

# DATA SHEET

SEE THE LAST 2 PAGES OF THIS DATA SHEET FOR A LIST OF ERRATA RELATED TO THIS PART.

## **P87C51MB2/P87C51MC2**

**80C51 8-bit microcontroller family with  
extended memory**

64KB/96KB OTP with 2KB/3KB RAM

Preliminary specification

2001 Apr 06

**80C51 8-bit microcontroller family with extended memory****64KB/96KB OTP with 2KB/3KB RAM****P87C51MB2/P87C51MC2****GENERAL DESCRIPTION**

The P87C51Mx2 represents the first microcontroller based on Philips Semiconductors' new 51MX core. The P87C51MC2 features 96 Kbytes of OTP program memory and 3 Kbytes of data SRAM, while the P87C51MB2 has 64 Kbytes of OTP and 2 Kbytes of RAM. In addition, both devices are equipped with a Programmable Counter Array (PCA), a watchdog timer that can be configured to different time ranges through SFR bits, as well as two enhanced UARTs or one enhanced UART and an SPI.

Philips Semiconductors' 51MX (Memory eXtension) core is an accelerated 80C51 architecture that executes instructions at twice the rate of standard 80C51 devices. The linear address range of the 51MX has been expanded to support up to 8 Mbytes of program memory and 8Mbytes of data memory. It retains full program code compatibility to enable design engineers to re-use 80C51 development tools, eliminating the need to move to a new, unfamiliar architecture. The 51MX core also retains 80C51 bus compatibility to allow for the continued use of 80C51-interfaced peripherals and Application Specific Integrated Circuits (ASICs).

The P87C51Mx2 provides greater functionality, increased performance and overall lower system cost. By offering an embedded memory solution combined with the enhancements to manage the memory extension, the P87C51Mx2 eliminates the need for software work-arounds. The increased program memory enables design engineers to develop more complex programs in a high-level language like C, for example, without struggling to contain the program within the traditional 64 Kbytes of program memory. These enhancements also greatly improve C Language efficiency for code size below 64 Kbytes.

The 51MX core is described in more details in the 51MX Architecture Reference.

**KEY FEATURES**

- Extended features of the 51MX Core:
  - 23-bit program memory space and 23-bit data memory space - linear program and data address range expanded to support up to 8 Mbytes each
  - Program counter expanded to 23 bits
  - Stack pointer extended to 16 bits enabling stack space beyond the 80C51 limitation
  - New 23-bit extended data pointer and two 24-bit universal pointers greatly improve C compiler code efficiency in using pointers to access variables in different spaces.
- 100% binary compatibility with the classic 80C51 so that existing code is completely reusable
- Up to 24 MHz CPU clock with 6 clock cycles per machine cycle
- 96 Kbytes or 64 Kbytes of on-chip OTP
- 3 Kbytes or 2 Kbytes of on-chip RAM
- Programmable Counter Array (PCA)
- Two full-duplex enhanced UARTs
- Industry-standard Serial Peripheral Interface (SPI)

**KEY BENEFITS**

- Increases program/data address range to 8 Mbytes each
- Enhances performance and efficiency for C programs
- Fully 80C51-compatible microcontroller
- Provides seamless and compelling upgrade path from classic 80C51
- Preserves 80C51 code base, investment/knowledge, and peripherals & ASICs
- Supported by 80C51 development and programming tools (Keil, Nohau, BP Micro, etc.)
- The P87C51Mx2 makes it possible to develop applications at a lower cost and with a reduced time-to-market

**80C51 8-bit microcontroller family with extended memory**  
**64KB/96KB OTP with 2KB/3KB RAM**
**P87C51MB2/P87C51MC2**
**COMPLETE FEATURES**

- Fully static
- Up to 24 MHz CPU clock with 6 clock cycles per machine cycle
- 96 Kbytes or 64 Kbytes of on-chip OTP
- 3 Kbytes or 2 Kbytes of on-chip RAM
- 23-bit program memory space and 23-bit data memory space
- Four-level interrupt priority
- 34 I/O lines (5 ports)
- Three Timers: Timer0, Timer1 and Timer2
- Two full-duplex enhanced UARTs with baud rate generator
- Framing error detection
- Automatic address recognition
- Supports industry-standard Serial Peripheral Interface (SPI) with a baud rate up to 6 Mbits/sec
- Power control modes
- Clock can be stopped and resumed
- Idle mode
- Power down mode
- Second DPTR register
- Asynchronous port reset
- Programmable Counter Array (PCA) (compatible with 8xC51Rx+) with five Capture/Compare modules
- Low EMI (inhibit ALE)
- Watchdog timer with programmable prescaler for different time ranges (compatible with 8xC66x with added prescaler)

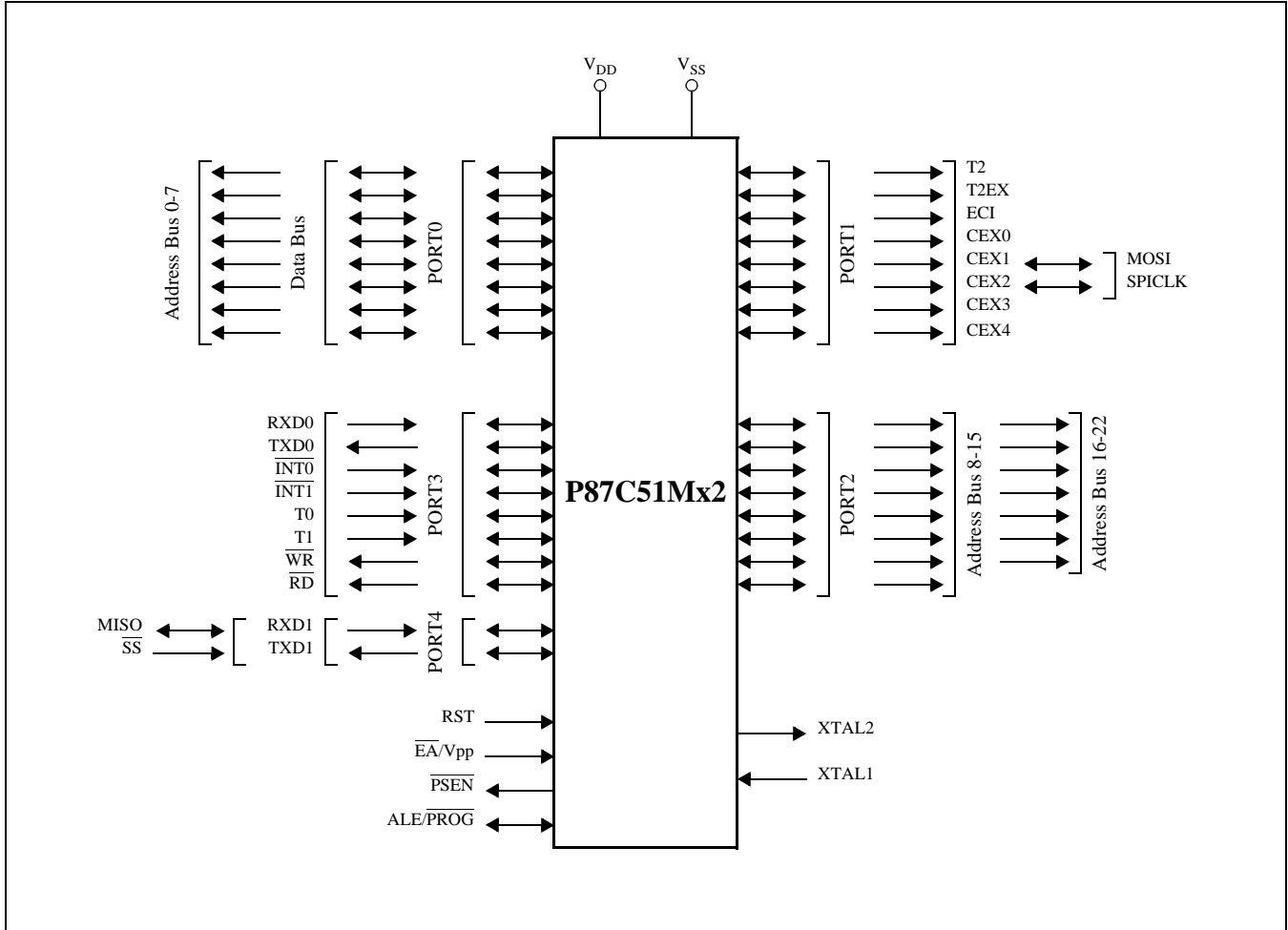
**ORDERING INFORMATION**

	PART ORDER NUMBER	MEMORY		TEMPERATURE RANGE AND PACKAGE	V <sub>DD</sub> VOLTAGE RANGE		FREQUENCY		DWG #
		OTP	RAM		V <sub>DD</sub> = 2.7-5.5V	V <sub>DD</sub> = 4.5-5.5V	V <sub>DD</sub> = 2.7-5.5V	V <sub>DD</sub> = 4.5-5.5V	
1	P87C51MB2BA	64 KB	2048 B	0 to +70°C, PLCC44	2.7-5.5V	4.5-5.5V	0-12MHz	0-24MHz	SOT187-2
2	P87C51MC2BA	96 KB	3072 B	0 to +70°C, PLCC44	2.7-5.5V	4.5-5.5V	0-12MHz	0-24MHz	SOT187-2

80C51 8-bit microcontroller family with extended memory  
64KB/96KB OTP with 2KB/3KB RAM

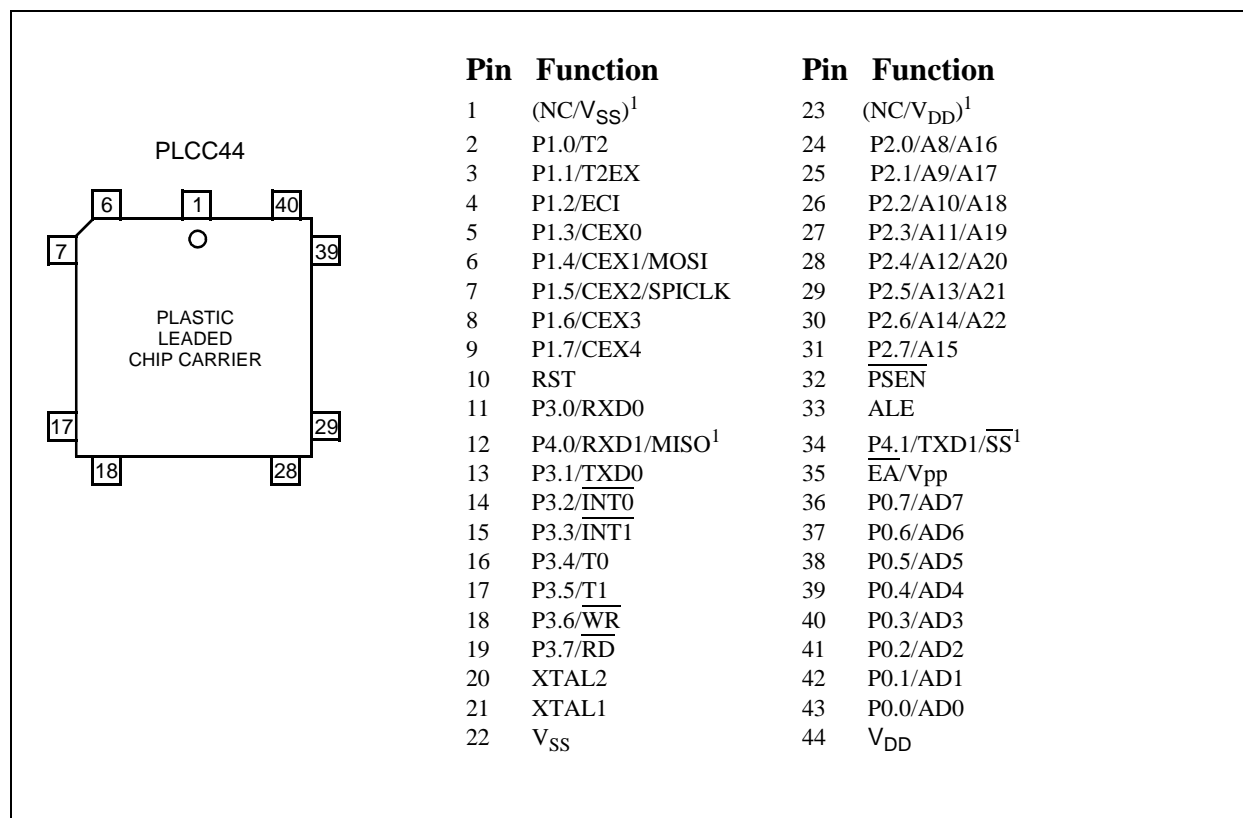
P87C51MB2/P87C51MC2

LOGIC SYMBOL



**80C51 8-bit microcontroller family with extended memory**

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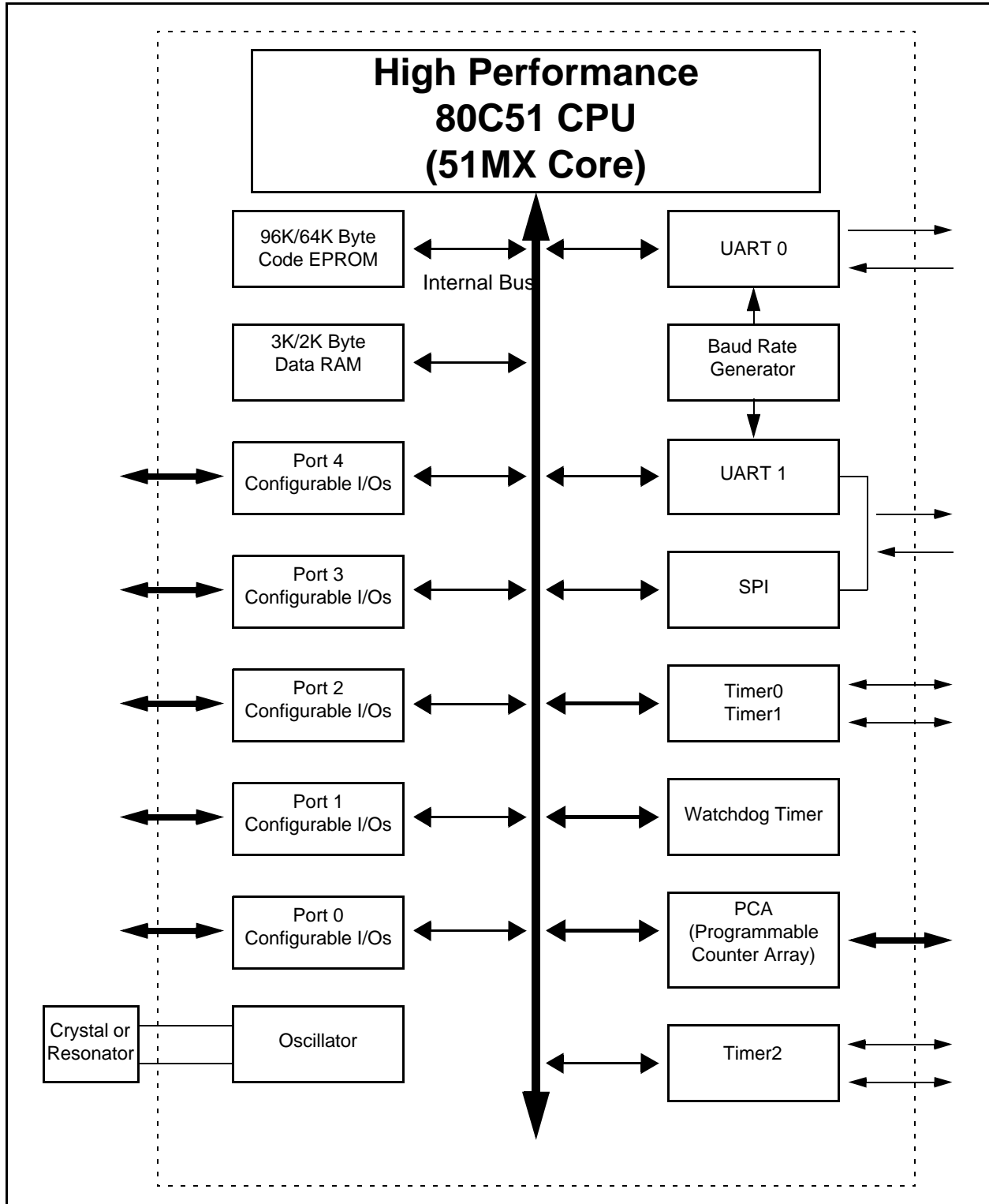
**P87C51MB2/P87C51MC2****PIN CONFIGURATION**

1. Pins 1, 12, 23, 34 were not internally connected in some derivatives. Please refer to section on Pin Descriptions for details.

**80C51 8-bit microcontroller family with extended memory**  
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**P87C51MB2/P87C51MC2**

**BLOCK DIAGRAM**



**80C51 8-bit microcontroller family with extended memory**

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**P87C51MB2/P87C51MC2****PIN DESCRIPTIONS**

MNEMONIC	PIN NO.	TYPE	NAME AND FUNCTION
P0.0 - P0.7	43 - 36	I/O	<b>Port 0:</b> Port 0 is an open drain, bidirectional I/O port. Port 0 pins that have 1s written to them float and can be used as high-impedance inputs. Port 0 is also the multiplexed low-order address and data bus during accesses to external program and data memory. In this application, it uses strong internal pull-ups when emitting 1s.
P1.0 - P1.7	2 - 9	I/O	<b>Port 1:</b> Port 1 is an 8-bit bidirectional I/O port with internal pull-ups on all pins. Port 1 pins that have 1s written to them are pulled high by the internal pull-ups and can be used as inputs. As inputs, port 1 pins that are externally pulled low will source current because of the internal pull-ups. (Note: When SFR bit SPEN (SPCTL.6) is '1', the pull-ups at P1.4 and P1.5 are disabled.)
	2	I/O	<b>P1.0 T2</b> Timer/Counter 2 external count input/Clockout
	3	I	<b>P1.1 T2EX</b> Timer/Counter 2 Reload/Capture/Direction Control
	4	I	<b>P1.2 ECI</b> External Clock Input to the PCA
	5	I/O	<b>P1.3 CEX0</b> Capture/Compare External I/O for PCA module 0
	6	I/O	<b>P1.4 CEX1</b> Capture/Compare External I/O for PCA module 1 (with pull-up on pin)
		I/O	<b>MOSI</b> SPI Master Out/Slave In (Selected when SFR bit SPEN (SPCTL.6) is '1', in which case the pull-up for this pin is disabled)
	7	I/O	<b>P1.5 CEX2</b> Capture/Compare External I/O for PCA module 2 (with pull-up on pin)
		I/O	<b>SPICLK</b> SPI Clock (Selected when SFR bit SPEN (SPCTL.6) is '1', in which case the pull-up for this pin is disabled)
	8	I/O	<b>P1.6 CEX3</b> Capture/Compare External I/O for PCA module 3
	9	I/O	<b>P1.7 CEX4</b> Capture/Compare External I/O for PCA module 4
P2.0 - P2.7	24 - 31	I/O	<b>Port 2:</b> Port 2 is a 8-bit bidirectional I/O port with internal pull-ups. Port 2 pins that have 1s written to them are pulled high by the internal pull-ups and can be used as inputs. As inputs, port 2 pins that are externally being pulled low will source current because of the internal pull-ups. (See DC Electrical Characteristics: $I_{IL}$ ). Port 2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that use 16-bit addresses (MOVX @ DPTR) or 23-bit addresses (MOVX @ EPTR, EMOV). In this application, it uses strong internal pull-ups when emitting 1s. During accesses to external data memory that use 8-bit addresses (MOV @ Ri), port2 emits the contents of the P2 Special Function Register.  Note that when 23-bit address is used, address bits A16-A22 will be output to P2.0-P2.6 when ALE is High, and address bits A8-A14 are output to P2.0-P2.6 when ALE is Low. Address bit A15 is output on P2.7 regardless of ALE.
P3.0 - P3.7	11,13 - 19	I/O	<b>Port 3:</b> Port 3 is an 8-bit bidirectional I/O port with internal pull-ups. Port 3 pins that have 1s written to them are pulled high by the internal pull-ups and can be used as inputs. As inputs, port 3 pins that are externally pulled low will source current because of the internal pull-ups.
	11	I	<b>P3.0 RXD0</b> Serial input port 0
	13	O	<b>P3.1 TXD0</b> Serial output port 0
	14	I	<b>P3.2 INT0</b> External interrupt 0
	15	I	<b>P3.3 INT1</b> External interrupt 1
	16	I	<b>P3.4 T0</b> Timer0 external input
	17	I	<b>P3.5 T1</b> Timer1 external input
	18	O	<b>P3.6 WR</b> External data memory write strobe
	19	O	<b>P3.7 RD</b> External data memory read strobe

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MNEMONIC	PIN NO.	TYPE	NAME AND FUNCTION
P4.0 - P4.1	12,34	I/O	<b>Port 4:</b> Port 4 is an 8-bit bidirectional I/O port with internal pull-ups on all pin. Port 4 pins that have 1s written to them are pulled high by the internal pull-ups and can be used as inputs. As inputs, port 4 pins that are externally pulled low will source current because of the internal pull-ups. (Note: When SFR bit SPEN (SPCTL.6) is '1', the pull-ups at these port pins are disabled.)
	12	I	<b>P4.0 RXD1</b> Serial input port 1. (Note: This pin is a no connect pin on some derivatives.) (with pull-up on pin)
		I/O	<b>MISO</b> SPI Master In/Slave Out (Selected when SFR bit SPEN (SPCTL.6) is '1', in which case the pull-up for this pin is disabled)
	34	O	<b>P4.1 TXD1</b> Serial output port 1. (Note: This pin is a no connect pin on some derivatives.) (with pull-up on pin)
		I	<b><math>\overline{SS}</math></b> SPI Slave Select (Selected when SFR bit SPEN (SPCTL.6) is '1', in which case the pull-up for this pin is disabled)
RST	10	I	<b>Reset:</b> A high on this pin for two machine cycles while the oscillator is running, resets the device. An internal diffused resistor to $V_{SS}$ permits a power-on reset using only an external capacitor to $V_{DD}$ .
ALE	33	O	<b>Address Latch Enable:</b> Output pulse for latching the low byte of the address during an access to external memory. In normal operation, ALE is emitted at a constant rate of 1/6 the oscillator frequency, and can be used for external timing or clocking. Note that one ALE pulse is skipped during each access to external data memory. If SFR bit AO (AUXR.0) is '0', ALE is emitted at the constant rate as indicated above. With this bit set to '1', ALE will be active only during a MOVX instruction.
$\overline{PSEN}$	32	O	<b>Program Store Enable:</b> The read strobe to external program memory. When executing code from the external program memory, $\overline{PSEN}$ is activated twice each machine cycle, except that two $\overline{PSEN}$ activations are skipped during each access to external data memory. $\overline{PSEN}$ is not activated during fetches from internal program memory.
$\overline{EA}/V_{pp}$	35	I	<b>External Access Enable/Programming Supply Voltage:</b> $\overline{EA}$ must be externally held low to enable the device to fetch code from external program memory locations. If $\overline{EA}$ is held high, the device executes from internal program memory. The value on the $\overline{EA}$ pin is latched when RST is released and any subsequent changes have no effect.
XTAL1	21	I	<b>Crystal 1:</b> Input to the inverting oscillator amplifier and input to the internal clock generator circuits.
XTAL2	20	O	<b>Crystal 2:</b> Output from the inverting oscillator amplifier.
$V_{SS}$	22	I	<b>Ground:</b> 0V reference.
$V_{DD}$	44	I	<b>Power Supply:</b> This is the power supply voltage for normal operation as well as Idle and Power Down modes.
(NC/ $V_{SS}$ )	1	I	<b>No Connect/Ground:</b> This pin is a no connect pin on some derivatives, but is internally connected to $V_{SS}$ on the P87C51Mx2. If connected externally, this pin must only be connected to the same $V_{SS}$ as at pin 22. (Note: Connecting the second pair of $V_{SS}$ and $V_{DD}$ pins is not required. However, they may be connected in addition to the primary $V_{SS}$ and $V_{DD}$ pins to improve power distribution, reduce noise in output signals, and improve system-level EMI characteristics.)
(NC/ $V_{DD}$ )	23	I	<b>No Connect/Power Supply:</b> This pin is a no connect pin on some derivatives, but is internally connected to $V_{DD}$ on the P87C51Mx2. If connected externally, this pin must only be connected to the same $V_{DD}$ as at pin 44. (Note: Connecting the second pair of $V_{SS}$ and $V_{DD}$ pins is not required. However, they may be connected in addition to the primary $V_{SS}$ and $V_{DD}$ pins to improve power distribution, reduce noise in output signals, and improve system-level EMI characteristics.)



**80C51 8-bit microcontroller family with extended memory**  
**64KB/96KB OTP with 2KB/3KB RAM**

**P87C51MB2/P87C51MC2**

**SPECIAL FUNCTION REGISTERS**

**Note: Special Function Register (SFR) accesses are restricted in the following ways:**

1. User must NOT attempt to access any SFR locations not defined.
2. SFR bits labeled '-', '0' or '1' can ONLY be written and read as follows:
  - '-' 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.

**Special Function Registers**

SYMBOL	DESCRIPTION	DIRECT ADDRESS	BIT ADDRESS, SYMBOL, OR ALTERNATE PORT FUNCTION								Reset Value
			MSB				LSB				
			E7	E6	E5	E4	E3	E2	E1	E0	
ACC*	Accumulator	E0H									00H
AUXR#	Auxiliary Function Register	8EH	-	-	-	-	-	-	EXTRAM	AO	00H%
AUXR1#	Auxiliary Function Register 1	A2H	-	-	-	LPEP	GF2	0	-	DPS	00H%
			F7	F6	F5	F4	F3	F2	F1	F0	
B*	B Register	F0H									00H
BRGR0#§	Baud Rate Generator Rate Low	86H‡	BRATE11	BRATE10	BRATE9	BRATE8	BRATE7	BRATE6	BRATE5	BRATE4	00H
BRGR1#§	Baud Rate Generator Rate High	87H‡	BRATE3	BRATE2	BRATE1	BRATE0	-	-	-	-	00H%
BRGCON#	Baud Rate Generator Control	85H‡	-	-	-	-	-	-	S0BRGS	BRGEN	00H%
CCAP0H#	Module 0 Capture High	FAH									XXH
CCAP1H#	Module 1 Capture High	FBH									XXH
CCAP2H#	Module 2 Capture High	FCH									XXH
CCAP3H#	Module 3 Capture High	FDH									XXH
CCAP4H#	Module 4 Capture High	FEH									XXH
CCAP0L#	Module 0 Capture Low	EAH									XXH
CCAP1L#	Module 1 Capture Low	EBH									XXH
CCAP2L#	Module 2 Capture Low	ECH									XXH
CCAP3L#	Module 3 Capture Low	EDH									XXH
CCAP4L#	Module 4 Capture Low	EEH									XXH
CCAPM0#	Module 0 Mode	DAH	-	ECOM_0	CAPP_0	CAPN_0	MAT_0	TOG_0	PWM_0	ECCF_0	00H%
CCAPM1#	Module 1 Mode	DBH	-	ECOM_1	CAPP_1	CAPN_1	MAT_1	TOG_1	PWM_1	ECCF_1	00H%
CCAPM2#	Module 2 Mode	DCH	-	ECOM_2	CAPP_2	CAPN_2	MAT_2	TOG_2	PWM_2	ECCF_2	00H%
CCAPM3#	Module 3 Mode	DDH	-	ECOM_3	CAPP_3	CAPN_3	MAT_3	TOG_3	PWM_3	ECCF_3	00H%
CCAPM4#	Module 4 Mode	DEH	-	ECOM_4	CAPP_4	CAPN_4	MAT_4	TOG_4	PWM_4	ECCF_4	00H%

**80C51 8-bit microcontroller family with extended memory**  
**64KB/96KB OTP with 2KB/3KB RAM**

**P87C51MB2/P87C51MC2**

**Special Function Registers (Continued)**

SYMBOL	DESCRIPTION	DIRECT ADDRESS	BIT ADDRESS, SYMBOL, OR ALTERNATE PORT FUNCTION								Reset Value
			MSB				LSB				
CCON#	PCA Counter Control	D8H	DF	DE	DD	DC	DB	DA	D9	D8	00H%
			CF	CR	-	CCF4	CCF3	CCF2	CCF1	CCF0	
CH#	PCA Counter High	F9H									00H
CL#	PCA Counter Low	E9H									00H
CMOD#	PCA Counter Mode	D9H	CIDL	WDTE	-	-	-	CPS1	CPS0	ECF	00H%
DPTR	Data Pointer (2 bytes)										00H
DPH	Data Pointer High	83H									00H
DPL	Data Pointer Low	82H									00H
EPL#	Extended Data Pointer Low	FCH <sup>†</sup>									00H
EPM#	Extended Data Pointer Middle	FDH <sup>†</sup>									00H
EPH#	Extended Data Pointer High	FEH <sup>†</sup>									00H
IEN0*	Interrupt Enable 0	A8H	AF	AE	AD	AC	AB	AA	A9	A8	00H
			EA	EC	ET2	ES0/ ES0R	ET1	EX1	ET0	EX0	
IEN1*	Interrupt Enable 1	E8H	EF	EE	ED	EC	EB	EA	E9	E8	00H%
			-	-	-	-	ESPI	ES1T	ES0T	ES1/ ES1R	
IP0*	Interrupt Priority	B8H	BF	BE	BD	BC	BB	BA	B9	B8	00H
			-	PPC	PT2	PS0/ PS0R	PT1	PX1	PT0	PX0	
IP0H	Interrupt Priority 0 High	B7H	-	PPCH	PT2H	PS0H/ PS0RH	PT1H	PX1H	PT0H	PX0H	00H
IP1*	Interrupt Priority 1	F8H	FF	FE	FD	FC	FB	FA	F9	F8	00H%
			-	-	-	-	PSPI	PS1T	PS0T	PS1/ PS1R	
IP1H	Interrupt Priority 1 High	F7H	-	-	-	-	PSPIH	PS1TH	PS0TH	PS1H/ PS1RH	00H%
MXCON#	MX Control Register	FFH <sup>†</sup>	-	-	-	-	-	EAM	ESMM	EIFM	00H%
P0*	Port 0	80H	87	86	85	84	83	82	81	80	FFH
			AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0	
P1*	Port 1	90H	97	96	95	94	93	92	91	90	FFH
			CEX4	CEX3	CEX2/ SPICLK	CEX1/ MOSI	CEX0	ECl	T2EX	T2	

**80C51 8-bit microcontroller family with extended memory**

64KB/96KB OTP with 2KB/3KB RAM

**P87C51MB2/P87C51MC2**

**Special Function Registers (Continued)**

SYMBOL	DESCRIPTION	DIRECT ADDRESS	BIT ADDRESS, SYMBOL, OR ALTERNATE PORT FUNCTION								Reset Value
			MSB				LSB				
P2*	Port 2	A0H	A7	A6	A5	A4	A3	A2	A1	A0	FFH
			AD15	AD14/ AD22	ADA13/ AD21	AD12/AD20	AD11/ AD19	AD10/ AD18	AD9/ AD17	AD8/ AD16	
P3*	Port 3	B0H	B7	B6	B5	B4	B3	B2	B1	B0	FFH
			$\overline{RD}$	$\overline{WR}$	T1	T0	$\overline{INT1}$	$\overline{INT0}$	TxD0	RxD0	
P4*#	Port 4	C0H <sup>†</sup>	C7 <sup>†</sup>	C6 <sup>†</sup>	C5 <sup>†</sup>	C4 <sup>†</sup>	C3 <sup>†</sup>	C2 <sup>†</sup>	C1 <sup>†</sup>	C0 <sup>†</sup>	FFH
			-	-	-	-	-	-	TxD1/ $\overline{SS}$	RxD1/ MISO	
PCON#	Power Control Register	87H	SMOD1	SMOD0	-	POF	GF1	GF0	PD	IDL	00H/10H <sup>&amp;</sup>
			D7	D6	D5	D4	D3	D2	D1	D0	
PSW*	Program Status Word	D0H	CY	AC	F0	RS1	RS0	OV	F1	P	00H
RCAP2H#	Timer2 Capture High	CBH									00H
RCAP2L#	Timer2 Capture Low	CAH									00H
S0CON*	Serial Port 0 Control	98H	9F	9E	9D	9C	9B	9A	99	98	00H
			SM0_0/ FE_0	SM1_0	SM2_0	REN_0	TB8_0	RB8_0	TI_0	RI_0	
S0BUF	Serial Port 0 Data Buffer Register	99H									xxH
S0ADDR	Serial Port 0 Address Register	A9H									00H
S0ADEN	Serial Port 0 Address Enable	B9H									00H
S0STAT#	Serial Port 0 Status	8CH <sup>†</sup>	DBMOD_0	INTLO_0	CIDIS_0	DBISEL_0	FE_0	BR_0	OE_0	STINT_0	00H <sup>%</sup>
			87 <sup>†</sup>	86 <sup>†</sup>	85 <sup>†</sup>	84 <sup>†</sup>	83 <sup>†</sup>	82 <sup>†</sup>	81 <sup>†</sup>	80 <sup>†</sup>	
S1CON#*	Serial Port 1 Control	80H <sup>†</sup>	SM0_1/ FE_1	SM1_1	SM2_1	REN_1	TB8_1	RB8_1	TI_1	RI_1	00H
S1BUF#	Serial Port 1 Data buffer Register	81H <sup>†</sup>									XXH
S1ADDR#	Serial Port 1 Address Register	82H <sup>†</sup>									00H
S1ADEN#	Serial Port 1 Address Enable	83H <sup>†</sup>									00H
S1STAT#	Serial Port 1 Status	84H <sup>†</sup>	DBMOD_1	INTLO_1	CIDIS_1	DBISEL1	FE_1	BR_1	OE_1	STINT_1	00H <sup>%</sup>
SP	Stack Pointer (or Stack Pointer Low Byte When EDATA Supported)	81H									08H
SPCTL#	SPI Control Register	E2H	SSIG	SPEN	DORD	MSTR	CPOL	CPHA	-	-	00H <sup>%</sup>
SPCFG#	SPI Configuration Register	E1H	SPIF	SPWCOL	-	-	PSC3	PSC2	PSC1	PSC0	00H <sup>%</sup>
SPDAT#	SPI Data	E3H									00H
SPE#	Stack Pointer High	FBH <sup>†</sup>									00H

**80C51 8-bit microcontroller family with extended memory**

64KB/96KB OTP with 2KB/3KB RAM

**P87C51MB2/P87C51MC2****Special Function Registers (Continued)**

SYMBOL	DESCRIPTION	DIRECT ADDRESS	BIT ADDRESS, SYMBOL, OR ALTERNATE PORT FUNCTION								Reset Value
			MSB				LSB				
TCON*	Timer Control Register	88H	8F	8E	8D	8C	8B	8A	89	88	00H
			TF1	TR1	TF0	TR0	IE1	IT1	IE0	IT0	
T2CON#*	Timer2 Control Register	C8H	CF	CE	CD	CC	CB	CA	C9	C8	00H
			TF2	EXF2	RCLK	TCLK	EXEN2	TR2	C/T2	CP/RL2	
T2MOD#	Timer2 Mode Control	C9H	-	-	-	-	-	-	T2OE	DCEN	00H <sup>%</sup>
TH0	Timer 0 High	8CH									00H
TH1	Timer 1 High	8DH									00H
TH2	Timer 2 High	CDH									00H
TL0	Timer 0 Low	8AH									00H
TL1	Timer 1 Low	8BH									00H
TL2	Timer 2 Low	CCH									00H
TMOD	Timer 0 and 1 Mode	89H	GATE	C/T	M1	M0	GATE	C/T	M1	M0	00H
WDTRST#	Watchdog Timer Reset	A6H									FFH
WDCON#	Watchdog Timer Control	8FH <sup>‡</sup>	-	-	-	-	-	WDPRE2	WDPRE1	WDPRE0	00H <sup>%</sup>

**Notes:**

\* SFRs are bit addressable.

# SFRs are modified from or added to the 80C51 SFRs.

‡ Extended SFRs accessed by preceding the instruction with 51MX escape (opcode A5h).

- Reserved bits, must be written with 0's.

&amp; Power on reset is 10H. Other reset is 00H.

§ BRGR1 and BRGR0 must only be written if BRGEN in BRGCON SFR is '0'. If any of them is written if BRGEN = 1, result is unpredictable.

% The unimplemented bits (labeled '-') in the SFRs are 'X's (unknown) at all times. '1's should NOT be written to these bits, as they may be used for other purposes in future derivatives. The reset values shown for these bits are '0's although they are unknown when read.

**80C51 8-bit microcontroller family with extended memory**

64KB/96KB OTP with 2KB/3KB RAM

**P87C51MB2/P87C51MC2****FUNCTIONAL DESCRIPTION**

The following paragraphs briefly describe the features of the P87C51Mx2. For more detailed information, please refer to the P87C51Mx2 User Manual or the 51MX Architecture Reference.

**INTERRUPTS**

Table 1 summarizes the interrupt sources, flag bits, vector addresses, enable bits, priority bits, polling priority, and whether each interrupt may wake up the CPU from Power Down mode.

Description	Interrupt Flag Bit(s)	Vector Address	Interrupt Enable Bit(s)	Interrupt Priority	Polling Priority	Power Down Wakeup
External Interrupt 0	IE0	0003h	EX0 (IEN0.0)	IPOH.0, IP0.0	1 (highest)	Yes
Timer 0 Interrupt	TF0	000Bh	ET0 (IEN0.1)	IPOH.1, IP0.1	2	No
External Interrupt 1	IE1	0013h	EX1 (IEN0.2)	IPOH.2, IP0.2	3	Yes
Timer 1 Interrupt	TF1	001Bh	ET1 (IEN0.3)	IPOH.3, IP0.3	4	No
Serial Port 0 Tx and Rx <sup>1,5</sup>	TI_0 & RI_0 <sup>5</sup>	0023h	ES0 (IEN0.4)	IPOH.4, IP0.4	6	No
Serial Port 0 Rx <sup>1,5</sup>	RI_0 <sup>5</sup>					
Timer 2 Interrupt	TF2, EXF2	002Bh	ET2 (IEN0.5)	IPOH.5, IP0.5	7	No
PCA interrupt	CF, CCFn*	0033h	EC (IEN0.6)	IPOH.6, IP0.6	5	No
Serial Port 1 Tx and Rx <sup>2,6</sup>	TI_1 & RI_1 <sup>6</sup>	0053h	ES1 (IEN1.0)	IP1H.0, IP1.0	11	No
Serial Port 1 Rx <sup>2,6</sup>	RI_1 <sup>6</sup>					
Serial Port 0 Tx <sup>3</sup>	TI_0	003Bh	EI10 (IEN1.1)	IP1H.1, IP1.1	8	No
Serial Port 1 Tx <sup>4</sup>	TI_1	0043h	EI11 (IEN1.2)	IP1H.2, IP1.2	9	No
SPI Interrupt	SPI	004Bh	EI11 (IEN1.3)	IP1H.3, IP1.3	10	No
Reserved		005Bh	EI12 (IEN1.4)	IP1H.4, IP1.4	12	No
		0063h	EI13 (IEN1.5)	IP1H.5, IP1.5	13	No
		006Bh	EI13 (IEN1.6)	IP1H.6, IP1.6	14	No
		0073h	EI14 (IEN1.7)	IP1H.7, IP1.7	15 (lowest)	No

1. S0STAT.5 = 0 selects combined Serial Port 0 Tx and Rx interrupt; S0STAT.5 = 1 selects Serial Port 0 Rx interrupt only (and TX interrupt will be different, see Note 3 below).
2. S1STAT.5 = 0 selects combined Serial Port 1 Tx and Rx interrupt; S1STAT.5 = 1 selects Serial Port 1 Rx interrupt only (and TX interrupt will be different, see Note 4 below).
3. This interrupt is used as Serial Port 0 Tx interrupt if and only if S0STAT.5 = 1, and is disabled otherwise.
4. This interrupt is used as Serial Port 1 Tx interrupt if and only if S1STAT.5 = 1, and is disabled otherwise.
5. If S0STAT.0 = 1, the following Serial Port 0 additional flag bits can cause this interrupt: FE\_0, BR\_0, OE\_0.
6. If S1STAT.0 = 1, the following Serial Port 1 additional flag bits can cause this interrupt: FE\_1, BR\_1, OE\_1.

**Table 1: Summary of Interrupts**

**80C51 8-bit microcontroller family with extended memory****64KB/96KB OTP with 2KB/3KB RAM****P87C51MB2/P87C51MC2****DATA RAM**

The P87C51MB2 and P87C51MC2 have 2 Kbytes and 3 K bytes of on-chip RAM respectively. Usages of the different data segments are described in the 51MX Architecture Reference.

Data Memory		Size (in Bytes)	
Type	Description	P87C51MB2	P87C51MC2
DATA	memory that can be addressed directly and indirectly	128	128
IDATA	memory that can be addressed indirectly (where direct address is for SFR only)	128	128
EDATA	memory that can only be addressed indirectly	1024	1024
XDATA	memory (on-chip "External Data") that is accessed using the MOVX instructions	768	1792
Total		2048	3072

**Table 2: On-Chip Data Memory Usage.****PORT 4**

The P87C51Mx2 has a fifth I/O port (Port 4) that is shared with the second UART pins (RXD1 and TXD1) and two of the SPI pins (MISO and SS). This port is also bit addressable and can be accessed in the same manner as any other ports, except that the associated SFR is in the extended SFR space. Accesses to this SFR space is the same as those to the conventional SFR space except that the instructions must be preceded by an escape code (A5h), as described in the 51MX Architecture Reference.

**LOW POWER MODES**

The P87C51Mx2 supports the standard 51MX low power modes - Stop Clock Mode, Idle Mode and Power-Down Mode.

The PCON register is the same as the standard 51MX PCON register. Note that bits PCON.7 and PCON.6 are for UART configurations (see section "UARTs").

**ONCE™ MODE**

The ONCE ("On-Circuit Emulation") Mode facilitates testing and debugging of systems without the device having to be removed from the circuit. It is supported in the P87C51Mx2.

**PERIPHERALS**

The P87C51Mx2 peripherals are described in more detail in the User Manual. The on-chip peripherals include:

- Timers:
  - Timers 0 and 1.
  - Timer 2.

**Note:** When Timer 1 or Timer 2 can only be used as a baud rate generator for UART 0, but not for UART 1.
- Two enhanced UARTs with an independent Baud Rate Generator - The section "UARTs" provides information regarding the two UARTs.
 

**Note:** UART 1 shares the RXD1 and TXD1 with the SPI pins. The SPEN (SPCTL.6) bit must be cleared '0' (reset value) to enable UART 1 operation.
- Serial Peripheral Interface (SPI). **Note:** The SPI shares pins with the UART 1 shares the RXD1 and TXD1 with the SPI pins. The SPEN (SPCTL.6) bit must be set to '1' to enable SPI operation.
- Watchdog Timer.
- Programmable Counter Array (PCA).

**80C51 8-bit microcontroller family with extended memory****64KB/96KB OTP with 2KB/3KB RAM****P87C51MB2/P87C51MC2****UARTS**

P87C51Mx2 includes two enhanced UART ports with one independent Baud Rate Generator:

- UART 0 is the standard 51MX enhanced UART as described in the User Manual. It can be selected to use Timer1 overflow, Timer2 overflow or the independent Baud Rate Generator.
- UART 1 only uses the independent Baud Rate Generator to generate its baud rate. It has the same baud rate for both transmission and reception.
- The Baud Rate Generator is described in the User Manual.

Each of the UARTs has one set of enhanced UART SFRs. Please refer to the descriptions on the corresponding SFRs in the User Manual:

Register	Description	SFR Location	51MX Extended SFR Location	See Description in User Manual on
S0CON	Serial Port 0 Control	98H		SCON
S0BUF	Serial Port 0 Data Buffer	99H		SBUF
S0ADDR	Serial Port 0 Address	A9H		SADDR
S0ADEN	Serial Port 0 Address Enable	B9H		SADEN
S0STAT	Serial Port 0 Status		8CH	SSTAT
S1CON	Serial Port 1 Control		80H	SCON
S1BUF	Serial Port 1 Data Buffer		81H	SBUF
S1ADDR	Serial Port 1 Address		82H	SADDR
S1ADEN	Serial Port 1 Address Enable		83H	SADEN
S1STAT	Serial Port 1 Status		84H	SSTAT

**Table 3: UARTs 0 and 1 SFRs.**

**PCON.7 and PCON.6 SFR Bits**

The PCON.7 and PCON.6 SFR bits configure the UARTs as follows:

- PCON.7 (SMOD1) - Baud Rate Control bit for serial port 0. When 0, the baud rate for UART 0 will be the input rate (T1 timer or baud rate generator, as determined by the BRGCON extended SFR) divided by two. When 1, the baud rate for UART 0 will be the input rate (T1 timer or baud rate generator). UART 1 is not affected by this bit
- PCON.6 (SMOD0) - Framing Error Location:
  - When 0, bit 7 of S0CON and S1CON will function as SM0 for UARTs 0 and 1 respectively.
  - When 1, bit 7 of S0CON and S1CON will be used for framing error status for UART 0 and 1 respectively.
 PCON.6 also determines when the UART receive interrupts RI\_0 and RI\_1 occur in UART modes 2 or 3. (Refer to User Manual for details.)

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**P87C51MB2/P87C51MC2****Baud Rate Selection**

UART 0 and UART 1 selects the baud rate differently as shown in Tables 4 and 5:

S0CON.7 (SM0_0)	S0CON.6 (SM1_0)	T2CON.5/4 (RCLK - Receive TCLK - Transmit)	PCON.7 (SMOD1)	BRGCON.1 (S0BRGS)	Receive/Transmit Baud Rate for UART 0
0	0	X	X	X	$f_{osc}/6$
0	1	0	0	X	$T1\_rate/32^*$
		0	1	X	$T1\_rate/16^*$
		1	X	0	$T2\_rate/16^*$
		1	X	1	$f_{osc}/(BRATE \times 16 + 16)^*$
1	0	X	0	X	$f_{osc}/32$
		X	1	X	$f_{osc}/16$
1	1	0	0	X	$T1\_rate/32^*$
		0	1	X	$T1\_rate/16^*$
		1	X	0	$T2\_rate/16^*$
		1	X	1	$f_{osc}/(BRATE \times 16 + 16)^*$

\* UART 0 can have different receive and transmit baud rates.

**Table 4: Baud Rate Generation for UART 0. Use T2CON.5 (RCLK) in Receive Baud Rate Selection, T2CON.4 (TCLK) in Transmit Baud Rate Selection**

S1CON.7 (SM0_1)	S1CON.6 (SM1_1)	Baud Rate for UART 1
0	0	$f_{osc}/6$
0	1	$f_{osc}/(BRATE \times 16 + 16)^*$
1	0	$f_{osc}/(BRATE \times 16 + 16)^*$
1	1	$f_{osc}/(BRATE \times 16 + 16)^*$

\* UART 1 has the same receive and transmit baud rate.

**Table 5: Baud Rate Generation for UART 1.**



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**P87C51MB2/P87C51MC2****SECURITY BITS**

The P87C51Mx2 has security bits to protect users' firmware codes. With none of the security bits programmed, the code in the program memory can be verified. With only security bit 1 (see Table 6) is programmed, MOV<sub>C</sub> instructions executed from external program memory are disabled from fetching code bytes from the internal memory.  $\overline{EA}$  is latched on Reset and all further programming of EPROM is disabled. When security bits 1 and 2 are programmed, in addition to the above, verify mode is disabled. When all three security bits are programmed, all of the conditions above apply and all external program memory execution is disabled.

Security Bits <sup>1,2</sup>				Protection Description
	Bit 1	Bit 2	Bit 3	
1	U	U	U	No program security features enabled. EEPROM is programmable and verifiable.
2	P	U	U	MOV <sub>C</sub> instructions executed from external program memory are disabled from fetching code bytes from internal memory, $\overline{EA}$ is sampled and latched on Reset, and further programming of the EPROM is disabled.
3	P	P	U	Same as 2, also verification is disabled.
4	P	P	P	Same as 3, external execution is disabled.

**Notes:**  
1. P - programmed. U- unprogrammed.  
2. Any other combination of security bits is not defined.

**Table 6: EPROM Security Bits**

**80C51 8-bit microcontroller family with extended memory**  
**64KB/96KB OTP with 2KB/3KB RAM**

**P87C51MB2/P87C51MC2**

**ABSOLUTE MAXIMUM RATINGS**

PARAMETER	RATING	UNIT
Operating temperature under bias	-55 to +125	°C
Storage temperature range	-65 to +150	°C
Voltage on EA/V <sub>PP</sub> pin to V <sub>SS</sub>	0 to + 13.0	V
Voltage on any other pin to V <sub>SS</sub>	-0.5 to V <sub>DD</sub> +0.5V	V
Maximum I <sub>OL</sub> per I/O pin	20	mA
Power dissipation (based on package heat transfer, not device power consumption)	1.5	W

**Notes:**

1. Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any conditions other than those described in the AC and DC Electrical Characteristics section of this specification are not implied.
2. 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.
3. Parameters are valid over operating temperature range unless otherwise specified. All voltages are with respect to V<sub>SS</sub> unless otherwise noted.

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**64KB/96KB OTP with 2KB/3KB RAM**
**P87C51MB2/P87C51MC2**
**DC ELECTRICAL CHARACTERISTICS**
 $V_{DD} = 2.7V$  to  $5.5V$  unless otherwise specified;

 $T_{amb} = 0$  to  $+70^{\circ}C$  for commercial, unless otherwise specified.

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN	TYP <sup>1</sup>	MAX	
$V_{IL}$	Input low voltage		-0.5		$0.2V_{DD}-0.1$	V
$V_{IH}$	Input high voltage (ports 0, 1, 2, 3, 4, EA)		$0.2V_{DD}+0.9$		$V_{DD}+0.5$	V
$V_{IH1}$	Input high voltage, XTAL1, RST		$0.7V_{DD}$		$V_{DD}+0.5$	V
$V_{OL}$	Output low voltage, ports 1, 2, 3, 4 <sup>8</sup>	$V_{DD} = 2.7V, I_{OL} = 1.6mA$			0.4	V
$V_{OL1}$	Output low voltage, port 0, ALE, $\overline{PSEN}$ <sup>7,8</sup>	$V_{DD} = 2.7V, I_{OL} = 3.2mA$			0.4	V
$V_{OH}$	Output high voltage, ports 1, 2, 3, 4	$V_{DD} = 4.5V, I_{OH} = -30\mu A$ $V_{DD} = 2.7V, I_{OH} = -10\mu A$	$V_{DD} - 0.7$			V
$V_{OH1}$	Output high voltage (port 0 in external bus mode), ALE <sup>9</sup> , $\overline{PSEN}$ <sup>3</sup>	$V_{DD} = 2.7V, I_{OH} = -3.2mA$	$V_{DD} - 0.7$			V
$I_{IL}$	Logical 0 input current, ports 1, 2, 3, 4	$V_{IN} = 0.4V$	-1		-75	$\mu A$
$I_{TL}$	Logical 1 -to-0 transition current, ports 1, 2, 3, 4 <sup>8</sup>	$4.5V < V_{DD} < 5.5V,$ $V_{IN} = 2.0V,$ See Note 4			-650	$\mu A$
$I_{L1}$	Input leakage current, port 0	$0.45 < V_{IN} < V_{DD}-0.3$			$\pm 10$	$\mu A$
$I_{CC}$	Power supply current					
	Active mode (see Note 5)	$V_{DD} = 5.5V$ $V_{DD} = 3.6V$			$7 + 2.7 / MHz \times f_{OSC}$ $4 + 1.3 / MHz \times f_{OSC}$	mA
	Idle mode (see Note 5)	$V_{DD} = 5.5V$ $V_{DD} = 3.6V$			$4 + 1.3 / MHz \times f_{OSC}$ $1 + 1.0 / MHz \times f_{OSC}$	mA
	Power-down mode or clock stopped (see Figure 16 for conditions)	$V_{DD} = 5.0V$ $V_{DD} = 5.5V$		20	100	$\mu A$ $\mu A$
$R_{RST}$	Internal reset pull-down resistor		40		225	k $\Omega$
$C_{10}$	Pin capacitance <sup>10</sup> (except $\overline{EA}$ )				15	pF

**Notes:**

- Typical ratings are not guaranteed. The values listed are at room temperature ( $+25^{\circ}C$ ), 5V, unless otherwise stated.
- Capacitive loading on ports 0 and 2 may cause spurious noise to be superimposed on the  $V_{OL}$  of ALE and ports 1, 3 and 4. The noise is due to external bus capacitance discharging into the port 0 and port 2 pins when these pins make 1-to-0 transitions during bus operations. In the worst cases (capacitive loading  $> 100$  pF), the noise pulse on the ALE pin may exceed 0.8 V. In such cases, it may be desirable to qualify ALE with a Schmitt Trigger, or use an address latch with a Schmitt Trigger STROBE input.  $I_{OL}$  can exceed these conditions provided that no single output sinks more than 5mA and no more than two outputs exceed the test conditions.
- Capacitive loading on ports 0 and 2 may cause the  $V_{OH}$  on ALE and  $\overline{PSEN}$  to momentarily fall below the  $V_{DD}-0.7V$  specification when the address bits are stabilizing.
- Pins of ports 1, 2, 3 and 4 source a transition current when they are being externally driven from 1 to 0. The transition current reaches its maximum value when  $V_{IN}$  is approximately 2 V for  $4.5V < V_{DD} < 5.5V$ .
- See Figures 13 through 16 for  $I_{CC}$  test conditions.  $f_{OSC}$  is the oscillator frequency in MHz.
- This value applies to  $T_{amb} = 0^{\circ}C$  to  $+70^{\circ}C$ .

**80C51 8-bit microcontroller family with extended memory****64KB/96KB OTP with 2KB/3KB RAM****P87C51MB2/P87C51MC2**

7. Load capacitance for port 0, ALE, and  $\overline{\text{PSEN}} = 100 \text{ pF}$ , load capacitance for all other outputs =  $80 \text{ pF}$
8. Under steady state (non-transient) conditions,  $I_{\text{OL}}$  must be externally limited as follows:

Maximum $I_{\text{OL}}$ per port pin:	15 mA
Maximum $I_{\text{OL}}$ per 8-bit port:	26 mA
Maximum total $I_{\text{OL}}$ for all outputs:	71 mA

If  $I_{\text{OL}}$  exceeds the test condition,  $V_{\text{OL}}$  may exceed the related specification. Pins are not guaranteed to sink current greater than the listed test conditions.
9. ALE is tested to  $V_{\text{OH1}}$ , except when ALE is off then  $V_{\text{OH}}$  is the voltage specification.
10. Pin capacitance is characterized but not tested.

**80C51 8-bit microcontroller family with extended memory**  
**64KB/96KB OTP with 2KB/3KB RAM**

**P87C51MB2/P87C51MC2**

**AC ELECTRICAL CHARACTERISTICS**

$T_{amb} = 0$  to  $+70^{\circ}\text{C}$  for commercial unless otherwise specified.<sup>1,2,3</sup>

SYMBOL	FIGURE(S)	PARAMETER	2.7V < VDD < 5.5V				4.5V < VDD < 5.5V				UNIT	
			Variable Clock <sup>4</sup>		$f_{osc}=12\text{MHz}^4$		Variable Clock <sup>4</sup>		$f_{osc}=24\text{MHz}^4$			
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX		
$f_{osc}$		Oscillator frequency	0	12			0	24			MHz	
$t_{CLCL}$	15	CLock cycle			83					41.5	ns	
$t_{LHLL}$	1,2	ALE pulse width	$t_{CLCL}^{-66}$		16			$t_{CLCL}^{-33}$		8	ns	
$t_{AVLL}$	1,2,3, 4,5,6	Address valid to ALE low	$t_{CHCX}^{-25}$		8			$t_{CHCX}^{-12}$		4	ns	
$t_{LLAX}$	1,2,3, 4,5,6	Address hold after ALE low	$t_{CLCX}^{-25}$		8			$t_{CLCX}^{-12}$		4	ns	
$t_{LLIV}$	1,2	ALE low to valid instruction in		$2t_{CLCL}^{-108}$	58			$2t_{CLCL}^{-54}$		29	ns	
$t_{LLPL}$	1,2	ALE low to $\overline{\text{PSEN}}$ low	$t_{CLCX}^{-25}$		8			$t_{CLCX}^{-12}$		4	ns	
$t_{PLPH}$	1,2	$\overline{\text{PSEN}}$ pulse width	$t_{CLCL}+t_{CHCX}^{-66}$		50			$t_{CLCL}+t_{CHCX}^{-33}$		25	ns	
$t_{PLIV}$	1,2	$\overline{\text{PSEN}}$ low to valid instruction in		$t_{CLCL}+t_{CHCX}^{-91}$	25			$t_{CLCL}+t_{CHCX}^{-46}$		12	ns	
$t_{PXIX}$	1,2	Input instruction hold after $\overline{\text{PSEN}}$	0		0			0		0	ns	
$t_{PXIZ}$	1,2	Input instruction float after $\overline{\text{PSEN}}$		$t_{CLCX}^{-25}$	8			$t_{CLCX}^{-12}$		4	ns	
$t_{AVIV}$	1	Address (A8-A15) to valid instruction in (non-Extended Addressing Mode)		$2t_{CLCL}+t_{CHCX}^{-36}$	180			$2t_{CLCL}+t_{CHCX}^{-28}$		81	ns	
$t_{AVIV1}$	2	Address (A8-A15) to valid instruction in (Extended Addressing Mode)		$t_{CLCL}+t_{CHCX}^{-44}$	89			$2t_{CLCL}+t_{CHCX}^{-34}$		33	ns	
$t_{PLAZ}$	1,2	$\overline{\text{PSEN}}$ low to address float		16	16			8		8	ns	
<b>Data Memory</b>												
$t_{RLRH}$	3,4	$\overline{\text{RD}}$ pulse width	$3t_{CLCL}^{-166}$		83			$3t_{CLCL}^{-83}$		41.5	ns	
$t_{WLWH}$	5,6	$\overline{\text{WR}}$ pulse width	$3t_{CLCL}^{-166}$		83			$3t_{CLCL}^{-83}$		41.5	ns	
$t_{RLDV}$	3,4	$\overline{\text{RD}}$ low to valid data in		$2t_{CLCL}+t_{CHCX}^{-141}$	58			$2t_{CLCL}+t_{CHCX}^{-70}$		29	ns	
$t_{RHDX}$	3,4	Data hold after $\overline{\text{RD}}$	0		0			0		0	ns	
$t_{RHDZ}$	3,4	Data float after $\overline{\text{RD}}$		$t_{CLCL}^{-34}$	49			$t_{CLCL}^{-17}$		24	ns	
$t_{LLDV}$	3,4	ALE low to valid data in		$4t_{CLCL}^{-250}$	83			$4t_{CLCL}^{-125}$		41	ns	
$t_{AVDV}$	3	Address (A8-A15) to valid data in (non-Extended Addressing Mode)		$4t_{CLCL}+t_{CHCX}^{-36}$	346			$4t_{CLCL}+t_{CHCX}^{-28}$		164	ns	
$t_{AVDV1}$	4	Address (A8-A15) to valid data in (Extended Addressing Mode)		$3t_{CLCL}+t_{CHCX}^{-44}$	255			$3t_{CLCL}+t_{CHCX}^{-34}$		116	ns	
$t_{LLWL}$	3,4, 5,6	ALE low to $\overline{\text{RD}}$ or $\overline{\text{WR}}$ low	$t_{CLCL}+t_{CLCX}^{-83}$	$t_{CLCL}+t_{CLCX}^{-83}$	208			$t_{CLCL}+t_{CLCX}^{-41}$	$t_{CLCL}+t_{CLCX}^{-41}$	104	ns	
$t_{AVWL}$	3,5	Address (A8-A15) valid to $\overline{\text{WR}}$ or $\overline{\text{RD}}$ low (non-Extended Addressing Mode)	$2t_{CLCL}^{-15}$		151			$2t_{CLCL}^{-20}$		63	ns	
$t_{AVWL1}$	4,6	Address (A8-A15) valid to $\overline{\text{WR}}$ or $\overline{\text{RD}}$ low (Extended Addressing Mode)	$t_{CLCL}^{-20}$		63			$t_{CLCL}^{-25}$		16.5	ns	
$t_{QVWX}$	5,6	Data valid to $\overline{\text{WR}}$ transition	$t_{CLCX}^{-33}$		0			$t_{CLCX}^{-16}$		0	ns	
$t_{WHQX}$	5,6	Data hold after $\overline{\text{WR}}$	$t_{CHCX}^{-24}$		9			$t_{CHCX}^{-11}$		5	ns	
$t_{QVWH}$	5,6	Data valid to $\overline{\text{WR}}$ high	$3t_{CLCL}+t_{CLCX}^{-207}$		75			$3t_{CLCL}+t_{CLCX}^{-103}$		37.5	ns	
$t_{RLAZ}$	3,4	$\overline{\text{RD}}$ low to address float		0	0			0		0	ns	
$t_{WHLH}$	3,4, 5,6	$\overline{\text{RD}}$ or $\overline{\text{WR}}$ high to ALE high	$t_{CHCX}^{-24}$	$t_{CHCX}^{-25}$	9	75		$t_{CHCX}^{-11}$	$t_{CHCX}^{-12}$	5	37	ns
<b>External Clock</b>												
$t_{CHCX}$	12	High time	33	$t_{CLCL}-t_{CLCX}$	33	50		16	$t_{CLCL}-t_{CLCX}$	16	24.5	ns
$t_{CLCX}$	12	Low time	33	$t_{CLCL}-t_{CHCX}$	33	50		16	$t_{CLCL}-t_{CHCX}$	16	24.5	ns
$t_{CLCH}$	12	Rise time		8	8			4		4	ns	
$t_{CHCL}$	12	Fall Time		8	8			4		4	ns	

## 80C51 8-bit microcontroller family with extended memory

64KB/96KB OTP with 2KB/3KB RAM

P87C51MB2/P87C51MC2

SYMBOL	FIGURE(S)	PARAMETER	2.7V < VDD < 5.5V				4.5V < VDD < 5.5V				UNIT
			Variable Clock <sup>4</sup>		f <sub>OSC</sub> =12MHz <sup>4</sup>		Variable Clock <sup>4</sup>		f <sub>OSC</sub> =24MHz <sup>4</sup>		
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
<b>Shift Register</b>											
t <sub>XLXL</sub>	7	Serial port clock cycle time	6t <sub>CLCL</sub>		500	6t <sub>CLCL</sub>		250	ns		
t <sub>QVXH</sub>	7	Output data setup to clock rising edge	5t <sub>CLCL</sub> -221		195	5t <sub>CLCL</sub> -110		98	ns		
t <sub>XHQX</sub>	7	Output data hold after clock rising edge	t <sub>CLCL</sub> -50		34	t <sub>CLCL</sub> -25		17	ns		
t <sub>XHDX</sub>	7	Input data hold after clock rising edge	0		0	0		0	ns		
t <sub>XHDV</sub>	7	Clock rising edge to input data valid	5t <sub>CLCL</sub> -222		195	5t <sub>CLCL</sub> -111		97	ns		
<b>SPI Interface</b>											
f <sub>SPI</sub>		Operating frequency - 3.0MHz - 6.0MHz	0	3.0	0	3.0	0	3.0	0	3.0	MHz
t <sub>SPICYC</sub>	8, 9, 10, 11	Cycle time - 3.0MHz - 6.0MHz	333	-	333	-	333	166	333	166	ns
t <sub>SPILEAD</sub>	10, 11	Enable lead time (Slave) - 3.0MHz - 6.0MHz	TBD	-	TBD	-	TBD	TBD	TBD	TBD	ns
t <sub>SPILAG</sub>	10, 11	Enable lag time (Slave) - 3.0MHz - 6.0MHz	TBD	-	TBD	-	TBD	TBD	TBD	TBD	ns
t <sub>SPICLKH</sub>	8, 9, 10, 11	SPICLK high time - Master - Slave	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	ns
t <sub>SPICLKL</sub>	8, 9, 10, 11	SPICLK low time - Master - Slave	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	ns
t <sub>SPIDSU</sub>	8, 9, 10, 11	Data setup time (Master or Slave)	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	ns
t <sub>SPIDH</sub>	8, 9, 10, 11	Data hold time (Master or Slave)	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	ns
t <sub>SPIA</sub>	10, 11	Access time (Slave)	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	ns
t <sub>SPIDIS</sub>	10, 11	Disable time (Slave) - 3.0MHz - 6.0MHz	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	ns
t <sub>SPIDV</sub>	8, 9, 10, 11	Enable to output data valid - 3.0MHz - 6.0MHz	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	ns
t <sub>SPIOH</sub>	8, 9, 10, 11	Output data hold time	0	0	0	0	0	0	0	0	ns
t <sub>SPIR</sub>	8, 9, 10, 11	Rise time - SPI outputs (SPICLK, MOSI, MISO) - SPI inputs (SPICLK, MOSI, MISO, SS)	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	ns
t <sub>SPIF</sub>	8, 9, 10, 11	Fall time - SPI outputs (SPICLK, MOSI, MISO) - SPI inputs (SPICLK, MOSI, MISO, SS)	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	ns

**Notes:**

- Parameters are valid over operating temperature range unless otherwise specified.
- Load capacitance for port 0, ALE, and PSEN = 100pF, load capacitance for all other outputs = 80pF.
- Interfacing the microcontroller to devices with float times up to 45ns is permitted. This limited bus contention will not cause damage to Port 0 drivers.
- Parts are tested down to 2 MHz, but are guaranteed to operate down to 0Hz.

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**EXPLANATION OF AC SYMBOLS**

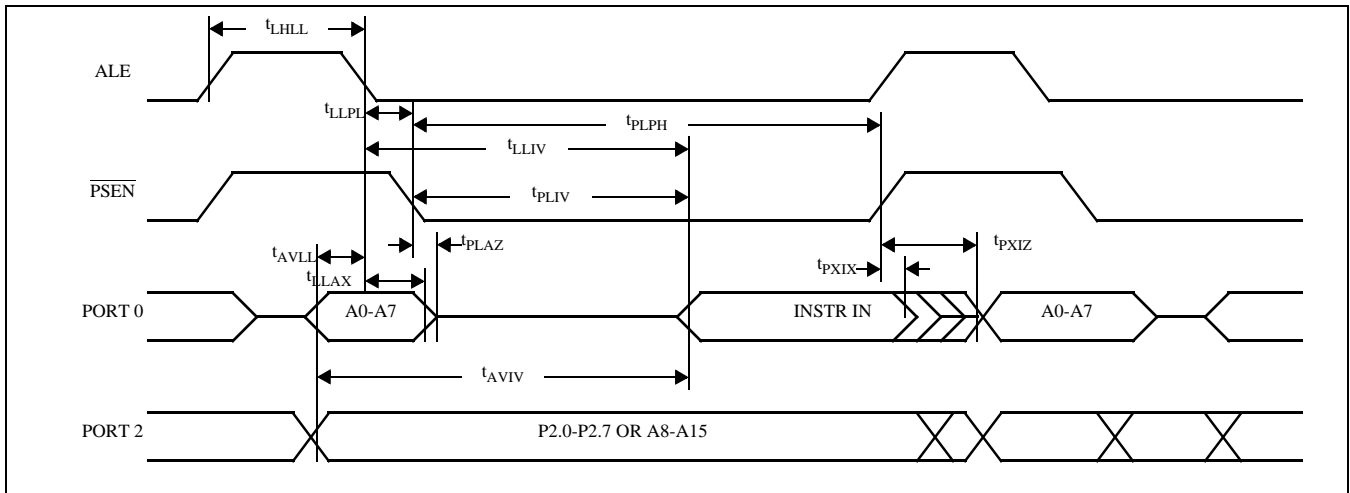
Each timing symbol has five characters. The first character is always 't' (= time). The other characters, depending on their positions, indicate the name of a signal or the logical status of that signal. The designations are:

- A – Address
- C – Clock
- D – Input data
- H – Logic level high
- I – Instruction (program memory contents)
- L – Logic level low, or ALE
- P – PSEN
- Q – Output data
- R – RD signal
- t – Time
- V – Valid
- W– WR signal
- X – No longer a valid logic level
- Z – Float

**Examples:**

$t_{AVLL}$  - Time for address valid to ALE low.

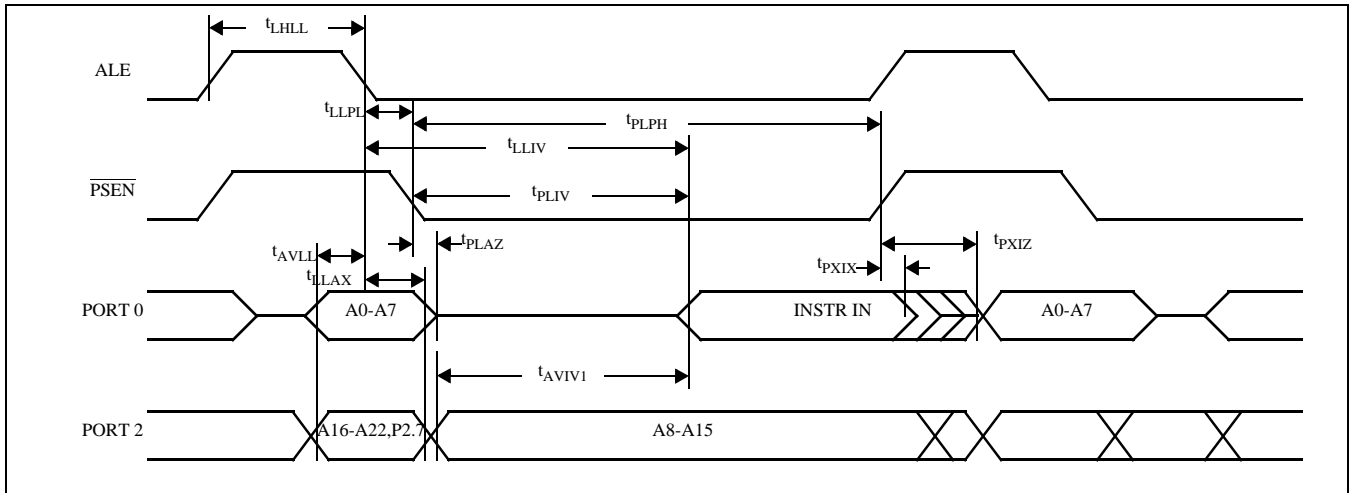
$t_{LLPL}$  - Time for ALE low to PSEN low



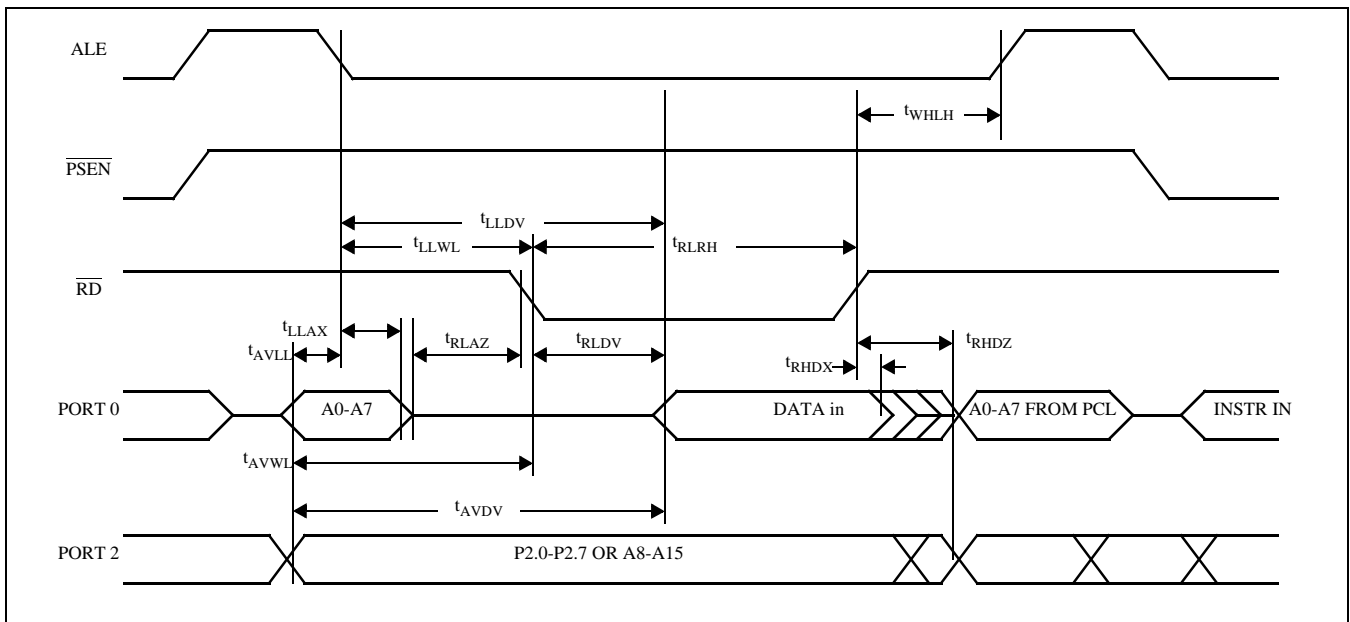
**Figure 1: External Program Memory Read Cycle (Non-Extended Memory Cycle)**

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**Figure 2: External Program Memory Read Cycle (Extended Memory Cycle)**

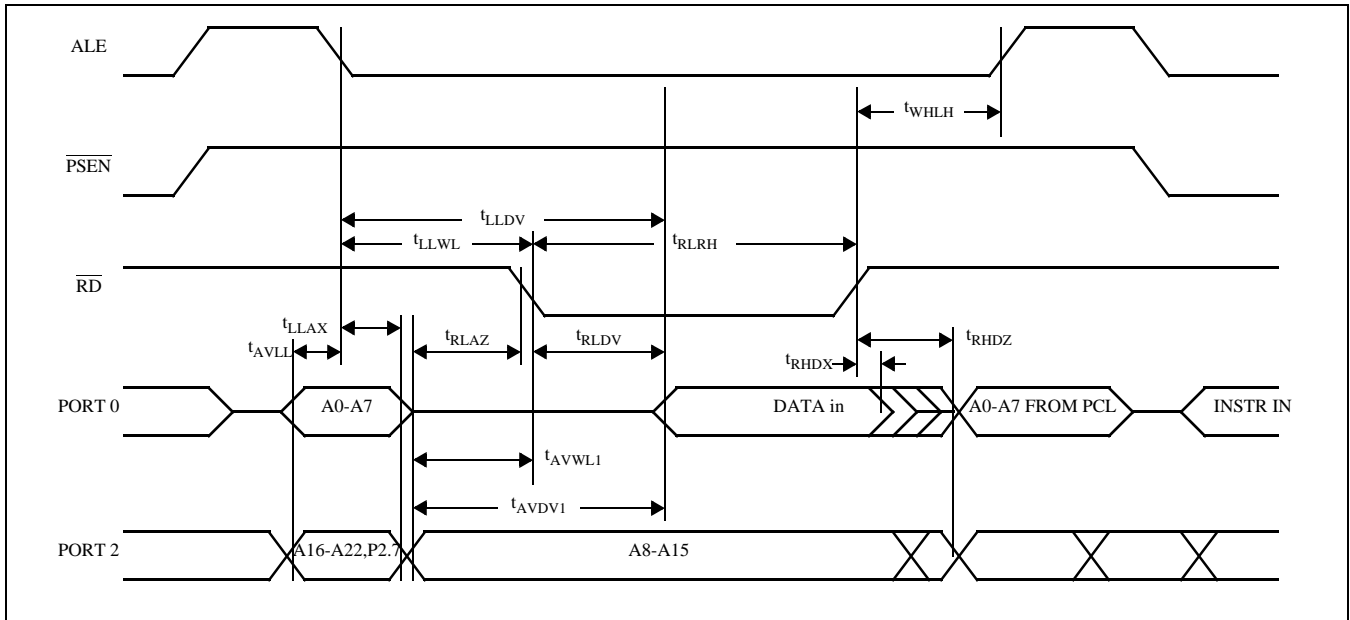


**Figure 3: External Data Memory Read Cycle (Non-Extended Memory Cycle)**

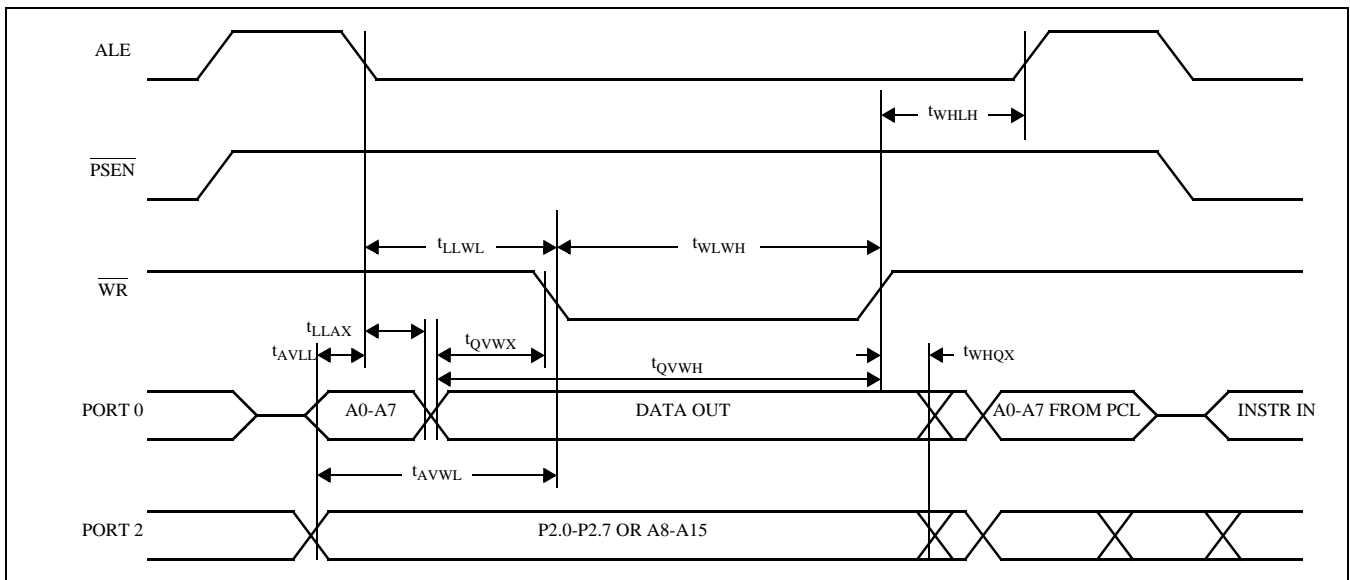


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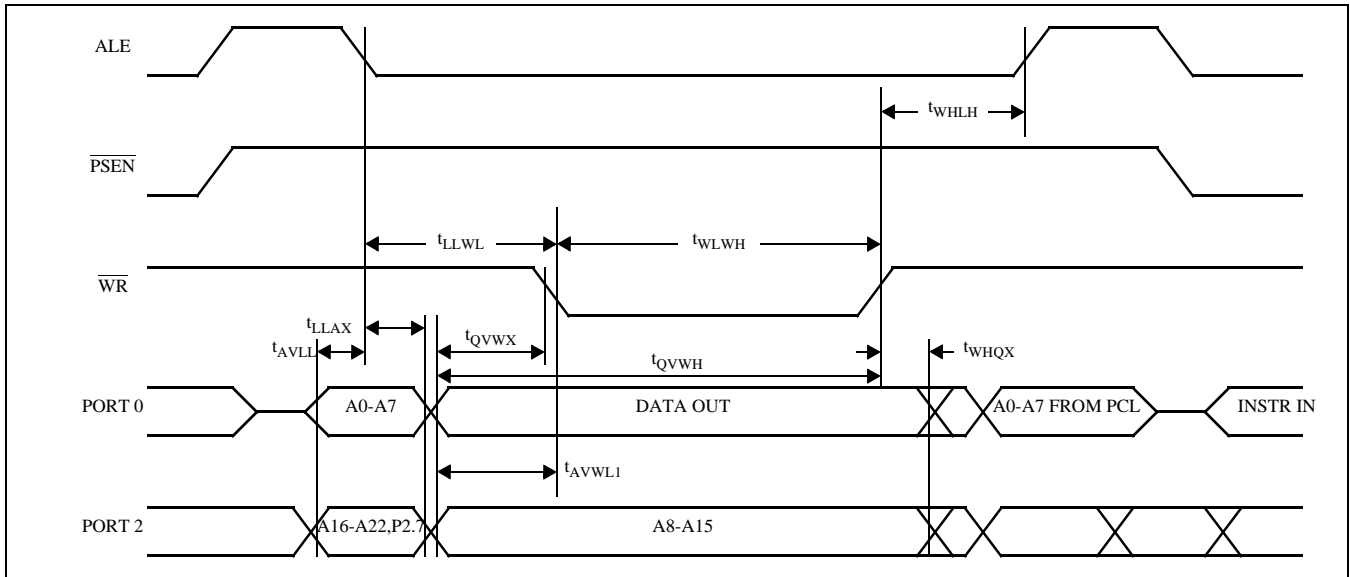
**Figure 4: External Data Memory Read Cycle (Extended Memory Cycle)**



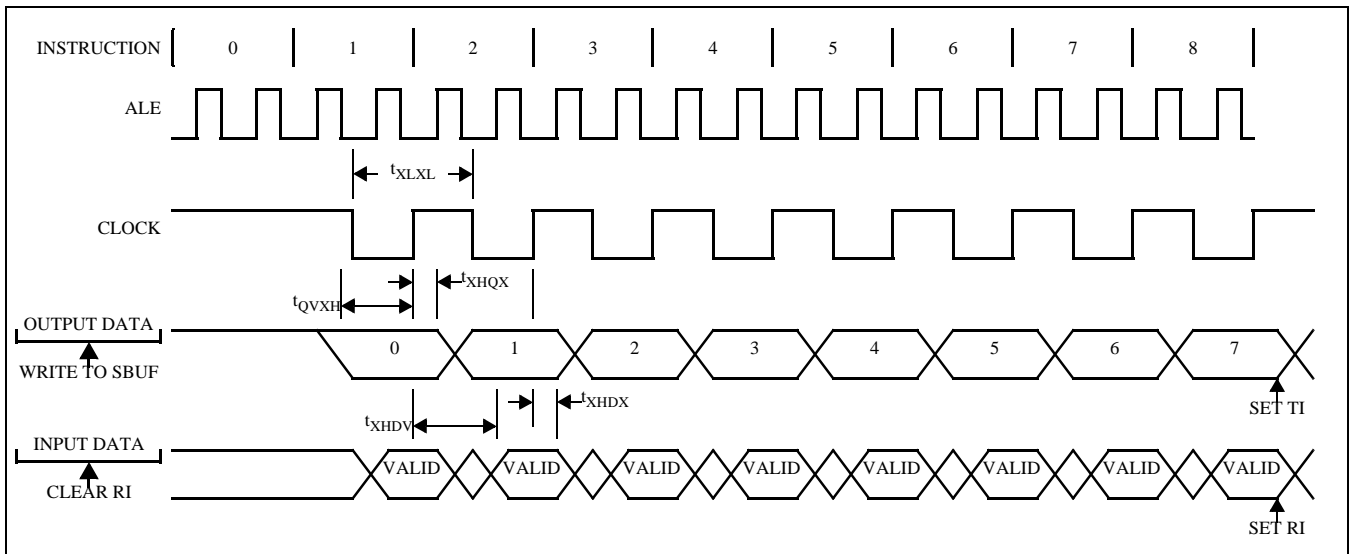
**Figure 5: External Data Memory Write Cycle (Non-Extended Memory Cycle)**

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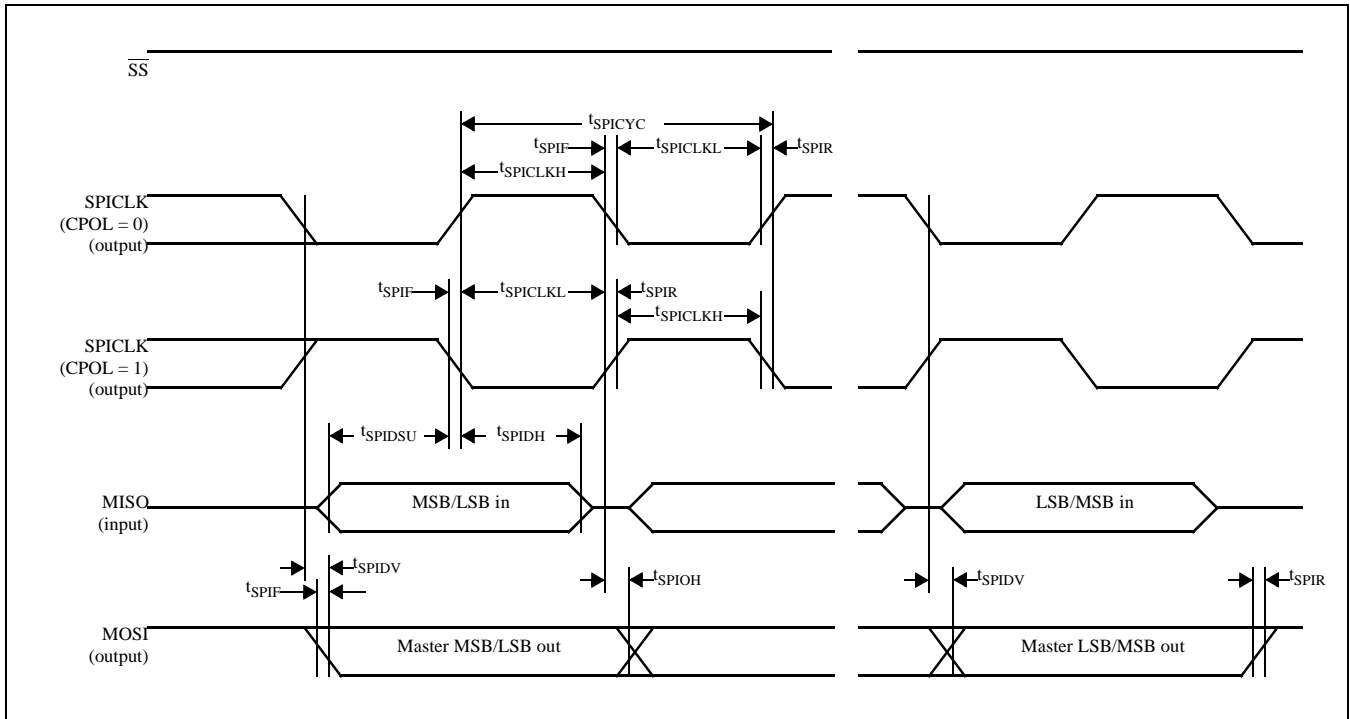
**Figure 6: External Data Memory Write Cycle (Extended Memory Cycle)**



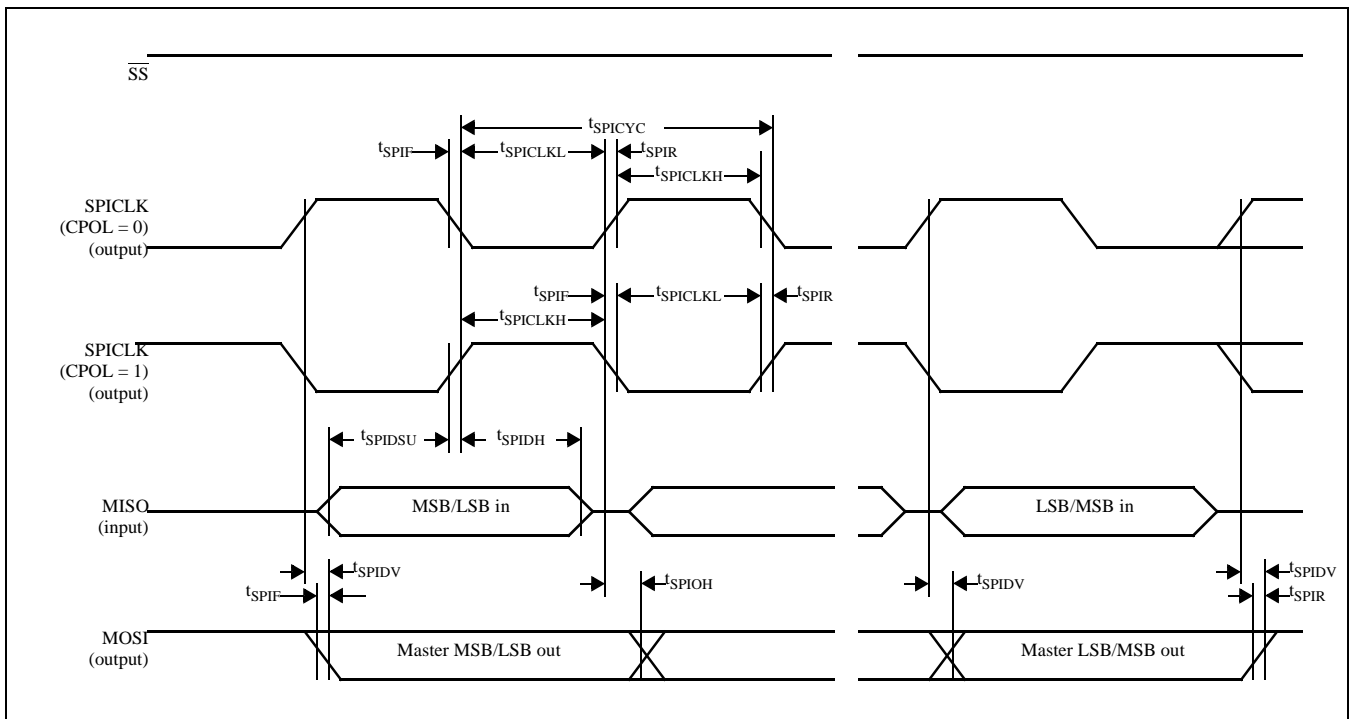
**Figure 7: Shift Register Mode Timing**

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**Figure 8: SPI Master Timing (CPHA = 0)**



**Figure 9: SPI Master Timing (CPHA = 1)**

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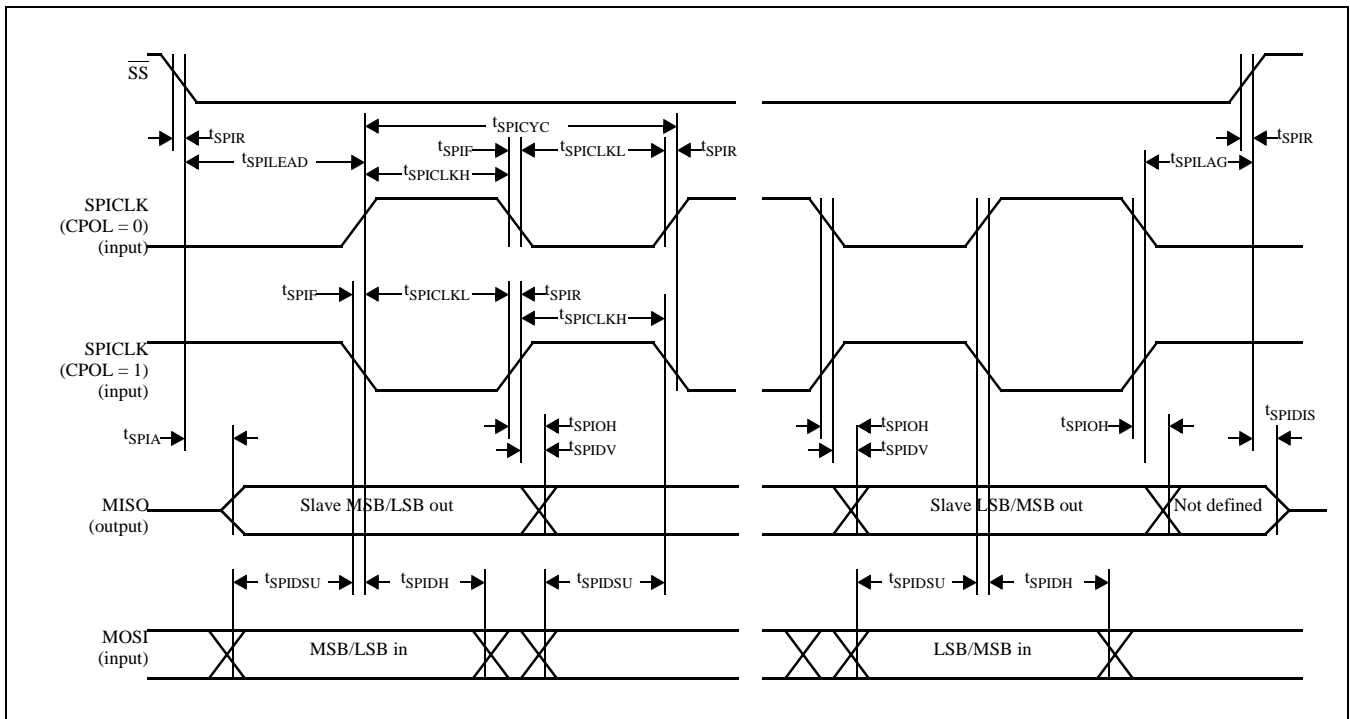


Figure 10: SPI Slave Timing (CPHA = 0)

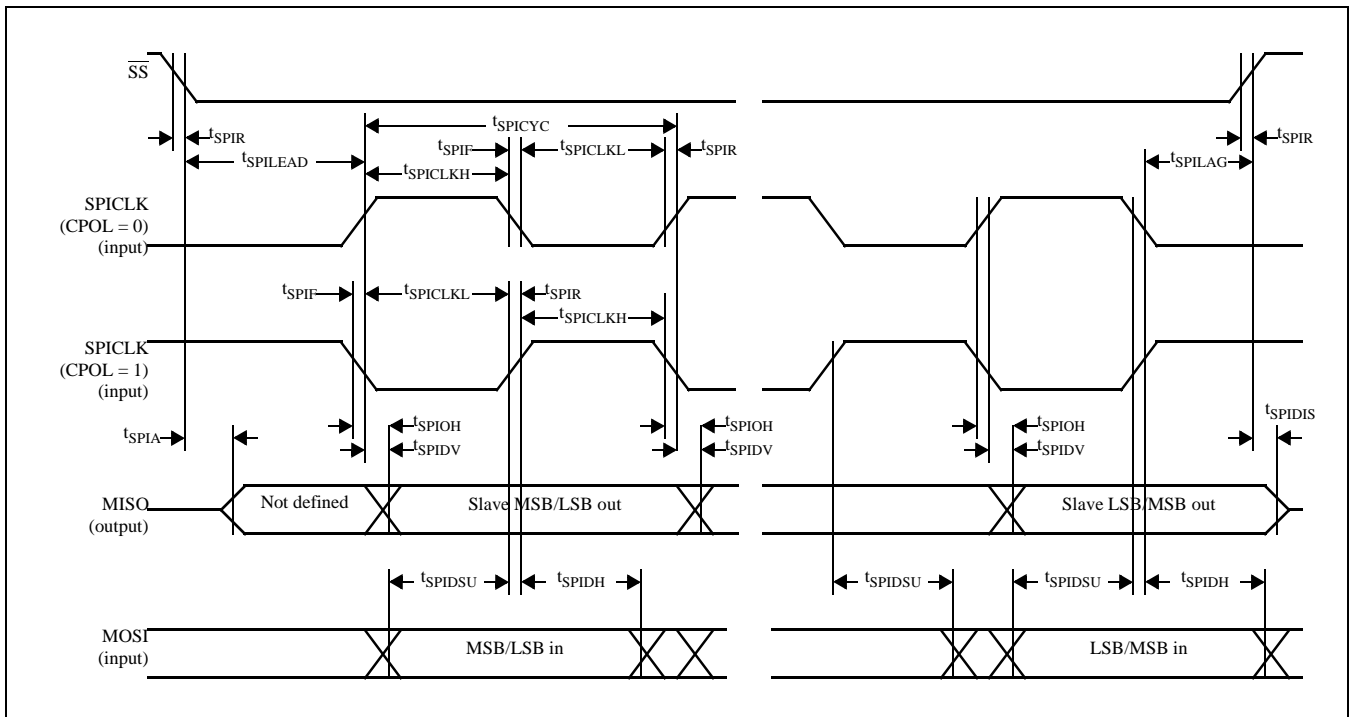


Figure 11: SPI Slave Timing (CPHA = 1)

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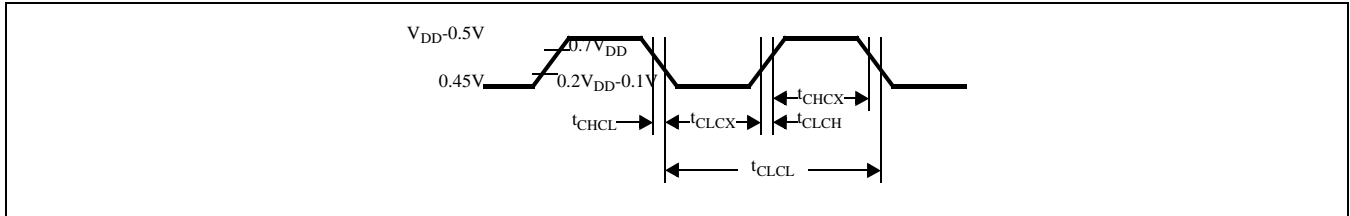


Figure 12: External Clock Drive

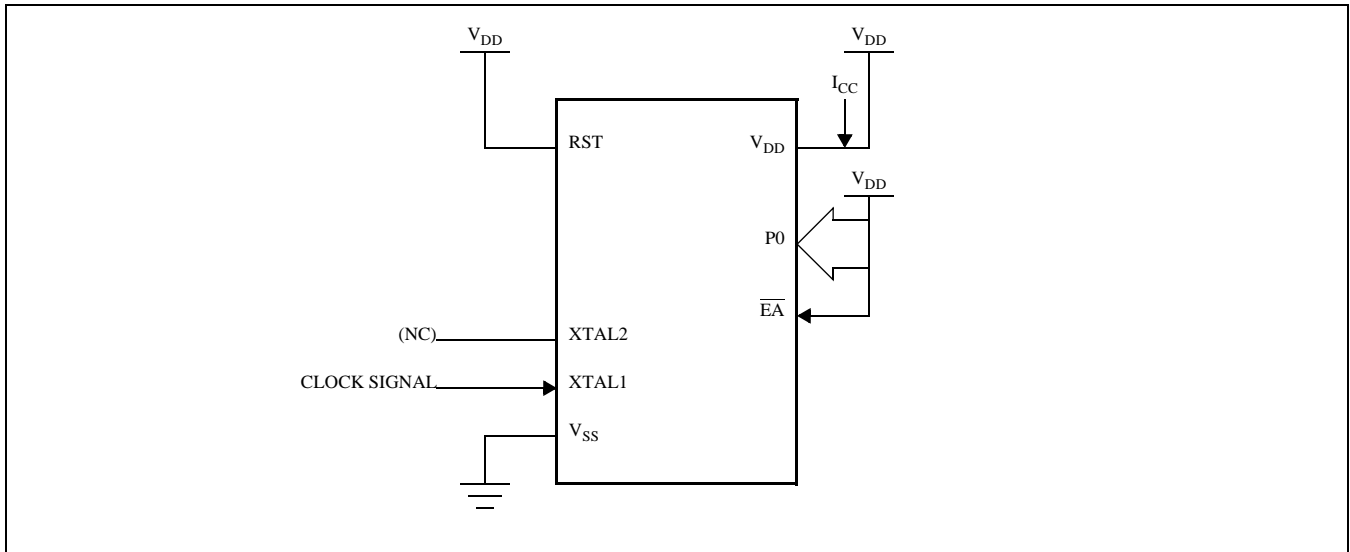
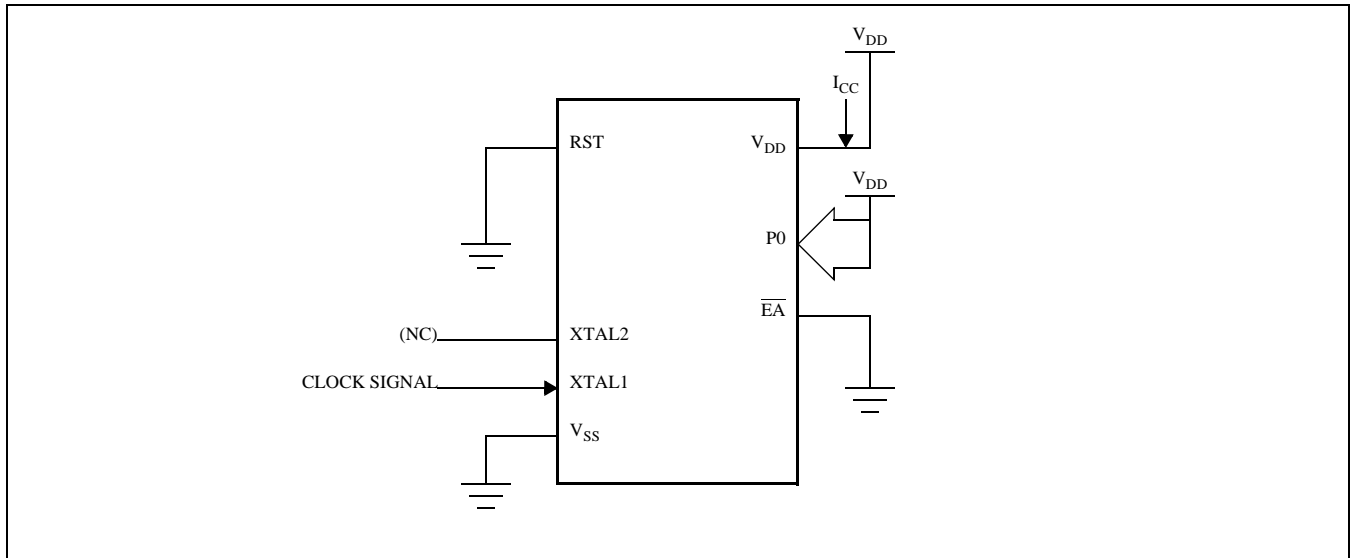


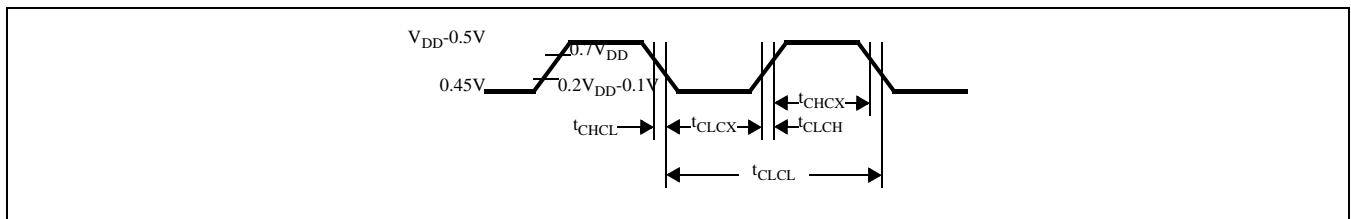
Figure 13:  $I_{CC}$  Test Condition, Active Mode (All other pins are disconnected)

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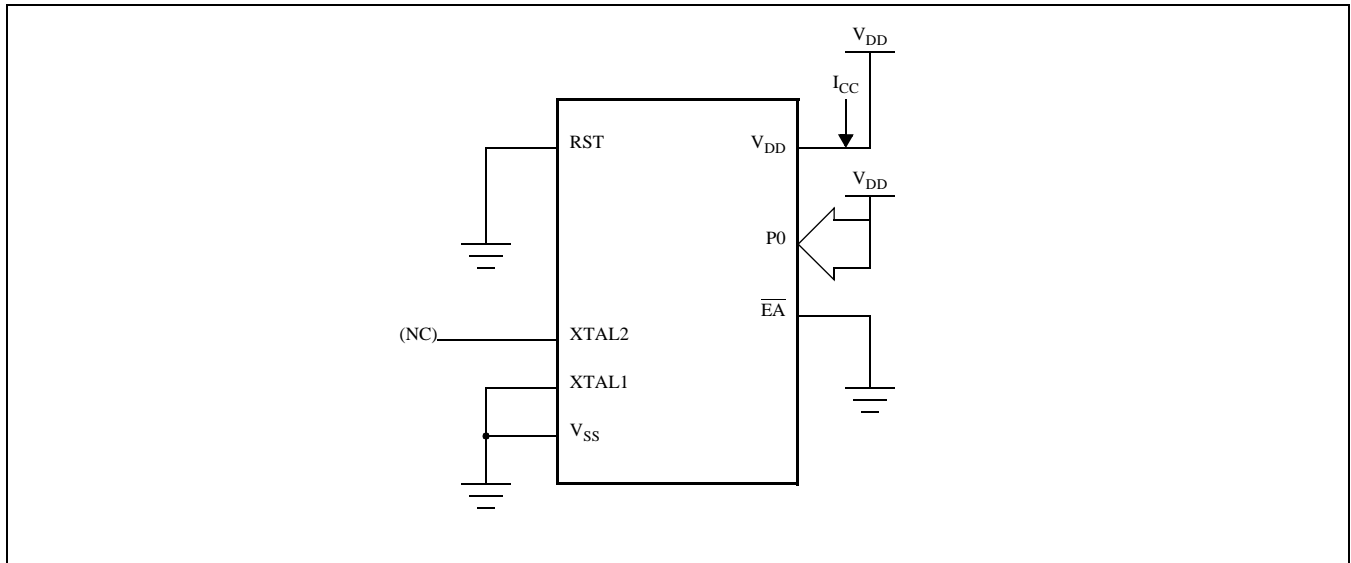
**Figure 14:  $I_{CC}$  Test Condition, Idle Mode (All other pins are disconnected)**



**Figure 15: Clock Signal Waveform for  $I_{CC}$  Tests in Active and Idle Modes  $t_{CLCH} = t_{CHCL} = 5\text{ns}$**

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**Figure 16: I<sub>CC</sub> Test Condition, Power Down Mode (All other pins are disconnected, V<sub>DD</sub> = 2.0V to 5.5V)**

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**Data sheet status**

Data sheet status	Product status	Definition [1]
Objective specification	Development	This data sheet contains the design target or goal specifications for product development. Specification may change in any manner without notice.
Preliminary specification	Qualification	This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
Product specification	Production	This data sheet contains final specifications. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.

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

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**Errata sheet**

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**FUNCTIONAL DEVIATIONS****Deviation #1**

RxD1 pin is an open drain configuration.

**Work-around:**

A resistor must be used if this pin is to be used as an output. These pins will become port 4 on the next release fixing this issue.

**Deviation #2**

Port 4 does not exist for the RxD1 and TxD1 pins. DC parameters differ from standard port pins.

**Work-around:**

None. These pins will become port 4 on the next release.

**Deviation #3**

RxD1, TxD1, and ALE pins will not go into once mode.

**Work-around:**

None. This will be fixed on the next release.

**Deviation #4**

In the UART, the contents of RB8 and SBUF change when they shouldn't if SM2=1 in modes 2 and 3.

**Work-around:**

None. Will be fixed on the next release.

**Deviation #5**

The UART double buffering will be implemented on the next release.

**Work-around:**

None.

**Deviation #6**

SPI block will be implemented on the next release.

**Work-around:**

None.

**Deviation #7**

Security bits are not 100% compatible with past 80c51 products.

**Work-around:**

The security bits will be compatible on the next release.

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## Errata sheet

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### Deviation #8

UART mode 0 receive data is sampled one clock later than standard 80C51 UARTS.

**Work-around:**

This requires an increased data hold time. This will be fixed on the next release.

### Deviation #9

The PCA Watchdog timer function may not function properly at 24 MHz  $f_{OSC}$  when the PCA Count Pulse selection is set to "internal clock,  $f_{OSC}/2$ ".

**Work-around:**

None. This will be fixed on the next release.