN No. | Orig. of Change | Submission Date | Description of Change |
| *G | 3816133 | RHPH | 11/19/2012 | Updated package diagram 51-85062 to *F Removed reference to the obsolete spec 001-14503 from Reference Documents section. |
| *H | 4487000 | ASRI | 09/15/2014 | Added More Information . Added PSoC Designer . Removed "Getting Started". Updated to new template. |

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