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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	Obsolete
Core Processor	ARM7®
Core Size	16/32-Bit
Speed	60MHz
Connectivity	CANbus, I²C, Microwire, SPI, SSI, SSP, UART/USART
Peripherals	POR, PWM, WDT
Number of I/O	46
Program Memory Size	256KB (256K x 8)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	16K x 8
Voltage - Supply (Vcc/Vdd)	1.65V ~ 3.6V
Data Converters	A/D 4x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 105°C (TA)
Mounting Type	Surface Mount
Package / Case	64-LQFP
Supplier Device Package	64-LQFP (10x10)
Purchase URL	https://www.e-xfl.com/product-detail/nxp-semiconductors/lpc2194jbd64-151

- 60 MHz maximum CPU clock available from programmable on-chip Phase-Locked Loop.
- On-chip crystal oscillator with an operating range of 1 MHz to 30 MHz.
- Two low power modes, Idle and Power-down.
- Processor wake-up from Power-down mode via external interrupt.
- Individual enable/disable of peripheral functions for power optimization.
- Dual power supply:
  - CPU operating voltage range of 1.65 V to 1.95 V (1.8 V ±0.15 V).
  - I/O power supply range of 3.0 V to 3.6 V (3.3 V ±10%) with 5 V tolerant I/O pads.

3. Ordering information

Table 1: Ordering information

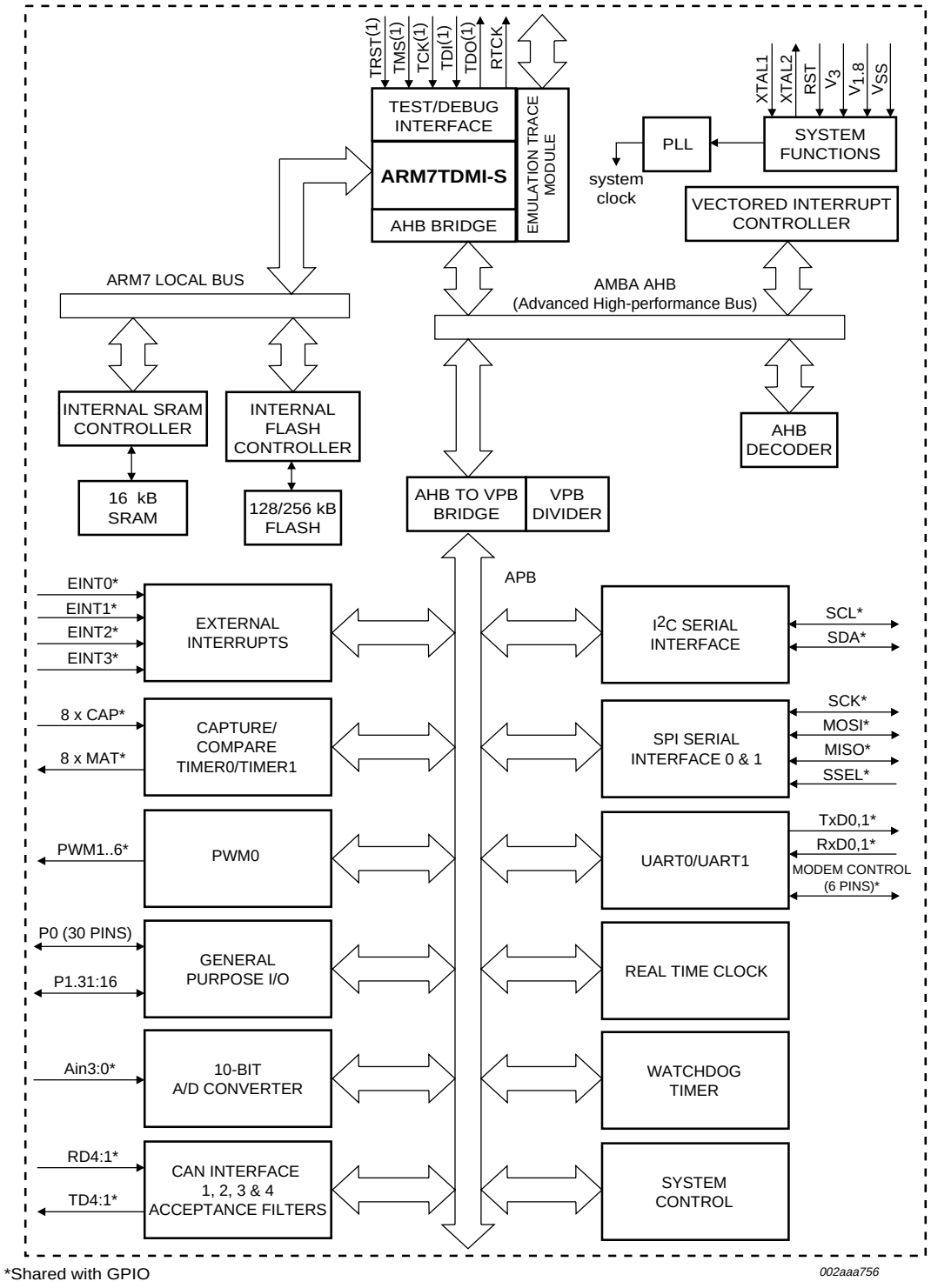
Type number	Package		
	Name	Description	Version
LPC2194JBD64	LQFP64	plastic low profile quad flat package, 64 leads, body 10 × 10 × 1.4 mm	SOT314-2

3.1 Ordering options

Table 2: Part options

Type number	Flash memory	RAM	CAN	Temperature range (°C)
LPC2194JBD64	256 kB	16 kB	4 channels	–40 to +105

4. Block diagram



(1) When test/debug interface is used, GPIO/other function sharing these pins are not available.

Fig 1. Block diagram.

5. Pinning information

5.1 Pinning

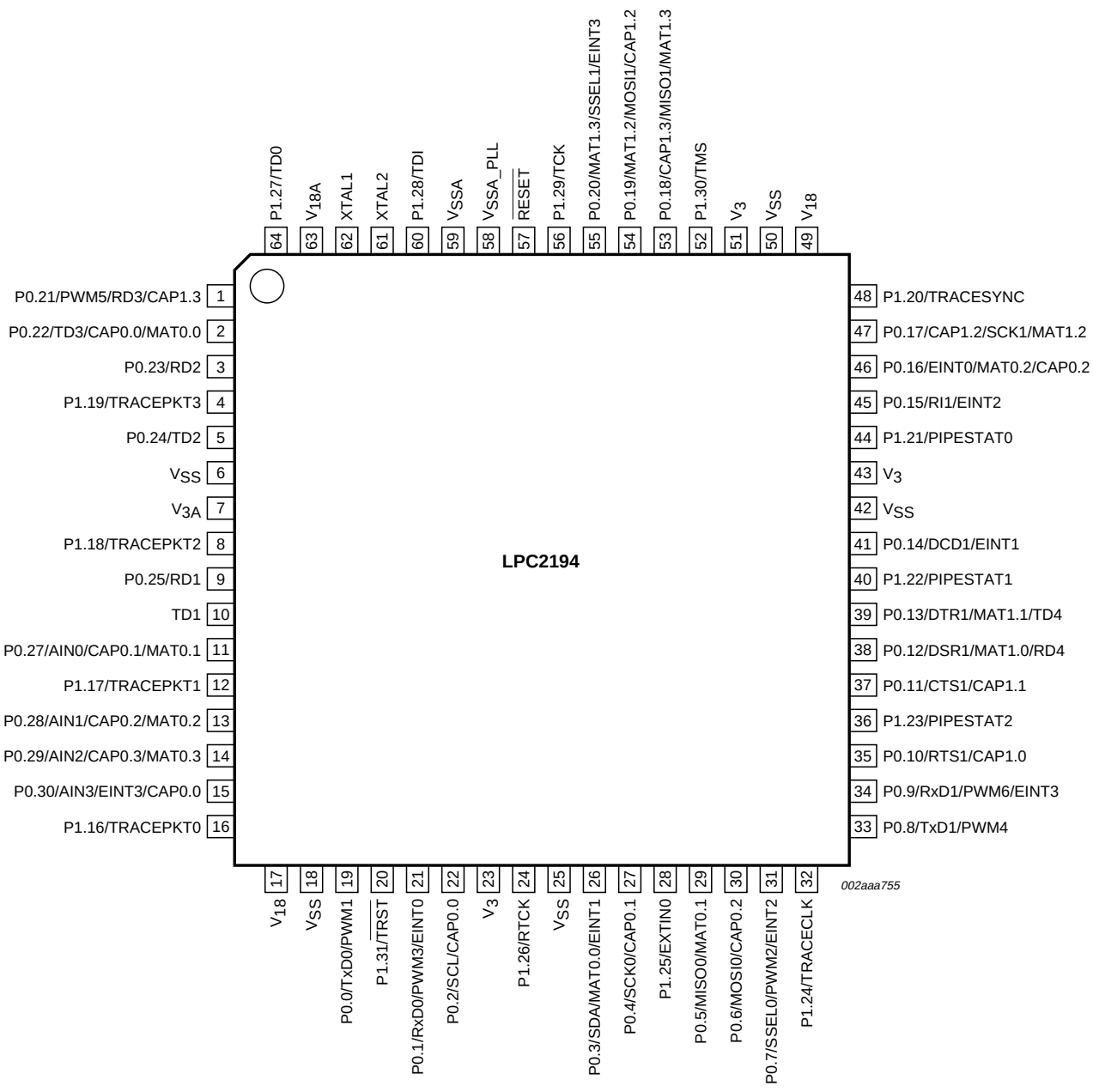


Fig 2. Pinning.

5.2 Pin description

Table 3: Pin description

Symbol	Pin	Type	Description
P0.0 to P0.31	19, 21, 22, 26, 27, 29-31, 33-35, 37-39, 41, 45-47, 53-55, 1-3, 5, 9, 11, 13-15	I/O	**Port 0:** Port 0 is a 32-bit bi-directional I/O port with individual direction controls for each bit. The operation of port 0 pins depends upon the pin function selected via the Pin Connect Block. Pins 26 and 31 of port 0 are not available.
P0.0	19	O	**TxD0 —** Transmitter output for UART0.
		O	**PWM1 —** Pulse Width Modulator output 1.
P0.1	21	I	**RxD0 —** Receiver input for UART0.
		O	**PWM3 —** Pulse Width Modulator output 3.
		I	**EINT0 —** External interrupt 0 input
P0.2	22	I/O	**SCL —** I^2C clock input/output. Open drain output (for I^2C compliance).
		I	**CAP0.0 —** Capture input for Timer0, channel 0.
P0.3	26	I/O	**SDA —** I^2C data input/output. Open drain output (for I^2C compliance).
		O	**MAT0.0 —** Match output for Timer0, channel 0.
		I	**EINT1 —** External interrupt 1 input.
P0.4	27	I/O	**SCK0 —** Serial clock for SPI0. SPI clock output from master or input to slave.
		I	**CAP0.1 —** Capture input for Timer0, channel 1.
P0.5	29	I/O	**MISO0 —** Master In Slave OUT for SPI0. Data input to SPI master or data output from SPI slave.
		O	**MAT0.1 —** Match output for Timer0, channel 1.
P0.6	30	I/O	**MOSI0 —** Master Out Slave In for SPI0. Data output from SPI master or data input to SPI slave.
		I	**CAP0.2 —** Capture input for Timer0, channel 2.
P0.7	31	I	**SSEL0 —** Slave Select for SPI0. Selects the SPI interface as a slave.
		O	**PWM2 —** Pulse Width Modulator output 2.
		I	**EINT2 —** External interrupt 2 input.
P0.8	33	O	**TxD1 —** Transmitter output for UART1.
		O	**PWM4 —** Pulse Width Modulator output 4.
P0.9	34	I	**RxD1 —** Receiver input for UART1.
		O	**PWM6 —** Pulse Width Modulator output 6.
		I	**EINT3 —** External interrupt 3 input.
P0.10	35	O	**RTS1 —** Request to Send output for UART1.
		I	**CAP1.0 —** Capture input for Timer1, channel 0.
P0.11	37	I	**CTS1 —** Clear to Send input for UART1.

Table 3: Pin description *...continued*

Symbol	Pin	Type	Description
TD1	10	O	**TD1 —** CAN1 transmitter output.
$\overline{\text{RESET}}$	57	I	**External Reset input:** A LOW on this pin resets the device, causing I/O ports and peripherals to take on their default states, and processor execution to begin at address 0. TTL with hysteresis, 5 V tolerant.
XTAL1	62	I	Input to the oscillator circuit and internal clock generator circuits.
XTAL2	61	O	Output from the oscillator amplifier.
V_{SS}	6, 18, 25, 42, 50	I	**Ground:** 0 V reference.
V_{SSA}	59	I	**Analog Ground:** 0 V reference. This should nominally be the same voltage as V_{SS}, but should be isolated to minimize noise and error.
V_{SSA_PLL}	58	I	**PLL Analog Ground:** 0 V reference. This should nominally be the same voltage as V_{SS}, but should be isolated to minimize noise and error.
V_{18}	17, 49	I	**1.8 V Core Power Supply:** This is the power supply voltage for internal circuitry.
V_{18A}	63	I	**Analog 1.8 V Core Power Supply:** This is the power supply voltage for internal circuitry. This should be nominally the same voltage as V_{18} but should be isolated to minimize noise and error.
V_3	23, 43, 51	I	**3.3 V Pad Power Supply:** This is the power supply voltage for the I/O ports.
V_{3A}	7	I	Analog 3.3 V Pad Power Supply: This should be nominally the same voltage as V_3 but should be isolated to minimize noise and error.

6. Functional description

Details of the LPC2194 systems and peripheral functions are described in the following sections.

6.1 Architectural overview

The ARM7TDMI-S is a general purpose 32-bit microprocessor, which offers high performance and very low power consumption. The ARM architecture is based on Reduced Instruction Set Computer (RISC) principles, and the instruction set and related decode mechanism are much simpler than those of microprogrammed Complex Instruction Set Computers. This simplicity results in a high instruction throughput and impressive real-time interrupt response from a small and cost-effective processor core.

Pipeline techniques are employed so that all parts of the processing and memory systems can operate continuously. Typically, while one instruction is being executed, its successor is being decoded, and a third instruction is being fetched from memory.

The ARM7TDMI-S processor also employs a unique architectural strategy known as THUMB, which makes it ideally suited to high-volume applications with memory restrictions, or applications where code density is an issue.

The key idea behind THUMB is that of a super-reduced instruction set. Essentially, the ARM7TDMI-S processor has two instruction sets:

- The standard 32-bit ARM set.
- A 16-bit THUMB set.

The THUMB set's 16-bit instruction length allows it to approach twice the density of standard ARM code while retaining most of the ARM's performance advantage over a traditional 16-bit processor using 16-bit registers. This is possible because THUMB code operates on the same 32-bit register set as ARM code.

THUMB code is able to provide up to 65% of the code size of ARM, and 160% of the performance of an equivalent ARM processor connected to a 16-bit memory system.

6.2 On-Chip Flash program memory

The LPC2194 incorporates a 256 kB Flash memory system. This memory may be used for both code and data storage. Programming of the Flash memory may be accomplished in several ways. It may be programmed In System via the serial port. The application program may also erase and/or program the Flash while the application is running, allowing a great degree of flexibility for data storage field firmware upgrades, etc. When on-chip bootloader is used, 248 kB of Flash memory is available for user code.

6.3 On-Chip static RAM

On-Chip static RAM may be used for code and/or data storage. The SRAM may be accessed as 8-bits, 16-bits, and 32-bits. The LPC2194 provides 16 kB of static RAM.

6.4 Memory map

The LPC2194 memory map incorporates several distinct regions, as shown in the following figures.

In addition, the CPU interrupt vectors may be re-mapped to allow them to reside in either Flash memory (the default) or on-chip static RAM. This is described in Section 6.20 “System control”.

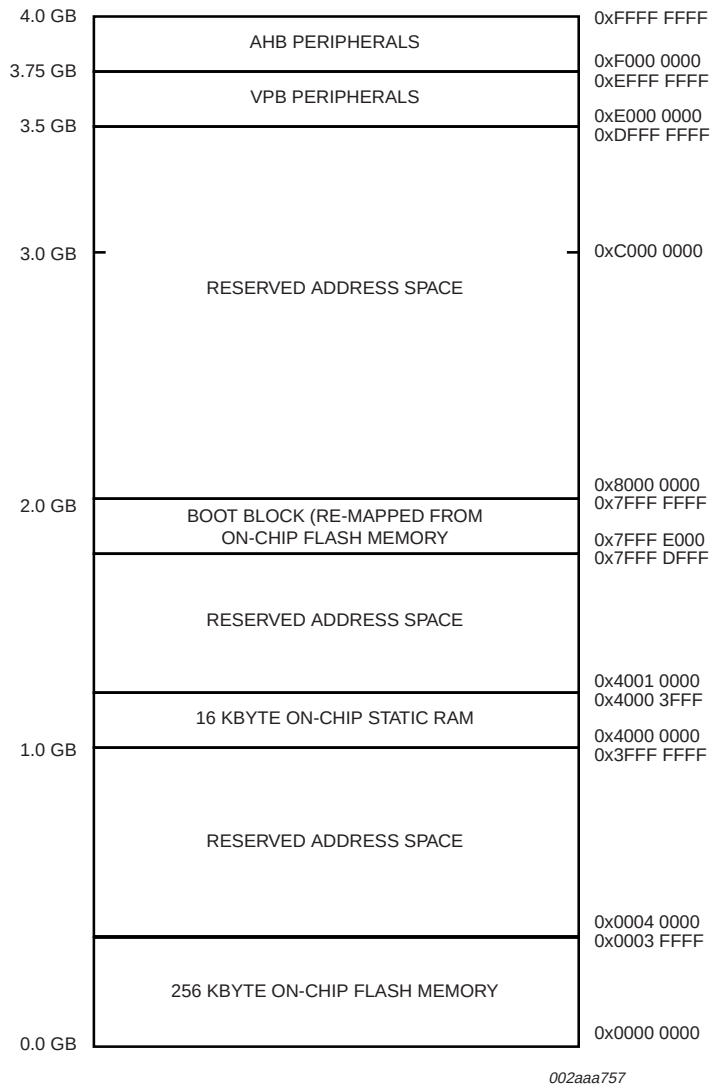


Fig 3. LPC2194 memory map.

6.5 Interrupt controller

The Vectored Interrupt Controller (VIC) accepts all of the interrupt request inputs and categorizes them as FIQ, vectored IRQ, and non-vectored IRQ as defined by programmable settings. The programmable assignment scheme means that priorities of interrupts from the various peripherals can be dynamically assigned and adjusted.

Fast Interrupt reQuest (FIQ) has the highest priority. If more than one request is assigned to FIQ, the VIC combines the requests to produce the FIQ signal to the ARM processor. The fastest possible FIQ latency is achieved when only one request is classified as FIQ, because then the FIQ service routine can simply start dealing with that device. But if more than one request is assigned to the FIQ class, the FIQ service routine can read a word from the VIC that identifies which FIQ source(s) is (are) requesting an interrupt.

Vectored IRQs have the middle priority. Sixteen of the interrupt requests can be assigned to this category. Any of the interrupt requests can be assigned to any of the 16 vectored IRQ slots, among which slot 0 has the highest priority and slot 15 has the lowest.

Non-vectored IRQs have the lowest priority.

The VIC combines the requests from all the vectored and non-vectored IRQs to produce the IRQ signal to the ARM processor. The IRQ service routine can start by reading a register from the VIC and jumping there. If any of the vectored IRQs are requesting, the VIC provides the address of the highest-priority requesting IRQs service routine, otherwise it provides the address of a default routine that is shared by all the non-vectored IRQs. The default routine can read another VIC register to see what IRQs are active.

6.5.1 Interrupt sources

Table 4 lists the interrupt sources for each peripheral function. Each peripheral device has one interrupt line connected to the Vectored Interrupt Controller, but may have several internal interrupt flags. Individual interrupt flags may also represent more than one interrupt source.

Table 4: Interrupt sources

Block	Flag(s)	VIC channel #
WDT	Watchdog Interrupt (WDINT)	0
-	Reserved for software interrupts only	1
ARM Core	Embedded ICE, DbgCommRx	2
ARM Core	Embedded ICE, DbgCommTx	3
Timer0	Match 0 - 3 (MR0, MR1, MR2, MR3) Capture 0 - 3 (CR0, CR1, CR2, CR3)	4
Timer1	Match 0 - 3 (MR0, MR1, MR2, MR3) Capture 0 - 3 (CR0, CR1, CR2, CR3)	5
UART0	Rx Line Status (RLS) Transmit Holding Register empty (THRE) Rx Data Available (RDA) Character Time-out Indicator (CTI)	6
UART1	Rx Line Status (RLS) Transmit Holding Register empty (THRE) Rx Data Available (RDA) Character Time-out Indicator (CTI) Modem Status Interrupt (MSI)	7
PWM0	Match 0 - 6 (MR0, MR1, MR2, MR3, MR4, MR5, MR6)	8

Table 6: Pin function select register 0 (PINSEL0 - 0xE002C000) *...continued*

PINSEL0	Pin name	Value		Function	Value after Reset
23:22	P0.11	0	0	GPIO Port 0.11	0
		0	1	CTS (UART1)	
		1	0	Capture 1.1 (Timer1)	
		1	1	Reserved	
25:24	P0.12	0	0	GPIO Port 0.12	0
		0	1	DSR (UART1)	
		1	0	Match 1.0 (Timer1)	
		1	1	RD4 (CAN controller 4)	
27:26	P0.13	0	0	GPIO Port 0.13	0
		0	1	DTR (UART1)	
		1	0	Match 1.1 (Timer1)	
		1	1	TD4 (CAN controller 4)	
29:28	P0.14	0	0	GPIO Port 0.14	0
		0	1	DCD (UART1)	
		1	0	EINT1	
		1	1	Reserved	
31:30	P0.15	0	0	GPIO Port 0.15	0
		0	1	RI (UART1)	
		1	0	EINT2	
		1	1	Reserved	

6.8 Pin function select register 1 (PINSEL1 - 0xE002C004)

The PINSEL1 register controls the functions of the pins as per the settings listed in Table 7. The direction control bit in the IODIR register is effective only when the GPIO function is selected for a pin. For other functions direction is controlled automatically. Settings other than those shown in the table are reserved, and should not be used.

Table 7: Pin function select register 1 (PINSEL1 - 0xE002C004)

PINSEL1	Pin Name	Value		Function	Value after Reset
1:0	P0.16	0	0	GPIO Port 0.16	0
		0	1	EINT0	
		1	0	Match 0.2 (Timer0)	
		1	1	Capture 0.2 (Timer0)	
3:2	P0.17	0	0	GPIO Port 0.17	0
		0	1	Capture 1.2 (Timer1)	
		1	0	SCK (SPI1)	
		1	1	Match 1.2 (Timer1)	
5:4	P0.18	0	0	GPIO Port 0.18	0
		0	1	Capture 1.3 (Timer1)	
		1	0	MISO (SPI1)	
		1	1	Match 1.3 (Timer1)	

Table 7: Pin function select register 1 (PINSEL1 - 0xE002C004) *...continued*

PINSEL1	Pin Name	Value		Function	Value after Reset
27:26	P0.29	0	0	GPIO Port 0.29	1
		0	1	AIN2 (A/D input 2)	
		1	0	Capture 0.3 (Timer0)	
		1	1	Match 0.3 (Timer0)	
29:28	P0.30	0	0	GPIO Port 0.30	1
		0	1	AIN3 (A/D input 0)	
		1	0	EINT3	
		1	1	Capture 0.0 (Timer0)	
31:30	P0.31	0	0	Reserved	0
		0	1	Reserved	
		1	0	Reserved	
		1	1	Reserved	

6.9 Pin function select register 2 (PINSEL2 - 0xE002C014)

The PINSEL2 register controls the functions of the pins as per the settings listed in Table 8. The direction control bit in the IODIR register is effective only when the GPIO function is selected for a pin. For other functions direction is controlled automatically. Settings other than those shown in the table are reserved, and should not be used.

Table 8: Pin function select register 2 (PINSEL2 - 0xE002C014)

PINSEL2 bits	Description	Reset value
1:0	Reserved	-
2	When 0, pins P1.31:26 are GPIO pins. When 1, P1.31:26 are used as Debug port.	0
3	When 0, pins P1.25:16 are used as GPIO pins. When 1, P1.25:16 are used as Trace port.	0
31:4 31:30	Reserved	-

6.10 General purpose parallel I/O

Device pins that are not connected to a specific peripheral function are controlled by the GPIO registers. Pins may be dynamically configured as inputs or outputs. Separate registers allow setting or clearing any number of outputs simultaneously. The value of the output register may be read back, as well as the current state of the port pins.

6.10.1 Features

- Direction control of individual bits.
- Separate control of output set and clear.
- All I/O default to inputs after reset.

I^2C implemented in LPC2194 supports bit rate up to 400 kbit/s (Fast I^2C).

6.14.1 Features

- Standard I^2C compliant bus interface.
- Easy to configure as Master, Slave, or Master/Slave.
- Programmable clocks allow versatile rate control.
- Bidirectional data transfer between masters and slaves.
- Multi-master bus (no central master).
- Arbitration between simultaneously transmitting masters without corruption of serial data on the bus.
- Serial clock synchronization allows devices with different bit rates to communicate via one serial bus.
- Serial clock synchronization can be used as a handshake mechanism to suspend and resume serial transfer.
- The I^2C bus may be used for test and diagnostic purposes.

6.15 SPI serial I/O controller

The LPC2194 contains two SPIs. The SPI is a full duplex serial interface, designed to be able to handle multiple masters and slaves connected to a given bus. Only a single master and a single slave can communicate on the interface during a given data transfer. During a data transfer the master always sends a byte of data to the slave, and the slave always sends a byte of data to the master.

6.15.1 Features

- Compliant with Serial Peripheral Interface (SPI) specification.
- Synchronous, Serial, Full Duplex, Communication.
- Combined SPI master and slave.
- Maximum data bit rate of one eighth of the input clock rate.

6.16 General purpose timers

The Timer is designed to count cycles of the peripheral clock (PCLK) and optionally generate interrupts or perform other actions at specified timer values, based on four match registers. It also includes four capture inputs to trap the timer value when an input signal transitions, optionally generating an interrupt. Multiple pins can be selected to perform a single capture or match function, providing an application with ‘or’ and ‘and’, as well as ‘broadcast’ functions among them.

6.16.1 Features

- A 32-bit Timer/Counter with a programmable 32-bit Prescaler.

- Four 32-bit capture channels per timer that can take a snapshot of the timer value when an input signal transitions. A capture event may also optionally generate an interrupt.
- Four 32-bit match registers that allow:
  - Continuous operation with optional interrupt generation on match.
  - Stop timer on match with optional interrupt generation.
  - Reset timer on match with optional interrupt generation.
- Four external outputs per timer corresponding to match registers, with the following capabilities:
  - Set LOW on match.
  - Set HIGH on match.
  - Toggle on match.
  - Do nothing on match.

6.17 Watchdog timer

The purpose of the Watchdog is to reset the microcontroller within a reasonable amount of time if it enters an erroneous state. When enabled, the Watchdog will generate a system reset if the user program fails to 'feed' (or reload) the Watchdog within a predetermined amount of time.

6.17.1 Features

- Internally resets chip if not periodically reloaded.
- Debug mode.
- Enabled by software but requires a hardware reset or a Watchdog reset/interrupt to be disabled.
- Incorrect/Incomplete feed sequence causes reset/interrupt if enabled.
- Flag to indicate Watchdog reset.
- Programmable 32-bit timer with internal pre-scaler.
- Selectable time period from ($t_{pclk} \times 256 \times 4$) to ($t_{pclk} \times 2^{32} \times 4$) in multiples of $t_{pclk} \times 4$.

6.18 Real time clock

The Real Time Clock (RTC) is designed to provide a set of counters to measure time when normal or idle operating mode is selected. The RTC has been designed to use little power, making it suitable for battery powered systems where the CPU is not running continuously (Idle mode).

6.18.1 Features

- Measures the passage of time to maintain a calendar and clock.
- Ultra Low Power design to support battery powered systems.

- Pulse period and width can be any number of timer counts. This allows complete flexibility in the trade-off between resolution and repetition rate. All PWM outputs will occur at the same repetition rate.
- Double edge controlled PWM outputs can be programmed to be either positive going or negative going pulses.
- Match register updates are synchronized with pulse outputs to prevent generation of erroneous pulses. Software must 'release' new match values before they can become effective.
- May be used as a standard timer if the PWM mode is not enabled.
- A 32-bit Timer/Counter with a programmable 32-bit Prescaler.

6.20 System control

6.20.1 Crystal oscillator

The oscillator supports crystals in the range of 1 MHz to 30 MHz. The oscillator output frequency is called f_{osc} and the ARM processor clock frequency is referred to as cclk for purposes of rate equations, etc. f_{osc} and cclk are the same value unless the PLL is running and connected. Refer to Section 6.20.2 "PLL" for additional information.

6.20.2 PLL

The PLL accepts an input clock frequency in the range of 10 MHz to 25 MHz. The input frequency is multiplied up into the range of 10 MHz to 60 MHz with a Current Controlled Oscillator (CCO). The multiplier can be an integer value from 1 to 32 (in practice, the multiplier value cannot be higher than 6 on this family of microcontrollers due to the upper frequency limit of the CPU). The CCO operates in the range of 156 MHz to 320 MHz, so there is an additional divider in the loop to keep the CCO within its frequency range while the PLL is providing the desired output frequency. The output divider may be set to divide by 2, 4, 8, or 16 to produce the output clock. Since the minimum output divider value is 2, it is insured that the PLL output has a 50% duty cycle.The PLL is turned off and bypassed following a chip Reset and may be enabled by software. The program must configure and activate the PLL, wait for the PLL to Lock, then connect to the PLL as a clock source.

6.20.3 Reset and wake-up timer

Reset has two sources on the LPC2194: the $\overline{\text{RESET}}$ pin and Watchdog Reset. The $\overline{\text{RESET}}$ pin is a Schmitt trigger input pin with an additional glitch filter. Assertion of chip Reset by any source starts the Wake-up Timer (see Wake-up Timer description below), causing the internal chip reset to remain asserted until the external Reset is de-asserted, the oscillator is running, a fixed number of clocks have passed, and the on-chip Flash controller has completed its initialization.

When the internal Reset is removed, the processor begins executing at address 0, which is the Reset vector. At that point, all of the processor and peripheral registers have been initialized to predetermined values.

The wake-up timer ensures that the oscillator and other analog functions required for chip operation are fully functional before the processor is allowed to execute instructions. This is important at power on, all types of Reset, and whenever any of the aforementioned functions are turned off for any reason. Since the oscillator and other functions are turned off during Power-down mode, any wake-up of the processor from Power-down mode makes use of the Wake-up Timer.

The Wake-up Timer monitors the crystal oscillator as the means of checking whether it is safe to begin code execution. When power is applied to the chip, or some event caused the chip to exit Power-down mode, some time is required for the oscillator to produce a signal of sufficient amplitude to drive the clock logic. The amount of time depends on many factors, including the rate of V_{DD} ramp (in the case of power on), the type of crystal and its electrical characteristics (if a quartz crystal is used), as well as any other external circuitry (e.g. capacitors), and the characteristics of the oscillator itself under the existing ambient conditions.

6.20.4 External interrupt inputs

The LPC2194 includes up to nine edge or level sensitive External Interrupt Inputs as selectable pin functions. When the pins are combined, external events can be processed as four independent interrupt signals. The External Interrupt Inputs can optionally be used to wake up the processor from Power-down mode.

6.20.5 Memory Mapping Control

The Memory Mapping Control alters the mapping of the interrupt vectors that appear beginning at address 0x00000000. Vectors may be mapped to the bottom of the on-chip Flash memory, or to the on-chip static RAM. This allows code running in different memory spaces to have control of the interrupts.

6.20.6 Power Control

The LPC2194 supports two reduced power modes: Idle mode and Power-down mode. In Idle mode, execution of instructions is suspended until either a Reset or interrupt occurs. Peripheral functions continue operation during Idle mode and may generate interrupts to cause the processor to resume execution. Idle mode eliminates power used by the processor itself, memory systems and related controllers, and internal buses.

In Power-down mode, the oscillator is shut down and the chip receives no internal clocks. The processor state and registers, peripheral registers, and internal SRAM values are preserved throughout Power-down mode and the logic levels of chip output pins remain static. The Power-down mode can be terminated and normal operation resumed by either a Reset or certain specific interrupts that are able to function without clocks. Since all dynamic operation of the chip is suspended, Power-down mode reduces chip power consumption to nearly zero.

A Power Control for Peripherals feature allows individual peripherals to be turned off if they are not needed in the application, resulting in additional power savings.

6.20.7 VPB bus

The VPB Divider determines the relationship between the processor clock (cclk) and the clock used by peripheral devices (PCLK). The VPB Divider serves two purposes. The first is that the VPB bus cannot operate at the highest speeds of the CPU. In order to compensate for this, the VPB bus may be slowed down to one half or one

fourth of the processor clock rate. The default condition at reset is for the VPB bus to run at one quarter of the CPU clock. The second purpose of the VPB Divider is to allow power savings when an application does not require any peripherals to run at the full processor rate. Because the VPB Divider is connected to the PLL output, the PLL remains active (if it was running) during Idle mode.

6.21 Emulation and debugging

The LPC2194 supports emulation and debugging via a JTAG serial port. A trace port allows tracing program execution. Debugging and trace functions are multiplexed only with GPIOs on Port 1. This means that all communication, timer and interface peripherals residing on Port 0 are available during the development and debugging phase as they are when the application is run in the embedded system itself.

6.21.1 Embedded ICE™

Standard ARM EmbeddedICE logic provides on-chip debug support. The debugging of the target system requires a host computer running the debugger software and an EmbeddedICE protocol convertor. EmbeddedICE protocol convertor converts the Remote Debug Protocol commands to the JTAG data needed to access the ARM core.

The ARM core has a Debug Communication Channel function built-in. The debug communication channel allows a program running on the target to communicate with the host debugger or another separate host without stopping the program flow or even entering the debug state. The debug communication channel is accessed as a co-processor 14 by the program running on the ARM7TDMI-S core. The debug communication channel allows the JTAG port to be used for sending and receiving data without affecting the normal program flow. The debug communication channel data and control registers are mapped in to addresses in the EmbeddedICE™ logic.

6.21.2 Embedded trace

Since the LPC2194 has significant amounts of on-chip memory, it is not possible to determine how the processor core is operating simply by observing the external pins. The Embedded Trace Macrocell provides real-time trace capability for deeply embedded processor cores. It outputs information about processor execution to the trace port.

The ETM is connected directly to the ARM core and not to the main AMBA system bus. It compresses the trace information and exports it through a narrow trace port. An external trace port analyzer must capture the trace information under software debugger control. Instruction trace (or PC trace) shows the flow of execution of the processor and provides a list of all the instructions that were executed. Instruction trace is significantly compressed by only broadcasting branch addresses as well as a set of status signals that indicate the pipeline status on a cycle by cycle basis. Trace information generation can be controlled by selecting the trigger resource. Trigger resources include address comparators, counters and sequencers. Since trace information is compressed the software debugger requires a static image of the code being executed. Self-modifying code can not be traced because of this restriction.

Table 10: Static characteristics *...continued*

T_{amb} = −40 °C to +85 °C for commercial, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ[1]	Max	Unit
V_{hys}	Hysteresis voltage	V_{TOL} is from 4.5 V to 5.5 V	-	0.5 V_{TOL}	-	V
V_{OL}	Low level output voltage[6]	I_{OL} = 3 mA	-	-	0.4	V
I_{lkg}	Input leakage to V_{SS}	$V_i = V_3$	-	2	4	µA
		V_i = 5 V	-	10	22	µA
Oscillator pins						
	X1 input Voltages		0	-	V_{18}	
	X2 output Voltages		0	-	V_{18}	

[1] Typical ratings are not guaranteed. The values listed are at room temperature (+25 ˚C), nominal supply voltages.

[2] Pin capacitance is characterized but not tested.

[3] Including voltage on outputs in 3-state mode.

[4] V_3 supply voltages must be present.

[5] 3-state outputs go into 3-state mode when V_3 is grounded.

[6] Accounts for 100 mV voltage drop in all supply lines.

[7] Only allowed for a short time period.

[8] Minimum condition for V_i = 4.5 V, maximum condition for V_i = 5.5 V.

Table 11: A/D converter DC electrical characteristics

V_{3A} = 2.5 V to 3.6 V unless otherwise specified; T_{amb} = −40 °C to +85 °C unless otherwise specified; A/D converter frequency 4.5 MHz.

Symbol	Parameter	Min	Max	Unit
AV_{IN}	Analog input voltage	0	V_{3A}	V
C_{IN}	Analog input capacitance	-	1	pF
DL_e	Differential non-linearity[1][2][3]	-	±1	LSB
IL_e	Integral non-linearity[1][4]	-	±2	LSB
OS_e	Offset error[1][5]	-	±3	LSB
G_e	Gain error[1][6]	-	±0.5	%
A_e	Absolute error[1][7]	-	±4	LSB

[1] Conditions: V_{SSA} = 0 V, V_{3A} = 3.3 V.

[2] The A/D is monotonic, there are no missing codes.

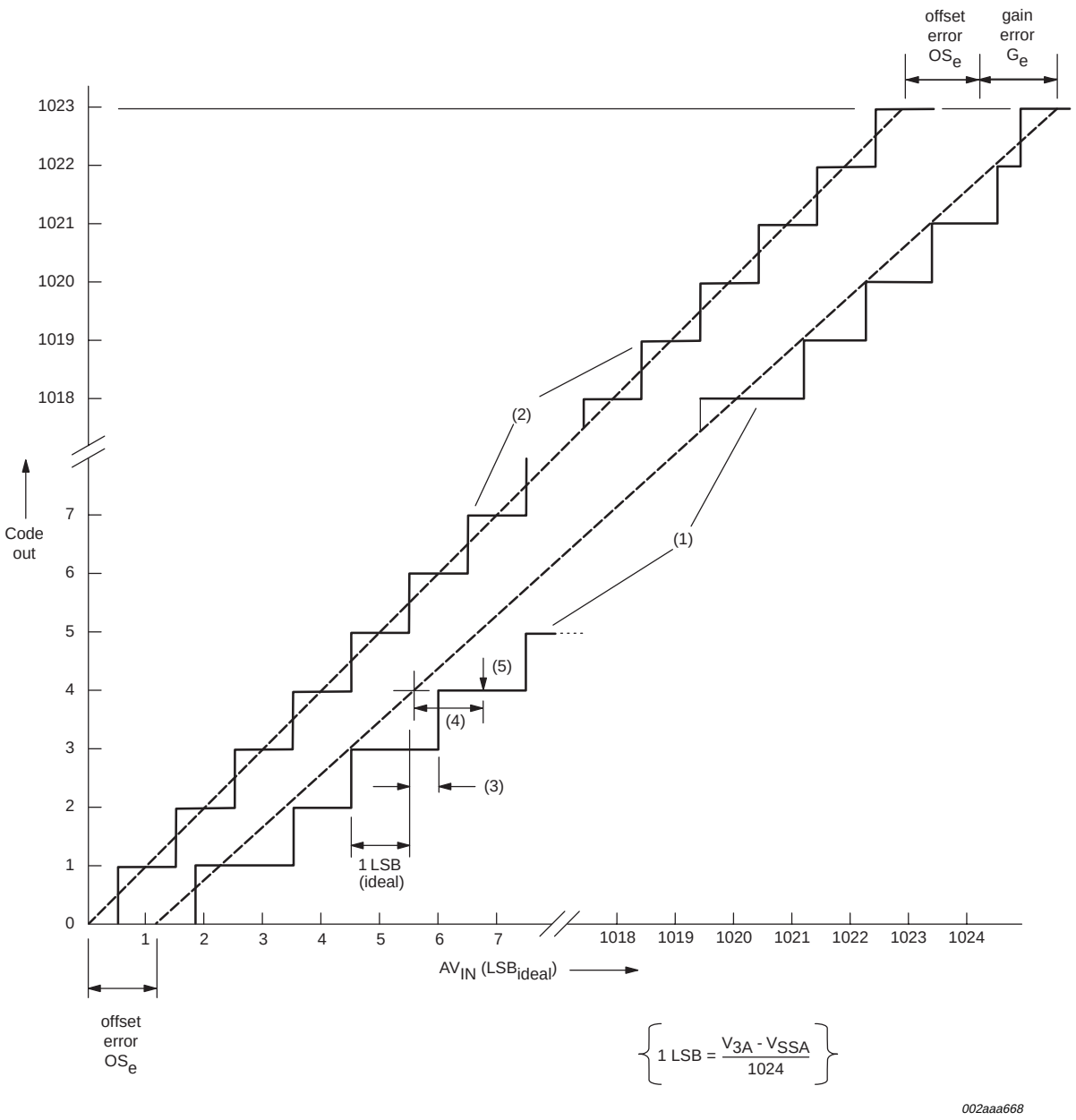
[3] The differential non-linearity (DLe) is the difference between the actual step width and the ideal step width. See Figure 4.

[4] The integral no-linearity (ILe) is the peak difference between the center of the steps of the actual and the ideal transfer curve after appropriate adjustment of gain and offset errors. See Figure 4.

[5] The offset error (OSe) is the absolute difference between the straight line which fits the actual curve and the straight line which fits the ideal curve. See Figure 4.

[6] The gain error (Ge) is the relative difference in percent between the straight line fitting the actual transfer curve after removing offset error, and the straight line which fits the ideal transfer curve. See Figure 4.

[7] The absolute voltage error (Ae) is the maximum difference between the center of the steps of the actual transfer curve of the non-calibrated A/D and the ideal transfer curve. See Figure 4.



(1) Example of an actual transfer curve.

(2) The ideal transfer curve.

(3) Differential non-linearity (DL_e).

(4) Integral non-linearity (IL_e).

(5) Center of a step of the actual transfer curve.

Fig 4. A/D conversion characteristics.

9. Dynamic characteristics

Table 12: Characteristics

T_{amb} = 0 °C to +70 °C for commercial, −40 °C to +85 °C for industrial, V_{18}, V_3 over specified ranges[1]

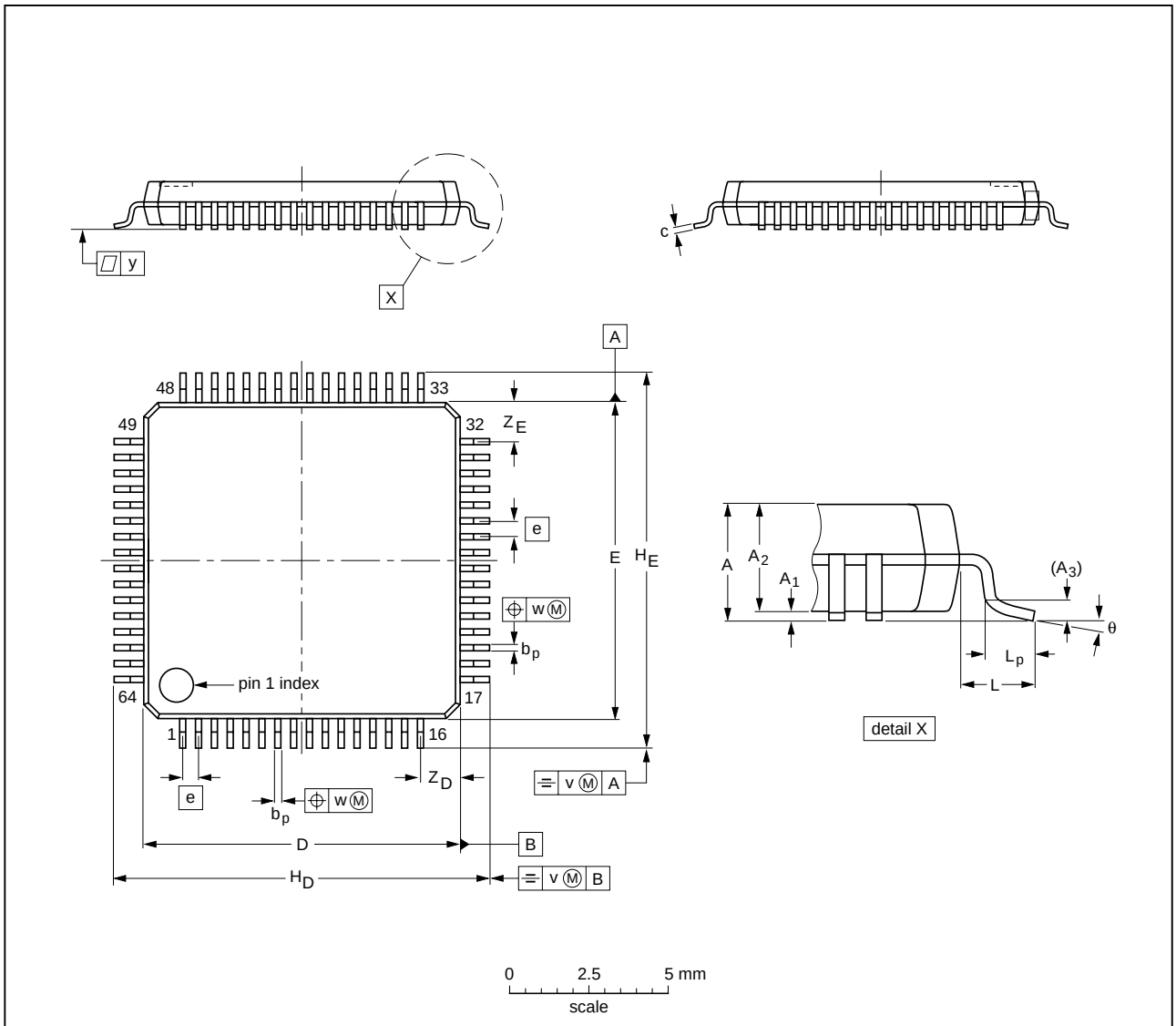
Symbol	Parameter	Conditions	Min	Typ[1]	Max	Unit
External Clock						
f_{osc}	Oscillator frequency supplied by an external oscillator (signal generator)		1	-	50	MHz
	External clock frequency supplied by an external crystal oscillator		1	-	30	MHz
	External clock frequency if on-chip PLL is used		10	-	25	MHz
	External clock frequency if ISP is used for initial code download		10	-	25	MHz
t_C	Oscillator clock period		20	-	1000	ns
t_{CHCX}	Clock high time		$t_c \times 0.4$	-	-	ns
t_{CLCX}	Clock low time		$t_c \times 0.4$	-	-	ns
t_{CLCH}	Clock rise time		-	-	5	ns
t_{CHCL}	Clock fall time		-	-	5	ns
Port Pins						
t_{RISE}	Port output rise time (except P0.2, P0.3)		-	10	-	ns
t_{FALL}	Port output fall time (except P0.2, P0.3)		-	10	-	ns
I^2C pins						
t_f	Output fall time from V_{IH} to V_{IL}		$20 + 0.1 \times C_b$[2]	-	-	ns

[1] Parameters are valid over operating temperature range unless otherwise specified.

[2] Bus capacitance C_b in pF, from 10 pF to 400 pF.

10. Package outline

LQFP64: plastic low profile quad flat package; 64 leads; body 10 x 10 x 1.4 mm **SOT314-2**



DIMENSIONS (mm are the original dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(1)}$	e	H_D	H_E	L	L_p	v	w	y	$Z_D^{(1)}$	$Z_E^{(1)}$	θ
mm	1.6	0.20 0.05	1.45 1.35	0.25	0.27 0.17	0.18 0.12	10.1 9.9	10.1 9.9	0.5	12.15 11.85	12.15 11.85	1	0.75 0.45	0.2	0.12	0.1	1.45 1.05	1.45 1.05	7^o 0^o

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT314-2	136E10	MS-026				~~00-01-19~~ 03-02-25

Fig 6.

Contents

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