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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	PIC
Core Size	8-Bit
Speed	4MHz
Connectivity	I²C, SPI
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	22
Program Memory Size	3.5KB (2K x 14)
Program Memory Type	OTP
EEPROM Size	-
RAM Size	128 x 8
Voltage - Supply (Vcc/Vdd)	2.5V ~ 5.5V
Data Converters	A/D 5x8b
Oscillator Type	External
Operating Temperature	0°C ~ 70°C (TA)
Mounting Type	Surface Mount
Package / Case	28-SSOP (0.209", 5.30mm Width)
Supplier Device Package	28-SSOP
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16lc72at-04-ss

2.2.2.4   PIE1 REGISTER

This register contains the individual enable bits for the peripheral interrupts.

Note: Bit PEIE (INTCON<6>) must be set to enable any peripheral interrupt.

REGISTER 2-4:   PIE1 REGISTER (ADDRESS 8Ch)

U-0	R/W-0	U-0	U-0	R/W-0	R/W-0	R/W-0	R/W-0
—	ADIE[1]	—	—	SSPIE	CCP1IE	TMR2IE	TMR1IE

bit7   bit0

R   = Readable bit
W   = Writable bit
U   = Unimplemented bit,
        read as '0'
- n = Value at POR reset

bit 7:   **Unimplemented:** Read as '0'

bit 6:   **ADIE**[1]: A/D Converter Interrupt Enable bit
1 = Enables the A/D interrupt
0 = Disables the A/D interrupt

bit 5-4: **Unimplemented**: Read as '0'

bit 3:   **SSPIE**: Synchronous Serial Port Interrupt Enable bit
1 = Enables the SSP interrupt
0 = Disables the SSP interrupt

bit 2:   **CCP1IE**: CCP1 Interrupt Enable bit
1 = Enables the CCP1 interrupt
0 = Disables the CCP1 interrupt

bit 1:   **TMR2IE**: TMR2 to PR2 Match Interrupt Enable bit
1 = Enables the TMR2 to PR2 match interrupt
0 = Disables the TMR2 to PR2 match interrupt

bit 0:   **TMR1IE**: TMR1 Overflow Interrupt Enable bit
1 = Enables the TMR1 overflow interrupt
0 = Disables the TMR1 overflow interrupt

Note 1: The PIC16C62B does not have an A/D module. This bit location is reserved on these devices. Always maintain this bit clear.

2.3   PCL and PCLATH

The program counter (PC) specifies the address of the instruction to fetch for execution. The PC is 13 bits wide. The low byte is called the PCL register and is readable and writable. The high byte is called the PCH register. This register contains the PC<12:8> bits and is not directly accessible. All updates to the PCH register go through the PCLATH register.

2.3.1   STACK

The stack allows any combination of up to 8 program calls and interrupts to occur. The stack contains the return address from this branch in program execution.
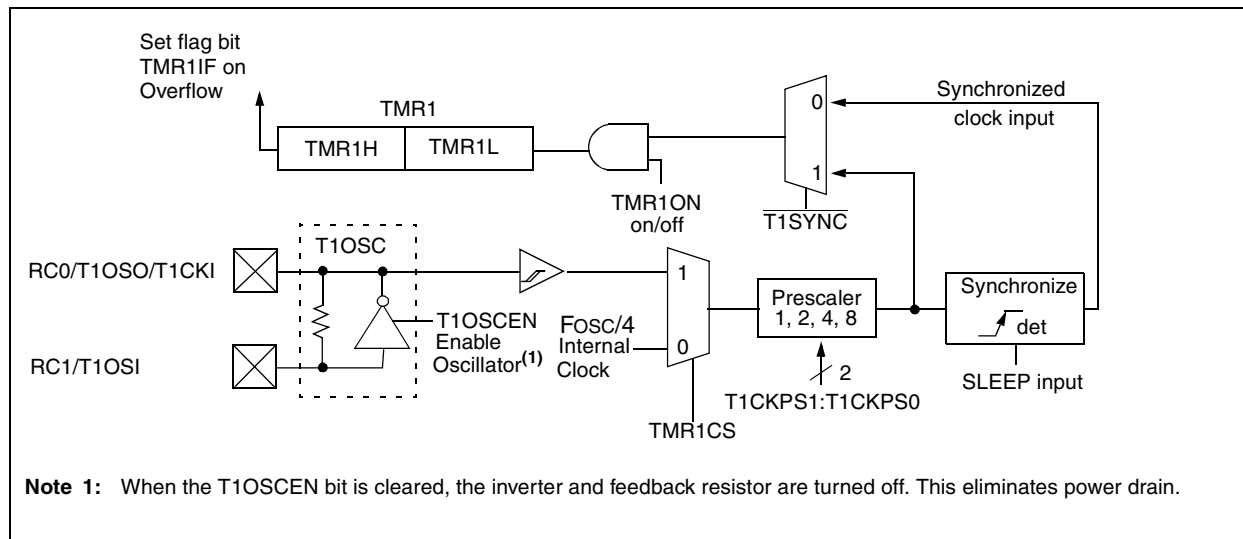
Mid-range devices have an 8 level deep hardware stack. The stack space is not part of either program or data space and the stack pointer is not accessible. The PC is PUSHed onto the stack when a `CALL` instruction is executed or an interrupt causes a branch. The stack is POPed in the event of a `RETURN, RETLW` or a `RET-FIE` instruction execution. PCLATH is not modified when the stack is PUSHed or POPed.

After the stack has been PUSHed eight times, the ninth push overwrites the value that was stored from the first push. The tenth push overwrites the second push (and so on).

2.4   Program Memory Paging

The `CALL` and `GOTO` instructions provide 11 bits of address to allow branching within any 2K program memory page. When doing a `CALL` or `GOTO` instruction, the upper bit of the address is provided by PCLATH<3>. The user must ensure that the page select bit is programmed to address the proper program memory page. If a return from a `CALL` instruction (or interrupt) is executed, the entire 13-bit PC is popped from the stack. Therefore, manipulation of the PCLATH<3> bit is not required for the return instructions.

3.2 PORTB and the TRISB Register

PORTB is an 8-bit wide bi-directional port. The corresponding data direction register is TRISB. Setting a TRISB bit (=1) will make the corresponding PORTB pin an input, (i.e., put the corresponding output driver in a hi-impedance mode). Clearing a TRISB bit (=0) will make the corresponding PORTB pin an output, (i.e., put the contents of the output latch on the selected pin).

Each of the PORTB pins has a weak internal pull-up. A single control bit can turn on all the pull-ups. This is performed by clearing bit $\overline{RBPU}$ (OPTION_REG<7>). The weak pull-up is automatically turned off when the port pin is configured as an output. The pull-ups are disabled on a Power-on Reset.

FIGURE 3-3: BLOCK DIAGRAM OF RB3:RB0 PINS

Note 1: I/O pins have diode protection to VDD and VSS.
2: To enable weak pull-ups, set the appropriate TRIS bit(s) and clear the $\overline{RBPU}$ bit (OPTION_REG<7>).

Four of PORTB's pins, RB7:RB4, have an interrupt on change feature. Only pins configured as inputs can cause this interrupt to occur (i.e. any RB7:RB4 pin configured as an output is excluded from the interrupt on change comparison). The input pins (of RB7:RB4) are compared with the old value latched on the last read of PORTB. The "mismatch" outputs of RB7:RB4 are OR'ed together to generate the RB Port Change Interrupt with flag bit RBIF (INTCON<0>).

This interrupt can wake the device from SLEEP. The user, in the interrupt service routine, can clear the interrupt in the following manner:

a) Any read or write of PORTB. This will end the mismatch condition.

b) Clear flag bit RBIF.

A mismatch condition will continue to set flag bit RBIF. Reading PORTB will end the mismatch condition and allow flag bit RBIF to be cleared.

The interrupt on change feature is recommended for wake-up on key depression operation and operations where PORTB is only used for the interrupt on change feature. Polling of PORTB is not recommended while using the interrupt on change feature.

RB0/INT is an external interrupt pin and is configured using the INTEDG bit (OPTION_REG<6>). RB0/INT is discussed in detail in Section 10.10.1.

FIGURE 3-4: BLOCK DIAGRAM OF RB7:RB4 PINS

Note 1: I/O pins have diode protection to VDD and VSS.
2: To enable weak pull-ups, set the appropriate TRIS bit(s) and clear the $\overline{RBPU}$ bit (OPTION_REG<7>).

FIGURE 5-1: **TIMER1 BLOCK DIAGRAM**

Note 1: When the T1OSCEN bit is cleared, the inverter and feedback resistor are turned off. This eliminates power drain.

8.0 SYNCHRONOUS SERIAL PORT (SSP) MODULE

8.1 SSP Module Overview

The Synchronous Serial Port (SSP) module is a serial interface useful for communicating with other peripheral or microcontroller devices. These peripheral devices may be Serial EEPROMs, shift registers, display drivers, A/D converters, etc. The SSP module can operate in one of two modes:

• Serial Peripheral Interface (SPI)
• Inter-Integrated Circuit (I2C)

For more information on SSP operation (including an I2C Overview), refer to the PIC**®** MCU Mid-Range Reference Manual, (DS33023). Also, refer to Application Note AN578, *"Use of the SSP Module in the I2C Multi-Master Environment."*

8.2 SPI Mode

This section contains register definitions and operational characteristics of the SPI module.

Additional information on SPI operation may be found in the PIC**®** MCU Mid-Range Reference Manual, (DS33023).

8.2.1 OPERATION OF SSP MODULE IN SPI MODE

A block diagram of the SSP Module in SPI Mode is shown in Figure 8-1.

The SPI mode allows 8-bits of data to be synchronously transmitted and received simultaneously. To accomplish communication, three pins are used:

• Serial Data Out (SDO)RC5/SDO
• Serial Data In (SDI)RC4/SDI/SDA
• Serial Clock (SCK)RC3/SCK/SCL

Additionally, a fourth pin may be used when in a slave mode of operation:

• Slave Select ($\overline{SS}$)RA5/$\overline{SS}$/AN4

When initializing the SPI, several options need to be specified. This is done by programming the appropriate control bits in the SSPCON register (SSPCON<5:0>) and SSPSTAT<7:6>. These control bits allow the following to be specified:

• Master Operation (SCK is the clock output)
• Slave Mode (SCK is the clock input)
• Clock Polarity (Idle state of SCK)
• Clock Edge (Output data on rising/falling edge of SCK)
• Clock Rate (master operation only)
• Slave Select Mode (Slave mode only)

To enable the serial port, SSP Enable bit, SSPEN (SSPCON<5>) must be set. To reset or reconfigure SPI mode, clear bit SSPEN, re-initialize the SSPCON reg-

ister, and then set bit SSPEN. This configures the SDI, SDO, SCK and $\overline{SS}$ pins as serial port pins. For the pins to behave as the serial port function, they must have their data direction bits (in the TRISC register) appropriately programmed. That is:

• SDI must have TRISC<4> set
• SDO must have TRISC<5> cleared
• SCK (master operation) must have TRISC<3> cleared
• SCK (Slave mode) must have TRISC<3> set
• $\overline{SS}$ must have TRISA<5> set (if used)

Note:	When the SPI is in Slave Mode with $\overline{SS}$ pin control enabled, (SSPCON<3:0> = 0100) the SPI module will reset if the $\overline{SS}$ pin is set to VDD.
Note:	If the SPI is used in Slave Mode with CKE = '1', then the $\overline{SS}$ pin control must be enabled.

FIGURE 8-1: SSP BLOCK DIAGRAM (SPI MODE)

10.2.3   RC OSCILLATOR

For timing insensitive applications, the "RC" device option offers additional cost savings. The RC oscillator frequency is a function of the supply voltage, the resistor (R_{EXT}) and capacitor (C_{EXT}) values, and the operating temperature. In addition to this, the oscillator frequency will vary from unit to unit due to normal process parameter variation. Furthermore, the difference in lead frame capacitance between package types will also affect the oscillation frequency, especially for low C_{EXT} values. The user also needs to take into account variation due to tolerance of external R and C components used. Figure 10-4 shows how the R/C combination is connected to the PIC16CXXX.

FIGURE 10-4:   RC OSCILLATOR MODE
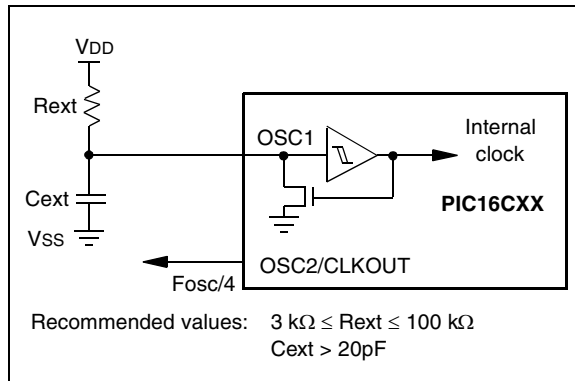
10.3   Reset

The PIC16CXXX differentiates between various kinds of reset:

- Power-on Reset (POR)
- $\overline{MCLR}$ reset during normal operation
- $\overline{MCLR}$ reset during SLEEP
- WDT Reset (during normal operation)
- WDT Wake-up (during SLEEP)
- Brown-out Reset (BOR)

Some registers are not affected in any reset condition; their status is unknown on POR and unchanged by any other reset. Most other registers are reset to a "reset state" on Power-on Reset (POR), on the $\overline{MCLR}$ and WDT Reset, on $\overline{MCLR}$ reset during SLEEP, and on Brown-out Reset (BOR). They are not affected by a WDT Wake-up from SLEEP, which is viewed as the resumption of normal operation. The $\overline{TO}$ and $\overline{PD}$ bits are set or cleared depending on the reset situation, as indicated in Table 10-4. These bits are used in software to determine the nature of the reset. See Table 10-6 for a full description of reset states of all registers.

A simplified block diagram of the on-chip reset circuit is shown in Figure 10-5.

The PIC devices have a $\overline{MCLR}$ noise filter in the $\overline{MCLR}$ reset path. The filter will ignore small pulses. However, a valid $\overline{MCLR}$ pulse must meet the minimum pulse width (TmcL, Specification #30).

No internal reset source (WDT, BOR, POR) willdrive the $\overline{MCLR}$ pin low.

and test the sample code. In addition, PICDEM-17 supports down-loading of programs to and executing out of external FLASH memory on board. The PICDEM-17 is also usable with the MPLAB-ICE or PICMASTER emulator, and all of the sample programs can be run and modified using either emulator. Additionally, a generous prototype area is available for user hardware.

12.17 SEEVAL Evaluation and Programming System

The SEEVAL SEEPROM Designer's Kit supports all Microchip 2-wire and 3-wire Serial EEPROMs. The kit includes everything necessary to read, write, erase or program special features of any Microchip SEEPROM product including Smart Serials™ and secure serials. The Total Endurance™ Disk is included to aid in trade-off analysis and reliability calculations. The total kit can significantly reduce time-to-market and result in an optimized system.

12.18 KEELOQ Evaluation and Programming Tools

KEELOQ evaluation and programming tools support Microchips HCS Secure Data Products. The HCS evaluation kit includes an LCD display to show changing codes, a decoder to decode transmissions, and a programming interface to program test transmitters.

Preliminary

NOTES:

13.2 DC Characteristics: PIC16LC62B/72A-04 (Commercial, Industrial)

DC CHARACTERISTICS			Standard Operating Conditions (unless otherwise stated) Operating temperature 0°C ≤ TA ≤ +70°C for commercial -40°C ≤ TA ≤ +85°C for industrial				
Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
D001	VDD	Supply Voltage	2.5 VBOR*	- -	5.5 5.5	V V	LP, XT, RC osc modes (DC - 4 MHz) BOR enabled (Note 7)
D002*	VDR	**RAM Data Retention Voltage** (Note 1)	-	1.5	-	V	
D003	VPOR	**VDD Start Voltage** to ensure internal Power-on Reset signal	-	VSS	-	V	See section on Power-on Reset for details
D004* D004A*	SVDD	**VDD Rise Rate** to ensure internal Power-on Reset signal	0.05 TBD	- -	- -	V/ms	PWRT enabled (PWRTE bit clear) PWRT disabled (PWRTE bit set) See section on Power-on Reset for details
D005	VBOR	Brown-out Reset voltage trip point	3.65	-	4.35	V	BODEN bit set
D010	IDD	**Supply Current** (Note 2, 5)	-	2.0	3.8	mA	XT, RC osc modes FOSC = 4 MHz, VDD = 3.0V (Note 4)
D010A			-	22.5	48	µA	LP OSC MODE FOSC = 32 kHz, VDD = 3.0V, WDT disabled
D020 D021 D021A	IPD	**Power-down Current** (Note 3, 5)	- - -	7.5 0.9 0.9	30 5 5	µA µA µA	VDD = 3.0V, WDT enabled, -40°C to +85°C VDD = 3.0V, WDT disabled, 0°C to +70°C VDD = 3.0V, WDT disabled, -40°C to +85°C
D022* D022A*	ΔIWDT ΔIBOR	Module Differential Current (Note 6) Watchdog Timer Brown-out Reset	- -	6.0 TBD	20 200	µA µA	WDTE BIT SET, VDD = 4.0V BODEN bit set, VDD = 5.0V

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: This is the limit to which VDD can be lowered without losing RAM data.

2: The supply current is mainly a function of the operating voltage and frequency. Other factors such as I/O pin loading and switching rate, oscillator type, internal code execution pattern, and temperature also have an impact on the current consumption.
The test conditions for all IDD measurements in active operation mode are:
OSC1 = external square wave, from rail to rail; all I/O pins tristated, pulled to VDD,
MCLR = VDD; WDT enabled/disabled as specified.

3: The power-down current in SLEEP mode does not depend on the oscillator type. Power-down current is measured with the part in SLEEP mode, with all I/O pins in hi-impedance state and tied to VDD and VSS.

4: For RC osc mode, current through Rext is not included. The current through the resistor can be estimated by the formula Ir = VDD/2Rext (mA) with Rext in kOhm.

5: Timer1 oscillator (when enabled) adds approximately 20 µA to the specification. This value is from characterization and is for design guidance only. This is not tested.

6: The Δ current is the additional current consumed when this peripheral is enabled. This current should be added to the base IDD or IPD measurement.

7: This is the voltage where the device enters the Brown-out Reset. When BOR is enabled, the device will perform a brown-out reset when VDD falls below VBOR.

PIC16C62B/72A

13.3   DC Characteristics: PIC16C62B/72A-04 (Commercial, Industrial, Extended)
PIC16C62B/72A-20 (Commercial, Industrial, Extended)
PIC16LC62B/72A-04 (Commercial, Industrial)

DC CHARACTERISTICS			Standard Operating Conditions (unless otherwise stated) Operating temperature 0°C ≤ TA ≤ +70°C for commercial -40°C ≤ TA ≤ +85°C for industrial -40°C ≤ TA ≤+125°C for extended Operating voltage VDD range as described in DC spec Section 13.1 and Section 13.2				
Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
	VIL	**Input Low Voltage** I/O ports		-			
D030		with TTL buffer	Vss	-	0.15VDD	V	For entire VDD range
D030A			Vss	-	0.8V	V	4.5V ≤ VDD ≤ 5.5V
D031		with Schmitt Trigger buffer	Vss	-	0.2VDD	V	
D032		$\overline{\text{MCLR}}$, OSC1 (in RC mode)	Vss	-	0.2VDD	V	
D033		OSC1 (in XT, HS and LP modes)	Vss	-	0.3VDD	V	Note1
	VIH	**Input High Voltage** I/O ports		-			
D040		with TTL buffer	2.0	-	VDD	V	4.5V ≤ VDD ≤ 5.5V
D040A			0.25VDD + 0.8V	-	Vdd	V	For entire VDD range
D041		with Schmitt Trigger buffer	0.8VDD	-	VDD	V	For entire VDD range
D042		MCLR	0.8VDD	-	VDD	V	
D042A		OSC1 (XT, HS and LP modes)	0.7VDD	-	VDD	V	Note1
D043		OSC1 (in RC mode)	0.9VDD	-	Vdd	V	
	IIL	**Input Leakage Current** (Notes 2, 3)					
D060		I/O ports	-	-	±1	μA	Vss ≤ VPIN ≤ VDD, Pin at hi-impedance
D061		$\overline{\text{MCLR}}$, RA4/T0CKI	-	-	±5	μA	Vss ≤ VPIN ≤ VDD
D063		OSC1	-	-	±5	μA	Vss ≤ VPIN ≤ VDD, XT, HS and LP osc modes
D070	IPURB	**PORTB weak pull-up current**	50	250	400	μA	VDD = 5V, VPIN = Vss
D080	VOL	**Output Low Voltage** I/O ports	-	-	0.6	V	IOL = 8.5 mA, VDD = 4.5V, -40°C to +85°C

*   These parameters are characterized but not tested.

†   Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: In RC oscillator mode, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended that the device be driven with external clock in RC mode.

   2: The leakage current on the $\overline{\text{MCLR}}$/VPP pin is strongly dependent on the applied voltage level. The specified levels represent normal operating conditions. Higher leakage current may be measured at different input voltages.

   3: Negative current is defined as current sourced by the pin.

DC CHARACTERISTICS		Standard Operating Conditions (unless otherwise stated) Operating temperature 0°C ≤ TA ≤ +70°C for commercial -40°C ≤ TA ≤ +85°C for industrial -40°C ≤ TA ≤+125°C for extended Operating voltage VDD range as described in DC spec Section 13.1 and Section 13.2					
Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
D083		OSC2/CLKOUT (RC osc mode)	-	-	0.6	V	IOL = 7.0 mA, VDD = 4.5V, -40°C to +125°C
			-	-	0.6	V	IOL = 1.6 mA, VDD = 4.5V, -40°C to +85°C
			-	-	0.6	V	IOL = 1.2 mA, VDD = 4.5V, -40°C to +125°C
D090	VOH	**Output High Voltage** I/O ports (Note 3)	VDD-0.7	-	-	V	IOH = -3.0 mA, VDD = 4.5V, -40°C to +85°C
			VDD-0.7	-	-	V	IOH = -2.5 mA, VDD = 4.5V, -40°C to +125°C
D092		OSC2/CLKOUT (RC osc mode)	VDD-0.7	-	-	V	IOH = -1.3 mA, VDD = 4.5V, -40°C to +85°C
			VDD-0.7	-	-	V	IOH = -1.0 mA, VDD = 4.5V, -40°C to +125°C
D150*	VOD	**Open-Drain High Voltage**	-	-	8.5	V	RA4 pin
D100	COSC2	**Capacitive Loading Specs on Output Pins** OSC2 pin	-	-	15	pF	In XT, HS and LP modes when external clock is used to drive OSC1.
D101	CIO	All I/O pins and OSC2 (in RC mode)	-	-	50	pF	
D102	Cb	SCL, SDA in I^{2}C mode	-	-	400	pF	

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: In RC oscillator mode, the OSC1/CLKIN pin is a Schmitt Trigger input. It is not recommended that the device be driven with external clock in RC mode.

2: The leakage current on the MCLR/VPP pin is strongly dependent on the applied voltage level. The specified levels represent normal operating conditions. Higher leakage current may be measured at different input voltages.

3: Negative current is defined as current sourced by the pin.

13.4   AC (Timing) Characteristics

13.4.1   TIMING PARAMETER SYMBOLOGY

The timing parameter symbols have been created following one of the following formats:

1. TppS2ppS	3. T$_{CC:ST}$ (I^{2}C specifications only)
2. TppS	4. Ts (I^{2}C specifications only)

T				
F	Frequency	T	Time

Lowercase letters (pp) and their meanings:

pp				
cc	CCP1	osc	OSC1
ck	CLKOUT	rd	$\overline{RD}$
cs	$\overline{CS}$	rw	$\overline{RD}$ or $\overline{WR}$
di	SDI	sc	SCK
do	SDO	ss	$\overline{SS}$
dt	Data in	t0	T0CKI
io	I/O port	t1	T1CKI
mc	$\overline{MCLR}$	wr	$\overline{WR}$

Uppercase letters and their meanings:

S				
F	Fall	P	Period
H	High	R	Rise
I	Invalid (Hi-impedance)	V	Valid
L	Low	Z	Hi-impedance
I^{2}C only			
AA	output access	High	High
BUF	Bus free	Low	Low

T$_{CC:ST}$ (I^{2}C specifications only)

CC				
HD	Hold	SU	Setup
ST			
DAT	DATA input hold	STO	STOP condition
STA	START condition		

Preliminary

PIC16C62B/72A

13.4.3   TIMING DIAGRAMS AND SPECIFICATIONS

FIGURE 13-5:   EXTERNAL CLOCK TIMING
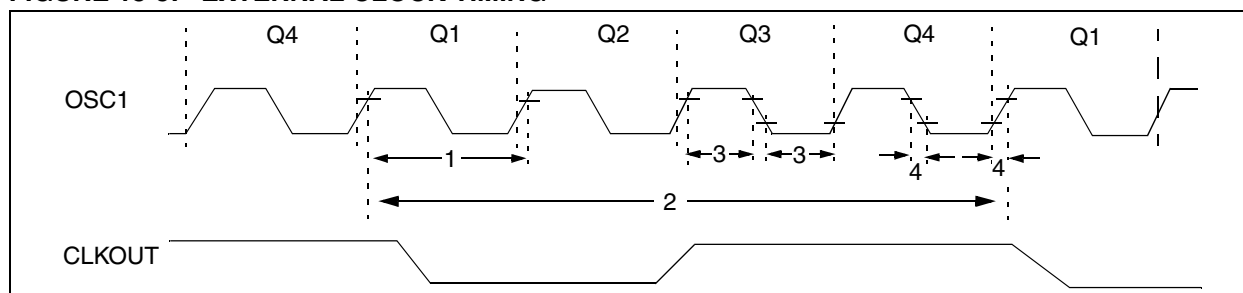
TABLE 13-2:   EXTERNAL CLOCK TIMING REQUIREMENTS

Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
1A	Fosc	External CLKIN Frequency (Note 1)	DC	—	4	MHz	RC and XT osc modes
			DC	—	4	MHz	HS osc mode (-04)
			DC	—	20	MHz	HS osc mode (-20)
			DC	—	200	kHz	LP osc mode
		Oscillator Frequency (Note 1)	DC	—	4	MHz	RC osc mode
			0.1	—	4	MHz	XT osc mode
			4	—	20	MHz	HS osc mode
			5	—	200	kHz	LP osc mode
1	Tosc	External CLKIN Period (Note 1)	250	—	—	ns	RC and XT osc modes
			250	—	—	ns	HS osc mode (-04)
			50	—	—	ns	HS osc mode (-20)
			5	—	—	μs	LP osc mode
		Oscillator Period (Note 1)	250	—	—	ns	RC osc mode
			250	—	10,000	ns	XT osc mode
			250	—	250	ns	HS osc mode (-04)
			50	—	250	ns	HS osc mode (-20)
			5	—	—	μs	LP osc mode
2	TCY	Instruction Cycle Time (Note 1)	200	—	DC	ns	TCY = 4/Fosc
3*	TosL, TosH	External Clock in (OSC1) High or Low Time	100	—	—	ns	XT oscillator
			2.5	—	—	μs	LP oscillator
			15	—	—	ns	HS oscillator
4*	TosR, TosF	External Clock in (OSC1) Rise or Fall Time	—	—	25	ns	XT oscillator
			—	—	50	ns	LP oscillator
			—	—	15	ns	HS oscillator

*   These parameters are characterized but not tested.

†   Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1:   Instruction cycle period (TCY) equals four times the input oscillator time-base period. All specified values are based on characterization data for that particular oscillator type under standard operating conditions with the device executing code. Exceeding these specified limits may result in an unstable oscillator operation and/or higher than expected current consumption. All devices are tested to operate at "min." values with an external clock applied to the OSC1/CLKIN pin.

When an external clock input is used, the "Max." cycle time limit is "DC" (no clock) for all devices.
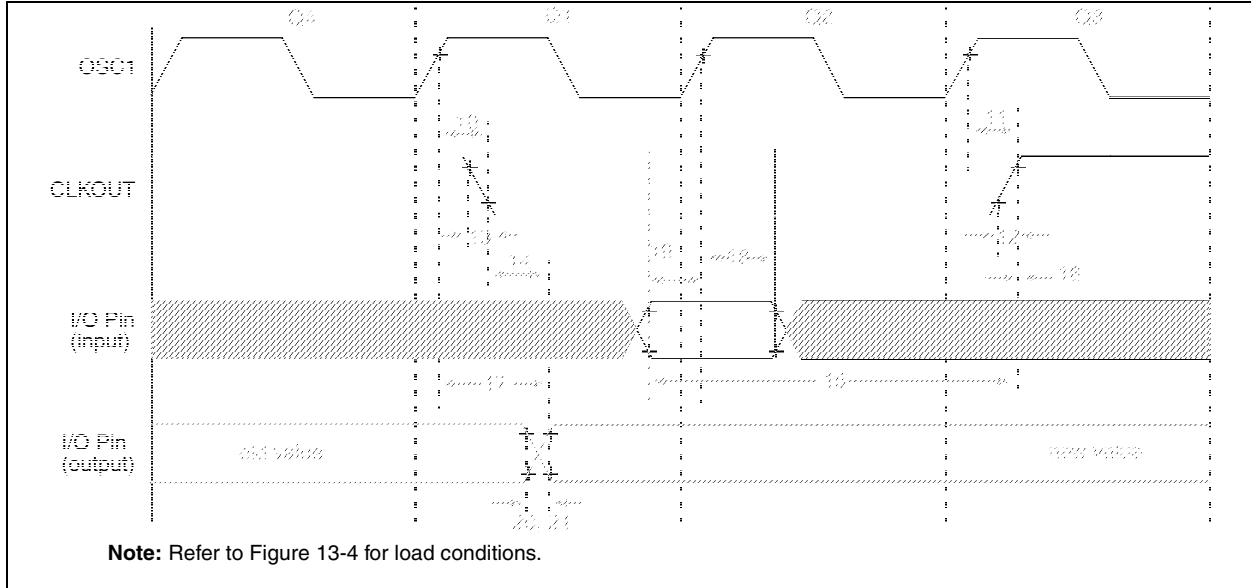
FIGURE 13-6:   CLKOUT AND I/O TIMING

Note: Refer to Figure 13-4 for load conditions.

TABLE 13-3:   CLKOUT AND I/O TIMING REQUIREMENTS

Param No.	Sym	Characteristic		Min	Typ†	Max	Units	Conditions
10*	TosH2ckL	OSC1↑ to CLKOUT↓		—	75	200	ns	Note 1
11*	TosH2ckH	OSC1↑ to CLKOUT↑		—	75	200	ns	Note 1
12*	TckR	CLKOUT rise time		—	35	100	ns	Note 1
13*	TckF	CLKOUT fall time		—	35	100	ns	Note 1
14*	TckL2ioV	CLKOUT ↓ to Port out valid		—	—	0.5TCY + 20	ns	Note 1
15*	TioV2ckH	Port in valid before CLKOUT ↑		Tosc + 200	—	—	ns	Note 1
16*	TckH2ioI	Port in hold after CLKOUT ↑		0	—	—	ns	Note 1
17*	TosH2ioV	OSC1↑ (Q1 cycle) to Port out valid		—	50	150	ns	
18*	TosH2ioI	OSC1↑ (Q2 cycle) to Port input invalid (I/O in hold time)	**PIC16CXX**	100	—	—	ns	
18A*			**PIC16LCXX**	200	—	—	ns	
19*	TioV2osH	Port input valid to OSC1↑ (I/O in setup time)		0	—	—	ns	
20*	TioR	Port output rise time	**PIC16CXX**	—	10	40	ns	
20A*			**PIC16LCXX**	—	—	80	ns	
21*	TioF	Port output fall time	**PIC16CXX**	—	10	40	ns	
21A*			**PIC16LCXX**	—	—	80	ns	
22††*	Tinp	INT pin high or low time		TCY	—	—	ns	
23††*	Trbp	RB7:RB4 change INT high or low time		TCY	—	—	ns	

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

†† These parameters are asynchronous events not related to any internal clock edge.

Note 1: Measurements are taken in RC Mode where CLKOUT output is 4 x TOSC.

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FIGURE 13-7: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER AND POWER-UP TIMER TIMING

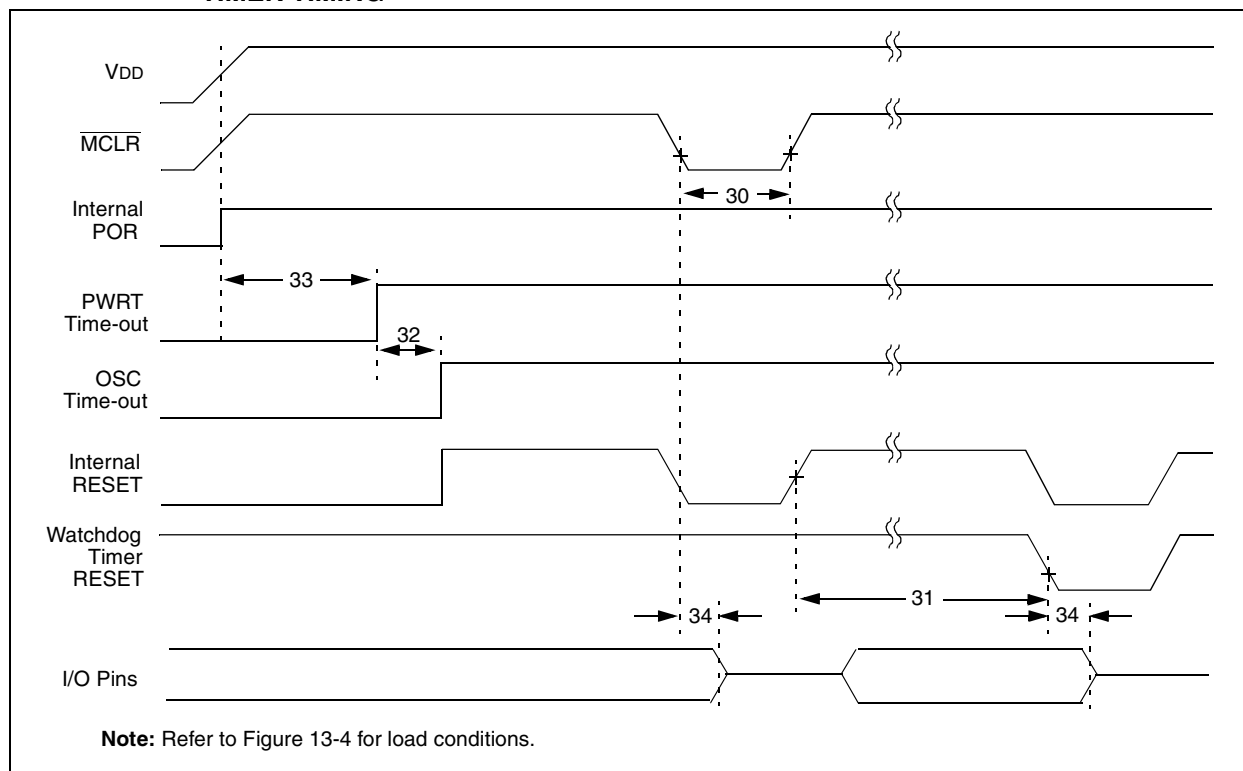**Note:** Refer to Figure 13-4 for load conditions.

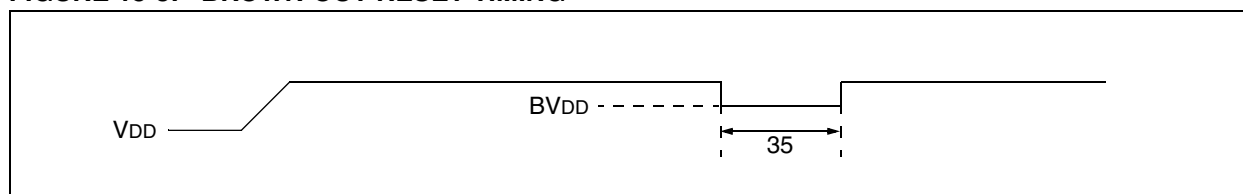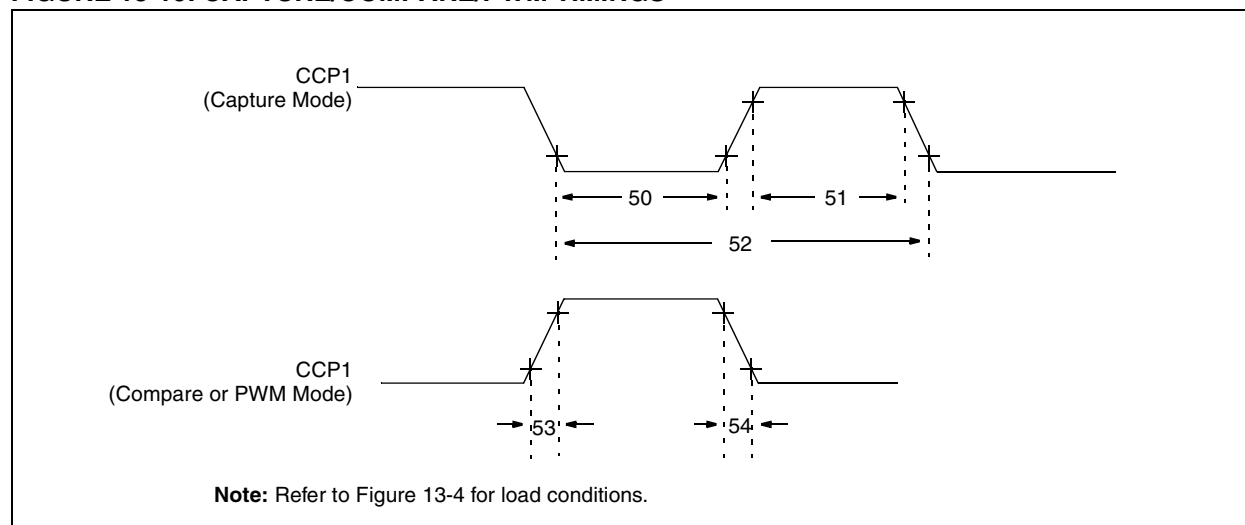**FIGURE 13-8:** BROWN-OUT RESET TIMING

TABLE 13-4: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER, POWER-UP TIMER AND BROWN-OUT RESET REQUIREMENTS

Param No.	Sym	Characteristic	Min	Typ†	Max	Units	Conditions
30	TmcL	$\overline{\text{MCLR}}$ Pulse Width (low)	2	—	—	μs	VDD = 5V, -40°C to +125°C
31*	Twdt	Watchdog Timer Time-out Period (No Prescaler)	7	18	33	ms	VDD = 5V, -40°C to +125°C
32	Tost	Oscillator Start-up Timer Period	—	1024 TOSC	—	—	TOSC = OSC1 period
33*	Tpwrt	Power-up Timer Period	28	72	132	ms	VDD = 5V, -40°C to +125°C
34	TIOZ	I/O Hi-impedance from $\overline{\text{MCLR}}$ Low or WDT reset	—	—	2.1	μs	
35	TBOR	Brown-out Reset Pulse Width	100	—	—	μs	VDD ≤ BVDD (D005)

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

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FIGURE 13-10: CAPTURE/COMPARE/PWM TIMINGS

Note: Refer to Figure 13-4 for load conditions.

TABLE 13-6: CAPTURE/COMPARE/PWM REQUIREMENTS

Param No.	Sym	Characteristic			Min	Typ†	Max	Units	Conditions
50*	TccL	CCP1 input low time	No Prescaler		0.5TCY + 20	—	—	ns	
			With Prescaler	PIC16CXX	10	—	—	ns	
				PIC16LCXX	20	—	—	ns	
51*	TccH	CCP1 input high time	No Prescaler		0.5TCY + 20	—	—	ns	
			With Prescaler	PIC16CXX	10	—	—	ns	
				PIC16LCXX	20	—	—	ns	
52*	TccP	CCP1 input period			$\frac{3TCY + 40}{N}$	—	—	ns	N = prescale value (1,4, or 16)
53*	TccR	CCP1 output rise time	PIC16CXX		—	10	25	ns	
			PIC16LCXX		—	25	45	ns	
54*	TccF	CCP1 output fall time	PIC16CXX		—	10	25	ns	
			PIC16LCXX		—	25	45	ns	

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.
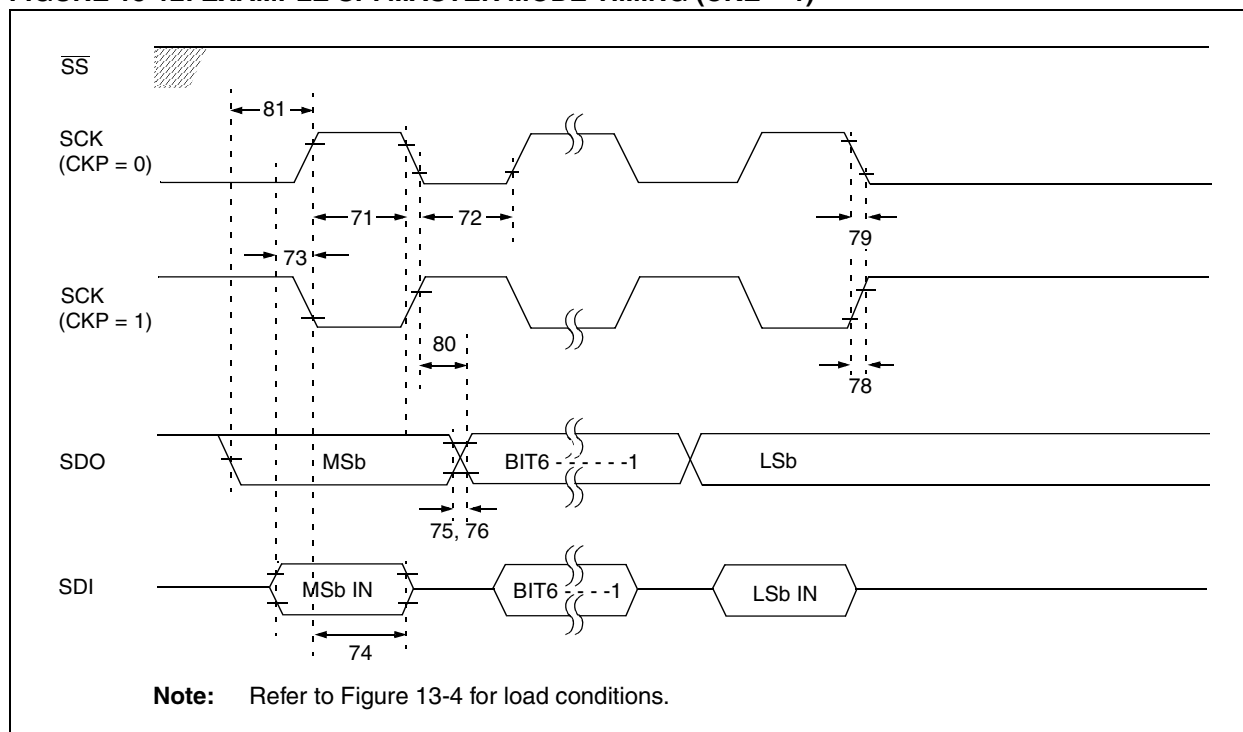
FIGURE 13-12: EXAMPLE SPI MASTER MODE TIMING (CKE = 1)

Note: Refer to Figure 13-4 for load conditions.

TABLE 13-8: EXAMPLE SPI MODE REQUIREMENTS (MASTER MODE, CKE = 1)

Param. No.	Symbol	Characteristic		Min	Typ†	Max	Units	Conditions
71	TscH	SCK input high time (slave mode)	Continuous	1.25TCY + 30	—	—	ns	
71A			Single Byte	40	—	—	ns	Note 1
72	TscL	SCK input low time (slave mode)	Continuous	1.25TCY + 30	—	—	ns	
72A			Single Byte	40	—	—	ns	Note 1
73	TdiV2scH, TdiV2scL	Setup time of SDI data input to SCK edge		100	—	—	ns	
73A	TB2B	Last clock edge of Byte1 to the 1st clock edge of Byte2		1.5TCY + 40	—	—	ns	Note 1
74	TscH2diL, TscL2diL	Hold time of SDI data input to SCK edge		100	—	—	ns	
75	TdoR	SDO data output rise time	PIC16CXX	—	10	25	ns	
			PIC16LCXX		20	45	ns	
76	TdoF	SDO data output fall time		—	10	25	ns	
78	TscR	SCK output rise time (master mode)	PIC16CXX	—	10	25	ns	
			PIC16LCXX		20	45	ns	
79	TscF	SCK output fall time (master mode)		—	10	25	ns	
80	TscH2doV, TscL2doV	SDO data output valid after SCK edge	PIC16CXX	—	—	50	ns	
			PIC16LCXX		—	100	ns	
81	TdoV2scH, TdoV2scL	SDO data output setup to SCK edge		TCY	—	—	ns	

† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: Specification 73A is only required if specifications 71A and 72A are used.

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FIGURE 13-17: A/D CONVERSION TIMING

Note 1: If the A/D clock source is selected as RC, a time of TCY is added before the A/D clock starts. This allows the SLEEP instruction to be executed.
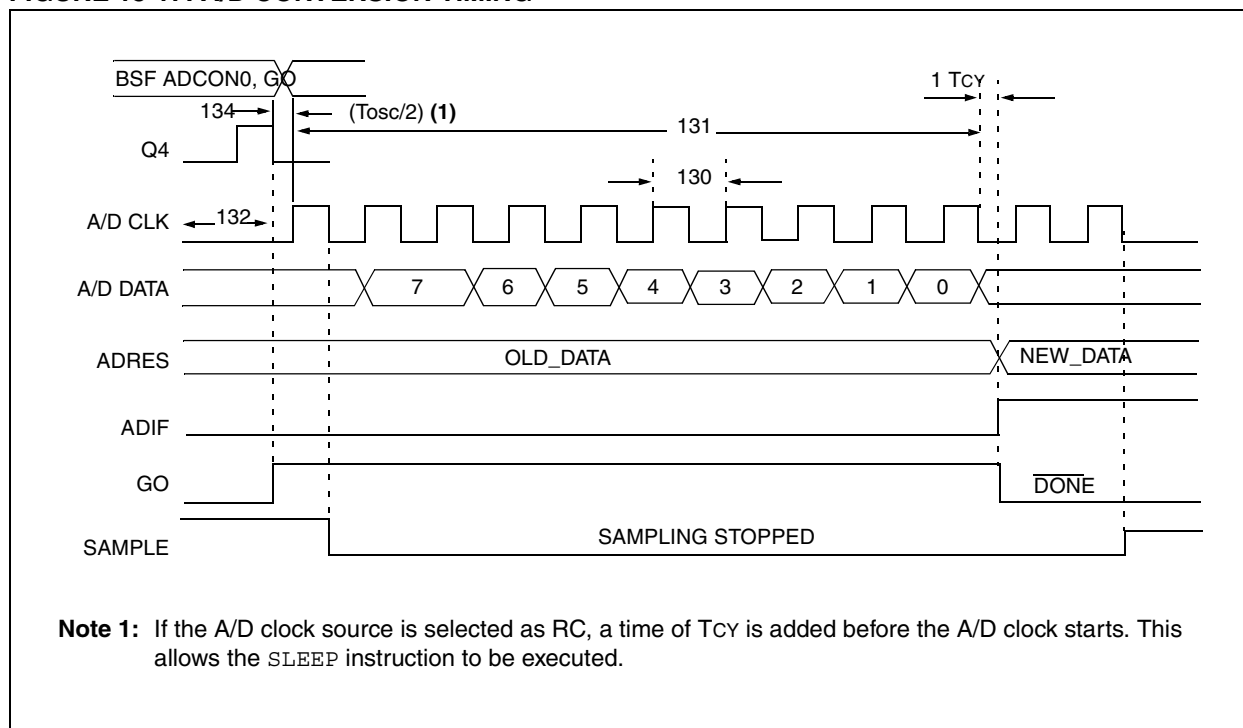
TABLE 13-14: A/D CONVERSION REQUIREMENTS

Param No.	Sym	Characteristic		Min	Typ†	Max	Units	Conditions
130	TAD	A/D clock period	PIC16CXX	1.6	—	—	µs	TOSC based, VREF ≥ 3.0V
			PIC16LCXX	2.0	—	—	µs	TOSC based, VREF full range
			PIC16CXX	2.0	4.0	6.0	µs	A/D RC Mode
			PIC16LCXX	3.0	6.0	9.0	µs	A/D RC Mode
131	TCNV	Conversion time (not including S/H time) (Note 1)		11	—	11	TAD	
132	TACQ	Acquisition time		Note 2	20	—	µs	
				5*	—	—	µs	The minimum time is the amplifier settling time. This may be used if the "new" input voltage has not changed by more than 1 LSb (i.e., 20.0 mV @ 5.12V) from the last sampled voltage (as stated on CHOLD).
134	TGO	Q4 to A/D clock start		—	TOSC/2	—	—	If the A/D clock source is selected as RC, a time of TCY is added before the A/D clock starts. This allows the SLEEP instruction to be executed.
135	Tswc	Switching from convert → sample time		1.5	—	—	TAD	

* These parameters are characterized but not tested.

† Data in "Typ" column is at 5V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

Note 1: ADRES register may be read on the following TCY cycle.

    2: See Section 9.1 for min conditions.

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15.0   PACKAGING INFORMATION

15.1   Package Marking Information

28-Lead PDIP (Skinny DIP)

```
MMMMMMMMMMMM
XXXXXXXXXXXXXX
     AABBCDE
      MICROCHIP
```

Example

```
PIC16C72A-04/SP

       1317HAT
       MICROCHIP
```

28-Lead CERDIP Windowed

```
MICROCHIP    XXXXXXXXXX
             XXXXXXXXXX
             XXXXXXXXXX
             AABBCDE
```

Example

```
MICROCHIP    PIC16C72A/JW

             1317CAT
```

28-Lead SOIC

```
MMMMMMMMMMMMMMMMM
XXXXXXXXXXXXXXXXXX
  AABBCDE
```

Example

```
PIC16C62B-20/SO

   1310/SAA
```

28-Lead SSOP

```
XXXXXXXXXXXX
XXXXXXXXXXXX

  AABBCDE
```

Example

```
PIC16C62B
20I/SS025

  1317SBP
```
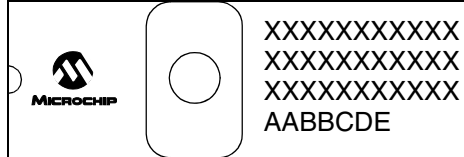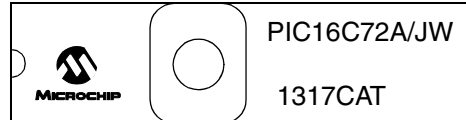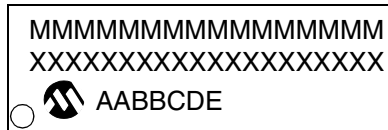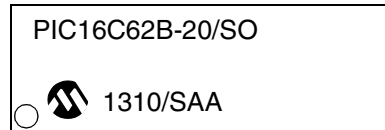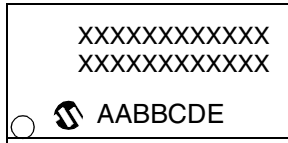
Legend: MM...M   Microchip part number information
XX...X   Customer specific information*
AA   Year code (last 2 digits of calendar year)
BB   Week code (week of January 1 is week '01')
C   Facility code of the plant at which wafer is manufactured
O = Outside Vendor
C = 5" Line
S = 6" Line
H = 8" Line
D   Mask revision number
E   Assembly code of the plant or country of origin in which part was assembled

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line thus limiting the number of available characters for customer specific information.

*   Standard OTP marking consists of Microchip part number, year code, week code, facility code, mask rev#, and assembly code. For OTP marking beyond this, certain price adders apply. Please check with your Microchip Sales Office. For QTP devices, any special marking adders are included in QTP price.

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