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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	Discontinued at Digi-Key
Core Processor	ARM® Cortex®-M0+
Core Size	32-Bit Single-Core
Speed	48MHz
Connectivity	I²C, LINbus, SCI, SPI, UART/USART, USB
Peripherals	DMA, POR, PWM, WDT
Number of I/O	51
Program Memory Size	256KB (256K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	32K x 8
Voltage - Supply (Vcc/Vdd)	1.62V ~ 3.63V
Data Converters	A/D 20x12b; D/A 2x12b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	64-TQFP
Supplier Device Package	64-TQFP (10x10)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/atsaml21j18a-aut

  - Static and Dynamic Power Gating Architecture
  - Battery backup support
  - Two Performance Levels
  - Embedded Buck/LDO regulator supporting on-the-fly selection
- Peripherals
  - 16-channel Direct Memory Access Controller (DMAC)
  - 12-channel Event System
  - Up to five 16-bit Timer/Counters (TC) including one low-power TC, each configurable as:
    - 16-bit TC with two compare/capture channels
    - 8-bit TC with two compare/capture channels
    - 32-bit TC with two compare/capture channels, by using two TCs
  - Two 24-bit and one 16-bit Timer/Counters for Control (TCC), with extended functions:
    - Up to four compare channels with optional complementary output
    - Generation of synchronized pulse width modulation (PWM) pattern across port pins
    - Deterministic fault protection, fast decay and configurable dead-time between complementary output
    - Dithering that increase resolution with up to 5 bit and reduce quantization error
  - 32-bit Real Time Counter (RTC) with clock/calendar function
  - Watchdog Timer (WDT)
  - CRC-32 generator
  - One full-speed (12Mbps) Universal Serial Bus (USB) 2.0 interface
    - Embedded host and device function
    - Eight endpoints
  - Up to six Serial Communication Interfaces (SERCOM) including one low-power SERCOM, each configurable to operate as either:
    - USART with full-duplex and single-wire half-duplex configuration
    - I^2C up to 3.4MHz
    - SPI
    - LIN slave
  - One AES encryption engine
  - One True Random Generator (TRNG)
  - One Configurable Custom Logic (CCL)
  - One 12-bit, 1MSPS Analog-to-Digital Converter (ADC) with up to 20 channels
    - Differential and single-ended input
    - Automatic offset and gain error compensation
    - Oversampling and decimation in hardware to support 13-, 14-, 15-, or 16-bit resolution
  - Two 12-bit, 1MSPS Dual Output Digital-to-Analog Converter (DAC)
  - Two Analog Comparators (AC) with window compare function
  - Three Operational Amplifiers (OPAMP)
  - Peripheral Touch Controller (PTC)
    - 169-Channel capacitive touch and proximity sensing
    - Wake-up on touch in standby mode
- Oscillators
  - 32.768kHz crystal oscillator (XOSC32K)

The Atmel SAM L21 devices are supported with a full suite of programs and system development tools, including C compilers, macro assemblers, program debugger/simulators, programmers and evaluation kits.

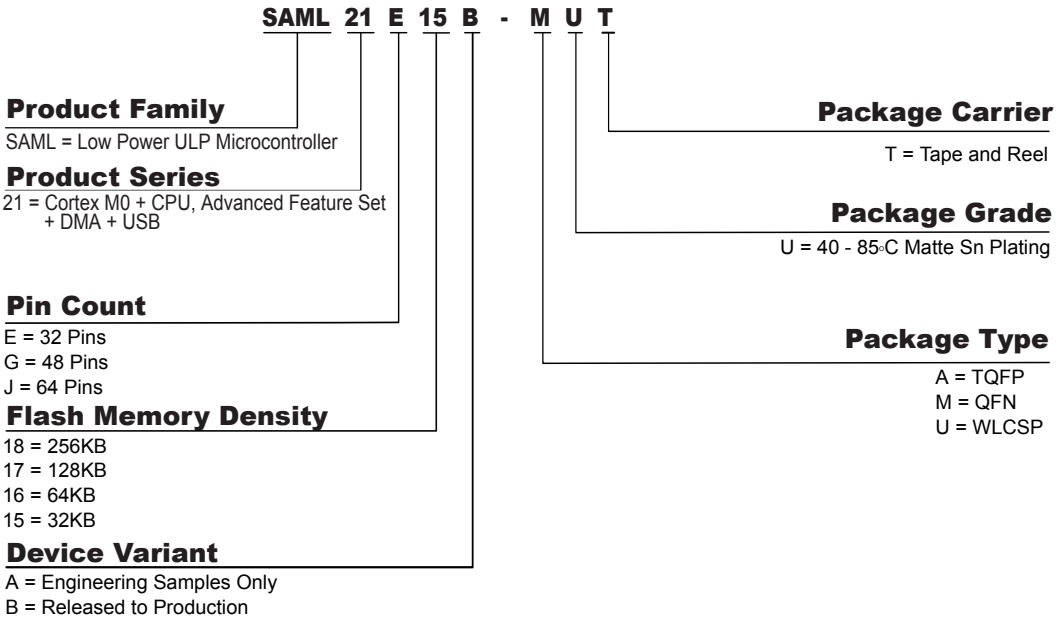
	SAM L21J	SAM L21G	SAM L21E
Real-Time Counter (RTC)	Yes	Yes	Yes
RTC alarms	1	1	1
RTC compare values	One 32-bit value or two 16-bit values	One 32-bit value or two 16-bit values	One 32-bit value or two 16-bit values
External Interrupt lines	16	16	16
Peripheral Touch Controller (PTC) channels (X- x Y-Lines) for mutual capacitance (2)	169 (13x13)	81 (9x9)	42 (7x6)
Peripheral Touch Controller (PTC) channels for self capacitance (Y-Lines only) (3)	16	10	7
Maximum CPU frequency	48MHz		
Packages	QFN TQFP WLCSP(4)	QFN TQFP	QFN TQFP
Oscillators	32.768kHz crystal oscillator (XOSC32K) 0.4-32MHz crystal oscillator (XOSC) 32.768kHz internal oscillator (OSC32K) 32KHz ultra-low-power internal oscillator (OSCULP32K) 16/12/8/4MHz high-accuracy internal oscillator (OSC16M) 48MHz Digital Frequency Locked Loop (DFLL48M) 96MHz Fractional Digital Phased Locked Loop (FDPLL96M)		
Event System channels	12	12	12
SW Debug Interface	Yes	Yes	Yes
Watchdog Timer (WDT)	Yes	Yes	Yes

Note:

1. For SAM L21E and SAM L21G, only TC0, TC1 and TC4 are available.
2. The number of X- and Y-lines depends on the configuration of the device, as some I/O lines can be configured as either X-lines or Y-lines. Refer to *Multiplexed Signals* for details. The number in the Configuration Summary is the maximum number of channels that can be obtained.

3. The number of Y-lines depends on the configuration of the device, as some I/O lines can be configured as either X-lines or Y-lines. The number given here is the maximum number of Y-lines that can be obtained.
4. WLCSP parts are programmed with a specific SPI bootloader. Refer to Application Note AT09002 for details.

3. Ordering Information



Note: The device variant (last letter of the ordering number) is independent of the die revision (DSU.DID.REVISION): The device variant denotes functional differences, whereas the die revision marks evolution of the die.

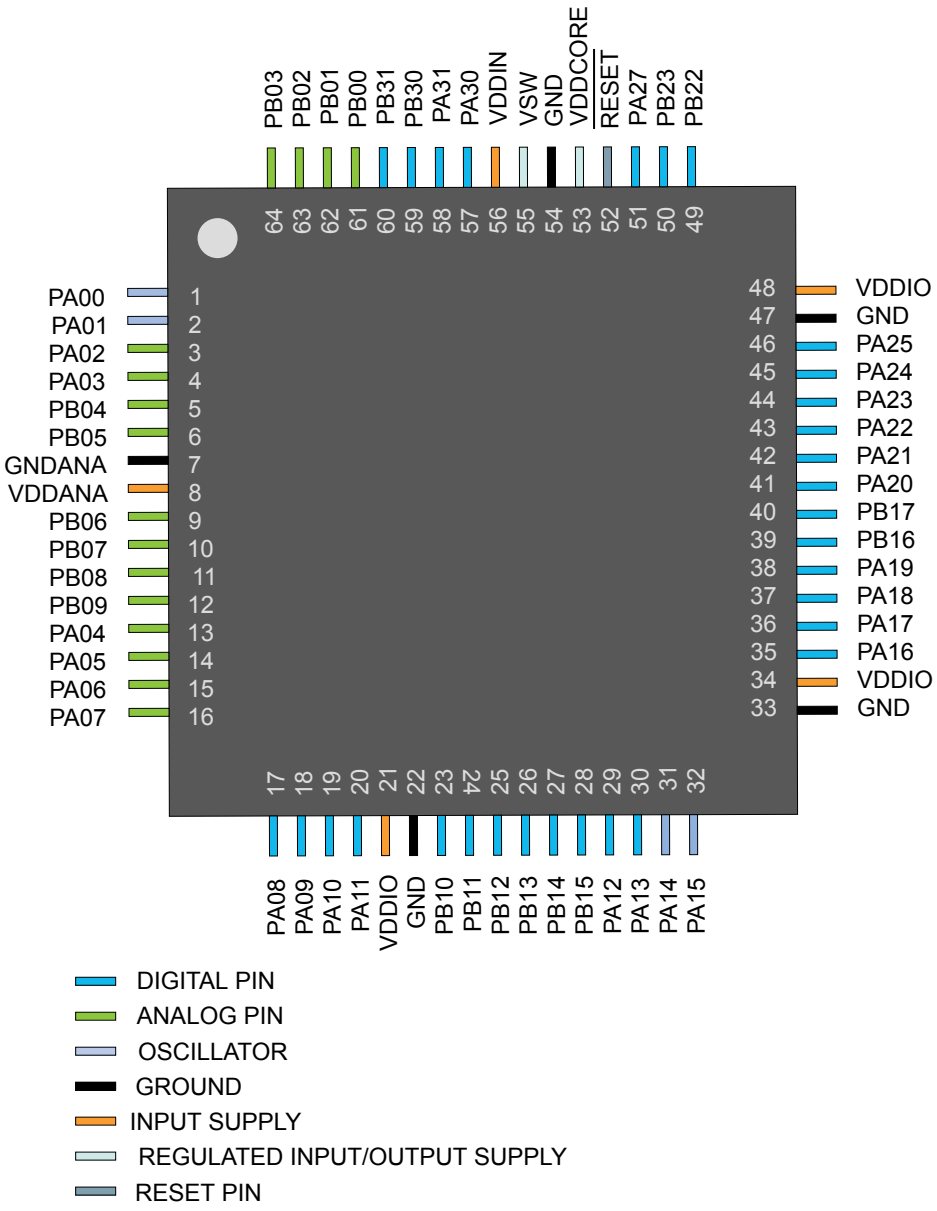
3.1. SAM L21J

Table 3-1. SAM L21J Ordering Codes

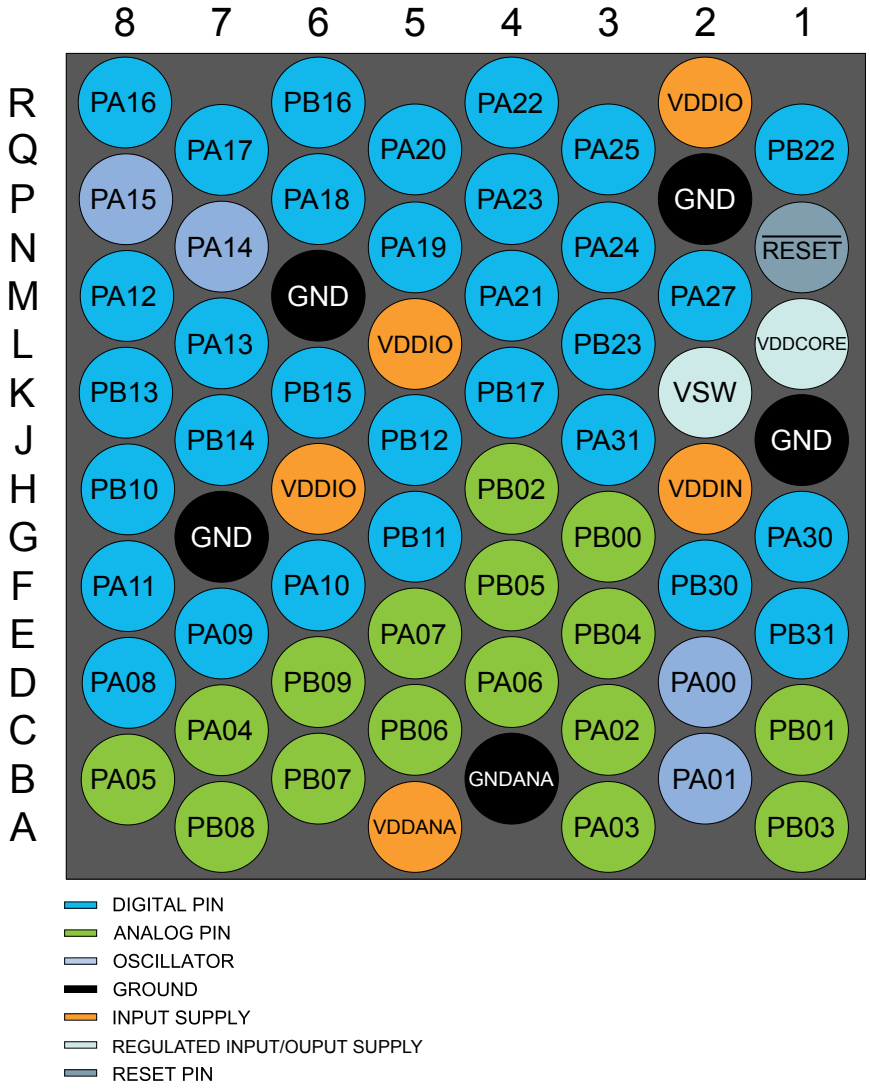
Ordering Code	FLASH (bytes)	SRAM (bytes)	Package	Carrier Type
ATSAML21J16B-AUT	64K	8K	TQFP64	Tape & Reel
ATSAML21J16B-MUT			QFN64	
ATSAML21J17B-AUT	128K	16K	TQFP64	Tape & Reel
ATSAML21J17B-MUT			QFN64	
ATSAML21J17B-UUT			WLCSP64	
ATSAML21J18B-AUT	256K	32K	TQFP64	Tape & Reel
ATSAML21J18B-MUT			QFN64	
ATSAML21J18B-UUT			WLCSP64	

5. Pinout

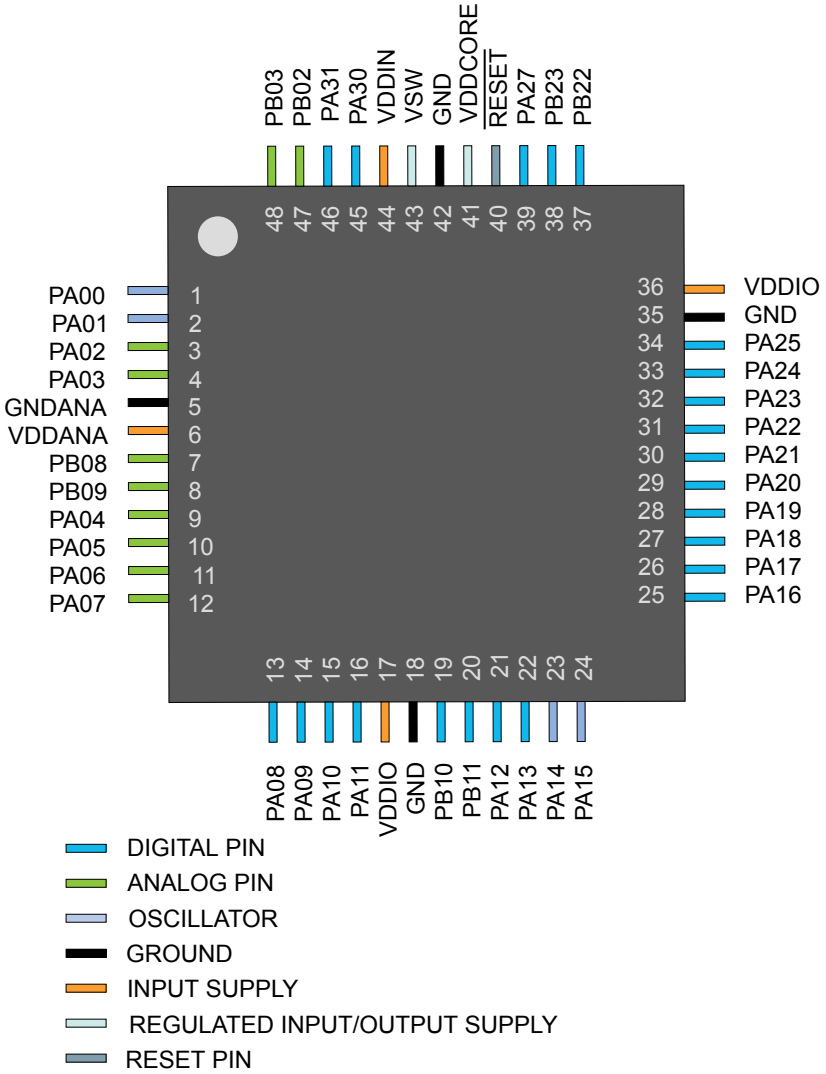
5.1. SAM L21J



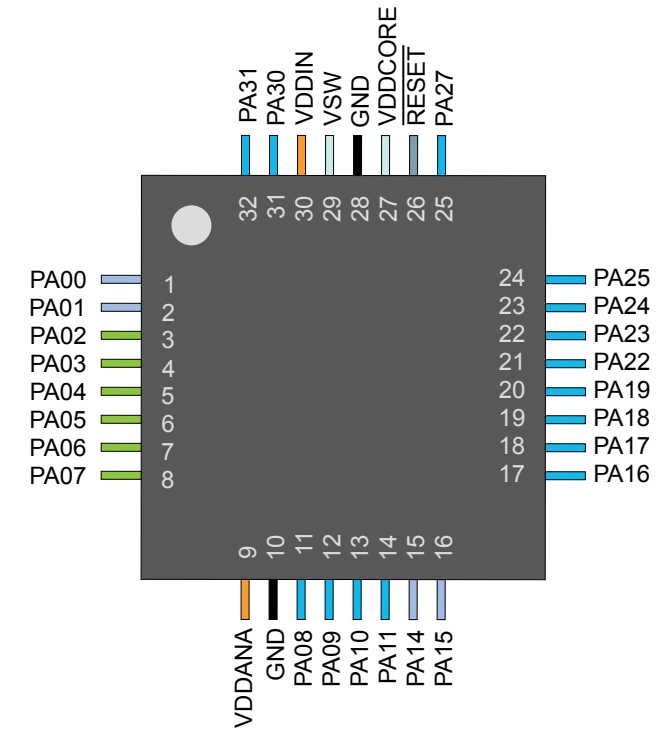
5.2. SAM L21J WLCSP64



5.3. SAM L21G


PB03
PB02
PA31
PA30
VDDIN
VSW
GND
VDDCORE
RESET
PA27
PB23
PB22
48
47
46
45
44
43
42
41
40
39
38
37
PA00
PA01
PA02
PA03
GNDANA
VDDANA
PB08
PB09
PA04
PA05
PA06
PA07
1
2
3
4
5
6
7
8
9
10
11
12
36
35
34
33
32
31
30
29
28
27
26
25
VDDIO
GND
PA25
PA24
PA23
PA22
PA21
PA20
PA19
PA18
PA17
PA16
13
14
15
16
17
18
19
20
21
22
23
24
PA08
PA09
PA10
PA11
VDDIO
GND
PB10
PB11
PA12
PA13
PA14
PA15
DIGITAL PIN
ANALOG PIN
OSCILLATOR
GROUND
INPUT SUPPLY
REGULATED INPUT/OUTPUT SUPPLY
RESET PIN

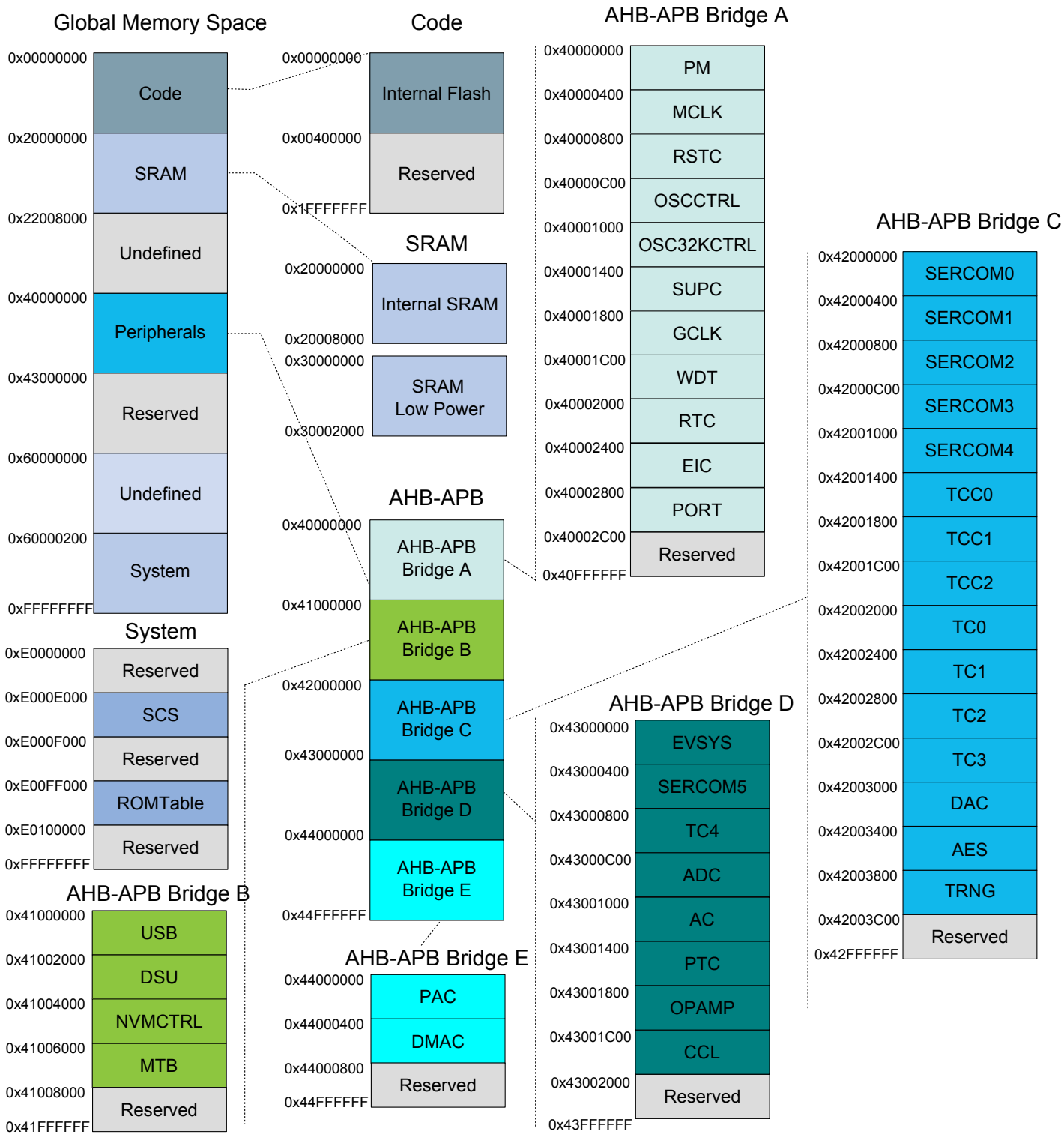
5.4. SAM L21E



- DIGITAL PIN
- ANALOG PIN
- OSCILLATOR
- GROUND
- INPUT SUPPLY
- REGULATED INPUT/OUTPUT SUPPLY
- RESET PIN

6. Product Mapping

Figure 6-1. Atmel SAM L21 Product Mapping



7. Processor and Architecture

7.1. Cortex M0+ Processor

The Atmel SAM L21 implements the ARM®Cortex™-M0+ processor, based on the ARMv6 Architecture and Thumb®-2 ISA. The Cortex M0+ is 100% instruction set compatible with its predecessor, the Cortex-M0 core, and upward compatible to Cortex-M3 and M4 cores. The implemented ARM Cortex-M0+ is revision r0p1. For more information refer to http://www.arm.com

7.1.1. Cortex M0+ Configuration

Table 7-1. Cortex M0+ Configuration in Atmel SAM L21

Features	Cortex M0+ options	Atmel SAM L21 configuration
Interrupts	External interrupts 0-32	29
Data endianness	Little-endian or big-endian	Little-endian
SysTick timer	Present or absent	Present
Number of watchpoint comparators	0, 1, 2	2
Number of breakpoint comparators	0, 1, 2, 3, 4	4
Halting debug support	Present or absent	Present
Multiplier	Fast or small	Fast (single cycle)
Single-cycle I/O port	Present or absent	Present
Wake-up interrupt controller	Supported or not supported	Not supported
Vector Table Offset Register	Present or absent	Present
Unprivileged/Privileged support	Present or absent	Absent - All software run in privileged mode only
Memory Protection Unit	Not present or 8-region	Not present
Reset all registers	Present or absent	Absent
Instruction fetch width	16-bit only or mostly 32-bit	32-bit

The ARM Cortex-M0+ core has two bus interfaces:

- Single 32-bit AMBA-3 AHB-Lite system interface that provides connections to peripherals and all system memory including Flash memory and RAM
- Single 32-bit I/O port bus interfacing to the PORT with 1-cycle loads and stores

7.1.1.1. Cortex M0+ Peripherals

- System Control Space (SCS)
  - The processor provides debug through registers in the SCS. Refer to the Cortex-M0+ Technical Reference Manual for details (http://www.arm.com)
- Nested Vectored Interrupt Controller (NVIC)

- External interrupt signals connect to the NVIC, and the NVIC prioritizes the interrupts. Software can set the priority of each interrupt. The NVIC and the Cortex-M0+ processor core are closely coupled, providing low latency interrupt processing and efficient processing of late arriving interrupts. Refer to the Cortex-M0+ Technical Reference Manual for details (http://www.arm.com).
  Note: When the CPU frequency is much higher than the APB frequency it is recommended to insert a memory read barrier after each CPU write to registers mapped on the APB. Failing to do so in such conditions may lead to unexpected behavior such as e.g. re-entering a peripheral interrupt handler just after leaving it.

- System Timer (SysTick)
  - The System Timer is a 24-bit timer clocked by CLK_CPU that extends the functionality of both the processor and the NVIC. Refer to the Cortex-M0+ Technical Reference Manual for details (http://www.arm.com).
- System Control Block (SCB)
  - The System Control Block provides system implementation information, and system control. This includes configuration, control, and reporting of the system exceptions. Refer to the Cortex-M0+ Devices Generic User Guide for details (http://www.arm.com)
- Micro Trace Buffer (MTB)
  - The CoreSight MTB-M0+ (MTB) provides a simple execution trace capability to the Cortex-M0+ processor. Refer to section MTB-Micro Trace Buffer and the CoreSight MTB-M0+ Technical Reference Manual for details (http://www.arm.com).

Related Links

Nested Vector Interrupt Controller on page 21

7.1.1.2. Cortex M0+ Address Map

Table 7-2. Cortex-M0+ Address Map

Address	Peripheral
0xE000E000	System Control Space (SCS)
0xE000E010	System Timer (SysTick)
0xE000E100	Nested Vectored Interrupt Controller (NVIC)
0xE000ED00	System Control Block (SCB)
0x41006000	Micro Trace Buffer (MTB)

7.1.1.3. I/O Interface

The device allows direct access to PORT registers. Accesses to the AMBA® AHB-Lite™ and the single cycle I/O interface can be made concurrently, so the Cortex M0+ processor can fetch the next instructions while accessing the I/Os. This enables single cycle I/O access to be sustained for as long as necessary.

7.2. Nested Vector Interrupt Controller

7.2.1. Overview

The Nested Vectored Interrupt Controller (NVIC) in the SAM L21 supports 32 interrupt lines with four different priority levels. For more details, refer to the Cortex-M0+ Technical Reference Manual (http://www.arm.com).

MASTER register. The MTB can be programmed to stop tracing automatically when the memory fills to a specified watermark level or to start or stop tracing by writing directly to the MASTER.EN bit. If the watermark mechanism is not being used and the trace buffer overflows, then the buffer wraps around overwriting previous trace packets.

The base address of the MTB registers is 0x41006000; this address is also written in the CoreSight ROM Table. The offset of each register from the base address is fixed and as defined by the CoreSight MTB-M0+ Technical Reference Manual. The MTB has four programmable registers to control the behavior of the trace features:

- POSITION: Contains the trace write pointer and the wrap bit
- MASTER: Contains the main trace enable bit and other trace control fields
- FLOW: Contains the WATERMARK address and the AUTOSTOP and AUTOHALT control bits
- BASE: Indicates where the SRAM is located in the processor memory map. This register is provided to enable auto discovery of the MTB SRAM location by a debug agent

See the CoreSight MTB-M0+ Technical Reference Manual for a detailed description of these registers.

7.4. High-Speed Bus System

7.4.1. Features

High-Speed Bus Matrix has the following features:

- Symmetric crossbar bus switch implementation
- Allows concurrent accesses from different masters to different slaves
- 32-bit data bus
- Operation at a one-to-one clock frequency with the bus masters

H2LBRIDGE has the following features:

- LP clock division support
- Write: Posted-write FIFO of 3 words, no bus stall until it is full
- Write: 1 cycle bus stall when full when LP clock is not divided
- 2 stall cycles on read when LP clock is not divided
- Ultra low latency mode:
  - Suitable when the HS clock frequency is not above half the maximum device clock frequency
  - Removes all intrinsic bridge stall cycles (except those needed for LP clock ratio adaptation)
  - Enabled by writing a '1' in 0x41008120 using a 32-bit write access

L2HBRIDGE has the following features:

- LP clock division support
- Write: Posted-write FIFO of 1 word, no bus stall until it is full
- Write: 1 cycle bus stall when full when LP clock is not divided
- 2 stall cycles on read when LP clock is not divided
- ultra low latency mode:
  - Suitable when the HS clock frequency is not above half the maximum device clock frequency
  - Removes all intrinsic bridge stall cycles (except those needed for LP clock ratio adaptation)
  - Enabled by writing a '1' in 0x41008120 using a 32-bit write access

The Quality of Service (QoS) level is independently selected for each master accessing the RAM. For any access to the RAM, the RAM also receives the QoS level. The QoS levels and their corresponding bit values for the QoS level configuration are shown in the following table.

Table 7-8. Quality of Service

Value	Name	Description
0x0	DISABLE	Background (no sensitive operation)
0x1	LOW	Sensitive Bandwidth
0x2	MEDIUM	Sensitive Latency
0x3	HIGH	Critical Latency

If a master is configured with QoS level DISABLE (0x0) or LOW (0x1) there will be a minimum latency of one cycle for the RAM access.

The priority order for concurrent accesses are decided by two factors. First, the QoS level for the master and second, a static priority given by the port ID. The lowest port ID has the highest static priority. See the tables below for details.

The MTB has a fixed QoS level HIGH (0x3).

The CPU QoS level can be written/read, using 32-bit access only, at address 0x41008114 bits [1:0]. Its reset value is 0x3.

Refer to different master QOSCTRL registers for configuring QoS for the other masters (USB, DMAC).

Table 7-9. HS SRAM Port Connections QoS

HS SRAM Port Connection	Port ID	Connection Type	QoS	default QoS
MTB - Micro Trace Buffer	4	Direct	STATIC-3	0x3
USB - Universal Serial Bus	3	Direct	IP-QOSCTRL	0x3
HMATRIXLP - Low-Power Bus Matrix	2	Bus Matrix	0x44000934(1), bits[1:0]	0x2
DSU - Device Service Unit	1	Bus Matrix	0x4100201C(1)	0x2
CM0+ - Cortex M0+ Processor	0	Bus Matrix	0x41008114(1), bits[1:0]	0x3

Note:

1. Using 32-bit access only.

Table 7-10. LP SRAM Port Connections QoS

LP SRAM Port Connection	Port ID	Connection Type	QoS	default QoS
DMAC - Direct Memory Access Controller - Write-Back Access	5, 6	Direct	IP-QOSCTRL.WRBQOS	0x2
DMAC - Direct Memory Access Controller - Fetch Access	3, 4	Direct	IP-QOSCTRL.FQOS	0x2

8. Packaging Information

8.1. Thermal Considerations

8.1.1. Thermal Resistance Data

The following table summarizes the thermal resistance data depending on the package.

Table 8-1. Thermal Resistance Data

Package Type	θ_{JA}	θ_{JC}
32-pin TQFP	68°C/W	25.8°C/W
48-pin TQFP	78.8°C/W	12.3°C/W
64-pin TQFP	66.7°C/W	11.9°C/W
32-pin QFN	37.2°C/W	3.1°C/W
48-pin QFN	31.6°C/W	10.3°C/W
64-pin QFN	32.2°C/W	10.1°C/W
64-pin WLCSP	36.8°C/W	5.0°C/W

Related Links

Junction Temperature on page 29

8.1.2. Junction Temperature

The average chip-junction temperature, T_J, in °C can be obtained from the following:

1. $T_J = T_A + (P_D \times \theta_{JA})$
2. $T_J = T_A + (P_D \times (\theta_{HEATSINK} + \theta_{JC}))$

where:

- θ_{JA} = Package thermal resistance, Junction-to-ambient (°C/W), see Thermal Resistance Data
- θ_{JC} = Package thermal resistance, Junction-to-case thermal resistance (°C/W), see Thermal Resistance Data
- $\theta_{HEATSINK}$ = Thermal resistance (°C/W) specification of the external cooling device
- P_D = Device power consumption (W)
- T_A = Ambient temperature (°C)

From the first equation, the user can derive the estimated lifetime of the chip and decide if a cooling device is necessary or not. If a cooling device is to be fitted on the chip, the second equation should be used to compute the resulting average chip-junction temperature T_J in °C.

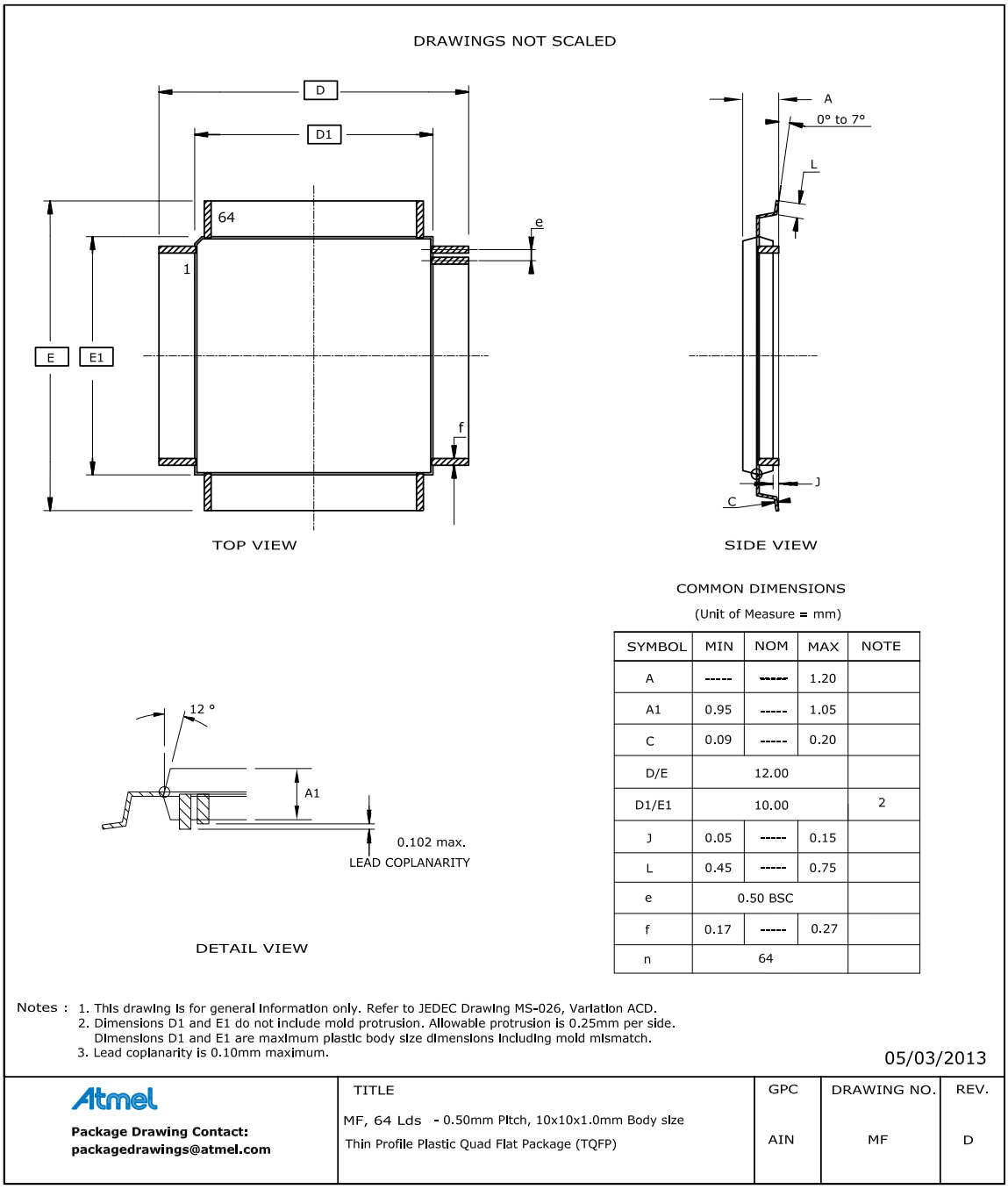
Related Links

Thermal Resistance Data on page 29

Table 8-4. Package Reference

JEDEC Drawing Reference	N/A
JESD97 Classification	E1

8.2.2. 64 pin TQFP



COMMON DIMENSIONS

(Unit of Measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	-----	-----	1.20	
A1	0.95	-----	1.05	
C	0.09	-----	0.20	
D/E		12.00		
D1/E1		10.00		2
J	0.05	-----	0.15	
L	0.45	-----	0.75	
e		0.50 BSC		
f	0.17	-----	0.27	
n		64		

Notes : 1. This drawing is for general information only. Refer to JEDEC Drawing MS-026, Variation ACD.
2. Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is 0.25mm per side. Dimensions D1 and E1 are maximum plastic body size dimensions including mold mismatch.
3. Lead coplanarity is 0.10mm maximum.

05/03/2013

	TITLE	GPC	DRAWING NO.	REV.
Atmel **Package Drawing Contact:** **packagedrawings@atmel.com**	MF, 64 Lds - 0.50mm Pitch, 10x10x1.0mm Body size Thin Profile Plastic Quad Flat Package (TQFP)	AIN	MF	D

Table 8-5. Device and Package Maximum Weight

300	mg

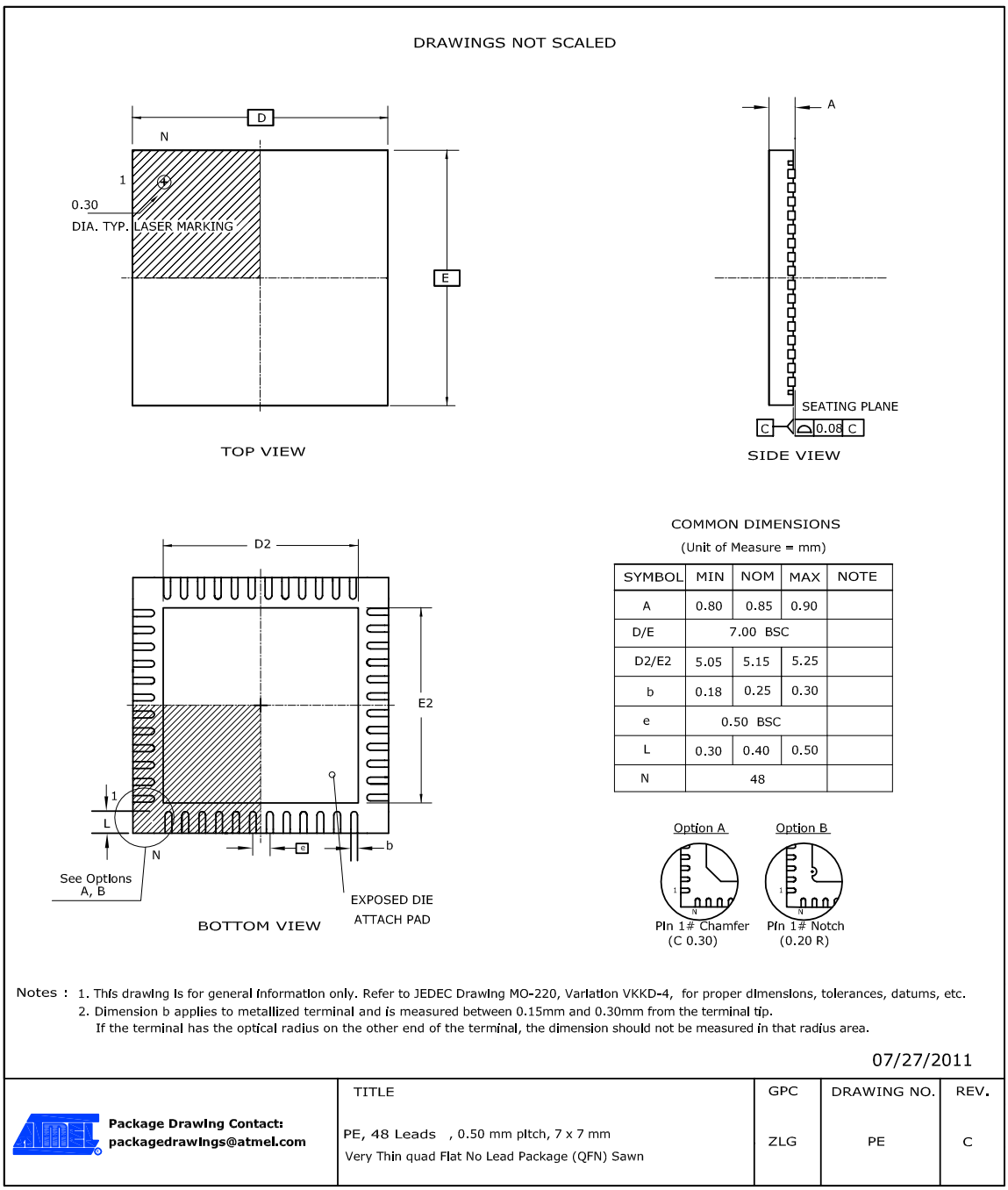
Table 8-12. Package Characteristics

Moisture Sensitivity Level	MSL3

Table 8-13. Package Reference

JEDEC Drawing Reference	MS-026
JESD97 Classification	E3

8.2.5. 48 pin QFN



Note: The exposed die attach pad is not connected electrically inside the device.

Table 8-14. Device and Package Maximum Weight

140	mg

Table 8-15. Package Characteristics

Moisture Sensitivity Level	MSL3

Table 8-16. Package Reference

JEDEC Drawing Reference	MO-220
JESD97 Classification	E3

8.2.6. 32 pin TQFP

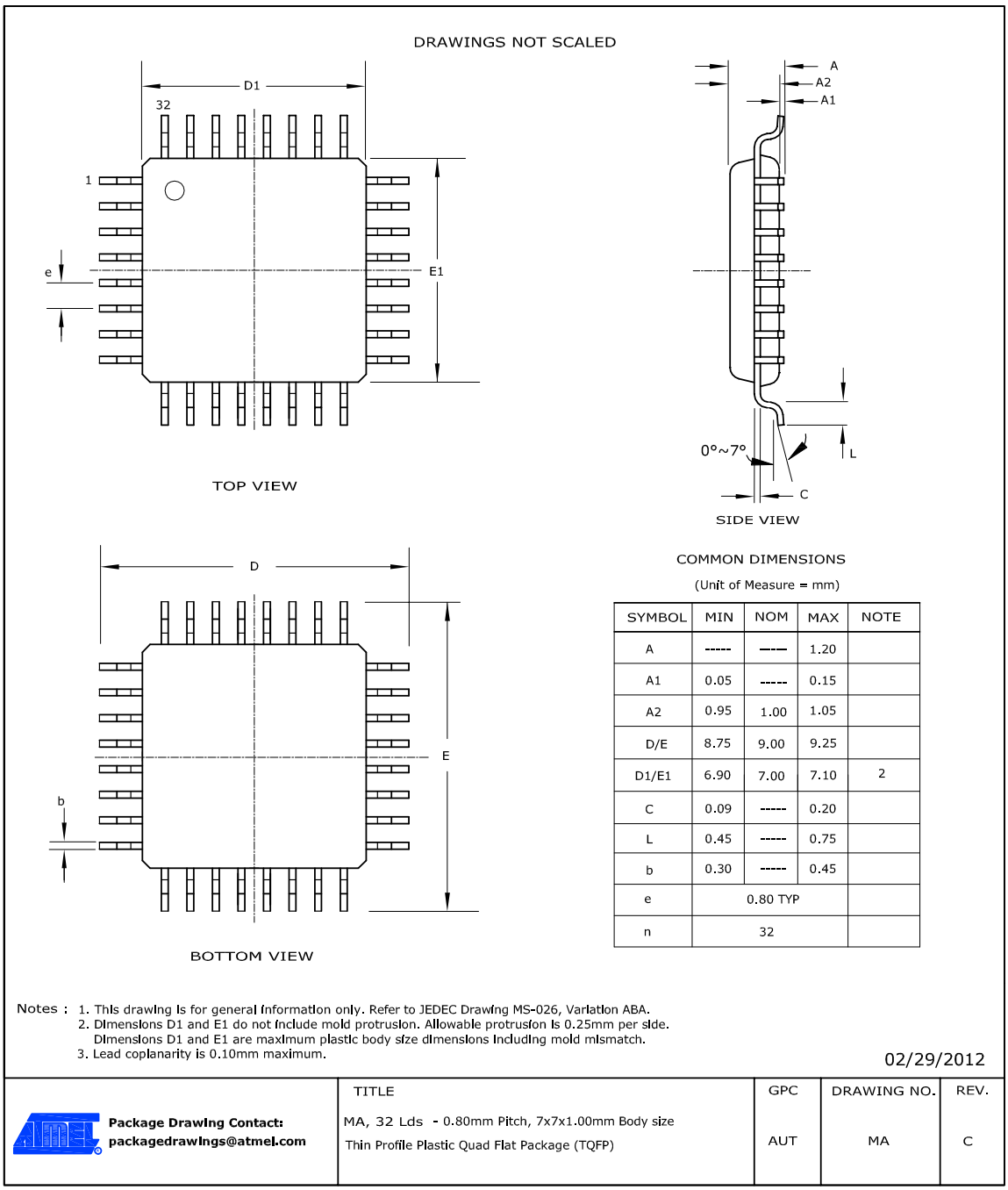


Table 8-17. Device and Package Maximum Weight

100	mg

Table 8-18. Package Charateristics

Moisture Sensitivity Level	MSL3

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