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"[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.

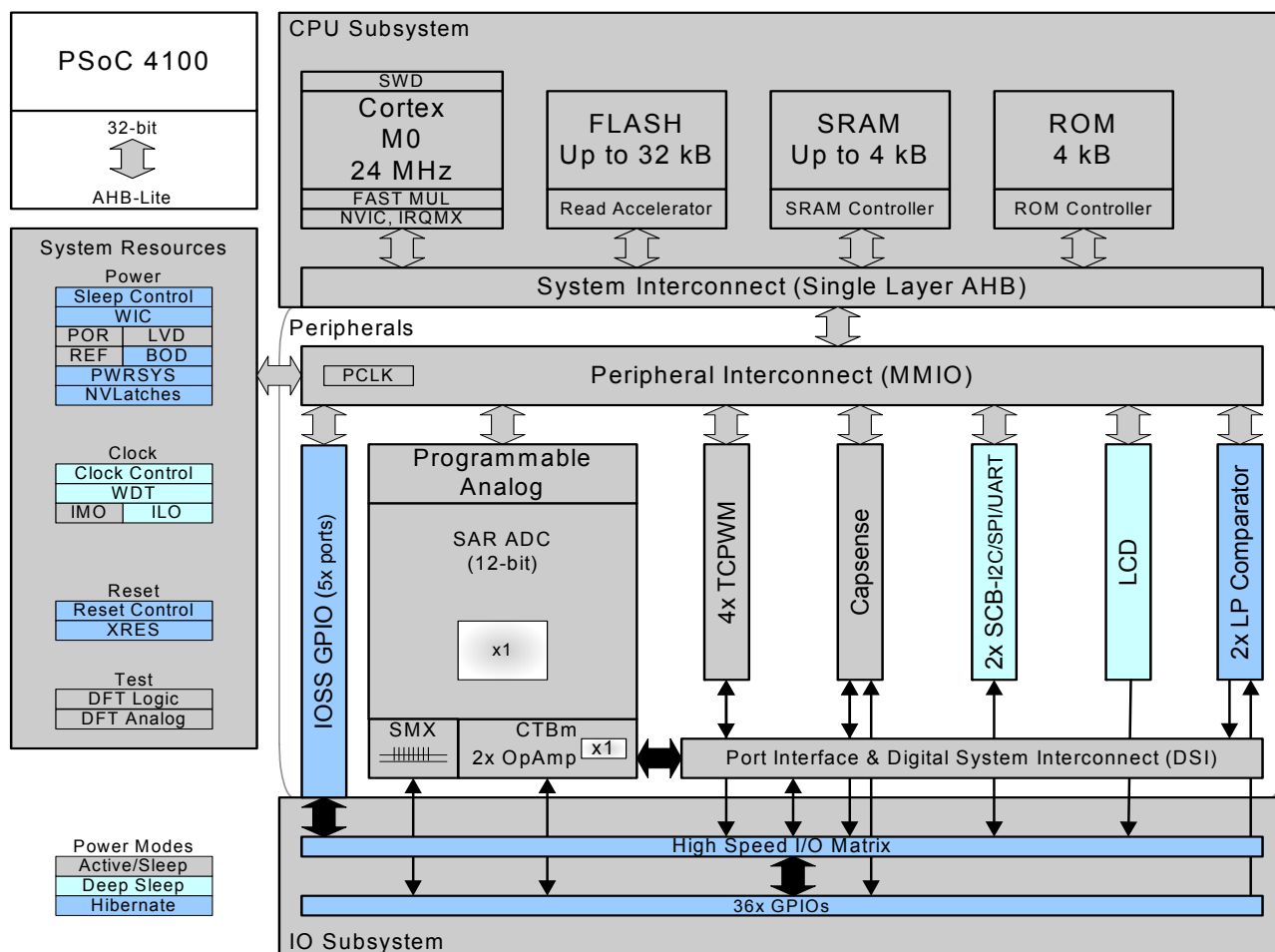
Applications of "[Embedded - Microcontrollers](#)"

Details

Product Status	Active
Core Processor	ARM® Cortex®-M0
Core Size	32-Bit Single-Core
Speed	24MHz
Connectivity	I ² C, 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	32KB (32K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	4K x 8
Voltage - Supply (Vcc/Vdd)	1.71V ~ 5.5V
Data Converters	A/D 8x12b SAR; D/A 2xIDAC
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	44-LQFP
Supplier Device Package	44-TQFP (10x10)
Purchase URL	https://www.e-xfl.com/product-detail/infineon-technologies/cy8c4125axi-483

Contents

Functional Definition	5	Analog Peripherals	22
CPU and Memory Subsystem	5	Digital Peripherals	26
System Resources	5	Memory	29
Analog Blocks	6	System Resources	29
Fixed Function Digital	7	Ordering Information.....	32
GPIO	7	Part Numbering Conventions	33
Special Function Peripherals.....	8	Packaging.....	34
Pinouts	9	Acronyms	38
Power	15	Document Conventions	40
Unregulated External Supply.....	15	Units of Measure	40
Regulated External Supply	16	Revision History	41
Development Support	17	Sales, Solutions, and Legal Information	42
Documentation	17	Worldwide Sales and Design Support.....	42
Online	17	Products	42
Tools.....	17	PSoC® Solutions	42
Electrical Specifications	18	Cypress Developer Community.....	42
Absolute Maximum Ratings.....	18	Technical Support	42
Device-Level Specifications	18		

Figure 2. Block Diagram


The PSoC 4100 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 Integrated Development Environment (IDE) provides fully integrated programming and debug support for the PSoC 4100 devices. The SWD interface is fully compatible with industry standard third party tools. With the ability to disable debug features, with very robust flash protection, and by allowing customer-proprietary functionality to be implemented in on-chip programmable blocks, the PSoC 4100 family provides a level of

security not possible with multi-chip application solutions or with microcontrollers.

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

Additionally, all device interfaces can be permanently disabled (device security) for applications concerned about phishing attacks due to a maliciously reprogrammed device or attempts to defeat security by starting and interrupting flash programming sequences. Because all programming, debug, and test interfaces are disabled when maximum device security is enabled, PSoC 4100 with device security enabled may not be returned for failure analysis. This is a trade-off the PSoC 4100 allows the customer to make.

Functional Definition

CPU and Memory Subsystem

CPU

The Cortex-M0 CPU in PSoC 4100 is part of the 32-bit MCU subsystem, which is optimized for low power operation with extensive clock gating. It mostly uses 16-bit instructions and executes a subset of the Thumb-2 instruction set. This enables fully compatible binary upward migration of the code to higher performance processors such as the Cortex-M3 and M4, thus enabling upward compatibility. The Cypress implementation includes a hardware multiplier that provides a 32-bit result in one cycle. It includes a nested vectored interrupt controller (NVIC) block with 32 interrupt inputs and also includes a Wakeup Interrupt Controller (WIC), which can wake the processor up from Deep Sleep mode allowing power to be switched off to the main processor when the chip is in Deep Sleep mode. The Cortex-M0 CPU provides a Non-Maskable Interrupt input (NMI), which is made available to the user when it is not in use for system functions requested by the user.

The CPU also includes a debug interface, the serial wire debug (SWD) interface, which is a two-wire form of JTAG; the debug configuration used for PSoC 4100 has four break-point (address) comparators and two watchpoint (data) comparators.

Flash

PSoC 4100 has a flash module with a flash accelerator tightly coupled to the CPU to improve average access times from the flash block. The flash block is designed to deliver 0 wait-state (WS) access time at 24 MHz. Part of the flash module can be used to emulate EEPROM operation if required.

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

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

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

SRAM

SRAM memory is retained during Hibernate.

SROM

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

System Resources

Power System

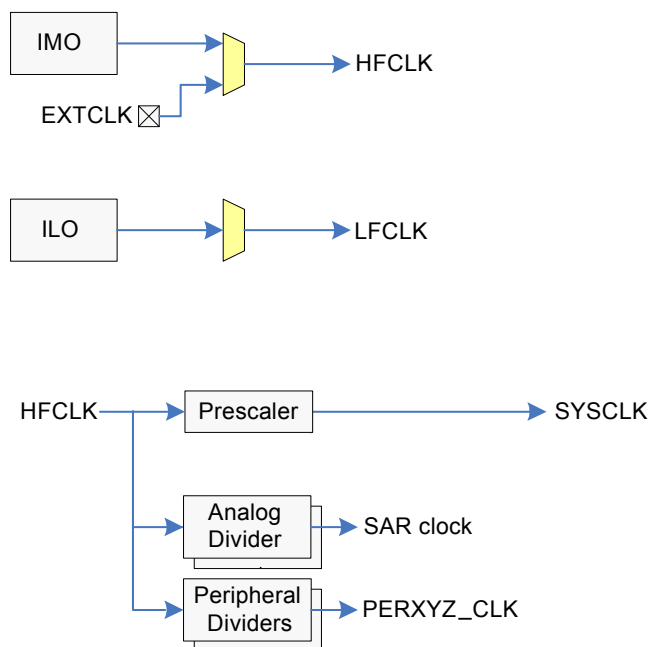
The power system is described in detail in the section [Power on page 15](#). It provides assurance that voltage levels are as required for each respective mode and either delay mode entry (on power-on reset (POR), for example) until voltage levels are as required for proper function or generate resets (brown-out detect (BOD)) or interrupts (low-voltage detect (LVD)). The PSoC 4100 operates with a single external supply over the range of 1.71 V to 5.5 V and has five different power modes, transitions between which are managed by the power system. PSoC 4100 provides Sleep, Deep Sleep, Hibernate, and Stop low-power modes.

Clock System

The PSoC 4100 clock system is responsible for providing clocks to all subsystems that require clocks and for switching between different clock sources without glitching. In addition, the clock system ensures that no metastable conditions occur.

The clock system for PSoC 4100 consists of the internal main oscillator (IMO) and the internal low-power oscillator (ILO) and provision for an external clock.

Figure 3. PSoC 4100 MCU Clocking Architecture



The HFCLK signal can be divided down (see [PSoC 4100 MCU Clocking Architecture](#)) to generate synchronous clocks for the analog and digital peripherals. There are a total of 12 clock dividers for PSoC 4100, each with 16-bit divide capability. The analog clock leads the digital clocks to allow analog events to occur before digital clock-related noise is generated. The 16-bit capability allows a lot of flexibility in generating fine-grained frequency values and is fully supported in PSoC Creator.

IMO Clock Source

The IMO is the primary source of internal clocking in the PSoC 4100. It is trimmed during testing to achieve the specified accuracy. Trim values are stored in nonvolatile latches (NVL). Additional trim settings from flash can be used to compensate for changes. The IMO default frequency is 24 MHz and it can be adjusted between 3 MHz to 24 MHz in steps of 1 MHz. The IMO tolerance with Cypress-provided calibration settings is $\pm 2\%$.

ILO Clock Source

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

Watchdog Timer

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

Reset

PSoC 4100 can be reset from a variety of sources including a software reset. Reset events are asynchronous and guarantee reversion to a known state. The reset cause is recorded in a register, which is sticky through reset and allows software to determine the cause of the reset. An XRES pin is reserved for external reset to avoid complications with configuration and multiple pin functions during power-on or reconfiguration. The XRES pin has an internal pull-up resistor that is always enabled.

Voltage Reference

The PSoC 4100 reference system generates all internally required references. A 1% voltage reference spec is provided for the 12-bit ADC. To allow better signal to noise ratios (SNR) and better absolute accuracy, it is possible to bypass the internal reference using a GPIO pin or to use an external reference for the SAR.

Analog Blocks

12-bit SAR ADC

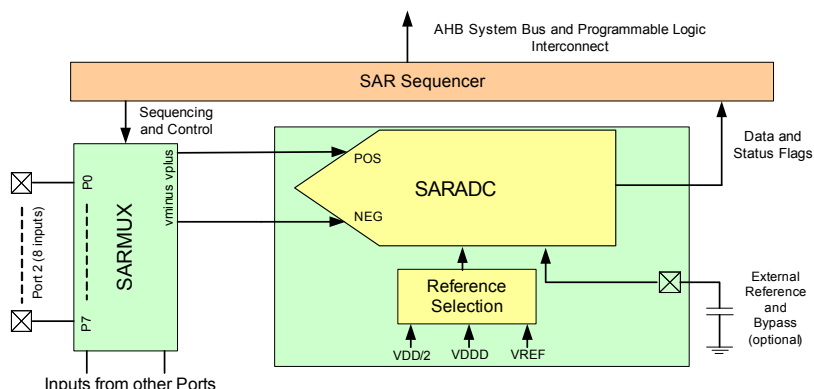
The 12-bit 806 ksp/s SAR ADC can operate at a maximum clock rate of 14.5 MHz and requires a minimum of 18 clocks at that frequency to do a 12-bit conversion.

The block functionality is augmented for the user by adding a reference buffer to it (trimmable to $\pm 1\%$) and by providing the choice (for the PSoC 4100 case) of three internal voltage references: V_{DD} , $V_{DD}/2$, and V_{REF} (nominally 1.024 V) as well as an external reference through a GPIO pin. The sample-and-hold (S/H) aperture is programmable allowing the gain bandwidth requirements of the amplifier driving the SAR inputs, which determine its settling time, to be relaxed if required. System performance will be 65 dB for true 12-bit precision providing appropriate references are used and system noise levels permit. To improve performance in noisy conditions, it is possible to provide an external bypass (through a fixed pin location) for the internal reference amplifier.

The SAR is connected to a fixed set of pins through an 8-input sequencer. The sequencer cycles through selected channels autonomously (sequencer scan) and does so with zero switching overhead (that is, aggregate sampling bandwidth is equal to 806 ksp/s whether it is for a single channel or distributed over several channels). The sequencer switching is effected through a state machine or through firmware driven switching. A feature provided by the sequencer is buffering of each channel to reduce CPU interrupt service requirements. To accommodate signals with varying source impedance and frequency, it is possible to have different sample times programmable for each channel. Also, signal range specification through a pair of range registers (low and high range values) is implemented with a corresponding out-of-range interrupt if the digitized value exceeds the programmed range; this allows fast detection of out-of-range values without the necessity of having to wait for a sequencer scan to be completed and the CPU to read the values and check for out-of-range values in software.

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

Figure 4. SAR ADC System Diagram



Pinouts

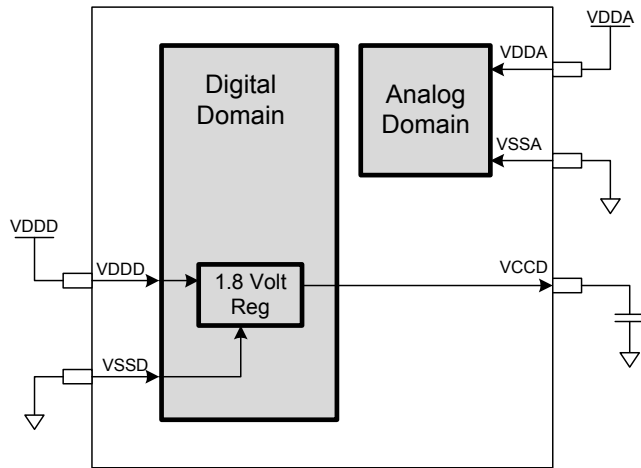
The following is the pin-list for PSoC 4100 (44-TQFP, 40-QFN, 28-SSOP, and 48-TQFP). Port 2 comprises of the high-speed Analog inputs for the SAR Mux. P1.7 is the optional external input and bypass for the SAR reference. Ports 3 and 4 contain the Digital Communication channels. All pins support CSD CapSense and analog mux bus connections.

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

Power

The following power system diagrams show the minimum set of power supply pins as implemented for PSoC 4100. The system has one regulator in Active mode for the digital circuitry. There is no analog regulator; the analog circuits run directly from the V_{DDA} input. There are separate regulators for the Deep Sleep and Hibernate (lowered power supply and retention) modes. There is a separate low-noise regulator for the bandgap. The supply voltage range is 1.71 V to 5.5 V with all functions and circuits operating over that range.

Figure 10. PSoC 4 Power Supply



The PSoC 4100 family allows two distinct modes of power supply operation: Unregulated External Supply, and Regulated External Supply modes.

Unregulated External Supply

In this mode, PSoC 4100 is powered by an external power supply that can be anywhere in the range of 1.8 V to 5.5 V. This range is also designed for battery-powered operation, for instance, the chip can be powered from a battery system that starts at 3.5 V and works down to 1.8 V. In this mode, the internal regulator of PSoC 4100 supplies the internal logic and the V_{CCD} output of the PSoC 4100 must be bypassed to ground via an external Capacitor (in the range of 1 μF to 1.6 μF ; X5R ceramic or better).

V_{DDA} and V_{DDD} must be shorted together; the grounds, V_{SSA} and V_{SS} must also be shorted together. Bypass capacitors must be used from V_{DDD} to ground, typical practice for systems in this frequency range is to use a capacitor in the 1- μF range in parallel with a smaller capacitor (0.1 μF for example). Note that these are simply rules of thumb and that, for critical applications, the PCB layout, lead inductance, and the Bypass capacitor parasitic should be simulated to design and obtain optimal bypassing.

Figure 11. 48-TQFP Package Example

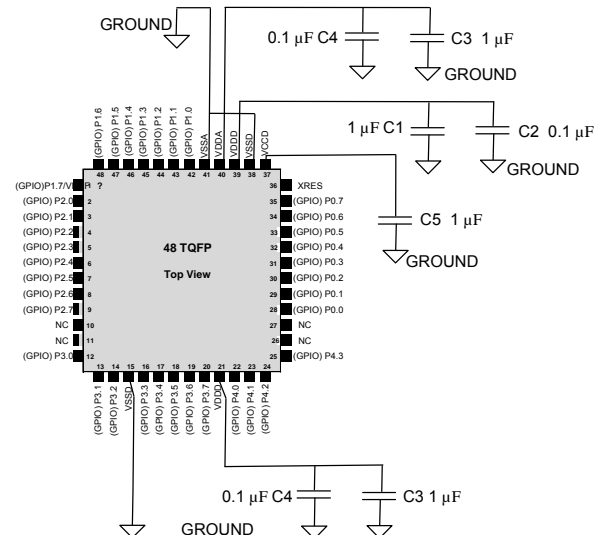
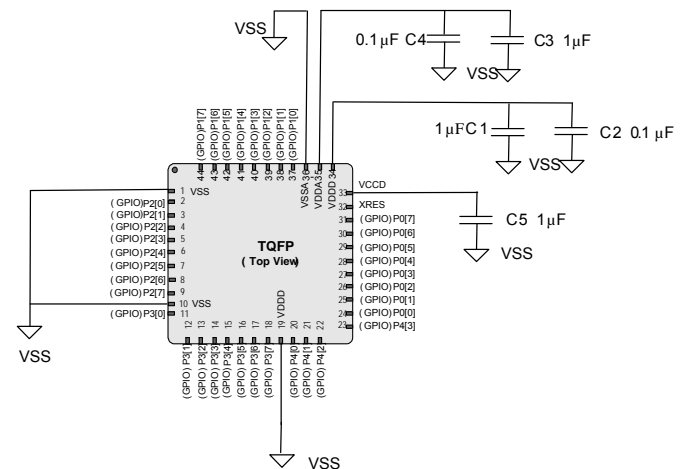


Figure 12. 44-TQFP Package Example



Power Supply	Bypass Capacitors
VDDD–VSS	0.1 μF ceramic at each pin (C2, C6) plus bulk capacitor 1 to 10 μF (C1). Total capacitance may be greater than 10 μF .
VDDA–VSSA	0.1 μF ceramic at pin (C4). Additional 1 μF to 10 μF (C3) bulk capacitor. Total capacitance may be greater than 10 μF .
VCCD–VSS	1 μF ceramic capacitor at the VCCD pin (C5)
VREF–VSSA (optional)	The internal bandgap may be bypassed with a 1 μF to 10 μF capacitor. Total capacitance may be greater than 10 μF .

Electrical Specifications

Absolute Maximum Ratings

Table 1. Absolute Maximum Ratings^[1]

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID1	V _{DDD_ABS}	Digital supply relative to V _{SSD}	-0.5	–	6	V	Absolute max
SID2	V _{CCD_ABS}	Direct digital core voltage input relative to V _{SSD}	-0.5	–	1.95	V	Absolute max
SID3	V _{GPIO_ABS}	GPIO voltage	-0.5	–	V _{DD} +0.5	V	Absolute max
SID4	I _{GPIO_ABS}	Maximum current per GPIO	-25	–	25	mA	Absolute max
SID5	I _{GPIO_injection}	GPIO injection current, Max for V _{IH} > V _{DDD} , and Min for V _{IL} < V _{SS}	-0.5	–	0.5	mA	Absolute max, current injected per pin
BID44	ESD_HBM	Electrostatic discharge human body model	2200	–	–	V	
BID45	ESD_CDM	Electrostatic discharge charged device model	500	–	–	V	
BID46	LU	Pin current for latch-up	-200	–	200	mA	

Device-Level Specifications

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

Table 2. DC Specifications

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID53	V _{DD}	Power Supply Input Voltage (V _{DDA} = V _{DDD} = V _{DD})	1.8	–	5.5	V	With regulator enabled
SID255	V _{DDD}	Power Supply Input Voltage unregulated	1.71	1.8	1.89	V	Internally unregulated Supply
SID54	V _{CCD}	Output voltage (for core logic)	–	1.8	–	V	
SID55	CEFC	External Regulator voltage bypass	1	1.3	1.6	μF	X5R ceramic or better
SID56	CEXC	Power supply decoupling capacitor	–	1	–	μF	X5R ceramic or better
Active Mode, V_{DD} = 1.71 V to 5.5 V. Typical Values measured at V_{DD} = 3.3 V							
SID9	IDD4	Execute from Flash; CPU at 6 MHz	–	–	2.8	mA	
SID10	IDD5	Execute from Flash; CPU at 6 MHz	–	2.2	–	mA	T = 25 °C
SID12	IDD7	Execute from Flash; CPU at 12 MHz,	–	–	4.2	mA	
SID13	IDD8	Execute from Flash; CPU at 12 MHz	–	3.7	–	mA	T = 25 °C
SID16	IDD11	Execute from Flash; CPU at 24 MHz	–	6.7	–	mA	T = 25 °C
SID17	IDD12	Execute from Flash; CPU at 24 MHz	–	–	7.2	mA	
Sleep Mode, V_{DD} = 1.7 V to 5.5 V							
SID25	IDD20	I ² C wakeup, WDT, and Comparators on. 6 MHz.	–	1.3	1.8	mA	V _{DD} = 1.71 to 5.5 V
SID25A	IDD20A	I ² C wakeup, WDT, and Comparators on. 12 MHz.	–	1.7	2.2	mA	V _{DD} = 1.71 to 5.5 V
Deep Sleep Mode, V_{DD} = 1.8 V to 3.6 V (Regulator on)							
SID31	IDD26	I ² C wakeup and WDT on.	–	1.3	–	μA	T = 25 °C
SID32	IDD27	I ² C wakeup and WDT on.	–	–	45	μA	T = 85 °C

Note

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

GPIO
Table 4. GPIO DC Specifications

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

Note

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

Analog Peripherals

Opamp

Table 8. Opamp Specifications (Guaranteed by Characterization)

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
	I_{DD}	Opamp block current. No load.	–	–	–	–	
SID269	I_{DD_HI}	Power = high	–	1100	1850	μA	
SID270	I_{DD_MED}	Power = medium	–	550	950	μA	
SID271	I_{DD_LOW}	Power = low	–	150	350	μA	
	GBW	Load = 20 pF, 0.1 mA. $V_{DDA} = 2.7$ V	–	–	–	–	
SID272	GBW_HI	Power = high	6	–	–	MHz	
SID273	GBW_MED	Power = medium	4	–	–	MHz	
SID274	GBW_LO	Power = low	–	1	–	MHz	
	I_{OUT_MAX}	$V_{DDA} \geq 2.7$ V, 500 mV from rail	–	–	–	–	
SID275	$I_{OUT_MAX_HI}$	Power = high	10	–	–	mA	
SID276	$I_{OUT_MAX_MID}$	Power = medium	10	–	–	mA	
SID277	$I_{OUT_MAX_LO}$	Power = low	–	5	–	mA	
	I_{OUT}	$V_{DDA} = 1.71$ V, 500 mV from rail	–	–	–	–	
SID278	$I_{OUT_MAX_HI}$	Power = high	4	–	–	mA	
SID279	$I_{OUT_MAX_MID}$	Power = medium	4	–	–	mA	
SID280	$I_{OUT_MAX_LO}$	Power = low	–	2	–	mA	
SID281	V_{IN}	Charge pump on, $V_{DDA} \geq 2.7$ V	–0.05	–	$V_{DDA} - 0.2$	V	
SID282	V_{CM}	Charge pump on, $V_{DDA} \geq 2.7$ V	–0.05	–	$V_{DDA} - 0.2$	V	
	V_{OUT}	$V_{DDA} \geq 2.7$ V	–	–	–	–	
SID283	V_{OUT_1}	Power = high, Iload=10 mA	0.5	–	$V_{DDA} - 0.5$	V	
SID284	V_{OUT_2}	Power = high, Iload=1 mA	0.2	–	$V_{DDA} - 0.2$	V	
SID285	V_{OUT_3}	Power = medium, Iload=1 mA	0.2	–	$V_{DDA} - 0.2$	V	
SID286	V_{OUT_4}	Power = low, Iload=0.1 mA	0.2	–	$V_{DDA} - 0.2$	V	
SID288	V_{OS_TR}	Offset voltage, trimmed	1	±0.5	1	mV	High mode
SID288A	V_{OS_TR}	Offset voltage, trimmed	–	±1	–	mV	Medium mode
SID288B	V_{OS_TR}	Offset voltage, trimmed	–	±2	–	mV	Low mode
SID290	$V_{OS_DR_TR}$	Offset voltage drift, trimmed	–10	±3	10	μV/°C	High mode. $T_A \leq 85$ °C
SID290Q	$V_{OS_DR_TR}$	Offset voltage drift, trimmed	15	±3	15	μV/°C	High mode. $T_A \leq 105$ °C
SID290A	$V_{OS_DR_TR}$	Offset voltage drift, trimmed	–	±10	–	μV/°C	Medium mode
SID290B	$V_{OS_DR_TR}$	Offset voltage drift, trimmed	–	±10	–	μV/°C	Low mode
SID291	CMRR	DC	70	80	–	dB	$V_{DDD} = 3.6$ V
SID292	PSRR	At 1 kHz, 100-mV ripple	70	85	–	dB	$V_{DDD} = 3.6$ V
	Noise		–	–	–	–	
SID293	V_{N1}	Input referred, 1 Hz - 1GHz, power = high	–	94	–	μVrms	
SID294	V_{N2}	Input referred, 1 kHz, power = high	–	72	–	nV/rtHz	
SID295	V_{N3}	Input referred, 10kHz, power = high	–	28	–	nV/rtHz	
SID296	V_{N4}	Input referred, 100kHz, power = high	–	15	–	nV/rtHz	

Table 8. Opamp Specifications (Guaranteed by Characterization) (continued)

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

Comparator

Table 9. Comparator DC Specifications

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/ Conditions
SID85	V _{OFFSET2}	Input offset voltage, Common Mode voltage range from 0 to $V_{DD}-1$	–	–	± 4	mV	
SID85A	V _{OFFSET3}	Input offset voltage. Ultra low-power mode ($V_{DDD} \geq 2.2$ V for Temp < 0 °C, $V_{DDD} \geq 1.8$ V for Temp > 0 °C)	–	± 12	–	mV	
SID86	V _{HYST}	Hysteresis when enabled, Common Mode voltage range from 0 to $V_{DD}-1$.	–	10	35	mV	Guaranteed by characterization
SID87	V _{ICM1}	Input common mode voltage in normal mode	0	–	$V_{DDD} - 0.1$	V	Modes 1 and 2.
SID247	V _{ICM2}	Input common mode voltage in low power mode ($V_{DDD} \geq 2.2$ V for Temp < 0 °C, $V_{DDD} \geq 1.8$ V for Temp > 0 °C)	0	–	V_{DDD}	V	
SID247A	V _{ICM3}	Input common mode voltage in ultra low power mode	0	–	$V_{DDD} - 1.15$	V	
SID88	CMRR	Common mode rejection ratio	50	–	–	dB	$V_{DDD} \geq 2.7$ V. Guaranteed by characterization
SID88A	CMRR	Common mode rejection ratio	42	–	–	dB	$V_{DDD} < 2.7$ V. Guaranteed by characterization
SID89	I _{CMP1}	Block current, normal mode	–	–	400	μ A	Guaranteed by characterization
SID248	I _{CMP2}	Block current, low power mode	–	–	100	μ A	Guaranteed by characterization
SID259	I _{CMP3}	Block current, ultra low power mode ($V_{DDD} \geq 2.2$ V for Temp < 0 °C, $V_{DDD} \geq 1.8$ V for Temp > 0 °C)	–	6	28	μ A	Guaranteed by characterization
SID90	Z _{CMP}	DC input impedance of comparator	35	–	–	M Ω	Guaranteed by characterization

Table 10. Comparator AC Specifications

(Guaranteed by Characterization)

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

Temperature Sensor

Table 11. Temperature Sensor Specifications

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

SAR ADC

Table 12. SAR ADC DC Specifications

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID94	A_RES	Resolution	–	–	12	bits	
SID95	A_CHNIS_S	Number of channels - single ended	–	–	8		8 full speed
SID96	A-CHNKS_D	Number of channels - differential	–	–	4		Diff inputs use neighboring I/O
SID97	A-MONO	Monotonicity	–	–	–		Yes. Based on characterization
SID98	A_GAINERR	Gain error	–	–	±0.1	%	With external reference. Guaranteed by characterization
SID99	A_OFFSET	Input offset voltage	–	–	2	mV	Measured with 1-V V _{REF} . Guaranteed by characterization
SID100	A_ISAR	Current consumption	–	–	1	mA	
SID101	A_VINS	Input voltage range - single ended	V _{SS}	–	V _{DDA}	V	Based on device characterization
SID102	A_VIND	Input voltage range - differential	V _{SS}	–	V _{DDA}	V	Based on device characterization
SID103	A_INRES	Input resistance	–	–	2.2	KΩ	Based on device characterization
SID104	A_INCAP	Input capacitance	–	–	10	pF	Based on device characterization
SID106	A_PSR	Power supply rejection ratio	70	–	–	dB	
SID107	A_CMRR	Common mode rejection ratio	66	–	–	dB	Measured at 1 V
SID111	A_INL	Integral non linearity	–1.7	–	+2	LSB	V _{DD} = 1.71 to 5.5, 806 ksp, V _{REF} = 1 to 5.5.
SID111A	A_INL	Integral non linearity	–1.5	–	+1.7	LSB	V _{DD} = 1.71 to 3.6, 806 ksp, V _{REF} = 1.71 to V _{DD} .

Table 12. SAR ADC DC Specifications *(continued)*

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID111B	A_INL	Integral non linearity	-1.5	–	+1.7	LSB	$V_{DD} = 1.71$ to 5.5, 500 ksp/s, $V_{REF} = 1$ to 5.5.
SID112	A_DNL	Differential non linearity	-1	–	+2.2	LSB	$V_{DD} = 1.71$ to 5.5, 806 ksp/s, $V_{REF} = 1$ to 5.5.
SID112A	A_DNL	Differential non linearity	-1	–	+2	LSB	$V_{DD} = 1.71$ to 3.6, 806 ksp/s, $V_{REF} = 1.71$ to V_{DD} .
SID112B	A_DNL	Differential non linearity	-1	–	+2.2	LSB	$V_{DD} = 1.71$ to 5.5, 500 ksp/s, $V_{REF} = 1$ to 5.5.

Table 13. SAR ADC AC Specifications (Guaranteed by Characterization)

Spec ID#	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID108	A_SAMP_1	Sample rate with external reference bypass cap	–	–	806	ksp/s	
SID108A	A_SAMP_2	Sample rate with no bypass cap. Reference = V_{DD}	–	–	500	ksp/s	
SID108B	A_SAMP_3	Sample rate with no bypass cap. Internal reference	–	–	100	ksp/s	
SID109	A_SNDR	Signal-to-noise and distortion ratio (SINAD)	65	–	–	dB	$F_{IN} = 10$ kHz
SID113	A_THD	Total harmonic distortion	–	–	-65	dB	$F_{IN} = 10$ kHz.

Table 19. LCD Direct Drive AC Specifications (Guaranteed by Characterization)

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

Table 20. Fixed UART DC Specifications (Guaranteed by Characterization)

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

Table 21. Fixed UART AC Specifications (Guaranteed by Characterization)

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

SPI Specifications

Table 22. Fixed SPI DC Specifications (Guaranteed by Characterization)

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

Table 23. Fixed SPI AC Specifications (Guaranteed by Characterization)

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID166	F _{SPI}	SPI operating frequency (master; 6X oversampling)	–	–	4	MHz	

Table 24. Fixed SPI Master Mode AC Specifications (Guaranteed by Characterization)

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

Table 25. Fixed SPI Slave Mode AC Specifications (Guaranteed by Characterization)

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

Memory

Table 26. Flash DC Specifications

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

Table 27. Flash AC Specifications

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

System Resources

Power-on-Reset (POR) with Brown Out

Table 28. Imprecise Power On Reset (IPOR)

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

Table 29. Precise Power On Reset (POR)

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

Note

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

Voltage Monitors

Table 30. Voltage Monitors DC Specifications

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

Table 31. Voltage Monitors AC Specifications

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

SWD Interface

Table 32. SWD Interface Specifications

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID213	F _{SWDCLK1}	$3.3\text{ V} \leq V_{DD} \leq 5.5\text{ V}$	–	–	14	MHz	SWDCLK ≤ 1/3 CPU clock frequency
SID214	F _{SWDCLK2}	$1.71\text{ V} \leq V_{DD} \leq 3.3\text{ V}$	–	–	7	MHz	SWDCLK ≤ 1/3 CPU clock frequency
SID215	T _{SWDI_SETUP}	T = 1/f SWDCLK	0.25*T	–	–	ns	Guaranteed by characterization
SID216	T _{SWDI_HOLD}	T = 1/f SWDCLK	0.25*T	–	–	ns	Guaranteed by characterization
SID217	T _{SWDO_VALID}	T = 1/f SWDCLK	–	–	0.5*T	ns	Guaranteed by characterization
SID217A	T _{SWDO_HOLD}	T = 1/f SWDCLK	1	–	–	ns	Guaranteed by characterization

Internal Main Oscillator
Table 33. IMO DC Specifications (Guaranteed by Design)

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

Table 34. IMO AC Specifications

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

Internal Low-Speed Oscillator
Table 35. ILO DC Specifications (Guaranteed by Design)

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

Table 36. ILO AC Specifications

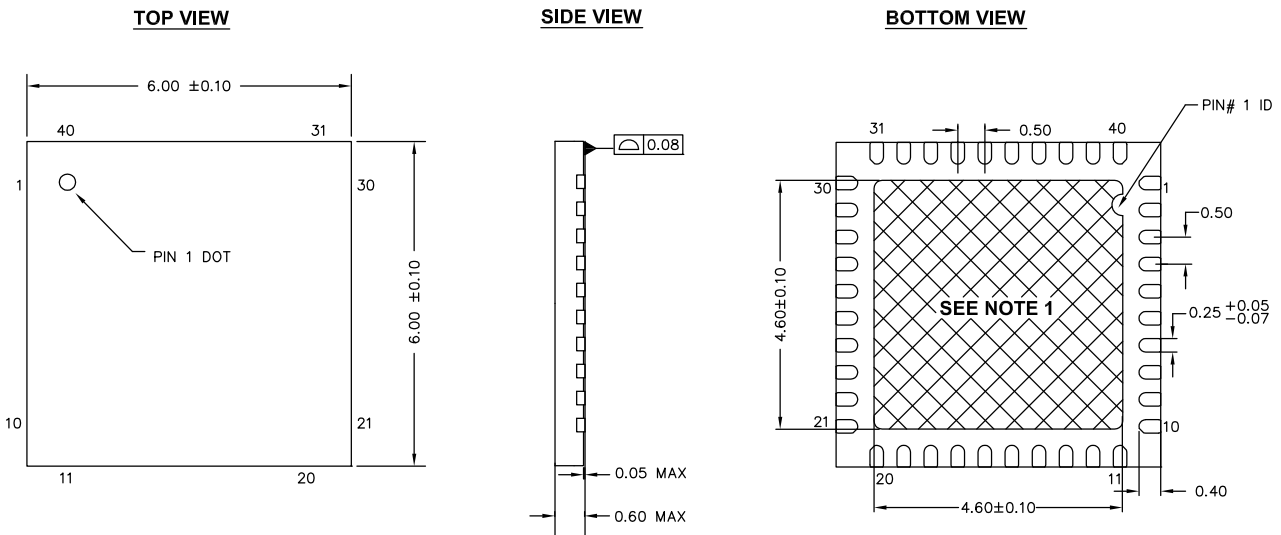
Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID234	T _{STARTILO1}	ILO startup time	–	–	2	ms	Guaranteed by characterization
SID236	T _{ILODUTY}	ILO duty cycle	40	50	60	%	Guaranteed by characterization
SID237	F _{ILOTRIM1}	32 kHz trimmed frequency	15	32	50	kHz	Max ILO frequency is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


Table 37. External Clock Specifications

Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID305	ExtClkFreq	External Clock input Frequency	0	–	24	MHz	Guaranteed by characterization
SID306	ExtClkDuty	Duty cycle; Measured at V _{DD/2}	45	–	55	%	Guaranteed by characterization

Table 38. Block Specs

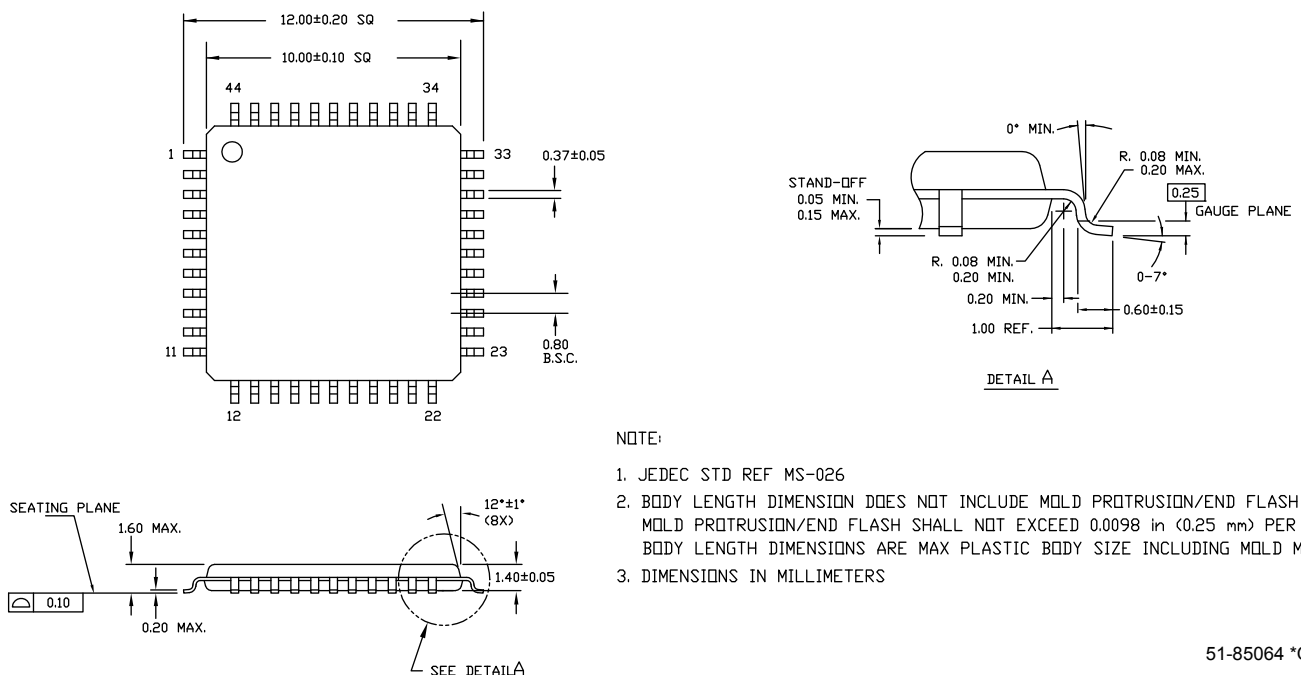
Spec ID	Parameter	Description	Min	Typ	Max	Units	Details/Conditions
SID257	T _{WS24} *	Number of wait states at 24 MHz	0	–	–		CPU execution from Flash. Guaranteed by characterization
SID260	V _{REFSAR}	Trimmed internal reference to SAR	–1	–	+1	%	Percentage of V _{bg} (1.024 V). Guaranteed by characterization
SID262	T _{CLKSWITCH}	Clock switching from clk1 to clk2 in clk1 periods	3	–	4	Periods	Guaranteed by design
* Tws24 is guaranteed by Design							

Figure 17. 40-pin QFN Package Outline

NOTES:

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

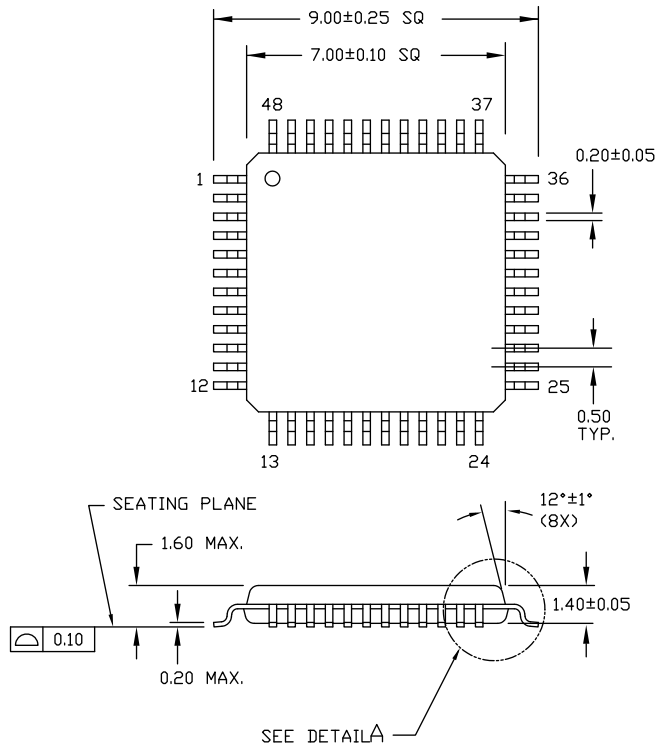
001-80659 *A

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

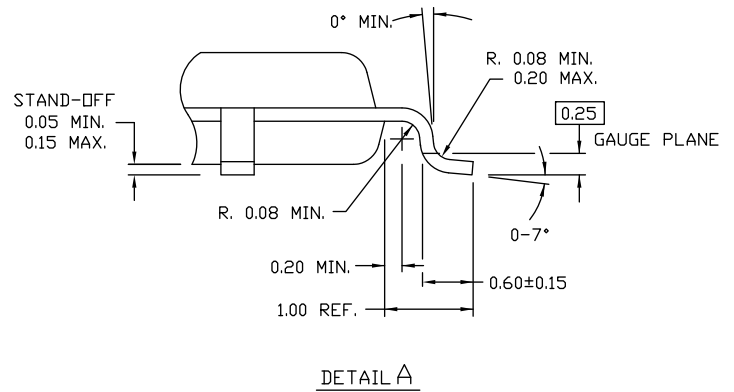
Figure 18. 44-pin TQFP Package Outline

NOTE:

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

51-85064 *G

Figure 19. 48-Pin TQFP Package Outline


DIMENSIONS ARE IN MILLIMETERS



51-85135 °C

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