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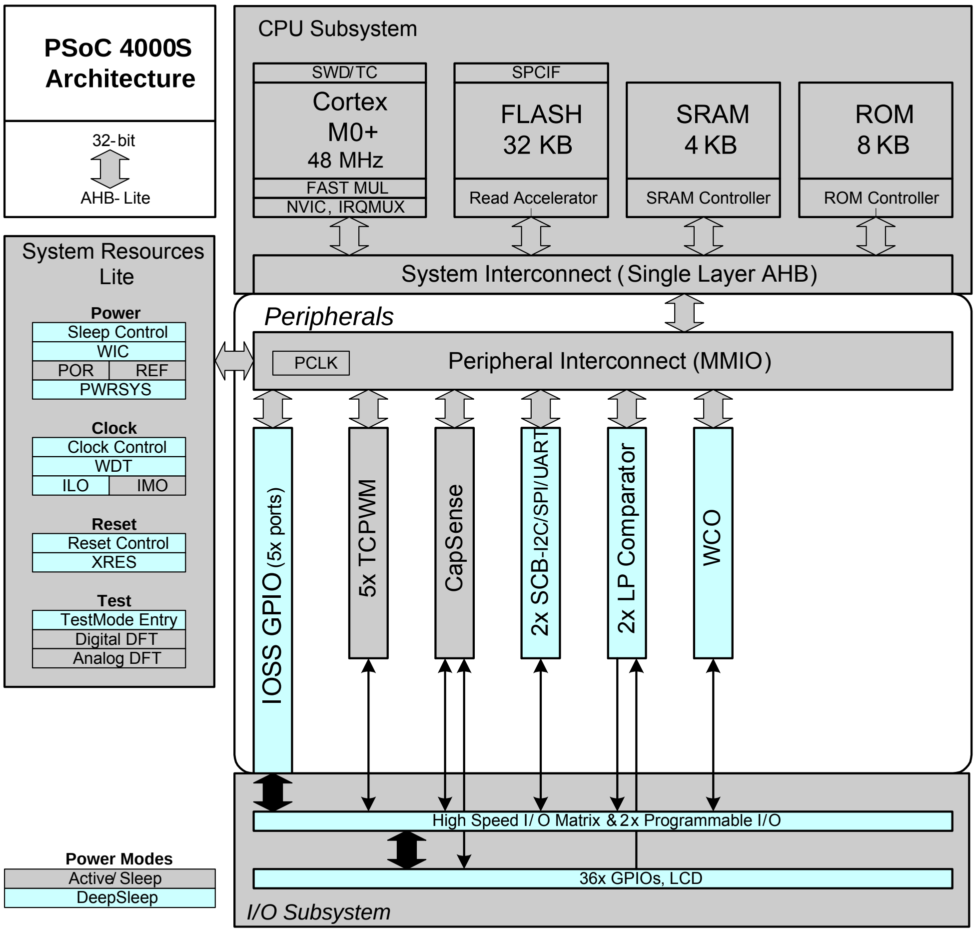
What is "Embedded - Microcontrollers"?

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

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Active
Core Processor	ARM® Cortex®-M0+
Core Size	32-Bit Single-Core
Speed	24MHz
Connectivity	I²C, IrDA, LINbus, Microwire, SmartCard, SPI, SSP, UART/USART
Peripherals	Brown-out Detect/Reset, CapSense, LCD, LVD, POR, PWM, WDT
Number of I/O	36
Program Memory Size	16KB (16K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	2K x 8
Voltage - Supply (Vcc/Vdd)	1.71V ~ 5.5V
Data Converters	A/D 1x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	48-LQFP
Supplier Device Package	48-TQFP (7x7)
Purchase URL	https://www.e-xfl.com/product-detail/infineon-technologies/cy8c4024azi-s403

Figure 1. Block Diagram



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

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

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

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

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

The debug circuits are enabled by default and can be disabled in firmware. If they are not enabled, the only way to re-enable them is to erase the entire device, clear flash protection, and reprogram the device with new firmware that enables debugging. Thus firmware control of debugging cannot be over-ridden without erasing the firmware thus providing security.

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

Watchdog Timer

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

Reset

The PSoC 4000S can be reset from a variety of sources including a software reset. Reset events are asynchronous and guarantee reversion to a known state. The reset cause is recorded in a register, which is sticky through reset and allows software to determine the cause of the reset. An XRES pin is reserved for external reset by asserting it active low. The XRES pin has an internal pull-up resistor that is always enabled.

Voltage Reference

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

Analog Blocks

Low-power Comparators (LPC)

The PSoC 4000S has a pair of low-power comparators, which can also operate in Deep Sleep modes. This allows the analog system blocks to be disabled while retaining the ability to monitor external voltage levels during low-power modes. The comparator outputs are normally synchronized to avoid metastability unless operating in an asynchronous power mode where the system wake-up circuit is activated by a comparator switch event. The LPC outputs can be routed to pins.

Current DACs

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

Analog Multiplexed Buses

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

Programmable Digital Blocks

The programmable I/O (Smart I/O) block is a fabric of switches and LUTs that allows Boolean functions to be performed in signals being routed to the pins of a GPIO port. The Smart I/O can perform logical operations on input pins to the chip and on signals going out as outputs.

Fixed Function Digital

Timer/Counter/PWM (TCPWM) Block

The TCPWM block consists of a 16-bit counter with user-programmable period length. There is a capture register to record the count value at the time of an event (which may be an I/O event), a period register that is used to either stop or auto-reload the counter when its count is equal to the period register, and compare registers to generate compare value signals that are used as PWM duty cycle outputs. The block also provides true and complementary outputs with programmable offset between them to allow use as dead-band programmable complementary PWM outputs. It also has a Kill input to force outputs to a predetermined state; for example, this is used in motor drive systems when an over-current state is indicated and the PWM driving the FETs needs to be shut off immediately with no time for software intervention. There are five TCPWM blocks in the PSoC 4000S.

Serial Communication Block (SCB)

The PSoC 4000S has two serial communication blocks, which can be programmed to have SPI, I2C, or UART functionality.

I^{2}C Mode: The hardware I^{2}C block implements a full multi-master and slave interface (it is capable of multi-master arbitration). This block is capable of operating at speeds of up to 400 kbps (Fast Mode) and has flexible buffering options to reduce interrupt overhead and latency for the CPU. It also supports EZI2C that creates a mailbox address range in the memory of the PSoC 4000S and effectively reduces I^{2}C communication to reading from and writing to an array in memory. In addition, the block supports an 8-deep FIFO for receive and transmit which, by increasing the time given for the CPU to read data, greatly reduces the need for clock stretching caused by the CPU not having read data on time.

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

The PSoC 4000S is not completely compliant with the I^{2}C spec in the following respect:

- GPIO cells are not overvoltage tolerant and, therefore, cannot be hot-swapped or powered up independently of the rest of the I^{2}C system.

UART Mode: This is a full-feature UART operating at up to 1 Mbps. It supports automotive single-wire interface (LIN), infrared interface (IrDA), and SmartCard (ISO7816) protocols, all of which are minor variants of the basic UART protocol. In addition, it supports the 9-bit multiprocessor mode that allows addressing of peripherals connected over common RX and TX lines. Common UART functions such as parity error, break detect, and frame error are supported. An 8-deep FIFO allows much greater CPU service latencies to be tolerated.

SPI Mode: The SPI mode supports full Motorola SPI, TI SSP (adds a start pulse used to synchronize SPI Codecs), and National Microwire (half-duplex form of SPI). The SPI block can use the FIFO.

GPIO

The PSoC 4000S has up to 36 GPIOs. The GPIO block implements the following:

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

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

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

Every I/O pin can generate an interrupt if so enabled and each I/O port has an interrupt request (IRQ) and interrupt service routine (ISR) vector associated with it (5 for PSoC 4000S).

Special Function Peripherals

CapSense

CapSense is supported in the PSoC 4000S through a CapSense Sigma-Delta (CSD) block that can be connected to any pins through an analog multiplex bus via analog switches. CapSense function can thus be provided on any available pin or group of pins in a system under software control. A PSoC Creator component is provided for the CapSense block to make it easy for the user.

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

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

The CapSense block also provides a 10-bit Slope ADC function, which can be used in conjunction with the CapSense function.

The CapSense block is an advanced, low-noise, programmable block with programmable voltage references and current source ranges for improved sensitivity and flexibility. It can also use an external reference voltage. It has a full-wave CSD mode that alternates sensing to VDDA and Ground to null out power-supply related noise.

LCD Segment Drive

The PSoC 4000S has an LCD controller, which can drive up to 8 commons and up to 28 segments. It uses full digital methods to drive the LCD segments requiring no generation of internal LCD voltages. The two methods used are referred to as Digital Correlation and PWM. Digital Correlation pertains to modulating the frequency and drive levels of the common and segment signals to generate the highest RMS voltage across a segment to light it up or to keep the RMS signal to zero. This method is good for STN displays but may result in reduced contrast with TN (cheaper) displays. PWM pertains to driving the panel with PWM signals to effectively use the capacitance of the panel to provide the integration of the modulated pulse-width to generate the desired LCD voltage. This method results in higher power consumption but can result in better results when driving TN displays. LCD operation is supported during Deep Sleep refreshing a small display buffer (4 bits; 1 32-bit register per port).

Pinouts

The following table provides the pin list for PSoC 4000S for the 48-pin TQFP, 40-pin QFN, 32-pin QFN, 24-pin QFN, and 25-ball CSP packages. All port pins support GPIO. Pin 11 is a No-Connect in the 48-TQFP.

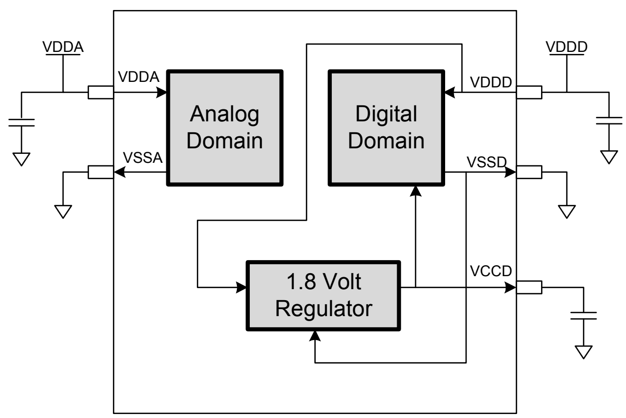
Table 1. PSoC 4000S Pin List

48-TQFP		32-QFN		24-QFN		25-CSP		40-QFN	
Pin	**Name**	**Pin**	**Name**	**Pin**	**Name**	**Pin**	**Name**	**Pin**	**Name**
28	P0.0	17	P0.0	13	P0.0	D1	P0.0	22	P0.0
29	P0.1	18	P0.1	14	P0.1	C3	P0.1	23	P0.1
30	P0.2	19	P0.2					24	P0.2
31	P0.3	20	P0.3					25	P0.3
32	P0.4	21	P0.4	15	P0.4	C2	P0.4	26	P0.4
33	P0.5	22	P0.5	16	P0.5	C1	P0.5	27	P0.5
34	P0.6	23	P0.6	17	P0.6	B1	P0.6	28	P0.6
35	P0.7					B2	P0.7	29	P0.7
36	XRES	24	XRES	18	XRES	B3	XRES	30	XRES
37	VCCD	25	VCCD	19	VCCD	A1	VCCD	31	VCCD
38	VSSD	26	VSSD	20	VSSD	A2	VSS		
39	VDDD	27	VDD	21	VDD	A3	VDD	32	VDDD
40	VDDA	27	VDD	21	VDD	A3	VDD	33	VDDA
41	VSSA	28	VSSA	22	VSSA	A2	VSS	34	VSSA
42	P1.0	29	P1.0					35	P1.0
43	P1.1	30	P1.1					36	P1.1
44	P1.2	31	P1.2	23	P1.2	A4	P1.2	37	P1.2
45	P1.3	32	P1.3	24	P1.3	B4	P1.3	38	P1.3
46	P1.4							39	P1.4
47	P1.5								
48	P1.6								
1	P1.7	1	P1.7	1	P1.7	A5	P1.7	40	P1.7
2	P2.0	2	P2.0	2	P2.0	B5	P2.0	1	P2.0
3	P2.1	3	P2.1	3	P2.1	C5	P2.1	2	P2.1
4	P2.2	4	P2.2					3	P2.2
5	P2.3	5	P2.3					4	P2.3
6	P2.4							5	P2.4
7	P2.5	6	P2.5					6	P2.5
8	P2.6	7	P2.6	4	P2.6	D5	P2.6	7	P2.6
9	P2.7	8	P2.7	5	P2.7	C4	P2.7	8	P2.7
10	VSSD					A2	VSS	9	VSSD
12	P3.0	9	P3.0	6	P3.0	E5	P3.0	10	P3.0
13	P3.1	10	P3.1			D4	P3.1	11	P3.1
14	P3.2	11	P3.2	7	P3.2	E4	P3.2	12	P3.2
16	P3.3	12	P3.3	8	P3.3	D3	P3.3	13	P3.3

Power

The following power system diagram shows the set of power supply pins as implemented for the PSoC 4000S. The system has one regulator in Active mode for the digital circuitry. There is no analog regulator; the analog circuits run directly from the V_{DD} input.

Figure 3. Power Supply Connections



There are two distinct modes of operation. In Mode 1, the supply voltage range is 1.8 V to 5.5 V (unregulated externally; internal regulator operational). In Mode 2, the supply range is1.8 V ±5% (externally regulated; 1.71 to 1.89, internal regulator bypassed).

Mode 1: 1.8 V to 5.5 V External Supply

In this mode, the PSoC 4000S is powered by an external power supply that can be anywhere in the range of 1.8 to 5.5 V. This range is also designed for battery-powered operation. For example, the chip can be powered from a battery system that starts at 3.5 V and works down to 1.8 V. In this mode, the internal regulator of the PSoC 4000S supplies the internal logic and its output is connected to the V_{CCD} pin. The VCCD pin must be bypassed to ground via an external capacitor (0.1 µF; X5R ceramic or better) and must not be connected to anything else.

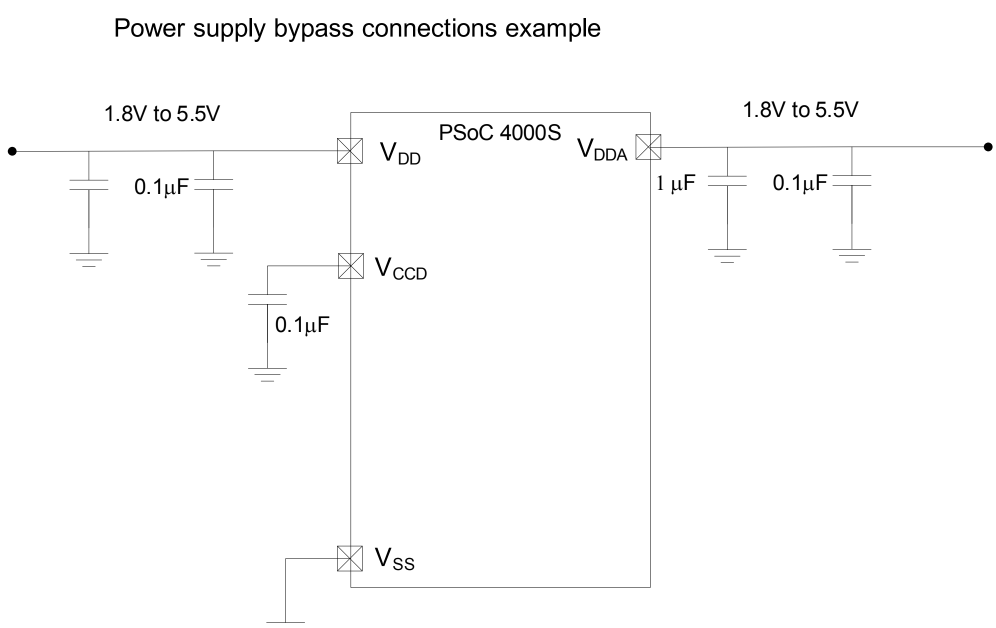
Mode 2: 1.8 V ±5% External Supply

In this mode, the PSoC 4000S is powered by an external power supply that must be within the range of 1.71 to 1.89 V; note that this range needs to include the power supply ripple too. In this mode, the VDD and VCCD pins are shorted together and bypassed. The internal regulator can be disabled in the firmware.

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

An example of a bypass scheme is shown in the following diagram.

Figure 4. External Supply Range from 1.8 V to 5.5 V with Internal Regulator Active



Development Support

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

Documentation

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

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

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

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

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

Online

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

Tools

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

Electrical Specifications

Absolute Maximum Ratings

Table 2. Absolute Maximum Ratings[1]

<table>
<tr><th>Spec ID#</th><th>Parameter</th><th>Description</th><th>Min</th><th>Typ</th><th>Max</th><th>Units</th><th>Details/ Conditions</th></tr>
<tr><td>SID1</td><td>V_{DDD_ABS}</td><td>Digital supply relative to V_{SS}</td><td>–0.5</td><td>–</td><td>6</td><td rowspan="3">V</td><td>–</td></tr>
<tr><td>SID2</td><td>V_{CCD_ABS}</td><td>Direct digital core voltage input relative to V_{SS}</td><td>–0.5</td><td>–</td><td>1.95</td><td>–</td></tr>
<tr><td>SID3</td><td>V_{GPIO_ABS}</td><td>GPIO voltage</td><td>–0.5</td><td>–</td><td>V_{DD}+0.5</td><td>–</td></tr>
<tr><td>SID4</td><td>I_{GPIO_ABS}</td><td>Maximum current per GPIO</td><td>–25</td><td>–</td><td>25</td><td rowspan="2">mA</td><td>–</td></tr>
<tr><td>SID5</td><td>$I_{GPIO\_injection}$</td><td>GPIO injection current, Max for V_{IH} > V_{DDD}, and Min for V_{IL} < V_{SS}</td><td>–0.5</td><td>–</td><td>0.5</td><td>Current injected per pin</td></tr>
<tr><td>BID44</td><td>ESD_HBM</td><td>Electrostatic discharge human body model</td><td>2200</td><td>–</td><td>–</td><td rowspan="2">V</td><td>–</td></tr>
<tr><td>BID45</td><td>ESD_CDM</td><td>Electrostatic discharge charged device model</td><td>500</td><td>–</td><td>–</td><td>–</td></tr>
<tr><td>BID46</td><td>LU</td><td>Pin current for latch-up</td><td>–140</td><td>–</td><td>140</td><td>mA</td><td>–</td></tr>
</table>

Device Level Specifications

All specifications are valid for –40 °C ≤ T_A ≤ 85 °C and T_J ≤ 100 °C, except where noted. Specifications are valid for 1.71 V to 5.5 V, except where noted.

Table 3. DC Specifications

Typical values measured at V_{DD} = 3.3 V and 25 °C.

<table>
<tr><th>Spec ID#</th><th>Parameter</th><th>Description</th><th>Min</th><th>Typ</th><th>Max</th><th>Units</th><th>Details/ Conditions</th></tr>
<tr><td>SID53</td><td>V_{DD}</td><td>Power supply input voltage</td><td>1.8</td><td>–</td><td>5.5</td><td rowspan="3">V</td><td>Internally regulated supply</td></tr>
<tr><td>SID255</td><td>V_{DD}</td><td>Power supply input voltage (V_{CCD} = V_{DD}= V_{DDA})</td><td>1.71</td><td>–</td><td>1.89</td><td>Internally unregulated supply</td></tr>
<tr><td>SID54</td><td>V_{CCD}</td><td>Output voltage (for core logic)</td><td>–</td><td>1.8</td><td>–</td><td>–</td></tr>
<tr><td>SID55</td><td>C_{EFC}</td><td>External regulator voltage bypass</td><td>–</td><td>0.1</td><td>–</td><td rowspan="2">µF</td><td>X5R ceramic or better</td></tr>
<tr><td>SID56</td><td>C_{EXC}</td><td>Power supply bypass capacitor</td><td>–</td><td>1</td><td>–</td><td>X5R ceramic or better</td></tr>
<tr><td colspan="8">Active Mode, V_{DD} = 1.8 V to 5.5 V. Typical values measured at VDD = 3.3 V and 25 °C.</td></tr>
<tr><td>SID10</td><td>I_{DD5}</td><td>Execute from flash; CPU at 6 MHz</td><td>–</td><td>1.2</td><td>2.0</td><td rowspan="3">mA</td><td>–</td></tr>
<tr><td>SID16</td><td>I_{DD8}</td><td>Execute from flash; CPU at 24 MHz</td><td>–</td><td>2.4</td><td>4.0</td><td>–</td></tr>
<tr><td>SID19</td><td>I_{DD11}</td><td>Execute from flash; CPU at 48 MHz</td><td>–</td><td>4.6</td><td>5.9</td><td>–</td></tr>
<tr><td colspan="7">Sleep Mode, VDDD = 1.8 V to 5.5 V (Regulator on)</td><td></td></tr>
<tr><td>SID22</td><td>I_{DD17}</td><td>I^2C wakeup WDT, and Comparators on</td><td>–</td><td>1.1</td><td>1.6</td><td rowspan="2">mA</td><td>6 MHz</td></tr>
<tr><td>SID25</td><td>I_{DD20}</td><td>I^2C wakeup, WDT, and Comparators on</td><td>–</td><td>1.4</td><td>1.9</td><td>12 MHz</td></tr>
</table>

Note

1. Usage above the absolute maximum conditions listed in Table 2 may cause permanent damage to the device. Exposure to Absolute Maximum conditions for extended periods of time may affect device reliability. The Maximum Storage Temperature is 150 °C in compliance with JEDEC Standard JESD22-A103, High Temperature Storage Life. When used below Absolute Maximum conditions but above normal operating conditions, the device may not operate to specification.

GPIO

Table 5. GPIO DC Specifications

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
SID57	V_{IH}[3]	Input voltage high threshold	$0.7 \times V_{DDD}$	–	–	V	CMOS Input
SID58	V_{IL}	Input voltage low threshold	–	–	$0.3 \times V_{DDD}$		CMOS Input
SID241	V_{IH}[3]	LVTTL input, $V_{DDD} < 2.7$ V	$0.7 \times V_{DDD}$	–	–		–
SID242	V_{IL}	LVTTL input, $V_{DDD} < 2.7$ V	–	–	$0.3 \times V_{DDD}$		–
SID243	V_{IH}[3]	LVTTL input, $V_{DDD} \geq 2.7$ V	2.0	–	–		–
SID244	V_{IL}	LVTTL input, $V_{DDD} \geq 2.7$ V	–	–	0.8		–
SID59	V_{OH}	Output voltage high level	V_{DDD} –0.6	–	–		I_{OH} = 4 mA at 3 V V_{DDD}
SID60	V_{OH}	Output voltage high level	V_{DDD} –0.5	–	–		I_{OH} = 1 mA at 3 V V_{DDD}
SID61	V_{OL}	Output voltage low level	–	–	0.6		I_{OL} = 4 mA at 1.8 V V_{DDD}
SID62	V_{OL}	Output voltage low level	–	–	0.6		I_{OL} = 10 mA at 3 V V_{DDD}
SID62A	V_{OL}	Output voltage low level	–	–	0.4		I_{OL} = 3 mA at 3 V V_{DDD}
SID63	R_{PULLUP}	Pull-up resistor	3.5	5.6	8.5	kΩ	–
SID64	$R_{PULLDOWN}$	Pull-down resistor	3.5	5.6	8.5		–
SID65	I_{IL}	Input leakage current (absolute value)	–	–	2	nA	25 °C, V_{DDD} = 3.0 V
SID66	C_{IN}	Input capacitance	–	–	7	pF	–
SID67[4]	V_{HYSTTL}	Input hysteresis LVTTL	25	40	–	mV	$V_{DDD} \geq 2.7$ V
SID68[4]	$V_{HYSCMOS}$	Input hysteresis CMOS	$0.05 \times V_{DDD}$	–	–		$V_{DD} < 4.5$ V
SID68A[4]	$V_{HYSCMOS5V5}$	Input hysteresis CMOS	200	–	–		$V_{DD} > 4.5$ V
SID69[4]	I_{DIODE}	Current through protection diode to V_{DD}/V_{SS}	–	–	100	µA	–
SID69A[4]	I_{TOT_GPIO}	Maximum total source or sink chip current	–	–	200	mA	–

Table 6. GPIO AC Specifications

(Guaranteed by Characterization)

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
SID70	T_{RISEF}	Rise time in fast strong mode	2	–	12	ns	3.3 V V_{DDD}, Cload = 25 pF
SID71	T_{FALLF}	Fall time in fast strong mode	2	–	12		3.3 V V_{DDD}, Cload = 25 pF
SID72	T_{RISES}	Rise time in slow strong mode	10	–	60	–	3.3 V V_{DDD}, Cload = 25 pF
SID73	T_{FALLS}	Fall time in slow strong mode	10	–	60	–	3.3 V V_{DDD}, Cload = 25 pF

Notes
3. V_{IH} must not exceed V_{DDD} + 0.2 V.
4. Guaranteed by characterization.

Table 6. GPIO AC Specifications
(Guaranteed by Characterization) *(continued)*

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
SID74	$F_{GPIOUT1}$	GPIO F_{OUT}; 3.3 V ≤ V_{DDD} ≤ 5.5 V Fast strong mode	–	–	33	MHz	90/10%, 25 pF load, 60/40 duty cycle
SID75	$F_{GPIOUT2}$	GPIO F_{OUT}; 1.71 V≤ V_{DDD}≤ 3.3 V Fast strong mode	–	–	16.7		90/10%, 25 pF load, 60/40 duty cycle
SID76	$F_{GPIOUT3}$	GPIO F_{OUT}; 3.3 V ≤ V_{DDD} ≤ 5.5 V Slow strong mode	–	–	7		90/10%, 25 pF load, 60/40 duty cycle
SID245	$F_{GPIOUT4}$	GPIO F_{OUT}; 1.71 V ≤ V_{DDD} ≤ 3.3 V Slow strong mode.	–	–	3.5		90/10%, 25 pF load, 60/40 duty cycle
SID246	F_{GPIOIN}	GPIO input operating frequency; 1.71 V ≤ V_{DDD} ≤ 5.5 V	–	–	48		90/10% V_{IO}

XRES

Table 7. XRES DC Specifications

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
SID77	V_{IH}	Input voltage high threshold	0.7 × V_{DDD}	–	–	V	CMOS Input
SID78	V_{IL}	Input voltage low threshold	–	–	0.3 × V_{DDD}		
SID79	R_{PULLUP}	Pull-up resistor	–	60	–	kΩ	–
SID80	C_{IN}	Input capacitance	–	–	7	pF	–
SID81[5]	$V_{HYSXRES}$	Input voltage hysteresis	–	100	–	mV	Typical hysteresis is 200 mV for V_{DD} > 4.5 V
SID82	I_{DIODE}	Current through protection diode to V_{DD}/V_{SS}	–	–	100	µA	

Table 8. XRES AC Specifications

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
SID83[5]	$T_{RESETWIDTH}$	Reset pulse width	1	–	–	µs	–
BID194[5]	$T_{RESETWAKE}$	Wake-up time from reset release	–	–	2.7	ms	–

Note
5. Guaranteed by characterization.

Table 12. 10-bit CapSense ADC Specifications *(continued)*

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SIDA109	A_SND	Signal-to-noise and Distortion ratio (SINAD)	–	61	–	dB	With 10-Hz input sine wave, external 2.4-V reference, V_{REF} (2.4 V) mode
SIDA110	A_BW	Input bandwidth without aliasing	–	–	22.4	kHz	8-bit resolution
SIDA111	A_INL	Integral Non Linearity. 1 ksps	–	–	2	LSB	V_{REF} = 2.4 V or greater
SIDA112	A_DNL	Differential Non Linearity. 1 ksps	–	–	1	LSB	

Digital Peripherals

Timer Counter Pulse-Width Modulator (TCPWM)

Table 13. TCPWM Specifications

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID.TCPWM.1	ITCPWM1	Block current consumption at 3 MHz	–	–	45	µA	All modes (TCPWM)
SID.TCPWM.2	ITCPWM2	Block current consumption at 12 MHz	–	–	155		All modes (TCPWM)
SID.TCPWM.2A	ITCPWM3	Block current consumption at 48 MHz	–	–	650		All modes (TCPWM)
SID.TCPWM.3	$TCPWM_{FREQ}$	Operating frequency	–	–	Fc	MHz	Fc max = CLK_SYS Maximum = 48 MHz
SID.TCPWM.4	$TPWM_{ENEXT}$	Input trigger pulse width	2/Fc	–	–	ns	For all trigger events[6]
SID.TCPWM.5	$TPWM_{EXT}$	Output trigger pulse widths	2/Fc	–	–		Minimum possible width of Overflow, Underflow, and CC (Counter equals Compare value) outputs
SID.TCPWM.5A	TC_{RES}	Resolution of counter	1/Fc	–	–		Minimum time between successive counts
SID.TCPWM.5B	PWM_{RES}	PWM resolution	1/Fc	–	–		Minimum pulse width of PWM Output
SID.TCPWM.5C	Q_{RES}	Quadrature inputs resolution	1/Fc	–	–		Minimum pulse width between Quadrature phase inputs

Note
6. Trigger events can be Stop, Start, Reload, Count, Capture, or Kill depending on which mode of operation is selected.

Table 18. UART DC Specifications[8]

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID160	I_{UART1}	Block current consumption at 100 Kbps	–	–	55	µA	–
SID161	I_{UART2}	Block current consumption at 1000 Kbps	–	–	312	µA	–

Table 19. UART AC Specifications[8]

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID162	F_{UART}	Bit rate	–	–	1	Mbps	–

Table 20. LCD Direct Drive DC Specifications[8]

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID154	I_{LCDLOW}	Operating current in low power mode	–	5	–	µA	16 × 4 small segment disp. at 50 Hz
SID155	C_{LCDCAP}	LCD capacitance per segment/common driver	–	500	5000	pF	–
SID156	LCD_{OFFSET}	Long-term segment offset	–	20	–	mV	–
SID157	I_{LCDOP1}	LCD system operating current Vbias = 5 V	–	2	–	mA	32 × 4 segments. 50 Hz. 25 °C
SID158	I_{LCDOP2}	LCD system operating current Vbias = 3.3 V	–	2	–	mA	32 × 4 segments. 50 Hz. 25 °C

Table 21. LCD Direct Drive AC Specifications[8]

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID159	F_{LCD}	LCD frame rate	10	50	150	Hz	–

Note
8. Guaranteed by characterization.

SWD Interface

Table 26. SWD Interface Specifications

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID213	F_SWDCLK1	3.3 V ≤ V_{DD} ≤ 5.5 V	–	–	14	MHz	SWDCLK ≤ 1/3 CPU clock frequency
SID214	F_SWDCLK2	1.71 V ≤ V_{DD} ≤ 3.3 V	–	–	7		SWDCLK ≤ 1/3 CPU clock frequency
SID215[11]	T_SWDI_SETUP	T = 1/f SWDCLK	0.25*T	–	–	ns	–
SID216[11]	T_SWDI_HOLD	T = 1/f SWDCLK	0.25*T	–	–		–
SID217[11]	T_SWDO_VALID	T = 1/f SWDCLK	–	–	0.5*T		–
SID217A[11]	T_SWDO_HOLD	T = 1/f SWDCLK	1	–	–		–

Internal Main Oscillator

Table 27. IMO DC Specifications

(Guaranteed by Design)

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID218	I_{IMO1}	IMO operating current at 48 MHz	–	–	250	µA	–
SID219	I_{IMO2}	IMO operating current at 24 MHz	–	–	180	µA	–

Table 28. IMO AC Specifications

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID223	$F_{IMOTOL1}$	Frequency variation at 24, 32, and 48 MHz (trimmed)	–	–	±2	%	
SID226	$T_{STARTIMO}$	IMO startup time	–	–	7	µs	–
SID228	$T_{JITRMSIMO2}$	RMS jitter at 24 MHz	–	145	–	ps	–

Internal Low-Speed Oscillator

Table 29. ILO DC Specifications

(Guaranteed by Design)

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID231[11]	I_{ILO1}	ILO operating current	–	0.3	1.05	µA	–

Table 30. ILO AC Specifications

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID234[11]	$T_{STARTILO1}$	ILO startup time	–	–	2	ms	–
SID236[11]	$T_{ILODUTY}$	ILO duty cycle	40	50	60	%	–
SID237	$F_{ILOTRIM1}$	ILO frequency range	20	40	80	kHz	–

Note

11. Guaranteed by characterization.

Ordering Information

The PSoC 4000S part numbers and features are listed in the following table.

Table 35. PSoC 4000S Ordering Information

Category	MPN	Features												Package				
		Max CPU Speed (MHz)	Flash (KB)	SRAM (KB)	Opamp (CTBm)	CapSense	10-bit CSD ADC	12-bit SAR ADC	LP Comparators	TCPWM Blocks	SCB Blocks	Smart I/Os	GPIO	WLCSP (0.35-mm pitch)	24-Pin QFN	32-Pin QFN	40-Pin QFN	48-Pin TQFP
4024	CY8C4024FNI-S402	24	16	2	0	0	1	0	2	5	2	8	21	✔				
	CY8C4024LQI-S401	24	16	2	0	0	1	0	2	5	2	8	19		✔			
	CY8C4024LQI-S402	24	16	2	0	0	1	0	2	5	2	16	27			✔		
	CY8C4024LQI-S403	24	16	2	0	0	1	0	2	5	2	16	34				✔	
	CY8C4024AZI-S403	24	16	2	0	0	1	0	2	5	2	16	36					✔
	CY8C4024FNI-S412	24	16	2	0	1	1	0	2	5	2	8	21	✔				
	CY8C4024LQI-S411	24	16	2	0	1	1	0	2	5	2	8	19		✔			
	CY8C4024LQI-S412	24	16	2	0	1	1	0	2	5	2	16	27			✔		
	CY8C4024LQI-S413	24	16	2	0	1	1	0	2	5	2	16	34				✔	
	CY8C4024AZI-S413	24	16	2	0	1	1	0	2	5	2	16	36					✔
4025	CY8C4025FNI-S402	24	32	4	0	0	1	0	2	5	2	8	21	✔				
	CY8C4025LQI-S401	24	32	4	0	0	1	0	2	5	2	8	19		✔			
	CY8C4025LQI-S402	24	32	4	0	0	1	0	2	5	2	16	27			✔		
	CY8C4025AZI-S403	24	32	4	0	0	1	0	2	5	2	16	36					✔
	CY8C4025FNI-S412	24	32	4	0	1	1	0	2	5	2	8	21	✔				
	CY8C4025LQI-S411	24	32	4	0	1	1	0	2	5	2	8	19		✔			
	CY8C4025LQI-S412	24	32	4	0	1	1	0	2	5	2	16	27			✔		
	CY8C4025AZI-S413	24	32	4	0	1	1	0	2	5	2	16	36					✔
4045	CY8C4045FNI-S412	48	32	4	0	1	1	0	2	5	2	8	21	✔				
	CY8C4045LQI-S411	48	32	4	0	1	1	0	2	5	2	8	19		✔			
	CY8C4045LQI-S412	48	32	4	0	1	1	0	2	5	2	16	27			✔		
	CY8C4045AZI-S413	48	32	4	0	1	1	0	2	5	2	16	36					✔

The nomenclature used in the preceding table is based on the following part numbering convention:

Field	Description	Values	Meaning
CY8C	Cypress Prefix		
4	Architecture	4	PSoC 4
A	Family	0	4000 Family
B	CPU Speed	2	24 MHz
		4	48 MHz

Packaging

The PSoC 4000S will be offered in 48-pin TQFP, 40-pin QFN, 32-pin QFN, 24-pin QFN, and 25-ball WLCSP packages. Package dimensions and Cypress drawing numbers are in the following table.

Table 36. Package List

Spec ID#	Package	Description	Package Dwg
BID20	48-pin TQFP	7 × 7 × 1.4 mm height with 0.5-mm pitch	51-85135
BID27	40-pin QFN	6 × 6 × 0.6 mm height with 0.5-mm pitch	001-80659
BID34A	32-pin QFN	5 × 5 × 0.6 mm height with 0.5-mm pitch	001-42168
BID34	24-pin QFN	4 × 4 × 0.6 mm height with 0.5-mm pitch	001-13937
BID34F	25-ball WLCSP	2.02 × 1.93 × 0.48 mm height with 0.35-mm pitch	002-09957

Table 37. Package Thermal Characteristics

Parameter	Description	Package	Min	Typ	Max	Units
T_A	Operating ambient temperature		–40	25	85	°C
T_J	Operating junction temperature		–40	–	100	°C
T_{JA}	Package θ_{JA}	48-pin TQFP	–	73.5	–	°C/Watt
T_{JC}	Package θ_{JC}	48-pin TQFP	–	33.5	–	°C/Watt
T_{JA}	Package θ_{JA}	40-pin QFN	–	17.8	–	°C/Watt
T_{JC}	Package θ_{JC}	40-pin QFN	–	2.8	–	°C/Watt
T_{JA}	Package θ_{JA}	32-pin QFN	–	20.8	–	°C/Watt
T_{JC}	Package θ_{JC}	32-pin QFN	–	5.9	–	°C/Watt
T_{JA}	Package θ_{JA}	24-pin QFN	–	21.7	–	°C/Watt
T_{JC}	Package θ_{JC}	24-pin QFN	–	5.6	–	°C/Watt
T_{JA}	Package θ_{JA}	25-ball WLCSP	–	54.6	–	°C/Watt
T_{JC}	Package θ_{JC}	25-ball WLCSP	–	0.5	–	°C/Watt

Table 38. Solder Reflow Peak Temperature

Package	Maximum Peak Temperature	Maximum Time at Peak Temperature
All	260 °C	30 seconds

Table 39. Package Moisture Sensitivity Level (MSL), IPC/JEDEC J-STD-020

Package	MSL
All except WLCSP	MSL 3
25-ball WLCSP	MSL 1

Package Diagrams

Figure 5. 48-pin TQFP Package Outline

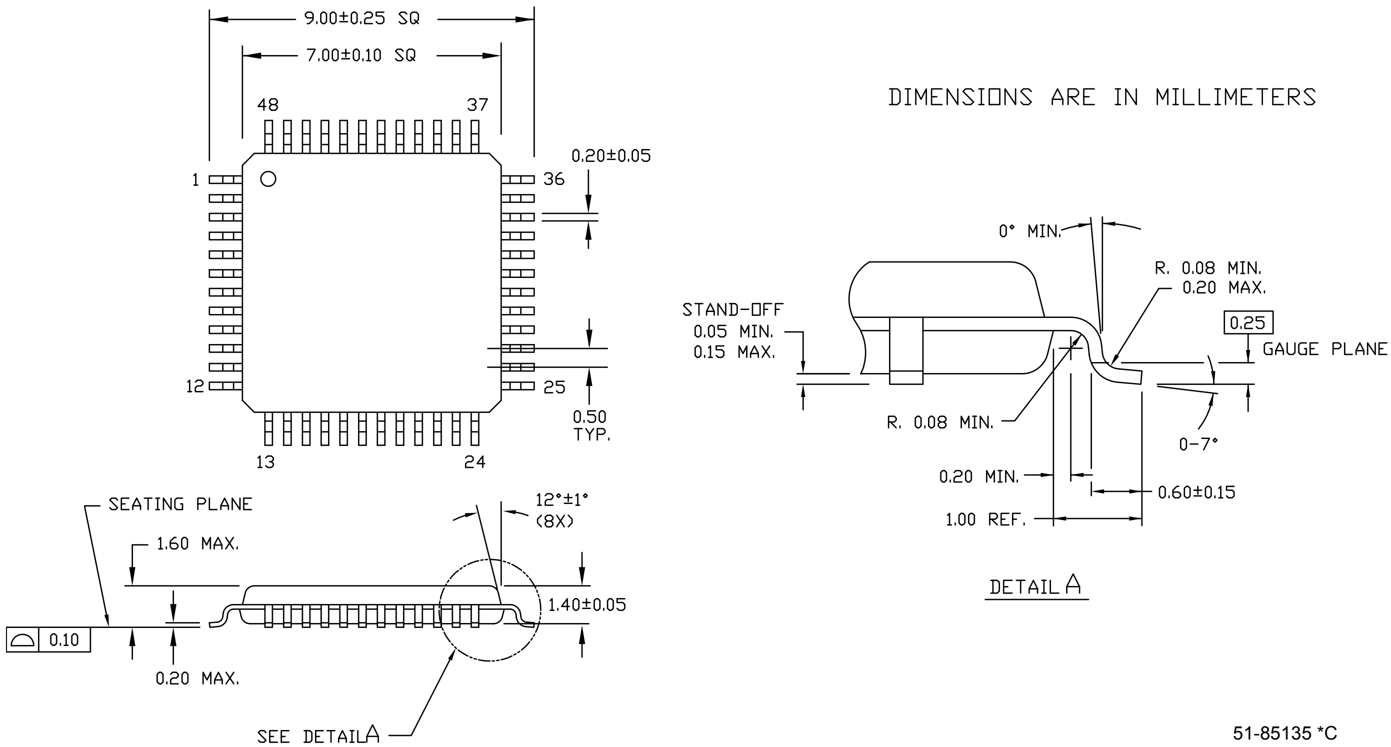
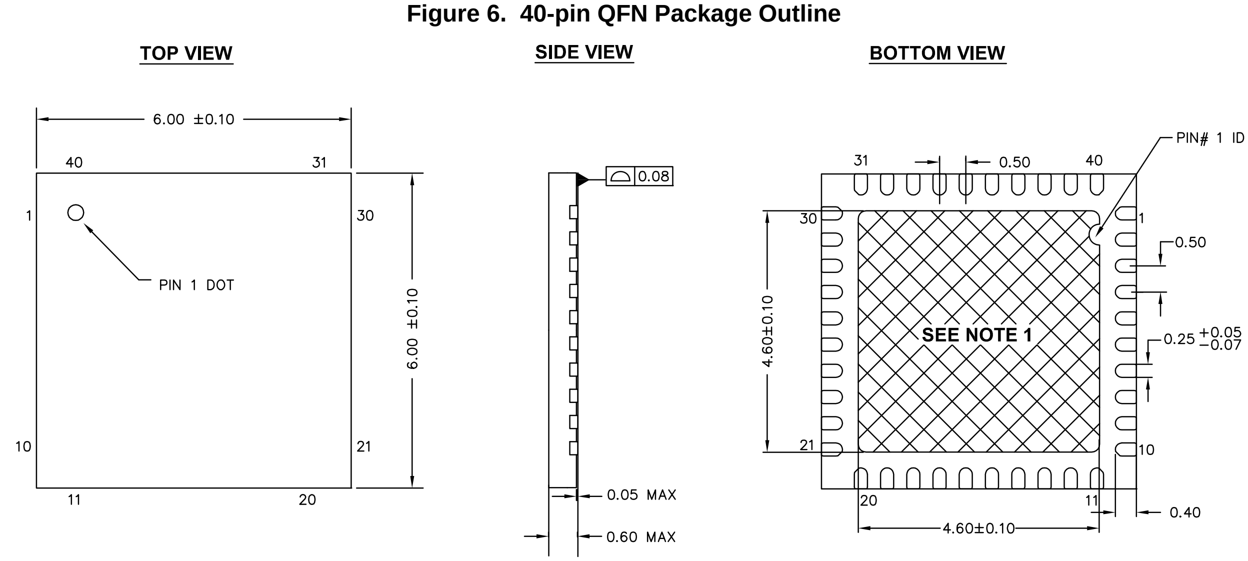


Figure 6. 40-pin QFN Package Outline

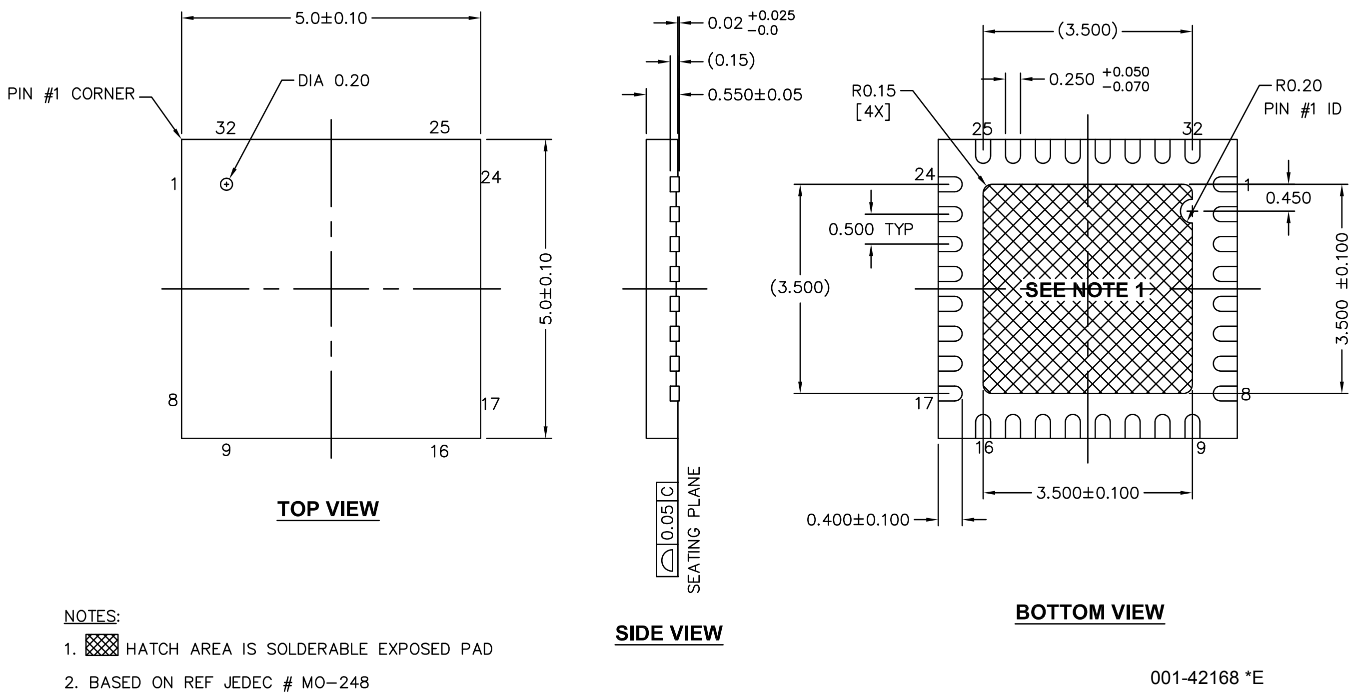


NOTES:

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

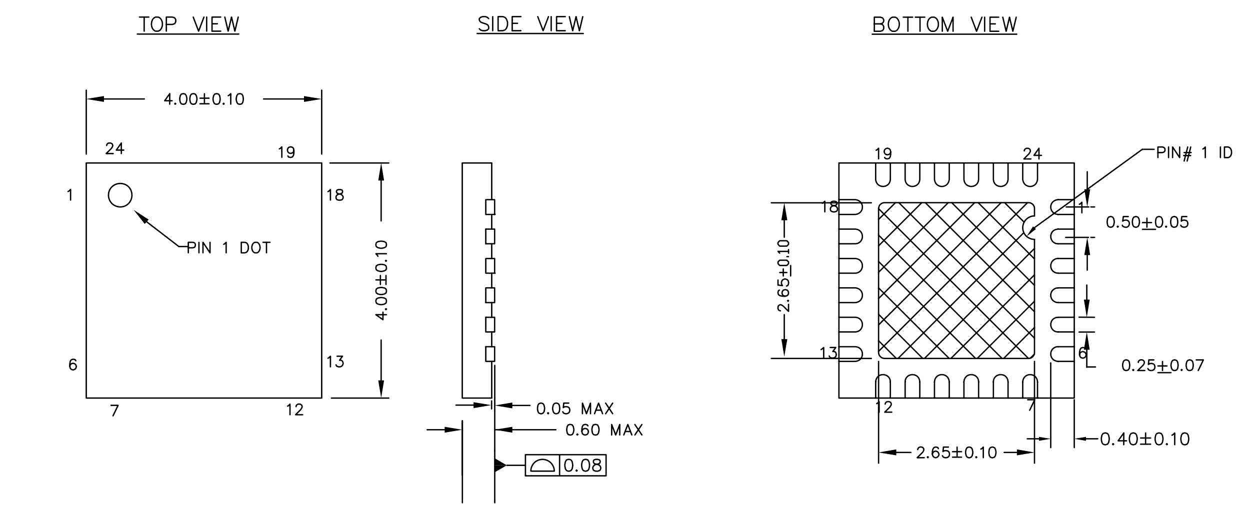
001-80659 *A

Figure 7. 32-pin QFN Package Outline



NOTES:
1. HATCH AREA IS SOLDERABLE EXPOSED PAD
2. BASED ON REF JEDEC # MO−248
3. PACKAGE WEIGHT: 0.0388g
4. DIMENSIONS ARE IN MILLIMETERS

Figure 8. 24-pin QFN Package Outline

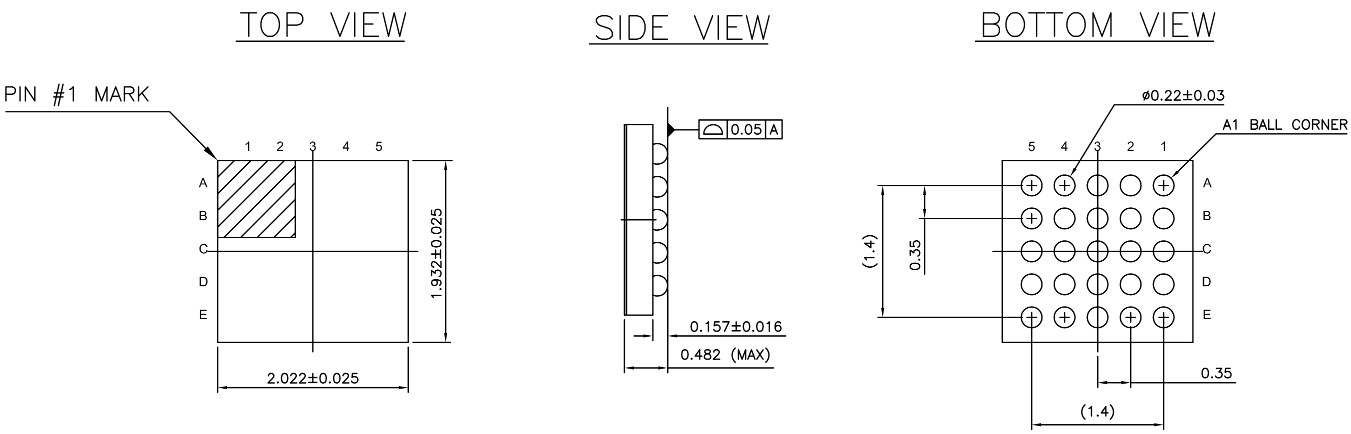


NOTES :
1. HATCH IS SOLDERABLE EXPOSED METAL.
2. REFERENCE JEDEC # MO−248
3. PACKAGE WEIGHT : 29 ± 3 mg
4. ALL DIMENSIONS ARE IN MILLIMETERS

001-13937 *F

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

Figure 9. 25-Ball WLCSP



ALL DIMENSIONS ARE IN MM
JEDEC Publication 95; Design Guide 4.18

002-09957 **

Table 40. Acronyms Used in this Document *(continued)*

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

Table 40. Acronyms Used in this Document *(continued)*

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

Document Conventions

Units of Measure

Table 41. Units of Measure

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

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