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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, LED, POR, PWM, WDT
Number of I/O	26
Program Memory Size	4KB (4K x 8)
Program Memory Type	FLASH
EEPROM Size	-
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	28-TSSOP (0.173", 4.40mm Width)
Supplier Device Package	28-TSSOP
Purchase URL	https://www.e-xfl.com/product-detail/nxp-semiconductors/p89lpc9381fdh-512

5. Functional diagram

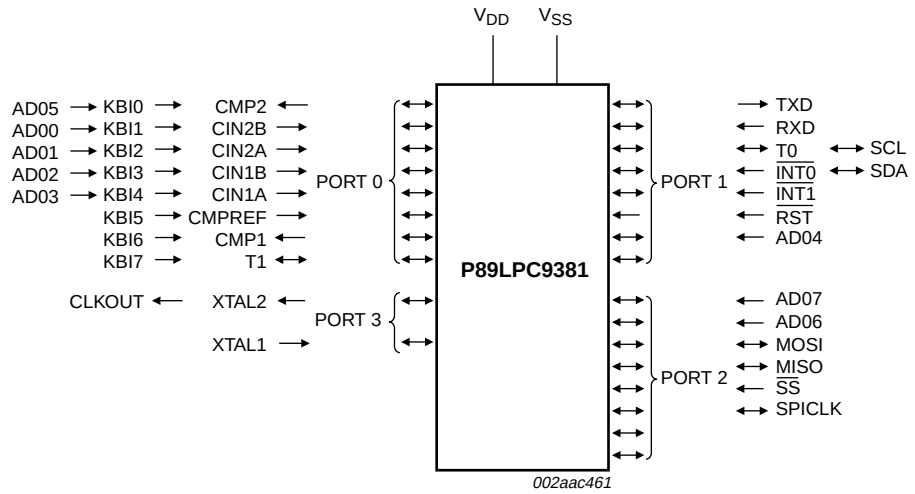


Fig 2. P89LPC9381 functional diagram

6. Pinning information

6.1 Pinning

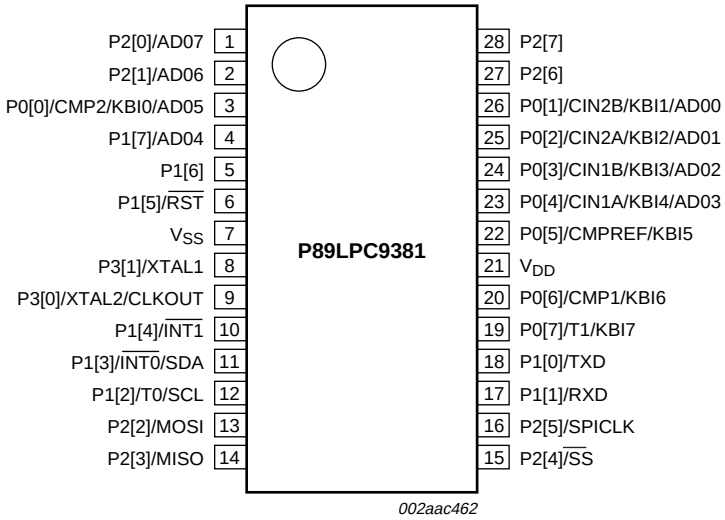


Fig 3. Pin configuration

6.2 Pin description

Table 3. Pin description

Symbol	Pin	Type	Description
P0[7:0]		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 10 “Static characteristics” for details. The Keypad Interrupt feature operates with Port 0 pins. All pins have Schmitt triggered inputs. Port 0 also provides various special functions as described below:
P0[0]/CMP2/ KBI0/AD05	3	I/O	**P0[0] —** Port 0 bit 0.
		O	**CMP2 —** Comparator 2 output.
		I	**KBI0 —** Keyboard input 0.
		I	**AD05 —** ADC0 channel 5 analog input.
P0[1]/CIN2B/ KBI1/AD00	26	I/O	**P0[1] —** Port 0 bit 1.
		I	**CIN2B —** Comparator 2 positive input B.
		I	**KBI1 —** Keyboard input 1.
		I	**AD00 —** ADC0 channel 0 analog input.

Table 3. Pin description *...continued*

Symbol	Pin	Type	Description
P0[2]/CIN2A/ KBI2/AD01	25	I/O	**P0[2] —** Port 0 bit 2.
		I	**CIN2A —** Comparator 2 positive input A.
		I	**KBI2 —** Keyboard input 2.
		I	**AD01 —** ADC0 channel 1 analog input.
P0[3]/CIN1B/ KBI3/AD02	24	I/O	**P0[3] —** Port 0 bit 3.
		I	**CIN1B —** Comparator 1 positive input B.
		I	**KBI3 —** Keyboard input 3.
		I	**AD02 —** ADC0 channel 2 analog input.
P0[4]/CIN1A/ KBI4/AD03	23	I/O	**P0[4] —** Port 0 bit 4.
		I	**CIN1A —** Comparator 1 positive input A.
		I	**KBI4 —** Keyboard input 4.
		I	**AD03 —** ADC0 channel 3 analog input.
P0[5]/CMPREF/ KBI5	22	I/O	**P0[5] —** Port 0 bit 5.
		I	**CMPREF —** Comparator reference (negative) input.
		I	**KBI5 —** Keyboard input 5.
P0[6]/CMP1/ KBI6	20	I/O	**P0[6] —** Port 0 bit 6.
		O	**CMP1 —** Comparator 1 output.
		I	**KBI6 —** Keyboard input 6.
P0[7]/T1/KBI7	19	I/O	**P0[7] —** Port 0 bit 7.
		I/O	**T1 —** Timer/counter 1 external count input or overflow output.
		I	**KBI7 —** Keyboard input 7.
P1[7:0]		I/O, I [1]	**Port 1:** Port 1 is an 8-bit I/O port with a user-configurable output type, except for three pins as noted below. During reset Port 1 latches are configured in the input only mode with the internal pull-up disabled. The operation of the configurable Port 1 pins as inputs and outputs depends upon the port configuration selected. Each of the configurable port pins are programmed independently. Refer to Section 7.13.1 “Port configurations” and Table 10 “Static characteristics” for details. P1[2] to P1[3] are open-drain when used as outputs. P1[5] is input only. All pins have Schmitt triggered inputs. Port 1 also provides various special functions as described below:
P1[0]/TXD	18	I/O	**P1[0] —** Port 1 bit 0.
		O	**TXD —** Transmitter output for the serial port.
P1[1]/RXD	17	I/O	**P1[1] —** Port 1 bit 1.
		I	**RXD —** Receiver input for the serial port.
P1[2]/T0/SCL	12	I/O	**P1[2] —** Port 1 bit 2 (open-drain when used as output).
		I/O	**T0 —** Timer/counter 0 external count input or overflow output (open-drain when used as output).
		I/O	**SCL —** I^2C-bus serial clock input/output.
P1[3]/$\overline{INT0}$/SDA	11	I/O	**P1[3] —** Port 1 bit 3 (open-drain when used as output).
		I	**$\overline{INT0}$ —** External interrupt 0 input.
		I/O	**SDA —** I^2C-bus serial data input/output.
P1[4]/$\overline{INT1}$	10	I	**P1[4] —** Port 1 bit 4.
		I	**$\overline{INT1}$ —** External interrupt 1 input.

Table 4. P89LPC9381 Special function registers *...continued*

** indicates SFRs that are bit addressable.*

Name	Description	SFR addr.	Bit functions and addresses								Reset value	
			MSB							LSB	Hex	Binary
FMCON	Program flash control (Read)	E4H	BUSY	-	-	-	HVA	HVE	SV	OI	70	0111 0000
	Program flash control (Write)	E4H										
FMDATA	Program flash data	E5H									00	0000 0000
I2ADR	I^2C slave address register	DBH	I2ADR.6	I2ADR.5	I2ADR.4	I2ADR.3	I2ADR.2	I2ADR.1	I2ADR.0	GC	00	0000 0000
	Bit address		**DF**	**DE**	**DD**	**DC**	**DB**	**DA**	**D9**	**D8**		
I2CON*	I^2C control register	D8H	-	I2EN	STA	STO	SI	AA	-	CRSEL	00	x000 00x0
I2DAT	I^2C data register	DAH										
I2SCLH	Serial clock generator/SCL duty cycle register high	DDH									00	0000 0000
I2SCLL	Serial clock generator/SCL duty cycle register low	DCH									00	0000 0000
I2STAT	I^2C status register	D9H	STA.4	STA.3	STA.2	STA.1	STA.0	0	0	0	F8	1111 1000
ICRAH	Input capture A register high	ABH									00	0000 0000
ICRAL	Input capture A register low	AAH									00	0000 0000
ICRBH	Input capture B register high	AFH									00	0000 0000
ICRBL	Input capture B register low	AEH									00	0000 0000
	Bit address		**AF**	**AE**	**AD**	**AC**	**AB**	**AA**	**A9**	**A8**		
IEN0*	Interrupt enable 0	A8H	EA	EWDRT	EBO	ES/ESR	ET1	EX1	ET0	EX0	00	0000 0000
	Bit address		**EF**	**EE**	**ED**	**EC**	**EB**	**EA**	**E9**	**E8**		
IEN1*	Interrupt enable 1	E8H	EIEE	EST	-	-	ESPI	EC	EKBI	EI2C	00[2]	00x0 0000
IEN2	Interrupt enable 2	D5H	-	-	-	-	-	-	EADC	-	00[2]	00x0 0000
	Bit address		**BF**	**BE**	**BD**	**BC**	**BB**	**BA**	**B9**	**B8**		
IP0*	Interrupt priority 0	B8H	-	PWDRT	PBO	PS/PSR	PT1	PX1	PT0	PX0	00[2]	x000 0000

Table 4. P89LPC9381 Special function registers *...continued*

** indicates SFRs that are bit addressable.*

Name	Description	SFR addr.	Bit functions and addresses								Reset value	
			MSB							LSB	Hex	Binary
PCON	Power control register	87H	SMOD1	SMOD0	BOPD	BOI	GF1	GF0	PMOD1	PMOD0	00	0000 0000
PCONA	Power control register A	B5H	RTCPD	-	VCPD	ADPD	I2PD	SPPD	SPD	-	00[2]	0000 0000
	Bit address		**D7**	**D6**	**D5**	**D4**	**D3**	**D2**	**D1**	**D0**		
PSW*	Program status word	D0H	CY	AC	F0	RS1	RS0	OV	F1	P	00	0000 0000
PT0AD	Port 0 digital input disable	F6H	-	-	PT0AD.5	PT0AD.4	PT0AD.3	PT0AD.2	PT0AD.1	-	00	xx00 000x
RSTSRC	Reset source register	DFH	-	-	BOF	POF	R_BK	R_WD	R_SF	R_EX		[3]
RTCCON	RTC control	D1H	RTCF	RTCS1	RTCS0	-	-	-	ERTC	RTCEN	60[2][4]	011x xx00
RTCH	RTC register high	D2H									00[4]	0000 0000
RTCL	RTC register low	D3H									00[4]	0000 0000
SADDR	Serial port address register	A9H									00	0000 0000
SADEN	Serial port address enable	B9H									00	0000 0000
SBUF	Serial Port data buffer register	99H									xx	xxxx xxxx
	Bit address		**9F**	**9E**	**9D**	**9C**	**9B**	**9A**	**99**	**98**		
SCON*	Serial port control	98H	SM0/FE	SM1	SM2	REN	TB8	RB8	TI	RI	00	0000 0000
SSTAT	Serial port extended status register	BAH	DBMOD	INTLO	CIDIS	DBISEL	FE	BR	OE	STINT	00	0000 0000
SP	Stack pointer	81H									07	0000 0111
SPCTL	SPI control register	E2H	SSIG	SPEN	DORD	MSTR	CPOL	CPHA	SPR1	SPR0	04	0000 0100
SPSTAT	SPI status register	E1H	SPIF	WCOL	-	-	-	-	-	-	00	00xx xxxx
SPDAT	SPI data register	E3H									00	0000 0000
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
TH0	Timer 0 high	8CH									00	0000 0000
TH1	Timer 1 high	8DH									00	0000 0000
TL0	Timer 0 low	8AH									00	0000 0000
TL1	Timer 1 low	8BH									00	0000 0000

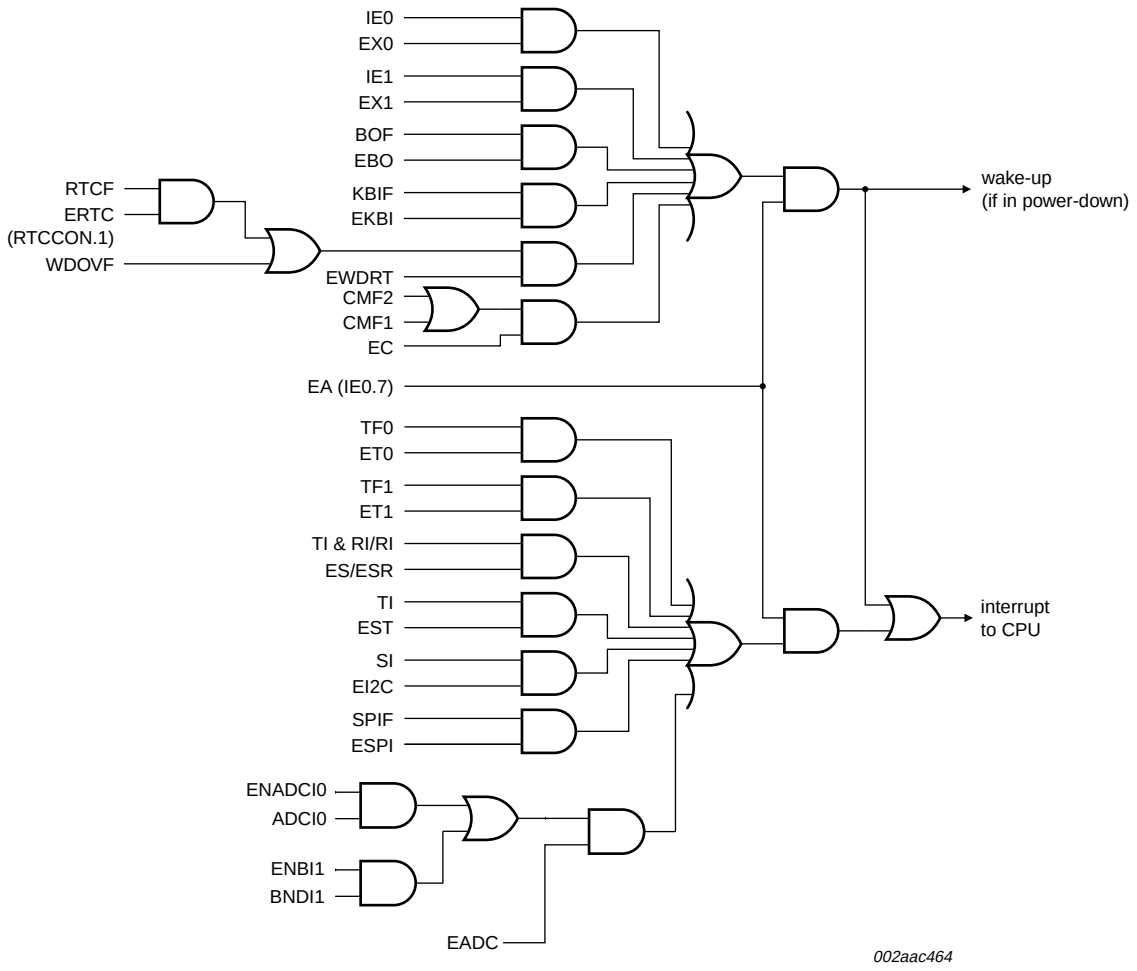


Fig 5. Interrupt sources, interrupt enables, and power-down wake-up sources

7.13 I/O ports

The P89LPC9381 has four I/O ports: Port 0, Port 1, Port 2, and Port 3. Ports 0, 1 and 2 are 8-bit ports, and 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 (28-pin package)
On-chip oscillator or watchdog oscillator	No external reset (except during power-up)	26
	External $\overline{\text{RST}}$ pin supported	25
External clock input	No external reset (except during power-up)	25
	External $\overline{\text{RST}}$ pin supported[1]	24
Low/medium/high speed oscillator (external crystal or resonator)	No external reset (except during power-up)	24
	External $\overline{\text{RST}}$ pin supported[1]	23

[1] Required for operation above 12 MHz.

7.13.1 Port configurations

All but three I/O port pins on the P89LPC9381 may be configured by software to one of four types on a bit-by-bit basis. These are: quasi-bidirectional (standard 80C51 port outputs), push-pull, open-drain, and input-only. Two configuration registers for each port select the output type for each port pin.

1. P1[5] ($\overline{\text{RST}}$) can only be an input and cannot be configured.
2. P1[2] (SCL/T0) and P1[3] (SDA/$\overline{\text{INT0}}$) may only be configured to be either input-only or open-drain.

7.13.1.1 Quasi-bidirectional output configuration

Quasi-bidirectional output type can be used as both an input and output without the need to reconfigure the port. This is possible because when the port outputs a logic HIGH, it is weakly driven, allowing an external device to pull the pin LOW. When the pin is driven LOW, it is driven strongly and able to sink a fairly large current. These features are somewhat similar to an open-drain output except that there are three pull-up transistors in the quasi-bidirectional output that serve different purposes.

The P89LPC9381 is a 3 V device, but the pins are 5 V tolerant. In quasi-bidirectional mode, if a user applies 5 V on the pin, there will be a current flowing from the pin to V_{DD}, causing extra power consumption. Therefore, applying 5 V in quasi-bidirectional mode is discouraged.

A quasi-bidirectional port pin has a Schmitt triggered input that also has a glitch suppression circuit.

7.13.1.2 Open-drain output configuration

The open-drain output configuration turns off all pull-ups and only drives the pull-down transistor of the port driver when the port latch contains a logic 0. To be used as a logic output, a port configured in this manner must have an external pull-up, typically a resistor tied to V_{DD}.

7.16 Reset

The P1[5]/$\overline{\text{RST}}$ pin can function as either an active-LOW reset input or as a digital input, P1[5]. The RPE (Reset Pin Enable) bit in UCFG1, when set to '1', enables the external reset input function on P1[5]. When cleared, P1[5] may be used as an input pin.

Remark: During a power-up sequence, The RPE selection is overridden and this pin will always functions 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 '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 P89LPC9381 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 P89LPC9381 *User's Manual*). Otherwise, instructions will be fetched from address 0000H.

7.17 Timers/counters 0 and 1

The P89LPC9381 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.

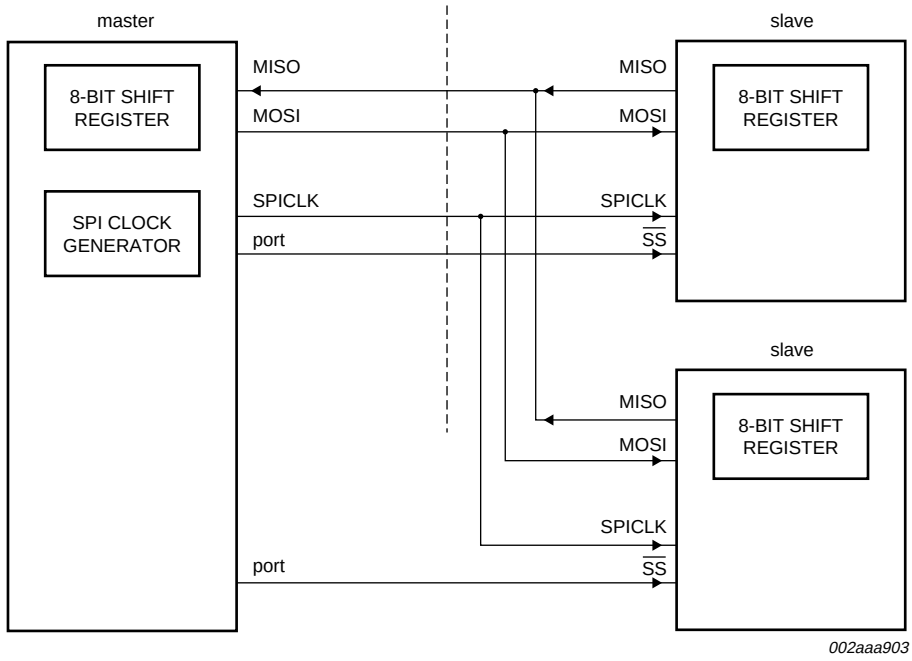


Fig 12. SPI single master multiple slaves configuration

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.

7.23 KBI

The Keypad Interrupt function is intended primarily to allow a single interrupt to be generated when Port 0 is equal to or not equal to a certain pattern. This function can be used for bus address recognition or keypad recognition. The user can configure the port via SFRs for different tasks.

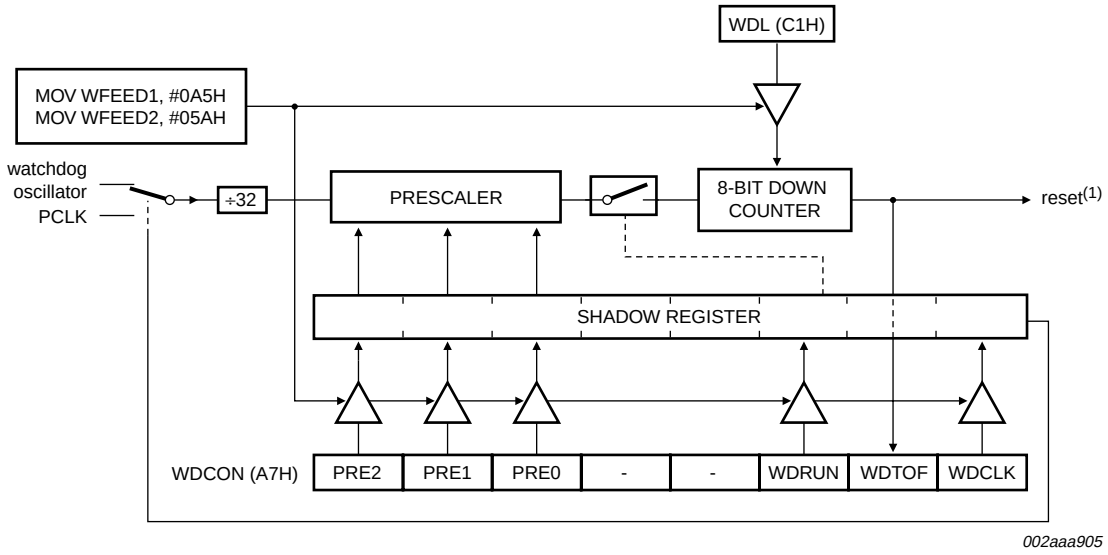
The Keypad Interrupt Mask Register (KBMASK) is used to define which input pins connected to Port 0 can trigger the interrupt. The Keypad Pattern Register (KBPATN) is used to define a pattern that is compared to the value of Port 0. The Keypad Interrupt Flag (KBIF) in the Keypad Interrupt Control Register (KBCON) is set when the condition is matched while the Keypad Interrupt function is active. An interrupt will be generated if enabled. The PATN_SEL bit in the Keypad Interrupt Control Register (KBCON) is used to define equal or not-equal for the comparison.

In order to use the Keypad Interrupt as an original KBI function like in 87LPC76x series, the user needs to set KBPATN = 0FFH and PATN_SEL = 1 (not equal), then any key connected to Port 0 which is enabled by the KBMASK register will cause the hardware to set KBIF and generate an interrupt if it has been enabled. The interrupt may be used to wake up the CPU from Idle or Power-down modes. This feature is particularly useful in handheld, battery-powered systems that need to carefully manage power consumption yet also need to be convenient to use.

In order to set the flag and cause an interrupt, the pattern on Port 0 must be held longer than six CCLKs.

7.24 Watchdog timer

The watchdog timer causes a system reset when it underflows as a result of a failure to feed the timer prior to the timer reaching its terminal count. It consists of a programmable 12-bit prescaler, and an 8-bit down counter. The down counter is decremented by a tap taken from the prescaler. The clock source for the prescaler is either the PCLK or the nominal 400 kHz Watchdog oscillator. The watchdog timer can only be reset by a power-on reset. When the watchdog feature is disabled, it can be used as an interval timer and may generate an interrupt. Figure 14 shows the watchdog timer in Watchdog mode. Feeding the watchdog requires a two-byte sequence. If PCLK is selected as the watchdog clock and the CPU is powered-down, the watchdog is disabled. The watchdog timer has a time-out period that ranges from a few µs to a few seconds. Please refer to the P89LPC9381 *User's Manual* for more details.



(1) Watchdog reset can also be caused by an invalid feed sequence, or by writing to WDCON not immediately followed by a feed sequence.

Fig 14. Watchdog timer in Watchdog mode (WDTE = 1)

7.25 Additional features

7.25.1 Software reset

The SRST bit in AUXR1 gives software the opportunity to reset the processor completely, as if an external reset or watchdog reset had occurred. Care should be taken when writing to AUXR1 to avoid accidental software resets.

7.25.2 Dual data pointers

The dual Data Pointers (DPTR) provides two different Data Pointers to specify the address used with certain instructions. The DPS bit in the AUXR1 register selects one of the two Data Pointers. Bit 2 of AUXR1 is permanently wired as a logic 0 so that the DPS bit may be toggled (thereby switching Data Pointers) simply by incrementing the AUXR1 register, without the possibility of inadvertently altering other bits in the register.

provides for programming through a serial clock/serial data interface. As shipped from the factory, the upper 512 B 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.

7.26.6 ICP

In-Circuit Programming is performed without removing the microcontroller from the system. The In-Circuit Programming facility consists of internal hardware resources to facilitate remote programming of the P89LPC9381 through a two-wire serial interface. The Philips In-Circuit Programming facility has made in-circuit programming 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 P89LPC9381 *User's Manual*.

7.26.7 IAP

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 In-Application Programming has made in-application programming 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 FF00 to FEFF hex, 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 P89LPC9381 *User's Manual*.

7.26.8 ISP

In-System Programming is performed without removing the microcontroller from the system. The In-System Programming facility consists of a series of internal hardware resources coupled with internal firmware to facilitate remote programming of the P89LPC9381 through the serial port. This firmware is provided by Philips and embedded within each P89LPC9381 device. The Philips In-System Programming facility has made in-system programming 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.

7.26.9 Power-on reset code execution

The P89LPC9381 contains two special flash elements: the Boot Vector and the Boot Status Bit. Following reset, the P89LPC9381 examines the contents of the Boot Status Bit. If the Boot Status Bit is set to zero, power-up execution starts at location 0000H, which is the normal start address of the user's application code. When the Boot Status Bit is set to a value other than zero, the contents of the Boot Vector is used as the high byte of the execution address and the low byte is set to 00H.

Table 8 shows the factory default Boot Vector setting for this device. A factory-provided bootloader is pre-programmed into the address space indicated and uses the indicated boot loader entry point to perform ISP functions. This code can be erased by the user. **Users who wish to use this loader should take precautions to avoid erasing the 1 kB sector that contains this boot loader. Instead, the page erase function can be used to erase the first eight 64 B pages located in this sector.** A custom bootloader can be written with the Boot Vector set to the custom boot loader, if desired.

Table 8. Default Boot Vector values and ISP entry points

Device	Default boot vector	Default bootloader entry point	Default bootloader code range	1 kB sector range
P89LPC9381	0FH	0F00H	0E00H to 0FFFH	0C00H to 0FFFH

7.26.10 Hardware activation of the bootloader

The bootloader can also be executed by forcing the device into ISP mode during a power-on sequence (see the P89LPC9381 *User's Manual* for specific information). This has the same effect as having a non-zero status byte. This allows an application to be built that will normally execute user code but can be manually forced into ISP operation. If the factory default setting for the Boot Vector (0FH) is changed, it will no longer point to the factory pre-programmed ISP bootloader code. After programming the flash, the status byte should be programmed to zero in order to allow execution of the user's application code beginning at address 0000H.

7.27 User configuration bytes

Some user-configurable features of the P89LPC9381 must be defined at power-up and therefore cannot be set by the program after start of execution. These features are configured through the use of the flash byte UCFG1. Please see the P89LPC9381 *User's Manual* for additional details.

7.28 User sector security bytes

There are four User Sector Security Bytes on the P89LPC9381. Each byte corresponds to one sector. Please see the P89LPC9381 *User's Manual* for additional details.

8. ADC

8.1 General description

The P89LPC9381 has a 10-bit, 8-channel multiplexed successive approximation analog-to-digital converter module. A block diagram of the ADC is shown in Figure 15. The ADC consists of an 8-input multiplexer which feeds a sample-and-hold circuit

9. Limiting values

Table 9. Limiting values

In accordance with the Absolute Maximum Rating System (IEC 60134).[1]

Symbol	Parameter	Conditions	Min	Max	Unit
$T_{amb(bias)}$	bias ambient temperature		–55	+125	°C
T_{stg}	storage temperature		–65	+150	°C
$I_{OH(I/O)}$	HIGH-state output current per input/output pin		-	20	mA
$I_{OL(I/O)}$	LOW-state output current per input/output pin		-	20	mA
$I_{I/Otot(max)}$	maximum total input/output current		-	100	mA
V_n	voltage on any other pin	except V_{SS}, with respect to V_{DD}	-	3.5	V
$P_{tot(pack)}$	total power dissipation (per package)	based on package heat transfer, not device power consumption	-	1.5	W

[1] The following applies to Table 9:

a) This product includes circuitry specifically designed for the protection of its internal devices from the damaging effects of excessive static charge. Nonetheless, it is suggested that conventional precautions be taken to avoid applying greater than the rated maximum.

b) Parameters are valid over operating temperature range unless otherwise specified. All voltages are with respect to V_{SS} unless otherwise noted.

Table 11. Dynamic characteristics (12 MHz) *…continued*

V_{DD} = 2.4 V to 3.6 V, unless otherwise specified.
T_{amb} = −40 °C to +85 °C for industrial applications, unless otherwise specified.[1][2]

Symbol	Parameter	Conditions	Variable clock		f_{osc} = 12 MHz		Unit
			Min	Max	Min	Max	
t_{SPILAG}	SPI enable lag time	see Figure 20 and 21					
	slave		250	-	250	-	ns
$t_{SPICLKH}$	SPICLK HIGH time	see Figure 18, 19, 20 and 21					
	master		$^{2}/_{CCLK}$	-	165	-	ns
	slave		$^{3}/_{CCLK}$	-	250	-	ns
$t_{SPICLKL}$	SPICLK LOW time	see Figure 18, 19, 20 and 21					
	master		$^{2}/_{CCLK}$	-	165	-	ns
	slave		$^{3}/_{CCLK}$	-	250	-	ns
t_{SPIDSU}	SPI data set-up time	see Figure 18, 19, 20 and 21	100	-	100	-	ns
t_{SPIDH}	SPI data hold time	see Figure 18, 19, 20 and 21	100	-	100	-	ns
t_{SPIA}	SPI access time	see Figure 20 and 21					
	slave		0	120	0	120	ns
t_{SPIDIS}	SPI disable time	see Figure 20 and 21					
	slave		0	240	-	240	ns
t_{SPIDV}	SPI enable to output data valid time	see Figure 18, 19, 20 and 21					
	slave		-	240	-	240	ns
	master		-	167	-	167	ns
t_{SPIOH}	SPI output data hold time	see Figure 18, 19, 20 and 21	0	-	0	-	ns
t_{SPIR}	SPI rise time	see Figure 18, 19, 20 and 21					
	SPI outputs (SPICLK, MOSI, MISO)		-	100	-	100	ns
	SPI inputs (SPICLK, MOSI, MISO, $\overline{SS}$)		-	2000	-	2000	ns
t_{SPIF}	SPI fall time	see Figure 18, 19, 20 and 21					
	SPI outputs (SPICLK, MOSI, MISO)		-	100	-	100	ns
	SPI inputs (SPICLK, MOSI, MISO, $\overline{SS}$)		-	2000	-	2000	ns

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

[2] Parts are tested to 2 MHz, but are guaranteed to operate down to 0 Hz.

Table 12. Dynamic characteristics (18 MHz)

V_{DD} = 3.0 V to 3.6 V, unless otherwise specified.
T_{amb} = −40 °C to +85 °C for industrial applications, unless otherwise specified.[1][2]

Symbol	Parameter	Conditions	Variable clock		f_{osc} = 18 MHz		Unit
			Min	Max	Min	Max	
$f_{osc(RC)}$	internal RC oscillator frequency		7.189	7.557	7.189	7.557	MHz
$f_{osc(WD)}$	internal watchdog oscillator frequency		320	520	320	520	kHz
f_{osc}	oscillator frequency		0	18	-	-	MHz
$T_{cy(clk)}$	clock cycle time	see Figure 17	55	-	-	-	ns
f_{CLKLP}	low-power select clock frequency		0	8	-	-	MHz
Glitch filter							
t_{gr}	glitch rejection time	P1[5]/$\overline{RST}$ pin	-	50	-	50	ns
		any pin except P1[5]/$\overline{RST}$	-	15	-	15	ns
t_{sa}	signal acceptance time	P1[5]/$\overline{RST}$ pin	125	-	125	-	ns
		any pin except P1[5]/$\overline{RST}$	50	-	50	-	ns
External clock							
t_{CHCX}	clock HIGH time	see Figure 17	22	$T_{cy(clk)} - t_{CLCX}$	22	-	ns
t_{CLCX}	clock LOW time	see Figure 17	22	$T_{cy(clk)} - t_{CHCX}$	22	-	ns
t_{CLCH}	clock rise time	see Figure 17	-	5	-	5	ns
t_{CHCL}	clock fall time	see Figure 17	-	5	-	5	ns
Shift register (UART mode 0)							
T_{XLXL}	serial port clock cycle time	see Figure 16	$16T_{cy(clk)}$	-	888	-	ns
t_{QVXH}	output data setup to clock rising edge time	see Figure 16	$13T_{cy(clk)}$	-	722	-	ns
t_{XHQX}	output data hold after clock rising edge time	see Figure 16	-	$T_{cy(clk)}$ + 20	-	75	ns
t_{XHDX}	input data hold after clock rising edge time	see Figure 16	-	0	-	0	ns
t_{XHDV}	input data valid to clock rising edge time	see Figure 16	150	-	150	-	ns
SPI interface							
f_{SPI}	SPI operating frequency						
	slave		0	$^{CCLK}/_{6}$	0	3.0	MHz
	master		-	$^{CCLK}/_{4}$	-	4.5	MHz
T_{SPICYC}	SPI cycle time	see Figure 18, 19, 20, 21					
	slave		$^{6}/_{CCLK}$	-	333	-	ns
	master		$^{4}/_{CCLK}$	-	222	-	ns
$t_{SPILEAD}$	SPI enable lead time	see Figure 20, 21					
	slave		250	-	250	-	ns
t_{SPILAG}	SPI enable lag time	see Figure 20, 21					
	slave		250	-	250	-	ns

Table 12. Dynamic characteristics (18 MHz) *…continued*

V_{DD} = 3.0 V to 3.6 V, unless otherwise specified.
T_{amb} = −40 °C to +85 °C for industrial applications, unless otherwise specified.[1][2]

Symbol	Parameter	Conditions	Variable clock		f_{osc} = 18 MHz		Unit
			Min	Max	Min	Max	
$t_{SPICLKH}$	SPICLK HIGH time	see Figure 18, 19, 20 and 21					
	master		$^{2}/_{CCLK}$	-	111	-	ns
	slave		$^{3}/_{CCLK}$	-	167	-	ns
$t_{SPICLKL}$	SPICLK LOW time	see Figure 18, 19, 20 and 21					
	master		$^{2}/_{CCLK}$	-	111	-	ns
	slave		$^{3}/_{CCLK}$	-	167	-	ns
t_{SPIDSU}	SPI data set-up time	see Figure 18, 19, 20 and 21	100	-	100	-	ns
t_{SPIDH}	SPI data hold time	see Figure 18, 19, 20 and 21	100	-	100	-	ns
t_{SPIA}	SPI access time	see Figure 20 and 21	0	80	0	80	ns
	slave						
t_{SPIDIS}	SPI disable time	see Figure 20 and 21	0	160	-	160	ns
	slave						
t_{SPIDV}	SPI enable to output data valid time	see Figure 18, 19, 20 and 21					
	slave		-	160	-	160	ns
	master		-	111	-	111	ns
t_{SPIOH}	SPI output data hold time	see Figure 18, 19, 20 and 21	0	-	0	-	ns
t_{SPIR}	SPI rise time	see Figure 18, 19, 20 and 21					
	SPI outputs (SPICLK, MOSI, MISO)		-	100	-	100	ns
	SPI inputs (SPICLK, MOSI, MISO, $\overline{SS}$)		-	2000	-	2000	ns
t_{SPIF}	SPI fall time	see Figure 18, 19, 20 and 21					
	SPI outputs (SPICLK, MOSI, MISO)		-	100	-	100	ns
	SPI inputs (SPICLK, MOSI, MISO, $\overline{SS}$)		-	2000	-	2000	ns

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

[2] Parts are tested to 2 MHz, but are guaranteed to operate down to 0 Hz.

11.1 Waveforms

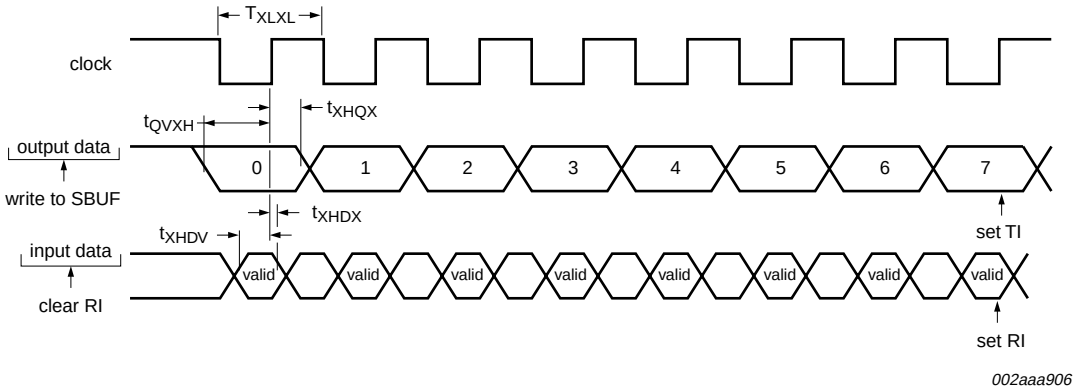


Fig 16. Shift register mode timing

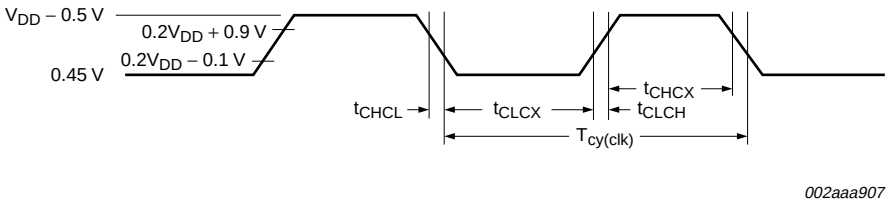


Fig 17. External clock timing

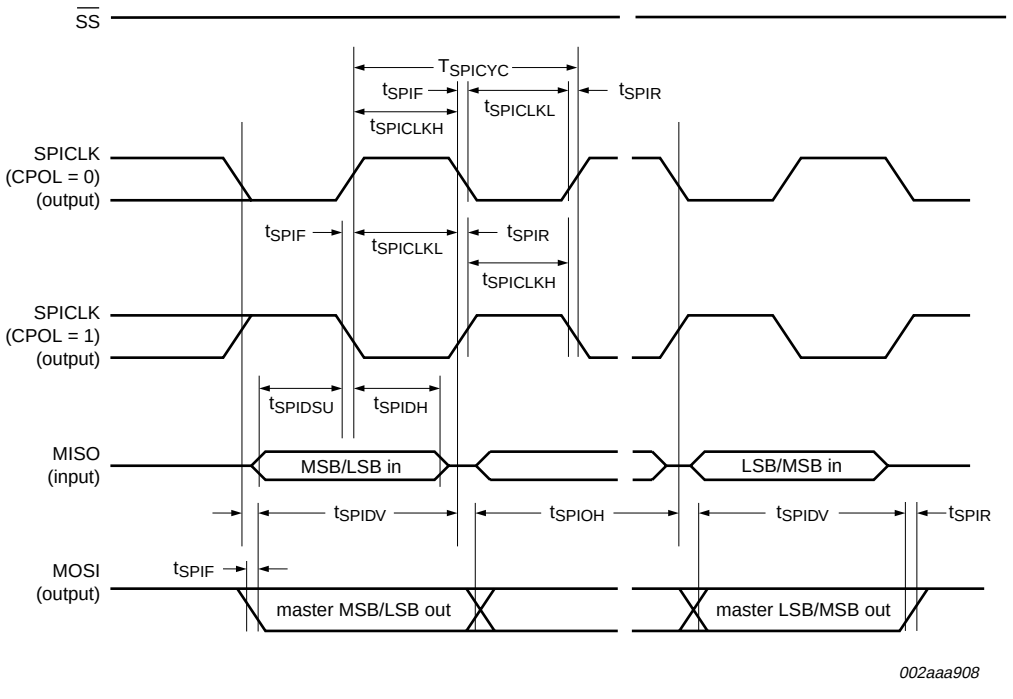


Fig 18. SPI master timing (CPHA = 0)

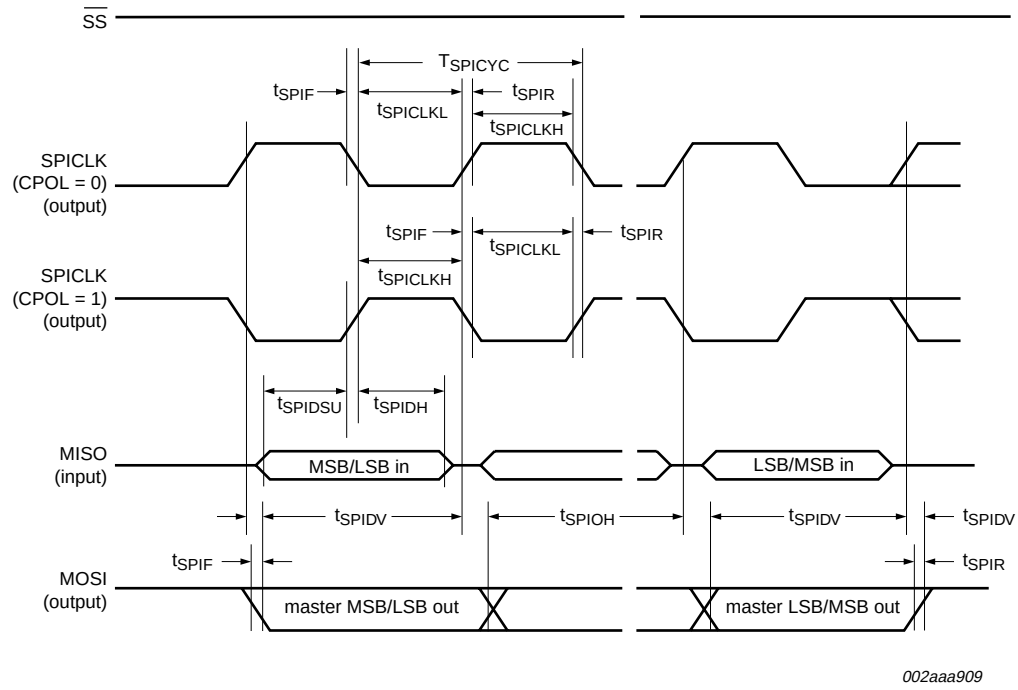


Fig 19. SPI master timing (CPHA = 1)

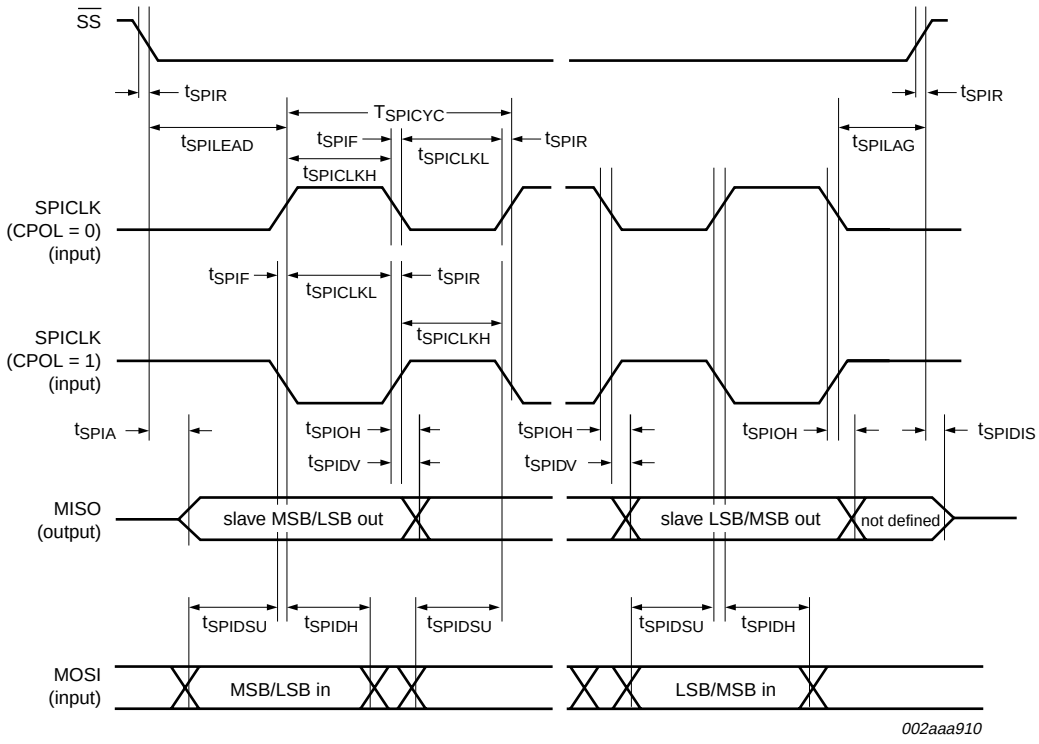


Fig 20. SPI slave timing (CPHA = 0)

8.1 General description 39
8.2 Features 40
8.3 Block diagram 40
8.4 ADC operating modes 41
8.4.1 Fixed channel, single conversion mode 41
8.4.2 Fixed channel, continuous conversion mode . 41
8.4.3 Auto scan, single conversion mode 41
8.4.4 Auto scan, continuous conversion mode 41
8.4.5 Dual channel, continuous conversion mode . . 41
8.4.6 Single step mode 42
8.5 Conversion start modes 42
8.5.1 Timer triggered start 42
8.5.2 Start immediately 42
8.5.3 Edge triggered 42
8.6 Boundary limits interrupt 42
8.7 Clock divider 42
8.8 Power-down and Idle mode 42
9 Limiting values 43
10 Static characteristics 44
11 Dynamic characteristics 46
11.1 Waveforms 50
11.2 ISP entry mode 52
12 Other characteristics 53
12.1 Comparator electrical characteristics 53
12.2 ADC electrical characteristics 54
13 Package outline 55
14 Abbreviations 56
15 Revision history 57
16 Legal information 58
16.1 Data sheet status 58
16.2 Definitions 58
16.3 Disclaimers 58
16.4 Trademarks 58
17 Contact information 58
18 Contents 59

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Date of release: 8 September 2006

Document identifier: P89LPC9381_1