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What is "Embedded - Microcontrollers"?

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

Applications of "Embedded - Microcontrollers"

Details	
Product Status	Obsolete
Core Processor	8051
Core Size	8-Bit
Speed	18MHz
Connectivity	I²C, SPI, UART/USART
Peripherals	Brown-out Detect/Reset, LCD, LED, POR, PWM, WDT
Number of I/O	23
Program Memory Size	8KB (8K x 8)
Program Memory Type	FLASH
EEPROM Size	512 x 8
RAM Size	256 x 8
Voltage - Supply (Vcc/Vdd)	2.4V ~ 3.6V
Data Converters	A/D 8x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	64-LQFP
Supplier Device Package	64-LQFP (14x14)
Purchase URL	https://www.e-xfl.com/product-detail/nxp-semiconductors/p89lpc9408fbd-557

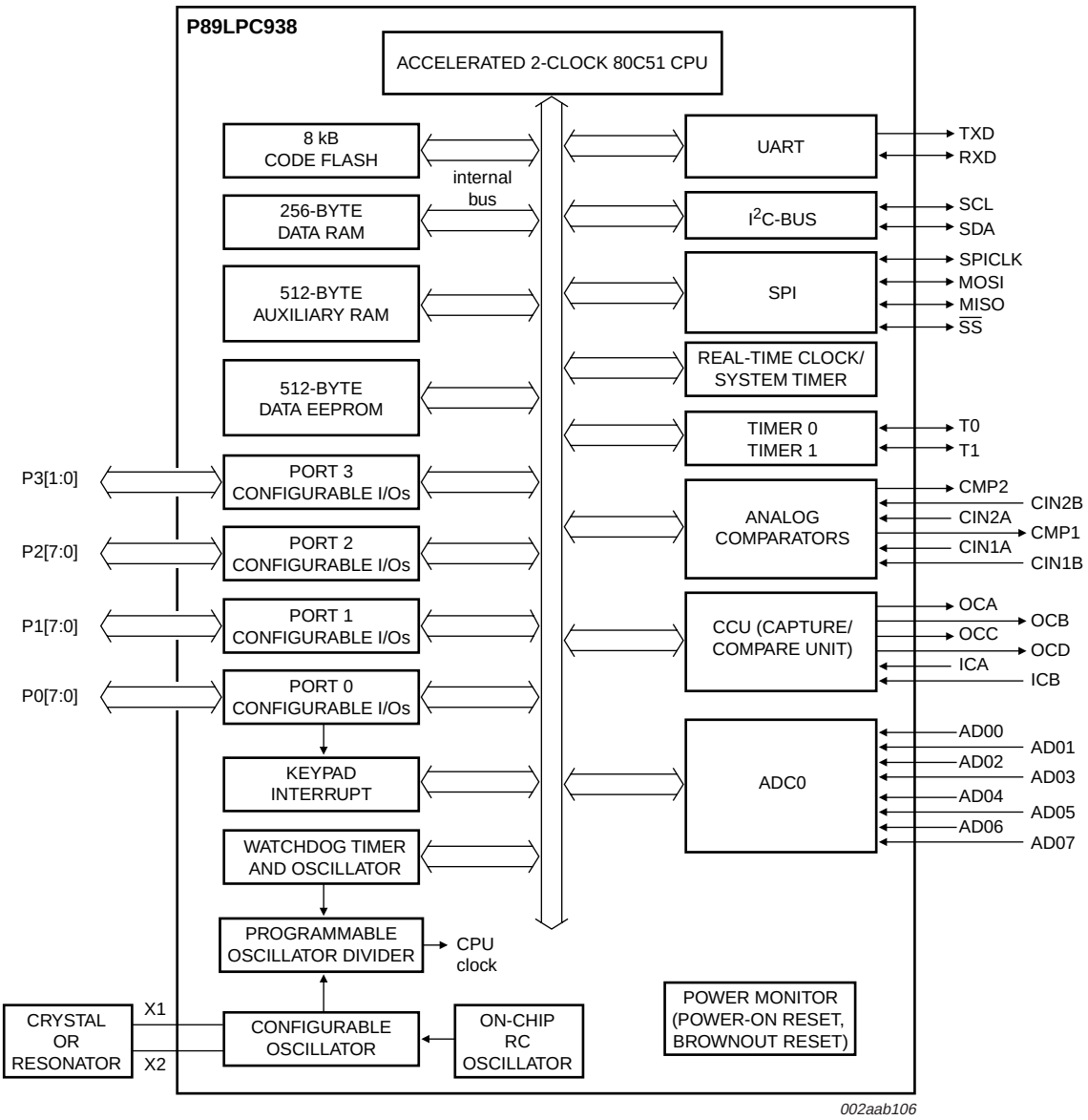


Fig 2. Microcontroller section block diagram

6. Pinning information

6.1 Pinning

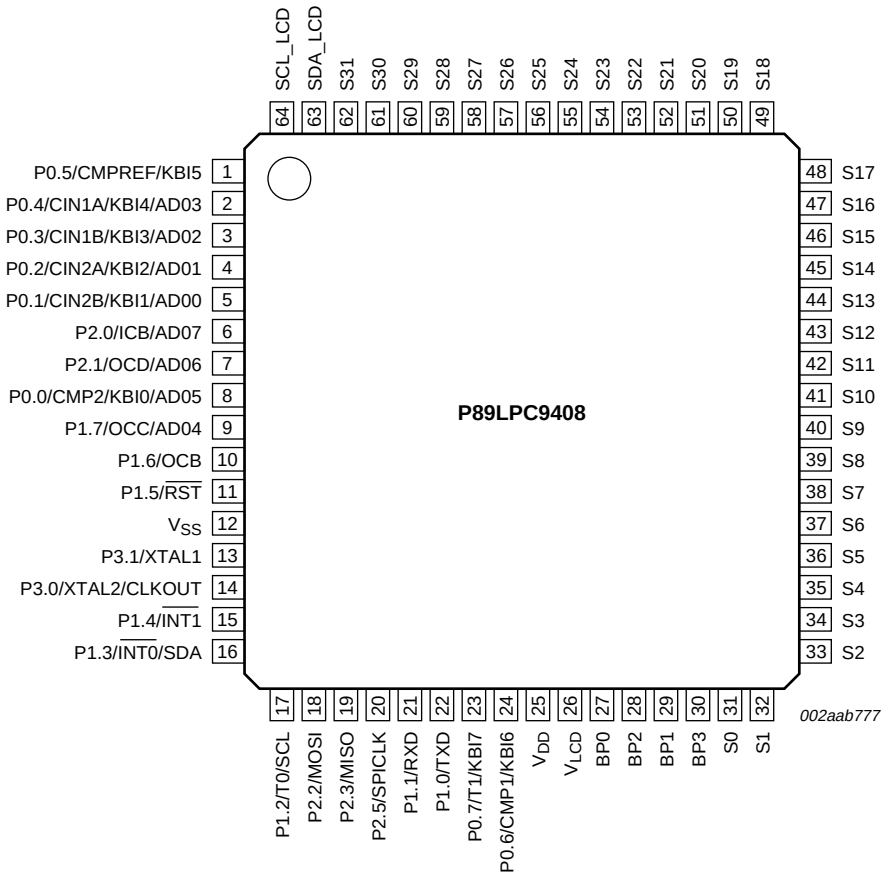


Fig 5. Pin configuration

6.2 Pin description

Table 3: Pin description

Symbol	Pin	Type	Description
P0.0 to P0.7		I/O	**Port 0:** Port 0 is an 8-bit I/O port with a user-configurable output type. During reset Port 0 latches are configured in the input only mode with the internal pull-up disabled. The operation of Port 0 pins as inputs and outputs depends upon the port configuration selected. Each port pin is configured independently. Refer to Section 7.13.1 "Port configurations" and Table 12 "Static electrical characteristics" for details. The Keypad Interrupt feature operates with Port 0 pins. All pins have Schmitt trigger inputs. Port 0 also provides various special functions as described below:

Table 3: Pin description *...continued*

Symbol	Pin	Type	Description
P2.5/SPICLK	20	I/O	**P2.5 —** Port 2 bit 5.
		I/O	**SPICLK —** SPI clock. When configured as master, this pin is output; when configured as slave, this pin is input.
P3.0 to P3.1		I/O	**Port 3:** Port 3 is a 2-bit I/O port with a user-configurable output type. During reset Port 3 latches are configured in the input only mode with the internal pull-up disabled. The operation of Port 3 pins as inputs and outputs depends upon the port configuration selected. Each port pin is configured independently. Refer to Section 7.13.1 "Port configurations" and Table 12 "Static electrical characteristics" for details. All pins have Schmitt triggered inputs. Port 3 also provides various special functions as described below:
P3.0/XTAL2/ CLKOUT	14	I/O	**P3.0 —** Port 3 bit 0.
		O	**XTAL2 —** Output from the oscillator amplifier (when a crystal oscillator option is selected via the flash configuration.
		O	**CLKOUT —** CPU clock divided by 2 when enabled via SFR bit (ENCLK -TRIM.6). It can be used if the CPU clock is the internal RC oscillator, watchdog oscillator or external clock input, except when XTAL1/XTAL2 are used to generate clock source for the RTC/system timer.
P3.1/XTAL1	13	I/O	**P3.1 —** Port 3 bit 1.
		I	**XTAL1 —** Input to the oscillator circuit and internal clock generator circuits (when selected via the flash configuration). It can be a port pin if internal RC oscillator or watchdog oscillator is used as the CPU clock source, **and** if XTAL1/XTAL2 are not used to generate the clock for the RTC/system timer.
SDA_LCD	63	I/O	**SDA LCD —** I^2C-bus data signal for the LCD controller.
SCL_LCD	64	I	**SCL LCD —** I^2C-bus clock signal for the LCD controller.
BP0 to BP3	27 to 30	O	**BP0 to BP3:** LCD backplane outputs.
S0 to S31	31 to 62	O	**S0 to S31:** LCD segment outputs
V_{SS}	12	I	**Ground:** 0 V reference.
V_{DD}	25	I	**Power supply:** This is the power supply voltage for normal operation as well as Idle and Power-down modes.
V_{LCD}	26	I	**LCD power supply:** LCD supply voltage.

[1] Input/output for P1.0 to P1.4, P1.6, P1.7. Input for P1.5.

7. Functional description

Remark: Please refer to the *P89LPC9408 User manual* for a more detailed functional description.

7.1 Special function registers

Remark: SFR accesses are restricted in the following ways:

- User must **not** attempt to access any SFR locations not defined.
- Accesses to any defined SFR locations must be strictly for the functions for the SFRs.
- SFR bits labeled '-', '0' or '1' can **only** be written and read as follows:
  - '-' Unless otherwise specified, **must** be written with '0', but can return any value when read (even if it was written with '0'). It is a reserved bit and may be used in future derivatives.
  - '0' **must** be written with '0', and will return a '0' when read.
  - '1' **must** be written with '1', and will return a '1' when read.

Table 4: Special function registers

** indicates SFRs that are bit addressable.*

Name	Description	SFR addr.	Bit functions and addresses								Reset value	
			MSB							LSB	Hex	Binary
	Bit address		E7	E6	E5	E4	E3	E2	E1	E0		
ACC*	Accumulator	E0H									00	0000 0000
AD0CON	ADC0 control register	97H	ENBI0	ENADCI0	TMM0	EDGE0	ADCI0	ENADC0	ADCS01	ADCS00	00	0000 0000
AD0INS	ADC0 input select	A3H	ADI07	ADI06	ADI05	ADI04	ADI03	ADI02	ADI01	ADI00	00	0000 0000
AD0MODA	ADC0 mode register A	C0H	BNDI0	BURST0	SCC0	SCAN0	-	-	-	-	00	0000 0000
AD0MODB	ADC0 mode register B	A1H	CLK2	CLK1	CLK0	-	-	-	-	-	00	000x 0000
AUXR1	Auxiliary function register	A2H	CLKLP	EBRR	ENT1	ENT0	SRST	0	-	DPS	00	0000 00x0
	Bit address		F7	F6	F5	F4	F3	F2	F1	F0		
B*	B register	F0H									00	0000 0000
BRGR0 [1]	Baud rate generator rate low	BEH									00	0000 0000
BRGR1 [1]	Baud rate generator rate high	BFH									00	0000 0000
BRGCON	Baud rate generator control	BDH	-	-	-	-	-	-	SBRGS	BRGEN	00 [1]	xxxx xx00
CCCRA	Capture compare A control register	EAH	ICECA2	ICECA1	ICECA0	ICESA	ICNFA	FCOA	OCMA1	OCMA0	00	0000 0000
CCCRB	Capture compare B control register	EBH	ICECB2	ICECB1	ICECB0	ICESB	ICNFB	FCOB	OCMB1	OCMB0	00	0000 0000
CCCRC	Capture compare C control register	ECH	-	-	-	-	-	FCOC	OCMC1	OCMC0	00	xxxx x000
CCCRD	Capture compare D control register	EDH	-	-	-	-	-	FCOD	OCMD1	OCMD0	00	xxxx x000
CMP1	Comparator 1 control register	ACH	-	-	CE1	CP1	CN1	OE1	CO1	CMF1	00 [2]	xx00 0000
CMP2	Comparator 2 control register	ADH	-	-	CE2	CP2	CN2	OE2	CO2	CMF2	00 [2]	xx00 0000
DEECON	Data EEPROM control register	F1H	EEIF	HVERR	ECTL1	ECTL0	-	-	-	EADR8	0E	0000 1110

Table 4: Special function registers *…continued*

** indicates SFRs that are bit addressable.*

Name	Description	SFR addr.	Bit functions and addresses								Reset value	
			MSB							LSB	Hex	Binary
TAMOD	Timer 0 and 1 auxiliary mode	8FH	-	-	-	T1M2	-	-	-	T0M2	00	xxx0 xxx0
		Bit address	8F	8E	8D	8C	8B	8A	89	88		
TCON*	Timer 0 and 1 control	88H	TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0	00	0000 0000
TCR20*	CCU control register 0	C8H	PLEEN	HLTRN	HLTEN	ALTCD	ALTAB	TDIR2	TMOD21	TMOD20	00	0000 0000
TCR21	CCU control register 1	F9H	TCOU2	-	-	-	PLLDV.3	PLLDV.2	PLLDV.1	PLLDV.0	00	0xxx 0000
TH0	Timer 0 high	8CH									00	0000 0000
TH1	Timer 1 high	8DH									00	0000 0000
TH2	CCU timer high	CDH									00	0000 0000
TICR2	CCU interrupt control register	C9H	TOIE2	TOCIE2D	TOCIE2C	TOCIE2B	TOCIE2A	-	TICIE2B	TICIE2A	00	0000 0x00
TIFR2	CCU interrupt flag register	E9H	TOIF2	TOCF2D	TOCF2C	TOCF2B	TOCF2A	-	TICF2B	TICF2A	00	0000 0x00
TISE2	CCU interrupt status encode register	DEH	-	-	-	-	-	ENCINT.2	ENCINT.1	ENCINT.0	00	xxxx x000
TL0	Timer 0 low	8AH									00	0000 0000
TL1	Timer 1 low	8BH									00	0000 0000
TL2	CCU timer low	CCH									00	0000 0000
TMOD	Timer 0 and 1 mode	89H	T1GATE	T1C/T	T1M1	T1M0	T0GATE	T0C/T	T0M1	T0M0	00	0000 0000
TOR2H	CCU reload register high	CFH									00	0000 0000
TOR2L	CCU reload register low	CEH									00	0000 0000
TPCR2H	Prescaler control register high	CBH	-	-	-	-	-	-	TPCR2H.1	TPCR2H.0	00	xxxx xx00
TPCR2L	Prescaler control register low	CAH	TPCR2L.7	TPCR2L.6	TPCR2L.5	TPCR2L.4	TPCR2L.3	TPCR2L.2	TPCR2L.1	TPCR2L.0	00	0000 0000
TRIM	Internal oscillator trim register	96H	RCCLK	ENCLK	TRIM.5	TRIM.4	TRIM.3	TRIM.2	TRIM.1	TRIM.0		[4] [5]

7.10 Memory organization

The various P89LPC9408 memory spaces are as follows:

- DATA

  128 bytes of internal data memory space (00H:7FH) accessed via direct or indirect addressing, using instructions other than MOVX and MOVC. All or part of the Stack may be in this area.

- IDATA

  Indirect Data. 256 bytes of internal data memory space (00H:FFH) accessed via indirect addressing using instructions other than MOVX and MOVC. All or part of the Stack may be in this area. This area includes the DATA area and the 128 bytes immediately above it.

- SFR

  Special Function Registers. Selected CPU registers and peripheral control and status registers, accessible only via direct addressing.

- XDATA

  'External' Data or Auxiliary RAM. Duplicates the classic 80C51 64 kB memory space addressed via the MOVX instruction using the DPTR, R0, or R1. All or part of this space could be implemented on-chip. The P89LPC9408 has 512 bytes of on-chip XDATA memory, plus extended SFRs located in XDATA.

- CODE

  64 kB of Code memory space, accessed as part of program execution and via the MOVC instruction. The P89LPC9408 has 8 kB of on-chip Code memory.

7.11 Data RAM arrangement

The 768 bytes of on-chip RAM are organized as shown in Table 6.

Table 6: On-chip data memory usages

Type	Data RAM	Size (bytes)
DATA	Memory that can be addressed directly and indirectly	128
IDATA	Memory that can be addressed indirectly	256
XDATA	Auxiliary ('External Data') on-chip memory that is accessed using the MOVX instructions	512

7.12 Interrupts

The P89LPC9408 uses a four priority level interrupt structure. This allows great flexibility in controlling the handling of the many interrupt sources. The P89LPC9408 supports 16 interrupt sources: external interrupts 0 and 1, timers 0 and 1, serial port TX, serial port RX, combined serial port RX/TX, brownout detect, watchdog/RTC, I^2C-bus, keyboard, comparators 1 and 2, SPI, CCU, data EEPROM write, and ADC completion.

Each interrupt source can be individually enabled or disabled by setting or clearing a bit in the interrupt enable registers IEN0, IEN1, or IEN2. The IEN0 register also contains a global disable bit, EA, which disables all interrupts.

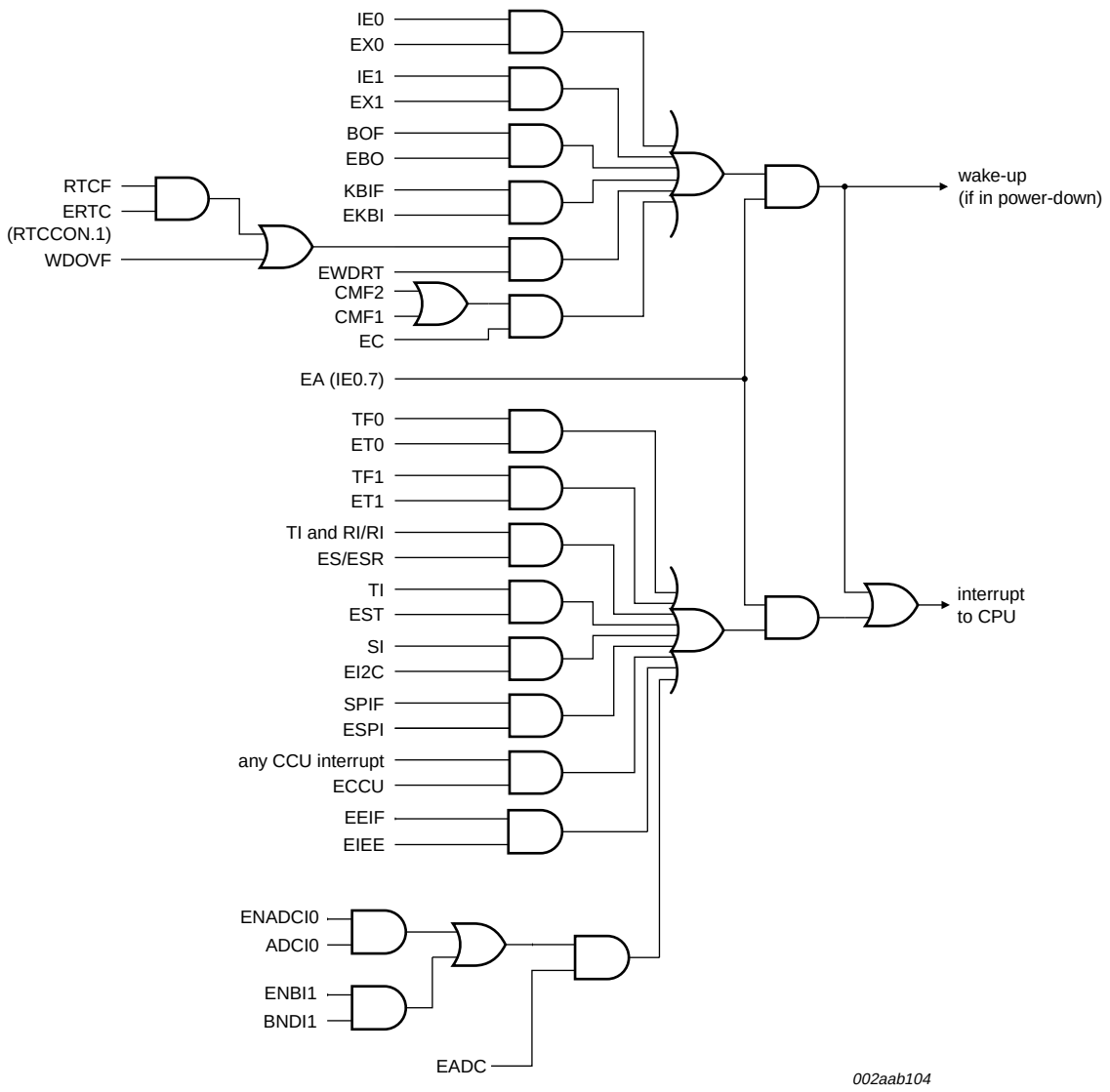


Fig 7. Interrupt sources, interrupt enables, and power-down wake-up sources

7.13 I/O ports

The P89LPC9408 has four I/O ports: Port 0 and Port 1 are 8-bit ports. Port 2 is a 5-bit port. Port 3 is a 2-bit port. The exact number of I/O pins available depends upon the clock and reset options chosen, as shown in Table 7.

Table 7: Number of I/O pins available

Clock source	Reset option	Number of I/O pins (not including LCD pins)
On-chip oscillator or watchdog oscillator	No external reset (except during power-up)	23
	External $\overline{\text{RST}}$ pin supported	22

7.13.1.4 Push-pull output configuration

The push-pull output configuration has the same pull-down structure as both the open-drain and the quasi-bidirectional output modes, but provides a continuous strong pull-up when the port latch contains a logic 1. The push-pull mode may be used when more source current is needed from a port output. A push-pull port pin has a Schmitt trigger input that also has a glitch suppression circuit.

7.13.2 Port 0 analog functions

The P89LPC9408 incorporates two Analog Comparators. In order to give the best analog function performance and to minimize power consumption, pins that are being used for analog functions must have the digital outputs and digital inputs disabled.

Digital outputs are disabled by putting the port output into the Input-Only (high-impedance) mode.

Digital inputs on Port 0 may be disabled through the use of the PT0AD register, bits 1:5. On any reset, PT0AD[1:5] defaults to logic 0s to enable digital functions.

7.13.3 Additional port features

After power-up, all pins are in Input-Only mode. **Please note that this is different from the LPC76x series of devices.**

- After power-up, all I/O pins except P1.5, may be configured by software.
- Pin P1.5 is input only. Pins P1.2 and P1.3 and are configurable for either input-only or open-drain.

Every output on the P89LPC9408 has been designed to sink typical LED drive current. However, there is a maximum total output current for all ports which must not be exceeded. Please refer to Table 12 “Static electrical characteristics” for detailed specifications.

All ports pins that can function as an output have slew rate controlled outputs to limit noise generated by quickly switching output signals. The slew rate is factory-set to approximately 10 ns rise and fall times.

7.14 Power monitoring functions

The P89LPC9408 incorporates power monitoring functions designed to prevent incorrect operation during initial power-up and power loss or reduction during operation. This is accomplished with two hardware functions: Power-on detect and Brownout detect.

7.14.1 Brownout detection

The Brownout detect function determines if the power supply voltage drops below a certain level. The default operation is for a Brownout detection to cause a processor reset, however it may alternatively be configured to generate an interrupt.

Brownout detection may be enabled or disabled in software.

If Brownout detection is enabled the brownout condition occurs when V_{DD} falls below the brownout trip voltage, V_{bo} (see Table 12 “Static electrical characteristics”), and is negated when V_{DD} rises above V_{bo}. If the P89LPC9408 device is to operate with a power supply

Remark: During a power-up sequence, the RPE selection is overridden and this pin will always function as a reset input. **An external circuit connected to this pin should not hold this pin LOW during a power-on sequence as this will keep the device in reset.** After power-up this input will function either as an external reset input or as a digital input as defined by the RPE bit. Only a power-up reset will temporarily override the selection defined by RPE bit. Other sources of reset will not override the RPE bit.

Reset can be triggered from the following sources:

- External reset pin (during power-up or if user configured via UCFG1).
- Power-on detect.
- Brownout detect.
- Watchdog timer.
- Software reset.
- UART break character detect reset.

For every reset source, there is a flag in the Reset Register, RSTSRC. The user can read this register to determine the most recent reset source. These flag bits can be cleared in software by writing a logic 0 to the corresponding bit. More than one flag bit may be set:

- During a power-on reset, both POF and BOF are set but the other flag bits are cleared.
- For any other reset, previously set flag bits that have not been cleared will remain set.

7.16.1 Reset vector

Following reset, the P89LPC9408 will fetch instructions from either address 0000H or the Boot address. The Boot address is formed by using the Boot Vector as the high byte of the address and the low byte of the address = 00H.

The Boot address will be used if a UART break reset occurs, or the non-volatile Boot Status bit (BOOTSTAT.0) = 1, or the device is forced into ISP mode during power-on (see *P89LPC9408 User manual*). Otherwise, instructions will be fetched from address 0000H.

7.17 Timers/counters 0 and 1

The P89LPC9408 has two general purpose counter/timers which are upward compatible with the standard 80C51 Timer 0 and Timer 1. Both can be configured to operate either as timers or event counter. An option to automatically toggle the T0 and/or T1 pins upon timer overflow has been added.

In the ‘Timer’ function, the register is incremented every machine cycle.

In the ‘Counter’ function, the register is incremented in response to a 1-to-0 transition at its corresponding external input pin, T0 or T1. In this function, the external input is sampled once during every machine cycle.

Timer 0 and Timer 1 have five operating modes (modes 0, 1, 2, 3 and 6). Modes 0, 1, 2 and 6 are the same for both Timers/Counters. Mode 3 is different.

- Seven interrupts with common interrupt vector (one Overflow, two Capture, four Compare)
- Safe 16-bit read/write via shadow registers.

7.19.1 CCU Clock (CCUCLK)

The CCU runs on the CCUCLK, which is either PCLK in basic timer mode, or the output of a PLL. The PLL is designed to use a clock source between 0.5 MHz to 1 MHz that is multiplied by 32 to produce a CCUCLK between 16 MHz and 32 MHz in PWM mode (asymmetrical or symmetrical). The PLL contains a 4-bit divider to help divide PCLK into a frequency between 0.5 MHz and 1 MHz.

7.19.2 CCU clock prescaling

This CCUCLK can further be divided down by a prescaler. The prescaler is implemented as a 10-bit free-running counter with programmable reload at overflow.

7.19.3 Basic timer operation

The timer is a free-running up/down counter with a direction control bit. If the timer counting direction is changed while the counter is running, the count sequence will be reversed. The timer can be written or read at any time.

When a reload occurs, the CCU Timer Overflow Interrupt Flag will be set, and an interrupt generated if enabled. The 16-bit CCU Timer may also be used as an 8-bit up/down timer.

7.19.4 Output compare

There are four output compare channels A, B, C and D. Each output compare channel needs to be enabled in order to operate and the user will have to set the associated I/O pin to the desired output mode to connect the pin. When the contents of the timer matches that of a capture compare control register, the Timer Output Compare Interrupt Flag (TOCFx) becomes set. An interrupt will occur if enabled.

7.19.5 Input capture

Input capture is always enabled. Each time a capture event occurs on one of the two input capture pins, the contents of the timer is transferred to the corresponding 16-bit input capture register. The capture event can be programmed to be either rising or falling edge triggered. A simple noise filter can be enabled on the input capture by enabling the Input Capture Noise Filter bit. If set, the capture logic needs to see four consecutive samples of the same value in order to recognize an edge as a capture event. An event counter can be set to delay a capture by a number of capture events.

7.19.6 PWM operation

PWM operation has two main modes, symmetrical and asymmetrical.

In asymmetrical PWM operation the CCU Timer operates in down-counting mode regardless of the direction control bit.

In symmetrical mode, the timer counts up/down alternately. The main difference from basic timer operation is the operation of the compare module, which in PWM mode is used for PWM waveform generation.

As with basic timer operation, when the PWM (compare) pins are connected to the compare logic, their logic state remains unchanged. However, since bit FCOx is used to hold the halt value, only a compare event can change the state of the pin.

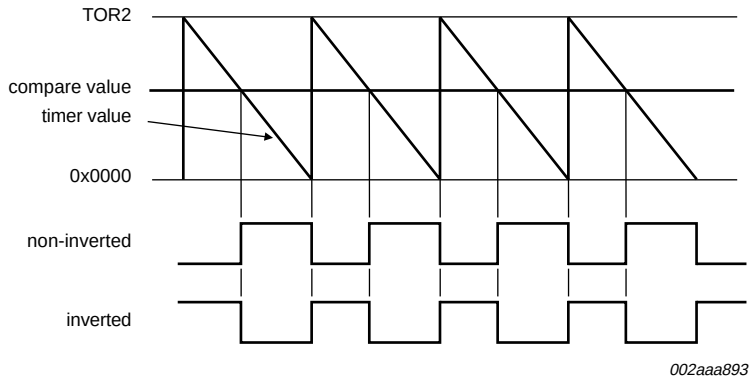


Fig 8. Asymmetrical PWM, down-counting

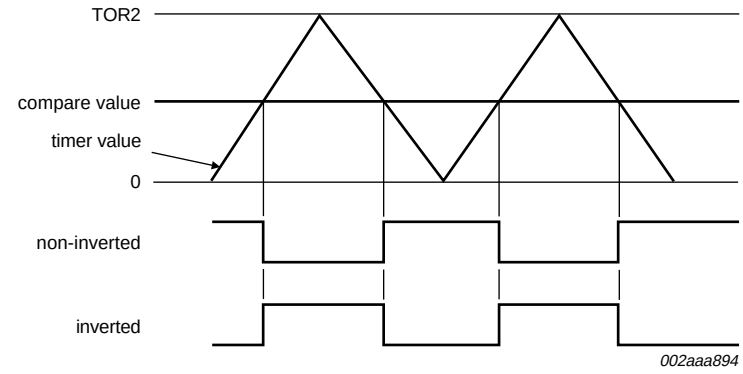


Fig 9. Symmetrical PWM

7.19.7 Alternating output mode

In asymmetrical mode, the user can set up PWM channels A/B and C/D as alternating pairs for bridge drive control. In this mode the output of these PWM channels are alternately gated on every counter cycle.

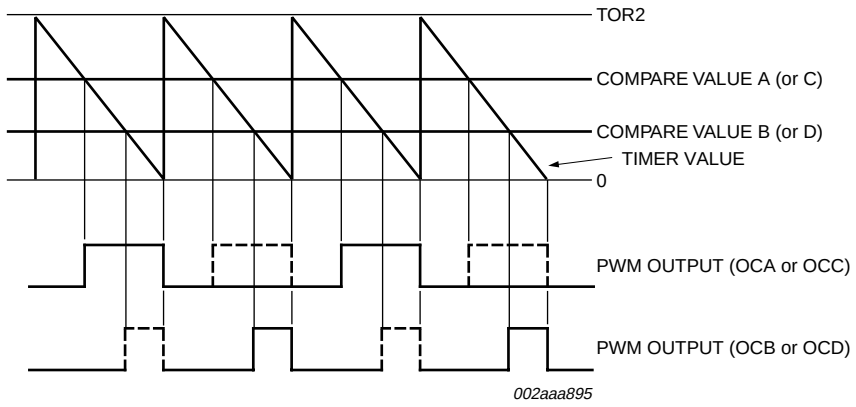


Fig 10. Alternate output mode

7.19.8 PLL operation

The PWM module features a Phase Locked Loop that can be used to generate a CCUCLK frequency between 16 MHz and 32 MHz. At this frequency the PWM module provides ultrasonic PWM frequency with 10-bit resolution provided that the crystal frequency is 1 MHz or higher. The PLL is fed an input signal of 0.5 MHz to 1 MHz and generates an output signal of 32 times the input frequency. This signal is used to clock the timer. The user will have to set a divider that scales PCLK by a factor of 1 to 16. This divider is found in the SFR register TCR21. The PLL frequency can be expressed as shown in Equation 1.

$$\text{PLL frequency} = \frac{\text{PLCK}}{(N+1)} \quad (1)$$

Where: N is the value of PLLDV3:0.

Since N ranges in 0 to 15, the CCLK frequency can be in the range of PCLK to $^{PCLK}/_{16}$.

7.20.3 Mode 2

11 bits are transmitted (through TXD) or received (through RXD): start bit (logic 0), 8 data bits (LSB first), a programmable 9th data bit, and a stop bit (logic 1). When data is transmitted, the 9th data bit (TB8 in SCON) can be assigned the value of logic 0 or logic 1. Or, for example, the parity bit (P, in the PSW) could be moved into TB8. When data is received, the 9th data bit goes into RB8 in Special Function Register SCON, while the stop bit is not saved. The baud rate is programmable to either $1/16$ or $1/32$ of the CPU clock frequency, as determined by the SMOD1 bit in PCON.

7.20.4 Mode 3

11 bits are transmitted (through TXD) or received (through RXD): a start bit (logic 0), 8 data bits (LSB first), a programmable 9th data bit, and a stop bit (logic 1). In fact, Mode 3 is the same as Mode 2 in all respects except baud rate. The baud rate in Mode 3 is variable and is determined by the Timer 1 overflow rate or the Baud Rate Generator (described in Section 7.20.5 “Baud rate generator and selection”).

7.20.5 Baud rate generator and selection

The P89LPC9408 enhanced UART has an independent Baud Rate Generator. The baud rate is determined by a baud rate preprogrammed into the BRGR1 and BRGR0 SFRs which together form a 16-bit baud rate divisor value that works in a similar manner as Timer 1 but is much more accurate. If the baud rate generator is used, Timer 1 can be used for other timing functions.

The UART can use either Timer 1 or the baud rate generator output (see Figure 12). Note that Timer T1 is further divided by 2 if the SMOD1 bit (PCON.7) is cleared. The independent Baud Rate Generator uses OSCCLK.

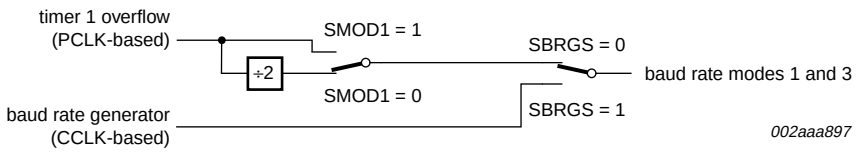


Fig 12. Baud rate sources for UART (Modes 1, 3)

7.20.6 Framing error

Framing error is reported in the status register (SSTAT). In addition, if SMOD0 (PCON.6) is logic 1, framing errors can be made available in SCON.7 respectively. If SMOD0 is logic 0, SCON.7 is SM0. It is recommended that SM0 and SM1 (SCON[7:6]) are set up when SMOD0 is logic 0.

7.20.7 Break detect

Break detect is reported in the status register (SSTAT). A break is detected when 11 consecutive bits are sensed LOW. The break detect can be used to reset the device and force the device into ISP mode.

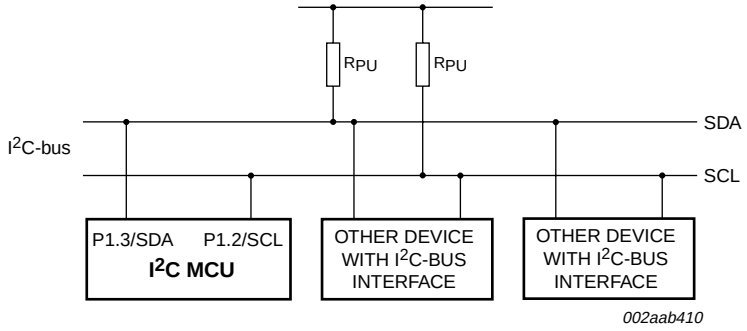


Fig 13. I²C-bus configuration

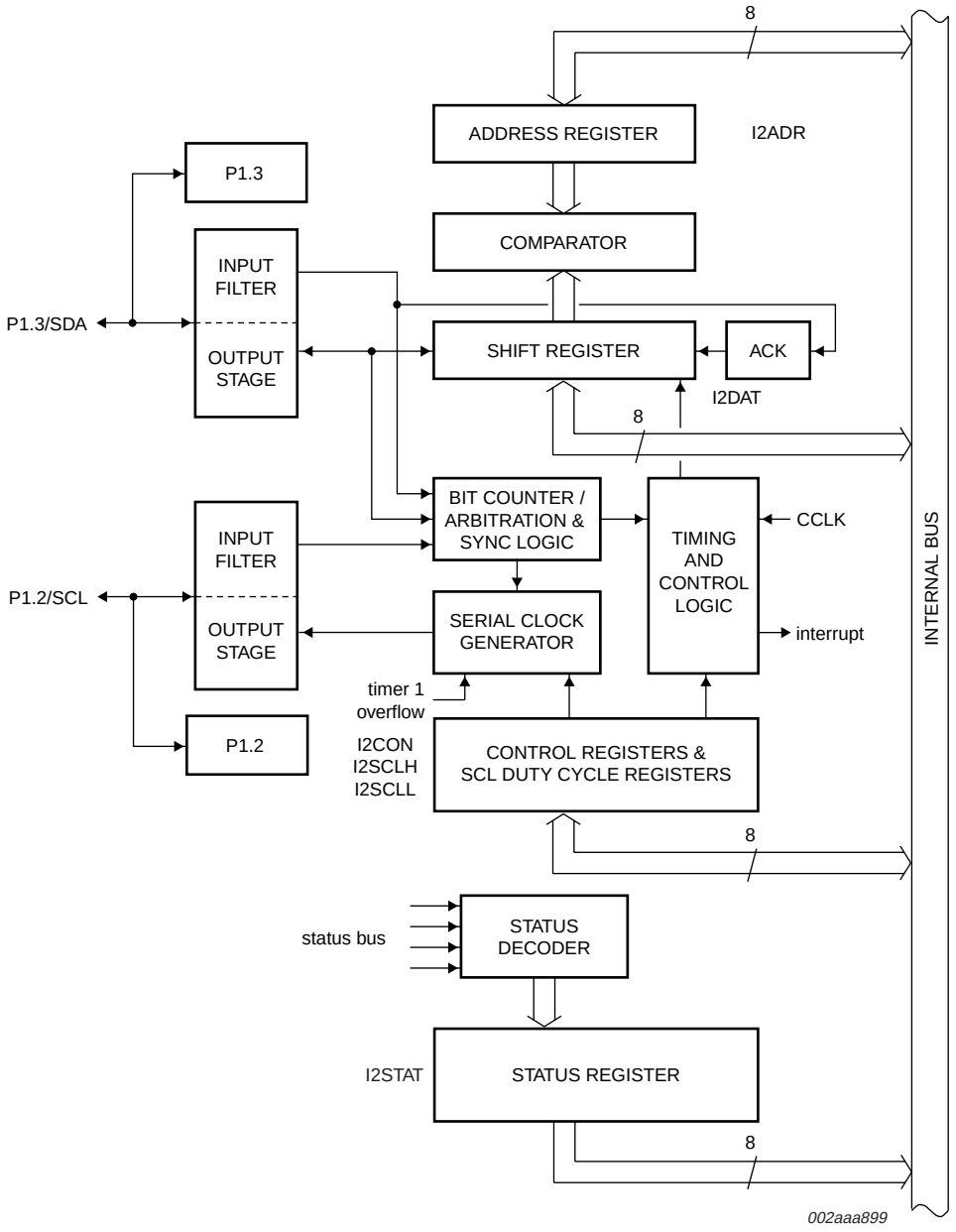


Fig 14. I²C-bus serial interface block diagram - P89LPC9408

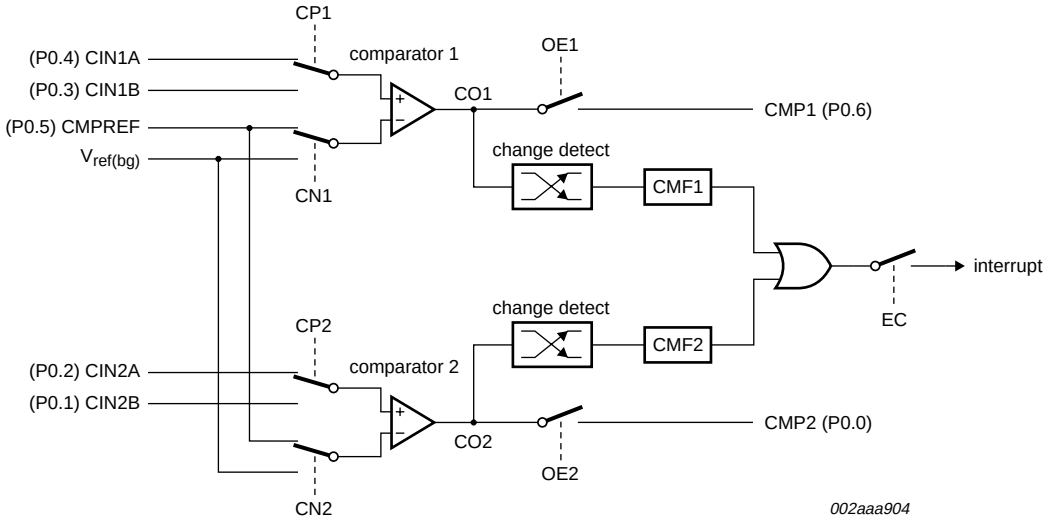


Fig 19. Comparator input and output connections

7.23.1 Internal reference voltage

An internal reference voltage generator may supply a default reference when a single comparator input pin is used. The value of the internal reference voltage, referred to as $V_{ref(bg)}$, is 1.23 V ± 10 %.

7.23.2 Comparator interrupt

Each comparator has an interrupt flag contained in its configuration register. This flag is set whenever the comparator output changes state. The flag may be polled by software or may be used to generate an interrupt. The two comparators use one common interrupt vector. If both comparators enable interrupts, after entering the interrupt service routine, the user needs to read the flags to determine which comparator caused the interrupt.

7.23.3 Comparators and power reduction modes

Either or both comparators may remain enabled when Power-down or Idle mode is activated, but both comparators are disabled automatically in Total Power-down mode.

If a comparator interrupt is enabled (except in Total Power-down mode), a change of the comparator output state will generate an interrupt and wake up the processor. If the comparator output to a pin is enabled, the pin should be configured in the push-pull mode in order to obtain fast switching times while in Power-down mode. The reason is that with the **oscillator** stopped, the temporary strong pull-up that normally occurs during switching on a quasi-bidirectional port pin does not take place.

Comparators consume power in Power-down and Idle modes, as well as in the normal operating mode. This fact should be taken into account when system power consumption is an issue. To minimize power consumption, the user can disable the comparators via PCONA.5, or put the device in Total Power-down mode.

7.27.2 Functional description

The LCD controller is a versatile peripheral device designed to interface microcontrollers to a wide variety of LCDs. It can directly drive any static or multiplexed LCD containing up to four backplanes and up to 32 segments. The display configurations possible with the LCD controller depend on the number of active backplane outputs required. A selection of display configurations is shown in Table 8. All of these configurations can be implemented in a typical system.

The microcontroller communicates to the LCD controller using the I^2C-bus.The appropriate biasing voltages for the multiplexed LCD waveforms are generated internally. The only other connections required to complete the system are to the power supplies (V_{DD}, V_{SS} and V_{LCD}) and the LCD panel chosen for the application.

Table 8: Selection of display configurations

Number of		7-Segments Numeric		14- Segments Alphanumeric		Dot Matrix
Back Planes	Segments	Digits	Indicator Symbols	Characters	Indicator Symbols	
4	128	16	16	8	16	128
3	96	12	12	6	12	96
2	64	8	8	4	8	64
1	32	4	4	2	4	32

7.27.3 LCD bias voltages

LCD biasing voltages are obtained from an internal voltage divider consisting of three series resistors connected between V_{LCD} and V_{SS}. The LCD voltage can be temperature compensated externally via the supply to pin V_{LCD}. A voltage selector drives the multiplexing of the LCD based on programmable configurations.

7.27.4 Oscillator

An internal oscillator provides the clock signals for the internal logic of the LCD controller and its LCD drive signals. After power-up, pin SDA must be HIGH to guarantee that the clock starts.

7.27.5 Timing

The LCD controller timing controls the internal data flow of the device. This includes the transfer of display data from the display RAM to the display segment outputs. The timing also generates the LCD frame signal whose frequency is derived from the clock frequency. The frame signal frequency is a fixed division of the clock frequency from either the internal or an external clock.

Frame frequency = $f_{CLK}/24$.

7.27.6 Display register

A display latch holds the display data while the corresponding multiplex signals are generated. There is a one-to-one relationship between the data in the display latch, the LCD segment outputs, and each column of the display RAM.

7.29.5 Flash programming and erasing

Four different methods of erasing or programming of the flash are available. The flash may be programmed or erased in the end-user application (IAP) under control of the application's firmware. Another option is to use the ICP mechanism. This ICP system provides for programming through a serial clock - serial data interface. As shipped from the factory, the upper 512 bytes of user code space contains a serial ISP routine allowing for the device to be programmed in circuit through the serial port. The flash may also be programmed or erased using a commercially available EPROM programmer which supports this device. This device does not provide for direct verification of code memory contents. Instead, this device provides a 32-bit CRC result on either a sector or the entire user code space.

7.29.6 In-Circuit Programming

In-Circuit Programming is performed without removing the microcontroller from the system. The ICP facility consists of internal hardware resources to facilitate remote programming of the P89LPC9408 through a two-wire serial interface. The Philips ICP facility has made ICP in an embedded application—using commercially available programmers—possible with a minimum of additional expense in components and circuit board area. The ICP function uses five pins. Only a small connector needs to be available to interface your application to a commercial programmer in order to use this feature. Additional details may be found in the *P89LPC9408 User manual*.

7.29.7 In-Application Programming

In-Application Programming is performed in the application under the control of the microcontroller's firmware. The IAP facility consists of internal hardware resources to facilitate programming and erasing. The Philips IAP has made IAP in an embedded application possible without additional components. Two methods are available to accomplish IAP. A set of predefined IAP functions are provided in a Boot ROM and can be called through a common interface, PGM_MTP. Several IAP calls are available for use by an application program to permit selective erasing and programming of flash sectors, pages, security bits, configuration bytes, and device ID. These functions are selected by setting up the microcontroller's registers before making a call to PGM_MTP at FF03H. The Boot ROM occupies the program memory space at the top of the address space from FF00H to FEFFH, thereby not conflicting with the user program memory space.

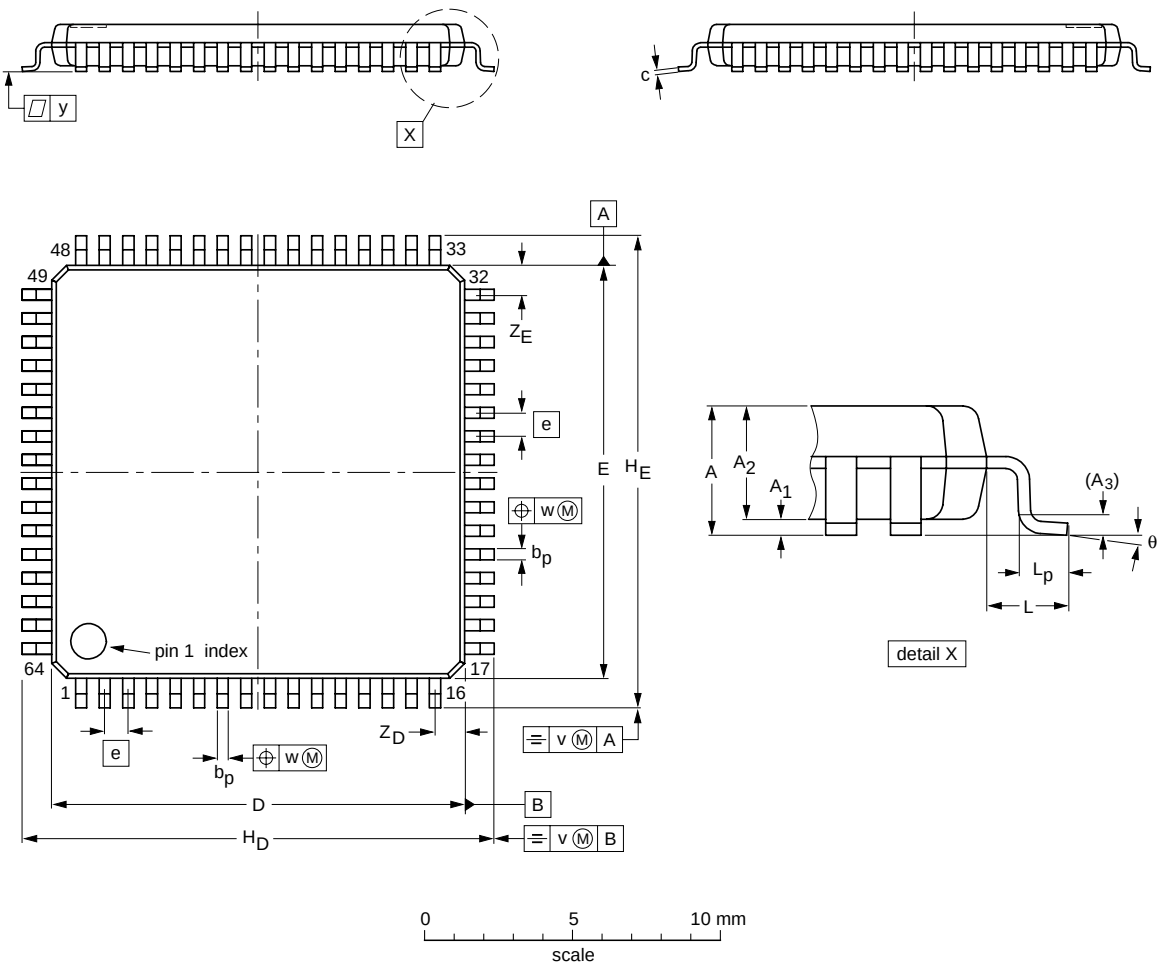
In addition, IAP operations can be accomplished through the use of four SFRs consisting of a control/status register, a data register, and two address registers. Additional details may be found in the *P89LPC9408 User manual*.

7.29.8 ISP

ISP is performed without removing the microcontroller from the system. The ISP facility consists of a series of internal hardware resources coupled with internal firmware to facilitate remote programming of the P89LPC9408 through the serial port. This firmware is provided by Philips and embedded within each P89LPC9408 device. The Philips ISP facility has made ISP in an embedded application possible with a minimum of additional expense in components and circuit board area. The ISP function uses five pins (V_{DD}, V_{SS}, TXD, RXD, and $\overline{RST}$). Only a small connector needs to be available to interface your application to an external circuit in order to use this feature.

14. Package outline

LQFP64: plastic low profile quad flat package; 64 leads; body 14 x 14 x 1.4 mm **SOT791-1**



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 0.05	1.45 1.35	0.25	0.45 0.30	0.20 0.09	14.1 13.9	14.1 13.9	0.8	16.15 15.85	16.15 15.85	1	0.75 0.45	0.2	0.2	0.1	1.2 0.8	1.2 0.8	7^o 0^o

Note

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

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	JEITA			
SOT791-1	136E18	MS-026	ED-7311EC			02-10-22

Fig 29. Package outline SOT791-1 (LQFP64)