# LPC2926/2927/2929

## ARM9 microcontroller with CAN, LIN, and USB

Rev. 5 — 28 September 2010 Product data sheet

## 1. General description

The LPC2926/2927/2929 combine an ARM968E-S CPU core with two integrated TCM blocks operating at frequencies of up to 125 MHz, Full-speed USB 2.0 OTG and device controller, CAN and LIN, 56 kB SRAM, up to 768 kB flash memory, external memory interface, three 10-bit ADCs, and multiple serial and parallel interfaces in a single chip targeted at consumer, industrial and communication markets. To optimize system power consumption, the LPC2926/2927/2929 has a very flexible Clock Generation Unit (CGU) that provides dynamic clock gating and scaling.

## 2. Features and benefits

- ARM968E-S processor running at frequencies of up to 125 MHz maximum.
- Multi-layer AHB system bus at 125 MHz with four separate layers.
- On-chip memory:
  - Two Tightly Coupled Memories (TCM), 32 kB Instruction TCM (ITCM), 32 kB Data TCM (DTCM).
  - Two separate internal Static RAM (SRAM) instances; 32 kB SRAM and 16 kB SRAM.
  - 8 kB ETB SRAM also available for code execution and data.
  - Up to 768 kB high-speed flash-program memory.
  - 16 kB true EEPROM, byte-erasable and programmable.
- Dual-master, eight-channel GPDMA controller on the AHB multi-layer matrix which can be used with the Serial Peripheral Interface (SPI) interfaces and the UARTs, as well as for memory-to-memory transfers including the TCM memories.
- External Static Memory Controller (SMC) with eight memory banks; up to 32-bit data bus; up to 24-bit address bus.
- Serial interfaces:
  - USB 2.0 full-speed device/OTG controller with dedicated DMA controller and on-chip device PHY.
  - Two-channel CAN controller supporting FullCAN and extensive message filtering.
  - Two LIN master controllers with full hardware support for LIN communication. The LIN interface can be configured as UART to provide two additional UART interfaces.
  - Two 550 UARTs with 16-byte Tx and Rx FIFO depths, DMA support, and RS485/EIA-485 (9-bit) support.
  - Three full-duplex Q-SPIs with four slave-select lines; 16 bits wide; 8 locations deep; Tx FIFO and Rx FIFO.
  - Two $I^2C$-bus interfaces.

- Other peripherals:
  - One 10-bit ADC with 5.0 V measurement range and eight input channels with conversion times as low as 2.44 μs per channel.
  - Two 10-bit ADCs, 8-channels each, with 3.3 V measurement range provide an additional 16 analog inputs with conversion times as low as 2.44 μs per channel. Each channel provides a compare function to minimize interrupts.
  - Multiple trigger-start option for all ADCs: timer, PWM, other ADC, and external signal input.
  - Four 32-bit timers each containing four capture-and-compare registers linked to I/Os.
  - Four six-channel PWMs (Pulse Width Modulators) with capture and trap functionality.
  - Two dedicated 32-bit timers to schedule and synchronize PWM and ADC.
  - Quadrature encoder interface that can monitor one external quadrature encoder.
  - 32-bit watchdog with timer change protection, running on safe clock.
- Up to 104 general-purpose I/O pins with programmable pull-up, pull-down, or bus keeper.
- Vectored Interrupt Controller (VIC) with 16 priority levels.
- Up to 21 level-sensitive external interrupt pins, including USB, CAN and LIN wake-up features.
- Configurable clock-out pin for driving external system clocks.
- Processor wake-up from power-down via external interrupt pins; CAN or LIN activity.
- Flexible Reset Generator Unit (RGU) able to control resets of individual modules.
- Flexible Clock-Generation Unit (CGU0) able to control clock frequency of individual modules:
  - On-chip very low-power ring oscillator; fixed frequency of 0.4 MHz; always on to provide a Safe_Clock source for system monitoring.
  - On-chip crystal oscillator with a recommended operating range from 10 MHz to 25 MHz. PLL input range 10 MHz to 25 MHz.
  - On-chip PLL allows CPU operation up to a maximum CPU rate of 125 MHz.
  - Generation of up to 11 base clocks.
  - Seven fractional dividers.
- Second CGU (CGU1) with its own PLL generates USB clocks and a configurable clock output.
- Highly configurable system Power Management Unit (PMU):
  - clock control of individual modules.
  - allows minimization of system operating power consumption in any configuration.
- Standard ARM test and debug interface with real-time in-circuit emulator.
- Boundary-scan test supported.
- ETM/ETB debug functions with 8 kB of dedicated SRAM also accessible for application code and data storage.
- Dual power supply:
  - CPU operating voltage: 1.8 V ± 5 %.
  - I/O operating voltage: 2.7 V to 3.6 V; inputs tolerant up to 5.5 V.
- 144-pin LQFP package.
- −40 °C to +85 °C ambient operating temperature range.


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# 3. Ordering information

**Table 1. Ordering information**

| Type number | Package | | |
|---|---|---|---|
| | Name | Description | Version |
| LPC2926FBD144 | LQFP144 | plastic low profile quad flat package; 144 leads; body 20 × 20 × 1.4 mm | SOT486-1 |
| LPC2927FBD144 | LQFP144 | plastic low profile quad flat package; 144 leads; body 20 × 20 × 1.4 mm | SOT486-1 |
| LPC2929FBD144 | LQFP144 | plastic low profile quad flat package; 144 leads; body 20 × 20 × 1.4 mm | SOT486-1 |

## 3.1 Ordering options

**Table 2. Part options**

| Type number | Flash memory | SRAM | SMC | USB OTG/ device | UART RS485 | LIN 2.0/ UART | CAN | Package |
|---|---|---|---|---|---|---|---|---|
| LPC2926FBD144 | 256 kB | 56 kB + 2 × 32 kB TCM | 32-bit | yes | 2 | 2 | 2 | LQFP144 |
| LPC2927FBD144 | 512 kB | 56 kB + 2 × 32 kB TCM | 32-bit | yes | 2 | 2 | 2 | LQFP144 |
| LPC2929FBD144 | 768 kB | 56 kB + 2 × 32 kB TCM | 32-bit | yes | 2 | 2 | 2 | LQFP144 |

[1] Note that parts LPC2926, LPC2927 and LPC2929 are not fully pin compatible with parts LPC2917, LPC2919 and LPC2917/01, LPC2919/01. The Modulation and Sampling Control SubSystem (MSCSS) and timer blocks have a reduced pinout on the LPC2926/2927/2929.


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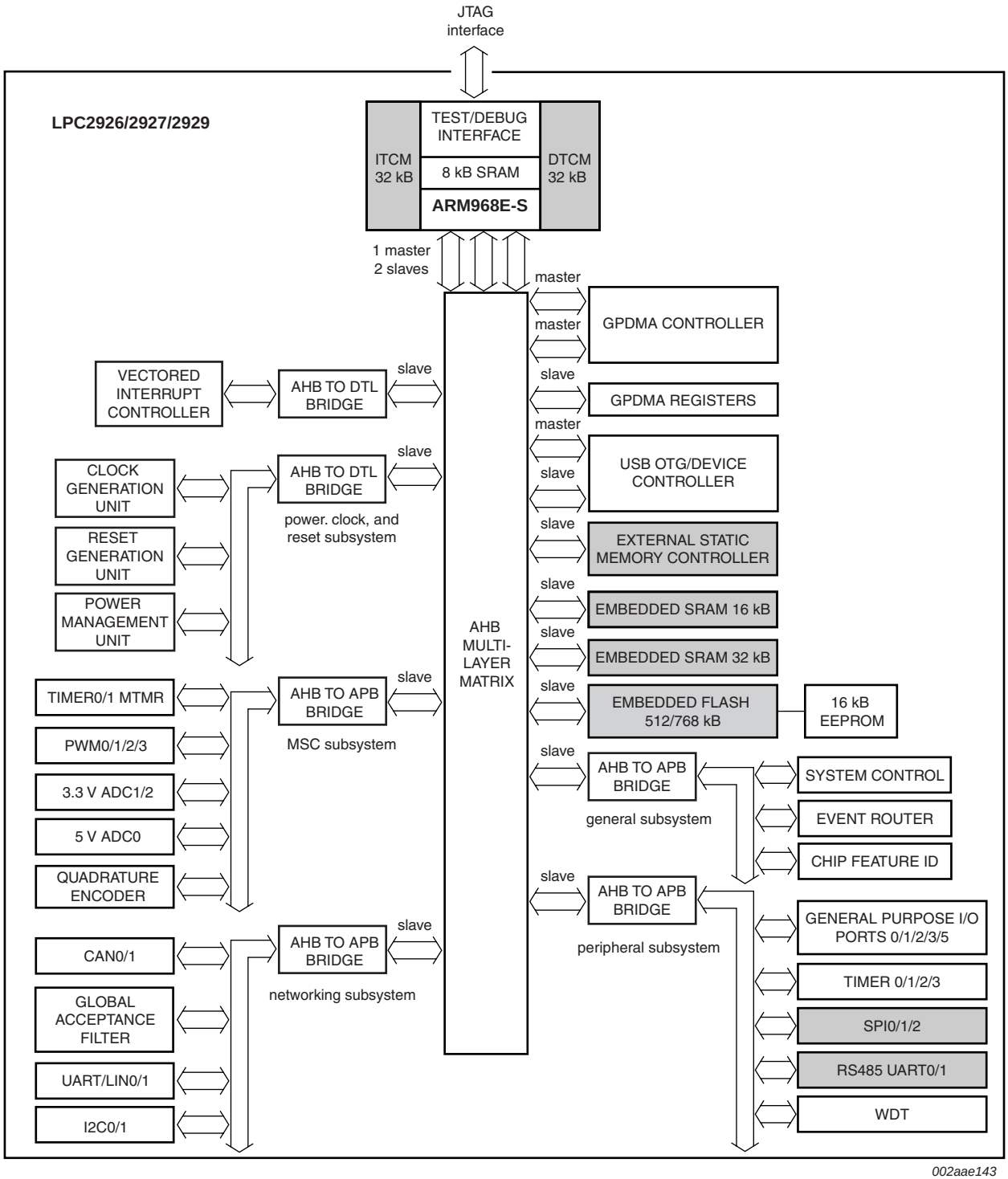
## 4. Block diagram




Grey-shaded blocks represent peripherals and memory regions accessible by the GPDMA.

**Fig 1. LPC2926/2927/2929 block diagram**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# 5. Pinning information

## 5.1 Pinning

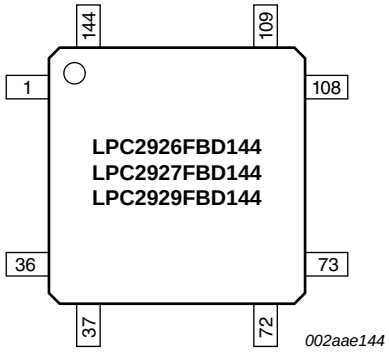


**Fig 2. Pin configuration for SOT486-1 (LQFP144)**

## 5.2 Pin description

### 5.2.1 General description

The LPC2926/2927/2929 uses five ports: port 0 with 32 pins, ports 1 and 2 with 28 pins each, port 3 with 16 pins, and port 5 with 2 pins. Port 4 is not used. The pin to which each function is assigned is controlled by the SFSP registers in the System Control Unit (SCU). The functions combined on each port pin are shown in the pin description tables in this section.

### 5.2.2 LQFP144 pin assignment

**Table 3. LQFP144 pin assignment**

| Pin name | Pin | Description | | | |
|---|---|---|---|---|---|
| | | Function 0 (default) | Function 1 | Function 2 | Function 3 |
| TDO | 1[1] | IEEE 1149.1 test data out | | | |
| P2[21]/SDI2/ PCAP2[1]/D19 | 2[1] | GPIO2, pin 21 | SPI2 SDI | PWM2 CAP1 | EXTBUS D19 |
| P0[24]/TXD1/ TXDC1/SCS2[0] | 3[1] | GPIO0, pin 24 | UART1 TXD | CAN1 TXD | SPI2 SCS0 |
| P0[25]/RXD1/ RXDC1/SDO2 | 4[1] | GPIO0, pin 25 | UART1 RXD | CAN1 RXD | SPI2 SDO |
| P0[26]/TXD1/SDI2 | 5[1] | GPIO0, pin 26 | - | UART1 TXD | SPI2 SDI |
| P0[27]/RXD1/SCK2 | 6[1] | GPIO0, pin 27 | - | UART1 RXD | SPI2 SCK |
| P0[28]/CAP0[0]/ MAT0[0] | 7[1] | GPIO0, pin 28 | - | TIMER0 CAP0 | TIMER0 MAT0 |
| P0[29]/CAP0[1]/ MAT0[1] | 8[1] | GPIO0, pin 29 | - | TIMER0 CAP1 | TIMER0 MAT1 |
| $V_{DD(IO)}$ | 9 | 3.3 V power supply for I/O | | | |


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**Table 3. LQFP144 pin assignment** *...continued*

| Pin name | Pin | Description | | | |
|---|---|---|---|---|---|
| | | Function 0 (default) | Function 1 | Function 2 | Function 3 |
| P2[22]/SCK2/ PCAP2[2]/D20 | 10[1] | GPIO2, pin 22 | SPI2 SCK | PWM2 CAP2 | EXTBUS D20 |
| P2[23]/SCS1[0]/ PCAP3[0]/D21 | 11[1] | GPIO2, pin 23 | SPI1 SCS0 | PWM3 CAP0 | EXTBUS D21 |
| P3[6]/SCS0[3]/ PMAT1[0]/TXDL1 | 12[1] | GPIO3, pin 6 | SPI0 SCS3 | PWM1 MAT0 | LIN1/UART TXD |
| P3[7]/SCS2[1]/ PMAT1[1]/RXDL1 | 13[1] | GPIO3, pin 7 | SPI2 SCS1 | PWM1 MAT1 | LIN1/UART RXD |
| P0[30]/CAP0[2]/ MAT0[2] | 14[1] | GPIO0, pin 30 | - | TIMER0 CAP2 | TIMER0 MAT2 |
| P0[31]/CAP0[3]/ MAT0[3] | 15[1] | GPIO0, pin 31 | - | TIMER0 CAP3 | TIMER0 MAT3 |
| P2[24]/SCS1[1]/ PCAP3[1]/D22 | 16[1] | GPIO2, pin 24 | SPI1 SCS1 | PWM3 CAP1 | EXTBUS D22 |
| P2[25]/SCS1[2]/ PCAP3[2]/D23 | 17[1] | GPIO2, pin 25 | SPI1 SCS2 | PWM3 CAP2 | EXTBUS D23 |
| $V_{SS(IO)}$ | 18 | ground for I/O | | | |
| P5[19]/USB_D+ | 19[2] | GPIO5, pin 19 | USB_D+ | - | - |
| P5[18]/USB_D– | 20[2] | GPIO5, pin 18 | USB_D– | - | - |
| $V_{DD(IO)}$ | 21 | 3.3 V power supply for I/O | | | |
| $V_{DD(CORE)}$ | 22 | 1.8 V power supply for digital core | | | |
| $V_{SS(CORE)}$ | 23 | ground for core | | | |
| $V_{SS(IO)}$ | 24 | ground for I/O | | | |
| P3[8]/SCS2[0]/ PMAT1[2] | 25[1] | GPIO3, pin 8 | SPI2 SCS0 | PWM1 MAT2 | - |
| P3[9]/SDO2/ PMAT1[3] | 26[1] | GPIO3, pin 9 | SPI2 SDO | PWM1 MAT3 | - |
| P2[26]/CAP0[2]/ MAT0[2]/EI6 | 27[1] | GPIO2, pin 26 | TIMER0 CAP2 | TIMER0 MAT2 | EXTINT6 |
| P2[27]/CAP0[3]/ MAT0[3]/EI7 | 28[1] | GPIO2, pin 27 | TIMER0 CAP3 | TIMER0 MAT3 | EXTINT7 |
| P1[27]/CAP1[2]/ TRAP2/PMAT3[3] | 29[1] | GPIO1, pin 27 | TIMER1 CAP2, ADC2 EXT START | PWM TRAP2 | PWM3 MAT3 |
| P1[26]/PMAT2[0]/ TRAP3/PMAT3[2] | 30[1] | GPIO1, pin 26 | PWM2 MAT0 | PWM TRAP3 | PWM3 MAT2 |
| $V_{DD(IO)}$ | 31 | 3.3 V power supply for I/O | | | |
| P1[25]/PMAT1[0]/ USB_VBUS/ PMAT3[1] | 32[1] | GPIO1, pin 25 | PWM1 MAT0 | USB_VBUS | PWM3 MAT1 |
| P1[24]/PMAT0[0]/ $\overline{\text{USB_CONNECT}}$/ PMAT3[0] | 33[1] | GPIO1, pin 24 | PWM0 MAT0 | $\overline{\text{USB_CONNECT}}$ | PWM3 MAT0 |
| P1[23]/RXD0/ USB_SSPND/$\overline{\text{CS5}}$ | 34[1] | GPIO1, pin 23 | UART0 RXD | USB_SSPND | EXTBUS $\overline{\text{CS5}}$ |


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**Table 3. LQFP144 pin assignment** *...continued*

| Pin name | Pin | Description | | | |
|---|---|---|---|---|---|
| | | Function 0 (default) | Function 1 | Function 2 | Function 3 |
| P1[22]/TXD0/ USB_UP_LED/ CS4 | 35[1] | GPIO1, pin 22 | UART0 TXD | USB_UP_LED | EXTBUS CS4 |
| TMS | 36[1] | IEEE 1149.1 test mode select, pulled up internally | | | |
| TCK | 37[1] | IEEE 1149.1 test clock | | | |
| P1[21]/CAP3[3]/ CAP1[3]/D7 | 38[1] | GPIO1, pin 21 | TIMER3 CAP3 | TIMER1 CAP3, MSCSS PAUSE | EXTBUS D7 |
| P1[20]/CAP3[2]/ SCS0[1]/D6 | 39[1] | GPIO1, pin 20 | TIMER3 CAP2 | SPI0 SCS1 | EXTBUS D6 |
| P1[19]/CAP3[1]/ SCS0[2]/D5 | 40[1] | GPIO1, pin 19 | TIMER3 CAP1 | SPI0 SCS2 | EXTBUS D5 |
| P1[18]/CAP3[0]/ SDO0/D4 | 41[1] | GPIO1, pin 18 | TIMER3 CAP0 | SPI0 SDO | EXTBUS D4 |
| P1[17]/CAP2[3]/ SDI0/D3 | 42[1] | GPIO1, pin 17 | TIMER2 CAP3 | SPI0 SDI | EXTBUS D3 |
| $V_{SS(IO)}$ | 43 | ground for I/O | | | |
| P1[16]/CAP2[2]/ SCK0/D2 | 44[1] | GPIO1, pin 16 | TIMER2 CAP2 | SPI0 SCK | EXTBUS D2 |
| P2[0]/MAT2[0]/ TRAP3/D8 | 45[1] | GPIO2, pin 0 | TIMER2 MAT0 | PWM TRAP3 | EXTBUS D8 |
| P2[1]/MAT2[1]/ TRAP2/D9 | 46[1] | GPIO2, pin 1 | TIMER2 MAT1 | PWM TRAP2 | EXTBUS D9 |
| P3[10]/SDI2/ PMAT1[4] | 47[1] | GPIO3, pin 10 | SPI2 SDI | PWM1 MAT4 | - |
| P3[11]/SCK2/ PMAT1[5]/USB_LS | 48[1] | GPIO3, pin 11 | SPI2 SCK | PWM1 MAT5 | USB_LS |
| P1[15]/CAP2[1]/ SCS0[0]/D1 | 49[1] | GPIO1, pin 15 | TIMER2 CAP1 | SPI0 SCS0 | EXTBUS D1 |
| P1[14]/CAP2[0]/ SCS0[3]/D0 | 50[1] | GPIO1, pin 14 | TIMER2 CAP0 | SPI0 SCS3 | EXTBUS D0 |
| P1[13]/SCL1/ EI3/WE | 51[1] | GPIO1, pin 13 | EXTINT3 | I2C1 SCL | EXTBUS WE |
| P1[12]/SDA1/ EI2/OE | 52[1] | GPIO1, pin 12 | EXTINT2 | I2C1 SDA | EXTBUS OE |
| $V_{DD(IO)}$ | 53 | 3.3 V power supply for I/O | | | |
| P2[2]/MAT2[2]/ TRAP1/D10 | 54[1] | GPIO2, pin 2 | TIMER2 MAT2 | PWM TRAP1 | EXTBUS D10 |
| P2[3]/MAT2[3]/ TRAP0/D11 | 55[1] | GPIO2, pin 3 | TIMER2 MAT3 | PWM TRAP0 | EXTBUS D11 |
| P1[11]/SCK1/ SCL0/CS3 | 56[1] | GPIO1, pin 11 | SPI1 SCK | I2C0 SCL | EXTBUS CS3 |
| P1[10]/SDI1/ SDA0/CS2 | 57[1] | GPIO1, pin 10 | SPI1 SDI | I2C0 SDA | EXTBUS CS2 |
| P3[12]/SCS1[0]/EI4/ USB_SSPND | 58[1] | GPIO3, pin 12 | SPI1 SCS0 | EXTINT4 | USB_SSPND |


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**Table 3. LQFP144 pin assignment** *...continued*

| Pin name | Pin | Description | | | |
|---|---|---|---|---|---|
| | | Function 0 (default) | Function 1 | Function 2 | Function 3 |
| $V_{SS(CORE)}$ | 59 | ground for digital core | | | |
| $V_{DD(CORE)}$ | 60 | 1.8 V power supply for digital core | | | |
| P3[13]/SDO1/ EI5/IDX0 | 61[1] | GPIO3, pin 13 | SPI1 SDO | EXTINT5 | QEI0 IDX |
| P2[4]/MAT1[0]/ EI0/D12 | 62[1] | GPIO2, pin 4 | TIMER1 MAT0 | EXTINT0 | EXTBUS D12 |
| P2[5]/MAT1[1]/ EI1/D13 | 63[1] | GPIO2, pin 5 | TIMER1 MAT1 | EXTINT1 | EXTBUS D13 |
| P1[9]/SDO1/ RXDL1/$\overline{CS1}$ | 64[1] | GPIO1, pin 9 | SPI1 SDO | LIN1 RXD/UART RXD | EXTBUS $\overline{CS1}$ |
| $V_{SS(IO)}$ | 65 | ground for I/O | | | |
| P1[8]/SCS1[0]/ TXDL1/$\overline{CS0}$ | 66[1] | GPIO1, pin 8 | SPI1 SCS0 | LIN1 TXD/UART TXD | EXTBUS $\overline{CS0}$ |
| P1[7]/SCS1[3]/RXD1/ A7 | 67[1] | GPIO1, pin 7 | SPI1 SCS3 | UART1 RXD | EXTBUS A7 |
| P1[6]/SCS1[2]/ TXD1/A6 | 68[1] | GPIO1, pin 6 | SPI1 SCS2 | UART1 TXD | EXTBUS A6 |
| P2[6]/MAT1[2]/ EI2/D14 | 69[1] | GPIO2, pin 6 | TIMER1 MAT2 | EXTINT2 | EXTBUS D14 |
| P1[5]/SCS1[1]/PMAT 3[5]/A5 | 70[1] | GPIO1, pin 5 | SPI1 SCS1 | PWM3 MAT5 | EXTBUS A5 |
| P1[4]/SCS2[2]/PMAT 3[4]/A4 | 71[1] | GPIO1, pin 4 | SPI2 SCS2 | PWM3 MAT4 | EXTBUS A4 |
| $\overline{TRST}$ | 72[1] | IEEE 1149.1 test reset NOT; active LOW; pulled up internally | | | |
| $\overline{RST}$ | 73[1] | asynchronous device reset; active LOW; pulled up internally | | | |
| $V_{SS(OSC)}$ | 74 | ground for oscillator | | | |
| XOUT_OSC | 75[3] | crystal out for oscillator | | | |
| XIN_OSC | 76[3] | crystal in for oscillator | | | |
| $V_{DD(OSC_PLL)}$ | 77 | 1.8 V supply for oscillator and PLL | | | |
| $V_{SS(PLL)}$ | 78 | ground for PLL | | | |
| P2[7]/MAT1[3]/ EI3/D15 | 79[1] | GPIO2, pin 7 | TIMER1 MAT3 | EXTINT3 | EXTBUS D15 |
| P3[14]/SDI1/ EI6/TXDC0 | 80[1] | GPIO3, pin 14 | SPI1 SDI | EXTINT6 | CAN0 TXD |
| P3[15]/SCK1/ EI7/RXDC0 | 81[1] | GPIO3, pin 15 | SPI1 SCK | EXTINT7 | CAN0 RXD |
| $V_{DD(IO)}$ | 82 | 3.3 V power supply for I/O | | | |
| P2[8]/CLK_OUT/ PMAT0[0]/SCS0[2] | 83[1] | GPIO2, pin 8 | CLK_OUT | PWM0 MAT0 | SPI0 SCS2 |
| P2[9]/ $\overline{USB_UP_LED}$/ PMAT0[1]/ SCS0[1] | 84[1] | GPIO2, pin 9 | $\overline{USB_UP_LED}$ | PWM0 MAT1 | SPI0 SCS1 |


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**Table 3. LQFP144 pin assignment** *...continued*

| Pin name | Pin | Description | | | |
|---|---|---|---|---|---|
| | | Function 0 (default) | Function 1 | Function 2 | Function 3 |
| P1[3]/SCS2[1]/ PMAT3[3]/A3 | 85[1] | GPIO1, pin 3 | SPI2 SCS1 | PWM3 MAT3 | EXTBUS A3 |
| P1[2]/SCS2[3]/ PMAT3[2]/A2 | 86[1] | GPIO1, pin 2 | SPI2 SCS3 | PWM3 MAT2 | EXTBUS A2 |
| P1[1]/EI1/ PMAT3[1]/A1 | 87[1] | GPIO1, pin 1 | EXTINT1 | PWM3 MAT1 | EXTBUS A1 |
| $V_{SS(CORE)}$ | 88 | ground for digital core | | | |
| $V_{DD(CORE)}$ | 89 | 1.8 V power supply for digital core | | | |
| P1[0]/EI0/ PMAT3[0]/A0 | 90[1] | GPIO1, pin 0 | EXTINT0 | PWM3 MAT0 | EXTBUS A0 |
| P2[10]/ PMAT0[2]/ SCS0[0] | 91[1] | GPIO2, pin 10 | $\overline{\text{USB_INT}}$ | PWM0 MAT2 | SPI0 SCS0 |
| P2[11]/ PMAT0[3]/SCK0 | 92[1] | GPIO2, pin 11 | $\overline{\text{USB_RST}}$ | PWM0 MAT3 | SPI0 SCK |
| P0[0]/PHB0/ TXDC0/D24 | 93[1] | GPIO0, pin 0 | QEI0 PHB | CAN0 TXD | EXTBUS D24 |
| $V_{SS(IO)}$ | 94 | ground for I/O | | | |
| P0[1]/PHA0/ RXDC0/D25 | 95[1] | GPIO0, pin 1 | QEI 0 PHA | CAN0 RXD | EXTBUS D25 |
| P0[2]/CLK_OUT/ PMAT0[0]/D26 | 96[1] | GPIO0, pin 2 | CLK_OUT | PWM0 MAT0 | EXTBUS D26 |
| P0[3]/$\overline{\text{USB_UP_LED}}$/ PMAT0[1]/D27 | 97[1] | GPIO0, pin 3 | $\overline{\text{USB_UP_LED}}$ | PWM0 MAT1 | EXTBUS D27 |
| P3[0]/IN0[6]/ PMAT2[0]/$\overline{\text{CS6}}$ | 98[1] | GPIO3, pin 0 | ADC0 IN6 | PWM2 MAT0 | EXTBUS $\overline{\text{CS6}}$ |
| P3[1]/IN0[7/ PMAT2[1]/$\overline{\text{CS7}}$ | 99[1] | GPIO3, pin 1 | ADC0 IN7 | PWM2 MAT1 | EXTBUS $\overline{\text{CS7}}$ |
| P2[12]/IN0[4] PMAT0[4]/SDI0 | 100[1] | GPIO2, pin 12 | ADC0 IN4 | PWM0 MAT4 | SPI0 SDI |
| P2[13]/IN0[5] PMAT0[5]/SDO0 | 101[1] | GPIO2, pin 13 | ADC0 IN5 | PWM0 MAT5 | SPI0 SDO |
| P0[4]/IN0[0]/ PMAT0[2]/D28 | 102[1] | GPIO0, pin 4 | ADC0 IN0 | PWM0 MAT2 | EXTBUS D28 |
| P0[5]/IN0[1]/ PMAT0[3]/D29 | 103[1] | GPIO0, pin 5 | ADC0 IN1 | PWM0 MAT3 | EXTBUS D29 |
| $V_{DD(IO)}$ | 104 | 3.3 V power supply for I/O | | | |
| P0[6]/IN0[2]/ PMAT0[4]/D30 | 105[1] | GPIO0, pin 6 | ADC0 IN2 | PWM0 MAT4 | EXTBUS D30 |
| P0[7]/IN0[3]/ PMAT0[5]/D31 | 106[1] | GPIO0, pin 7 | ADC0 IN3 | PWM0 MAT5 | EXTBUS D31 |
| $V_{DDA(ADC3V3)}$ | 107 | 3.3 V power supply for ADC | | | |
| JTAGSEL | 108[1] | TAP controller select input; LOW-level selects the ARM debug mode; HIGH-level selects boundary scan; pulled up internally. | | | |


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**Table 3. LQFP144 pin assignment** *...continued*

| Pin name | Pin | Description | | | |
|---|---|---|---|---|---|
| | | Function 0 (default) | Function 1 | Function 2 | Function 3 |
| $V_{DDA(ADC5V0)}$ | 109 | 5 V supply voltage for ADC0 and 5 V reference for ADC0. | | | |
| VREFP | 110[3] | HIGH reference for ADC | | | |
| VREFN | 111[3] | LOW reference for ADC | | | |
| P0[8]/IN1[0]/TXDL0/ A20 | 112[4] | GPIO0, pin 8 | ADC1 IN0 | LIN0 TXD/UART TXD | EXTBUS A20 |
| P0[9]/IN1[1]/ RXDL0/A21 | 113[4] | GPIO0, pin 9 | ADC1 IN1 | LIN0 RXD/UART TXD | EXTBUS A21 |
| P0[10]/IN1[2]/ PMAT1[0]/A8 | 114[4] | GPIO0, pin 10 | ADC1 IN2 | PWM1 MAT0 | EXTBUS A8 |
| P0[11]/IN1[3]/ PMAT1[1]/A9 | 115[4] | GPIO0, pin 11 | ADC1 IN3 | PWM1 MAT1 | EXTBUS A9 |
| P2[14]/SDA1/ PCAP0[0]/$\overline{BLS0}$ | 116[1] | GPIO2, pin 14 | I2C1 SDA | PWM0 CAP0 | EXTBUS $\overline{BLS0}$ |
| P2[15]/SCL1/ PCAP0[1]/$\overline{BLS1}$ | 117[1] | GPIO2, pin 15 | I2C1 SCL | PWM0 CAP1 | EXTBUS $\overline{BLS1}$ |
| P3[2]/MAT3[0]/ PMAT2[2]/ USB_SDA | 118[1] | GPIO3, pin 2 | TIMER3 MAT0 | PWM2 MAT2 | USB_SDA |
| $V_{SS(IO)}$ | 119 | ground for I/O | | | |
| P3[3]/MAT3[1]/ PMAT2[3]/ USB_SCL | 120[1] | GPIO3, pin 3 | TIMER3 MAT1 | PWM2 MAT3 | USB_SCL |
| P0[12]/IN1[4]/ PMAT1[2]/A10 | 121[4] | GPIO0, pin 12 | ADC1 IN4 | PWM1 MAT2 | EXTBUS A10 |
| P0[13]/IN1[5]/ PMAT1[3]/A11 | 122[4] | GPIO0, pin 13 | ADC1 IN5 | PWM1 MAT3 | EXTBUS A11 |
| P0[14]/IN1[6]/ PMAT1[4]/A12 | 123[4] | GPIO0, pin 14 | ADC1 IN6 | PWM1 MAT4 | EXTBUS A12 |
| P0[15]/IN1[7]/ PMAT1[5]/A13 | 124[4] | GPIO0, pin 15 | ADC1 IN7 | PWM1 MAT5 | EXTBUS A13 |
| P0[16]IN2[0]/ TXD0/A22 | 125[4] | GPIO0, pin 16 | ADC2 IN0 | UART0 TXD | EXTBUS A22 |
| P0[17]/IN2[1]/ RXD0/A23 | 126[4] | GPIO0, pin 17 | ADC2 IN1 | UART0 RXD | EXTBUS A23 |
| $V_{DD(CORE)}$ | 127 | 1.8 V power supply for digital core | | | |
| $V_{SS(CORE)}$ | 128 | ground for digital core | | | |
| P2[16]/TXD1/ PCAP0[2]/$\overline{BLS2}$ | 129[1] | GPIO2, pin 16 | UART1 TXD | PWM0 CAP2 | EXTBUS $\overline{BLS2}$ |
| P2[17]/RXD1/ PCAP1[0]/$\overline{BLS3}$ | 130[1] | GPIO2, pin 17 | UART1 RXD | PWM1 CAP0 | EXTBUS $\overline{BLS3}$ |
| $V_{DD(IO)}$ | 131 | 3.3 V power supply for I/O | | | |
| P0[18]/IN2[2]/ PMAT2[0]/A14 | 132[4] | GPIO0, pin 18 | ADC2 IN2 | PWM2 MAT0 | EXTBUS A14 |


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**Table 3. LQFP144 pin assignment** *...continued*

| Pin name | Pin | Description | | | |
|---|---|---|---|---|---|
| | | Function 0 (default) | Function 1 | Function 2 | Function 3 |
| P0[19]/IN2[3]/ PMAT2[1]/A15 | 133[4] | GPIO0, pin 19 | ADC2 IN3 | PWM2 MAT1 | EXTBUS A15 |
| P3[4]/MAT3[2]/ PMAT2[4]/TXDC1 | 134[1] | GPIO3, pin 4 | TIMER3 MAT2 | PWM2 MAT4 | CAN1 TXD |
| P3[5]/MAT3[3]/ PMAT2[5]/RXDC1 | 135[1] | GPIO3, pin 5 | TIMER3 MAT3 | PWM2 MAT5 | CAN1 RXD |
| P2[18]/SCS2[1]/ PCAP1[1]/D16 | 136[1] | GPIO2, pin 18 | SPI2 SCS1 | PWM1 CAP1 | EXTBUS D16 |
| P2[19]/SCS2[0]/ PCAP1[2]/D17 | 137[1] | GPIO2, pin 19 | SPI2 SCS0 | PWM1 CAP2 | EXTBUS D17 |
| P0[20]/IN2[4]/ PMAT2[2]/A16 | 138[4] | GPIO0, pin 20 | ADC2 IN4 | PWM2 MAT2 | EXTBUS A16 |
| P0[21]/IN2[5]/ PMAT2[3]/A17 | 139[4] | GPIO0, pin 21 | ADC2 IN5 | PWM2 MAT3 | EXTBUS A17 |
| P0[22]/IN2[6]/ PMAT2[4]/A18 | 140[4] | GPIO0, pin 22 | ADC2 IN6 | PWM2 MAT4 | EXTBUS A18 |
| $V_{SS(IO)}$ | 141 | ground for I/O | | | |
| P0[23]/IN2[7]/ PMAT2[5]/A19 | 142[4] | GPIO0, pin 23 | ADC2 IN7 | PWM2 MAT5 | EXTBUS A19 |
| P2[20]/ PCAP2[0]/D18 | 143[1] | GPIO2, pin 20 | SPI2 SDO | PWM2 CAP0 | EXTBUS D18 |
| TDI | 144[1] | IEEE 1149.1 data in, pulled up internally | | | |

[1] Bidirectional pad; analog port; plain input; 3-state output; slew rate control; 5 V tolerant; TTL with hysteresis; programmable pull-up/pull-down/repeater.

[2] USB pad.

[3] Analog pad; analog I/O.

[4] Analog I/O pad.

# 6. Functional description

## 6.1 Architectural overview

The LPC2926/2927/2929 consists of:

- An ARM968E-S processor with real-time emulation support
- An AMBA multi-layer Advanced High-performance Bus (AHB) for interfacing to the on-chip memory controllers
- Two DTL buses (an universal NXP interface) for interfacing to the interrupt controller and the Power, Clock and Reset Control cluster (also called subsystem).
- Three ARM Peripheral Buses (APB - a compatible superset of ARM's AMBA advanced peripheral bus) for connection to on-chip peripherals clustered in subsystems.
- One ARM Peripheral Bus for event router and system control.


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The LPC2926/2927/2929 configures the ARM968E-S processor in little-endian byte order. All peripherals run at their own clock frequency to optimize the total system power consumption. The AHB-to-APB bridge used in the subsystems contains a write-ahead buffer one transaction deep. This implies that when the ARM968E-S issues a buffered write action to a register located on the APB side of the bridge, it continues even though the actual write may not yet have taken place. Completion of a second write to the same subsystem will not be executed until the first write is finished.

## 6.2 ARM968E-S processor

The ARM968E-S is a general purpose 32-bit RISC processor, 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 (CISC). This simplicity results in a high instruction throughput and impressive real-time interrupt response from a small and cost-effective controller core.

Amongst the most compelling features of the ARM968E-S are:

- Separate directly connected instruction and data Tightly Coupled Memory (TCM) interfaces
- Write buffers for the AHB and TCM buses
- Enhanced 16 $\times$ 32 multiplier capable of single-cycle MAC operations and 16-bit fixed-point DSP instructions to accelerate signal-processing algorithms and applications.

Pipeline techniques are employed so that all parts of the processing and memory systems can operate continuously. The ARM968E-S is based on the ARMv5TE five-stage pipeline architecture. Typically, in a three-stage pipeline architecture, while one instruction is being executed its successor is being decoded and a third instruction is being fetched from memory. In the five-stage pipeline additional stages are added for memory access and write-back cycles.

The ARM968E-S processor also employs a unique architectural strategy known as THUMB, which makes it ideally suited to high-volume applications with memory restrictions or to applications where code density is an issue.

The key idea behind THUMB is that of a super-reduced instruction set. Essentially, the ARM968E-S processor has two instruction sets:

- Standard 32-bit ARMv5TE set
- 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 controller using 16-bit registers. This is possible because THUMB code operates on the same 32-bit register set as ARM code.

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

The ARM968E-S processor is described in detail in the ARM968E-S data sheet Ref. 2.


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## 6.3 On-chip flash memory system

The LPC2926/2927/2929 includes a 256 kB, 512 kB or 768 kB flash memory system. This memory can be used for both code and data storage. Programming of the flash memory can be accomplished via the flash memory controller or the JTAG.

The flash controller also supports a 16 kB, byte-accessible on-chip EEPROM integrated on the LPC2926/2927/2929.

## 6.4 On-chip static RAM

In addition to the two 32 kB TCMs the LPC2926/2927/2929 includes two static RAM memories: one of 32 kB and one of 16 kB. Both may be used for code and/or data storage.

In addition, 8 kB SRAM for the ETB can be used as static memory for code and data storage. However, DMA access to this memory region is not supported.


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## 6.5 Memory map

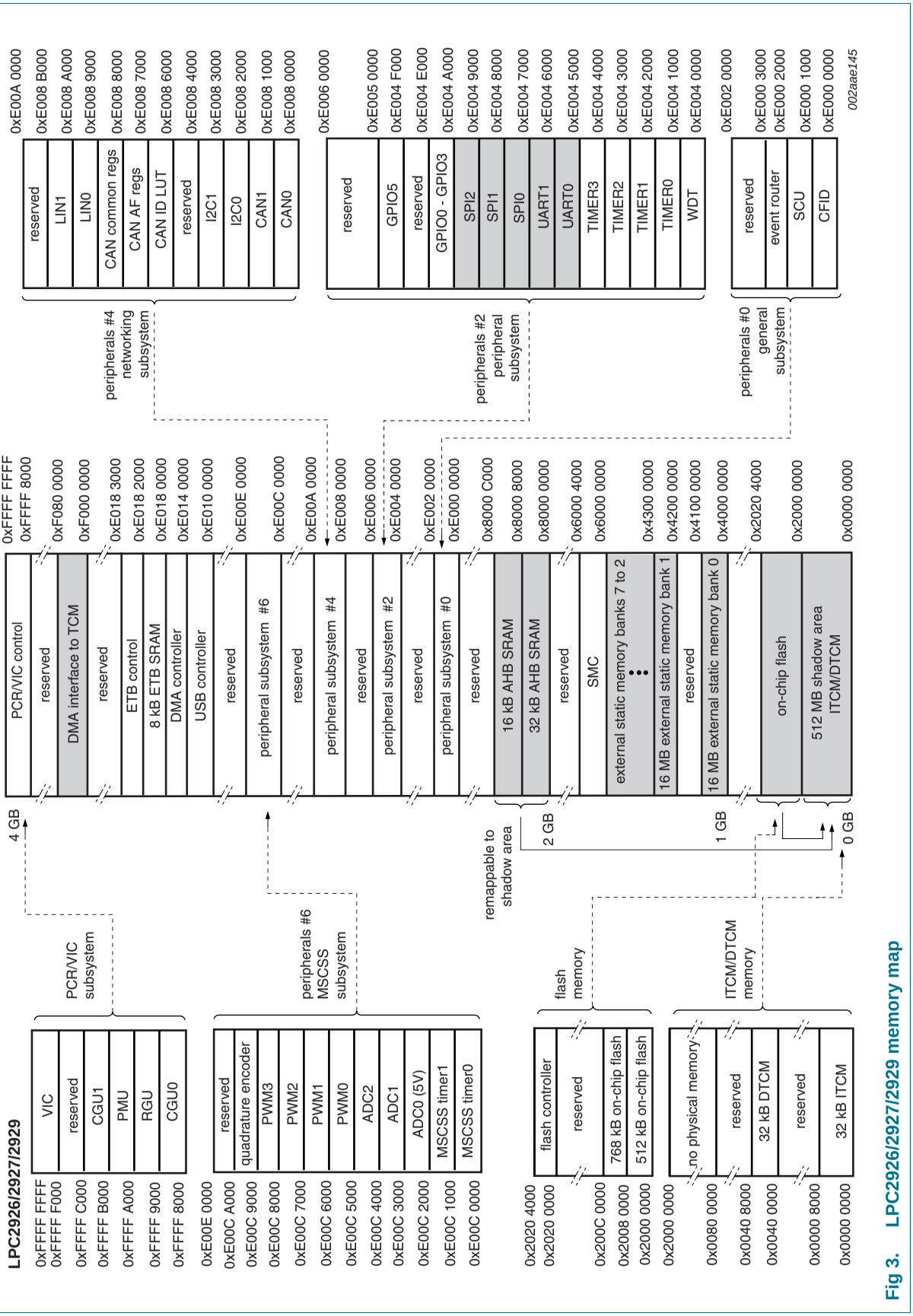


**Fig 3. LPC2926/2927/2929 memory map**


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## 6.6 Reset, debug, test, and power description

### 6.6.1 Reset and power-up behavior

The LPC2926/2927/2929 contains external reset input and internal power-up reset circuits. This ensures that a reset is extended internally until the oscillators and flash have reached a stable state. See Section 8 for trip levels of the internal power-up reset circuit[1]. See Section 9 for characteristics of the several start-up and initialization times. Table 4 shows the reset pin.

**Table 4. Reset pin**

| Symbol | Direction | Description |
|---|---|---|
| $\overline{\text{RST}}$ | IN | external reset input, active LOW; pulled up internally |

At activation of the $\overline{\text{RST}}$ pin the JTAGSEL pin is sensed as logic LOW. If this is the case the LPC2926/2927/2929 is assumed to be connected to debug hardware, and internal circuits re-program the source for the BASE_SYS_CLK to be the crystal oscillator instead of the Low-Power Ring Oscillator (LP_OSC). This is required because the clock rate when running at LP_OSC speed is too low for the external debugging environment.

### 6.6.2 Reset strategy

The LPC2926/2927/2929 contains a central module, the Reset Generator Unit (RGU) in the Power, Clock and Reset Subsystem (PCRSS), which controls all internal reset signals towards the peripheral modules. The RGU provides individual reset control as well as the monitoring functions needed for tracing a reset back to source.

### 6.6.3 IEEE 1149.1 interface pins (JTAG boundary scan test)

The LPC2926/2927/2929 contains boundary-scan test logic according to IEEE 1149.1, also referred to in this document as Joint Test Action Group (JTAG). The boundary-scan test pins can be used to connect a debugger probe for the embedded ARM processor. Pin JTAGSEL selects between boundary-scan mode and debug mode. Table 5 shows the boundary scan test pins.

**Table 5. IEEE 1149.1 boundary-scan test and debug interface**

| Symbol | Description |
|---|---|
| JTAGSEL | TAP controller select input. LOW level selects ARM debug mode and HIGH level selects boundary scan and flash programming; pulled up internally |
| $\overline{\text{TRST}}$ | test reset input; pulled up internally (active LOW) |
| TMS | test mode select input; pulled up internally |
| TDI | test data input, pulled up internally |
| TDO | test data output |
| TCK | test clock input |

1. Only for 1.8 V power sources


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#### 6.6.3.1 ETM/ETB

The ETM provides real-time trace capability for deeply embedded processor cores. It outputs information about processor execution to a trace buffer. A software debugger allows configuration of the ETM using a JTAG interface and displays the trace information that has been captured in a format that a user can easily understand. The ETB stores trace data produced by the ETM.

The ETM/ETB module has the following features:

- Closely tracks the instructions that the ARM core is executing.
- On-chip trace data storage (ETB).
- All registers are programmed through JTAG interface.
- Does not consume power when trace is not being used.
- THUMB/Java instruction set support.

### 6.6.4 Power supply pins

Table 6 shows the power supply pins.

**Table 6. Power supply pins**

| Symbol | Description |
|---|---|
| $V_{DD(CORE)}$ | digital core supply 1.8 V |
| $V_{SS(CORE)}$ | digital core ground (digital core, ADC0/1/2) |
| $V_{DD(IO)}$ | I/O pins supply 3.3 V |
| $V_{SS(IO)}$ | I/O pins ground |
| $V_{DD(OSC_PLL)}$ | oscillator and PLL supply |
| $V_{SS(OSC)}$ | oscillator ground |
| $V_{SS(PLL)}$ | PLL ground |
| $V_{DDA(ADC3V3)}$ | ADC1 and ADC2 3.3 V supply |
| $V_{DDA(ADC5V0)}$ | ADC0 5.0 V supply |

## 6.7 Clocking strategy

### 6.7.1 Clock architecture

The LPC2926/2927/2929 contains several different internal clock areas. Peripherals like Timers, SPI, UART, CAN and LIN have their own individual clock sources called base clocks. All base clocks are generated by the Clock Generator Unit (CGU0). They may be unrelated in frequency and phase and can have different clock sources within the CGU.

The system clock for the CPU and AHB Bus infrastructure has its own base clock. This means most peripherals are clocked independently from the system clock. See Figure 4 for an overview of the clock areas within the device.

Within each clock area there may be multiple branch clocks, which offers very flexible control for power-management purposes. All branch clocks are outputs of the Power Management Unit (PMU) and can be controlled independently. Branch clocks derived from the same base clock are synchronous in frequency and phase. See Section 6.16 for more details of clock and power control within the device.


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Two of the base clocks generated by the CGU0 are used as input into a second, dedicated CGU (CGU1). The CGU1 uses its own PLL and fractional dividers to generate two base clocks for the USB controller and one base clock for an independent clock output.

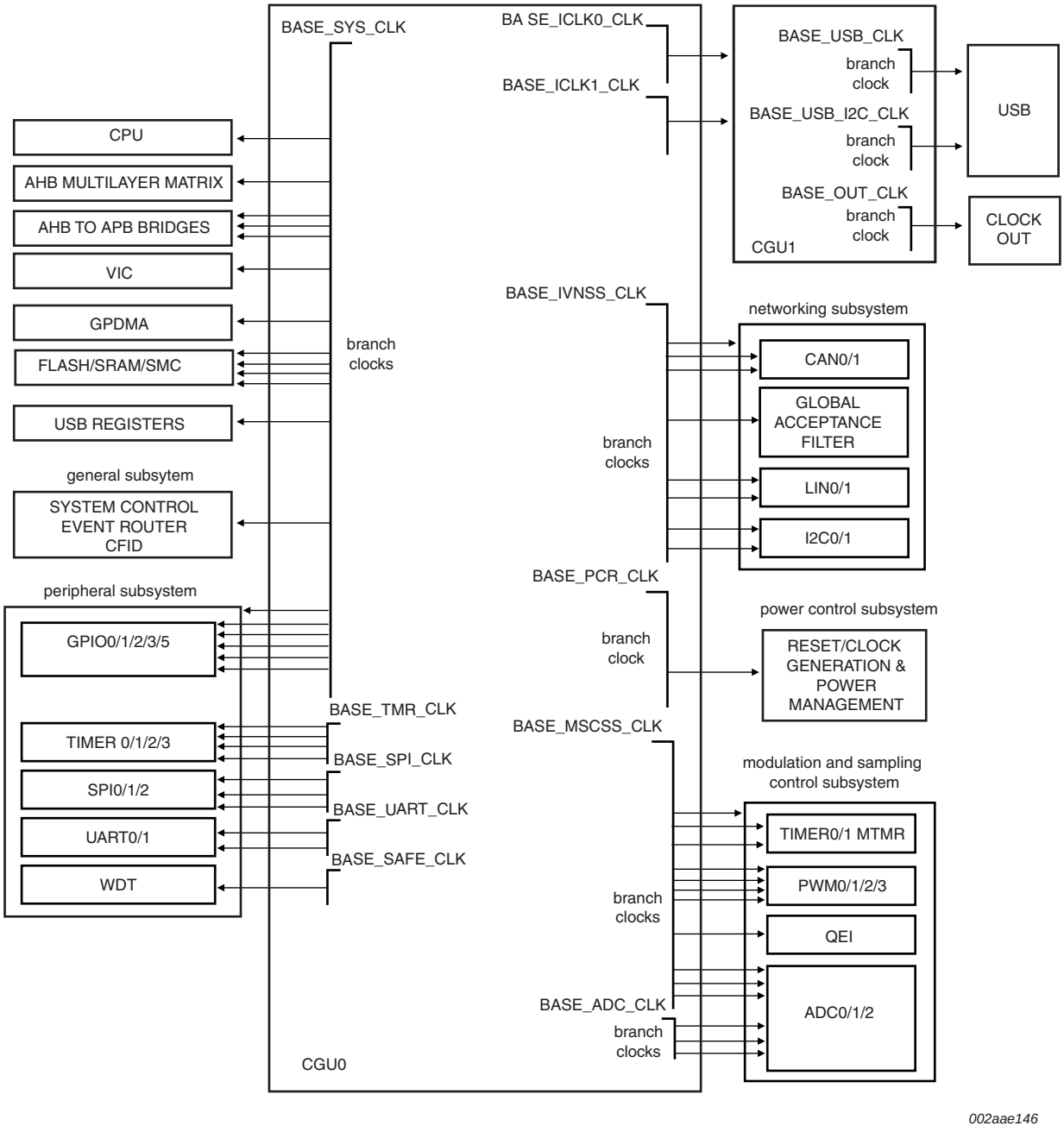


**Fig 4. LPC2926/2927/2929 overview of clock areas**


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### 6.7.2 Base clock and branch clock relationship

Table 7 contains an overview of all the base blocks in the LPC2926/2927/2929 and their derived branch clocks. A short description is given of the hardware parts that are clocked with the individual branch clocks. In relevant cases more detailed information can be found in the specific subsystem description. Some branch clocks have special protection since they clock vital system parts of the device and should not be switched off. See Section 6.16.5 for more details of how to control the individual branch clocks.

**Table 7. CGU0 base clock and branch clock overview**

| Base clock | Branch clock name | Parts of the device clocked by this branch clock | Remark |
|---|---|---|---|
| BASE_SAFE_CLK | CLK_SAFE | watchdog timer | [1] |
| BASE_SYS_CLK | CLK_SYS_CPU | ARM968E-S and TCMs | |
| | CLK_SYS_SYS | AHB bus infrastructure | |
| | CLK_SYS_PCRSS | AHB side of bridge in PCRSS | |
| | CLK_SYS_FMC | Flash Memory Controller | |
| | CLK_SYS_RAM0 | Embedded SRAM Controller 0 (32 kB) | |
| | CLK_SYS_RAM1 | Embedded SRAM Controller 1 (16 kB) | |
| | CLK_SYS_SMC | External Static Memory Controller | |
| | CLK_SYS_GESS | General Subsystem | |
| | CLK_SYS_VIC | Vectored Interrupt Controller | |
| | CLK_SYS_PESS | Peripheral Subsystem | [2][3] |
| | CLK_SYS_GPIO0 | GPIO bank 0 | |
| | CLK_SYS_GPIO1 | GPIO bank 1 | |
| | CLK_SYS_GPIO2 | GPIO bank 2 | |
| | CLK_SYS_GPIO3 | GPIO bank 3 | |
| | CLK_SYS_GPIO5 | GPIO bank 5 | |
| | CLK_SYS_IVNSS_A | AHB side of bridge of IVNSS | |
| | CLK_SYS_MSCSS_A | AHB side of bridge of MSCSS | |
| | CLK_SYS_DMA | GPDMA | |
| | CLK_SYS_USB | USB registers | |
| BASE_PCR_CLK | CLK_PCR_SLOW | PCRSS, CGU, RGU and PMU logic clock | [1][4] |
| BASE_IVNSS_CLK | CLK_IVNSS_APB | APB side of the IVNSS | |
| | CLK_IVNSS_CANCA | CAN controller Acceptance Filter | |
| | CLK_IVNSS_CANC0 | CAN channel 0 | |
| | CLK_IVNSS_CANC1 | CAN channel 1 | |
| | CLK_IVNSS_I2C0 | I2C0 | |
| | CLK_IVNSS_I2C1 | I2C1 | |
| | CLK_IVNSS_LIN0 | LIN channel 0 | |
| | CLK_IVNSS_LIN1 | LIN channel 1 | |


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**Table 7. CGU0 base clock and branch clock overview** *...continued*

| Base clock | Branch clock name | Parts of the device clocked by this branch clock | Remark |
|---|---|---|---|
| BASE_MSCSS_CLK | CLK_MSCSS_APB | APB side of the MSCSS | |
| | CLK_MSCSS_MTMR0 | Timer 0 in the MSCSS | |
| | CLK_MSCSS_MTMR1 | Timer 1 in the MSCSS | |
| | CLK_MSCSS_PWM0 | PWM 0 | |
| | CLK_MSCSS_PWM1 | PWM 1 | |
| | CLK_MSCSS_PWM2 | PWM 2 | |
| | CLK_MSCSS_PWM3 | PWM 3 | |
| | CLK_MSCSS_ADC0_APB | APB side of ADC 0 | |
| | CLK_MSCSS_ADC1_APB | APB side of ADC 1 | |
| | CLK_MSCSS_ADC2_APB | APB side of ADC 2 | |
| | CLK_MSCSS_QEI | Quadrature encoder | |
| BASE_UART_CLK | CLK_UART0 | UART 0 interface clock | |
| | CLK_UART1 | UART 1 interface clock | |
| BASE_ICLK0_CLK | - | CGU1 input clock | |
| BASE_SPI_CLK | CLK_SPI0 | SPI 0 interface clock | |
| | CLK_SPI1 | SPI 1 interface clock | |
| | CLK_SPI2 | SPI 2 interface clock | |
| BASE_TMR_CLK | CLK_TMR0 | Timer 0 clock for counter part | |
| | CLK_TMR1 | Timer 1 clock for counter part | |
| | CLK_TMR2 | Timer 2 clock for counter part | |
| | CLK_TMR3 | Timer 3 clock for counter part | |
| BASE_ADC_CLK | CLK_ADC0 | Control of ADC 0, capture sample result | |
| | CLK_ADC1 | Control of ADC 1, capture sample result | |
| | CLK_ADC2 | Control of ADC 2, capture sample result | |
| reserved | - | - | |
| BASE_ICLK1_CLK | - | CGU1 input clock | |

[1] This clock is always on (cannot be switched off for system safety reasons).

[2] In the peripheral subsystem parts of the timers, watchdog timer, SPI and UART have their own clock source. See Section 6.13 for details.

[3] The clock should remain activated when system wake-up on timer or UART is required.

[4] In the Power Clock and Reset Control subsystem parts of the CGU, RGU, and PMU have their own clock source. See Section 6.16 for details.

**Table 8. CGU1 base clock and branch clock overview**

| Base clock | Branch clock name | Parts of the device clocked by this branch clock | Remark |
|---|---|---|---|
| BASE_OUT_CLK | CLK_OUT_CLK | clock out pin | |
| BASE_USB_CLK | CLK_USB_CLK | USB clock | |
| BASE_USB_I2C_CLK | CLK_USB_I2C_CLK | USB OTG I2C clock | |


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## 6.8 Flash memory controller

The flash memory has a 128-bit wide data interface and the flash controller offers two 128-bit buffer lines to improve system performance. The flash has to be programmed initially via JTAG. In-system programming must be supported by the bootloader. Flash memory contents can be protected by disabling JTAG access. Suspension of burning or erasing is not supported.

The Flash Memory Controller (FMC) interfaces to the embedded flash memory for two tasks:

- Memory data transfer
- Memory configuration via triggering, programming, and erasing

The key features are:

- Programming by CPU via AHB
- Programming by external programmer via JTAG
- JTAG access protection
- Burn-finished and erase-finished interrupt

### 6.8.1 Functional description

After reset, flash initialization is started, which takes $t_{init}$ time (see Section 9). During this initialization, flash access is not possible and AHB transfers to flash are stalled, blocking the AHB bus.

During flash initialization, the index sector is read to identify the status of the JTAG access protection and sector security. If JTAG access protection is active, the flash is not accessible via JTAG. In this case, ARM debug facilities are disabled and flash memory contents cannot be read. If sector security is active, only the unsecured sections can be read.

Flash can be read synchronously or asynchronously to the system clock. In synchronous operation, the flash goes into standby after returning the read data. Started reads cannot be stopped, and speculative reading and dual buffering are therefore not supported.

With asynchronous reading, transfer of the address to the flash and of read data from the flash is done asynchronously, giving the fastest possible response time. Started reads can be stopped, so speculative reading and dual buffering are supported.

Buffering is offered because the flash has a 128-bit wide data interface while the AHB interface has only 32 bits. With buffering a buffer line holds the complete 128-bit flash word, from which four words can be read. Without buffering every AHB data port read starts a flash read. A flash read is a slow process compared to the minimum AHB cycle time, so with buffering the average read time is reduced. This can improve system performance.

With single buffering, the most recently read flash word remains available until the next flash read. When an AHB data-port read transfer requires data from the same flash word as the previous read transfer, no new flash read is done and the read data is given without wait cycles.


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When an AHB data port read transfer requires data from a different flash word to that involved in the previous read transfer, a new flash read is done and wait states are given until the new read data is available.

With dual buffering, a secondary buffer line is used, the output of the flash being considered as the primary buffer. On a primary buffer, hit data can be copied to the secondary buffer line, which allows the flash to start a speculative read of the next flash word.

Both buffer lines are invalidated after:

- Initialization
- Configuration-register access
- Data-latch reading
- Index-sector reading

The modes of operation are listed in Table 9.

**Table 9. Flash read modes**

| | |
|---|---|
| **Synchronous timing** | |
| No buffer line | for single (non-linear) reads; one flash-word read per word read |
| Single buffer line | default mode of operation; most recently read flash word is kept until another flash word is required |
| **Asynchronous timing** | |
| No buffer line | one flash-word read per word read |
| Single buffer line | most recently read flash word is kept until another flash word is required |
| Dual buffer line, single speculative | on a buffer miss a flash read is done, followed by at most one speculative read; optimized for execution of code with small loops (less than eight words) from flash |
| Dual buffer line, always speculative | most recently used flash word is copied into second buffer line; next flash-word read is started; highest performance for linear reads |

### 6.8.2 Pin description

The flash memory controller has no external pins. However, the flash can be programmed via the JTAG pins, see Section 6.6.3.

### 6.8.3 Clock description

The flash memory controller is clocked by CLK_SYS_FMC, see Section 6.7.2.

### 6.8.4 Flash layout

The ARM processor can program the flash for ISP (In-System Programming) through the flash memory controller. Note that the flash always has to be programmed by ‘flash words’ of 128 bits (four 32-bit AHB bus words, hence 16 bytes).

The flash memory is organized into eight ‘small’ sectors of 8 kB each and up to 11 ‘large’ sectors of 64 kB each. The number of large sectors depends on the device type. A sector must be erased before data can be written to it. The flash memory also has sector-wise protection. Writing occurs per page which consists of 4096 bits (32 flash words). A small sector contains 16 pages; a large sector contains 128 pages.


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Table 10 gives an overview of the flash-sector base addresses.

**Table 10. Flash sector overview**

| Sector number | Sector size (kB) | Sector base address |
|---|---|---|
| 11 | 8 | 0x2000 0000 |
| 12 | 8 | 0x2000 2000 |
| 13 | 8 | 0x2000 4000 |
| 14 | 8 | 0x2000 6000 |
| 15 | 8 | 0x2000 8000 |
| 16 | 8 | 0x2000 A000 |
| 17 | 8 | 0x2000 C000 |
| 18 | 8 | 0x2000 E000 |
| 0 | 64 | 0x2001 0000 |
| 1 | 64 | 0x2002 0000 |
| 2 | 64 | 0x2003 0000 |
| 3[1] | 64 | 0x2004 0000 |
| 4[1] | 64 | 0x2005 0000 |
| 5[1] | 64 | 0x2006 0000 |
| 6[1] | 64 | 0x2007 0000 |
| 7[1] | 64 | 0x2008 0000 |
| 8[1] | 64 | 0x2009 0000 |
| 9[1] | 64 | 0x200A 0000 |
| 10[1] | 64 | 0x200B 0000 |

[1] Availability of sector 3 to sector 10 depends on device type, see Section 3 “Ordering information”.

The index sector is a special sector in which the JTAG access protection and sector security are located. The address space becomes visible by setting the FS_ISS bit and overlaps the regular flash sector’s address space.

Note that the index sector, once programmed, cannot be erased. Any flash operation must be executed out of SRAM (internal or external).

### 6.8.5 Flash bridge wait-states

To eliminate the delay associated with synchronizing flash-read data, a predefined number of wait-states must be programmed. These depend on flash memory response time and system clock period. The minimum wait-states value can be calculated with the following formulas:

Synchronous reading:

$$WST > \frac{t_{acc(clk)}}{t_{t_{tclk(sys)}}} - 1 \quad (1)$$

Asynchronous reading:

$$WST > \frac{t_{acc(addr)}}{t_{tclk(sys)}} - 1 \quad (2)$$


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**Remark:** If the programmed number of wait-states is more than three, flash-data reading cannot be performed at full speed (i.e. with zero wait-states at the AHB bus) if speculative reading is active.

### 6.8.6 EEPROM

EEPROM is a non-volatile memory mostly used for storing relatively small amounts of data, for example for storing settings. It contains one 16 kB memory block and is byte-programmable and byte-erasable.

The EEPROM can be accessed only through the flash controller.

## 6.9 External static memory controller

The LPC2926/2927/2929 contains an external Static Memory Controller (SMC) which provides an interface for external (off-chip) memory devices.

Key features are:

- Supports static memory-mapped devices including RAM, ROM, flash, burst ROM and external I/O devices
- Asynchronous page-mode read operation in non-clocked memory subsystems
- Asynchronous burst-mode read access to burst-mode ROM devices
- Independent configuration for up to eight banks, each up to 16 MB
- Programmable bus-turnaround (idle) cycles (one to 16)
- Programmable read and write wait states (up to 32), for static RAM devices
- Programmable initial and subsequent burst-read wait state for burst-ROM devices
- Programmable write protection
- Programmable burst-mode operation
- Programmable external data width: 8 bits, 16 bits or 32 bits
- Programmable read-byte lane enable control

### 6.9.1 Description

The SMC simultaneously supports up to eight independently configurable memory banks. Each memory bank can be 8 bits, 16 bits or 32 bits wide and is capable of supporting SRAM, ROM, burst-ROM memory, or external I/O devices.

A separate chip select output is available for each bank. The chip select lines are configurable to be active HIGH or LOW. Memory-bank selection is controlled by memory addressing. Table 11 shows how the 32-bit system address is mapped to the external bus memory base addresses, chip selects, and bank internal addresses.


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**Table 11. External memory-bank address bit description**

| 32-bit system address bit field | Symbol | Description |
|---|---|---|
| 31 to 29 | BA[2:0] | external static-memory base address (three most significant bits); the base address can be found in the memory map; see Ref. 1. This field contains '010' when addressing an external memory bank. |
| 28 to 26 | CS[2:0] | chip select address space for eight memory banks; see Ref. 1. |
| 25 and 24 | - | always '00'; other values are 'mirrors' of the 16 MB bank address. |
| 23 to 0 | A[23:0] | 16 MB memory banks address space |

**Table 12. External static-memory controller banks**

| CS[2:0] | Bank |
|---|---|
| 000 | bank 0 |
| 001 | bank 1 |
| 010 | bank 2 |
| 011 | bank 3 |
| 100 | bank 4 |
| 101 | bank 5 |
| 110 | bank 6 |
| 111 | bank 7 |

### 6.9.2 Pin description

The external static-memory controller module in the LPC2926/2927/2929 has the following pins, which are combined with other functions on the port pins of the LPC2926/2927/2929. Table 13 shows the external memory controller pins.

**Table 13. External memory controller pins**

| Symbol | Pin name | Direction | Description |
|---|---|---|---|
| EXTBUS $\overline{CSx}$ | CSx | OUT | memory-bank x select, x runs from 0 to 7 |
| EXTBUS $\overline{BLSy}$ | $\overline{BLSy}$ | OUT | byte-lane select input y, y runs from 0 to 3 |
| EXTBUS $\overline{WE}$ | $\overline{WE}$ | OUT | write enable (active LOW) |
| EXTBUS $\overline{OE}$ | OE | OUT | output enable (active LOW) |
| EXTBUS A[23:0] | A[23:0] | OUT | address bus |
| EXTBUS D[31:0] | D[31:0] | IN/OUT | data bus |

### 6.9.3 Clock description

The External Static Memory Controller is clocked by CLK_SYS_SMC, see Section 6.7.2.

### 6.9.4 External memory timing diagrams

A timing diagram for reading from external memory is shown in Figure 5. The relationship between the wait-state settings is indicated with arrows.


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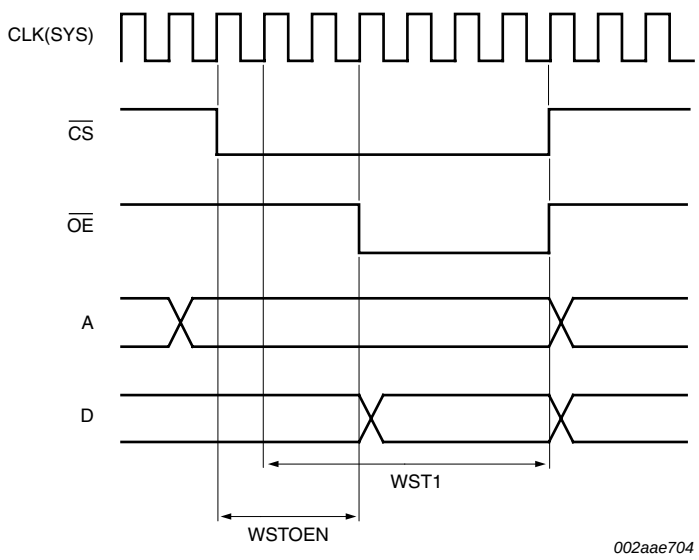
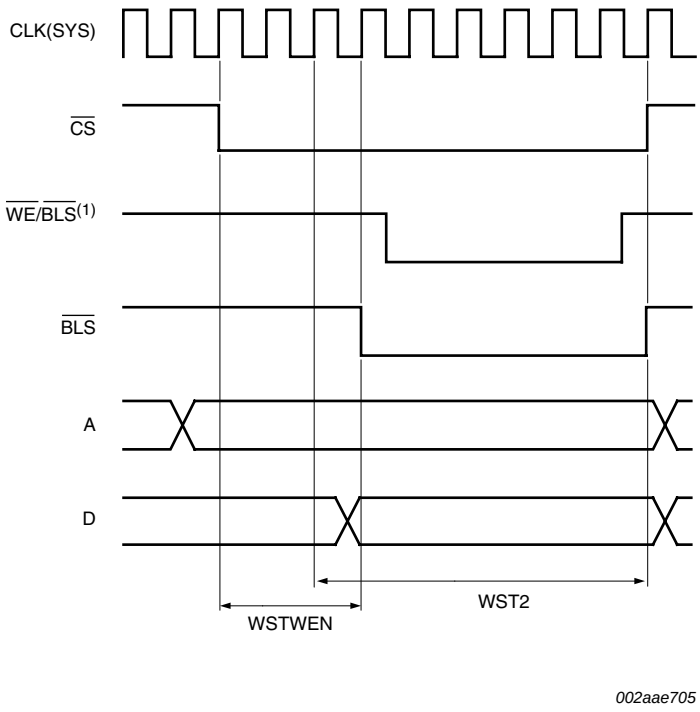



WSTOEN = 3, WST1 = 6

**Fig 5. Reading from external memory**

A timing diagram for writing to external memory is shown In Figure 6. The relationship between wait-state settings is indicated with arrows.




WSTWEN = 3, WST2 = 7

(1) $\overline{BLS}$ has the same timing as $\overline{WE}$ in configurations that use the byte lane enable signals to connect to write enable (8 bit devices).

**Fig 6. Writing to external memory**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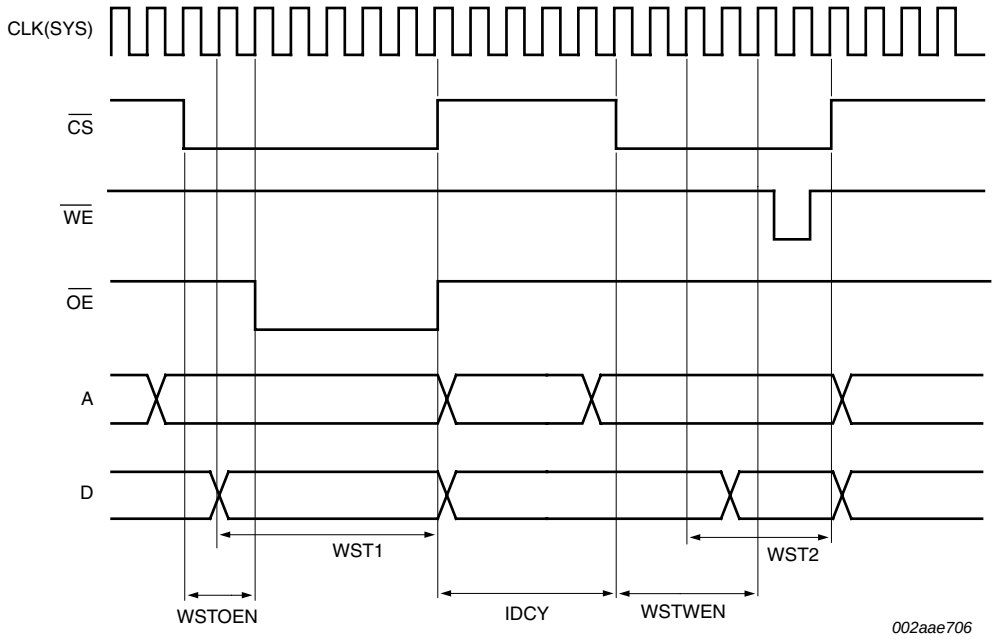
Usage of the idle/turn-around time (IDCY) is demonstrated In Figure 7. Extra wait states are added between a read and a write cycle in the same external memory device.




WSTOEN = 2, WSTWEN = 4, WST1 = 6, WST2 = 4, IDCY = 5

**Fig 7. Reading/writing external memory**

Address pins on the device are shared with other functions. When connecting external memories, check that the I/O pin is programmed for the correct function. Control of these settings is handled by the SCU.

## 6.10 General Purpose DMA (GPDMA) controller

The GPDMA controller allows peripheral-to memory, memory-to-peripheral, peripheral-to-peripheral, and memory-to-memory transactions. Each DMA stream provides unidirectional serial DMA transfers for a single source and destination. For example, a bidirectional port requires one stream for transmit and one for receives. The source and destination areas can each be either a memory region or a peripheral, and can be accessed through the same AHB master or one area by each master.

The GPDMA controls eight DMA channels with hardware prioritization. The DMA controller interfaces to the system via two AHB bus masters, each with a full 32-bit data bus width. DMA operations may be set up for 8-bit, 16-bit, and 32-bit data widths, and can be either big-endian or little-endian. Incrementing or non-incrementing addressing for source and destination are supported, as well as programmable DMA burst size. Scatter or gather DMA is supported through the use of linked lists. This means that the source and destination areas do not have to occupy contiguous areas of memory.

### 6.10.1 DMA support for peripherals

The GPDMA supports the following peripherals: SPI0/1/2 and UART0/1. The GPDMA can access both embedded SRAM blocks (16 kB and 32 kB), both TCMs, external static memory, and flash memory.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### 6.10.2 Clock description

The GPDMA controller is clocked by CLK_SYS_DMA derived from BASE_SYS_CLK, see Section 6.7.2.

## 6.11 USB interface

The Universal Serial Bus (USB) is a 4-wire bus that supports communication between a host and one or more (up to 127) peripherals. The bus supports hot plugging and dynamic configuration of the devices. All transactions are initiated by the Host controller.

The LPC2926/2927/2929 USB interface includes a device and OTG controller with on-chip PHY for device. The OTG switching protocol is supported through the use of an external controller. Details on typical USB interfacing solutions can be found in Section 10.2.

### 6.11.1 USB device controller

The device controller enables 12 Mbit/s data exchange with a USB Host controller. It consists of a register interface, serial interface engine, endpoint buffer memory, and a DMA controller. The serial interface engine decodes the USB data stream and writes data to the appropriate endpoint buffer. The status of a completed USB transfer or error condition is indicated via status registers. An interrupt is also generated if enabled. When enabled, the DMA controller transfers data between the endpoint buffer and the on-chip SRAM.

The USB device controller has the following features:

- Fully compliant with *USB 2.0 specification (full speed)*.
- Supports 32 physical (16 logical) endpoints with a 2 kB endpoint buffer RAM.
- Supports Control, Bulk, Interrupt and Isochronous endpoints.
- Scalable realization of endpoints at run time.
- Endpoint Maximum packet size selection (up to USB maximum specification) by software at run time.
- Supports SoftConnect and GoodLink features.
- While USB is in the Suspend mode, the LPC2926/2927/2929 can enter the Power-down mode and wake up on USB activity.
- Supports DMA transfers with the on-chip SRAM blocks on all non-control endpoints.
- Allows dynamic switching between CPU-controlled slave and DMA modes.
- Double buffer implementation for Bulk and Isochronous endpoints.

### 6.11.2 USB OTG controller

USB OTG (On-The-Go) is a supplement to the USB 2.0 specification that augments the capability of existing mobile devices and USB peripherals by adding host functionality for connection to USB peripherals.

The OTG Controller integrates the device controller, and a master-only $I^2C$ interface to implement OTG dual-role device functionality. The dedicated $I^2C$ interface controls an external OTG transceiver.


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The USB OTG controller has the following features:

- Fully compliant with *On-The-Go supplement to the USB 2.0 Specification, Revision 1.0a*.
- Hardware support for Host Negotiation Protocol (HNP).
- Includes a programmable timer required for HNP and Session Request Protocol (SRP).
- Supports any OTG transceiver compliant with the *OTG Transceiver Specification (CEA-2011), Rev. 1.0*.

### 6.11.3 Pin description

**Table 14. USB OTG port pins**

| Pin name | Direction | Description | Connection |
|---|---|---|---|
| USB_VBUS | I | $V_{BUS}$ status input. When this function is not enabled via its corresponding PINSEL register, it is driven HIGH internally. | USB Connector |
| USB_D+ | I/O | Positive differential data | USB Connector |
| USB_D− | I/O | Negative differential data | USB Connector |
| $\overline{\text{USB_CONNECT}}$ | O | SoftConnect control signal | Control |
| $\overline{\text{USB_UP_LED}}$ | O | GoodLink LED control signal | Control |
| USB_SCL | I/O | $I^2C$ serial clock | External OTG transceiver |
| USB_SDA | I/O | $I^2C$ serial data | External OTG transceiver |
| USB_LS | O | Low speed status (applies to host functionality only) | External OTG transceiver |
| $\overline{\text{USB_RST}}$ | O | USB reset status | External OTG transceiver |
| $\overline{\text{USB_INT}}$ | O | USB transceiver interrupt | External OTG transceiver |
| USB_SSPND | O | Bus suspend status | External OTG transceiver |

### 6.11.4 Clock description

Access to the USB registers is clocked by the CLK_SYS_USB, derived from BASE_SYS_CLK, see Section 6.7.2. The CGU1 provides two independent base clocks to the USB block, BASE_USB_CLK and BASE_USB_I2C_CLK (see Section 6.16.3).


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## 6.12 General subsystem

### 6.12.1 General subsystem clock description

The general subsystem is clocked by CLK_SYS_GESS, see Section 6.7.2.

### 6.12.2 Chip and feature identification

The Chip/Feature ID (CFID) module contains registers which show and control the functionality of the chip. It contains an ID to identify the silicon and also registers containing information about the features enabled or disabled on the chip.

The key features are:

- Identification of product
- Identification of features enabled

The CFID has no external pins.

### 6.12.3 System Control Unit (SCU)

The system control unit contains system-related functions. The key feature is configuration of the I/O port-pins multiplexer. It defines the function of each I/O pin of the LPC2926/2927/2929. The I/O pin configuration should be consistent with peripheral function usage.

The SCU has no external pins.

### 6.12.4 Event router

The event router provides bus-controlled routing of input events to the vectored interrupt controller for use as interrupt or wake-up signals.

Key features:

- Up to 20 level-sensitive external interrupt pins, including the receive pins of SPI, CAN, LIN, USB, and UART, as well as the $I^2C$-bus SCL pins plus three internal event sources.
- Input events can be used as interrupt source either directly or latched (edge-detected).
- Direct events disappear when the event becomes inactive.
- Latched events remain active until they are explicitly cleared.
- Programmable input level and edge polarity.
- Event detection maskable.
- Event detection is fully asynchronous, so no clock is required.

The event router allows the event source to be defined, its polarity and activation type to be selected and the interrupt to be masked or enabled. The event router can be used to start a clock on an external event.

The vectored interrupt-controller inputs are active HIGH.


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#### 6.12.4.1 Pin description

The event router module in the LPC2926/2927/2929 is connected to the pins listed below. The pins are combined with other functions on the port pins of the LPC2926/2927/2929. Table 15 shows the pins connected to the event router.

**Table 15. Event-router pin connections**

| Symbol | Direction | Description | Default polarity |
|---|---|---|---|
| EXTINT[0:7] | I | external interrupt input 0 to 7 | 1 |
| CAN0 RXD | I | CAN0 receive data input wake-up | 0 |
| CAN1 RXD | I | CAN1 receive data input wake-up | 0 |
| I2C0_SCL | I | I2C0 SCL clock input | 0 |
| I2C1_SCL | I | I2C1 SCL clock input | 0 |
| LIN0 RXD | I | LIN0 receive data input wake-up | 0 |
| LIN1 RXD | I | LIN1 receive data input wake-up | 0 |
| SPI0 SDI | I | SPI0 receive data input | 0 |
| SPI1 SDI | I | SPI1 receive data input | 0 |
| SPI2 SDI | I | SPI2 receive data input | 0 |
| UART0 RXD | I | UART0 receive data input | 0 |
| UART1 RXD | I | UART1 receive data input | 0 |
| USB_SCL | I | USB $I^2C$-bus serial clock | 0 |
| - | n/a | CAN interrupt (internal) | 1 |
| - | n/a | VIC FIQ (internal) | 1 |
| - | n/a | VIC IRQ (internal) | 1 |

## 6.13 Peripheral subsystem

### 6.13.1 Peripheral subsystem clock description

The peripheral subsystem is clocked by a number of different clocks:

- CLK_SYS_PESS
- CLK_UART0/1
- CLK_SPI0/1/2
- CLK_TMR0/1/2/3
- CLK_SAFE see Section 6.7.2

### 6.13.2 Watchdog timer

The purpose of the watchdog timer is to reset the ARM9 processor within a reasonable amount of time if the processor enters an error state. The watchdog generates a system reset if the user program fails to trigger it correctly within a predetermined amount of time.

Key features:

- Internal chip reset if not periodically triggered
- Timer counter register runs on always-on safe clock
- Optional interrupt generation on watchdog time-out


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- Debug mode with disabling of reset
- Watchdog control register change-protected with key
- Programmable 32-bit watchdog timer period with programmable 32-bit prescaler.

#### 6.13.2.1 Functional description

The watchdog timer consists of a 32-bit counter with a 32-bit prescaler.

The watchdog should be programmed with a time-out value and then periodically restarted. When the watchdog times out, it generates a reset through the RGU.

To generate watchdog interrupts in watchdog debug mode the interrupt has to be enabled via the interrupt enable register. A watchdog-overflow interrupt can be cleared by writing to the clear-interrupt register.

Another way to prevent resets during debug mode is via the Pause feature of the watchdog timer. The watchdog is stalled when the ARM9 is in debug mode and the PAUSE_ENABLE bit in the watchdog timer control register is set.

The Watchdog Reset output is fed to the Reset Generator Unit (RGU). The RGU contains a reset source register to identify the reset source when the device has gone through a reset. See Section 6.16.4.

#### 6.13.2.2 Clock description

The watchdog timer is clocked by two different clocks; CLK_SYS_PESS and CLK_SAFE, see Section 6.7.2. The register interface towards the system bus is clocked by CLK_SYS_PESS. The timer and prescale counters are clocked by CLK_SAFE which is always on.

### 6.13.3 Timer

The LPC2926/2927/2929 contains six identical timers: four in the peripheral subsystem and two in the Modulation and Sampling Control SubSystem (MSCSS) located at different peripheral base addresses. This section describes the four timers in the peripheral subsystem. Each timer has four capture inputs and/or match outputs. Connection to device pins depends on the configuration programmed into the port function-select registers. The two timers located in the MSCSS have no external capture or match pins, but the memory map is identical, see Section 6.15.6. One of these timers has an external input for a pause function.

The key features are:

- 32-bit timer/counter with programmable 32-bit prescaler
- Up to four 32-bit capture channels per timer. These take a snapshot of the timer value when an external signal connected to the TIMERx CAPn input changes state. A capture event may also optionally generate an interrupt
- Four 32-bit match registers per timer 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


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- Up to 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
- Pause input pin (MSCSS timers only)

The timers are designed to count cycles of the clock and optionally generate interrupts or perform other actions at specified timer values, based on four match registers. They also include capture inputs to trap the timer value when an input signal changes state, optionally generating an interrupt. The core function of the timers consists of a 32 bit prescale counter triggering the 32 bit timer counter. Both counters run on clock CLK_TMRx (x runs from 0 to 3) and all time references are related to the period of this clock. Note that each timer has its individual clock source within the Peripheral SubSystem. In the Modulation and Sampling SubSystem each timer also has its own individual clock source. See Section 6.16.5 for information on generation of these clocks.

#### 6.13.3.1 Pin description

The four timers in the peripheral subsystem of the LPC2926/2927/2929 have the pins described below. The two timers in the modulation and sampling subsystem have no external pins except for the pause pin on MSCSS timer 1. See Section 6.15.6 for a description of these timers and their associated pins. The timer pins are combined with other functions on the port pins of the LPC2926/2927/2929, see Section 6.12.3. Table 16 shows the timer pins (x runs from 0 to 3).

**Table 16. Timer pins**

*Note that CAP0 and CAP1 are not pinned out on Timer1.*

| Symbol | Pin name | Direction | Description |
|---|---|---|---|
| TIMERx CAP[0] | CAPx[0] | IN | TIMER x capture input 0 |
| TIMERx CAP[1] | CAPx[1] | IN | TIMER x capture input 1 |
| TIMERx CAP[2] | CAPx[2] | IN | TIMER x capture input 2 |
| TIMERx CAP[3] | CAPx[3] | IN | TIMER x capture input 3 |
| TIMERx MAT[0] | MATx[0] | OUT | TIMER x match output 0 |
| TIMERx MAT[1] | MATx[1] | OUT | TIMER x match output 1 |
| TIMERx MAT[2] | MATx[2] | OUT | TIMER x match output 2 |
| TIMERx MAT[3] | MATx[3] | OUT | TIMER x match output 3 |

#### 6.13.3.2 Clock description

The timer modules are clocked by two different clocks; CLK_SYS_PESS and CLK_TMRx (x = 0 to 3), see Section 6.7.2. Note that each timer has its own CLK_TMRx branch clock for power management. The frequency of all these clocks is identical as they are derived from the same base clock BASE_CLK_TMR. The register interface towards the system bus is clocked by CLK_SYS_PESS. The timer and prescale counters are clocked by CLK_TMRx.


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### 6.13.4 UARTs

The LPC2926/2927/2929 contains two identical UARTs located at different peripheral base addresses. The key features are:

- 16-byte receive and transmit FIFOs.
- Register locations conform to 550 industry standard.
- Receiver FIFO trigger points at 1 byte, 4 bytes, 8 bytes and 14 bytes.
- Built-in baud rate generator.
- Support for RS-485/9-bit mode allows both software address detection and automatic address detection using 9-bit mode.

The UART is commonly used to implement a serial interface such as RS232. The LPC2926/2927/2929 contains two industry-standard 550 UARTs with 16-byte transmit and receive FIFOs, but they can also be put into 450 mode without FIFOs.

**Remark:** The LIN controller can be configured to provide two additional standard UART interfaces (see Section 6.14.2).

#### 6.13.4.1 Pin description

The UART pins are combined with other functions on the port pins of the LPC2926/2927/2929. Table 17 shows the UART pins (x runs from 0 to 1).

**Table 17. UART pins**

| Symbol | Pin name | Direction | Description |
|---|---|---|---|
| UARTx TXD | TXDx | OUT | UART channel x transmit data output |
| UARTx RXD | RXDx | IN | UART channel x receive data input |

#### 6.13.4.2 Clock description

The UART modules are clocked by two different clocks; CLK_SYS_PESS and CLK_UARTx (x = 0 to 1), see Section 6.7.2. Note that each UART has its own CLK_UARTx branch clock for power management. The frequency of all CLK_UARTx clocks is identical since they are derived from the same base clock BASE_CLK_UART. The register interface towards the system bus is clocked by CLK_SYS_PESS. The baud generator is clocked by the CLK_UARTx.

### 6.13.5 Serial Peripheral Interface (SPI)

The LPC2926/2927/2929 contains three Serial Peripheral Interface modules (SPIs) to allow synchronous serial communication with slave or master peripherals.

The key features are:

- Master or slave operation.
- Each SPI supports up to four slaves in sequential multi-slave operation.
- Supports timer-triggered operation.
- Programmable clock bit rate and prescale based on SPI source clock (BASE_SPI_CLK), independent of system clock.
- Separate transmit and receive FIFO memory buffers; 16 bits wide, 32 locations deep.


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- Programmable choice of interface operation: Motorola SPI or Texas Instruments Synchronous Serial Interfaces.
- Programmable data-frame size from 4 to 16 bits.
- Independent masking of transmit FIFO, receive FIFO and receive overrun interrupts.
- Serial clock-rate master mode: fserial_clk $\leq f_{clk(SPI)}/2$.
- Serial clock-rate slave mode: fserial_clk = $f_{clk(SPI)}/4$.
- Internal loopback test mode.

The SPI module can operate in:

- Master mode:
  - Normal transmission mode
  - Sequential slave mode
- Slave mode

#### 6.13.5.1 Functional description

The SPI module is a master or slave interface for synchronous serial communication with peripheral devices that have either Motorola SPI or Texas Instruments Synchronous Serial Interfaces.

The SPI module performs serial-to-parallel conversion on data received from a peripheral device. The transmit and receive paths are buffered with FIFO memories (16 bits wide × 32 words deep). Serial data is transmitted on pins SDOx and received on pins SDIx.

The SPI module includes a programmable bit-rate clock divider and prescaler to generate the SPI serial clock from the input clock CLK_SPIx.

The SPI module's operating mode, frame format, and word size are programmed through the SLVn_SETTINGS registers.

A single combined interrupt request SPI_INTREQ output is asserted if any of the interrupts are asserted and unmasked.

Depending on the operating mode selected, the SPI SCS outputs operate as an active-HIGH frame synchronization output for Texas Instruments synchronous serial frame format or an active-LOW chip select for SPI.

Each data frame is between four and 16 bits long, depending on the size of words programmed, and is transmitted starting with the MSB.

#### 6.13.5.2 Pin description

The SPI pins are combined with other functions on the port pins of the LPC2926/2927/2929, see Section 6.12.3. Table 18 shows the SPI pins (x runs from 0 to 2; y runs from 0 to 3).

**Table 18. SPI pins**

| Symbol | Pin name | Direction | Description |
|---|---|---|---|
| SPIx SCSy | SCSy | IN/OUT | SPIx chip select[1][2] |


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**Table 18. SPI pins** *...continued*

| Symbol | Pin name | Direction | Description |
|---|---|---|---|
| SPIx SCK | SCKx | IN/OUT | SPIx clock[1] |
| SPIx SDI | SDIx | IN | SPIx data input |
| SPIx SDO | SDOx | OUT | SPIx data output |

[1] Direction of SPIx SCS and SPIx SCK pins depends on master or slave mode. These pins are output in master mode, input in slave mode.

[2] In slave mode there is only one chip select input pin, SPIx SCS0. The other chip selects have no function in slave mode.

#### 6.13.5.3 Clock description

The SPI modules are clocked by two different clocks; CLK_SYS_PESS and CLK_SPIx (x = 0, 1, 2), see Section 6.7.2. Note that each SPI has its own CLK_SPIx branch clock for power management. The frequency of all clocks CLK_SPIx is identical as they are derived from the same base clock BASE_CLK_SPI. The register interface towards the system bus is clocked by CLK_SYS_PESS. The serial-clock rate divisor is clocked by CLK_SPIx.

The SPI clock frequency can be controlled by the CGU. In master mode the SPI clock frequency (CLK_SPIx) must be set to at least twice the SPI serial clock rate on the interface. In slave mode CLK_SPIx must be set to four times the SPI serial clock rate on the interface.

### 6.13.6 General-purpose I/O

The LPC2926/2927/2929 contains four general-purpose I/O ports located at different peripheral base addresses. In the 144-pin package all four ports are available. All I/O pins are bidirectional, and the direction can be programmed individually. The I/O pad behavior depends on the configuration programmed in the port function-select registers.

The key features are:

- General-purpose parallel inputs and outputs
- Direction control of individual bits
- Synchronized input sampling for stable input-data values
- All I/O defaults to input at reset to avoid any possible bus conflicts

#### 6.13.6.1 Functional description

The general-purpose I/O provides individual control over each bidirectional port pin. There are two registers to control I/O direction and output level. The inputs are synchronized to achieve stable read-levels.

To generate an open-drain output, set the bit in the output register to the desired value. Use the direction register to control the signal. When set to output, the output driver actively drives the value on the output: when set to input the signal floats and can be pulled up internally or externally.

#### 6.13.6.2 Pin description

The five GPIO ports in the LPC2926/2927/2929 have the pins listed below. The GPIO pins are combined with other functions on the port pins of the LPC2926/2927/2929. Table 19 shows the GPIO pins.


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Table 19. GPIO pins

| Symbol | Pin name | Direction | Description |
|---|---|---|---|
| GPIO0 pin[31:0] | P0[31:0] | IN/OUT | GPIO port x pins 31 to 0 |
| GPIO1 pin[27:0] | P1[27:0] | IN/OUT | GPIO port x pins 27 to 0 |
| GPIO2 pin[27:0] | P2[27:0] | IN/OUT | GPIO port x pins 27 to 0 |
| GPIO3 pin[15:0] | P3[15:0] | IN/OUT | GPIO port x pins 15 to 0 |
| GPIO5 pin[19:18] | P5[19:18] | IN/OUT | GPIO port x pins 19 and 18 |

#### 6.13.6.3 Clock description

The GPIO modules are clocked by several clocks, all of which are derived from BASE_SYS_CLK; CLK_SYS_PESS and CLK_SYS_GPIOx (x = 0, 1, 2, 3, 5), see Section 6.7.2. Note that each GPIO has its own CLK_SYS_GPIOx branch clock for power management. The frequency of all clocks CLK_SYS_GPIOx is identical to CLK_SYS_PESS since they are derived from the same base clock BASE_SYS_CLK.

## 6.14 Networking subsystem

### 6.14.1 CAN gateway

Controller Area Network (CAN) is the definition of a high-performance communication protocol for serial data communication. The two CAN controllers in the LPC2926/2927/2929 provide a full implementation of the CAN protocol according to the *CAN specification version 2.0B*. The gateway concept is fully scalable with the number of CAN controllers, and always operates together with a separate powerful and flexible hardware acceptance filter.

The key features are:

- Supports 11-bit as well as 29-bit identifiers
- Double receive buffer and triple transmit buffer
- Programmable error-warning limit and error counters with read/write access
- Arbitration-lost capture and error-code capture with detailed bit position
- Single-shot transmission (i.e. no re-transmission)
- Listen-only mode (no acknowledge; no active error flags)
- Reception of ‘own’ messages (self-reception request)
- FullCAN mode for message reception

#### 6.14.1.1 Global acceptance filter

The global acceptance filter provides look-up of received identifiers - called acceptance filtering in CAN terminology - for all the CAN controllers. It includes a CAN ID look-up table memory, in which software maintains one to five sections of identifiers. The CAN ID look-up table memory is 2 kB large (512 words, each of 32 bits). It can contain up to 1024 standard frame identifiers or 512 extended frame identifiers or a mixture of both types. It is also possible to define identifier groups for standard and extended message formats.


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#### 6.14.1.2 Pin description

The two CAN controllers in the LPC2926/2927/2929 have the pins listed below. The CAN pins are combined with other functions on the port pins of the LPC2926/2927/2929. Table 20 shows the CAN pins (x runs from 0 to 1).

**Table 20. CAN pins**

| Symbol | Pin name | Direction | Description |
|---|---|---|---|
| CANx TXD | TXDC0/1 | OUT | CAN channel x transmit data output |
| CANx RXD | RXDC0/1 | IN | CAN channel x receive data input |

### 6.14.2 LIN

The LPC2926/2927/2929 contain two LIN 2.0 master controllers. These can be used as dedicated LIN 2.0 master controllers with additional support for sync break generation and with hardware implementation of the LIN protocol according to spec 2.0.

**Remark:** Both LIN channels can be also configured as UART channels.

The key features are:

- Complete LIN 2.0 message handling and transfer
- One interrupt per LIN message
- Slave response time-out detection
- Programmable sync-break length
- Automatic sync-field and sync-break generation
- Programmable inter-byte space
- Hardware or software parity generation
- Automatic checksum generation
- Fault confinement
- Fractional baud rate generator

#### 6.14.2.1 Pin description

The two LIN 2.0 master controllers in the LPC2926/2927/2929 have the pins listed below. The LIN pins are combined with other functions on the port pins of the LPC2926/2927/2929. Table 21 shows the LIN pins. For more information see Ref. 1 subsection 3.43, LIN master controller.

**Table 21. LIN controller pins**

| Symbol | Pin name | Direction | Description |
|---|---|---|---|
| LIN0/1 TXD | TXDL0/1 | OUT | LIN channel 0/1 transmit data output |
| LIN0/1 RXD | RXDL0/1 | IN | LIN channel 0/1 receive data input |

### 6.14.3 $I^2C$-bus serial I/O controllers

The LPC2926/2927/2929 each contain two $I^2C$-bus controllers.

The $I^2C$-bus is bidirectional for inter-IC control using only two wires: a Serial CLock line (SCL) and a Serial DAta line (SDA). Each device is recognized by a unique address and can operate as either a receiver-only device (e.g., an LCD driver) or as a transmitter with the capability to both receive and send information (such as memory). Transmitters and/or


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receivers can operate in either master or slave mode, depending on whether the chip has to initiate a data transfer or is only addressed. The $I^2C$ is a multi-master bus, and it can be controlled by more than one bus master connected to it.

The main features if the $I^2C$-bus interfaces are:

- $I^2C0/1$ use standard I/O pins with bit rates of up to 400 kbit/s (Fast $I^2C$-bus) and do not support powering off of individual devices connected to the same bus lines.
- 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 can be used for test and diagnostic purposes.
- All $I^2C$-bus controllers support multiple address recognition and a bus monitor mode.

#### 6.14.3.1 Pin description

Table 22. $I^2C$-bus pins[1]

| Symbol | Pin name | Direction | Description |
|---|---|---|---|
| I2C SCL0/1 | SCL0/1 | I/O | I2C clock input/output |
| I2C SDA0/1 | SDA0/1 | I/O | I2C data input/output |

[1] Note that the pins are not $I^2C$-bus compliant open-drain pins.

## 6.15 Modulation and sampling control subsystem

The Modulation and Sampling Control Subsystem (MSCSS) in the LPC2926/2927/2929 includes four Pulse Width Modulators (PWMs), three 10-bit successive approximation Analog-to-Digital Converters (ADCs) and two timers.

The key features of the MSCSS are:

- Two 10-bit, 400 ksample/s, 8-channel ADCs with 3.3 V inputs and various trigger-start options
- One 10-bit, 400 ksample/s, 8-channel ADC with 5 V inputs (5 V measurement range) and various trigger-start options
- Four 6-channel PWMs (Pulse Width Modulators) with capture and trap functionality
- Two dedicated timers to schedule and synchronize the PWMs and ADCs
- Quadrature encoder interface

### 6.15.1 Functional description

The MSCSS contains Pulse Width Modulators (PWMs), Analog-to-Digital Converters (ADCs) and timers.


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Figure 8 provides an overview of the MSCSS. An AHB-to-APB bus bridge takes care of communication with the AHB system bus. Two internal timers are dedicated to this subsystem. MSCSS timer 0 can be used to generate start pulses for the ADCs and the first PWM. The second timer (MSCSS timer 1) is used to generate ‘carrier’ signals for the PWMs. These carrier patterns can be used, for example, in applications requiring current control. Several other trigger possibilities are provided for the ADCs (external, cascaded or following a PWM). The capture inputs of both timers can also be used to capture the start pulse of the ADCs.

The PWMs can be used to generate waveforms in which the frequency, duty cycle and rising and falling edges can be controlled very precisely. Capture inputs are provided to measure event phases compared to the main counter. Depending on the applications, these inputs can be connected to digital sensor motor outputs or digital external signals. Interrupt signals are generated on several events to closely interact with the CPU.

The ADCs can be used for any application needing accurate digitized data from analog sources. To support applications like motor control, a mechanism to synchronize several PWMs and ADCs is available (sync_in and sync_out).

Note that the PWMs run on the PWM clock and the ADCs on the ADC clock, see Section 6.16.2.


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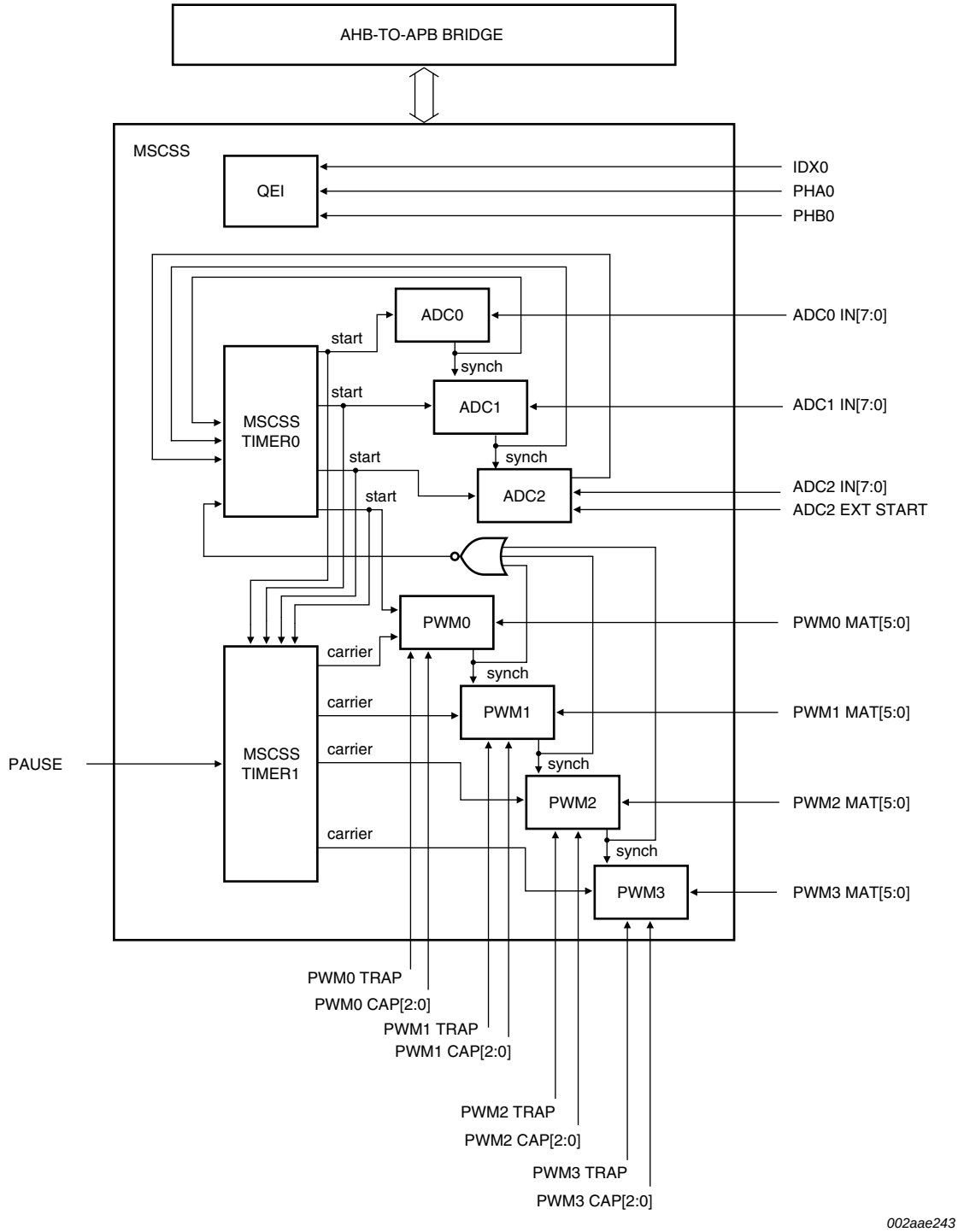


**Fig 8. Modulation and Sampling Control SubSystem (MSCSS) block diagram**


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### 6.15.2 Pin description

The pins of the LPC2926/2927/2929 MSCSS associated with the three ADC modules are described in Section 6.15.4.2. Pins connected to the four PWM modules are described in Section 6.15.5.4, pins directly connected to the MSCSS timer 1 module are described in Section 6.15.6.1, and pins connected to the quadrature encoder interface are described in Section 6.15.7.1.

### 6.15.3 Clock description

The MSCSS is clocked from a number of different sources:

- CLK_SYS_MSCSS_A clocks the AHB side of the AHB-to-APB bus bridge
- CLK_MSCSS_APB clocks the subsystem APB bus
- CLK_MSCSS_MTMR0/1 clocks the timers
- CLK_MSCSS_PWM[0:3] clocks the PWMs.

Each ADC has two clock areas; a APB part clocked by CLK_MSCSS_ADCx_APB (x = 0, 1, or 2) and a control part for the analog section clocked by CLK_ADCx = 0, 1, or 2), see Section 6.7.2.

All clocks are derived from the BASE_MSCSS_CLK, except for CLK_SYS_MSCSS_A which is derived form BASE_SYS_CLK, and the CLK_ADCx clocks which are derived from BASE_CLK_ADC. If specific PWM or ADC modules are not used their corresponding clocks can be switched off.

### 6.15.4 Analog-to-digital converter

The MSCSS in the LPC2926/2927/2929 includes three 10-bit successive-approximation analog-to-digital converters.

The key features of the ADC interface module are:

- ADC0: Eight analog inputs; time-multiplexed; measurement range up to 5.0 V.
- ADC1 and ADC2: Eight analog inputs; time-multiplexed; measurement range up to 3.3 V.
- External reference-level inputs.
- 400 ksamples per second at 10-bit resolution up to 1500 ksamples per second at 2-bit resolution.
- Programmable resolution from 2-bit to 10-bit.
- Single analog-to-digital conversion scan mode and continuous analog-to-digital conversion scan mode.
- Optional conversion on transition on external start input, timer capture/match signal, PWM_sync or ‘previous’ ADC.
- Converted digital values are stored in a register for each channel.
- Optional compare condition to generate a ‘less than’ or an ‘equal to or greater than’ compare-value indication for each channel.
- Power-down mode.


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### 6.15.4.1 Functional description

The ADC block diagram, Figure 9, shows the basic architecture of each ADC. The ADC functionality is divided into two major parts; one part running on the MSCSS Subsystem clock, the other on the ADC clock. This split into two clock domains affects the behavior from a system-level perspective. The actual analog-to-digital conversions take place in the ADC clock domain, but system control takes place in the system clock domain.

A mechanism is provided to modify configuration of the ADC and control the moment at which the updated configuration is transferred to the ADC domain.

The ADC clock is limited to 4.5 MHz maximum frequency and should always be lower than or equal to the system clock frequency. To meet this constraint or to select the desired lower sampling frequency, the clock generation unit provides a programmable fractional system-clock divider dedicated to the ADC clock. Conversion rate is determined by the ADC clock frequency divided by the number of resolution bits plus one. Accessing ADC registers requires an enabled ADC clock, which is controllable via the clock generation unit, see Section 6.16.2.

Each ADC has four start inputs. Note that start 0 and start 2 are captured in the system clock domain while start 1 and start 3 are captured in the ADC domain. The start inputs are connected at MSCSS level, see Section 6.15 for details.

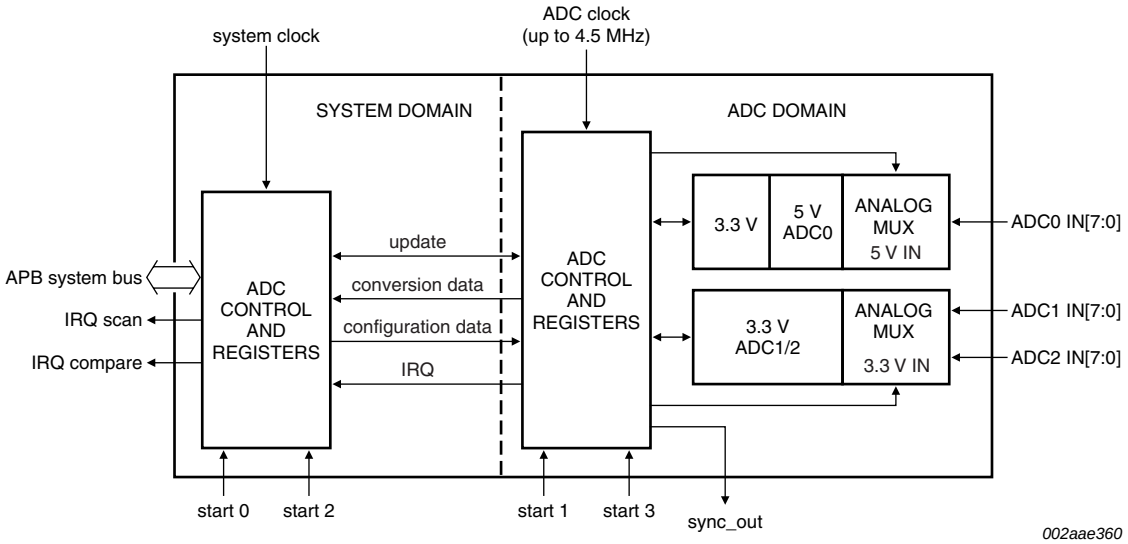


**Fig 9. ADC block diagram**

### 6.15.4.2 Pin description

The three ADC modules in the MSCSS have the pins described below. The ADCx input pins are combined with other functions on the port pins of the LPC2926/2927/2929. The VREFN and VREFP pins are common to all ADCs. Table 23 shows the ADC pins.


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**Table 23. ADC pins**

| Symbol | Pin name | Direction | Description |
|---|---|---|---|
| ADC0 IN[7:0] | IN0[7:0] | IN | analog input for 5.0 V ADC0, channel 7 to channel 0. |
| ADC1/2 IN[7:0] | IN1/2[7:0] | IN | analog input for 3.3 V ADC1/2, channel 7 to channel 0. |
| ADC2_EXT_START | CAP1[2] | IN | ADC external start-trigger input. |
| VREFN | VREFN | IN | ADC LOW reference level. |
| VREFP | VREFP | IN | ADC HIGH reference level. |
| $V_{DDA(ADC5V0)}$ | $V_{DDA(ADC5V0)}$[1] | IN | 5 V high-power supply and HIGH reference for ADC0. Connect to clean 5 V as HIGH reference. May also be connected to 3.3 V if 3.3 V measurement range for ADC0 is needed.[2][3] |
| $V_{DDA(ADC3V3)}$ | $V_{DDA(ADC3V3)}$ | IN | ADC1 and ADC2 3.3 V supply (also used for ADC0).[3] |

[1] VREFP, VREFN, $V_{DDA(ADC3V3)}$ must be connected for the 5 V ADC0 to operate properly.

[2] The analog inputs of ADC0 are internally multiplied by a factor of 3.3 / 5. If $V_{DDA(ADC5V0)}$ is connected to 3.3 V, the maximum digital result is 1024 × 3.3 / 5.

[3] $V_{DDA(ADC5V0)}$ and $V_{DDA(ADC3V3)}$ must be set as follows: $V_{DDA(ADC5V0)} = V_{DDA(ADC3V3)} \times 1.5$.

**Remark:** The following formula only applies to ADC0:

Voltage variations on VREFP (i.e. those that deviate from voltage variations on the $V_{DDA(ADC5V5)}$ pin) are visible as variations in the measurement result. The following formula is used to determine the conversion result of an input voltage $V_I$ on ADC0:

$$\left(\frac{2}{3}\left(V_I - \frac{1}{2}V_{DDA(ADC5V0)}\right) + \frac{1}{2}V_{DDA(ADC3V3)}\right) \times \frac{1024}{V_{VREFP} - V_{VREFN}} \quad (3)$$

**Remark:** Note that the ADC1 and ADC2 accept an input voltage up to of 3.6 V (see Table 34) on the ADC1/2 IN pins. If the ADC is not used, the pins are 5 V tolerant. The ADC0 pins are 5 V tolerant.

### 6.15.4.3 Clock description

The ADC modules are clocked from two different sources; CLK_MSCSS_ADCx_APB and CLK_ADCx (x = 0, 1, or 2), see Section 6.7.2. Note that each ADC has its own CLK_ADCx and CLK_MSCSS_ADCx_APB branch clocks for power management. If an ADC is unused both its CLK_MSCSS_ADCx_APB and CLK_ADCx can be switched off.

The frequency of all the CLK_MSCSS_ADCx_APB clocks is identical to CLK_MSCSS_APB since they are derived from the same base clock BASE_MSCSS_CLK. Likewise the frequency of all the CLK_ADCx clocks is identical since they are derived from the same base clock BASE_ADC_CLK.

The register interface towards the system bus is clocked by CLK_MSCSS_ADCx_APB. Control logic for the analog section of the ADC is clocked by CLK_ADCx, see also Figure 9.


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### 6.15.5 Pulse Width Modulator (PWM)

The MSCSS in the LPC2926/2927/2929 includes four PWM modules with the following features.

- Six pulse-width modulated output signals
- Double edge features (rising and falling edges programmed individually)
- Optional interrupt generation on match (each edge)
- Different operation modes: continuous or run-once
- 16-bit PWM counter and 16-bit prescale counter allow a large range of PWM periods
- A protective mode (TRAP) holding the output in a software-controllable state and with optional interrupt generation on a trap event
- Three capture registers and capture trigger pins with optional interrupt generation on a capture event
- Interrupt generation on match event, capture event, PWM counter overflow or trap event
- A burst mode mixing the external carrier signal with internally generated PWM
- Programmable sync-delay output to trigger other PWM modules (master/slave behavior)

#### 6.15.5.1 Functional description

The ability to provide flexible waveforms allows PWM blocks to be used in multiple applications; e.g. dimmer/lamp control and fan control. Pulse-width modulation is the preferred method for regulating power since no additional heat is generated, and it is energy-efficient when compared with linear-regulating voltage control networks.

The PWM delivers the waveforms/pulses of the desired duty cycles and cycle periods. A very basic application of these pulses can be in controlling the amount of power transferred to a load. Since the duty cycle of the pulses can be controlled, the desired amount of power can be transferred for a controlled duration. Two examples of such applications are:

- Dimmer controller: The flexibility of providing waves of a desired duty cycle and cycle period allows the PWM to control the amount of power to be transferred to the load. The PWM functions as a dimmer controller in this application.
- Motor controller: The PWM provides multi-phase outputs, and these outputs can be controlled to have a certain pattern sequence. In this way the force/torque of the motor can be adjusted as desired. This makes the PWM function as a motor drive.


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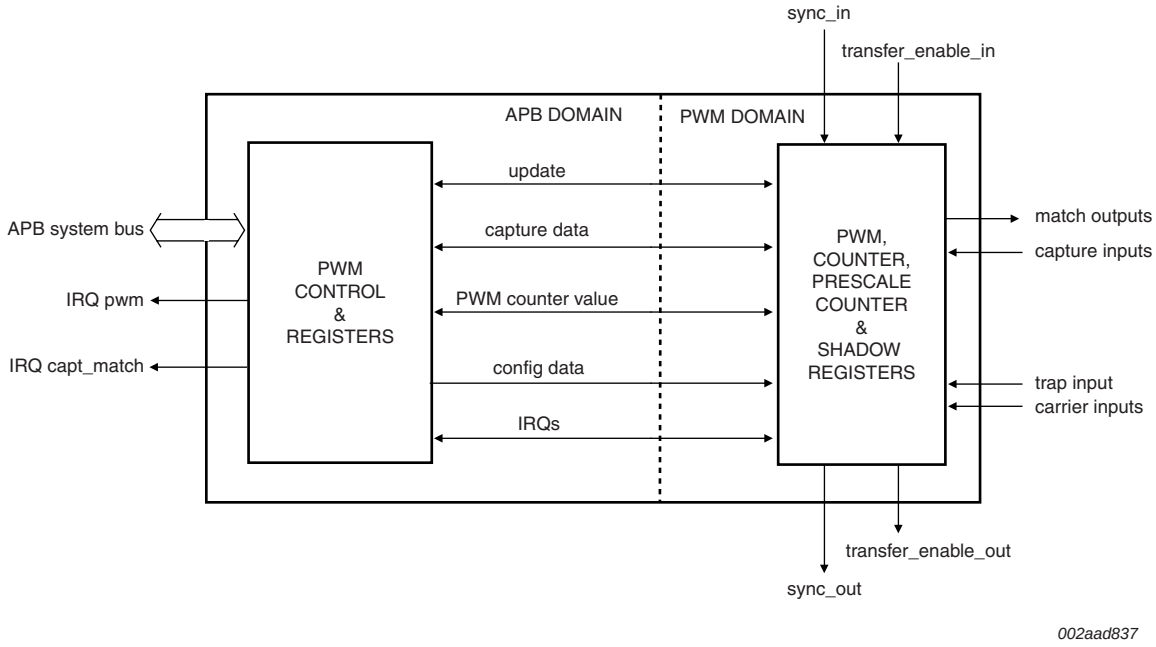


**Fig 10. PWM block diagram**

The PWM block diagram in Figure 10 shows the basic architecture of each PWM. PWM functionality is split into two major parts, a APB domain and a PWM domain, both of which run on clocks derived from the BASE_MSCSS_CLK. This split into two domains affects behavior from a system-level perspective. The actual PWM and prescale counters are located in the PWM domain but system control takes place in the APB domain.

The actual PWM consists of two counters; a 16-bit prescale counter and a 16-bit PWM counter. The position of the rising and falling edges of the PWM outputs can be programmed individually. The prescale counter allows high system bus frequencies to be scaled down to lower PWM periods. Registers are available to capture the PWM counter values on external events.

Note that in the Modulation and Sampling SubSystem, each PWM has its individual clock source CLK_MSCSS_PWMx (x runs from 0 to 3). Both the prescale and the timer counters within each PWM run on this clock CLK_MSCSS_PWMx, and all time references are related to the period of this clock. See Section 6.16 for information on generation of these clocks.

#### 6.15.5.2 Synchronizing the PWM counters

A mechanism is included to synchronize the PWM period to other PWMs by providing a sync input and a sync output with programmable delay. Several PWMs can be synchronized using the trans_enable_in/trans_enable_out and sync_in/sync_out ports. See Figure 8 for details of the connections of the PWM modules within the MSCSS in the LPC2926/2927/2929. PWM 0 can be master over PWM 1; PWM 1 can be master over PWM 2, etc.


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#### 6.15.5.3 Master and slave mode

A PWM module can provide synchronization signals to other modules (also called Master mode). The signal sync_out is a pulse of one clock cycle generated when the internal PWM counter (re)starts. The signal trans_enable_out is a pulse synchronous to sync_out, generated if a transfer from system registers to PWM shadow registers occurred when the PWM counter restarted. A delay may be inserted between the counter start and generation of trans_enable_out and sync_out.

A PWM module can use input signals trans_enable_in and sync_in to synchronize its internal PWM counter and the transfer of shadow registers (Slave mode).

#### 6.15.5.4 Pin description

Each of the four PWM modules in the MSCSS has the following pins. These are combined with other functions on the port pins of the LPC2926/2927/2929. Table 24 shows the PWM0 to PWM3 pins.

**Table 24. PWM pins**

| Symbol | Pin name | Direction | Description |
|---|---|---|---|
| PWMn CAP[0] | PCAPn[0] | IN | PWM n capture input 0 |
| PWMn CAP[1] | PCAPn[1] | IN | PWM n capture input 1 |
| PWMn CAP[2] | PCAPn[2] | IN | PWM n capture input 2 |
| PWMn MAT[0] | PMATn[0] | OUT | PWM n match output 0 |
| PWMn MAT[1] | PMATn[1] | OUT | PWM n match output 1 |
| PWMn MAT[2] | PMATn[2] | OUT | PWM n match output 2 |
| PWMn MAT[3] | PMATn[3] | OUT | PWM n match output 3 |
| PWMn MAT[4] | PMATn[4] | OUT | PWM n match output 4 |
| PWMn MAT[5] | PMATn[5] | OUT | PWM n match output 5 |
| PWMn TRAP | TRAPn | IN | PWM n trap input |

#### 6.15.5.5 Clock description

The PWM modules are clocked by CLK_MSCSS_PWMx (x = 0 to 3), see Section 6.7.2. Note that each PWM has its own CLK_MSCSS_PWMx branch clock for power management. The frequency of all these clocks is identical to CLK_MSCSS_APB since they are derived from the same base clock BASE_MSCSS_CLK.

Also note that unlike the timer modules in the Peripheral SubSystem, the actual timer counter registers of the PWM modules run at the same clock as the APB system interface CLK_MSCSS_APB. This clock is independent of the AHB system clock.

If a PWM module is not used its CLK_MSCSS_PWMx branch clock can be switched off.

### 6.15.6 Timers in the MSCSS

The two timers in the MSCSS are functionally identical to the timers in the peripheral subsystem, see Section 6.13.3. The features of the timers in the MSCSS are the same as the timers in the peripheral subsystem, but the capture inputs and match outputs are not available on the device pins. These signals are instead connected to the ADC and PWM modules as outlined in the description of the MSCSS, see Section 6.15.1.

See Section 6.13.3 for a functional description of the timers.


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#### 6.15.6.1 Pin description

MSCSS timer 0 has no external pins.

MSCSS timer 1 has a PAUSE pin available as external pin. The PAUSE pin is combined with other functions on the port pins of the LPC2926/2927/2929. Table 25 shows the MSCSS timer 1 external pin.

**Table 25. MSCSS timer 1 pin**

| Symbol | Direction | Description |
|---|---|---|
| MSCSS PAUSE | IN | pause pin for MSCSS timer 1 |

#### 6.15.6.2 Clock description

The timer modules in the MSCSS are clocked by CLK_MSCSS_MTMRx (x = 0 to 1), see Section 6.7.2. Note that each timer has its own CLK_MSCSS_MTMRx branch clock for power management. The frequency of all these clocks is identical to CLK_MSCSS_APB since they are derived from the same base clock BASE_MSCSS_CLK.

Note that, unlike the timer modules in the Peripheral SubSystem, the actual timer counter registers run at the same clock as the APB system interface CLK_MSCSS_APB. This clock is independent of the AHB system clock.

If a timer module is not used its CLK_MSCSS_MTMRx branch clock can be switched off.

### 6.15.7 Quadrature Encoder Interface (QEI)

A quadrature encoder, also known as a 2-channel incremental encoder, converts angular displacement into two pulse signals. By monitoring both the number of pulses and the relative phase of the two signals, the user can track the position, direction of rotation, and velocity. In addition, a third channel, or index signal, can be used to reset the position counter. The quadrature encoder interface decodes the digital pulses from a quadrature encoder wheel to integrate position over time and determine direction of rotation. In addition, the QEI can capture the velocity of the encoder wheel.

The QEI has the following features:

- Tracks encoder position.
- Increments/decrements depending on direction.
- Programmable for 2× or 4× position counting.
- Velocity capture using built-in timer.
- Velocity compare function with less than interrupt.
- Uses 32-bit registers for position and velocity.
- Three position compare registers with interrupts.
- Index counter for revolution counting.
- Index compare register with interrupts.
- Can combine index and position interrupts to produce an interrupt for whole and partial revolution displacement.
- Digital filter with programmable delays for encoder input signals.
- Can accept decoded signal inputs (clk and direction).
- Connected to APB.


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#### 6.15.7.1 Pin description

The QEI module in the MSCSS has the following pins. These are combined with other functions on the port pins of the LPC2926/2927/2929. Table 26 shows the QEI pins.

**Table 26. QEI pins**

| Symbol | Pin name | Direction | Description |
|---|---|---|---|
| QEI0 IDX | IDX0 | IN | Index signal. Can be used to reset the position. |
| QEI0 PHA | PHA0 | IN | Sensor signal. Corresponds to PHA in quadrature mode and to direction in clock/direction mode. |
| QEI0 PHB | PHB0 | IN | Sensor signal. Corresponds to PHB in quadrature mode and to clock signal in clock/direction mode. |

#### 6.15.7.2 Clock description

The QEI module is clocked by CLK_MSCSS_QEI, see Section 6.7.2. The frequency of this clock is identical to CLK_MSCSS_APB since they are derived from the same base clock BASE_MSCSS_CLK.

If the QEI is not used its CLK_MSCSS_QEI branch clock can be switched off.

## 6.16 Power, Clock and Reset Control Subsystem (PCRSS)

The Power, Clock and Reset Control Subsystem in the LPC2926/2927/2929 includes the Clock Generator Units (CGU0 and CGU1), a Reset Generator Unit (RGU) and a Power Management Unit (PMU).

Figure 11 provides an overview of the PCRSS. An AHB-to-DTL bridge controls the communication with the AHB system bus.


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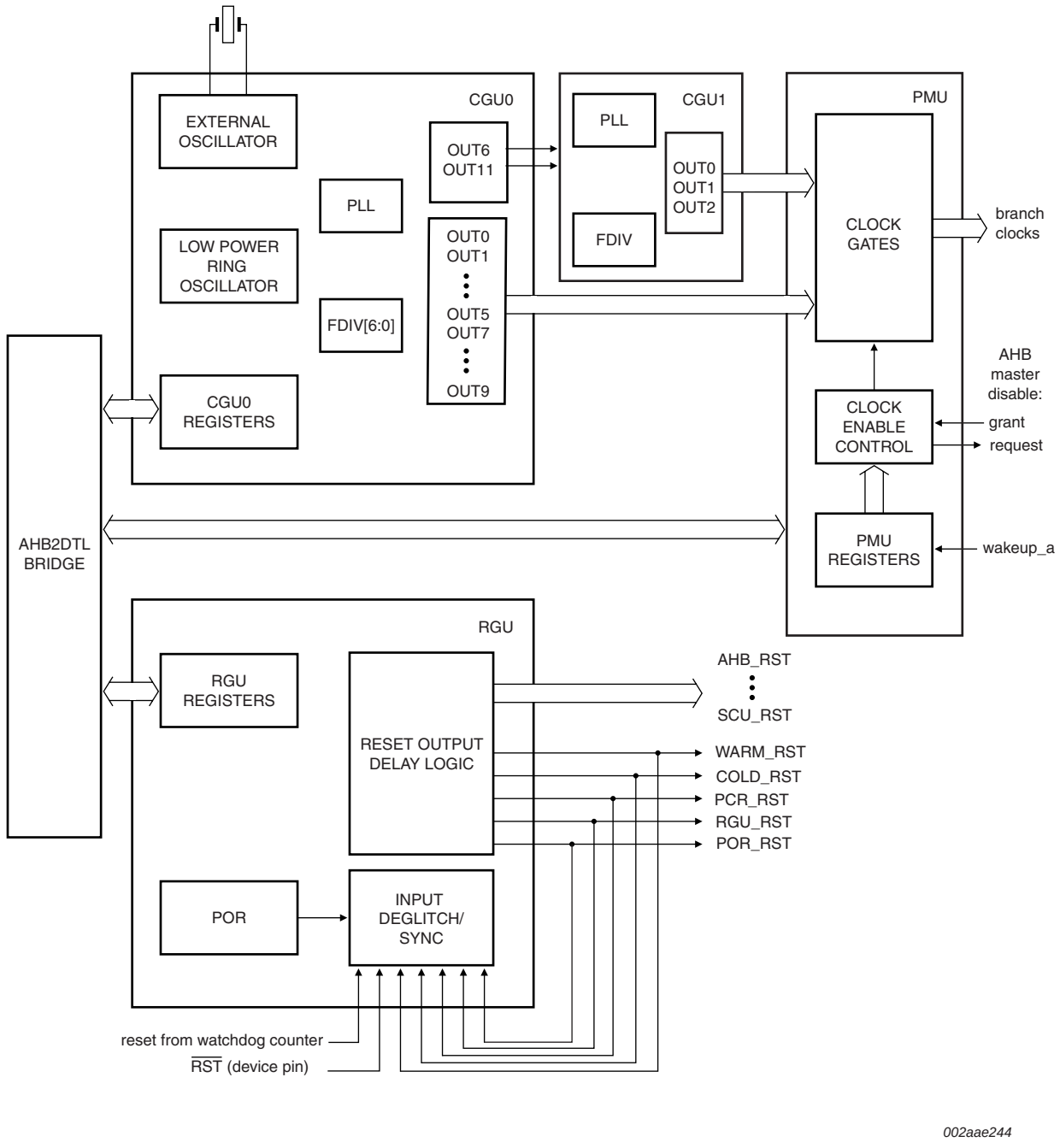


**Fig 11. PCRSS block diagram**

### 6.16.1 Clock description

The PCRSS is clocked by a number of different clocks. CLK_SYS_PCRSS clocks the AHB side of the AHB to DTL bus bridge and CLK_PCR_SLOW clocks the CGU, RGU and PMU internal logic, see Section 6.7.2. CLK_SYS_PCRSS is derived from BASE_SYS_CLK, which can be switched off in low-power modes. CLK_PCR_SLOW is derived from BASE_PCR_CLK and is always on in order to be able to wake up from low-power modes.


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### 6.16.2 Clock Generation Unit (CGU0)

The key features are:

- Generation of 11 base clocks, selectable from several embedded clock sources.
- Crystal oscillator with power-down.
- Control PLL with power-down.
- Very low-power ring oscillator, always on to provide a safe clock.
- Individual source selector for each base clock, with glitch-free switching.
- Autonomous clock-activity detection on every clock source.
- Protection against switching to invalid or inactive clock sources.
- Embedded frequency counter.
- Register write-protection mechanism to prevent unintentional alteration of clocks.

**Remark:** Any clock-frequency adjustment has a direct impact on the timing of all on-board peripherals.

#### 6.16.2.1 Functional description

The clock generation unit provides 11 internal clock sources as described in Table 27.

**Table 27. CGU0 base clocks**

| Number | Name | Frequency (MHz) [1] | Description |
|---|---|---|---|
| 0 | BASE_SAFE_CLK | 0.4 | base safe clock (always on) |
| 1 | BASE_SYS_CLK | 125 | base system clock |
| 2 | BASE_PCR_CLK | 0.4 [2] | base PCR subsystem clock |
| 3 | BASE_IVNSS_CLK | 125 | base IVNSS subsystem clock |
| 4 | BASE_MSCSS_CLK | 125 | base MSCSS subsystem clock |
| 5 | BASE_ICLK0_CLK | 125 | base internal clock 0, for CGU1 |
| 6 | BASE_UART_CLK | 125 | base UART clock |
| 7 | BASE_SPI_CLK | 50 | base SPI clock |
| 8 | BASE_TMR_CLK | 125 | base timers clock |
| 9 | BASE_ADC_CLK | 4.5 | base ADCs clock |
| 10 | reserved | - | - |
| 11 | BASE_ICLK1_CLK | 125 | base internal clock 1, for CGU1 |

[1] Maximum frequency that guarantees stable operation of the LPC2926/2927/2929.

[2] Fixed to low-power oscillator.

For generation of these base clocks, the CGU consists of primary and secondary clock generators and one output generator for each base clock.


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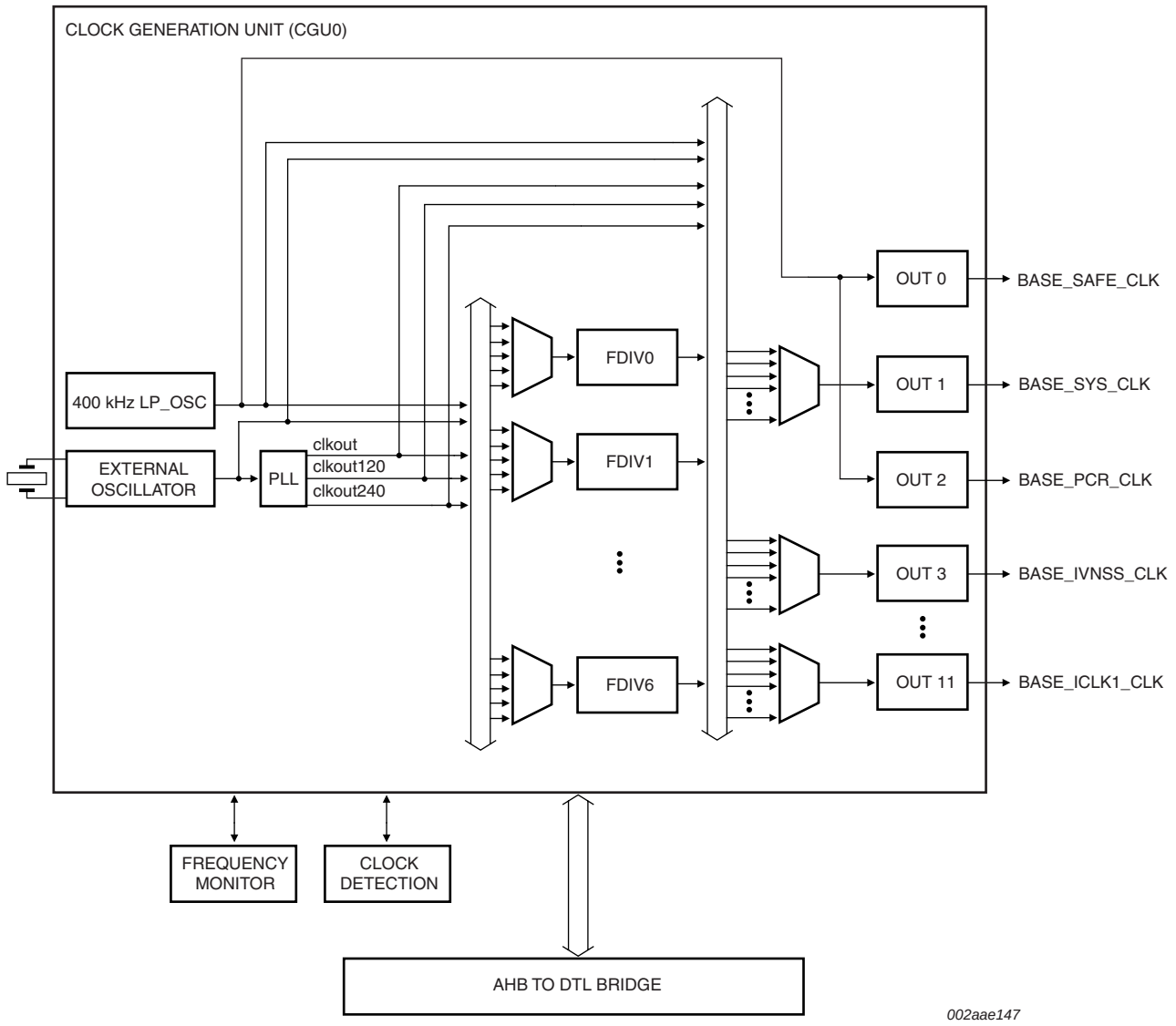


**Fig 12. Block diagram of the CGU0 (see Table 27 for all base clocks)**

There are two primary clock generators: a low-power ring oscillator (LP_OSC) and a crystal oscillator. See Figure 12.

LP_OSC is the source for the BASE_PCR_CLK that clocks the CGU0 itself and for BASE_SAFE_CLK that clocks a minimum of other logic in the device (like the watchdog timer). To prevent the device from losing its clock source LP_OSC cannot be put into power-down. The crystal oscillator can be used as source for high-frequency clocks or as an external clock input if a crystal is not connected.

Secondary clock generators are a PLL and seven fractional dividers (FDIV[0:6]). The PLL has three clock outputs: normal, 120° phase-shifted and 240° phase-shifted.


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**Configuration of the CGU0:** For every output generator generating the base clocks a choice can be made from the primary and secondary clock generators according to Figure 13.

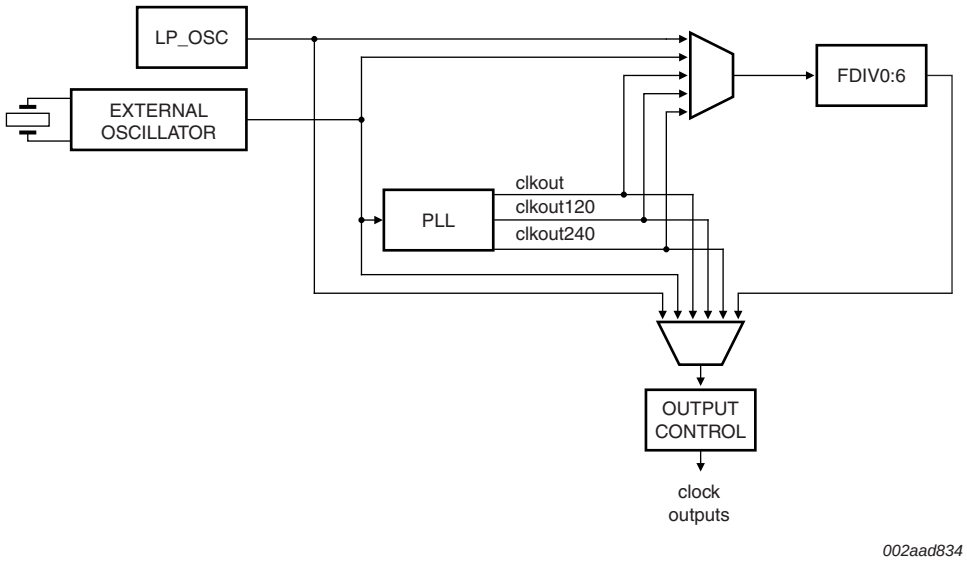


**Fig 13. Structure of the clock generation scheme**

Any output generator (except for BASE_SAFE_CLK and BASE_PCR_CLK) can be connected to either a fractional divider (FDIV[0:6]) or to one of the outputs of the PLL or to LP_OSC/crystal oscillator directly. BASE_SAFE_CLK and BASE_PCR_CLK can use only LP_OSC as source.

The fractional dividers can be connected to one of the outputs of the PLL or directly to LP_OSC/crystal Oscillator.

The PLL is connected to the crystal oscillator.

In this way every output generating the base clocks can be configured to get the required clock. Multiple output generators can be connected to the same primary or secondary clock source, and multiple secondary clock sources can be connected to the same PLL output or primary clock source.

Invalid selections/programming - connecting the PLL to an FDIV or to one of the PLL outputs itself for example - will be blocked by hardware. The control register will not be written, the previous value will be kept, although all other fields will be written with new data. This prevents clocks being blocked by incorrect programming.

**Default Clock Sources:** Every secondary clock generator or output generator is connected to LP_OSC at reset. In this way the device runs at a low frequency after reset. It is recommended to switch BASE_SYS_CLK to a high-frequency clock generator as one of the first steps in the boot code after verifying that the high-frequency clock generator is running.

**Clock Activity Detection:** Clocks that are inactive are automatically regarded as invalid, and values of ‘CLK_SEL’ that would select those clocks are masked and not written to the control registers. This is accomplished by adding a clock detector to every clock


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generator. The RDET register keeps track of which clocks are active and inactive, and the appropriate 'CLK_SEL' values are masked and unmasked accordingly. Each clock detector can also generate interrupts at clock activation and deactivation so that the system can be notified of a change in internal clock status.

Clock detection is done using a counter running at the *BASE_PCR_CLK* frequency. If no positive clock edge occurs before the counter has 32 cycles of BASE_PCR_CLK the clock is assumed to be inactive. As *BASE_PCR_CLK* is slower than any of the clocks to be detected, normally only one BASE_PCR_CLK cycle is needed to detect activity. After reset all clocks are assumed to be 'non-present', so the RDET status register will be correct only after 32 *BASE_PCR_CLK* cycles.

Note that this mechanism cannot protect against a currently-selected clock going from active to inactive state. Therefore an inactive clock may still be sent to the system under special circumstances, although an interrupt can still be generated to notify the system.

**Glitch-Free Switching:** Provisions are included in the CGU to allow clocks to be switched glitch-free, both at the output generator stage and also at secondary source generators.

In the case of the PLL the clock will be stopped and held low for long enough to allow the PLL to stabilize and lock before being re-enabled. For all non-PLL Generators the switch will occur as quickly as possible, although there will always be a period when the clock is held low due to synchronization requirements.

If the current clock is high and does not go low within 32 *cycles of BASE_PCR_CLK* it is assumed to be inactive and is asynchronously forced low. This prevents deadlocks on the interface.

#### 6.16.2.2 PLL functional description

A block diagram of the PLL is shown in Figure 14. The input clock is fed directly to the analog section. This block compares the phase and frequency of the inputs and generates the main clock[2]. These clocks are either divided by $2 \times P$ by the programmable post divider to create the output clock, or sent directly to the output. The main output clock is then divided by M by the programmable feedback divider to generate the feedback clock. The output signal of the analog section is also monitored by the lock detector to signal when the PLL has locked onto the input clock.

2. Generation of the main clock is restricted by the frequency range of the PLL clock input. See Table 36, Dynamic characteristics.


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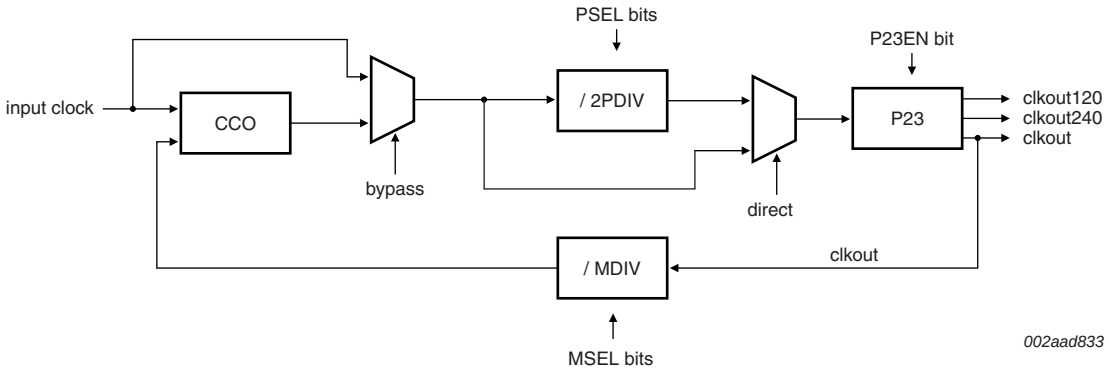


**Fig 14. PLL block diagram**

**Triple output phases:** For applications that require multiple clock phases two additional clock outputs can be enabled by setting register P23EN to logic 1, thus giving three clocks with a 120° phase difference. In this mode all three clocks generated by the analog section are sent to the output dividers. When the PLL has not yet achieved lock the second and third phase output dividers run unsynchronized, which means that the phase relation of the output clocks is unknown. When the PLL LOCK register is set the second and third phase of the output dividers are synchronized to the main output clock CLKOUT PLL, thus giving three clocks with a 120° phase difference.

**Direct output mode:** In normal operating mode (with DIRECT set to logic 0) the CCO clock is divided by 2, 4, 8 or 16 depending on the value on the PSEL[1:0] input, giving an output clock with a 50 % duty cycle. If a higher output frequency is needed the CCO clock can be sent directly to the output by setting DIRECT to logic 1. Since the CCO does not directly generate a 50 % duty cycle clock, the output clock duty cycle in this mode can deviate from 50 %.

**Power-down control:** A Power-down mode has been incorporated to reduce power consumption when the PLL clock is not needed. This is enabled by setting the PD control register bit. In this mode the analog section of the PLL is turned off, the oscillator and the phase-frequency detector are stopped and the dividers enter a reset state. While in Power-down mode the LOCK output is low, indicating that the PLL is not in lock. When Power-down mode is terminated by clearing the PD control-register bit the PLL resumes normal operation, and makes the LOCK signal high once it has regained lock on the input clock.

### 6.16.2.3 Pin description

The CGU0 module in the LPC2926/2927/2929 has the pins listed in Table 28 below.

**Table 28. CGU0 pins**

| Symbol | Direction | Description |
|---|---|---|
| XOUT_OSC | OUT | Oscillator crystal output |
| XIN_OSC | IN | Oscillator crystal input or external clock input |


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### 6.16.3 Clock generation for USB (CGU1)

The CGU1 block is functionally identical to the CGU0 block and generates two clocks for the USB interface and a dedicated output clock. The CGU1 block uses its own PLL and fractional divider. The PLLs used in CGU0 and CGU1 are identical (see Section 6.16.2.2).

The clock input to the CGU1 PLL is provided by one of two base clocks generated in the CGU0: BASE_ICLK0_CLK or BASE_ICLK1_CLK. The base clock not used for the PLL can be configured to drive the output clock directly.

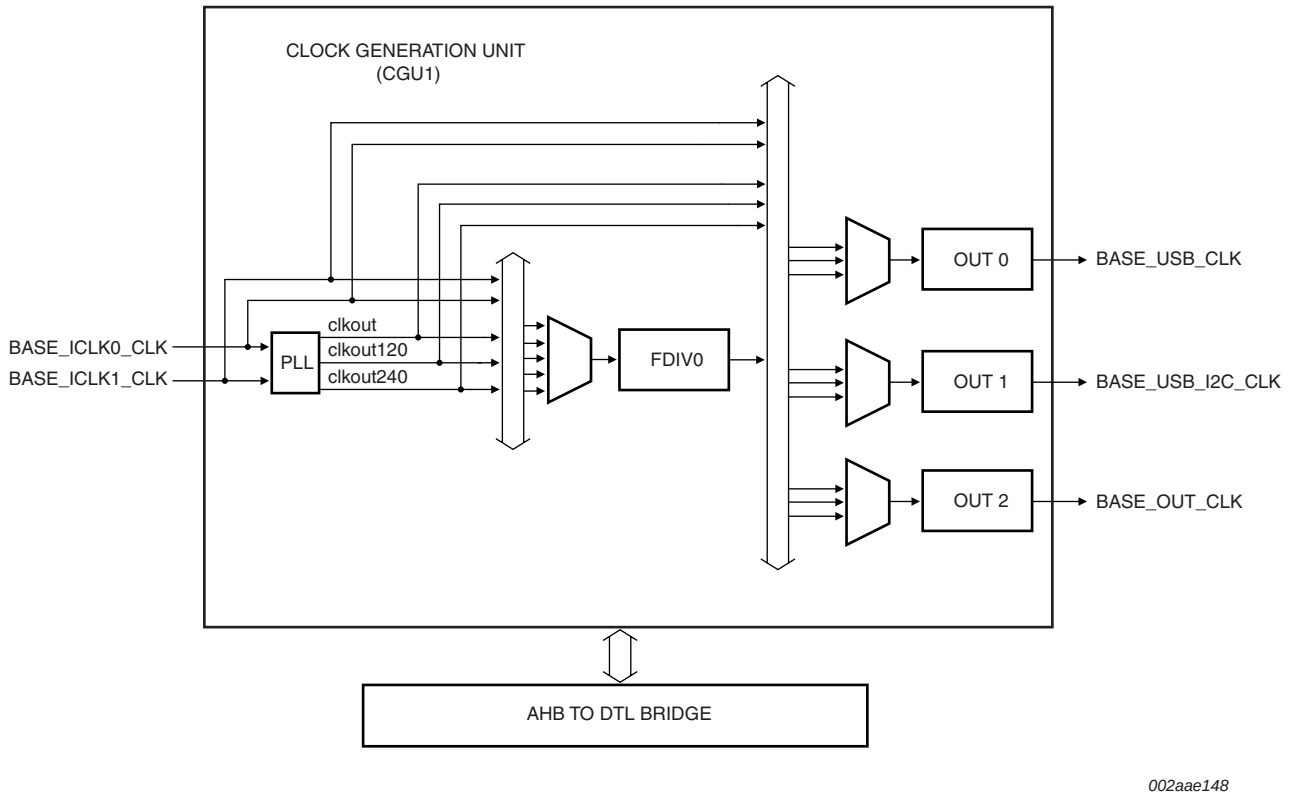


**Fig 15. Block diagram of the CGU1**

#### 6.16.3.1 Pin description

The CGU1 module in the LPC2926/2927/2929 has the pins listed in Table 28 below.

**Table 29. CGU1 pins**

| Symbol | Direction | Description |
|---|---|---|
| CLK_OUT | OUT | clock output |

### 6.16.4 Reset Generation Unit (RGU)

The RGU controls all internal resets.

The key features of the Reset Generation Unit (RGU) are:

- Reset controlled individually per subsystem


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- Automatic reset stretching and release
- Monitor function to trace resets back to source
- Register write-protection mechanism to prevent unintentional resets

#### 6.16.4.1 Functional description

Each reset output is defined as a combination of reset input sources including the external reset input pins and internal power-on reset, see Table 30. The first five resets listed in this table form a sort of cascade to provide the multiple levels of impact that a reset may have. The combined input sources are logically OR-ed together so that activating any of the listed reset sources causes the output to go active.

**Table 30. Reset output configuration**

| Reset output | Reset source | Parts of the device reset when activated |
|---|---|---|
| POR_RST | power-on reset module | LP_OSC; is source for RGU_RST |
| RGU_RST | POR_RST, $\overline{\text{RST}}$ pin | RGU internal; is source for PCR_RST |
| PCR_RST | RGU_RST, WATCHDOG | PCR internal; is source for COLD_RST |
| COLD_RST | PCR_RST | parts with COLD_RST as reset source below |
| WARM_RST | COLD_RST | parts with WARM_RST as reset source below |
| SCU_RST | COLD_RST | SCU |
| CFID_RST | COLD_RST | CFID |
| FMC_RST | COLD_RST | embedded Flash Memory Controller (FMC) |
| EMC_RST | COLD_RST | embedded SRAM-Memory Controller |
| SMC_RST | COLD_RST | external Static Memory Controller (SMC) |
| GESS_A2V_RST | WARM_RST | GeSS AHB-to-APB bridge |
| PESS_A2V_RST | WARM_RST | PeSS AHB-to-APB bridge |
| GPIO_RST | WARM_RST | all GPIO modules |
| UART_RST | WARM_RST | all UART modules |
| TMR_RST | WARM_RST | all timer modules in PeSS |
| SPI_RST | WARM_RST | all SPI modules |
| IVNSS_A2V_RST | WARM_RST | IVNSS AHB-to-APB bridge |
| IVNSS_CAN_RST | WARM_RST | all CAN modules including Acceptance filter |
| IVNSS_LIN_RST | WARM_RST | all LIN modules |
| MSCSS_A2V_RST | WARM_RST | MSCSS AHB to APB bridge |
| MSCSS_PWM_RST | WARM_RST | all PWM modules |
| MSCSS_ADC_RST | WARM_RST | all ADC modules |
| MSCSS_TMR_RST | WARM_RST | all timer modules in MSCSS |
| I2C_RST | WARM_RST | all I2C modules |
| QEI_RST | WARM_RST | Quadrature encoder |
| DMA_RST | WARM_RST | GPDMA controller |
| USB_RST | WARM_RST | USB controller |
| VIC_RST | WARM_RST | Vectored Interrupt Controller (VIC) |
| AHB_RST | WARM_RST | CPU and AHB Bus infrastructure |


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#### 6.16.4.2 Pin description

The RGU module in the LPC2926/2927/2929 has the following pins. Table 31 shows the RGU pins.

**Table 31. RGU pins**

| Symbol | Direction | Description |
|---|---|---|
| $\overline{\text{RST}}$ | IN | external reset input, Active LOW; pulled up internally |

### 6.16.5 Power Management Unit (PMU)

This module enables software to actively control the system's power consumption by disabling clocks not required in a particular operating mode.

Using the base clocks from the CGU as input, the PMU generates branch clocks to the rest of the LPC2926/2927/2929. Output clocks branched from the same base clock are phase- and frequency-related. These branch clocks can be individually controlled by software programming.

The key features are:

- Individual clock control for all LPC2926/2927/2929 sub-modules.
- Activates sleeping clocks when a wake-up event is detected.
- Clocks can be individually disabled by software.
- Supports AHB master-disable protocol when AUTO mode is set.
- Disables wake-up of enabled clocks when Power-down mode is set.
- Activates wake-up of enabled clocks when a wake-up event is received.
- Status register is available to indicate if an input base clock can be safely switched off (i.e. all branch clocks are disabled).

#### 6.16.5.1 Functional description

The PMU controls all internal clocks coming out of the CGU0 for power-mode management. With some exceptions, each branch clock can be switched on or off individually under control of software register bits located in its individual configuration register. Some branch clocks controlling vital parts of the device operate in a fixed mode. Table 32 shows which mode-control bits are supported by each branch clock.

By programming the configuration register the user can control which clocks are switched on or off, and which clocks are switched off when entering Power-down mode.

Note that the standby-wait-for-interrupt instructions of the ARM968E-S processor (putting the ARM CPU into a low-power state) are not supported. Instead putting the ARM CPU into power-down should be controlled by disabling the branch clock for the CPU.

**Remark:** For any disabled branch clocks to be re-activated their corresponding base clocks must be running (controlled by CGU0).

Table 32 shows the relation between branch and base clocks, see also Section 6.7.1. Every branch clock is related to one particular base clock: it is not possible to switch the source of a branch clock in the PMU.


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**Table 32. Branch clock overview**

*Legend:*
*'1' Indicates that the related register bit is tied off to logic HIGH, all writes are ignored*
*'0' Indicates that the related register bit is tied off to logic LOW, all writes are ignored*
*'+' Indicates that the related register bit is readable and writable*

| Branch clock name | Base clock | Implemented switch on/off mechanism | | |
|---|---|---|---|---|
| | | WAKE-UP | AUTO | RUN |
| CLK_SAFE | BASE_SAFE_CLK | 0 | 0 | 1 |
| CLK_SYS_CPU | BASE_SYS_CLK | + | + | 1 |
| CLK_SYS | BASE_SYS_CLK | + | + | 1 |
| CLK_SYS_PCR | BASE_SYS_CLK | + | + | 1 |
| CLK_SYS_FMC | BASE_SYS_CLK | + | + | + |
| CLK_SYS_RAM0 | BASE_SYS_CLK | + | + | + |
| CLK_SYS_RAM1 | BASE_SYS_CLK | + | + | + |
| CLK_SYS_SMC | BASE_SYS_CLK | + | + | + |
| CLK_SYS_GESS | BASE_SYS_CLK | + | + | + |
| CLK_SYS_VIC | BASE_SYS_CLK | + | + | + |
| CLK_SYS_PESS | BASE_SYS_CLK | + | + | + |
| CLK_SYS_GPIO0 | BASE_SYS_CLK | + | + | + |
| CLK_SYS_GPIO1 | BASE_SYS_CLK | + | + | + |
| CLK_SYS_GPIO2 | BASE_SYS_CLK | + | + | + |
| CLK_SYS_GPIO3 | BASE_SYS_CLK | + | + | + |
| CLK_SYS_IVNSS_A | BASE_SYS_CLK | + | + | + |
| CLK_SYS_MSCSS_A | BASE_SYS_CLK | + | + | + |
| CLK_SYS_DMA | BASE_SYS_CLK | + | + | + |
| CLK_SYS_USB | BASE_SYS_CLK | + | + | + |
| CLK_PCR_SLOW | BASE_PCR_CLK | + | + | 1 |
| CLK_IVNSS_APB | BASE_IVNSS_CLK | + | + | + |
| CLK_IVNSS_CANC0 | BASE_IVNSS_CLK | + | + | + |
| CLK_IVNSS_CANC1 | BASE_IVNSS_CLK | + | + | + |
| CLK_IVNSS_I2C0 | BASE_IVNSS_CLK | + | + | + |
| CLK_IVNSS_I2C1 | BASE_IVNSS_CLK | + | + | + |
| CLK_IVNSS_LIN0 | BASE_IVNSS_CLK | + | + | + |
| CLK_IVNSS_LIN1 | BASE_IVNSS_CLK | + | + | + |
| CLK_MSCSS_APB | BASE_MSCSS_CLK | + | + | + |
| CLK_MSCSS_MTMR0 | BASE_MSCSS_CLK | + | + | + |
| CLK_MSCSS_MTMR1 | BASE_MSCSS_CLK | + | + | + |
| CLK_MSCSS_PWM0 | BASE_MSCSS_CLK | + | + | + |
| CLK_MSCSS_PWM1 | BASE_MSCSS_CLK | + | + | + |
| CLK_MSCSS_PWM2 | BASE_MSCSS_CLK | + | + | + |
| CLK_MSCSS_PWM3 | BASE_MSCSS_CLK | + | + | + |
| CLK_MSCSS_ADC0_APB | BASE_MSCSS_CLK | + | + | + |
| CLK_MSCSS_ADC1_APB | BASE_MSCSS_CLK | + | + | + |


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**Table 32. Branch clock overview** *…continued*

*Legend:*
*'1' Indicates that the related register bit is tied off to logic HIGH, all writes are ignored*
*'0' Indicates that the related register bit is tied off to logic LOW, all writes are ignored*
*'+' Indicates that the related register bit is readable and writable*

| Branch clock name | Base clock | Implemented switch on/off mechanism | | |
|---|---|---|---|---|
| | | WAKE-UP | AUTO | RUN |
| CLK_MSCSS_ADC2_APB | BASE_MSCSS_CLK | + | + | + |
| CLK_MSCSS_QEI | BASE_MSCSS_CLK | + | + | + |
| CLK_OUT_CLK | BASE_OUT_CLK | + | + | + |
| CLK_UART0 | BASE_UART_CLK | + | + | + |
| CLK_UART1 | BASE_UART_CLK | + | + | + |
| CLK_SPI0 | BASE_SPI_CLK | + | + | + |
| CLK_SPI1 | BASE_SPI_CLK | + | + | + |
| CLK_SPI2 | BASE_SPI_CLK | + | + | + |
| CLK_TMR0 | BASE_TMR_CLK | + | + | + |
| CLK_TMR1 | BASE_TMR_CLK | + | + | + |
| CLK_TMR2 | BASE_TMR_CLK | + | + | + |
| CLK_TMR3 | BASE_TMR_CLK | + | + | + |
| CLK_ADC0 | BASE_ADC_CLK | + | + | + |
| CLK_ADC1 | BASE_ADC_CLK | + | + | + |
| CLK_ADC2 | BASE_ADC_CLK | + | + | + |
| CLK_USB_I2C | BASE_USB_I2C_CLK | + | + | + |
| CLK_USB | BASE_USB_CLK | + | + | + |

## 6.17 Vectored Interrupt Controller (VIC)

The LPC2926/2927/2929 contains a very flexible and powerful Vectored Interrupt Controller to interrupt the ARM processor on request.

The key features are:

- Level-active interrupt request with programmable polarity.
- 56 interrupt request inputs.
- Software interrupt request capability associated with each request input.
- Interrupt request state can be observed before masking.
- Software-programmable priority assignments to interrupt requests up to 15 levels.
- Software-programmable routing of interrupt requests towards the ARM-processor inputs IRQ and FIQ.
- Fast identification of interrupt requests through vector.
- Support for nesting of interrupt service routines.


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### 6.17.1 Functional description

The Vectored Interrupt Controller routes incoming interrupt requests to the ARM processor. The interrupt target is configured for each interrupt request input of the VIC. The targets are defined as follows:

- Target 0 is ARM processor FIQ (fast interrupt service).
- Target 1 is ARM processor IRQ (standard interrupt service).

Interrupt-request masking is performed individually per interrupt target by comparing the priority level assigned to a specific interrupt request with a target-specific priority threshold. The priority levels are defined as follows:

- Priority level 0 corresponds to ‘masked’ (i.e. interrupt requests with priority 0 never lead to an interrupt).
- Priority 1 corresponds to the lowest priority.
- Priority 15 corresponds to the highest priority.

Software interrupt support is provided and can be supplied for:

- Testing RTOS (Real-Time Operating System) interrupt handling without using device-specific interrupt service routines.
- Software emulation of an interrupt-requesting device, including interrupts.

### 6.17.2 Clock description

The VIC is clocked by CLK_SYS_VIC, see Section 6.7.2.


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# 7. Limiting values

**Table 33. Limiting values**

*In accordance with the Absolute Maximum Rating System (IEC 60134).*

| Symbol | Parameter | Conditions | | Min | Max | Unit |
|---|---|---|---|---|---|---|
| **Supply pins** | | | | | | |
| $P_{tot}$ | total power dissipation | | [1] | - | 1.5 | W |
| $V_{DD(CORE)}$ | core supply voltage | | | –0.5 | +2.0 | V |
| $V_{DD(OSC_PLL)}$ | oscillator and PLL supply voltage | | | –0.5 | +2.0 | V |
| $V_{DDA(ADC3V3)}$ | 3.3 V ADC analog supply voltage | | | –0.5 | +4.6 | V |
| $V_{DDA(ADC5V0)}$ | 5.0 V ADC analog supply voltage | | | –0.5 | +6.0 | V |
| $V_{DD(IO)}$ | input/output supply voltage | | | –0.5 | +4.6 | V |
| $I_{DD}$ | supply current | average value per supply pin | [2] | - | 98 | mA |
| $I_{SS}$ | ground current | average value per ground pin | [2] | - | 98 | mA |
| **Input pins and I/O pins** | | | | | | |
| $V_{XIN_OSC}$ | voltage on pin XIN_OSC | | | –0.5 | +2.0 | V |
| $V_{I(IO)}$ | I/O input voltage | | [3][4][5] | –0.5 | $V_{DD(IO)}$ + 3.0 | V |
| $V_{I(ADC)}$ | ADC input voltage | for ADC1/2: I/O port 0 pin 8 to pin 23. | [4][5] | –0.5 | $V_{DDA(ADC3V3)}$ + 0.5 | V |
| | | for ADC0: I/O port 0 pin 5 to pin 7; I/O port 2 pins 12 and 13; I/O port 3 pins 0 and 1. | [4][5][6][7] | –0.5 | $V_{DDA(ADC5V0)}$ + 0.5 | V |
| $V_{VREFP}$ | voltage on pin VREFP | | | –0.5 | +3.6 | V |
| $V_{VREFN}$ | voltage on pin VREFN | | | –0.5 | +3.6 | V |
| $I_{I(ADC)}$ | ADC input current | average value per input pin | [2] | - | 35 | mA |
| **Output pins and I/O pins configured as output** | | | | | | |
| $I_{OHS}$ | HIGH-level short-circuit output current | drive HIGH, output shorted to $V_{SS(IO)}$ | [8] | - | –33 | mA |
| $I_{OLS}$ | LOW-level short-circuit output current | drive LOW, output shorted to $V_{DD(IO)}$ | [8] | - | +38 | mA |
| **General** | | | | | | |
| $T_{stg}$ | storage temperature | | | –65 | +150 | °C |
| $T_{amb}$ | ambient temperature | | | –40 | +85 | °C |


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**Table 33. Limiting values** *...continued*

*In accordance with the Absolute Maximum Rating System (IEC 60134).*

| Symbol | Parameter | Conditions | | Min | Max | Unit |
|---|---|---|---|---|---|---|
| **ESD** | | | | | | |
| $V_{ESD}$ | electrostatic discharge voltage | on all pins | | | | |
| | | human body model | [9] | −2000 | +2000 | V |
| | | charged device model | | −500 | +500 | V |
| | | on corner pins | | | | |
| | | charged device model | | −750 | +750 | V |

[1] Based on package heat transfer, not device power consumption.

[2] Peak current must be limited at 25 times average current.

[3] For I/O Port 0, the maximum input voltage is defined by $V_{I(ADC)}$.

[4] Only when $V_{DD(IO)}$ is present.

[5] Note that pull-up should be off. With pull-up do not exceed 3.6 V.

[6] For these input pins a fixed amplification of $^{2}/_{3}$ is performed on the input voltage before feeding into the ADC0 itself. The maximum input voltage on ADC0 is $V_{DDA(ADC5V0)}$.

[7] Not exceeding 6 V.

[8] 112 mA per $V_{DD(IO)}$ or $V_{SS(IO)}$ should not be exceeded.

[9] Human-body model: discharging a 100 pF capacitor via a 10 kΩ series resistor.


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# 8. Static characteristics

**Table 34. Static characteristics**

*$V_{DD(CORE)}$ = $V_{DD(OSC_PLL)}$ ; $V_{DD(IO)}$ = 2.7 V to 3.6 V; $V_{DDA(ADC3V3)}$ = 3.0 V to 3.6 V; $V_{DDA(ADC5V0)}$ = 3.0 V to 5.5 V; $T_{vj}$ = −40 °C to +85 °C; all voltages are measured with respect to ground; positive currents flow into the IC; unless otherwise specified.*[1]

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **Supplies** | | | | | | | |
| Core supply | | | | | | | |
| $V_{DD(CORE)}$ | core supply voltage | | | 1.71 | 1.80 | 1.89 | V |
| $I_{DD(CORE)}$ | core supply current | Device state after reset; system clock at 125 MHz; $T_{amb}$ = 85 °C; executing code `while(1){}` from flash. | | - | 75 | - | mA |
| | | all clocks off | [2] | - | 30 | 475 | µA |
| I/O supply | | | | | | | |
| $V_{DD(IO)}$ | input/output supply voltage | | | 2.7 | - | 3.6 | V |
| $I_{DD(IO)}$ | I/O supply current | Power-down mode | | - | 0.5 | 3.25 | µA |
| Oscillator/PLL supply | | | | | | | |
| $V_{DD(OSC_PLL)}$ | oscillator and PLL supply voltage | | | 1.71 | 1.80 | 1.89 | V |
| $I_{DD(OSC_PLL)}$ | oscillator and PLL supply current | Normal mode | | - | - | 1 | mA |
| | | Power-down mode | | - | - | 2 | µA |
| Analog-to-digital converter supply | | | | | | | |
| $V_{DDA(ADC3V3)}$ | 3.3 V ADC analog supply voltage | | [3] | 3.0 | 3.3 | 3.6 | V |
| $V_{DDA(ADC5V0)}$ | 5.0 V ADC analog supply voltage. | | [4] | 3.0 | 5.0 | 5.5 | V |
| $I_{DDA(ADC3V3)}$ | 3.3 V ADC analog supply current | Normal mode | | - | - | 1.9 | mA |
| | | Power-down mode | | - | - | 4 | µA |
| $I_{DDA(ADC5V0)}$ | 5.0 V ADC analog supply current. | Normal mode | | - | - | 1 | mA |
| | | Power-down mode | | - | - | 1 | µA |
| **Input pins and I/O pins configured as input** | | | | | | | |
| $V_I$ | input voltage | all port pins and $V_{DD(IO)}$ applied<br>see Section 7 | [5][6] | −0.5 | - | +5.5 | V |
| | | port 0 pins 8 to 23 when ADC1/2 is used | [6] | | | $V_{VREFP}$ | |
| | | all port pins and $V_{DD(IO)}$ not applied | | −0.5 | - | +3.6 | V |
| | | all other I/O pins, $\overline{RST}$, $\overline{TRST}$, TDI, JTAGSEL, TMS, TCK | | −0.5 | - | $V_{DD(IO)}$ | V |
| $V_{IH}$ | HIGH-level input voltage | all port pins, $\overline{RST}$, $\overline{TRST}$, TDI, JTAGSEL, TMS, TCK | | 2.0 | - | - | V |


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**Table 34. Static characteristics** *...continued*

*$V_{DD(CORE)}$ = $V_{DD(OSC_PLL)}$ ; $V_{DD(IO)}$ = 2.7 V to 3.6 V; $V_{DDA(ADC3V3)}$ = 3.0 V to 3.6 V; $V_{DDA(ADC5V0)}$ = 3.0 V to 5.5 V; $T_{vj}$ = −40 °C to +85 °C; all voltages are measured with respect to ground; positive currents flow into the IC; unless otherwise specified.*[1]

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{IL}$ | LOW-level input voltage | all port pins, $\overline{RST}$, $\overline{TRST}$, TDI, JTAGSEL, TMS, TCK | | - | - | 0.8 | V |
| $V_{hys}$ | hysteresis voltage | | | 0.4 | - | - | V |
| $I_{LIH}$ | HIGH-level input leakage current | | | - | - | 1 | µA |
| $I_{LIL}$ | LOW-level input leakage current | | | - | - | 1 | µA |
| $I_{I(pd)}$ | pull-down input current | all port pins, $V_I$ = 3.3 V; $V_I$ = 5.5 V | | 25 | 50 | 100 | µA |
| $I_{I(pu)}$ | pull-up input current | all port pins, $\overline{RST}$, $\overline{TRST}$, TDI, JTAGSEL, TMS: $V_I$ = 0 V; $V_I$ > 3.6 V is not allowed | | −25 | −50 | −115 | µA |
| $C_i$ | input capacitance | | [7] | - | 3 | 8 | pF |
| **Output pins and I/O pins configured as output** | | | | | | | |
| $V_O$ | output voltage | | | 0 | - | $V_{DD(IO)}$ | V |
| $V_{OH}$ | HIGH-level output voltage | $I_{OH}$ = −4 mA | | $V_{DD(IO)}$ − 0.4 | - | - | V |
| $V_{OL}$ | LOW-level output voltage | $I_{OL}$ = 4 mA | | - | - | 0.4 | V |
| $C_L$ | load capacitance | | | - | - | 25 | pF |
| **USB pins USB_D+ and USB_D−** | | | | | | | |
| Input characteristics | | | | | | | |
| $V_{IH}$ | HIGH-level input voltage | | | 1.5 | - | - | V |
| $V_{IL}$ | LOW-level input voltage | | | - | - | 1.3 | V |
| $V_{hys}$ | hysteresis voltage | | | 0.4 | - | - | V |
| Output characteristics | | | | | | | |
| $Z_o$ | output impedance | with 33 Ω series resistor | | 36.0 | - | 44.1 | Ω |
| $V_{OH}$ | HIGH-level output voltage | (driven) for low-/full-speed; $R_L$ of 15 kΩ to GND | | 2.9 | - | 3.5 | V |
| $V_{OL}$ | LOW-level output voltage | (driven) for low-/full-speed; with 1.5 kΩ resistor to 3.6 V external pull-up | | - | - | 0.18 | V |
| $I_{OH}$ | HIGH-level output current | at $V_{OH}$ = $V_{DD(IO)}$ − 0.3 V; without 33 Ω external series resistor | | 20.8 | - | 41.7 | mA |
| | | at $V_{OH}$ = $V_{DD(IO)}$ − 0.3 V; with 33 Ω external series resistor | | 4.8 | - | 5.3 | mA |


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**Table 34. Static characteristics** *...continued*

*$V_{DD(CORE)}$ = $V_{DD(OSC_PLL)}$ ; $V_{DD(IO)}$ = 2.7 V to 3.6 V; $V_{DDA(ADC3V3)}$ = 3.0 V to 3.6 V; $V_{DDA(ADC5V0)}$ = 3.0 V to 5.5 V; $T_{vj}$ = −40 °C to +85 °C; all voltages are measured with respect to ground; positive currents flow into the IC; unless otherwise specified.*[1]

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $I_{OL}$ | LOW-level output current | at $V_{OL}$ = 0.3 V; without 33 Ω external series resistor | | 26.7 | - | 57.2 | mA |
| | | at $V_{OL}$ = 0.3 V; with 33 Ω external series resistor | | 5.0 | - | 5.5 | mA |
| $I_{OHS}$ | HIGH-level short-circuit output current | drive high; pad connected to ground | | - | - | 90.0 | mA |
| $I_{OLS}$ | LOW-level short-circuit output current | drive high; pad connected to $V_{DD(IO)}$ | | - | - | 95.1 | mA |
| **Oscillator** | | | | | | | |
| $V_{XIN_OSC}$ | voltage on pin XIN_OSC | | | 0 | - | 1.8 | V |
| $R_{s(xtal)}$ | crystal series resistance | $f_{osc}$ = 10 MHz to 15 MHz | [8] | | | | |
| | | $C_{xtal}$ = 10 pF; $C_{ext}$ = 18 pF | | - | - | 160 | Ω |
| | | $C_{xtal}$ = 20 pF; $C_{ext}$ = 39 pF | | - | - | 60 | Ω |
| | | $f_{osc}$ = 15 MHz to 20 MHz | [8] | | | | |
| | | $C_{xtal}$ = 10 pF; $C_{ext}$ = 18 pF | | - | - | 80 | Ω |
| $C_i$ | input capacitance | of XIN_OSC | [9] | - | | 2 | pF |
| **Power-up reset** | | | | | | | |
| $V_{trip(high)}$ | high trip level voltage | | [10] | 1.1 | 1.4 | 1.6 | V |
| $V_{trip(low)}$ | low trip level voltage | | [10] | 1.0 | 1.3 | 1.5 | V |
| $V_{trip(dif)}$ | difference between high and low trip level voltage | | [10] | 50 | 120 | 180 | mV |

[1] All parameters are guaranteed over the virtual junction temperature range by design. Pre-testing is performed at $T_{amb}$ = 85 °C on wafer level. Cased products are tested at $T_{amb}$ = 25 °C (final testing). Both pre-testing and final testing use correlated test conditions to cover the specified temperature and power-supply voltage range.

[2] Leakage current is exponential to temperature; worst-case value is at 85 °C $T_{vj}$. All clocks off. Analog modules and flash powered down.

[3] $V_{DDA(ADC3V3)}$ must correlate with $V_{DDA(ADC5V0)}$: $V_{DDA(ADC3V3)}$ = $V_{DDA(ADC5V0)}$ / 1.5.

[4] $V_{DDA(ADC5V0)}$ must correlate with $V_{DDA(ADC3V3)}$: $V_{DDA(ADC5V0)}$ = $V_{DDA(ADC3V3)}$ × 1.5.

[5] Not 5 V-tolerant when pull-up is on.

[6] For I/O Port 0, the maximum input voltage is defined by $V_{I(ADC)}$.

[7] For Port 0, pin 0 to pin 15 add maximum 1.5 pF for input capacitance to ADC. For Port 0, pin 16 to pin 31 add maximum 1.0 pF for input capacitance to ADC.

[8] $C_{xtal}$ is crystal load capacitance and $C_{ext}$ are the two external load capacitors.

[9] This parameter is not part of production testing or final testing, hence only a typical value is stated. Maximum and minimum values are based on simulation results.

[10] The power-up reset has a time filter: $V_{DD(CORE)}$ must be above $V_{trip(high)}$ for 2 µs before reset is de-asserted; $V_{DD(CORE)}$ must be below $V_{trip(low)}$ for 11 µs before internal reset is asserted.


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**Table 35. ADC static characteristics**

*$V_{DDA(ADC3V3)}$ = 3.0 V to 3.6 V; $T_{amb}$ = −40 °C to +85 °C unless otherwise specified; ADC frequency 4.5 MHz.*

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{VREFN}$ | voltage on pin VREFN | | | 0 | - | $V_{VREFP}$ − 2 | V |
| $V_{VREFP}$ | voltage on pin VREFP | | | $V_{VREFN}$ + 2 | - | $V_{DDA(ADC3V3)}$ | V |
| $V_{IA}$ | analog input voltage | for 3.3 V ADC1/2 | | $V_{VREFN}$ | - | $V_{VREFP}$ | V |
| $Z_i$ | input impedance | between $V_{VREFN}$ and $V_{VREFP}$ | | 4.4 | - | - | kΩ |
| | | between $V_{VREFN}$ and $V_{DDA(ADC5V0)}$ | | 13.7 | - | 23.6 | kΩ |
| $C_{ia}$ | analog input capacitance | for ADC0/1/2 | | - | - | 1 | pF |
| $E_D$ | differential linearity error | for ADC0/1/2 | [1][2][3] | - | - | ±1 | LSB |
| $E_{L(adj)}$ | integral non-linearity | for ADC0/1/2 | [1][4] | - | - | ±2 | LSB |
| $E_O$ | offset error | for ADC0/1/2 | [1][5] | - | - | ±3 | LSB |
| $E_G$ | gain error | for ADC0/1/2 | [1][6] | - | - | ±0.5 | % |
| $E_T$ | absolute error | for ADC0/1/2 | [1][7] | - | - | ±4 | LSB |
| $R_{vsi}$ | voltage source interface resistance | for ADC0/1/2 | [8] | - | - | 40 | kΩ |
| FSR | full scale range | for ADC0/1/2 | | 2 | - | 10 | bit |

[1] Conditions: $V_{SS(IO)}$ = 0 V, $V_{DDA(ADC3V3)}$ = 3.3 V.

[2] The ADC is monotonic, there are no missing codes.

[3] The differential linearity error ($E_D$) is the difference between the actual step width and the ideal step width. See Figure 17.

[4] The integral non-linearity ($E_{L(adj)}$) 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 17.

[5] The offset error ($E_O$) is the absolute difference between the straight line which fits the actual curve and the straight line which fits the ideal curve. See Figure 17.

[6] The gain error ($E_G$) 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 17.

[7] The absolute error ($E_T$) is the maximum difference between the center of the steps of the actual transfer curve of the non-calibrated ADC and the ideal transfer curve. See Figure 17.

[8] See Figure 16.

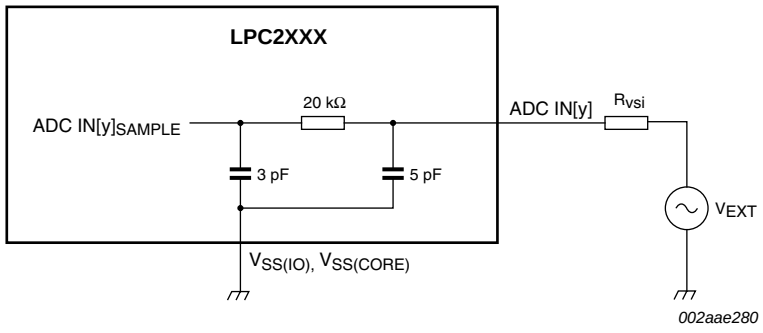


**Fig 16. Suggested ADC interface - LPC2926/2927/2929 ADC1/2 IN[y] pin**


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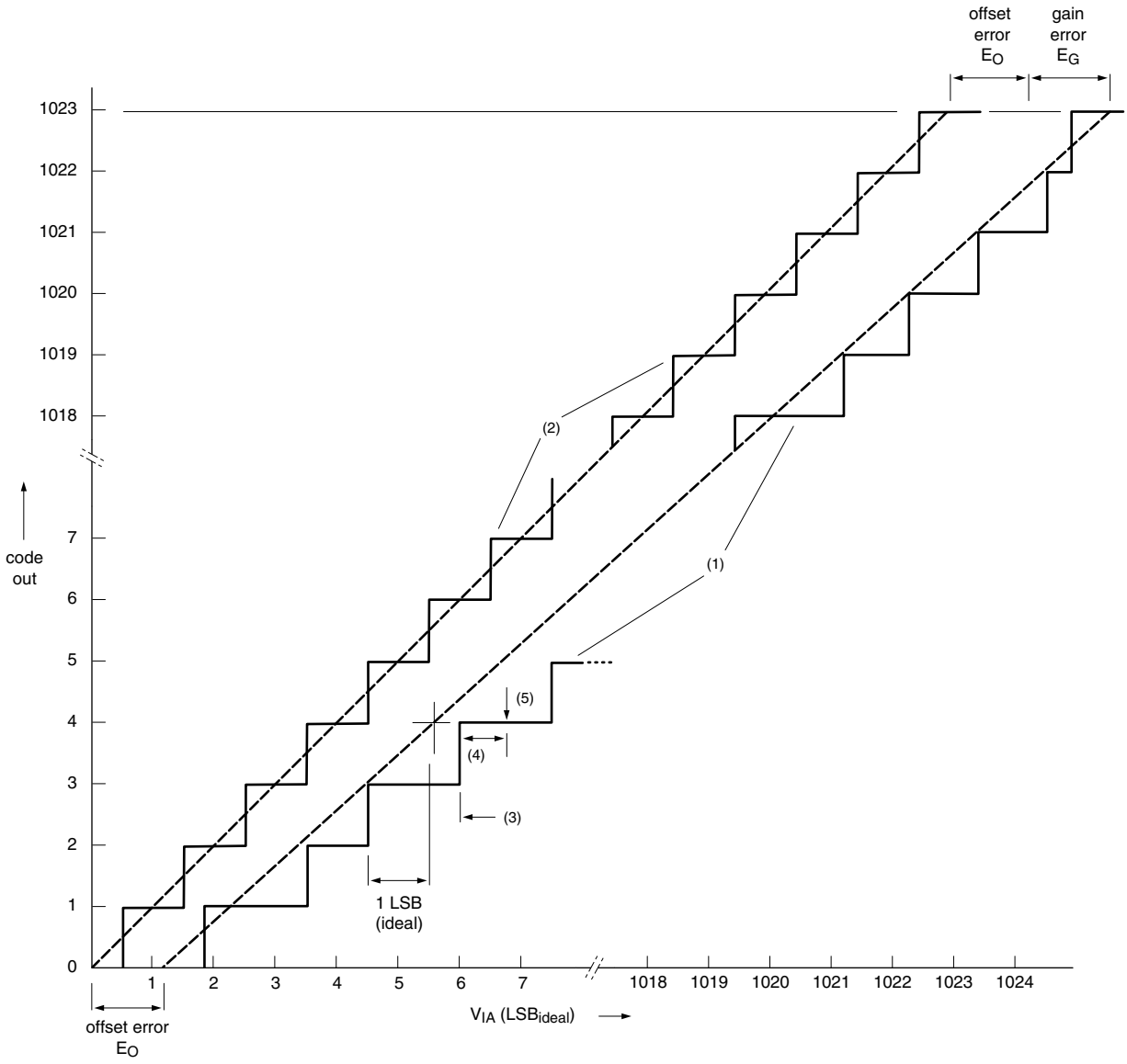


(1) Example of an actual transfer curve.

(2) The ideal transfer curve.

(3) Differential linearity error ($E_D$).

(4) Integral non-linearity ($E_{L(adj)}$).

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

**Fig 17. ADC characteristics**


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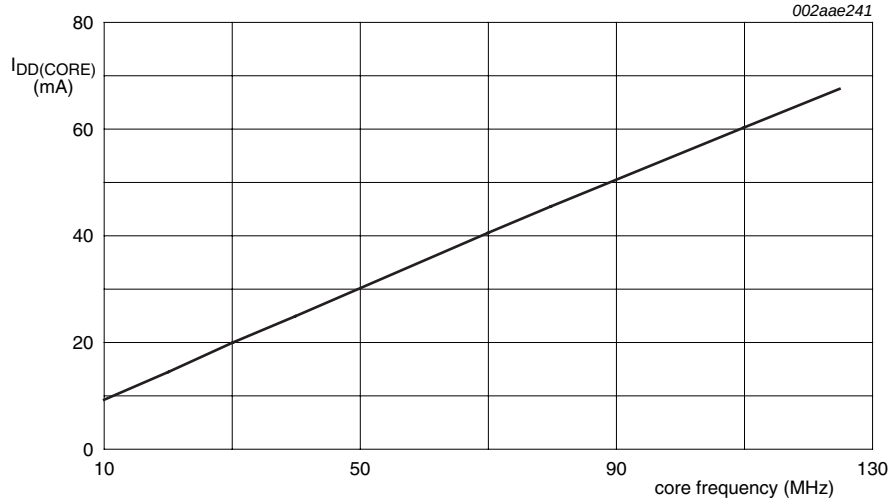
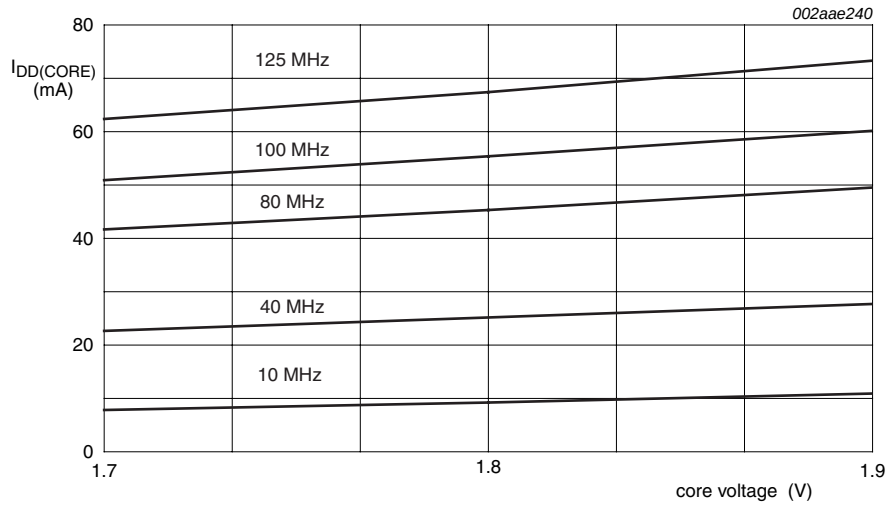
## 8.1 Power consumption




Conditions: $T_{amb}$ = 25 °C; active mode entered executing code from flash; core voltage 1.8 V; all peripherals enabled but not configured to run.

**Fig 18. $I_{DD(CORE)}$ at different core frequencies (active mode)**




Conditions: $T_{amb}$ = 25 °C; active mode entered executing code from flash; all peripherals enabled but not configured to run.

**Fig 19. $I_{DD(CORE)}$ at different core voltages $V_{DD(CORE)}$ (active mode)**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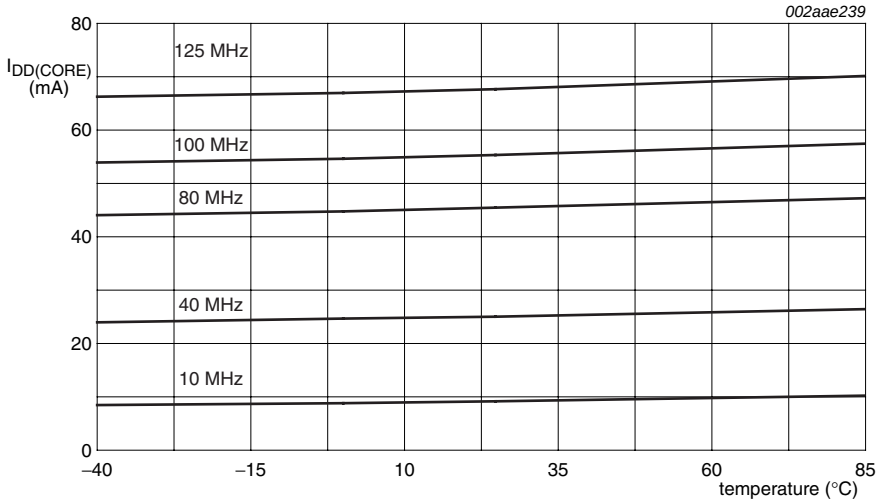
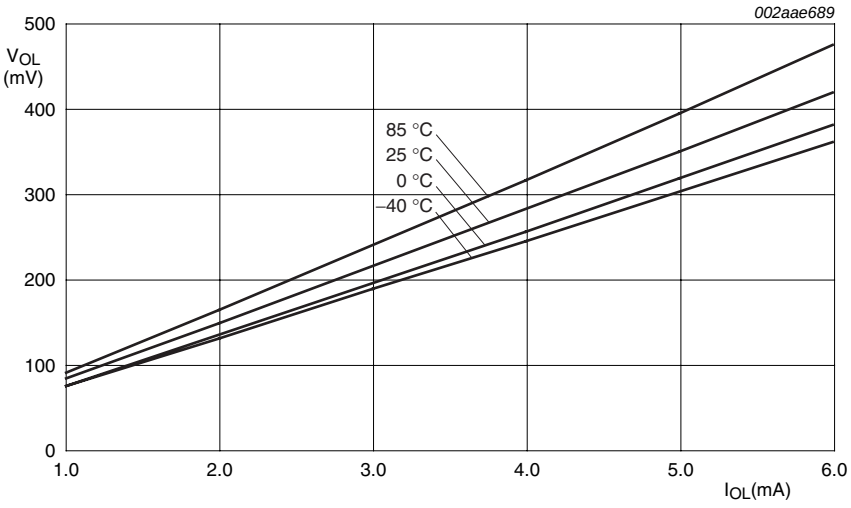



Conditions: active mode entered executing code from flash; core voltage 1.8 V; all peripherals enabled but not configured to run.

**Fig 20. $I_{DD(CORE)}$ at different temperatures (active mode)**

## 8.2 Electrical pin characteristics




$V_{DD(IO)}$ = 3.3 V.

**Fig 21. Typical LOW-level output voltage versus LOW-level output current**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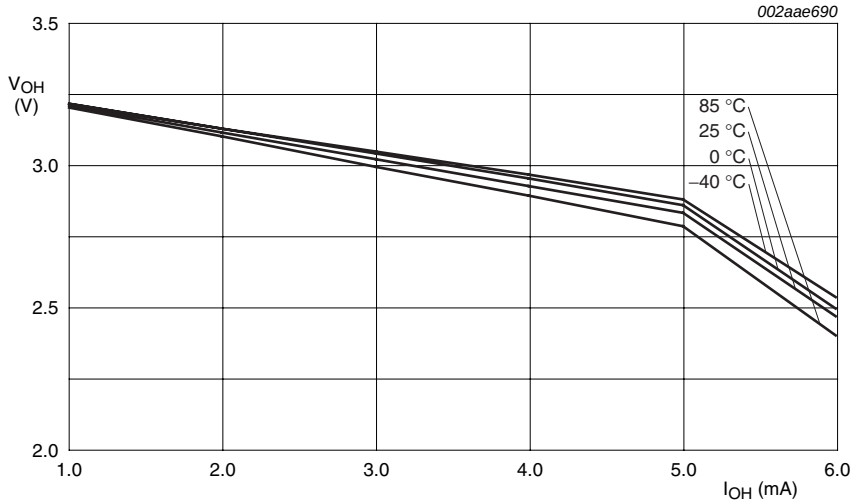
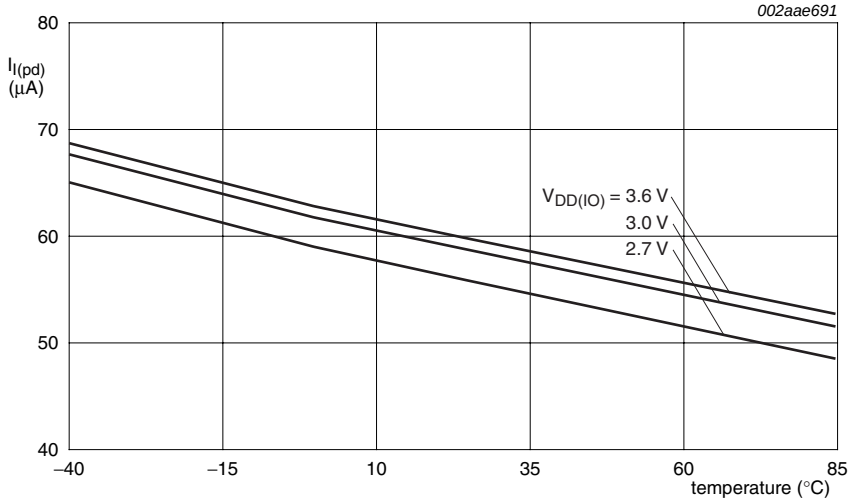



$V_{DD(IO)}$ = 3.3 V.

**Fig 22. Typical HIGH-level output voltage versus HIGH-level output current**




$V_I$ = 3.3 V.

**Fig 23. Typical pull-down current versus temperature**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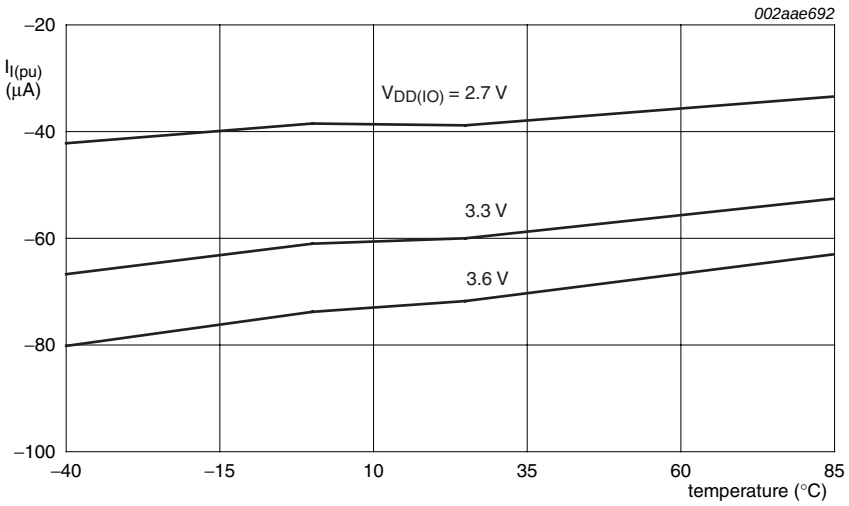


$V_I$ = 0 V.

**Fig 24. Typical pull-up current versus temperature**


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# 9. Dynamic characteristics

## 9.1 Dynamic characteristics: I/O and CLK_OUT pins, internal clock, oscillators, PLL, and CAN

**Table 36. Dynamic characteristics**

*$V_{DD(CORE)}$ = $V_{DD(OSC_PLL)}$; $V_{DD(IO)}$ = 2.7 V to 3.6 V; $V_{DDA(ADC3V3)}$ = 3.0 V to 3.6 V; all voltages are measured with respect to ground; positive currents flow into the IC; unless otherwise specified.*[1]

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **I/O pins** | | | | | | | |
| $t_{THL}$ | HIGH to LOW transition time | $C_L$ = 30 pF | | 4 | - | 13.8 | ns |
| $t_{TLH}$ | LOW to HIGH transition time | $C_L$ = 30 pF | | 4 | - | 13.8 | ns |
| **CLK_OUT pin** | | | | | | | |
| $f_{clk}$ | clock frequency | on pin CLK_OUT | | - | - | 40 | MHz |
| **Internal clock** | | | | | | | |
| $f_{clk(sys)}$ | system clock frequency | | [2] | 10 | - | 125 | MHz |
| $T_{clk(sys)}$ | system clock period | | [2] | 8 | - | 100 | ns |
| **Low-power ring oscillator** | | | | | | | |
| $f_{ref(RO)}$ | RO reference frequency | | | 0.4 | 0.5 | 0.6 | MHz |
| $t_{startup}$ | start-up time | at maximum frequency | [3] | - | 6 | - | µs |
| **Oscillator** | | | | | | | |
| $f_{i(osc)}$ | oscillator input frequency | maximum frequency is the clock input of an external clock source applied to the XIN_OSC pin | | 10 | - | 100 | MHz |
| $t_{startup}$ | start-up time | at maximum frequency | [3] [4] | - | 500 | - | µs |
| **PLL** | | | | | | | |
| $f_{i(PLL)}$ | PLL input frequency | | | 10 | - | 25 | MHz |
| $f_{o(PLL)}$ | PLL output frequency | | | 10 | - | 160 | MHz |
| | | CCO; direct mode | | 156 | - | 320 | MHz |
| $t_{a(clk)}$ | clock access time | | | - | - | 63.4 | ns |
| $t_{a(A)}$ | address access time | | | - | - | 60.3 | ns |
| **Jitter specification for CAN** | | | | | | | |
| $t_{jit(cc)(p-p)}$ | cycle to cycle jitter (peak-to-peak value) | on CAN TXDC pin | [3] | - | 0.4 | 1 | ns |

[1] All parameters are guaranteed over the virtual junction temperature range by design. Pre-testing is performed at $T_{amb}$ = 85 °C ambient temperature on wafer level. Cased products are tested at $T_{amb}$ = 25 °C (final testing). Both pre-testing and final testing use correlated test conditions to cover the specified temperature and power supply voltage range.

[2] See Table 27.

[3] This parameter is not part of production testing or final testing, hence only a typical value is stated.

[4] Oscillator start-up time depends on the quality of the crystal. For most crystals it takes about 1000 clock pulses until the clock is fully stable.


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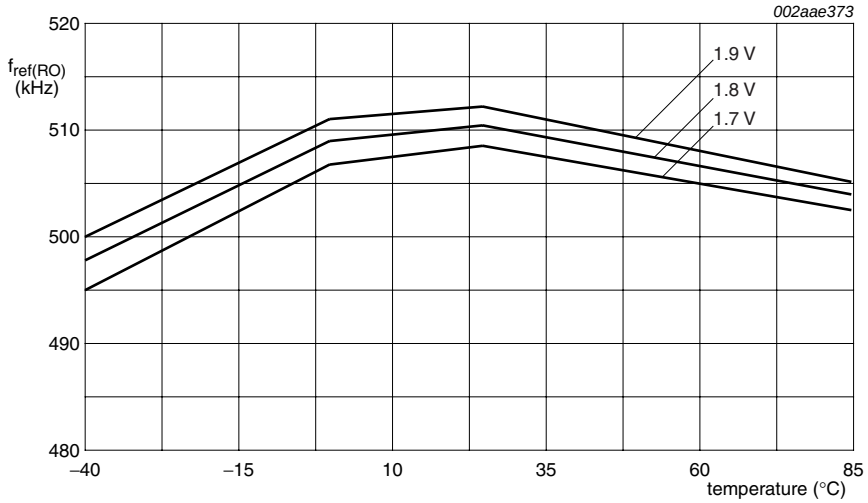


**Fig 25. Low-power ring oscillator thermal characteristics**


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## 9.2 USB interface

**Table 37. Dynamic characteristics: USB pins (full-speed)**

*$C_L$ = 50 pF; $R_{pu}$ = 1.5 kΩ on D+ to $V_{DD(3V3)}$, unless otherwise specified.*

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $t_r$ | rise time | 10 % to 90 % | | 8.5 | - | 13.8 | ns |
| $t_f$ | fall time | 10 % to 90 % | | 7.7 | - | 13.7 | ns |
| $t_{FRFM}$ | differential rise and fall time matching | $t_r / t_f$ | | - | - | 109 | % |
| $V_{CRS}$ | output signal crossover voltage | | | 1.3 | - | 2.0 | V |
| $t_{FEOPT}$ | source SE0 interval of EOP | see Figure 26 | | 160 | - | 175 | ns |
| $t_{FDEOP}$ | source jitter for differential transition to SE0 transition | see Figure 26 | | −2 | - | +5 | ns |
| $t_{JR1}$ | receiver jitter to next transition | | | −18.5 | - | +18.5 | ns |
| $t_{JR2}$ | receiver jitter for paired transitions | 10 % to 90 % | | −9 | - | +9 | ns |
| $t_{EOPR1}$ | EOP width at receiver | must reject as EOP; see Figure 26 | [1] | 40 | - | - | ns |
| $t_{EOPR2}$ | EOP width at receiver | must accept as EOP; see Figure 26 | [1] | 82 | - | - | ns |

[1] Characterized but not implemented as production test. Guaranteed by design.

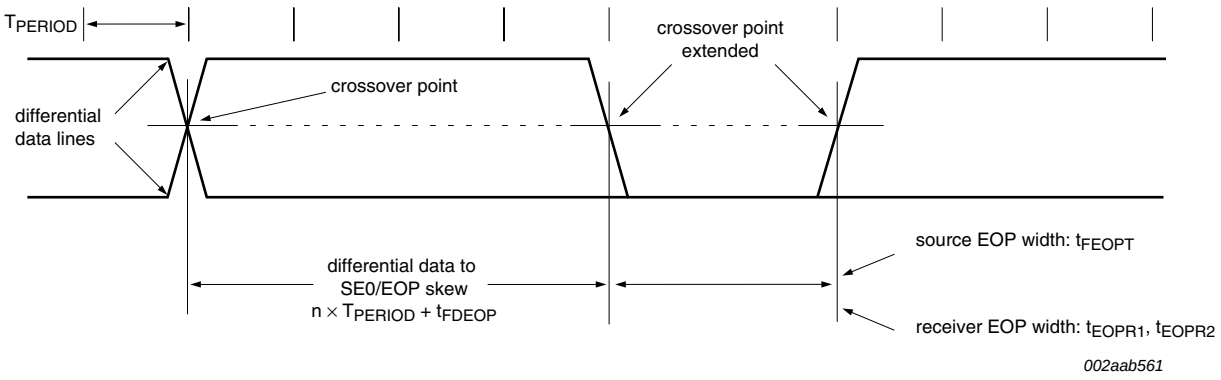


**Fig 26. Differential data-to-EOP transition skew and EOP width**


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## 9.3 Dynamic characteristics: I²C-bus interface

**Table 38. Dynamic characteristic: I²C-bus pins**

*$V_{DD(CORE)}$ = $V_{DD(OSC_PLL)}$; $V_{DD(IO)}$ = 2.7 V to 3.6 V; $V_{DDA(ADC3V3)}$ = 3.0 V to 3.6 V; all voltages are measured with respect to ground; positive currents flow into the IC; unless otherwise specified*[1]

| Symbol | Parameter | Conditions | Min | Typ[2] | Max | Unit |
|---|---|---|---|---|---|---|
| $t_{f(o)}$ | output fall time | $V_{IH}$ to $V_{IL}$ | $20 + 0.1 \times C_b$[3] | - | - | ns |

[1] All parameters are guaranteed over the virtual junction temperature range by design. Pre-testing is performed at $T_{amb}$ = 85 °C ambient temperature on wafer level. Cased products are tested at $T_{amb}$ = 25 °C (final testing). Both pre-testing and final testing use correlated test conditions to cover the specified temperature and power supply voltage range.

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

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


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## 9.4 Dynamic characteristics: SPI

**Table 39. Dynamic characteristics of SPI pins**

*$V_{DD(CORE)}$ = $V_{DD(OSC_PLL)}$ ; $V_{DD(IO)}$ = 2.7 V to 3.6 V; $V_{DDA(ADC3V3)}$ = 3.0 V to 3.6 V; $V_{DDA(ADC5V0)}$ = 3.0 V to 5.5 V; $T_{vj}$ = −40 °C to +85 °C; all voltages are measured with respect to ground; positive currents flow into the IC; unless otherwise specified.*[1]

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $f_{SPI}$ | SPI operating frequency | master operation | $1/65024 f_{clk(SPI)}$ | - | $1/2 f_{clk(SPI)}$ | MHz |
| | | slave operation | $1/65024 f_{clk(SPI)}$ | - | $1/4 f_{clk(SPI)}$ | MHz |
| $t_{su(SPI_MISO)}$ | SPI_MISO set-up time | $T_{amb}$ = 25 °C; measured in SPI Master mode; see Figure 27 | - | 11 | - | ns |

[1] All parameters are guaranteed over the virtual junction temperature range by design. Pre-testing is performed at $T_{amb}$ = 85 °C ambient temperature on wafer level. Cased products are tested at $T_{amb}$ = 25 °C (final testing). Both pre-testing and final testing use correlated test conditions to cover the specified temperature and power supply voltage range.

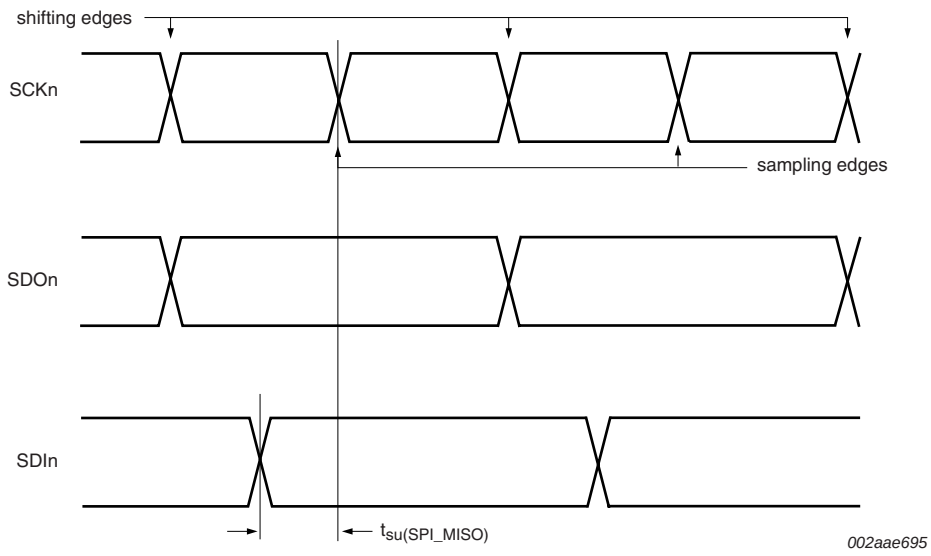


**Fig 27. SPI data input set-up time in SSP Master mode**


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## 9.5 Dynamic characteristics: flash memory and EEPROM

**Table 40. Flash characteristics**

*$T_{amb}$ = −40 °C to +85 °C; $V_{DD(CORE)}$ = $V_{DD(OSC_PLL)}$; $V_{DD(IO)}$ = 2.7 V to 3.6 V; $V_{DDA(ADC3V3)}$ = 3.0 V to 3.6 V; all voltages are measured with respect to ground.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $N_{endu}$ | endurance | [1] | 10000 | - | - | cycles |
| $t_{ret}$ | retention time | powered | 10 | - | - | years |
| | | unpowered | 20 | - | - | years |
| $t_{prog}$ | programming time | word | 0.95 | 1 | 1.05 | ms |
| $t_{er}$ | erase time | global | 95 | 100 | 105 | ms |
| | | sector | 95 | 100 | 105 | ms |
| $t_{init}$ | initialization time | | - | - | 150 | µs |
| $t_{wr(pg)}$ | page write time | | 0.95 | 1 | 1.05 | ms |
| $t_{fl(BIST)}$ | flash word BIST time | | - | 38 | 70 | ns |
| $t_{a(clk)}$ | clock access time | | - | - | 63.4 | ns |
| $t_{a(A)}$ | address access time | | - | - | 60.3 | ns |

[1] Number of program/erase cycles.

**Table 41. EEPROM characteristics**

*$T_{amb}$ = −40 °C to +85 °C; $V_{DD(CORE)}$ = $V_{DD(OSC_PLL)}$; $V_{DD(IO)}$ = 2.7 V to 3.6 V; $V_{DDA(ADC3V3)}$ = 3.0 V to 3.6 V; all voltages are measured with respect to ground.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $f_{clk}$ | clock frequency | | 200 | 375 | 400 | kHz |
| $N_{endu}$ | endurance | | 100000 | 500000 | - | cycles |
| $t_{ret}$ | retention time | powered | 10 | - | - | years |


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## 9.6 Dynamic characteristics: external static memory

**Table 42. External static memory interface dynamic characteristics**

*$V_{DD(CORE)}$ = $V_{DD(OSC_PLL)}$; $V_{DD(IO)}$ = 2.7 V to 3.6 V; $V_{DDA(ADC3V3)}$ = 3.0 V to 3.6 V; all voltages are measured with respect to ground.*[1]

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $T_{CLCL}$ | clock cycle time | | 8 | - | 100 | ns |
| $t_{a(R)int}$ | internal read access time | | - | - | 20.5 | ns |
| $t_{a(W)int}$ | internal write access time | | - | - | 24.9 | ns |
| **Read cycle parameters** | | | | | | |
| $t_{CSLAV}$ | $\overline{CS}$ LOW to address valid time | | –5 | –2.5 | - | ns |
| $t_{OELAV}$ | $\overline{OE}$ LOW to address valid time | | –5 – WSTOEN × $T_{CLCL}$ | –2.5 – WSTOEN × $T_{CLCL}$ | - | ns |
| $t_{CSLOEL}$ | $\overline{CS}$ LOW to $\overline{OE}$ LOW time | | - | 0 + WSTOEN × $T_{CLCL}$ | - | ns |
| $t_{su(DQ)}$ | data input/output set-up time | | 11 | 16 | 22 | ns |
| $t_{h(D)}$ | data input hold time | | 0 | 2.5 | 5 | ns |
| $t_{CSHOEH}$ | $\overline{CS}$ HIGH to $\overline{OE}$ HIGH time | | - | 0 | - | ns |
| $t_{BLSLBLSH}$ | $\overline{BLS}$ LOW to $\overline{BLS}$ HIGH time | | - | (WST1 – WSTOEN + 1) × $T_{CLCL}$ | - | ns |
| $t_{OELOEH}$ | $\overline{OE}$ LOW to $\overline{OE}$ HIGH time | | - | (WST1 – WSTOEN + 1) × $T_{CLCL}$ | - | ns |
| $t_{BLSLAV}$ | $\overline{BLS}$ LOW to address valid time | | - | 0 + WSTOEN × $T_{CLCL}$ | - | ns |
| **Write cycle parameters** | | | | | | |
| $t_{CSHBLSH}$ | $\overline{CS}$ HIGH to $\overline{BLS}$ HIGH time | [2] | - | 0 | - | ns |
| $t_{CSLWEL}$ | $\overline{CS}$ LOW to $\overline{WE}$ LOW time | | - | (WSTWEN + 0.5) × $T_{CLCL}$ | - | ns |
| $t_{CSLBLSL}$ | $\overline{CS}$ LOW to $\overline{BLS}$ LOW time | [3] | - | WSTWEN × $T_{CLCL}$ | - | ns |
| $t_{WELDV}$ | $\overline{WE}$ LOW to data valid time | | - | (WSTWEN + 0.5) × $T_{CLCL}$ | - | ns |
| $t_{CSLDV}$ | $\overline{CS}$ LOW to data valid time | | –0.5 | –0.1 | 0.3 | ns |
| $t_{WELWEH}$ | $\overline{WE}$ LOW to $\overline{WE}$ HIGH time | | - | (WST2 – WSTWEN + 1) × $T_{CLCL}$ | - | ns |
| $t_{BLSLBLSH}$ | $\overline{BLS}$ LOW to $\overline{BLS}$ HIGH time | [4] | - | (WST2 – WSTWEN + 2) × $T_{CLCL}$ | - | ns |

[1] All parameters are guaranteed over the virtual junction temperature range by design. Pre-testing is performed at $T_{amb}$ = 85 °C ambient temperature on wafer level. Cased products are tested at $T_{amb}$ = 25 °C (final testing). Both pre-testing and final testing use correlated test conditions to cover the specified temperature and power supply voltage range.

[2] When the byte lane select signals are used to connect the write enable input (8 bit devices), $t_{CSHBLSH} = -0.5 \times T_{CLCL}$.

[3] When the byte lane select signals are used to connect the write enable input (8 bit devices), $t_{CSLBLSL} = t_{CSLWEL}$.

[4] For 16 and 32 bit devices.


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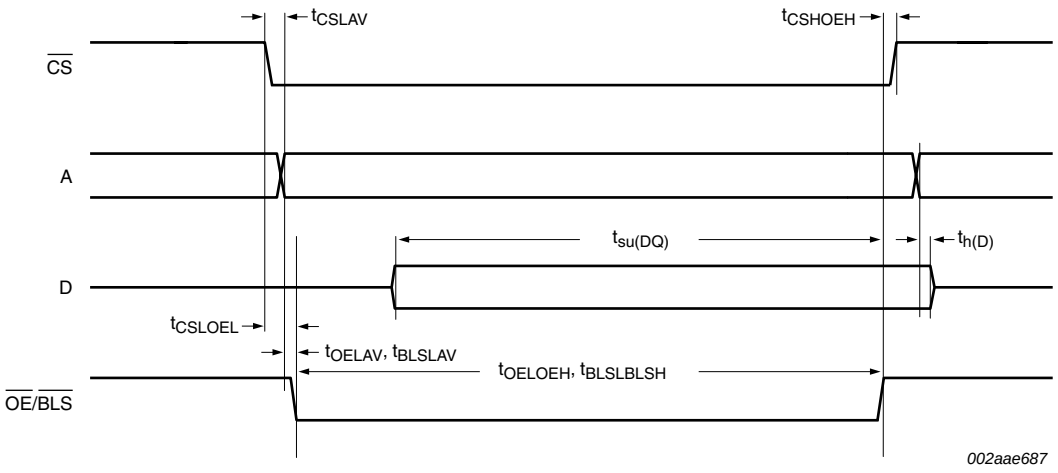


**Fig 28. External memory read access**

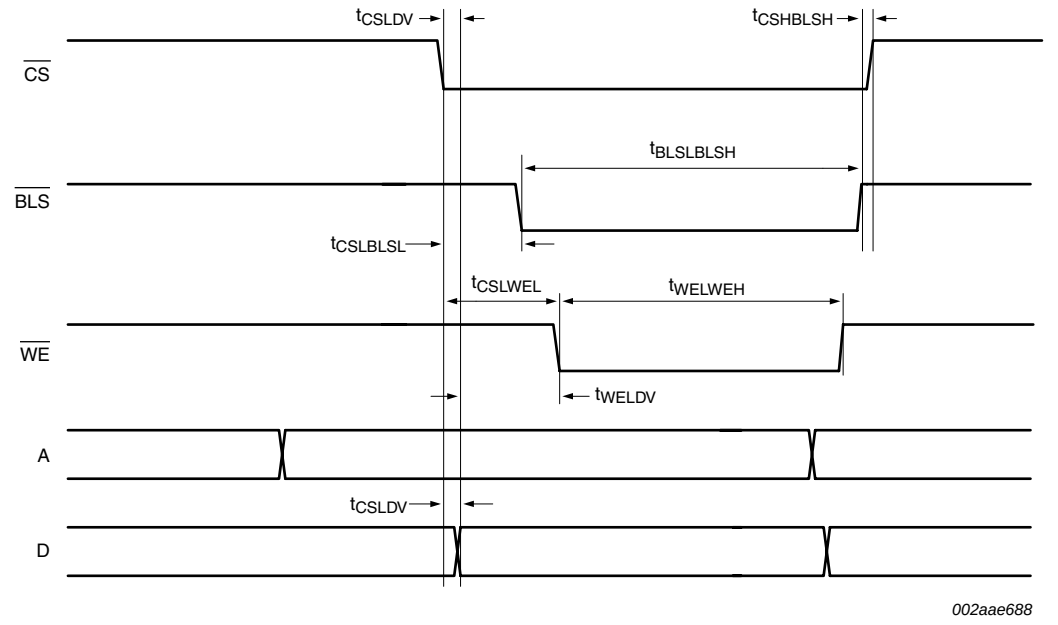


**Fig 29. External memory write access**


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### 9.7 Dynamic characteristics: ADC

**Table 43. ADC dynamic characteristics**

*$V_{DD(CORE)}$ = $V_{DD(OSC_PLL)}$; $V_{DD(IO)}$ = 2.7 V to 3.6 V; $V_{DDA(ADC3V3)}$ = 3.0 V to 3.6 V; all voltages are measured with respect to ground.*[1]

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **5.0 V ADC0** | | | | | | | |
| $f_{i(ADC)}$ | ADC input frequency | | [2] | 4 | - | 4.5 | MHz |
| $f_{s(max)}$ | maximum sampling rate | $f_{i(ADC)}$ = 4.5 MHz; $f_s = f_{i(ADC)} / (n + 1)$ with n = resolution | | | | | |
| | | resolution 2 bit | | - | - | 1500 | ksample/s |
| | | resolution 10 bit | | - | - | 400 | ksample/s |
| $t_{conv}$ | conversion time | In number of ADC clock cycles | | 3 | - | 11 | cycles |
| | | In number of bits | | 2 | - | 10 | bits |
| **3.3 V ADC1/2** | | | | | | | |
| $f_{i(ADC)}$ | ADC input frequency | | [2] | 4 | - | 4.5 | MHz |
| $f_{s(max)}$ | maximum sampling rate | $f_{i(ADC)}$ = 4.5 MHz; $f_s = f_{i(ADC)} / (n + 1)$ with n = resolution | | | | | |
| | | resolution 2 bit | | - | - | 1500 | ksample/s |
| | | resolution 10 bit | | - | - | 400 | ksample/s |
| $t_{conv}$ | conversion time | In number of ADC clock cycles | | 3 | - | 11 | cycles |
| | | In number of bits | | 2 | - | 10 | bits |

[1] All parameters are guaranteed over the virtual junction temperature range by design. Pre-testing is performed at $T_{amb}$ = 85 °C ambient temperature on wafer level. Cased products are tested at $T_{amb}$ = 25 °C (final testing). Both pre-testing and final testing use correlated test conditions to cover the specified temperature and power supply voltage range.

[2] Duty cycle clock should be as close as possible to 50 %.

## 10. Application information

### 10.1 Operating frequency selection

The LPC2926/2927/2929 is specified to operate at a maximum frequency of 125 MHz, maximum temperature of 85 °C, and maximum core voltage of 1.89 V. Figure 30 and Figure 31 show that the user can achieve higher operating frequencies for the LPC2926/2927/2929 by controlling the temperature and the core voltage accordingly.


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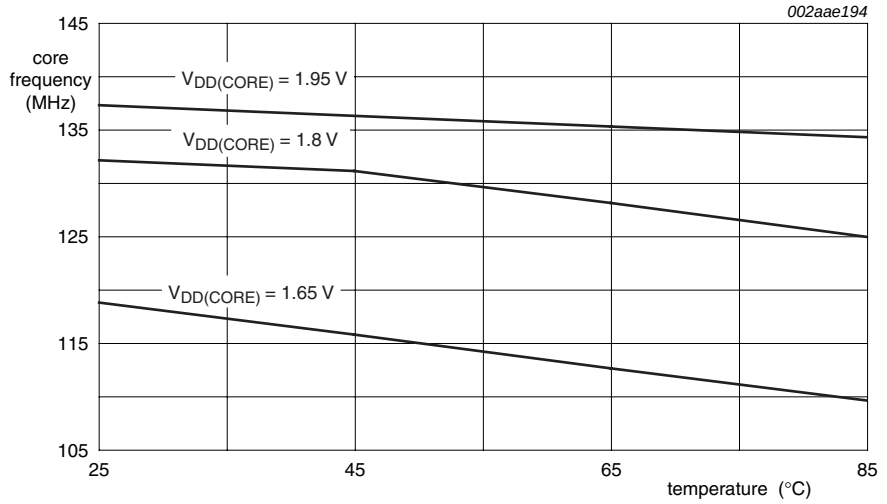


**Fig 30. Core operating frequency versus temperature for different core voltages.**

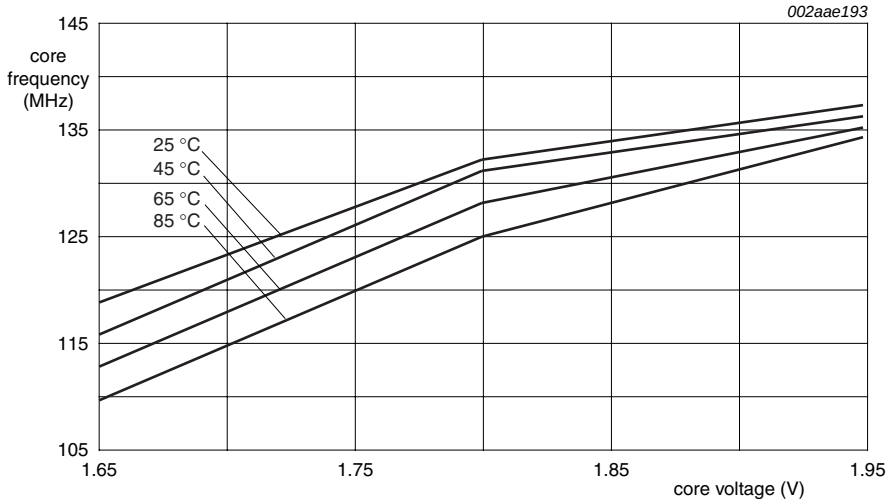


**Fig 31. Core operating frequency versus core voltage for different temperatures**


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## 10.2 Suggested USB interface solutions

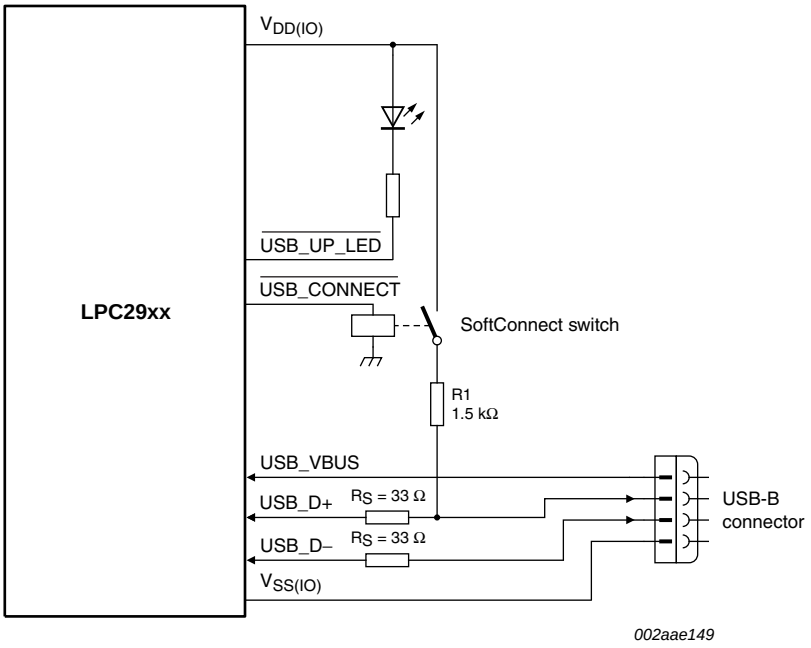


**Fig 32. LPC2926/2927/2929 USB interface on a self-powered device**

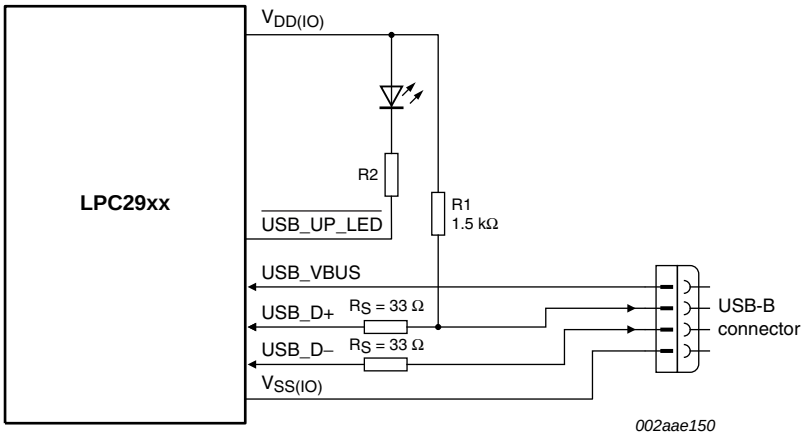


**Fig 33. LPC2926/2927/2929 USB interface on a bus-powered device**


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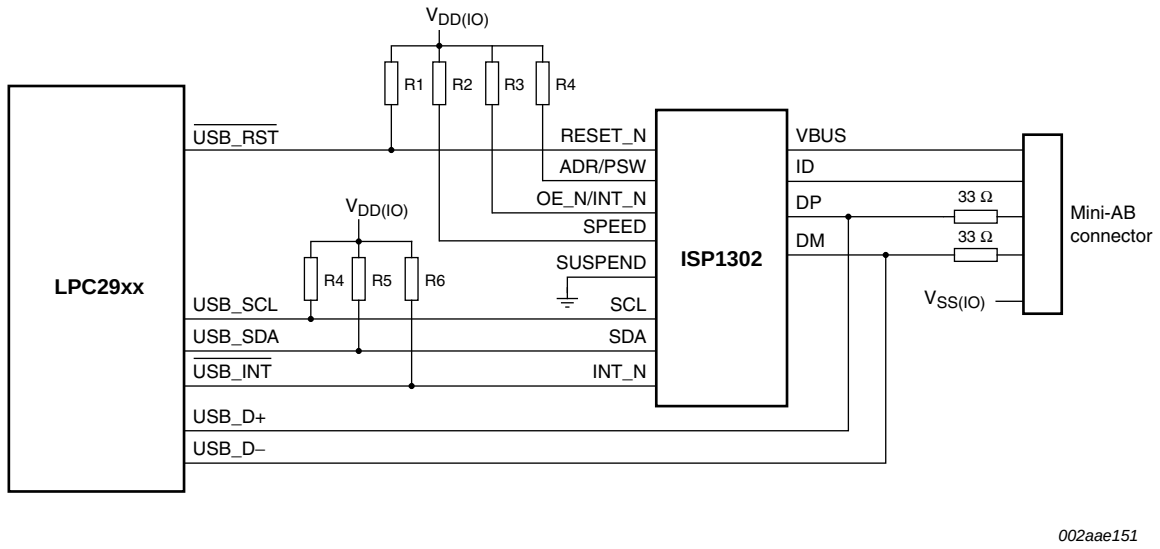


**Fig 34. LPC2926/2927/2929 USB OTG port configuration**

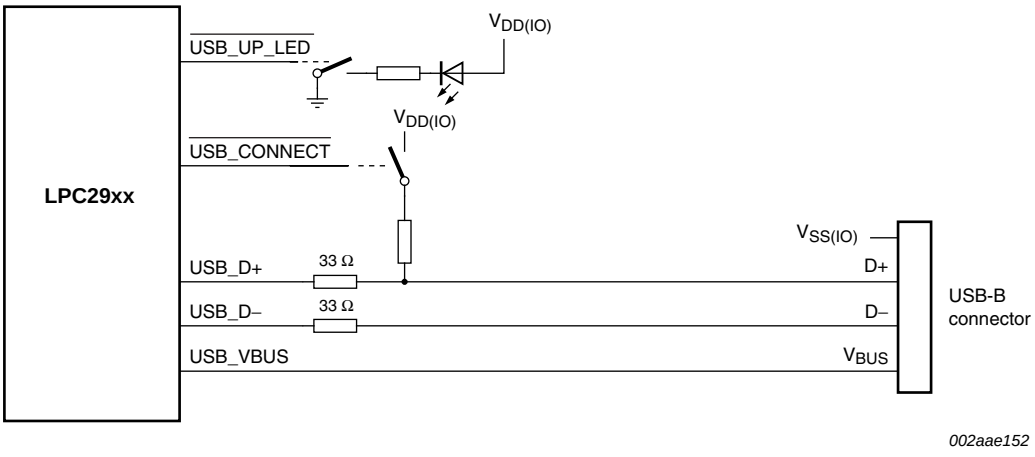


**Fig 35. LPC2926/2927/2929 USB device port configuration**


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## 10.3 SPI signal forms

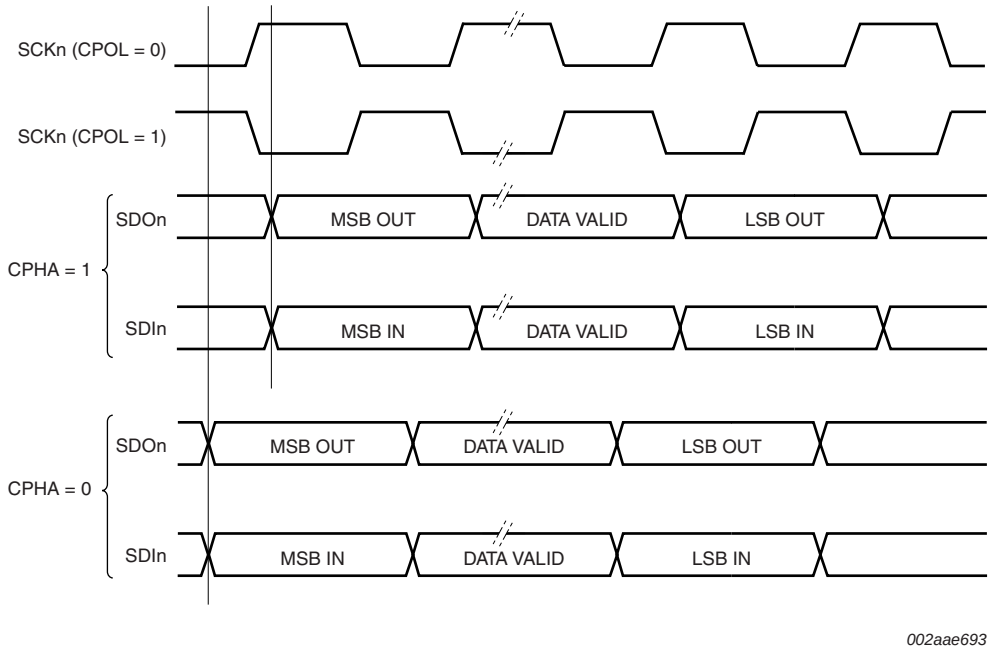


**Fig 36. SPI timing in master mode**

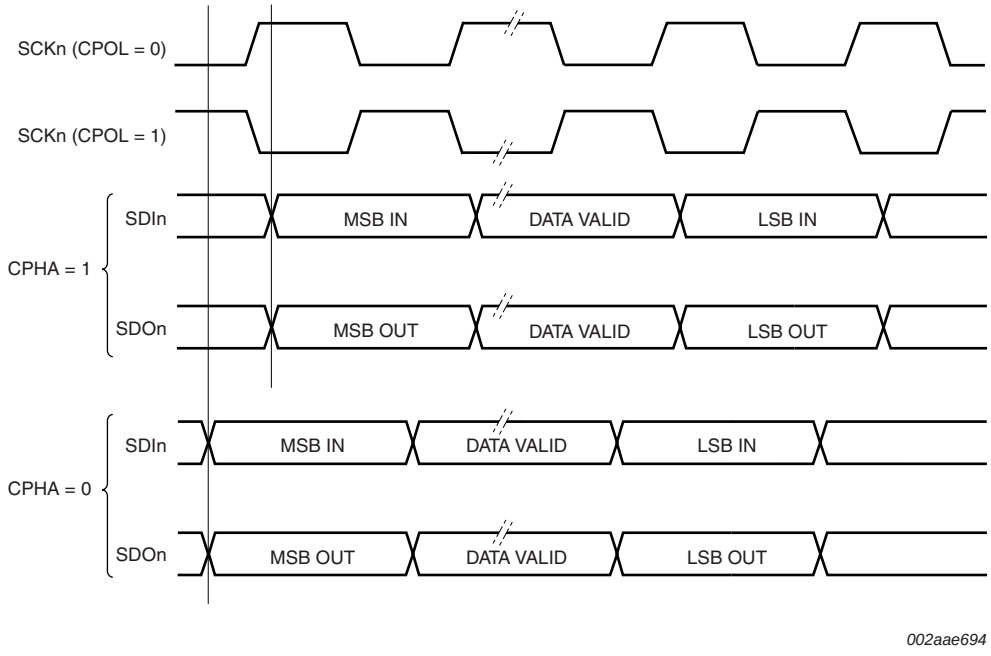


**Fig 37. SPI timing in slave mode**


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## 10.4 XIN_OSC input

The input voltage to the on-chip oscillators is limited to 1.8 V. If the oscillator is driven by a clock in slave mode, it is recommended that the input be coupled through a capacitor with $C_i$ = 100 pF. To limit the input voltage to the specified range, choose an additional capacitor to ground $C_g$ which attenuates the input voltage by a factor $C_i/(C_i + C_g)$. In slave mode, a minimum of 200 mV (RMS) is needed. For more details see the *LPC29xx User manual UM10316*.

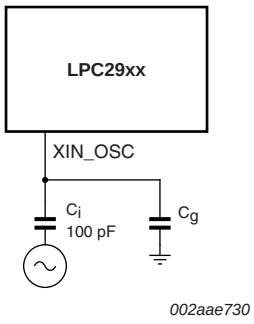


**Fig 38. Slave mode operation of the on-chip oscillator**

## 10.5 XIN_OSC Printed Circuit Board (PCB) layout guidelines

The crystal should be connected on the PCB as close as possible to the oscillator input and output pins of the chip. Take care that the load capacitors $C_{x1}$ and $C_{x2}$, and $C_{x3}$ in case of third overtone crystal usage, have a common ground plane. The external components must also be connected to the ground plain. Loops must be made as small as possible, in order to keep the noise coupled in via the PCB as small as possible. Also parasitics should stay as small as possible. Values of $C_{x1}$ and $C_{x2}$ should be chosen smaller accordingly to the increase in parasitics of the PCB layout.


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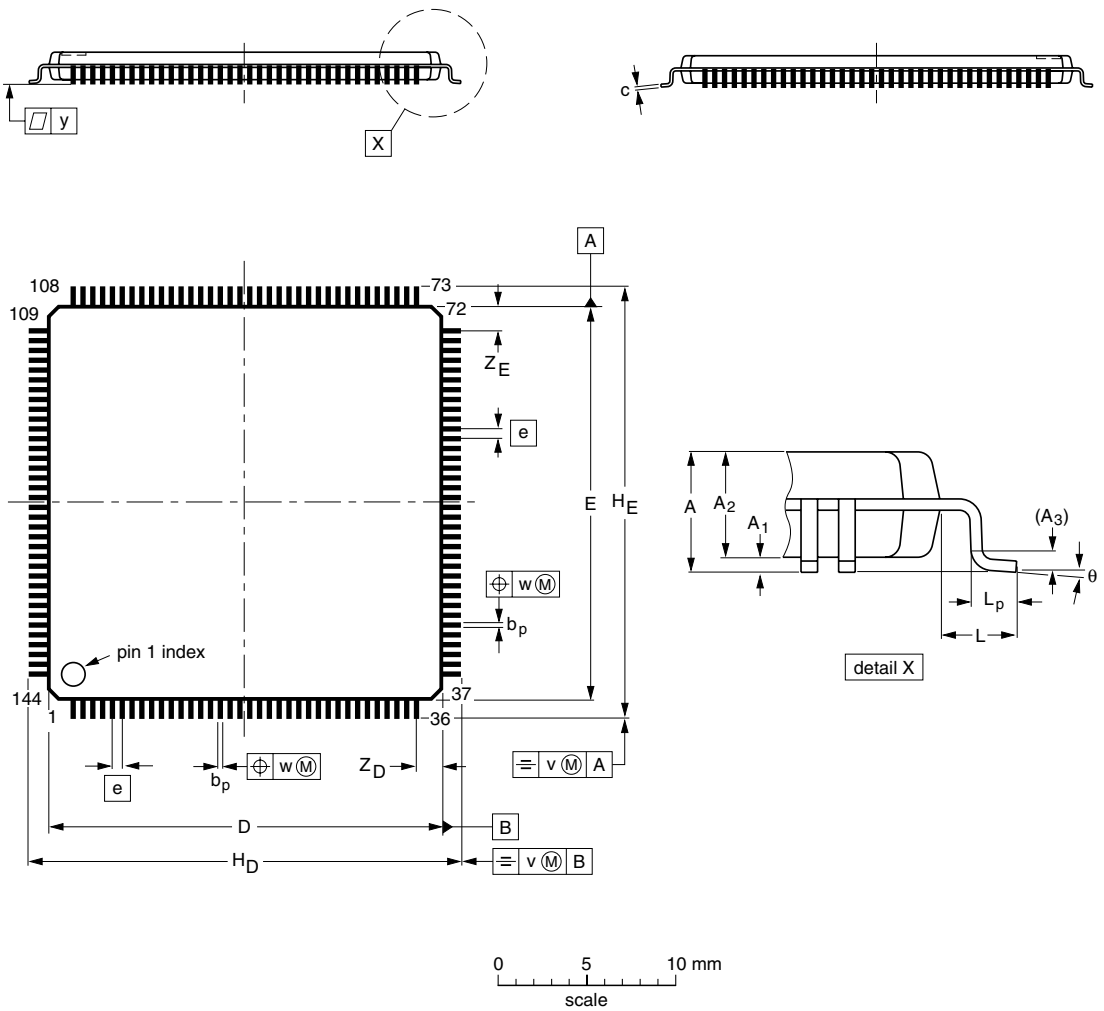
# 11. Package outline

**LQFP144: plastic low profile quad flat package; 144 leads; body 20 x 20 x 1.4 mm** **SOT486-1**




**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 | 0.15<br>0.05 | 1.45<br>1.35 | 0.25 | 0.27<br>0.17 | 0.20<br>0.09 | 20.1<br>19.9 | 20.1<br>19.9 | 0.5 | 22.15<br>21.85 | 22.15<br>21.85 | 1 | 0.75<br>0.45 | 0.2 | 0.08 | 0.08 | 1.4<br>1.1 | 1.4<br>1.1 | $7^o$<br>$0^o$ |

**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 | | | |
| SOT486-1 | 136E23 | MS-026 | | | | ~~00-03-14~~<br>03-02-20 |

**Fig 39. Package outline SOT486-1 (LQFP144)**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# 12. Soldering of SMD packages

This text provides a very brief insight into a complex technology. A more in-depth account of soldering ICs can be found in Application Note *AN10365 "Surface mount reflow soldering description"*.

## 12.1 Introduction to soldering

Soldering is one of the most common methods through which packages are attached to Printed Circuit Boards (PCBs), to form electrical circuits. The soldered joint provides both the mechanical and the electrical connection. There is no single soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and Surface Mount Devices (SMDs) are mixed on one printed wiring board; however, it is not suitable for fine pitch SMDs. Reflow soldering is ideal for the small pitches and high densities that come with increased miniaturization.

## 12.2 Wave and reflow soldering

Wave soldering is a joining technology in which the joints are made by solder coming from a standing wave of liquid solder. The wave soldering process is suitable for the following:

- Through-hole components
- Leaded or leadless SMDs, which are glued to the surface of the printed circuit board

Not all SMDs can be wave soldered. Packages with solder balls, and some leadless packages which have solder lands underneath the body, cannot be wave soldered. Also, leaded SMDs with leads having a pitch smaller than ~0.6 mm cannot be wave soldered, due to an increased probability of bridging.

The reflow soldering process involves applying solder paste to a board, followed by component placement and exposure to a temperature profile. Leaded packages, packages with solder balls, and leadless packages are all reflow solderable.

Key characteristics in both wave and reflow soldering are:

- Board specifications, including the board finish, solder masks and vias
- Package footprints, including solder thieves and orientation
- The moisture sensitivity level of the packages
- Package placement
- Inspection and repair
- Lead-free soldering versus SnPb soldering

## 12.3 Wave soldering

Key characteristics in wave soldering are:

- Process issues, such as application of adhesive and flux, clinching of leads, board transport, the solder wave parameters, and the time during which components are exposed to the wave
- Solder bath specifications, including temperature and impurities


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## 12.4 Reflow soldering

Key characteristics in reflow soldering are:

- Lead-free versus SnPb soldering; note that a lead-free reflow process usually leads to higher minimum peak temperatures (see Figure 40) than a SnPb process, thus reducing the process window
- Solder paste printing issues including smearing, release, and adjusting the process window for a mix of large and small components on one board
- Reflow temperature profile; this profile includes preheat, reflow (in which the board is heated to the peak temperature) and cooling down. It is imperative that the peak temperature is high enough for the solder to make reliable solder joints (a solder paste characteristic). In addition, the peak temperature must be low enough that the packages and/or boards are not damaged. The peak temperature of the package depends on package thickness and volume and is classified in accordance with Table 44 and 45

**Table 44. SnPb eutectic process (from J-STD-020C)**

| Package thickness (mm) | Package reflow temperature (°C) | |
|---|---|---|
| | Volume ($mm^3$) | |
| | < 350 | ≥ 350 |
| < 2.5 | 235 | 220 |
| ≥ 2.5 | 220 | 220 |

**Table 45. Lead-free process (from J-STD-020C)**

| Package thickness (mm) | Package reflow temperature (°C) | | |
|---|---|---|---|
| | Volume ($mm^3$) | | |
| | < 350 | 350 to 2000 | > 2000 |
| < 1.6 | 260 | 260 | 260 |
| 1.6 to 2.5 | 260 | 250 | 245 |
| > 2.5 | 250 | 245 | 245 |

Moisture sensitivity precautions, as indicated on the packing, must be respected at all times.

Studies have shown that small packages reach higher temperatures during reflow soldering, see Figure 40.


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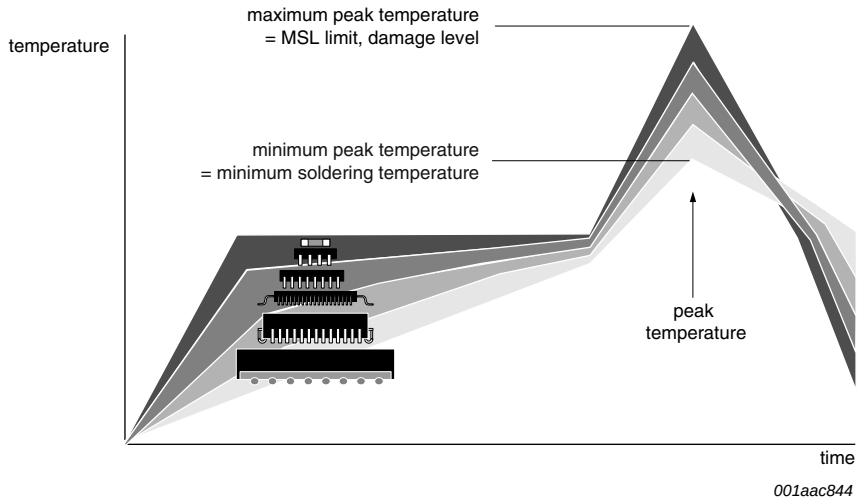


MSL: Moisture Sensitivity Level

**Fig 40. Temperature profiles for large and small components**

For further information on temperature profiles, refer to Application Note *AN10365 "Surface mount reflow soldering description"*.


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## 13. Abbreviations

Table 46. Abbreviations list

| Abbreviation | Description |
|---|---|
| AHB | Advanced High-performance Bus |
| AMBA | Advanced Microcontroller Bus Architecture |
| APB | ARM Peripheral Bus |
| BIST | Built-In Self Test |
| CCO | Current Controlled Oscillator |
| CISC | Complex Instruction Set Computers |
| DMA | Direct Memory Access |
| DSP | Digital Signal Processing |
| DTL | Device Transaction Level |
| EOP | End Of Packet |
| ETB | Embedded Trace Buffer |
| ETM | Embedded Trace Macrocell |
| FIQ | Fast Interrupt reQuest |
| GPDMA | General Purpose DMA |
| IRQ | Interrupt ReQuest |
| LIN | Local Interconnect Network |
| LSB | Least Significant Bit |
| MAC | Media Access Control |
| MSB | Most Significant Bit |
| MSC | Modulation and Sampling Control |
| PHY | PHYsical layer |
| PLL | Phase-Locked Loop |
| Q-SPI | Queued SPI |
| RISC | Reduced Instruction Set Computer |
| SFSP | SCU Function Select Port x, y (use without the P if there are no x, y) |
| TAP | Test Access Port |
| TTL | Transistor-Transistor Logic |
| UART | Universal Asynchronous Receiver Transmitter |

## 14. References

**[1]** **UM10316 —** *LPC29xx user manual*

**[2]** **ARM —** ARM web site

**[3]** **ARM-SSP —** ARM primecell synchronous serial port (PL022) technical reference manual

**[4]** **CAN —** ISO 11898-1: 2002 road vehicles - Controller Area Network (CAN) - part 1: data link layer and physical signalling

**[5]** **LIN —** LIN specification package, revision 2.0



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# 15. Revision history

**Table 47. Revision history**

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---|---|---|---|---|
| LPC2926_27_29 v.5 | 20100928 | Product data sheet | - | LPC2927_29 v.4 |
| Modifications: | | • Added LPC2926 device. | | |
| LPC2927_29 v.4 | 20100414 | Product data sheet | - | LPC2927_29 v.3 |
| Modifications: | | • Section 1: Target market “medical” removed.<br>• Document template updated.<br>• USB logo added. | | |
| LPC2927_29 v.3 | 20091208 | Product data sheet | - | LPC2927_29 v.2 |
| LPC2927_29 v.2 | 20090622 | Preliminary data sheet | - | LPC2927_29 v.1 |
| LPC2927_29 v.1 | 20090115 | Preliminary data sheet | - | - |


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# 16. Legal information

## 16.1 Data sheet status

| Document status[1][2] | Product status[3] | Definition |
|---|---|---|
| Objective [short] data sheet | Development | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet | Qualification | This document contains data from the preliminary specification. |
| Product [short] data sheet | Production | This document contains the product specification. |

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

[3] The product status of device(s) described in this document may have changed since this document was published and may differ in case of multiple devices. The latest product status information is available on the Internet at URL http://www.nxp.com.

## 16.2 Definitions

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# 18. Contents

**1 General description . . . . . 1**
**2 Features and benefits . . . . . 1**
**3 Ordering information . . . . . 3**
3.1 Ordering options . . . . . 3
**4 Block diagram . . . . . 4**
**5 Pinning information . . . . . 5**
5.1 Pinning . . . . . 5
5.2 Pin description . . . . . 5
5.2.1 General description . . . . . 5
5.2.2 LQFP144 pin assignment . . . . . 5
**6 Functional description . . . . . 11**
6.1 Architectural overview . . . . . 11
6.2 ARM968E-S processor . . . . . 12
6.3 On-chip flash memory system . . . . . 13
6.4 On-chip static RAM . . . . . 13
6.5 Memory map . . . . . 14
6.6 Reset, debug, test, and power description . . . 15
6.6.1 Reset and power-up behavior . . . . . 15
6.6.2 Reset strategy . . . . . 15
6.6.3 IEEE 1149.1 interface pins (JTAG boundary scan test) . . . . . 15
6.6.3.1 ETM/ETB . . . . . 16
6.6.4 Power supply pins . . . . . 16
6.7 Clocking strategy . . . . . 16
6.7.1 Clock architecture . . . . . 16
6.7.2 Base clock and branch clock relationship . . . . 18
6.8 Flash memory controller . . . . . 20
6.8.1 Functional description . . . . . 20
6.8.2 Pin description . . . . . 21
6.8.3 Clock description . . . . . 21
6.8.4 Flash layout . . . . . 21
6.8.5 Flash bridge wait-states . . . . . 22
6.8.6 EEPROM . . . . . 23
6.9 External static memory controller . . . . . 23
6.9.1 Description . . . . . 23
6.9.2 Pin description . . . . . 24
6.9.3 Clock description . . . . . 24
6.9.4 External memory timing diagrams . . . . . 24
6.10 General Purpose DMA (GPDMA) controller . . 26
6.10.1 DMA support for peripherals . . . . . 26
6.10.2 Clock description . . . . . 27
6.11 USB interface . . . . . 27
6.11.1 USB device controller . . . . . 27
6.11.2 USB OTG controller . . . . . 27
6.11.3 Pin description . . . . . 28
6.11.4 Clock description . . . . . 28
6.12 General subsystem . . . . . 29
6.12.1 General subsystem clock description . . . . . 29
6.12.2 Chip and feature identification . . . . . 29
6.12.3 System Control Unit (SCU) . . . . . 29
6.12.4 Event router . . . . . 29
6.12.4.1 Pin description . . . . . 30
6.13 Peripheral subsystem . . . . . 30
6.13.1 Peripheral subsystem clock description . . . . . 30
6.13.2 Watchdog timer . . . . . 30
6.13.2.1 Functional description . . . . . 31
6.13.2.2 Clock description . . . . . 31
6.13.3 Timer . . . . . 31
6.13.3.1 Pin description . . . . . 32
6.13.3.2 Clock description . . . . . 32
6.13.4 UARTs . . . . . 33
6.13.4.1 Pin description . . . . . 33
6.13.4.2 Clock description . . . . . 33
6.13.5 Serial Peripheral Interface (SPI) . . . . . 33
6.13.5.1 Functional description . . . . . 34
6.13.5.2 Pin description . . . . . 34
6.13.5.3 Clock description . . . . . 35
6.13.6 General-purpose I/O . . . . . 35
6.13.6.1 Functional description . . . . . 35
6.13.6.2 Pin description . . . . . 35
6.13.6.3 Clock description . . . . . 36
6.14 Networking subsystem . . . . . 36
6.14.1 CAN gateway . . . . . 36
6.14.1.1 Global acceptance filter . . . . . 36
6.14.1.2 Pin description . . . . . 37
6.14.2 LIN . . . . . 37
6.14.2.1 Pin description . . . . . 37
6.14.3 $I^2C$-bus serial I/O controllers . . . . . 37
6.14.3.1 Pin description . . . . . 38
6.15 Modulation and sampling control subsystem . 38
6.15.1 Functional description . . . . . 38
6.15.2 Pin description . . . . . 41
6.15.3 Clock description . . . . . 41
6.15.4 Analog-to-digital converter . . . . . 41
6.15.4.1 Functional description . . . . . 42
6.15.4.2 Pin description . . . . . 42
6.15.4.3 Clock description . . . . . 43
6.15.5 Pulse Width Modulator (PWM) . . . . . 44
6.15.5.1 Functional description . . . . . 44
6.15.5.2 Synchronizing the PWM counters . . . . . 45
6.15.5.3 Master and slave mode . . . . . 46
6.15.5.4 Pin description . . . . . 46
6.15.5.5 Clock description . . . . . 46
6.15.6 Timers in the MSCSS . . . . . 46
6.15.6.1 Pin description . . . . . 47

continued >>


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6.15.6.2 Clock description . . . . . 47
6.15.7 Quadrature Encoder Interface (QEI) . . . . . 47
6.15.7.1 Pin description . . . . . 48
6.15.7.2 Clock description . . . . . 48
6.16 Power, Clock and Reset Control Subsystem (PCRSS) . . . . . 48
6.16.1 Clock description . . . . . 49
6.16.2 Clock Generation Unit (CGU0) . . . . . 50
6.16.2.1 Functional description . . . . . 50
6.16.2.2 PLL functional description . . . . . 53
6.16.2.3 Pin description . . . . . 54
6.16.3 Clock generation for USB (CGU1) . . . . . 55
6.16.3.1 Pin description . . . . . 55
6.16.4 Reset Generation Unit (RGU) . . . . . 55
6.16.4.1 Functional description . . . . . 56
6.16.4.2 Pin description . . . . . 57
6.16.5 Power Management Unit (PMU) . . . . . 57
6.16.5.1 Functional description . . . . . 57
6.17 Vectored Interrupt Controller (VIC) . . . . . 59
6.17.1 Functional description . . . . . 60
6.17.2 Clock description . . . . . 60
**7 Limiting values . . . . . 61**
**8 Static characteristics . . . . . 63**
8.1 Power consumption . . . . . 68
8.2 Electrical pin characteristics . . . . . 69
**9 Dynamic characteristics . . . . . 72**
9.1 Dynamic characteristics: I/O and CLK_OUT pins, internal clock, oscillators, PLL, and CAN . . . . . 72
9.2 USB interface . . . . . 74
9.3 Dynamic characteristics: $I^2C$-bus interface . . . 75
9.4 Dynamic characteristics: SPI . . . . . 76
9.5 Dynamic characteristics: flash memory and EEPROM . . . . . 77
9.6 Dynamic characteristics: external static memory . . . . . 78
9.7 Dynamic characteristics: ADC . . . . . 80
**10 Application information . . . . . 80**
10.1 Operating frequency selection . . . . . 80
10.2 Suggested USB interface solutions . . . . . 82
10.3 SPI signal forms . . . . . 84
10.4 XIN_OSC input . . . . . 85
10.5 XIN_OSC Printed Circuit Board (PCB) layout guidelines . . . . . 85
**11 Package outline . . . . . 86**
**12 Soldering of SMD packages . . . . . 87**
12.1 Introduction to soldering . . . . . 87
12.2 Wave and reflow soldering . . . . . 87
12.3 Wave soldering . . . . . 87
12.4 Reflow soldering . . . . . 88
**13 Abbreviations . . . . . 90**
**14 References . . . . . 90**
**15 Revision history . . . . . 91**
**16 Legal information . . . . . 92**
16.1 Data sheet status . . . . . 92
16.2 Definitions . . . . . 92
16.3 Disclaimers . . . . . 92
16.4 Trademarks . . . . . 93
**17 Contact information . . . . . 93**
**18 Contents . . . . . 94**

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105318, г.Москва, ул.Щербаковская д.3, офис 1107, 1118, ДЦ «Щербаковский»

Телефон: +7 495 668-12-70 (многоканальный)

Факс: +7 495 668-12-70 (доб.304)

E-mail: info@moschip.ru

Skype отдела продаж:
moschip.ru
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moschip.ru_9